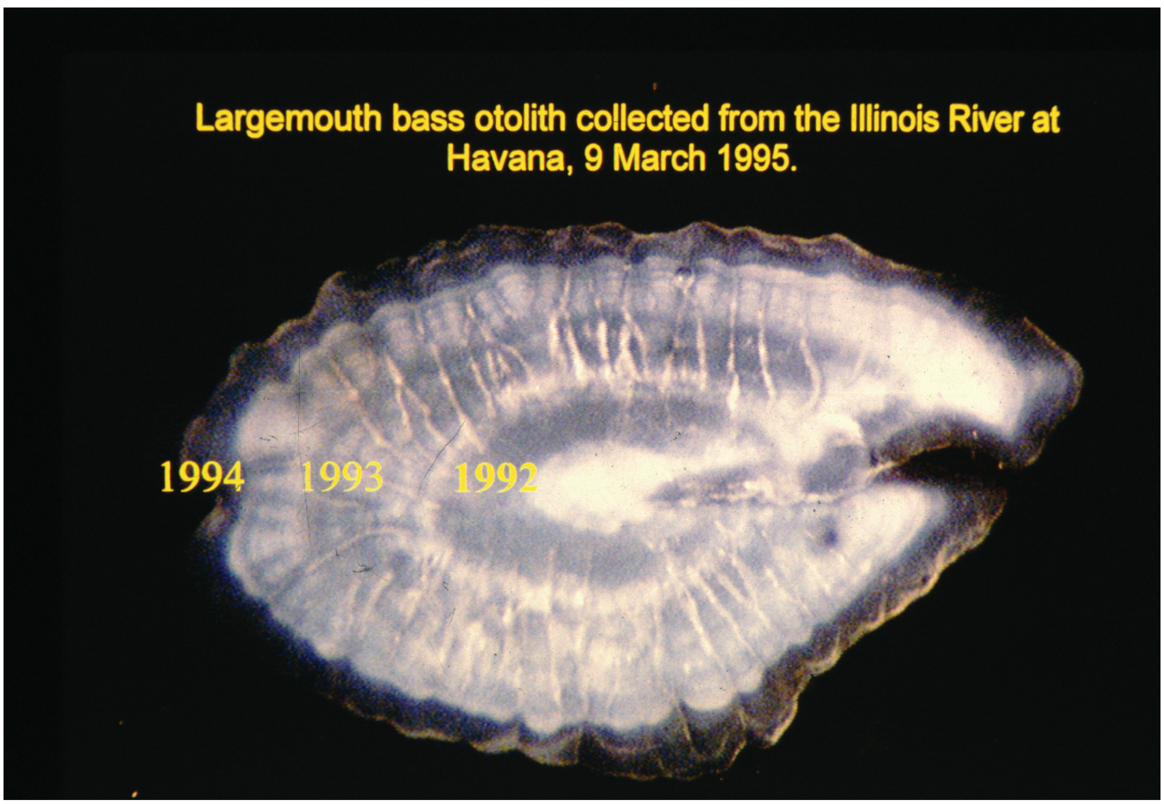
Long Term Resource Monitoring Program

Technical Report
2007-T002

Analysis of Fish Age Structure and Growth in the Illinois River



June 2007

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Cover photo, largemouth bass otolith collected from the Illinoir River at Havana, 9 March 1995, by Kevin S. Irons, Illinois Natural History Survey.

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June 2007

Suggested citation:

Smith, M. A., M. A. Pegg, and K. S. Irons. 2007. Analysis of fish age structure and growth in the Illinois River. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, June 2007. LTRMP Technical Report 2007–T002. 55 pp.

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Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Upper Midwest Environmental Sciences Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This report was prepared under Strategy 1.3.2 and Tasks 1.3.2.2 and 1.3.2.4 as specified in Goal 1, *Develop a Better Understanding of the Ecology of the Upper Mississippi River System and its Resource Problems* of the Operating Plan (U.S. Fish and Wildlife Service 1993). This report was developed with full funding provided by the LTRMP.

Analysis of Fish Age Structure and Growth in the Illinois River

by

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Abstract: Otoliths and other calcified structures have been used to age and determine growth rates of fish from a variety of habitats. Sagittal otoliths were removed from fishes representing five species from La Grange Pool of the Illinois River for age determination. Species collected included largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), white bass (*Morone chrysops*), and freshwater drum (*Aplodinotus grunniens*). Common univariate techniques were used to analyze the significance of spatial and temporal variation in growth and back-calculated mean length-at-age for all five species. For largemouth bass, black crappie, and bluegill, age-frequency distributions were derived using an age-length key in conjunction with LTRMP fish length data. Annual mortality rates were calculated and compared to mean spring (March through May) discharge of La Grange Pool. For largemouth bass and bluegill, the proportion of Age-0 fish collected was also compared to mean spring discharge to determine if extreme events (mean spring discharge >991 m^3/sec or <425 m^3/sec) affect year-class strength, recruitment, or age structure. Responses to spatial and temporal variation of river conditions were variable among species. Largemouth bass, bluegill, and white bass seemed to be more affected by temporal variation whereas black crappie mean length-at-age varied more with habitat variability. Freshwater drum mean length-at-age did not seem to be affected by time or habitat. Our results suggest that largemouth bass and bluegill age structure may be affected by extreme spring discharge events. Black crappie age structure did not exhibit this trend, but black crappie were the only species that exhibited significant variation in growth among habitats. Our results suggest that fish populations in La Grange Pool are not influenced in the same ways by river conditions.

Key words: age structure, growth, Illinois River, La Grange Pool, otolith

Introduction

Fisheries managers can acquire a great deal of information about the health and sustainability of a fish population from its size and age structure. This information is also important for evaluating the successes or failures of management activities. Similarly, knowing the conditions that promote desired growth and age structure for a particular species allows managers to tailor their efforts accordingly.

If a strong relation exists between the size of fish calcified (or hard) structures and overall body length at capture, biologists can estimate a fish's length at age by proportionately extrapolating information from those structures. These data can then provide information on growth rates. Many factors, both biotic and abiotic, affect fish growth. Biotic factors include size, quality, and availability of food organisms, the condition of the fish itself, and competition from other organisms. Abiotic factors, such as water quality and the timing, duration, and magnitude of floods affect fish growth and can be very difficult to control.

Fish growth, particularly in largemouth bass (*Micropterus salmoides*), has been well documented in lakes and reservoirs across the United States. Much less is known, however, about age structure and growth of fishes in large, floodplain rivers such as the Illinois River (Raibley et al. 1998). Our objectives were to document age and growth information, year-class strength, and mortality for several sport fish species in La Grange Pool of the Illinois River using existing otolith data and investigate relations between river conditions, recruitment, and age structure. Ultimately, we address the questions (1) does age structure change through time in response to extreme events and (2) do growth rates differ among habitats? Our results will be used to make recommendations for incorporation of age and growth analyses in the Long Term Resource Monitoring Program (LTRMP).

Methods

Otoliths were collected from largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), white bass (*Morone chrysops*), and freshwater drum (*Aplodinotus grunniens*) from La Grange Pool intermittently from 1992 to 2001 using day electrofishing in the fall. A small subset of fish was also collected during angling tournaments to supplement the electrofishing sample when available. Age determinations typically followed methods described by Pegg et al. (1998). Sagittal otoliths were removed from all fish collected and stored in envelopes. Each envelope was labeled with species, date of capture, location of capture, total body length, weight, and sex (sex was not recorded for freshwater drum). For age determination, otoliths were soaked in glycerin, placed on a dark background, and illuminated with a fiber optic light source. A dissecting microscope with varying magnification levels was used. Image analysis software (Optimas) was used to measure distances from otolith focus to margin and between annuli. These data were then exported into a data file for further investigation.

Locations of capture and years of otolith collection differed among species (Table 1). All fish collections were from La Grange Pool, located between river kilometers 128.8 and 254.3 (Figure 1). Sample location types included main channel border (MCB), side channel (SC), backwater contiguous (BWC), and backwater isolated (BWI) and were derived from criteria proposed by Wilcox (1993). The MCB habitat refers to areas along the shoreline of the main river channel or to collections where location of harvest could not be determined (e.g., fish from bass fishing tournaments). Locations in side channels are designated SC. BWC refers to backwater areas contiguous to the main channel, whereas BWI refers to backwaters isolated from the main channel.

Statistical Analysis

Largemouth Bass, Black Crappie, and Bluegill

The same statistical analyses were performed for largemouth bass, black crappie, and bluegill. However, location and year of otolith collection differed among these species (Table 1).

A strong relation existed between overall length at capture and otolith length from focus to margin (Figure 2 A, B, and C), therefore it was possible to back-calculate length-at-age using the direct proportion method described in Devries and Frie (1996). From these data, mean length-at-age were calculated (collapsed across years, locations, and sex; Table 2). Sex-specific mean lengths were then calculated for all ages. Site- and sex-specific mean length-at-age were compared using analysis of variance (ANOVA) with further tests among sites or year compared using a post hoc Tukey's test ($\alpha = 0.05$).

Annual growth increment in millimeters was calculated for each fish collected for each year of its life using back-calculated mean length-at-age data. Growth was quantified by taking the difference between back-calculated growth at Age-x and Age-x+1. Size-specific growth was calculated for each species using linear regression analysis for each year of otolith collection. Mean length-at-hatch information was taken from Becker (1983) for these three species to quantify growth for Age-0 individuals. Mean growth increment by age was calculated by collapsing across years, locations, and sex (Table 3). Age-specific mean growth was calculated for each location and year. Analysis of variance with subsequent Tukey's tests was used to test for differences in growth among locations and among years.

Additional fish population metrics were calculated from the LTRMP monitoring of La Grange Pool (Gutreuter et al. 1995). Length and abundance data from day electrofishing were used for fish from August 1 to October 31 each year and combined with ages from otoliths to construct an age-length key for each year. Age-frequency distributions were prepared using the age-length key. Because LTRMP electrofishing effort is the same each year, age-frequency graphs could be directly compared across years. Mean spring (March through May) discharge data were taken from the USGS water resources web page, USGS Water Data for Illinois, available at *http://nwis.waterdata.usgs.gov/il/nwis* (U.S. Geological Survey 2005) for years 1993–1998 and 2000–2001. For this study, we define "extreme" events as episodes where mean spring discharge was >991 m^3/second or <425 m^3/second (Figure 3). The proportion of Age-0 fish to total fish caught (independent variable) was compared to mean spring discharge (dependent variable) using linear regression analysis. Black crappie were not examined in this analysis due to insufficient sample sizes of Age-0 fish.

Annual mortality rates were calculated using linear regression between fish age (independent variable) versus the natural log of catch (dependent variable) following Krebs (1999). Linear regression was then used to test the relation between mean spring discharge (independent variable) and annual mortality (dependent variable) for 1993–1998 and 2000–2001.

Freshwater Drum and White Bass

A strong relation existed between overall length at capture and otolith length from focus to margin (Figure 2 D and E), therefore it was possible to back-calculate length-at-age using the direct proportion method described in Devries and Frie (1996). Small sample sizes limited further analyses for freshwater drum and white bass. Therefore, only back-calculated mean length-at-age data were estimated and analyzed. Analyses for back-calculated mean length-at-age data were similar to those used for the other species. Mean length-at-age were calculated (collapsed across years, locations, and sex; Table 2). For white bass, sex-specific mean length-at-age were calculated for each year of otolith collection using back-calculated data and compared using an ANOVA among sites and years. A post hoc Tukey's test was used to compare spatial and temporal variation in back-calculated mean length-at-age for each sex (white bass only) and both sexes together.

Results

Largemouth Bass

Back-calculated mean length-at-age were determined for males, females, and sexes combined (Figure 4). The combined largemouth bass data showed that Age-1 and Age-2 had significantly different back-calculated mean lengths with respect to year of collection (Table 4). Age-1 largemouth bass showed the most variation within each sex (Table 4). For males, significant variation among years was found for Age-1, Age-2, and Age-4. Similarly, Age-1 females showed significant variation among years. Although variation of back-calculated mean length-at-age exists among locations, patterns were not obvious (Tables 5–7). However, largemouth bass collected from Lake Chautauqua had significantly smaller back-calculated mean lengths compared to other locations for all years.

Size-specific growth was calculated for each year (Figure 5). Other than the year 2001, size-specific growth rates were similar across years. Annual growth increments of largemouth bass showed little variation with respect to location collected. Significant differences in annual growth among locations were only found for Age-1 fish with few exceptions (Table 8). Largemouth bass collected from Lake Chautauqua grew significantly slower in their first and second years of life than bass collected from other locations. Variation in annual growth was found across years (Table 9).

The 2000 growing season exhibited significantly higher growth for Age-2, Age-3, and Age-4 largemouth bass.

The overall age structure of largemouth bass in La Grange Pool did not change during our study but strong year classes were observed in some years (Figure 6). Age-0 bass abundances were positively correlated with spring discharge and explained 40% of the variability in age-0 bass abundances (Figure 7). Annual mortality was variable ranging from 8% in 1994 to 79% in 1993 (Figure 8) and averaged 45% from 1993 to 2001. There was no relation between mean spring discharge and mortality (Figure 9).

Black Crappie

Back-calculated mean length-at-age were calculated for each year (Figure 10) for males, females, and for sexes combined. Back-calculated mean lengths differed among years for Age-1 and Age-2 (Table 10). Spatial patterns in back-calculated mean length-at-age were more evident for black crappies than largemouth bass (Tables 11–13). Side channel habitats showed smaller mean length-at-age, whereas backwaters produced larger mean length-at-age for males, females, and combined sexes. Also, significant spatial variation in back-calculated mean length was apparent for Age-2+. No discernible sexually dimorphic growth of black crappie was observed in La Grange Pool population (Figure 10).

Annual growth increment in black crappies was similar for all years (Figure 11) and, with a few exceptions, locations (Table 14). Although sample sizes were small and differences were not always significant, growth of black crappies in Lily Lake tended to be higher compared to other locations. Similar to the back-calculated mean length data, significant variation in growth among location was not limited to Age-1 and Age-2. Age-specific differences in growth showed no obvious patterns among years (Table 15).

Black crappie age structure changed during the study (Figure 12). Evidence of strong cohorts (1993 and 1996) moving through the population was found. Annual mortality varied from 15% in 1994 to 90% in 1996 and averaged 55% from 1994 to 2001 (Figure 13). No relation was observed between mortality and discharge (Figure 14).

Bluegill

Back-calculated mean length-at-age were calculated for each year (Figure 15) for males, females, and for sexes combined. Significant variation among years was found for Ages 1–4, with greater variation among females than males (Table 16). Patterns of variation in bluegill back-calculated mean length-at-age among locations were not as apparent as they were among years (Tables 17–19). As with temporal variation, female bluegills demonstrated more variation in back-calculated mean lengths than males between locations.

Size-specific growth increments for bluegill were variable among years (Figure 16). Annual growth of bluegills showed little variation among locations (Table 20). Significant differences in growth among locations were only found in Age-1 and Age-2 bluegills. Age-1 and Age-2 bluegills taken from Lake Chautauqua in 2000 showed significantly higher growth. Bluegill growth in 1991 was slower for Age-1, Age-2, and Age-3 individuals (Table 21). The 2000 growing season demonstrated higher bluegill growth for Age-1 and Age-2.

Bluegill age structure did not change through time throughout our study years (Figure 17). Our collections were dominated by Age-0, Age-1, and Age–2 bluegills. Strong year classes could be found in most years. A positive relation was observed between mean spring discharge and the proportion of bluegill collected that were Age-0 ($r^2 = 0.5$; Figure 18). Annual mortality was fairly stable and ranged from 59% in 1994 to 75% in 1997 and averaged 69% from 1993 to 2001 (Figure 19). No relation was observed between mean spring discharge and annual mortality of bluegills (Figure 20).

