National Water-Quality Assessment Program

In cooperation with the Ohio Environmental Protection Agency

Comparison of U.S. Geological Survey and Ohio Environmental Protection Agency Fish-Collection Methods Using the Index of Biotic Integrity and Modified Index of Well-Being, 1996–97

Water-Resources Investigations Report 00-4255

U.S. Department of the Interior
U.S. Geological Survey

Cover photo: View of River Raisin at fish-sampling site near Manchester, Michigan. Photo by Alex Covert, U.S. Geological Survey, 1996.

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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to

- describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers,
- describe how water quality is changing over time, and
- improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of a select set of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the study units, and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch

Robert M. Hirsch
Chief Hydrologist

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CONVERSION FACTORS

Multiply	By	To obtain
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter
centimeter (cm)	0.3937	inch
kilometer (km)	0.6214	mile

Comparison of U.S. Geological Survey and Ohio Environmental Protection Agency Fish-Collection Methods Using the Index of Biotic Integrity and Modified Index of Well-Being, 1996–97

By S. Alex Covert

Abstract

The U.S. Geological Survey (USGS) and Ohio Environmental Protection Agency (OEPA) collected data on fish from 10 stream sites in 1996 and 3 stream sites in 1997 as part of a comparative study of fish community assessment methods. The sites sampled represent a wide range of basin sizes (ranging from 132–6,330 square kilometers) and surrounding land-use types (urban, agricultural, and mixed). Each agency used its own fish-sampling protocol. Using the Index of Biotic Integrity and Modified Index of Well-Being, differences between data sets were tested for significance by means of the Wilcoxon signed-ranks test ($\alpha = 0.05$). Results showed that the median of Index of Biotic Integrity differences between data sets was not significantly different from zero (p = 0.2521); however, the same statistical test showed the median differences in the Modified Index of Well-Being scores to be significantly different from zero (p = 0.0158). The differences observed in the Index of Biotic Integrity scores are likely due to natural variability, increased variability at sites with degraded water quality, differences in sampling methods, and low-end adjustments in the Index of Biotic Integrity calculation when fewer than 50 fish were collected. The Modified Index of Well-Being scores calculated by OEPA were significantly higher than those calculated by the USGS. This finding was attributed to the comparatively large numbers and biomass of fish collected by the OEPA. By combining the two indices and viewing them in terms of the percentage attainment of Ohio Warmwater Habitat criteria, the two agencies' data seemed comparable, although the Index of Biotic Integrity scores were more similar than the Modified Index of Well-Being scores.

Introduction

Since the 1970s, Federal and state government agencies have increased their interest and research in aquatic biology as part of water-resources assessments. This is particularly true in Ohio, where the Ohio Environmental Protection Agency (OEPA) and the U.S. Geological Survey (USGS) have established substantial data-collection programs in the area of aquatic biology. OEPA has been one of the leading agencies to develop and incorporate numeric biological water-quality criteria into water-quality assessments. "In the case of Ohio, these regulatory biological criteria are supported by the most extensive sampling, assessment, and implementation program in the nation" (Southerland and Stribling, 1995). The USGS collects physical, chemical, and biological data as part of the National Water-Quality Assessment (NAWQA) program. This program, which began in 1991, assesses water quality in study units representing major river basins and aquifer systems across the Nation. Biological approaches include the characterization of fish, invertebrate, and algal communities.

“Interagency collaboration and the use of comparable biological methods can reduce costs, expand the base of biological information useful for decision making, and enhance scientific understanding of biological processes in relation to physical and chemical processes in ecosystems” (Elizabeth Fellows, U.S. Environmental Protection Agency, quoted in Gurtz and Muir, 1994). For these reasons, the Intergovernmental Task Force on Monitoring Water Quality (ITFM) set as a priority the development of comparable biological methods for interagency use. Certain similarities in OEPA and USGS objectives and methods suggest that collaboration and data sharing of this type might be feasible between the two agencies. (Hereafter, “USGS” is used in reference to NAWQA activities in Lake Erie-Lake St. Clair Basin part of Ohio.) Both agencies describe the status and trends of surface waters on the basis of biological data. The similarity of objectives is apparent in the types of fish-community data collected by the two agencies: specifically, species distribution, composition, and relative-abundance data. Fish-collection methods of the two agencies also are similar; according to 45 biologists participating in an Interagency Biological Methods Workshop, differences in fish-sample-collection programs were relatively minor and would not affect data comparability (Gurtz and Muir, 1994).

In order to determine the feasibility and limitations of fish-community data exchange between OEPA and USGS programs, the two agencies did an investigation in which both agencies sampled the same sets of sites independently, after which biotic-index data derived from the two sets of samplings were compared.

Purpose and scope

This report describes the OEPA-USGS study methodology and discusses the qualitative and statistical comparison of the data. The data sets resulted from samplings at 10 sites in 1996 and 3 sites in 1997, representing a wide range of drainage areas and land-use/land-cover settings. The Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb) were the specific measures compared; attainment of applicable aquatic-life standards also was examined.

Acknowledgments

The author thanks Terry Keiser, Head of Biological Sciences Department at Ohio Northern University, for his assistance in fish data collection. The author also acknowledges Marc Smith and the staff at the Ohio Environmental Protection Agency for collecting and compiling fish data.

Study area and sampling sites

The USGS and OEPA used electroshocking methods and equipment to collect fish at the same 10 stream sites from late July to mid-October in 1996 and 1997 during low-flow conditions. The 10 sampling sites and reaches were selected for the USGS Lake Erie-Lake St. Clair Basin (LERI) study unit as part of the NAWQA program (fig. 1). A “reach” in this report is any continuous distance electrofished in one sampling pass. In 1996, all 10 sites were sampled by both agencies. The USGS sampled one reach at each site one time. The OEPA sampled a single reach at 7 of the 10 sites twice and the remaining 3 sites once. In 1997, three reaches were sampled, once by each agency, in each of three rivers.

Equipment and sampling methods

The USGS and OEPA collected fish by use of pulsed direct-current (DC) electrofishing equipment and techniques during daylight hours (table 1). The USGS also used seining techniques where applicable. Each agency used its own fish-sampling protocol (Meador and others, 1993; Ohio Environmental Protection Agency, 1989). For both agencies, the choice of electrofishing equipment and sampling techniques used depends on water depth and flow. In this study, two methods were used: wading and boat. Wading methods in this study utilized a small tote-barge for hauling equipment. The tote-barge is pulled by a sampling-crew member, and everyone in the crew walks in the water. Another wading method not used in this study utilizes backpack electroshocking equipment. Boat methods require that the equipment and crew be in a motor-powered boat.

The two protocols describe the selection of the appropriate electroshocking method differently. The USGS protocol bases the method selection on the description of a wadeable stream. “Towed electrofishing gear is usually more effective,” than backpack electrofishing, “in relatively wide (greater than about 5 m) wadeable streams with deep pools (greater than 1 m deep)” (Meador and others, 1993). Boat methods

