ILLINOIS NATURAL HISTORY SURVEY
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Long-term Survey and Assessment of Large-River Fishes in Illinois, 2016

Jason A. DeBoer, Andrya L. Whitten, Edward F. Culver, Benjamin J. Lubinski, Jerrod Parker, Drew Costenbader, Daniel K. Gibson-Reinemer, Andrew F. Casper, Yong Cao, John H. Chick, and John E. Epifanio

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Long-term Survey and Assessment of Large-River Fishes in Illinois

F-101-R-28

Annual Report to the Illinois Department of Natural Resources

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DISCLAIMER

The findings, conclusions, and views expressed herein are those of the researchers and should not be considered as the official position of the United States Fish and Wildlife Service or the Illinois Department of Natural Resources.

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Long-term Survey and Assessment of Large-River Fishes in Illinois (F-101-R) is supported by the Federal Aid in Sport Fish Restoration Act (P.L. 81-6814, Dingell-Johnson/Wallop-Breaux), with funds administered by the U.S. Fish and Wildlife Service and the Illinois Department of Natural Resources (IDNR). The Illinois Department of Natural Resources and Dr. Leellen Solter, Interim Director of the Illinois Natural History Survey (INHS), and INHS staff provided administrative support. Staff from the Illinois River Biological Station, Great Rivers Field Station, and INHS staff based at the University of Illinois Champaign-Urbana provided expertise and support for clerical, data entry, data verification, and field collections. This survey was originally conceived and initiated in 1957 by the late Dr. William C. Starrett.

EXECUTIVE SUMMARY

This report presents a summary of those data collected during segment 28 (2016-17) of the Long-term Survey and Assessment of Large-River Fishes in Illinois (LTEF), an annual survey by members of the Illinois Natural History Survey, with funds administered by the U.S. Fish and Wildlife Service and the Illinois Department of Natural Resources. Sampling for the LTEF program was conducted on: six reaches of the Illinois River Waterway, four segments or pools of the Mississippi River, and navigable portions of the Iroquois and Kankakee Rivers. In all segments of the LTEF program, all fish species collected were accurately identified, tallied, measured, and weighed. The catch rates of sportfish species were calculated as the number of individuals collected per hour ($CPUE_N$ ± standard error). Structural indices [Proportional Size Distribution (PSD) and Relative Weight (W_r)] were also calculated for several species of interest to regional managers. Catch rates and species varied among all sampling locations and sampling periods. Emerald Shiners and Gizzard Shad comprised the majority of the individuals caught, and Silver Carp and Common Carp accounted for the greatest proportion of the biomass collected in most sampling areas of the survey. Future analysis of $CPUE_N$ and PSD trends in sportfish populations sampled by the program may indicate inter-annual recruitment patterns or/and long-term trends in Illinois sportfish populations.

Program Changes – excerpted from Fritts et al. 2017

Biologists participating in the fixed-site, historic AC monitoring program have contributed to a regional understanding of the temporal and spatial differences in Illinois Waterway fish communities. However, the survey in its historic form is not the most efficient way to achieve ongoing program goals while adapting to changing river conditions. The greatest challenge to maintaining the fixed-site survey has been the degradation/loss of fixed sampling sites because of sedimentation; over half of the original sampling locations selected by Dr. William Starrett for their "good" habitat characteristics have become unnavigable or have been highly altered by erosion and the accumulation of sediments as of 2015.

Although adherence to the original standardized methodology has long been one of the strengths of LTEF, the interplay of new statistical tools and advanced field sampling designs have allowed more powerful and comprehensive analyses. Other field assessment programs in the basin (e.g., LTRM) have demonstrated that they can complement and enhance LTEF's ability to generate insight into the structure and function of large river fisheries. The LTEF program has been re-evaluated and fully transitioned to a pulsed-DC methodology adapted from the LTRM during 2016.

The principal changes are a shift from fixed-site sampling to stratified-random sampling at the reach scale to benefit statistical inference and a concurrent shift from AC electrofishing to pulsed-DC electrofishing to increase the breadth of the diversity and size classes of fishes encountered. These changes in methodology implemented during the 2016 field season are based on quantitative assessments of program data and other results from recent peer-reviewed publications. These refinements will likely improve the program's ability to detect and describe patterns and trends in the fish assemblages of the Illinois River and other large rivers of Illinois and the Midwest.

Sportfish

Catch rates and sizes of popular sportfish species varied greatly among the rivers and reaches sampled during 2016. Channel Catfish was the most-abundantly collected sportfish species in all segments of our study. Collections of black bass species were greatest in the Upper Illinois Waterway. Our long-term datasets allow us to observe tremendous annual variations in the relative abundance and size distribution of many sportfish species, like White Bass. These observations should serve as a catalyst for future research investigating the effects environmental changes and management policies on the health and sustainability of Illinois' sportfishes. Although the factors controlling the annual variations in the relative abundances of fishes in Midwestern rivers may be difficult to identify, our ability to detect and possibly explain such changes is dependent upon the execution of well-designed fisheries surveys. The operation and maintenance of the LTEF program and the data it generates can contribute to more comprehensive and nuanced understandings that can, in turn, aid in the development of more effective and sustainable management policies for sportfishes in the rivers of Illinois.

Invasive Species

Although the main focus of F-101-R programs are to conduct monitoring to improve our understanding of population dynamics, life histories, and habitat requirements of sportfish species, the programs sampling strategies may also be useful for documenting trends in the relative abundance of non-native species occupying Illinois large river ecosystems. However, we advise that researchers use caution when interpreting the data we collect on invasive species as our sampling protocols (e.g., restriction to main-channel habitats) may limit our probability of encountering the greatest densities of the species in some instances. Our monitoring and analyses suggest densities of Silver Carp are greatest in the Lower Illinois River but that body condition of Silver Carp in the Lower Illinois River has been much lower during the last 5-6 years than during the preceding years.

JOB ACCOMPLISHMENTS DEFINED BY F-101-R-28 WORK PLAN

Job 1: *Prepare electrofishing equipment and train staff*

Project workers maintained and repaired electrofishing and netting equipment as need throughout Project Segment 28. Full-time staff also trained seasonal staff members in the use of computerized data entry programs, electrofishing techniques, troubleshooting and repairing sampling gear, and statistical analysis of fisheries data.

Job 2: *Sample fish by pulsed-DC electrofishing on the Illinois and Mississippi Rivers*

Project workers completed all electrofishing and netting assignments in the Illinois, Iroquois, Kankakee, and Mississippi Rivers during Project Segment 28.

Job 3: *Update computer database*

All F-101-R Segment 28 (2016) project data were transferred to the project database and archived in fire-resistant file cabinets at the Illinois River Biological Station, Havana.

Job 4: *Analyze data*

Project staff used Segment 28 data to investigate trends in catch-per-unit effort and stock size indices to investigate spatial and temporal trends in fish populations. Those analyses are included in this report.

Job 5: *Presentation of results*

Project workers Jason DeBoer, Andrya Whitten, Jerrod Parker, Seth Love, and Daniel Gibson-Reinemer, presented the results of electrofishing sampling at numerous professional meetings (Appendix II). Project workers also completed the composition of the annual project report. Additionally, two peered-reviewed manuscripts and one agency report produced using LTEF data were published during Project Segment 28:

Gibson-Reinemer, D. K., Chick, J. H., VanMiddlesworth, T. D., VanMiddlesworth, M. M. and Casper, A. F., 2017. Widespread and enduring demographic collapse of invasive common carp (Cyprinus carpio) in the Upper Mississippi River System. Biological Invasions 19:1905-1916.

Fritts, M. W., J. A. DeBoer, D. K. Gibson-Reinemer, B. J. Lubinski, M. A. McClelland, and A. F. Casper. 2017. Over 50 years of fish community monitoring in Illinois' large rivers: the evolution of methods used by the INHS's Long-term Survey and Assessment of Large-River Fishes in Illinois. Illinois Natural History Survey Bulletin 41(1): 1–18.

DeBoer, J. A., and L. E. Solomon. 2017. Environmental factors affecting growth rates of popular sportfish in the Illinois River. Illinois Natural History Survey Report 415(3).

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PREFACE

This report presents a summary of data collected during 2016 during segment 28 of Federal Aid project F-101-R, the Long-Term Survey and Assessment of Large-River Fishes in Illinois. The purpose of this document is to provide information on the large-scale trends in fish populations in Illinois' large river ecosystems. Although we gather data on many other fish species in the course of our sampling, this report is primarily focused on recreationally valued sportfishes in accordance with Goal 3 of the 2010-2015 Strategic Plan for the Conservation of Illinois Fisheries Resources. Some historical data will be included in this report to facilitate longer-term analyses when appropriate. Previous summaries of the long-term data set, begun in 1957, were given by Sparks and Starrett (1975), Sparks (1977), Sparks and Lerczak (1993), Lerczak and Sparks (1994), Lerczak *et al*. (1994), Koel and Sparks (1999), McClelland and Pegg (2004), McClelland and Sass (2010), and McClelland *et al.* (2012). The format used in this report is revised from previous annual reports on this project (Lerczak *et al*. 1993, 1994, 1995, and 1996; Koel et al. 1997 and 1998; Koel and Sparks 1999; Arnold *et al*. 2000; McClelland and Pegg 2001, 2002, 2003, 2004, 2005; McClelland and Cook 2006; McClelland and Sass 2007, 2008, 2009, 2010; Michaels, Tyszko, and McClelland 2011; Tyszko et al. 2012; Fritts et al. 2013; Fritts et al. 2014; DeBoer et al. 2015). The annual reports for project F-101-R will continue to build upon previously collected data. Fish common names used throughout this report follow Page et al. (2013). We have used English units of measure throughout the report. While this practice is generally discouraged in scientific writing, the use of the English measurement system is preferred by many public agencies in the United States, including the Illinois Department of Natural Resources. Throughout this report, we have frequently used many abbreviations. Here are the principle abbreviations and definitions:

RM: River Mile
AC: Alternating Current
DC: Direct Current
°F: Temperature expressed as degrees Fahrenheit
Hz: Hertz
W: Watts
µS: Microseimens
ppm: parts per million
in: inches
lb: Pounds

All data collected by F-101-R funded projects is maintained at the Illinois River Biological Station, Havana, IL, and most components of project data can be provided upon request. All inquiries about the LTEF dataset should be directed to project staff on site (Telephone 309-543-6000; email jadeboer@illinois.edu, or afcasper@illinois.edu).

CHAPTER 1
INTRODUCTION

The large rivers of Illinois have experienced dramatic changes that have been attributed to both natural and anthropogenic forces during the previous century (Theiling 1998). These changes have dramatically altered the viability of our riverine ecosystems, and Illinois' fisheries managers are faced with the increasingly difficult task of maintaining the viability of these once-thriving riverine fisheries (Sparks and Starret 1975). The purpose of this Long-term Survey and Assessment of Large-River Fishes in Illinois (LTEF) is to provide Illinois' fisheries managers with rigorous and robust information and analyses about the status, trend, condition, and other critical qualities (such as management evaluations) of Illinois's large-river sportfisheries throughout the large rivers of Illinois.

Ultimately, the ability of managers, public policymakers, and stakeholders to protect and improve the quality and sustainability of Illinois' sportfish resources depends on accurate assessments of the state of the fisheries. In particular, we need to gain insight into how the fisheries respond to stressors and management actions. Unfortunately, many critical responses of fish communities to environmental stressors (e.g., floods, droughts) and management actions are inherently out-of-synch or delayed in relation to the driving factor. Thus, long-term, large-scale ecological monitoring data are critical for making inferences about temporal and spatial variations in the structure and function of ecosystems (Bolgrien et al. 2005; Dodds et al. 2013). These inferences can enhance the predictive understanding of natural resource managers, aiding them in the development and implementation of more effective resource stewardship policies at local and statewide scales. Standardized, continuous, high-quality fisheries monitoring surveys can therefore offer fisheries managers with critical insights that cannot be provided by shorter-term programs. A long-term record of consistent and scientifically robust monitoring, such as carried out by the LTEF program for over 50 years, is critical for providing insights for successful management.

The LTEF program follows respected, standardized protocols to collect fisheries data using boat-mounted electrofishing and netting gears throughout the largest rivers in Illinois (Figure 1.1). Data generated from these surveys have previously been used to document large-scale changes in the structure of riverine fish communities (Sparks and Starrett 1975, Pegg and McClelland 2004; McClelland et al. 2012), estimate the effects of flow alterations on riverine fish communities (Koel and Sparks 2002; Yang et al. 2008), determine the impacts of improved water quality (Parker et al. 2016), investigate the evolving role of non-native species in Illinois' riverine ecosystems (Raibley et al. 1995; Irons et al. 2006; Irons et al. 2007; Sass et al. 2010; Irons et al. 2011; Liss et al. 2013; Liss et al. 2014; Lamer et al. 2014), and evaluate the efficiency of electrofishing gears for large river fisheries research (McClelland et al.2012; McClelland et al. 2013). Given this impressive legacy of scientific research, the LTEF program can continue to provide high-quality data for important assessments of riverine sportfish populations in relation to contemporary environmental perturbation such as climate variability, on-going loss of side-channel and backwater habitat to sedimentation, unnatural water-level fluctuations from navigation, poor water quality, and river channel maintenance and dredging activities.

[The following paragraphs are excerpted from Fritts et al. 2017]

Biologists participating in the fixed-site, historic AC monitoring program have contributed to a regional understanding of the temporal and spatial differences in Illinois Waterway fish communities. However, the survey in its historic form is not the most efficient way to achieve ongoing program goals while adapting to changing river conditions. Benefits include a high degree of confidence that changes in the assemblage (e.g., species loss or gain) or population characteristics (e.g., size/age structure or condition indices) measured at any given site reflect actual corresponding changes in the biotic or abiotic conditions at that site. However, the greatest challenge to maintaining the fixed-site survey has been the degradation/loss of fixed sampling sites because of sedimentation. Excessive sedimentation in backwater and side channel habitats has been well documented in the Illinois Waterway (Bhowmik and Demissie 1989), and approximately half of the original sampling locations selected by Starrett for their "good" habitat characteristics have become unnavigable or have been highly altered by erosion and the accumulation of sediments as of 2015 (see Figure 2.1).

Although adherence to the original standardized methodology has long been one of the strengths of LTEF, the interplay of new statistical tools and advanced field sampling designs have allowed more powerful and comprehensive analyses. Other field assessment programs in the basin (e.g., LTRM) have demonstrated that they can complement and enhance LTEF's ability to generate insight into the structure and function of large river fisheries. To take advantage of these advances, and in recognition of the changing nature of threats to the river resource (decadal climate shifts and chronic sedimentation have largely replaced point-source pollution as the top threats), LTEF has been re-evaluated and will fully transition to a pulsed-DC methodology adapted from the LTRM during 2016. This marks an opportunity to increase the scope and quantitative power of an already strong tool for river management. Going forward, these changes will build on the program's past success and provide more information and understanding for managers, policy analysts, and scientists working on the next generation of management and restoration issues.

The principal changes are a shift from fixed-site sampling to stratified-random sampling at the reach scale to benefit statistical robustness and a concurrent shift from AC electrofishing to pulsed-DC electrofishing to increase the breadth of the diversity and size classes of fishes encountered. These changes in methodology were implemented during the 2016 field season and are based on quantitative assessments of program data and other results from recent peer-reviewed publications. These refinements will likely improve the program's ability to detect and describe patterns and trends in the fish assemblages of the Illinois River and other large rivers of Illinois and the Midwest.

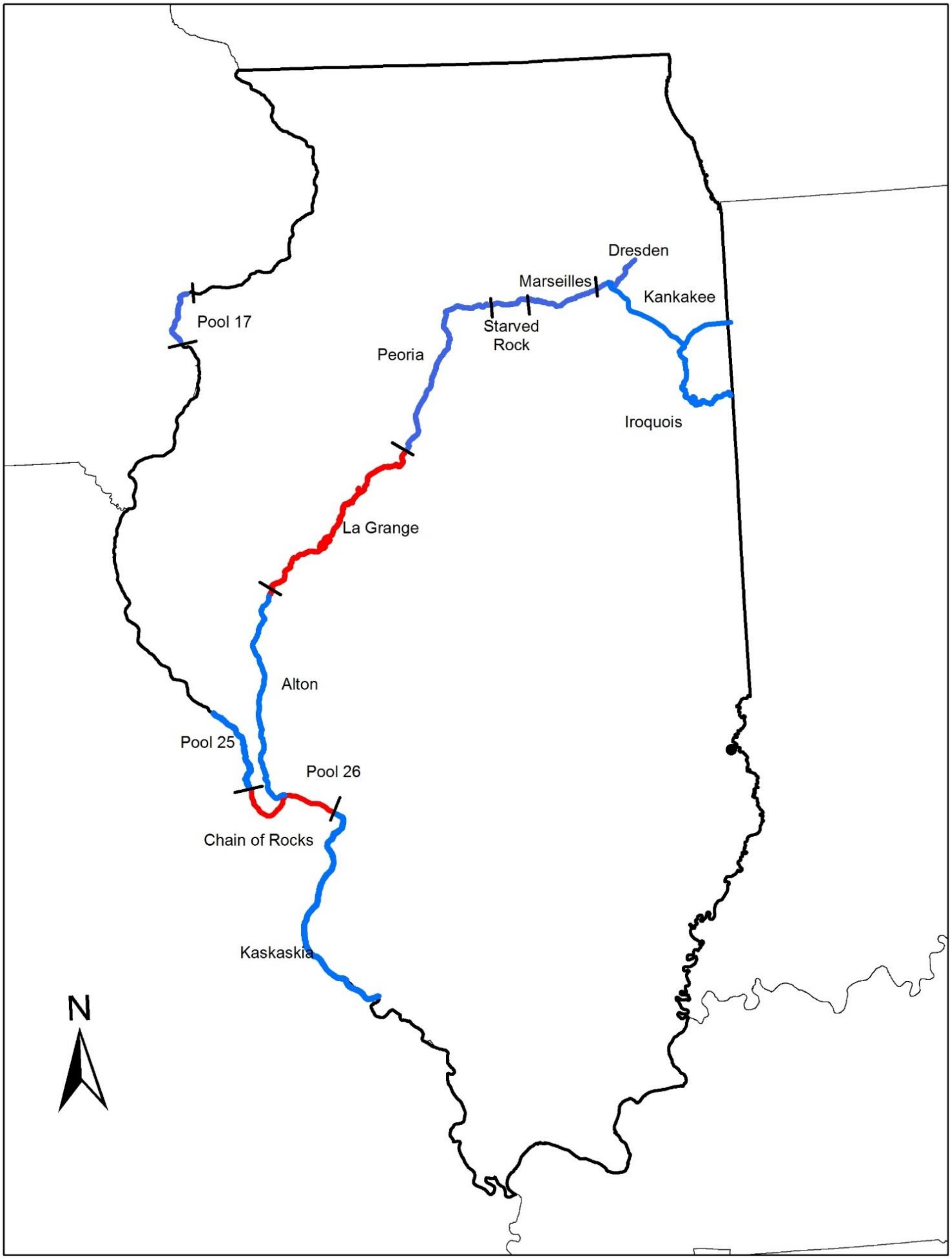

Figure 1.1. Map of the Illinois Waterway, and the Illinois portions of the Mississippi, Iroquois, and Kankakee Rivers illustrating areas sampled by the Long-term Survey and Assessment of Large-River Fishes in Illinois (colored in blue) during 2016. Areas currently sampled by the US Army Corps of Engineers Upper Mississippi River Restoration Environmental Management Program's (UMRR-EMP) Long Term Resource Monitoring element (LaGrange Reach, Illinois River and Pool 26, Mississippi River) are colored red.

