and counsel. L. E. Roberts, Assistant Chief for Research of the Oklahoma Department of Wildlife Conservation made available the data and financial assistance to the author. Mrs. Earl Jones was of invaluable assistance in computer programming and processing of these data. Dr. M. D. Grosslein advised the author on creel survey procedures. Dr. R. C. Summerfelt reviewed the manuscript.

A STUDY OF FISH MOVEMENTS FROM THE OKEFENOKEE SWAMP INTO THE SUWANNEE RIVER[1]

by

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ABSTRACT

The construction of a dike dividing the Okefenokee Swamp and the Suwannee River in 1960 and the phenomenal poundage of bowfin found in the river prompted an investigation to determine what fish were entering the river by passing over the dike from the swamp. Twenty thousand nine hundred and forty-six fish weighing 18,590.3 pounds were calculated to have moved over the spillway from February 20, 1969 to June 26, 1970. Bowfin comprised seventy-nine percent by weight of the fish and yellow bullhead were the most numerous species to come over. Ninety percent of the movement occurred at night. Movement was related to water temperature, depth of discharge, and spawning activity and is reported for each major species.

The study establishes that the swamp does influence the river fishery and that the high bowfin population was, in part, due to their spilling over the dike. Management implications are discussed.

INTRODUCTION

The Suwannee River at its headwaters drains the Okefenokee Swamp. In 1960, construction of a dike with two spillways was completed at the southwestern corner of the swamp. The design of the spillways created vertical barriers that limited fish movement from the river into the swamp, except during extreme high water flows. Fish movement from the swamp into the river was not restricted, except during severe droughts. Population studies on the Suwannee River fishery below the dike have consistently indicated that bowfin *(Amia calva)* made up 80 percent of the total weight of fish (Holder, 1970). Using the criteria established by Swingle (1950) on farm pond populations, these studies had F/C values ranging from .08 to .14 and at values ranging from 89 to 99 percent.

Since the bowfin population in the Suwannee River was considered somewhat phenomenal, it became desirable to know what fish movements occurred from the Okefenokee Swamp, and what effect they had on the river fishery. Detail studies in Ohio, Illinois, and Maryland have shown that significant fish losses occur over impoundments during certain environmental conditions (Clark, 1942; Lowder, 1958; Elser, 1960; and Lewis, Heidinger, and Konikoff, 1968). If significant movement occurred over the spillways, it might be bene-

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ficial or pose a potential limitation to management practices on the Suwannee. This paper describes a study on the movements of fish over the East Prong Spillway into the Suwannee River from February 20, 1969 to June 26, 1970.

DESCRIPTION OF STUDY AREA

The Okefenokee Swamp is a 412,000 acre peat filled depression located in Ware, Charlton, and Clinch counties of southeast Georgia and Baker county of Florida (Cypert, 1961). The swamp rests on a basin 110 to 130 feet above sea level and tilts toward the southwestern corner. It has a 1,100 square mile drainage area (U. S. Study Commission, 1963). This small drainage area makes the water level in it dependent upon local rainfall. Most of the drainage flows into the Suwannee River and the remaining small portion flows in the St. Mary's River.

Wright and Wright (1932), described the major habitat types in the Okefenokee Swamp as marsh or "prairies", wooded cypress swamps or "bays", watercourses, hammocks, barrens of pine and scrub, and marginal bogs. More recent description of the major habitat types are swamp forests and scrub, marshes or "prairies", open water areas, tree islands or hammocks, and upland areas (Cypert, Pers. Comm.). During wet seasons, most of the swamp may be covered with water, and during a severe drought, only the open water areas may contain water. Natural fires are common and the periodic burning of peat from these fires slows or rejuvenates the natural succession of vegetation within the swamp. The last major fire occurred in 1954 and 1955 and burned most of the area (Cypert, 1961). Over 371,000 acres of the Okefenokee Swamp is managed by the Bureau of Sports Fisheries and Wildlife as a National Wildlife Refuge (Calvert, Pers. Comm.).

In 1960, construction of a 4.73 mile dike (sill) was completed from Pocket Island to Pine Island in the southwestern corner of the swamp to prevent further erosion of the Suwannee River channel where it leaves the swamp and to retard the water flow out of the swamp during a severe drought. The dike impounds the East Prong and the North Prong of the Suwannee River, creating a body of water of approximately 5,000 acres (Figure 1). During high waterflows, this water will connect with other waters in the swamp, creating one large body of shallow water. The dike has two spillways that are located approximately one mile apart. One is 200 feet wide and receives most of the East Prong drainage. The other is 108 feet wide and drains the North Prong tributary. The North Prong and the East Prong merge approximately 150 yards below the East Prong Spillway to form the Suwannee River which flows for 33 miles in Georgia before entering Florida.

The water is dark colored from the dissolved humus as a result of the vegetation that flourishes in the watershed. The pH is around 4.5, and the specific conductance is around 41 microhms.

METHODS AND MATERIALS

Sill traps, constructed by sewing a three-quarter inch bar mesh nylon netting of 45 pound strength to a three-quarter inch galvanized pipe frame, were used for sampling fish movement over the spillway (Figures 2 and 3). Each frame, 40 inches high and 60 inches wide, was constructed to hold the trap in position. Two six inch extensions attached to the lower front corners of each frame anchored the lower part of the traps in place. The top of the traps was supported by a concrete bridge that ran across the spillway. Excess webbing was included to create a bag for confining the fish once they entered the trap.