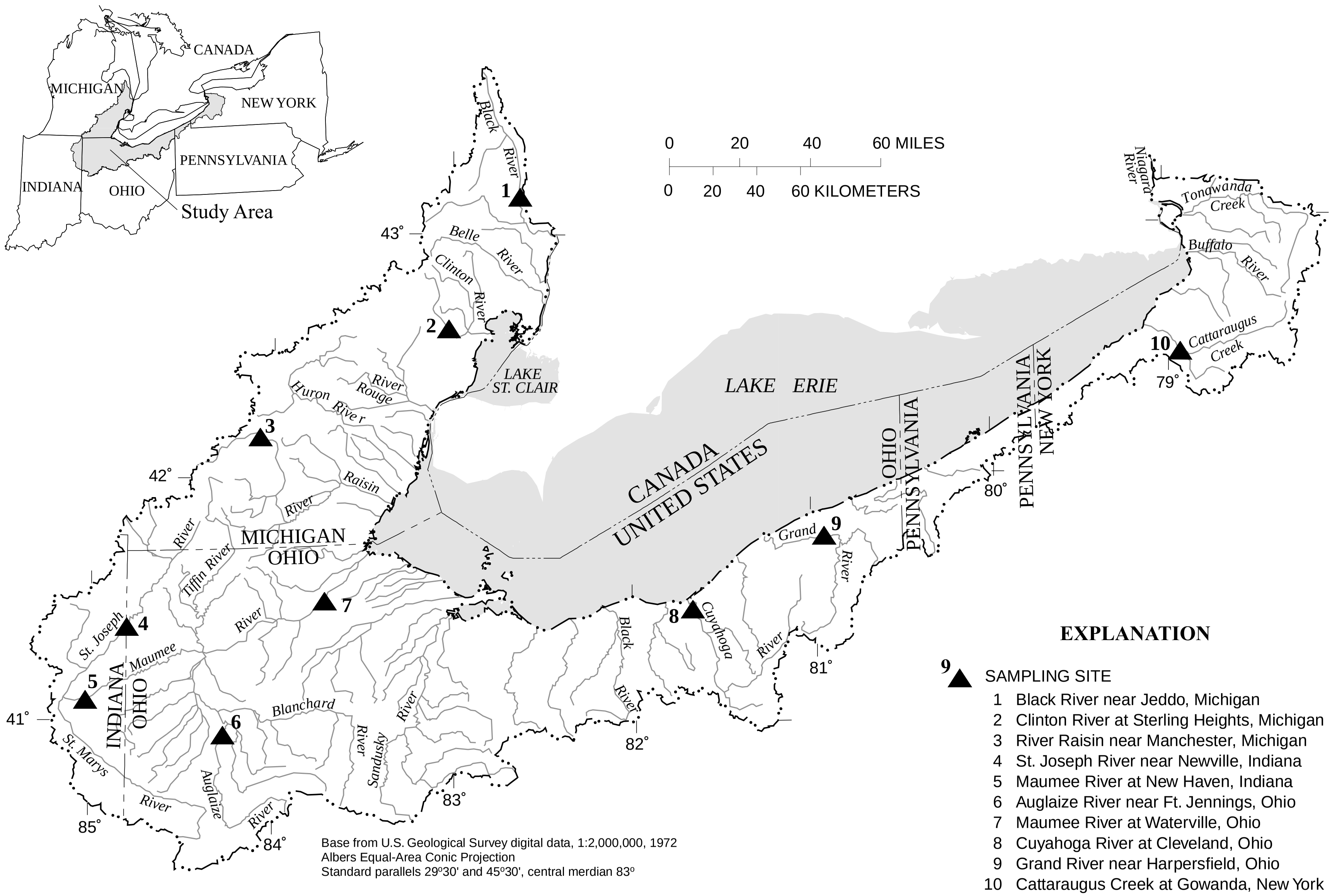

Figure 1. Study area and location of sampling sites, Lake Erie-Lake St. Clair Basin, Michigan, Indiana, Ohio, and New York.

Table 1. U.S. Geological Survey and Ohio Environmental Protection Agency electroshocking equipment

[cm, centimeter; in., inch; ft, foot; DC, direct current]

Type	U.S. Geological Survey		Ohio Environmental Protection Agency		
	1996	1997			
Equipment Used At Wading Sites					
Electrofishing unit	Boyd Electrofisher	Smith-Root 2.5 GPP Electrofisher	Model 1736 VDC T&J Electrofisher,	*or*	Smithroot 3.5 GPP Electrofisher,
Rated output current	5 amperes	8 amperes	7 amperes,		11 amperes,
DC output volts	500 volts	500/1,000 volts (low/high)	300 volts;		1,000 volts
Anode	11-in. anode ring	11-in. anode ring	Net ring		
Cathode	10-ft aluminum boat	12-ft aluminum boat	Approximately 15.2 X 45.7 cm stainless steel strip		
Tote-barge	10-ft aluminum boat	12-ft aluminum boat	Light, plastic boat		
Equipment Used At Boat Sites					
Electrofishing unit	Smith-Root Custom Electrofisher		Smith-Root VI-A Electrofisher,	*or*	Smith-Root 3.5 GPP Electrofisher,
Rated output current	20 amperes		8 amperes,		11 amperes,
DC output volts	1,000 volts		996 volts;		1,000 volts
Anode	Two umbrella-shaped stainless-steel cable configurations		Four stainless steel cables arranged in a line on boom on front of boat		
Cathode	Boat		Four flexible galvanized steel conduit arranged in a line on front of boat		
Boat (motor-powered)	16-ft metal boat		12-, 14-, or 16-ft metal boat		

are used in nonwadeable streams. The OEPA protocol bases the method selection on the accommodation of boats and equipment in the stream. Boat methods are used if a stream can accommodate a boat and equipment. Wading methods are used in “smaller, wadeable streams that can not accommodate the boat methods” (Ohio Environmental Protection Agency, 1989). Equipment used by each agency is listed in table 1.

Wading sites

Where wading methods are used, the USGS requires two successive sampling passes, in an upstream direction. A sampling pass in this report is any continuous electroshocking effort from end to end of a reach. Four to six crew members are involved. The USGS samples all of the habitat features within a sampling reach. One person carries the anode pole and controls the electroshocking. One person is needed to pull the tote-barge. Two to four people net the fish. An extra person transports the fish from the netters to the livewell on the tote-barge in larger rivers.

The OEPA requires one sampling pass in an upstream direction. Two to three people collect the fish. The OEPA samples all of the habitat features within a sampling reach. One person, the primary netter, operates the anode net ring. One person pulls the tote-barge. Other member or members may be used to net fish.

Boat sites

Where fish are collected from a boat, the USGS requires two successive passes, one along each bank, in a downstream direction. Three people are needed: one person controls the boat, and the other two people net the fish. The USGS samples all of the habitat features within a sampling reach.

The OEPA requires one pass in a downstream direction. Two people are specified: one person to control the boat and the other person to net the fish. The OEPA samples all of the habitat features within a sampling reach. The actual shocking time is considered an important factor. Minimum shocking times are specified in order to catch the required numbers and kinds of fish to adequately represent the sampling reach. The minimum shocking time is given as 1,300 to 1,600 seconds for a 0.5-km reach. The minimum time is increased (2,000 seconds) for slow-moving waters with many obstacles.

Processing fish samples in the field

The IBI and MIwb were compared in this report to study differing fish-collection methodologies. These indices require species identification, numbers of fish of each species, total weight of each species, and numbers of anomalies. Both agencies make an effort to train crew members in fish identification skills. These skills are used in the field to identify fish species. Both agencies, however, keep fish for later lab identification if any uncertainty exists. Taxonomic nomenclature for both agencies follows that established by the American Fisheries Society (Walsh and Meador, 1998). The total weight for each species and number of external anomalies is collected by the USGS and OEPA. Therefore, differences in equipment and in techniques used by experienced, trained personnel after the fish are captured probably are minimal and unlikely to affect reported results.

Analysis tools

Two major tools available for analysis of fish-community data are the IBI, developed by Karr (1981), and the Index of Well-Being (Iwb), developed by Gammon (1976). The IBI is based on fish-community structural and functional characteristics and is a measure of the health of an aquatic ecosystem. Fish communities at study-area stream sites are compared to those at reference stream sites (streams relatively unaffected by human activity) that drain similar-sized basins within the same ecoregion. The comparison allows a score to be assigned to each of 12 metrics. A summation of the metric scores gives an overall value from 12 to 60. Higher values usually indicate healthier aquatic ecosystems. The IBI used by the OEPA is specifically tailored to the surface waters of Ohio (Ohio Environmental Protection Agency, 1987). The Iwb is calculated from numbers of individuals, biomass, and the Shannon diversity index based on the numbers and weight of fish (Ohio Environmental Protection Agency, 1987). The Shannon diversity index takes into account species richness and proportion of each species within the local aquatic community (Shannon and Weaver, 1949). The OEPA modified the Iwb by excluding fish that were defined as highly tolerant from the numbers of individuals and biomass calculations. A higher score indicates a healthier aquatic ecosystem. The OEPA-modified versions of these indices (IBI and MIwb) were also applied to USGS data in this comparison. The calculation methods and specifics of each index are described by OEPA (1987).

The IBI and MIwb scores were calculated by the respective agency for each site sampled. The mean IBI and MIwb scores were calculated for each OEPA site that had been visited more than once. Both sets of scores were compared to Ohio Warmwater Habitat criteria.

