# ABSTRACT

Edward F. Grune, Jr. Some effects of stream channelization on sunfish populations in Swift Creek, Pitt County, North Carolina. (Under the direction of Dr. Charles O'Rear) Department of Biology, East Carolina University. May 1977.

Fish populations from channelized and natural (old-channelized) portions of Swift Creek, Pitt Co., NC. were sampled using rotenone collection methods. Measurements were taken from the collected specimens to determine the growth rates of native fish species and an average size at each age. The sunfish (genus Lepomis) were the only group containing sufficient numbers of individuals collected in each section to permit a comparison. Analysis of the data showed that there were more fish of all ages, particularly older fish, in the natural section than in the channelized section. The sunfish in the natural section also generally grew faster, after a longer initial lag, than did the fish from the channelized section. Data is also presented which supports other studies concerning the effects of stream channelization on fish in the respect that game-fish species seem to be more seriously impacted by disturbances associated with channelization than are non-game fish species. It is also believed that the fish populations of the channelized section of Swift Creek are gradually returning to a "natural" state.

# SOME EFFECTS OF STREAM CHANNELIZATION ON SUNFISH POPULATIONS IN SWIFT CREEK, PITT COUNTY, NORTH CAROLINA

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by

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## INTRODUCTION

An analysis of a stream fishery resource must include first a consideration of the stream ecosystem. The trophic base of a stream has two components: food and organic material originating inside the stream (autochthanous), and; food entering the stream from upland sources in the form of organic matter or terrestrial animals (allochthanous). The stream ecosystem does not comply with concepts developed to explain material movement within a lentic system. In moving water products of metabolism are passed downstream -- recycling does not occur on one site at any time. The stream ecosystem utilizes allochthanous material rather than solar radiation as its major energy source (Hynes, 1969). Russell-Hunter (1970) compared the primary productivity of running water to that of an oligotrophic lake.

The allochthanous matter entering a stream is usually composed of leaf litter which decomposes rapidly into organic detritus. Detritus forms much of the food base of benthic systems (Hynes, 1963). Allochthanous material is known to be utilized for energy by stream organisms including phytoplankton, zooplankton, benthic invertebrates, and fishes (Nelson & Scott, 1962). Removal of the canopy and control of woody growth adjacent to a stream would greatly reduce the amount of allochthanous material that might enter a stream ecosystem and ultimately be used as a food source for the stream's fish.

The majority of natural streams in eastern North Carolina are best described as blackwater swamps. These natural streams have broad, wooded flood plains. The typical vegetation associated with such swamps are cypress, tupelo and water oak. These trees usually provide an extensive canopy cover over the stream. The stream also contains adequate cover for fish, in the form of snags, limbs, other debris, as well as aquatic vegetation. There is normally a series of deep pools and shallow areas, with an associated low flow regimen. These pools usually contain water in them even during drought conditions. Fish populations vary from stream to stream depending on actual conditions within the stream, but either the Chain pickerel (*Esox niger*) or the Largemouth Bass (*Micropterus salmoides*) or an association of the two often comprise the top carnivore position. The smaller centrarchid sunfish (*Lepomis* & *Pomoxis* Genera) comprise a major portion of the fish community, while various minnows, shiners, and darters make up the forage base. In the spring these streams are utilized as spawning grounds for numerous anadromous fish species.

Farmers in this area have cut over this flood plain land to obtain the good quality soils available there for agricultural purposes. Often they have gone to a point near the stream that is locally described as "too wet to plow, but too dry to fish." To protect this cropland from periodic floods the farmers in the local watershed districts, together with the U. S. Soil Conservation Service (SCS) have sponsored watershed improvement projects on these streams. Such projects range from clearing and snagging of obstructed streams to stream channelization. Stream channelization is the straightening and deepening of a natural stream channel to conform with hydrological conditions of increased flow capacity. In-stream and over-stream cover is removed by cutting back vegetation from the stream to distances up to 100 feet. There are few, if any, deep pools in a channelized stream, and during low-flow conditions the stream may meander inside its banks. Under high-flow conditions the unstable bottom is scoured, removing any rooted aquatic vegetation and associated fish food organisms, those fish unable to find cover usually move downstream.

In some small rechanneled streams that have a maximum flow velocity lower than that required to scour the bottom material, there is often the problem of aquatic vegetation clogging the stream. Swicegood and Kriz (1973) observed that reduction in water carrying capacity caused by unrestricted vegetation growth necessitated the reconstruction of some eastern North Carolina drainage channels every ten to fifteen years.

Nathaniel P. Reed, Assistant Secretary of the Interior for Fish and Wildlife (in Gillette, 1972a) maintains that improvement of stream channels has reduced local populations of fish, plant life, and ducks 80 to 99%, and contrary to the claims of the sponsors, the loss is often permanent. Reed goes on to state that if all 1119 watershed projects in planning at that time for the southeast alone were actually completed, then 25,000 to 60,000 acres of stream habitat would be adversely affected, and somewhere between 120,000 and 300,000 acres of forested wildlife habitat would be damaged or destroyed by these alterations (Gillette, 1972). Peters and Alvord (1964) found that standing crops of fishes were many times higher in natural streams. Martin (1962) reported collecting a crop of fish on the Tippah River in Mississippi prior to channelization of 887 fish per acre weighing 241 pounds. Four years after channelization another sample was taken consisting of 1,498 fish per acre weighing only five pounds. The data shows a 98% reduction in the weight of fish per acre coupled with a 60% increase in the number of fish alone might be misleading, until it is pointed out that 99% (1,486) of these fish were minnows, shiners, and darters which have a combined weight of 4.4 pounds. Emerson (1971) cited a study performed by the Missouri Department of Conservation which stated that the yield of fish in unchanneled portions was approximately 256 Kg/acre, but fish yields in the channelized parts amounted to only 51 Kg/acre. Hansen and Muncy (1971) found that stream channelization seemed to affect the number of large catfish the area would support. There were many small catfish in the channelized area as in the unchannelized areas, but the number of large catfish was greatly reduced in the channelized area. They theorized that this effect may be in part due to the canopy of trees that covered the unchannelized area resulting in lower water temperatures and smaller temperature fluctuations.

Physiological studies have also been performed on fish using stresses similar to those involved in channelization. Heimstra et al. (1971) showed that increased turbidity reduced the activity of Largemouth Bass and sunfish, making them less able to locate food and more susceptible to predation. They also noted that metabolic energy is required in the coughing response to clear clogged gills of silt. Bradley (1972), summarizing other works before a Congressional committee studying channelization, stated that all credible evidence suggests that downstream fish habitat is adversely affected resulting in clogging of gills, increased intake of sediment-fixed pesticides, destruction of spawning grounds, and depletion of oxygen content. All conditions in question may be caused by a substantial increase in sedimentation caused by channel improvement.

Morris et al. (1968) indicated that there was a drastic reduction in the standing crop of drift organisms in his channelized stream. He believed that the decrease was due to a lack of suitable substrate for attachment. Chapin's (1975) study of an adjacent Swift Creek watershed sub-basin found a greater biomass of macroinvertebrates in an untouched swamp than in a channeled system regardless of time passage since channelization. This study also found a large biomass per unit area in the newly channeled stream, but this population was less diverse, and less stable under high flow regimes, when compared to the old channeled system.

Gillette (1972b) reporting on a study done on Crow Creek, Kentucky by the Philadelphia Academy of Natural Sciences indicated that they found an "ecological disaster." A long search could find no rooted plants in the streambed, and no established populations of fish or other animals. A few "aquatic creatures and some rotting insect pupae were found in the wet clay banks, now wider and deeper than before... blackflies (Simulium sp.) were now the dominant organism, and even they apparently drifted from untouched areas upstream." Buntz (1969) in his study of the Kissimmee River, Florida, reported that 99% of the productive area was destroyed by channelization, with a subsequent reduction in the size and variety of aquatic life. All benthic flora and fauna was concentrated on a narrow shelf along the margin of the river. The dominant organisms reported are Corbicula and Pomacea snails, unionids, waterbugs, Gambusia and blue-green algae (Phil. Acad. Nat. Sci., 1973).

