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Relationships Between River Surface Levels and Fish Assemblages in the Ocklawaha and Withlacoochee Rivers, Florida and the General Implications for Setting Minimum Flows and Levels

Final Report

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Mark W. Rogers and Micheal S. Allen
Principle Investigators

Department of Fisheries and Aquatic Sciences
The University of Florida
7922 NW 71st Street
Gainesville, FL 32653

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EXECUTIVE SUMMARY

Increasing human population growth and water use led the Florida legislature to mandate the establishment of Minimum Flows and Levels (MFLs) for Florida water resources. Minimum Flows and Levels are required to prevent significant ecological harm to aquatic communities. However, defining minimum flows that prevent significant harm is challenging. We reviewed a long-term Florida Fish and Wildlife Conservation Commission (FFWCC) data set from several Florida rivers to evaluate trends in fish abundance and fish communities and relate those trends to historical river levels. Our objective was to determine how river levels affected fish abundance and communities in Florida rivers to facilitate the establishment of MFLs.

Electrofishing was conducted on eight Florida rivers during 1983-1996. Electrofishing data were used to estimate catch per effort, biomass per effort, species diversity, species richness and species evenness at several stations within each river. Electrofishing data were also used to estimate species specific catch per effort and biomass per effort for sportfish (largemouth bass *Micropterus salmoides*, bluegill *Lepomis macrochirus*, redear sunfish *Lepomis microlophus*, redbreast sunfish *Lepomis auritus*, and spotted sunfish *Lepomis punctatus*) within each station. Electrofishing data were only used from stations that were sampled for at least three years when the river level was at bank-full conditions. Estimates from electrofishing data were compared using repeated measures analysis of variance where stations were treated as subjects and year was the fixed effect. Historical water level data were obtained from USGS gauging stations within 4.8 – 8.0 river kilometers of sampling stations to determine bank full elevations and select samples used for analyses. Historical water levels were also used to relate fish metrics, that significantly differed among years, to water levels using multiple regression models.

Three stations (Ocklawaha Station 2, Ocklawaha Station 4, and Withlacoochee Station 3) met our criteria of at least 3 years of sampling during bank-full conditions. Repeated measures analysis of variance results indicated variability in fish abundance and community metrics at Ocklawaha Station 2, but little variation at Ocklawaha Station 4 and Withlacoochee Station 3. Thus, we only used results from Ocklawaha Station 2 to evaluate relationships between fish abundance and community metrics with historical water levels in our multiple regression models. Results of the multiple regression models at Ocklawaha Station 2 indicated that fish abundance, species richness, and species evenness were negatively related to river levels during the year prior to sampling, and species diversity was negatively related to variability in river level during the two years prior to sampling. Spotted sunfish exhibited the most variability in species-specific catch per effort and spotted sunfish abundance was negatively related to river levels.

We concluded that low river levels negatively affect fish communities by reducing fish abundance. Regulations such as MFLs should be set to reduce the periodicity of low flow events in order to prevent sequential years of adverse effects on fish populations. Fish populations naturally exhibit variable recruitment and are resistent to unfavorable periods assuming that conditions allow for adult survival and high recruitment during some years. Reducing the periodicity of low flow events, by establishing minimum thresholds that limit effects from water withdrawals at low water levels during consecutive years, should allow persistence of fish populations and fish communities in Florida's rivers. We also concluded that the FFWCC should continue monitoring fish populations to increase the amount of information available to evaluate effects of flow on fish and evaluate relationships between river levels and habitat availability.

INTRODUCTION

Due to the generally low gradient of Florida's rivers, Florida's river fish communities may be strongly influenced by fluctuating river levels. High water levels create inundated areas that fish may utilize (Keith 1975), whereas low water surface levels may limit fish movements, reduce available habitat, or degrade water quality (Bennett et al. 1995; Heggenes et al. 1996; Albanese 2001). Understanding impacts of river surface levels on fish communities is becoming increasingly important in Florida due to legislation requiring Minimum Flows and Levels (MFLs) and increasing demands for water use (Subsection 373.042 (2), *Florida Statutes* (F.S.)).

Instream flow levels are primary sources of environmental variability and disturbance in lotic systems (Stanford and Ward 1983; Poff and Ward 1989). Variable flows influence the structure of lotic communities, and effects of flow events on aquatic communities vary (Hynes 1970; Horwitz 1978; Schlosser 1987; Bain et al. 1988; Poff and Ward 1989; Fausch and Bramblett 1991; Poff and Allan 1995). Variable stream flows indirectly affect stream fishes by changing habitat availability, nutrient cycling, and food availability (Stalnaker 1981; Elwood and Waters 1969; Fisher et al. 1982; Schlosser and Ebel 1989; Schlosser 1990). Variable stream flows directly affect stream fishes through decreased survival during early life history stages and may induce physiological stress on adult fishes (Starett 1951; Larimore et al. 1959; Tramer 1978; Schlosser 1985; Finger and Stewart 1987; Schlosser 1990). Increased water levels influence fish production by release of nutrients from decomposing vegetation, addition of food organisms to the water from terrestrial areas, and increased habitat availability (Keith 1975). Decreased water levels may enhance usage by species preferring slower moving water or species more tolerant to stream conditions induced by low water levels.

The Florida Fish and Wildlife Conservation Commission (FFWCC) annually monitored fish populations in Florida's major rivers starting in 1983 to detect trends in abundance, biomass and species composition (Bass 1990). Using the FFWCC database, our objectives were to: (1) determine if relative abundance and community composition of river fish populations differed among years at sampling sites, (2) relate changes in fish community metrics to historical river levels for each system.

METHODS

Fish data were collected on eight Florida rivers during 1983-1996 as part of the FFWCC's river monitoring program. Historical USGS water level data, from gauges within 4.8 – 8.0 river kilometers of sampling sites, were used to determine the river stage during sampling. Limits on the distance from the sampling site to the USGS gauge allowed us to meet the assumption that stage data measured at the gauge represented river levels at the sampling site because bank-full estimates were indexed to water level elevations at each USGS gauge based on the Krummrich-Runyon Procedure (Appendix A). Variable water flows likely affect not only fish community composition and habitat use, but also catchability (i.e., the proportion of the population captured with a given amount of sampling effort). Variable water flows affect electrofishing catchability by preventing boat access to inundated floodplains or by decreasing vulnerability to dip-netting due to increased flows. We standardized for variable catchability in our analyses according to the Krumrich-Runyon Procedure (Appendix A) by only including rivers with at least three years of sampling data collected during "standard conditions" (i.e., ± 0.15 m of bank full elevation) to allow comparisons among years. We increased the criteria for "standard conditions" to ± 0.23 m to include more sampling data for analysis, but the increased interval did not allow use of any more samples. Fish data were not used in any analyses if the river was not sampled during "standard conditions."

We reviewed historical gauge data and electrofishing data collected from 16 sites at 7 rivers for our analysis. Three sites on the Ocklawaha River (Stations 1, 2, and 4) and one site on the

Withlacoochee River (Station 3) met our criteria for sampling conditions (Figure 1). All sites were bordered by woody floodplains with high connectedness to the river during out-of-bank flow events. Although Ocklawaha Station 1 (N029^{0}12.242', W081^{0}59.596') met our sampling criteria, we did not include it in our analyses because the gauge station for that site (USGS Conner gauge 02240000) was downstream from the confluence of the Ocklawaha and Silver rivers and Ocklawaha Station 1 is located upstream of the confluence (Figure 1). The positive relationship between Silver River and Conner gauge readings (r^2 = 0.65) provided evidence that the Silver River largely influenced the Ocklawaha River, and Conner gauge readings probably did not represent flow conditions at Ocklawaha Station 1. Thus, data from three sites at two rivers were used in our analyses (Figures 1-4).

Sampling was conducted using one 10-minute electrofishing transect at three areas within Ocklawaha Station 4 (N029^{0}28.413', W081^{0}45.981'), four areas at Ocklawaha Station 2 (N029^{0}17.768', W081^{0}55.103'), and two areas at Withlacoochee Station 3 (N028^{0}53.472', W082^{0}15.998'). Sampling crews recorded each species captured, measured total length (TL) of each fish (nearest cm), and weighed each fish (g). In some cases, small fish within the same size class were weighed as a batch to estimate mean weight. In cases where fish weights were unavailable, missing weights were estimated using the length-weight relationship:

$$W = \alpha L^{\beta} \tag{1}$$

where W = average weight, L = total length and α and β describe the shape of the relationship. Parameters were estimated using the $\log_{10}$-transformed model:

$$\log_{10} W = \log_{10} \alpha + \beta \log_{10} L \tag{2}$$

Mean catch-per-effort (fish/min; CPM) and mean biomass-per-effort (g/min; BPM) were estimated for each sampling site for all fish and bluegill *Lepomis macrochirus*, largemouth bass *Micropterus salmoides*, redbreast sunfish *Lepomis auritus*, redear sunfish *Lepomis microlophus*, and spotted sunfish *Lepomis punctatus*. Mean CPM and BPM were also estimated for lentic sportfish (bluegill and largemouth bass) and lotic sportfish (redbreast sunfish and spotted sunfish). Means were used to standardize for sampling effort and allow replication (2-4 electrofishing transects) within each site each year. Species richness (*S*) was estimated as the total number of species captured at each site each year. Mean species diversity for each site was estimated using the Shannon-Wiener Index:

$$H' = \sum_{i=1}^{s} \left(p_i\right)\left(\ln p_i\right) \tag{3}$$

where H' = species diversity index, s = the number of species and p_i = proportion of total sample belonging to the i^{th} species (Krebs 1999). Mean species evenness for each site was estimated using:

$$J' = \frac{H'}{H'_{MAX}} \tag{4}$$

where J' = species evenness index, H' = Shannon-Wiener index value, and H'_{MAX} = the maximum possible value of H' (Krebs 1999).

Repeated-measures analysis of variance was used to assess differences in $\log_e$-transformed total, lentic and lotic, and species specific CPM and BPM, species richness, species diversity and species evenness where stations were treated as subjects and year was the fixed effect. The LSMEANS procedure (SAS 1996) was used to separate means if the overall ANOVA was significant ($\alpha < 0.05$).

We sought to explain variability in sampling and community indices across years using river stage measures as independent variables in multiple regression models. The first and third quantiles for river stage levels during 1982-1996 were estimated for each site using PROC UNIVARIATE (SAS 1996; Koel and Sparks 2002). River stage variables used were number of days above, between, and below the 1st and 3rd quantile (high stage days, average stage days, and low stage days, respectively) for 2 years, 1 year, and 6 months prior to sampling. Other river stage variables included the range of stage levels, mean, and coefficient of variation (CV) of the stage during the same time periods. The variables included in multiple regression models allowed for representation of low and high water effects on fish populations (Appendix D). Multiple regression models were constructed using stepwise regression and significant variables were retained in the models when $P < 0.05$. Multi-collinearity between variables was assessed using the variance inflation factor (VIF) and variables with VIF values ≥ 10 were not used. Resulting stepwise multiple regression models and univariate models were compared using Mallow's Cp where models were penalized for extra parameters (Myers 1990).