Daily estimated number of fish to come over were derived by relating the number of fish caught in the sampled segment of the spillway to its entire width. The projected total number was determined from these average daily

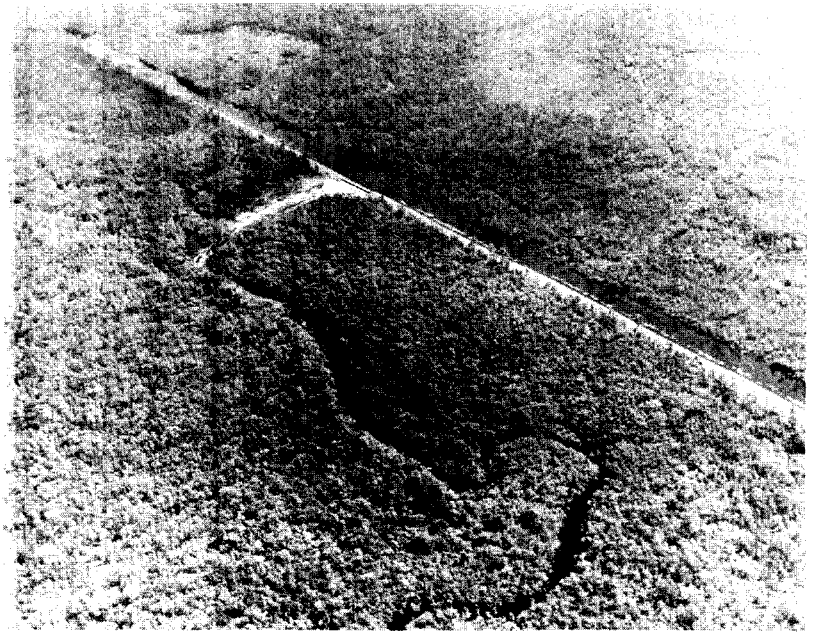

FIGURE 1. Aerial view of dike that divides Okefenokee Swamp and Suwannee River.

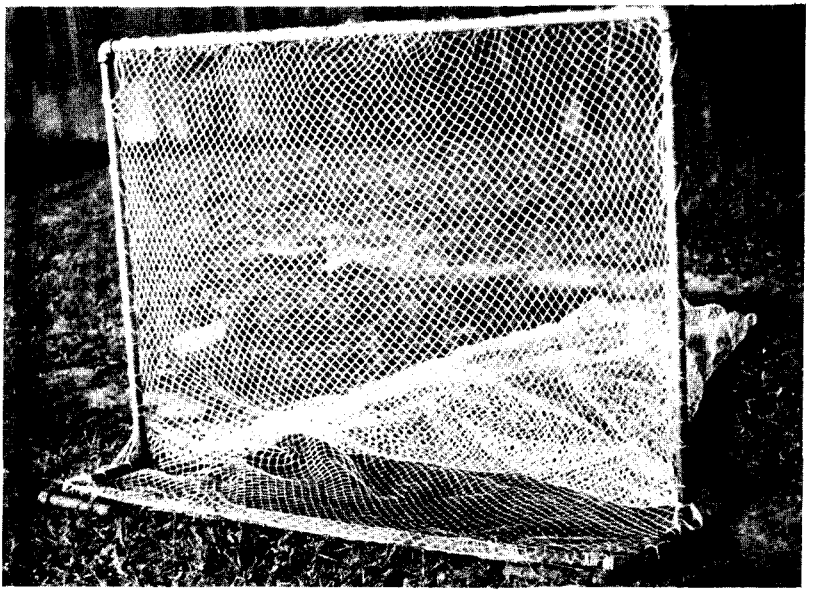

FIGURE 2. Design of Trap.

FIGURE 3. Setting of trap at East Prong Spillway.

estimates. The study was designed to sample 10 percent of the spillway width; however, due to breakage or loss of the traps as a result of excessive discharge of water and vegetation, the sample area was frequently five or seven and a half percent. The traps were randomly set at various locations on the spillway over a period of one to four days for each week of sampling. The one day intervals occurred once in May 1969 whenever the traps were damaged from excessive vegetation during removal, and once in April 1970 whenever water discharge of greater than 22 inches made sampling difficult. The traps were not used during one week in April and July 1969 and two weeks in May 1969 since fish had not been captured for several weeks prior to the period of sampling cessation. They were not set for one week in November because of difficulties in removing them during extreme high water flows.

Water temperature, depth of water discharge, sample area, and number of each species of fish caught were recorded for each day of sampling. Whenever specimens were suitable, length, weight, and sex were recorded. The sampling data recorded represented the day the traps were checked. Dissolved oxygen and pH of the water were determined periodically by a Hach Chemical kit. Dissolved oxygen ranged from 4.5 ppm to 8.5 ppm and pH ranged from 4.4 to 4.8.

Problems periodically encountered in sampling were breakage of frames from excessive quantities of bladderwort *(Ulricularia sp.)* and needlerush *(Eleocharis acicularis)* accumulating in the bag, wear of netting material,

and difficulty in removing the trap during high water flows. Deepening the bag from the original three to four feet to five and six feet alleviated most of these problems. The netting material worked extremely well, except for the problem of wear at the corners from rubbing action against the concrete pillars. The material was pliable, durable, and fitted over the frame easily. Its advantages for sampling far outweighed that of one-half inch wire mesh which was also tested.