CHAPTER 2
SPORTFISH ASSESSMENTS IN THE ILLINOIS RIVER

Section 2.1 - Pulsed-DC Electrofishing Collections

Sportfish populations were monitored in 6 reaches of the Illinois Waterway using boat-mounted pulsed-DC electrofishing gear. Additionally, 4 segments or pools of the Mississippi River were sampled via the same methodology (see Appendix I). Sites were randomly selected using GIS layers of main-channel border habitats in all study areas. The La Grange Reach of the Illinois River and Pool 26 of the Mississippi River are currently monitored by the U.S. Army Corps of Engineers Upper Mississippi River Restoration Environmental Management Program's (UMRR-EMP) Long Term Resource Monitoring Program component (LTRMP, http://www.umesc.usgs.gov/ltrmp.html) and are, therefore, not included in F-101-R monitoring (Figure 1.1), except for 2 fixed sites in LaGrange Reach (see Figure 2.1).

Electrofishing collections were conducted based on established LTRMP protocols for monitoring fish populations in large rivers as described by Gutreuter et al. (1995) during three sampling periods (15 June – 31 July, 1 August – 15 September, 16 September – 31 October). Boat-mounted pulsed-DC electrofishing was used to catch fish. A three-person crew consisting of a pilot and two dippers performed 15-minute electrofishing runs at a collection site. Power was supplied by a 5,000-W generator with voltage and amperage adjusted to achieve LTRMP standardized power goals using 60 Hz and a 25% duty cycle (Gutreuter et al. 1995). Stunned fish were caught with a dip net of 1/8-in (0.3-cm) mesh and placed in an aerated livewell until sampling was completed. Fish were then identified to species, measured (TL and weight), and returned to the water. Non-carp cyprinids, darters, centrarchids < 4 in, and clupeids < 8 in were counted, but not weighed, as we have regression equations developed during 2015 that are > 95% accurate for fishes of this size. This saves time while sampling and reduces bias from weighing very small fishes in field conditions that may bias weight measurements.

In Sections 2.5 and 2.6, we have distinguished between those data collected above and below the Great Bend region of the Illinois River. Therefore, sampling statistics calculated for data collected above the Starved Rock Lock and Dam (RM 231; RKM 371.8) will be presented separately from those results derived from the sampling below that structure. Fisheries data collected by LTRM surveys in the LaGrange Reach in the Lower Illinois River have been included in species-specific CPUE graphs to increase the spatial continuity of the data used for the following analyses, but not in summary paragraphs or in W_r calculations, as LTRM only weighs select fishes, and only during Period 3.

During 2015, standard methods for recording external fish parasites and deformities, eroded fins, lesions, and tumors (DELT) abnormalities were implemented. These methods were based upon Ohio Environmental Protection Agency procedures (1989: Table 2.1). This supplemental data regarding fish health will allow for examinations into the relative health of sportfishes and the environmental quality of the rivers they inhabit. Quantifying the extent of diseases and parasitism in fishes have been used as indicators of biotic integrity since the Karr (1981) originally outlined his methods for the IBI (Index of Biotic Integrity). Illinois does not currently have an IBI, or regional IBIs, for use on the medium to large rivers throughout the state. Documenting the health of riverine fishes throughout the state will prove invaluable for the development of such indices.

Table 2.1. Definition of fish abnormalities documented during 2016.

Code	Abnormality	Assessment
D	Deformity(ies)	Atypical morphology of skeletal system (Head, Spine, Fins) that does not appear to be healed injury
E	Eroded Fins	Incomplete fin membranes, spines, rays: asymmetrical (not obviously caused by deformity)
L	Lesions/Ulcers	Inflamed wounds not obviously caused through by capture during sampling
T	Tumors	Firm abnormal protruding growths
M	Multiple DELT	Combination of different DELT categories; deformities (D), eroded fins (E), lesions (L), tumors (T)
AL	Anchor Worms Light	≤ 5 anchor worms present
AH	Anchor Worms Heavy	> 5 anchor worms present
BL	Black Spot Light	Small slightly raised black spots with relatively large spacing in comparison to body size not covering most of the body: not part of natural coloration
BH	Black Spot Heavy	Small slightly raised black spots with relatively small spacing in comparison to body size covering most of the body: not part of natural coloration
B	Blind	Obvious blindness in one or both eyes including completely missing eyes with healed skin
W	Wound	Wound not accounted for by other codes, excluding obvious recent injuries from capture; ex. broken rostrum, heron injuries, etc.

Section 2.2 - Ancillary Habitat Quality Measurements

Measurements for ancillary habitat-quality parameters (i.e., water temperature, dissolved oxygen, Secchi disk transparency, conductivity, surface velocity, water depth, and river stage) were recorded prior to each electrofishing run. Stage height was recorded from a single U.S. Army Corps of Engineers or U.S. Geological Survey (USGS) river gauge for each sampled reach for standardization (Table 2.2).

Section 2.3 - 2016 Illinois River Ancillary Habitat Quality Data

Pulsed-DC electrofishing was conducted between 8:00 AM and 5:50 PM central standard time during the three sampling periods specified in Section 2.1. Physical measurements for ancillary water-quality parameters were collected at each DC-sampling site, and are summarized in Table 2.2.

Section 2.4 - Statistical Analyses

For each site, the number of individual fish and total weight were tallied for each species in the field. The resulting catch data are summarized and reported by river segments, divided between main-channel border habitat and side-channel border habitat. Data collected during the three sampling periods were pooled for the calculation of catch statistics. Catch rates were quantified as the number of individuals collected per hour of electrofishing (expressed as $CPUE_N$ ± standard error). In regions where the CPUE of sportfish species was greater than 1 fish/hr, proportional size distribution (PSD) scores (Neumann and Allen 2007) were calculated as an index of sportfish size structures. Condition [relative weight (W_r)] was calculated instead of PSD for Silver Carp (Irons et al. 2011). Recent research in the Wabash River indicates that 60-Hz pulsed-DC electrofishing is ineffective for sampling Flathead Catfish in riverine environments (Moody-Carpenter 2013). Therefore, Flathead Catfish were excluded from our analyses of catch rates and sportfish size structures. In previous years' reports, species-specific CPUE plots showed AC and pulsed-DC survey results. In this year's report, and likely going forward, species-specific CPUE plots show side-channel border (SCB) and main-channel border (MCB) habitats. The pulsed-DC results from previous years and MCB results from this year are the same; pulsed-DC sampling was previously only done in MCB habitat. However, most of the historic AC sites were located in SCB (or other off-channel) habitat, thus we decided – for continuity's sake – to label them as such for this report, knowing there are subtle differences among the two gears (e.g., McClelland and Sass 2012).

Table 2.2. Summary of ancillary water quality data collected during pulsed-DC electrofishing surveys on six reaches of the Illinois River during 2016. Values are expressed as the mean observed parameter value ± standard error.

Navigational Reaches	Total EF Effort (h)	EF Power Used (Watts)	Depth (ft)	Secchi Depth (in)	Water Temperature (°F)	DO (ppm)	Conductivity (µS)	Stage Height (ft)
Dresden (RM 271.5-286)	**3.05**	**5776.3 ± 151.9**	**6.4 ± 0.8**	**30.4 ± 0.8**	**77.0 ± 2.2**	**6.8 ± 0.2**	**835.3 ± 20.4**	**505.7 ± 0.1**
Period 1	1	6464.0 ± 0.0	4.4 ± 1.0	38.6 ± 1.0	84.7 ± 0.6	6.6 ± 0.5	909.0 ± 8.7	505.5 ± 0.0
Period 2	1	5450.0 ± 50.0	8.3 ± 1.3	27.9 ± 1.3	79.2 ± 0.1	6.7 ± 0.0	756.5 ± 9.0	506.1 ± 0.0
Period 3	1.05	5415.0 ± 120.7	6.5 ± 1.5	24.7 ± 1.5	67.2 ± 0.3	7.1 ± 0.3	840.3 ± 22.7	505.4 ± 0.0
Marseilles (RM 247-271.5)	**5.00**	**4813.8 ± 135.4**	**7.1 ± 0.6**	**18.1 ± 0.6**	**73.2 ± 2.1**	**8.0 ± 0.2**	**671.4 ± 24.7**	**7.7 ± 0.6**
Period 1	1.50	5659.2 ± 102.0	7.8 ± 0.7	22.8 ± 0.7	83.2 ± 0.3	7.5 ± 0.3	766.5 ± 14.5	5.9 ± 0.0
Period 2	1.75	4342.9 ± 84.1	8.6 ± 1.2	11.6 ± 1.2	76.6 ± 0.4	7.2 ± 0.1	531.4 ± 14.2	11.4 ± 0.0
Period 3	1.75	4560.0 ± 38.7	5.1 ± 0.6	20.6 ± 0.6	61.2 ± 0.5	9.2 ± 0.0	729.9 ± 4.8	5.4 ± 0.0
Starved Rock (RM 231-247)	**3.00**	**5431.3 ± 96.8**	**4.6 ± 0.6**	**21.9 ± 0.6**	**77.1 ± 2.6**	**8.3 ± 0.3**	**741.5 ± 5.8**	**459.5 ± 0.1**
Period 1	1.00	5460.0 ± 0.0	5.9 ± 1.0	19.4 ± 1.0	80.6 ± 0.2	8.6 ± 0.7	728.5 ± 2.7	459.8 ± 0.0
Period 2	1	5800.0 ± 0.0	5.3 ± 1.0	20.9 ± 1.0	85.5 ± 0.1	7.8 ± 0.1	759.3 ± 5.5	459.1 ± 0.0
Period 3	1	5033.8 ± 70.0	2.6 ± 0.5	25.6 ± 0.5	65.3 ± 0.1	8.4 ± 0.2	736.8 ± 13.0	459.7 ± 0.1
Peoria (RM 158-231)	**15.75**	**5295.5 ± 97.0**	**4.3 ± 0.3**	**13.4 ± 0.3**	**76.8 ± 1.0**	**7.8 ± 0.2**	**734.8 ± 11.8**	**14.0 ± 0.3**
Period 1	5.25	5680.5 ± 50.4	4.0 ± 0.5	12.9 ± 0.5	82.5 ± 0.3	7.7 ± 0.4	734.7 ± 29.4	13.6 ± 0.7
Period 2	5.25	5378.4 ± 96.0	4.5 ± 0.5	12.4 ± 0.5	81.6 ± 1.0	7.6 ± 0.4	693.3 ± 13.1	14.2 ± 0.7
Period 3	5.25	4827.6 ± 238.8	4.3 ± 0.5	15.0 ± 0.5	66.3 ± 0.5	8.2 ± 0.1	776.3 ± 9.7	14.1 ± 0.3
La Grange (RM 80-158)	**1.5**	**4790.8 ± 181.0**	**7.3 ± 1.1**	**8.9 ± 1.1**	**74.5 ± 2.2**	**6.4 ± 0.1**	**646.0 ± 35.7**	**9.3 ± 1.2**
Period 1	0.5	5272.5 ± 92.5	5.3 ± 0.8	8.9 ± 0.8	77.8 ± 0.1	6.6 ± 0.0	703.5 ± 12.5	6.7 ± 0.0
Period 2	0.5	4300.0 ± 100.0	9.8 ± 2.3	8.7 ± 2.3	78.2 ± 0.1	6.1 ± 0.2	533.5 ± 0.5	12.8 ± 0.0
Period 3	0.5	4800.0 ± 0.0	7.0 ± 1.0	9.1 ± 1.0	67.6 ± 0.3	6.7 ± 0.1	701.0 ± 2.0	8.3 ± 0.0
Alton (RM 0-80)	**14.25**	**4639.6 ± 58.5**	**6.1 ± 0.5**	**8.2 ± 0.5**	**78.9 ± 0.9**	**5.9 ± 0.2**	**589.2 ± 16.4**	**23.2 ± 0.6**
Period 1	4.75	4997.5 ± 100.5	5.9 ± 0.8	8.6 ± 0.8	83.4 ± 0.5	6.1 ± 0.3	626.2 ± 18.0	20.6 ± 1.1
Period 2	4.75	4499.9 ± 81.9	6.0 ± 0.9	6.2 ± 0.9	80.8 ± 0.8	4.9 ± 0.2	528.0 ± 12.2	25.4 ± 0.4
Period 3	4.75	4421.6 ± 65.8	6.2 ± 0.9	9.7 ± 0.9	72.5 ± 1.7	6.9 ± 0.4	613.3 ± 41.4	23.5 ± 0.8

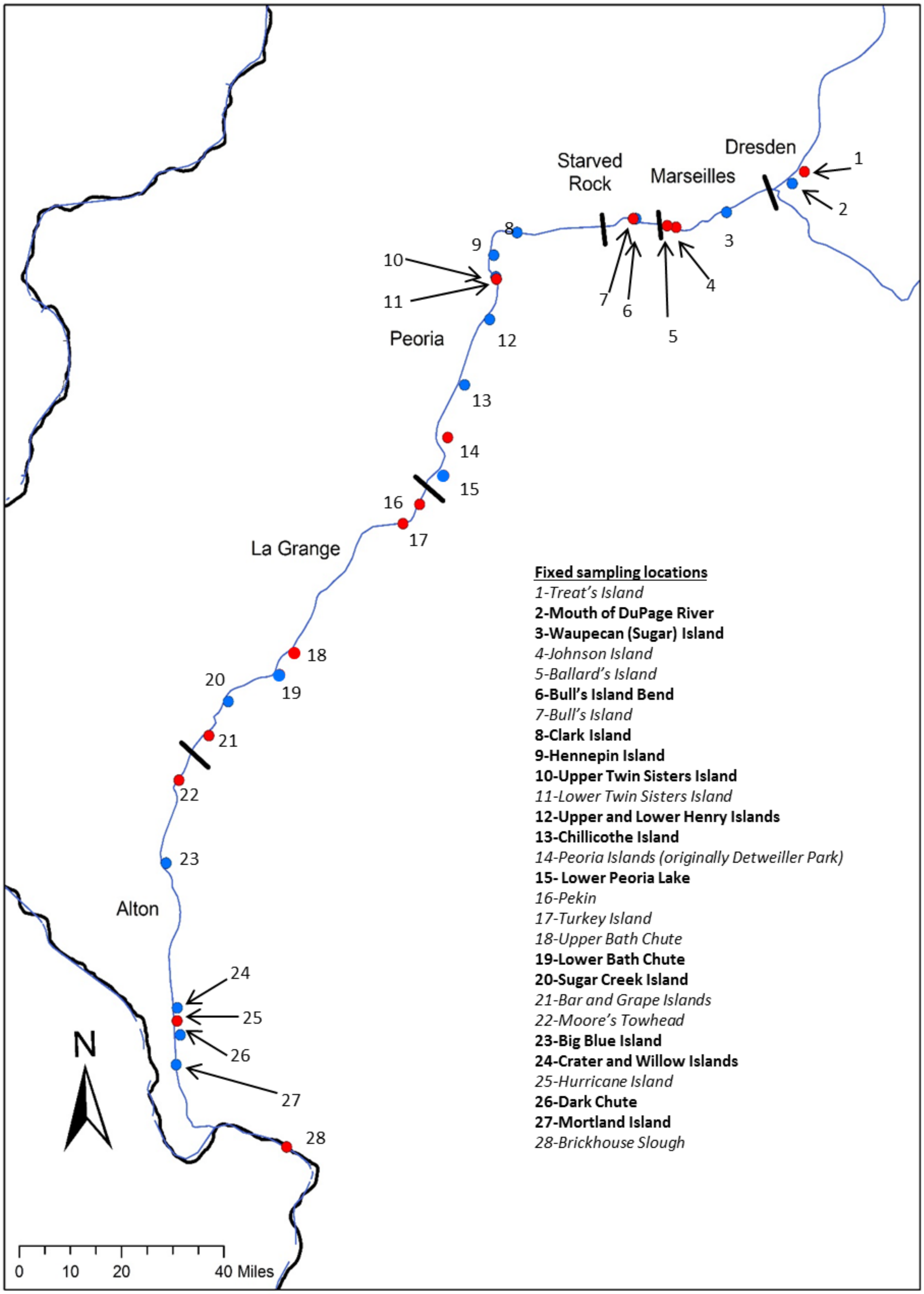

Figure 2.1. Map of the Illinois Waterway, and the fixed locations sampled by the Long-term Survey and Assessment of Large-River Fishes in Illinois (F-101-R) using AC electrofishing gear 1959-2015. Sites that were abandoned for 2016 and future sampling are listed in italics (red dots); sites that have been assimilated into the pulsed-DC protocol are listed in bold (blue dots).

Section 2.5 - 2016 Upper Illinois River Electrofishing Catch Statistics

We collected 843 fish representing 33 species and 1 hybrid during 2.3 hours of pulsed-DC electrofishing at 9 sites in side-channel border habitat on the Upper Illinois and Lower Des Plains rivers. Bluegill was the most abundant species in our survey of this region (286 fish; 33.9% of total catch) followed by Gizzard Shad (94; 11.2%), and Largemouth Bass (90; 10.7%). Silver Carp contributed the greatest biomass of fishes collected in the survey of this region (210.8 lb; 32.8% total collected biomass), followed by Common Carp (128.5 lb; 20.0%), and Largemouth Bass (103.9 lb; 16.2%).

We collected 2,155 fish representing 48 species during 8.75 hours of pulsed-DC electrofishing at 35 sites in main-channel border habitat in this region. Emerald Shiner was the most abundant species in our survey of this region (449 fish; 20.8% of total catch) followed by Gizzard Shad (409; 19.0%), and Bluegill (215; 10.0%). Smallmouth Buffalo contributed the greatest biomass of fishes collected in the survey of this region (205.9 lb; 31.5% total collected biomass), followed by Common Carp (161.7 lb; 24.7%), and Silver Carp (69.3 lb; 10.6%).

Threatened and Endangered Species

Twenty-five Banded Killifish (Illinois Threatened) were collected during pulsed-DC electrofishing surveys of this region. These fishes were identified in the field and released, and were not verified by INHS museum staff.

Bluegill

Catch rates of Bluegill in the Upper Illinois River during 2016 were well above average, though variable, in SCB habitat, and slightly below average in MCB habitat (Figure 2.2). The PSD values indicate that the Bluegill population of the Upper Illinois River has likely been dominated by small young-of-year and juvenile individuals for a while, but PSD has increased in recent years.

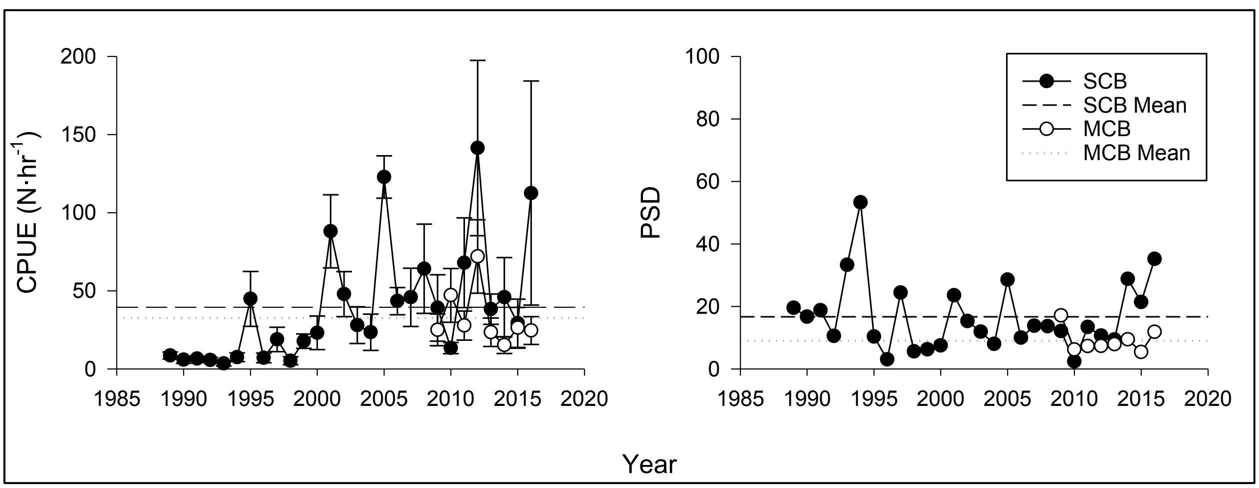

Figure 2.2. Catch per unit effort (mean ± SE; SE is calculated across sites and periods for side-channel border sampling, and across sites and periods for main-channel border sampling) and proportional size distribution of Bluegill collected in side-channel border (SCB) and main-channel border (MCB) electrofishing surveys in the Upper Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

Channel Catfish

Catch rates of Channel Catfish in the Upper Illinois River during 2016 were slightly above average for SCB habitat, and slightly below average for MCB habitat (Figure 2.3). The relative abundance of Channel Catfish is generally lower in the Upper Illinois River than in other study areas covered by LTEF sampling programs. The PSD values suggest that Channel Catfish populations in the Upper Illinois River are dominated by larger, mature individuals.