Length frequencies were constructed for each sportfish species (bluegill, spotted sunfish, redbreast sunfish, redear sunfish, and largemouth bass) for each sampling year to examine differences in sampling and community indices by size classes. Length frequencies typically showed unimodal distributions for all sport fish during all years and therefore prevented further analyses based on length classes.

RESULTS

Variability in river stages differed among sites during the data collection period. River stage was most variable based on coefficient of variation estimates at Ocklawaha Station 2 and moderately variable at Ocklawaha Station 4, but little variability occurred at Withlacoochee Station 3 (Table 1). Stage ranges were similar at all three stations (Table 1). Although Ocklawaha Stations 2 and 4 are regulated, fish population and community responses to river levels were expected to reflect the biology of the fish.

Catch per effort and biomass per effort estimates had very little variability among years within most sites. Repeated measures analyses indicated that significant differences in catch per effort between years were common at Ocklawaha Station 2, but only occurred for spotted sunfish CPM and lotic species CPM at Ocklawaha Station 3 (Tables 2-4). Total CPM, redbreast sunfish CPM and spotted sunfish CPM decreased through time at Ocklawaha Station 2. Spotted sunfish CPM and lotic species CPM also decreased through time at Withlacoochee Station 3. Similarly, biomass per effort estimates seldom differed between years within most sites. Community indices were only variable between years at Ocklawaha Station 2. Repeated measures analyses showed no differences in CPM, BPM or community indices among years at Ocklawaha Station 4 (Table 3). In summary, Ocklawaha Station 2 exhibited the most variation in river stage, differences among years, and spotted sunfish parameters differed more than other fish species among years.

The lack of variability in abundance and community indices among years at most sites limited our multiple regression analyses to Ocklawaha Station 2. Results of multiple regression models based on Ocklawaha Station 2 data suggested that river stages were related to abundance and community indices among years (Table 5). Total CPM was negatively related to the number of low stage days (LOW_{OY}) in the year prior to sampling, which suggested total abundance decreased with increased number of low stage days during the year prior to sampling (Table 5, Figure 5). Lotic sportfish CPM was positively related to increased minimum stage in the year prior to sampling (MIN_{OY}), indicating that increased minimum flows may enhance abundance of lotic sportfish (Table 5, Figure 6). Lotic sportfish BPM was also positively related to increased minimum stage during the year prior to sampling (MIN_{OY}), indicating that increased minimum flows may enhance abundance of lotic sportfish (Table 5, Figure 7). Species richness was negatively related to the minimum stage level during the year prior to sampling (MIN_{OY}), indicating that lower minimum flows may lead to lower numbers of species captured during sampling (Table 5, Figure 8). Species diversity was negatively related to increased variation around the mean stage during the two years prior to sampling (CV_{TY}), indicating that increased flow variation decreased species diversity (Table 5, Figure 9). Although high water variables were available in multiple regression models, only low and average water variables helped explain variability in fish abundance and communities among years.

Multiple regression models indicated that spotted sunfish abundance was related to flows at Ocklawaha Station 2. Spotted sunfish CPM and BPM were negatively related to the minimum stage in the year prior to sampling (MIN_{OY}), indicating that spotted sunfish abundance may decrease following low flows (Table 5, Figures 10-11).

DISCUSSION

Fish abundance and community indices seldom differed among years within sites. The general lack of differences between years within sites was not expected because there were variable flows between all sampling periods and hydrological variation is a major cause of variation in stream fish communities (Grossman et al. 1990). Differences in abundance and community indices between years at Ocklawaha Station 2 and not at other sites, may be due to higher flow variability at Ocklawaha Station 2 during the study. We expected differences to occur at Withlacoochee Station 3 because there were no regulating factors such as the inflow of Silver River upstream of Ocklawaha Station 2 or the Rodman dam upstream of Ocklawaha Station 4. The lack of differences at Withlacoochee 3 may have resulted from the low variation in stages throughout the study period. The increased variation in stage at Ocklawaha Station 2 may have caused larger fish community changes resulting in yearly differences we observed. Similarly, variability in stream fish abundance increased with increased discharge variability in an evaluation of 18 coastal streams in northwestern France (Oberdorff et al. 2001). In our study, abundance and community changes at Ocklawaha Station 2 may have been solely due to variations in river levels, however we do not know how variability in river level influenced habitat availability. Multiple studies have shown variation in stream fish assemblages with flow levels, but other studies have largely attributed assemblage structure to habitat characteristics. Talmage et al. (2002) explained 30-50% of the variability in warmwater streamfish abundance and species richness using percent overhanging vegetation, percent woody debris, and substrate characteristics. Thus, the relationships between habitat availability and fluctuating river levels should be further examined in Florida's rivers.

The lack of differences between lentic species CPM and BPM and detected differences between lotic species CPM and BPM among years may be due to differing life history traits. Species-specific responses to environmental variables affect: recruitment, mortality and movement patterns; and Bain et al. (1988) concluded that species with differing life histories and microhabitat needs respond differently to variable water levels. In our analyses, lotic species recruitment and mortality may be affected by flow variablility leading to relationships between abundance and flow. Lotic species may have also moved to more suitable areas during certain flow conditions leading to increased variability in abundance. Lotic organisms commonly avoid stressful conditions through movement (Edington 1968; Martin and Gentry 1974; Matthews 1987; Poff and Ward 1990). In contrast, lentic species may have had less restrictive habitat preferences and therefore exhibited fewer responses to variable flows resulting in no significant relationship between abundance and flows (Orth 1987).

Species richness of stream fish communities has differed due to variable water levels (Reice et al. 1990). Our results indicated that species richness was highest in years with lowest stage variability. Similarly, Horwitz (1978) reported a negative relationship between species richness and flow variability in headwaters of 15 midwestern rivers. Stream macroinvertebrate species richness and density have also declined as disturbance frequency increased in a manipulated disturbance frequency experiment (Robinson and Minshall 1986). In contrast, Grossman et al. (1990) postulated that reduced hydrologic variability may lead to species loss regardless of habitat modifications. Oberdorff et al. (2001) suggested that variability in assemblages is more likely caused by indirect effects of discharge variability (e.g., the frequency with which discharge is below the minimum value required for critical habitat requirements of species) rather than direct effects of variability in stream discharge.

In an evaluation of data from the Escambia River, Florida as part of Florida's long term monitoring program, Bass (1990) concluded that the Escambia River stream fish assemblages were stable and persistent despite annual variations in river levels. Bass (1990) found that Escambia River upstream sites were more stable and persistent than downstream sites where salt water intrusion may have influenced community structure. In our study, between year differences were only found in the upstream site of the Ocklawaha River.

Our multiple regression models indicated that spotted sunfish abundance was positively related to river stage. Similarly, Rutherford et al. (2001) reported increased spotted sunfish abundance with increased abundance of standing trees in the Atchafalaya River Basin, Louisiana, which likely occured during high stage events. Rutherford et al. (2001) also found higher spotted sunfish abundance in "green water" habitats that were characterized by high dissolved oxygen differentials (i.e., surface to bottom gradient) and low velocity. Green water habitats in Rutherford et al. (2001) were often found late in the flood pulse cycle after river stages were stabilized and water quality had improved after the influx of organic materials from surrounding swamps. The results of Rutherford et al. (2001) and our study indicate that spotted sunfish populations respond to variability in river levels and that spotted sunfish population trends may be important to monitor.

Our conclusions may be limited by low sample sizes and sampling biases. Our regression models are based on a low number of observations with a high number of variables, which increases the likelihood of finding a significant relationship between predictor and response variables when there is no biological relationship. Another source of errors is the limited number of fish samples. Sampling was conducted at each station during 1-2 consecutive days per year and only one transect was conducted at each area within stations, which increases the vulnerability of the data to sampling errors. Electrofishing catch rates vary with multiple factors such as fish species, fish size, fish behavior, population density, environmental conditions (i.e. water temperature, water conductivity, and water clarity), and sampling crew, which can mask the true relationship between catch rates and population abundance (Hardin and Connor 1992; Hilborn and Walters 1992; Reynolds 1996; Bayley and Austen 2002). We attempted to standardize sampling conditions by including data collected during bank-full conditions. Temporal trends in population size can lead to variability in abundance among years (Oberdorff et al. 2001). Although we did not detect temporal trends in abundance, they may have existed and we were unable to detect them due the few and sporadic sampling dates in our analyses.

Stream fish communities are inherently variable, thus Schlosser (1990) suggested long-term monitoring of stream fishes to enhance understanding of stream fish communities and allow managers to detect changes in stream fish communities. We suggest that the FFWCC continue to monitor stream fish assemblages, however more attention should be given to sampling during conditions that allow for more comparisons among years and increased opportunities to relate potential changes to fluctuating river levels. Increased sampling during similar river level conditions would allow the FFWCC to further evaluate impacts of river stage on fish communities and facilitate the establishment of MFLs in Florida. The FFWCC should also monitor relationships between habitat characteristics and habitat utilization by fishes at varying flow rates to better understand how river levels affect fish populations in Florida.

The relationship between species richness and spotted sunfish abundance may allow spotted sunfish to serve as an indicator of community responses to river flows based on our results at

Ocklawaha Station 2. Species richness and spotted sunfish abundance decreased with decreased minimum flows, suggesting that species richness and spotted sunfish are both sensitive to low flows. Using spotted sunfish as an indicator is advantageous because they are easily captured using electrofishing gears, thus sampling effort required to monitor spotted sunfish may be less than effort required to monitor other organisms (e.g., benthic, sessile, or rare species).

Implications for Setting Minimum Flows and Levels

Our results indicated that total abundance and species richness was lowest during years with lowest minimum flows. Thus, low flows appear to negatively affect total fish abundance and species richness, and sequential years of low flows may compound negative affects leading to harmful impacts on Florida's river communities. Therefore, we suggest setting MFLs to account for the periodicity and duration of low flow events and to reduce negative effects on recruitment by preventing low flows during consecutive years. We also suggest that the threshold used to set infrequent low and frequent low levels should consider life history attributes and not allow a duration greater than the generation time for most species.