White Bass

Back-calculated mean length-at-age were calculated for each year (Figure 21) for males, females, and for sexes combined. There appeared to be more variation in back-calculated mean lengths among years for males than females (Table 22). Significant variation existed for Age-1, Age-2, and Age-3 males among years. Only Age-4 females were significantly different. When both sexes were analyzed together, Age-1, Age-2, and Age-3 demonstrated significant differences in back-calculated mean length among years. Very little evidence was found suggesting location or habitat had an effect on white bass age structure (Tables 23–25).

Freshwater Drum

Back-calculated mean length-at-age of freshwater drum were calculated for both years (Figure 22). Significant variation in back-calculated mean length was only found for Age-2 among the 2 years (Table 26). Back-calculated mean lengths from Bath Chute (SC) were significantly longer than those from BWC or MCB for Age-1 and Age-2 (Table 27). Variation in back-calculated mean length between locations was not significant beyond Age-2.

Discussion

Our results suggest that species-specific growth responses to spatial and temporal variation of river conditions in La Grange Pool were inconsistent. Largemouth bass growth was more variable over time than among locations. Black crappie, by contrast, showed more variation spatially whereas white bass were more variable over time. Gutreuter et al. (1999) suggest that this relation is contingent upon each species' complex interaction with the moving littoral zone. Furthermore, Gutreuter et al. (1999) suggest that the more a species exploits this zone, the more affected they are by fluctuating river conditions and extreme events. We looked at mean spring discharge of the Illinois River at Kingston Mines (Figure 3) and identified 1993, 1996, and 2000 as years with extreme spring discharge. From our analyses, we found that whereas the age structure of black crappie changed through time (Figure 12), it cannot be concluded that extreme spring discharges were the cause. Because the gear did a poor job of collecting Age-0 black crappie, we were unable to compare mean spring discharge to year-class strength. The age structure of bluegill and largemouth bass remained similar throughout the years of this study and were dominated by Age-0, Age-1, and Age-2 fish. There did appear to be a correlation between mean spring discharge and the percent of largemouth bass collected that were Age-0. Raibley et al. (1998) found that strong cohorts of largemouth bass were produced in years with high spring floods whereas weaker cohorts were produced in years where water levels were low. We observed this same relation for bluegill. Strong year classes of bluegill were observed in every year but they were stronger when mean spring discharge was higher.

Small sample sizes made it impossible to draw any conclusions about the effect of extreme events on the age structure of white bass or freshwater drum. However, we wanted to determine whether or not these mean length-at-age differed spatially or temporally. Gutreuter et al. (1999) concluded that white bass growth in La Grange Pool showed no response to water level fluctuations and believed this was because of the open water niche this species occupies. We found a great deal of variation in back-calculated mean length-at-age among years for white bass. It is impossible to conclude from our results that the variation was the result of water level fluctuation and it is likely that there are other contributing factors.

Koel and Sparks (2002) found that the length of the spring flood was one of the most important parameters influencing abundance of Age-0 fish in the Illinois River. We think it would be beneficial to investigate any relation between spring flood duration and numbers of Age-0 fish. It could be that flood duration is more of a driving factor of year-class strength than mean spring discharge. It would also be useful to compare flood duration with annual mortality of each species. Answering these questions would greatly increase our knowledge of how fish communities respond to water level fluctuations and could influence the operation of locks and dams.

There is little evidence to suggest that growth rates differed among locations for all species we analyzed except black crappie. This could be due to the well-documented finding that all fish move quite a bit between different habitat types in lotic systems (Pitlo 2001). Back-calculated mean lengths tended to be greater for black crappie taken from backwater areas than those from MCB or SC habitats for most ages (Tables 11–13). Consistent with the back-calculated mean-length-at-age data, black crappie annual growth increments varied among locations with BWC areas exhibiting higher growth than MCB or SC areas (Table 14). Our findings suggest that certain habitats of the Illinois River may offer better potential for growth than others for this species. This may be due to factors such as availability or condition of prey, habitat availability, water quality, and competition. In Lake Chautauqua (BWI), mean length-at-age and mean annual growth increments of all species tended to be significantly different from other areas (Tables 5, 8, 11, 13, 14, 17–20, and 23–25). Because this was not observed in BWC habitats, isolated backwaters may not have enough intermingling with the main channel to respond to conditions in a manner similar to that of the MCB or SC. This idea warrants further investigation.

Lake Chautauqua is the only BWI area from which otoliths were collected for this study. The variations in mean lengths and mean annual growth mentioned above could indicate that this type of habitat yields quite different growth rates and age structures compared to the other habitats we analyzed. For example, bluegill and black crappie mean length-at-age and growth were higher in Lake Chautauqua than in other areas. On the other hand, largemouth bass and white bass taken from Lake Chautauqua had lower mean length-at-age and growth than those taken from other areas. Figure 5 shows that largemouth bass had very different growth with respect to size in 2001 such that larger bass experienced higher growth. All of these bass were collected from Lake Chautauqua. These trends may mean that isolated backwaters are subjected to environmental conditions that are more lacustrine compared to contiguous, lotic habitats connected to the Illinois River.

Future Recommendations

Incorporating age and growth analyses into the LTRMP could prove valuable in the future. Many of the limitations of this study would not be an issue with a fish sampling design fully implemented as part of the LTRMP. One of the difficulties we encountered was that the gear did a poor job of collecting very small fish. The multiple gear approach employed by the LTRMP would compensate for this because the gears used target both small and large sized fish. Another limitation to this study was that locations of otolith collection differed among years. Also, there were very few fish aged from certain locations in some years. A standardized protocol that targets meaningful samples sizes from all habitats is another reason why LTRMP is well suited for these types of age and growth analyses because the program samples the same types of habitats or “aquatic area types” every year and collects many fish from each location. This would allow for direct comparison of mean length-at-age and growth increments among habitats and years while maintaining adequate sample sizes.

We suggest a given number of fish (up to 5) from each 10mm length group be taken for aging if this sampling were to be adopted by the LTRMP. This would mean approximately 125 fish would need to be aged per species. Obviously, this number would be slightly higher for fish that grow larger and slightly lower for fish that stay relatively small throughout their lives. It would take approximately six person-hours for an experienced individual to extract and read all otoliths for one species. This number could then be multiplied by number of species in order to determine the total amount of effort required to complete the task. Certain factors would need to be considered when selecting species to age. For example, only 52 largemouth bass (total) were collected from La Grange Pool in 2005 LTRMP sampling. Even if all of these fish were aged, there would not likely be enough information to make any inferences about spatial or temporal variation in mean length-at-age or growth. If this extra sampling is ever included in the LTRMP, it is our opinion that the information gained would outweigh expected costs.

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Table 1. Locations and years of otolith collection for each fish species used for age and growth analyses from La Grange Pool of the Illinois River. Species include largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), white bass (*Morone chrysops*), and freshwater drum (*Aplodinotus grunniens*). Location types include areas along the shoreline of the main river channel (MCB), side channels (SC), backwaters contiguous to the main river channel (BWC), and backwaters isolated from the main river channel (BWI).

	Largemouth bass	Black crappie	Bluegill	White bass	Freshwater drum
Locations	MCB-ubiquitous (MCB)	MCB-ubiquitous (MCB)	MCB-ubiquitous (MCB)	MCB-ubiquitous (MCB)	MCB-ubiquitous (MCB)
	Lake Chautauqua (BWI)	Lake Chautauqua (BWI)	Lake Chautauqua (BWI)	Lake Chautauqua (BWI)	Bath Chute (SC)
	Coal docks (BWC)	Coal docks (BWC)	Coal docks (BWC)	Matanzas Lake (BWC)	BWI-ubiquitous (BWI)
	Globe levee (BWC)	Globe levee (BWC)	Globe levee (BWC)	Side channel (SC)	
	Matanzas Lake (BWC)	Matanzas Lake (BWC)	Matanzas Lake (BWC)		
	Muscooten Bay (BWC)	Muscooten Bay (BWC)	Muscooten Bay (BWC)		
	Treadway Lake (BWC)	Treadway Lake (BWC)	Treadway Lake (BWC)		
	Lily Lake (BWC)	Lily Lake (BWC)	Lily Lake (BWC)		
	LTRMP marina (BWC)	Liverpool Ditch (BWC)	Liverpool Ditch (BWC)		
	Liverpool Ditch (BWC)	Snicarte Slough (BWC)	Snicarte Slough (BWC)		
	Snicarte Slough (BWC)	Bath Chute (SC)	Bath Chute (SC)		
	Patterson Bay (BWC)				
	Bath Chute (SC)				
Years	1993–1998, 2000–2001	1994–1998, 2000–2001	1993–1998, 2000–2001	1994–1998, 2000–2001	1992–1993

Table 2. Mean total length-at-age (mm) for each species collected from La Grange Pool of the Illinois River from 1993 to 2001.

Species	Age	Mean	*N*	Standard deviation	Standard error
Largemouth bass	1	140	694	38.09	1.45
(Micropterus salmoides)	2	234	366	49.79	2.60
	3	297	242	41.40	2.66
	4	338	152	37.44	3.04
	5	376	72	31.83	3.75
	6	401	26	33.89	6.65
	7	417	10	30.88	9.77
	8	439	6	33.47	13.66
	9	454	3	38.37	22.15
Black crappie	1	110	411	19.94	0.98
(Pomoxis nigromaculatus)	2	171	230	25.05	1.65
	3	214	122	25.72	2.33
	4	243	70	20.32	2.43
	5	268	16	23.24	5.81
Bluegill	1	71	408	21.14	1.05
(Lepomis macrochirus)	2	119	164	23.18	1.81
	3	145	55	17.58	2.37
	4	164	29	12.75	2.37
	5	182	12	7.13	2.06
White bass	1	156	276	36.76	2.21
(Morone chrysops)	2	218	163	49.47	3.87
	3	269	73	55.45	6.49
	4	318	30	40.95	7.48
	5	377	3	27.45	15.85
Freshwater drum	1	105	133	40.58	3.52
(Aplodinotus grunniens)	2	174	108	32.15	3.09
	3	217	80	35.50	3.97
	4	249	52	40.85	5.66
	5	279	38	50.80	8.24
	6	284	24	38.69	7.90
	7	293	12	49.82	14.38
	8	298	9	27.36	9.12
	9	315	9	29.79	9.93
	10	320	6	28.85	11.78
	11	330	5	29.41	13.15
	12	347	5	22.58	10.10
	13	360	4	24.34	12.17
	14	372	4	23.71	11.86
	15	384	4	23.94	11.97
	16	402	2	4.39	3.10
	17	414	2	4.02	2.84

Table 3. Mean growth increments (mm) by age for each species collected from La Grange Pool of the Illinois River from 1993 to 2001.

Species	Age	Mean	*N*	Standard deviation	Standard error
Largemouth bass	1	135	694	38.09	1.45
(Micropterus salmoides)	2	89	366	27.81	1.45
	3	63	242	26.89	1.73
	4	43	152	21.43	1.74
	5	32	72	14.94	1.76
	6	22	26	9.22	1.81
	7	15	10	4.18	1.32
	8	15	6	3.12	1.27
	9	15	3	2.57	1.48
Black crappie	1	108	411	19.94	0.98
(Pomoxi nigromaculatus)	2	60	230	16.07	1.06
	3	46	122	14.73	1.33
	4	37	70	9.82	1.17
	5	23	16	8.67	2.17
Bluegill	1	68	408	21.14	1.05
(Lepomis macrochirus)	2	49	164	15.15	1.18
	3	30	55	11.22	1.51
	4	22	29	6.82	1.27
	5	21	12	9.87	2.85

Table 4. Mean total length-at-age (mm) for largemouth bass (*Micropterus salmoides*) for both sexes (and undetermined sex), males, and females from La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different with respect to year ($P < 0.05$). Sample sizes are in parentheses. Sex was not determined in 1993.

	Year								Tukey's test		
Age	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**2000**	**2001**	**df**	**f-value**	**p-value**
					Sexes combined						
1	125^{b} (53)	123^{b} (200)	152^{a} (191)	156^{a} (61)	146^{a} (50)	139^{ab} (45)	148^{a} (61)	137^{ab} (33)	7	13.52	<0.0001
2	240 (25)	208 (99)	243 (125)	244 (48)	245 (17)	244 (19)	242 (21)	246 (12)	7	5.75	<0.0001
3	312^{ab} (16)	276^{b} (78)	307^{ab} (86)	305^{ab} (23)	309^{ab} (13)	295^{ab} (15)	326^{a} (4)	303^{ab} (7)	7	5.23	<0.0001
4	323 (4)	314 (51)	350 (65)	361 (11)	349 (9)	345 (9)		344 (3)	6	6.92	<0.0001
5	359 (3)	348 (9)	381 (43)	389 (7)	378 (4)	374 (6)			5	2.13	0.072
6	397 (2)	371 (5)	413 (14)	410 (3)		386 (2)			4	1.67	0.194
7	375 (1)	412 (2)	436 (4)	428 (1)		399 (2)			4	1.13	0.438
8		438 (1)	453 (3)			417 (2)			2	0.58	0.612
9			498 (1)			432 (2)			1	69.57	0.076
10						436 (1)					
11						448 (1)					
12						456 (1)					
					Males						
1		118^{b} (54)	154^{ab} (75)	146^{ab} (5)	144^{ab} (23)	142^{ab} (23)	157^{a} (23)	147^{ab} (10)	6	6.77	<0.0001
2		198^{b} (48)	243^{ab} (56)	231^{ab} (5)	244^{ab} (10)	238^{ab} (8)	242^{ab} (9)	265^{a} (4)	6	5.46	<0.0001
3		265 40)	296 (38)	297 (1)	307 (7)	277 (5)	287 (1)	326 (1)	6	3.22	0.007
4		308^{b} (29)	331^{ab} (28)		350^{a} (6)	340^{ab} (3)			3	5.50	0.002
5		357 (5)	362 (19)		378 (3)	359 (2)			3	0.66	0.587
6		383 (2)	386 (5)						1	0.04	0.854
7			388 (1)								
8			402 (1)								
					Females						
1		127^{b} (50)	160^{a} (82)	161^{a} (15)	148^{ab} (26)	136^{ab} (22)	149^{ab} (35)	139^{ab} (17)	6	5.43	<0.0001
2		219 (47)	247 (64)	246 (15)	247 (7)	249 (11)	242 (12)	237 (8)	6	1.83	0.096
3		286 (36)	317 (46)	309 (8)	312 (6)	305 (10)	339 (3)	299 (6)	6	2.48	0.028
4		321 (21)	367 (36)	376 (4)	346 (3)	348 (6)		344 (3)	5	5.20	0.000
5		338 (4)	399 (23)	401 (3)	379 (1)	382 (4)			4	4.11	0.009
6		364 (3)	427 (9)			386 (2)			2	4.89	0.030
7		412 (2)	452 (3)			399 (2)			2	5.38	0.074
8		438^{b} (1)	479^{a} (2)			417^{b} (2)			2	195.35	0.005
9			498 (1)			432 (2)			1	69.57	0.076
10						436 (1)					
11						448 (1)					
12						456 (1)					

Table 5. Mean total length-at-age (mm) for largemouth bass (*Micropterus salmoides*; both sexes and undetermined sex) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations													Tukey's test		
Age	MCB	Lake Chautauqua	Coal docks	Globe levee	Matanzas Lake	Muscooten Bay	Treadway Lake	Lily Lake	LTRMP marina	Liverpool Ditch	Snicarte Slough	Patterson Bay	Bath Chute	d.f.	f-value	p-value
								1993								
1	184[ab] (11)	70[c] (19)	136[abc] (18)		118[bc] (2)	172[ab] (1)	195[a] (2)							5	28.85	<0.0001
2	280[a] (11)	107[b] (3)	228[a] (8)			234[a] (1)	277[a] (2)							4	15.00	<0.0001
3	327 (10)		281 (4)			271 (1)	327 (1)							3	1.79	0.203
4	332 (3)		296 (1)											1	0.23	0.679
								1994								
1	119 (133)		143 (21)	121 (1)	126 (17)		131 (6)	119 (13)	124 (9)					6	1.55	0.163
2	207 (89)		212 (6)				161 (1)		232 (3)					3	0.56	0.646
3	274 (73)		283 (3)						310 (2)					2	0.89	0.416
4	314 (49)		319 (2)											1	0.04	0.839
5	345 (8)		373 (1)											1	0.45	0.523
								1995								
1	160 (47)		145 (37)	157 (1)					144 (43)			157 (63)		4	2.13	0.079
2	256 (46)		230 (23)	221 (1)					224 (12)			243 (43)		4	2.15	0.079
3	302 (42)		294 (12)						328 (6)			318 (26)		3	2.20	0.095
4	344 (34)		340 (6)						376 (3)			360 (22)		3	1.81	0.154
5	375 (23)		374 (3)						406 (3)			386 (14)		3	1.08	0.368
6	405 (9)								449 (1)			421 (4)		2	1.13	0.357
7	388 (1)								461 (1)			448 (2)		2	1.68	0.479
8	402 (1)								477 (1)			482 (1)				
9												498 (1)				

