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Effects of recreational electrofishing on sturgeon habitat in the Cape Fear River drainage.

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Final Report to:
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INTRODUCTION

The shortnose sturgeon (*Acipenser brevirostrum*) is a federally-listed endangered species. This fish was reportedly abundant in North Carolina waters in the early 1900s, but due to overfishing and habitat degradation it now occurs only rarely in the Cape Fear River and Albemarle Sound drainages and has apparently been extirpated from other state waters (Ross et al. 1984, NMFS 1998). In spite of Endangered Species Act (1973) protections and a moratorium on Atlantic sturgeon (*A. oxyrinchus*) harvest in North Carolina (1991), shortnose sturgeon are still very rare in state waters. Consequently, concerns about habitat quality and the possible need for enhancement with cultured fish are current shortnose sturgeon management issues in North Carolina.

The Shortnose Sturgeon Recovery Plan (NMFS 1998) outlines priority tasks for recovery of each shortnose sturgeon population segment. In addition, it provides general guidelines for conditions that must be met for stock enhancement or restoration using cultured shortnose sturgeon. Among these recommendations for the Cape Fear River population is the need to assess sturgeon bycatch in other fisheries and the impacts of non-indigenous species. Enhancement or restoration of shortnose sturgeon populations cannot be considered until it has been established that essential habitats are available to sustain the species, and that mortalities from bycatch or from predation by non-indigenous fishes are not a significant threat to these efforts (NMFS 1998).

The 1966 introduction of flathead catfish (*Pylodictis olivaris*) and blue catfish (*Ictalurus furcatus*) into the Cape Fear River (Moser and Roberts in press) had several potentially significant repercussions for already rare sturgeon populations. Both catfish species attain very large sizes and occur in shortnose sturgeon spawning and nursery habitats. The flathead catfish is piscivorous and is known to feed on other demersal species (particularly other catfishes). The blue catfish is omnivorous and could act as both a potential predator on and/or a competitor for food of the shortnose sturgeon juveniles. The rapid expansion of these non-indigenous catfishes heralded the demise of native icatlurids in the upper Cape Fear River and the 1981 establishment of a novel recreational electrofishing fishery to target non-native catfish (Moser and Roberts 1999).

Sturgeon, like catfish, possess exceptional electro-sensory capabilities. Consequently, they are likely to be significantly impacted by electrofishing developed to target catfish (Morris and Novak 1968). Avoidance of electroshocking and the results of being shocked could reduce feeding or alter spawning behavior and subsequently reduce sturgeon fitness. In this study, we examined both the effects of catfish predation on shortnose sturgeon and the potential impact of recreational electrofishing, which is prosecuted intensively in the Cape Fear River main stem from the mouth of the Black River to Lock and Dam #3 (Figure 1).

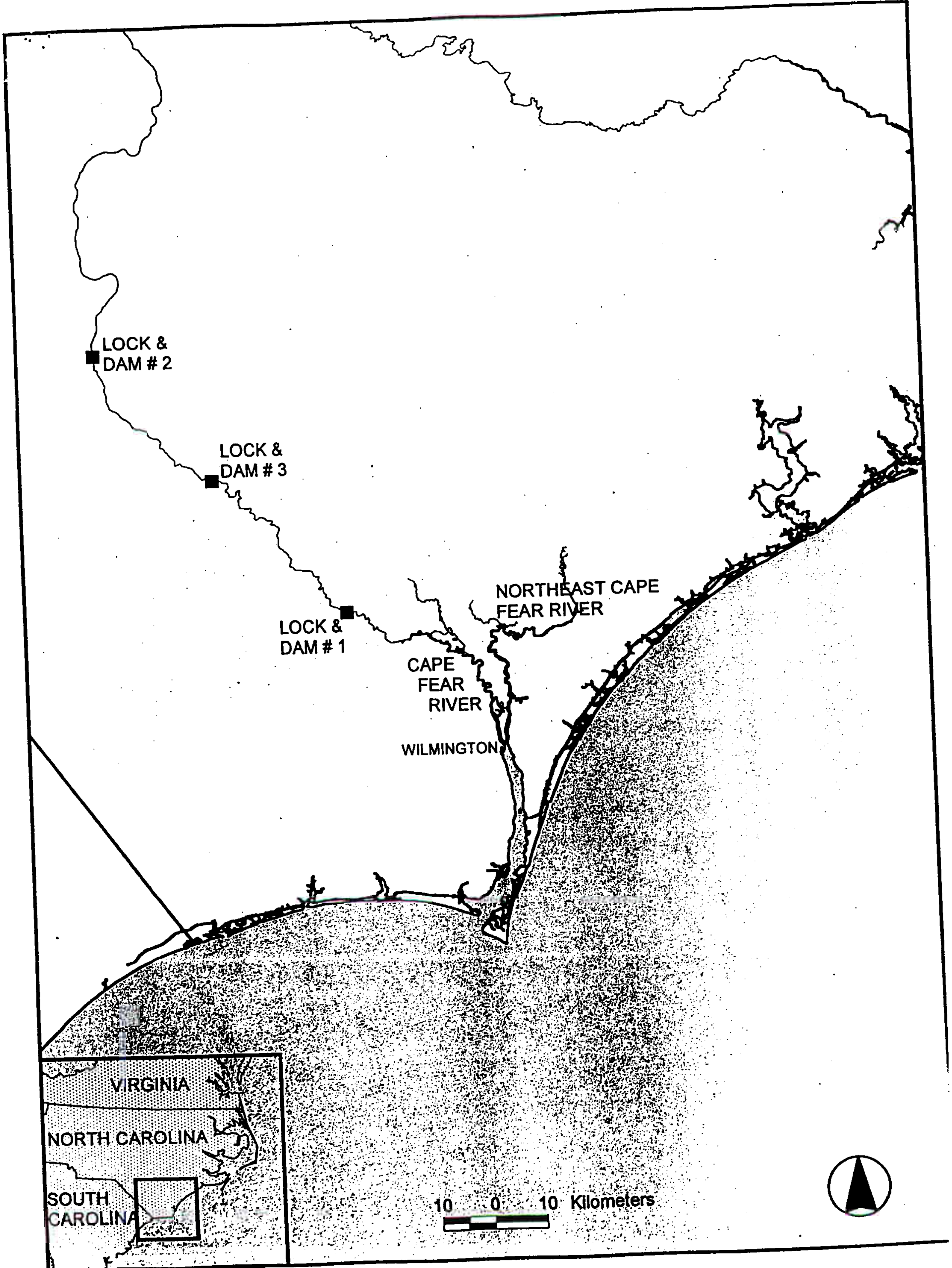

Figure 1. Lower Cape Fear River drainage, North Carolina.

MATERIALS AND METHODS

Electrofishing

Juvenile hatchery-reared shortnose sturgeon and channel catfish were exposed to simulated electrofishing conditions while being held in ambient Cape Fear River water. The electrofishing device was a hand-cranked "telephone" generator supplied by a local recreational fisherman. It consisted of a 5-bar telephone generator wired to a capacitor. A pulley connected the generator to a bicycle wheel that permitted hand-cranking at approximately 80 revolutions per minute during a one minute treatment. This use of the gear was consistent with that of local electrofishers. Two insulated wires were connected to the capacitor and acted as electrodes, which were positioned along the bottom of the treatment area in each experiment. We also observed behavioral responses of fish when they were subjected to a variety of DC frequencies and pulse widths by using a commercially available back-pack electroshocker (Smith Root Model 12A). This enabled us to empirically determine the frequency and pulse width that elicited the same response as that produced by the hand-cranked generator.

Shortnose sturgeon juveniles were obtained from the U.S. Fish and Wildlife Service fish hatcheries at Warm Springs, Georgia and Bear's Bluff , South Carolina. Blue catfish juveniles were obtained from Southeastern Pond Stocking and Aquatic Maintenance. Fish were maintained in aerated 8, 800 gallon tanks with water circulated from the Cape Fear River for over eight months prior to testing, to allow adequate acclimation to their new setting and for water quality to approximate conditions when electrofishing is prosecuted most intensely. Unfortunately, during this period an electrical storm caused a power outage and the backup generation system for tanks housing the sturgeon failed, resulting in mass mortality. Consequently, scaled down experiments were conducted with a small number of fish held in a backup facility (Cape Fear Community College). The experiments were conducted in two, 800 gal tanks: one treatment and one control tank. Fish were fed ad libitum (approximately 72 g) on Hi-Pro #3 every evening. Salinity, conductivity, dissolved oxygen and water temperature were recorded prior to each electroshocking test and these parameters were also recorded continuously in the control tank using a data logger (Yellow Springs Instruments 6600).

