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Effects of Annual Flow Regime on Redbreast Sunfish and Bluegill Growth in a  
Southeastern Coastal Plain Stream.

(Under the Direction of STEPHEN W. GOLLADAY)

Recent interest in restoring the connectivity of rivers and their floodplains has highlighted our lack of knowledge about the effects of flooding and drought on fishes. Three statistical models for testing the effects of annual flow regime on fish growth, estimated from sagittal otolith annuli, were compared. Redbreast sunfish (*Lepomis auritus*) and bluegill (*Lepomis macrochirus*), were electroshocked and angled from Ichawaynochaway Creek, a fifth order black-water stream on the Gulf Coastal Plain. Annual differences in growth were detected for age 1 bluegill and ages 1-3 redbreast sunfish, but two of the statistical models were confounded by significant interactions with fish age. In the third model, both species exhibited enhanced growth during low flow conditions at age 1 while age 2 redbreast sunfish growth correlated positively with high flow variables. Instream flow should be managed for a variety of annual flow regimes to allow satisfactory growth of all age classes.

INDEX WORDS: Age, Growth, Redbreast sunfish, Bluegill, Instream flow,  
Ichawaynochaway Creek, Otolith

EFFECTS OF ANNUAL FLOW REGIME ON REDBREAST SUNFISH AND  
BLUEGILL GROWTH IN A SOUTHEASTERN COASTAL PLAIN STREAM

by

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## CHAPTER 1

### INTRODUCTION

In light of current controversies over instream flow management, which threaten to lower water levels and further disconnect rivers from their floodplains, more information is needed about the importance of flow regime to fishes. Recently in Georgia, issues of water allocation have been controversial because of the much-publicized inter-state negotiations over water in the Apalachicola-Chattahoochee-Flint basin, or the so-called “Tri- State Water Wars”. Additionally, southwest Georgia is a major agricultural area where large groundwater withdrawals occur for irrigation. With so many demands for water, knowing how best to manage water resources is often difficult. Current management plans in the region focus on low flow levels or the minimum amount of water to be left in a system, but little attention is given to the effects of flood prevention on aquatic flora and fauna that are adapted to seasonal floods.

One reason for this scarcity of information is that the response of fishes to different flow regimes is difficult to measure. Evaluations of instream flow management options often concentrate on the presence or absence of high quality habitats for certain species (Bovee, 1982; Reiser et al., 1989), but often do not address other factors, such as water quality, predator/prey interactions, competition, or disease, that may be affected by changes in instream flows,. Habitat-based models of instream flow effects often use a measure of habitat suitability that is based on species abundances in specific habitat types, rather than quantifying effects of flow or habitat changes on individual performance (e.g., growth or reproductive success). Growth provides an assessment of overall habitat suitability that can be used to evaluate management techniques because it integrates the effects of water chemistry, food availability, and physiological conditions on individual fish (Murphy and Willis, 1996). However, studies of the relationships

between environmental conditions and growth of warmwater stream fishes are scarce (Putman, 1995).

One hypothesis that may help to explain the relationship between fish growth and instream flow is Junk's (1989) Flood Pulse Concept (FPC). The FPC predicts that fishes in rivers with predictable and prolonged annual flooding will adapt to be able to use floodplain productivity. In fact, this concept assumes that "...the overwhelming bulk of the riverine animal biomass derives directly or indirectly from production within the floodplain and not from downstream transport of organic matter produced elsewhere in the basin (Junk et al., 1989, p.112)." Thus the growth and reproduction of fishes in these systems is dependent on sufficient instream flows to provide access to the floodplain. In systems without predictable and prolonged flooding, the FPC predicts that aquatic organisms will not adapt to take advantage of flooded areas and will react to floods as catastrophic events that "reset the physical and biological environment (Junk et al. 1989, p.116)." The distinction between a river with a predictable pulse of long duration and one with short and unpredictable pulses has not been quantitatively defined. Thus the biological importance of flooding and the question of what process(es) dominates production in mid-sized temperate rivers remains unanswered.

As an explanation of variations in annual fish growth, the FPC has been supported in large tropical systems (e.g., Holden, 1963; Dudley, 1974; Krykhtin, 1975; Welcomme, 1979), but evidence from temperate and subtropical systems is scarce and frequently conflicting. Quist and Guy (1999) reported that greater than average growth for channel catfish (*Ictalurus punctatus*) in the Kansas River at Fort Riley, Kansas was positively correlated with increased mean annual discharge. Similarly, in the Des Moines River, Iowa, channel catfish grew more slowly during drought years (Carlander, 1969). On the Yockanookany River, Mississippi, channel catfish caught in sections of the river that were coupled with the floodplain were larger than those from sections that were decoupled from the floodplain, which suggests greater growth in areas with access to the

floodplain (Flotemersch, 1996). Bluegill and largemouth bass growth in the upper Mississippi River was greater in a year with substantial warm-season flooding than during low-water years (Gutreuter et al., 1999).

Some studies have found that fish respond to fluctuations in water levels differently at different life stages. In the upper Mississippi River, largemouth bass and bluegill growth responses were dependent on body size, reflecting ontogenetic niche differences (Gutreuter et al., 1999). Largemouth bass in the 150 mm size class grew 73% less during a low water year than a high water year, whereas age 0 largemouth bass growth was not related to flow. Bluegill growth was greatest during the flood year for 20-50mm fish. Paragamian and Wiley (1987) suggested an even more complicated relationship: in the Maquoketa River, Iowa, instantaneous growth rates of age 1 smallmouth bass increased with increasing seasonal discharge up to an optimum level of  $10 \text{ m}^3 \text{ s}^{-1}$ , beyond which growth declined again. Annual growth among fish age 2-4 did not respond to changes in water levels.

Still other studies have shown that the FPC may not be applicable in temperate and sub-tropical rivers. Rutherford et al. (1995) found that blue catfish, channel catfish, and gizzard shad growth in the lower Mississippi River was not related to the extent or duration of annual flooding, although freshwater drum growth was positively related to the extent of inundation. Mayo (1999) also found that growth of blue catfish, channel catfish, and flathead catfish from the lower Mississippi River did not correlate with the extent of floodplain inundation. Channel catfish growth was also not correlated with water levels in the upper Mississippi River (Helms, 1975). Growth of rock bass, bluegill, largemouth bass, smallmouth bass, and channel catfish in Illinois streams were unrelated to discharge, stream depth, and stream width (Putman et al., 1995).

Clearly, the FPC does not consistently explain the relationship between fish growth and water level in temperate and subtropical streams, but the reason for its failure is unclear. Are studies that refute the FPC conducted on rivers that do not meet the

requirements of predictable and extended annual floods? Does the theory only apply to rivers with extremely large floodplains, such as large tropical rivers? Have human activities in many temperate and subtropical watersheds altered floodplains to the extent that they no longer support their natural functions? Is the fundamental mechanism of the FPC, the breakdown and recycling of organic matter and nutrients resulting in high floodplain productivity, simply not as important to fish growth as Junk et al. (1989) proposed?

The purpose of this study was to test the hypothesis that, as the FPC suggests, annual fish growth is greater during flood years than drought years in a mid-sized stream with an average of 22 days a year of overbank flooding, typically in the early spring, and also to provide managers with specific information about the response of southeastern coastal plain fishes to fluctuations in instream flow. Other researchers have used widely varying statistical approaches to examine the effects of environmental conditions on growth (e.g., Paragamian and Wiley, 1987; Maceina, 1992; Weisberg, 1993; Gutreuter et al., 1999) and there does not appear to be a common consensus as to which model is best. In this study, three of these statistical models were used to compare annual growth estimates derived from otoliths.

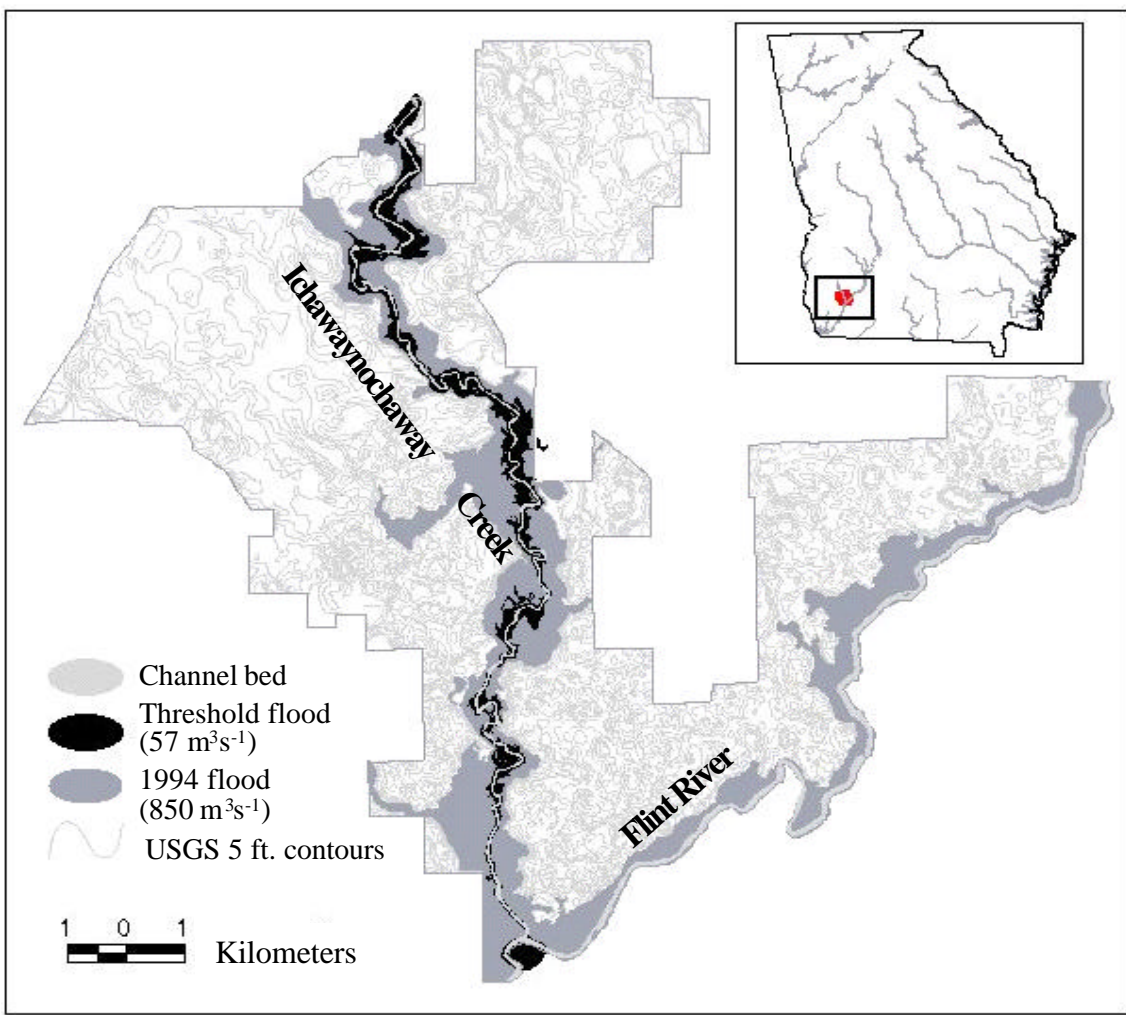
## CHAPTER 2

### METHODS

#### Site Description

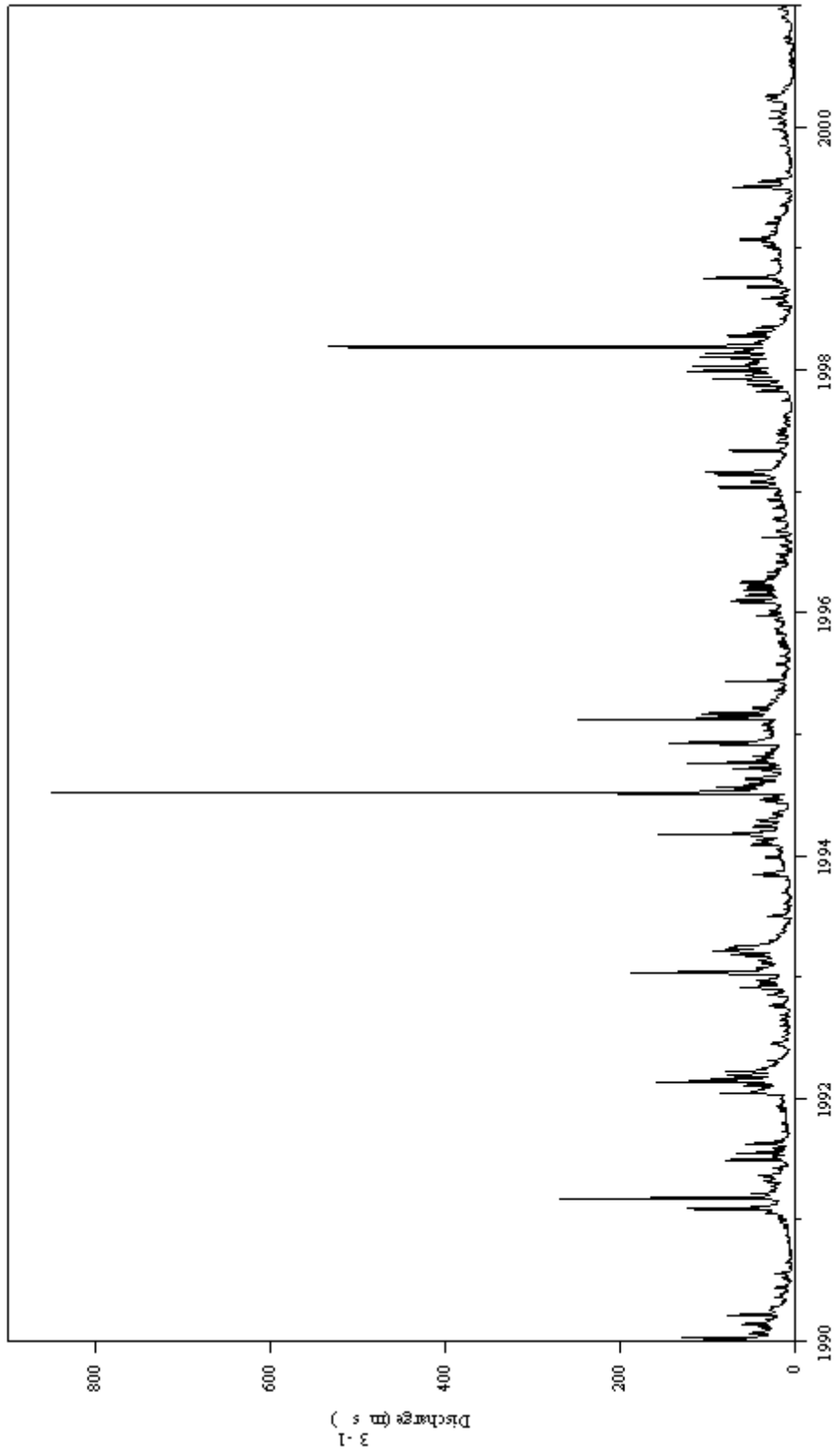
The study was conducted at the Ichauway Ecological Reserve on the Gulf Coastal Plain in Baker County, southwest Georgia (Figure 1). Fish were taken from Ichawaynochaway Creek, a fifth-order, black-water tributary of the Flint River that originates in a headwater swamp forest and flows over the Dougherty Plain. Ichawaynochaway Creek has experienced relatively little direct human disturbance; the lower portions of the watershed consist mostly of forests and the watershed upstream is dominated by agricultural fields in the uplands and largely intact riparian zones in the stream valley (Golladay and Battle, 2001). Morphological features of the riparian zone include relatively limited, low lying floodplain areas interspersed among sand ridges and lower riparian terraces (Palik et al., 1998). Ichawaynochaway Creek has a drainage area of about 2700 km<sup>2</sup>. The upper portion of the creek has a broad floodplain, with a floodplain to channel ratio of > 50:1; the lower portion of the creek is constrained, with some deeply incised limestone sections where the floodplain to channel ratio approaches 1:1 (Golladay et al., 2000). Within the main channel, sandy runs alternate with limestone shoals and deeper pools. Significant inputs of groundwater can occur, especially under baseflow conditions (Hicks, Gill, and Longworth, 1995).

Average annual discharge in Ichawaynochaway Creek is 22 m<sup>3</sup>s<sup>-1</sup> (Alhadeff et al., 1999) with typical low summer/fall flows and moderate winter/early spring floods (Figure 2). Since 1940, overbank flooding, or a flow of at least 56.64 cms<sup>-1</sup> at the USGS gaging station in Milford, GA (#02353500), has occurred an average of 22 days per year. The last six years in southwest Georgia encompass a wide variety of flow regimes, from the 1999-2001 drought to the two largest floods on record in 1994 and 1998, to more



**Figure 1**

Location and extent of floodplain inundation along Ichawaynochaway Creek on the Ichauway Ecological Reserve, Baker County, GA. “Channel bed” is the area inundated during within – bank flows and “Threshold flood” is the minimum level of inundation defined as a flood event. “1994 flood” is the largest flood on the historic record.



**Figure 2**  
Ichawynochaway Creek average daily discharge at Milford, GA, 1990 - 2000.

typical seasonal floods from 1995 to 1997. This broad range of flow conditions within a few years created an ideal situation to investigate the effects of natural variations in streamflow on local fishes.

### Environmental Variables

Discussions of streamflow indices often focus on grouping streams into ecologically significant classes; many of these same indices can be used as indicators of interannual variability within a single stream. Indices were chosen to reflect several ecologically significant aspects of streamflow (Clausen and Biggs, 1997; Richter et al., 1997; Gan et al., 1991; Poff et al., 1997):

- 1) measures of the central tendency and variability,
- 2) high and low flow indices, and
- 3) temperature indices.

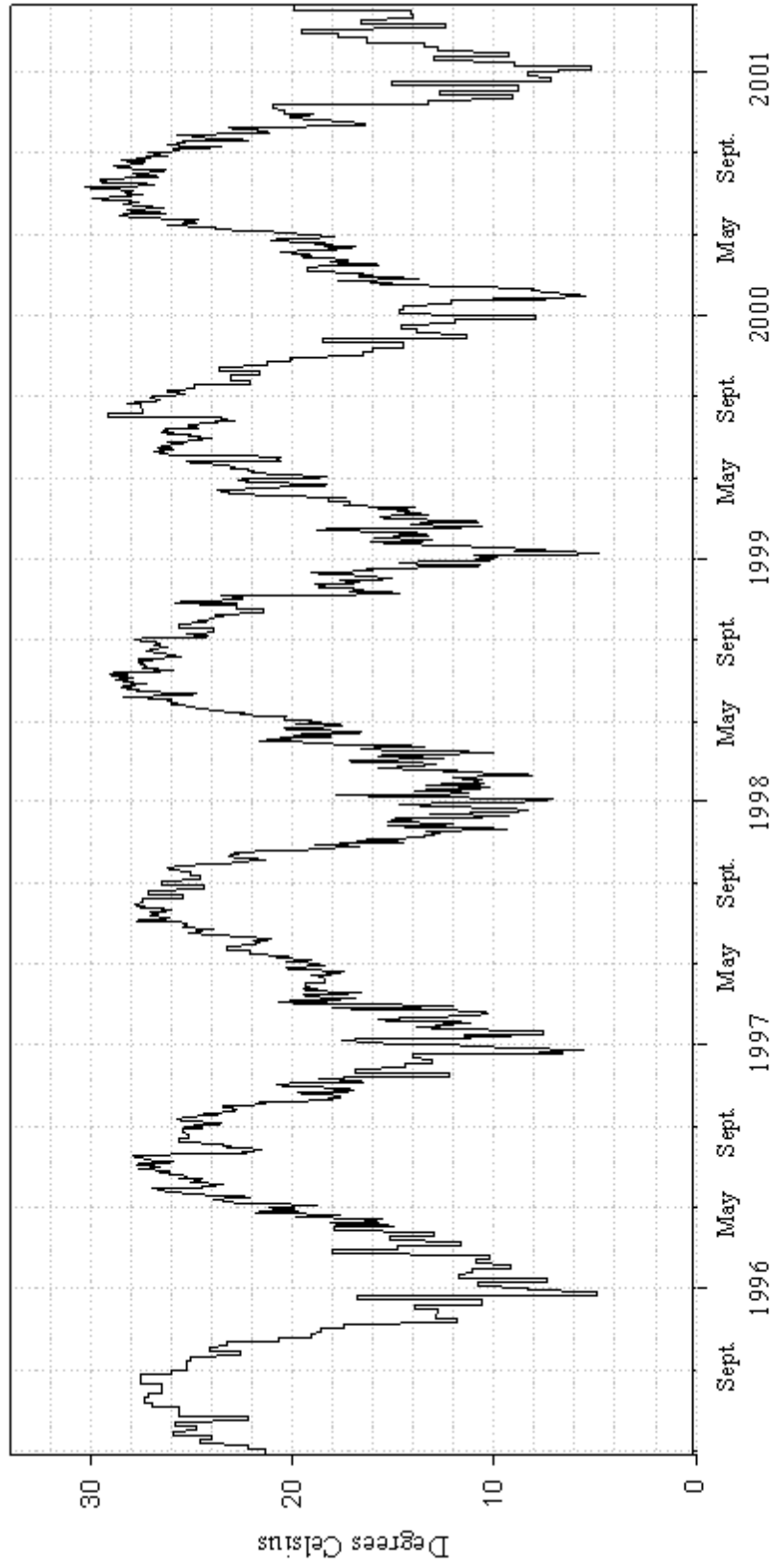
All flow indices were based on average daily discharge records from the USGS gaging station on Ichawaynochaway Creek at Milford, GA (USGS station #02353500), located about 16 km upstream from the Ichauway Ecological Reserve.

Measures of the central tendency and variability were chosen based on variables used by Clausen and Biggs (1997). The mean (MEAN) and median (MED) annual discharge, annual sum of the average daily discharges (SUMQ), and 25<sup>th</sup> (P25) and 75<sup>th</sup> (P75) percentile flows were calculated to represent average flow conditions. Measures of variability included skewness (SKEW), the coefficient of variation (CV), variance (VAR), and constancy (CONST). To calculate constancy, discharge was natural log transformed and divided into 6 “states”, or classes, from -3 to +2. The number of days per year that average daily flow fell within each state was then used to calculate CONST, or “...the degree of uniformity among states...” (Gan et al., 1991) for each 12 month period.

High flows were represented by the maximum discharge (MAX), the 99<sup>th</sup> (P99), 95<sup>th</sup> (P95), and 90<sup>th</sup> (P90) percentile annual flows (Clausen and Biggs, 1997), the frequency and duration of flood events greater than three (FRE3, DUR3), and five (FRE5, DUR5) times the historic mean (Clausen and Biggs, 2000), and the number of days (NOVER) and annual sum of average daily discharges (SUMOVER) during periods of overbank flow (Mayo, 1999). Overbank flow was estimated with the elevation of significant overbank flooding from the USGS 7.5 minute topographic quadrangle for Elmodel, Baker County, Georgia. A stage height of 3 meters at the Elmodel, GA gaging station located on Jones Center property (USGS station #02354800) was chosen as representative of significant overbank flooding in the study area. Using this information and the USGS rating curve for Ichawaynochaway Creek at Elmodel, a discharge of 85 m<sup>3</sup>s<sup>-1</sup> at Elmodel, or 57 m<sup>3</sup>s<sup>-1</sup> at the Milford station, was chosen as the threshold for significant overbank flooding, or the minimum discharge that constitutes a flood event. Figure 1 delineates the approximate area flooded on the Ichauway Ecological Reserve because of a flood of this level as well as the area inundated by the largest flood on record and the area occupied by stream channel itself.

Low flow variables included the minimum discharge (MIN), 1<sup>st</sup> (P1), 5<sup>th</sup> (P5), and 10<sup>th</sup> (P10) percentile flows, and the number of days (NUNDER) and sum of average daily discharges (SUMUNDER) during periods of within-bank flow.