Table 5. (Continued)

	Locations													Tukey's test		
Age	MCB	Lake Chautauqua	Coal docks	Globe levee	Matanzas Lake	Muscooten Bay	Treadway Lake	Lily Lake	LTRMP marina	Liverpool Ditch	Snicarte Slough	Patterson Bay	Bath Chute	d.f.	f-value	p-value
								1996								
1	155 (29)		199 (1)			156 (31)								2	0.84	0.436
2	240 (19)		293 (1)			245 (28)								2	0.91	0.409
3	299 (7)		338 (1)			306 (15)								2	0.68	0.519
4	350 (1)		361 (1)			362 (9)								2	0.09	0.913
5						389 (7)										
6						410 (3)										
7						428 (1)										
								1997								
1	178 (4)		151 (7)		136 (7)	135 (12)					152 (15)		136 (5)	5	0.95	0.456
2	306[a] (1)		248[ab] (3)		208[b] (3)	205[b] (2)					290[ab] (4)		231[ab] (4)	5	4.43	0.019
3	329 (1)		310 (3)		293 (3)	262 (1)					335 (2)		316 (3)	5	1.52	0.295
4	352 (1)		346 (3)		358 (2)	333 (1)							351 (2)	4	0.89	0.545
5	366 (1)		383 (2)		381 (1)									2	3.29	0.363
								1998								
1	124[b] (16)				151[a] (16)			142[ab] (13)						2	4.19	0.022
2	223 (4)				261 (12)			207 (3)						2	2.44	0.119
3	296[a] (4)				312[a] (9)			219[b] (2)						2	4.95	0.027
4	349 (3)				343 (6)									1	0.10	0.763
5	371 (1)				375 (5)									1	0.02	0.889
6					386 (2)											
7					399 (2)											
8					417 (2)											
9					432 (2)											
10					436 (1)											
11					448 (1)											
12					456 (1)											

Table 5. (Continued)

	Locations													Tukey's test		
Age	MCB	Lake Chautauqua	Coal docks	Globe levee	Matanzas Lake	Muscooten Bay	Treadway Lake	Lily Lake	LTRMP marina	Liverpool Ditch	Snicarte Slough	Patterson Bay	Bath Chute	d.f.	f-value	p-value
								2000								
1		62[b] (1)	160[a] (21)							144[a] (39)				2	4.92	0.011
2			261 (6)							234 (15)				1	1.50	0.236
3										326 (4)						
								2001								
1		137 (33)														
2		246 (12)														
3		303 (7)														
4		344 (3)														

Table 6. Mean total length-at-age (mm) for male largemouth bass (*Micropterus salmoides*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). All fish collected in 1993 were either immature or sex was not determined. Sample sizes are in parentheses.

	Locations											Tukey's test		
Age	**MCB**	**Lake Chautaqua**	**Coal docks**	**Matanzas Lake**	**Muscooten Bay**	**Lily Lake**	**LTRMP marina**	**Liverpool Ditch**	**Snicarte Slough**	**Patterson Bay**	**Bath Chute**	**d.f.**	**f-value**	**p-value**
							1994							
1	112 (47)		167 (5)				143 (2)					2	4.50	0.016
2	196 (45)		220 (1)				246 (2)					2	1.19	0.314
3	263 (38)		279 (1)				318 (1)					2	1.44	0.250
4	309 (28)		289 (1)									1	0.41	0.526
5	257 (5)													
6	383 (2)													
							1995							
1	154 (27)		146 (17)				171 (9)			153 (22)		3	1.37	0.258
2	248 (27)		246 (11)				232 (4)			236 (14)		3	0.39	0.761
3	293 (23)		310 (4)				312 (2)			297 (9)		3	0.37	0.777
4	327 (19)		372 (1)				330 (1)			334 (7)		3	0.77	0.523
5	361 (12)		383 (1)				373 (1)			359 (5)		3	0.37	0.775
6	391 (4)									366 (1)		1	3.02	0.180
7	388 (1)													
8	402 (1)													
							1996							
1	135 (1)				149 (4)							1	1.05	0.380
2	209 (1)				236 (4)							1	0.40	0.571
3					297 (1)									

Table 6. (Continued.)

Age	Locations											Tukey's test		
	MCB	Lake Chautaqua	Coal docks	Matanzas Lake	Muscooten Bay	Lily Lake	LTRMP marina	Liverpool Ditch	Snicarte Slough	Patterson Bay	Bath Chute	d.f.	f-value	p-value
							1997							
1	202[a] (2)		151[ab] (3)	147[ab] (4)	113[b] (4)				147[ab] (7)		132[ab] (3)	5	2.52	0.070
2	306 (1)		234 (2)	223 (2)	223 (1)				271 (2)		229 (2)	5	1.54	0.348
3	329 (1)		304 (2)	292 (2)					324 (1)		304 (1)	4	0.61	0.700
4	352 (1)		340 (2)	358 (2)							354 (1)	3	0.65	0.652
5	366 (1)		387 (1)	381 (1)										
							1998							
1	139 (6)			144 (8)		142 (9)						2	0.05	0.948
2	236 (2)			266 (4)		182 (2)						2	1.57	0.295
3	297[ab] (2)			319[a] (2)		149[b] (1)						2	21.61	0.044
4	341 (2)			336 (1)								1	0.09	0.816
5	371 (1)			347 (1)										
							2000							
1			164 (6)					154 (17)				1	0.51	0.482
2			239 (2)					242 (7)				1	0.01	0.941
3								287 (1)						
							2001							
1		147 (10)												
2		265 (4)												
3		326 (1)												

Table 7. Mean total length-at-age (mm) for female largemouth bass (*Micropterus salmoides*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). All fish collected in 1993 were either immature or sex was not determined. Sample sizes are in parentheses.

	Locations											Tukey's test		
Age	MCB	Coal docks	Globe levee	Matanzas Lake	Muscooten Bay	Lily lake	LTRMP marina	Liverpool Ditch	Snicarte Slough	Patterson Bay	Bath chute	d.f.	f-value	p-value
							1994							
1	125 (43)	141 (6)	121 (1)									2	0.50	0.609
2	218 (43)	234 (4)										1	0.41	0.527
3	286 (34)	284 (2)										1	0.00	0.965
4	320 (20)	350 (1)										1	0.42	0.524
5	326 (3)	372 (1)										1	0.48	0.559
							1995							
1	171 (18)	147 (18)	157 (1)				170 (5)			159 (40)		4	1.39	0.244
2	271 (17)	215 (12)	221 (1)				255 (5)			246 (29)		4	3.53	0.012
3	316^{ab} (17)	286^{a} (8)					336^{b} (4)			329^{ab} (17)		3	3.38	0.027
4	369^{ab} (14)	333^{a} (5)					399^{b} (2)			372^{ab} (15)		3	3.79	0.020
5	397 (10)	369 (2)					422 (2)			402 (9)		3	1.54	0.237
6	416 (5)						449 (1)			439 (3)		2	1.05	0.408
7							461 (1)			448 (2)		1	0.13	0.781
8							477 (1)			482 (1)				
9										498 (1)				
							1996							
1	213^{a} (2)				153^{b} (13)							1	6.44	0.025
2	283 (2)				240 (13)							1	2.58	0.132
3	327 (1)				306 (7)							1	0.21	0.660
4					376 (4)									
5					401 (3)									

Table 7. (Continued)

	Locations										Tukey's test		
Age	MCB	Coal docks	Globe levee	Matanzas Lake	Muscooten Bay	Lily lake	LTRMP marina	Liverpool Ditch	Snicarte Slough	Patterson Bay	Bath chute	d.f.	f-value	p-value
							1997							
1	154 (2)	150 (4)		121 (3)	146 (8)				159 (7)		141 (2)	5	0.27	0.922
2		275 (1)		177 (1)	188 (1)				310 (2)		234 (2)	4	5.93	0.150
3		323 (1)		295 (1)	262 (1)				346 (1)		322 (2)	4	0.39	0.814
4		357 (1)			333 (1)						348 (1)			
5		379 (1)												
							1998							
1	115[a] (10)			159[b] (8)		141[ab] (4)						2	6.39	0.008
2	210 (2)			258 (8)		255 (1)						2	1.31	0.323
3	295 (2)			310 (7)		288 (1)						2	0.35	0.714
4	363 (1)			345 (5)								1	0.33	0.596
5				382 (4)										
6				386 (2)										
7				399 (2)										
8				417 (2)										
9				432 (2)										
10				436 (1)										
11				448 (1)										
12				456 (1)										
							2000							
1		158 (15)						143 (20)				1	2.06	0.160
2		272 (4)						227 (8)				1	2.64	0.135
3								339 (3)						

Table 8. Mean annual growth increment (mm) for largemouth bass (*Micropterus salmoides*) in La Grange Pool of the Illinois River. Values with different superscripts indicate significant differences among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations													Tukey's test		
Age	MCB	Lake Chautaqua	Coal docks	Globe levee	Matanzas Lake	Muscooten Bay	Treadway Lake	Lily lake	LTRMP marina	Liverpool Ditch	Snicarte Slough	Patterson Bay	Bath chute	d.f.	f-value	p-value
1993																
1	179^{ab} (11)	65^{c} (19)	131^{abc} (18)		113^{bc} (2)	167^{ab} (1)	190^{a} (2)							5	28.85	<0.0001
2	96 (11)	56 (3)	86 (8)			62 (1)	83 (2)							4	1.75	0.178
3	46 (10)		54 (4)			37 (1)	47 (1)							3	0.30	0.823
4	38^{a} (3)		20^{b} (1)											1	55.94	0.017
1994																
1	114 (133)		138 (21)	116 (1)	121 (17)		126 (6)	114 (13)	119 (9)					6	1.55	0.163
2	89 (89)		85 (6)				64 (1)		88 (3)					3	0.38	0.764
3	73 (73)		51 (3)						85 (2)					2	1.17	0.315
4	43^{a} (49)		15^{b} (2)											1	4.33	0.043
5	38 (8)		23 (1)											1	0.75	0.416
1995																
1	155 (47)		140 (37)	152 (1)					139 (43)			152 (63)		4	2.13	0.079
2	95 (46)		84 (23)	65 (1)					80 (12)			81 (43)		4	2.05	0.092
3	50 (42)		55 (12)						59 (6)			57 (26)		3	0.72	0.545
4	43 (34)		40 (6)						30 (3)			43 (22)		3	0.55	0.651
5	35 (23)		32 (3)						29 (3)			30 (14)		3	0.40	0.754
6	18 (9)								12 (1)			19 (4)		2	0.90	0.436
7	10 (1)								12 (1)			14 (2)		2	0.81	0.617
8	13 (1)								16 (1)			12 (1)				
9												16 (1)				

Table 8. (Continued)

	Locations													Tukey's test		
Age	MCB	Lake Chautaqua	Coal docks	Globe levee	Matanzas Lake	Muscooten Bay	Treadway Lake	Lily lake	LTRMP marina	Liverpool Ditch	Snicarte Slough	Patterson Bay	Bath chute	d.f.	f-value	p-value
1996																
1	150 (29)		194 (1)			151 (31)								2	0.84	0.436
2	88 (19)		94 (1)			87 (28)								2	0.03	0.968
3	60 (7)		45 (1)			63 (15)								2	0.20	0.817
4	15 (1)		23 (1)			46 (9)								2	1.10	0.380
5						33 (7)										
6						27 (3)										
7						21 (1)										
1997																
1	173 (4)		146 (7)		131 (7)	130 (12)					147 (15)		131 (5)	5	0.95	0.456
2	128 (1)		88 (3)		83 (3)	90 (2)					99 (4)		90 (4)	5	0.23	0.941
3	23 (1)		62 (3)		85 (3)	74 (1)					44 (2)		91 (3)	5	2.62	0.121
4	23 (1)		36 (3)		65 (2)	70 (1)							56 (2)	4	2.77	0.174
5	14 (1)		28 (2)		19 (1)									2	1.09	0.561
1998																
1	119[b] (16)				146[a] (16)			137[ab] (13)						2	4.19	0.022
2	91 (4)				104 (12)			76 (3)						2	1.31	0.298
3	73 (4)				52 (9)			35 (2)						2	2.69	0.108
4	52 (3)				37 (6)									1	0.79	0.403
5	19 (1)				22 (5)									1	0.03	0.875
6					21 (2)											
7					12 (2)											
8					19 (2)											
9					15 (2)											

Table 8. (Continued)

	Locations													Tukey's test		
Age	MCB	Lake Chautaqua	Coal docks	Globe levee	Matanzas Lake	Muscooten Bay	Treadway Lake	Lily lake	LTRMP marina	Liverpool Ditch	Snicarte Slough	Patterson Bay	Bath Chute	d.f.	f-value	p-value
10					8 (1)											
11					12 (1)											
12					8 (1)											
2000																
1		57[a] (1)	155[b] (21)							139[b] (39)				2	4.92	0.011
2			98 (6)							84 (15)				1	1.10	0.307
3										93 (4)						
2001																
1		132 (33)														
2		105 (12)														
3		89 (7)														
4		104 (3)														

Table 9. Mean annual growth increment (mm) in length for largemouth bass (*Micropterus salmoides*) in La Grange Pool of the Illinois River. Values with different superscripts indicate significant differences among years ($P < 0.05$). Sample sizes are given below each mean.

