SEASONAL OCCURRENCE AND DIVERSITY OF FISH IN A HEATED DISCHARGE CHANNEL, TENNESSEE RIVER[1]

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ABSTRACT

The fish population in the heated discharge channel from Colbert Steam Plant on the Tennessee River was sampled from January 1972 to December 1973 to determine the effects of temperature on species composition, relative abundance, and diversity. Electrofishing (108 samples) and gill netting (36 samples) yielded a total of 34 species; median number of species per sample for each type of gear was nine. Species that were commonly collected from the discharge channel at maximum summer temperatures (33—35 C) included: spotted gar, gizzard and threadfin shad, carp, bluegill, longear sunfish, spotted bass, largemouth bass, and channel catfish. The occurrence of only three species (skipjack herring, sauger, and walleye) was considered temperature dependent; these species apparently avoided the heated effluent at temperatures above 30 C. Mortalities resulting from temperature differences were not observed.

Regression analysis of two diversity indices computed for the electrofishing data indicated that species diversity was inversely related to temperature in the discharge channel ($P < 0.05$) but that the Shannon index ($\bar{H}$) was not temperature dependent.

INTRODUCTION

The potential of significant damage to fish populations resulting from heated waste-water discharges is generally recognized. However, only minimal effects on warmwater fish populations have been demonstrated at existing fossil-fueled electric stations, particularly at those plants that discharge into a lotic environment. Six years of study of the effects of a heated discharge into the White River (Indiana) has revealed little or no effect on fish growth, reproduction, or movement (Benda and Proffitt, 1974). On the basis of the cluster analysis of data on occurrence and distribution of fish in the upper Potomac River, Cairns and Kaesler (1971), reported no changes in the environment which could be ascribed to operation of a power plant. Based on the ability of the fish to either seek out or avoid heated segments of the Wabash River (Indiana), Gammon (1971 and 1973) reported no significant alteration of the fish population of that river. Similar observations on the fishery of the upper Delaware River were made by Trembley (1960); he reported that all the species found in adjacent portions of this river were present in the heated discharge zone at least part of the year. Trembley also noted an overall increase of some species in relation to the discharge, but an almost complete elimination of most species from the maximum heated zone during summer months.

Previous fishery studies at fossil-fueled electric generating stations on mainstream reservoirs of the Tennessee River have been limited to intermittent surveys to determine species composition, relative abundance, and sport fishing in discharge canals and basins (Dryer and Benson, 1956; Tennessee Valley Authority, 1969 and 1973). Results from these studies have indicated a seasonal concentration of various species, intensive seasonal fishing pressure, and no direct mortalities from the effects of temperature differences.

The objective of this study was to determine the effect of temperature on species composition, relative abundance, and diversity of the adult fish population in the heated discharge channel from Colbert Steam Plant on Pickwick Reservoir, a mainstream impoundment of the Tennessee River.

MATERIALS AND METHODS

Study Area

Colbert Steam Plant, constructed and operated by the Tennessee Valley Authority (TVA), is located on Pickwick Reservoir in northwest Alabama (Fig. 1). It is a five-unit, fossil-fueled plant with a total electrical generating capacity of 1,396 MW. At peak load, 56 $m^3 sec^{-1}$ of water for condenser cooling is pumped from Pickwick Reservoir and discharged into an oblong basin, approximately 700m in circumference. The heated effluent (ΔT 5 to 8 C) passes from the discharge basin down the lower 4.5km of Cane Creek before returning to the Tennessee River (Pickwick Reservoir) 1.6km downstream from the plant intake. Time of travel from the discharge basin to the river is 2.5 to 3 hours, depending on plant load and reservoir elevation; temperature of the effluent seldom drops more than 1.0 C from the point of discharge to the mouth of the creek. Thus the lower 4.5km of Cane Creek is essentially a complex discharge canal; at the upper end the discharge basin and ambient section of the creek form a y-maze with reference to temperature selection of fish moving upstream. Fish moving downstream are confronted with a steep thermal gradient at the junction of the discharge basin of Cane Creek. Water temperature upstream from the discharge basin is similar to that for Pickwick Reservoir, which seasonally ranges from 5 to 30 C.

The mixing zone where the heated effluent returns to the river (TRM 244) varies according to reservoir elevation. At elevations above 125m (mean sea level), the major portion of the heated water follows the shallow overbank area on the left side of the river and is only gradually diffused into the mainstream. At lower elevations this overbank is exposed, and the heated effluent is contained in the creek channel until it reaches the main river channel where it mixes rapidly.

Pickwick Reservoir (surface area 17,449 ha), formed by Pickwick Landing Dam and bounded upstream by Wilson Dam, is part of the 1,046-km navigation system of the Tennessee River. The reservoir is 85km long, and maximum width is 2.4km. Width is about 0.7km at the Colbert plant site which is 24km downstream from Wilson Dam. Waterflow conditions and habitat at the plant site are essentially riverine.

