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Ictalurids in Iowa's Streams and Rivers: Status, Distribution, and Relationships with Biotic Integrity

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Abstract.—Anthropogenic alterations to Iowa's landscape have greatly altered lotic systems with consequent effects on the biodiversity of freshwater fauna. Ictalurids are a diverse group of fishes and play an important ecological role in aquatic ecosystems. However, little is known about their distribution and status in lotic systems throughout Iowa. The purpose of this study was to describe the distribution of ictalurids in Iowa and examine their relationship with ecological integrity of streams and rivers. Historical data (i.e., 1884–2002) compiled for the Iowa Aquatic Gap Analysis Project (IAGAP) were used to detect declines in the distribution of ictalurids in Iowa streams and rivers at stream segment and watershed scales. Eight variables characterizing ictalurid assemblages were used to evaluate relationships with index of biotic integrity (IBI) ratings. Comparisons of recent and historic data from the IAGAP database indicated that 9 of Iowa's 10 ictalurid species experienced distribution declines at one or more spatial scales. Analysis of variance indicated that ictalurid assemblages differed among samples with different IBI ratings. Specifically, total ictalurid, sensitive ictalurid, and *Noturus* spp. richness increased as IBI ratings increased. Results indicate declining ictalurid species distributions and biotic integrity are related, and management strategies aimed to improve habitat and increase biotic integrity will benefit ictalurid species.

Introduction

Fishes are the most diverse of all vertebrate groups, and the United States has among the highest diversity of temperate freshwater fishes in the world (Warren and Burr 1994). One of the most ubiquitous groups of fishes is the family Ictaluridae, representing 5.1% of all fish species in the United States (Warren and Burr 1994). Ictalurids are ecologically diverse varying in size from a few grams (e.g., *Noturus* spp.) to more than 50 kg (e.g., blue catfish *Ictalurus furcatus* and flathead catfish *Pylodictis olivaris*). Similarly, ictalurid species live in a variety of habitats from riffles in small streams to the main channel of great rivers and serve multiple roles in aquatic systems by functioning as benthic invertivores (e.g., yellow bullhead *Ameiurus natalis* and stonecat *N. flavus*) to top carnivores (e.g., channel catfish *I. punctatus* and flathead catfish). Not only are ictalurids ecologically diverse, they also require different management strategies and vary in their conservation status. For example, channel catfish is among the most popular and widely distributed sport fishes in the United States (Hubert 1999). Flathead catfish and blue catfish also provide important recreational fisheries, and all three species are commercially harvested (Graham 1999; Hubert 1999; Jackson 1999).

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In contrast, many ictalurids do not support fisheries and are of high conservation concern. Specifically, 58% of described ictalurid species in North America are considered vulnerable, threatened, endangered, extinct, or to have imperiled populations by the American Fisheries Society (e.g., Neosho madtom *N. placidus* and pygmy madtom *N. stanauli*; Jelks et al. 2008).

Ictalurids are common in eastern U.S. waters. In Iowa, ictalurids represent approximately 7% of the total number of fish species and include black bullhead *A. melas*, yellow bullhead, brown bullhead *A. nebulosus*, blue catfish, channel catfish, slender madtom *N. exilis*, stonecat, tadpole madtom *N. gyrinus*, freckled madtom *N. nocurnus*, and flathead catfish (Harlan and Speaker 1987; Loan-Wilsey et al. 2005). Although ictalurids inhabit a variety of aquatic ecosystems (e.g., lakes, ponds, rivers, reservoirs, and wetlands), all of Iowa's ictalurid species occur in lotic systems. Similar to other regions of North America, conservation of ictalurids is important in Iowa. Specifically, 5 of Iowa's 10 ictalurid species (i.e., brown bullhead, blue catfish, slender madtom, tadpole madtom, and freckled madtom) are classified as species of greatest conservation need (SGCN) by the Iowa Department of Natural Resources (IDNR; Zohrer 2006). However, degradation of Iowa's lotic systems caused by anthropogenic alterations to the landscape may be the cause for a decline in the distribution and abundance of this diverse group of fishes.

Humans have altered Iowa's lotic systems by channelizing streams, draining wetlands, constructing instream barriers, removing native vegetation, and introducing nonnative species (Bulkley 1975; Menzel 1981; Wilton 2004). Extensive row crop agriculture has been one of the primary contributors to landscape alteration and has been linked to imperilment of freshwater ecosystems across the Midwest and particularly Iowa (Menzel 1981, 1983; Karr et al. 1985; Roth et al. 1996; Wang et al. 1997; Allan 2004; Heitke et al. 2006; Rowe et al. 2009a). Agricultural land composes more than 70% of Iowa's landscape (Natural Resource Conservation Service 2007) and will continue to contribute to imperilment of freshwater ecosystems and a loss of biodiversity in the state.