	Year														Tukey's test		
Age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	d.f.	f-value	p-value
1	168^{a}	115^{b}	154^{ab}	135^{ab}	131^{ab}	126^{ab}	130^{ab}	139^{ab}	143^{ab}	140^{ab}	125^{ab}	146^{ab}	144^{ab}	129^{ab}	14	1.96	0.018
	(4)	(5)	(17)	(85)	(62)	(78)	(161)	(98)	(23)	(37)	(33)	(21)	(45)	(21)			
2	113^{a}	88^{ab}	90^{ab}	91^{ab}	89^{ab}	87^{ab}	95^{ab}	70^{b}	98^{ab}	106^{ab}	99^{ab}	76^{ab}	96^{ab}	114^{a}	13	4.07	<0.0001
	(4)	(4)	(5)	(17)	(85)	(62)	(50)	(60)	(32)	(10)	(4)	(7)	(21)	(5)			
3		49^{ab}	67^{ab}	47^{b}	57^{ab}	58^{ab}	70^{ab}	52^{ab}	74^{ab}	66^{ab}	53^{ab}		90^{ab}	91^{a}	11	3.11	0.001
		(4)	(4)	(5)	(17)	(85)	(53)	(29)	(21)	(7)	(6)		(7)	(4)			
4			33^{b}	43^{b}	48^{b}	37^{b}	43^{b}	41^{b}	33^{b}	53^{b}	52^{b}			105^{a}	9	4.23	<0.0001
			(4)	(4)	(5)	(17)	(73)	(26)	(8)	(9)	(3)			(3)			
5				29	24	31	32	34	37	22	26				7	0.66	0.702
				(4)	(4)	(5)	(16)	(31)	(4)	(4)	(4)						
6					19	16	27	21	29						4	1.02	0.417
					(4)	(4)	(4)	(12)	(2)								
7						16	14	16	15						3	0.10	0.956
						(4)	(3)	(1)	(2)								
8							15	15		17					2	0.13	0.886
							(3)	(2)		(1)							
9								14			17				1	0.56	0.591
								(2)			(1)						
10									8								
									(1)								
11										12							
										(1)							
12											8						
											(1)						

Table 10. Mean total length-at-age (mm) for black crappie (*Pomoxis nigromaculatus*; both sexes and undetermined sex) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations										Tukey's test		
Age	MCB	Bath chute	Lake Chautauqua	Coal docks	Lily Lake	Liverpool Ditch	Matanzas Lake	Muscooten Bay	Snicarte Slough	Treadway Lake	d.f.	f-value	p-value
							1994						
1	109 (23)	96 (17)			111 (7)	108 (4)				105 (19)	4	2.10	0.091
2	169^{ab} (13)	146^{b} (5)			174^{a} (7)					164^{ab} (19)	3	2.45	0.078
3	212 (9)	188 (4)			209 (7)					193 (9)	3	1.99	0.142
4	248 (6)	225 (4)			241 (6)					230 (7)	3	1.35	0.290
							1995						
1	114 (19)	95 (1)			121 (2)			109 (1)		113 (41)	4	0.38	0.824
2	173 (18)	136 (1)			208 (2)			152 (1)		164 (33)	4	1.93	0.120
3	207 (1)				249 (2)					203 (9)	2	2.62	0.127
4	232 (1)				273 (2)					229 (6)	2	2.31	0.180
5	274 (1)				275 (1)					249 (6)	2	0.70	0.539
6	286 (1)												
							1996						
1	115 (29)							109 (25)			1	2.23	0.141
2	180^{a} (20)							163^{b} (13)			1	6.70	0.015
3	233^{a} (19)							214^{b} (11)			1	5.93	0.022
4								241 (2)					
							1997						
1	91^{b} (32)	100^{ab} (5)		105^{ab} (19)			105^{ab} (21)	110^{a} (10)	101^{ab} (14)		5	4.56	0.001
2	160 (5)	170 (3)		165 (5)			168 (19)	186 (7)	173 (8)		5	1.10	0.374
3	195 (3)	205 (1)		205 (4)			209 (15)	220 (5)	222 (2)		5	0.51	0.763
4	258 (1)	234 (1)		245 (4)			244 (15)	256 (4)	244 (1)		5	0.47	0.792
5							272 (2)						

Table 10. (Continued.)

Age	Locations										Tukey's test		
	MCB	Bath chute	Lake Chautauqua	Coal docks	Lily Lake	Liverpool Ditch	Matanzas Lake	Muscooten Bay	Snicarte Slough	Treadway Lake	d.f.	f-value	p-value
							1998						
1					112 (9)		110 (11)				1	0.04	0.852
2					170 (6)		182 (11)				1	0.66	0.431
3					220 (2)		218 (5)				1	0.01	0.917
4					276 (1)		259 (4)				1	3.21	0.171
5					301 (1)		276 (4)				1	6.31	0.087
							2000						
1			130^{a} (40)	101^{b} (4)		116^{ab} (33)					2	5.29	0.007
2			156 (6)	137 (1)		173 (19)					2	1.12	0.344
3				174 (1)		223 (12)					1	2.18	0.168
4						236 (4)							
							2001						
1			117 (25)										
2			208 (8)										
3			228 (1)										
4			264 (1)										
5			297 (1)										

Table 11. Mean total length-at-age (mm) for black crappie (*Pomoxis nigromaculatus*) for both sexes (and undetermined sex), males, and females in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different with respect to year ($P < 0.05$). Sample sizes are in parentheses.

	Year							Tukey's test		
Age	1994	1995	1996	1997	1998	2000	2001	d.f.	f-value	p-value
					Both sexes					
1	105^{bc} (70)	113^{ab} (64)	112^{abc}(54)	101^{c} (101)	111^{abc} (20)	122^{a} (77)	117^{ab} (25)	6	11.95	<0.0001
2	165^{b} (44)	168^{b} (55)	173^{b} (33)	170^{b} (47)	178^{b} (17)	168^{b} (26)	208^{a} (8)	6	4.07	0.001
3	202 (29)	211 (12)	226 (30)	210 (30)	219 (7)	219 (13)	228 (1)	6	2.68	0.018
4	237 (23)	240 (9)	241 (2)	246 (26)	263 (5)	236 (4)	264 (1)	6	1.64	0.152
5		256 (8)		272 (2)	281 (5)		297 (1)	3	2.30	0.129
6		286 (1)								
					Males					
1	107^{b} (33)	118^{ab} (13)	112^{ab} (21)	100^{b} (44)	110^{b} (7)	118^{ab} (35)	130^{a} (14)	6	7.13	<0.0001
2	170^{b} (20)	174^{b} (12)	170^{b} (12)	166^{b} (18)	168^{b} (5)	161^{b} (11)	215^{a} (5)	6	4.58	0.001
3	201 (12)	220 (5)	230 (12)	209 (12)	220 (2)	202 (7)		5	3.31	0.013
4	240 (11)	248 (4)	248 (1)	240 (12)	276 (1)	230 (2)		5	0.96	0.460
5		272 (4)			301 (1)			1	6.18	0.089
6		286 (1)								
					Females					
1	103^{b} (34)	110^{ab} (25)	113^{ab} (32)	106^{b} (43)	111^{ab} (13)	126^{a} (41)	112^{ab} (7)	6	7.26	<0.0001
2	161^{b} (23)	163^{b} (22)	175^{ab} (21)	176^{ab} (28)	181^{ab} (12)	174^{ab} (14)	208^{a} (2)	6	2.56	0.023
3	202 (16)	215 (4)	223 (18)	215 (17)	218 (5)	240 (6)		5	2.36	0.051
4	234 (12)	243 (3)	233 (1)	251 (14)	259 (4)	241 (2)		5	1.42	0.247
5		244 (2)		272 (2)	276 (4)			2	2.28	0.198

Table 12. Mean total length-at-age (mm) for male black crappies (*Pomoxis nigromaculatus*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations										Tukey's test		
Age	MCB	Bath Chute	Lake Chautauqua	Coal docks	Lily Lake	Liverpool Ditch	Matanzas Lake	Muscooten Bay	Snicarte Slough	Treadway Lake	d.f.	f-value	p-value
							1994						
1	110 (13)	103 (9)			131 (1)	112 (1)				104 (9)	4	1.34	0.281
2	165^{b} (8)	163^{b} (2)			217^{a} (1)					170^{b} (9)	3	4.79	0.014
3	203^{ab} (5)	189^{b} (2)			245^{a} (1)					195^{b} (4)	3	3.47	0.071
4	247^{ab} (5)	223^{b} (2)			274^{a} (1)					230^{ab} (3)	3	4.23	0.053
							1995						
1	109 (6)				115 (1)					127 (6)	2	3.14	0.087
2	163 (5)				181 (1)					183 (6)	2	1.57	0.260
3	207 (1)				230 (1)					221 (3)	2	0.33	0.754
4	232 (1)				263 (1)					248 (2)	2	0.28	0.802
5	274 (1)				275 (1)					268 (2)	2	0.06	0.942
6	286 (1)												
							1996						
1	111 (11)							114 (10)			1	0.29	0.594
2	176 (6)							164 (6)			1	1.50	0.248
3	233 (6)							226 (6)			1	0.39	0.547
4								248 (1)					
							1997						
1	91b (14)	101^{ab} (3)		102^{ab} (7)			106^{ab} (10)	111^{a} (4)	97^{ab} (6)		5	3.75	0.007
2	157 (1)	179 (1)		141 (1)			165 (8)	179 (4)	160 (3)		5	0.66	0.663
3	224^{a} (1)			174^{b} (1)			209^{ab} (7)	218^{ab} (3)			3	3.61	0.065
4	258 (1)			210 (1)			238 (7)	250 (3)			3	1.74	0.236

Table 12. (Continued.)

	Locations										Tukey's test		
Age	MCB	Bath Chute	Lake Chautauqua	Coal docks	Lily Lake	Liverpool Ditch	Matanzas Lake	Muscooten Bay	Snicarte Slough	Treadway Lake	d.f.	f-value	p-value
						1998							
1					112 (6)		97 (1)				1	0.59	0.477
2					164 (4)		187 (1)				1	0.37	0.586
3					220 (2)								
4					276 (1)								
5					301 (1)								
						2000							
1			126 (16)	101 (4)		114 (15)					2	1.92	0.164
2			144 (2)	137 (1)		168 (8)					2	1.10	0.378
3				174 (1)		207 (6)					1	1.53	0.272
4						230 (2)							
						2001							
1			130 (14)										
2			215 (5)										

Table 13. Mean total length-at-age (mm) for female black crappies (*Pomoxis nigromaculatus*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations										Tukey's test		
Age	MCB	Bath Chute	Lake Chautauqua	Coal docks	Lily Lake	Liverpool Ditch	Matanzas Lake	Muscooten Bay	Snicarte Slough	Treadway Lake	d.f.	f-value	p-value
							1994						
1	109 (8)	89 (8)			107 (6)	112 (2)				105 (10)	4	2.13	0.102
2	177^{a} (4)	135^{b} (3)			167^{ab} (6)					159^{ab} (10)	3	2.78	0.069
3	229 (3)	188 (2)			203 (6)					191 (5)	3	1.94	0.177
4	252 (1)	228 (2)			234 (5)					231 (4)	3	0.24	0.866
							1995						
1	109 (10)	95 (1)			127 (1)			109 (1)		112 (12)	4	0.60	0.668
2	163^{ab} (10)	136^{b} (1)			234^{a} (1)			152^{b} (1)		158^{ab} (9)	4	2.82	0.058
3					269 (1)					197 (3)	1	3.68	0.195
4					284 (1)					223 (2)	1	2.11	0.384
5										244 (2)			
							1996						
1	120^{a} (17)							105b (15)			1	6.81	0.014
2	182^{a} (14)							163^{b} (7)			1	4.42	0.049
3	233^{a} (13)							199^{b} (5)			1	11.06	0.004
4								233 (1)					
							1997						
1	96 (8)	99 (2)		111 (10)			104 (11)	122 (4)	105 (8)		5	1.89	0.120
2	180 (3)	166 (2)		171 (4)			170 (11)	195 (3)	180 (5)		5	1.42	0.258
3	241 (1)	205 (1)		215 (3)			209 (8)	225 (2)	222 (2)		5	0.72	0.622
4		234 (1)		256 (3)			249 (8)	276 (1)	244 (1)		4	1.36	0.322
5							272 (2)						

Table 13. (Continued.)

	Locations										Tukey's test		
Age	MCB	Bath Chute	Lake Chautauqua	Coal docks	Lily Lake	Liverpool Ditch	Matanzas Lake	Muscooten Bay	Snicarte Slough	Treadway Lake	d.f.	f-value	p-value
							1998						
1					110 (3)		112 (10)				1	0.03	0.861
2					183 (2)		181 (10)				1	0.01	0.924
3							218 (5)						
4							259 (4)						
5							276 (4)						
							2000						
1			133[a] (23)			118[b] (18)					1	5.43	0.025
2			165 (3)			177 (11)					1	0.21	0.656
3						240 (6)							
4						241 (2)							
							2001						
1			112 (7)										
2			208 (2)										

Table 14. Mean annual growth increment (mm) of black crappies (*Pomoxis nigromaculatus*) in La Grange Pool of the Illinois River. Values with different superscripts indicate significant differences among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations										Tukey's test		
Age	MCB	Bath Chute	Lake Chautauqua	Coal docks	Lily Lake	Liverpool Ditch	Matanzas Lake	Muscooten Bay	Snicarte Slough	Treadway Lake	d.f.	f-value	p-value
1994													
1	106 (23)	94 (17)			108 (7)	105 (4)				102 (19)	4	2.10	0.091
2	61 (13)	57 (5)			63 (7)					60 (19)	3	0.22	0.881
3	41 (9)	43 (4)			35 (7)					36 (9)	3	0.50	0.688
4	43 (6)	37 (4)			33 (6)					44 (7)	3	2.92	0.061
1995													
1	111 (19)	93 (1)			119 (2)			106 (1)		111 (41)	4	0.38	0.824
2	59^{ab} (18)	41^{b} (1)			86^{a} (2)			43^{b} (1)		53^{ab} (33)	4	4.31	0.005
3	48 (1)				42 (2)					31 (9)	2	2.70	0.121
4	25 (1)				24 (2)					38 (6)	2	1.98	0.219
5	42^{a} (1)				12^{b} (1)					20^{b} (6)	2	9.00	0.022
6	11 (1)												
1996													
1	113 (29)							106 (25)			1	2.23	0.141
2	57 (20)							54 (13)			1	0.90	0.349
3	54 (19)							56 (11)			1	0.43	0.519
4								57 (2)					
1997													
1	89^{b} (32)	98^{ab} (5)		103^{ab} (19)			103^{ab} (21)	108^{a} (10)	99^{ab} (14)		5	4.56	0.001
2	54 (5)	66 (3)		63 (5)			62 (19)	65 (7)	64 (8)		5	0.32	0.897
3	47 (3)	38 (1)		47 (4)			45 (15)	46 (5)	43 (2)		5	0.07	0.996
4	35 (1)	29 (1)		39 (4)			35 (15)	33 (4)	31 (1)		5	0.24	0.942
5							32 (2)						

Table 14. (Continued.)

Age	Locations										Tukey's test		
	MCB	Bath Chute	Lake Chautauqua	Coal docks	Lily Lake	Liverpool Ditch	Matanzas Lake	Muscooten Bay	Snicarte Slough	Treadway Lake	d.f.	f-value	p-value
							1998						
1					109 (9)		108 (11)				1	0.04	0.852
2					61 (6)		71 (11)				1	1.23	0.285
3					79^{a} (2)		45^{b} (5)				1	8.21	0.035
4					41 (1)		36 (4)				1	0.29	0.626
5					25^{a} (1)		17^{b} (4)				1	71.64	0.004
							2000						
1			127^{a} (40)	99^{b} (4)		114^{ab} (33)					2	5.29	0.007
2			66 (6)	43 (1)		57 (19)					2	0.43	0.654
3				37 (1)		52 (12)					1	1.10	0.316
4						41 (4)							
							2001						
1			114 (25)										
2			71 (8)										
3			54 (1)										
4			36 (1)										
5			33 (1)										

Table 15. Mean annual growth increment (mm) in length for black crappie (*Pomoxis nigromaculatus*) in La Grange Pool of the Illinois River. Values with different superscripts indicate significant differences among years ($P < 0.05$). Sample sizes are given beneath each mean.

	Year												Tukey's test		
Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	d.f.	f-value	p-value
1	107^{ab}	100^{ab}	111^{ab}	108^{ab}	108^{ab}	116^{ab}	103^{ab}	94^{b}	115^{ab}	108^{ab}	128^{a}	104^{ab}	11	12.88	<0.0001
	(1)	(30)	(7)	(22)	(126)	(16)	(40)	(69)	(12)	(13)	(58)	(17)			
2		50	57	74	57	56	60	70	67	68	56	70	10	3.29	0.001
		(1)	(30)	(7)	(22)	(100)	(7)	(19)	(15)	(9)	(13)	(7)			
3			48	37	40	36	52	35	50	63	45		8	5.21	<0.0001
			(1)	(30)	(7)	(7)	(57)	(4)	(2)	(5)	(9)				
4				25^{bc}	39^{ab}	15^{c}	54^{a}	34^{abc}			40^{ab}		5	6.50	<0.0001
				(1)	(30)	(1)	(4)	(29)			(5)				
5					42^{a}	19^{b}		32^{ab}	19^{b}			33^{ab}	4	7.32	0.004
					(1)	(7)		(2)	(5)			(1)			
6						11									
						(1)									

Table 16. Mean total length-at-age (mm) for bluegill (*Lepomis macrochirus*) for both sexes (and undetermined sex), males, and females in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different with respect to year *(P* < 0.05). Sample sizes are in parentheses. Sex was not determined in 1993 or 1994.