The fish fauna of Pickwick Reservoir is composed primarily of typical warmwater species (Lagler, 1956). However some of the species, such as sauger *(Stizostedion canadense)*, have recently been considered cool water or "lukewarm" species in relation to thermal requirements (K. E. F. Hokanson, personal communication). Cove rotenone samples in 1971 yielded a mean standing stock biomas of 502kg/ha, consisting of 48 species (Tennessee Valley Authority, 1972). Dominant species by weight were: Gizzard shad *(Dorosoma cepedianum)*, 58 percent; threadfin shad *(Dorosoma petenense)*, 13 percent; smallmouth buffalo *(Ictiobus bubalus)*, 7 percent; carp *(Cyprinus carpio)*, 6 percent; and freshwater drum *(Aplodinotus grunniens)* and channel catfish *(Ictalurus punctatus)*, each 4 percent. Combined weight of sauger, largemouth bass *(Micropterus salmoides)*, and smallmouth bass *(Micropterus dolomieui)* was 2.5 percent.

Electrofishing with pulsed D.C. (boat-mounted boom shocker) was the primary method of sampling since it was more versatile for sampling shallow or swift reaches in both the heated and ambient zones of lower Cane Creek. Night electrofishing samples were collected at approximately two-week intervals from two stations (B and C) within the heated effluent and from an upstream control station (A) from January 1972—October 1973 (Fig. 1). Station B included the discharge basin and had a shoreline distance of about 0.7km. Station C extended from approximately CCM 0.5 to CCM 0.8 and had a shoreline distance of 1.7km. Station A extended from CCM 2.8 upstream to approximately CCM 3.2; shoreline distance was 1.0km. Relative abundance was based upon the catch per 0.3km of shoreline electrofished. Samples were not collected during periods of high turbidity which were generally of short duration. Night electrofishing, generally more effective in this area, also reduced interference with sport fishermen. Captured fish (except shad) were held in live-wells, processed after each station, and then released. Number of each species and total length (nearest mm) were recorded. Gizzard and threadfin shad, usually present in large numbers, were estimated to the nearest hundred specimens that were turned up in the electrical field.

Three gill nets (3.8cm bar-mesh, 30.4m long, and 2.4m deep) were fished overnight at Station B at approximately two-week intervals from January 1972—November 1973. The catch by species was recorded as number per net-night and total length of each fish was measured. Previous experience with both gill nets and electrofishing in the heated discharge basin (B) indicated that electrofishing yielded a better overall estimate of species composition, but that gill nets were more effective for collecting some species.

To summarize the numerical structure of the fish population in lower Cane Creek, two diversity indices were computed for the 36 electrofishing samples from each station:

(1) Shannon index (Shannon and Weaver, 1963)

$$\bar{H} = \Sigma P_i \log P_i$$

where P_i is the proportion of individuals in the i-th species.

(2) "Species richness" as used by Margalef (1958)

$$D = S - 1/\log N$$

where S is the number of species and N the number of individuals. All calculations were based on natural logarithms ($\log_e$).

Water temperature was taken with a calibrated electric thermometer at the midpoint of each sampling station (surface and bottom) during each electrofishing or gill net cruise. Continuous

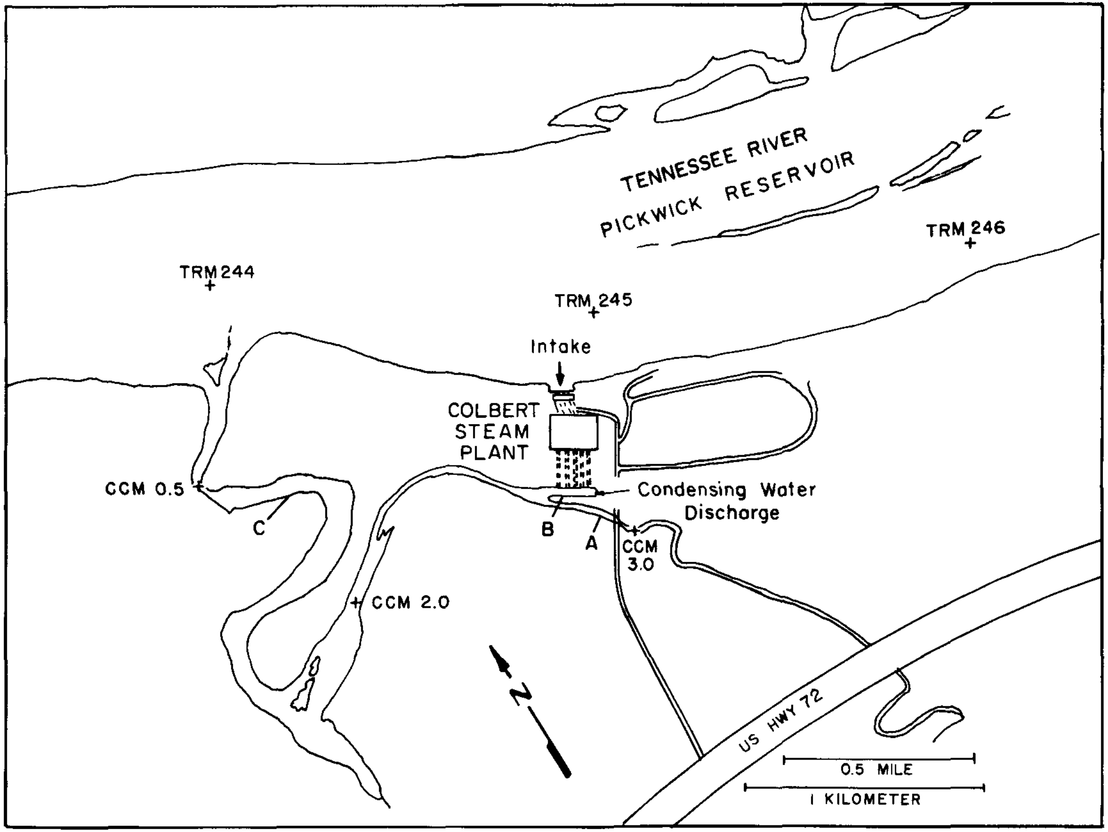

Figure 1. A map of lower Cane Creek which receives the heated effluent from Colbert Steam Plant (CCM—Cane Creek Mile; TRM—Tennessee River Mile).