The total catch in the traps was compared to population data collected from the Okefenokee Swamp during the summer of 1968 in two one-acre areas. Fish were collected by enclosing one acre areas with an 840 foot by one-half inch block off net and treating each with emulsifiable rotenone at a concentration of one and a half parts per million. The results of these are averaged together. Population data on the Suwannee River from 1966 to 1968 are included to illustrate the resident fish population in the river. More recent studies on the Suwannee are not included because of management practices which altered the structure of the river population.

RESULTS

Three hundred and sixty-nine fish were captured in the traps from 162 days of sampling (Table 1). Warmouth *(Chaenobryttus gulosus),* flier *(Centrarchus macropterus),* and chain pickerel *(Esox Niger)* were the most abundant game species. Bowfin *(Amia calva),* yellow bullhead *(Ictalurus natalis),* and lake chubsucker *(Erimyzon sucetta)* were the most abundant non-game species. The remaining species were captured less often and included largemouth bass *(Micropterus salmoides),* Florida gar *(Lepisosteus platyrhincus),* redfin pickerel *(Esox americanus americanus),* bluegill *(Lepomis macrochirus),* and spotted sunfish *(Lepomis punctatus).*

Bowfin averaged 477 millimeters in total length and 1,053 grams in weight and were the largest fish netted. Their sex ratio was four males to six females, and this species made up 79.0 percent of the total weight of fish captured.

More yellow bullheads were netted than any other species; however, they were smaller individually and comprised 8.7 percent of the total weight. Their average length was 161 millimeters, and their average weight was 68 grams. This species had a sex ratio of four males to six females.

Warmouth occurred in the nets less often. This species averaged 205 grams in weight and made up 6.5 percent of the total weight.

Flier averaged 143 millimeters in total length and 69 grams in weight and comprised only 1.4 percent by weight of the catch. Their sex ratio was equal.

Chain pickerel averaged 296 millimeters in total length and 167 grams in weight. This species made up 2.1 percent of the total weight. Their sex ratio was six males to four females. Pickerel that ranged from approximately 70 millimeters to 134 millimeters long were observed to come over the spillway during April 1969 but were not captured in the traps because they passed through the netting as a result of their small size.

Lake Chubsucker averaged 215 millimeters in total length and 169 grams in weight and made up 1.8 percent of the total weight. Their sex ratio is not available because of the low sample size and the decomposed state of several specimens. The remaining five species totaled 15 fish and made up 1.4 percent by weight of the catch.

The total number of fish to leave the swamp and enter the Suwannee River via the East Prong Spillway was calculated to be 20,946 fish that weighed 18,590.3 pounds (Table 2). These values do not include the number and weight of smaller sized fish that passed through the three-quarter inch bar mesh netting. The number of bowfin was determined to be 6361 fish that weighed 14,743.6 pounds. Yellow bullhead were determined to be 6990 fish. Their calculated weight was 1047.0 pounds. The projected number of warmouth to

move over the spillway was 3405 fish. Their calculated weight was 1537.5 pounds. Flier was calculated to be 1,337 fish that weighed 203.2 pounds. The number of chain pickerel was calculated to be 1,097 fish that weighed 403.5 pounds. Lake chubsucker was determined to be 823 fish that weighed 306.1 pounds. The remaining species were calculated to be 933 fish that weighed 339.1 pounds.

The weight percentages of fish population in the swamp were bowfin, 30.6 percent; lake chubsucker, 28.2 percent; warmouth, 15.7 percent; bluespot sunfish *(Enneacanthus gloriosus)*, 8.1 percent; banded sunfish *(Enneacanthus obesus)*, 7.0 percent; largemouth bass, 4.7 percent; chain pickerel, 1.4 percent; yellow bullhead, .5 percent; and remaining species, 1.1 percent (Table 3). For comparison, the percentages of the weight of the netted fish were bowfin, 79.0 percent; bullhead catfish, 7.8 percent; warmouth, 6.5 percent; chain pickerel, 2.1 percent; lake chubsucker, 1.8 percent; largemouth bass, .4 percent; Florida gar, .8 percent; bluegill, .1 percent; and other species, .1 percent. Bluespot and banded sunfish are small sized species and would not be represented in the catch. In addition to bowfin, yellow bullhead occurred in the net catches stronger than indicated by their abundance in the swamp population. The weight percentages of the resident fish population in the Suwannee from May 1966 to November 1968 were bowfin 81.64 percent; Florida gar, 6.13 percent; lake chubsucker, 2.84 percent; largemouth bass, 2.27 percent; chain pickerel, 1.23 percent; warmouth, 1.18 percent; spotted sucker *(Minytrema melanops)*, .52 percent; flier, .52 percent; bluegill, .43 percent; yellow bullhead, .33 percent; dollar sunfish *(Lepomis marginatus)*, .14 percent; and others, 2.77 percent (Table 4).

A comparison of fish caught during night to fish caught during daylight from twenty-one individual days of sampling that fish were captured showed that ninety percent of the catch occurred during the night (Table 5). The nocturnally oriented species consisted of yellow bullhead, warmouth, bowfin, and lake chubsucker. Chain pickerel and flier did not exhibit any preference between day and night movement. The number of other species caught was too low for comparison.