Understanding the status of species and cause for declines remains an important focus of fisheries scientists. A common method for detecting trends in a species' status is to compare presence–absence or abundance data from fixed locations over a long time period (Shaffer et al. 1998). However, monetary constraints usually limit the extent of long-term monitoring projects. An alternative strategy is to compare historical survey data to current survey data, but historical data may be unavailable, difficult to interpret, or collected with varying or unknown methodologies and effort (Shaffer et al. 1998; Tingley and Beissinger 2009). However, when available, historical data are often relatively inexpensive to acquire and can reveal trends in data over long time periods. In Iowa, historical stream fish assemblage data have been compiled into an extensive database as part of the Iowa Aquatic Gap Analysis Project (IAGAP; Loan-Wilsey et al. 2005). By analyzing these data, changes in the distribution of ictalurid species over time can be assessed. Unfortunately, sample data in the IAGAP database were collected with varying effort and gears (e.g., electrofishing, seines, dip nets, and fish kills). Evaluating distributional trends of fish from samples collected with differing methods can be problematic. Therefore, the only way to use all of the data in the IAGAP database for evaluating distributional trends is to accept differences in sampling methods and interpret trends cautiously.

Monitoring of stream fish assemblages is commonly conducted with assessments of biotic integrity. The concept of an index of biotic integrity (IBI) was developed during the late 1970s and early 1980s to incorporate species and trophic composition, fish abundance, and condition as an integrated measure of how energy sources, water and habitat quality, flow regimes, and biotic interactions affect aquatic biota (Karr 1981). Use of IBIs has become common for stream evaluations (Simon 1999; Scardi et al. 2008), and many studies have found relationships between poor biotic integrity and declines in the quality of fish habitat (Roth et al. 1996; Wang et al. 1997; Lammert and Allan 1999). Monitoring of Iowa's interior stream and river fish assemblages is limited, and surveys that are conducted are typically in association with IBI assessments.

Iowa's IBI assessments are used for problem investigations, project evaluations, status and trend monitoring, establishing biological criteria, and determining acceptable levels of pollutants (i.e., total maximum daily load; Wilton 2004). Index of biotic integrity scores are interpreted in reference to sites within the same ecoregion that represent streams least disturbed by human activities (Wilton 2004). The IBI is composed of 12 metrics to create an overall score that varies from 0 to 100 (Wilton 2004; Table 1). Six of the metrics are based on trophic

TABLE 1. Iowa index of biotic integrity metrics, descriptions, and expected directions of response to declining stream conditions (Wilton 2004).

Iowa index of biotic integrity metrics	Description	Expected direction of response to declining conditions
Number of native species	Total number of native fish species collected	–
Number of sucker species	Total number of species belonging to the sucker family (Catostomidae)	–
Number of sensitive species	Total number of species classified as sensitive	–
Number of benthic invertivore species	Total number of species classified as benthic invertivores	–
Percent abundance of three dominant fish species	Proportion of sampled fish respresented by the three most abundant fish species	+
Percent abundance of benthic invertivores	Proportion of sampled fish classified as benthic invertivores	–
Percent abundance of omnivores	Proportion of sampled fish classified as omnivores	+
Percent abundance of top carnivores	Proportion of sampled fish classified as carnivores	–
Percent abundance of simple lithophilous spawners	Proportion of sampled fish belonging to the simple lithophilous-spawning guild	–
Fish assemblage tolerance index	Sum of the products of each species proportional abundance and species tolerance value (sensitive = 0, intermediate = 5, tolerant = 10)	+
Adjusted catch per unit effort	The number of fish collected per 100-foot of stream length	–
Percent fish with deformities, eroded fins, lesions, or tumors (DELTs)	Proportion of sampled fish with at least one DELT	+

classifications and tolerance ratings assigned to each fish species, including nine of Iowa's ictalurid species (Table 2). Overall IBI scores are categorized as having poor, fair, good, or excellent biotic integrity ratings (Wilton 2004). Iowa's biological assessments and IBI scores were not developed for monitoring specific groups of fishes (e.g., ictalurids); however, IBIs are the primary monitoring tool used to assess Iowa stream fish assemblages and may provide insight on ictalurid populations.

The purpose of this study was to evaluate the status of ictalurid species in Iowa and examine their relationships with ecological integrity of streams and rivers. Specifically, the first objective was to use historical data to detect declines in the distribution of Iowa's ictalurid species in streams and rivers at two spatial scales. Changes in the distribution of ictalurids were assessed at a stream segment scale to detect localized extirpations and at a watershed scale to detect statewide declines. The second objective of this study was to examine ictalurid assemblages and their relationship with IBI ratings.