temperature monitors were installed at five locations within lower Cane Creek in April 1972 (Hydraulic Data Branch, TVA). Also, a water quality monitor for the heated effluent was installed in a standard instrumentation trailer to measure pH, dissolved oxygen, temperature, and conductivity. Data from these monitors were processed by the Water Quality Branch of TVA.

RESULTS

Species Composition and Relative Abundance

A total of 34 species, consisting primarily of adult and larger subadult specimens, were collected by electrofishing and gill netting in lower Cane Creek (Table 1). Selectivity of the collecting gear generally excluded small forage species, e.g., minnows and darters. Thirty species were captured by electrofishing in both the heated zone (Station B and C) and ambient zone (Station A). Gill netting, used only at B, yielded 27 species. Species collected only by electrofishing were: American eel, threadfin shad, longear sunfish, warmouth, and green sunfish. Those collected only by gill netting

Table 1. Species composition of adult fish collected in relation to the heated discharge from Colbert Steam Plant into lower Cane Creek.

Common Name[1]	*Scientific Name*	*Sampling Station*[2]		
		B	*C*	*A*
Spotted gar	*Lepisosteus oculatus*	X	X	X
Longnose gar	*Lepisosteus osseus*	X	X	X
American eel	*Anguilla rostrata*	X		
Skipjack herring	*Alosa chrysochloris*	X	X	X
Gizzard Shad	*Dorosoma cepedianum*	X	X	X
Threadfin shad	*Dorosoma petenense*	X	X	X
Mooneye	*Hiodon tergisus*	X		
Carp	*Cyprinus carpio*	X	X	X
River carpsucker	*Carpiodes carpio*	X	X	X
Northern hog sucker	*Hypentelium nigricans*	X		
Smallmouth buffalo	*Ictiobus bubalus*	X	X	X
Spotted sucker	*Minytrema melanops*	X	X	X
River redhorse	*Moxostoma carinatum*	X		X
Golden redhorse	*Moxostoma erythrurum*	X	X	X
Blue catfish	*Ictalurus furcatus*	X		
Black bullhead	*Ictalurus melas*	X		
Yellow bullhead	*Ictalurus natalis*	X	X	X
Channel catfish	*Ictalurus punctatus*	X	X	X
Flathead catfish	*Pylodictis olivaris*	X		
White bass	*Morone chrysops*	X	X	X
Yellow bass	*Morone mississippiensis*	X	X	X
Striped bass	*Morone saxatalis*	X		
Green sunfish	*Lepomis cyanellus*	X		X
Warmouth	*Lepomis gulosus*			X
Bluegill	*Lepomis macrochirus*	X	X	X
Longear sunfish	*Lepomis megalotis*	X	X	X
Redear sunfish	*Lepomis microlophus*	X	X	X
Smallmouth bass	*Micropterus dolomieui*	X	X	X
Spotted bass	*Micropterus punctulatus*	X	X	X
Largemouth bass	*Micropterus salmoides*	X	X	X
White crappie	*Pomoxis annularis*	X	X	X
Sauger	*Stizostedion canadense*	X	X	X
Walleye	*Stizostedion vitreum*	X		
Freshwater drum	*Alpodinotus grunniens*	X	X	X

[1] American Fisheries Society, Spec. publ. No. 6, A List of Common and Scientific Names of Fishes from the United States and Canada.
[2] Stations B and C in the heated discharge zone; Station A, upstream control.

were: northern hog sucker, mooneye, blue catfish, and striped bass. Species collected by only one type of gear, with the exception of threadfin shad and longear sunfish, appeared in only one sample. Excluding these seven uncommon species, species composition between stations was similar. The median number of species per electrofishing sample (36 samples per station) at Station B, C, and A was eight, ten, and eight respectively. The median number collected by gill netting (36 samples) at B was nine.

Gizzard shad was the dominant species with regard to frequency of occurrence and numbers collected by electrofishing at each of the three sampling stations. Substantial numbers were collected at water temperatures that ranged from 4.2 C to 36.0 C. Gizzard shad made up approximately 70 percent of the catch at each of the stations (B and C) in the heated zone and 55 percent of the catch in the control (A). Peak abundance, exceeding 400 per 0.3km of shoreline sampled, occurred during April in the discharge basin when the effluent temperature ranged from 18.0 C to 21.0 C. This concentration consisted primarily of fish in spawning condition.

Threadfin shad were also abundant in all three sampling areas; frequency of occurrence was more variable but somewhat more temperature dependent than that for gizzard shad. Threadfin shad were not collected from the ambient zone (Station A) during January through March at water temperatures of 4.2 C to 13.5 C. This species occurred frequently in the heated zone at the maximum water temperatures (34.0—36.0 C). The combined number of threadfin and gizzard shad made up approximately 90 percent of the fish collected from each station by electrofishing.