According to Gillette (1972a), Soil Conservation Service officials are inclined to regard these accusations as 'nonsense', however, the Department of Agriculture has no clear idea of the collective impact of 20 years of remaking stream channels. The SCS seems to think that streams recover quickly, an opinion apparently drawn from the fact that the brush tends to grow back quickly along banks skinned bare of vegetation. The SCS claims in one of its information pamphlets that a rechanneled stream four years after improvement is again "beautiful and tranquil...with vegetated banks to provide food and shelter for wildlife." (SCS, 1970). Watershed work plans published by the SCS and the local sponsoring agency require that the stream improvement project be maintained by routine measures to prevent the stream from reverting to natural conditions. Some of these operations do not lend themselves well to providing a "beautiful and tranquil" stream with vegetated banks. Maintenance operations considered by the SCS include: removal of debris from channels following storms; control of woody growth in an adjacent to channels; control of aquatic plants in channel bottoms; removal of sediment from channels; replacement or repairing pipes and bridges; fertilization and mowing of vegetation on spoil and; removal of debris from drainage pipes through spoil. In addition, the work plan agreement calls for inspection of the project to assure proper maintenance.

Tarplee et al. (1971) conclude that fish populations, as represented by species diversity, in a channeled stream may recover to natural levels in approximately 15 years, provided that no further alteration of the stream bed, bank, forest canopy, or aquatic vegetation occurs. Bayless and Smith (1964) place this figure closer to 40 years provided that there is no subsequent disturbance to the stream following channel construction. Tarplee et al. (1971) noted that there was a 78.8% reduction in the food macrobenthic population in channeled streams, and also concluded that game fish are more adversely affected than are non-game fish. Bayless and Smith (1964) concluded that numbers of game fish per acre decreased drastically in channelized waters.

# OBJECTIVES

Since previously cited references indicate reduced population numbers and reduced fish size, the objective of this study then, is to quantify the difference in growth characteristics of fish from channelized streams when compared to the same species from a natural stream.

The centrarchids were selected as the primary fish group to be examined in this study for several reasons. First, they are secondary consumers, toward the top of the food chain. Second, they are resident species, non-migratory, and not affected by any environment other than the one being studied (Hasler & Wisby, 1958; Gerking, 1953). Third, they are abundant in eastern North Carolina, accounting for more than 66% of the total freshwater sports-fish catch (Fish, 1967). Finally, there is an abundance of literature available on their growth in comparable systems (Carlander, 1953). Growth rates of other fish were also observed, although not specifically examined. These fish were included primarily because of their presence in the samples. They included the pickerels (Chain & Redfin), various suckers, minnows, and darters, the former two being important predators, and the latter three included because of their importance as a forage base.

A study of growth gives the systems ecologist many opportunities to inquire into the dynamic balance and state of change in aquatic ecosystems (Weatherly, 1972).

With the exception of human involvement especially acute or chronic toxicity, any significant change in the population composition of fishes is likely to have its origin in the biologic system which produces and supports that population (Burgess, 1965). In fish, growth is very labile, influenced by food, space and a wide range of other factors. Fish affect the trophic status of other organisms in their environment, and alter the condition of the water in various ways.

In an unpolluted or stable aquatic environment sufficient food is generally available for fishes, and they grow at an average or normal rate for that given species. Much literature is available on these normal growth rates (Carlander, 1953). Pollution, and other environmental disturbances should, therefore, be reflected in changing growth rates (Gunning & LaNasa, 1973). Fish may be small either in an overfished system where the young fish never have a chance to grow or in an overcrowded where they are stunted. A check of ages can quickly reveal the difference, and the extent of that difference (Carlander, 1953).

One way of determining fish age is by the arrangement of more or less circular ridges or circuli on the upper surface of the scale (Carlander, 1953). These are usually, but not always, concentric around a central spot or focus (Tesch, 1971). Several of these circuli are formed each year. The circuli formed when the fish is growing more slowly are closer together than the circuli formed when the fish (and the scale) grow more rapidly. Since in the temperate zone the winter is the only period of the year when the fish stop growing, or grow very slowly, the age of the fish can be determined by counting the number of breaks in the growth (annuli) (Carlander, 1953). Since this break in growth occurs in winter Hile (1950) proposed that January 1 be considered the birthday of all fish in the northern hemisphere, and July 1 be the birthday of all fish in the southern hemisphere.

Since the "normal" growth rate of fish depends directly on the availability and utilization of food material (Gerking, 1954), and to a lesser extent on other variables such as temperature, those fish which inhabit a channelized stream, with its lower food concentration should show a significant reduction in the growth rate when compared to those from a natural stream.

## STUDY AREA

Swift Creek (Figure 1) is located in southern Pitt and northern Craven Counties, North Carolina. The creek rises south of Greenville, and flows southeasterly approximately 53 km. to its junction with the Neuse River near Vanceboro. The watershed consists of 446,100 hectares of which 17,398 ha. are in cropland; 22,829 ha. are in woodland; 1,473 ha. are in pastureland; 2,909 ha. are in miscellaneous uses (SCS, 1968). The towns of Winterville and Ayden are in the last land-use category. The land elevations range from 70 ft. msl. at the headwaters near Greenville, to 12 ft. msl. at the outlet, Atkinson's Fish Hole. The topography is nearly flat to gently rolling, with a fairly well-defined flood plain along the main stream and large tributaries. Practically all of the flood plain is swampy and wooded (SCS, 1968).

The stream was channelized in the thirties by the WPA, and follows a nearly straight course with few meanders. The original course of the stream is almost indistinguishable due to the intensive agricultural practices in the area. The old channelized area shows dredge spoil piles on either side of the creek. These spoil piles are overgrown with vegetation.

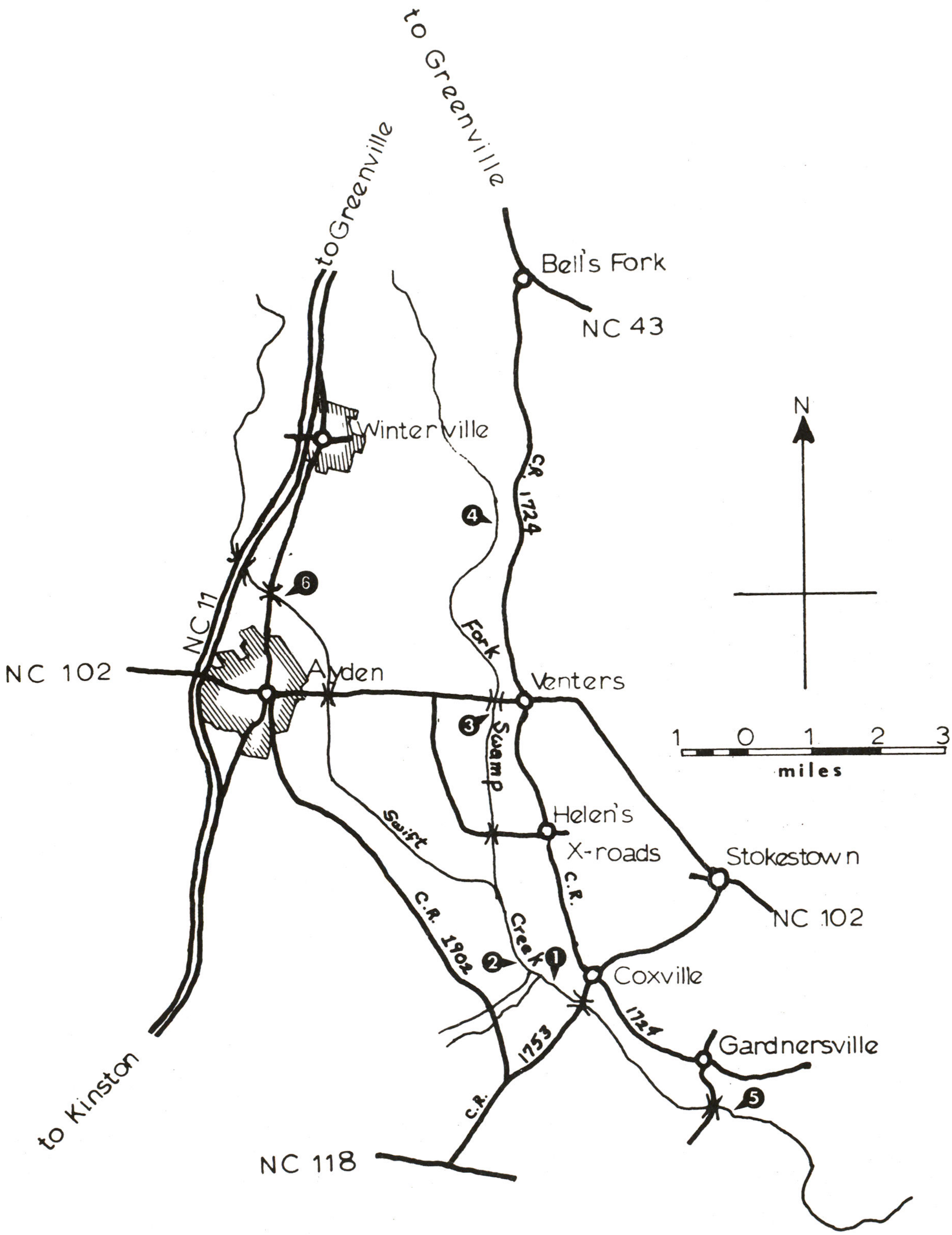



Figure 1.) Study area on western Swift Creek Watershed. Sample collections shown in circles.