Methods

Sources of Data

The IAGAP species occurrence database was completed in 2005 as part of a comprehensive data acquisition project (Loan-Wilsey et al. 2005). The database includes stream fish assemblage data obtained from published literature, federal reports, museum collections, IDNR reports and field notes, statewide biological inventory databases, and unpublished data of individual researchers (e.g., graduate student theses). Samples included in the IAGAP database were collected with varying effort and gears (e.g., electrofishing, seines, dip nets, and fish kills). However, samples were only included in the database if

Table 2. Trophic classification and tolerance rating for Iowa's ictalurid species used in the Iowa index of biotic integrity (Wilton 2004).

Species	Trophic classification	Tolerance rating
Black bullhead	Generalist	Tolerant
Channel catfish	Top carnivore	Intermediate
Flathead catfish	Top carnivore	Intermediate
Brown bullhead	Insectivore	Intermediate
Yellow bullhead	Benthic invertivore	Intermediate
Stonecat	Benthic invertivore	Intermediate
Freckled madtom	Benthic invertivore	Intermediate
Slender madtom	Benthic invertivore	Sensitive
Tadpole madtom	Benthic invertivore	Sensitive

thought to contain most, if not all, fish species in the sampled stream reach (Loan-Wilsey et al. 2005). The IDNR-IBI database is a continually updated database for biological assessments of Iowa's streams and rivers. The database includes sampled fish abundance data, IBI metrics, and IBI scores.

Evaluating Status and Distribution

Methods similar to Patton et al. (1998) were followed to evaluate species distribution declines. Specifically, the IAGAP database was used to determine distributions of Iowa's ictalurid species at an 8-digit hydrologic unit code watershed scale. To assess trends over time, the IAGAP database was used to identify ictalurid occurrences during six time periods. Depicting distributional trends across more than six time periods would be overcomplicated and difficult to interpret, while depicting trends across fewer time periods would reduce the interpretive value. Time periods included (1) before 1910, (2) 1910 through 1929, (3) 1930 through 1949, (4) 1950 through 1969, (5) 1970 through 1989, and (6) 1990 through 2002. The IAGAP database includes 10,993 fish assemblage samples collected from 2,969 unique U.S. Geological Survey National Hydrography Dataset stream segments across Iowa between 1884 and 2002. The first sample period (before 1910) included 37 samples in 21 of Iowa's 55 watersheds. No samples were included during the second time period (1910–1929) due to a lack of sampling. The third sample period (1930–1949) included 140 samples in 43 watersheds. The fourth sample period (1950–1969) included 389 samples in 33 watersheds, the fifth sample period (1970–1989) included 2,744 samples in 54 watersheds, and the sixth sample period (1990–2002) included 7,672 samples in 52 watersheds. The number of watersheds each species was sampled during the first five time periods combined (i.e., before 1990) was subtracted from the number of watersheds the same species was sampled during the most recent time period (i.e., 1990 through 2002). Four watersheds were not sampled both before 1990 and after 1990 and were therefore excluded from analysis. Species with values less than zero were considered to have decreasing distributions at the watershed scale. The number of samples included in the IAGAP database from the most recent time period is much greater than the number of samples included from all previous time periods combined. This temporal distribution of samples is likely to result in underestimates of declines and overestimates of increases in species distribution with the methods used. Therefore, we primarily focused on declines for this study and did not identify species with values greater than zero as having increasing distributions.

Trends in the distribution of ictalurids at the stream segment scale were assessed by identifying specific stream segments that were sampled during a minimum of three different decades, including the most recent decade included in the database (i.e., 1993 through 2002). A decadal time scale was used to assess distributional trends at the stream segment scale to increase the number of stream segments included in the analysis. Decades were defined as every 10-year period starting with the year of the most recent sample in the IAGAP database (i.e., 2002). The earliest decade represented in the IAGAP database was 1883 through 1892, although the earliest sample in the database was from 1884. Stream segments were only selected if they were sampled across multiple decades and more than once before 1993 to increase the likelihood that the fish assemblage was adequately sampled during that time period. The number of stream segments where each species was sampled before 1993 was subtracted from the number of stream segments the same species was sampled from 1993 through 2002. Species with values less than zero were considered to have decreasing distributions at the stream segment scale.

Evaluating Assemblage Characteristics

Ictalurid assemblages were characterized with variables describing species richness, abundance, and tolerance ratings for all samples in the IDNR-IBI database. Tolerance ratings were previously assigned to Iowa's ictalurid species for IBI assessments based on literature review (Wilton 2004). Associations among ictalurid assemblage variables were evaluated, and those exhibiting high correlation (i.e., $r > 0.70$) were removed from future analyses to reduce multicollinearity. Retained ictalurid assemblage variables included number of ictalurid species, number of sensitive ictalurid species, number of tolerant ictalurid species, number of *Noturus* species, percent abundance of ictalurids, percent abundance of sensitive ictalurids, percent abundance of tolerant ictalurids, and percent abundance of *Noturus* species. Retained assemblage variable statistics and IBI scores were calculated to describe ictalurid assemblage characteristics and relationships with ecological integrity in Iowa's streams.