Average daily water temperatures for 1997-2000 in Ichawaynochaway Creek were measured with a Hydrolab Datasonde 3 or Hydrolab Datasonde 4 on the Ichauway Ecological Reserve in Newton, GA (Figure 3). For days with missing data, including all of 1995 - 1996, water temperature was estimated from air temperatures obtained from the Georgia Environmental Monitoring Network website for Newton, GA (<http://www.griffin.peachnet.edu>). A linear relationship ( $r^2 = 0.929$ ,  $p < .0001$ ) between weekly average air temperature and weekly average water temperature was established



**Figure 3**

Ichawanochoaway Creek average daily water temperatures measured instream or estimated from air temperatures.

with data for 1997-2000 (Erickson, 2000) and used to fill in missing data points with estimated water temperatures:

$$T_{\text{water}} = 3.2699 + 0.8730 * T_{\text{air}} \quad (1)$$

Days when average daily temperature reached or exceeded 20 °C were considered part of the growing season based on observations of growth rates and water temperature at time of annulus formation in redbreast sunfish and bluegill in other studies (e.g. Carlander, 1977; Coutant, 1977; Lemke, 1977; Tyus and Nikirk, 1990).

Indices of interannual temperature variation included the number of degree days over 20 °C (DEGDAY), number of degree days over 20 °C during overbank flood events (DEGDAYFL), and the number of days of overbank flooding during which water temperature equaled or exceeded 20 °C (DAYFLHOT) (Mayo, 1999).

In all, 28 annual environmental indices were calculated for 1995-2000. A description of each index can be found in Table 1. A correlation matrix of all 28 variables was examined and several groups of intercorrelated variables were apparent. One variable from each intercorrelated group was arbitrarily chosen as a representative variable such that the final dataset included six independent environmental variables (Table 2).

### Fish Sampling

Five fish species were chosen to represent different habitat guilds: two backwater/channel margin species (redbreast sunfish (*Lepomis auritus*) and bluegill (*Lepomis macrochirus*)), a shoal specialist (shoal bass (*Micropterus cataractae*)), a pool and run species (largemouth bass (*Micropterus salmoides*)), and a benthic species (channel catfish (*Ictalurus punctatus*) (Jenkins and Burkhead, 1994). Fish were collected at various locations on the Ichauway Ecological Reserve by electroshocking, angling, and on trot lines from June 2000 to May 2001. After capture, fish were euthanized and placed on ice for further processing.

*Table 1.* Descriptions of the environmental indices used to quantify the flow regime in Ichawaynochaway Creek. All variables were calculated from average daily discharge data obtained from the USGS gaging station at Milford, GA.

Index Name	Units	Description
VAR	$\text{m}^3\text{s}^{-1}$	variance of the annual streamflow
CV	unitless	coefficient of variation of the annual streamflow
SKEW	unitless	skewness of the annual streamflow
CONST	unitless	constancy
SUMQ	$\text{m}^3\text{s}^{-1}$	sum of the annual discharge
MAX	$\text{m}^3\text{s}^{-1}$	maximum annual discharge
P99	$\text{m}^3\text{s}^{-1}$	99th percentile discharge
P95	$\text{m}^3\text{s}^{-1}$	95th percentile discharge
P90	$\text{m}^3\text{s}^{-1}$	90th percentile discharge
P75	$\text{m}^3\text{s}^{-1}$	75th percentile discharge
MEAN	$\text{m}^3\text{s}^{-1}$	mean annual discharge
MEDIAN	$\text{m}^3\text{s}^{-1}$	median annual discharge
P25	$\text{m}^3\text{s}^{-1}$	25th percentile discharge
P10	$\text{m}^3\text{s}^{-1}$	10th percentile discharge
P5	$\text{m}^3\text{s}^{-1}$	5th percentile discharge
P1	$\text{m}^3\text{s}^{-1}$	1st percentile discharge
MIN	$\text{m}^3\text{s}^{-1}$	minimum annual discharge
FRE3	# events	frequency of flood events at least 3 times the historic mean discharge
FRE5	# events	frequency of flood events at least 5 times the historic mean discharge
DUR3	days	average duration of flood events at least 3 times the historic mean discharge
DUR5	days	average duration of flood events at least 5 times the historic mean discharge
NOVER	days	number of days of overbank flooding
NUNDER	days	number of days of within - bank flow
SUMOVER	$\text{m}^3\text{s}^{-1}$	sum of daily discharge s during overbank flow
SUMUNDER	$\text{m}^3\text{s}^{-1}$	sum of daily discharge s during within - bank flow
DEGDAY	degree days	number of degree days over 20 °C per year
DEGDAYFL	degree days	number of degree days over 20 °C during overbank flood conditions
DAYFLHOT	days	number of days over 20 °C during overbank flood conditions

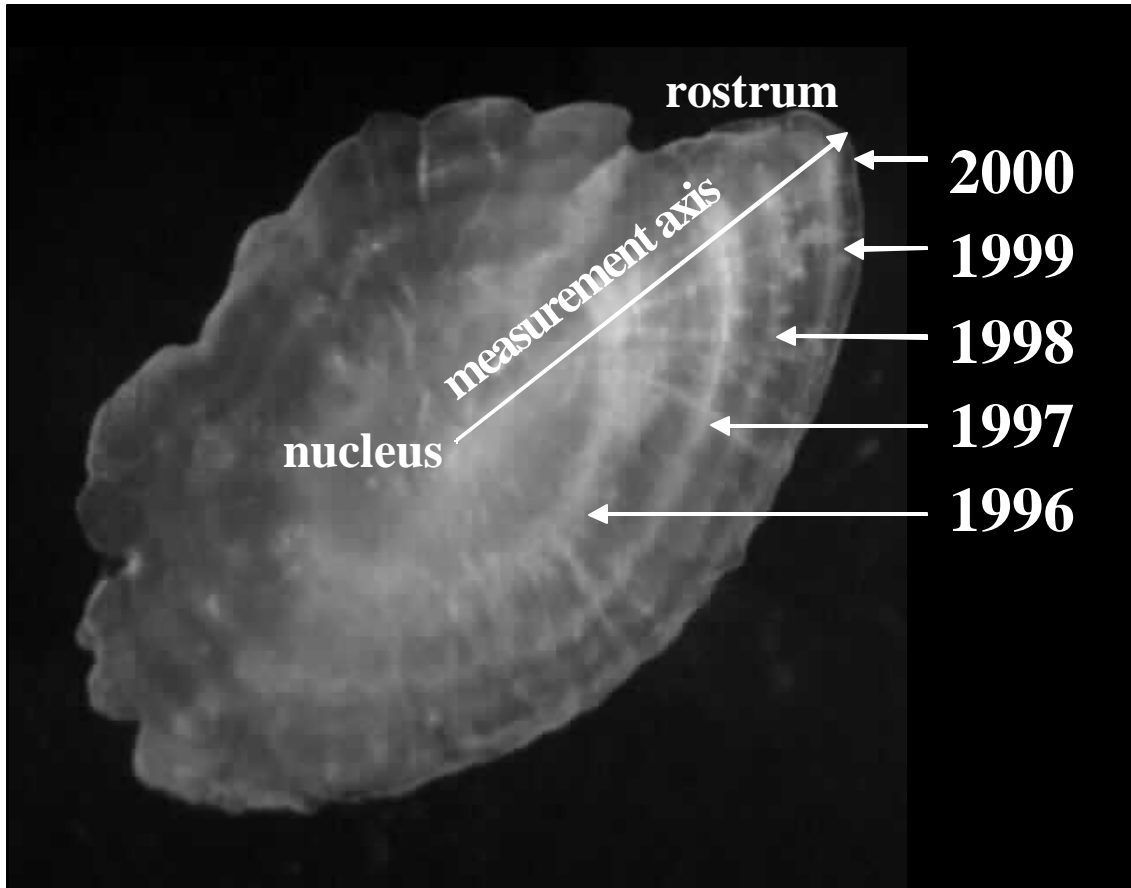
*Table 2.* Correlation matrix of the 6 independent environmental variables ( $\alpha = 0.05$ ). Variables were arbitrarily chosen to represent each group of intercorrelated variables from the original set of 28 variables.

	CV	P95	MIN	DUR3	DEGDAY	DEGDAYFL
				r		
				p		
CV	1.00	0.36	0.04	0.11	0.68	0.65
	.	0.48	0.94	0.83	0.14	0.16
P95	0.36	1.00	0.77	0.71	-0.41	0.27
	0.48	.	0.07	0.11	0.42	0.60
MIN	0.04	0.77	1.00	0.75	-0.60	0.36
	0.94	0.07	.	0.08	0.21	0.48
DUR3	0.11	0.71	0.75	1.00	-0.50	0.58
	0.83	0.11	0.08	.	0.31	0.22
DEGDAY	0.68	-0.41	-0.60	-0.50	1.00	0.35
	0.14	0.42	0.21	0.31	.	0.47
DEGDAYFL	0.65	0.27	0.36	0.58	0.35	1.00
	0.16	0.60	0.48	0.22	0.47	.

### Age & Growth

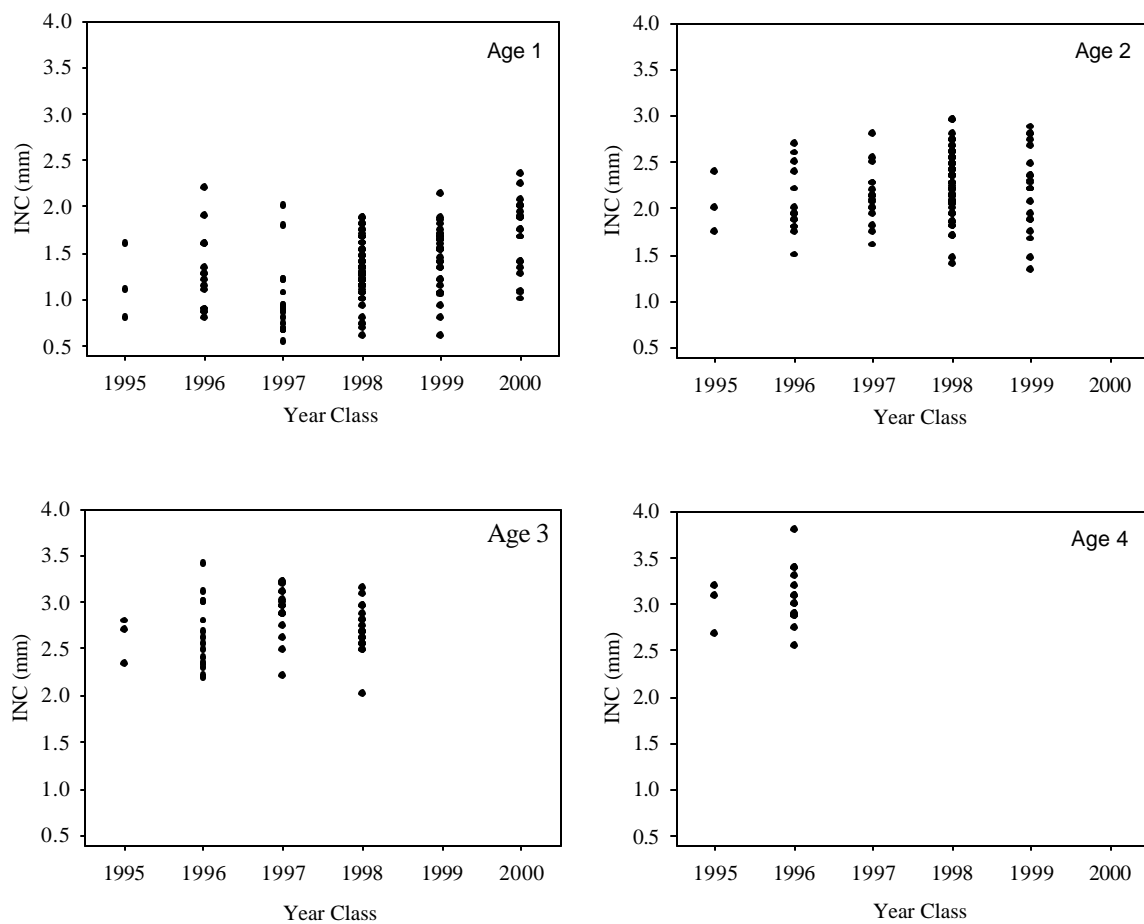
Both sagittal otoliths were removed from each fish, cleaned in a 10% bleach solution, rinsed with ethanol, and allowed to air dry completely. Redbreast sunfish, bluegill, shoal bass, and largemouth bass otoliths were examined in whole view under a stereo-microscope with reflected light and 10X – 30.5X magnification. The number of annual rings on each otolith was recorded and the radius to each annulus was measured along the anterior axis from nucleus to rostrum (Figure 4). “Age 1 growth” refers to the growth from the hatch date to the time of complete formation of the first annulus. Otolith annuli were measured twice by the same reader; for those fish that were not consistently aged or whose growth increments differed by more than 0.1 mm, a third set of measurements was taken. In cases where two out of three readings agreed, those measurements were used, but when all three readings differed or the reader was not confident in the measurements, the fish was not included in the final dataset. Increment widths were then plotted against growth year for each age (Figure 5) and otoliths from outliers were reexamined under the microscope. Incomplete final rings were not included in the analysis.

The assumptions that otolith growth and somatic growth were proportional and that the observed opaque rings on the otoliths were true annual marks were examined in several ways. A linear relationship between otolith radius and total length at time of capture was tested ( $\alpha = 0.10$ ) to verify the assumption that otolith growth and somatic growth were proportional. Marginal increment analyses were conducted to verify the annular nature and timing of opaque band formation. When the width of the translucent edge beyond the last opaque band, or the marginal increment, is plotted against the capture date, the dates when a translucent edge is not present indicate the time of opaque band formation. Opaque bands must be laid down at about the same time and only once a year to be useful in the study of annual growth rates.



**Figure 4**

Whole view of redbreast sunfish sagittal otolith under reflected light showing axis of measurement and locations of annuli.



**Figure 5**

Plot of redbreast sunfish annual otolith growth increments (INC) versus year class used to identify possible outliers caused by aging or measurement errors.

Total lengths were back-calculated (BCL) by direct proportion by using total otolith radius ( $R_T$ ), radius to annulus  $i$  ( $R_i$ ), and total length at capture (TL):

$$BCL_i = TL * R_i / R_T \quad (2)$$

Back-calculated total length increments (BCLINC) are the difference between consecutive back-calculated total lengths:

$$BCLINC = BCL_i - BCL_{i-1} \quad (3)$$

Gutreuter et al. (1999) found that back-calculation of total lengths "... did not alter the general pattern evident in the otolith or scale measurements (p.2285)". Back-calculation also introduces another source of error (Weisberg and Frie, 1987), which can be avoided by using otolith measurements directly. Results from back-calculated length increment data (BCLINC) were compared to results from non-standardized otolith increment measurements (INC) to determine whether back-calculation of lengths was necessary or beneficial in this study. Sample sizes for growth models based on back-calculated length increments were smaller than those based on otolith increment widths because some fish heads and otoliths without length measurements were donated to the project by local anglers. Thus, for some fish, TL was not available and BCL could not be calculated.

Growth estimates from fish caught with different gears were compared to test for possible gear biases. T-tests between mean annual otolith growth of electroshocked and angled fish were run separately for each AGE X YEAR combination.

### Statistical Analysis

The average percent error in age determinations was calculated between the first and second otolith readings and is defined as:

$$APE_j = (100) \frac{1}{R} \sum_{i=1}^r \frac{|X_{ij} - X_j|}{X_j} \quad (4)$$

where  $X_{ij}$  is the  $i^{\text{th}}$  age determination of the  $j^{\text{th}}$  fish,  $X_j$  is the mean age of the  $j^{\text{th}}$  fish, and  $R$  is the number of times each fish was aged.  $APE_j$  was then averaged across all fish of the same species (Campana et al., 1995).

Similarly, the precision of radius measurements was calculated by defining  $X_{ij}$  as the  $i^{\text{th}}$  radius measurement of the  $j^{\text{th}}$  fish,  $X_j$  as the mean radius of the  $j^{\text{th}}$  fish, and  $R$  as the number of times each radius was measured. The average percent error in radius measurements between the first two readings was calculated separately for each radius of each fish.  $APE_j$  was then averaged for each radius across fish of the same species. Only fish with the same age determinations in the first two readings were included in this calculation to ensure that only measurement error, and not errors in aging, were considered.

### Growth Models

The effects of fish age on growth must be removed before effects of environmental conditions can be tested. Three statistical models for separating the effects of age from the effects of environmental conditions were compared using otolith increment widths (INC) and back-calculated total length increments (BCLINC).

In the first model, one-way ANOVAs were run for each age to test for significant differences among years in annual growth increments. Pearson correlation coefficients between mean annual growth increments (INC and BCLINC) at each age with significant differences and each environmental variable (ENV) were then tested at a significance level of 0.10. Pearson correlations of median increments were also tested to reduce the influence of outliers. Seventy-fifth percentile increments were tested to determine whether faster growing fish showed a clearer response to environmental conditions than the mean or median annual fish growth.

The second model was based on a model suggested by Maceina (1992):

$$\text{INC} = b_0 - b_1\text{AGE} + b_2(1/\text{AGE}) * \text{ENV} \quad (5)$$

where INC is length increment, AGE is fish age, ENV is the environmental variable in question, and  $b_0$ ,  $b_1$ , and  $b_2$  are regression coefficients. The ENV variable is weighted by a factor of  $1/AGE$  because slower-growing older fish are assumed to respond to environmental conditions less than faster-growing younger fish. Observations for the dependent growth variable (INC) are the mean, median, and 75<sup>th</sup> percentile observed growth increments for each AGE x YEAR combination, as opposed to the growth measurements for each individual fish. Thus,  $n$  equals the number of AGE x YEAR combinations and not the total number of fish caught. As a preliminary analysis of the effect of the environmental variables on growth, Pearson correlation coefficients were calculated between the dependent variables INC and LOGINC, the independent variable AGE, and each environmental variable and its interaction term (i.e., ENV x  $1/AGE$ ). Annual growth was regressed against age and the residuals were examined for non-normality or auto-correlation.

The third model for separating the effects of age from yearly environmental effects was based on a repeated measures analysis where each individual fish contributes one set of data points (Weisberg 1993). The model is:

$$INC = b_1AGE + b_2YEAR + b_3AGE*YEAR \quad (6)$$

where INC is the length increment, AGE is a class variable representing the age of the fish, YEAR is a variable representing annual conditions (ENV), and  $b_1$ -  $b_3$  are regression coefficients. A term for the intercept is purposefully left out to facilitate interpretation of the regression coefficients. The coefficient estimates for  $b_1$ -  $b_3$  are calculated and can be interpreted relative to the most recent year, which is not estimable but can be thought of as having a value of 0. The interpretation of  $b_1$  and  $b_2$  is complicated when significant AGE x YEAR interaction terms are present (i.e., when different AGE classes respond to the same YEAR differently). In this case, the values of the AGE and YEAR coefficients cannot be interpreted independently of their interactions.

## CHAPTER 3

### RESULTS

#### Fish Sampling

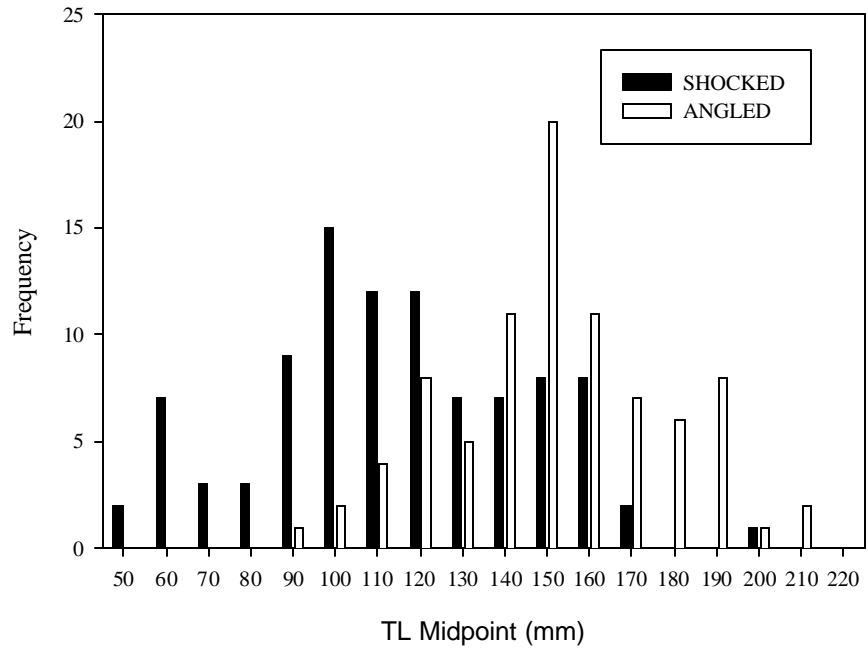
One hundred forty-five channel catfish, 54 shoal bass, 69 largemouth bass, 244 redbreast sunfish and 139 bluegill were collected in Ichawaynochaway Creek during the study. Insufficient numbers of largemouth bass and shoal bass from older age classes were collected to be statistically useful and these species were not included in the analysis. Electroshocking was biased toward smaller fish and angling favored larger fish (Figure 6a-b). Large fish may have been able to avoid the electroshocking boat because of extreme water clarity during the severe drought in 2000; an observer on the bank commented that fish could be seen fleeing ahead of the boat. The drought also exposed many shoals and other obstacles, which made accessibility and maneuvering with the shockboat difficult. Angling bias probably reflected the anglers' selection of hook and bait sizes, which favored fish with larger gapes.

Annual otolith growth increments (INC) of electroshocked and angled fish revealed that growth of angled fish was significantly greater than growth of electroshocked fish ( $P < 0.10$ ) for several AGE x YEAR combinations by as much as 0.3 mm (Table 3). Angling may have been biased toward faster growing fish because angled fish had significantly larger growth increments in several YEAR x AGE combinations.

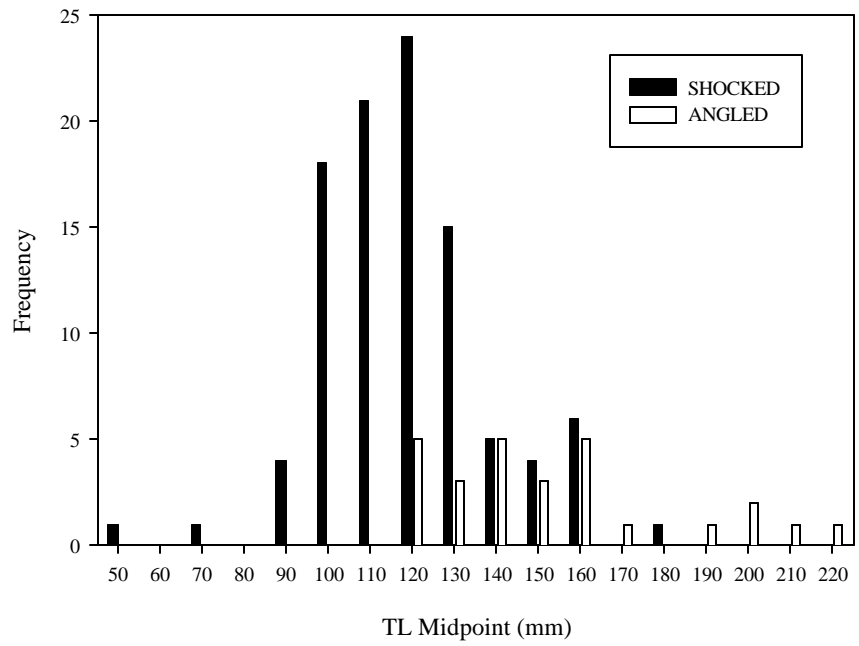
#### Otoliths

A total of 357 fish were aged. Channel catfish otoliths could not be aged in whole view, sections, or after cracking and burning and were not included in further analysis.

a)



b)



**Figure 6**

Length-frequency histograms for fish collected by electroshocking and angling from June 2000 to May 2001 on Ichawaynochaway Creek in Baker County, GA. a) redbreast sunfish and b) bluegill.

*Table 3.* Results of t-tests for differences in mean growth (INC) for each AGE X YEAR combination between shocked and angled fish caught during 2000 – 20001 in Ichawaynochaway Creek, Baker County, GA.