The total catch of fish for each month is compared to average water temperature and average depth of water discharge for each month during the 17 month sampling period (Table 6). Periods of increased movement occurred from February 1969 to May 1969 and from November 1969 through April 1970. The increased number of fish in the traps during March 1969 and April 1970 indicates pronounced fish movement as a result of the rapid increase in the depth of water discharge. Little or no fish movements over the spillway occurred from June 1969 to October 1969 and from May 1970 to June 1970. The average monthly water temperature during this period varied from 74° F to 86° F. The average depth of water discharge for this same period fluctuated from 4.3 inches to 11.3 inches. These periods of decreased movement corresponded to water temperature above 74° F. Less than one percent of the fish were captured at temperatures greater than 80° F.

The relationships of catch of each major species to season, water temperature, or depth of discharge is illustrated in Figures 4 to 9. A definite relationship exists between bowfin movement and low water temperatures (Figure 4). Movement began in November when water temperatures were falling fast and decreased when water temperatures were rising. Bowfin was the only species captured at water temperatures less than 52° F. The number caught in November is probably underestimated since night traps were not set from November 10-15, 1969 during the period of maximum water discharge. If bowfin movement was related to only high water discharge, it appears that the bowfin catch should have been the highest during April 1-10, 1970 when the depth of discharge was above 20 inches. Only one bowfin was captured during this high water period. Bowfin movement over the spillway coincides with the period of gonadal development and may be more the result of seasonal

change in their physiology than the effect of temperature. Obvious changes in the development of bowfin gonads in the Okefenokee Swamp occurs from October to period of spawning during April (Holder, 1970).

The relationships of movement to season and rising water temperature is best illustrated from catches of warmouth and flier (Figures 5 and 6).

Warmouth were consistently captured in March and April 1970 whenever the temperatures were fast rising. This species was also consistently caught during the spring of 1970 at similar water temperatures. The initial movement occurred just prior to the spawning period. Ripe warmouth were caught in the traps and were also creeled by fishermen just above and below the spillway in April 1969 and 1970. The warmouth movement began at 56°F and usually ceased at temperatures above 69°F. The number of warmouth to come over the spillway also appeared to be related to depth of water discharge as well as to the rapid temperature increase. The maximum warmouth movement occurred in March 1969 and in April 1970 whenever depth of water discharge had increased.

Flier movement in February and March 1969 strongly indicated a pattern with season and temperature. The specimens were first collected in the nets whenever the water temperature began fluctuating from 52°F to 57°F and many specimens were sexually ripe. This pattern was less obvious during the same period in 1970 when a lower number was captured in the traps; however, it still corresponded seasonally. If increased water flows were a primary influence on flier movement, the number captured in the spring of 1970 should have been stronger.

Chain pickerel appeared sporadically in the traps and their low catch indicates little movement over the spillway (Figure 7). At all times this species was collected during periods of increased water flows, indicating a relationship between their movement and increase in depth of discharge.

The yellow bullhead pattern was similar to pickerel in that they appeared to occur irregularly, except for a profound movement during a period of increased flows in April, 1970 (Figure 8). The catch of bullheads in March, April, and May 1970 may reflect a seasonal movement pattern related to rising water temperature associated with spring. Nets were not left overnight during week of maximum water discharge in November 1969. Since bullheads were nocturnally oriented in movement, it is possible that additional movement occurred that was not recorded for that week.

The presence of lake chubsuckers in the traps in April 1969, October and November 1969, and March and April 1970 (Figure 9) suggests that chubsuckers exhibit some movement during the period of rising or falling water temperatures; however, their abundance was low if related to their abundance in the swamp. The spring catches did correspond favorably to the period that lake chubsucker spawning occurs in the Suwannee River. No relationship with depth of water discharge was clear since the chubsuckers were captured at various depths of water discharge.

DISCUSSION

This study established that the Okefenokee Swamp contributes significant numbers and pounds of fish to the Suwanee River and that movement of several species to the river is influenced by several environmental conditions. The high catch of bowfin and warmouth agrees with the papers of Clark (1940), Lowder (1958), and Elser (1960) that the more dominant species in each impoundment tended to exhibit the greatest loss. However, as pointed out by Elser (1960), some species that were abundant in the lake did not show up in the catch proportionately at the spillway. This pattern was observed for the lake chubsucker and largemouth bass. The lake chubsucker was the second most abundant species, and the largemouth bass was the sixth most abundant

species in the population studies. Their catch in the nets was low in relation to their abundance in the swamp. The small movement of lake chubsucker may possibly be a reflection of their behavior pattern. The studies by Lowder (1958), Elser (1960), and Lewis, Heidinger, and Konikoff (1968) showed largemouth bass to be one of the principal species to exhibit loss over the spillway; however, Elser (1960) did note that this bass loss was inconsistent in the Maryland study. He postulated in his paper that the turbulence created at the lip of vertical spillways created a sound which discouraged certain fish from approaching the spillway. Since the spillway in this study is a vertical one of concrete pillars and wooden planks, the spillway design may be a probable factor for the low bass loss.

The studies made by Lowder (1958), Elser (1960), and Lewis, Heidinger and Koinikoff (1968) showed major losses of fish over impoundments to occur principally in the spring. The catches of warmouth, flier, yellow bullhead, and lake chubsucker correspond with this pattern. Lowder (1958) reported a definite increase in number to spill over with increase in depth of water discharge. Similar patterns were indicated at Wyle Lake, Maryland by Elser (1960) and at Chautaugua Lake, Illinois by Lewis, Heidinger and Konikoff (1968). The increased catch of yellow bullhead and warmouth during increased flows supports this relationship well.