On the first day of electroshock experiments, all fish were weighed and measured. The tank containing the experimental fish was lined with a seine net, which, when raised, allowed us to observe fish behaviors. These fish were then exposed to the output from the "telephone" generator four to five times a day for two weeks. During the one minute exposure, the following behaviors were recorded, the second at which it occurred, how long it lasted and the recovery time:

- Twitching – rapid twitching/swimming usually accompanied by heightened operculation.
- Lateral roll – fish rolls over to one side. This behavior was often preceded by a period of rigor when the fish would form a rigid "S" shaped curve and remains motionless.
- Belly up – fish completely rolls upside-down.
- Avoidance.

Fish in the control tank were not exposed to the output from the "telephone" generator, but were regularly disturbed to replicate activities associated with the electroshocking treatment. After two weeks, all fish were again weighed and measured. The electroshock experiment was conducted a second time; however, the seine net was removed and no observations were made during shocking. This test was conducted to insure that disturbance associated with making the observations was not confounding the results. After two weeks, the fish were again weighed and measured. All electroshock experiments were conducted in October and November 1999. Weights and total-lengths of experimental and control fish were compared before and after the electroshock experiments to determine any deleterious effects of electroshocking on shortnose sturgeon. The instantaneous growth rate (G) was computed as: $G = (\ln W_t - \ln W_0)t^{-1}$ where W_t was the mean weight at the end of the experiment, W_0 was the mean weight at the start of the experiment, and t was the length of the experiment in days.

Catfish predation

Large adult flathead catfish (> 3000 g) were collected from the Cape Fear River using gillnets (Mallin et al. 1999). They were held in the River in floating net pens and were not fed for one week prior to experimentation. Hatchery-reared shortnose sturgeon, channel catfish (*Ictalurus punctatus*) and striped bass (*Morone saxatilis*) juveniles were held in aerated 800 gal tanks with flow-through Cape Fear River water for over three months prior to experimentation and were fed ad libitum during this period. Temperature, salinity and dissolved oxygen were recorded daily.

To initiate experiments, one flathead catfish was moved to an empty aerated 800 gallon tank with water circulated from the Cape Fear River and allowed to acclimate to the tank for 24 h. Then, ten each of shortnose sturgeon, channel catfish and striped bass were placed in fish cages and lowered into the tank containing the flathead catfish. They remained in the cage for 24 hours to acclimate and were then released. Every day for a period of two weeks, the fish were counted in order to determine consumption rates and preferential prey species of the flathead catfish. After two weeks, the flathead catfish was returned to the Cape Fear River and replaced with a new one. This experiment was repeated four times; however, in the last three replicates striped bass were not available. The first three replicates were conducted between February 17th and April 19th 1999, the fourth from November 30th to December 14th 1999.

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RESULTS

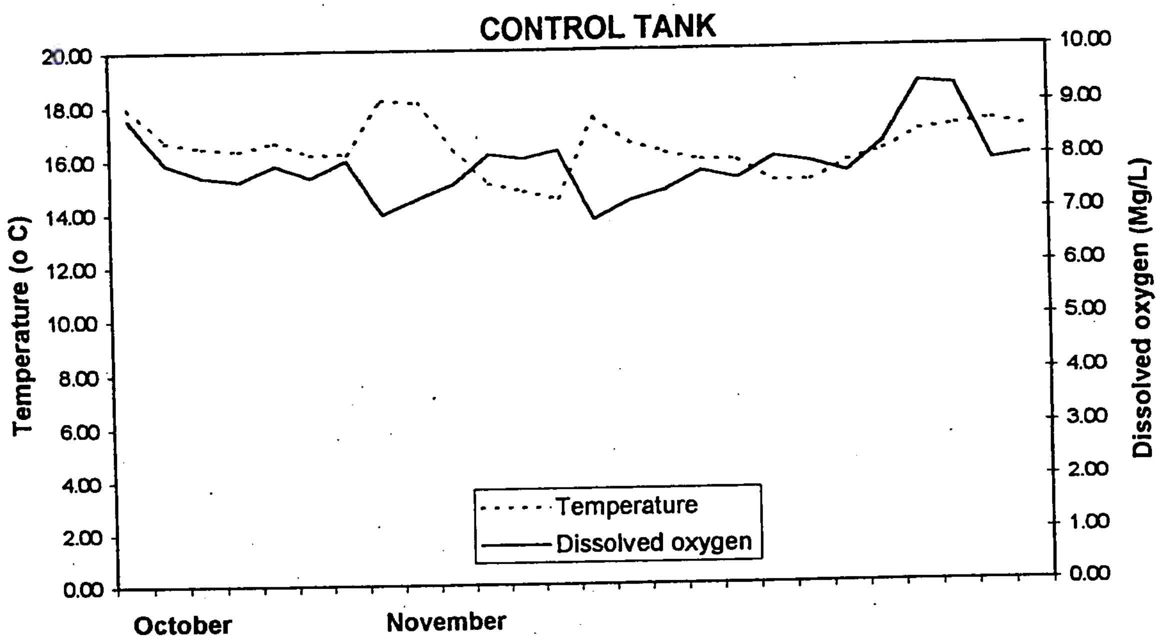
Electrofishing

Water quality in the control and experimental tanks was very similar (Figure 2 and 3). The temperature ranged from 14.5 – 18.1 ^{0}C. Dissolved oxygen was also within a narrow range. At the end of November, the salinity began to rise from 0.00 ‰ to a maximum of 4.1 ‰ in the control tank and 3.4 ‰ in the experimental tank. Thus conductivity increased from an average of 101.8 µmols/cm in the control tank and 95.4 µmols/cm in the experimental tank when salinity was 0.00, to a maximum of 5057 and 5042.5 µmols/cm respectively.

Average lengths and weights of fish used were similar in the control and experimental tanks, although shortnose sturgeon were larger and heavier than channel catfish (Figure 4 and 5). Both species increased in length and weight over the four week experimental period. Instantaneous daily growth rates for shortnose sturgeon in the first replicate were lower (0.013 d^{-1}) for fish exposed to electroshocking and .0214 d^{-1} for controls. In contrast, electroshocked sturgeon in the second replicate grew faster (0.024 d^{-1} than controls (0.022 d^{-1}). As for sturgeon, electroshocked catfish in the first replicate grew more slowly (0.003 d^{-1}) than controls (0.016 d^{-1}), but in the second replicate, the shocked catfish grew faster (0.034 d^{-1}) than controls (0.007 d^{-1}). Consequently, there were similar growth rates observed between treatments when the growth rate was calculated over the entire four week time period for each species (Figure 4 and 5).

Using the back-pack electroshocker, we were able to elicit the same type of sturgeon and catfish responses as obtained with the hand cranked generator when 100 volt output was produced at 10 Hz and 10 pulses/second (as in Quinn 1986). Sturgeon were initially more responsive to the electroshocking treatment than catfish; however, they recovered quickly and moved to avoid the stimulus (Figure 6). More sturgeon than catfish rolled onto their side or completely rolled upside-down within the first 15 seconds. They also exhibited more twitching, rigor and avoidance behaviors than did catfish (Table 1). But, sturgeon generally recovered immediately after the experiment. Over 75% of the sturgeon recovered immediately, with maximum recovery times of 5 minutes. In contrast, catfish tended to display electronarcosis and as the shocking continued, more catfish lost equilibrium. Catfish also took longer to recover than sturgeon, sometimes up to 8 minutes after the experiment had ended (Figure 6). The average recovery time for catfish was 3.5 min and only 7 fish recovered immediately.

Figure 2. Water quality in control tanks during electroshocking experiments.