Species	Year	Age	Angled		Shocked		Pr >  t
			Mean (mm)	Standard Deviation (mm)	Mean (mm)	Standard Deviation (mm)	
Redbreast	1996	1	1.2981	0.4369	1.2395	0.1421	0.8583
	1997	1	0.8484	0.1932	0.7000	0.1414	0.3123
	1998	1	1.3031	0.2292	1.2573	0.1612	0.3988
	1999	1	1.5913	0.1279	1.2875	0.2647	0.0034
	1997	2	0.7745	0.1902	0.7035	0.1421	0.6274
	1998	2	1.2165	0.1769	1.1000	0.1414	0.3857
	1999	2	1.0204	0.2018	0.9026	0.1943	0.0216
	2000	2	1.1223	0.1381	0.8709	0.1721	0.0108
	1998	3	0.5848	0.1928	0.5360	0.1895	0.7455
Bluegill	1999	3	0.8423	0.1839	0.9500	0.2121	0.4483
	1997	1	1.1024	0.1990	1.2283	0.1934	0.4154
	1998	1	1.3275	0.3192	1.1386	0.2709	0.0146
	1998	2	0.9150	0.2492	0.5051	0.1023	0.3533
	1999	2	0.9835	0.2531	0.9780	0.2148	0.9272
	1999	3	0.8950	0.1732	0.6253	0.0774	0.0471
	2000	3	0.7501	0.1165	0.6868	0.1581	0.2001

Several otoliths were removed from the dataset during the aging procedures. One bluegill and seven redbreast sunfish did not have a complete annulus and were not included in the analysis. Nine bluegill and 18 redbreast sunfish otoliths were unclear and also were not included in the analysis. After plotting increment widths against year and age, 18 redbreast sunfish, or 8% of the sample, and 24 bluegill otoliths, or 16% of the sample, were determined to have been incorrectly aged from the first three readings, usually because of difficulty in distinguishing the edge of the nucleus from the first annulus. These otoliths were remeasured a fourth time and assigned a final age. The precision of increment width measurements ranged between 0.5% and 3.9% average error. Ages were assigned with 2.9% average error for bluegill and 3.2% for redbreast sunfish. The final otolith increment (INC) dataset included 129 bluegill ages zero to five and 219 redbreast sunfish ages zero to seven (Table 4). Fifty-five of the redbreast sunfish (25% of the total sample) and 12 of the bluegill (1% of the total sample) donated by local anglers were without length information and could not be included in the back-calculated total length increment (BCLINC) dataset.

The 1998 year class was the most abundant year class in the sample for both species (Figure 7). This is probably not an artifact of a bias in gear vulnerability because the 1998 year class was most abundant in both the 2000 collection, when the fish were age 2, and in the 2001 collection, when the fish were age 3, using the same methods.

Assumptions about growth and annuli formation were supported by the linear regression and marginal increment analyses. Otolith radius and total length (TL) were linearly related in both species ( $P < 0.0001$ ,  $r^2 = 0.95$  for redbreast sunfish and 0.89 for bluegill). The marginal increment analysis (Figure 8a-b) revealed that the translucent edge of the otolith was widest in both species in September and thinnest during March and April, although samples were not taken during December and January. By early

*Table 4.* Summary of annual growth data for redbreast sunfish and bluegill collected from Ichawaynochaway Creek, Baker County, GA. a) otolith increment (INC) data and b) back-calculated length increment (BCLINC) data.

a)

Year	Age	Redbreast sunfish			Bluegill		
		n	Mean (mm)	Standard Deviation	n	Mean (mm)	Standard Deviation
1994	1	1	0.90	.	0	.	.
1995	1	3	1.13	0.42	0	.	.
1995	2	1	1.00	.	0	.	.
1996	1	22	1.19	0.36	4	1.50	0.08
1996	2	3	1.00	0.20	0	.	.
1996	3	1	0.60	.	0	.	.
1997	1	27	0.88	0.22	12	1.04	0.25
1997	2	22	0.80	0.16	4	0.93	0.30
1997	3	3	0.53	0.15	0	.	.
1997	4	1	0.30	.	0	.	.
1998	1	107	1.28	0.21	86	1.17	0.29
1998	2	27	1.13	0.21	12	0.94	0.23
1998	3	22	0.61	0.17	4	0.65	0.21
1998	4	3	0.40	0.10	0	.	.
1998	5	1	0.30	.	0	.	.
1999	1	42	1.38	0.30	22	1.21	0.30
1999	2	107	0.96	0.21	86	0.97	0.22
1999	3	27	0.80	0.20	12	0.74	0.18
1999	4	22	0.44	0.15	4	0.53	0.10
1999	5	3	0.27	0.06	0	.	.
1999	6	1	0.30	.	0	.	.
2000	1	17	1.42	0.26	5	1.61	0.39
2000	2	30	0.87	0.22	18	1.05	0.18
2000	3	42	0.47	0.19	47	0.65	0.19
2000	4	8	0.34	0.11	7	0.59	0.18
2000	5	10	0.27	0.16	2	0.20	0.14
2000	7	1	0.10	.	0	.	.

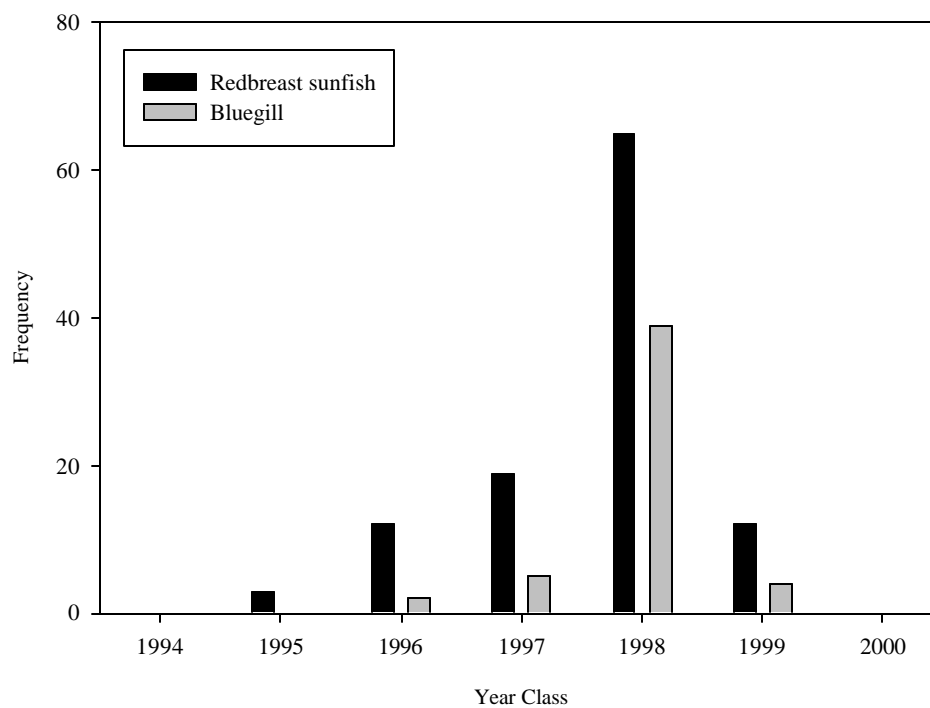
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b)

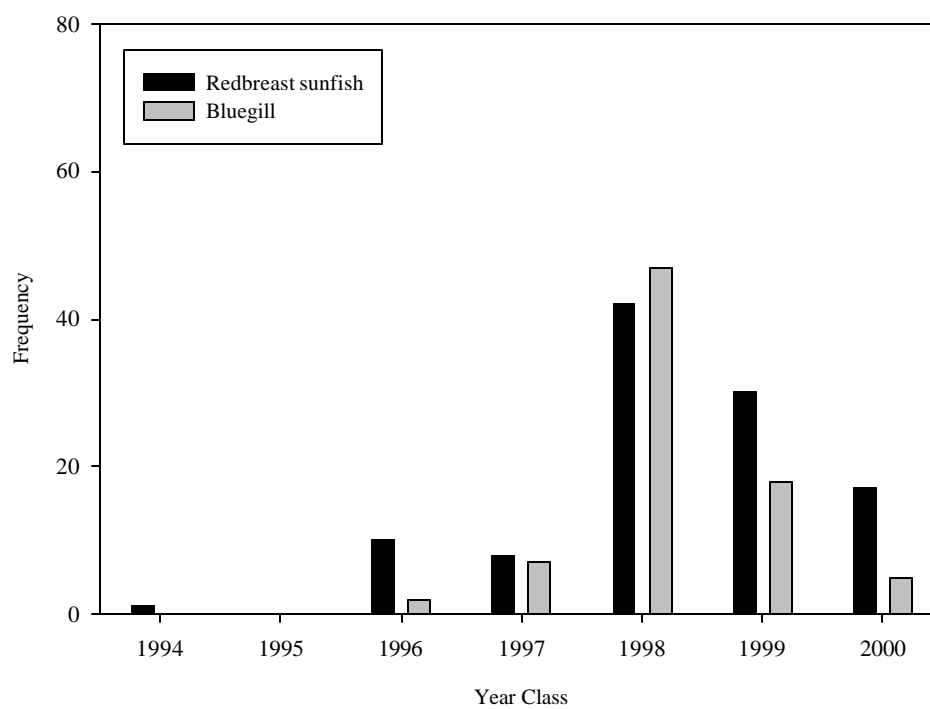
Year	Age	Redbreast sunfish			Bluegill		
		n	Mean (mm)	Standard Deviation	n	Mean (mm)	Standard Deviation
1994	1	1	48.86	.	0	.	.
1995	1	3	59.83	19.57	0	.	.
1995	2	1	54.29	.	0	.	.
1996	1	22	66.42	22.54	4	70.62	10.23
1996	2	3	53.81	15.32	0	.	.
1996	3	1	32.57	.	0	.	.
1997	1	27	46.63	11.01	12	53.03	14.16
1997	2	22	40.25	6.55	4	56.38	15.70
1997	3	3	28.36	7.94	0	.	.
1997	4	1	16.29	.	0	.	.
1998	1	107	67.50	10.74	86	56.19	13.22
1998	2	27	59.38	13.87	12	49.98	15.13
1998	3	22	31.99	9.07	4	32.41	20.23
1998	4	3	21.33	5.59	0	.	.
1998	5	1	16.29	.	0	.	.
1999	1	42	70.21	16.27	22	58.77	14.58
1999	2	107	51.01	13.26	86	47.04	10.69
1999	3	27	42.33	12.93	12	36.37	7.75
1999	4	22	23.48	8.14	4	23.96	4.53
1999	5	3	14.30	3.89	0	.	.
1999	6	1	16.29	.	0	.	.
2000	1	17	71.53	17.70	5	78.10	21.83
2000	2	30	44.01	12.14	18	51.17	9.51
2000	3	42	23.87	9.80	47	31.90	10.22
2000	4	8	16.99	6.39	7	31.39	10.60
2000	5	10	15.56	10.82	2	5.19	.
2000	7	1	5.43	.	0	.	.

. = no data

a)

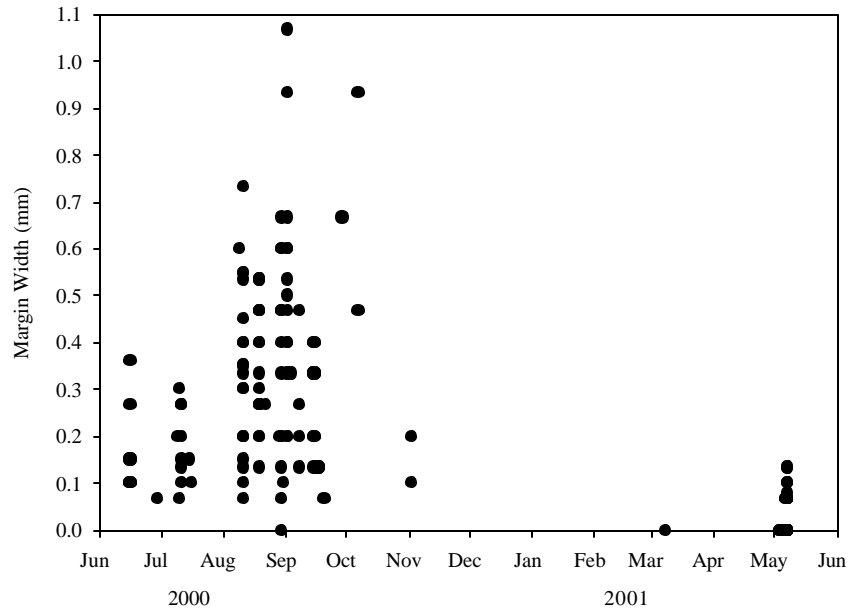


b)

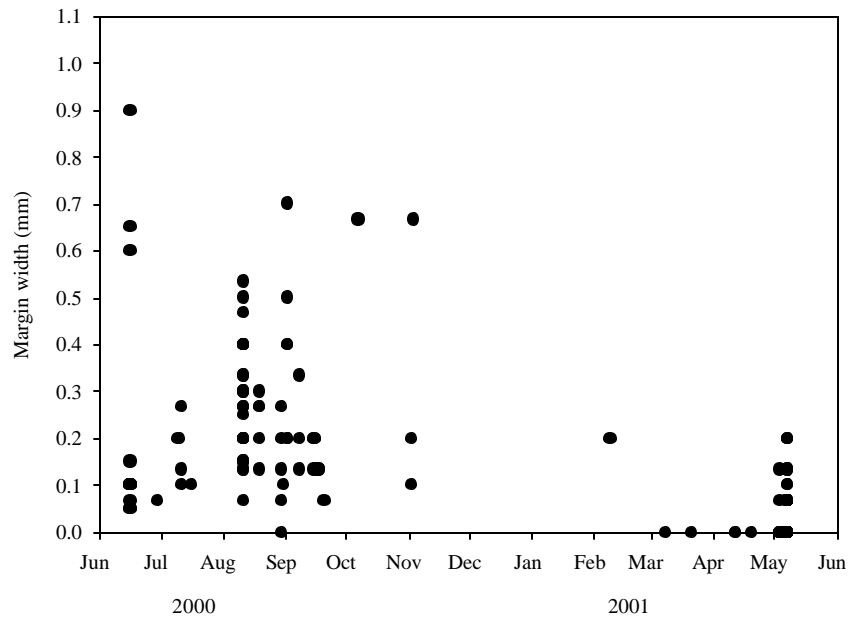
**Figure 7**

Year class - frequency histogram for fish caught on Ichawaynochaway Creek, Baker County, GA in a) 2000 and b) 2001.

a)



b)



**Figure 8**

Marginal increment analysis for a) redbreast sunfish and b) bluegill otoliths collected from May 2000 to June 2001 in Ichawaynochaway Creek, Baker County, GA.

May, a translucent edge was once again visible in some fish, indicating that the opaque band formation was complete and rapid growth had resumed. The single cycle of opaque band formation during the year suggested that these bands were true annular marks. Average water temperatures during April and May, when rapid growth resumed, were 20.0 °C and 22.9 °C, respectively, which supported the assumption that the growing season began when the water temperature reached about 20 °C.

### Environmental Variables

Several groups of intercorrelated variables were apparent in the correlation matrix of environmental variables. A single representative variable was chosen from each group; low-flow variables were represented by MIN, P95 represented high-flow variables, and DEGDAY and DEGDAYFL represented independent aspects of the temperature regime. The coefficient of variation (CV), representing flood variability, and DUR3, representing flood duration, were not correlated with any other environmental variables. These six independent environmental variables were retained for further analysis.

### Growth Models

In the first model, one-way ANOVAs detected significant differences in annual growth among years for redbreast sunfish ages 1-3 and age 1 bluegill (Table 5a). Solutions to the models revealed that growth of age 1 redbreast sunfish in 1994 - 1998 was significantly less than growth in 2000, but age 2 - 3 growth was significantly greater in 1998-1999 than in the year 2000. Age 1 bluegill grew significantly less in 1997-1999 than in 2000 (Table 5b).

Only DEGDAY for age 1 fish was significantly correlated ( $P = 0.05$ ,  $r = 0.81$ ) with mean redbreast sunfish growth (Table 6a). For bluegill, DUR3 was significantly

*Table 5.* Results of 1-way ANOVAs of annual otolith growth among years for redbreast sunfish and bluegill from Ichawaynochaway Creek, Baker County, GA. a) P-values of the year term for each ANOVA and b) solutions to significant ANOVAs (coefficient estimates are relative to the year 2000).

a)

Species	Age	<i>p</i> -value
Redbreast sunfish	1	< 0.0001
	2	< 0.0001
	3	< 0.0001
	4	0.2608
	5	0.9811
Bluegill	1	0.0014
	2	0.4888
	3	0.2756
	4	0.5309

b)

Species	Age	Year	Coefficient	
			Estimate	<i>p</i> -value
Redbreast sunfish	1	1994	-0.5198	0.0484
		1995	-0.2865	0.0736
		1996	-0.2334	0.0049
		1997	-0.5402	< 0.0001
		1998	-0.1393	0.0372
		1999	-0.0431	0.5567
	2	1995	0.1339	0.5245
		1996	0.1339	0.2859
		1997	-0.0707	0.2246
		1998	0.2641	< 0.0001
		1999	0.0923	0.0319
		3	1996	0.1282
Bluegill	1	1997	0.0615	0.5782
		1998	0.1342	0.0069
		1999	0.3325	< 0.0001
		1996	-0.1133	0.5608
		1997	-0.5717	0.0003
		1998	-0.4440	0.0011
		1999	-0.4073	0.0053

*Table 6.* Pearson correlation coefficients between annual otolith growth increments (INC) and environmental variables (ENV) for redbreast sunfish and bluegill. The sign of the *p*-values indicates the direction of the correlation. a) Mean otolith increments (INC), b) median otolith increments, c) 75<sup>th</sup> percentile otolith increments, and d) median otolith increments excluding 1997.

a)

ENV	Redbreast sunfish			Bluegill
	Age 1 n=7	Age 2 n=6	Age 3 n=5	Age 1 n=5
	r	r	r	r
	p	p	p	p
CV	0.26	0.49	-0.03	-0.33
	0.62	0.33	0.97	0.59
P95	-0.62	0.40	-0.15	-0.61
	0.19	0.44	0.81	0.27
MIN	-0.60	0.49	0.40	-0.29
	0.21	0.32	0.51	0.64
DUR3	-0.61	0.38	0.44	-0.82
	0.15	0.46	0.46	0.09
DEGDAY	0.81	0.24	0.11	0.21
	0.05	0.65	0.86	0.74
DEGDAYFL	0.17	0.70	0.59	-0.45
	0.75	0.12	0.29	0.45

b)

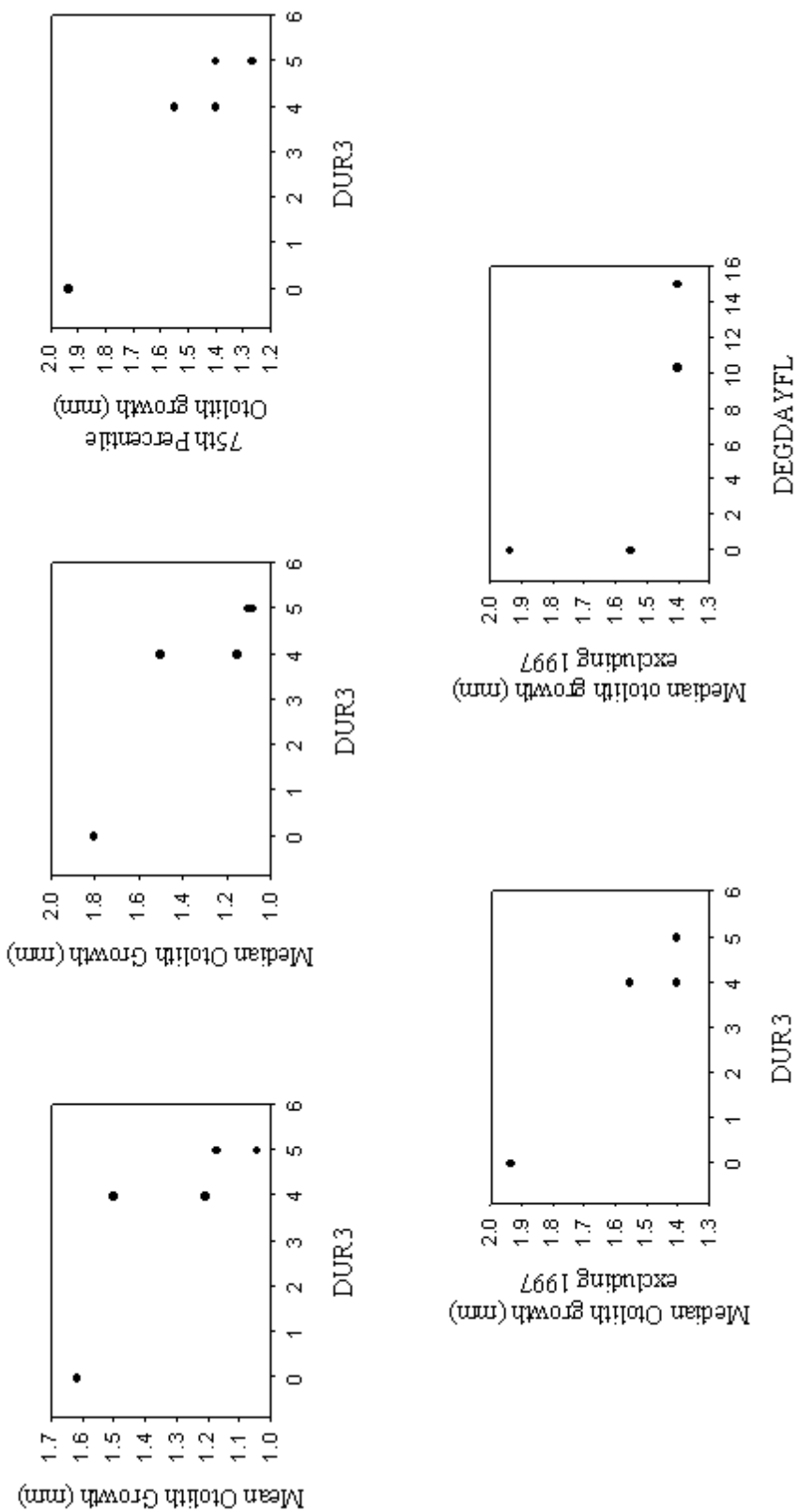
ENV	Redbreast sunfish			Bluegill
	Age 1 n=7	Age 2 n=6	Age 3 n=5	Age 1 n=5
	r	r	r	r
	p	p	p	p
CV	0.32	0.43	-0.04	-0.32
	0.54	0.40	0.95	0.60
P95	-0.59	0.25	-0.03	-0.64
	0.22	0.64	0.96	0.25
MIN	-0.75	0.30	-0.08	-0.36
	0.09	0.56	0.90	0.55
DUR3	-0.67	0.33	0.54	-0.91
	0.10	0.52	0.35	0.03
DEGDAY	0.86	0.30	0.02	0.21
	0.03	0.56	0.98	0.73
DEGDAYFL	0.05	0.71	0.61	-0.58
	0.92	0.11	0.28	0.30

c)