Statistical analyses were done by means of Statit 3.0c (Statware, Inc., 1990). The Wilcoxon signed-rank test was used to determine whether the median difference of IBI and MIwb scores between paired observations equaled zero. The test was two-tailed to detect a difference in either direction. An α level of 0.05 was chosen.

Similarities and differences between U.S. Geological Survey and Ohio Environmental Protection Agency index scores

The OEPA consistently had higher scores at most sites for the IBI (table 2; fig. 2), although the median of differences between USGS and OEPA scores was not significantly different from zero (Wilcoxon signed-ranks test, $p = 0.2521$).

Reach A in the Clinton River produced highly variable results (table 2). The differences between the USGS and OEPA IBI scores were 15 and 24 in 1996 and 1997, respectively. In 1996, the OEPA score was higher, whereas the USGS score was higher for the next year. Because of the high within-year-sampling variability, the 1996 OEPA data for reach A in the Clinton River were not statistically compared with USGS data. No apparent reason could be assigned to this variability.

The electrofishing method chosen by each agency, boat or wading, was a possible source of data variability (table 3). When the USGS and the OEPA both used boat methods on the Maumee River at New Haven and on the Cuyahoga River, no differences in IBI scores were greater than 4; however, when the OEPA used the boat method and the USGS used the wading method on the Maumee River at Waterville in 1997 and on the St. Joseph River, differences in IBI scores were greater than or equal to 4.

The number of fish collected can influence all of the metrics of the IBI in which a percentage is calculated. As is evident from figure 3, the OEPA consistently captured more fish at most sites in terms of

Table 2. U.S. Geological Survey (USGS) and Ohio Environmental Protection Agency (OEPA) Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb) scores for the 18 sampling reaches

[A, B, and C correspond to the 3 reaches that were sampled by each agency in the specified river; N/A, not applicable; □ □, both agencies used wading methods; ■ ■, both agencies used boat methods; □ ■, OEPA used boat methods and USGS used wading methods]

Method	Year	Site location and reach	IBI scores		MIwb scores	
			USGS	OEPA	USGS	OEPA
□ □	1996	Grand River—A	48	44 (38, 50)*	8.9	9.5 (9.3, 9.7)*
□ □	1997	Grand River—A	52	40	8.7	8.0
□ □	1997	Grand River—B	54	48	N/A	8.6
□ □	1997	Grand River—C	52	52	9.9	10.1
■ ■	1996	Maumee River at New Haven	34	30 (30, 30)*	6.9	8.0 (7.8, 8.1)*
□ □	1996	Maumee River at Waterville	26	30 (28, 32)*	6.1	7.7 (7.3, 8.1)*
□ ■	1997	Maumee River at Waterville—A	32	42	7.8	8.6
□ ■	1997	Maumee River at Waterville—B	30	38	6.5	8.6
□ ■	1997	Maumee River at Waterville—C	28	32	7.2	8.5
□ ■	1996	St. Joseph River	22	28 (26, 30)*	4.0	7.4 (7.3, 7.4)*
□ □	1996	Auglaize River	32	35 (34, 36)*	7.0	9.3 (9.0, 9.6)*
□ □	1996	River Raisin	44	52 (52, 52)*	8.0	8.6 (8.3, 8.9)*
□ □	1996	Black River	38	42	6.9	9.1
■ ■	1996	Cuyahoga River	16	14	5.5	4.0
□ □	1996	Clinton River—A	12	27 (14, 40)*	2.3	4.7 (4.1, 5.2)*
□ □	1997	Clinton River—A	38	14	5.4	5.1
□ □	1997	Clinton River—B	38	42	7.1	6.8
□ □	1996	Cattaraugus Creek	36	38	6.2	7.4

* Mean score (individual score).

relative numbers of fish captured (per 0.3 or 1.0 km, depending on the method used) . Exceptions were when both agencies used the boat method.

The USGS and OEPA report similar IBI scores and, thus, similar descriptions of the status of aquatic ecosystems. The IBI score can be misleading, however, in that two fairly different sets of individual metrics may yield similar IBI scores. For example, the USGS may score higher on the number of total species metric but lower on the percent of tolerant fish metric than the OEPA; the IBI score nonetheless is the same. A comparison of the individual metric scores (1, 3, or 5) of the IBI (fig. 4) revealed that the differences between the USGS and OEPA for three of the metrics were considerable. The USGS had higher scores for two metrics, percent top carnivores and percent DELTs. The OEPA captured greater numbers of fish per effort as a function of distance.

The MIwb scores between the USGS and OEPA were considerably different (fig. 2). The Wilcoxon signed-ranks test showed that the median of differences among USGS and OEPA MIwb scores was significantly different from zero ($p = 0.0158$). The OEPA level of “significant departure” for MIwb scores starts at 0.5.

With reference to attainment of Warmwater Habitat (WWH) criteria based on IBI and MIwb scores, fish-community designations are similar for the two agencies (fig. 5). At one site (Maumee River at Waterville, reach B), data from the OEPA sample indicated that the WWH criteria for the IBI was satisfied, but data from the USGS sample indicated otherwise. At Clinton River, reach A, the USGS data suggested that WWH criteria for the IBI were met, but the OEPA data suggested the criteria were not met. At four sites (Maumee River at Waterville, reach A in 1996 and reach B in 1997; Auglaize River; and Black River), the OEPA data suggested that WWH criteria for the MIwb were met but USGS data suggested the criteria were not met.