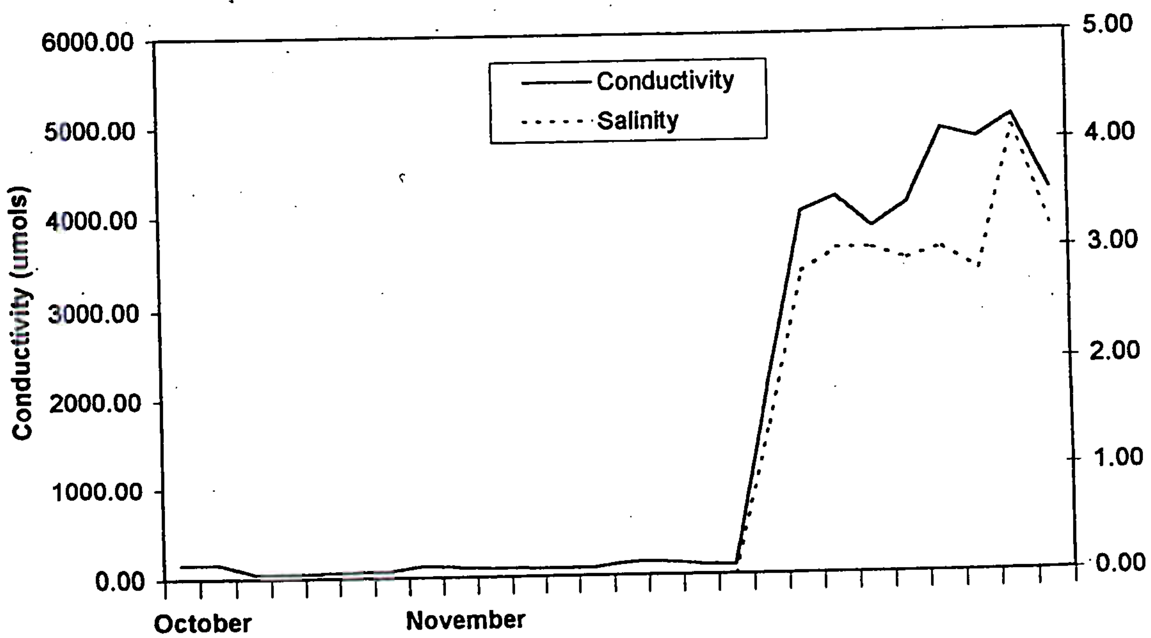


Figure 3. Water quality in experimental tanks during electroshocking experiments.

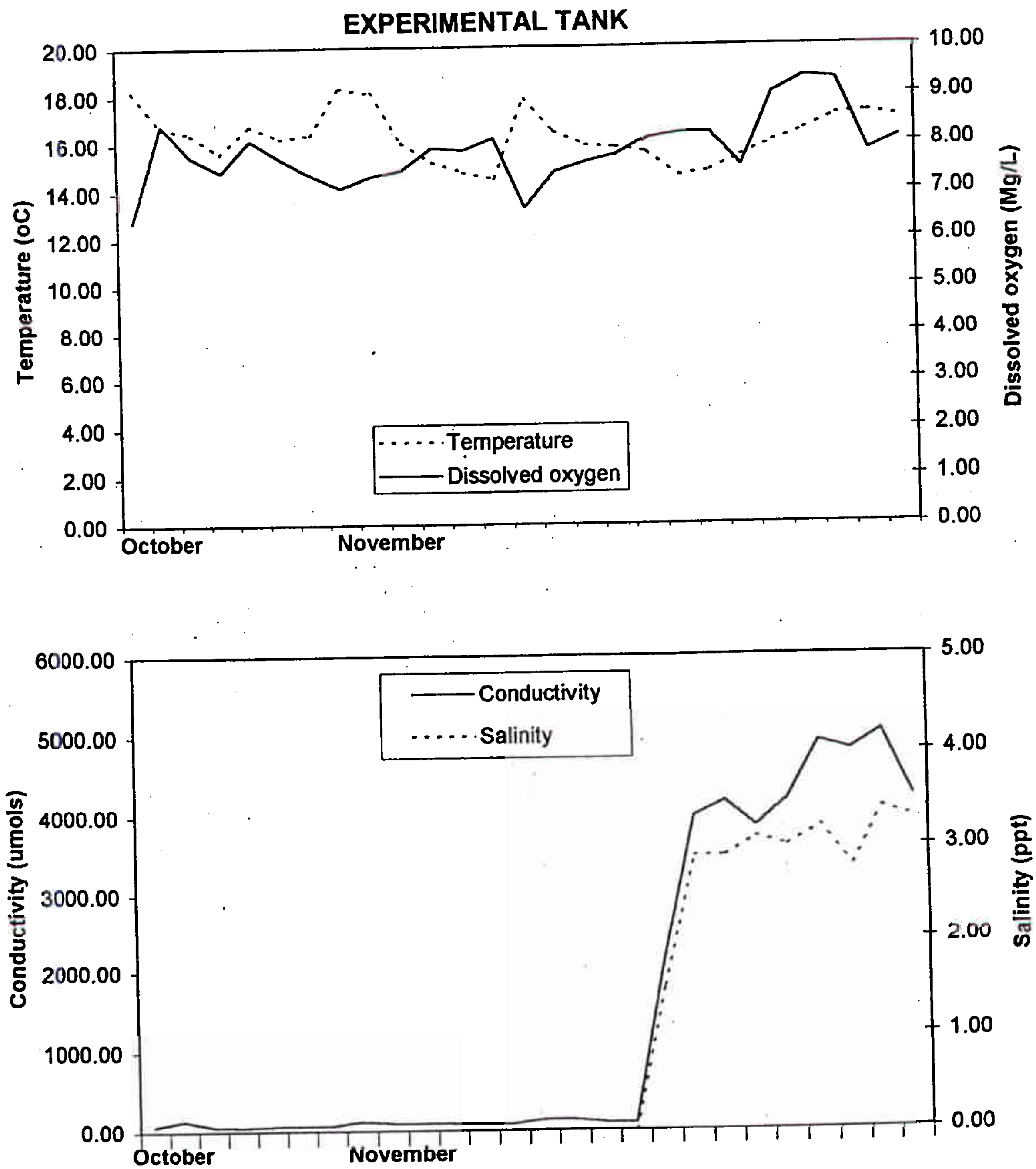


Figure 4. Mean total length (mm) and weight (g) of shortnose sturgeon in control (upper panel) and electroshocking treatments (bottom panel) conducted over the 32 day period from 10/22/99 – 11/23/99.

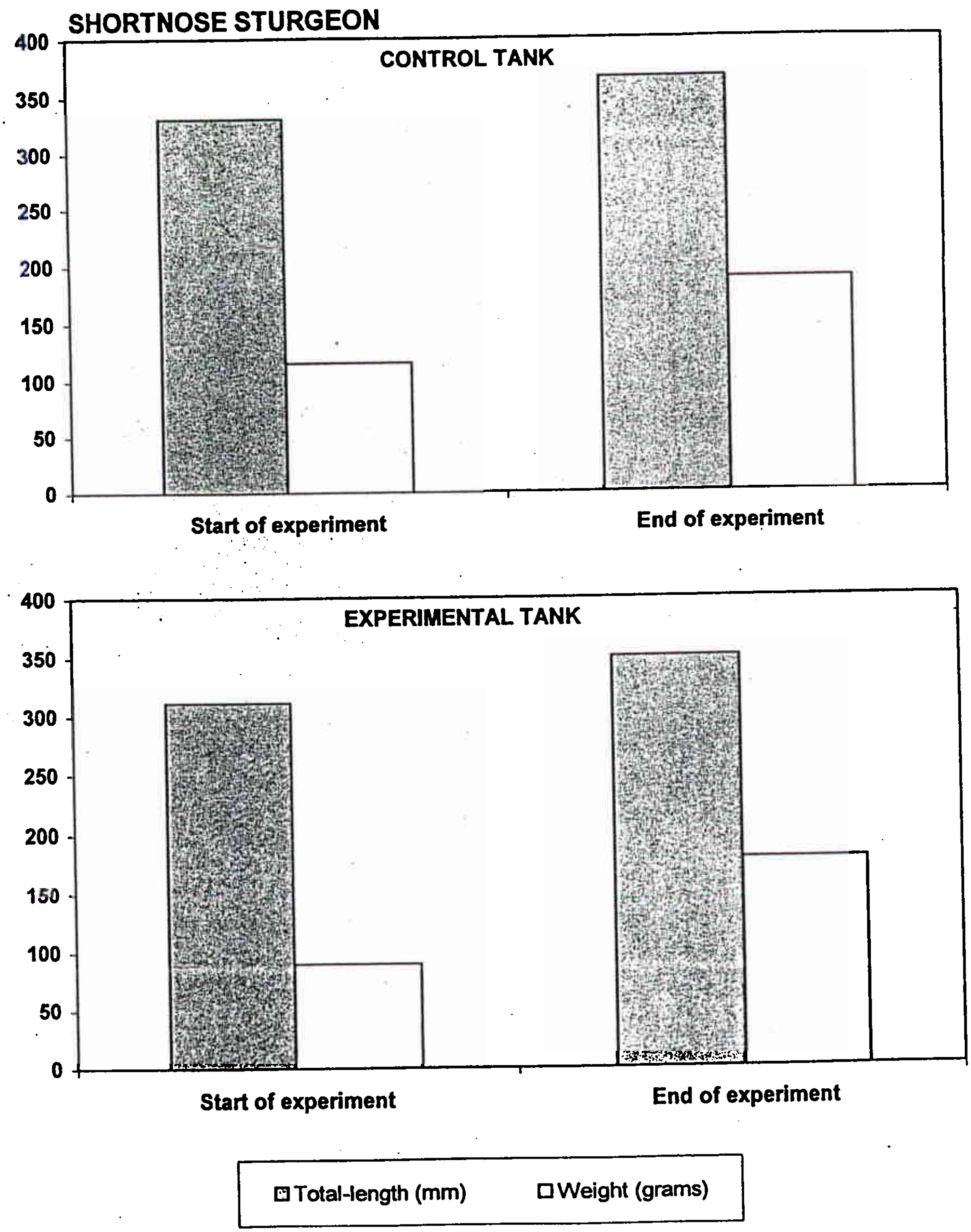


Figure 5. Mean total length (mm) and weight (g) of channel catfish sturgeon in control (upper panel) and electroshocking treatments (bottom panel) conducted over the 32 day period from 10/22/99 – 11/23/99.