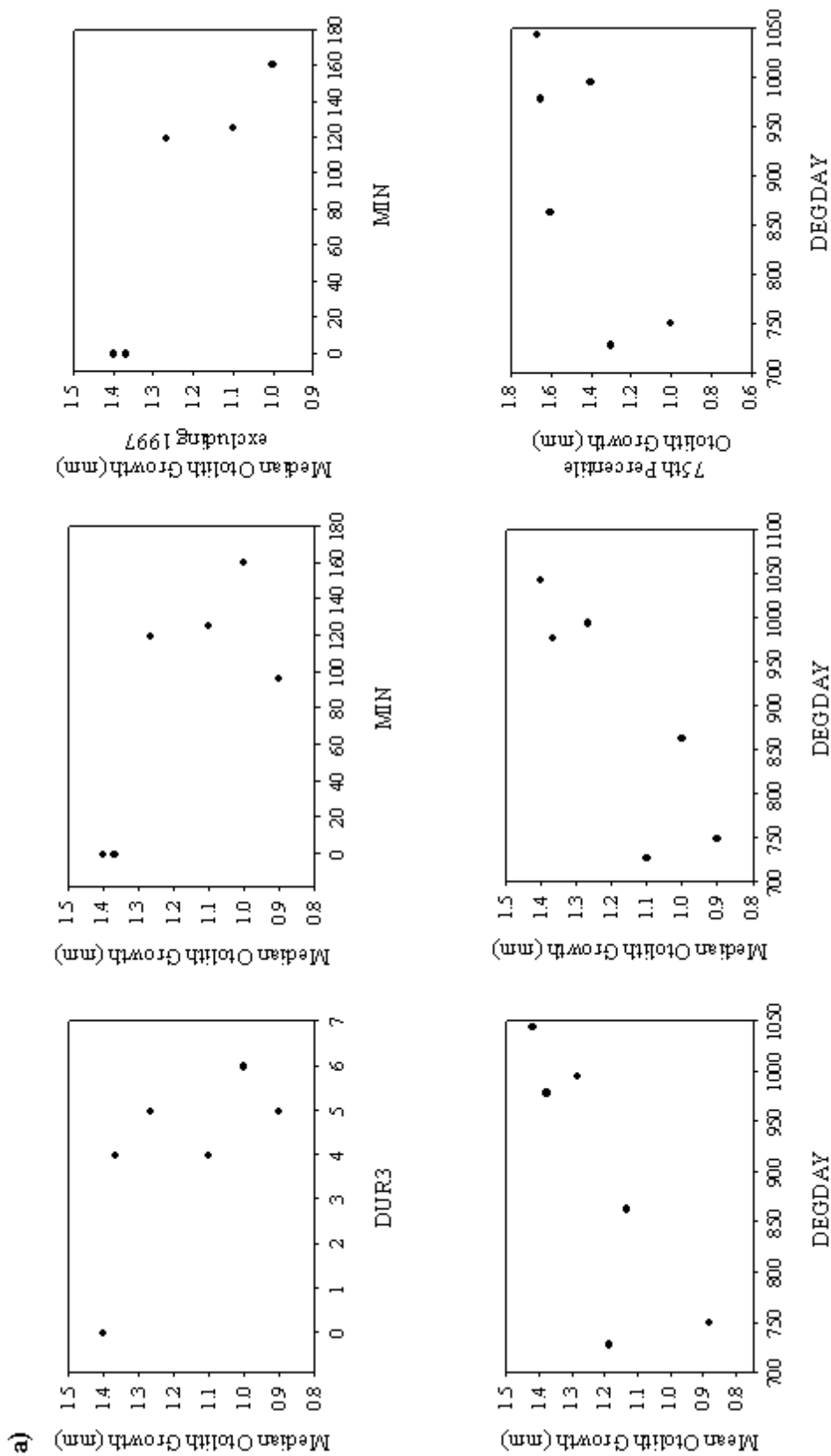
	Redbreast sunfish			Bluegill
	Age 1 n=7	Age 2 n=6	Age 3 n=5	Age 1 n=5
	r	r	r	r
ENV	p	p	p	p
CV	0.24	0.33	0.23	-0.07
	0.65	0.53	0.71	0.91
P95	-0.68	0.32	0.07	-0.66
	0.14	0.54	0.91	0.22
MIN	-0.42	0.22	-0.08	-0.49
	0.40	0.67	0.90	0.41
DUR3	-0.42	0.10	0.59	-0.96
	0.35	0.85	0.29	0.01
DEGDAY	0.75	0.22	0.14	0.47
	0.09	0.68	0.82	0.43
DEGDAYFL	0.43	0.34	0.68	-0.38
	0.40	0.51	0.20	0.53

d)

	Redbreast sunfish			Bluegill
	Age 1 n=6	Age 2 n=5	Age 3 n=4	Age 1 n=4
	r	r	r	r
ENV	p	p	p	p
CV	0.27	0.46	-0.09	-0.44
	0.66	0.44	0.91	0.56
P95	-0.49	0.88	0.10	-0.57
	0.40	0.05	0.90	0.43
MIN	-0.91	0.57	0.00	-0.29
	0.03	0.31	1.00	0.71
DUR3	-0.67	0.80	0.74	-0.89
	0.14	0.10	0.26	0.11
DEGDAY	0.80	-0.18	-0.19	-0.04
	0.11	0.77	0.81	0.96
DEGDAYFL	-0.33	0.66	0.56	-0.91
	0.59	0.23	0.44	0.09

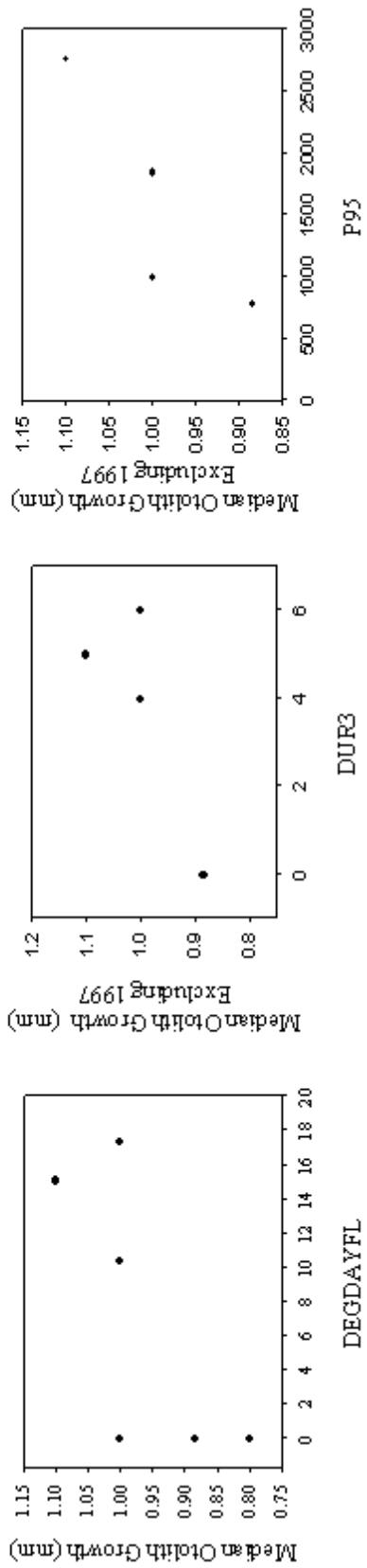


**Figure 9**  
Age 1 bluegill annual otolith growth versus significantly correlated environmental variables.



**Figure 10** Redbreast sunfish annual otolith growth versus significantly correlated environmental variables for a) age 1 fish and b) age 2 fish.

b)



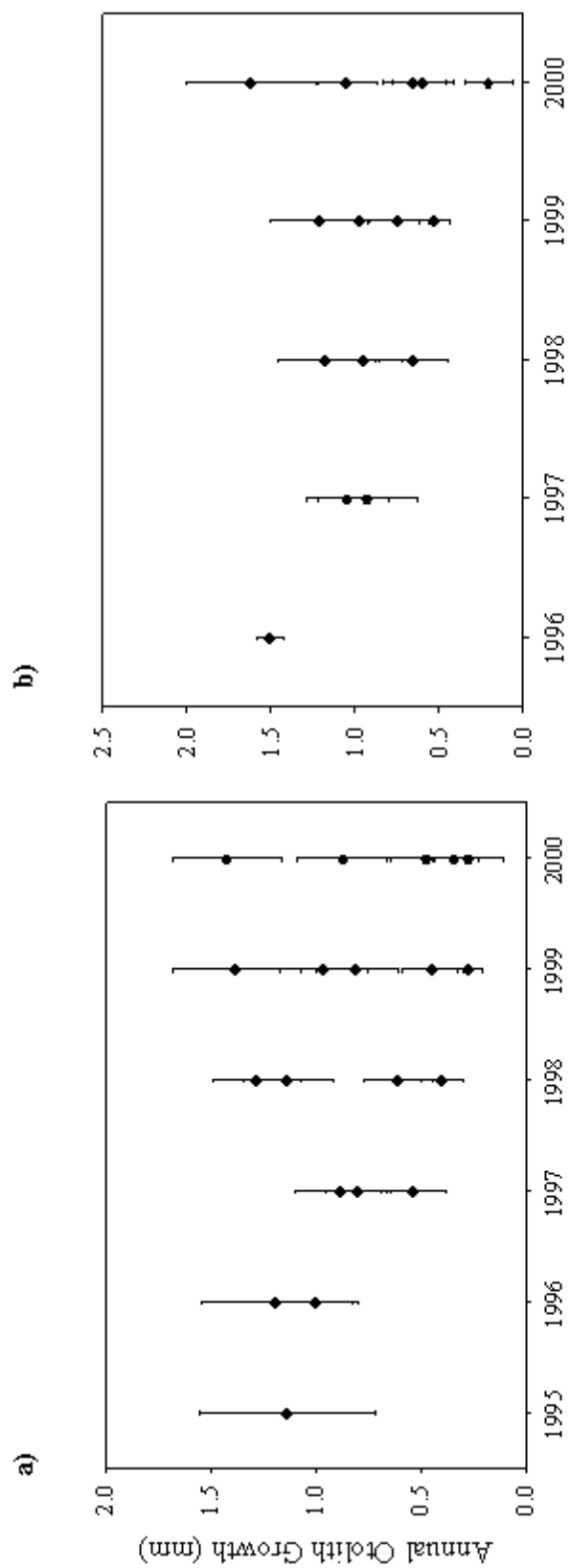
and negatively correlated with mean annual growth ( $P = 0.09$ ,  $r = -0.82$ ) (Table 6a, Figure 9) but none of the other environmental variables were significant.

MIN and DUR3 were significantly negatively correlated with median growth of age 1 redbreast sunfish ( $P = 0.09$  and  $0.10$ ,  $r = -0.75$  and  $-0.67$ , respectively) (Table 6b, Figure 10), indicating that outliers may have obscured a relationship with mean growth. DEGDAY was significantly positively correlated with age 1 median growth ( $P = 0.03$ ,  $r = 0.86$ ) and DEGDAYFL was marginally positively correlated ( $P = 0.11$ ,  $r = 0.71$ ) with age 2 median growth (Table 6b, Figure 10). The relationship between DUR3 and age 1 bluegill growth was still significant and negative with median instead of mean growth increments ( $P = 0.03$ ,  $r = -0.91$ ) (Table 6b, Figure 9).

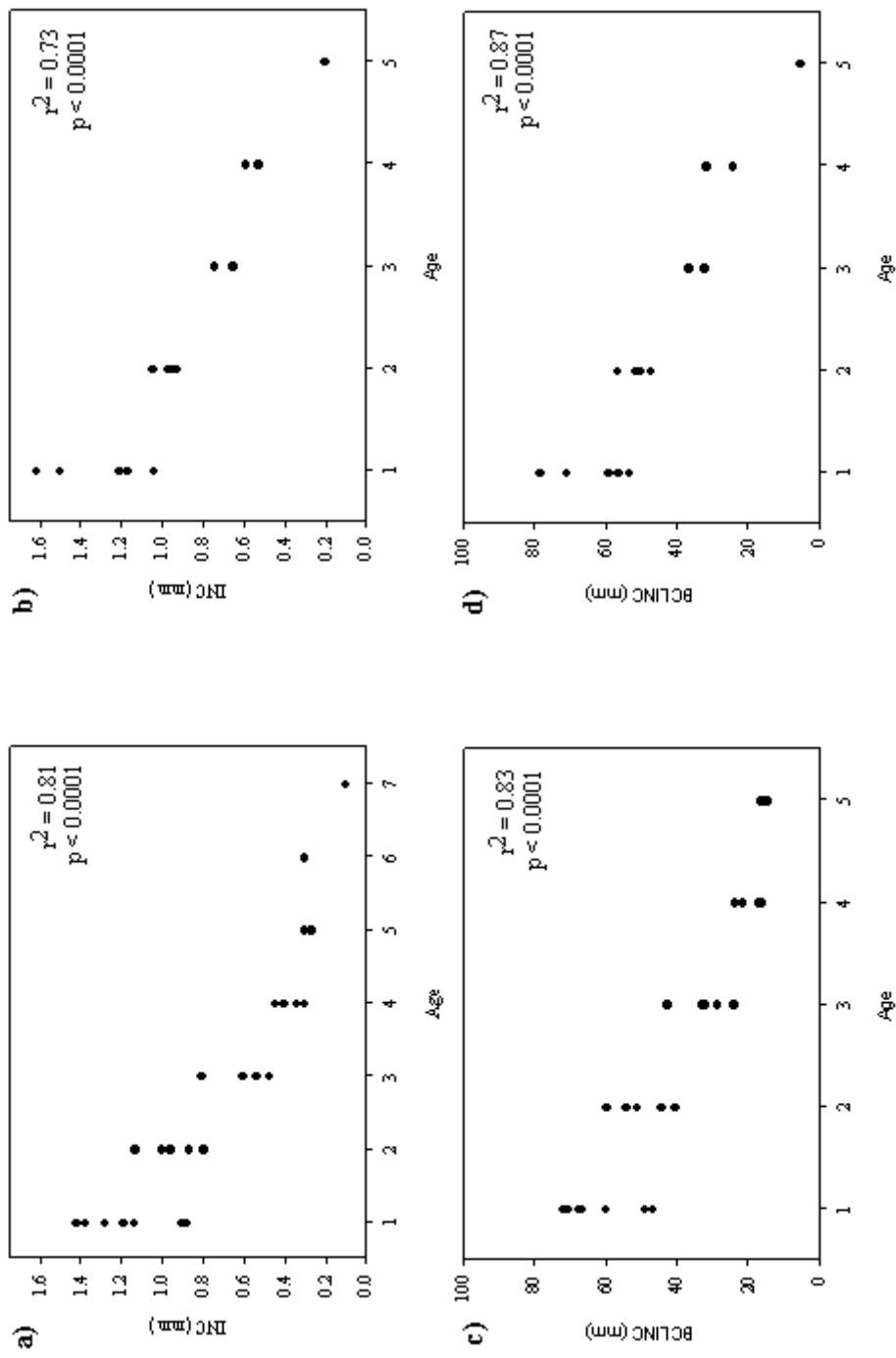
Seventy-fifth percentile growth increments were only significantly correlated with DEGDAY for age 1 redbreast sunfish ( $P = 0.09$ ,  $r = 0.75$ ) (Table 6c, Figure 10). Age 1 bluegill 75<sup>th</sup> percentile growth increments were again significantly correlated with DUR3 ( $P = 0.01$ ,  $r = -0.96$ ) (Table 6c, Figure 9).

Growth of all ages of redbreast sunfish and bluegill was lower in 1997 than in any other year (Figure 11), but none of the environmental variables showed an extreme value in 1997. Correlations between median growth and the environmental variables excluding 1997 were tested to see if there was an underlying relationship with flow that was obscured by some other extreme environmental condition. Age 1 redbreast sunfish median growth showed a significant negative relationship to MIN ( $P = 0.03$ ,  $r = -0.91$ ), while age 2 redbreast sunfish growth was positively correlated with P95 ( $P = 0.05$ ,  $r = 0.88$ ) and DUR3 ( $P = 0.10$ ,  $r = 0.80$ ) (Table 6d, Figure 9). Age 1 bluegill growth was negatively correlated with DEGDAYFL ( $P = 0.09$ ,  $r = -0.91$ ) and DUR3 ( $P = 0.11$ ,  $r = -0.89$ ) (Table 6d).

In the second analysis, based on Maceina's (1992) growth model, INC and BCLINC declined with AGE, as expected (Figure 12a-d). Growth increments were log-



**Figure 11**  
 Mean annual otolith growth increments plus or minus one standard deviation for each age of a) redbreast sunfish and b) bluegill from Ichawaynochaway Creek, Baker County, GA.



**Figure 12** Mean annual growth increments for each age of redbreast sunfish and bluegill. a) redbreast sunfish otolith increments (INC), b) bluegill otolith increments (INC), c) redbreast sunfish back-calculated total length increments (BCLINC), and d) bluegill back-calculated total length increments (BCLINC).

transformed to reduce the effect of non-homogenous residuals (Figures 13a–d and 14a-d). This transformation also resulted in an improved fit in both otolith increment datasets and in the redbreast sunfish back-calculated length dataset (Figure 15a-d). The final model, based on Maceina (1992) and the best transformation of the variables, was:

$$\log(\text{INC}) = b_0 + b_1 * \text{AGE} + b_2 * (1/\text{AGE}) * \text{ENV} \quad (7)$$

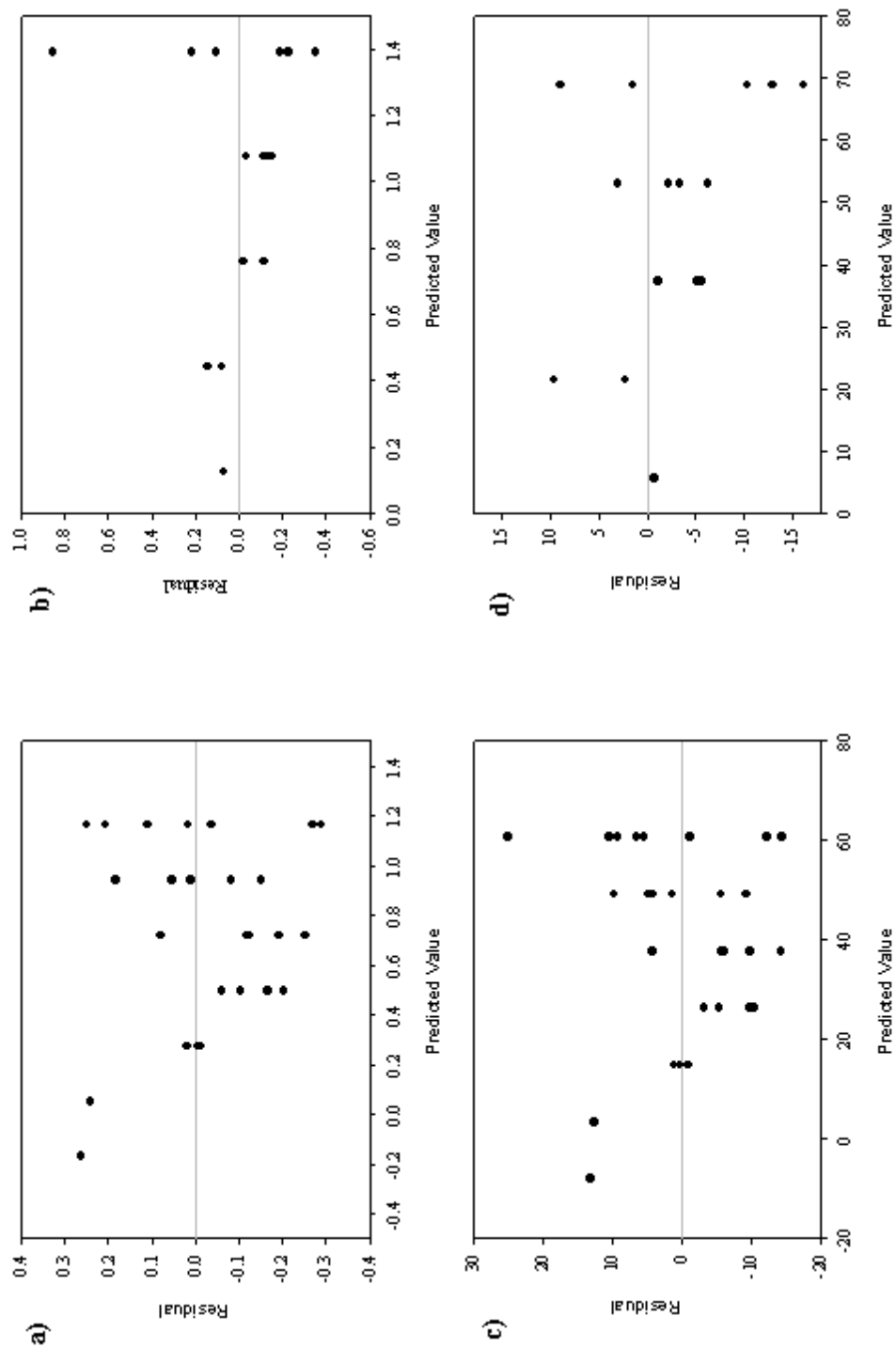
Standard deviations of the growth increments declined for both species with increasing AGE, indicating that older fish not only had smaller growth increments, but also less variation in growth (Figure 16a-d). This trend supported the assumption that older fish respond to environmental conditions less than younger fish.

In the preliminary Pearson correlations, none of the environmental variables were significantly correlated with either INC or LOGINC. All of the interaction terms were significantly correlated with INC, LOGINC and AGE, indicating possible collinearity problems between AGE and the interaction terms (1/AGE)\*ENV.

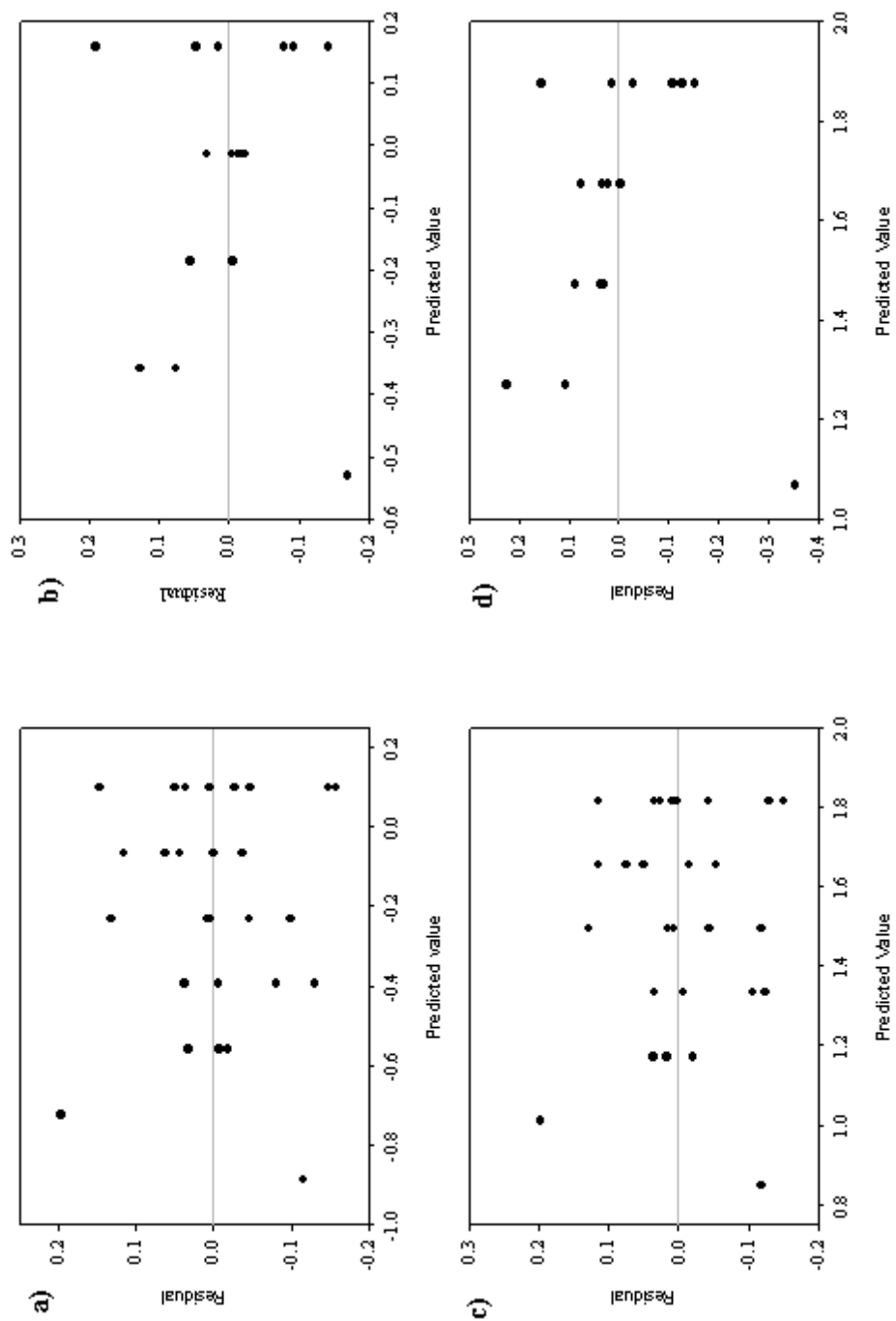
The growth model, Eq. (7), did not find any significant environmental variables for redbreast sunfish mean growth (Table 7a-b). Using median redbreast sunfish growth, CV and DEGDAY were significant and increased the growth response (Table 7c). For the 75<sup>th</sup> percentile growth increments, CV, DEGDAY and DEGDAYFL all had significant positive effects on growth (Table 7d).