Many fish populations naturally exhibit variable recruitment due to biological and environmental factors such as parental stock size, predator-prey interactions, weather and water level (Warner and Chesson 1985; Sammons and Bettoli 2000). Years with weak year classes are often followed by years with strong year classes leading to sustainable populations (Warner and Chesson 1985). Fish reproductive success is often a function of variable water levels leading to increased or decreased recruitment (the number of fish that survive to age-1) (Ploskey 1986), thus fisheries managers often manipulate water levels to enhance recruitment. In contrast, undesirable water levels may lead to low recruitment (Ploskey 1986) and sequential years of undesirable water levels may compound negative affects of water levels on fish populations. In controlled systems that do not allow for natural fluctuations in flows, multiple years of weak year classes may lead to long-term negative impacts on fish populations. Long-term effects of weak year classes and the numbers of consecutive weak year classes that lead to negative impacts, are species specific where long lived species are more likely resilient to weak year classes.

The “storage effect” is defined as the ability of populations to “store” production of strong year classes until environmental conditions are favorable (Warner and Chesson 1985). The storage effect is likely most beneficial to highly fecund species that are long-lived or have multiple spawning events during the year (Warner and Chesson 1985). The storage effect has contributed to the persistence of multiple fish species in multiple systems. Evidence of the storage effect has been shown for pelagic marine species due to relationships between recruitment and upwellings and water temperatures (Pfister 1997). Similarly, coral reef fish populations have exhibited the storage effect due to relationships between recruitment and habitat disturbance (Syms and Jones 2000). In freshwater systems, the storage effect has been observed in neo-tropical floodplain lakes where species-specific responses to water level affected recruitment and assemblage structure (Rodriguez and Lewis 1994). In Florida rivers, the storage effect may allow the persistence of fish through unfavorable spawning conditions such as low water. Because fish populations are generally resilient to short periods of poor spawning conditions, we recommend that MFLs criteria should focus on the periodicity and duration of low flow events by setting multiple MFLs.

Setting MFLs to prevent low flows during consecutive years may prevent compounded negative effects of low flows and allow communities to rebound to natural levels after low flow years. Minimum Flows and Levels should provide a minimum threshold that prevents adverse effects from water withdrawals, thus allowing a safety factor to prevent biological harm to Florida’s river communities. Further research should evaluate long-term effects of low flows on Florida's fish communities and the ability of fish populations to recover after low flow years by quantifying reproductive success and re-colonization rates. Further research should also focus on the number and duration of consecutive low flow events that populations are resilient to, thereby increasing our understanding of how low flow effects may be compounded by drought conditions.

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Table 1. Summary stage data for sampling stations used in MFL analysis.

Station	Ocklawaha Station 2	Ocklawaha Station 4	Withlacoochee Station 3
Bank Full (m)	1.13	1.14	11.52
Mean Stage (m)	1.30	1.43	11.42
Stage Range (m)	0.66 - 2.34	0.54 - 2.25	10.56 - 12.38
Stage CV Range (%)	14 - 33	18 - 23	1 - 4

Table 2. Results of repeated measures analyses of variance (ANOVA) tests on total and species specific catch per minute and biomass per minute and species richness, species diversity, and species evenness for Ocklawaha Station 2 during years sampled under standard conditions (CPM = catch per minute, BPM = biomass per minute, BLUE = bluegill, LMB = largemouth bass, RBSU = redbreast sunfish, SPSU = spotted sunfish, lentic = LMB and RBSU, lotic = RBSU and SPSU). Differing letters indicate significant differences among years at Ocklawaha Station 2.

				Least Squares Means				
Dependent Variable	Effect	$F_{df1, df2} = x$	P	1984	1986	1987	1989	1994
Total CPM	year	$8.03_{4,15}$	0.0011	A	A	A	B	B
BLUE CPM	year	$1.56_{4,15}$	0.2370					
LMB CPM	year	$1.98_{4,15}$	0.1489					
RBSU CPM	year	$6.30_{4,15}$	0.0035	A	A	A	A	B
SPSU CPM	year	$11.85_{4,15}$	0.0002	A	B	B	BC	C
RESU CPM	year	$2.47_{4,14}$	0.0928					
Total BPM	year	$1.89_{4,15}$	0.1651					
BLUE BPM	year	$0.73_{4,15}$	0.5869					
LMB BPM	year	$0.79_{4,15}$	0.5488					
RBSU BPM	year	$3.02_{4,15}$	0.0517					
SPSU BPM	year	$22.41_{4,15}$	< 0.0001	A	BCD	C	DE	E
RESU BPM	year	$1.18_{4,14}$	0.3626					
Lotic CPM	year	$13.58_{4,15}$	< 0.0001	A	BC	AB	C	D
Lotic BPM	year	$5.69_{4,15}$	0.0054	A	BC	AB	B	C
Lentic CPM	year	$1.22_{4,15}$	0.3439					
Lentic BPM	year	$0.13_{4,15}$	0.9685					
Richness	year	$13.78_{4,15}$	< 0.0001	A	AB	B	AB	B
Diversity	year	$8.44_{4,15}$	0.0009	A	A	A	A	B
Evenness	year	$2.03_{4,15}$	0.1422					

Table 3. Results of repeated measures analyses of variance (ANOVA) tests on total and species specific catch per minute and biomass per minute and species richness, species diversity, and species evenness for Oklawaha Station 4 during years sampled under standard conditions. (CPM = catch per minute, BPM = biomass per minute, BLUE = bluegill, LMB = largemouth bass, RBSU = redbreast sunfish, SPSU = spotted sunfish).

No among year differences were found at Ocklawaha Station 4.

					Least Squares Means				
Dependent Variable	Effect	$F_{df1, df2} = x$	P		1986	1989	1990	1991	1994
Total CPM	year	$0.69_{4,10}$	0.6137						
BLUE CPM	year	$1.32_{4,10}$	0.3284						
LMB CPM	year	$2.61_{4,10}$	0.1000						
RBSU CPM	year	$0.70_{4,10}$	0.6082						
SPSU CPM	year	$0.93_{4,9}$	0.4866						
RESU CPM	year	$0.83_{4,8}$	0.5421						
Total BPM	year	$2.11_{4,10}$	0.1537						
BLUE BPM	year	$0.50_{4,10}$	0.7339						
LMB BPM	year	$2.42_{4,10}$	0.1172						
RBSU BPM	year	$0.60_{4,10}$	0.6728						
SPSU BPM	year	$0.92_{4,9}$	0.4927						
RESU BPM	year	$0.67_{4,8}$	0.6317						
Lotic CPM	year	$0.67_{4,10}$	0.6305						
Lotic BPM	year	$0.43_{4,10}$	0.7817						
Lentic CPM	year	$1.26_{4,10}$	0.3486						
Lentic BPM	year	$1.77_{4,10}$	0.2120						
Richness	year	$2.96_{4,10}$	0.0749						
Diversity	year	$3.41_{4,10}$	0.0528						
Evenness	year	$1.42_{4,10}$	0.2965						

Table 4. Results of repeated measures analyses of variance (ANOVA) tests on total and species specific catch per minute and biomass per minute and species richness, species diversity, and species evenness for Withlacoochee Station 3 during years sampled under standard conditions. (CPM = catch per minute, BPM = biomass per minute, BLUE = bluegill, LMB = largemouth bass, RBSU = redbreast sunfish, SPSU = spotted sunfish, lentic = LMB and RBSU, lotic = RBSU and SPSU). Differing letters indicate significant differences among years at Withlacoochee Station 3.

				Least Squares Means				
Dependent Variable	Effect	$F_{df1,\ df2} = x$	P	1984	1986	1989	1991	1993
Total CPM	year	$1.55_{4,5}$	0.3181					
BLUE CPM	year	$3.52_{4,5}$	0.1002					
LMB CPM	year	$2.40_{4,5}$	0.1815					
RBSU CPM	year	$1.66_{4,5}$	0.2941					
SPSU CPM	year	$10.09_{4,5}$	0.0130	A	A	A	A	B
RESU CPM	year	$3.53_{4,5}$	0.0996					
Total BPM	year	$3.36_{4,5}$	0.1079					
BLUE BPM	year	$3.36_{4,5}$	0.1082					
LMB BPM	year	$2.55_{4,5}$	0.1657					
RBSU BPM	year	$1.23_{4,5}$	0.4026					
SPSU BPM	year	$5.27_{4,5}$	0.0486	A	A	A	AB	B
RESU BPM	year	$0.15_{4,5}$	0.9540					
Lotic CPM	year	$5.42_{4,5}$	0.0461	A	A	A	A	B
Lotic BPM	year	$3.47_{4,5}$	0.1023					
Lentic CPM	year	$2.65_{4,5}$	0.1567					
Lentic BPM	year	$1.03_{4,5}$	0.4758					
Richness	year	$1.97_{4,5}$	0.2381					
Diversity	year	$1.52_{4,5}$	0.3243					
Evenness	year	$0.82_{4,5}$	0.5649					

Table 5. Results from multiple regression models explaining variability in sampling and community indices where year effects were significant at Ocklawaha Station 2 (CPM = catch per minute, BPM = biomass per minute, SPSU = spotted sunfish, lentic = largemouth bass and bluegill, lotic = redbreast sunfish and spotted sunfish, LOW = number of low stage days, MIN = minimum stage, CV = coefficient of variation, AVE = number of average stage days, Max = maximum stage, OY = year prior to sampling, TY = two years prior to sampling).