Lewis, Heidinger and Konikoff (1968) suggested that the rapid decline of fish movements in Chautaugua Lake following a period of maximum occurrence was possibly from depletion of population in proximity of the spillway. The catch of chain pickerel and yellow bullhead in the net may indicate a similar pattern; however, the author is inclined to believe that the high catch of yellow bullhead in the nets was more from the high water conditions when the various areas in the swamp connect becoming one large body of water. This hypothesis is based on the low population of yellow bullhead in the swamp population studies in relation to their catch in the net.

For several species, there appeared to be a relationship between movement and temperature that may be more pronounced during specific seasons as a result of the condition of the species. Bowfin movement occurred during the winter at low water temperatures while gonadal development was progressing. Warmouth, lake chubsucker, and flier were caught in the spring during the period of sexual maturation and spawning and during rising water temperatures.

The one factor that appeared to be related inversely to the catch was high water temperature. This relationship was profound from May 1969 to October 1969 and from May 1970 until termination of sampling in June 1970. Of the 369 fish captured throughout the study, 14 (3.8 percent) were collected during this period. The negative relationship of fish movement to high temperatures is supported by the low catch of fish during September and October, 1969 whenever average depth of discharge had increased for two consecutive months. Four fish were captured during this period.

Night movement of black bullheads was reported by Lewis, Heidinger and Konikoff (1968). This study showed that most of the fish movement occurred during the night, especially that of yellow bullhead, bowfin, warmouth, and lake chubsucker.

A comparison of the swamp bowfin population to the catch of bowfin at the spillway indicates that bowfin made up the bulk of fish passing into the river and that the percent of weight was considerably higher than that in the swamp (Figure 10). The 79 percent by weight catch of bowfin in the traps agrees remarkably close to the river bowfin population. Consecutive years of high water with bowfin movement out of the swamp would lead to a high poundage of bowfin moving into the river. This phenomenal poundage is considered undesirable to the Suwannee River fishery and the spillway design appears to be a major contributing factor. The presence of warmouth, chain

pickerel, flier, and yellow bullhead could be considered desirable for the river since these species comprised a major portion of the Suwannee River creel.

The question in mind deals with the management implications of the spillway structure. While it may have a negative effect on the river fishery by the spilling over of bowfin, it may be beneficial or detrimental to the swamp fishery. For example, the barrier created by the dike may limit the number of bowfin returning to the swamp to spawn which over a period of time may lead to a lower population of bowfin. This assumption is supported by the high frequency of bowfin, collected at the spillways during March 11, 1970, that had upper lip abrasions as a result of attempted movement up the spillway, possibly to spawn. Out of a sample of forty-five bowfin, forty were in this condition. Recently hatched bowfin fry were collected from the Okefenokee Swamp this spring. If spawning occurred in the river, it was not observed. On the other hand, the fact that the dike exists as the dividing point between the Okefenokee Swamp and the Suwannee River does provide an upstream boundary for studying and managing the fishery of the Suwannee River. Without the dike the river would be more difficult to study and perhaps manage.

Assuming that the dike structure of the spillway is detrimental to the river or swamp fishery, several spillway modifications can be considered. One is construction of vertical prongs spaced a certain distance apart on the lip of the spillway. This selective barrier will permit thin bodied fish such as chain pickerel, flier, and warmouth to pass over the spillway. At the same time, it will restrict passage of the larger and thicker bodied bowfin. The second alternative is the construction of a sloping incline on at least a portion of the downstream side of the spillway. This will permit upstream movement into the swamp as well as the downstream movement. This application essentially means making possible natural changes to occur in either the swamp or river fishery. Another modification is simply a combination of alternatives one and two. This idea is intended to limit bowfin into the swamp and at the same time limit their passage at that size into the river without restricting the movement of other fish into and out of the swamp. One more approach that can be considered is the construction of an electric weir that can be operated during certain seasons and specific conditions. The weir would limit movement of certain species out of the swamp according to the periods and conditions that these species are known to exhibit definite movement patterns. If greatest movement of undesirable species occurs during the winter and at night, the weir can be activated during that period. Before such modifications on the spillway structure are proposed, further study on the long range effect of the dike to the swamp or river fishery will be necessary.

This study establishes a base for identifying partially the influence of the swamp on the Suwannee River fishery and conclusively shows that significant poundage of certain fish, primarily bowfin, move from the Okefenokee Swamp over the spillway into the Suwannee River during certain environmental conditions.

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TABLE 1

NUMBER, SEX RATIO, AVERAGE LENGTH, AVERAGE WEIGHT, TOTAL WEIGHT AND PERCENTAGE OF TOTAL BY WEIGHT OF EACH SPECIES CAUGHT AT EAST PRONG SPILLWAY FROM FEBRUARY 20, 1969 TO JUNE 26, 1970

Species	Number	Sex Ratio M to F	Average Length (mm)	Average Weight (gm)	Total Weight	Percent of Total Weight
Bowfin	101	4 : 6	477	1,053	106,353	79.0
Yellow Bullhead	155	4 : 6	161	68	10,540	7.8
Warmouth	43	7 : 3	197	205	8,815	6.5
Flier	27	5 : 5	143	69	1,863	1.4
Chain Pickerel	16	6 : 4	296	167	2,839	2.1
Lake Chubsucker	12	------[1]	215	169	2,366	1.8
Largemouth Bass	6	------[1]	180	87	522	.4
Florida Gar	3	------[1]	457	378	1,134	.8
Redfin Pickerel	2	------[1]	232	70	70	T
Bluegill	3	------[1]	108	24	72	.1
Spotted Sunfish	1	------[1]	168	123	123	.1
Total	369	------[1]	261	365	134,697	100.0

------[1] = Not included because of low sample size.