	Year								Tukey's test		
Age	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**2000**	**2001**	**d.f.**	**f-value**	**p-value**
					Both sexes						
1	49^{d} (41)	75^{c} (48)	78^{c} (54)	67^{c} (42)	67^{c} (98)	118^{a} (9)	71^{c} (102)	95^{b} (14)	7	23.63	<0.0001
2	79^{c} (9)	123^{b} (24)	127^{b} (32)	117^{b} (24)	118^{b} (26)	153^{a} (5)	114^{b} (40)	158^{a} (4)	7	11.46	<0.0001
3	109^{b} (2)	144^{a} (13)	155^{a} (11)	143^{a} (12)	148^{a} (10)	157^{a} (2)	129^{ab} (5)		6	3.99	0.003
4		163^{ab} (10)	172^{a} (4)	166^{ab} (7)	164^{ab} (5)	180^{a} (1)	141^{b} (2)		5	2.52	0.059
5		184 (7)	181 (2)	185 (1)	173 (1)	183 (1)			4	0.43	0.783
6			189 (1)								
					Males						
1			92^{b} (17)	69^{b} (12)	69^{b} (40)	128^{a} (3)	80^{b} (52)	125^{a} (6)	5	17.12	<0.0001
2			136 (15)	121 (7)	122 (10)	170 (1)	124 (15)	164 (1)	5	2.13	0.080
3			155 (6)	150 (2)	147 (4)				2	0.23	0.802
4				171 (1)	169 (3)				1	0.03	0.888
					Females						
1			74^{b} (15)	66^{b} (26)	70^{b} (30)	113^{a} (6)	65^{b} (31)	81^{b} (4)	5	10.55	<0.0001
2			122^{bc} (11)	115^{c} (17)	118^{c} (16)	149^{ab} (4)	110^{c} (24)	156^{a} (3)	5	6.71	<0.0001
3			156 (4)	141 (10)	149 (6)	157 (2)	129 (5)		4	2.45	0.077
4			171^{ab} (3)	166^{ab} (6)	157^{ab} (2)	180^{a} (1)	141^{b} (2)		4	3.32	0.063
5			179 (1)	185 (1)	173 (1)	183 (1)					
6			189 (1)								

Table 17. Mean total length-at-age (mm) for bluegill (*Lepomis macrochirus*; both sexes and undetermined sex) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations										Tukey's test		
Age	MCB	Bath chute	Lake Chautauqua	Treadway Lake	Muscooten Bay	Matanzas Lake	Lily Lake	Snicarte Slough	Coal docks	Liverpool Ditch	d.f.	f-value	p-value
							1993						
1			49 (41)										
2			79 (9)										
3			109 (2)										
							1994						
1	60 (6)	79 (33)		70 (9)							2	2.73	0.076
2	120 (4)	126 (12)		122 (8)							2	0.20	0.820
3	150 (3)	150 (4)		137 (6)							2	1.96	0.192
4	160^{ab} (2)	177^{a} (3)		156^{b} (5)							2	6.82	0.023
5	180 (1)	189 (1)		183 (5)							2	0.20	0.829
							1995						
1	84^{a} (29)			72^{b} (25)							1	4.85	0.032
2	132^{a} (22)			116^{b} (10)							1	5.95	0.021
3	157 (8)			151 (3)							1	0.20	0.666
4	180 (2)			164 (2)							1	2.32	0.267
5				181 (2)									
6				189 (1)									
							1996						
1	64 (17)				70 (25)						1	2.43	0.127
2	107^{b} (8)				122^{a} (16)						1	4.88	0.038
3	131 (3)				147 (9)						1	3.30	0.099
4	158 (2)				170 (5)						1	2.15	0.202
5					185 (1)								

Table 17. (Continued.)

Age	Locations										Tukey's test		
	MCB	Bath chute	Lake Chautauqua	Treadway Lake	Muscooten Bay	Matanzas Lake	Lily Lake	Snicarte Slough	Coal docks	Liverpool Ditch	d.f.	f-value	p-value
							1997						
1	65^{b} (63)	75^{b} (3)			102^{a} (2)	73^{b} (7)		71^{b} (15)	64^{b} (8)		5	3.49	0.006
2	121 (7)				126 (2)	118 (7)		118 (8)	117 (2)		4	0.18	0.946
3					142 (2)	150 (7)		148 (1)			2	0.51	0.619
4					158 (1)	165 (4)					1	0.28	0.633
5						173 (1)							
							1998						
1						116 (1)	119 (8)				1	0.07	0.802
2						141 (1)	156 (4)				1	1.56	0.300
3						155 (1)	159 (1)						
4						180 (1)							
5						183 (1)							
							2000						
1			85^{a} (39)						59^{b} (39)	69^{b} (24)	2	21.67	<0.0001
2			156^{a} (4)						106^{b} (27)	120^{b} (9)	2	9.84	0.000
3									129 (4)	126 (1)	1	0.01	0.912
4									141 (2)				
							2001						
1			95 (14)										
2			158 (4)										

Table 18. Mean total length-at-age (mm) for male bluegill (*Lepomis macrochirus*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sex was not determined in 1993 or 1994. Sample sizes are in parentheses.

	Locations									Tukey's test		
Age	MCB	Bath chute	Lake Chautauqua	Treadway Lake	Muscooten Bay	Matanzas Lake	Lily Lake	Snicarte Slough	Coal docks	Liverpool Ditch	d.f.	f-value	p-value
							1995						
1	93 (15)			85 (2)							1	0.16	0.694
2	136 (14)			147 (1)							1	0.25	0.624
3	153 (5)			169 (1)							1	0.30	0.612
							1996						
1	61 (5)				75 (7)						1	4.35	0.064
2	114 (4)				132 (3)						1	1.85	0.232
3					150 (2)								
4					171 (1)								
							1997						
1	67 (26)	77 (2)				78 (4)		72 (4)	68 (4)		4	0.71	0.593
2	131 (2)					115 (4)		126 (3)	121 (1)		3	0.49	0.704
3						147 (4)							
4						169 (3)							
							1998						
1							128 (3)						
2							170 (1)						
							2000						
1			86^{a} (35)						61^{b} (8)	76^{ab} (9)	2	7.24	0.002
2			150 (3)						111 (7)	126 (5)	2	2.77	0.102
							2001						
1			125 (6)										
2			164 (1)										

Table 19. Mean total length-at-age (mm) for female bluegill (*Lepomis macrochirus*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sex was not determined in 1993 or 1994. Sample sizes are in parentheses.

	Locations									Tukey's test		
Age	MCB	Lake Chautauqua	Treadway Lake	Muscooten Bay	Matanzas Lake	Lily Lake	Snicarte Slough	Coal docks	Liverpool Ditch	d.f.	f-value	p-vlaue
							1995					
1	78 (8)		70 (7)							1	1.30	0.274
2	125 (8)		115 (3)							1	2.06	0.185
3	164 (3)		132 (1)							1	8.08	0.105
4	180 (2)		154 (1)							1	18.62	0.145
5			179 (1)									
6			189 (1)									
							1996					
1	63 (8)			68 (18)						1	1.05	0.316
2	100^{b} (4)			120^{a} (13)						1	5.51	0.033
3	131 (3)			146 (7)						1	2.34	0.165
4	158 (2)			169 (4)						1	1.52	0.286
5				185 (1)								
							1997					
1	68^{ab} (17)			102^{a} (2)	65^{ab} (3)		73^{ab} (5)	64^{b} (3)		4	2.10	0.111
2	117 (1)			126 (2)	122 (3)		113 (5)	113 (1)		4	0.40	0.804
3				142 (2)	154 (3)		148 (1)			2	0.51	0.645
4				158 (1)	156 (1)							

Table 19. (Continued.)

	Locations									Tukey's test		
Age	MCB	Lake Chautauqua	Treadway Lake	Muscooten Bay	Matanzas Lake	Lily Lake	Snicarte Slough	Coal docks	Liverpool Ditch	d.f.	f-value	p-vlaue
5					173 (1)							
							1998					
1					116 (1)	113 (5)				1	0.05	0.828
2					141 (1)	151 (3)				1	2.08	0.286
3					155 (1)	159 (1)						
4					180 (1)							
5					183 (1)							
							2000					
1		99[a] (1)						61[b] (23)	74[ab] (7)	2	3.50	0.044
2		175[a] (1)						106[b] (19)	112[b] (4)	2	6.12	0.008
3								129 (4)	126 (1)	1	0.01	0.912
4								141 (2)				
							2001					
1		81 (4)										
2		156 (3)										

Table 20. Mean annual growth increment (mm) of bluegill (*Lepomis macrochirus*) in La Grange Pool of the Illinois River. Values with different superscripts indicate significant differences among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations										Tukey's test		
Age	MCB	Bath chute	Lake Chautauqua	Treadway Lake	Muscooten Bay	Matanzas Lake	Lily Lake	Snicarte Slough	Coal docks	Liverpool Ditch	d.f.	f-value	p-value
							1993						
1			47 (41)										
2			33 (9)										
3			31 (2)										
							1994						
1	58 (6)	76 (33)		68 (9)							2	2.73	0.076
2	54 (4)	56 (12)		50 (8)							2	0.56	0.577
3	32 (3)	39 (4)		29 (6)							2	0.65	0.541
4	22 (2)	30 (3)		23 (5)							2	2.09	0.194
5	26 (1)	19 (1)		27 (5)							2	0.42	0.686
							1995						
1	81^{a} (29)			70^{b} (25)							1	4.85	0.032
2	45 (22)			48 (10)							1	0.36	0.554
3	33 (8)			23 (3)							1	2.73	0.133
4	12 (2)			22 (2)							1	10.39	0.084
5				16 (2)									
6				10 (1)									
							1996						
1	61 (17)				67 (25)						1	2.43	0.127
2	45 (8)				52 (16)						1	0.92	0.347
3	36 (3)				24 (9)						1	4.75	0.054
4	26 (2)				19 (5)						1	0.99	0.366
5					13 (1)								

Table 20. (Continued.)

	Locations										Tukey's test		
Age	MCB	Bath chute	Lake Chautauqua	Treadway Lake	Muscooten Bay	Matanzas Lake	Lily Lake	Snicarte Slough	Coal docks	Liverpool Ditch	d.f.	f-value	p-value
							1997						
1	62^{b} (63)	73^{b} (3)			100^{a} (2)	70^{b} (7)		69^{b} (15)	61^{b} (8)		5	3.49	0.006
2	54^{a} (7)				24^{b} (2)	45^{ab} (7)		44^{ab} (8)	50^{a} (2)		4	3.01	0.042
3					16 (2)	32 (7)		38 (1)			2	2.25	0.176
4					19 (1)	20 (4)					1	0.00	0.979
5						17 (1)							
							1998						
1						113 (1)	116 (8)				1	0.07	0.802
2						25 (1)	39 (4)				1	8.24	0.064
3						14 (1)	12 (1)						
4						25 (1)							
5						3 (1)							
							2000						
1			82^{a} (39)						57^{b} (39)	66^{b} (24)	2	21.67	<0.0001
2			73^{a} (4)						48^{b} (27)	53^{b} (9)	2	5.94	0.006
3									36 (4)	42 (1)	1	0.34	0.601
4									24 (2)				
							2001						
1			92 (14)										
2			71 (4)										

Table 21. Mean annual growth increment (mm) in length for bluegill (*Lepomis macrochirus*) in La Grange Pool of the Illinois River. Values with different superscripts indicate significant differences among years ($P < 0.05$). Sample sizes are given beneath each mean.

	Year												Tukey's test		
Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	d.f.	f-value	p-value
1	65^{cd}	63^{cd}	53^{d}	55^{d}	80^{abc}	70^{bcd}	68^{cd}	64^{cd}	90^{ab}	61^{cd}	75^{abcd}	95^{a}	11	9.45	<0.0001
	(8)	(6)	(13)	(57)	(55)	(39)	(35)	(77)	(7)	(35)	(66)	(10)			
2		45^{bc}	37^{c}	41^{bc}	62^{ab}	38^{c}	50^{bc}	49^{bc}	42^{bc}	40^{c}	53^{abc}	71^{a}	10	7.85	<0.0001
		(8)	(6)	(13)	(25)	(31)	(17)	(17)	(5)	(3)	(35)	(4)			
3			21^{ab}	34^{ab}	42^{a}	27^{ab}	29^{ab}	30^{ab}	12^{b}	31^{ab}	41^{a}		8	2.98	0.009
			(8)	(6)	(6)	(14)	(10)	(5)	(1)	(2)	(3)				
4				23	26	19	18	22			24		5	0.92	0.487
				(8)	(4)	(3)	(7)	(5)			(1)				
5					26	8	13	17	3				4	3.83	0.059
					(8)	(1)	(1)	(1)	(1)						
6						10									
						(1)									

Table 22. Mean total length-at-age (mm) for white bass (*Morone chrysops*) for both sexes (and undetermined sex), males, and females in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different with respect to year ($P < 0.05$). Sample sizes are in parentheses.

	Year							Tukey's test		
Age	1994	1995	1996	1997	1998	2000	2001	d.f.	f-value	p-value
					Both sexes					
1	163^{ab} (84)	159^{ab} (43)	148^{bc} (8)	159^{ab} (44)	168^{ab} (10)	128^{c} (65)	189^{a} (22)	6	12.64	<0.0001
2	260^{a} (35)	226^{ab} (41)	204^{bc} (7)	236^{ab} (15)	256^{a} (5)	169^{c} (51)	254^{a} (9)	6	29.36	<0.0001
3	301^{a} (32)	271^{ab} (9)	282^{ab} (5)	289^{a} (8)	275^{ab} (1)	193^{b} (17)	288^{a} (1)	6	17.64	<0.0001
4	320 (18)	333 (2)	322 (1)	336 (6)		259 (3)		4	2.30	0.087
5	362 (1)	360 (1)				409 (1)				
					Males					
1		162^{ab} (23)	144^{b} (6)	161^{ab} (16)	157^{ab} (7)	126^{b} (48)	183^{a} (13)	5	9.61	<0.0001
2		222^{a} (22)	205^{ab} (5)	242^{a} (5)	252^{a} (4)	163^{b} (40)	225^{a} (5)	5	16.30	<0.0001
3		253^{ab} (6)	294^{a} (3)	270^{a} (2)	275^{a} (1)	178^{b} (15)	288^{a} (1)	5	19.79	<0.0001
4						191 (2)				
					Females					
1	170 (2)	155 (18)	159 (2)	158 (28)	195 (3)	141 (14)	198 (9)	6	2.88	0.015
2	273 (2)	230 (18)	200 (2)	233 (10)	272 (1)	189 (11)	290 (4)	6	4.26	0.004
3	300 (2)	323 (2)	263 (2)	295 (6)		302 (2)		4	0.50	0.737
4	313^{b} (2)	339^{ab} (1)	322^{b} (1)	336^{ab} (6)		394^{a} (1)		4	5.14	0.038
5		360 (1)				409 (1)				

Table 23. Mean total length-at-age (mm) for white bass (*Morone chrysops*; both sexes and undetermined sex) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations				Tukey's test		
Age	MCB	Lake Chautauqua	Matanzas Lake	Sc	d.f.	f-value	p-value
				1994			
1	164 (78)			155 (6)	1	0.55	0.459
2	259 (33)			257 (2)	1	0.02	0.892
3	302 (30)			284 (2)	1	1.12	0.298
4	321 (16)			313 (2)	1	0.22	0.647
5	362 (1)						
				1995			
1	160 (42)			148 (1)	1	0.16	0.693
2	227 (40)			213 (1)	1	0.15	0.698
3	269 (8)			290 (1)	1	0.20	0.669
4	333 (2)						
5	360 (1)						
				1996			
1	148 (8)						
2	204 (7)						
3	282 (5)						
4	322 (1)						
				1997			
1	161 (35)		151 (4)	154 (5)	2	0.19	0.824
2	243 (9)		250 (3)	200 (3)	2	1.65	0.233
3	305 (3)		306 (2)	261 (3)	2	1.62	0.286
4	343 (3)		330 (1)	330 (2)	2	0.61	0.599
				1998			
1			168 (10)				
2			256 (5)				
3			275 (1)				
				2000			
1	139^{a} (28)	120^{b} (37)			1	7.39	0.009
2	178 (20)	163 (31)			1	2.81	0.100
3	240 (1)	190 (16)			1	1.02	0.328
4		259 (3)					
5		409 (1)					
				2001			
1		189 (22)					
2		254 (9)					
3		288 (1)					