The canopy has grown back over the stream. Stumps, logs, and snags are in the stream providing cover for fish. The bottom is sandy, sand and muck, or silt and muck with many deep holes in the stream.

Part of Swift Creek was again channelized in 1964-1965 by the U. S. Army Corps of Engineers. This section extends from Vanceboro upstream to the Gum Swamp lateral, approximately 1 km. upstream from the bridge at county road 1753. The banks and spoil are vegetated with some woody growth, but these trees are not large enough to provide a canopy. Trees on the southwest bank do shade the near shore during the afternoon. The smooth bottom is shifting sand, with a few shallow holes. There are scattered beds of macrophytes, primarily pondweed, Potomageton sp. and smartweed, Polygonium sp. along the edge at depth of not more than 0.5 meter.

An estimate by the USGS of the 10 year - 7 day low flow in the study area is 0.001 $m^3$ $sec^{-1}$. During the course of this study flow volumes as great as 18.8 $m^3$ $sec^{-1}$ have been recorded. Data collected over a period greater than a year shows that under high-flow conditions there are similar temperatures in both the natural and channelized segments, while under low-flow the channelized segment showed a higher temperature than did the natural segment. The lack of canopy over the stream with increased insolation to the stream probably accounts for the temperature differences. Dissolved oxygen concentrations in the two stream segments also appear to be related to flow. During high-flow periods turbulence serves to keep dissolved oxygen concentrations similar between stream segments. However, during low flow periods there is a significant difference between natural and channelized segments. In the channelized segments, the percent saturation was between 50 and 85%. The shallow water with an extensive diatom coating on the bottom in the channelized sector probably accounts for the high D.O. there, while the larger amount of pool area and lower velocity in the natural segment provide less physical aeration of the water mass in the natural segment.

## METHODS

The key to the assessment of a fish stock in any aquatic system is knowledge of the specific taxonomy, number of individuals, sex, year class, and rates of growth (Lagler, 1971). Total poisoning of a stream has been shown to provide better knowledge of all these parameters, and has no residual effect on the system when properly detoxified (Lawrence, 1956).

Fish used in this study were obtained in conjunction with a stream survey by the district fishery biologist. The fish were killed using synergized rotenone (tradename PRO-NOX-FISH,® S.B. Penick & Co.) in a concentration of about 1 pint per 200 linear feet of stream. The rotenone was detoxified at the lower end of the study area with potassium permanganate (Price and Calsetta, 1956). Block-nets were used on both the upstream and the downstream ends of the study section to delineate the area and to prevent additional fish from travelling into the study area.

Standard length in centimeters, weight in grams, and a scale sample were taken from each fish collected. Scales were taken from the left side in an area even with the anterior margin of the dorsal fin, dorsal to the lateral line. The scales were then placed in a folded piece of glassine weighing paper, coded to the individual, and returned to the laboratory for age determination.

In the laboratory the scales were soaked in 5% potassium hydroxide to soften and to aid in cleaning them (Tesch, 1971). The scales were then brushed with the blunt end of a toothpick to remove any residual dirt. Using a binocular microscope, several scales were selected for mounting, avoiding obvious regenerated or poor quality scales (Drummond, 1966). A temporary mount was made by placing the scales between two cover slips. The slides were then examined for age group, using a XEROX model 1013 microfiche viewer (Wright and Kolb 1970). One problem was incurred, in the use of slides. The short focal length of the viewer precluded the use of regular microscope slides in favor of cover slips. With several modifications, the viewer would be able to take slides or glass plates.

Occasionally problems are encountered while aging fish. False annuli and regenerated scales are the most common. A false annulus occurs when the growth of a fish is stopped for some period in addition to the usual winter break. Often these false annuli may be distinguished from true annuli by their appearance or position, but at times there is no way of knowing whether a break on the scale is a true or false annulus. The result is that it may be impossible to accurately age the fish (Carlander, 1953). A study by Prather (1966) in Alabama showed that between 75 and 85% of fish of known stocking history were aged correctly.

Most scales grow with the fish throughout life, but occasionally scales are lost and are replaced by new scales. These scales are known as regenerated, and can be distinguished by a pebbly area near the center of the scale. These scales were made by laying down scale material in a haphazard manner until the new scale is approximately the same size as the surrounding scales. Regenerated scales are not used in age determination since they tell nothing of the age and growth prior to the time the scale was replaced (Carlander, 1953). Other marks on scales include rays or radii which extend from the focus and may branch or bend at the annuli (Tesch, 1971).

Since the scale method of age determination is simple, accurate and inexpensive, it was selected as the method of choice for age determination over more complicated methods such as ray sections, opercular or vertebral bone sections, or otolith methods of age determination.

Upon determining the age group of collected individuals, the data was analyzed for each species at each age. An average standard length and an average weight for each age was obtained using FISHLEN, a program written for ECUCC's Burroughs 5700 computer.

Mean standard length and mean weight for each species age group were used to calculate Fulton's Coefficient of Condition (K factor) as cited in Ricker (1971).

$$K = 1/w^3$$

Nikolskii (1963) used this factor to determine the difference in "fitness" between specimens of the same species from different habitats. The higher the K factor the more healthy the fish.

Diversity indices for each sample were calculated using the formula

$$D = S/\sqrt{I} \quad \text{(Menhinick, 1964).}$$

where S represents the number of species and I represents the number of individuals collected in each sample.

Menhinick (1964) found that this diversity formula provides an intense index of the "universe" regardless of sample size and that the indices differentiate between universes having different numbers of species for a given number of individuals. The higher the index number, the more diverse the population within each sample.

The Mann Whitney U Test (Sokol & Rohlf, 1969) was used to determine the significance of the data. Where one or both of the data pairs is larger than 20 individuals the U statistic was transformed to a z ratio.

For the purpose of this study the following fish are considered to be game fish, common and scientific names are as officially recognized by the American Fish Society (1970): Chain pickerel, Esox niger; Redfin pickerel, Esox Americanus; Largemouth Bass, Micropeterus salmoides; Warmouth, Lepomis gulosus; Pumpkinseed, Lepomis gibbosus; Robin, Lepomis auritis; Bluegill, Lepomis macrochirus; Black crappie, Pomoxis nigromaculatus; and Mud sunfish, Acantharchus pomotis. Game fish are any fish actively sought by a fisherman for sport or food. Other fish may also be considered game fish. Forage fish are usually smaller fish, lower down in the food chain that are consumed by the larger carnivorous game fish.

# RESULTS AND DISCUSSION

Observations made on Swift Creek for a period of approximately two years seem to indicate that the non-maintained Corps of Engineers' project is approaching the "natural" condition. There appears to be a greater number of spawning sunfish as evidenced by the increasing abundance of nests within the channelized area. It is believed that this increase in the number is due to the additional cover available, combined [illegible] a more suitable substrate (sand as opposed to silt and muck), than that present in the natural segment. It was noted that multiple nests (i.e. two or more nests utilizing the same piece of cover) were occupied by the more gregarious nesters such as Pumpkinseed or Robins while solitary nests were defended by Bluegill. It was noted that nesting sunfish used any cover available in the channelized portion. In addition to overhanging brush, bridge pilings and support pieces were extensively used.

The results of the rotenone samples of Swift Creek indicate that there is no great difference in the percentage of game fish species caught per sample between the natural and channelized systems. However, there is a decrease in the number of game fish individuals collected per sample in the channelized system when compared to the forage fish caught in the same sample (Tables 1-6). This observation supports the conclusions of Tarplee et al. (1971) and Bayless and Smith (1964) that game fish are more adversely affected by channelization than are non-game fish.