Variable	Model	R^2	F	DF	P
Total CPM	$\log_e(CPM) = \log_e(3.42) - 0.14\log_e(LOW_{OY})$	0.95	48.48	1,3	0.006
Lotic sportfish CPM	$\log_e(CPM_{lotic}) = \log_e(-1.60) + 2.70\log_e(MIN_{OY})$	0.98	84.58	1,3	0.003
Lotic sportfish BPM	$\log_e(BPM_{lotic}) = \log_e(2.38) + 2.32\log_e(MIN_{OY})$	0.94	23.52	1,3	0.017
Species richness	$\log_e(S') = \log_e(0.68) + 1.39\log_e(MIN_{OY})$	0.91	28.74	1,3	0.013
Species diversity	$H' = 2.64 - 0.04(CV_{TY})$	0.94	27.47	1,3	0.017
SPSU CPM	$\log_e(CPM_{SPSU}) = \log_e(-1.10) + 2.81\log_e(MIN_{OY})$	0.84	15.54	1,3	0.029
SPSU BPM	$\log_e(BPM_{SPSU}) = \log_e(5.83) - 6.31\log_e(MIN_{OY})$	0.86	17.78	1,3	0.024

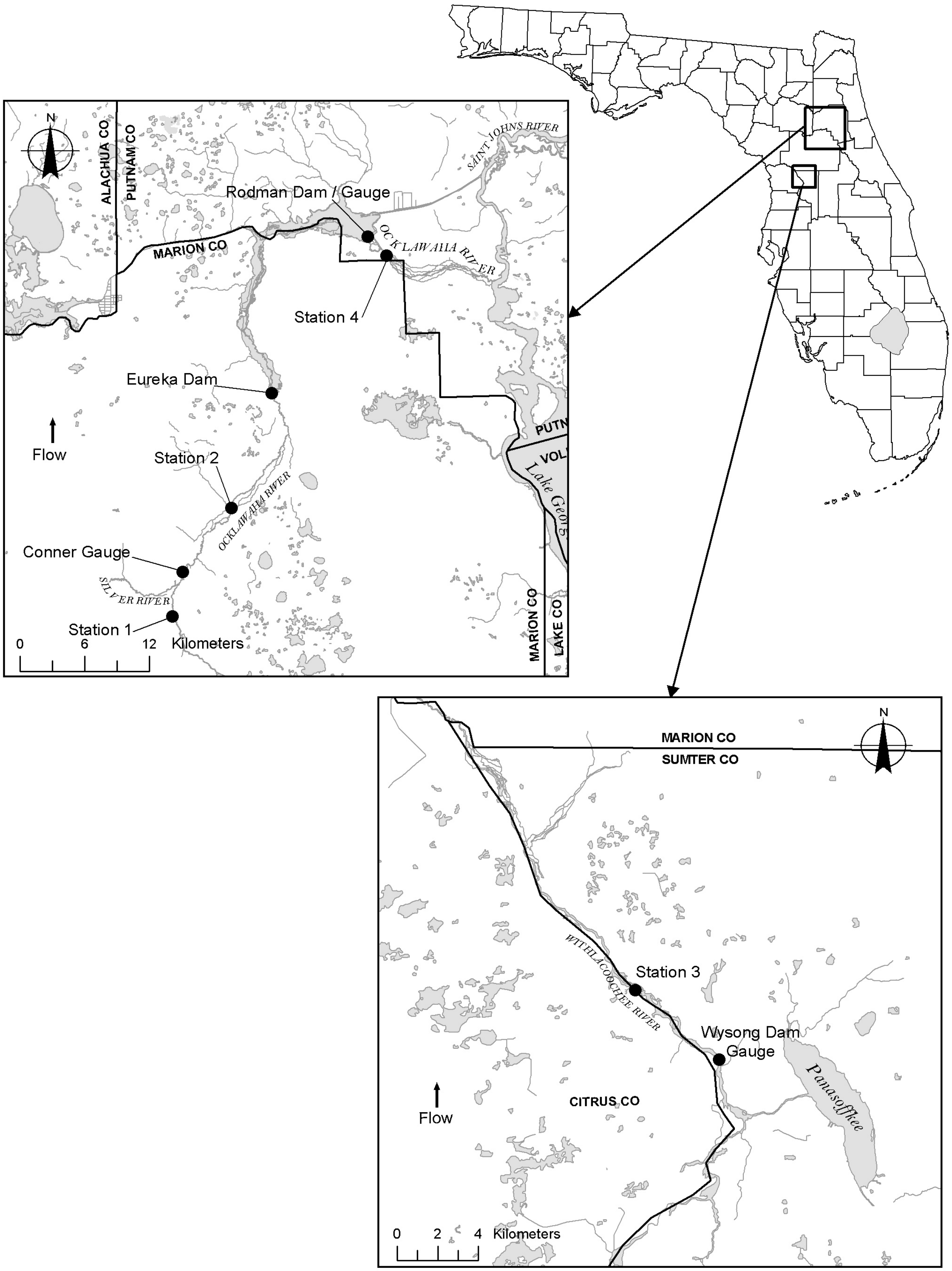

Figure 1. Map of sampling stations.

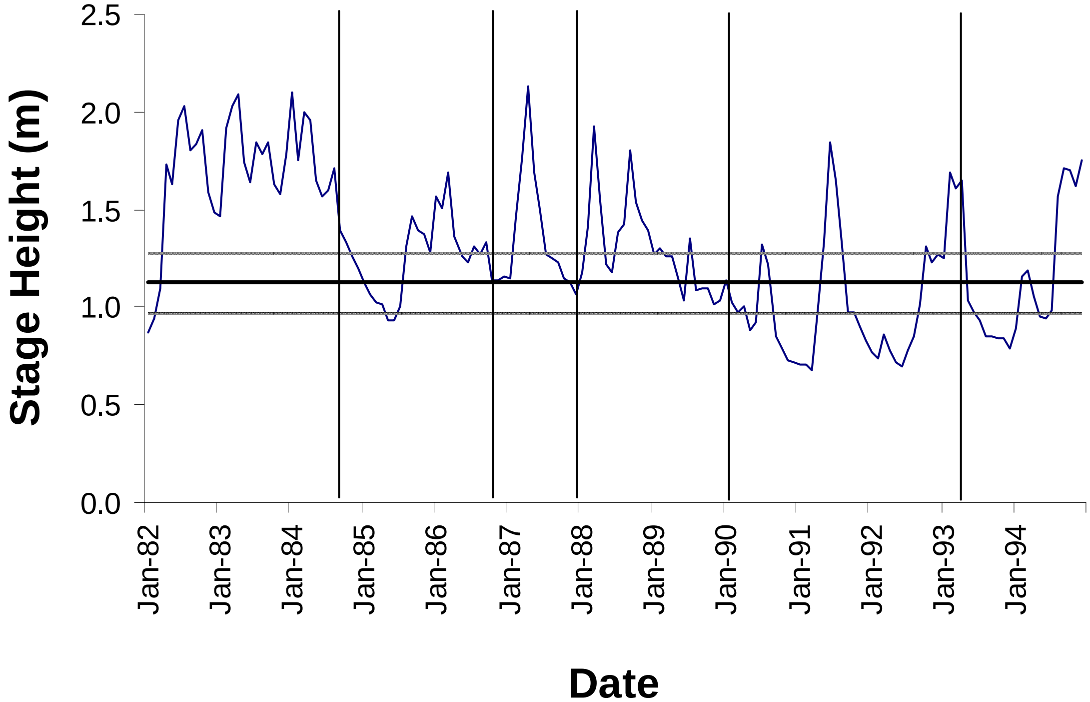

Figure 2. Historical stage data at Connor gauge. Horizontal solid line represents bank full height at Ocklawaha Station 2 and horizontal light-colored bars represent upper and lower limits of bank full. Vertical bars indicate sample dates during bank full conditions at Ocklawaha Station 2.

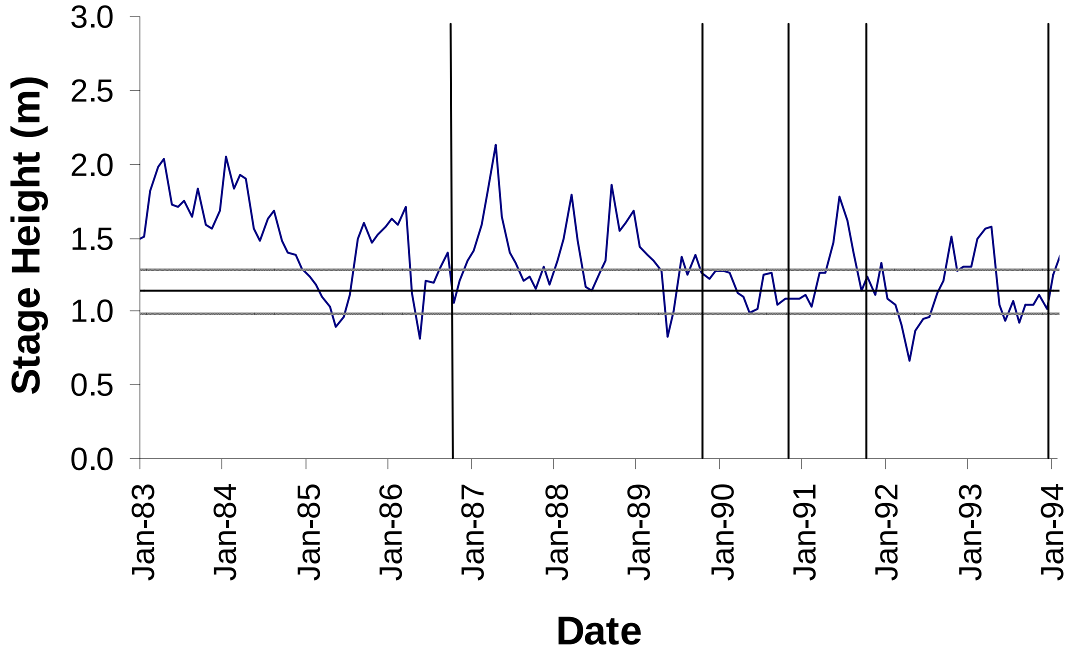

Figure 3. Historical stage data at Rodman gauge. Horizontal solid line represents bank full height at Ocklawaha Station 4 and horizontal light-colored bars represent upper and lower limits of bank full. Vertical bars indicate sample dates during bank full conditions at Ocklawaha Station 4.

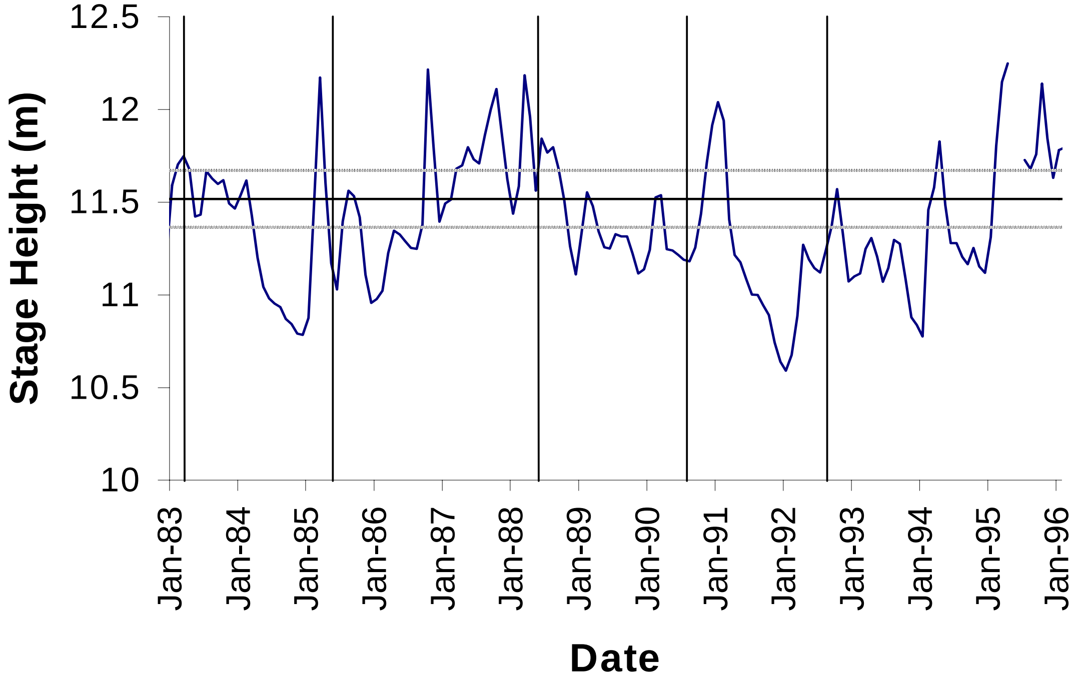

Figure 4. Historical stage data at Wysong Dam gauge. Horizontal solid line represents bank full height at Withlacoochee Station 3 and horizontal light-colored bars represent upper and lower limits of bank full. Vertical bars indicate sample dates during bank full conditions at Withlacoochee Station 3.