Table 24. Mean total length-at-age (mm) for male white bass (*Morone chrysops*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations				Tukey's test		
Age	MCB	Lake Chautauqua	Matanzas Lake	Sc	d.f.	f-value	p-value
				1995			
1	163 (22)			148 (1)	1	0.27	0.608
2	223 (22)			213 (1)	1	0.08	0.778
3	245 (5)			290 (1)	1	2.30	0.204
				1996			
1	144 (6)						
2	205 (5)						
3	294 (3)						
				1997			
1	162 (13)		161 (2)	152 (1)	2	0.04	0.963
2	254 (3)		266 (1)	184 (1)	2	0.99	0.504
3			325 (1)	215 (1)			
				1998			
1			157 (7)				
2			252 (4)				
3			275 (1)				
				2000			
1	138[a] (15)	120[b] (33)			1	5.80	0.020
2	183[a] (11)	156[b] (29)			1	11.38	0.002
3		178 (15)					
4		191 (2)					
				2001			
1		183 (13)					
2		225 (5)					
3		288 (1)					

Table 25. Mean total length-at-age (mm) for female white bass (*Morone chrysops*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations				Tukey's test		
Age	MCB	Lake Chautauqua	Matanzas Lake	Sc	d.f.	f-value	p-value
			1994				
1	170 (2)						
2	273 (2)						
3	300 (2)						
4	313 (2)						
			1995				
1	155 (18)						
2	230 (18)						
3	323 (2)						
4	339 (1)						
5	360 (1)						
			1996				
1	159 (2)						
2	200 (2)						
3	263 (2)						
4	322 (1)						
			1997				
1	160 (22)		142 (2)	155 (4)	2	0.25	0.780
2	238 (6)		242 (2)	208 (2)	2	0.44	0.662
3	305 (3)		286 (1)	284 (2)	2	0.56	0.619
4	343 (3)		330 (1)	330 (2)	2	0.61	0.599
			1998				
1			195 (3)				
2			272 (1)				
			2000				
1	137 (12)	162 (2)			1	0.85	0.374
2	172^{b} (9)	264^{a} (2)			1	18.78	0.002
3	240 (1)	363 (1)					
4		394 (1)					
5		409 (1)					
			2001				
1		198 (9)					
2		290 (4)					

Table 26. Mean total length-at-age (mm) for freshwater drum (*Aplodinotus grunniens*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different with respect to year ($P < 0.05$). Sample sizes are in parentheses.

	Year		Tukey's test		
Age	**1992**	**1993**	**d.f.**	**f-value**	**p-value**
1	109 (37)	104 (96)	1	0.36	0.551
2	163[b] (29)	178[a] (79)	1	4.77	0.031
3	206 (21)	220 (59)	1	2.41	0.124
4	239 (13)	253 (39)	1	1.00	0.321
5	271 (12)	283 (26)	1	0.43	0.515
6	280 (8)	286 (16)	1	0.10	0.753
7	284 (3)	296 (9)	1	0.10	0.753
8	319 (2)	292 (7)	1	1.62	0.244
9	342 (2)	308 (7)	1	2.44	0.162
10		320 (6)			
11		330 (5)			
12		347 (5)			
13		360 (4)			
14		372 (4)			
15		384 (4)			
16		402 (2)			
17		414 (2)			
18		421 (1)			
19		429 (1)			
20		438 (1)			
21		446 (1)			

Table 27. Mean total length-at-age (mm) for freshwater drum (*Aplodinotus grunniens*) in La Grange Pool of the Illinois River. Mean lengths with different superscripts were significantly different among locations ($P < 0.05$). Sample sizes are in parentheses.

	Locations			Tukey's test		
Age	**MCB**	**Bath chute**	**BWC**	**d.f.**	**f-value**	**p-value**
			1992			
1	112 (33)	82 (4)		1	0.85	0.364
2	166 (25)	148 (4)		1	1.07	0.310
3	209 (19)	180 (2)		1	1.17	0.294
4	240 (12)	227 (1)		1	0.10	0.762
5	273 (11)	255 (1)		1	0.15	0.709
6	280 (7)	281 (1)		1	0.00	0.973
7	273 (2)	308 (1)		1	14.36	0.164
8	302 (1)	336 (1)				
9	325 (1)	359 (1)				
			1993			
1	101^{b} (74)	128^{a} (14)	85^{b} (8)	2	6.99	0.002
2	178^{ab} (61)	198^{a} (10)	156^{b} (8)	2	4.18	0.019
3	223 (46)	234 (5)	197 (8)	2	2.35	0.105
4	259 (28)	256 (3)	228 (8)	2	1.81	0.179
5	294 (17)	276 (2)	258 (7)	2	1.07	0.359
6	293 (8)	250 (1)	283 (7)	2	0.44	0.654
7	313 (3)	267 (1)	291 (5)	2	0.23	0.800
8	272 (2)	283 (1)	304 (4)	2	0.98	0.452
9	289 (2)	303 (1)	318 (4)	2	0.64	0.573
10	305 (2)	318 (1)	331 (3)	2	0.35	0.731
11	280 (1)	336 (1)	345 (3)	2	15.29	0.061
12	308 (1)	355 (1)	357 (3)	2	13.91	0.067
13	325 (1)	371 (1)	372 (2)	2	5.77	0.282
14	338 (1)	384 (1)	383 (2)	2	5.31	0.293
15	351 (1)	396 (1)	395 (2)	2	3.26	0.365
16		405 (1)	399 (1)			
17		417 (1)	411 (1)			
18			421 (1)			
19			429 (1)			
20			438 (1)			
21			446 (1)			

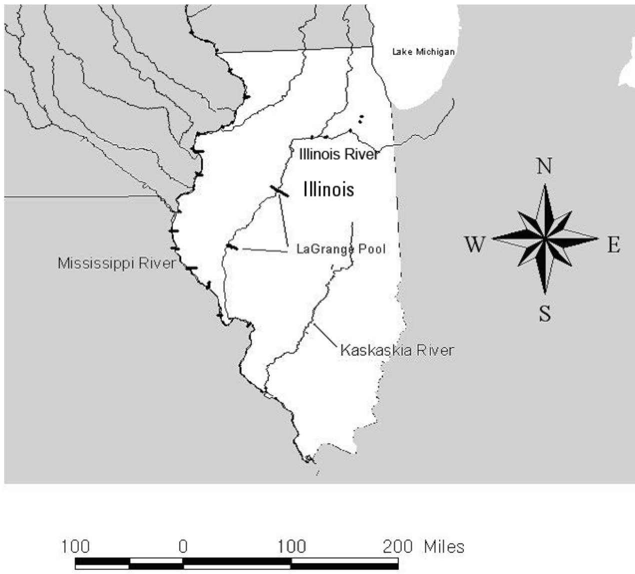


Figure 1. La Grange Pool of the Illinois River located between river kilometers 128.8 and 254.3. River kilometer 0 is located near Alton, Illinois, at the confluence with the Mississippi River.

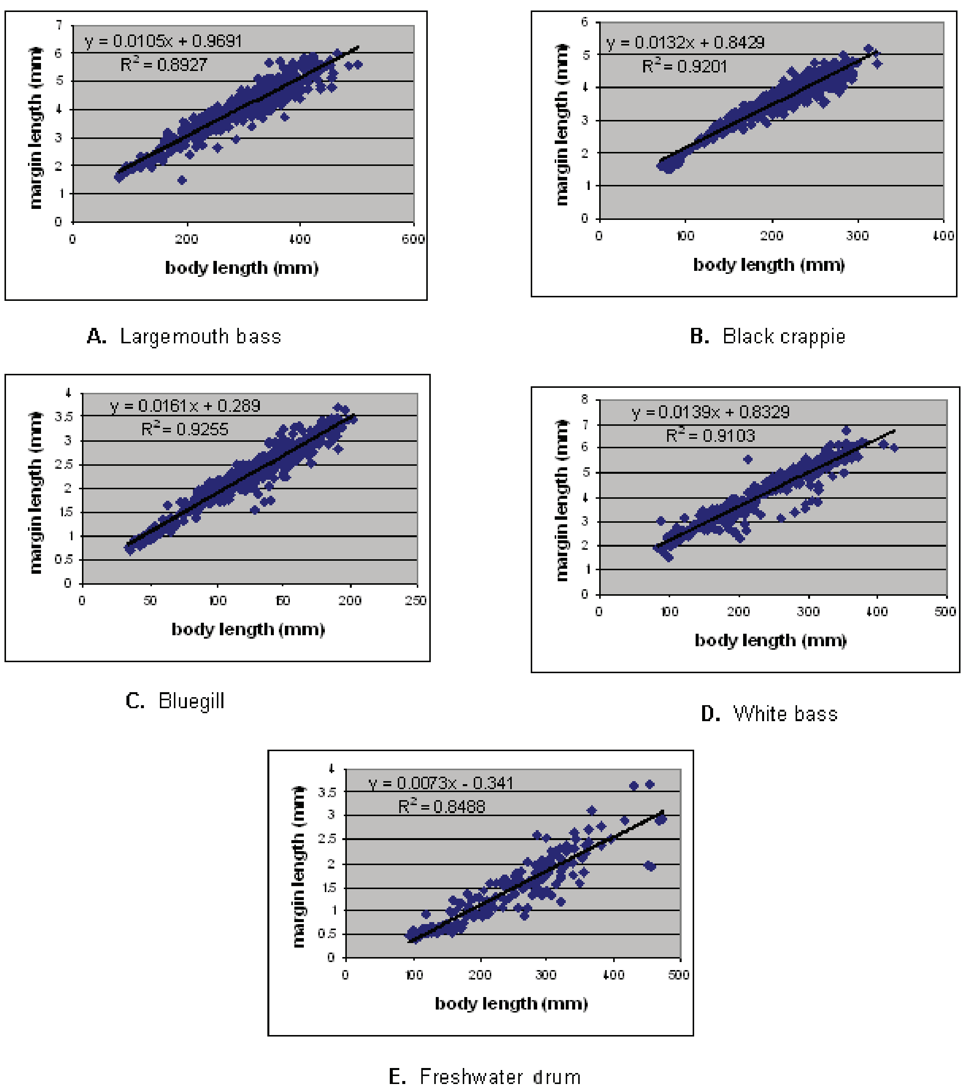


Figure 2. Relation of total body length (mm) and otolith length from focus to margin for (*A*) largemouth bass (*Micropterus salmoides*), (*B*) black crappie (*Pomoxis nigromaculatus*), (*C*) bluegill (*Lepomis macrochirus*), (*D*) white bass (*Morone chrysops*), and (*E*) freshwater drum (*Aplodinotus grunniens*) in La Grange Pool of the Illinois River.

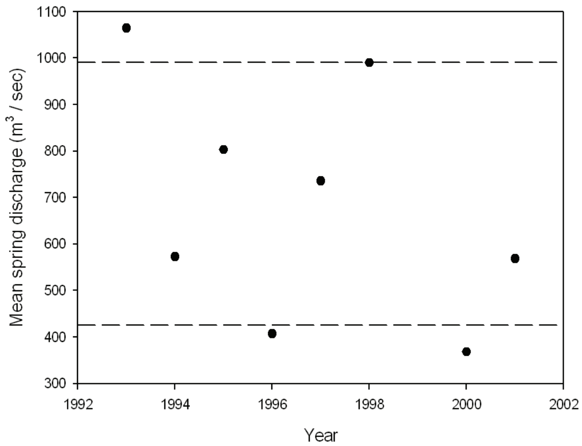
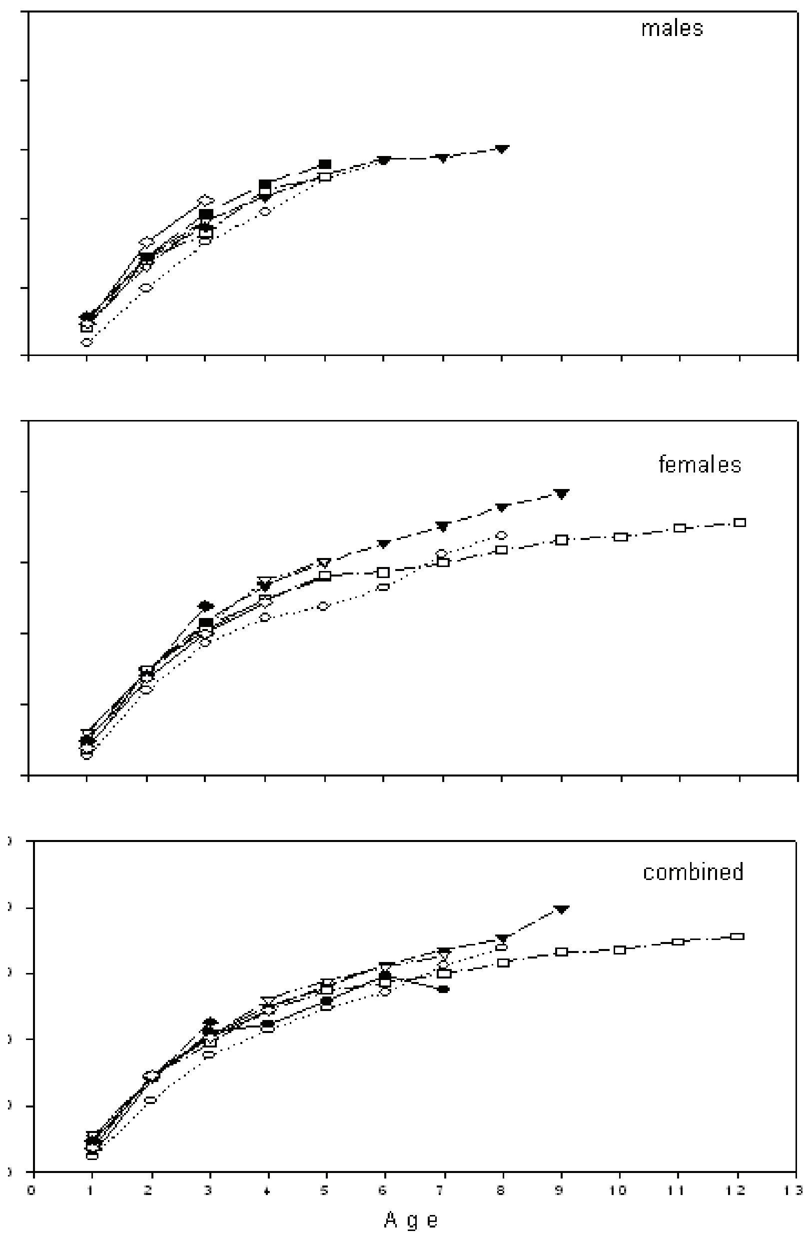


Figure 3. Mean spring discharge of La Grange Pool of the Illinois River. Dashed lines represent “extreme” high and low discharges defined for this study. Extreme discharges occurred in 1993, 1996, 1998, and 2000.



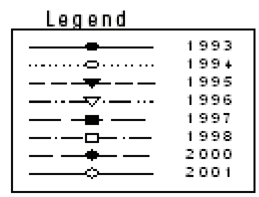


Figure 4. Largemouth bass (*Micropterus salmoides*) mean total length-at-age (mm) for males, females, and combined in La Grange Pool of the Illinois River.