The frequency of occurrence of selected game and food species in relation to the annual temperature regime for each station is presented in Figures 2, 3, and 4. This group represents the dominant predatory species collected in this study. Channel catfish, which occurred in 92 percent of the gill net samples, demonstrated a wide range of thermal tolerance (Fig. 3). This species was also present in 45 percent of the electrofishing samples from the heated zone (both stations combined) and in 28 percent of the electrofishing samples from the control.

Largemouth bass, which occurred in approximately 90 percent of the electrofishing samples at each sampling station, also showed a eurythermal response to the heated effluent. Peak abundance in the discharge zone occurred in the winter and spring months. Although there was an increase in the relative abundance of largemouth bass in the control (A) when the effluent temperature approached 35.0 C, the greatest concentration at this station appeared to be in relation to a heavy fall concentration (600/0.3km) of gizzard and threadfin shad.

Although smallmouth bass did not occur as frequently as largemouth bass, they did show a preference for conditions in the heated zone. Smallmouth bass were collected in 53 percent of the electrofishing samples from Station B and in 42 percent of the samples from Station C; but in the control, this species was collected only once. Only one specimen was collected by gill net at Station B. In the heated discharge, this species was collected at temperatures that ranged from 11.2 C to 35.1 C. Those specimens collected at the temperatures above 33 C were usually less than 200mm long. Total length of smallmouth bass collected in the heated effluent ranged from 41 to 401mm.

Spotted bass had a pattern of occurrence similar to that for smallmouth bass. In the electrofishing samples at Stations B and C spotted bass were present in 47 percent and 36 percent of the samples, respectively, but occurred only twice (5.5 percent) at Station A. This species was vulnerable to gill netting, as it occurred in 44 percent of these samples (Fig. 3). Although spotted bass were not as abundant as largemouth bass, maximum temperature tolerance (35.0 C), as determined by presence or absence, was similar.

Of the predatory game species that frequented the heated effluent, sauger and walleye were the only species whose presence or absence appeared to be temperature dependent (Fig. 3). Gill netting was more effective for collecting both species at Station B. Walleye were collected only at this station; however, to get to Station B adult fish had to come through either Station C or A. The largest concentration of both species occurred in the heated zone. Sauger were collected from late November through early June in the discharge basin (Station B) at water temperatures ranging from 11.2 C to 29.0 C. At Station C, this species was collected at temperatures of 7.2 C to 29.0 C. The presence of sauger in the control station was generally coincidental with peak abundance in the discharge basin; however, single specimens were collected in the ambient zone on two occasions (late August and September) when this species was not observed in the heated discharge. Walleye, although fewer in number, were present in the heated discharge at similar temperatures and seasonal periods as sauger (Fig. 3). In the gill net catch at Station B, walleye and sauger occurred in 31 percent and 44 percent of the samples respectively.