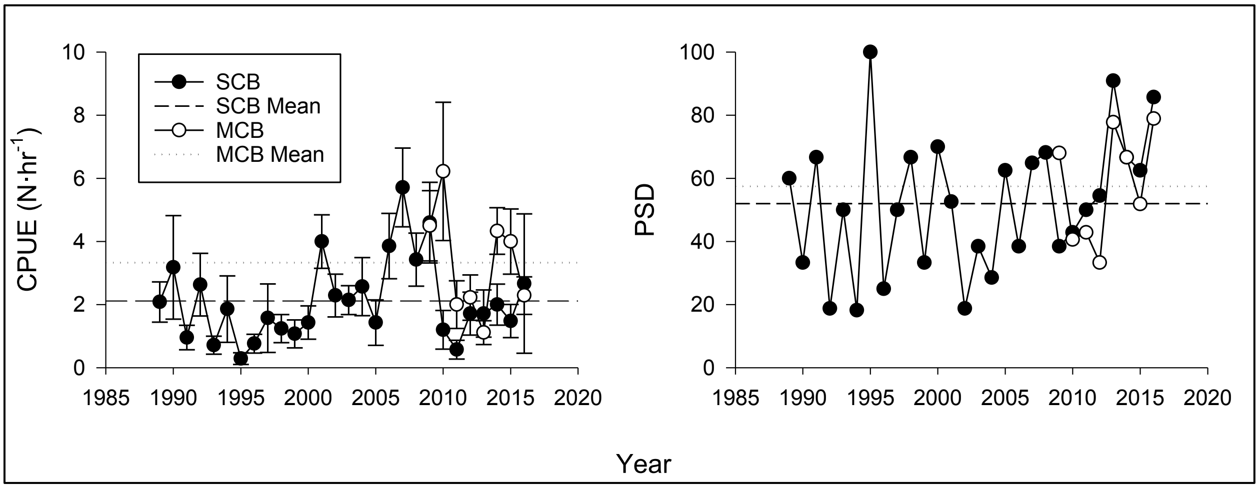

Figure 2.3. Catch per unit effort (mean ± SE) and proportional size distribution of Channel Catfish collected in side-channel border and main-channel border electrofishing surveys in the Upper Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

Largemouth Bass

Largemouth Bass CPUE was the highest since 1989 for SCB habitat, though highly variable (Figure 2.4), reflecting the large number of fish sampled from Fixed Site 2, near Channahon, IL (Figure 2.1), whereas CPUE in MCB habitat was slightly below average. PSD values for both habitat areas decreased from recent years, indicating an influx of new recruits. There is no doubt the Upper Illinois River has an excellent population of catchable Largemouth Bass.

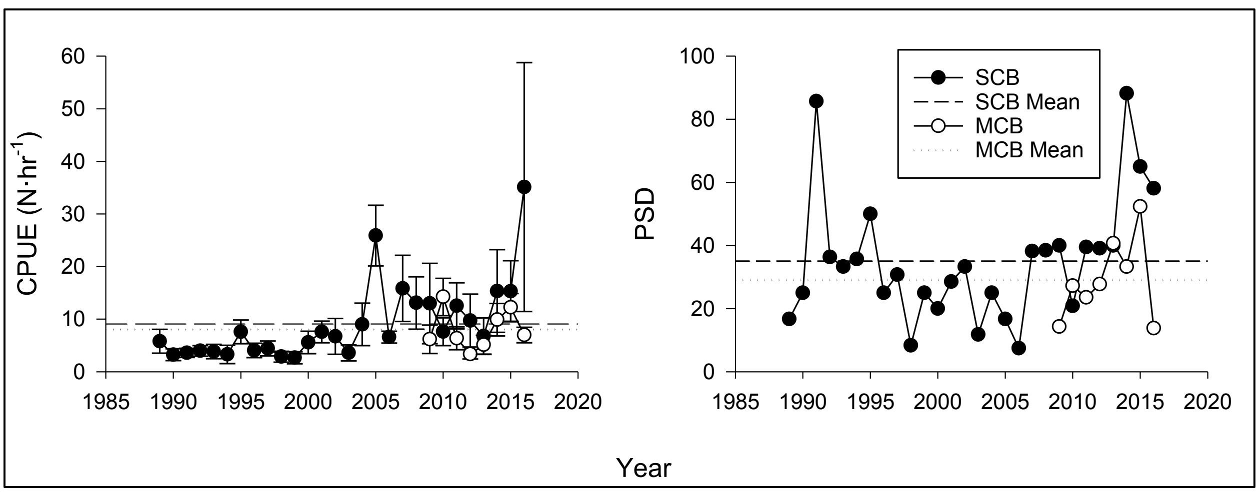

Figure 2.4. Catch per unit effort (mean ± SE) and proportional size distribution of Largemouth Bass collected in side-channel border and main-channel border electrofishing surveys in the Upper Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

Smallmouth Bass

Similar to Largemouth Bass, catch rates of Smallmouth Bass in the Upper Illinois River were the highest ever recorded in both SCB and MCB habitats; catch rates in SCB habitat have been increasing overall since 2000 (Figure 2.5). The variability of PSD values through time indicates that Smallmouth Bass recruitment trends in this region are sporadic. We believe future study of the effects of abiotic and biotic environmental variables on the population dynamics of Smallmouth Bass is warranted.

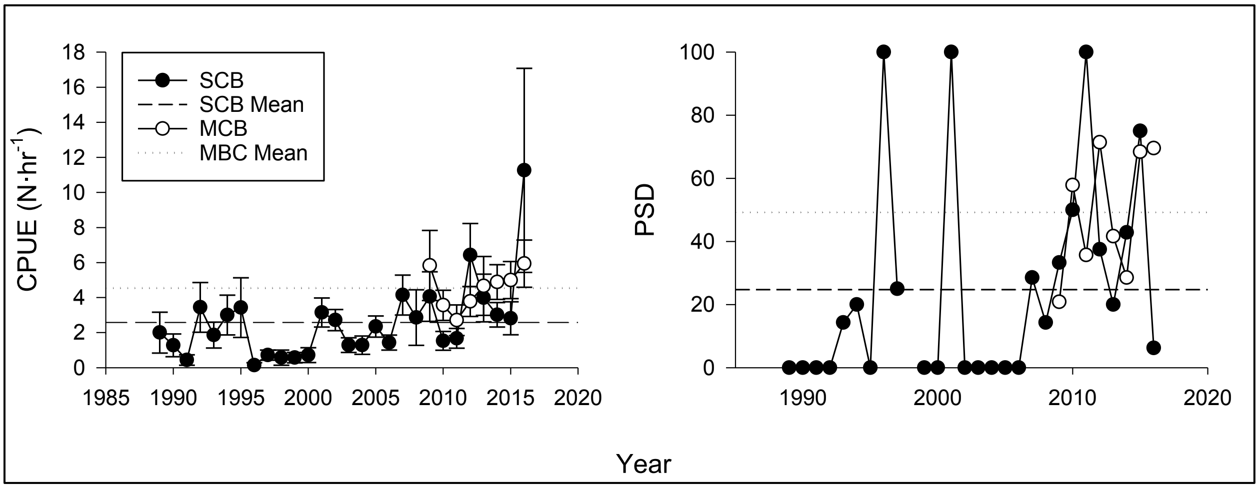

Figure 2.5. Catch per unit effort (mean ± SE) and proportional size distribution of Smallmouth Bass collected in side-channel border and main-channel border electrofishing surveys in the Upper Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

Section 2.6 - 2016 Lower Illinois River Electrofishing Catch Statistics

We collected 3,491 fish representing 54 species and 1 hybrid during 8.75 hours of pulsed-DC electrofishing at 35 sites in side-channel border habitat on the Lower Illinois River. Silver Carp was the most abundant species in our survey of this region (717 fish; 20.5% of total catch) followed by Emerald Shiner (691; 19.8%), and Bluegill (347; 9.9%). Silver Carp contributed the greatest biomass of fishes collected in our survey of this region (2278.1 lb; 45.3% total collected biomass), followed by Common Carp (1294.9 lb; 25.7%), and Bigmouth Buffalo (451.1; 9.0%).

We collected 5,538 fish representing 54 species during 22.75 hours of pulsed-DC electrofishing at 91 sites in main-channel border habitat this region. Emerald Shiner was the most abundant species in our survey of this region (1,772 fish; 32.0% of total catch) followed by Gizzard Shad (1,739; 31.4%), and Freshwater Drum (227; 4.6%). Silver Carp contributed the greatest biomass of fishes collected in the survey of this region (653.1 lb; 33.9% total collected biomass), followed by Common Carp (411.8 lb; 21.4%), and Channel Catfish (164.6 lb; 8.6%).

Threatened and Endangered Species

One Banded Killifish (Illinois Threatened) and one American Eel (Illinois Threatened) were collected during pulsed-DC electrofishing surveys of this region. These fishes were identified in the field and released, and were not verified by INHS museum staff.

Black Crappie and White Crappie

Catch rates of Black Crappie and White Crappie in SCB habitat in the Lower Illinois River were similar to 2015, when they showed a nice rebound after several years with low catch rates (Figure 2.6). CPUE of Black Crappie and White Crappie is generally low in our MCB sites in the lower Illinois River, and likely indicates a preference for SCB habitat. PSD values during 2016 were higher than 2015, but still below average, indicating the year classes we believe were produced during floods in 2013 and 2015 are still present and growing.

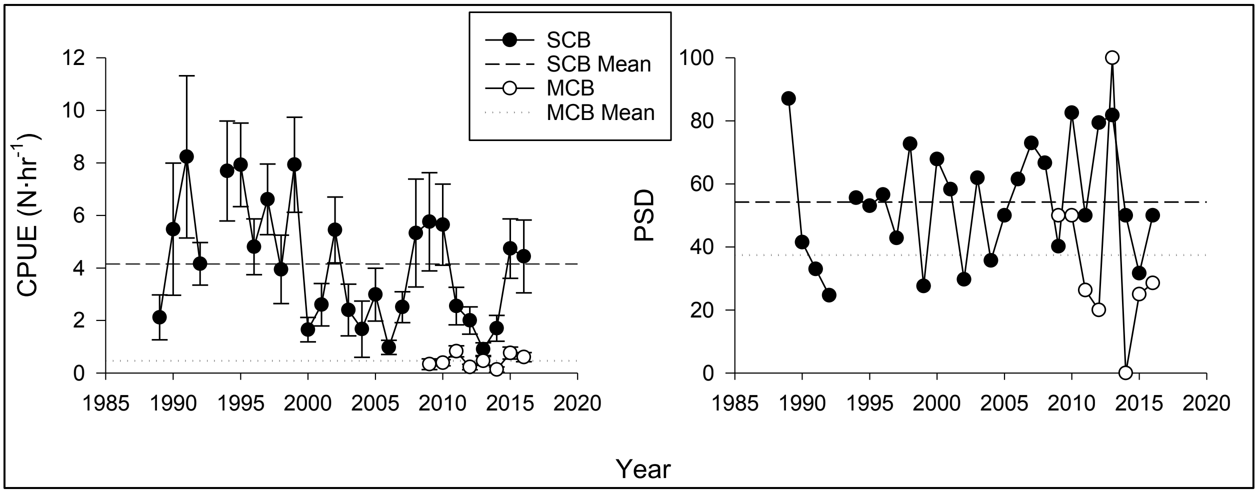

Figure 2.6. Catch per unit effort (mean ± SE) and proportional size distribution of Black Crappie and White Crappie collected in side-channel border and main-channel border electrofishing surveys in the Lower Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

Bluegill

Similar to Crappies, catch rates of Bluegill in the Lower Illinois River were similar to 2015, when they showed a nice rebound after several years with low catch rates (Figure 2.7). Also, similar to Crappies, CPUE of Bluegill is generally low in our MCB sites in the lower Illinois River, and likely indicates a preference for SCB habitat. The low PSD values are likely indicative of a population dominated by smaller, younger individuals, likely resulting from poor recruitment, which we believe exists because of depauperate overwintering habitat (Solomon et al. 2017).

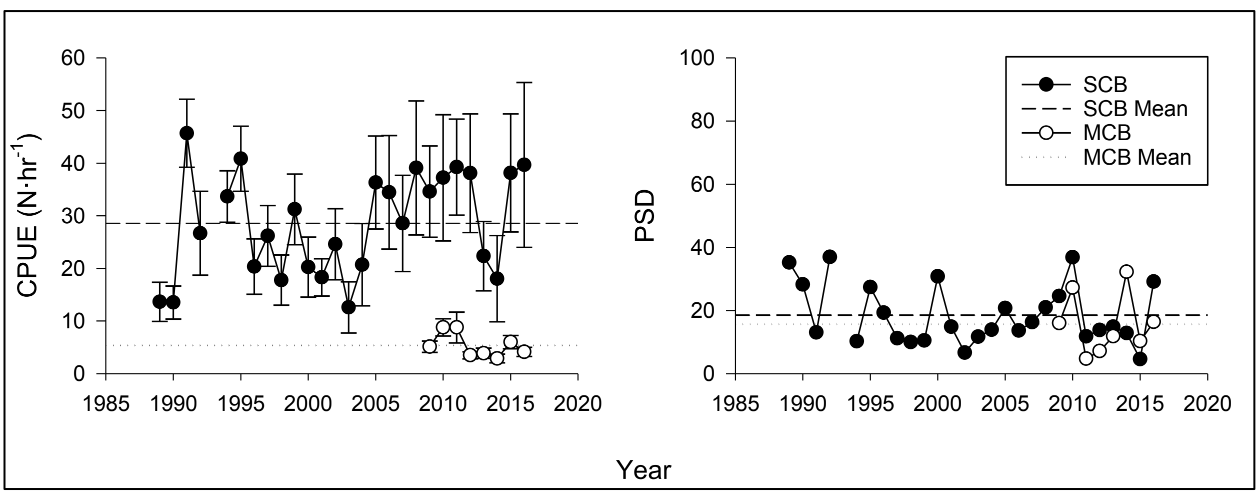

Figure 2.7. Catch per unit effort (mean ± SE) and proportional size distribution of Bluegill collected in side-channel border and main-channel border electrofishing surveys in the Lower Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

Channel Catfish

Catch rates of Channel Catfish in the Lower Illinois River were very low in SCB habitat, and average in MCB habitat (Figure 2.8), although PSD values in 2016 in this region were above average for both SCB and MCB habitats. Recent trends in CPUE indicate that Channel Catfish CPUE in SCB habitat in the Lower Illinois River has decreased substantially since 2010. This trend should be monitored in coming years to ensure our changing sampling protocol is not biasing catch rates.

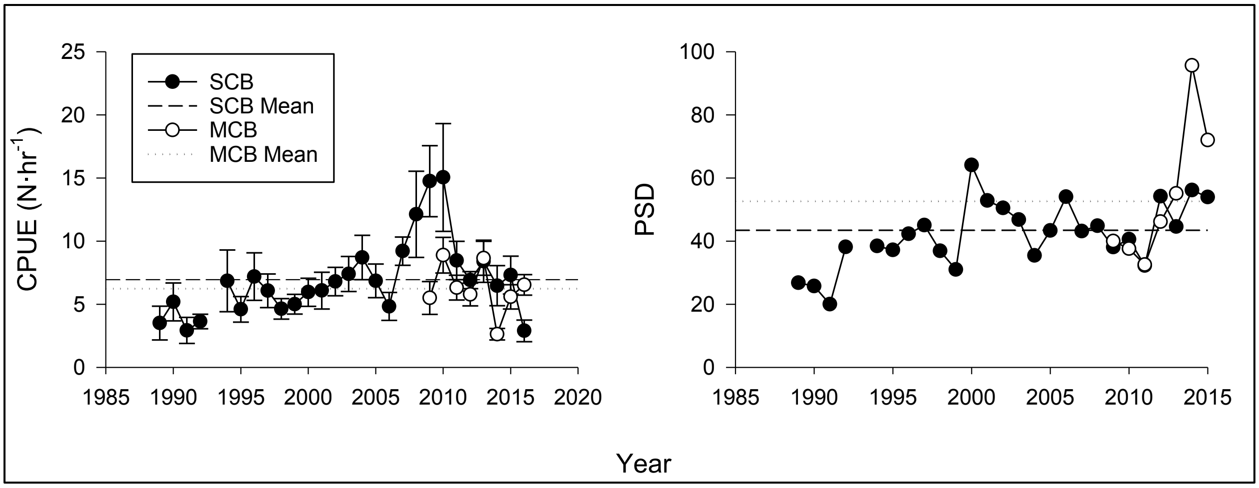

Figure 2.8. Catch per unit effort (mean ± SE) and proportional size distribution of Channel Catfish collected in side-channel border and main-channel border electrofishing surveys in the Lower Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

Largemouth Bass

Catch rates of Largemouth Bass in the Lower Illinois River during 2016 were slightly above average in SCB habitat, and low in MCB habitat (Figure 2.9). PSD values calculated for both habitats during 2016 were below average. We believe Largemouth Bass, similar to Bluegill and maybe Crappies, struggle to overwinter successfully in the Lower Illinois River because of poor backwater habitat quality.

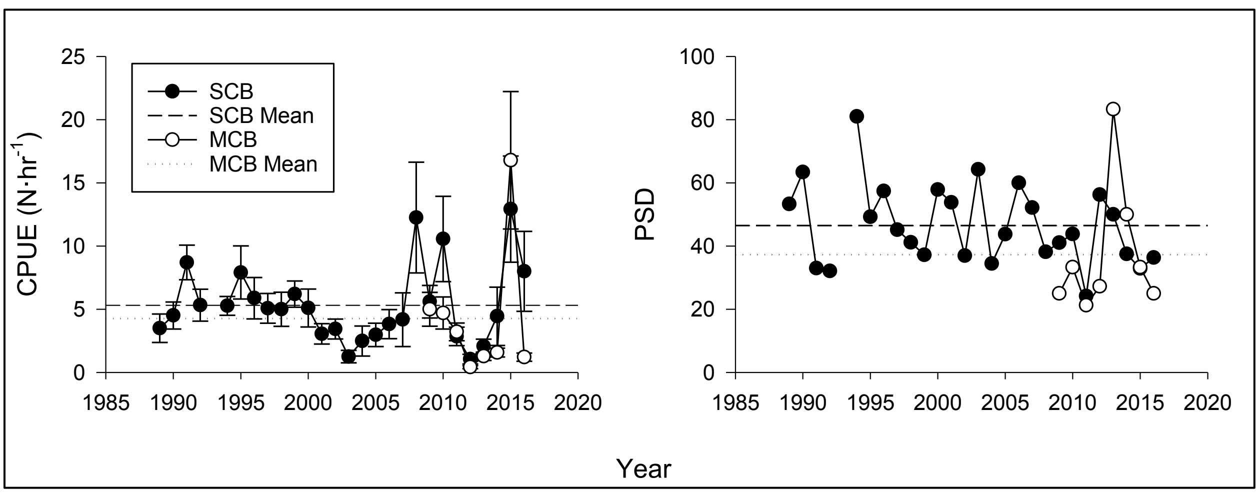

Figure 2.9. Catch per unit effort (mean ± SE) and proportional size distribution of Largemouth Bass collected in side-channel border and main-channel border electrofishing surveys in the Lower Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

White Bass

White Bass CPUE in the Lower Illinois River during 2016 was slightly below the long-term average for SCB and MCB habitats (Figure 2.10). The disparity between the average PSD value of White Bass collected in SCB and MCB habitats likely indicates habitat preference of different size classes of White Bass.