Table 7 presents species diversity and average weight per fish for each of the six samples plus data presented by Bayless and Smith

(1962) on Swift Creek included in Appendix A-1 and A-2. The species diversity of the channelized areas and channelized to natural transition area is reduced 38% when compared to the diversity of the natural areas and channelized to natural transition area.

Tarplee et al. (1971) concluded that overall quality of streams, based on species diversity, was reduced 27.5% following stream improvement. They also found that species diversity was shown to increase with increasing cover over a period of time. Chapin (1975) found a greater invertebrate diversity in a non-channelized or old channelized stream than in a newly channelized stream.

An analysis of the data of average weight per fish shows that there is a 42% increase in the number of fish per kilogram in the channelized areas and channelized to natural transition area samples over the natural samples. Tarplee et al. (1971) observing the relationships of fish weights, found a 38% increase in the number of fish per pound from a channelized stream system over a natural stream system. Data previously cited by Emerson (1971) and Martin (1962) also supports these observations in that there are more smaller fish in a channelized system.

Age analysis showed that there were generally more fish of all ages, particularly older fish, in the natural system than in the channelized system (Table 8). There were no fish over Age Group V found in the channelized portion, whereas ages up to VI in the Lepomis sunfish and Age Group VII in the Largemouth Bass were found in the natural sector. Of the fish examined for growth, the only group with individuals living in both the channelized and natural sections in sufficient numbers to

Table 1. Results of rotenone sample 1 made May 14, 1974 on the channelized portion of Swift Creek. Length of study area approximately 200 ft. Results ranked in order of decreasing abundance of catch.

| Species | Number | % | Weight | % |
|---|---|---|---|---|
| Shiners N. crysoleucas | 1673 | 83.6 | 4819 g. | 66.8 |
| Robin L. auritis | 112 | 5.6 | 860 | 11.9 |
| Pumpkinseed L. gibbosus | 67 | 3.3 | 872 | 12.1 |
| Bluegill L. macrochirus | 59 | 2.9 | 347 | 4.8 |
| Coastal shiner N. petersoni | 42 | 2.1 | 32 | 0.4 |
| American eel A. rostrata | 20 | 1.0 | 211 | 2.9 |
| Redfin pickerel E. americanus | 15 | 0.8 | 40 | 0.56 |
| Pirate Perch A. sayanus | 5 | 0.25 | 2 | 0.09 |
| Mud sunfish A. pomotis | 2 | 0.1 | 9 | 0.12 |
| Mud minnow U. pygmaea | 2 | 0.1 | 0.5 | 0.01 |
| Johnny Darter E. nigrum | 1 | 0.05 | 1 | 0.01 |
| Chubsuckers Erimyson sp. | 1 | 0.05 | 12 | 0.17 |
| Carolina madtom N. furiosus | 1 | 0.05 | 0.1 | < 0.01 |

Table 2. Results of rotenone sample 2 made May 14, 1974 on the channelized to natural transition portion of Swift Creek. Length of study area approximately 200 ft. Results ranked in order of decreasing abundance of catch.

| Species | Number | % | Weight | % |
|---|---|---|---|---|
| Shiners *N. crysoleucas* | 206 | 35.9 | 668 | 4.1 |
| Robin *L. auritis* | 109 | 19.0 | 3805 | 23.6 |
| Pumpkinseed *L. gibbosus* | 95 | 16.5 | 3184 | 19.7 |
| Bluegill *L. macrochirus* | 69 | 12.0 | 1984 | 12.3 |
| Coastal shiner *N. petersoni* | 23 | 4.0 | 18 | 0.11 |
| Bluespotted sunfish *E. gloriosus* | 16 | 2.7 | 28 | 0.17 |
| Chubsucker *Erimyzon sp.* | 12 | 2.1 | 1286 | 8.0 |
| Warmouth *L. gulosus* | 10 | 1.7 | 323 | 2.0 |
| Largemouth Bass *M. salmoides* | 9 | 1.5 | 1189 | 7.3 |
| Pirate Perch *A. sayanus* | 7 | 1.2 | 44 | 0.27 |
| Gizzard Shad *D. cepedianum* | 6 | 1.1 | 2181 | 13.5 |
| Redfin pickerel *E. americanus* | 4 | 0.69 | 201 | 1.2 |
| Chain pickerel *E. niger* | 3 | 0.52 | 1125 | 7.0 |
| American eel *A. rostrata* | 3 | 0.52 | 60 | 0.37 |
| Black Crappie *P. nigromaculatus* | 1 | 0.17 | 6 | 0.03 |

Table 3. Results of rotenone sample 3 made September 17, 1974 on the natural portion of Swift Creek. Length of study area approximately 100 yds. Results ranked in order of decreasing abundance of catch.

| Species | Number | % | Weight | % |
|---|---|---|---|---|
| Robin *L. auritis* | 16 | 45 | 313 | 18 |
| Coastal Shiner *N. petersoni* | 4 | 11 | 8 | 0.5 |
| Golden Shiner *N. crysoleucas* | 3 | 8 | 20 | 1 |
| Johnny Darter *E. nigrum* | 3 | 8 | 5 | 0.2 |
| Carolina madtom *N. furiosus* | 2 | 5 | 5 | 0.2 |
| Chubsucker *Erimyzon sp.* | 2 | 5 | 100 | 5 |
| Chain pickerel *E. niger* | 2 | 5 | 1125 | 66 |
| Bluegill *L. macrochirus* | 2 | 5 | 104 | 6 |
| Redfin pickerel *E. americanus* | 1 | 2 | 10 | 0.5 |

Table 4. Results of rotenone sample 4 made September 17, 1974 on the natural portion of Swift Creek. Length of study area approximately 100 yds. Results ranked in order of decreasing abundance of catch.

| Species | Number | % | Weight | % |
|---|---|---|---|---|
| Pirate Perch *A. sayanus* | 15 | 19 | 118 | 8 |
| Robin *L. auritis* | 13 | 17 | 243 | 16 |
| Warmouth *L. gulosus* | 13 | 17 | 629 | 41 |
| Golden Shiner *N. crysoleucas* | 13 | 17 | 128 | 9 |
| Bluegill *L. macrochirus* | 10 | 13 | 129 | 9 |
| Chubsucker *Erimyzon sp.* | 4 | 5 | 200 | 13 |
| Pumpkinseed *L. gibbosus* | 4 | 5 | 65 | 4 |
| Carolina madtom *N. furiosus* | 4 | 5 | 4 | 0.3 |
| Bluespotted sunfish *E. gloriosus* | 2 | 3 | 18 | 1 |

Table 5. Results of rotenone sample 5 taken June 9, 1975 on the channelized portion of Swift Creek. Length of sample area approximately 200 ft. Results ranked in order of decreasing abundance of catch.

| Species | Number | % | Weight | % |
|---|---|---|---|---|
| Shiners (various species) | 190 | 65 | 465.0 | 32 |
| Robin *L. auritis* | 37 | 13 | 772.0 | 53 |
| Pirate Perch *A. sayanus* | 25 | 9 | 8.4 | < 1 |
| Coastal Shiner *N. petersoni* | 21 | 7 | 1.9 | < 1 |
| Mosquitofish *G. affinis* | 5 | 2 | 6.5 | < 1 |
| Largemouth Bass *M. salmoides* | 4 | 1 | 152.7 | 11 |
| Redfin pickerel *E. americanus* | 3 | 1 | 25.2 | 2 |
| Eastern mudminnow *U. pygmaea* | 3 | 1 | 0.3 | < 1 |
| Bluespotted sunfish *E. gloriosus* | 1 | 1 | 5.4 | < 1 |
| Pumpkinseed *L. gibbosus* | 1 | 1 | 13.7 | < 1 |
| Johnny Darter *E. nigrum* | 1 | 1 | 0.6 | 1 |
| Banded Pygmy sunfish *E. zonatum* | 1 | 1 | 0.1 | < 1 |

Table 6. Results of rotenone sample 6 made June 9, 1975 on the natural portion of Swift Creek. Length of sample area is approximately 200 ft. Results ranked in order of decreasing abundance.