Associations between ictalurid assemblage variables and IBI scores were assessed by comparing mean assemblage variable values for each IBI rating category (i.e., poor [IBI = 0–25], fair [26–50], good [51–70], excellent [71–100]). Multivariate analysis of variance (MANOVA) was used to determine whether ictalurid assemblage variables differed between IBI ratings (Johnson 1998). If MANOVA results were significant, then individual one-way analysis of variance and individual pair-wise comparisons were used to determine how each ictalurid assemblage variable differed between samples with different IBI ratings. All analyses were conducted with SAS 9.2 (SAS Institute 2009). A type I error rate of 0.05 was used for all statistical tests.

Results

Distributional trends were evaluated at a watershed scale for all 10 of Iowa's ictalurid species. Black bullhead, yellow bullhead, channel catfish, stonecat, tadpole madtom, and flathead catfish appear widespread in Iowa and have been sampled from streams or rivers in more than 50% of Iowa's watersheds (Figure 1). Brown bullhead, blue catfish, slender madtom, and freckled madtom have more restricted distributions and have been sampled from streams and rivers in less than 33% of Iowa's watersheds (Figure 1). Black bullhead, brown bullhead, blue catfish, slender madtom, and tadpole madtom appeared to decline in distribution at the watershed scale (Table 3). Brown bullhead, blue catfish, and tadpole madtom exhibited the largest declines, with declines of 40% or greater. Results indicated blue catfish exhibited a 100% decline in distribution. However, blue catfish are not extirpated from Iowa, and our results likely reflect inadequate samples from the Missouri River during the most recent time period included in the IAGAP database.

Fifty-two stream segments in the IAGAP database were sampled at least once during three different decades, including the most recent decade. Samples at the stream segment scale indicate that distributions of black bullhead, brown bullhead, channel catfish, stonecat, tadpole madtom, and flathead catfish declined (Table 4). Declines of 40% or greater were exhibited by black bullhead, brown bullhead, and tadpole madtom. Blue catfish were never sampled in any of the 52 stream segments.

The IDNR-IBI database included data for 753 fish samples collected between 1994 and 2006, and 537 samples included at least one ictalurid species. Brown bullhead and blue catfish were not included in the database and were excluded from analysis. Eight variables were used to characterize ictalurid assemblages for all 753 fish assemblage samples (Table 5). On average, ictalurid species richness was 1.4 (SE = 0.04), comprising 7.8% (SE = 0.3) of the total species and 2.7% (SE = 0.2) of total fish abundance (Table 6). However, ictalurids composed up to 50.0% of the total number of species and 64.4% of total fish abundance (Table 6). The mean IBI score for fish assemblage samples was 41.8 (0.7) and varied from 0 to 90 (Table 6).

Overall, ictalurid assemblage variables differed among IBI categories (Pillai's trace = 0.20; $F_{24,\ 2232} = 6.6$; $P < 0.0001$; Figure 2). The number of ictalurid species, number of sensitive ictalurid species, number of *Noturus* species, and percent abundance of ictalurids differed among IBI categories (Figure 2). The number of tolerant ictalurid species, percent abundance of sensitive ictalurid species, percent abundance of tolerant ictalurid species, and percent