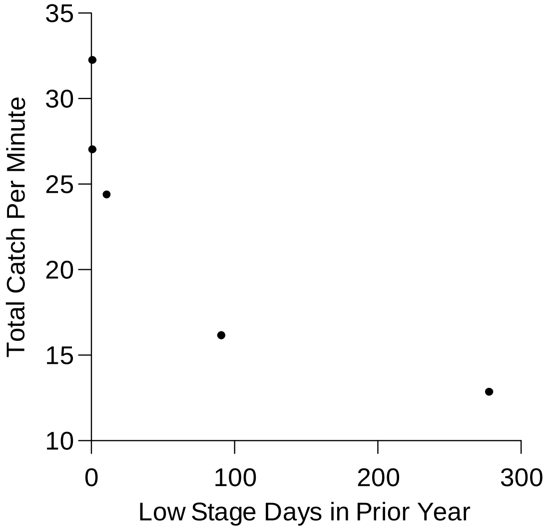

Figure 5. Total catch per minute versus number of low stage days in the year prior to sampling at Ocklawaha Station 2.

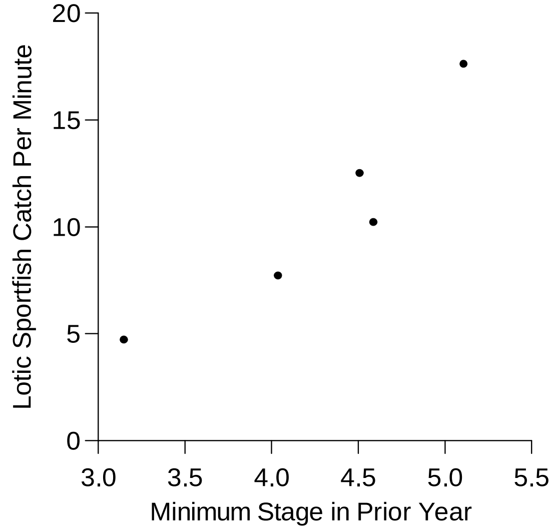

Figure 6. Lotic sportfish (redear sunfish and spotted sunfish) versus stage in the year prior to sampling at Ocklawaha Station 2.

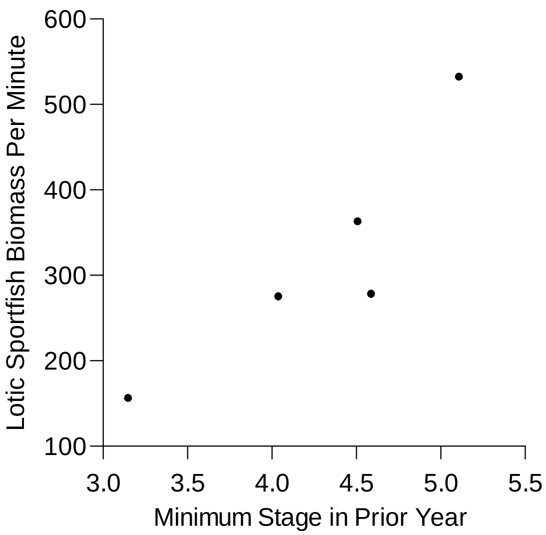

Figure 7. Lotic sportfish biomass (redear sunfish and spotted sunfish) versus minimum stage during the year prior to sampling at Ocklawaha Station 2.

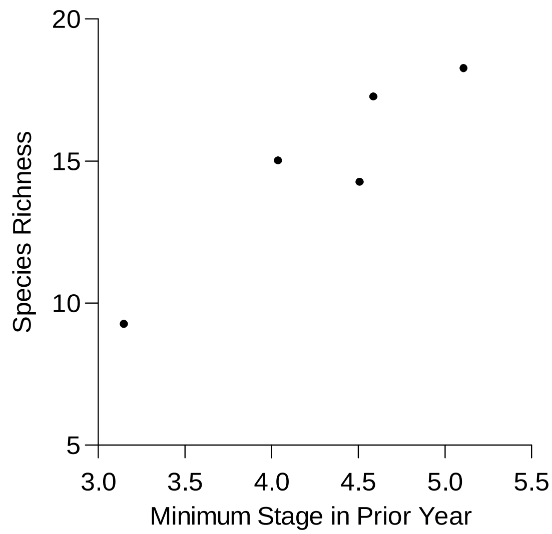

Figure 8. Species richness versus minimum stage during the year prior to sampling at Ocklawaha Station 2.

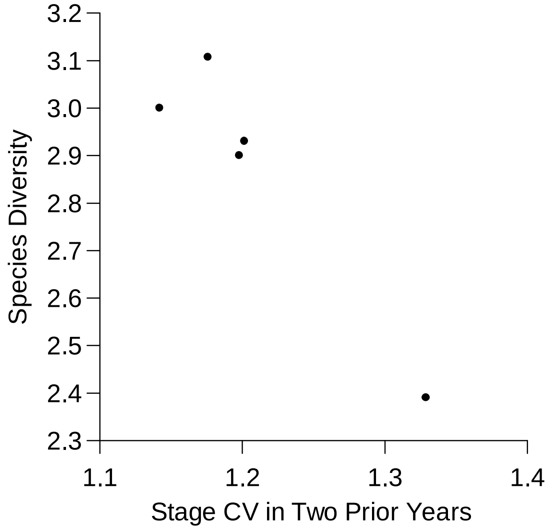

Figure 9. Species diversity versus coefficent of variation of stage during the two years prior to sampling at Ocklawaha Station 2.

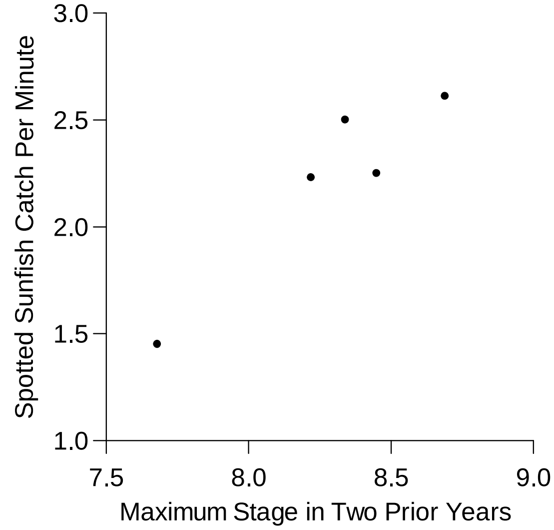

Figure 10. Spotted sunfish catch per minute versus maximum stage during the two years prior to sampling at Ocklawaha Station 2.

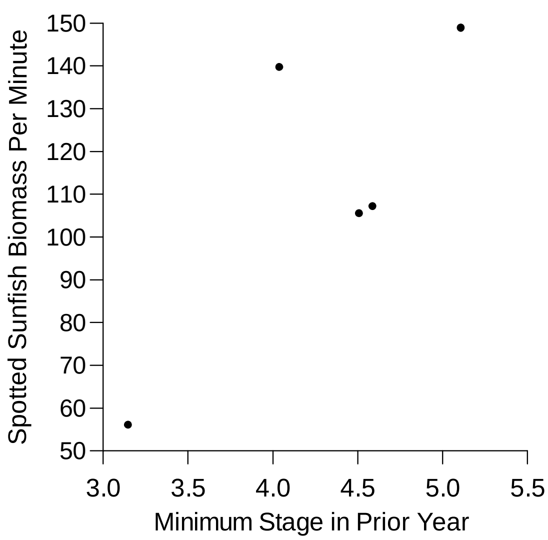

Figure 11. Spotted sunfish biomass per minute versus minimum stage during the year prior to sampling at Ocklawaha Station 2.

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Appendix A:

Description of Krummrich-Runyon Procedure

Hypothesis: The abundance, diversity, and size distribution of riverine fish populations are directly related to the timing, magnitude, frequency, and duration of flooding and in-bank river stage events.

1. Hypothesis is based on observations of fisheries and fish populations, but no defining determinations have been made.
2. Evaluations examine the before and after abundance, size distribution, and diversity of fish populations relative to significant flooding and in-bank events.
3. Flooding and in-bank events are defined by the river stage's exceedance of the bank-full water level.
4. Bank-full is defined as water level at which inundation of floodplain begins, or conversely, when floodplain becomes isolated from the main channel of stream.
5. Bank-full is determined by topographical measurements of floodplain and linked to nearest river gauge.
6. Evaluations need to utilize a range of one foot around (six inches above and below) the bank-full water level.

Appendix B:

Summary statistics of sampling and community indices and sportfish specific indices for all stations sampled under standard conditions

Summary statistics of community indices for stations sampled during standard conditions (SD = standard deviation, CV = coefficient of variation, CPM = catch per minute, BPM = biomass per minute, lentic = largemouth bass and bluegill, lotic = redbreast sunfish and spotted sunfish).