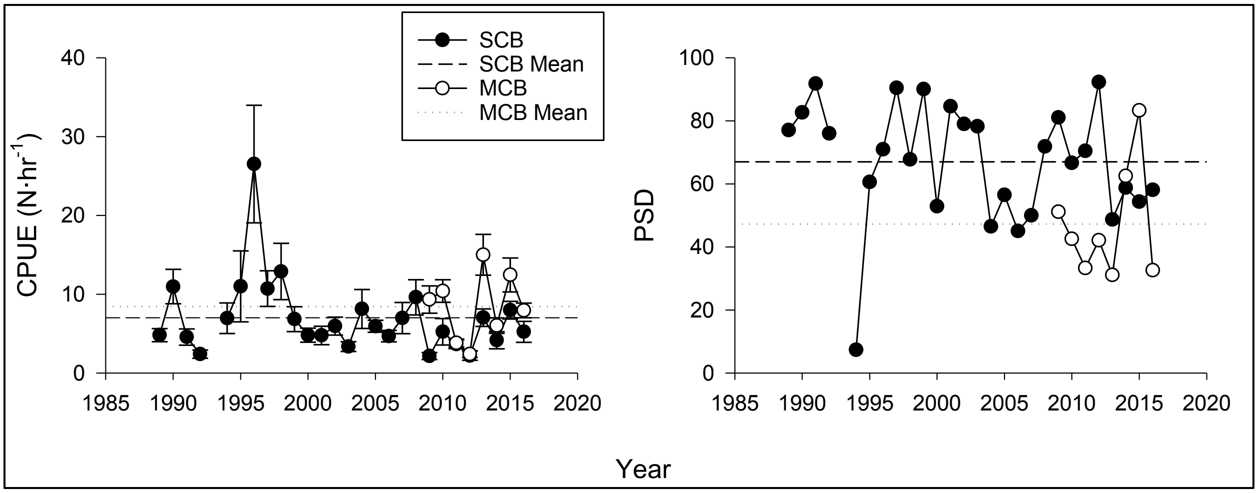

Figure 2.10. Catch per unit effort (mean ± SE) and proportional stock-density of White Bass collected in side-channel border and main-channel border electrofishing surveys in the Lower Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

Silver Carp

Silver Carp were first detected in F-101-R surveys in the IL River during 2001 (Figure 2.11). Since 2012, CPUE in SCB habitat has increased every year, and was the second-highest on record during 2016. Catch rates in MCB habitat were below average. Since approximately 2010, the relative weight of Silver Carp in the Lower Illinois River has plateaued around 94 (Figure 2.11). Given both anecdotal and documented evidence of Silver Carp spawning activity during recent high-flow periods, the increase in CPUE of Silver Carp in SCB habitat is not unexpected.

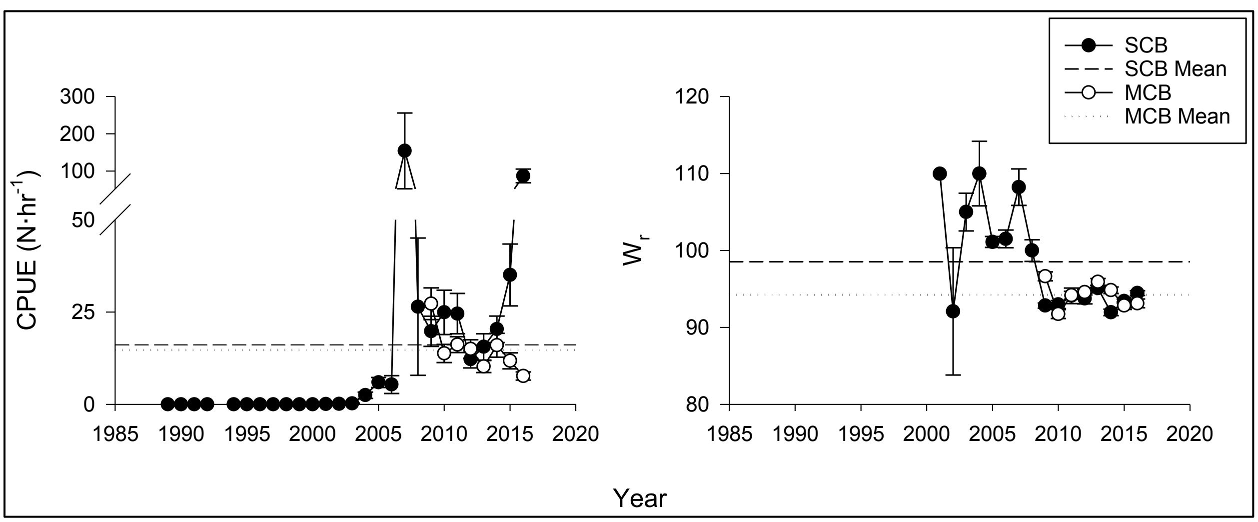

Figure 2.11. Catch per unit effort (mean ± SE) and condition (relative weight-W_r) of Silver Carp collected in side-channel border and main-channel border electrofishing surveys in the Lower Illinois River. The dashed lines represent the long-term averages in each habitat type used since F-101-R sampling initiated in 1989.

Section 2.7 - Additional research projects

Section 2.7.1 - Life-history expression of three popular sportfish from three distinct habitats in the Illinois River Watershed

Understanding how a fish's environment affects life-history expression throughout its geographic range is important for effectively managing and conserving important resources. Largemouth Bass, Black Crappie, and Bluegill are popular sportfish in the Midwest, making their management and conservation a priority for many natural resource agencies. We collected Largemouth Bass, Black Crappie, and Bluegill from three distinct habitats in the Illinois River Watershed – the Upper Illinois River/Lower Des Plaines River, LaGrange reach of the Lower Illinois River, and The Nature Conservancy's Emiquon Preserve, a large restored floodplain wetland – during Spring 2015 and 2016 to better understand the effect of environmental differences on sportfish life-history expression. We weighed and measured fishes, categorized visible parasite presence or absence, and extracted otoliths (to estimate fish age), gonads (to determine sex, estimate fecundity, and calculate GSI), and livers (to calculate HSI). Many life-history traits differed among habitats, though the results were often sex- and species-specific; the most-dramatic differences were in ovary weight-somatic weight relationships. Environmental factors appear to affect fish life-history expression, but more research is needed on additional factors involved (e.g., biotic interactions) and the mechanisms of effect. We presented this research at multiple conferences during 2017, and plan to publish these data once sample processing and a comprehensive analysis is complete.

Section 2.7.2 – Biotic response to the establishment and expansion of Asian carp in the Illinois River

As a heavily modified river system that connects the Mississippi River watershed to the Great Lakes watershed, the Illinois River Waterway (IRW) is a conduit for the movement of invasive species between watersheds. The most-recent – and perhaps most-feared – invasives are Asian carps, which threaten the Great Lakes themselves, and countless highly productive miles of connected rivers as well. Our analysis shows individual Asian carp condition decreased while their population biomass increased during their establishment in the Illinois River. Concurrently, analysis of 22 years of producer and consumer abundance and biomass data shows phytoplankton density and macrozooplankton density and biomass decreased – zooplankton by over 90% – during the same period, though the responses of age-0 native fish biomass and adult native fish biomass were more nuanced. Our findings provide compelling evidence of a middle-out change in trophic assemblage from an invasive planktivore: the effects extend toward the base represented by phytoplankton, laterally through competition with other planktivores, and toward the apex though competition with juvenile stages of top predators. Ultimately, the response to the Asian carp middle-out disruption is multi-trophic, yet different trophic levels exhibited different temporal responses. This manuscript was submitted to *Ecology*, reviewed, and rejected, though with an invitation to revise and resubmit to *Ecological Applications*. That revision and resubmission is currently underway.

Section 2.7.3 – Patterns of intersex prevalence, vitellogenin, and reproductive condition in two commercially harvested fish along a pollution gradient in the Illinois River complex

Master's student Madeleine VanMiddlesworth successfully defended her thesis in November 2017. Her thesis abstract is below, and multiple manuscripts are currently in preparation.

The Illinois River in Illinois is characterized by a pollution gradient originating from highly urbanized and industrialized upstream sources that contain elevated levels of endocrine-disrupting chemicals (EDCs). Controlled exposures of fish to EDCs in laboratory have produced increased feminization of male gonadal tissue in fish (i.e. intersex condition), elevated levels of the blood lipoprotein vitellogenin (VTG), and decreased reproduction. However, assessments of the prevalence and distribution of VTG and intersex in wild fish populations are necessary and few have been performed on the Illinois River. Such field studies may provide insight into both the extent of exposure of fish to EDCs and whether there are species-specific differences in response to this exposure. Long-term data suggests that common carp populations are declining in the Illinois River while the age structure of channel catfish has shifted to primarily older fish. This study assessed gonadosomatic index (GSI), liver somatic index (LSI), intersex condition, elevated VTG levels, and fecundity indices in common carp (*Cyprinus carpio*) and channel catfish (*Ictalurus punctatus*) along a pollution gradient in the Illinois River, Illinois from the headwaters to the confluence with the Mississippi River.

Common carp and channel catfish were collected along a downstream gradient of sites in the Illinois River from River Kilometer 32 to 446. Microscopic analysis of thin sections of male gonadal tissue were assessed for prevalence of intersex (oocytes in testicular tissue) in both species. In addition, I utilized a carp-specific Enzyme-Linked Immunosorbent Assay (ELISA) to contrast carp blood plasma VTG between fish caught at Upper and Lower Illinois River watershed sites. I found evidence of intersex condition in male testes from both fish species and VTG induction in male common carp, however rates of intersex were low compared to other fish species and did not vary spatially. Male carp VTG levels were not different among sites and averaged 6.7 ug/mL across all sites. This level of VTG is near or below method detection limits and low in comparison to levels in females, which had blood concentrations in the <100 ug/mL range.

I also investigated whether landscape and point-source pollution factors were related to patterns of reproductive health in common carp and channel catfish. Reproductive condition was indexed using LSI, GSI, total fecundity and relative fecundity. An Akaike's Information Criterion (AIC) modeling approach was used to identify the most influential landscape and point-source pollution-related variables. The AIC_c modeling produced only one candidate model in which a single health attribute, male GSI in common carp, was affected by temperature and proportion of urbanization and wetland land uses in the tributaries immediately upstream of sampling sites. These results suggest that the other select landscape attributes considered (distance of the site downstream from Chicago, adjacent land use, local point-source pollution load, and site environmental variables) had little demonstrable effect on the reproductive condition of common carp and channel catfish between locations.

Reproductive metrics in fish from the heavily urbanized upper and highly agricultural lower basin sites were compared to fish collected from a disconnected, restored floodplain wetland preserve. Common carp from the Emiquon Preserve had both smaller gonads and smaller, fewer eggs at a given body length than carp from the Upper Illinois or Lower Illinois River sites. The fecundity and GSI of channel catfish did not differ between Upper River and Lower River locations. The LSI was elevated in male common carp from the Upper River and both genders of channel catfish from the Upper River locations.

This study provided a baseline assessment of intersex, vitellogenin, and reproduction in two commercially important species. While many studies have examined common carp in the lab and aquaculture environments for signs of endocrine disruption, little has been documented for either wild populations of carp or channel catfish. The declining population trends for these two important Illinois River fishes and the physiological differences between species necessitates continued investigation of endocrine disruption. Contrary to the results from the examination of other select species in this river system, I found little evidence of endocrine disruption in common carp and catfish. Because this result is in strong contrast to other species in this system and elsewhere in the North America, it is essential to continue to monitor the reproductive health of these species as well as others in the Illinois River to determine the potential long-term consequences of EDCs.

Section 2.7.4 – LTEF dataset analysis

Data from the LTEF were used to document the collapse of common carp populations across several decades. Information on catch rates and body condition helped to identify a virus as the likely mechanism for the collapse. The information provided by LTEF sampling was critical for identifying long-term trends. This manuscript was published in March 2017 in the journal *Biological Invasions*.

The long-term data from LTEF sampling was also the centerpiece of a manuscript that documented the effect of the Clean Water Act on fish populations in the Illinois River. This manuscript, which is currently in revision at the journal *BioScience*, is intended to highlight the importance of long-term monitoring for a broad audience of scientists and policymakers.

CHAPTER 3
SPORTFISH ASSESSMENTS IN THE MISSISSIPPI RIVER

During 2016, the allocation of sampling pools on the Mississippi River (MS River) was modified to improve sampling efficiency; staff at the Illinois River Biological Station coordinated with Iowa DNR staff who are also using LTRM-based sampling on the MS River. Iowa DNR is on an alternating annual schedule for Pools 16 and 17, and we agreed to sample the opposite pool as them. Thus, this year's report describes sampling in Pool 17 **only**, sampled by LTEF since 2014.

The results in the following sections have been divided between those data collected in Pool 17 and data collected in Pool 25, the Chain of Rocks Reach, and the Kaskaskia Reach (the Lower Mississippi River Sampling Area). We have made this distinction because of the geographic distance between the two sections. Fisheries data collected by LTRMP surveys in Pool 26 in the Lower Mississippi River Sampling Area have been included in CPUE calculations to increase the spatial continuity of the data used for the following analyses, but not in summary paragraphs or in W_r calculations, as LTRM only weighs select fishes, and only during Period 3. These data are a product of the U.S. Army Corps of Engineers' Upper Mississippi River Restoration—Environmental Management Program, Long Term Resource Monitoring Program (LTRMP) element, as distributed by the U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin (www.umesc.usgs.gov/ltrmp.html).

Section 3.1 - 2016 Mississippi River Ancillary Habitat Quality Data

Pulsed-DC electrofishing was conducted according to the methods described in Section 2.1 between 9:00 AM and 3:05 PM central standard time during the three sampling periods specified in Section 2.1. Physical measurements for ancillary water-quality parameters were collected at each site and are summarized in Table 3.1.

Table 3.1. Summary of ancillary water quality data collected during pulsed-DC electrofishing surveys on six sampling areas of the Mississippi River during 2016. Values are expressed as the mean observed parameter value ± standard error.

Navigational Reaches	Total EF Effort (h)	EF Power Used (Watts)	Depth (ft)	Secchi Depth (in)	Water Temperature (°F)	DO (ppm)	Conductivity (µS)	Stage Height (ft)
Pool 17 (RM 437-457)	**3.00**	**3884.3 ± 75.7**	**7.5 ± 0.7**	**14.3 ± 1.2**	**78.3 ± 1.1**	**6.7 ± 0.2**	**428.8 ± 10.7**	**10.3 ± 0.7**
Time Period 1	1.00	4178.0 ± 74.0	9.3 ± 1.3	19.7 ± 1.0	81.5 ± 0.7	6.9 ± 0.5	462.8 ± 14.9	8.2 ± 0.0
Time Period 2	1.00	3835.0 ± 56.8	6.0 ± 1.1	13.1 ± 0.3	80.1 ± 0.6	6.5 ± 0.2	419.5 ± 20.9	9.2 ± 0.0
Time Period 3	1.00	3640.0 ± 69.3	7.5 ± 1.0	10.2 ± 0.2	73.2 ± 0.2	6.8 ± 0.1	404.3 ± 0.5	13.4 ± 0.0
Pool 25 (RM 242-273.5)	**4.50**	**3837.0 ± 62.9**	**10.2 ± 1.3**	**10.5 ± 0.6**	**77.4 ± 1.6**	**8.0 ± 0.2**	**407.7 ± 9.3**	**38.5 ± 0.4**
Time Period 1	1.50	3930.7 ± 78.4	8.7 ± 3.2	12.9 ± 0.8	82.3 ± 0.4	8.2 ± 0.2	407.2 ± 19.7	36.5 ± 0.0
Time Period 2	1.50	3968.3 ± 130.8	12.4 ± 2.0	8.5 ± 0.6	81.0 ± 0.6	6.9 ± 0.1	419.7 ± 18.8	38.7 ± 0.4
Time Period 3	1.50	3612.0 ± 42.6	9.5 ± 1.1	10.3 ± 0.7	69.0 ± 1.9	8.7 ± 0.3	396.3 ± 9.3	40.4 ± 0.2
Chain of Rocks (RM 165.5-200.5)	**5.25**	**3926.4 ± 86.4**	**9.4 ± 1.0**	**6.6 ± 0.5**	**78.4 ± 1.3**	**6.8 ± 0.2**	**421.3 ± 16.2**	**17.3 ± 0.7**
Time Period 1	1.75	3977.3 ± 34.1	5.4 ± 0.6	4.9 ± 0.9	84.3 ± 0.3	6.2 ± 0.2	407.0 ± 7.4	16.5 ± 1.1
Time Period 2	1.75	4073.1 ± 236.0	9.7 ± 1.3	6.5 ± 0.8	79.7 ± 0.6	6.7 ± 0.2	452.6 ± 43.4	14.9 ± 0.8
Time Period 3	1.75	3728.9 ± 84.9	13.0 ± 1.8	8.3 ± 0.5	71.4 ± 1.9	7.6 ± 0.2	404.4 ± 21.0	20.5 ± 0.1
Kaskaskia (RM 117-165.5)	**7.25**	**3895.4 ± 50.6**	**9.1 ± 0.7**	**6.4 ± 0.5**	**77.4 ± 1.5**	**6.9 ± 0.2**	**417.2 ± 8.6**	**19.4 ± 0.6**
Time Period 1	2.25	4030.4 ± 46.8	8.2 ± 1.2	4.5 ± 0.5	85.1 ± 0.2	6.1 ± 0.1	416.1 ± 9.8	18.3 ± 0.5
Time Period 2	2.50	3968.3 ± 119.3	9.5 ± 1.6	6.4 ± 0.3	79.5 ± 0.9	6.2 ± 0.2	417.4 ± 20.0	19.9 ± 0.9
Time Period 3	2.50	3687.6 ± 30.6	9.6 ± 0.9	8.3 ± 1.2	67.5 ± 1.9	8.4 ± 0.4	418.0 ± 14.7	19.9 ± 1.4

Section 3.2 - 2016 Pool 17 Pulsed-DC Electrofishing Catch Statistics

We collected 2,126 fish representing 35 species during 3.0 hours of pulsed-DC electrofishing at 12 sites in Pool 17. Emerald Shiner was the most abundant species in our catch (1,422 fish; 66.9% of total catch) followed by Gizzard Shad (248; 11.7%), and Channel Shiner (146; 6.9%). Common Carp represented the greatest proportion of the total collected biomass (102.3 lb; 36.4% of total collected biomass) followed by River Carpsucker (28.3 lb; 10.1%), and Smallmouth Buffalo (21.5 lb; 7.7%).

Threatened and Endangered Species

Several fishes believed to be sand darters were captured in Pool 17 during 2016. These specimens are currently being identified by INHS museum staff in Champaign.

Bluegill

Bluegill catch rates in Pool 17 during 2016 were slightly below average since 2014 (Figure 3.1). The PSD value for fish sampled during 2016 was low, likely indicating an influx of recruits in 2016.

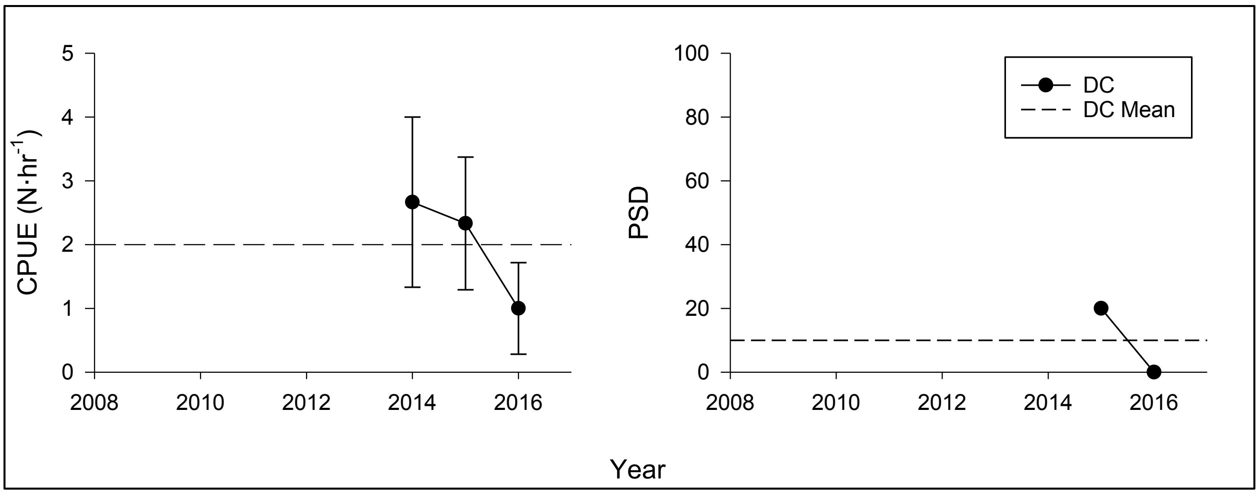

Figure 3.1. Catch per unit effort (mean ± SE) and proportional size distribution of Bluegill collected by pulsed-DC electrofishing surveys in Pool 17. The dashed lines represent the average since F-101-R sampling initiated in 2014.