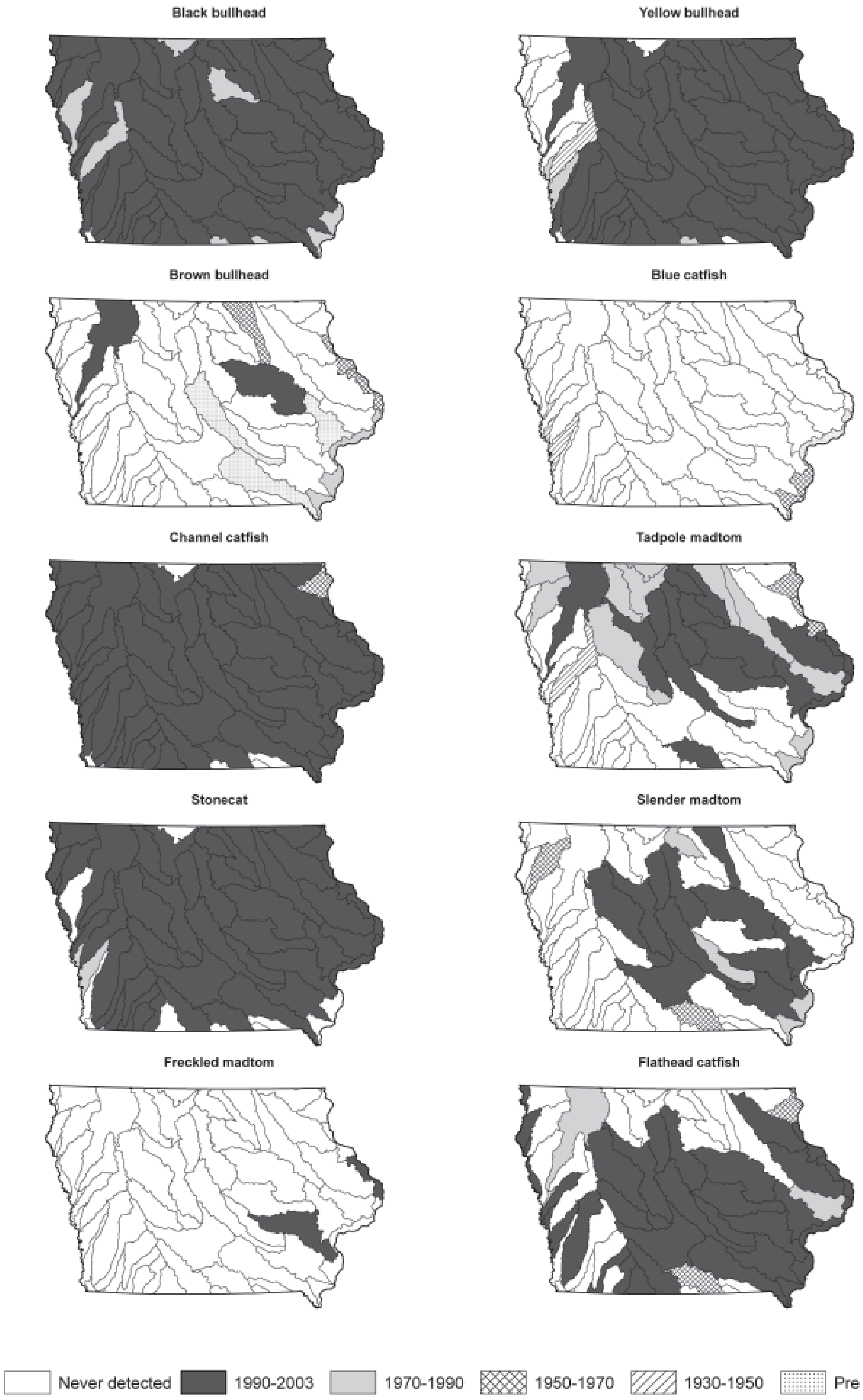

FIGURE 1. The most recent time period each of Iowa's ictalurid species were sampled in each of Iowa's 55 eight-digit hydrologic unit code watersheds from samples in the Iowa Aquatic Gap Analysis Project database.

TABLE 3. Number of 8-digit hydrologic unit code watersheds each ictalurid species was sampled during the pre-1990 and 1990 through 2002 time periods in Iowa streams. The number of watersheds each species was sampled during the pre-1990 time period was subtracted from the number of watersheds the species was sampled during the 1990 through 2002 time period. A negative difference indicates a decline in distribution at the watershed scale.

	Time period				
Species	Pre-1990	1990–2002	Difference	Change (%)	Declined
Black bullhead	50	47	–3	–6	Yes
Yellow bullhead	36	43	7	19	
Brown bullhead	10	2	–8	–80	Yes
Blue catfish	4	0	–4	–100	Yes
Channel catfish	49	49	0	0	
Slender madtom	13	11	–2	–15	Yes
Stonecat	38	45	7	18	
Tadpole madtom	26	15	–11	–42	Yes
Freckled madtom	2	2	0	0	
Flathead catfish	27	28	1	4	

abundance of *Noturus* species were similar across IBI categories. The number of ictalurid species (mean ± SE; 0.9 ± 0.09–1.8 ± 0.1) and number of *Noturus* species (0.2 ± 0.05–1.1 ± 0.07) were lowest for samples with poor IBI ratings and highest for samples with excellent ratings. The number of sensitive ictalurid species (0.03 ± 0.03–0.3 ± 0.04) was lowest for samples with poor or fair IBI ratings and highest for samples with excellent IBI ratings. The percent abundance of ictalurids significantly differed among IBI ratings but did not exhibit a clear trend.

Discussion

Most ictalurid species in Iowa appear to be declining in distribution at a stream segment or watershed scale. More substantial declines (i.e., >40% reduction in distribution) were only exhibited at both scales by brown bullhead and tadpole madtom. Declines of Iowa's ictalurids are not unique; Jelks et al. (2008) reported that 700 North American freshwater and diadromous fish taxa are considered vulnerable, threatened, or endangered, including 26 ictalurid species. Even more concerning is the ex-

TABLE 4. Number of stream segments each ictalurid species was sampled in Iowa streams during the pre-1993 and 1993 through 2002 time periods that were also sampled during three different decades, including the most recent. The number of stream segments each species was sampled during the pre-1993 time period was subtracted from the number of stream segments the species was sampled during the 1993 through 2002 time period. A negative difference indicates a decrease in distribution at the stream segment scale.