Variable	Site	Mean	SD	CV (%)	Minimum	Maximum	N
Total CPM	Ocklawaha Station 2	21.51	5.31	29	17.04	28.76	4
	Ocklawaha Station 4	12.69	5.91	48	7.71	18.70	3
	Withlacoochee Station 3	36.80	22.23	52	21.08	52.52	2
Total BPM	Ocklawaha Station 2	1262.99	588.57	49	837.39	2074.42	4
	Ocklawaha Station 4	1542.87	683.37	43	940.06	2233.81	3
	Withlacoochee Station 3	1329.75	388.72	31	1054.89	1604.62	2
Lentic CPM	Ocklawaha Station 2	5.71	3.65	64	3.46	11.08	4
	Ocklawaha Station 4	4.44	3.79	84	1.94	8.78	3
	Withlacoochee Station 3	6.30	3.21	45	4.03	8.57	2
Lotic CPM	Ocklawaha Station 2	9.73	1.99	27	7.72	12.17	4
	Ocklawaha Station 4	3.46	1.74	48	1.74	5.18	3
	Withlacoochee Station 3	9.77	4.18	39	6.81	12.72	2
Lentic BPM	Ocklawaha Station 2	454.74	323.76	69	207.21	918.86	4
	Ocklawaha Station 4	442.13	268.64	55	217.02	709.27	3
	Withlacoochee Station 3	322.20	148.06	47	217.50	426.89	2
Lotic BPM	Ocklawaha Station 2	319.46	87.00	34	241.57	431.83	4
	Ocklawaha Station 4	92.36	63.92	66	35.60	158.58	3
	Withlacoochee Station 3	210.09	127.16	52	120.17	300.01	2
Diversity	Ocklawaha Station 2	1.86	0.18	10	1.61	2.01	4
	Ocklawaha Station 4	2.11	0.18	9	1.91	2.25	3
	Withlacoochee Station 3	1.99	0.17	9	1.87	2.11	2
Richness	Ocklawaha Station 2	13.80	1.86	13	11.40	15.40	4
	Ocklawaha Station 4	15.20	1.74	12	13.60	17.00	3
	Withlacoochee Station 3	18.30	2.12	12	16.80	19.80	2
Evenness	Ocklawaha Station 2	0.72	0.05	7	0.65	0.76	4
	Ocklawaha Station 4	0.78	0.06	8	0.71	0.83	3
	Withlacoochee Station 3	0.69	0.08	12	0.63	0.75	2

Summary statistics of community indices for stations sampled during standard conditions (SD = standard deviation, CV = coefficient of variation, CPM = catch per minute, BPM = biomass per minute, RBSU = redbreast sunfish, SPSU = spotted sunfish, BLUE = bluegill, LMB = largemouth bass).

Variable	Site	Mean	SD	CV (%)	Minimum	Maximum	N
BLUE CPM	Ocklawaha Station 2	4.61	3.60	78	0.40	12.10	20
	Ocklawaha Station 4	3.36	3.46	103	0.20	11.70	15
	Withlacoochee Station 3	5.79	4.40	76	1.60	15.40	10
LMB CPM	Ocklawaha Station 2	1.10	0.56	51	0.30	2.43	20
	Ocklawaha Station 4	1.09	0.90	83	0.10	3.30	15
	Withlacoochee Station 3	0.46	0.38	81	0.10	1.44	11
RBSU CPM	Ocklawaha Station 2	6.14	2.60	42	0.50	10.70	20
	Ocklawaha Station 4	1.74	1.28	74	0.10	4.50	15
	Withlacoochee Station 3	2.76	2.23	81	0.80	6.92	10
SPSU CPM	Ocklawaha Station 2	3.59	3.02	84	0.50	10.84	20
	Ocklawaha Station 4	1.72	1.22	71	0.00	4.60	15
	Withlacoochee Station 3	7.01	4.37	62	0.90	14.10	10
RESU CPM	Ocklawaha Station 2	1.21	0.64	53	0.00	2.59	20
	Ocklawaha Station 4	0.93	0.87	94	0.00	2.80	15
	Withlacoochee Station 3	1.65	1.29	78	0.00	3.85	11
BLUE BPM	Ocklawaha Station 2	158.34	155.44	98	23.00	566.90	20
	Ocklawaha Station 4	74.58	47.29	63	3.71	158.50	15
	Withlacoochee Station 3	220.75	72.21	159	18.70	542.90	10
LMB BPM	Ocklawaha Station 2	296.40	231.15	78	28.11	892.51	20
	Ocklawaha Station 4	367.54	348.54	95	49.50	1351.72	15
	Withlacoochee Station 3	92.23	75.10	69	5.20	235.74	11
RBSU BPM	Ocklawaha Station 2	225.90	97.11	43	22.40	404.00	20
	Ocklawaha Station 4	55.84	52.97	95	1.00	175.00	15
	Withlacoochee Station 3	64.60	117.69	76	6.60	260.30	10
SPSU BPM	Ocklawaha Station 2	93.56	83.28	89	15.10	318.59	20
	Ocklawaha Station 4	36.52	31.02	85	0.00	102.56	15
	Withlacoochee Station 3	145.49	81.45	119	10.30	402.10	10
RESU BPM	Ocklawaha Station 2	110.40	67.10	61	0.00	240.00	20
	Ocklawaha Station 4	72.14	70.21	97	0.00	277.20	15
	Withlacoochee Station 3	109.92	81.34	89	0.00	300.60	11

Summary statistics of sampling and community indices at Ocklawaha Station 2 (SD = standard deviation, CV = coefficient of variation, CPM = catch per minute, BPM = biomass per minute, lentic = largemouth bass and bluegill, lotic = spotted sunfish and spotted sunfish).

Variable	Year	Mean	SD	CV (%)	Minimum	Maximum	N
Total CPM	1984	31.24	5.09	16	27.24	38.40	4
	1986	26.00	3.71	14	21.60	30.60	4
	1987	23.37	5.75	25	20.36	31.99	4
	1989	15.13	7.00	46	9.00	25.20	4
	1992	11.83	4.98	42	7.00	17.60	4
Total BPM	1984	1740.51	308.91	18	1456.48	2032.92	4
	1986	1159.75	743.62	64	746.40	2274.09	4
	1987	1320.61	588.48	45	933.84	2195.49	4
	1989	1322.42	899.60	68	733.55	2635.00	4
	1992	771.68	402.25	52	316.70	1234.60	4
Lentic CPM	1984	4.11	0.51	12	3.50	4.54	4
	1986	6.80	4.95	73	3.80	14.20	4
	1987	6.33	4.34	69	3.98	12.84	4
	1989	4.40	5.34	121	1.50	12.40	4
	1992	6.93	3.12	45	4.50	11.40	4
Lotic CPM	1984	16.56	1.07	6	15.49	17.96	4
	1986	10.18	3.13	31	6.80	13.80	4
	1987	11.54	2.37	21	9.59	14.98	4
	1989	6.68	1.24	19	5.10	8.00	4
	1992	3.68	2.13	58	1.60	6.10	4
Lentic BPM	1984	437.92	85.40	20	324.40	518.21	4
	1986	443.79	452.49	102	113.00	1099.40	4
	1987	494.92	468.62	95	134.97	1182.79	4
	1989	506.88	454.35	90	198.50	1181.50	4
	1992	390.18	157.93	40	265.20	612.40	4
Lotic BPM	1984	530.79	71.47	13	451.93	608.46	4
	1986	276.75	39.18	14	218.30	302.04	4
	1987	361.51	89.98	25	307.97	496.14	4
	1989	273.67	122.19	45	192.13	452.00	4
	1992	154.58	112.17	73	37.50	300.50	4
Diversity	1984	2.00	0.17	8	1.76	2.15	4
	1986	2.11	0.28	13	1.69	2.26	4
	1987	1.90	0.13	7	1.75	2.06	4
	1989	1.93	0.18	9	1.66	2.05	4
	1992	1.39	0.17	12	1.17	1.55	4
Richness	1984	17.25	3.59	21	12.00	20.00	4
	1986	16.25	3.10	19	12.00	19.00	4
	1987	13.25	0.50	4	13.00	14.00	4
	1989	14.00	1.15	8	13.00	15.00	4
	1992	8.25	0.96	12	7.00	9.00	4
Evenness	1984	0.71	0.01	2	0.69	0.72	4
	1986	0.76	0.06	7	0.68	0.81	4
	1987	0.74	0.06	8	0.66	0.80	4
	1989	0.73	0.06	8	0.65	0.77	4
	1992	0.66	0.06	10	0.57	0.71	4

Summary statistics of sampling and community indices at Ocklawaha Station 4. (SD = standard deviation, CV = coefficient of variation, CPM = catch per minute, BPM = biomass per minute, lentic = largemouth bass and bluegill, lotic = spotted sunfish and redbreast sunfish).

Variable	Year	Mean	SD	CV (%)	Minimum	Maximum	N
Total CPM	1986	13.56	4.99	37	8.86	18.80	3
	1989	15.40	3.76	24	11.30	18.70	3
	1990	13.83	7.40	53	8.60	22.30	3
	1991	11.57	8.43	73	6.40	21.30	3
	1994	9.10	4.96	54	3.40	12.40	3
Total BPM	1986	1986.58	544.83	27	1386.26	2449.70	3
	1989	2151.13	1651.07	77	1014.90	4045.05	3
	1990	1735.70	424.40	24	1305.53	2154.08	3
	1991	905.50	320.00	35	601.90	1239.70	3
	1994	935.44	476.54	51	391.71	1280.50	3
Lentic CPM	1986	4.30	2.98	69	1.79	7.60	3
	1989	3.90	2.95	76	2.10	7.30	3
	1990	7.03	6.12	87	3.30	14.10	3
	1991	5.30	5.55	105	1.90	11.70	3
	1994	1.67	1.36	82	0.60	3.20	3
Lotic CPM	1986	3.67	0.92	25	2.69	4.50	3
	1989	5.37	3.52	66	2.10	9.10	3
	1990	2.57	0.67	26	2.00	3.30	3
	1991	2.83	1.10	39	1.70	3.90	3
	1994	2.87	2.48	86	0.20	5.10	3
Lentic BPM	1986	585.99	426.91	73	97.62	888.29	3
	1989	726.25	611.63	84	356.00	1432.22	3
	1990	494.20	75.34	15	416.58	567.03	3
	1991	242.97	178.05	73	99.70	442.30	3
	1994	161.24	51.27	32	115.21	216.50	3
Lotic BPM	1986	69.80	28.59	41	38.69	94.92	3
	1989	134.99	113.85	84	42.83	262.26	3
	1990	53.83	35.85	67	29.50	95.00	3
	1991	108.17	65.16	60	56.00	181.20	3
	1994	95.00	76.15	80	11.00	159.50	3
Diversity	1986	2.42	0.19	8	2.22	2.59	3
	1989	2.18	0.10	5	2.06	2.24	3
	1990	2.06	0.28	14	1.74	2.27	3
	1991	1.88	0.20	11	1.66	2.05	3
	1994	2.01	0.13	6	1.87	2.12	3
Richness	1986	17.67	2.08	12	16.00	20.00	3
	1989	16.33	1.53	9	15.00	18.00	3
	1990	16.00	1.00	6	15.00	17.00	3
	1991	13.33	0.58	4	13.00	14.00	3
	1994	12.67	3.51	28	9.00	16.00	3
Evenness	1986	0.84	0.04	4	0.80	0.87	3
	1989	0.78	0.04	5	0.74	0.82	3
	1990	0.74	0.12	16	0.61	0.84	3
	1991	0.72	0.07	10	0.65	0.78	3
	1994	0.80	0.04	5	0.76	0.85	3

Summary statistics of sampling and community indices at Withlacoochee Station 3 (SD = standard deviation, CV = coefficient of variation, CPM = catch per minute, BPM = biomass per minute).