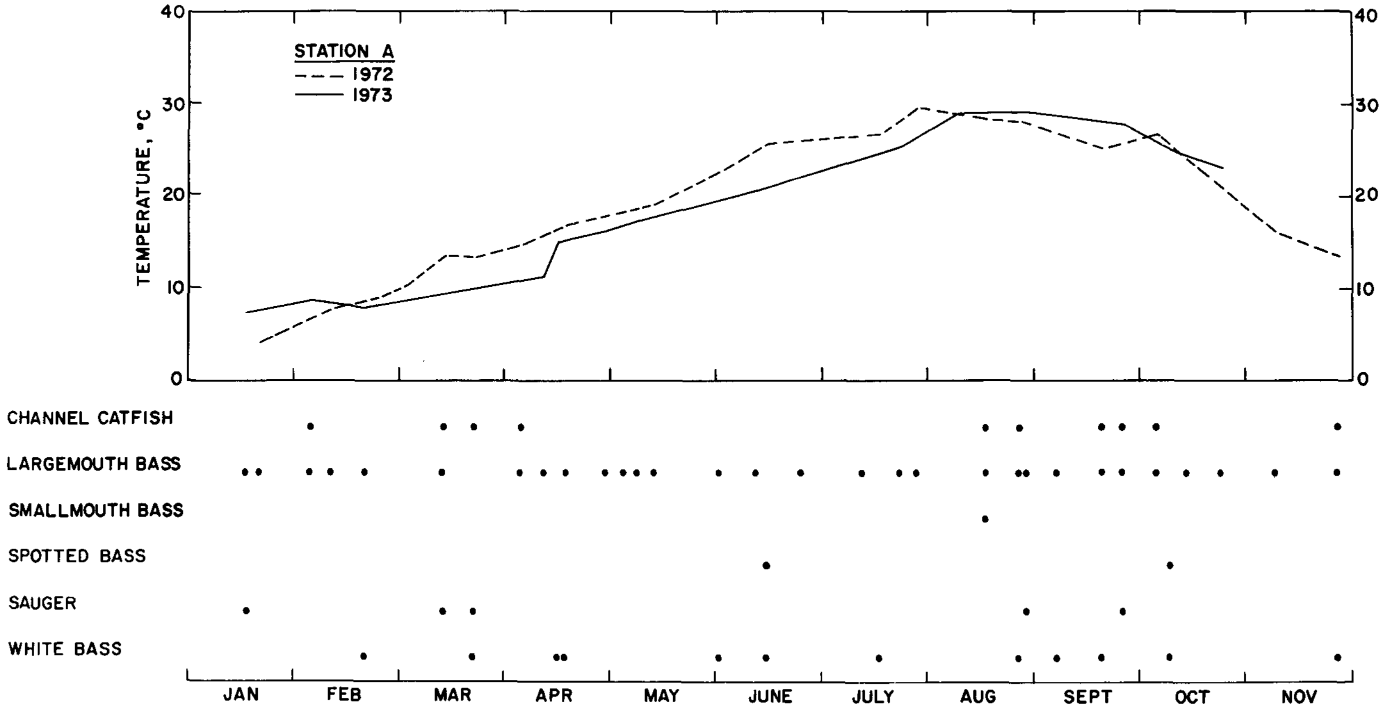

Figure 2. Frequency of occurrence of selected game fish in Cane Creek (Station A, upstream control) as determined by electrofishing.

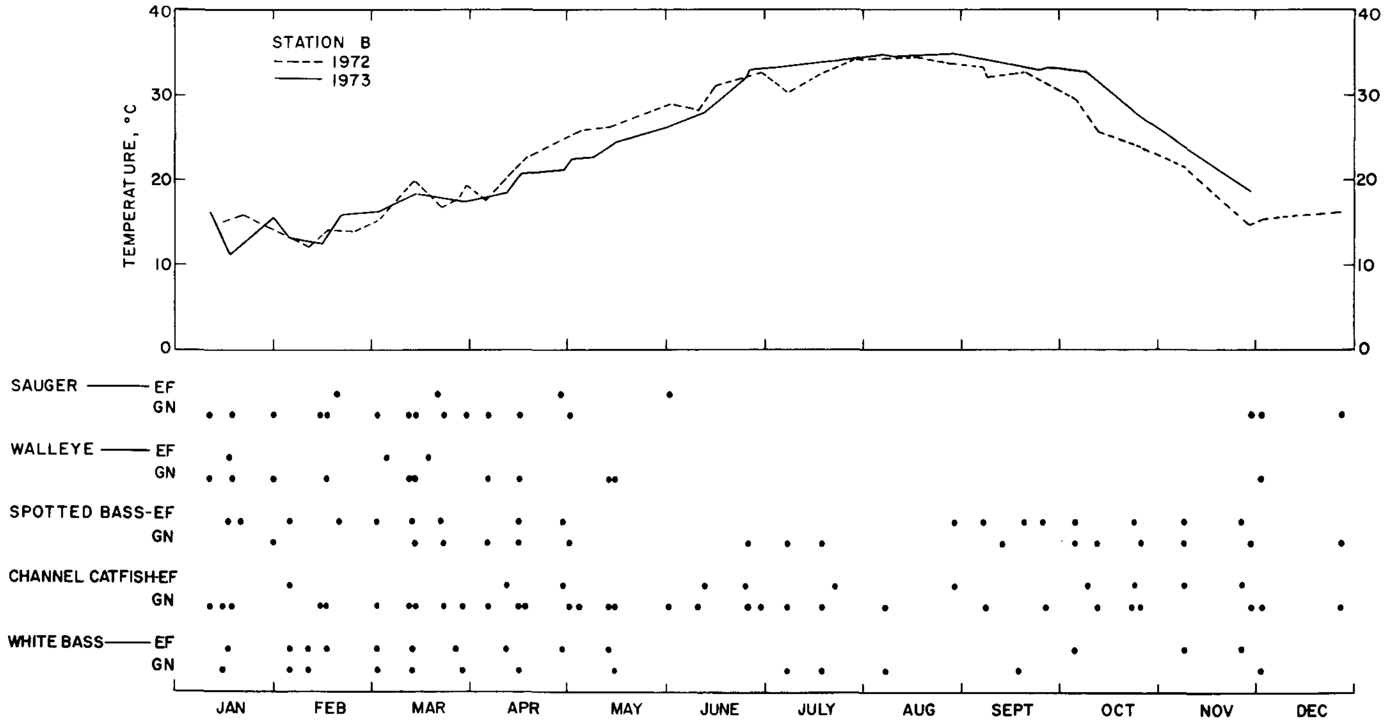

Figure 3. Frequency of occurrence of selected game fish in the heated effluent (Station B) from Colbert Steam Plant, as determined by electrofishing (EF) and gill netting (GN).