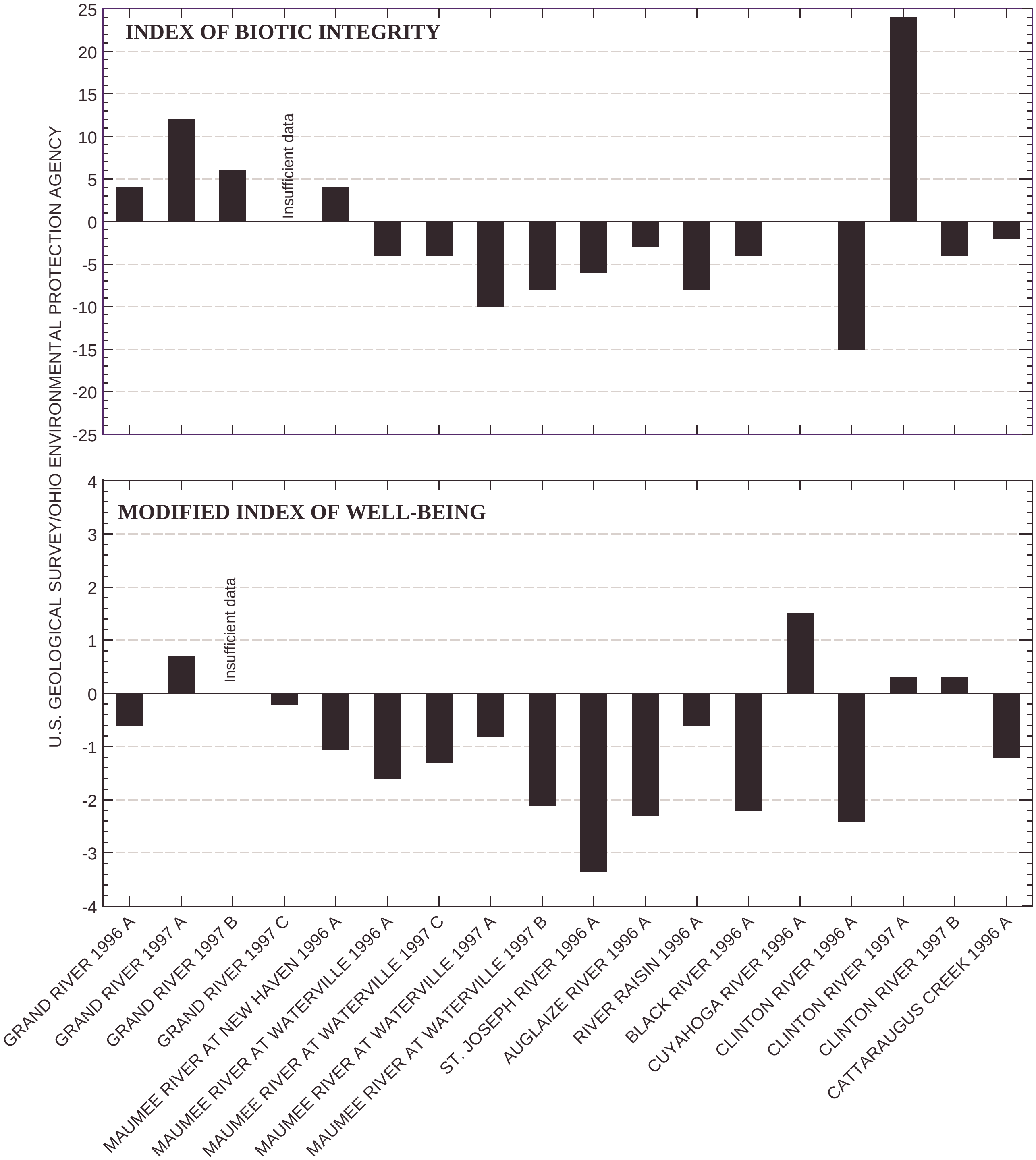

Figure 2. Differences (U.S. Geological Survey/Ohio Environmental Protection Agency) for Index of Biotic Integrity and Modified Index of Well-Being scores for streams in the Lake Erie-Lake St. Clair Basin. (Sampling sites with A, B, and C correspond to the three reaches (left to right at each site represents upstream to downstream) that were sampled by each agency in the specified river.)

Table 3. U.S. Geological Survey and Ohio Environmental Protection Agency Index of Biotic Integrity (IBI), individual metric, and Modified Index of Well-Being (MIwb) scores in 1996 and 1997

[mi[2], square miles; N, number of given metric; V, value of each IBI metric (1, 3, or 5); %, percentage of total number of fish; km, kilometer; DELT, deformities, eroded fins, lesions, and tumors; @, wading metric replaced by boat metric]

Year	Agency	Reach	Date	Drainage area (mi^2)	Total species N(V)	Darter species N(V)	Sunfish species N(V)	Sucker species N(V)	Intolerant species N(V)	Tolerant species %(V)	Omnivores %(V)	Insectivores %(V)	Top carnivores %(V)	Number per 0.3 or 1.0 km N(V)	Simple lithophils %(V)	DELT anomalies %(V)	IBI	MIwb
Grand River (Ohio)																		
1996	USGS	A	08/06/96	552	31(5)	7(5)	3(3)	2(1)	3(3)	15(5)	14(5)	62(5)	17(5)	374(3)	46(5)	1.2(3)	48	8.9
	EPA	A	09/17/96	552	37(5)	5(3)	6(5)	3(3)	7(5)	35(1)	36(1)	38(3)	21.8(5)	450(3)	13(1)	0.2(3)	38	9.3
	EPA	A	10/03/96	552	32(5)	5(3)	6(5)	3(3)	4(3)	13(5)	13(5)	67(5)	17.3(5)	642(3)	22(3)	0.2(5)	50	9.7
1997	USGS	A	07/22/97	552	38(5)	6(3)	6(5)	6(5)	6(5)	10(5)	12(5)	69(5)	15(5)	420(3)	48(5)	4.0(1)	52	8.7
	EPA	A	08/14/97	552	21(3)	7(5)	1(1)	0(1)	5(3)	25(3)	23(3)	70(5)	3.0(3)	594(3)	38(5)	0.0(5)	40	8.0
	USGS	B	07/22/97	552	33(5)	7(5)	4(5)	7(5)	7(5)	13(5)	13(5)	72(5)	11(5)	744(3)	45(5)	3.2(1)	54	N/A
	EPA	B	08/14/97	552	22(3)	6(3)	4(5)	3(3)	5(3)	13(5)	14(5)	75(5)	9.1(5)	374(3)	49(5)	0.7(3)	48	8.6
	USGS	C	07/23/97	553	30(5)	5(3)	4(5)	5(3)	5(3)	10(5)	10(5)	76(5)	10(5)	1061(5)	47(5)	0.7(3)	52	9.9
	EPA	C	08/14/97	553	24(5)	6(3)	2(3)	4(3)	5(3)	7(5)	8(5)	81(5)	6.9(5)	813(5)	46(5)	0.0(5)	52	10.1
Maumee River At New Haven (Indiana)																		
(OEPA and USGS calculated the IBI using boat criteria. Number of darter species replaced with percent round-bodied suckers.)																		
1996	EPA		09/05/96	1,966	18(3)	2(1)@	4(5)	4(3)	0(1)	34(1)	17(3)	73(5)	2(1)	270(3)	?(1)	2.0(3)	30	8.1
	USGS		10/10/96	1,966	13(3)	37(3)@	2(3)	1(1)	1(1)	14(5)	22(3)	65(5)	4(1)	105(1)	45(5)	4.1(3)	34	6.9
	EPA		10/17/96	1,966	13(3)	22(3)@	2(3)	5(3)	1(1)	29(1)	26(3)	66(5)	3(1)	104(1)	23(3)	1.4(3)	30	7.8
Maumee River At Waterville (Ohio)																		
1996	USGS		08/08/96	6,328	23(5)	1(1)	2(3)	3(1)	0(1)	34(1)	40(1)	23(1)	16(5)	58(1)	12(1)	0.0(5)	26	6.1
	EPA		09/10/96	6,328	15(3)	1(1)	1(1)	2(1)	1(1)	7(3)	28(3)	47(3)	19.7(5)	148(1)	21(3)	0.8(3)	28	7.3
	EPA		10/03/96	6,328	17(3)	2(1)	3(3)	3(1)	1(1)	23(1)	40(1)	58(5)	2.4(3)	801(5)	32(3)	0.0(5)	32	8.1
(OEPA calculated the IBI using boat criteria. Number of darter species replaced with percent round-bodied suckers.)																		
1997	USGS	C	07/31/97	6,320	21(3)	2(1)	4(5)	4(3)	3(3)	44(1)	48(1)	25(1)	11(5)	66(1)	18(3)	5.7(1)	28	7.2
	EPA	C	10/02/97	6,320	12(3)	36(3)@	0(1)	5(3)	0(1)	13(5)	27(3)	43(3)	10(3)	158(1)	37(5)	4.4(1)	32	8.5
	USGS	A	07/30/97	6,328	23(5)	0(1)	5(5)	5(3)	1(1)	32(1)	32(3)	34(3)	13(5)	81(1)	21(3)	5.0(1)	32	7.8
	EPA	A	10/02/97	6,328	12(3)	58(5)@	0(1)	4(3)	0(1)	8(5)	14(5)	67(5)	8(3)	286(3)	61(5)	1.3(3)	42	8.6
	USGS	B	07/31/97	6,330	26(5)	0(1)	6(5)	4(3)	3(3)	54(1)	53(1)	20(1)	8(5)	92(1)	8(1)	1.8(3)	30	6.5
	EPA	B	10/02/97	6,330	12(3)	53(5)@	1(1)	4(3)	0(1)	15(5)	24(3)	63(5)	4(1)	244(3)	57(5)	2.1(3)	38	8.6
St. Joseph River (Indiana)																		
(OEPA calculated the IBI using boat criteria. Number of darter species replaced with percent round-bodied suckers.)																		
1996	USGS		07/22/96	609	14(3)	1(1)	2(3)	2(1)	1(1)	60(1)	37(1)	47(3)	13(5)	28(1)	6(1)	7.0(1)	22	4.0
	EPA		09/10/96	609	17(3)	15(1)@	5(5)	5(3)	0(1)	50(1)	31(1)	49(3)	13(5)	136(1)	18(1)	4.9(1)	26	7.3
	EPA		10/17/96	609	15(3)	24(3)@	3(3)	5(3)	1(1)	16(3)	66(1)	29(3)	3(1)	310(3)	26(3)	1.6(3)	30	7.4

Table 3. U.S. Geological Survey and Ohio Environmental Protection Agency Index of Biotic Integrity (IBI), individual metric, and Modified Index of Well-Being (MIwb) scores in 1996 and 1997—Continued