	Time period				
Species	Pre-1993	1993–2002	Difference	Change (%)	Declined
Black bullhead	29	17	–12	–41	Yes
Yellow bullhead	16	17	1	6	
Brown bullhead	5	0	–5	–100	Yes
Channel catfish	31	25	–6	–19	Yes
Slender madtom	6	6	0	0	
Stonecat	24	19	–5	–21	Yes
Tadpole madtom	10	6	–4	–40	Yes
Freckled madtom	0	1	1		
Flathead catfish	11	9	–2	–18	Yes

TABLE 5. Descriptions of eight ictalurid assemblage variables used to characterize ictalurid assemblages in Iowa streams.

Ictalurid metrics	Description
Number of ictalurid species	Total number of ictalurid species collected
Number of sensitive ictalurid species	Total number of ictalurid species collected classified as sensitive
Number of tolerant ictalurid species	Total number of ictalurid species collected classified as tolerant
Number of *Noturus* species	Total number of species collected from the *Noturus* genus
Percent abundance of ictalurids	Proportion of sampled fish belonging to the ictalurid family
Percent abundance of sensitive	Proportion of sampled fish belonging to the ictalurid family and classified as sensitive
Percent abundance of tolerant	Proportion of sampled fish belonging to the ictalurid family and classified as tolerant
Percent abundance of *Noturus*	Proportion of sampled fish belonging to the *Noturus* genus

tinction of 123 North American freshwater species (e.g., fishes, mollusks, crayfishes, and amphibians) since 1900 (Ricciardi and Rasmussen 1999). Miller et al. (1989) reported similar patterns where at least 40 taxa of North American fishes were reported to have gone extinct from 1900 to 1984. In Iowa, many ictalurids are designated as SGCN, including brown bullhead, blue catfish, slender madtom, tadpole madtom, and freckled madtom (Zohrer 2006). Results of this study suggest declining or limited distributions warrant the designation of these species as SGCN. While other species of ictalurids also appeared to decline, their current distribution is widespread (i.e., black bullhead, channel catfish, stonecat, and flathead catfish).

Detecting distributional trends can be difficult. For example, assessing distributional trends at a fine scale (i.e., stream segment) may not accurately reflect the status of a species due to natural population fluctuations and localized events (e.g., floods, drought, and fish kills), and assessing trends at a watershed scale may be too coarse to detect subtle changes (Grossman et al. 1982; Schlosser 1985; Danehy et al. 1998). However, assessing distributional trends at multiple scales can help compensate for possible sources of error associated with each scale. Our results indicated that more ictalurid species experienced declines at the stream segment scale than at the watershed scale. Similar studies have also detected changes in fish distributions at smaller scales but not watershed scales (Anderson et al. 1995; Patton et al. 1998). For instance, Patton et al. (1998) examined distributional trends of native fishes in Wyoming. The authors reported that when data were adjusted to account for gear bias, seven species declined at the stream site scale but exhibited either no change or an increase at a watershed scale. Despite the difficulty of detecting large-scale distribution trends, our evaluation indicated that five ictalurid species (i.e., black bullhead, brown bullhead,

TABLE 6. Mean, minimum, maximum values, and the standard error of Iowa index of biotic integrity scores and eight retained ictalurid assemblage variables calculated from 753 stream fish assemblage samples in the Iowa Department of Natural Resource index of biotic integrity database.

Ictalurid metric	Mean	Minimum	Maximum	Standard error
Index of biotic integrity	41.80	0.00	90.00	0.70
Number of ictalurid species	1.36	0.00	5.00	0.04
Number of sensitive ictalurid species	0.11	0.00	2.00	0.01
Number of tolerant ictalurid species	0.19	0.00	1.00	0.01
Number of *Noturus* species	0.55	0.00	3.00	0.02
Percent abundance of ictalurids	2.65	0.00	64.36	0.21
Percent abundance of sensitive	0.13	0.00	26.79	0.04
Percent abundance of tolerant	0.40	0.00	61.39	0.10
Percent abundance of *Noturus*	0.74	0.00	26.79	0.07