CHANNEL CATFISH

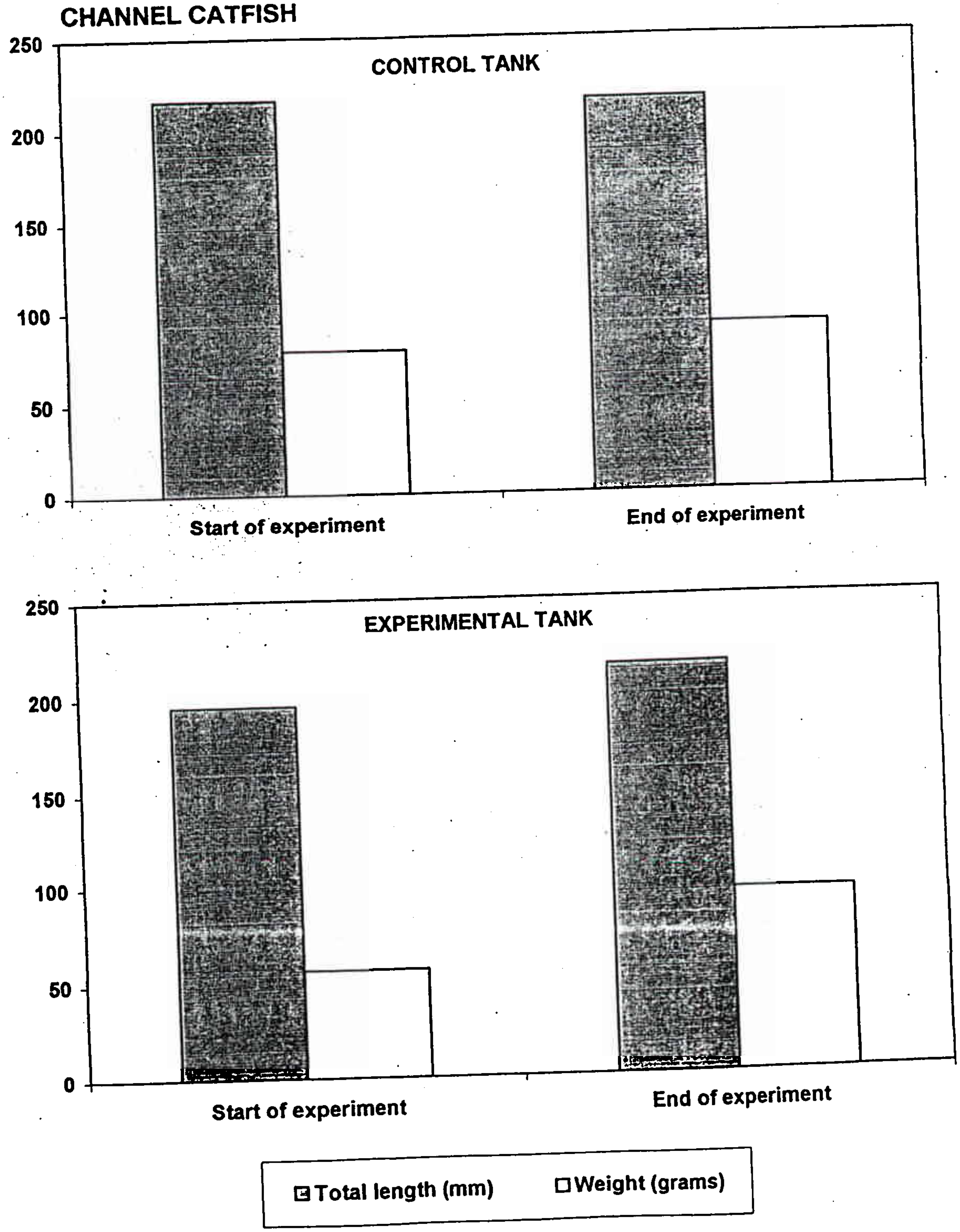


Figure 6. Total number of shortnose sturgeon (top panel) and channel catfish (bottom panel) that exhibited either a lateral roll (dark bars) or complete loss of equilibrium (open bars) during 28 observation periods of 60 seconds each.

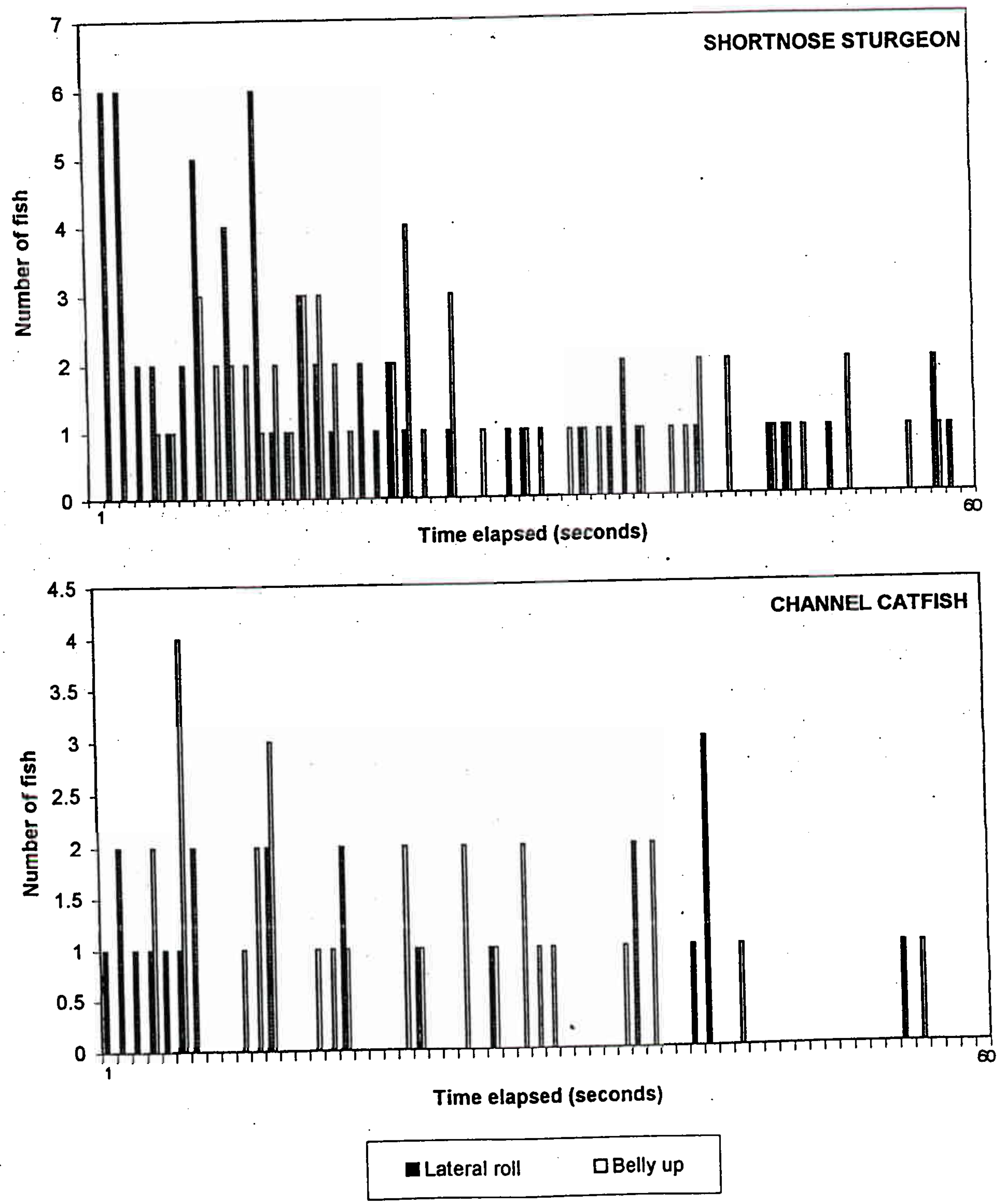


Table 1. Percent of all shortnose sturgeon and channel catfish that exhibited twitching, partial (roll) or complete (belly up) loss of equilibrium or avoidance in response to electroshocking during the first two week experiment (n=8 fish of each species observed during 48 electroshocking bouts).