Variable	Year	Mean	SD	CV (%)	Minimum	Maximum	N
Total CPM	1984	30.97	18.16	59	18.13	43.81	2
	1986	43.00	11.46	27	34.90	51.10	2
	1989	26.74	12.53	47	17.88	35.60	2
	1991	70.30	63.92	91	25.10	115.50	2
	1993	13.00	5.09	39	9.40	16.60	2
Total BPM	1984	1640.13	136.53	8	1543.59	1736.67	2
	1986	1900.95	942.93	50	1234.20	2567.70	2
	1989	1609.95	158.16	10	1498.12	1721.78	2
	1991	906.89	507.21	56	548.24	1265.54	2
	1993	590.85	198.77	34	450.30	731.40	2
Lentic CPM	1984	7.16	3.81	53	4.47	9.86	2
	1986	11.40	6.22	55	7.00	15.80	2
	1989	3.25	0.92	28	2.60	3.90	2
	1991	2.65	0.78	29	2.10	3.20	2
	1993	7.05	4.31	61	4.00	10.10	2
Lotic CPM	1984	11.54	9.16	79	5.07	18.02	2
	1986	14.55	2.76	19	12.60	16.50	2
	1989	12.60	5.09	40	9.00	16.20	2
	1991	8.30	3.68	44	5.70	10.90	2
	1993	1.85	0.21	11	1.70	2.00	2
Lentic BPM	1984	402.62	133.91	33	307.93	497.31	2
	1986	490.45	247.84	51	315.20	665.70	2
	1989	228.39	79.22	35	172.38	284.40	2
	1991	229.67	145.34	63	126.90	332.44	2
	1993	259.85	134.00	52	165.10	354.60	2
Lotic BPM	1984	215.88	160.69	74	102.25	329.51	2
	1986	376.85	193.11	51	240.30	513.40	2
	1989	305.49	236.30	77	138.40	472.58	2
	1991	106.57	33.48	31	82.90	130.24	2
	1993	45.65	12.23	27	37.00	54.30	2
Diversity	1984	2.09	0.05	2	2.05	2.12	2
	1986	2.19	0.14	6	2.10	2.29	2
	1989	2.10	0.02	1	2.09	2.11	2
	1991	1.82	0.35	19	1.58	2.07	2
	1993	1.76	0.31	18	1.54	1.98	2
Richness	1984	16.50	4.95	30	13.00	20.00	2
	1986	21.00	2.83	13	19.00	23.00	2
	1989	19.50	2.12	11	18.00	21.00	2
	1991	20.00	0.00	0	20.00	20.00	2
	1993	14.50	0.71	5	14.00	15.00	2
Evenness	1984	0.75	0.07	9	0.71	0.80	2
	1986	0.72	0.08	11	0.67	0.78	2
	1989	0.71	0.02	3	0.69	0.72	2
	1991	0.61	0.12	19	0.53	0.69	2
	1993	0.66	0.13	19	0.57	0.75	2

Appendix C:

Sportfish specific estimates for all stations sampled under standard conditions

Summary statistics of species specific catch per minute (CPM) and biomass per minute (BPM) for Ocklawaha Station 2 sampled during standard conditions (BLUE = bluegill, LMB = largemouth bass, RBSU = redbreast sunfish, SPSU = spotted sunfish).

Variable	Year	Species	Mean	SD	CV	Min	Max	N
CPM	1984	BLUE	2.81	0.62	21.94	2.2	3.4	4
	1986	BLUE	5.53	4.41	79.75	2.8	12.1	4
	1987	BLUE	4.88	3.74	76.71	2.2	10.4	4
	1989	BLUE	3.58	5.17	144.71	0.4	11.3	4
	1992	BLUE	6.28	3.26	51.99	4.1	11.1	4
	1984	LMB	1.30	0.17	12.78	1.1	1.5	4
	1986	LMB	1.28	0.55	43.14	1.0	2.1	4
	1987	LMB	1.45	0.87	59.91	0.4	2.4	4
	1989	LMB	0.83	0.32	38.81	0.5	1.1	4
	1992	LMB	0.65	0.45	69.37	0.3	1.3	4
	1984	RBSU	7.96	1.89	23.75	6.4	10.7	4
	1986	RBSU	7.13	1.38	19.43	5.8	8.6	4
	1987	RBSU	8.13	1.30	15.99	6.7	9.8	4
	1989	RBSU	4.95	1.42	28.69	3.1	6.5	4
	1992	RBSU	2.53	1.85	73.34	0.5	4.8	4
	1984	SPSU	8.60	2.55	29.67	5.3	10.8	4
	1986	SPSU	3.05	1.78	58.50	1.0	5.2	4
	1987	SPSU	3.42	1.20	35.26	2.4	5.2	4
	1989	SPSU	1.73	0.22	12.85	1.5	2.0	4
	1992	SPSU	1.15	0.50	43.48	0.5	1.7	4
	1984	RESU	1.25	0.44	34.80	0.6	1.5	4
	1986	RESU	1.23	0.50	40.75	0.8	1.9	4
	1987	RESU	1.61	0.73	45.56	0.9	2.6	4
	1989	RESU	1.50	0.56	37.32	0.8	2.0	4
	1992	RESU	0.45	0.42	93.40	0.0	0.9	4
BPM	1984	BLUE	117.95	29.45	24.97	90.5	159.4	4
	1986	BLUE	179.79	228.91	127.32	31.5	520.9	4
	1987	BLUE	127.40	112.43	88.25	35.7	290.3	4
	1989	BLUE	121.25	158.39	130.63	23.0	357.0	4
	1992	BLUE	245.30	214.57	87.47	126.7	566.9	4
	1984	LMB	319.96	69.35	21.67	233.9	403.4	4
	1986	LMB	264.00	229.96	87.10	81.5	578.5	4
	1987	LMB	367.52	368.97	100.39	28.1	892.5	4
	1989	LMB	385.63	296.29	76.83	175.5	824.5	4
	1992	LMB	144.88	81.59	56.32	45.5	245.0	4
	1984	RBSU	287.05	46.16	16.08	248.1	345.3	4
	1986	RBSU	217.31	48.14	22.15	148.3	257.5	4
	1987	RBSU	278.24	85.45	30.71	216.6	404.0	4
	1989	RBSU	225.05	124.27	55.22	131.0	404.0	4
	1992	RBSU	121.85	96.72	79.38	22.4	249.0	4

continued . Summary statistics of species specific catch per minute (CPM) and biomass per minute (BPM) for Ocklawaha Station 2 sampled during standard conditions (BLUE = bluegill, LMB = largemouth bass, RBSU = redbreast sunfish, SPSU = spotted sunfish).

1984	SPSU	243.73	59.25	24.31	189.3	318.6	4
1986	SPSU	59.44	18.97	31.92	36.4	79.0	4
1987	SPSU	83.27	16.83	20.21	65.8	102.2	4
1989	SPSU	48.62	11.80	24.28	40.0	65.5	4
1992	SPSU	32.73	15.57	47.59	15.1	51.5	4
1984	RESU	147.82	63.37	42.87	58.0	201.6	4
1986	RESU	106.13	84.94	80.04	43.7	230.3	4
1987	RESU	104.41	33.85	32.42	76.7	153.3	4
1989	RESU	138.63	70.48	50.84	84.5	240.0	4
1992	RESU	55.00	63.84	116.07	0.0	137.5	4

Summary statistics of species specific catch per minute (CPM) and biomass per minute (BPM) for Ocklawaha Station 4 sampled during standard conditions (BLUE = bluegill, LMB = largemouth bass, RBSU = redbreast sunfish, SPSU = spotted sunfish).

Variable	Year	Species	Mean	SD	CV	Min	Max	N
CPM	1986	BLUE	3.24	2.15	66.21	1.4	5.6	3
	1989	BLUE	1.93	1.86	96.12	0.4	4.0	3
	1990	BLUE	5.70	5.22	91.58	2.2	11.7	3
	1991	BLUE	4.57	5.14	112.61	1.4	10.5	3
	1994	BLUE	1.33	1.55	116.27	0.2	3.1	3
	1986	LMB	1.06	0.84	78.86	0.4	2.0	3
	1989	LMB	1.97	1.22	62.14	0.9	3.3	3
	1990	LMB	1.33	0.97	72.84	0.5	2.4	3
	1991	LMB	0.73	0.40	55.11	0.5	1.2	3
	1994	LMB	0.33	0.21	62.45	0.1	0.5	3
	1986	RBSU	2.41	0.66	27.54	1.7	3.0	3
	1989	RBSU	2.47	2.05	83.12	0.4	4.5	3
	1990	RBSU	1.00	1.15	115.33	0.1	2.3	3
	1991	RBSU	1.27	1.19	94.19	0.3	2.6	3
	1994	RBSU	1.57	1.21	77.21	0.2	2.5	3
	1986	SPSU	1.26	0.25	20.14	1.0	1.5	3
	1989	SPSU	2.90	1.51	52.18	1.7	4.6	3
	1990	SPSU	1.57	0.67	42.50	1.0	2.3	3
	1991	SPSU	1.57	1.78	113.53	0.3	3.6	3
	1994	SPSU	1.30	1.30	100.00	0.0	2.6	3
	1986	RESU	0.76	0.11	13.89	0.7	0.9	3
	1989	RESU	0.67	0.29	43.30	0.5	1.0	3
	1990	RESU	0.40	0.46	114.56	0.0	0.9	3
	1991	RESU	1.53	1.42	92.54	0.0	2.8	3
	1994	RESU	1.27	1.32	104.24	0.1	2.7	3
BPM	1986	BLUE	81.77	58.13	71.08	19.4	134.5	3
	1989	BLUE	64.01	36.63	57.23	22.0	89.5	3
	1990	BLUE	93.04	33.74	36.27	68.6	131.5	3
	1991	BLUE	69.03	45.76	66.28	35.7	121.2	3
	1994	BLUE	65.07	82.23	126.37	3.7	158.5	3
	1986	LMB	504.22	377.43	74.85	78.2	796.8	3
	1989	LMB	662.24	599.28	90.49	266.5	1351.7	3
	1990	LMB	401.17	46.69	11.64	348.0	435.5	3
	1991	LMB	173.93	137.22	78.89	49.5	321.1	3
	1994	LMB	96.17	33.27	34.59	58.0	119.0	3
	1986	RBSU	48.82	18.60	38.10	31.2	68.3	3
	1989	RBSU	74.36	76.11	102.36	13.5	159.7	3
	1990	RBSU	29.33	38.76	132.13	1.0	73.5	3
	1991	RBSU	70.00	91.75	131.07	5.3	175.0	3
	1994	RBSU	56.67	40.45	71.39	11.0	88.0	3

continued. Summary statistics of species specific catch per minute (CPM) and biomass per minute (BPM) for Ocklawaha Station 4 sampled during standard conditions (BLUE = bluegill, LMB = largemouth bass, RBSU = redbreast sunfish, SPSU = spotted sunfish).