| Species | Number | % | Weight | % |
|---|---|---|---|---|
| Redfin pickerel *E. americanus* | 19 | 27 | 304.4 | 41 |
| Pirate Perch *A. sayanus* | 18 | 26 | 10.1 | 1 |
| Shiners (various species) | 12 | 17 | 92.8 | 13 |
| Chubsucker *Erimyzon sp.* | 7 | 10 | 162.7 | 22 |
| White catfish *I. catus* | 7 | 10 | 101.4 | 14 |
| Pumpkinseed *L. gibbosus* | 3 | 4 | 31.9 | 4 |
| Robin *L. auritis* | 2 | 3 | 34.0 | 5 |
| Eastern mudminnow *U. pygmaea* | 1 | 1 | 1.7 | < 1 |
| Mosquitofish *G. affinis* | 1 | 1 | 1.4 | < 1 |

Table 7. Species diversity index (Menhinick, 1964) and average weight per fish of samples collected from Swift Creek, Pitt County, North Carolina.

| Sample Number | System Type | N* | S* | Diversity Index | Average Wt/fish |
|---|---|---|---|---|---|
| 1 | Channelized | 13 | 2001 | 0.29 | 3.6 g. |
| 2 | Channel to Natural Transition | 15 | 573 | 0.62 | 28.1 g. |
| 3 | Natural | 9 | 35 | 1.52 | 48.2 g. |
| 4 | Natural | 9 | 78 | 1.02 | 19.6 g. |
| 5 | Channelized | 12 | 292 | 0.7 | 4.9 g. |
| 6 | Natural | 9 | 70 | 1.08 | 10.5 g. |
| App. A1 | Natural | 15 | 50 | 2.1 | - |
| App. A2 | Channelized | 12 | 1315 | 0.33 | - |

* N indicates number of species captured. S indicates the number of individuals captured in a single sample.

Table 8. Numbers of fish from each age group collected from the channelized and natural stream sections and the levels of significant difference in the lengths of sunfish from the two stream sections.

| Species | | AGE GROUP I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|---|
| <u>Esox niger</u> | | | | | | | | |
| | natural | 0 | 0 | 0 | 4 | 3 | 2 | |
| | channel | 3 | - | | | | | |
| <u>E. americanus</u> | | | | | | | | |
| | natural | 8 | 4 | 4 | | | | |
| | channel | 1 | 1 | 1 | | | | |
| <u>Etheostoma nigrum</u> | | | | | | | | |
| | natural | 2 | | | | | | |
| | channel | - | | | | | | |
| <u>Enneacanthus obesus</u> | | | | | | | | |
| | natural | 0 | 0 | 1 | 1 | | | |
| | channel | - | | | | | | |
| <u>Micropterus salmoides</u> | | | | | | | | |
| | natural | 0 | 1 | 1 | 3 | 0 | 0 | 4 |
| | channel | 0 | 4 | 3 | - | | | |
| <u>Lepomis macrochirus</u> | | | | | | | | |
| | natural | 27 (.2) | 9 (.1) | 9 (.1) | 9 (.1) | 2 (*) | | |
| | channel | 31 | 7 | 3 | 4 | - | | |
| <u>L. gibbosus</u> | | | | | | | | |
| | natural | 6 (NS) | 2 (.2) | 8 (*) | 2 (*) | 0 | 1 (*) | |
| | channel | 7 | 7 | 1 | 1 | - | - | |
| <u>L. gulosus</u> | | | | | | | | |
| | natural | 7 (.1) | 0 | 11 (*) | 4 (.1) | - (*) | | |
| | channel | 3 | 0 | 1 | 2 | 1 | | |
| <u>L. auritis</u> | | | | | | | | |
| | natural | 23 (.3) | 43 (.15) | 23 (.1) | 2 (.2) | 3 (*) | 1 (*) | |
| | channel | 32 | 9 | 8 | 3 | - | - | |

(*) indicates where tests of signficance not performed

Note: Where one or both of the data pairs is larger than 20 individuals the U statistic was transformed to a z ratio.

provide an adequate sample were members of the genus Lepomis. Graphs showing age-length and length-weight relationships of these fish are presented in figures 2 through 6.

Bluegill sunfish: Lepomis macrochirus

From the data presented in Figure 2, the growth rates of Bluegill populations in Swift Creek may be observed. Bluegill of Age Group I in both the natural and channeled systems grew larger than literature values for similar lotic system types. The year I fish of the channelized portion also exceeded the year I fish of the natural system in length (statistically significant at the $p = 0.2$ level). However, these natural Bluegill weighed more, resulting in a larger coefficient of condition (K factor = 0.048) than those from the channelized portion (K factor = 0.036).

By Age Group II the length of the Bluegill in the channelized system had decreased when compared to the length of the Bluegill in natural and literature values. The weight, hence K factor, of the natural stream's Bluegill population exceeded that of the channelized system. This length and weight difference also continues through Age Group IV, (statistically significant at the $p = 0.1$ level).

Robin sunfish: Lepomis auritis

The Robin shows a somewhat different growth relationship than that of the Bluegill. These relationships are shown in Figure 3. The literature data far exceeds the experimental data obtained for both natural and

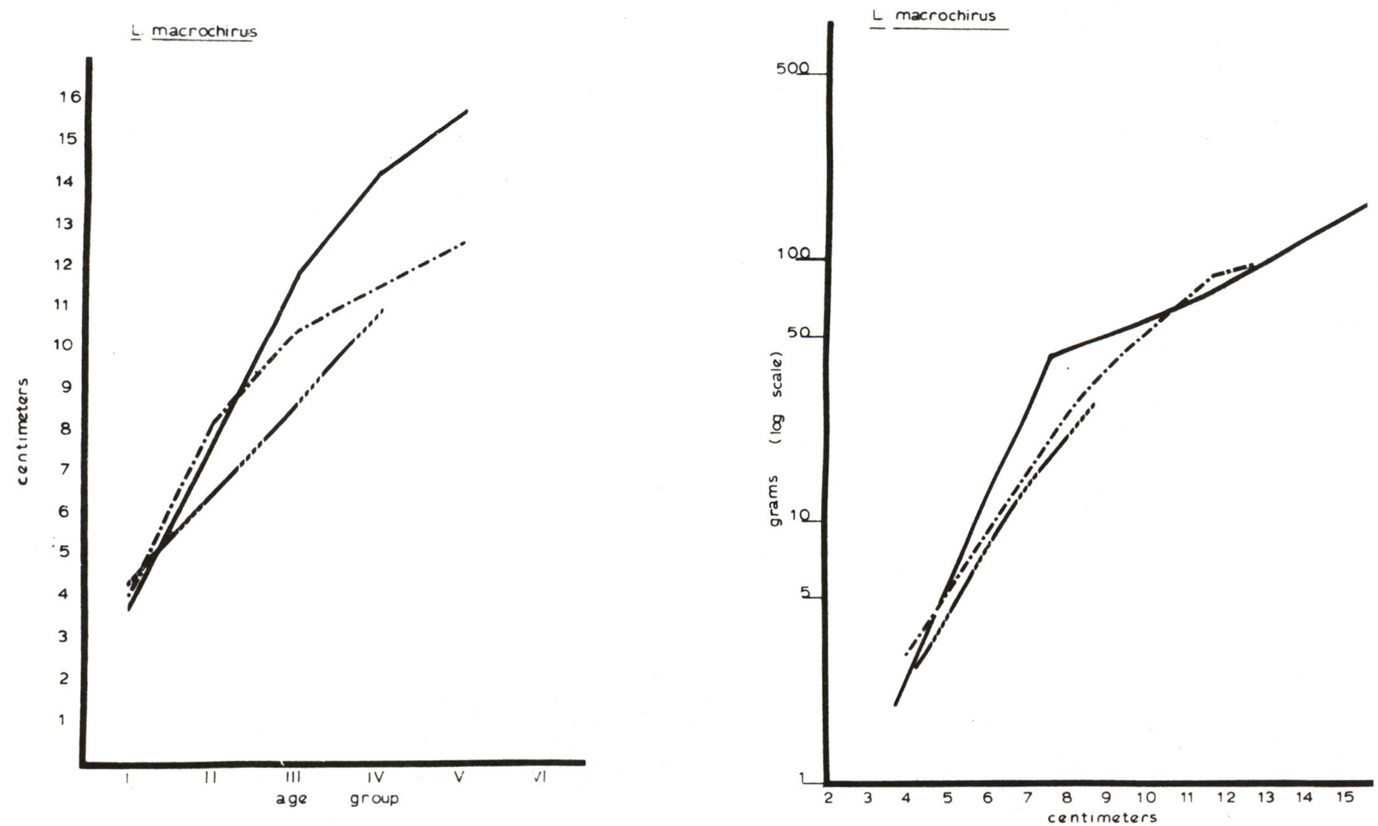



Figure 2.) Mean age - length and length - weight relationships of the Bluegill, Lepomis macrochirus from Swift Creek. Solid line, literature values; dashed line, natural system; broken line, channelized system.