	Twitch	Roll	Belly up	Avoidance
Sturgeon	12.5	16.1	17.1	10.0
Channel catfish	8.3	6.0	8.8	5.5

Catfish predation.

Salinity and temperature were the most variable water quality parameters during the catfish predation study (Figure 7). The temperature during experiment three was higher than in experiments one and two, although the temperature dropped below 10 ^{0}C only during experiment one. Salinity was generally lower during experiment three, and was elevated at the start of experiment two, peaking at 9.9 ‰ (Figure 7).

Size ranges of prey used in catfish predation studies differed among experiments due to availability of each size class (Table 2). Although sturgeon were longer than catfish in experiments 2-4, they were similar in weight and girth due to their long heterocercal tails. When striped bass were available, these were eaten first (Table 3). In experiment two, when striped bass were removed, channel catfish were missing from the tank. Flathead catfish did not eat any of the shortnose sturgeon in our experiments.

Figure 7. Water quality conditions during the four flathead catfish predation experiments: temperature °C (light line), salinity ppt (heavy line), and dissolved oxygen mg/L (dotted line).

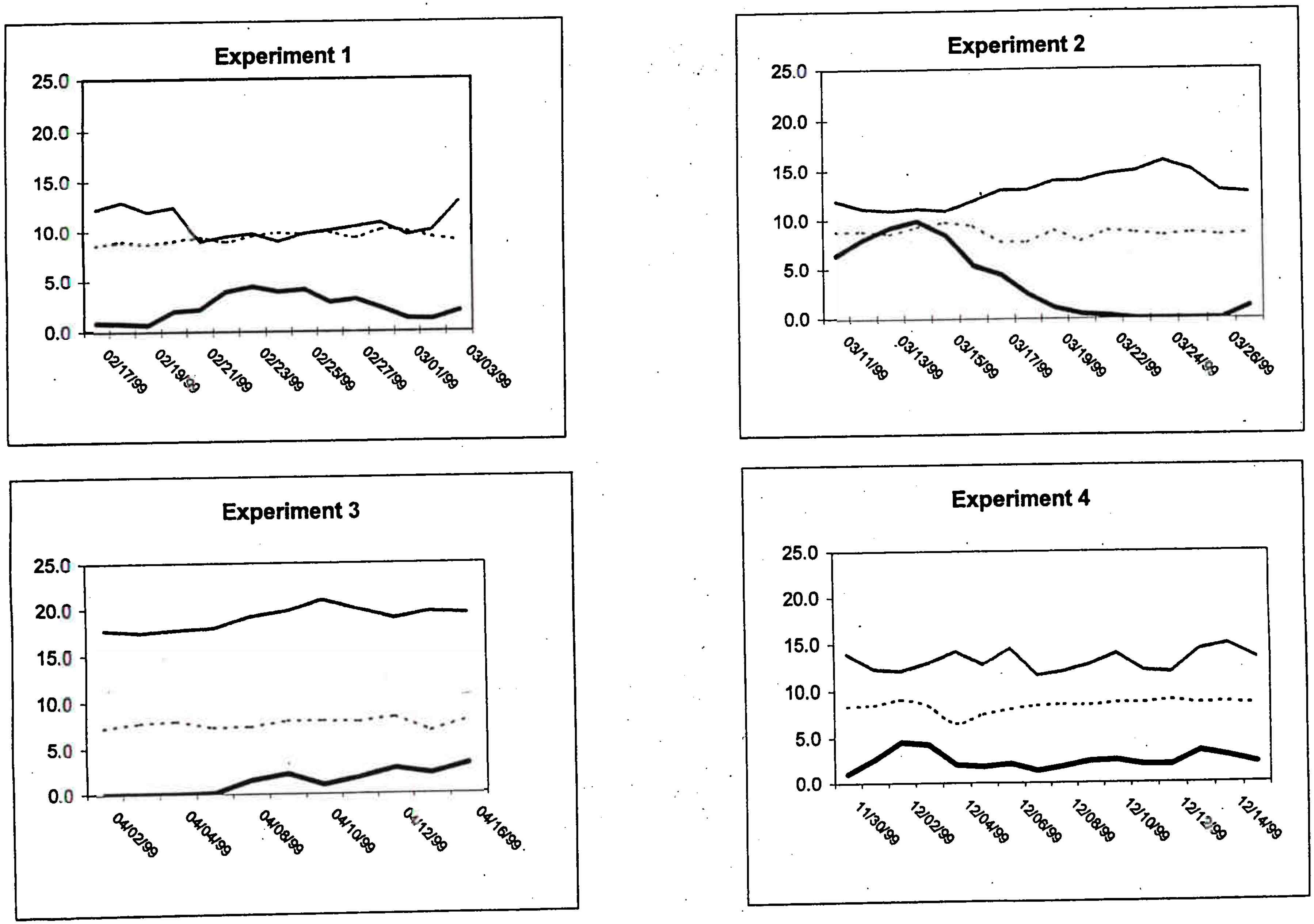


Table 2. Size ranges of fish used in flathead catfish predation study (total-length, mm).

	Striped bass	Channel catfish	Shortnose sturgeon	Flathead Catfish
Experiment 1	136-154	140-160	168-199	698
Experiment 2	-	98-124	172-199	640
Experiment 3	-	80-120	141-213	697
Experiment 4	-	181-258	298-355	695

- striped bass not used

Table 3. Number of each prey species consumed by flathead catfish in each experiment.

	Striped bass	Channel catfish	Shortnose sturgeon
Experiment 1	2	0	0
Experiment 2	-	3	0
Experiment 3	-	0	0
Experiment 4	-	0	0

DISCUSSION

Shortnose sturgeon are very sensitive to electrical currents produced by hand-held generators used for recreational electrofishing. We documented a variety of behaviors that sturgeon exhibited more frequently than did catfish (the species targeted by this gear) including: avoidance, twitching, rigor, and loss of equilibrium. However, the sturgeon recovered very rapidly during the one minute treatments they were exposed to in our experiments. The one minute treatments are conservative in that it is unlikely that the fish would be exposed to shocking of this duration during normal electrofishing. Moreover, it is unlikely that sturgeon would ever be subjected to four-five electroshocking events on a single day, even during periods of intensive fishing pressure. The fact that both experimental and control sturgeon exhibited similar positive growth rates indicates that sturgeon are able to recover from even excessive amounts of electroshocking of this type and are able to feed normally. However, subtle changes in feeding behavior would not have been detected in our tank experiments. Sturgeon were fed ad libitum and had to expend very little effort to feed; whereas in natural conditions a relatively short period of inactivity due to shocking could result in missed feeding opportunities. Moreover, behavior associated with courtship and spawning could easily be disrupted by electroshocking, as evidenced by the sensitivity of sturgeon to very low level electrical output.

We found no evidence that flathead catfish fed preferentially on shortnose sturgeon juveniles. The flathead catfish in our experiments seemed to feed most readily on striped bass, with channel catfish preferred over sturgeon when the bass were not available. A number of studies have documented predation of flathead catfish on other ictalurids, which has led to extirpation of native catfishes in rivers where flathead catfish have been introduced (reviewed in Moser and Roberts in press). While we found no evidence that flathead catfish fed as readily on sturgeon as on other catfish, we were also disappointed that so few prey were taken by the flathead catfish in our experiments. The flathead catfish were starved prior to experimentation and were allowed extended periods to recover from gillnetting and to acclimate to experimental tanks. One possible reason for the low feeding rates of our predators may have been the relatively low water temperatures during experimental periods. Yet, feeding was observed during the periods of lowest temperature, and no feeding occurred during experiment 3, which had the highest temperature (Figure 7). Future experiments could limit food choices to only sturgeon to determine whether flathead catfish will take them if nothing else is available. Moreover, the ability of flathead catfish to feed on sturgeon of a variety of sizes should be examined to insure that they are not able to target a size range of sturgeon juveniles that was not available in our experiments.

In summary, we found that the direct effects of electroshocking are more likely to negatively impact shortnose sturgeon than the indirect effect of removing potential flathead catfish predators. Unfortunately, due to unavoidable reductions in the number of fish available for the experiments and the time periods when they could be conducted (due to hurricanes), these experiments represent a pilot effort. Nevertheless, they clearly indicated that extensive periods of electroshocking could negatively effect shortnose sturgeon, particularly during critical, easily disrupted behaviors, such as courtship and spawning. Moreover, the energy expended to avoid shocking in summer could depress fitness of sturgeon already stressed by low oxygen and high temperature conditions. Further research to assess these issues should be conducted before restoration of shortnose sturgeon in the Cape Fear River drainage is considered.