P95 and DUR3 were significant and were negatively related to bluegill mean growth (Table 7a-b). DUR3 was significantly negatively related to median growth and DUR3 and DEGDAY both significantly reduced 75<sup>th</sup> percentile bluegill growth (Table 7c-d). Collinearity problems, as indicated by variance inflation factors greater than 10, were not evident in any model for either species.

The third model, based on Weisberg's (1993) growth model, found significant interactions between all of the environmental variables and age for redbreast sunfish (Table 8a-b). For bluegill, there were significant interactions between AGE and DEGDAY, DUR3, CV, and P95. The presence of significant interaction terms

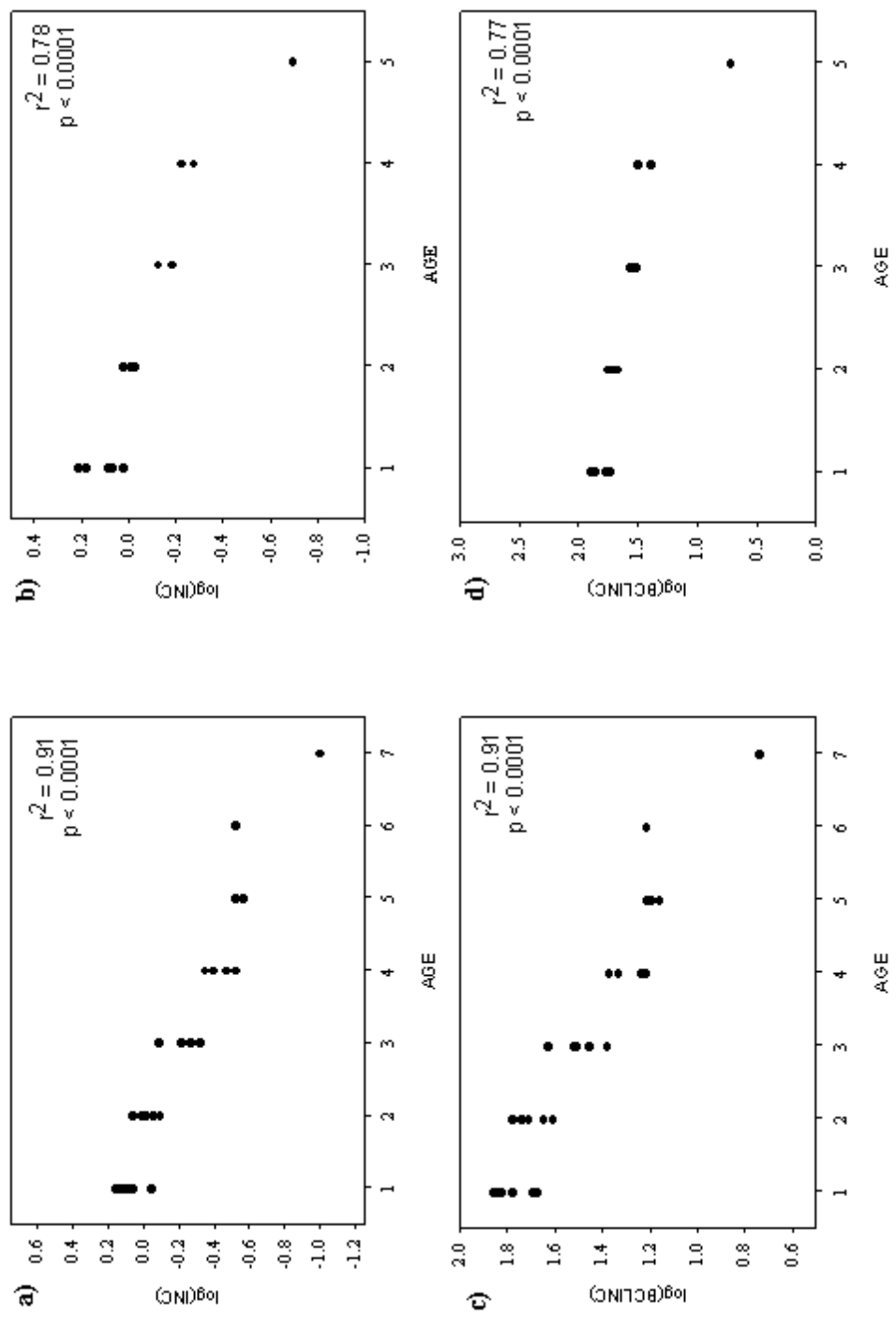


**Figure 13**  
Residuals from the regressions of AGE against INC and BCLINC. a) redbreast sunfish otolith increments (INC), b) bluegill otolith increments (INC), c) redbreast sunfish back-calculated length increments (BCLINC), and d) bluegill back-calculated total length increments (BCLINC).

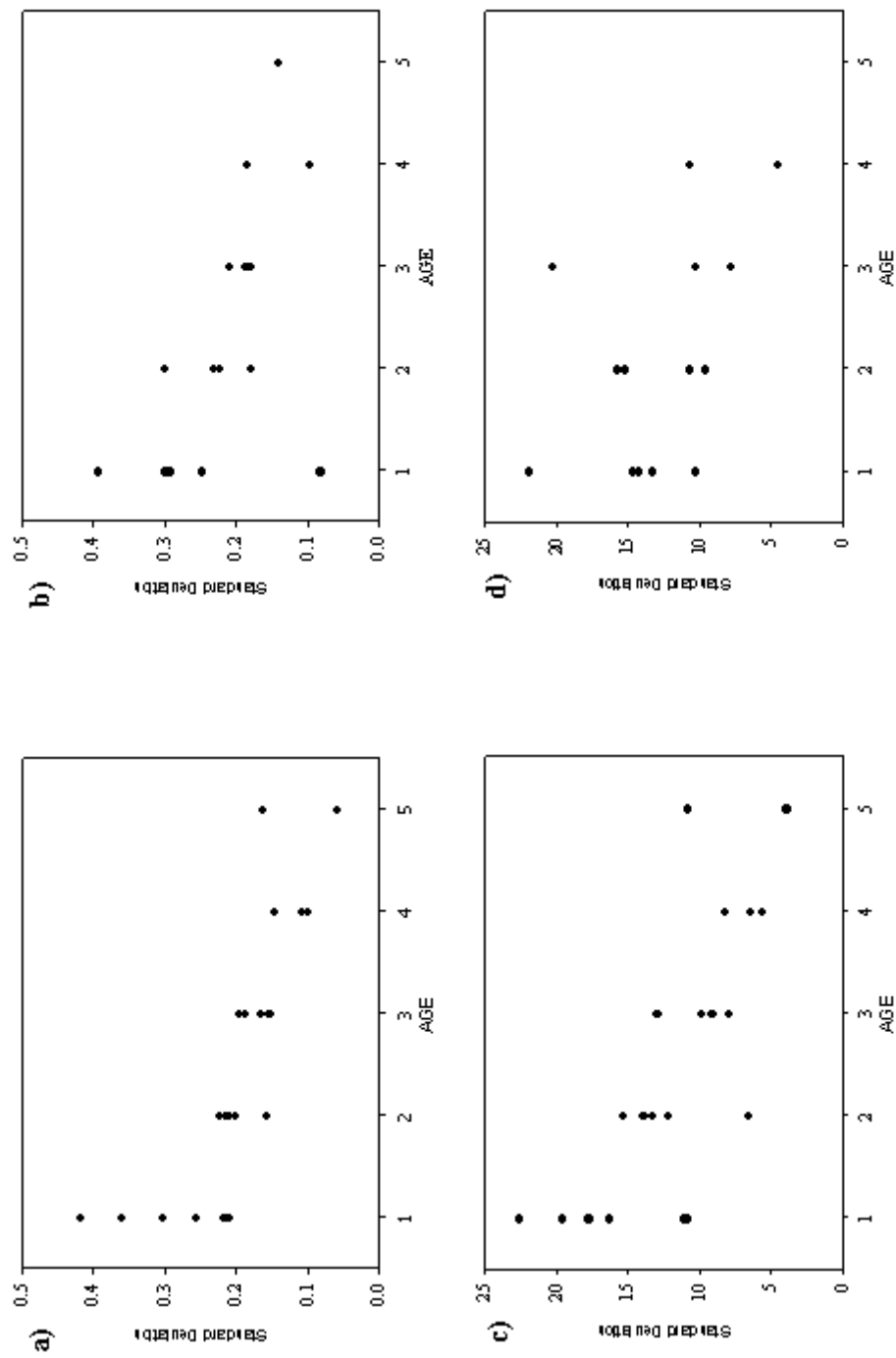


**Figure 14**

Residuals from the regressions of  $\log(\text{INC})$  and  $\log(\text{BCLINC})$  against AGE. A) redbreast sunfish otolith increments (INC), b) bluegill otolith increments (INC), c) redbreast sunfish back-calculated total length increments (BCLINC) and d) bluegill back-calculated total length increments (BCLINC).



**Figure 15** Mean log-transformed annual growth increments versus age. A) redbreast sunfish otolith increments (INC), b) bluegill otolith increments (INC), c) redbreast sunfish back-calculated total length increments (BCLINC), and d) bluegill back-calculated total length increments (BCLINC).



**Figure 16**

Standard deviations of growth increments versus AGE. A) redbreast sunfish otolith increments (INC), b) bluegill otolith increments (INC), c) redbreast sunfish back-calculated total length increments (BCLINC), and d) bluegill back-calculated total length increments (BCLINC).

Table 7. Results of Model 2:  $INC = AGE + (1/AGE)*ENV$  (Eq. (5)). Includes variance inflation factors (VIF) and significance values for the  $(1/AGE)*ENV$  term. a) mean otolith increments, b) back-calculated length increments, c) median otolith increments, and d) 75<sup>th</sup> percentile otolith increments.

a)

ENV	Redbreast sunfish				Bluegill			
	r <sup>2</sup>	adj r <sup>2</sup>	p	VIF	r <sup>2</sup>	adj r <sup>2</sup>	p	VIF
CV	0.92	0.91	0.8816	2.69	0.89	0.88	0.1404	3.27
MIN	0.92	0.92	0.3253	1.49	0.89	0.87	0.2649	1.43
P95	0.93	0.92	0.2451	2.07	0.91	0.89	0.0652	2.07
DUR3	0.92	0.91	0.3390	1.93	0.91	0.89	0.0569	1.85
DEGDAY	0.89	0.88	0.0015	3.15	0.86	0.84	0.2179	4.20
DEGDAYFL	0.93	0.92	0.2384	1.19	0.88	0.86	0.4523	1.13

b)

ENV	Redbreast sunfish				Bluegill			
	r <sup>2</sup>	adj r <sup>2</sup>	p	VIF	r <sup>2</sup>	adj r <sup>2</sup>	p	VIF
CV	0.91	0.91	0.8556	2.69	0.82	0.79	0.1043	3.27
MIN	0.92	0.91	0.5877	1.49	0.79	0.75	0.3918	1.43
P95	0.92	0.91	0.4026	2.07	0.81	0.78	0.1725	2.07
DUR3	0.91	0.90	0.5649	1.93	0.80	0.77	0.1921	1.85
DEGDAY	0.88	0.87	0.0048	3.15	0.86	0.84	0.7393	4.20
DEGDAYFL	0.92	0.91	0.2230	1.19	0.78	0.74	0.5576	1.13

c)

ENV	Redbreast sunfish				Bluegill			
	r <sup>2</sup>	adj r <sup>2</sup>	p	VIF	r <sup>2</sup>	adj r <sup>2</sup>	p	VIF
CV	0.86	0.85	0.0275	2.73	0.78	0.75	0.9070	3.27
MIN	0.83	0.82	0.5698	1.52	0.79	0.76	0.4677	1.43
P95	0.83	0.82	0.8441	2.14	0.81	0.78	0.2248	2.07
DUR3	0.82	0.81	0.9927	2.02	0.84	0.82	0.0520	1.85
DEGDAY	0.88	0.87	0.0043	3.15	0.81	0.78	0.2164	4.20
DEGDAYFL	0.85	0.83	0.1142	1.21	0.82	0.79	0.1618	1.13

d)

ENV	Redbreast sunfish				Bluegill			
	r <sup>2</sup>	adj r <sup>2</sup>	p	VIF	r <sup>2</sup>	adj r <sup>2</sup>	p	VIF
CV	0.88	0.87	0.0056	2.73	0.88	0.86	0.7848	3.27
MIN	0.83	0.82	0.9010	1.52	0.89	0.87	0.2650	1.43
P95	0.83	0.82	0.7688	2.14	0.89	0.88	0.1679	2.07
DUR3	0.81	0.79	0.7751	2.02	0.92	0.91	0.0166	1.85
DEGDAY	0.90	0.90	0.0003	3.15	0.90	0.89	0.0818	3.93
DEGDAYFL	0.87	0.86	0.0131	1.21	0.90	0.88	0.1367	4.20

Table 8. Results of Model 3:  $INC = AGE + ENV + AGE*ENV$  (Eq.(6)). Includes significance values for environmental variables (ENV) and interaction terms (AGE\*ENV). Reduced model does not include the interaction term. a) otolith increment (INC) dataset and b) back-calculated total length increment (BCLINC) dataset.

a)

ENV	Redbreast sunfish			Bluegill		
	Full model		Reduced model	Full model		Reduced model
	ENV	ENV*AGE	ENV	ENV	ENV*AGE	ENV
DEGDAY	0.0038	< 0.0001	< 0.0001	0.0019	0.0203	0.0043
DEGDAYFL	.	.	< 0.0001	0.5311	0.6817	0.3167
DUR3	0.2494	< 0.0001	0.0004	0.0137	0.0196	0.0127
CV	0.0038	< 0.0001	< 0.0001	0.0019	0.0203	0.0043
MIN	0.0447	< 0.0001	< 0.0001	0.0181	0.5602	0.0047
P95	0.0038	< 0.0001	< 0.0001	0.0019	0.0203	0.0043

. = stopped because of infinite likelihood

b)

ENV	Redbreast sunfish			Bluegill		
	Full model		Reduced model	Full model		Reduced model
	ENV	ENV*AGE	ENV	ENV	ENV*AGE	ENV
DEGDAY	0.0137	0.0007	< 0.0001	0.1209	0.0112	0.1203
DEGDAYFL	0.0075	0.0602	< 0.0001	0.5445	0.4156	0.2137
DUR3	0.1909	0.0141	0.0010	0.0679	0.0085	0.0675
CV	0.0137	0.0007	< 0.0001	0.1209	0.0112	0.1203
MIN	0.1007	0.0246	< 0.0001	0.4576	0.1378	0.2200
P95	0.0137	0.0007	< 0.0001	0.1209	0.0112	0.1203

confounded direct interpretation of the regression coefficients in these models. The only significant ENV variable that was not confounded by interactions with AGE was MIN, which had a significant negative relationship to bluegill growth.

In all three models, the use of back-calculated length increments instead of otolith increments resulted in generally lower significance values, but similar trends, for both species. This result may be related to the smaller sample size in the back-calculated length increment dataset and /or less accurate estimates of each AGE x YEAR mean growth estimate because of the smaller number of fish available for estimating the means.

## CHAPTER 4

### DISCUSSION

Standard otolith analysis techniques (Secor et al., 1991) were successfully used to detect yearly differences in growth from a single year's collection of relatively short-lived centrarchid species from a warmwater stream. Channel catfish otoliths did not have clear enough annuli to be analyzed even after sectioning and grinding. The use of short-lived species such as redbreast sunfish and bluegill allowed greater confidence in age estimates because annuli are more widely spaced in young fish and easier to count and measure than the outer annuli of older fish. Confidence in age estimates is essential for statistical tests of relationships between annual growth and environmental conditions.

Back-calculation of total length increments did not significantly change or improve the results based on direct otolith increment measurements, but did reduce sample sizes. The use of short-lived species was beneficial because it allowed analysis of otoliths in whole view, where a standardized axis of measurement was easier to identify. Back-calculation of lengths may still be necessary for otoliths that require sectioning because the location of the measurement axis is likely to be more variable.

Two of the statistical models for testing the relationship between growth and environmental variables were confounded by interactions with fish age, which indicated that the response of fish growth to environmental conditions was age-specific. Model 2 was only able to detect interactions that were a linearly decreasing function of age and model 3, while allowing many more degrees of freedom, was uninterpretable because of significant age interactions. Only model 1 was capable of communicating specific interactions between growth and age.

By combining the results of all three models, a few trends were apparent. For bluegill, age 1 was the only age that showed significant annual differences in growth.

Older fish were either unaffected by environmental conditions or the sample size was too small to detect any effects. Age 1 bluegill growth was consistently negatively correlated with the annual duration of flooding (DUR3) in the first 2 models. Other significant relationships included negative relationships with P95, MIN, and DEGDAYFL, all of which indicate that high and prolonged floods, particularly during the growing season, are related to reduced age 1 growth rates.

Redbreast sunfish growth had a more complicated pattern, perhaps because ages 1-3 all had significant differences in growth among years. For age 1 fish, the 2000 drought year was the best year for growth, whereas ages 2 and 3 fish grew relatively poorly that year. Although environmental variables and mean growth were not correlated, median age 1 growth was significantly negatively correlated with MIN and DUR3, indicating that low minimum flows and shorter periods of flooding enhance growth. Thus both bluegill and redbreast sunfish favored lower flows at age 1. On the other hand, high and prolonged flows (P95 and DUR3) correlated positively with age 2 median growth when 1997 was excluded. It is worthy of note that none of the environmental variables examined in this study had extreme values for 1997, the year in which growth of all ages of both species was lowest; some other, unmeasured aspect of these fishes' environment clearly had a greater effect on growth in 1997 than any of the variables examined here.

Redbreast sunfish seem to shift from greater growth with low flows at age 1 to greater growth with high flows at age 2. Other studies have found similar age dependent growth effects. Thompson (1964) and Carlander (1977) both reported a positive correlation between first year growth of largemouth bass and lake water levels followed by a negative correlation in the second year of growth. Gutreuter et al. (1999) reported that growth of largemouth bass and bluegill was size dependent; the growth of small largemouth bass and bluegill did not increase as dramatically as the growth of larger fish during a year with extreme flooding on the upper Mississippi River.

There are several possible explanations for a shift in growth response. Density-dependent growth and/or an ontogenetic shift in diet could have occurred. Although sampling techniques were not designed to calculate catch-per-unit-effort in this study, the large sample size of redbreast sunfish from the 1998 year class (the year of the second largest flood on the historic record) suggests that reproductive success may be greater during flood years. This could lead to an increase in age 1 density to the point that food is a limiting resource.

Food could also be a limiting resource for young fish if their diets are greatly restricted by their small gape-size. Putman et al. (1995) found that growth trajectories of small and large bluegill were significantly different in Illinois streams and suggested that an ontogenetic shift in diet or habitat use was responsible for this difference. In Ichawaynochaway Creek, age 1 fish may depend on a food source that is more abundant during low flow years, whereas older fish may be able to alleviate the constraint of density dependent growth by consuming a wider variety of prey, including terrestrial invertebrates that are likely to be found on the floodplain. Many authors have reported that the main prey of small bluegill is zooplankton, and that larger bluegill consume a wide variety of aquatic and terrestrial prey (Gerking, 1994; Jenkins and Burkhead, 1994). Data documenting a shift in redbreast sunfish diet, however, are not available.

The decreased growth of age 1 redbreast sunfish during flood years may also be related to increases in turbidity. In Ichawaynochaway Creek, particulate organic matter concentrations increase dramatically at higher discharges (Golladay et al., 2000). Greater turbidity can decrease the success of visual predators (Tyus and Nikirk, 1990) or lead to reduced primary production in the main channel. Increased water clarity in the lower Mississippi River was associated with increased production of phytoplankton, zooplankton, and macroinvertebrates (Rutherford et al., 1995). Similarly, growth of bluegill in Illinois streams was negatively related to percent area shaded, which may have contributed to reduced primary productivity and lower invertebrate grazer abundance

(Putman et al., 1994). The relationship between water clarity and discharge in Ichawaynochaway Creek could hinder the production of zooplankton and invertebrate grazers during floods and also reduce foraging success. Older fish with larger gape sizes may be better able to utilize larger, more visible prey in the main channel and on the floodplain.

The hypothesis that annual fish growth is greater during flood years than drought years was not fully supported for redbreast sunfish or bluegill. In fact, age 1 fish of both species grew faster during drought years than flood years. However, at least for age 2 redbreast sunfish, the predictions of the FPC may be supported; larger and longer duration floods did correlate with greater annual growth in a stream with predictable annual flooding. A better understanding of the factors affecting age 1 growth is needed to fully accept or reject the predictions of the FPC.

Based on the results of this study, instream flows should be managed to allow for a variety of annual flow regimes. Although baseflows may provide better conditions for growth of age 1 fish, at least for redbreast sunfish and bluegill, overbank flooding may also be necessary for greater growth of older fish. Warm-season floods may have the most potential to improve redbreast sunfish growth beyond age 1. Any management strategy that greatly alters the frequency or extent of historic high or low flows is likely to have a negative effect on the growth of fishes that are adapted to streams with naturally variable streamflow, like Ichawaynochaway Creek. By managing for flood suppression and/or increased prescribed minimum flows, the natural extreme flows are eliminated and fish growth may be negatively affected. In fact, 1997, the year in which most ages of both redbreast sunfish and bluegill experienced the worst growth in Ichawaynochaway Creek, was, hydrologically speaking, an average year (Appendix C); there was moderate winter flooding, average low summer baseflows, and no major tropical storms. It is possible that simply maintaining average flow conditions could actually harm species and life stages that depend on periodic extreme flows.

Redbreast sunfish and bluegill are just two of at least 55 fish species known to inhabit Ichawyanochaway Creek (Freeman and Freeman, 1992). If growth response to instream flows differs between these two closely related species and even among ages within each species, then the effects of instream flow variations on growth of the whole assemblage is undoubtedly quite complex. For now, managers should take care to consider the effects of instream flow management options, particularly if they eliminate the natural extremes, not only on different species and guilds, but also on different life stages within a species whenever this information is available.

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## APPENDIX A

### Calculation of Colwell's Index of Constancy (Gan et al., 1991)

First, a matrix of days in columns and flow categories, or "states", in rows was constructed. The number of times that discharge was in a particular state on a particular day was recorded; in this case, 1 was the maximum value since only one year at a time, thus one value for each day, was considered.