Channel Catfish

Catch rates and PSD values of Channel Catfish in Pool 17 were slightly below average during 2016. These results likely indicate that the bulk of the sampled population is comprised of larger, mature fish.

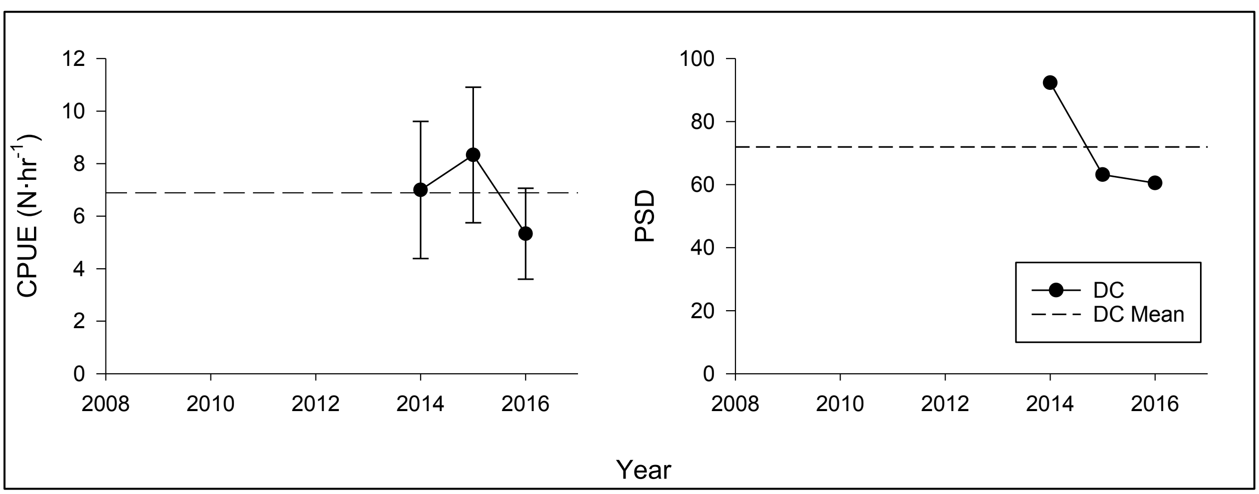

Figure 3.2. Catch per unit effort (mean ± SE) and proportional size distribution of Channel Catfish collected by pulsed-DC electrofishing surveys in Pool 17. The dashed lines represent the average since F-101-R sampling initiated in 2014.

Largemouth Bass

Catch rates of Largemouth Bass in Pool 17 have been decreasing since sampling began in 2014, with (Figure 3.3), with an almost-even mix of large and small fish based on PSD values.

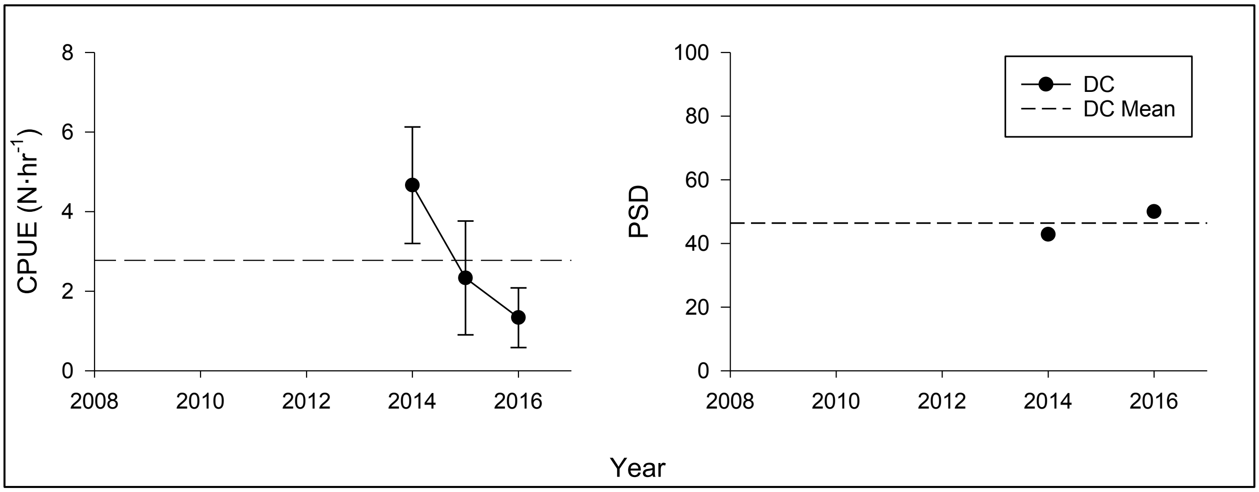

Figure 3.3. Catch per unit effort (mean ± SE) and proportional size distribution of Largemouth Bass collected by pulsed-DC electrofishing surveys in Pool 17. The dashed lines represent the average since F-101-R sampling initiated in 2014.

Smallmouth Bass

Smallmouth Bass CPUE in Pool 17 during 2016 was below the 3-year average (Figure 3.4). The PSD value for 2016 indicates few large fish are sampled in this area.

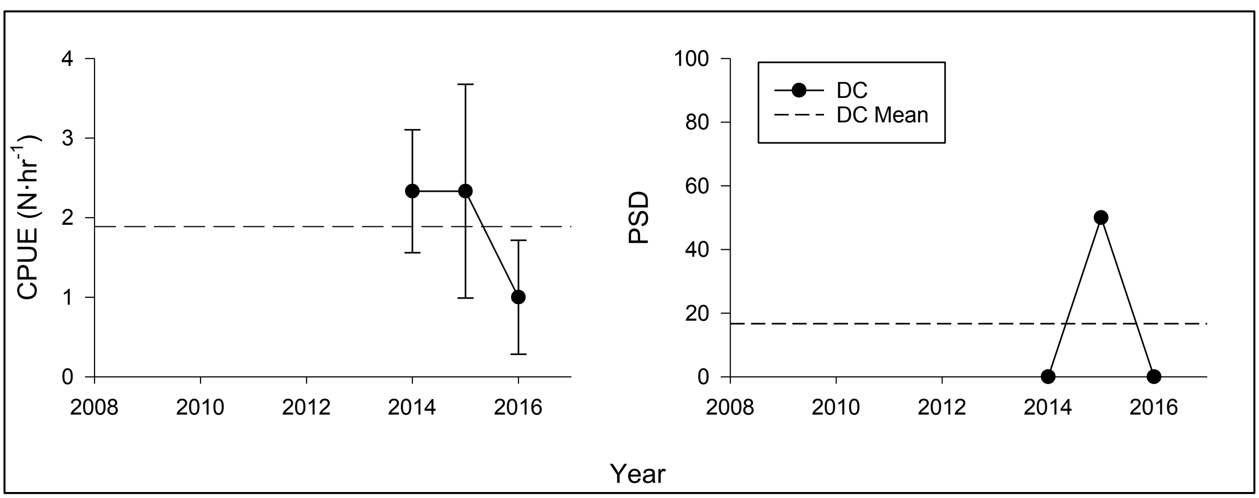

Figure 3.4. Catch per unit effort (mean ± SE) and proportional size distribution of Smallmouth Bass collected by pulsed-DC electrofishing surveys in Pool 17. The dashed lines represent the average since F-101-R sampling initiated in 2014.

White Bass

Catch rates of White Bass in Pool 17 during 2016 were similar to those in 2015, slightly above the 3-year average (Figure 3.5). Stable PSD values from 2014 to 2016 indicates a good population of large fish.

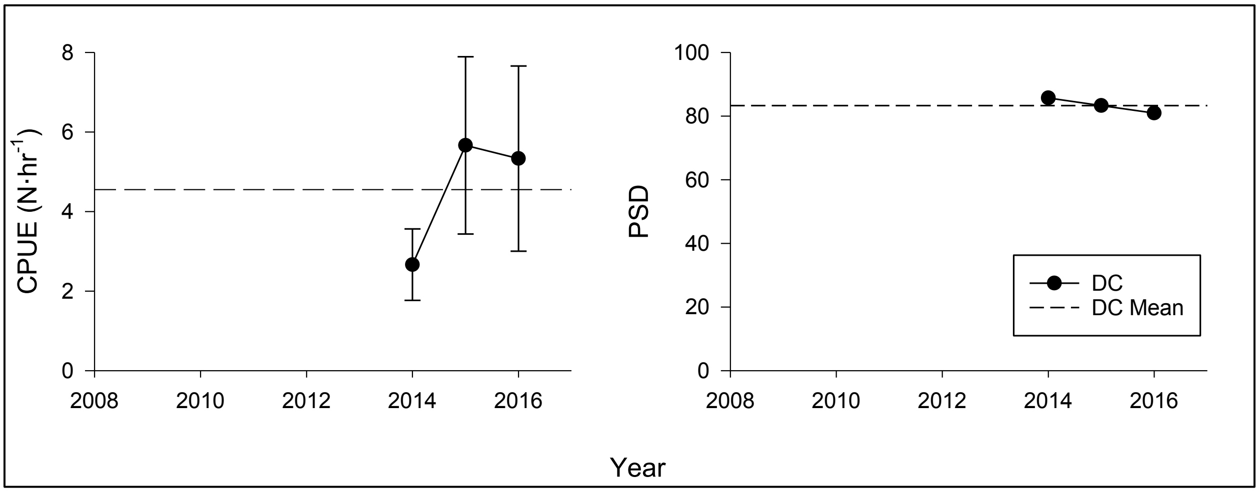

Figure 3.5. Catch per unit effort (mean ± SE) and proportional size distribution of White Bass collected by pulsed-DC electrofishing surveys in Pool 17. The dashed lines represent the average since F-101-R sampling initiated in 2014.

Section 3.3 - 2016 Lower Mississippi River Sampling Area Pulsed-DC Electrofishing Catch Statistics

We collected 1,824 fish representing 41 species and 1 hybrid during 16.75 hours of pulsed-DC electrofishing at 67 sites in the Lower Mississippi River Sampling Area. Emerald Shiner was the most abundant species in our catch (452 fish; 24.8% of total catch) followed by Common Carp (272; 14.9%), and Freshwater Drum (204; 11.2%). Common Carp represented the largest proportion of the total collected biomass (1,513.7 lb; 46.0% of total collected biomass) followed by Silver Carp (414.1 lb; 12.6%), and Smallmouth Buffalo (233.9 lb; 7.1%).

Threatened and Endangered Species

Two American Eel (Illinois Threatened), two Chestnut Lamprey (Iowa Threatened), and two Freckled Madtom (Iowa Endangered) were sampled during pulsed-DC electrofishing surveys on the Lower Mississippi River Sampling Area. These fish were identified in the field, and were not verified by INHS museum staff.

Bluegill

The catch rate of Bluegill in the Lower Mississippi River Sampling Area was low in 2016 after a rebound in 2015 (Figure 3.6). Low PSD values indicate that the sampled population is dominated by small individuals, perhaps limited by overwintering habitat like those in the Lower Illinois River. Similar values since 2009 may indicate that annual production of year classes has been relatively consistent.

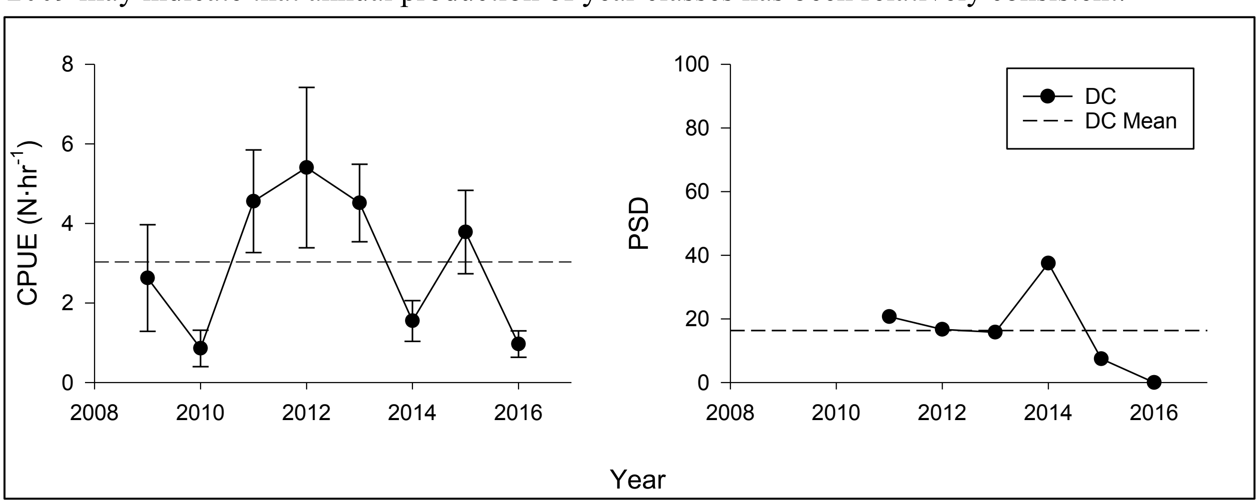

Figure 3.6. Catch per unit effort (mean ± SE) and proportional size distribution of Bluegill collected by pulsed-DC electrofishing surveys in the Lower Mississippi River Sampling Area. The dashed lines represent the long-term averages since F-101-R sampling initiated in 2009.

Channel Catfish

Catch rates of Channel Catfish in the Lower Mississippi River Sampling Area during 2016 decreased again (Figure 3.7). Typically, high and stable PSD values during the past six years indicated that the sampled population is largely composed of larger individuals, though PSD was the lowest ever during 2016, perhaps indicating an influx of new recruits.

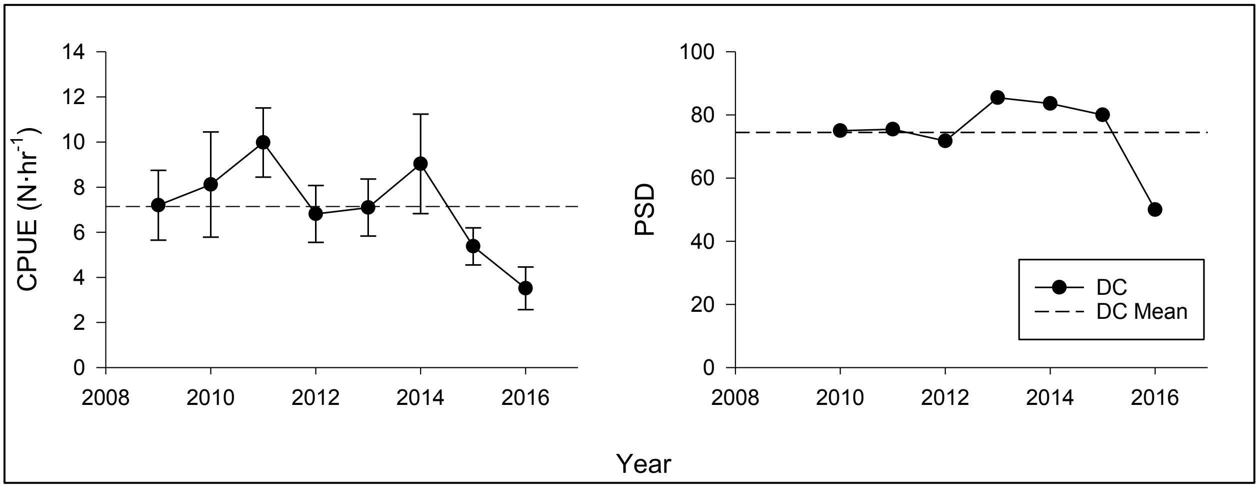

Figure 3.7. Catch per unit effort (mean ± SE) and proportional size distribution of Channel Catfish collected by pulsed-DC electrofishing surveys in the Lower Mississippi River Sampling Area. The dashed lines represent the long-term averages since F-101-R sampling initiated in 2009.

White Bass

White Bass CPUE was lowest ever during 2016, although CPUE in the Lower Mississippi River Sampling Area has been erratic since 2009 (Figure 3.8), and likely tied to highly variable PSD values, indicating recruitment of White Bass in the Lower Mississippi River sampling reaches may be cyclical or episodic.

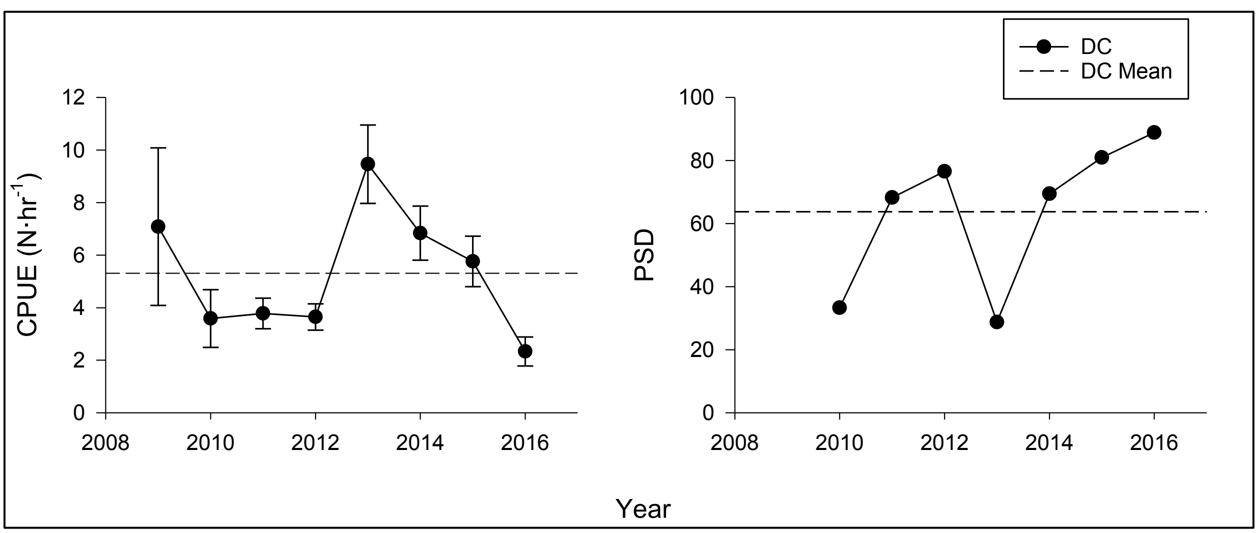

Figure 3.8. Catch per unit effort (mean ± SE) and proportional size distribution of White Bass collected by pulsed-DC electrofishing surveys in the Lower Mississippi River Reaches. The dashed lines represent the long-term averages since F-101-R sampling initiated in 2009.

Silver Carp

Catch rates of Silver Carp in the Lower Mississippi River Sampling Area were similar to 2015, but were still higher than average (Figure 3.9). The W_r for Silver Carp in this region has remained fairly consistent over time.