ACKNOWLEDGEMENTS

We thank the U.S. Army Corps of Engineers for supplying the sturgeon and striped bass used in our experiments. The personnel of Warm Springs, Bears Bluff and Edenton fish hatcheries accommodated our needs for fish and Southeastern Pond Stocking and Aquatic Maintenance delivered them in fine condition. Special thanks to Cape Fear Community College for making space, and their expertise, available throughout the study. Without their help, this work would have ended with the deaths of fish at our primary fish holding facility. Michael Williams was instrumental in providing catfish for the predation study and the North Carolina National Estuarine Research Reserve kindly provided office support. This project was funded by a North Carolina Sea Grant, Fishery Resource Grant.

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I have permission from Mr. Ashley to give you a copy of his report and would appreciate it if you would put it in with my final report. I think the information Mr. Ashley has obtained is also beneficial.

Thank you,

Robin

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

Division of Boating and Inland Fisheries

Final Report

Determination of Current Food Habits of Flathead Catfish in the Cape Fear River

Project Type: Survey

Period Covered: April 1986 - December 1986

Keith V. Ashley

Bobby Buff

Raleigh, North Carolina

December 1986

Abstract: Current food habits of flathead catfish in the Cape Fear River were determined through analysis of 184 stomachs collected during the spring and summer of 1986. Fish were collected with a 5-bar, hand-cranked telephone generator (magneto). The objective was to determine if frequency of occurrence and percent by numbers of individual food items in the diet of flathead catfish changed significantly between 1979 and 1986. Current data indicates ictalurids, clupeids and centrarchids remain the primary food items in the diet of Cape Fear River flatheads; however, a shift from ictalurids to clupeids as the primary food item occurred between 1979 and 1986. Centrarchids occurred with equal frequency in flathead stomachs during 1979 and 1986 but were less numerous in the 1986 samples. There is no evidence to support anglers claims that flatheads may be responsible for the reputed decline in sunfish populations within the river. Decapods were more abundant in flathead stomachs in 1986 while frequency of occurrence remained unchanged. Pelecypods were less abundant in the 1986 samples but occurred with significantly higher frequency.

Flathead catfish (*Pylodictis olivaris*) are native to the New and French Broad Rivers of western North Carolina and were once common to the Nolichucky River. It is a solitary species preferring medium to large rivers with deep holes and abundant drift piles, sunken logs, log jams and standing timber (Minckley and Deacon 1959, Cross 1967, Morris et al. 1968, Pflieger 1975 and Glodek 1979). The Cape Fear River was stocked with flathead catfish in 1966 when 11 adults weighing 107.0 kg were released near Fayetteville, North Carolina by North Carolina Wildlife Resources

Commission personnel. This is the only known introduction of flathead catfish into the Cape Fear system. Guier and Nichols (1977) documented the establishment of a reproducing flathead population in 1976 with the collection of 5 specimens representing several age groups. Fourteen additional specimens, ranging in size from 10.0 g to 22.7 kg, were collected during 1977 providing further evidence of flathead reproduction within the Cape Fear River (Guier et al. 1980). Since its initial introduction the flathead population has expanded to inhabit 201 km of the mainstream Cape Fear and is considered the top level predator within the system (Guier et al. 1980).

The highly predatory feeding habits of flathead catfish were suspected of having adverse effects on the native fish species of the Cape Fear River. As early as 1970 NCWRC fisheries biologists received reports from local fishermen that native bullhead populations were declining. The fishermen attributed this decline to flathead predation. Apparently, rapid expansion of the flathead population during the mid 1970s resulted in a tremendous reduction in the bullhead population. This study was initiated in response to complaints from local fishermen concerning a perceived decline in sunfish populations within the river. The objective of this study was to determine if frequency of occurrence and percent by numbers of individual food items of flathead catfish in the Cape Fear River have changed significantly since 1979.

We wish to thank Mr. and Mrs. Earl Russell and Mr. James D. Davis for their assistance with data collection. This study was funded in part

through Dingell-Johnson Federal Aid in Fish Restoration, Project F-22, North Carolina.

METHODS

The Cape Fear River forms at the confluence of the Deep and Haw Rivers in piedmont North Carolina and flows southeasterly for approximately 274 km where it discharges into the Atlantic Ocean at Cape Fear near Southport (Louder 1963). Ninety percent of the drainage basin lies within the Coastal Plain and encompasses an area of approximately 1,916,600 ha (7,400 mi^2). Below river km 219 the river is regulated during low and moderate stages by 3 federal navigation locks and dams. The lunar tidal influence extends from the mouth of the river upstream to Lock and Dam #1, a distance of approximately 113 km.

Flathead catfish were collected from 1 April 1986 through 30 September 1986 from the mainstream Cape Fear River at Fayetteville, Tarheel/Elizabethtown, Elwell's Ferry and Riegelwood. All flathead catfish collected during this study were taken with a 5-bar, hand-cranked telephone generator as described by Morris and Novak (1968). Morris and Novak reported flathead catfish are particularly susceptible to capture using this device. The collecting operation was conducted using a shocking boat and a pickup or chase boat. Areas shocked included drift piles, log jams, sunken logs and standing timber located in the deeper pool areas along both banks.

Stomach contents were collected from all flathead catfish exceeding 1.0 kg in weight using the pulsed gastric lavage technique described by Foster (1977). Approximately 25.0 % of all fish were sacrificed to verify the effectiveness of the pulsed gastric lavage technique. All flatheads were weighed (kg) and measured (cm) prior to removal of the stomach contents. Individual food items were identified (if possible), sorted, counted and weighed.

Food habit data (frequency of occurrence, percent by numbers) collected during this study were statistically compared (α = 0.05) with food habit data collected by Guier et al. (1980) using the following statistical test for comparing the equality of 2 percentages (Sokal and Rohlf 1969):

$$t_s = \frac{\arcsin\sqrt{p_1} - \arcsin\sqrt{p_2}}{\sqrt{820.8\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where: p_1 = the proportion of food item 1 in the 1979 samples

p_2 = the proportion of food item 1 in the 1986 samples

n_1 = sample size for 1979

n_2 = sample size for 1986

820.8 = a constant representing the parametric variance of a distribution of arcsine transformations of proportions or percentages.

RESULTS

Examination of stomachs from sacrificed fish indicated pulsed gastric lavage removed approximately 100.0 % of all material present. Occasionally, a large particle would become lodged in the esophagus and require removal with forceps. It is an excellent technique for collecting stomach contents without injury to the fish.

Contents from 184 flathead catfish stomachs were examined and analyzed (Table 1). Fifty-five percent (102) of the stomachs were empty. Fish were the dominant food item in the diet of Cape Fear River flathead catfish during 1986 by frequency of occurrence, percent by numbers and percent by weight (Table 1). Fish accounted for 65.5 % by number and 97.0 % by weight of all food items consumed by flatheads during 1986. Unidentified fish remains occurred in 28.0 % of the stomachs.

Clupeids (12.1 % by number; 57.1 % by weight) were the most dominant food item group comprising the diet of Cape Fear River flathead catfish (Table 1). They occurred in approximately 18.0 % of the stomachs containing food (Table 2). White shad (*Alosa sapidissima*) accounted for approximately 51.0 % by weight of the diet during 1986; however, they occurred in stomachs collected during April and May suggesting their consumption may be related to seasonal influences (distribution and abundance). It is interesting to note the occurrence of white shad weighing 1.1 kg and 1.5 kg in the stomachs of flathead catfish weighing 6.5 kg and 17.2 kg, respectively. Gizzard shad (*Dorosoma cepedianum*) represented an additional 7.5 % by number and 6.4 % by weight of the diet.

Ictalurids, most notably white catfish (*Ictalurus catus*), blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*) and flathead catfish (*Pylodictis olivaris*), were the second most preferred forage items consumed by flatheads. They occurred in approximately 20.0 % of the stomachs containing food (Table 2). Two specimens of snail bullhead (*Ictalurus brunneus*), representing 1.2 % by number and 1.3 % by weight of the diet, accounted for the only other ictalurid comprising the food habits of Cape Fear River flatheads.

Centrarchids occurred in only 8.5 % of the stomachs containing food (Table 2) and accounted for only 4.6 % by number and 3.5 % by weight of the diet. Largemouth bass (*Micropterus salmoides*) were not found in any of the 82 stomachs containing food.