[mi^2, square miles; N, number of given metric; V, value of each IBI metric (1, 3, or 5); %, percentage of total number of fish; km, kilometer; DELT, deformities, eroded fins, lesions, and tumors; @, wading metric replaced by boat metric]

Year	Agency	Reach	Date	Drainage area (mi^2)	Total species N(V)	Darter species N(V)	Sunfish species N(V)	Sucker species N(V)	Intolerant species N(V)	Tolerant species %(V)	Omnivores %(V)	Insectivores %(V)	Top carnivores %(V)	Number per 0.3 or 1.0 km N(V)	Simple lithophils %(V)	DELT anomalies %(V)	IBI	MIwb
Auglaize River (Ohio)																		
1996	USGS		07/26/96	327	19(3)	2(1)	4(5)	4(3)	1(1)	31(1)	25(3)	58(5)	2.9(3)	93(1)	28(3)	0.9(3)	32	7.0
	EPA		09/09/96	327	30(5)	3(1)	6(5)	4(3)	2(1)	42(1)	31(3)	64(5)	2.1(3)	672(3)	5(1)	0.6(3)	34	9.0
	EPA		10/03/96	327	28(5)	3(1)	5(5)	4(3)	1(1)	34(1)	28(3)	67(5)	2.1(3)	791(5)	10(1)	0.1(3)	36	9.6
River Raisin (Michigan)																		
1996	USGS		07/23/96	132	21(3)	5(3)	0(1)	3(3)	6(5)	10(5)	8(5)	76(5)	13(5)	338(3)	61(5)	1.9(1)	44	8.0
	EPA		09/04/96	132	26(5)	4(3)	2(3)	4(3)	7(5)	8(5)	7(5)	85(5)	4.7(3)	924(5)	43(5)	0.0(5)	52	8.9
	EPA		10/18/96	132	23(5)	4(3)	3(3)	4(3)	7(5)	12(5)	4(5)	77(5)	10.8(5)	380(3)	56(5)	0.0(5)	52	8.3
Black River (Michigan)																		
1996	USGS		07/24/96	464	17(3)	3(1)	2(3)	2(1)	2(1)	14(5)	10(5)	79(5)	4.3(3)	106(1)	63(5)	0(5)38	38	6.9
	EPA		09/04/96	464	25(5)	4(3)	3(3)	3(3)	3(3)	17(3)	15(5)	76(5)	4.6(3)	623(3)	35(3)	0.4(3)	42	9.1
Cuyahoga River (Ohio) (OEPA and USGS calculated the IBI using boat criteria. Number of darter species replaced with percent round-bodied suckers.)																		
1996	EPA		08/12/96	786	7(1)	3(1)@	0(1)	2(1)	0(1)	24(3)	91(1)	8(1)	1(1)	146(1)	11(1)	10.4(1)	14	4 .0
	USGS		10/08/96	786	6(1)	2(1)@	0(1)	2(1)	0(1)	17(3)	97(1)	2(1)	1(1)	447(3)	9(1)	8 (1)	16	5.5
Clinton River (Michigan)																		
1996	USGS	A	07/25/96	309	6(1)	0(1)	1(1)	1(1)	0(1)	7(1)	7(1)	33(1)	40(1)	17(1)	20(1)	0.0(1)	12	2.3
	EPA	A	09/04/96	309	10(1)	2(1)	4(5)	2(1)	0(1)	10(5)	5(5)	60(5)	34.5(5)	71(1)	43(5)	0.0(5)	40	5.2
	EPA	A	10/08/96	309	7(1)	2(1)	2(3)	1(1)	0(1)	7(1)	0(1)	50(1)	46.7(1)	38(1)	23(1)	0.0(1)	14	4.1
1997	USGS	A	07/29/97	309	8(1)	1(1)	2(3)	2(1)	1(1)	2(5)	2(5)	67(5)	12(5)	69(1)	41(5)	0.0(5)	38	5.4
	EPA	A	09/09/97	309	8(1)	2(1)	2(3)	1(1)	0(1)	3(1)	3(1)	80(1)	16.7(1)	40(1)	57(1)	0.0(1)	14	5.1
	USGS	B	07/29/97	309	16(3)	2(1)	4(5)	3(3)	1(1)	16(5)	15(5)	45(3)	10(5)	56(1)	41(5)	7.0(1)	38	7.1
	EPA	B	09/09/97	309	15(3)	3(3)	4(5)	2(1)	1(1)	8(5)	5(5)	75(5)	14.3(5)	107(1)	34(3)	0.0(5)	42	6.8
Cattaraugus Creek (New York)																		
1996	USGS		08/07/96	436	11(1)	0(1)	0(1)	3(3)	3(3)	18(3)	18(5)	71(5)	6.6(5)	90(1)	63(5)	1.1(3)	36	6.2
	EPA		10/02/96	436	16(3)	2(1)	0(1)	4(3)	4(3)	7(5)	5(5)	70(5)	3.7(3)	641(3)	17(1)	0.0(5)	38	7.4

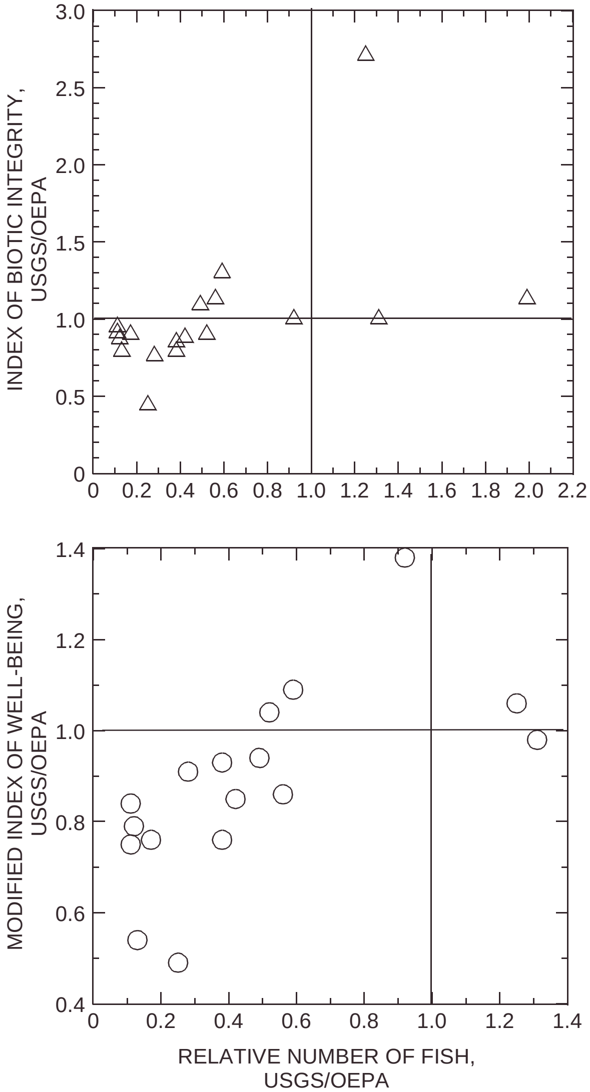

Figure 3. Index of Biotic Integrity and Modified Index of Well-Being scores plotted against the relative number of fish collected in the Lake Erie-Lake St. Clair Basin. (Axes are ratios, U.S. Geological Survey (USGS)/Ohio Environmental Protection Agency (OEPA). A data point greater than 1.0 indicates the USGS scored higher, whereas a data point below 1.0 indicates the OEPA scored higher.)

Data comparability and sources of data variability

In order to determine the limits of exchanging fish-community data, this study design included possible sources of variability by allowing each agency to use its own fish-sampling protocol. Variability in IBI and MIwb scores can be affected by temporal, spatial, and sampling differences, and (or) by anthropogenic sources. Variability from spatial and temporal differences in sampling was minimized in this study because the sampling was done in the same reaches during the same seasons. Anthropogenic sources of variability, as reflected in land use/cover among the 10 study sites, differed considerably; however, only the potential anthropogenic effects at the most disturbed sites were examined in this study.