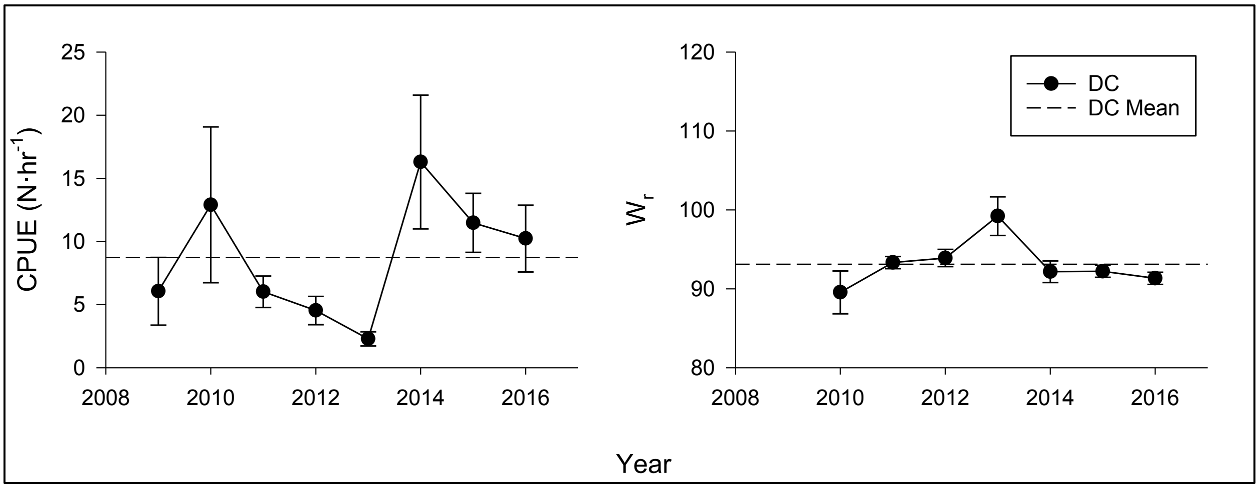

Figure 3.9. Catch per unit effort (mean ± SE) and condition (relative weight-W_r) of Silver Carp collected by pulsed-DC electrofishing survey in the Lower Mississippi River Sampling Area. The dashed lines represent the long-term averages since F-101-R sampling initiated in 2009.

CHAPTER 4
SPORTFISH ASSESSMENTS OF ILLINOIS RIVER TRIBUTARIES

Section 4.1 - Iroquois and Kankakee Rivers Fixed Site Ancillary Habitat Quality Data

The 2016 Iroquois and Kankakee River field season was limited to Period 3 and a subset of fixed sites representative of larger reaches. Four Iroquois River sites were selected to represent four reaches (Figure 4.1) and nine Kankakee River sites were selected to represent six reaches (Figure 4.3). This decrease in sampling effort was done to allow time for targeted studies, facilitate long-term continuity, and lessen our impact on frequently encountered threatened or endangered species, especially River Redhorse (*Moxostoma carinatum*). Period 3 was selected for sampling, as this period yields the greatest diversity of fishes.

Pulsed-DC electrofishing was conducted between 10:00 a.m. and 5:30 p.m. central standard time during Period 3. All 2016 Iroquois and Kankakee sites were sampled using standard boat mounted pulsed-DC electrofishing following the same protocols governing electrofishing of the larger rivers (Gutreuter et al. 1995). Physical measurements for ancillary water-quality parameters were collected at each site and are summarized in Table 4.1.

Table 4.1 Summary of ancillary water quality data collected during pulsed-DC electrofishing surveys of the Iroquois and Kankakee Rivers during 2016. Values are expressed as the mean observed parameter value ± standard error.

River	Total EF Effort (h)	DC EF Power Used (W)	Depth (ft)	Secchi Depth (in)	Water Temp (°C)	DO (mg/l)	Conductivity (µS/cm)	Stage Height (ft)
Iroquois	1.00	4250 ± 29	1.9 ±0.3	48.3 ± 6.3	12.1 ± 0.1	7.3 ± 0.2	690.0 ± 7.7	3.9 ± 0.1
Kankakee	2.25	4346 ± 57	2.9 ± 0.5	32.8 ± 2.5	17.0 ± 0.7	7.0 ± 0.3	598.0 ± 38.6	2.4 ± 0.1

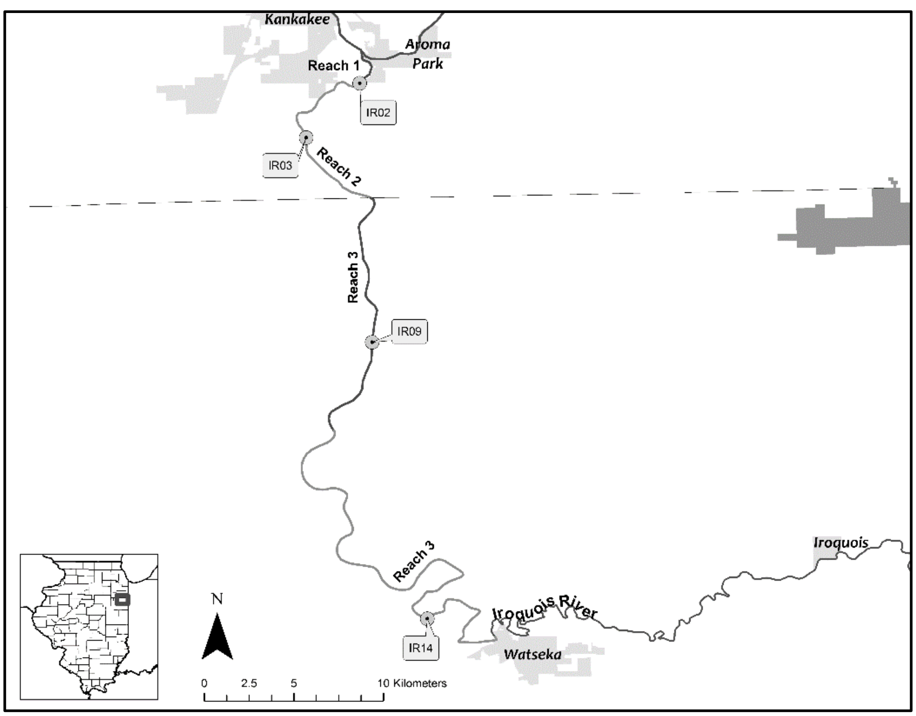

Figure 4.1 Locations of Iroquois River fixed sites sampled in 2016.

Section 4.2 - Iroquois River Fixed Site Electrofishing Catch Statistics

We collected 193 fishes representing 22 species from 7 families during one hour of pulsed-DC electrofishing at four sites in the Iroquois River. Channel Catfish were the most abundant species (60 fish, 31% of total catch), followed by Gizzard Shad (27 fish, 14%), and Shorthead Redhorse (22 fish, 11%). Channel Catfish contributed the greatest biomass of fishes collected (193.0 lb., 61% of total biomass), followed by Common Carp (26 lb., 8%), and Black Buffalo (23 lb., 7%).

Threatened and Endangered Species

One River Redhorse (State Threatened) was collected during 2016 Iroquois River main stem sampling.

Iroquois River Fish Abnormalities

Six DELT or external parasites were documented in Iroquois River fishes in 2016 (3.1% of fish) and comparable to the 3.5% reported in 2015. These included one fish with a tumor, two fish blind in one eye, and fish with recent wounds.

Channel Catfish

Due to the limited sampling conducted in 2016, it is difficult to make direct comparisons with previous years. However, we believe a sufficient number of Channel Catfish (60 fish) were collected for comparisons with previous year's catches. The mean length of Channel Catfish in 2016 was 20.3" with a mean weight of 3.2 lbs. The CPUE of Channel Catfish in the Iroquois River remain the highest among the rivers sampled by LTEF (Figure 4.2). Proportional size distribution (PSD) of the population increased slightly in 2016 (Figure 4.2). The high PSD and CPUE indicate ample angler opportunities for large fish. The continued lack of young-of-year and juvenile fish combined with high PSD and CPUE lends credibility to the hypothesis that smaller tributaries are likely being used for rearing areas. Further investigations are needed to identify and protect these rearing areas to maintain the fishery.

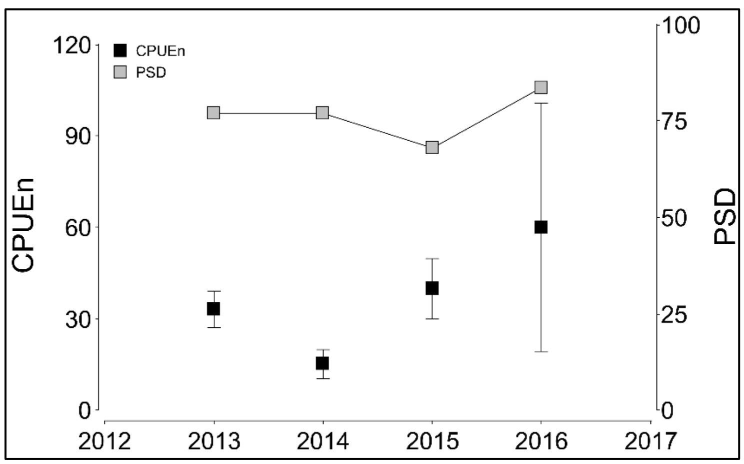

Figure 4.2 Catch per unit effort (fish/hr) and proportional size distribution (PSD) of Channel Catfish collected during electrofishing surveys of the Iroquois River.

Section 4.3 - Kankakee River Fixed Site Electrofishing Catch Statistics

We collected 531 fishes representing 43 species from 11 families during 2.25 hours of pulsed-DC electrofishing at nine sites in the Kankakee River (Figure 4.3). Gizzard Shad were the most abundant species (76 fish, 14% of total catch), followed by Shorthead Redhorse (70, 13%), and Golden Redhorse (54, 10%). Common Carp contributed the greatest biomass of fishes collected (139.3 lb., 31% of total collected biomass), followed by Golden Redhorse (76.5lb, 17%), and Shorthead Redhorse (46.1 lb., 10.2%).

Threatened and Endangered Species

One River Redhorse (State Threatened) was collected during 2016 Kankakee River main stem sampling.

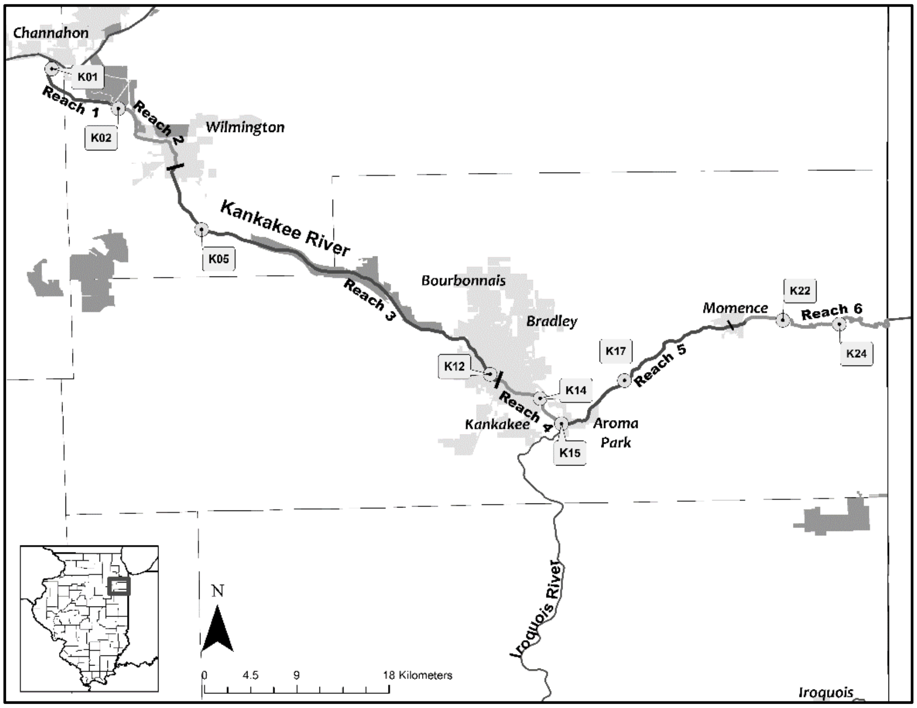

Figure 4.3 Locations of Kankakee River fixed sites sampled in 2016.

Kankakee River Fish Abnormalities

Twenty DELT or external parasites were documented in Kankakee River fishes in 2016 (3.8% of fish) and comparable to the 4.2% reported in 2015. The most common abnormality was eroded fins (9 fish, 1.7%), followed by fish with recent wounds (5 fish, 0.9%), and lesions (2 fish, 0.4%). We also documented one fish with a deformed spine, one with light anchor worms, one with light blackspot, and one fish blind in one eye.

Smallmouth Bass

Due to the limited sampling conducted in 2016, it is difficult to make direct comparisons with previous years. However, we believe a sufficient number of Smallmouth Bass (45 fish) were collected for comparisons with previous year's catches. The mean length of Smallmouth Bass in 2016 was 7.94" with a mean weight of 0.56lbs. Catch per unit effort (CPUE) declined slightly from 2015, but remains the highest among the rivers sampled by LTEF (Figure 4.4). Proportional size distribution (PSD) decreased slightly from 2015 following 2013's strong year class and lower PSD (Figure 4.4). The decrease in PSD seems to indicate that quality size fish (≥11") may be experiencing higher mortality. This may be caused by angling pressure, as Smallmouth Bass are a popular target fish from Kankakee River anglers. However, data suggests that fish are recruiting to larger size classes. Twenty percent of 2016 Smallmouth Bass were in the preferred category (≥14") with 4% memorable (≥17") (Neumann, Guy, & Willis, 2012). Overall, the population appears healthy with larger fish providing opportunities for anglers and sufficient numbers of juvenile fish to replace losses.

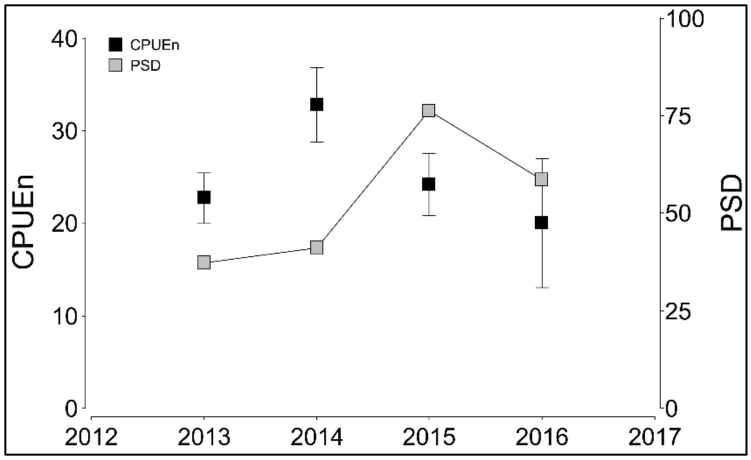

Figure 4.4 Catch per unit effort (fish/hr) and proportional size distribution (PSD) of Smallmouth Bass collected during electrofishing surveys of the Kankakee River.

Section 4.4 - Side-scan Sonar Mapping

Kankakee River

Video imagery recorded through side-scan sonar using a Hummingbird 999ci HD at a frequency of 455 kHz between 5/7/15 and 6/4/15 was processed into rasters using SonarTRX version 13.1.5390.33984 (Leraand Engineering Inc.). Examination of the known substrate composition from ground-truthing surveys overlaid on the images allowed us to readily distinguish seven distinct substrate types; bedrock, rock (rubble/cobble, boulder, or gravel), embedded rock, sand, silt, aquatic vegetation, and large woody debris. Bedrock areas can be identified as smooth fractured surfaces, rock areas as small irregular shadows, embedded rock as smooth areas occasionally dotted by rock peaks, sand as dunes and bedforms created by flow, silt as uniformly smooth areas, aquatic vegetation appears as “fuzzy” lighter areas created by plants above the bed with lines of shadow caused by stems, and large woody debris as recognizable tree forms seen as lighter trunk and branch areas raised from the river bed with strong shadows opposite the beam source (Figure 4.5).

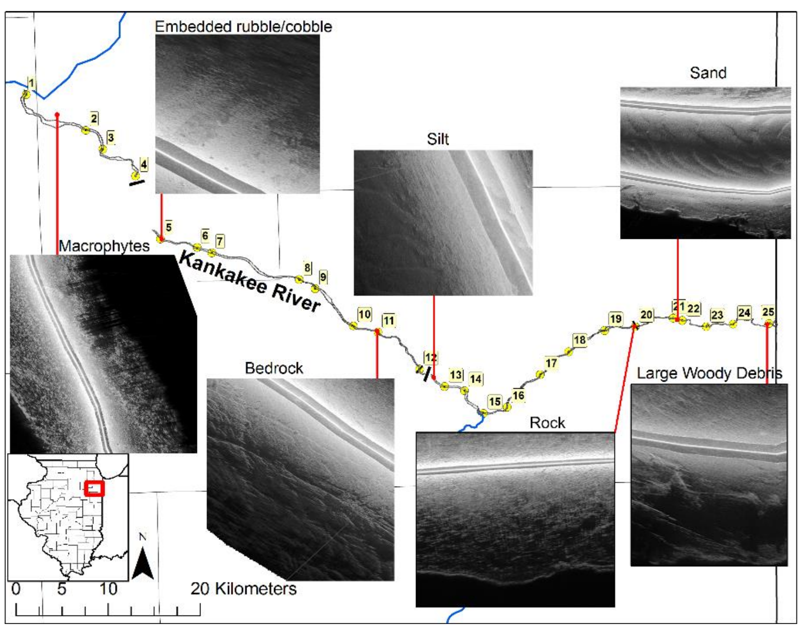

Figure 4.5 Kankakee River side-scan sonar imagery with examples of the seven types of substrates readily identifiable through visual examination.

A 500m segment of imagery centered on each of the 25 fixed site locations was imported into Google Earth Pro version 7.1.4.1529. This allowed finer-scale manual processing of substrate composition at fish collection locations for analyses. Polygons were drawn in Google Earth and used to calculate the proportion of classifiable image area occupied by the seven substrate types. Results show large amounts of sand from the Illinois-Indiana State Line to the Kankakee Dam, coarse rock and bedrock near Momence and throughout Reach 3 (Kankakee to Wilmington Dam), and large proportions of silt and vegetation near the confluence with the Des Plaines River (Figure 4.6).

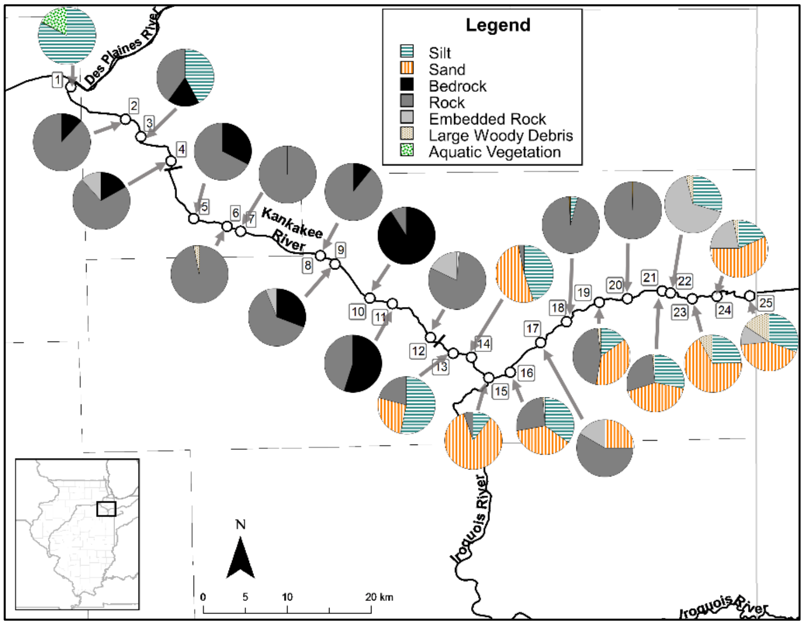

Figure 4.6 Map showing the substrate composition at each of 25 fixed electrofishing locations in the Kankakee River.

To assess the relationships among fish assemblage structure and substrate composition, distance-based linear models were constructed in Primer 6 & Permanova+ version 6.1.16 (PRIMER-E Ltd 2013). Fish data from 2013-2015 collected using direct current boat electrofishing was combined and CPUEn calculated for each site. Logit transformed proportional substrate data was used to assess the ability of substrate differences to explain the Bray-Curtis fish assemblage similarity among sites. All model combinations were evaluated using Akaike's Information Criterion adjusted for small sample size (AICc) (Bedrick & Tsai, 1994). If multiple models competed with a ΔAICc of ≤ 2, or a ΔAICc between 2-3 with a higher k than the ΔAICc = 0 model, the model with the highest R^2 was selected as the best model. The best model explained 29.7% of the similarity among sites using the proportion of aquatic vegetation, bedrock, and rock substrates. This model was visualized using distance-based redundancy analysis (Figure 4.7).