Cyprinids represented 16.1 % by number but less than 1.0 % by weight of the flathead diet during 1986. Longnose gar (*Lepisosteus osseus*) and yellow perch (*Perca flavescens*) accounted for an additional 4.6 % by number and 1.1 % by weight of all food items consumed (Table 1). The occurrence of 1 southern flounder (*Paralicthys lethostigma*), 2 spot (*Leiostomus xanthurus*) and 3 crabs (Brachyura) in stomachs of fish collected at the Riegelwood station is a reflection of saltwater intrusion resulting from the extensive and prolonged drought which occurred during the summer of 1986.

Decapods (crayfish) accounted for 11.5 % by number but only 1.2 % by weight of the flathead diet and occurred in 12.0 % of the stomachs containing food (Tables 1 and 2). Pelecypods (freshwater clams) represented an even higher percentage of the diet by percent number (18.4 %) but less than 1.0 % by weight and occurred relatively infrequently in the diet (8.5 % of the stomachs).

DISCUSSION

Food habit data collected by Guier et al. (1980) included data collected from flathead catfish taken near Lillington, NC; however, since there was no comparable station during this study the Lillington data was not included in the data analysis. In addition, individual weights for the food items examined and analyzed by Guier et al. (1980) could not be located making it impossible to compare the data from both studies on a percent by weight basis. Figures 1 and 2 compare the frequency of occurrence and percent total numbers, respectively, of individual food items comprising the diet of flathead catfish collected from the Cape Fear River during 1979 and 1986.

Flathead catfish exceeding 300 mm feed primarily on fish (Minckley and Deacon 1959, Turner and Summerfelt 1970, Pflieger 1975 and Borawa 1982). In an earlier study, in which they examined and analyzed the stomach contents of 105 Cape Fear River flathead catfish, Guier et al. (1980) reported they fed predominantly on ictalurids (39.0 %), clupeids (12.0 %) and centrarchids (10.0 %) during 1979 (Figure 1). Data collected during the present study indicates flatheads are still utilizing these forage items heavily; however, there was a significantly higher proportion, both in frequency of occurrence and percent by numbers, of clupeid food items in the 1986 samples. This coincides with a significant reduction, again, both in frequency of occurrence and percent by numbers, of ictalurid food items indicating a shift in food habits from ictalurids to clupeids between 1979 and 1986.

Shad availability is dependent upon the annual shad run up the river which normally occurs between March 15 and May 1 in any given year. Guier et al. (1980) conducted their sampling in May and June and August and September of 1979 while sampling was conducted from April through September during the present study. The shift in food habits from ictalurids to clupeids could be the result of the temporal difference in sampling schedules between the 2 studies. By beginning their sampling in May Guier et al. (1980) may have missed the majority of the shad run up the river in 1979 and therefore their food habit data would not adequately reflect the true percentage of shad (especially white shad) in the flathead diet for 1979. In addition, the shad forage base (especially white shad) available to flathead catfish in 1986 could have been much larger than that available in 1979 and could be another explanation for the shift in food habits. According to Mr. Earl Russell (personal communication), more white shad were observed coming back down the river in 1986 than in the past 5 to 6 years. Furthermore, the majority of adult white shad returning down river die and sink to the bottom becoming easy prey for flathead catfish.

Edmundson (1974) reported sunfish were the dominant forage consumed by flathead catfish in Bluestone Reservoir, West Virginia and they occurred in approximately 23.0 % of the flathead stomachs examined by Guier et al. (1980). However, there was no significant difference in the frequency of occurrence of centrarchid food items in the flathead diet between 1979 and 1986 (Figure 1). There was a significantly lower number of sunfish food items in the 1986 diet indicating sunfish were not as heavily foraged upon in 1986 (Figure 2). A decline in the available sunfish forage base between 1979 and 1986 could explain the lower number of sunfish in the 1986 diet; however, there is no data to support anglers' claims that flatheads are responsible for the reputed decline in sunfish populations within the Cape Fear River.

Ictalurids and cyprinids were the principal food items consumed by flathead catfish in a riverine system (Morris et al. 1968). There was a significantly higher proportion (both in frequency of occurrence and percent total numbers) of cyprinid food items in the 1986 diet; however, since they accounted for less than 1.0 % by weight of the food items consumed (Table 1), their occurrence would be considered insignificant.

According to Hackney (1965), flathead catfish selected centrarchids and ictalurids over cyprinids in experiments conducted in plastic-lined pools and earthen ponds. There was no significant difference in the proportion of unidentified fish remains comprising the diet between 1979 and 1986.

Previous studies (Norris et al. 1968, Edmundson 1974 and Pflieger 1975) have indicated crayfish can serve as a major food item in the diet of flathead catfish. The number of decapods consumed in 1986 was significantly higher than the number consumed during 1979 (Figure 2) but frequency of occurrence remained the same indicating more crayfish may have been available for consumption during 1986. Frequency of occurrence of pelecypods was significantly higher in the 1986 samples while the percent total numbers was significantly lower. This may indicate either preference for clams by flathead catfish increased during 1986 or that there may have been fewer clams available for consumption.

In summary, the diet of flathead catfish in the Cape Fear River between 1979 and 1986 remained fairly constant regarding the consumption of primary food items (ictaluirds, clupeids and centrarchids). A shift in food habits from catfish to shad as the primary food item occurred between 1979 and 1986 and was probably the result of temporal differences between sampling schedules between 1979 and 1986 or the result of a larger shad forage base in 1986 or both. Sunfish were consumed with equal frequency in 1979 and 1986 but occurred in fewer numbers in the 1986 samples indicating a possible decline in the sunfish forage base since 1979. There is no data to support anglers claims that flatheads are responsible for the reputed decline in sunfish populations within the Cape Fear River. Crayfish were more abundant in flathead stomachs during 1986 while frequency of occurrence remained unchanged. Finally, freshwater clams were less abundant in flathead stomachs in 1986 but occurred with significantly higher frequency.

RECOMMENDATIONS

1. Flathead catfish should not be stocked in any system dominated by ictalurids and clupeids unless it is to be used as a predator to control these species.
2. Food habits of flathead catfish in the Cape Fear River should be examined in the near future (within the next 5 - 10 years) to determine if dietary preference has changed or has stablilized.

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Table 1. Numbers, weights and percent composition of food items in stomachs of flathead catfish collected from the Cape Fear River, North Carolina during 1986. (n = 82)

Food Item	Number	Weight (g)	% No.	% Wt.
Crustecea				
Decapoda				
Astacidae	15.0	65.1	8.62	1.19
Palaemonidae	5.0	1.5	2.87	0.03
Pelecypoda	32.0	22.5	18.39	0.41
Gastropoda	1.0	4.0	0.57	0.07
Brachyura	3.0	66.0	1.72	1.21
Insecta				
Terrestrial insects	3.0	1.5	1.72	0.03
Tricoptera	1.0	1.0	0.57	0.02
Osteichthyes				
Seminonotiformes				
Lepisosteidae				
Lepisosteus osseus	7.0	38.0	4.02	0.70
Clupeiformes				
Clupeidae				
Alosa sapidissima	8.0	2,763.0	4.60	50.70
Dorosoma cepedianum	13.0	348.0	7.47	6.39
Cypriniformes				
Cyprinidae				
Notropis spp.	28.0	30.5	16.09	0.56
Siluriformes				
Ictaluridae				
Ictalurus brunneus	2.0	72.0	1.15	1.32
Ictalurus catus	5.0	13.0	2.87	0.24
Ictalurus furcatus	5.0	1,096.0	2.87	20.11
Ictalurus punctatus	5.0	368.0	2.87	6.75
Pylodictis olivaris	1.0	10.0	0.57	0.18
Perciformes				
Centrarchidae				

Table 1. Cont.

Food Item	Number	Weight (g)	% No.	% Wt.
Lepomis macrochirus	6.0	172.0	3.45	3.16
Lepomis microlophus	2.0	16.0	1.15	0.29
Percidae				
Perca flavescens	1.0	23.0	0.57	0.42
Sciaenidae				
Leiostomus xanthurus	2.0	93.0	1.15	1.71
Pleuronectiformes				
Bothidae				
Paralicthyes lethostigma	1.0	12.0	0.57	0.22
Unidentified fish remains	28.0	234.0	16.09	4.29
Totals	174.0	5,450.1	99.95	100.00

Table 2. Frequency of occurrence of food items in flathead catfish stomachs collected from the Cape Fear River, North Carolina during 1979 and 1986.