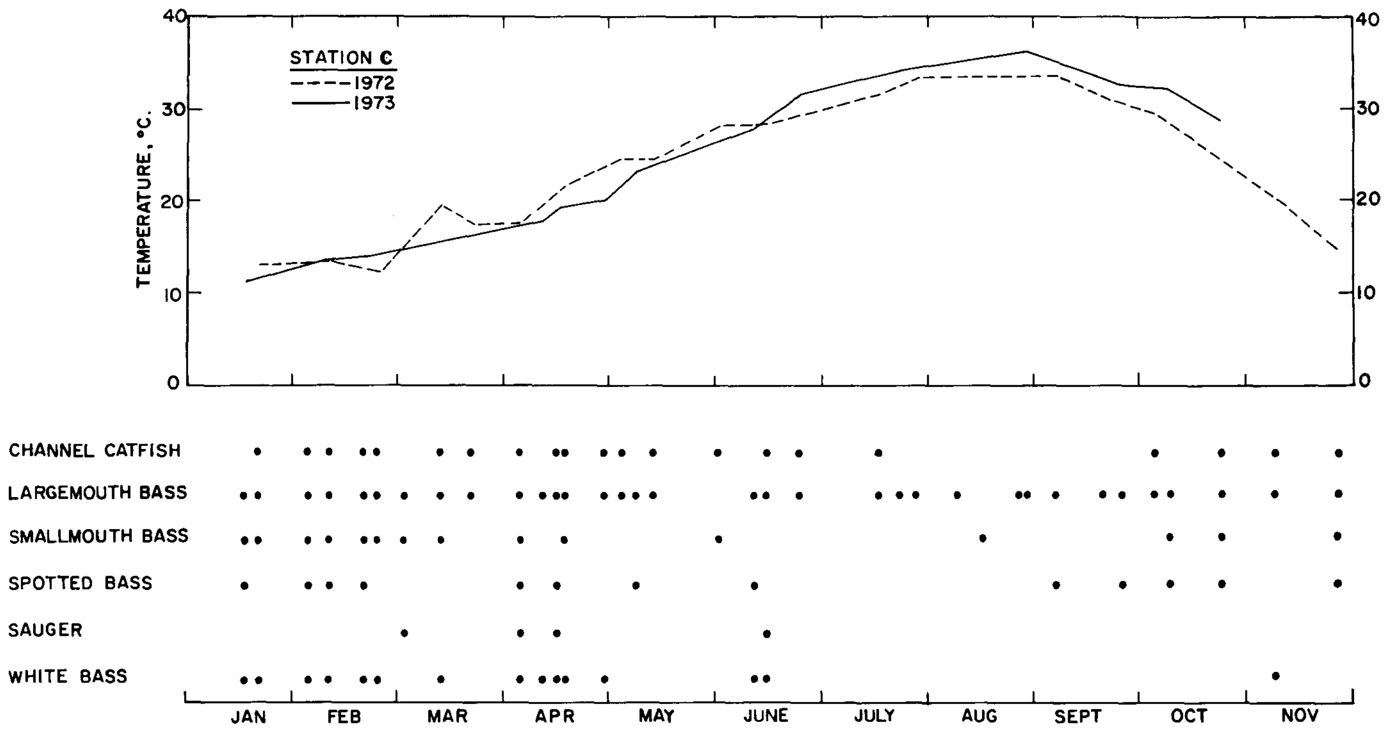

Figure 4. Frequency of occurrence of selected game fish in the heated effluent from Colbert Steam Plant, collected by electrofishing, Station C (lower discharge zone).

Frequency of occurrence of white bass as determined by electrofishing was essentially the same at all stations. Also, this species occurred in 36 percent of the gill net samples at Station B. In the heated effluent white bass were captured at temperatures which ranged from 12.2 C to 34.0 C and in the control at temperatures that ranged from 7.2 C to 28.1 C. Peak abundance (1.8—3.7/0.3km) in the discharge zone was in March; relative abundance was less in the control with no evidence of a peak concentration.

White crappie, another important game fish of the Tennessee River system, were collected infrequently at all three stations. Occurrence was generally associated with cooler effluent temperatures in the winter and spring, but on one occasion two specimens were collected at temperatures exceeding 34.0 C.

Skipjack herring, a non-game predatory species, was common in the heated zone of Cane Creek from October to June at temperatures below 30 C; however, on two occasions this species was captured in Station B when the effluent temperature exceeded 30 C. This species was collected only once from the control station, but occurred in 70 percent of the gill net samples from the discharge basin.

Other species collected frequently at all stations by electrofishing were: carp, bluegill, and longear sunfish. These species demonstrated a eurythermal response occurring consistently at both the minimum and maximum temperatures for each station. The more or less constant numbers of bluegill and longear sunfish indicated that resident populations of both species existed within each sampling area, whereas the number of carp increased dramatically in April and May at Station B. This concentration (>50/0.3km) was apparently due to an upstream spawning migration that terminated in the discharge basin.

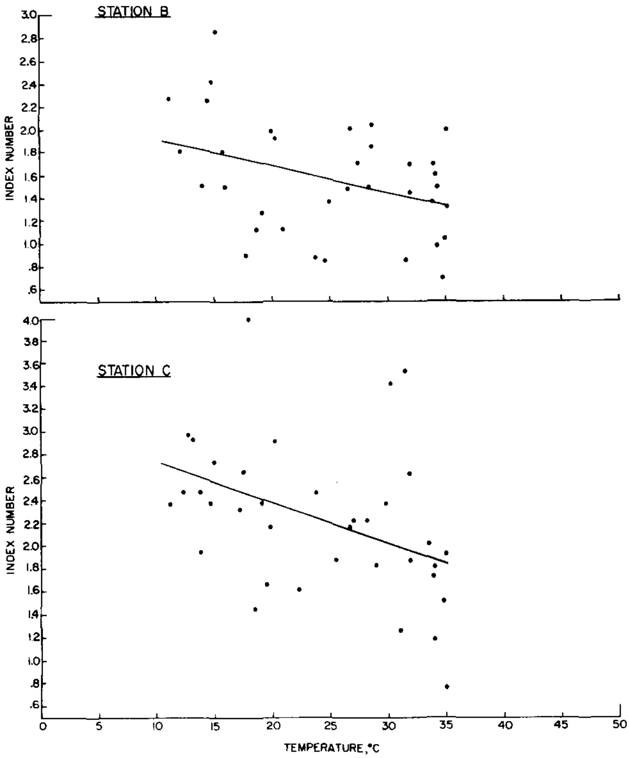

Figure 5. Species diversity (D = S − 1/log N) of the electrofishing catch in relation to temperature at two stations within the heated discharge from Colbert Steam Plant, 1972-73.