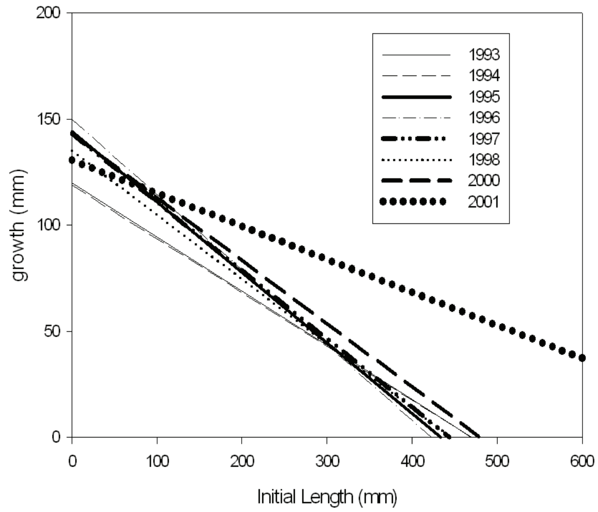


Figure 5. Size specific annual growth in length of largemouth bass (*Micropterus salmoides*) in La Grange Pool of the Illinois River.

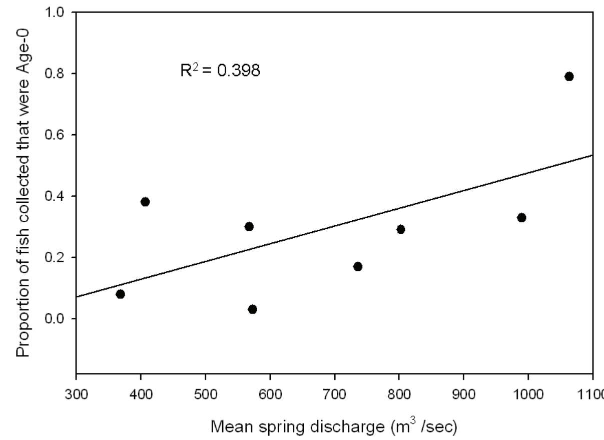


Figure 7. Proportion of largemouth bass (*Micropterus salmoides*) collected that were Age-0 versus mean spring discharge of La Grange Pool of the Illinois River from 1993 to 2001 (without 1999).

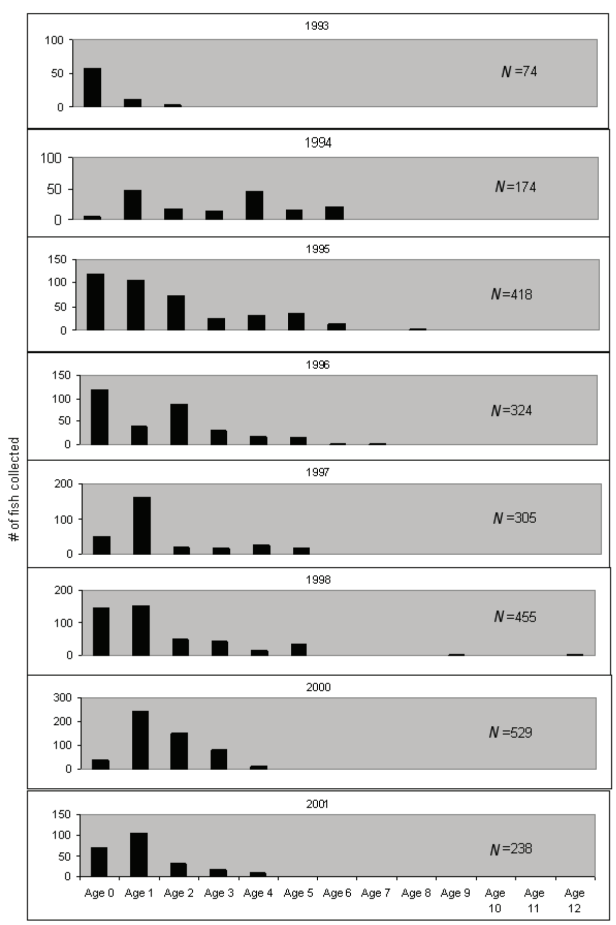


Figure 6. Age-frequency graphs for all largemouth bass (*Micropterus salmoides*) collected for the Long Term Resource Monitoring Program using day electrofishing in La Grange Pool of the Illinois River. Effort is consistent across years. *N* is annual sample size.

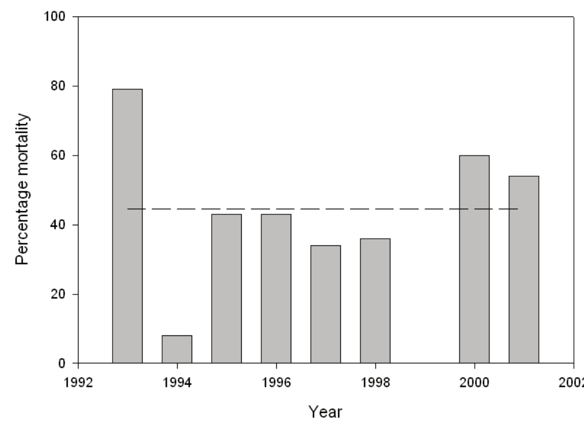


Figure 8. Percent annual mortality of largemouth bass (*Micropterus salmoides*) from 1993 to 2001 (except 1999) in La Grange Pool of the Illinois River. The dashed line represents average mortality for all years.

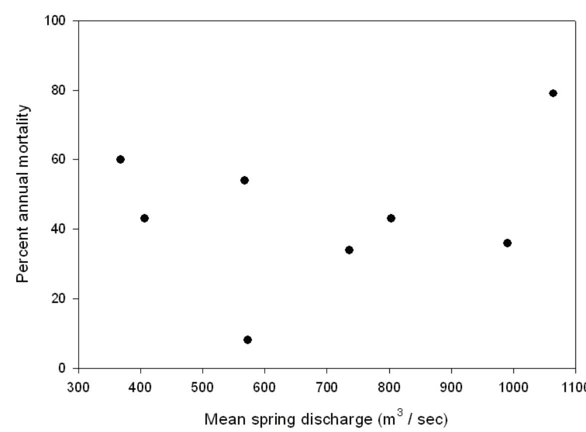


Figure 9. Percent annual mortality of largemouth bass (*Micropterus salmoides*) versus mean spring discharge of La Grange Pool of the Illinois River from 1993 to 2001 (without 1999).

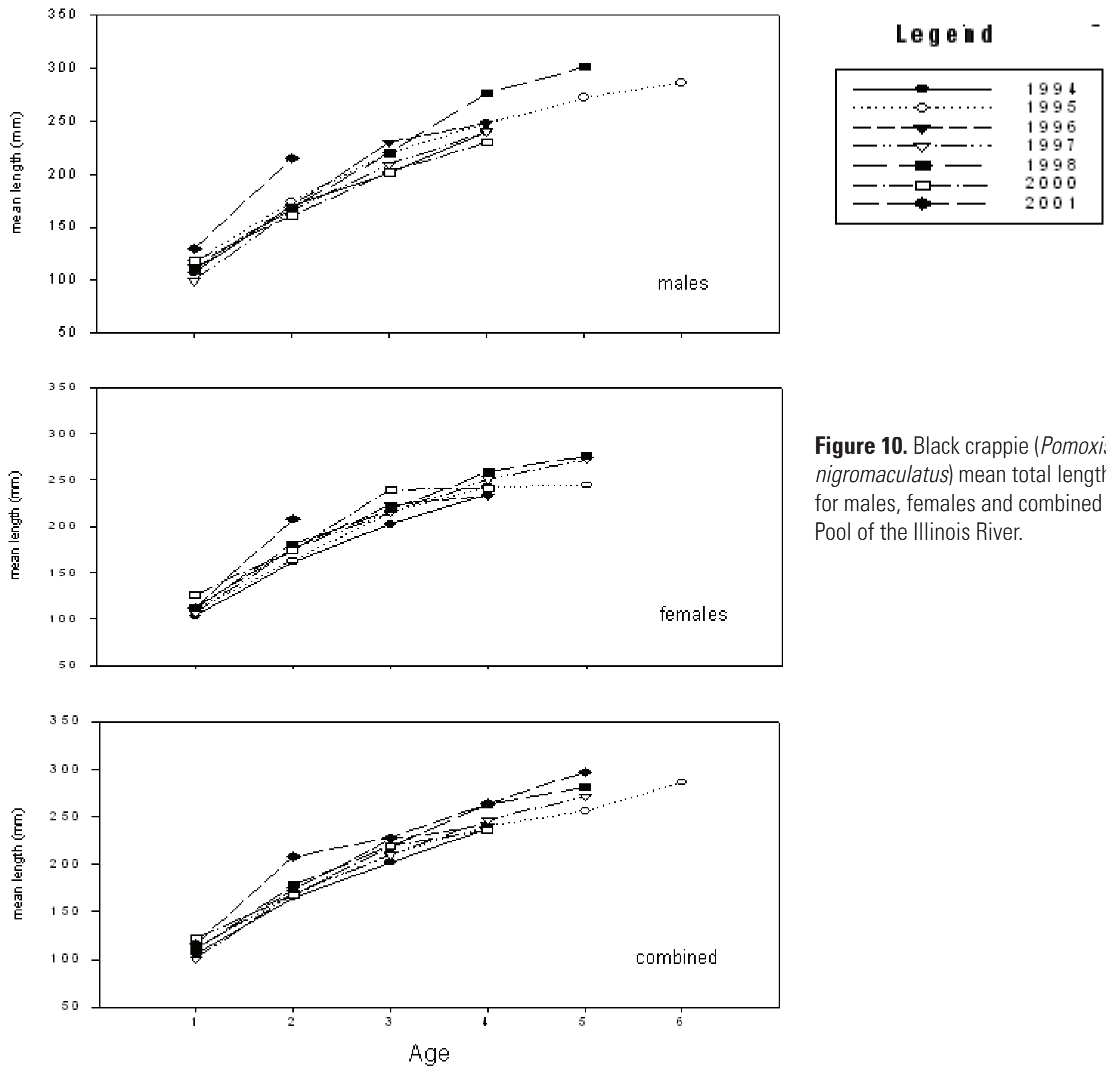


Figure 10. Black crappie (*Pomoxis nigromaculatus*) mean total length-at-age (mm) for males, females and combined in La Grange Pool of the Illinois River.

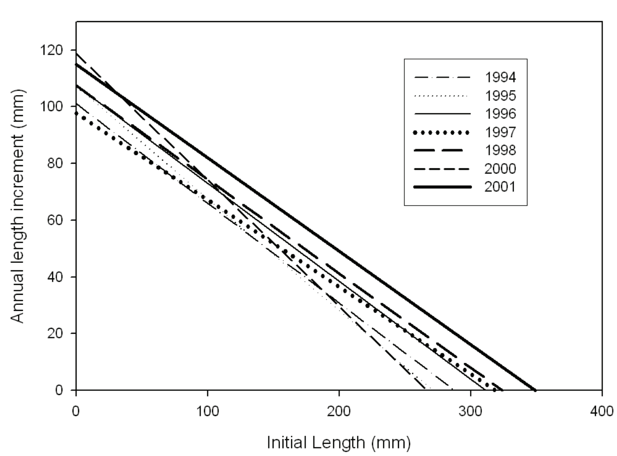


Figure 11. Size specific annual growth in length of black crappie (*Pomoxis nigromaculatus*) in La Grange Pool of the Illinois River.

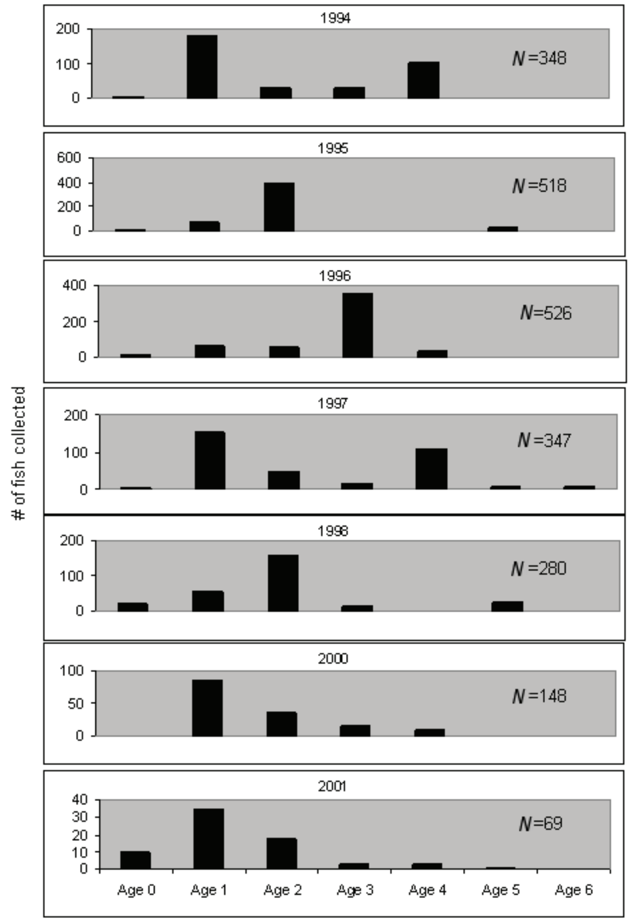


Figure 12. Age-frequency graphs for all black crappie (*Pomoxis nigromaculatus*) collected for the Long Term Resource Monitoring Program using day electrofishing in La Grange Pool of the Illinois River. Effort is consistent across years. *N* is annual sample size.

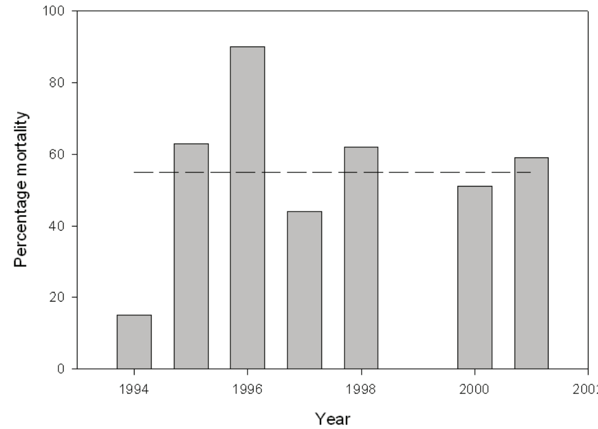


Figure 13. Percent annual mortality of black crappie (*Pomoxis nigromaculatus*) from 1994 to 2001 (except 1999) in La Grange Pool of the Illinois River. The dashed line represents average mortality for all years.