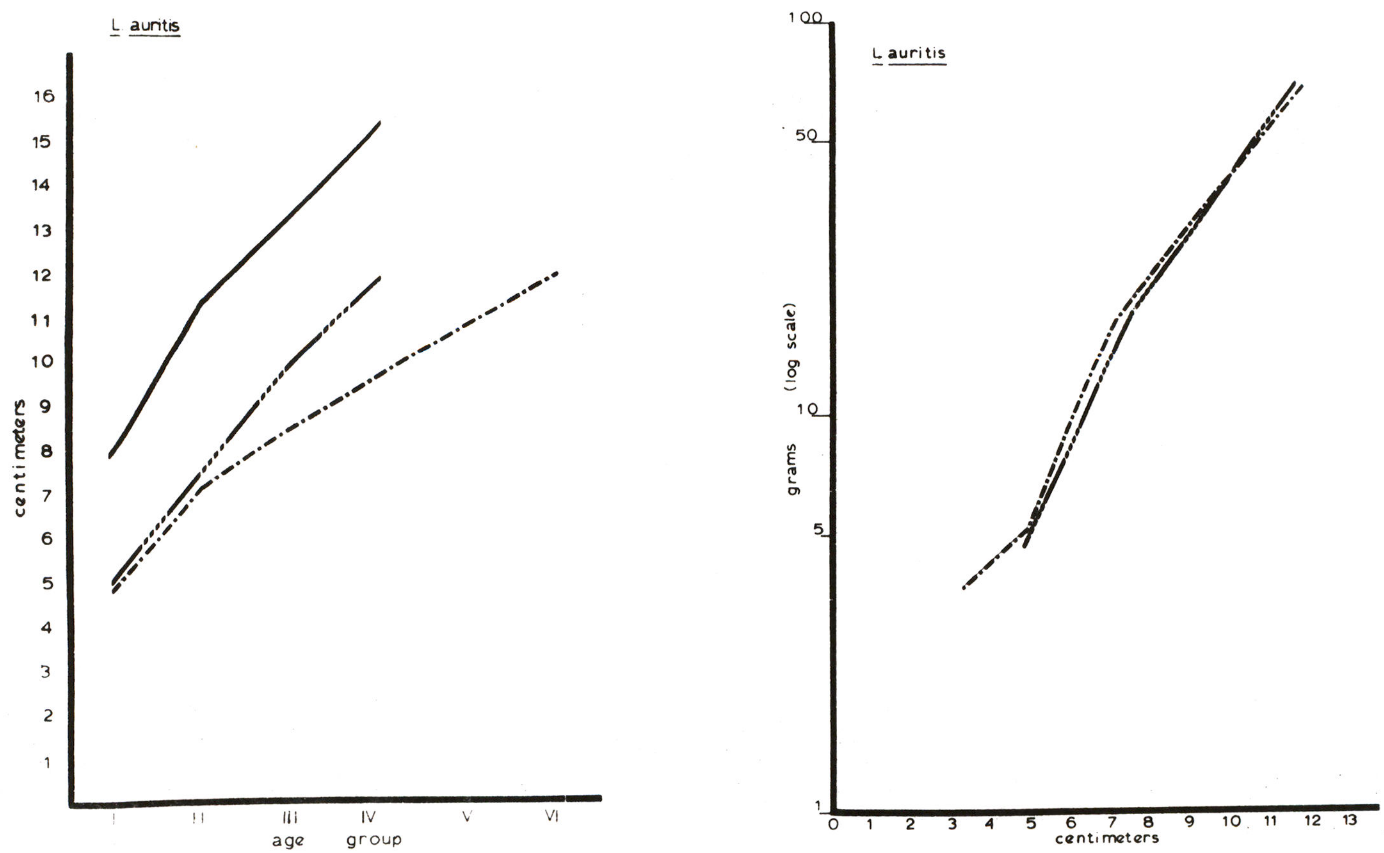



Figure 3.) Mean age - length and length - weight relationships of the Robin, Lepomis auritis from Swift Creek. Dashed line, natural system; broken line, channelized system. Solid line, Smith, 1971. No literature values available for length - weight relationships.

channelized sectors. The length of the Robin from the channelized portion also exceeded the natural section's population for Age Group I through IV. The Mann Whitney U Test showed a significant difference in the lengths of the fish from the natural and channelized sections for Age Group I at the $p = 0.3$ level. Age Group II showed significance at the $p = 0.15$ level, Age Group III at $p = 0.1$, and Age Group IV at $p = 0.2$.

The weights of the fish from the natural section were greater than those from the channelized section, except in the instances where the fish from the channelized portion exceeded 10 centimeters in length. This results in a K factor in the natural sector greater in Age Groups I through III than the K factor in the channelized sector.

Warmouth sunfish: Lepomis gulosus

The growth characteristics of the Warmouth sunfish follows the same general pattern as the two preceeding species, as shown in Figure 4. Length of Warmouth from the channelized portion of Age Group I exceeds literature values and the data collected for the natural sector's lengths. There were no Group II members taken in either natural or channelized segments. The channelized section's Age Group III contained only one member and that single member was smaller than Age Group III members of the natural sector. Members of Age Group IV from the channelized portion are longer than their natural stream counterparts. Literature values for length exceed observed data in both the natural and channelized portions except for the single instance of Age Group I, channelized. The Mann-Whitney U Test shows a significant

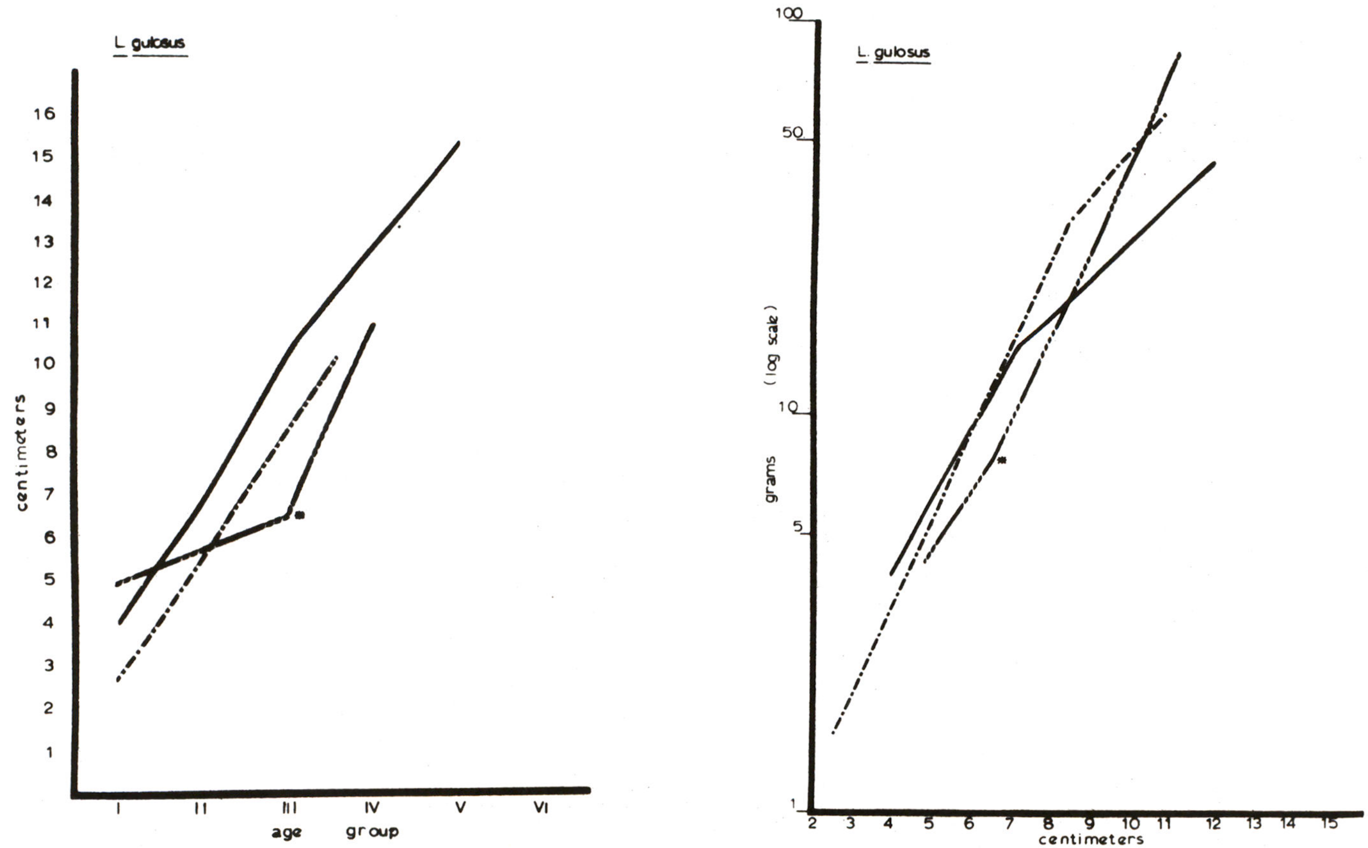



Figure 4.) Mean age - length and length - weight relationships of the Warmouth, Lepomis gulosus from Swift Creek. Solid line, literature values; dashed line, natural system; broken line, channelized system. *; Age Group III, N=1; Age Group II, N=0.