Index of Biotic Integrity scores

Most of the differences in IBI scores fell within the OEPA range of “insignificant departure” (4 or fewer IBI points) (Ohio Environmental Protection Agency, 1987). In other words, a difference of 4 or fewer IBI points could be accounted for by natural or background variability. Differences of greater than 4 IBI points directed further analysis. Rankin and Yoder (1990) conclude that those rivers most affected by human degradation exhibit the most variability in IBI scores. Perhaps this was the case where the difference in IBI scores was much greater than 4 (for example, the Clinton River, reach A).

The differences greater than 4 IBI points may represent sampling variability in some form. Sampling variability can include, but is not limited to, electroshocking methods, sampling equipment, water conditions during sampling, amount of fishing effort (as a function of time), and technical skill level of the crew. Although the quantitative requirements for sampling fish between the USGS and OEPA were not the same, the differences in requirements would be easy to reconcile. The requirements specify the number of passes, the number of crew members, the equipment to use, and the length of the reaches to be fished. Numerous suggestions in the sampling protocols, however, leave room for individual operator preference and allow subjective decisions that come with experience; hence, the exact sampling approach at a site is difficult to replicate. The length of time and pattern that electrical current is applied to the water can be variable. Electricity can be applied continuously or sporadically. Another variable, in-stream movement of the sampling effort, is under the control of the operator. One technique is to collect fish in a zig-zag pattern from bank to bank. Natural barriers, such as riffles, can be used to herd the fish. The habitat features to sample is another decision that depends on the individual operator.

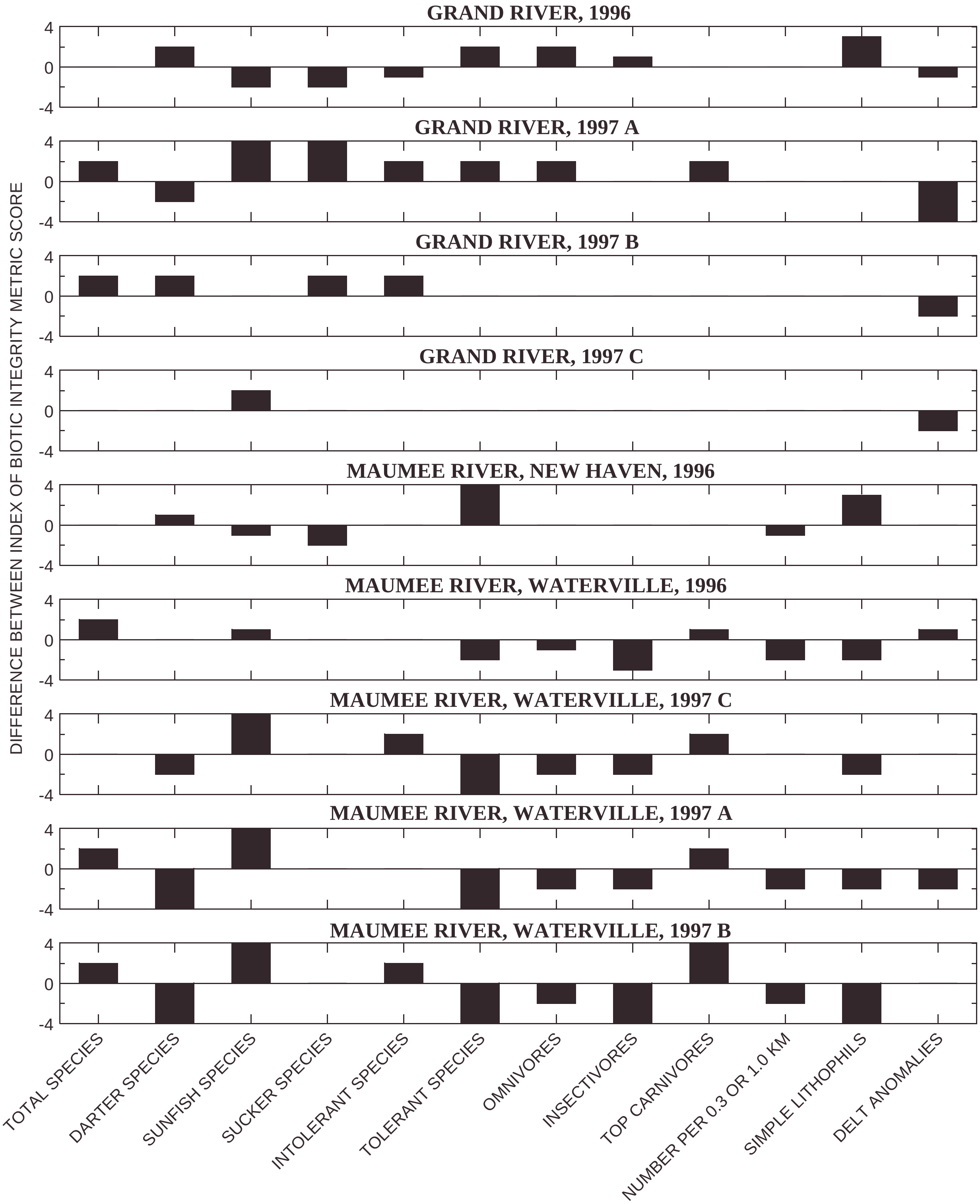

Figure 4. Differences between U.S. Geological Survey and Ohio Environmental Protection Agency for each metric of the Index of Biotic Integrity at stream sites in the Lake Erie-Lake St. Clair Basin. (Sampling sites with A, B, and C correspond to the three reaches that were sampled by each agency in the specified river.)

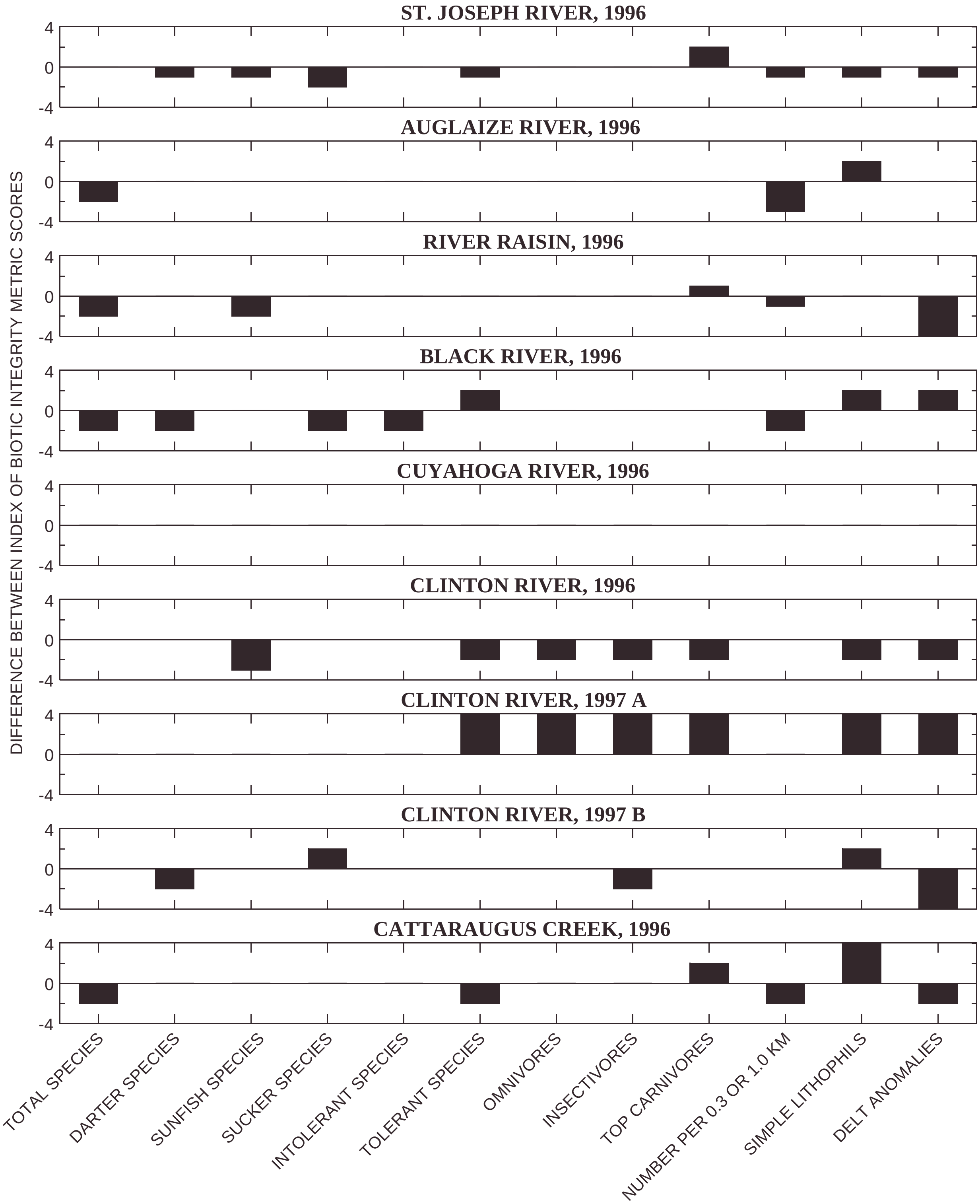

Figure 4. Differences between U.S. Geological Survey and Ohio Environmental Protection Agency for each metric of the Index of Biotic Integrity at stream sites in the Lake Erie-Lake St. Clair Basin—Continued.