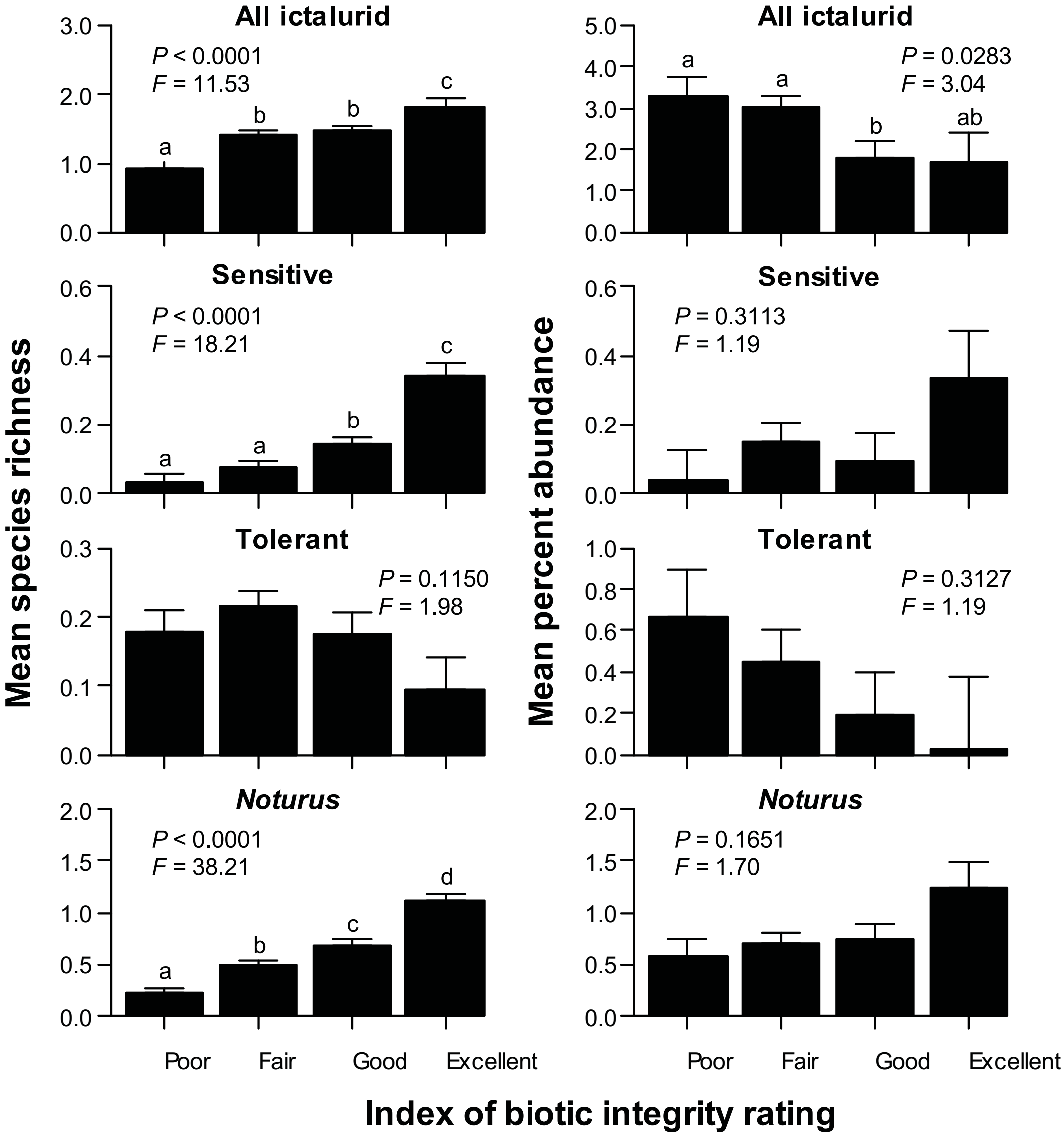

FIGURE 2. Mean ictalurid assemblage variable values for fish assemblage samples with poor, fair, good, and excellent index of biotic integrity (IBI) ratings from the Iowa Department of Natural Resources-IBI database. Ictalurid assemblage variables include species richness and percent abundance for all ictalurid, sensitive ictalurid, tolerant ictalurid, and *Noturus* species. Error bars indicate standard error, and different letters above bars indicate significant differences ($P < 0.05$).

blue catfish, slender madtom, and tadpole madtom) experienced declines at the watershed scale. We are confident that our analysis adequately detected these declines, since approximately 70% of all samples in the IAGAP database were collected during the most recent time period (i.e., 1990 through 2002). More samples during the most recent time period leads to conservative estimates of species distribution declines, at least with the method used to evaluate trends in this study. Detection of large-scale declines in ictalurid distributions may indicate more severe imperilment, warranting more immediate attention.

Overall, ictalurid assemblage variables differed among samples with different IBI ratings. Three of four ictalurid assemblage variables describing species richness differed among samples with different IBI ratings. The number of ictalurid species, number of sensitive ictalurid species, and number of *Noturus* species were lowest when IBI ratings were poor and highest when IBI ratings were excellent. However, three of four ictalurid assemblage variables describing percent abundance (i.e., percent abundance of sensitive ictalurid species, percent abundance of tolerant ictalurid species, and percent abundance of *Noturus* species) did not differ among samples with different IBI ratings. In general, abundance-based metrics are informative but are often discounted in IBI assessments because of their inherent variability (Trebitz et al. 2003). Taxa richness measurements are typically more stable than abundance measurements (e.g., Rahel 1990). Yant et al. (1984) found that an assemblage may be considered unstable over time based on relative abundances but stable based on species presence–absence data. Angermeier et al. (2000) showed that species richness indices alone could discriminate site quality almost as well as composite indices (e.g., IBI). Although trends between ictalurid abundance variables and biotic integrity were not significant, relationships with species richness variables were informative.