difference between the natural and channelized Warmouth lengths at the p = 0.1 level for all ages.

Comparing weights between channelized and natural sections shows that the Warmouth from the natural section weighed more at each length than did those from the channelized section. The K factors of the natural Warmouth were greater in Age Groups I and III, while only in Age Group IV channelized was there a larger K factor.

Pumpkinseed sunfish: Lepomis gibbosus

The Pumpkinseed sunfish displays a different growth relationship (Figure 5) from the others previously discussed. Age Group I Pumpkinseed from the natural portion are greater in length than literature values and data on Age Group I Pumpkinseed from the channelized segment. The length of Age Group I Pumpkinseed from the channelized stream is also greater than the literature values stated. By Age Group II, the length of the channelized and literature Pumpkinseed were approximately the same, while fish collected from the natural segment were shorter. Literature values then extended rapidly upward in subsequent age groups while the natural and channelized lengths did not change as rapidly. Growth of Pumpkinseed from Age Groups III and IV from the channelized segment exceeds that of equivalent ages from the natural sector. The natural portion does, however, possess older individuals (up to Age Group IV). There was no significant difference at the p = 0.1 level between lenghts of fish from the natural and channelized systems according to the Mann-Whitney U Test for Age Groups III and IV. Age Groups I and II were significant at the p = 0.1 level.

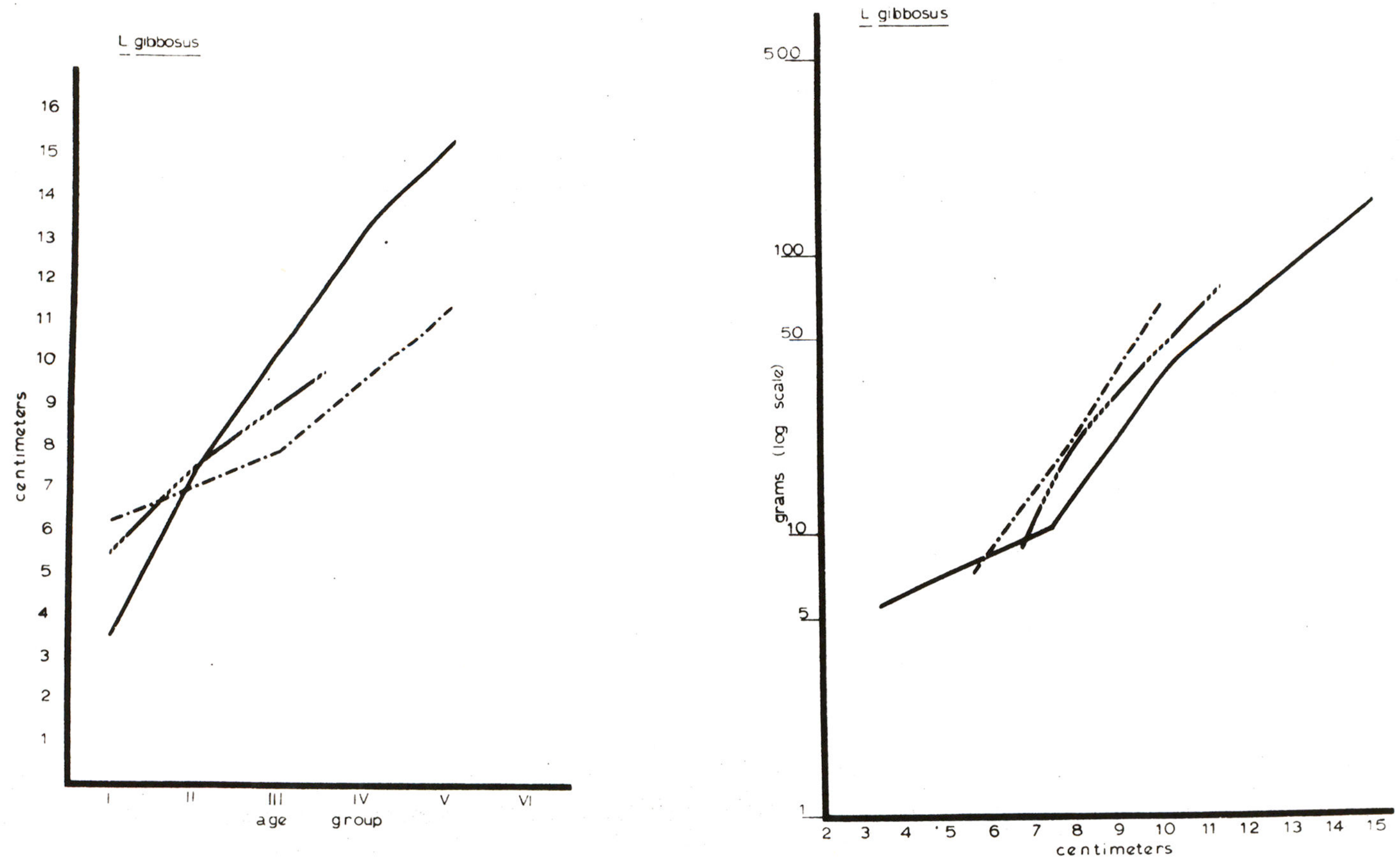
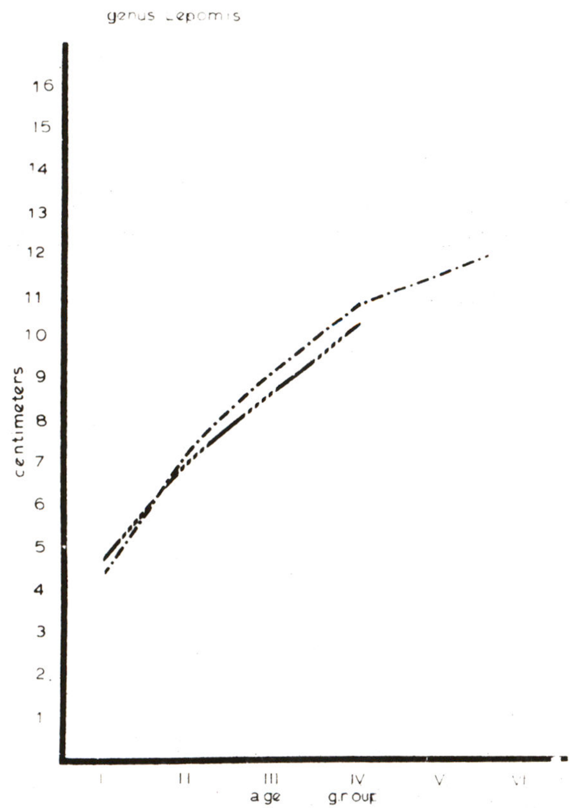



Figure 5.) Mean age - length and length - weight relationships of the Pumpkinseed, Lepomis gibbosus from Swift Creek. Solid line, literature values; dashed line, natural system; broken line, channelized system.

The literature values for weight show lower trend than the weight plots of the natural and channelized segments (i.e. long, skinny fish with a resultant low K factor). The plots of the average weights of the natural and channelized segment fall close together, with the exception of Age Group IV. But in these plots, the natural segment is consistently greater than the channelized segment. Although the length of fish from the channelized system was greater after Age Group I, the weights were only slightly lower than those of fish from the natural system. As a result, the K factor of Pumpkinseed from the channelized area was greater at each age group except IV.