Let  $Y_i$  equal the row totals, or number of days that discharge was in each state,  $s$  equal the number of rows, or 6 states in this case, and  $Z$  equal the sum of row and column totals, equal to 365 in the case of a single year's data. Then constancy ( $C$ ) is defined as:

$$C = 1 - H(Y)/\log s$$

where

$$H(Y) = -\sum_i (Y_i/Z)\log(Y_i/Z)$$

APPENDIX B

Individual fish data. R1 - R7 are otolith radii measured in mm from nucleus toward rostrum.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
1	Micropterus	salmoides	shocked	16-Jun-00	300	243	.	.	.	.	.	.	.
2	Lepomis	macrochirus	shocked	16-Jun-00	118	87	1.800	2.400	.	.	.	.	.
3	Lepomis	macrochirus	shocked	16-Jun-00	102	77	0.700	1.800	1.900	.	.	.	.
4	Lepomis	auritus	shocked	16-Jun-00	95	73	1.300	1.850	2.000	.	.	.	.
5	Lepomis	macrochirus	shocked	16-Jun-00	103	77	0.900	2.100	2.200	.	.	.	.
6	Lepomis	auritus	shocked	16-Jun-00	108	80	.	.	.	.	.	.	.
7	Lepomis	microlophus	shocked	16-Jun-00	115	89	1.350	2.000	2.100	.	.	.	.
8	Lepomis	macrochirus	shocked	16-Jun-00	106	80	1.200	2.200	2.250	.	.	.	.
9	Lepomis	macrochirus	shocked	16-Jun-00	111	75	1.500	2.150	.	.	.	.	.
10	Lepomis	macrochirus	shocked	16-Jun-00	108	82	2.250	.	.	.	.	.	.
11	Lepomis	auritus	shocked	16-Jun-00	82	64	1.209	1.560	.	.	.	.	.
12	Lepomis	macrochirus	shocked	16-Jun-00	105	78	1.250	2.200	2.350	.	.	.	.
13	Lepomis	macrochirus	shocked	16-Jun-00	114	87	0.900	2.200	2.300	.	.	.	.
14	Lepomis	macrochirus	shocked	16-Jun-00	109	82	0.900	2.100	2.200	.	.	.	.
15	Lepomis	macrochirus	shocked	16-Jun-00	106	80	.	.	.	.	.	.	.
16	Lepomis	macrochirus	shocked	16-Jun-00	114	86	.	.	.	.	.	.	.
17	Lepomis	macrochirus	shocked	16-Jun-00	119	91	1.541	2.546	2.613	.	.	.	.
18	Lepomis	microlophus	shocked	16-Jun-00	126	98	1.200	2.200	2.350	.	.	.	.
19	Lepomis	auritus	shocked	16-Jun-00	98	74	1.200	1.850	1.950	.	.	.	.
20	Lepomis	auritus	shocked	16-Jun-00	95	75	1.100	1.700	1.800	.	.	.	.
21	Lepomis	auritus	shocked	16-Jun-00	105	84	1.350	2.000	2.150	.	.	.	.
22	Lepomis	macrochirus	shocked	16-Jun-00	91	69	0.900	2.000	2.100	.	.	.	.
23	Lepomis	auritus	shocked	16-Jun-00	104	81	1.300	2.050	2.150	.	.	.	.
24	Lepomis	macrochirus	shocked	16-Jun-00	113	76	1.000	2.200	2.300	.	.	.	.
25	Lepomis	macrochirus	shocked	16-Jun-00	97	74	2.000	2.100	.	.	.	.	.
26	Lepomis	macrochirus	shocked	16-Jun-00	97	75	1.200	2.100	.	.	.	.	.
27	Lepomis	macrochirus	shocked	16-Jun-00	106	80	1.550	2.250	2.300	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
28	Lepomis	auritus	shocked	16-Jun-00	57	44	1.150	.	.	.	.	.	.
29	Lepomis	macrochirus	shocked	16-Jun-00	108	83	1.000	2.200	2.300	.	.	.	.
30	Lepomis	auritus	shocked	16-Jun-00	161	132	1.273	2.479	2.747	.	.	.	.
31	Ictalurus	punctatus	angled	9-Jun-00	.	.	.	.	.	.	.	.	.
32	Micropterus	salmoides	angled	13-Jun-00	.	.	2.200	4.200	5.200	.	.	.	.
33	Ictalurus	punctatus	angled	9-Jun-00	.	.	.	.	.	.	.	.	.
34	Ictalurus	punctatus	angled	9-Jun-00	.	.	.	.	.	.	.	.	.
35	Micropterus	salmoides	angled	29-Jun-00	.	.	2.814	3.417	.	.	.	.	.
36	Micropterus	salmoides	angled	29-Jun-00	281	230	2.200	4.400	4.800	.	.	.	.
37	Lepomis	auritus	angled	29-Jun-00	166	128	1.273	2.211	2.680	3.015	3.082	.	.
38	Micropterus	salmoides	angled	29-Jun-00	454	375	1.573	3.003	4.290	5.005	5.291	5.434	5.720
39	Micropterus	cataractae	angled	30-Jun-00	223	182	2.900	3.500	.	.	.	.	.
40	Lepomis	auritus	angled	9-Jul-00	137	105	0.871	2.010	2.479	2.680	.	.	.
41	Lepomis	auritus	angled	10-Jul-00	133	102	1.742	2.546	2.613	.	.	.	.
42	Lepomis	macrochirus	angled	10-Jul-00	163	124	1.400	2.400	2.800	3.400	3.600	.	.
43	Lepomis	auritus	angled	10-Jul-00	123	98	1.400	2.200	2.500	.	.	.	.
44	Lepomis	auritus	angled	11-Jul-00	153	118	1.340	2.747	2.948	.	.	.	.
45	Lepomis	auritus	angled	11-Jul-00	142	119	1.206	2.144	2.881	3.149	.	.	.
46	Lepomis	auritus	angled	11-Jul-00	134	107	1.139	2.412	2.680	.	.	.	.
47	Lepomis	auritus	angled	11-Jul-00	148	114	1.005	2.278	2.412	.	.	.	.
48	Lepomis	auritus	angled	11-Jul-00	146	115	1.206	2.479	2.747	.	.	.	.
49	Lepomis	auritus	angled	11-Jul-00	201	156	1.600	2.400	3.400	3.800	3.900	.	.
50	Lepomis	auritus	angled	11-Jul-00	152	119	.	.	.	.	.	.	.
51	Lepomis	auritus	angled	11-Jul-00	117	90	1.150	1.950	2.100	.	.	.	.
52	Micropterus	cataractae	angled	11-Jul-00	173	137	2.948	3.283	.	.	.	.	.
53	Micropterus	cataractae	angled	11-Jul-00	185	151	2.948	3.216	.	.	.	.	.
54	Micropterus	cataractae	angled	11-Jul-00	157	134	2.814	3.149	.	.	.	.	.
55	Micropterus	cataractae	angled	11-Jul-00	223	182	2.900	3.500	.	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
56	Micropterus	cataractae	angled	11-Jul-00	200	161	2.747	3.350	.	.	.	.	.
57	Lepomis	auritus	angled	11-Jul-00	147	117	.	.	.	.	.	.	.
58	Lepomis	macrochirus	angled	11-Jul-00	127	95	1.340	2.479	2.613	.	.	.	.
59	Lepomis	auritus	angled	15-Jul-00	121	95	1.700	2.150	2.300	.	.	.	.
60	Micropterus	cataractae	angled	17-Jul-00	187	149	3.200	3.700	.	.	.	.	.
61	Lepomis	auritus	angled	16-Jul-00	170	136	1.600	2.400	2.800	3.100	3.300	3.400	.
62	Lepomis	auritus	angled	16-Jul-00	186	143	.	.	.	.	.	.	.
63	Ictalurus	punctatus	angled	25-Jul-00	603	483	.	.	.	.	.	.	.
64	Ictalurus	punctatus	angled	25-Jul-00	445	362	.	.	.	.	.	.	.
65	Lepomis	auritus	angled	3-Aug-00	140	110	.	.	.	.	.	.	.
66	Lepomis	auritus	angled	9-Aug-00	114	88	1.541	2.144	.	.	.	.	.
67	Micropterus	cataractae	angled	9-Aug-00	249	199	2.000	3.500	3.800	.	.	.	.
68	Lepomis	auritus	shocked	11-Aug-00	97	73	1.250	1.800	.	.	.	.	.
69	Lepomis	auritus	shocked	11-Aug-00	167	134	1.139	1.943	2.613	3.082	3.283	.	.
70	Lepomis	macrochirus	shocked	11-Aug-00	130	100	.	.	.	.	.	.	.
71	Lepomis	macrochirus	shocked	11-Aug-00	99	123	0.900	2.000	2.400	.	.	.	.
72	Lepomis	macrochirus	shocked	11-Aug-00	123	95	1.005	1.742	2.412	2.680	.	.	.
73	Lepomis	auritus	shocked	11-Aug-00	130	100	1.340	2.211	2.345	.	.	.	.
74	Lepomis	macrochirus	shocked	11-Aug-00	101	77	1.407	2.077	2.211	.	.	.	.
75	Lepomis	macrochirus	shocked	11-Aug-00	116	86	1.150	2.150	2.300	.	.	.	.
76	Lepomis	macrochirus	shocked	11-Aug-00	104	77	0.700	2.000	2.200	.	.	.	.
77	Lepomis	auritus	shocked	11-Aug-00	97	75	1.350	2.050	2.150	.	.	.	.
78	Lepomis	macrochirus	shocked	11-Aug-00	113	85	1.200	1.950	2.100	.	.	.	.
79	Lepomis	macrochirus	shocked	11-Aug-00	105	81	1.200	2.150	2.350	.	.	.	.
80	Lepomis	macrochirus	shocked	11-Aug-00	125	96	1.100	2.100	2.600	.	.	.	.
81	Lepomis	macrochirus	shocked	11-Aug-00	113	86	1.100	2.050	2.300	.	.	.	.
82	Lepomis	auritus	shocked	11-Aug-00	119	93	1.650	2.200	.	.	.	.	.
83	Lepomis	macrochirus	shocked	11-Aug-00	143	108	.	.	.	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
84	Lepomis	macrochirus	shocked	11-Aug-00	111	84	.	.	.	.	.	.	.
85	Lepomis	auritus	shocked	11-Aug-00	152	121	1.340	1.943	2.345	2.747	2.814	.	.
86	Lepomis	macrochirus	shocked	11-Aug-00	111	84	1.500	2.250	2.450	.	.	.	.
87	Lepomis	macrochirus	shocked	11-Aug-00	134	102	1.474	2.412	2.814	.	.	.	.
88	Lepomis	auritus	shocked	11-Aug-00	161	125	0.800	1.800	2.900	3.000	.	.	.
89	Lepomis	auritus	shocked	11-Aug-00	131	102	1.474	2.546	2.881	.	.	.	.
90	Lepomis	macrochirus	shocked	11-Aug-00	140	108	1.474	2.412	2.948	.	.	.	.
91	Lepomis	auritus	shocked	11-Aug-00	98	71	1.850	.	.	.	.	.	.
92	Lepomis	auritus	shocked	11-Aug-00	110	86	1.700	2.050	.	.	.	.	.
93	Lepomis	auritus	shocked	11-Aug-00	97	74	1.700	1.900	.	.	.	.	.
94	Lepomis	macrochirus	shocked	11-Aug-00	161	122	1.340	2.211	2.881	3.283	.	.	.
95	Lepomis	macrochirus	shocked	11-Aug-00	103	77	0.700	1.900	2.200	.	.	.	.
96	Lepomis	macrochirus	shocked	11-Aug-00	126	95	1.000	2.200	2.500	.	.	.	.
97	Lepomis	macrochirus	shocked	11-Aug-00	123	92	1.072	2.479	2.613	.	.	.	.
98	Lepomis	auritus	shocked	11-Aug-00	115	90	1.750	2.200	.	.	.	.	.
99	Lepomis	macrochirus	shocked	11-Aug-00	131	99	0.900	2.400	2.800	.	.	.	.
100	Lepomis	macrochirus	shocked	11-Aug-00	128	97	1.100	2.200	2.600	.	.	.	.
101	Lepomis	macrochirus	shocked	11-Aug-00	103	85	1.407	2.144	2.412	.	.	.	.
102	Lepomis	macrochirus	shocked	11-Aug-00	157	121	1.340	2.010	2.546	3.015	.	.	.
103	Lepomis	auritus	shocked	11-Aug-00	116	90	1.407	2.144	.	.	.	.	.
104	Lepomis	macrochirus	shocked	11-Aug-00	126	93	1.340	2.412	2.747	.	.	.	.
105	Lepomis	macrochirus	shocked	11-Aug-00	121	91	1.675	2.479	2.747	.	.	.	.
106	Lepomis	auritus	shocked	11-Aug-00	136	117	1.139	2.144	2.680	.	.	.	.
107	Lepomis	auritus	shocked	11-Aug-00	107	83	1.650	1.950	.	.	.	.	.
108	Lepomis	auritus	shocked	11-Aug-00	81	63	1.560	.	.	.	.	.	.
109	Lepomis	macrochirus	shocked	11-Aug-00	162	115	1.943	2.747	3.149	.	.	.	.
110	Lepomis	auritus	shocked	11-Aug-00	156	120	0.600	1.800	2.600	2.900	.	.	.
111	Lepomis	auritus	shocked	11-Aug-00	95	75	1.833	.	.	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
112	Lepomis	macrochirus	shocked	11-Aug-00	123	93	1.273	2.077	2.412	.	.	.	.
113	Lepomis	auritus	shocked	11-Aug-00	118	92	1.250	2.100	2.250	.	.	.	.
114	Lepomis	auritus	shocked	11-Aug-00	150	119	1.675	2.747	2.948	.	.	.	.
115	Lepomis	macrochirus	shocked	11-Aug-00	103	77	1.050	2.050	2.200	.	.	.	.
116	Lepomis	macrochirus	shocked	11-Aug-00	122	91	1.000	2.100	2.300	.	.	.	.
117	Lepomis	auritus	shocked	11-Aug-00	151	117	1.541	2.613	3.015	.	.	.	.
118	Lepomis	auritus	shocked	11-Aug-00	90	70	1.599	.	.	.	.	.	.
119	Lepomis	auritus	shocked	11-Aug-00	95	74	1.900	.	.	.	.	.	.
120	Lepomis	macrochirus	shocked	11-Aug-00	122	91	1.072	2.278	2.479	.	.	.	.
121	Lepomis	microlophus	shocked	11-Aug-00	169	130	1.340	3.082	.	.	.	.	.
122	Lepomis	microlophus	shocked	11-Aug-00	148	114	1.139	2.077	2.814	.	.	.	.
123	Lepomis	microlophus	shocked	11-Aug-00	170	132	1.072	1.876	2.613	3.015	.	.	.
124	Lepomis	gulosus	shocked	11-Aug-00	128	102	2.000	3.400	.	.	.	.	.
125	Lepomis	microlophus	shocked	11-Aug-00	148	115	0.804	1.742	2.613	2.881	.	.	.
126	Lepomis	gulosus	shocked	11-Aug-00	134	107	1.139	1.608	2.747	3.417	.	.	.
127	Lepomis	auritus	angled	11-Aug-00	187	151	0.938	1.608	2.345	2.881	3.283	.	.
128	Micropterus	cataractae	angled	11-Aug-00	174	139	2.010	2.814	.	.	.	.	.
129	Lepomis	auritus	angled	11-Aug-00	118	90	1.200	1.850	2.200	.	.	.	.
130	Micropterus	cataractae	angled	11-Aug-00	275	224	2.500	3.700	4.100	.	.	.	.
131	Micropterus	cataractae	angled	11-Aug-00	247	201	2.900	3.800	.	.	.	.	.
132	Micropterus	cataractae	shocked	11-Aug-00	202	164	2.345	3.350	.	.	.	.	.
133	Micropterus	salmoides	shocked	11-Aug-00	176	140	2.400	3.300	.	.	.	.	.
134	Micropterus	salmoides	shocked	11-Aug-00	187	150	2.500	3.700	.	.	.	.	.
135	Micropterus	salmoides	shocked	11-Aug-00	277	226	2.800	4.200	4.900	.	.	.	.
136	Micropterus	salmoides	shocked	11-Aug-00	323	266	2.400	4.200	4.600	.	.	.	.
137	Ictalurus	punctatus	shocked	11-Aug-00	581	480	.	.	.	.	.	.	.
138	Lepomis	auritus	angled	22-Aug-00	152	121	1.541	2.546	2.814	.	.	.	.
139	Micropterus	cataractae	angled	22-Aug-00	359	296	2.145	4.004	5.291	5.434	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
140	Micropterus	cataractae	angled	29-Aug-00	209	172	2.412	3.417	.	.	.	.	.
141	Lepomis	auritus	angled	29-Aug-00	153	118	1.273	2.546	2.747	.	.	.	.
142	Lepomis	auritus	angled	30-Aug-00	139	107	1.340	2.144	2.546	.	.	.	.
143	Lepomis	auritus	angled	30-Aug-00	188	150	1.742	2.479	3.015	3.350	3.484	.	.
144	Micropterus	cataractae	angled	30-Aug-00	194	156	2.077	3.082	.	.	.	.	.
145	Lepomis	auritus	angled	30-Aug-00	176	140	1.000	1.700	2.300	3.000	3.200	.	.
146	Lepomis	auritus	angled	30-Aug-00	167	130	1.407	2.479	3.149	.	.	.	.
147	Lepomis	auritus	angled	30-Aug-00	149	116	1.474	2.613	2.814	.	.	.	.
148	Micropterus	salmoides	angled	30-Aug-00	202	161	2.900	3.900	.	.	.	.	.
149	Micropterus	salmoides	angled	30-Aug-00	240	193	2.900	3.800	.	.	.	.	.
150	Micropterus	cataractae	angled	30-Aug-00	240	193	2.800	3.600	.	.	.	.	.
151	Micropterus	cataractae	angled	30-Aug-00	237	194	2.278	3.350	.	.	.	.	.
152	Lepomis	auritus	angled	30-Aug-00	173	136	0.737	1.809	2.948	3.015	.	.	.
153	Lepomis	auritus	angled	30-Aug-00	156	121	1.206	2.278	2.747	.	.	.	.
154	Lepomis	auritus	angled	30-Aug-00	159	126	0.800	1.800	3.000	3.000	.	.	.
155	Lepomis	auritus	angled	30-Aug-00	150	120	1.340	2.345	2.814	.	.	.	.
156	Lepomis	auritus	angled	30-Aug-00	151	118	1.139	2.345	2.680	.	.	.	.
157	Lepomis	auritus	angled	30-Aug-00	154	120	1.139	2.412	2.881	.	.	.	.
158	Lepomis	auritus	angled	30-Aug-00	136	104	1.206	1.943	2.546	.	.	.	.
159	Lepomis	auritus	angled	30-Aug-00	139	109	0.700	2.000	2.600	.	.	.	.
160	Lepomis	auritus	angled	31-Aug-00	205	163	1.000	2.200	2.700	3.100	3.400	3.500	.
161	Lepomis	macrochirus	angled	30-Aug-00	152	113	1.072	2.211	3.015	3.283	.	.	.
162	Lepomis	punctatus	angled	30-Aug-00	110	85	1.206	2.010	2.479	.	.	.	.
163	Lepomis	punctatus	angled	30-Aug-00	146	114	0.938	1.742	2.814	3.015	.	.	.
164	Lepomis	punctatus	angled	30-Aug-00	111	89	1.474	2.211	2.546	.	.	.	.
165	Ictalurus	punctatus	angled	4-Sep-00	291	225	.	.	.	.	.	.	.
166	Ictalurus	punctatus	angled	4-Sep-00	280	223	.	.	.	.	.	.	.
167	Lepomis	auritus	angled	4-Sep-00	149	115	1.608	2.546	2.881	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
168	Lepomis	auritus	angled	19-Aug-00	.	.	0.900	2.200	3.100	3.400	.	.	.
169	Lepomis	auritus	angled	19-Aug-00	.	.	0.670	2.010	2.948	3.216	.	.	.
170	Lepomis	auritus	angled	19-Aug-00	.	.	1.340	2.412	2.881	.	.	.	.
171	Lepomis	auritus	angled	19-Aug-00	.	.	1.139	2.211	2.747	.	.	.	.
172	Lepomis	auritus	angled	19-Aug-00	.	.	1.273	2.345	2.814	.	.	.	.
173	Lepomis	auritus	angled	19-Aug-00	.	.	1.273	2.412	2.747	.	.	.	.
174	Lepomis	auritus	angled	19-Aug-00	.	.	0.871	1.943	2.345	3.015	3.216	.	.
175	Lepomis	auritus	angled	19-Aug-00	.	.	1.005	2.144	2.546	.	.	.	.
176	Lepomis	auritus	angled	19-Aug-00	.	.	1.139	2.412	2.881	.	.	.	.
177	Lepomis	auritus	angled	19-Aug-00	.	.	1.139	2.345	2.881	.	.	.	.
178	Lepomis	auritus	angled	19-Aug-00	.	.	1.273	2.345	2.881	.	.	.	.
179	Lepomis	auritus	angled	19-Aug-00	.	.	1.206	1.876	2.546	2.881	3.015	.	.
180	Lepomis	auritus	angled	19-Aug-00	.	.	.	.	.	.	.	.	.
181	Lepomis	auritus	angled	19-Aug-00	.	.	1.541	2.278	2.479	.	.	.	.
182	Lepomis	auritus	angled	19-Aug-00	.	.	1.407	2.345	2.747	.	.	.	.
183	Lepomis	auritus	angled	19-Aug-00	.	.	1.273	2.345	2.814	.	.	.	.
184	Lepomis	auritus	angled	19-Aug-00	.	.	0.670	1.876	2.881	3.149	.	.	.
185	Lepomis	auritus	angled	19-Aug-00	.	.	1.675	2.546	2.814	.	.	.	.
186	Lepomis	auritus	angled	19-Aug-00	.	.	.	.	.	.	.	.	.
187	Lepomis	auritus	angled	19-Aug-00	.	.	1.474	2.680	2.948	.	.	.	.
188	Ictalurus	punctatus	angled	4-Sep-00	.	.	.	.	.	.	.	.	.
189	Ictalurus	punctatus	angled	4-Sep-00	.	.	.	.	.	.	.	.	.
190	Ictalurus	punctatus	angled	4-Sep-00	.	.	.	.	.	.	.	.	.
191	Micropterus	cataraetae	angled	6-Sep-00	232	195	.	.	.	.	.	.	.
192	Lepomis	auritus	angled	2-Sep-00	.	.	1.340	2.345	2.881	.	.	.	.
193	Lepomis	auritus	angled	2-Sep-00	.	.	1.100	1.800	2.400	3.100	3.500	.	.
194	Lepomis	auritus	angled	2-Sep-00	.	.	1.273	2.278	2.881	.	.	.	.
195	Lepomis	macrochirus	angled	2-Sep-00	.	.	1.600	2.400	3.100	3.600	3.800	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
196	Lepomis	auritus	angled	2-Sep-00	.	.	2.412	.	.	.	.	.	.
197	Lepomis	auritus	angled	2-Sep-00	.	.	0.900	2.100	3.000	3.500	.	.	.
198	Lepomis	auritus	angled	2-Sep-00	.	.	1.608	2.479	3.082	.	.	.	.
199	Lepomis	auritus	angled	2-Sep-00	.	.	1.608	2.613	2.948	.	.	.	.
200	Lepomis	auritus	angled	2-Sep-00	.	.	0.700	1.800	2.600	3.000	.	.	.
201	Lepomis	auritus	angled	2-Sep-00	.	.	1.273	2.412	3.082	.	.	.	.
202	Lepomis	macrochirus	angled	2-Sep-00	.	.	1.100	2.100	3.300	4.000	.	.	.
203	Lepomis	auritus	angled	2-Sep-00	.	.	1.675	2.613	.	.	.	.	.
204	Lepomis	auritus	angled	2-Sep-00	.	.	1.742	2.747	3.216	.	.	.	.
205	Lepomis	auritus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
206	Lepomis	auritus	angled	2-Sep-00	.	.	1.675	2.613	2.814	.	.	.	.
207	Lepomis	auritus	angled	2-Sep-00	.	.	1.206	2.278	3.015	3.216	.	.	.
208	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
209	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
210	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
211	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
212	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
213	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
214	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
215	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
216	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
217	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
218	Ictalurus	punctatus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
219	Lepomis	auritus	angled	2-Sep-00	.	.	1.273	2.278	2.613	.	.	.	.
220	Lepomis	auritus	angled	8-Sep-00	181	141	0.670	2.144	3.149	3.350	.	.	.
221	Lepomis	auritus	angled	8-Sep-00	133	102	1.206	2.278	2.546	.	.	.	.
222	Lepomis	auritus	angled	8-Sep-00	186	145	0.938	2.546	3.283	3.417	.	.	.
223	Lepomis	macrochirus	angled	8-Sep-00	141	116	1.608	2.546	2.881	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
224	Lepomis	auritus	angled	8-Sep-00	149	115	1.273	2.278	2.747	.	.	.	.
225	Micropterus	cataractae	angled	8-Sep-00	219	178	2.546	3.350	.	.	.	.	.
226	Micropterus	cataractae	angled	8-Sep-00	265	216	3.300	4.000	.	.	.	.	.
227	Micropterus	cataractae	angled	8-Sep-00	263	213	3.100	3.700	.	.	.	.	.
228	Lepomis	auritus	angled	17-Sep-00	178	139	0.938	2.144	2.948	3.082	.	.	.
229	Micropterus	cataractae	angled	17-Sep-00	275	227	1.500	3.300	4.000	.	.	.	.
230	Lepomis	auritus	angled	17-Sep-00	122	97	1.876	2.278	2.412	.	.	.	.
231	Lepomis	auritus	angled	17-Sep-00	162	124	1.072	2.144	2.881	3.015	.	.	.
232	Lepomis	auritus	angled	15-Sep-00	152	119	0.938	2.278	2.881	3.082	.	.	.
233	Lepomis	auritus	angled	15-Sep-00	159	124	1.474	2.546	2.881	.	.	.	.
234	Lepomis	auritus	angled	15-Sep-00	138	108	1.139	2.278	2.680	.	.	.	.
235	Lepomis	auritus	angled	15-Sep-00	154	121	1.139	2.412	2.814	.	.	.	.
236	Lepomis	auritus	angled	15-Sep-00	155	119	1.206	2.479	2.814	.	.	.	.
237	Lepomis	auritus	angled	15-Sep-00	165	129	0.670	2.077	2.814	2.948	.	.	.
238	Lepomis	auritus	angled	15-Sep-00	156	121	1.340	2.479	2.814	.	.	.	.
239	Lepomis	auritus	angled	15-Sep-00	157	123	0.536	1.742	2.613	2.814	.	.	.
240	Micropterus	cataractae	angled	15-Sep-00	248	201	2.500	3.600	.	.	.	.	.
241	Lepomis	auritus	angled	2-Sep-00	.	.	1.675	2.747	.	.	.	.	.
242	Lepomis	auritus	angled	2-Sep-00	.	.	.	.	.	.	.	.	.
243	Micropterus	cataractae	angled	20-Sep-00	220	178	2.400	3.600	.	.	.	.	.
244	Micropterus	cataractae	angled	20-Sep-00	452	382	.	.	.	.	.	.	.
245	Micropterus	cataractae	angled	20-Sep-00	292	243	3.300	4.400	.	.	.	.	.
246	Micropterus	cataractae	angled	20-Sep-00	248	202	2.500	3.700	.	.	.	.	.
247	Micropterus	cataractae	angled	20-Sep-00	428	355	1.900	3.700	4.700	5.400	5.700	6.100	6.100
248	Micropterus	cataractae	angled	20-Sep-00	393	325	2.145	4.433	5.577	6.006	.	.	.
249	Lepomis	auritus	angled	20-Sep-00	155	123	1.809	2.345	2.680	2.881	2.948	.	.
250	Ictalurus	punctatus	angled	25-Sep-00	287	225	.	.	.	.	.	.	.
251	Ictalurus	punctatus	angled	25-Sep-00	280	226	.	.	.	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
252	Ictalurus	punctatus	angled	25-Sep-00	294	227	.	.	.	.	.	.	.
253	Ictalurus	punctatus	angled	25-Sep-00	311	229	.	.	.	.	.	.	.
254	Ictalurus	punctatus	angled	25-Sep-00	366	281	.	.	.	.	.	.	.
255	Ictalurus	punctatus	angled	25-Sep-00	335	264	.	.	.	.	.	.	.
256	Ictalurus	punctatus	angled	1-Oct-00	288	216	.	.	.	.	.	.	.
257	Ictalurus	punctatus	angled	1-Oct-00	349	266	.	.	.	.	.	.	.
258	Ictalurus	punctatus	angled	1-Oct-00	299	232	.	.	.	.	.	.	.
259	Ictalurus	punctatus	angled	1-Oct-00	337	251	.	.	.	.	.	.	.
260	Ictalurus	punctatus	angled	1-Oct-00	320	242	.	.	.	.	.	.	.
261	Ictalurus	punctatus	angled	1-Oct-00	411	315	.	.	.	.	.	.	.
262	Ictalurus	punctatus	angled	1-Oct-00	296	222	.	.	.	.	.	.	.
263	Micropterus	cataractae	angled	29-Sep-00	362	336	1.300	2.900	4.100	4.700	5.000	5.200	5.600
264	Lepomis	auritus	angled	29-Sep-00	161	128	1.273	2.479	3.149	.	.	.	.
265	Ictalurus	punctatus	angled	30-Sep-00	.	.	.	.	.	.	.	.	.
266	Ictalurus	punctatus	angled	30-Sep-00	.	.	.	.	.	.	.	.	.
267	Ictalurus	punctatus	angled	30-Sep-00	.	.	.	.	.	.	.	.	.
268	Ictalurus	punctatus	angled	30-Sep-00	.	.	.	.	.	.	.	.	.
269	Ictalurus	punctatus	angled	30-Sep-00	.	.	.	.	.	.	.	.	.
270	Ictalurus	punctatus	angled	30-Sep-00	.	.	.	.	.	.	.	.	.
271	Ictalurus	punctatus	angled	30-Sep-00	.	.	.	.	.	.	.	.	.
272	Micropterus	cataractae	angled	5-Oct-00	315	257	2.000	4.200	4.800	.	.	.	.
273	Micropterus	cataractae	angled	5-Oct-00	266	221	3.100	4.300	.	.	.	.	.
274	Micropterus	cataractae	angled	5-Oct-00	309	254	.	.	.	.	.	.	.
275	Micropterus	cataractae	angled	5-Oct-00	311	250	1.700	3.700	4.600	4.800	.	.	.
276	Micropterus	cataractae	angled	5-Oct-00	495	408	.	.	.	.	.	.	.
277	Micropterus	salmoides	angled	5-Oct-00	294	241	.	.	.	.	.	.	.
278	Micropterus	cataractae	angled	5-Oct-00	332	275	2.500	4.100	4.700	.	.	.	.
279	Ictalurus	punctatus	angled	2-Oct-00	282	228	.	.	.	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
280	Ictalurus	punctatus	angled	1-Oct-00	.	.	.	.	.	.	.	.	.
281	Ictalurus	punctatus	angled	1-Oct-00	.	.	.	.	.	.	.	.	.
282	Ictalurus	punctatus	angled	1-Oct-00	.	.	.	.	.	.	.	.	.
283	Ictalurus	punctatus	angled	1-Oct-00	.	.	.	.	.	.	.	.	.
284	Ictalurus	punctatus	angled	1-Oct-00	.	.	.	.	.	.	.	.	.
285	Ictalurus	punctatus	angled	1-Oct-00	.	.	.	.	.	.	.	.	.
286	Ictalurus	punctatus	angled	1-Oct-00	.	.	.	.	.	.	.	.	.
287	Ictalurus	punctatus	angled	7-Oct-00	.	.	.	.	.	.	.	.	.
288	Ictalurus	punctatus	angled	7-Oct-00	.	.	.	.	.	.	.	.	.
289	Ictalurus	punctatus	angled	7-Oct-00	.	.	.	.	.	.	.	.	.
290	Lepomis	auritus	angled	7-Oct-00	.	.	1.742	2.680	.	.	.	.	.
291	Lepomis	auritus	angled	7-Oct-00	.	.	0.938	1.809	2.278	.	.	.	.
292	Lepomis	macrochirus	angled	7-Oct-00	.	.	1.809	2.680	3.350	.	.	.	.
293	Ictalurus	punctatus	angled	7-Oct-00	.	.	.	.	.	.	.	.	.
294	Ictalurus	punctatus	angled	7-Oct-00	.	.	.	.	.	.	.	.	.
295	Micropterus	cataractae	angled	13-Oct-00	285	233	2.800	3.900	.	.	.	.	.
296	Micropterus	cataractae	angled	13-Oct-00	340	281	2.000	4.400	5.000	.	.	.	.
297	Micropterus	cataractae	angled	13-Oct-00	442	366	2.400	3.900	4.900	5.400	.	.	.
298	Micropterus	cataractae	angled	17-Oct-00	422	344	.	.	.	.	.	.	.
299	Micropterus	cataractae	angled	17-Oct-00	447	369	2.000	4.000	5.100	5.600	5.900	.	.
300	Micropterus	cataractae	angled	17-Oct-00	440	370	2.145	3.718	4.719	5.291	5.577	.	.
301	Micropterus	cataractae	angled	17-Oct-00	302	250	3.300	4.500	.	.	.	.	.
302	Micropterus	cataractae	angled	27-Oct-00	296	243	2.100	3.500	4.500	.	.	.	.
303	Micropterus	cataractae	angled	27-Oct-00	386	317	2.100	3.800	4.800	5.300	.	.	.
304	Micropterus	cataractae	angled	3-Nov-00	256	209	2.700	4.100	.	.	.	.	.
305	Micropterus	cataractae	angled	3-Nov-00	355	290	2.600	4.400	5.000	.	.	.	.
306	Micropterus	cataractae	angled	3-Nov-00	340	278	2.288	3.718	4.433	4.719	4.862	5.005	.
307	Micropterus	cataractae	angled	3-Nov-00	363	297	1.859	3.432	5.148	5.577	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
308	Micropterus	salmoides	angled	3-Nov-00	247	198	3.100	4.400	.	.	.	.	.
309	Lepomis	macrochirus	angled	3-Nov-00	160	124	1.675	2.814	3.484	.	.	.	.
310	Lepomis	auritus	angled	2-Nov-00	193	154	2.200	2.700	3.100	3.400	3.500	.	.
311	Lepomis	auritus	angled	2-Nov-00	179	142	0.800	1.800	2.500	3.000	3.300	3.500	.
312	Lepomis	auritus	angled	2-Nov-00	192	153	.	.	.	.	.	.	.
313	Morone	saxatilis	angled	2-Nov-00	268	216	4.400	5.500	5.600	.	.	.	.
314	Ictalurus	punctatus	trot line	13-Nov-00	613	497	.	.	.	.	.	.	.
315	Ictalurus	punctatus	trot line	14-Nov-00	333	266	.	.	.	.	.	.	.
316	Ictalurus	punctatus	trot line	14-Nov-00	465	370	.	.	.	.	.	.	.
317	Ictalurus	punctatus	angled	14-Nov-00	355	277	.	.	.	.	.	.	.
318	Ictalurus	punctatus	angled	14-Nov-00	384	318	.	.	.	.	.	.	.
319	Lepomis	auritus	angled	2-Feb-01	153	122	1.407	2.412	2.814	.	.	.	.
320	Ictalurus	punctatus	trot line	5-Dec-00	287	219	.	.	.	.	.	.	.
321	Lepomis	macrochirus	angled	26-Jan-01	208	160	.	.	.	.	.	.	.
322	Micropterus	salmoides	angled	26-Jan-01	370	306	.	.	.	.	.	.	.
323	Ictalurus	punctatus	angled	9-Feb-01	569	445	.	.	.	.	.	.	.
324	Lepomis	auritus	angled	9-Feb-01	86	66	1.050	1.500	1.850	.	.	.	.
325	Lepomis	auritus	angled	9-Feb-01	113	80	1.150	1.750	2.250	.	.	.	.
326	Lepomis	auritus	angled	9-Feb-01	113	89	1.350	2.100	2.250	.	.	.	.
327	Lepomis	auritus	angled	9-Feb-01	101	78	1.750	2.000	.	.	.	.	.
328	Lepomis	macrochirus	angled	9-Feb-01	123	92	1.072	2.278	2.479	.	.	.	.
329	Lepomis	macrochirus	angled	9-Feb-01	117	88	1.050	2.200	2.500	.	.	.	.
330	Lepomis	auritus	angled	9-Feb-01	128	97	0.737	1.608	2.144	2.680	2.881	.	.
331	Lepomis	auritus	angled	9-Feb-01	152	117	1.005	1.675	2.546	.	.	.	.
332	Lepomis	auritus	angled	9-Feb-01	190	152	0.900	1.900	2.500	2.800	3.100	3.400	3.500
333	Lepomis	macrochirus	angled	9-Feb-01	218	169	1.500	2.800	3.700	4.100	4.200	.	.
334	Lepomis	macrochirus	angled	15-Feb-01	202	156	0.603	1.876	2.613	3.216	.	.	.
335	Lepomis	auritus	angled	23-Feb-01	182	147	1.139	2.144	3.015	3.216	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
336	Lepomis	auritus	angled	23-Feb-01	148	119	1.206	2.144	2.680	.	.	.	.
337	Lepomis	auritus	angled	28-Feb-01	212	170	1.139	1.876	2.479	3.082	3.350	.	.
338	Lepomis	auritus	angled	28-Feb-01	115	90	1.000	1.950	2.150	.	.	.	.
339	Lepomis	auritus	angled	28-Feb-01	98	81	0.950	1.600	2.050	2.250	.	.	.
340	Ictalurus	punctatus	angled	10-Mar-01	510	425	.	.	.	.	.	.	.
341	Ictalurus	punctatus	angled	10-Mar-01	495	397	.	.	.	.	.	.	.
342	Ictalurus	punctatus	angled	10-Mar-01	384	312	.	.	.	.	.	.	.
343	Ictalurus	punctatus	angled	10-Mar-01	315	260	.	.	.	.	.	.	.
344	Ictalurus	punctatus	angled	10-Mar-01	335	266	.	.	.	.	.	.	.
345	Ictalurus	punctatus	angled	10-Mar-01	371	294	.	.	.	.	.	.	.
346	Ictalurus	punctatus	angled	10-Mar-01	490	403	.	.	.	.	.	.	.
347	Ictalurus	punctatus	angled	10-Mar-01	373	306	.	.	.	.	.	.	.
348	Ictalurus	punctatus	angled	10-Mar-01	312	251	.	.	.	.	.	.	.
349	Ictalurus	punctatus	angled	10-Mar-01	345	280	.	.	.	.	.	.	.
350	Ictalurus	punctatus	angled	10-Mar-01	327	257	.	.	.	.	.	.	.
351	Lepomis	auritus	angled	8-Mar-01	137	105	1.340	2.278	2.680	.	.	.	.
352	Lepomis	auritus	angled	8-Mar-01	116	92	1.206	2.010	2.278	.	.	.	.
353	Lepomis	auritus	angled	8-Mar-01	123	96	1.000	2.050	2.400	.	.	.	.
354	Lepomis	auritus	angled	8-Mar-01	142	109	1.206	1.943	2.479	2.479	.	.	.
355	Lepomis	auritus	angled	8-Mar-01	155	121	0.900	1.700	2.400	2.900	3.000	.	.
356	Lepomis	macrochirus	angled	2-Mar-01	120	90	1.050	2.000	2.450	.	.	.	.
357	Lepomis	macrochirus	angled	9-Mar-01	138	104	1.608	2.211	2.613	.	.	.	.
358	Lepomis	auritus	angled	9-Mar-01	125	99	.	.	.	.	.	.	.
359	Lepomis	auritus	angled	9-Mar-01	106	83	.	.	.	.	.	.	.
360	Lepomis	auritus	angled	9-Mar-01	154	120	1.340	2.211	2.747	.	.	.	.
361	Lepomis	auritus	angled	9-Mar-01	143	113	1.139	2.144	2.680	.	.	.	.
362	Lepomis	auritus	angled	9-Mar-01	188	150	1.100	1.900	2.700	3.300	3.600	.	.
363	Lepomis	macrochirus	angled	9-Mar-01	122	91	1.742	2.479	2.680	.	.	.	.



ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
392	Ictalurus	punctatus	angled	1-Mar-01	.	.	.	.	.	.	.	.	.
393	Ictalurus	punctatus	angled	1-Mar-01	.	.	.	.	.	.	.	.	.
394	Ictalurus	punctatus	angled	1-Mar-01	.	.	.	.	.	.	.	.	.
395	Ictalurus	punctatus	angled	1-Mar-01	.	.	.	.	.	.	.	.	.
396	Lepomis	auritus	angled	1-Mar-01	.	.	.	.	.	.	.	.	.
397	Lepomis	auritus	angled	1-Mar-01	.	1.300	2.100	2.900	3.300	.	.	.	.
398	Ictalurus	punctatus	angled	10-Apr-01	351	278	.	.	.	.	.	.	.
399	Ictalurus	punctatus	angled	14-Apr-01	359	282	.	.	.	.	.	.	.
400	Ictalurus	punctatus	angled	12-Apr-01	336	269	.	.	.	.	.	.	.
401	Ictalurus	punctatus	angled	12-Apr-01	338	271	.	.	.	.	.	.	.
402	Ictalurus	punctatus	angled	12-Apr-01	329	259	.	.	.	.	.	.	.
403	Ictalurus	punctatus	angled	12-Apr-01	230	179	.	.	.	.	.	.	.
404	Lepomis	macrochirus	angled	12-Apr-01	157	119	0.938	2.077	2.747	3.283	.	.	.
405	Lepomis	auritus	angled	12-Apr-01	165	127	1.675	2.747	3.149	.	.	.	.
406	Ictalurus	punctatus	angled	8-Apr-01	.	.	.	.	.	.	.	.	.
407	Ictalurus	punctatus	angled	8-Apr-01	.	.	.	.	.	.	.	.	.
408	Ictalurus	punctatus	angled	8-Apr-01	.	.	.	.	.	.	.	.	.
409	Ictalurus	punctatus	angled	8-Apr-01	.	.	.	.	.	.	.	.	.
410	Ictalurus	punctatus	angled	8-Apr-01	.	.	.	.	.	.	.	.	.
411	Ictalurus	punctatus	angled	8-Apr-01	.	.	.	.	.	.	.	.	.
412	Ictalurus	punctatus	angled	8-Apr-01	.	.	.	.	.	.	.	.	.
413	Ictalurus	punctatus	angled	8-Apr-01	.	.	.	.	.	.	.	.	.
414	Ictalurus	punctatus	angled	3-Apr-01	422	341	.	.	.	.	.	.	.
415	Ictalurus	punctatus	angled	5-Apr-01	370	298	.	.	.	.	.	.	.
416	Ictalurus	punctatus	angled	4-Apr-01	326	258	.	.	.	.	.	.	.
417	Ictalurus	punctatus	angled	4-Apr-01	311	245	.	.	.	.	.	.	.
418	Ictalurus	punctatus	angled	2-Mar-01	292	227	.	.	.	.	.	.	.
419	Micropterus	salmoides	angled	2-Mar-01	233	186	2.700	3.900	3.900	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
420	Micropterus	salmoides	angled	2-Mar-01	330	271	.	.	.	.	.	.	.
421	Lepomis	macrochirus	angled	12-Apr-01	185	144	0.800	1.900	2.700	3.600	3.600	.	.
422	Lepomis	macrochirus	angled	12-Apr-01	143	108	0.700	1.600	2.100	2.600	.	.	.
423	Lepomis	macrochirus	angled	12-Apr-01	195	151	1.340	1.876	2.747	3.350	3.350	.	.
424	Ictalurus	punctatus	angled	8-Apr-01	251	201	.	.	.	.	.	.	.
425	Ictalurus	punctatus	angled	8-Apr-01	323	254	.	.	.	.	.	.	.
426	Ictalurus	punctatus	angled	8-Apr-01	443	348	.	.	.	.	.	.	.
427	Ictalurus	punctatus	angled	8-Apr-01	399	330	.	.	.	.	.	.	.
428	Ictalurus	punctatus	angled	8-Apr-01	342	280	.	.	.	.	.	.	.
429	Ictalurus	punctatus	angled	8-Apr-01	344	275	.	.	.	.	.	.	.
430	Ictalurus	punctatus	angled	8-Apr-01	349	268	.	.	.	.	.	.	.
431	Ictalurus	punctatus	angled	8-Apr-01	281	216	.	.	.	.	.	.	.
432	Ictalurus	punctatus	angled	8-Apr-01	338	269	.	.	.	.	.	.	.
433	Ictalurus	punctatus	angled	8-Apr-01	306	240	.	.	.	.	.	.	.
434	Ictalurus	punctatus	angled	8-Apr-01	368	285	.	.	.	.	.	.	.
435	Ictalurus	punctatus	angled	8-Apr-01	309	248	.	.	.	.	.	.	.
436	Ictalurus	punctatus	angled	8-Apr-01	253	200	.	.	.	.	.	.	.
437	Ictalurus	punctatus	angled	8-Apr-01	506	411	.	.	.	.	.	.	.
438	Ictalurus	punctatus	angled	8-Apr-01	.	.	.	.	.	.	.	.	.
439	Ictalurus	punctatus	angled	8-Apr-01	378	300	.	.	.	.	.	.	.
440	Ictalurus	punctatus	angled	18-Apr-01	369	288	.	.	.	.	.	.	.
441	Ictalurus	punctatus	angled	18-Apr-01	339	269	.	.	.	.	.	.	.
442	Ictalurus	punctatus	angled	18-Apr-01	262	206	.	.	.	.	.	.	.
443	Lepomis	auritus	angled	20-Apr-01	141	110	2.278	2.881	.	.	.	.	.
444	Lepomis	macrochirus	angled	20-Apr-01	153	116	1.072	2.278	2.948	2.948	.	.	.
445	Micropterus	salmoides	angled	20-Apr-01	215	179	2.100	3.500	3.500	.	.	.	.
446	Ictalurus	punctatus	shocked	8-May-01	374	295	.	.	.	.	.	.	.
447	Ictalurus	punctatus	shocked	8-May-01	475	385	.	.	.	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
448	Ictalurus	punctatus	shocked	8-May-01	315	249	.	.	.	.	.	.	.
449	Ictalurus	punctatus	shocked	8-May-01	386	309	.	.	.	.	.	.	.
450	Lepomis	macrochirus	angled	4-May-01	163	124	1.206	2.479	3.149	3.283	.	.	.
451	Lepomis	macrochirus	angled	4-May-01	140	106	0.871	1.876	2.680	2.680	.	.	.
452	Lepomis	auritus	angled	4-May-01	154	122	1.675	2.814	2.814	.	.	.	.
453	Micropterus	salmoides	angled	4-May-01	176	133	3.100	3.200	.	.	.	.	.
454	Lepomis	macrochirus	angled	4-May-01	154	117	1.139	1.809	2.680	2.747	.	.	.
455	Micropterus	salmoides	angled	4-May-01	158	128	2.948	3.015	.	.	.	.	.
456	Lepomis	macrochirus	angled	4-May-01	126	96	1.340	1.876	2.680	2.680	.	.	.
457	Lepomis	macrochirus	angled	4-May-01	166	127	1.474	2.278	3.216	3.216	.	.	.
458	Lepomis	macrochirus	angled	4-May-01	128	98	0.938	1.541	2.412	.	.	.	.
459	Lepomis	auritus	angled	4-May-01	155	117	1.072	2.345	2.814	2.814	.	.	.
460	Lepomis	macrochirus	angled	4-May-01	143	108	1.072	2.211	2.814	2.814	.	.	.
461	Lepomis	auritus	angled	4-May-01	126	100	1.340	2.278	2.278	.	.	.	.
462	Lepomis	macrochirus	angled	4-May-01	123	92	1.139	1.876	2.345	.	.	.	.
463	Lepomis	auritus	angled	4-May-01	179	141	1.273	2.345	3.149	3.216	.	.	.
464	Micropterus	cataractae	angled	4-May-01	283	231	2.500	4.500	4.500	.	.	.	.
465	Micropterus	salmoides	shocked	8-May-01	244	202	1.900	4.000	4.000	.	.	.	.
466	Micropterus	salmoides	shocked	8-May-01	149	121	2.400	2.400	.	.	.	.	.
467	Micropterus	salmoides	shocked	8-May-01	166	133	1.400	2.800	2.800	.	.	.	.
468	Micropterus	salmoides	shocked	8-May-01	243	197	2.100	3.900	4.000	.	.	.	.
469	Micropterus	salmoides	shocked	8-May-01	170	141	2.800	2.800	.	.	.	.	.
470	Micropterus	salmoides	shocked	8-May-01	288	238	1.700	3.700	4.600	4.600	.	.	.
471	Micropterus	salmoides	shocked	8-May-01	212	170	2.500	3.700	3.700	.	.	.	.
472	Micropterus	salmoides	shocked	8-May-01	241	196	2.300	3.900	3.900	.	.	.	.
473	Micropterus	cataractae	shocked	8-May-01	161	131	2.747	2.747	.	.	.	.	.
474	Micropterus	salmoides	shocked	8-May-01	250	209	2.200	3.900	3.900	.	.	.	.
475	Micropterus	salmoides	shocked	8-May-01	172	139	2.900	2.900	.	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
476	Micropterus	salmoides	shocked	8-May-01	304	260	3.400	5.100	5.100	.	.	.	.
477	Micropterus	salmoides	shocked	8-May-01	132	122	2.600	2.700	.	.	.	.	.
478	Micropterus	salmoides	shocked	8-May-01	160	129	2.700	2.700	.	.	.	.	.
479	Micropterus	salmoides	shocked	8-May-01	230	194	1.800	4.000	4.000	.	.	.	.
480	Micropterus	salmoides	shocked	8-May-01	126	100	2.500	2.500	.	.	.	.	.
481	Micropterus	salmoides	shocked	8-May-01	142	113	2.600	2.700	.	.	.	.	.
482	Micropterus	cataractae	shocked	8-May-01	160	131	2.546	2.747	.	.	.	.	.
483	Micropterus	salmoides	shocked	8-May-01	116	93	2.000	2.100	.	.	.	.	.
484	Micropterus	salmoides	shocked	8-May-01	135	111	2.300	2.400	.	.	.	.	.
485	Micropterus	salmoides	shocked	8-May-01	171	144	.	.	.	.	.	.	.
486	Micropterus	salmoides	shocked	8-May-01	121	97	2.100	2.200	.	.	.	.	.
487	Micropterus	salmoides	shocked	8-May-01	112	89	2.000	2.000	.	.	.	.	.
488	Micropterus	salmoides	shocked	8-May-01	212	171	2.300	3.800	3.800	.	.	.	.
489	Micropterus	salmoides	shocked	8-May-01	177	142	3.100	3.100	.	.	.	.	.
490	Micropterus	salmoides	shocked	8-May-01	245	197	2.200	4.100	4.100	.	.	.	.
491	Micropterus	salmoides	shocked	8-May-01	147	119	2.700	2.700	.	.	.	.	.
492	Micropterus	salmoides	shocked	8-May-01	183	149	3.100	3.100	.	.	.	.	.
493	Micropterus	cataractae	shocked	8-May-01	135	109	2.144	2.211	.	.	.	.	.
494	Micropterus	salmoides	shocked	8-May-01	166	131	2.900	3.000	.	.	.	.	.
495	Micropterus	salmoides	shocked	8-May-01	253	206	2.100	4.100	4.100	.	.	.	.
496	Micropterus	salmoides	shocked	8-May-01	127	101	2.300	2.400	.	.	.	.	.
497	Micropterus	salmoides	shocked	8-May-01	122	99	2.000	2.000	.	.	.	.	.
498	Micropterus	salmoides	shocked	8-May-01	145	116	2.500	2.500	.	.	.	.	.
499	Micropterus	salmoides	shocked	8-May-01	153	121	2.600	2.600	.	.	.	.	.
500	Micropterus	salmoides	shocked	8-May-01	132	107	2.500	2.500	.	.	.	.	.
501	Micropterus	salmoides	shocked	8-May-01	181	147	3.200	3.200	.	.	.	.	.
502	Micropterus	salmoides	shocked	8-May-01	146	116	2.600	2.600	.	.	.	.	.
503	Micropterus	salmoides	shocked	8-May-01	255	206	2.300	3.900	4.100	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
504	Micropterus	salmoides	shocked	8-May-01	255	207	1.900	4.100	4.100	.	.	.	.
505	Micropterus	salmoides	shocked	8-May-01	252	205	2.500	4.000	4.000	.	.	.	.
506	Micropterus	cataractae	shocked	8-May-01	287	235	2.400	4.100	4.100	.	.	.	.
507	Micropterus	salmoides	shocked	8-May-01	237	187	2.800	4.300	4.300	.	.	.	.
508	Micropterus	salmoides	shocked	8-May-01	142	114	2.400	2.500	.	.	.	.	.
509	Micropterus	salmoides	shocked	8-May-01	260	211	2.300	4.100	4.300	.	.	.	.
510	Micropterus	salmoides	shocked	8-May-01	234	188	1.700	3.600	3.600	.	.	.	.
511	Micropterus	salmoides	shocked	8-May-01	220	179	1.700	3.400	3.500	.	.	.	.
512	Micropterus	salmoides	shocked	8-May-01	130	103	2.000	2.000	.	.	.	.	.
513	Micropterus	salmoides	shocked	8-May-01	271	218	2.000	4.500	4.500	.	.	.	.
514	Micropterus	salmoides	shocked	8-May-01	250	206	2.300	4.300	4.300	.	.	.	.
515	Micropterus	salmoides	shocked	8-May-01	206	162	1.700	3.500	.	.	.	.	.
516	Micropterus	salmoides	shocked	8-May-01	213	173	2.100	3.300	3.400	.	.	.	.
517	Lepomis	auritus	angled	7-May-01	.	.	1.139	2.144	2.546	.	.	.	.
518	Lepomis	macrochirus	angled	7-May-01	.	.	1.500	2.100	2.700	3.300	3.600	.	.
519	Lepomis	auritus	angled	7-May-01	.	.	1.474	1.809	2.278	.	.	.	.
520	Lepomis	auritus	angled	7-May-01	.	.	1.541	2.814	2.814	.	.	.	.
521	Lepomis	auritus	angled	7-May-01	.	.	0.938	1.809	2.278	2.613	2.814	2.814	.
522	Lepomis	auritus	angled	7-May-01	.	.	0.804	1.809	2.948	2.948	.	.	.
523	Lepomis	auritus	angled	7-May-01	.	.	1.742	2.479	2.881	2.881	.	.	.
524	Lepomis	auritus	angled	7-May-01	.	.	1.206	2.144	2.680	2.747	.	.	.
525	Lepomis	macrochirus	angled	7-May-01	.	.	1.200	2.000	2.800	3.500	3.500	.	.
526	Lepomis	auritus	angled	7-May-01	.	.	1.340	2.211	2.814	.	.	.	.
527	Lepomis	auritus	angled	7-May-01	.	.	1.273	2.077	2.479	.	.	.	.
528	Lepomis	auritus	angled	7-May-01	.	.	1.300	2.300	3.100	3.400	3.600	.	.
529	Lepomis	auritus	angled	7-May-01	.	.	1.139	2.144	2.546	2.546	.	.	.
530	Lepomis	macrochirus	angled	7-May-01	.	.	0.700	2.100	2.900	2.900	.	.	.
531	Lepomis	auritus	angled	7-May-01	.	.	1.072	2.077	2.881	2.881	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
532	Lepomis	macrochirus	angled	7-May-01	.	.	1.876	2.345	2.948	2.948	.	.	.
533	Lepomis	macrochirus	angled	7-May-01	.	.	1.206	2.412	3.149	3.149	.	.	.
534	Lepomis	auritus	angled	7-May-01	.	.	0.900	2.000	2.800	3.200	3.500	3.500	.
535	Lepomis	macrochirus	angled	7-May-01	.	.	1.005	2.144	2.747	2.747	.	.	.
536	Lepomis	macrochirus	angled	7-May-01	.	.	1.206	2.345	3.216	3.216	.	.	.
537	Lepomis	auritus	angled	7-May-01	.	.	1.072	2.077	2.613	2.680	.	.	.
538	Lepomis	macrochirus	angled	7-May-01	.	.	1.474	2.479	3.283	3.283	.	.	.
539	Lepomis	auritus	angled	7-May-01	.	.	1.407	2.211	2.680	2.680	.	.	.
540	Lepomis	auritus	angled	7-May-01	.	.	1.273	2.211	2.546	2.546	.	.	.
541	Lepomis	auritus	angled	7-May-01	.	.	1.541	2.680	2.680	.	.	.	.
542	Lepomis	auritus	angled	7-May-01	.	.	1.273	2.211	2.546	2.546	.	.	.
543	Lepomis	auritus	angled	7-May-01	.	.	.	.	.	.	.	.	.
544	Lepomis	auritus	angled	7-May-01	.	.	1.072	1.876	2.546	2.546	.	.	.
545	Lepomis	macrochirus	angled	7-May-01	.	.	1.474	2.278	2.881	2.881	.	.	.
546	Lepomis	auritus	shocked	8-May-01	126	100	1.340	2.345	2.345	.	.	.	.
547	Lepomis	macrochirus	shocked	8-May-01	156	119	1.675	2.412	3.283	3.283	.	.	.
548	Lepomis	macrochirus	shocked	8-May-01	129	98	.	.	.	.	.	.	.
549	Lepomis	auritus	shocked	8-May-01	127	98	1.407	2.211	2.278	.	.	.	.
550	Lepomis	auritus	shocked	8-May-01	158	123	1.675	2.479	2.814	.	.	.	.
551	Lepomis	macrochirus	shocked	8-May-01	147	112	0.938	2.144	2.613	2.747	.	.	.
552	Lepomis	macrochirus	shocked	8-May-01	121	92	0.737	1.474	2.211	2.412	.	.	.
553	Lepomis	auritus	shocked	8-May-01	146	117	1.541	2.412	2.680	.	.	.	.
554	Lepomis	macrochirus	shocked	8-May-01	121	93	1.206	2.412	.	.	.	.	.
555	Lepomis	macrochirus	shocked	8-May-01	131	99	1.273	1.943	2.680	2.680	.	.	.
556	Lepomis	auritus	shocked	8-May-01	155	123	1.005	1.876	2.479	2.814	3.082	.	.
557	Lepomis	auritus	shocked	8-May-01	137	108	1.206	2.345	2.747	.	.	.	.
558	Lepomis	auritus	shocked	8-May-01	119	96	1.407	2.211	2.211	.	.	.	.
559	Lepomis	macrochirus	shocked	8-May-01	116	87	0.871	2.077	2.546	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
560	Lepomis	auritus	shocked	8-May-01	140	110	1.072	2.144	2.479	2.479	.	.	.
561	Lepomis	auritus	shocked	8-May-01	109	89	1.072	2.077	2.077	.	.	.	.
562	Lepomis	auritus	shocked	8-May-01	130	101	1.407	2.345	2.412	.	.	.	.
563	Lepomis	auritus	shocked	8-May-01	148	117	0.670	1.675	2.412	2.814	.	.	.
564	Lepomis	auritus	shocked	8-May-01	87	68	1.675	1.675	.	.	.	.	.
565	Lepomis	macrochirus	shocked	8-May-01	129	98	1.005	1.943	2.546	2.613	.	.	.
566	Lepomis	macrochirus	shocked	8-May-01	93	69	1.100	2.000	2.000	.	.	.	.
567	Lepomis	auritus	shocked	8-May-01	117	91	.	.	.	.	.	.	.
568	Lepomis	macrochirus	shocked	8-May-01	98	78	1.943	2.010	.	.	.	.	.
569	Lepomis	macrochirus	shocked	8-May-01	68	48	1.340	1.407	.	.	.	.	.
570	Lepomis	auritus	shocked	8-May-01	63	49	1.340	.	.	.	.	.	.
571	Lepomis	auritus	shocked	8-May-01	93	74	1.072	1.943	2.010	.	.	.	.
572	Lepomis	auritus	shocked	8-May-01	162	127	1.000	2.000	2.900	3.300	.	.	.
573	Lepomis	auritus	shocked	8-May-01	197	157	1.000	1.900	2.400	2.900	3.600	.	.
574	Lepomis	auritus	shocked	8-May-01	136	106	1.139	2.077	2.479	2.479	.	.	.
575	Lepomis	auritus	shocked	8-May-01	108	86	1.000	1.900	1.900	.	.	.	.
576	Lepomis	auritus	shocked	8-May-01	121	93	.	.	.	.	.	.	.
577	Lepomis	auritus	shocked	8-May-01	91	76	1.100	1.900	1.900	.	.	.	.
578	Lepomis	macrochirus	shocked	8-May-01	104	77	1.005	2.077	2.077	.	.	.	.
579	Lepomis	macrochirus	shocked	8-May-01	154	119	1.005	2.077	3.015	3.082	.	.	.
580	Lepomis	auritus	shocked	8-May-01	145	103	1.206	1.943	2.680	2.747	.	.	.
581	Lepomis	macrochirus	shocked	8-May-01	109	82	1.005	2.144	2.345	.	.	.	.
582	Lepomis	auritus	shocked	8-May-01	150	118	1.206	2.278	2.680	2.680	.	.	.
583	Lepomis	auritus	shocked	8-May-01	104	89	1.072	1.876	2.010	.	.	.	.
584	Lepomis	auritus	shocked	8-May-01	73	58	1.407	1.407	.	.	.	.	.
585	Lepomis	macrochirus	shocked	8-May-01	157	118	1.407	2.546	3.350	3.350	.	.	.
586	Lepomis	macrochirus	shocked	8-May-01	102	78	1.407	2.211	2.278	.	.	.	.
587	Lepomis	macrochirus	shocked	8-May-01	103	78	1.340	2.077	2.144	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
588	Lepomis	auritus	shocked	8-May-01	128	100	1.541	2.479	2.479	.	.	.	.
589	Lepomis	macrochirus	shocked	8-May-01	102	77	0.804	2.077	2.077	.	.	.	.
590	Lepomis	auritus	shocked	8-May-01	129	100	1.139	2.345	2.412	.	.	.	.
591	Lepomis	macrochirus	shocked	8-May-01	116	89	1.072	1.742	2.278	2.412	.	.	.
592	Lepomis	auritus	shocked	8-May-01	96	76	1.742	1.876	.	.	.	.	.
593	Lepomis	auritus	shocked	8-May-01	100	78	0.800	1.800	1.900	.	.	.	.
594	Lepomis	auritus	shocked	8-May-01	135	107	1.206	2.211	2.546	2.613	.	.	.
595	Lepomis	macrochirus	shocked	8-May-01	107	81	0.900	2.200	2.200	.	.	.	.
596	Lepomis	auritus	shocked	8-May-01	142	110	1.139	2.211	2.613	2.680	.	.	.
597	Lepomis	macrochirus	shocked	8-May-01	138	104	.	.	.	.	.	.	.
598	Lepomis	macrochirus	shocked	8-May-01	115	86	0.871	1.742	2.278	.	.	.	.
599	Lepomis	macrochirus	shocked	8-May-01	150	115	1.005	2.144	2.747	2.747	.	.	.
600	Lepomis	auritus	shocked	8-May-01	115	90	0.900	2.000	2.000	.	.	.	.
601	Lepomis	macrochirus	shocked	8-May-01	117	80	0.871	1.541	2.144	2.144	.	.	.
602	Lepomis	macrochirus	shocked	8-May-01	107	80	1.407	2.144	2.144	.	.	.	.
603	Lepomis	auritus	shocked	8-May-01	170	135	.	.	.	.	.	.	.
604	Lepomis	auritus	shocked	8-May-01	59	46	1.092	1.170	.	.	.	.	.
605	Lepomis	macrochirus	shocked	8-May-01	159	122	1.474	2.077	2.948	3.015	.	.	.
606	Lepomis	auritus	shocked	8-May-01	101	79	0.900	2.000	2.100	.	.	.	.
607	Lepomis	auritus	shocked	8-May-01	109	85	1.300	2.100	2.100	.	.	.	.
608	Lepomis	macrochirus	shocked	8-May-01	115	87	0.938	1.675	2.479	2.479	.	.	.
609	Lepomis	macrochirus	shocked	8-May-01	128	97	1.005	1.943	2.613	2.680	.	.	.
610	Lepomis	macrochirus	shocked	8-May-01	138	104	0.871	2.144	2.814	.	.	.	.
611	Lepomis	macrochirus	shocked	8-May-01	131	99	1.407	2.345	2.546	.	.	.	.
612	Lepomis	macrochirus	shocked	8-May-01	151	113	1.206	2.010	2.948	2.948	.	.	.
613	Lepomis	macrochirus	shocked	8-May-01	176	135	1.100	2.300	3.000	3.300	.	.	.
614	Lepomis	macrochirus	shocked	8-May-01	116	88	0.938	1.809	2.345	2.412	.	.	.
615	Lepomis	macrochirus	shocked	8-May-01	120	90	1.340	2.345	2.412	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
616	Lepomis	macrochirus	shocked	8-May-01	143	109	0.804	1.943	2.680	2.680	.	.	.
617	Lepomis	auritus	shocked	8-May-01	114	90	1.500	2.200	2.300	.	.	.	.
618	Lepomis	macrochirus	shocked	8-May-01	108	80	1.000	2.200	2.200	.	.	.	.
619	Lepomis	auritus	shocked	8-May-01	120	98	.	.	.	.	.	.	.
620	Lepomis	auritus	shocked	8-May-01	93	72	1.750	1.750	.	.	.	.	.
621	Lepomis	auritus	shocked	8-May-01	109	78	1.900	1.900	.	.	.	.	.
622	Lepomis	auritus	shocked	8-May-01	151	120	1.139	2.077	2.680	2.680	.	.	.
623	Lepomis	macrochirus	shocked	8-May-01	126	97	1.005	2.144	2.747	2.747	.	.	.
624	Lepomis	auritus	shocked	8-May-01	58	45	1.273	.	.	.	.	.	.
625	Lepomis	auritus	shocked	8-May-01	161	125	1.273	2.144	2.546	2.814	.	.	.
626	Lepomis	macrochirus	shocked	8-May-01	119	92	1.139	2.077	2.479	.	.	.	.
627	Lepomis	auritus	shocked	8-May-01	59	46	1.273	1.273	.	.	.	.	.
628	Lepomis	auritus	shocked	8-May-01	51	40	1.005	1.072	.	.	.	.	.
629	Lepomis	auritus	shocked	8-May-01	62	48	1.273	.	.	.	.	.	.
630	Lepomis	auritus	shocked	8-May-01	109	84	1.072	1.943	1.943	.	.	.	.
631	Lepomis	macrochirus	shocked	8-May-01	105	80	1.005	2.144	2.144	.	.	.	.
632	Lepomis	macrochirus	shocked	8-May-01	121	91	1.139	1.809	2.479	2.479	.	.	.
633	Lepomis	macrochirus	shocked	8-May-01	98	73	0.938	2.077	2.077	.	.	.	.
634	Lepomis	macrochirus	shocked	8-May-01	117	89	1.206	2.211	2.345	.	.	.	.
635	Lepomis	auritus	shocked	8-May-01	83	65	1.072	1.742	1.742	.	.	.	.
636	Lepomis	macrochirus	shocked	8-May-01	130	98	1.206	2.144	2.479	2.546	.	.	.
637	Lepomis	macrochirus	shocked	8-May-01	119	89	1.072	2.278	2.345	.	.	.	.
638	Lepomis	macrochirus	shocked	8-May-01	102	76	0.938	1.876	2.144	.	.	.	.
639	Lepomis	auritus	shocked	8-May-01	112	87	1.608	2.144	2.144	.	.	.	.
640	Lepomis	auritus	shocked	8-May-01	95	74	1.300	2.000	.	.	.	.	.
641	Lepomis	auritus	shocked	8-May-01	156	125	0.938	1.809	2.546	2.814	3.015	.	.
642	Lepomis	auritus	shocked	8-May-01	118	92	1.340	2.278	2.278	.	.	.	.
643	Lepomis	auritus	shocked	8-May-01	87	61	1.474	1.474	.	.	.	.	.