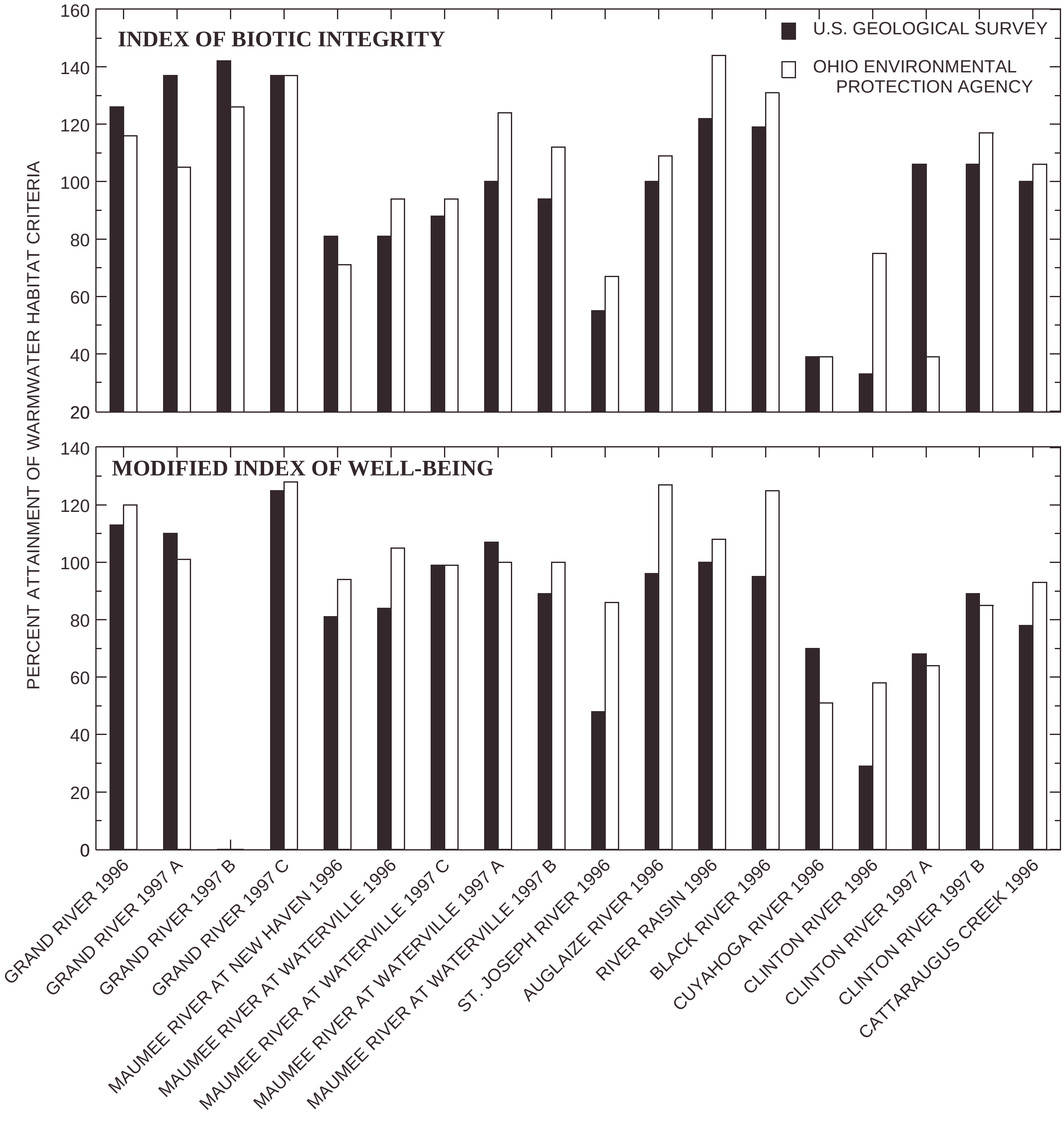

Figure 5. Percentage of attainment of Warmwater Habitat criteria for Index of Biotic Integrity and Modified Index of Well-Being scores for streams in the Lake Erie-Lake St. Clair Basin. (Sampling sites with A, B, and C correspond to the three reaches that were sampled by each agency in the specified river. For sites that fall into an ecoregion with no criteria for warmwater habitat, percent attainment was calculated using the Ohio Environmental Protection Agency (1987) narrative criteria for “Good”.)

One evident source of sampling variability was the method—boat or wading—of fish collection used (table 3), and results may indicate that fish data obtained using the two methods cannot be compared. Two IBI metrics do not compare when different methods are used: relative numbers of fish and percentage of darter species or round-bodied suckers.

The major differences in the relative numbers of fish are a direct result of the calculation of the IBI and greater capture rates. This has implications on many of the results and may have been avoided had the same methods been selected. The number of fish collected is calculated per 0.3 and 1.0 km for wading and boat methods, respectively, in order to normalize the number of fish captured and allow comparison of data collected by the same method. In those instances when the USGS used the wading method and the OEPA used the boat method, the calculated number of fish caught per reach was much lower for USGS. For example, the OEPA caught approximately 143 fish at one 0.5 km reach (boat), whereas the USGS captured 135 fish in 0.5 km (wading). Converting the number of fish using the boat method calculations, the OEPA caught 286 fish per 1.00 km; using the wading method calculations, the USGS captured 81 fish in 0.3 km. The OEPA had a metric score of 3, whereas the USGS scored 1. The boat-site criterion is actually lower in terms of the numbers of fish required to meet that criterion. Thus, because the number of fish captured by the wading method is normalized with a shorter distance than for the boat method, the relative-number metric does not accurately compare scores if both methods are used at the same site.

The use of number of darter species or percentage of round-bodied suckers as an IBI metric depends on the electroshocking methods: for wading sites, number of darter species is used, whereas for boat sites, the percentage of round-bodied suckers is used. When the USGS used wading methods and the OEPA used boat methods, the USGS scored lower on this metric, although the differences were not significant. Again, this metric does not accurately compare scores if both methods are used at the same site.

Sampling results can be affected by the type of electrofishing equipment used. One potential source of sampling variability might have been the differing numbers of fish captured due to the use of different equipment, especially in 1996. The USGS used a less powerful electroshocker during 1996 (table 1) and the OEPA consistently collected a higher number of fish for most sites that year (fig. 3).

Besides being a source of variability in and of itself, the number of fish collected can influence all of the metrics of the IBI in which a percentage is calculated. If the relative number (number per specified distance) of fish collected is less than 50 individuals, then the metrics are adjusted for percentages of tolerant fishes, omnivores, insectivores, top carnivores, simple lithophils, and DELTs. These adjustments (called low-end adjustments) reflect the low ecosystem health and skewness exerted on the those metrics that often results from such low numbers (Ohio Environmental Protection Agency, 1987). For samples of 50 to 200 fish (relative number, including tolerants), these same metrics can also be low-end adjusted if the metric data meet certain requirements. These adjustments were based on many reference sites (Ohio Environmental Protection Agency, 1987). This study involved 18 samples from 10 study sites. Because of the small sample size, the cutoff point of 50 individuals caused large differences between the USGS and OEPA IBI scores in certain situations. For example, the 1997 USGS and OEPA IBI scores at reach A in the Clinton River were 38 and 14, respectively. The USGS collected 69 fish and the OEPA collected 40, a difference of 29 fish. If the USGS had caught fewer fish, the adjustments for low numbers would have resulted in a smaller difference in the IBI scores.