Genus Lepomis

Data from individuals of the four sunfish species previously mentioned were combined under the genus Lepomis, (Figure 6) Average length of Age Group I members from the channelized sector exceeded the average length of the members from the natural sector. The average lengths of Age Group II members of both natural and channelized were approximately the same, (average length, channelized - 7.2 cm.: average length, natural = 7.3 cm.). However, the average weight of the fish from the natural sector was greater, (19.7 gm. as opposed to 16.1), with a larger K factor. The average length of fish from the natural sector of Age Group III and older, exceeds that of equivalent age groups from the channelized portion. Weights were also greater in the natural sector than in the channelized sector. (The Mann-Whitney U Test showed no significant difference between lengths of natural and channelized fish populations at the 5% level).



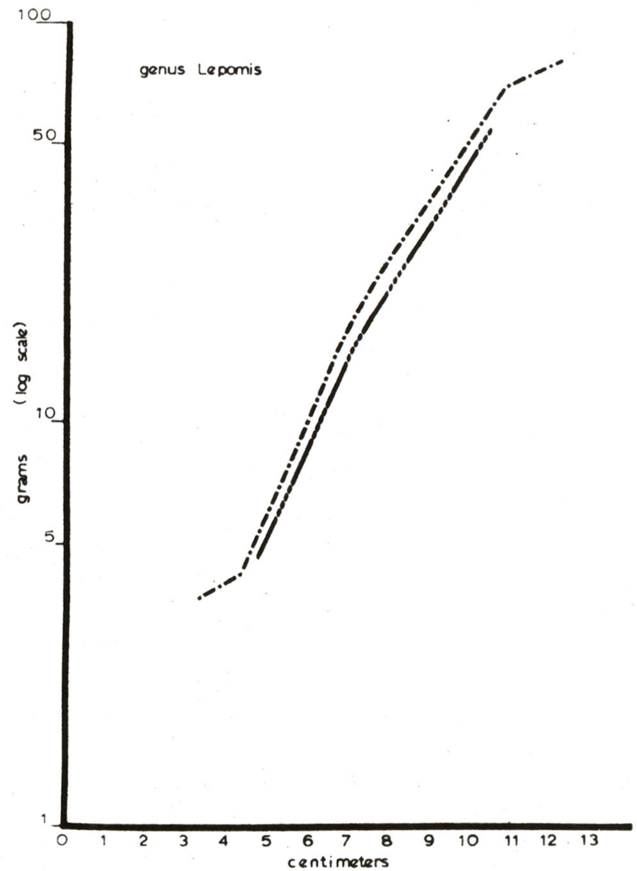




Figure 6.) Mean age - length and length - weight relationships of the genus Lepomis from Swift Creek. Dashed line, natural system; broken line, channelized system. Literature values not available

The fish population of the channelized sector showed a larger number of Age Group I individuals than in the natural sector. There were progressively fewer individuals in subsequent age groups through Age Group V. The number of fish from the natural sector was greater in each age group after II, than from the channelized portion through Age Group VI (Table 9). The total number of individuals from the natural system was greater than the total from the channelized system.

Table 9. Numbers of individuals at each Age Group of genus Lepomis.

| Age Group | | Natural | Channel |
|---|---|---|---|
| I | | 63 | 73 |
| II | | 54 | 23 |
| III | | 51 | 13 |
| IV | | 17 | 7 |
| V | | 5 | 1 |
| VI | | 2 | |
| | Total | 192 | 117 |

# SUMMARY

This study has shown that the U. S. Army Corps of Engineers' channel improvement on portions of the Swift Creek watershed has affected fish populations within the creek. Game fish were more adversely affected than were non-game fish, in that there were more non-game or forage fish in the channelized portion than there were in the natural portion.

Age analysis of collected fish has shown that there were more fish of all ages, including more older fish, in the natural system. Analysis also showed that, generally, Age Group I fish from the channelized section were larger than their counterparts from the natural section. These smaller fish from the natural stream, however, weighed more than those from the channelized stream. In subsequent age groups the age-length relationships changed, species to species, but weights of the fish from the natural system generally exceeded those of fish from the channelized system. The trend toward more, smaller fish in the downstream, channelized area and fewer, larger fish in the upstream natural area is opposite to the conclusion drawn by Larimore and Smith (1963).

Observations on nesting sunfish appear to indicate that the unmaintained channelized system is reverting to its natural condition. Further study would be necessary to determine whether a complete reversion is possible and the time required for that change.

An increase in the number of sample stations or number of samples might have improved the statistical reliability of the data presented in this paper. However, since the availability of the samples was dependent on the permission of the Division of Inland Fisheries, Wildlife Resources Commission, and the schedules of the district fishery biologists, more extensive sampling was not possible. Attempts to use seines were not productive since the large flow volume in the channelized portion and the snags and holes in the natural portion hindered free movement. Gill nets and traps also proved unsuccessful.

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# Appendix A

Summary of the Biological, Chemical and Physical Conditions at Individual Sampling Stations, Fork Swamp and Swift Creek, Pitt County (Bayless and Smith 1962).

Appendix A-1

F8-8 FORK SWAMP (Pitt County) August 18, 1960
At Venters Crossroads
Ecological Class 11
Sanitation Class D-Swp
50 yd. sample area

This is a small, turbid stream of the upper coastal plain. Fishing pressure is very light. This stream is difficult to fish because of the silt-muck bottom and heavy under brush along the banks. It is a relatively poor fishing stream. Redfin pickerel and Warmouth were the dominant game species. A poor forage fish population was recovered. The stream appears to have been dredged in the past.

**Chemical and Physical Data**

| | |
|---|---|
| $O_2$ | 6.3 ppm |
| $CO_2$ | 11.6 ppm |
| ph | 6.4 |
| Total Alk. | 20.5 ppm |
| Av. Wid. | 17.2 ft. |
| Av. dep. | 1.7 ft. |
| Velocity | 0.35 ft/sec. |
| Volume cfs | 9.29 |
| Secchi disc. | 10.5 in. |
| Water temp. | $73^{\circ}$ F. |
| Bottom | silt, muck |

**Checklist of Species**

Redfin Pickerel (4)
Silvery minnow (2)
Golden shiner (7)
Lake chubsucker (4)
White catfish (3)
Yellow Bullhead (4)
Brown Bullhead (1)
American eel (P)
Largemouth Bass (1)
Mosquitofish (3)
Pirate Perch (6)
Flier (3)
Warmouth (6)
Bluespotted sunfish (1)
Pumpkinseed (7)
Bluegill (4)

**Bottom Fauna**

Nematomorpha, Pelecypoda

| | |
|---|---|
| Av. vol./ $ft.^2$ | 9.86 ml |
| Av. no. / $ft.^2$ | indeterminate (Nematomorpha) |

Appendix A-2

F8-10 SWIFT CREEK (Pitt County) Aug. 30, 1961

Ecological Class 5
Sanitation Class D-Swp.
100 yd. sample area

At this point, this is a moderate size, turbid stream of the lower Coastal Plain. It is a poor fishing stream, although fishing pressure for carp and catfish is light to moderate. An unusually large number of silvery minnows furnish an excellent forage fish population. This stream is generally fished from the bank.

Chemical and Physical Data

| | |
|---|---|
| $O_2$ | 4.0 ppm |
| $CO_2$ | 10.6 ppm |
| pH | 6.7 |
| Total alk. | 20.0 ppm |
| Av. wid. | 33.9 ft. |
| Av. dep. | 5.0 ft. |
| Velocity | 0.5 ft./ sec. |
| Volume cfs | 76.1 |
| Bottom type | clay, muck, sand detritus |
| Secchi disc | 4.5 in. |
| Water temp. | 76°F. |

Checklist of Species

Redfin pickerel (3)
Silvery minnow (1206)
Golden shiner (48)
Comely shiner (2)
Lake chubsucker (8)
Yellow Bullhead (1)
American eel (P)
Pirate Perch (12)
Carp (3)
Flier (1)
Warmouth (P)
Bluegill (8)
White catfish (4)
Mosquitofish (19)

Bottom Fauna

Diptea, Oligochaeta, Hirudinea, Pelecypoda, Hemiptera

Av. vol./ft.$^2$ o.5 ml

Av. no./ ft.$^2$ 141.0