TABLE 2

THE ESTIMATED NUMBER AND WEIGHT OF FISH TO COME OVER THE EAST PRONG SPILLWAY INTO THE SUWANNEE RIVER FROM FEBRUARY 20, 1969 TO JUNE 26, 1970

Species	Number	Percent Number	Weight (lbs)	Percent Weight
Bowfin	6,361	30.4	14,753.6	79.4
Yellow Bullhead	6,990	33.4	1,047.0	5.6
Warmouth	3,405	16.2	1,537.5	8.3
Flier	1,337	6.4	203.2	1.1
Chain Pickerel	1,097	5.2	403.5	2.2
Lake Chubsucker	823	3.9	306.4	1.6
Other Species	933	4.5	339.1	1.8
Total	20,946	100.0	18,590.3	100.0

TABLE 3

MEAN NUMBER, WEIGHT, AND TOTAL WEIGHT PERCENTAGE OF VARIOUS SPECIES OF FISH COLLECTED AUGUST 11 AND 12, 1969 FROM TWO ROTENONE POPULATION STUDIES IN THE OKEFENOKEE SWAMP

Species	Number	Weight (lbs)	Percent of Total Weight
Bowfin	8	17.07	30.6
Lake Chubsucker	54	15.72	28.2
Warmouth	117	8.77	15.7
Bluespot Sunfish	1882	4.52	8.1
Banded Sunfish	2780	3.89	7.0
Largemouth Bass	6	2.60	4.7
Chain Pickerel	9	.80	1.4
Bluegill	1	.72	1.3
Flier	7	.43	.8
Florida Gar	1	.38	.7
Yellow Bullhead	4	.27	.5
Others	2241	.60	1.1
Total	7110	55.77	100.0

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TABLE 4

MEAN NUMBER, WEIGHT, AND TOTAL WEIGHT PERCENTAGE OF VARIOUS SPECIES OF FISH COLLECTED FROM FOUR ROTENONE STUDIES FROM MAY 1966 TO NOVEMBER 1968 IN SUWANNEE RIVER

Species	Number	Weight (lbs)	Percent of Total Weight
Bowfin	389	823.48	81.64
Florida Gar	80	61.78	6.13
Lake Chubsucker	42	28.64	2.84
Largemouth Bass	14	22.86	2.27
Chain Pickerel	26	12.42	1.23
Warmouth	298	11.92	1.18
Spotted Sucker	2	5.29	.52
Flier	53	5.30	.52
Bluegill	26	4.33	.43
Yellow Bullhead	16	3.31	.33
Dollar Sunfish	354	1.39	.14
Others	2144	27.91	2.77
Total	3444	1008.63	100.00

TABLE 5

COMPARISON OF FISH CAUGHT DURING NIGHT TO FISH CAUGHT DURING DAYLIGHT FROM TWENTY-ONE DAYS OF SPILLWAY SAMPLING THAT FISH WERE COLLECTED

Species	Number Day	Percent Day	Number Night	Percent Night
Yellow Bullhead	1	1.4	69	98.6
Bowfin	2	5.1	37	94.9
Warmouth	2	11.8	15	88.2
Lake Chubsucker	0	0.0	7	100.0
Chain Pickerel	3	42.9	4	57.1
Flier	3	60.0	2	40.0
Others	4	50.0	4	50.0
Total	15	9.9	136	90.1

TABLE 6

CATCH OF EACH SPECIES OF FISH, AVERAGE WATER DEPTH OF WATER DISCHARGE, AND AVERAGE WATER TEMPERATURE BY MONTH AT THE EAST PRONG SPILLWAY

	Feb 1969	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June 1970
Yellow Bullhead	0	6	0	3	1	1	0	0	1	0	0	0	0	6	136	1	0
Bowfin	3	9	0	1	0	0	0	0	0	8	16	35	26	2	1	0	0
Warmouth	0	7	2	2	0	0	0	0	0	1	0	0	2	7	22	0	0
Flier	11	8	0	1	0	0	0	0	1	0	0	0	1	1	2	2	0
Chain Pickerel	0	3	1	1	0	0	0	1	0	1	1	0	3	1	4	0	0
Lake Chubsucker	0	0	1	0	0	0	0	0	1	1	0	0	2	2	5	0	0
Largemouth Bass	0	0	5	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Bluegill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Florida Gar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Redfin Pickerel	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Spotted Sunfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Total	14	33	9	8	1	1	0	1	3	11	17	35	34	20	179	3	0
Average Depth Discharge (in.)	6.7	9.1	7.3	8.7	7.1	4.3	7.0	8.0	11.3	15.9	9.6	11.2	12.6	9.6	17.9	5.9	6.9
Average Water Temp. (F°)	54	57	73	78	83	86	83	80	74	60	52	47	52	61	69	77	82