ID	Genus	Species	Gear	Date Captured	Total Length (mm)	Standard Length (mm)	R1	R2	R3	R4	R5	R6	R7
644	Lepomis	auritus	shocked	8-May-01	59	46	1.340	1.340	.	.	.	.	.
645	Lepomis	macrochirus	shocked	8-May-01	99	75	1.943	1.943	.	.	.	.	.
646	Lepomis	macrochirus	shocked	8-May-01	85	64	0.900	1.800	1.900	.	.	.	.
647	Lepomis	macrochirus	shocked	8-May-01	119	91	.	.	.	.	.	.	.
648	Lepomis	auritus	shocked	8-May-01	142	111	1.206	2.211	2.546	.	.	.	.
649	Lepomis	auritus	shocked	8-May-01	85	66	1.206	1.675	1.742	.	.	.	.
650	Lepomis	macrochirus	shocked	8-May-01	116	87	0.871	1.809	2.345	.	.	.	.
651	Lepomis	auritus	shocked	8-May-01	92	73	1.000	1.900	1.900	.	.	.	.
652	Lepomis	macrochirus	shocked	8-May-01	85	63	1.809	1.809	.	.	.	.	.
653	Lepomis	auritus	shocked	8-May-01	73	58	1.500	1.500	.	.	.	.	.
654	Lepomis	auritus	shocked	8-May-01	122	95	1.005	2.077	2.613	2.613	.	.	.
655	Lepomis	auritus	shocked	8-May-01	67	52	1.407	1.407	.	.	.	.	.
656	Lepomis	auritus	shocked	8-May-01	87	67	1.675	1.675	.	.	.	.	.
657	Lepomis	auritus	shocked	8-May-01	112	89	1.340	2.211	2.211	.	.	.	.
658	Lepomis	macrochirus	shocked	8-May-01	129	98	1.340	2.077	2.747	2.747	.	.	.
659	Lepomis	auritus	shocked	8-May-01	47	36	1.072	1.072	.	.	.	.	.
660	Lepomis	macrochirus	shocked	8-May-01	47	36	1.072	1.072	.	.	.	.	.
661	Lepomis	auritus	shocked	8-May-01	115	90	.	.	.	.	.	.	.
662	Micropterus	salmoides	angled	24-Apr-01	175	140	3.015	3.015	.	.	.	.	.
663	Micropterus	salmoides	angled	24-Apr-01	147	118	2.546	2.613	.	.	.	.	.
664	Ictalurus	punctatus	angled	5-Apr-01	609	510	.	.	.	.	.	.	.

APPENDIX C  
Values of the Environmental Indices

Index	1995	1996	1997	1998	1999	2000
Average Flows						
P75 (m <sup>3</sup> s <sup>-1</sup> )	26	24	27	39	15	12
MEAN (m <sup>3</sup> s <sup>-1</sup> )	22	19	22	32	10	7
MEDIAN (m <sup>3</sup> s <sup>-1</sup> )	15	16	15	18	7	4
P25 (m <sup>3</sup> s <sup>-1</sup> )	10	10	9	13	2	1
Flow Variability						
CONST (unitless)	1.61	1.60	1.71	1.69	1.81	1.86
SUMQ (m <sup>3</sup> s <sup>-1</sup> )	7881	6922	7980	11528	3689	2536
SKEW (unitless)	5.49	1.66	2.08	7.52	1.81	1.27
CV (unitless)	108	68	95	144	79	34
VAR (m <sup>3</sup> s <sup>-1</sup> )	542	167	427	2095	101	54
High Flows						
MAX (m <sup>3</sup> s <sup>-1</sup> )	247	73	123	532	62	30
P99(m <sup>3</sup> s <sup>-1</sup> )	119	61	93	211	49	29
P95 (m <sup>3</sup> s <sup>-1</sup> )	53	52	66	78	28	22
P90 (m <sup>3</sup> s <sup>-1</sup> )	38	35	50	55	23	18
NOVER (days)	17	10	26	31	2	0
SUMOVER (m <sup>3</sup> s <sup>-1</sup> )	1711	620	2074	3841	123	0
FRE3 (unitless)	4	6	9	11	2	0
FRE5 (unitless)	4	0	5	6	0	0
DUR3 (days)	6	4	5	5	4	0
DUR5 (days)	2	0	3	3	0	0
Low Flows						
P10 (m <sup>3</sup> s <sup>-1</sup> )	7	7	5	8	1	1
P5 (m <sup>3</sup> s <sup>-1</sup> )	6	5	3	5	0	0
P1 (m <sup>3</sup> s <sup>-1</sup> )	5	4	3	4	0	0
MIN (m <sup>3</sup> s <sup>-1</sup> )	5	4	3	3	0	0
NUNDER (days)	348	356	339	334	363	366
SUMUNDER (m <sup>3</sup> s <sup>-1</sup> )	6171	6302	5905	7687	3566	2536
Growing Season						
DEGDAY (degree-days)	864 *	729	751	996	979	1045
DEGDAYFL (degree-days)	17.37 *	0	0	15.12	10.38	0
DAYFLHOT (days)	3	0	0	4	2	0

\* note: n = 250 for 1995 degree day estimates