1986	SPSU	20.98	11.78	56.13	7.4	28.9	3
1989	SPSU	60.63	37.75	62.27	29.3	102.6	3
1990	SPSU	24.50	10.33	42.17	16.0	36.0	3
1991	SPSU	38.17	39.27	102.89	6.2	82.0	3
1994	SPSU	38.33	45.42	118.49	0.0	88.5	3
1986	RESU	100.55	40.34	40.12	54.2	127.7	3
1989	RESU	55.56	12.65	22.77	41.2	65.0	3
1990	RESU	30.67	42.75	139.40	0.0	79.5	3
1991	RESU	107.60	148.64	138.14	0.0	277.2	3
1994	RESU	66.33	51.56	77.73	8.5	107.5	3

Summary statistics of species specific catch per minute (CPM) and biomass per minute (BPM) for Withlacoochee Station 3 sampled during standard conditions (BLUE = bluegill, LMB = largemouth bass, RBSU = redbreast sunfish, SPSU = spotted sunfish).

Variable	Year	Species	Mean	SD	CV	Min	Max	N
CPM	1984	BLUE	6.31	2.99	47.31	4.2	8.4	2
	1986	BLUE	11.10	6.08	54.79	6.8	15.4	2
	1989	BLUE	2.50	0.85	33.94	1.9	3.1	2
	1991	BLUE	2.15	0.78	36.18	1.6	2.7	2
	1993	BLUE	6.90	4.38	63.54	3.8	10.0	2
	1984	LMB	0.85	0.83	97.13	0.3	1.4	2
	1986	LMB	0.30	0.14	47.14	0.2	0.4	2
	1989	LMB	0.50	0.26	53.01	0.3	0.8	3
	1991	LMB	0.50	0.00	0.00	0.5	0.5	2
	1993	LMB	0.15	0.07	47.14	0.1	0.2	2
	1984	RBSU	4.06	4.05	99.63	1.2	6.9	2
	1986	RBSU	4.85	0.92	18.95	4.2	5.5	2
	1989	RBSU	1.60	0.71	44.19	1.1	2.1	2
	1991	RBSU	2.50	2.12	84.85	1.0	4.0	2
	1993	RBSU	0.80	0.00	0.00	0.8	0.8	2
	1984	SPSU	7.48	5.11	68.34	3.9	11.1	2
	1986	SPSU	9.70	1.84	18.95	8.4	11.0	2
	1989	SPSU	11.00	4.38	39.86	7.9	14.1	2
	1991	SPSU	5.80	1.56	26.82	4.7	6.9	2
	1993	SPSU	1.05	0.21	20.20	0.9	1.2	2
	1984	RESU	2.86	1.40	49.10	1.9	3.9	2
	1986	RESU	2.80	1.27	45.46	1.9	3.7	2
	1989	RESU	0.93	1.07	114.69	0.0	2.1	3
	1991	RESU	0.35	0.35	101.02	0.1	0.6	2
	1993	RESU	1.65	0.35	21.43	1.4	1.9	2
BPM	1984	BLUE	292.10	70.66	24.19	242.1	342.1	2
	1986	BLUE	406.10	193.46	47.64	269.3	542.9	2
	1989	BLUE	111.05	35.29	31.77	86.1	136.0	2
	1991	BLUE	57.70	55.15	95.59	18.7	96.7	2
	1993	BLUE	236.80	159.24	67.25	124.2	349.4	2
	1984	LMB	110.53	63.26	57.23	65.8	155.3	2
	1986	LMB	84.35	54.38	64.47	45.9	122.8	2
	1989	LMB	78.23	65.47	83.69	18.8	148.4	3
	1991	LMB	171.97	90.19	52.44	108.2	235.7	2
	1993	LMB	23.05	25.24	109.52	5.2	40.9	2
	1984	RBSU	58.16	69.26	119.08	9.2	107.1	2
	1986	RBSU	168.95	129.19	76.47	77.6	260.3	2
	1989	RBSU	49.49	29.69	59.98	28.5	70.5	2
	1991	RBSU	21.67	21.31	98.35	6.6	36.7	2
	1993	RBSU	24.70	2.83	11.45	22.7	26.7	2

continued . Summary statistics of species specific catch per minute (CPM) and biomass per minute (BPM) for Withlacoochee Station 3 sampled during standard conditions (BLUE = bluegill, LMB = largemouth bass, RBSU = redbreast sunfish, SPSU = spotted sunfish).

1984	SPSU	157.72	91.43	57.97	93.1	222.4	2
1986	SPSU	207.90	63.92	30.75	162.7	253.1	2
1989	SPSU	256.00	206.62	80.71	109.9	402.1	2
1991	SPSU	84.90	12.16	14.33	76.3	93.5	2
1993	SPSU	20.95	15.06	71.89	10.3	31.6	2
1984	RESU	131.45	49.09	37.35	96.7	166.2	2
1986	RESU	102.45	75.87	74.06	48.8	156.1	2
1989	RESU	116.65	161.21	138.20	0.0	300.6	3
1991	RESU	109.05	122.68	112.50	22.3	195.8	2
1993	RESU	86.65	49.85	57.53	51.4	121.9	2

Appendix D:

Summary statistics of stage data for all stations sampled under standard conditions

Stage data for Ocklawaha Station 2 (High = days above average, Ave = days at average, Low = days below average, TY = two years prior to sampling, OY = one year prior to sampling, and SM = six months prior to sampling, SD = standard deviation, CV = coefficient of variation).

Variable	1984	1986	1987	1989	1992
High TY	560	58	158	96	67
Ave TY	172	530	572	546	158
Low TY	0	114	10	90	472
High OY	261	48	110	7	2
Low OY	0	0	10	90	277
Ave OY	106	317	256	279	88
High SM	84	2	33	7	2
Low SM	0	0	0	61	96
Ave SM	101	183	182	116	86
TY minimum (m)	1.25	0.89	1.07	0.93	0.66
TY maximum (m)	2.27	2.20	2.34	2.24	2.04
TY range (m)	1.02	1.31	1.27	1.31	1.38
TY mean (m)	1.64	1.25	1.37	1.25	0.99
TY SD	0.80	0.72	0.89	0.87	1.07
TY CV (%)	14	18	20	20	33
OY minimum (m)	1.25	1.09	1.07	0.93	0.66
OY maximum (m)	2.23	2.20	2.34	1.80	1.70
OY range (m)	0.98	1.11	1.27	0.87	1.04
OY mean (m)	1.69	1.36	1.40	1.19	0.89
OY SD	0.85	0.64	1.06	0.56	0.70
OY CV (%)	15	14	23	14	24
SM minimum (m)	1.25	1.09	1.07	0.93	0.66
SM maximum (m)	1.91	1.56	1.58	1.80	1.70
SM range (m)	0.66	0.47	0.51	0.87	1.04
SM mean (m)	1.52	1.26	1.24	1.12	1.01
SM SD	0.54	0.33	0.40	0.55	0.80
SM CV (%)	11	8	10	15	24

Stage data for Ocklawaha Station 4 (High = days above average, Ave = days at average, Low = days below average, TY = two years prior to sampling, OY = one year prior to sampling, and SM = six months prior to sampling, SD = standard deviation, CV = coefficient of variation.)

Variable	1986	1989	1990	1991	1994
High TY	189	192	65	94	75
Ave TY	332	457	472	413	287
Low TY	210	82	194	224	370
High OY	116	45	2	92	56
Low OY	84	56	137	87	189
Ave OY	166	264	227	187	121
High SM	15	12	0	86	3
Low SM	58	17	90	24	142
Ave SM	112	155	95	75	40
TY minimum (m)	0.59	0.63	0.63	0.84	0.54
TY maximum (m)	2.11	2.25	2.01	2.18	1.97
TY range (m)	1.52	1.62	1.38	1.34	1.43
TY mean (m)	1.28	1.36	1.23	1.22	2.04
TY SD	0.94	0.89	0.73	0.73	0.88
TY CV (%)	22	20	18	18	23
OY minimum (m)	0.59	0.63	0.85	0.84	0.83
OY maximum (m)	2.11	1.86	1.54	2.18	1.97
OY range (m)	1.52	1.23	0.68	1.34	1.14
OY mean (m)	1.33	1.28	1.15	1.29	1.17
OY SD	1.03	0.77	0.49	0.84	0.87
OY CV (%)	24	18	13	20	23
SM minimum (m)	0.64	0.74	0.85	1.02	0.83
SM maximum (m)	1.62	1.67	1.47	2.18	1.58
SM range (m)	0.98	0.93	0.62	1.16	0.74
SM mean (m)	1.19	1.26	1.12	1.42	1.03
SM SD	0.72	0.56	0.47	0.89	0.42
SM CV (%)	19	14	13	20	12

Stage data for Withlacoochee Station 3 (High = days above average, Ave = days at average, Low = days below average, TY = two years prior to sampling, OY = one year prior to sampling, and SM = six months prior to sampling, SD = standard deviation, CV = coefficient of variation.)

Variable	1984	1986	1989	1991	1993
High TY	347	77	456	0	105
Ave TY	334	301	276	600	226
Low TY	51	353	0	131	401
High OY	135	58	227	0	0
Low OY	11	179	0	99	239
Ave OY	221	129	139	267	127
High SM	46	9	118	0	0
Low SM	0	60	0	30	57
Ave SM	138	114	65	153	126
TY minimum (m)	11.06	10.69	11.34	11.06	10.56
TY maximum (m)	12.22	12.22	12.38	11.66	12.11
TY range (m)	1.17	1.53	1.04	0.60	1.55
TY mean (m)	11.61	11.27	11.74	11.29	11.18
TY SD	0.90	1.21	0.74	0.46	1.30
TY CV (%)	2	3	2	1	4
OY minimum (m)	1.11	10.69	11.37	11.07	10.56
OY maximum (m)	11.95	12.22	12.38	11.66	11.56
OY range (m)	0.84	1.53	1.01	0.59	1.01
OY mean (m)	11.57	11.29	11.74	11.26	10.98
OY SD	0.58	1.42	0.75	0.47	0.91
OY CV (%)	2	4	2	1	3
SM minimum (m)	11.34	11.00	11.45	11.13	11.07
SM maximum (m)	11.74	11.74	11.92	1.14	11.56
SM range (m)	0.41	0.74	0.47	0.27	0.49
SM mean (m)	11.56	11.36	11.70	11.23	11.23
SM SD	0.37	0.79	0.42	0.20	0.37
SM CV (%)	1	2	1	1	1