Based on concentrations of ripe adults of various species collected by electrofishing and gill netting, the following species apparently spawned within the 4.5km heated discharge zone of Cane Creek: gizzard shad, carp, spotted sucker, largemouth bass, white bass, yellow bass, bluegill, and longear sunfish. Larval fish collections also indicated that spawning occurred in the heated discharge (Wrenn, 1974).

Periodic analysis of the stomach contents of predatory species indicated that gizzard and threadfin shad, skipjack herring, and logperch *(Percina caprodes)* were eaten most frequently. Crayfish were common in the stomach contents of spotted bass. Based on the number present in the stomach samples, bottom dwelling logperch (seldom collected by electrofishing) were common in the heated zone of Cane Creek.

Diversity

Comparison of the diversity indices, D and $\bar{H}$, between stations indicated that overall species diversity and relative abundance (equitability) were greater in the heated zone than in the ambient zone of lower Cane Creek. Also, species diversity was significantly different between stations within the thermal effluent. Regression analysis of both indices in relation to water temperature at each station revealed that only species diversity (D) at Stations B and C was temperature dependent (Fig. 5). Species diversity was inversely related to increased effluent temperatures at both Station B ($r = -0.36; 0.01 < P < 0.05$) and Station C ($r = -0.42; P < 0.01$). The regression equation for Station B is:

$$D = 2.153 - .0237\ T$$

and for Station C:

$$D = 3.096 - .0356\ T$$

where D = "species richness" in index units ($\log_e$) and T = temperature (°C). Species diversity, lowest in the control station, did not show a corresponding increase as the species diversity declined in relation to higher effluent temperatures in the heated zone. Index units of $\bar{H}$ for the control station ranged from 0.2 to 1.2, and in the heated zone values ranged from 0.3 to 1.7.

DISCUSSION

Although regression analysis showed diversity declined significantly in relation to increased effluent temperatures, the Shannon index ($\bar{H}$) was not significantly related to temperature. The highest value of species diversity, at Station C in the heated zone of lower Cane Creek, may have been due to the proximity of this station to Pickwick Reservoir. Harrell and Dorris (1967) noted that species diversity (D) increased in relation to stream order.

Diversity, as determined by the Shannon index, is primarily a function of the proportions of the more common species (equitability), and only secondarily by the length of the species list (Sager and Hasler, 1969). The lack of significant relation between $\bar{H}$ and temperature indicated that several species remained in the heated effluent in similar numbers throughout the year. Moss (1973) indicated that diversity, variously and precisely defined in several different formulae, is a concept to which it is difficult to give concrete meaning. Presumably it is generally a reliable index of environmental health (Dahlberg and Odum, 1970). Gammon (1973) reported that diversity ($\bar{H}$) of the fish population was not significantly altered by the heated effluent from a new power plant on the Wabash River (Indiana) and that in the absence of a dramatic change in the overall fish community, it was necessary to examine separate species populations for signs of change.

Occurrence of most of the common species collected from three stations in Cane Creek, with the exception of threadfin shad, skipjack herring, sauger, and walleye, did not appear to be temperature dependent. Threadfin shad, a highly desirable forage species that has been abundant in mainstream reservoirs of the Tennessee River since about 1948 (Tennessee Valley Authority, 1954), avoided temperatures below 13 C in the control station (A). Strawn (1963) reported that a winter (field) temperature of 5 C was lethal for this species and that chronic exposure below 9 C was detrimental. Various authors have reported winter concentrations of threadfin shad in heated effluents (Adair and DeMont, 1971; Barkley and Perrin, 1971; and Dryer and Benson, 1956).

Gizzard shad, also an important forage species, but not as desirable as threadfin shad (Houser and Netsch, 1971), did not appear to avoid the extreme upper temperatures (34-36 C) in the heated zone nor the lowest temperatures (4-5 C) in the ambient zone. The tendency for shad to invade warm-water effluents (Miller, 1960) has been documented in other studies (Adair and DeMont, 1971; Proffitt, 1969; Benda and Proffitt, 1974; and Gammon, 1971).

Skipjack herring, sauger, and walleye were not captured in the heated zone at temperatures above 30 C; however, when present in lower Cane Creek (about November to June) these species had a distinct preference for the heated discharge zone. Apparently food supply and increased water flow in the effluent also attracted these highly predaceous species. Dryer and Benson (1956) reported that the abundance of sauger and skipjack in the heated discharge from New Johnsonville Steam Plant on Kentucky Reservoir (Tennessee River) was directly related to numbers of threadfin shad during the winter months. Gammon (1971) reported that skipjack herring avoided effluent temperatures above 29 C, but that turbidity and food supply may have also been limiting. Following start-up of a power plant on the Wabash River, sauger avoided heated zones above 29 C (Gammon, 1973). Trembley (1960) reported that walleye were attracted to a heated effluent in the Delaware River, but maximum body temperature for specimens caught in the effluent was 28.9 C; he also observed walleye undergoing heat death at approximately 30.6 C. Dendy (1948) reported that the summer temperature preference for sauger and walleye in Norris Reservoir was approximately 20 and 25 C respectively.