A large change in streamflow can affect the collection of fish. Increased flow and decreased clarity can reduce sampling effectiveness (Ohio Environmental Protection Agency, 1987). The fish-collection protocols of both agencies indicate that sampling should be done during stable-flow conditions for this reason; however, the large difference in the numbers of fish between the two agencies prompted an evaluation of the streamflow data. Streamflow records were examined for one week prior to sampling. The three samples of highest concern were those collected by the OEPA at the Grand River on October 3, 1996, by the USGS at the Auglaize River on July 26, 1996, and by the OEPA at Cattaraugus Creek on October 2, 1996. Greater magnitudes of change in streamflow were expected to correlate closely with numbers of fish captured, but, in fact, no relation was found between daily streamflow and numbers of fish captured.

The amount of time that electricity was applied to the water was recorded in 1997. This measure is one way to indirectly explain numbers of fish captured.

Greater shocking times were expected to correlate closely with greater numbers of fish. The different number of passes performed by each agency adds some difficulty to the analysis. The total shock time for the USGS was divided by 2 to represent one sampling pass. Correspondingly, the number of fish collected by the USGS should also be divided by 2; however, the number of fish captured for the first pass is usually higher than any subsequent passes, so comparing an average number of fish would be a misrepresentation of reality. A comparison of the USGS and OEPA electroshocking times did not reveal a relation to the number of fish captured. At the Maumee River at Waterville, the USGS applied a longer shocking time (than did OEPA), but collected fewer fish. This result may be attributable to the OEPA's use of the boat method (table 3). For the Grand River, the shock times for the OEPA were greater and produced only slightly greater numbers of fish.

In summary, the number of fish collected is a major component of many of the factors affecting the comparability of IBI scores between the USGS and OEPA. Two major considerations arise from this investigation that relate directly to the number of fish captured. First, because of the small numbers of fish collected by the USGS at some of the sites, not all of the metrics measured by the IBI may be adequately represented, especially where the USGS chose tote-barge wading methods and OEPA chose boat methods (table 3). This has implications on many of the results and may have been avoided had the same methods been selected. Because the scoring of metrics in the IBI differs depending on the method used, problems can occur with results not falling into the calibration range intended for a given site (Yoder and Smith, 1999) and with differences in how low-end adjustments are applied. Second, the OEPA performs one pass on each of two separate visits and then combines the data; between passes, there is sufficient time for fish to repopulate the area; resulting in greater apparent OEPA sampling effectiveness compared to that of the USGS.

Modified Index of Well-Being scores

Similar IBI scores do not necessarily signify low sampling variability. Because it is a multimetric biological index that incorporates several factors, the IBI is not extremely sensitive to the total numbers of fish collected. For this reason, the MIwb was also included in the analysis.

Three components make up and affect the MIwb scores: the numbers of fish, the weights of the fish, and the percentage of tolerant fish collected. As discussed previously, the numbers of fish collected by the OEPA were considerably higher than those of the USGS. In only four instances did the USGS collect more fish than the OEPA; thus, it follows that this would help explain why the MIwb scores computed by the OEPA were usually higher than those of the USGS (fig. 2). Of the four times when the USGS had higher MIwb scores than the OEPA, only two of the differences were greater than the 0.5 accounted for by natural variation: reach A in the Grand River, 1997, and the Cuyahoga River, 1996 (fig. 2). The OEPA caught more fish in reach A of the Grand River, but 25 percent of those fish were tolerant species. This lowered the OEPA-MIwb compared to the USGS score. In the Cuyahoga River, the number of fish and percentage of tolerant fish species caught by each agency were similar, an indication that the USGS captured larger fish. Of the remaining MIwb scores, the main metric causing the large differences was the higher number of fish collected by the OEPA. As with the IBI, the differences between use of the wading and boat methods, which affected relative numbers of fish collected, were a major influence on differences in MIwb scores.

Comparison of index scores in relation to aquatic-life criteria

The OEPA has established numeric aquatic-life criteria on the basis of the regional reference-site concept (Yoder and Rankin 1995; Simon and Lyons, 1995). The various ecoregions in Ohio have differing levels of "tolerance, resilience, and attainable quality of ecosystems" (Omernik, 1995), which are accounted for in these criteria. IBI and MIwb results are shown in figure 5 as a percentage of the attainment of the Warmwater Habitat (WWH) criteria for the ecoregions in which the sampling sites were located. The WWH-use designation is the most commonly applied aquatic-life use designation in Ohio (Yoder and Rankin, 1995). This and other aquatic-life use designations are based on the potential to support a healthy fish community. The goal, then, as presented in the Clean Water Act and supported by the aquatic-life criteria, is to maintain or improve the integrity of the aquatic ecosystem. The IBI and MIwb scores have been directly compared throughout most of this report. Perhaps comparing the attainment of an aquatic-life use mandated by law would be a more relevant analysis with respect to how well fish-community data can be shared for purposes of assessing and maintaining the integrity of aquatic ecosystems. The results of the comparison done in this study show that the fish communities, as measured by the attainment of aquatic-life use designations are similar for the two agencies. With respect to the IBI, there were only 2 sampled reaches out of 18 where one agency's data met the WWH criteria (100 percent attainment) and the other's did not. With respect to the MIwb, there were only 4 such reaches out of 17.

Summary and conclusions

The Index of Biotic Integrity and Modified Index of Well-Being can be used to help evaluate aquatic ecosystem health. A comparison of these two indices was used to determine the feasibility and limitations of fish-community data exchange between U.S. Geological Survey and Ohio Environmental Protection Agency programs.

The analysis indicated that the USGS and OEPA IBI scores were similar, although OEPA tended to report higher IBI scores. However, the median of differences of IBI scores was not statistically different from zero.

Small differences in the individual IBI metric scores were found between the two agencies. Several factors may have contributed to these differences in the form of temporal, spatial, sampling, and (or) anthropogenic variability. IBI scores for rivers that have been affected by major anthropogenic activity are more variable than those in less affected streams (Rankin and Yoder, 1990). Another possible factor is that low-end adjustments may have inflated the differences between certain metrics when small numbers of fish were collected. Calculation of relative numbers of fish at the same site based on two different methods (wading and boat) can also cause differences in IBI scores.

The MIwb scores were considerably different between the two agencies, OEPA having higher scores. This finding was attributed to the higher reported numbers of fish captured by the OEPA. Despite the differing MIwb scores, there were only four instances where the OEPA MIwb values indicated the stream met the Warmwater Habitat criteria and the corresponding USGS values did not.

On the basis of IBI scores alone, the fish-sampling results of the two agencies are comparable. Examination of the MIwb scores highlights differences in the fish data, specifically in the numbers of fish captured by each agency. Yet, if both agencies' results for the two indices are viewed relative to the percentage attainment of Ohio Warmwater Habitat criteria, considerable data comparability is once again evident.

One common factor, the number of fish captured, drives most of the differences in IBI and MIwb scores between the two agencies. The OEPA consistently collected more fish, for several possible reasons: differences in electroshocking equipment (particularly in 1996), the type of electrofishing method used (boat or wading) and the associated difference in how the fish-number metric in the IBI was calculated, differences in streamflow, unknown influences of sampling-crew experience, and the OEPA approach of one sampling pass each on two separate visits, thus allowing a period of time for fish to possibly repopulate the area.

There are several areas in which the use of similar sampling approaches by the two agencies would minimize the differences in numbers of fish collected and, thus, the variability in the comparison and exchange of fish-community data. These include the following:

- Use of electroshocking equipment comparable in output power.
- Choice of the identical method of electroshocking based on the depth, width, and flow of the river (if there is a question as to which method to use and a check of past electrofishing methods used at that site for a reference).
- No collection of fish if streamflow is changing quickly.
- Continued training of field crews on electroshocking methods.
- Interagency communication on specific issues to help facilitate data exchange.

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