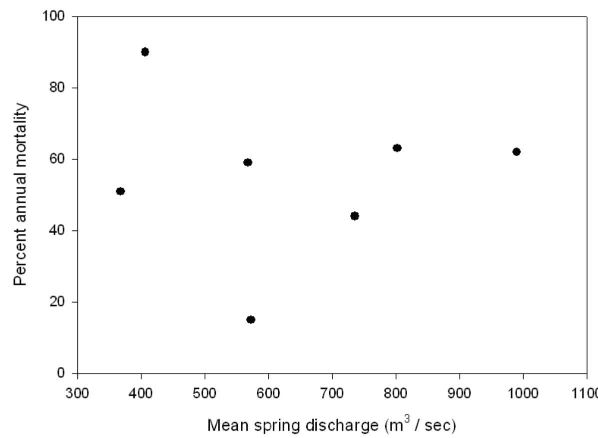
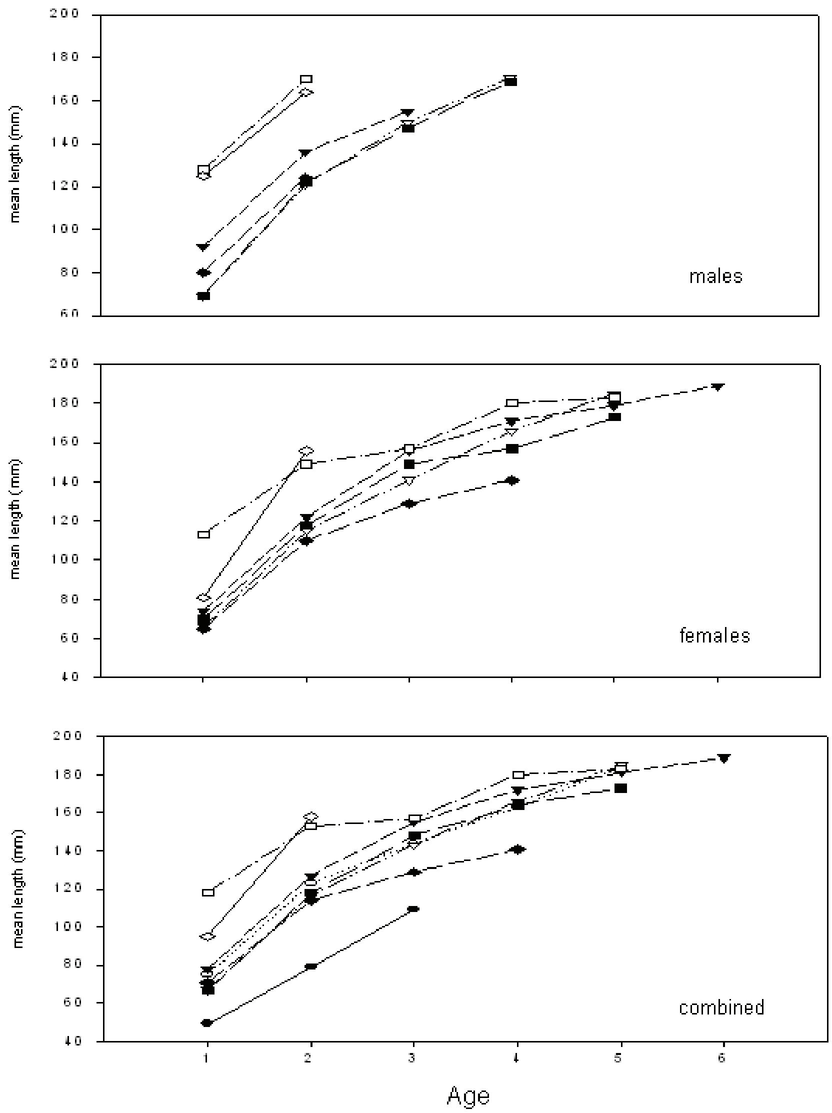


Figure 14. Mean spring discharge versus percent annual mortality of black crappie (*Pomoxis nigromaculatus*) in La Grange Pool of the Illinois River from 1993 to 2001 (without 1999).



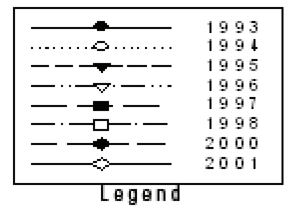


Figure 15. Bluegill (*Lepomis macrochirus*) mean total length-at-age (mm) for males, females, and combined in La Grange Pool of the Illinois River.

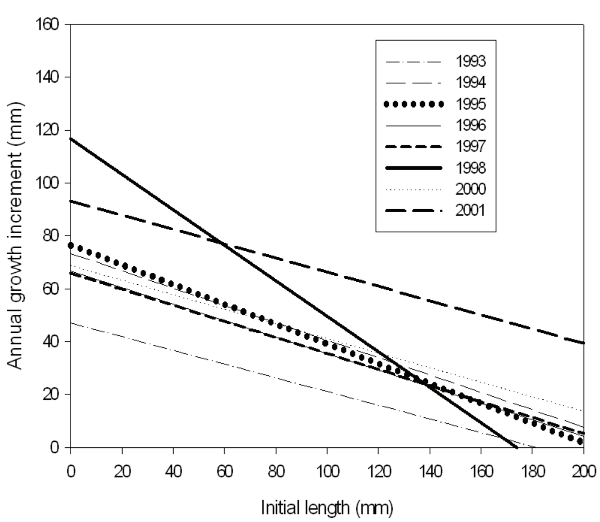


Figure 16. Size specific annual growth in length of bluegill (*Lepomis macrochirus*) in La Grange Pool of the Illinois River.

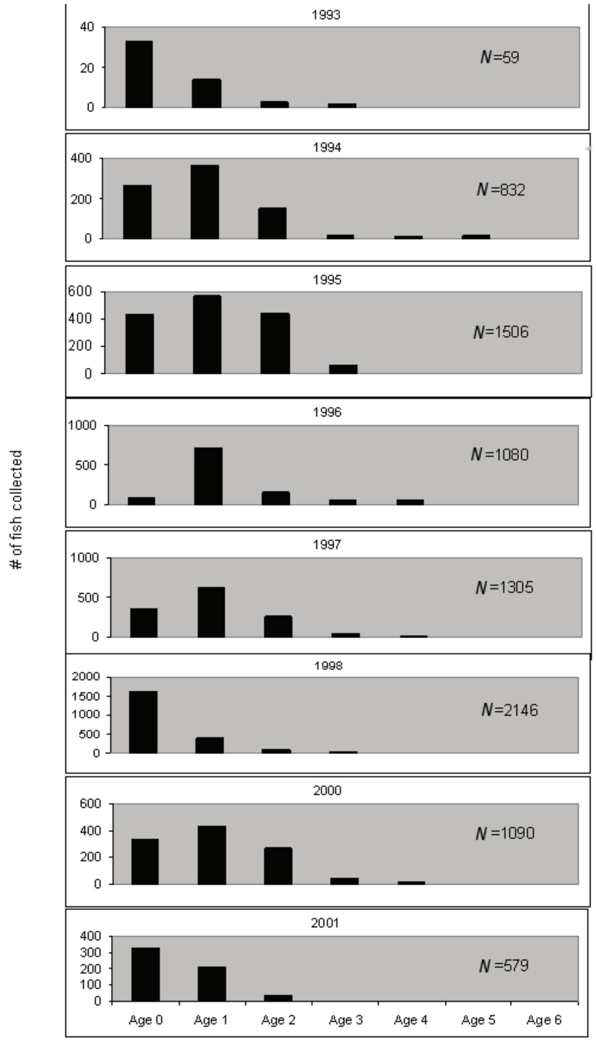


Figure 17. Age-frequency graphs for all bluegill (*Lepomis macrochirus*) collected for the Long Term Resource Monitoring Program using day electrofishing in La Grange Pool of the Illinois River. Effort is consistent across years. *N* is annual sample size.

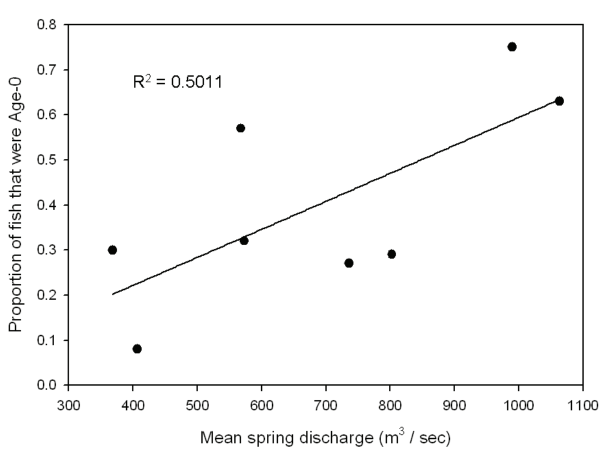


Figure 18. Proportion of Age-0 bluegill (*Lepomis macrochirus*) collected versus mean spring discharge of La Grange Pool of the Illinois River from 1993 to 2001 (without 1999).

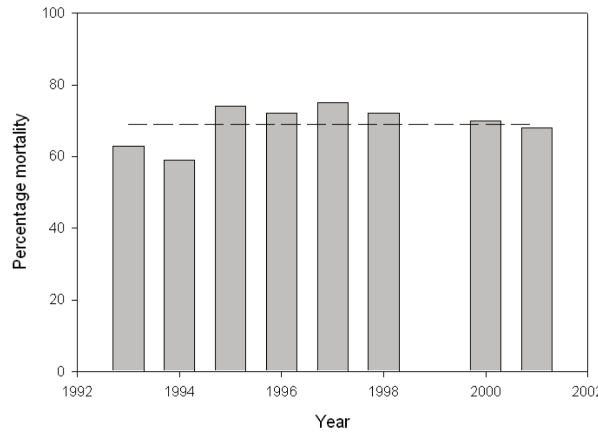


Figure 19. Percent annual mortality of bluegill (*Lepomis macrochirus*) from 1993 to 2001 (except 1999) in LaGrange Pool of the Illinois River. The dashed line represents average mortality for all years.

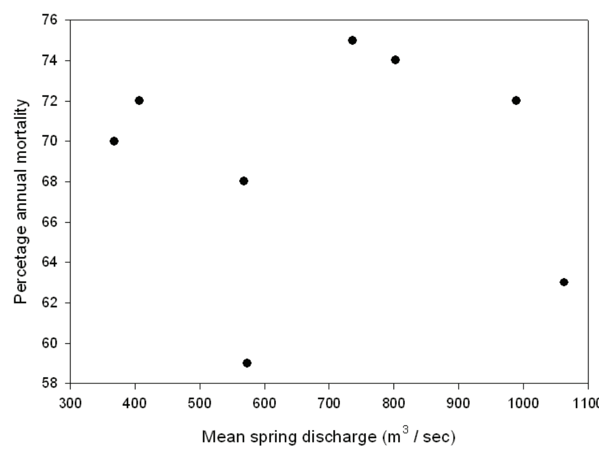


Figure 20. Percent annual mortality of bluegill (*Lepomis macrochirus*) versus mean spring discharge of La Grange Pool of the Illinois River from 1993 to 2001 (without 1999).

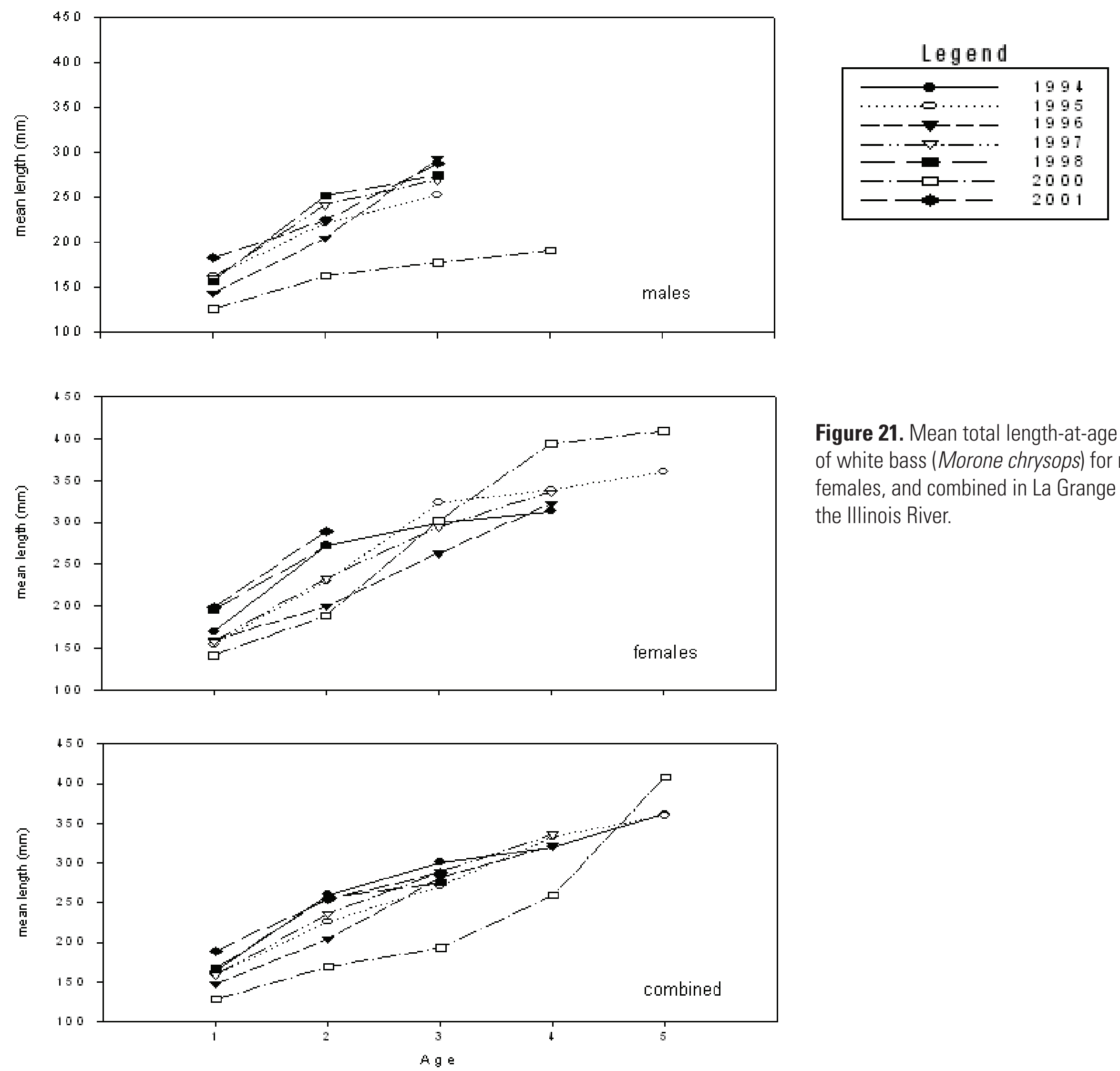


Figure 21. Mean total length-at-age (mm) of white bass (*Morone chrysops*) for males, females, and combined in La Grange Pool of the Illinois River.

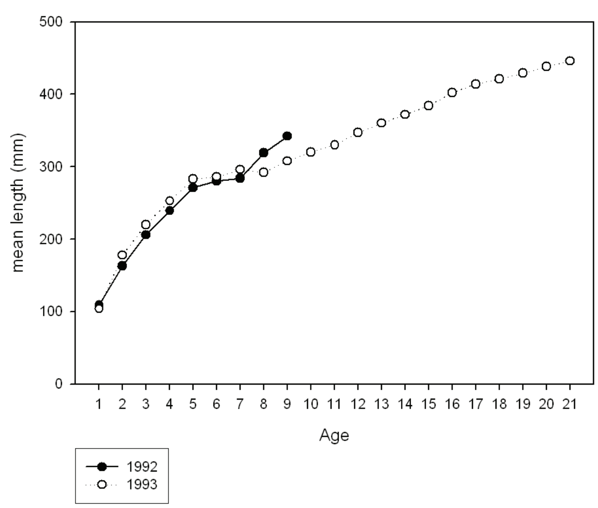


Figure 22. Mean total length-at-age (mm) of freshwater drum (*Aplodinotus grunniens*) in La Grange Pool of the Illinois River.

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE June 2007	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE Analysis of fish age structure and growth in the Illinois River	5. FUNDING NUMBERS
6. AUTHOR(S) Michael A. Smith[1], Mark A. Pegg[2], and Kevin S. Irons[3]	
7. PERFORMING ORGANIZATION NAME AND ADDRESS [1]Illinois State Water Survey-Peoria Office, Center for Watershed Science, 1320 S.W. Monarch, Peoria, Illinois 61652 [2]School of Natural Resources, University of Nebraska-Lincoln, 12 Plant Industry, Lincoln, Nebraska 68583 [3]Illinois Natural History Survey, Illinois River Biological Station, 704 N. Schrader, Havana, Illinois 62644	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Geological Survey Upper Midwest Environmental Sciences Center 2630 Fanta Reed Road La Crosse, Wisconsin, 54603	10. SPONSORING/MONITORING AGENCY REPORT NUMBER 2007-T002

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT Release unlimited. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (1-800-553-6847 or 703-487-4650). Also available to registered users from the Defense Technical Information Center, Attn: Help Desk, 8725 Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218 (1-800-225-3842 or 703-767-9050).	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Abstract: Otoliths and other calcified structures have been used to age and determine growth rates of fish from a variety of habitats. Sagittal otoliths were removed from fishes representing five species from La Grange Pool of the Illinois River for age determination. Species collected included largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), white bass (*Morone chrysops*), and freshwater drum (*Aplodinotus grunniens*). Common univariate techniques were used to analyze the significance of spatial and temporal variation in growth and back-calculated mean length-at-age for all five species.

14. SUBJECT TERMS Age structure, growth, Illinois River, La Grange Pool, otolith	15. NUMBER OF PAGES 55 pp.
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

Analysis of Fish Age Structure and Growth in the Illinois River 2007-T002

The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.