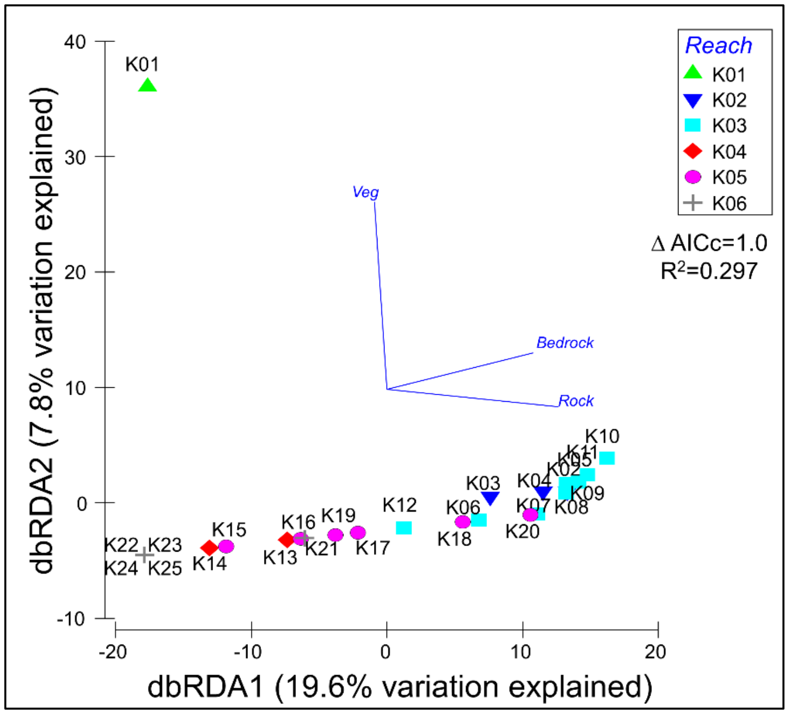

Figure 4.7 Graphic representation of the distance-based linear model selected to explain differences in fish assemblage structure among sites using substrate. A third axis, not shown, explained an additional 2.27% of variation.

Similar modeling approaches were used to assess the ability of substrate differences among sites to explain differences in the CPUE of sportfish species. We used linear models and logit transformed proportional substrate variables. Models were constructed in R version 3.2.0 (R Foundation 2015) and AICc scores were calculated using package "AICcmodavg 2.0-4" (Mazerolle, 2013). The amount of variation in sportfish CPUE explained by substrate composition varied from 12% for Bluegill to 54% for Northern Pike (Table 4.2). Interestingly, the relationships among substrate predictor variables and species CPUEn in the selected models agrees with species habitat preferences. For example, the Northern Pike model indicates that catch rates increase with increased sand (sand and embedded rock) and increased large woody debris. The sand component of the model corresponds to their preference for sluggish water and woody debris provides concealment for their ambush predation (Becker, 1983). This example displays an important caveat when examining fish and substrate relationships in lotic systems; flow acts as a strong structuring mechanism of fish and substrate, and relationships are influenced by this unmeasured confounding factor.

Table 4.2 Summary of the models selected to explain differences in sportfish catch rates among sites using substrate composition. The (+) or (-) next to each variable indicates the direction of its relationship for a given species catch rate.

Species	Best Model	$adjR^2$	Δ AICc
Rock Bass	Bedrock(+) + Large Woody Debris(+) + Rock(+)	0.32	2.4
Bluegill	Silt(+) + Vegetation(+)	0.12	2.5
Largemouth Bass	Bedrock(-) + Sand(+) + Vegetation(+)	0.28	2.0
Smallmouth Bass	Bedrock(+) + Silt(-)	0.38	0.0
Channel Catfish	Rock(+)	0.20	0.0
Flathead Catfish	Bedrock(+) + Embedded Rock(+) + Rock(-)	0.29	2.0
Northern Pike	Embedded Rock(+) + Large Woody Debris(+) + Sand(+)	0.54	2.0
Walleye	Embedded Rock(+) + Silt(-)	0.19	1.6

Iroquois River

Side-scan sonar video for the Iroquois River was recorded between 7/7/16 and 7/26/16 using a Hummingbird 999ci HD set at a frequency of 455 kHz. The shorter wetted width of the Iroquois River allowed us to adequately survey the river with a single downstream pass in the center of the channel. Boat speed under 6km/hr was maintained in a downstream direction while recording imagery. Video was converted into rasterized images clipped at 40m per side using SonarTRX version 13.1.5390.33984 (Leraand Engineering Inc.). Rasters were compiled as a mosaic dataset using ArcMap 10.2.2 (Environmental Systems Research Institute, Inc.). Footprints of the dataset were combined to create a single 54km continuous image of the Iroquois River extending from the town of Watseka to the Iroquois' confluence with the Kankakee River (Figure 4.8).

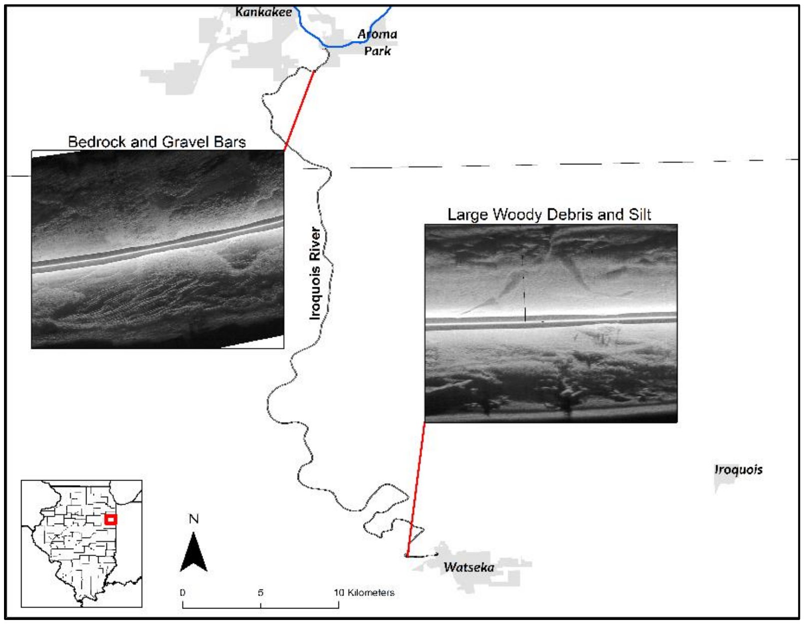

Figure 4.8 Side-scan sonar imagery of the Iroquois River with two examples of common substrate types within the River.

We plan to classify substrates in the Iroquois following the protocol used for the Kankakee River. Specifically, a 500-m section of imagery centered on each of the 15 fixed electrofishing site locations will be classified. This will allow us to incorporate Iroquois River data in future analyses examining the effects of substrate composition on fish structure and the abundance of sportfish species.

Section 4.5 Substrate Influences on Fish Composition in the Kankakee River

Introduction and Methodology

During the late 19th century, drainage districts began channelizing the Indiana portion of the Kankakee River watershed and by 1918 400km of sinuous river had become 132km drainage ditch (Bhowmik, Bonini, Bogner, & Byrne, 1980). The confinement of the channel increased erosion and movement of sand from Indiana to Illinois. Area residents have been voicing their concerns regarding sand movement since the early 20th century (Morrison, 1976). Growing concern among residents led to Illinois Governor James Thompson establishing a task force to fund a series of studies to address the concerns. The Illinois State Water and Geological Surveys found that large amounts of sand were moving within the river (Bhowmik et al., 1980), but that a state of dynamic equilibrium had been reached sometime between 1954 and 1973 based on aerial photos (Gross & Berg, 1981).

The continued concern of local residents and state fisheries biologists initiated this study. Given the importance of the Kankakee River fishery, this study was an attempt to characterize the effects of sand accumulation on fishes. Side-scan sonar imagery of the Illinois portion of the Kankakee River recorded in spring 2015 was used to identify contiguous areas that shifted from predominantly sand to coarse rocky substrates downstream. Four sites between the cities of Momence and Aroma Park were selected. Each site contained an upstream 200m transect predominantly composed of sand, a 200m transitional transect composed of sand and coarse rock, and a 200m transect predominantly composed of rock substrate (Figure 4.9).

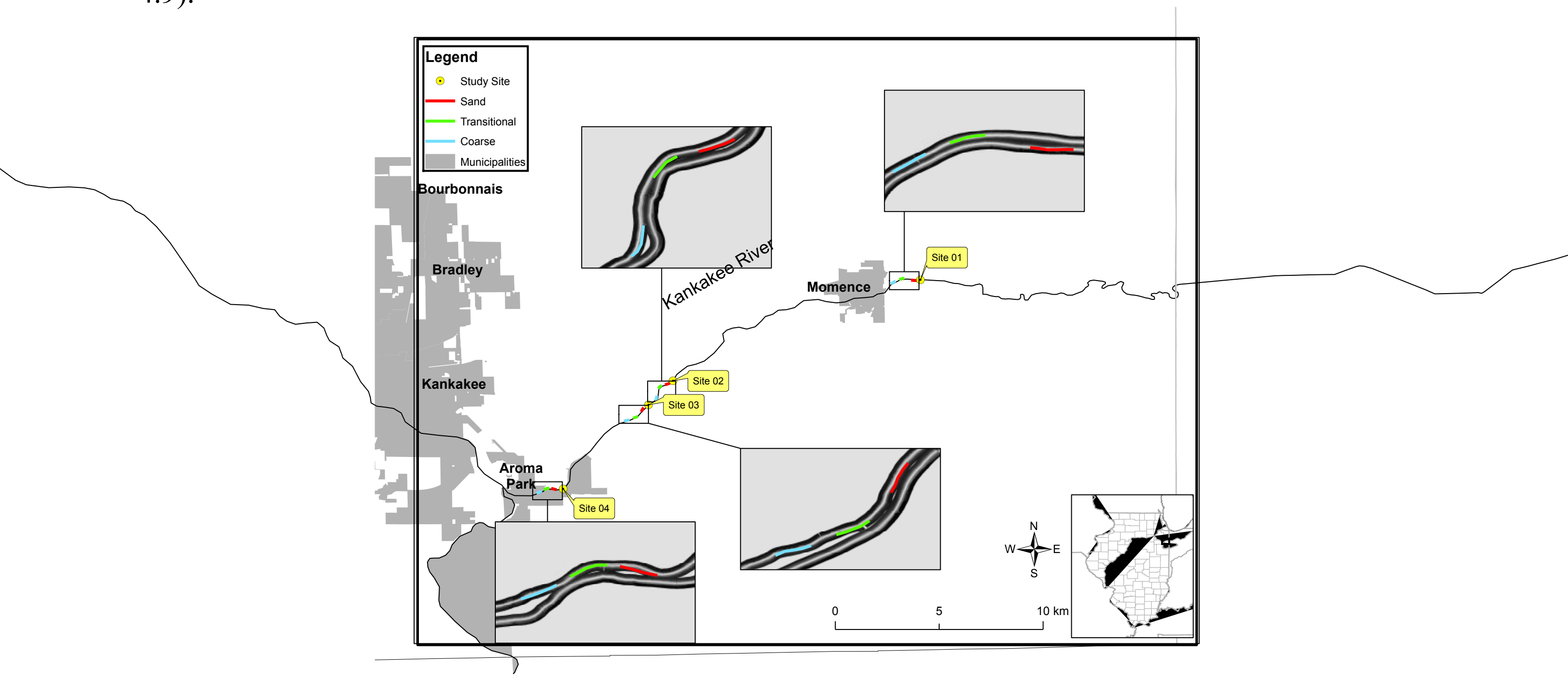

Figure 4.9 Map displaying locations of the four study sites that each contained three contiguous areas of distinct substrates; sand, transitional (mix of sand and rock), and coarse (rock).

Each site survey was conducted in a single day and repeated within three weeks between 8/23/2016 and 10/13/2016. Side-scan sonar imagery of all three substrate transects were recorded using a Hummingbird 999ci HD set at a frequency of 455 kHz for increased range (Kaeser, Litts, & Tracy, 2013) and followed by fixed distance standard boat electrofishing procedures of each substrate transect separately. Start and stop points were identified using a Garmin GPSMap76Cx loaded with the polylines for each transect. The total electrofishing effort for surveys was 3 hours and 46 minutes. Effort among 200-m transects varied from 6 minutes 20 seconds to 12 minutes and 6 seconds with a mean of 9 minutes and 24 seconds. Catch per unit effort was calculated as fish per hour (CPUE) to allow comparisons among survey bouts. Side-scan sonar imagery was converted to Google Earth rasters using SonarTRX version 13.1.5390.33984 (Leraand Engineering Inc.). Google Earth Pro version 7.1.4.1529 was used to construct polygons identifying and calculating the area of distinct substrate types. All three sonar surveys were overlaid in Google Earth to define a common classifiable area (i.e. area with sufficient resolution to visually assess) shared among surveys, so that the same area was classified for each survey. Substrate identification was based on training data garnered from in-situ ground-truthing surveys conducted in 2015 (Section 4.4). The proportion of substrate types at each transect for each survey was calculated based on the total classifiable area.

Substrate Findings

The classification of substrate imagery indicated that sites and transects were chosen appropriately. Sand transects contained the largest amounts of sand substrate (mean = 58.3%), transitional areas contained the largest amount of embedded rock substrate (mean = 39.1%), and coarse areas contained the largest amounts of rock substrate (mean = 42.4%) (Table 4.3). Results of classification also revealed a significant difference in the proportion of sand at all transect types between 2015 and the first set of 2016 surveys ($p=0.049$), but not between 2015 and the second set of 2016 surveys ($p=0.53$). Examinations of rainfall and discharge at Momence Illinois during 2016 sampling indicated a heavy rainfall event of 4.75" on 8/16/16 likely displaced a large amount of sand prior to the first set of surveys. The sand then reaccumulated following a decrease in the river's carrying capacity, as discharge diminished during the second set of surveys (Figure 4.10). This result demonstrates the mobility and ephemeral nature of sand accretion within the Kankakee River and highlights the potential of flow alteration to dramatically alter substrates within the River.

Table 4.3 Summary of substrate classification. Numbers given as the proportion of classifiable area covered by a given substrate type ± standard error.

	Transect Substrate Type		
Substrate Type	Sand	Transitional	Coarse
Silt	0.032 ± 0.016	0.117 ± 0.021	0.086 ± 0.018
Sand	0.583 ± 0.118	0.269 ± 0.076	0.114 ± 0.067
Bedrock	0.000 ± 0.000	0.020 ± 0.012	0.216 ± 0.093
Rock	0.109 ± 0.043	0.200 ± 0.050	0.424 ± 0.094
Embedded Rock	0.274 ± 0.102	0.391 ± 0.083	0.155 ± 0.077
Large Woody Debris	0.000 ± 0.000	0.000 ± 0.000	0.003 ± 0.001
Vegetation	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000

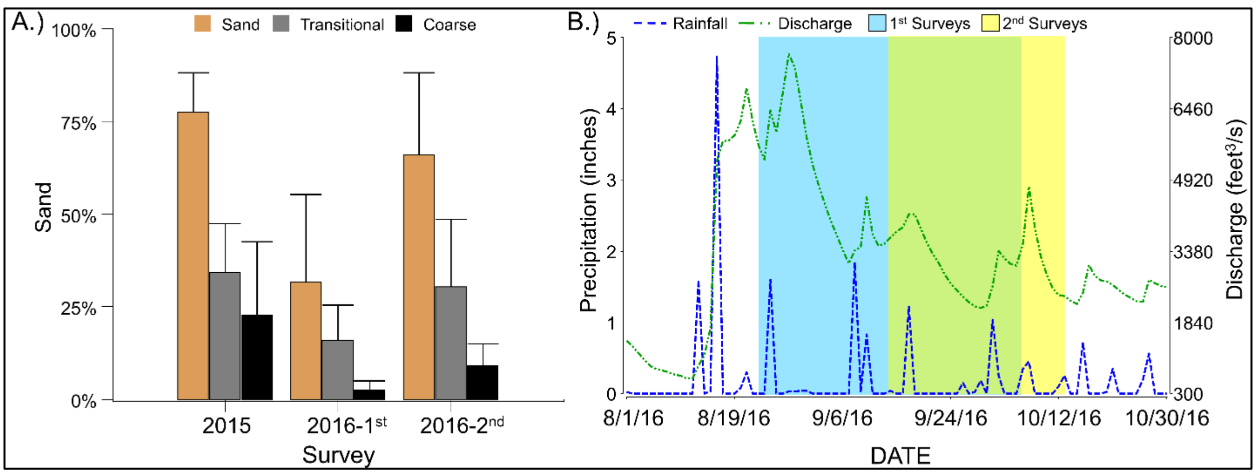

Figure 4.10 Sand movement within our study sites. A.) Bar chart with standard error bars showing differences in the percentages of sand at the three transect types for 2015, the first set of 2016 surveys, and the 2nd set of 2016 surveys. B.) Figure showing daily rainfall amounts and average daily discharge at Momence Illinois with graphic overlay of the time periods when the first and second set of 2016 surveys were conducted.

Fish Findings

We collected 15 state-threatened River Redhorse and three state-endangered Weed Shiners during electrofishing surveys. One-way analyses of variance (ANOVA) were run to assess differences in the CPUE of individual fish species among transects. We found no significant differences in species catch rates among transects at $p \leq 0.05$; however, Northern Hog Sucker ($p = 0.055$) and Common Carp (0.099) catch rates were significant at $p \leq 0.10$ with Northern Hog Sucker most abundant at coarse transects and Common Carp most abundant at transitional transects. Though no significant differences were observed in species richness or sportfish CPUE among transect types, differences were evident in some species (Table 4.4) and the lack of significant results may be due to a relatively low sample size (n=24, 8/transect type).

Table 4.4 Summary of species richness and catch per unit effort for sportfish among substrate transects reported as means.

Transect	Species Richness	Smallmouth Bass	Largemouth Bass	Rock Bass	Bluegill	Walleye	Northern Pike	Flathead Catfish	Channel Catfish
Sand	11.88	24.92	0.81	7.72	7.32	5.14	1.59	0.93	2.6
Transitional	15.38	32.65	3.92	6.3	8.05	3.13	1.57	0.75	1.11
Coarse	15.13	31.19	2.46	11.35	4.32	0.78	0	0.81	1.75

Section 4.6 Mackinaw River Smallmouth Bass

The Mackinaw River is a 5th-order tributary of the Illinois River originating in Sibley, IL and flowing for 214 km before joining the Illinois River near Pekin, IL (Figure 1). Over 90% of the Mackinaw's 3,338-km^2 basin is composed of row crop agriculture with the remainder being approximately 5% deciduous forest and 4% low-intensity residential. The river is meandering, with a sinuosity of 1.8, and low gradient, dropping 0.52 m/km. Due to concerns regarding the health of Smallmouth Bass population in the Mackinaw River, we began a pilot study in 2016 to characterize the population structure of Smallmouth Bass in the Mackinaw River and attempt to identify factors that may be negatively impacting the population's health.

Our study focused on 93 km of the Mackinaw River located between the N 1725 East Rd Bridge in Lexington and the I-155 Bridge in Hopedale (Figures 4.11). This Reach contains several higher-gradient regions that are more likely to contain habitat preferred by Smallmouth Bass. Due to variability in water depth, a three-probe pulsed-DC tow barge and single netter pulsed-DC boat electrofishing were used to capture Smallmouth Bass. The tow barge was used to survey approximately 3 km of river during 3 hours of electrofishing, while the boat was used at 2 sites for a total of 2 hours. We removed scales from the left side of each Smallmouth Bass two to five rows below the lateral line even with the center of the spinous dorsal fin for subsequent aging (Schneider, Laarman, & Gowing, 2000) and implanted a Biomark MiniHPT8 passive transponder tag before release. Scales from Kankakee River Smallmouth Bass, a known healthy population (Clodfelter, 1991), were also collected during regular sampling for age and growth comparisons.