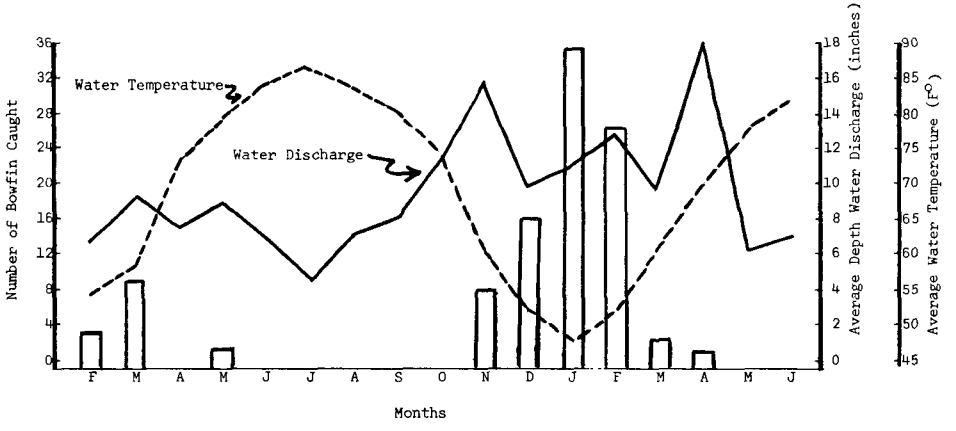

Figure 4 Comparison of Bowfin Catch to Average Monthly Depth of Water Discharge and Average Monthly Water Temperature from February 1969 to June 1970

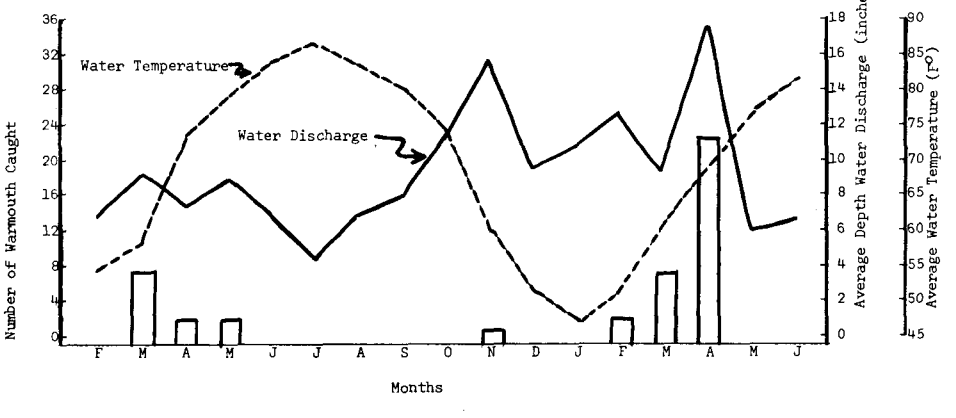

Figure 5 Comparison of Warmouth Catch to Average Monthly Depth of Water Discharge and Average Monthly Water Temperature from February 1969 to June 1970

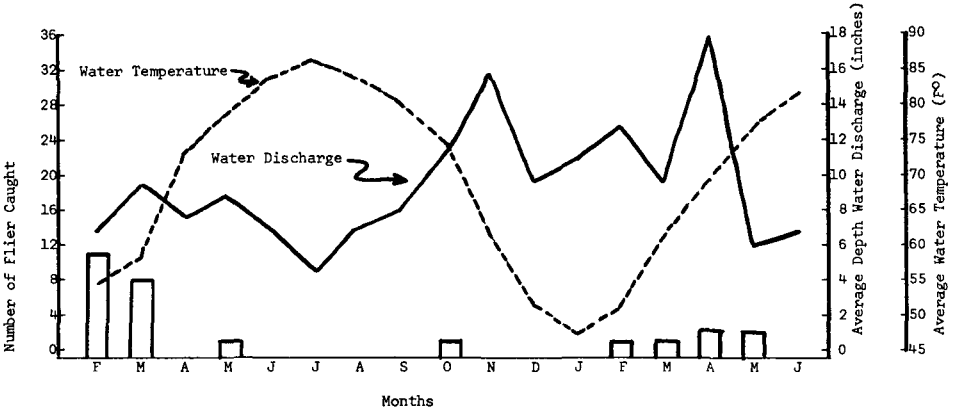

Figure 6 Comparison of Flier Catch to Average Monthly Depth of Water Discharge and Average Monthly Water Temperature from February 1969 to June 1970

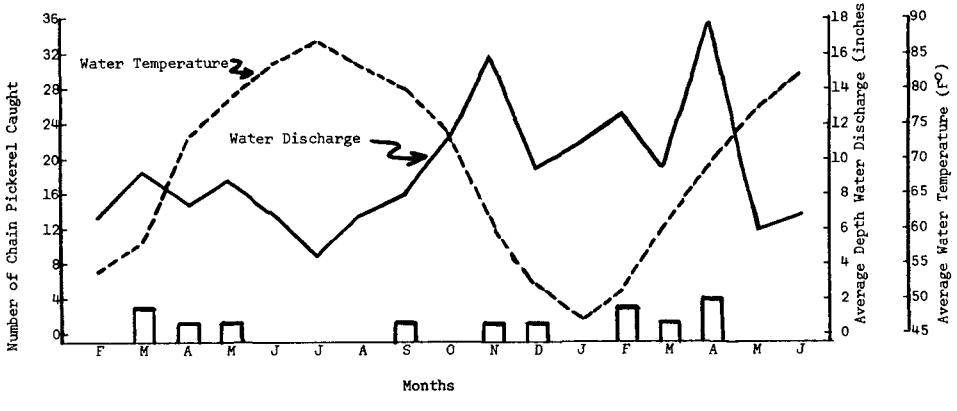

Figure 7 Comparison of Chain Pickerel Catch to Average Monthly Depth of Water Discharge and Average Monthly Water Temperature from February 1969 to June 1970