	Year			
	1979		1986	
Food Item	Number	Percent	Number	Percent
Clupeidae	11.0	16.7	15.0	18.0
Ictaluridae	22.0	33.4	16.0	20.0
Centrarchidae	15.0	22.7	7.0	8.5
Percidae	0.0	0.0	1.0	1.0
Cyprinidae	1.0	1.5	10.0	12.0
Lepisosteidae	1.0	1.5	4.0	5.0
Sciaenidae	0.0	0.0	2.0	2.0
Bothidae	0.0	0.0	1.0	1.0
Fish Remains	26.0	39.4	23.0	28.0
Decapoda	7.0	10.6	10.0	12.0
Pelecypoda	2.0	3.0	7.0	8.5
Gastropoda	2.0	3.0	1.0	1.0
Brachyura	0.0	0.0	3.0	4.0
Insecta	19.0	28.8	4.0	5.0
Totals	106.0		174.0	

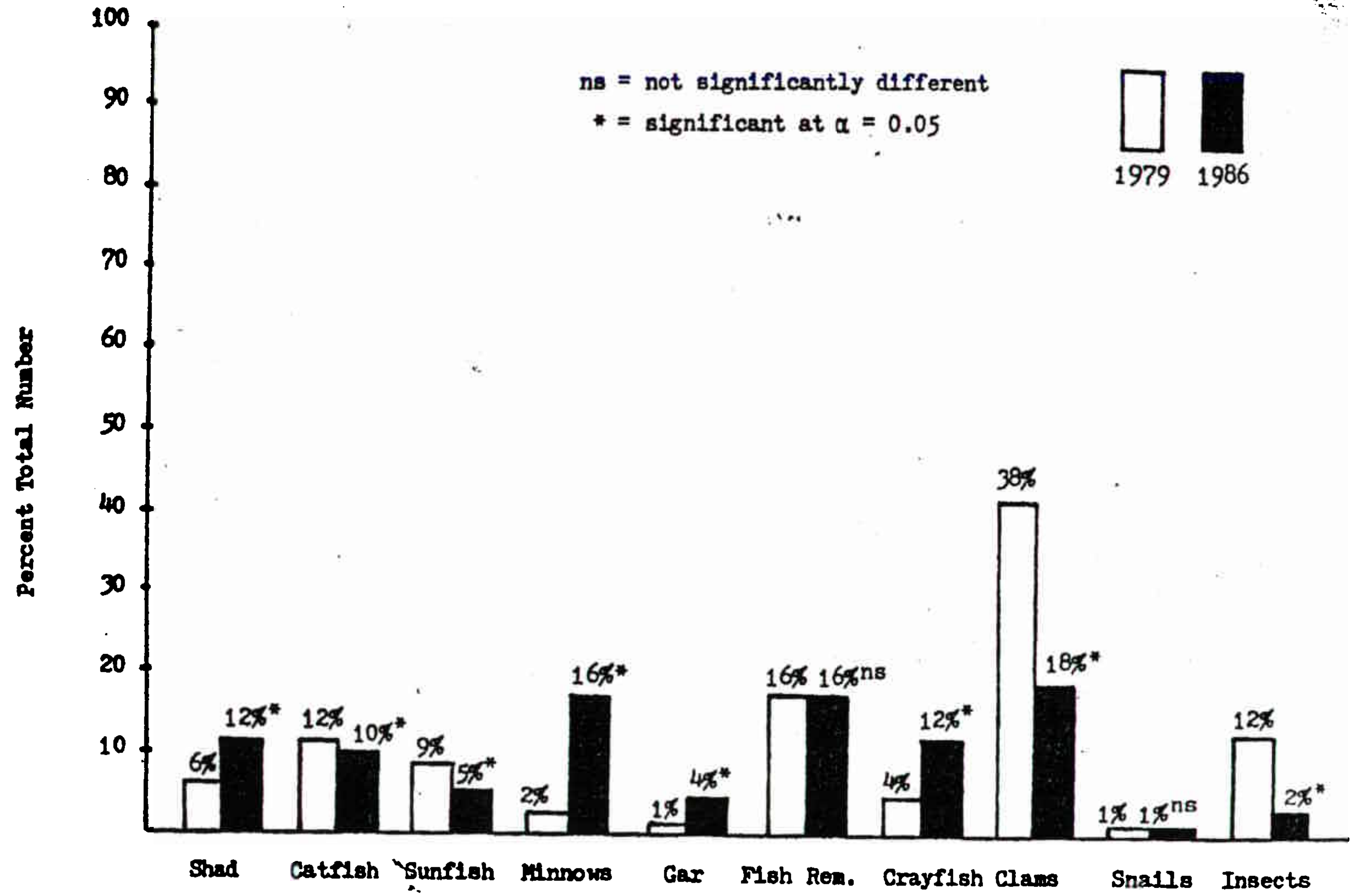

Figure 2. Percent total numbers of food items occurring in flathead catfish stomachs collected from the Cape Fear River, North Carolina during 1979 and 1986.

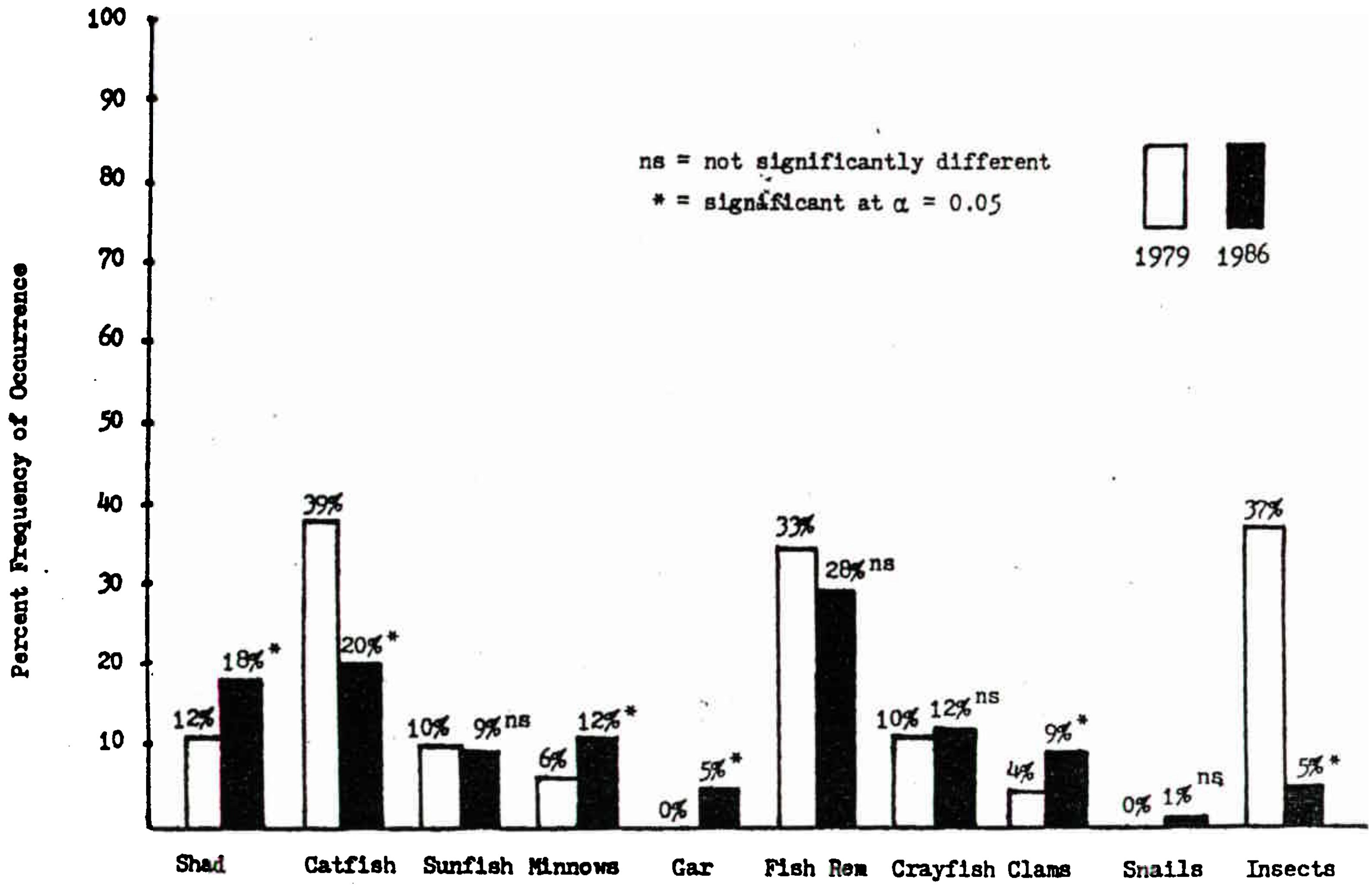

Figure 1. Percent frequency of occurrence of food items occurring in flathead catfish stomachs collected from the Cape Fear River, North Carolina during 1979 and 1986.