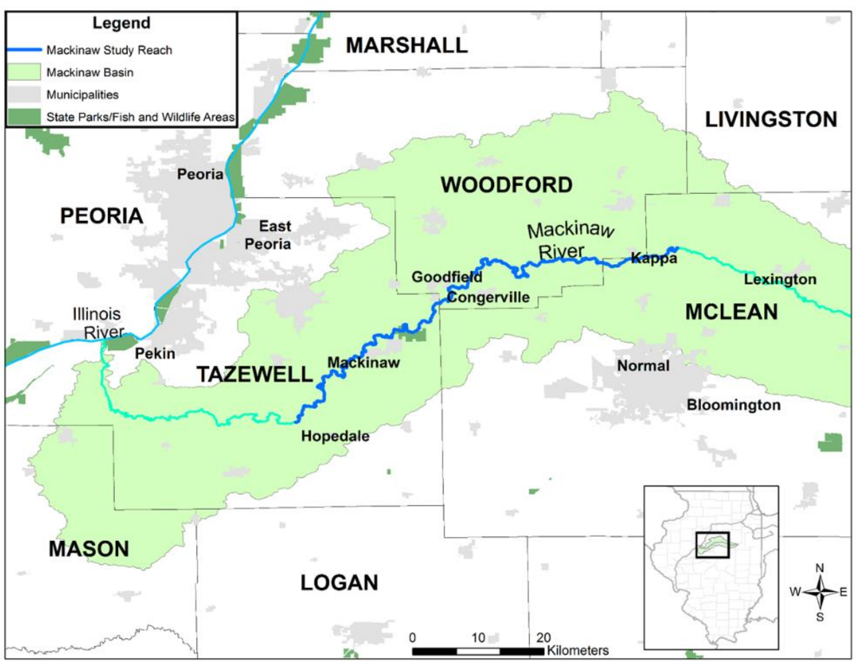

Figure 4.11 Map of Mackinaw River Smallmouth Bass study area.

During five hours of electrofishing in the Mackinaw River, only 12 Smallmouth Bass were captured. The total length of these fish ranged from 85 mm to 462 mm with an average of 230 mm. Length, weight, and scales from 58 Smallmouth Bass were collected from the Kankakee River. Two scales from each fish were imaged using an AmScope SE306-AZ-E2 ocular camera. Scales were aged by four readers blind to the source river and fish size. The distance of each annuli to the scales focus was measured for back calculations of length-at-age following equations in Schneider (2000). Relative weight (Murphy, Willis, and Springer, 1991) and regressions of natural log transformed length and weight were used to compare the condition of both populations.

Mackinaw River Smallmouth Bass ages ranged from 0 to 10 with a mean of 5 years, and Kankakee River fish ages ranged from 0 to 11 with a mean of 4. Back-calculations of length-at-age and length-weight relationships showed no significant differences between the two populations (Figure 4.12). We did note that error associated with back-calculated length at age increased at ages ≥ 6 (Figure 4.12: A) and will be using pectoral rays for future aging (Rude et al., 2013). Length-weight regressions had similar slopes and were well fitted for both populations (Figure 4.12, B). Relative weights of both Smallmouth Bass populations were also similar (Mackinaw mean W_r=0.92, Kankakee mean W_r=0.86) (Figure 4.12, B).

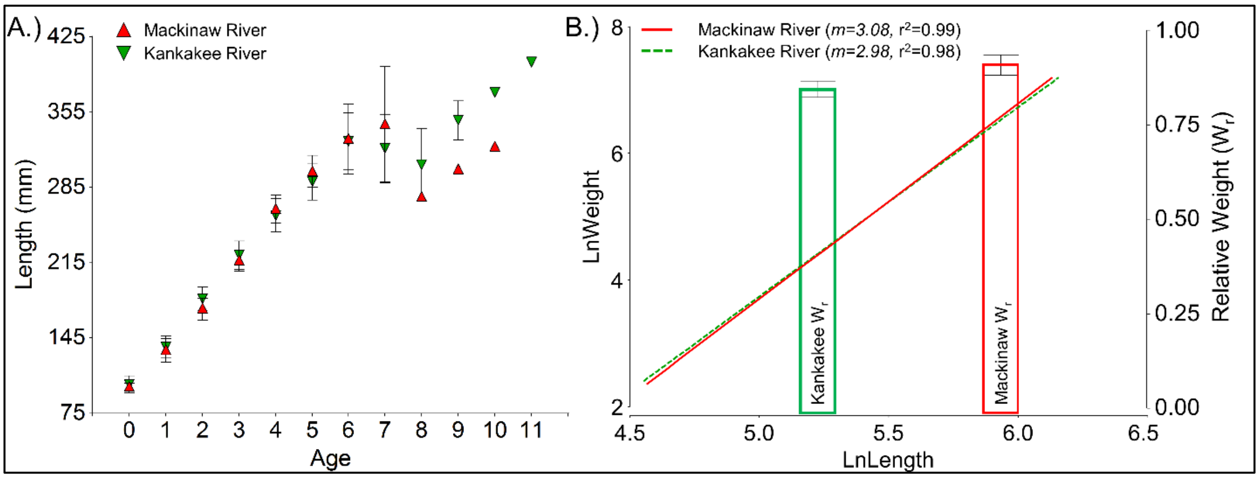

Figure 4.12 Smallmouth Bass total length relationships with age and weight. A.) Dot plot with standard error bars showing the results of back-calculated length at age based on the radii of scale annuli. B.) Regressions of the relationships between length and weight with bar charts displaying relative weight (W_r) of the two populations.

To assess the effects of water temperature on Mackinaw River Smallmouth Bass, 20 HOBO Pendant temperature loggers (Onset) were placed on 11/7/16 and 11/8/16 approximately every 10 km within the River (Figure 4.13). Temperature will be recorded in 30 minute intervals for an entire year. The temperature data will be used to model the relationship between air (National Climatic Data Center) and water temperatures. This will enable accurate estimates of past water temperatures for growing season days and may identify areas reaching injurious temperatures.

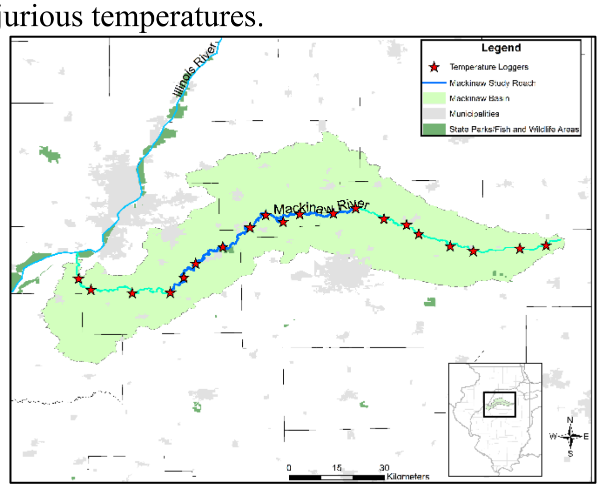

Figure 4.13 Locations where water temperature loggers were deployed in 2016.

The condition of Smallmouth Bass in the Mackinaw River compares favorably with the Kankakee. However, their abundance is much lower in the Mackinaw (2.4 fish/hr during net only Smallmouth Bass surveys in the Mackinaw vs 23 fish/hr during community surveys in the Kankakee). Though the smaller size of the Mackinaw is likely a strong factor causing lower catch rates, another likely cause is the extreme flashiness of the River. A study presented by Sallee *et al.* (1991) found that variability in winter discharge negatively affected overwintering mortality of Smallmouth Bass in the Kankakee River. Comparisons between the two rivers show that winter discharge variability in the Mackinaw is much greater than that of the Kankakee (Table 4.5). A lack of off-channel habitat and deep pools could be compounding overwintering mortality in the Mackinaw.

Table 4.5 Coefficient of variation (CV) for winter discharge (December-February) in the Mackinaw (USGS: Congerville) and Kankakee Rivers (USGS: Wilmington).

Water Year	Mackinaw	Kankakee
2008	151.7	74.4
2009	111.1	73.5
2010	121.2	54.4
2011	173.8	55.4
2012	88.4	38.1
2013	90.3	62.5
2014	129.2	37.3
2015	43.0	28.7

CHAPTER 5
CONCLUSIONS

Fish monitoring conducted on the Illinois and Mississippi Rivers during 2016 was useful for describing the diversity and heterogeneity of fish communities in large Midwestern Rivers. Additional sampling in the Iroquois and Kankakee Rivers has also provided new insights into the unique structure of fish communities in major tributaries of Illinois' large rivers. Catch rates and species varied greatly among rivers, among reaches within each river, and among sampling periods. However, any analysis of annual variations in species richness or catch rates should consider the effects of abiotic and biotic factors known to affect the capture efficiency of a specific type of fishing gear (Yuccoz *et al.* 2001). We are confident that our current and future efforts to operate a wide-ranging, well-standardized fish monitoring survey of Illinois' largest river systems will contribute to a more comprehensive and nuanced understanding of the spatial and temporal dynamics of fish communities in our state. Although the capture efficiency of our gears may vary among the different biological and environmental conditions encountered in our surveys, our observations of spatial and temporal changes in the relative abundance of some fish species in relation to both localized and large-scale environmental changes may comprise a substantial contribution to our collective intimations of the complexity of large river ecosystems (*sensu* Dodds *et al.* 2012). Inter-annual variations in the relative abundance of important forage species, like Gizzard Shad, or popular sportfish species, like Largemouth Bass and Channel Catfish, may be related to some combination of timely hydrologic events, broader aquatic community dynamics, and the implementation of fisheries and water-quality management directives. In addition, it may be useful to assess sampling replicate variability; if annual difference is greater than the variability, it is likely of interest to us and DNR. Our ability to effectively detect such changes is dependent upon the collection of fisheries data during additional years' sampling efforts. Our current and previous efforts are forming the basis for more comprehensive and robust analyses that will, hopefully, contribute to the development of more effective and sustainable management policies for the rivers of Illinois.

Sportfish

Catch rates and sizes of popular sportfish species varied greatly among the rivers and reaches sampled during 2016. Collections of black bass species were greatest in the Upper Illinois Waterway. Catch rates of Black Crappie and White Crappie were very low among all reaches sampled during 2016. Our observations of the annual variation observed in the relative abundance and size distribution of many sportfish species should serve as a catalyst for future research investigating the effects environmental change and management policy on the health and sustainability of Illinois sportfishes.

Invasive Species

Although the main focus of F-101-R programs are to conduct monitoring to improve our understanding of population dynamics, life histories, and habitat requirements of recreationally fished species, the programs sampling strategies may also be useful for documenting trends in the relative abundance of non-native species occupying Illinois large river ecosystems. However, we advise that researchers use caution when interpreting the data we collect on invasive species as our sampling protocols (i.e., restriction to main-channel habitats) may limit our probability of encountering the greatest densities of the species in some instances. Our monitoring and analyses indicate densities of Silver Carp are greatest in the Lower Illinois River and that body condition of Silver Carp was highest in the lower Mississippi River Sampling Areas.

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Appendix I. Reaches and pools sampled by LTEF pulsed-DC electrofishing surveys (and our partners) during 2016 with the upstream and downstream limits (RM), the number of sampling locations within each study area (N), and the locations of the USGS gauges used to record stage height in each study area are included in ascending (downstream to upstream) order.

River	Monitoring Institution	Reach/Pool	Downstream	Upstream	N	Gage
Illinois	INHS, F-101-R	Alton	0.0	80.0	45	Florence, IL
	INHS, F-101-R	Peoria	158.0	231.0	44	Henry, IL
	INHS, F-101-R	Starved Rock	231.0	247.0	9	Ottawa, IL
	INHS, F-101-R	Marseilles	247.0	271.5	18	Morris, IL
Des Plaines	INHS, F-101-R	Dresden	271.5	286.0	9	Brandon Road Lock and Dam
Kankakee	INHS, F-101-R					
Iroquois	INHS, F-101-R					
Mississippi	INHS, F-101-R	Kaskaskia Confluence	117.0	165.5	30	Chester, IL or Brickeys, MO
	INHS, F-101-R	Chain of Rocks	165.5	200.5	21	Saint Louis, MO
	INHS, F-101-R	Pool 25	242.0	273.5	18	Mosier Landing, IL
	WIU, F-121-R	Pool 21	325.0	343.0	12	Quincy, IL
	WIU, F-121-R	Pool 20	343.0	364.5	12	Gregory Landing, MO
	WIU, F-121-R	Pool 19	364.5	410.5	27	Fort Madison, IA
	INHS, F-101-R	Pool 17	437.0	457.0	12	Muscatine, IA
Ohio	SIU, F-47-R	Mississippi Confluence	981.0	962.5	12	Birds Point, MO
	SIU, F-47-R	Pool 53	962.5	939.0	15	Metropolis, IL
	SIU, F-47-R	Pool 52	939.0	918.5	12	Paducah, KY
	SIU, F-47-R	Smithland	848.0	918.5	42	Golconda, IL
Wabash	EIU, F -186-R	New Harmony, IN	444.5	487.0	21	Mount Carmel, IL
	EIU, F -186-R	Mt. Carmel, IL	412.0	444.5	27	Mount Carmel, IL
	EIU, F -186-R	Vincennes, IN	385.5	412.0	18	Mount Carmel, IL
	EIU, F -186-R	Palestine, IL	351.0	385.5	21	Mount Carmel, IL
	EIU, F -186-R	Terra Haute, IN	315.5	351.0	15	Mount Carmel, IL

Appendix II. Publications, reports, and presentations that resulted from research conducted during segments 6-28 of project F-101-R (funded under Federal Aid in Sportfish Restoration Act, P.L. 81-681, Dingell-Johnson, Wallup-Breaux).

I. Book Chapters

Irons, K.S., G.G. Sass, M.A. McClelland, and T.M. O'Hara. The Long Term Resource Monitoring Program: Insights into the Asian Carp Invasion of the Illinois River, Illinois, USA. *In* Invasive Asian Carps in North America. American Fisheries Society Special Publication. Bethesda, MD. 2010.

II. Publications. Manuscripts published or accepted for publication during Segment 27 are printed in bold.

Gibson-Reinemer, D. K., Chick, J. H., VanMiddlesworth, T. D., VanMiddlesworth, M. M. and Casper, A. F., 2017. Widespread and enduring demographic collapse of invasive common carp (Cyprinus carpio) in the Upper Mississippi River System. Biological Invasions 19:1905-1916.

Fritts, M. W., J. A. DeBoer, D. K. Gibson-Reinemer, B. J. Lubinski, M. A. McClelland, and A. F. Casper. 2017. Over 50 years of fish community monitoring in Illinois' large rivers: the evolution of methods used by the INHS's Long-term Survey and Assessment of Large-River Fishes in Illinois. Illinois Natural History Survey Bulletin.

Tiemann, J.S., C.A. Taylor, D. Wylie, J. Lamer, P.W. Willink, F.M. Veraldi, S.M. Pescitelli, B. Lubinski, T. Thomas, R. Sauer, and B. Cantrell. 2015. Range Expansions and New Drainage Records for Select Illinois Fishes. Transactions of the Illinois State Academy of Science 108:47-52.

Parker, J., J. Epifanio, A. Casper, and Y. Cao. 2016. The effects of improved water quality on fish assemblages in a heavily modified large river system. River Research and Applications 32:992-1007 (DOI: 10.1002/rra.2917)

Lamer, J. T., Sass, G. G., Boone, J. Q., Arbieva, Z. H., Green, S. J., and J. M. Epifanio. 2014. Restriction site-associated DNA sequencing generates high-quality single nucleotide polymorphisms for assessing hybridization between bighead and silver carp in the United States and China. Molecular Ecology Resources. 14(1):79-86

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McClelland, M.A and G.G. Sass. 2012. Assessing fish collections from random and fixed site sampling methods on the Illinois River. Journal of Freshwater Ecology. 27(3): 325-333.

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Lerczak, T.V., R.E. Sparks, and K.D. Blodgett. 1995. Long-term trends (1959-1994) in fish populations of the Illinois River. Transactions of the Illinois State Academy of Science 88 (Supplement):74. (Abstract)
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Lerczak, T.V., R.E. Sparks, and K.D. Blodgett. 1994. Some upstream-to-downstream differences in Illinois River fish communities. Transactions of the Illinois State Academy of Science 87(Supplement):53. (Abstract)

III. Essays

DeBoer, J. A., and L. E. Solomon. 2017. Environmental factors affecting growth rates of popular sportfish in the Illinois River. Illinois Natural History Survey Report 415(3).
Pegg, M.A. 2002. Aquatic resource monitoring in the Upper Mississippi River Basin. INHS Reports. Number 371:8-9.

IV. Popular Articles

"Monitoring the Illinois River Fisheries." Greg G. Sass and Michael A. McClelland. Outdoor Illinois Magazine. XVII/12:18-19. December, 2009.

V. Technical Papers presented during F-101-R Segment 28 (presenters in bold, '*' denotes student presenter, '+' denotes invited presentation)

Costenbader, Drew; Parker, Jerrod; Epifanio, John; Age and Growth of Smallmouth Bass of the Mackinaw River. Illinois Chapter of the American Fisheries Society Annual Conference, Moline, IL.

DeBoer, J. A., A. K. Fritts, M. W. Fritts, R. M. Pendleton, L. E. Solomon, T. D. VanMiddlesworth, and A. F. Casper. 2017. Differences in and factors affecting growth of centrarchid sportfish in the Illinois River. Platform. Midwest Fish and Wildlife Conference. Lincoln, NE.

DeBoer, J. A., A. K. Fritts, M. W. Fritts, R. M. Pendleton, L. E. Solomon, T. D. VanMiddlesworth, and A. F. Casper. 2017. Differences in and factors affecting growth of centrarchid sportfish in the Illinois River. Platform. Mississippi River Research Consortium. La Crosse, WI.

Gibson-Reinemer, D.K., A.F. Casper, T.D. VanMiddlesworth, M. VanMiddlesworth, and J.H. Chick. Dramatic collapse of common carp (*Cyprinus carpio*) in the Upper Mississippi River System. American Fisheries Society, Kansas City, MO, August 2016.

Love, S. A., N. J. Lederman, R. L. Haun, J. A. DeBoer, and A. F. Casper. 2017. Assessing the impact of Asian carp removal in the upper Illinois River on a native planktivore (*Dorosoma cepedianum*). Poster. Mississippi River Research Consortium. La Crosse, WI.

Love, S. A., N. J. Lederman, R. L. Haun, J. A. DeBoer, and A. F. Casper. 2017. Assessing the impact of Asian carp removal in the upper Illinois River on a native planktivore (*Dorosoma cepedianum*). Poster. Illinois Chapter of the American Fisheries Society Annual Meeting. Moline, IL.

Parker, Jerrod; Epifanio, John; Cao, Yong; Sand Trends and Habitat Degradation; Kankakee River Watershed Conference, Bourbonnais, IL.

Parker, Jerrod; Epifanio, John; Cao, Yong; Explaining differences in fish assemblages using side-scan sonar. Illinois Chapter of the American Fisheries Society Annual Conference, Moline, IL.

Parker, Jerrod, Epifanio, John; Cao, Yong; Using Side-scan Sonar to Classify River Aquatic Habitat. Midwest Fish & Wildlife Conference 2017, Lincoln, NE.

Whitten, A. L., J. A. DeBoer, D. K. Gibson-Reinemer, and A. F. Casper. 2017. Tracking changes in riverine fish assemblages in response to disturbance. Poster. Mississippi River Research Consortium. La Crosse, WI.

VI. Data Requests received during F-101-R Segment 28

1. Josh Sherwood, Illinois Natural History Survey
2. David Coulter, Southern Illinois University
3. Mike McClelland, Illinois DNR
4. Greg King, University of Illinois
5. Bob Hrabik, Missouri Department of Conservation
6. Levi Solomon, Illinois Rive Biological Station
7. Matt O'Hara, Illinois DNR