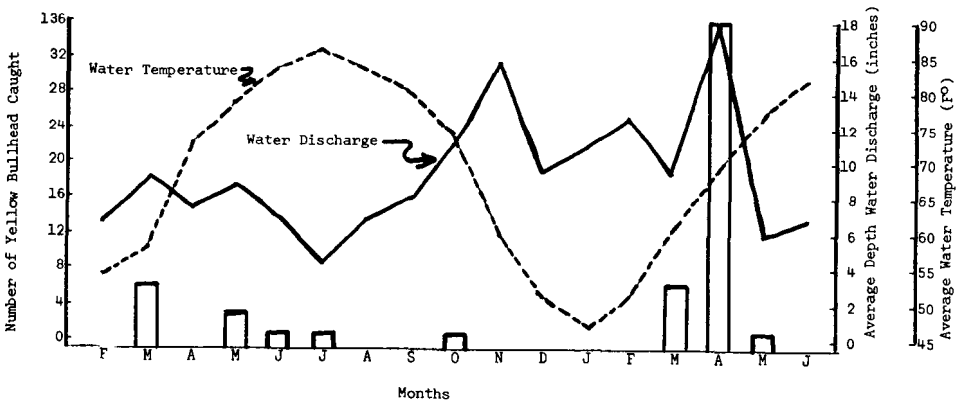

Figure 8 Comparison of Yellow Bullhead Catch to Average Monthly Depth of Water Discharge and Average Monthly Water Temperature from February 1969 to June 1970

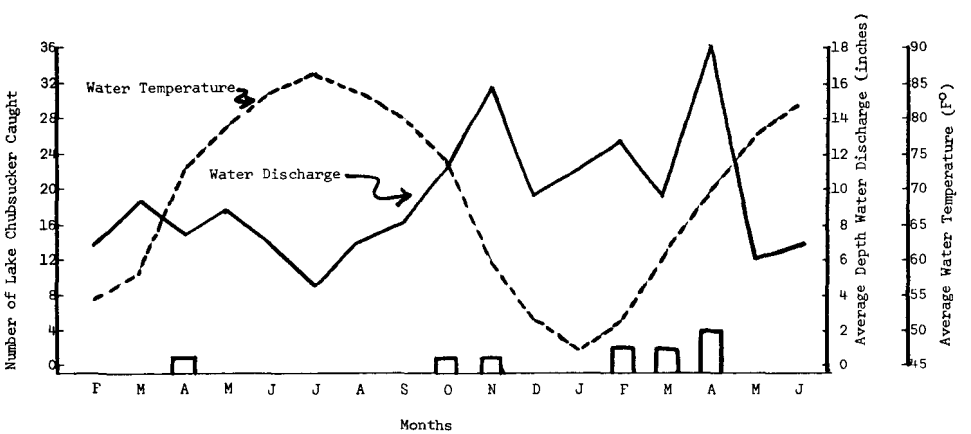

Figure 9 Comparison of Lake Chubsucker Catch to Average Monthly Depth of Water Discharge and Average Monthly Water Temperature from February 1969 to June 1970

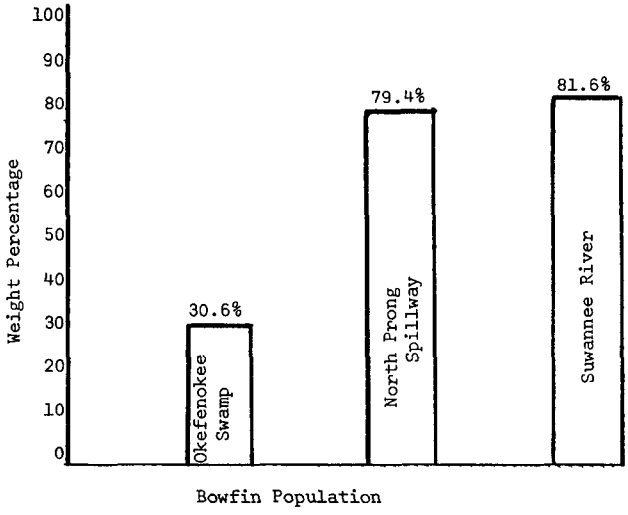

Figure 10 Comparison of Bowfin Weight Percentages of Fish Population in the Okefenokee Swamp, Over the East Prong Spillway, and in the Suwannee River

SEASONAL CYCLES OF NET PLANKTON IN A COLD-TAILWATER AND A NATURAL STREAM IN THE STATE OF ARKANSAS

by

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ABSTRACT

The information presented here is a phase of an overall investigation entitled "Environmental Changes Produced by Cold-water Outlets from Three Arkansas Reservoirs", supported by funds provided by the Office of Water Resources Research, and published in a bulletin by Hoffman and Kilambi (1970). The data herein presented compare the seasonal cycles of net plankton of a natural stream (Kings River) with a new tailwater (Beaver Reservoir, impounded in 1965). Quantitative net plankton abundance and physico-chemical conditions at each area were monitored bimonthly from September 1967, through October 1968.

Mid-winter blooms of Chrysophyta at the Beaver Dam stations were preceded by an increase in average monthly temperatures and followed by a decrease in silica concentrations. Downstream from Beaver Dam, late summer blooms of Cyanophyta were recorded. Most of these increases occurred in