Declines in the distribution of Iowa's ictalurid species are likely associated with the same mechanisms responsible for low biotic integrity in many of Iowa's streams and rivers. Anthropogenic alterations are often related to habitat loss and degradation (Menzel 1983; Shields et al. 1994; Waters 1995; Walser and Bart 1999) and corresponding low fish biotic integrity (Allan et al. 1997; Fitzpatrick et al. 2001; Heitke et al. 2006; Lau et al. 2006; Rowe et al. 2009a). Agriculture has been one of the primary contributors to the degradation of streams in the Midwest (Karr et al. 1985; Waters 1995), and changes in habitat due to agricultural practices have had consequent negative impacts on fish assemblages (Roth et al. 1996; Wang et al. 1997; Walser and Bart 1999; Heitke et al. 2006; Rowe et al. 2009b). For instance, Roth et al. (1996) found that habitat quality and IBI scores decreased as percentage of agricultural land increased in watersheds of Michigan streams. Specifically in Iowa, alterations to the landscape associated with agriculture have been found to result in structurally simple lotic habitats dominated by fine sediments and altered fish assemblages (Rowe et al. 2009a).

Specific practices associated with agriculture may have direct and indirect effects on fish species. Iowa has a long history of draining wetlands, removing riparian habitats, and channelizing streams to convert land for agricultural use (Bulkley 1975; Menzel 1981; Wilton 2004). Removing riparian vegetation also removes a source of large woody debris that provides essential cover for many fish species (Naiman and Décamps 1997; Lau et al. 2006). Stream channelization leads to decreased habitat complexity and increased water velocities (Waters 1995; Lau et al. 2006), which are possible mechanisms for decreased biotic integrity (Lau et al. 2006; Smiley and Dibble 2008). Alterations associated with agricultural practices are also responsible for declines in aquatic macrophytes (Menzel 1983) that are important for many species, including brown bullhead (Cross and Collins 1995; Smith 2002). Specifically in Iowa, low biotic integrity scores are often associated with physical habitat characteristics that are consequences of agricultural practices such as fine substrates, incised streambanks, altered riparian habitats, and a lack of instream cover (Heitke et al. 2006; Rowe et al. 2009a).

Some ictalurid species may be more sensitive to habitat alterations than others, and two of Iowa's four madtom species (i.e., *Noturus* spp.) are designated as sensitive (Wilton 2004). Madtoms are particularly susceptible to habitat degradation due to their highly specific habitat requirements and short life spans (Burr and Stoeckel 1999). All madtoms are benthic invertivores, and most inhabit flowing streams where they are frequently found in or near riffles or in pools where there is an abundance of cover (e.g., rocks, logs, vegetation; Burr and Stoeckel 1999). All madtom species are also cavity nesters and require specific substrata (e.g., rocks, logs, shells, vegetation) for reproduction (Burr and Stoeckel 1999). Sedimentation in aquatic systems can be a direct consequence of agricultural practices and threatens required madtom habitats (Menzel 1983; Waters 1995; Walser and Bart 1999). Sedimentation is linked to reduced habitat complexity (e.g., riffles, pools; Waters 1995; Walser and Bart 1999) and may also fill interstitial spaces and cover potential nesting cavities. In Missouri streams, Berkman and Rabeni (1987) found that benthic insectivore fish (e.g., *Noturus* spp.) abundance decreased in riffles as the percent of fine sediment increased. Similarly, Quist et al. (2003) found that military training index values were negatively correlated with benthic insectivore catch per unit effort and positively correlated with percent silt in pools and riffles. A loss of substrate complexity may be a leading cause for declines of madtoms in Iowa and has been linked to the imperilment of frecklebelly madtom *N. munitus* and orangefin madtom *N. gilberti* in other regions (Simonson and Neves 1992; Piller et al. 2004).

Similar to many freshwater species, catfishes are facing imperilment globally. In North America, the ecological diversity of ictalurids and variety of management goals further complicates conservation efforts. Understanding the current status of ictalurids and their relationship with ecological integrity may provide insight for their conservation. Our results quantify declines of ictalurids in Iowa and illustrate their relationships with ecological integrity. Results suggest that declining ictalurid species distributions and biotic integrity are related, and management strategies aimed to improve habitat and increase biotic integrity will benefit ictalurid biodiversity.

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