Apparently summer avoidance of the heated discharge from Colbert Steam Plant by sauger and walleye was ultimately determined by thermal intolerance; however, the departure from the effluent by these migratory species coincides with their seasonal migration from the tailwaters of dams on both the mainstream and major tributaries of the Tennessee River (Eschmeyer and Manges, 1945; Tennessee Valley Authority, 1960). Walburg, Kaiser, and Hudson (1971) have also reported a fall-to-spring concentration of sauger and walleye in the Lewis and Clark Lake tailwater on the Missouri River; the fewest numbers occurred from June to September when the maximum temperature was 20 C. Rawson (1957) reported that walleye in Lac La Rouge were widely scattered in the deeper waters during August and September; he suggested that pursuit of some food organisms was the cause of this movement rather than thermal preference (surface water of this lake rarely exceeded 19 C).

Smallmouth bass, although not excluded from the heated discharge zone at maximum effluent temperatures, did demonstrate a size/age dependency in relation to upper extreme temperatures (34-36 C). Few specimens that exceeded 200mm were collected in water above 33 C. When present, this species also preferred water conditions in the effluent as it was collected only once from the ambient zone. Trembley (1960) did not indicate a size/age dependence for smallmouth bass frequenting a heated effluent in the Delaware River; he reported that body temperatures of smallmouth bass collected in the heated effluent ranged up to 34.5 C. Maximum summer preference of both adult and underyearling smallmouth bass tested in a horizontal gradient was 31 C (Barans and Tubb, 1973).

Although Gammon (1971) indicated that spotted bass had a field preferendum of 27 C and avoided heated zones, this species in the present study tolerated temperatures above 34 C. Benda and Proffitt (1974) captured spotted bass in a heated discharge canal when temperatures ranged between 35 and 37 C.

White bass also tolerated effluent temperatures up to 34 C. Gammon (1973) reported that this species showed some attraction to heated zones in the Wabash River, but preferred temperatures 28 to 29.5 C. Barans and Tubb (1973) reported that the summer thermal preferendum was 30 C for this species.

Tolerance of maximum effluent temperatures in the Colbert discharge channel (seldom exceeding 35 C for any extended period) by other common species collected in this study (largemouth bass, bluegill, longear sunfish, channel catfish, and carp) was similar to that reported for these species in various studies (Benda and Proffitt, 1974; Clugston, 1973; Gammon, 1971 and 1973; Neill, Strawn, and Dunn, 1966; Neill, 1972; and Smith, 1971).

Although primary emphasis in this study was on the response of fish to the elevated temperature in the discharge channel, it is recognized that winter fish concentrations in a heated discharge are subject to lethal cold shock if the plant shuts down. Such a kill was reported on the Susquehanna River when fish in a heated zone were subjected to a sudden 24.5 C temperature drop (Sport Fishing Institute Bull. No. 223, April 1971). Based on the midwinter temperature differential (7.0-8.0 C) in the heated discharge from Colbert Steam Plant, plus the unlikelihood of all five of its units being down, it does not appear that cold shock would occur at this plant. Also, in the 20-year operation of the plant such a problem has not been experienced. Laboratory studies on the lower lethal threshold for smallmouth bass (Horning and Pearson, 1973), largemouth bass, channel catfish, and bluegill (Hart, 1952) indicated that these species can withstand an instantaneous drop of about 15 C.

Other water quality parameters of the heated effluent which could limit the presence of fish were essentially the same as those of the ambient river water (e.g., dissolved oxygen ranged from 5.4 to 11.3 mg/l and pH ranged from 7.0 to 8.0). Also, chlorination for slime control in the condenser tubes is not used at this plant.

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INTERACTIONS OF BLUE TILAPIA AND LARGEMOUTH BASS IN A POWER PLANT COOLING RESERVOIR

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ABSTRACT

In the presence of a dense population of blue tilapia, the population of northern largemouth bass declined in three years to one-third its 1972 abundance in Trinidad Lake, Texas. A pond experiment with Florida largemouth bass indicated that bass failed to reproduce successfully at a tilapia density of 2000 lb/A, but at 1000 lb/A some bass spawning occurred. Trends in gonosomatic indices suggest that eggs were retained by bass at high tilapia densities.

INTRODUCTION

Various cichlids of the genus *Tilapia* have been brought into the United States, principally for evaluation as biological controls of vegetation (Courtenay and Robbins 1973). Among these species, the blue tilapia, *T. aurea,* has become established in numerous lakes in Florida (Crittenden 1962; Buntz and Manooch 1968; Courtenay and Robbins 1973). High standing crops in ponds (Swingle 1960) and lakes (Crittenden 1962) of the southern United States make this species of high potential for commercial production, but interference with spawning of other species, particularly centrarchids, occurs at high densities of tilapia (Buntz and Manooch 1968).

In Trinidad Lake, Henderson County, Texas, blue tilapia were inadvertently introduced in the late 1960's. Since that time, the population has increased to nearly 2000 pounds per acre (unpublished data). Since 1972, population levels of blue tilapia and other species have been monitored by netting activities. Recruitment of northern largemouth bass, *Micropterus salmoides salmoides,* has apparently ceased to occur, and annual stocking of Florida largemouth bass, *M. salmoides floridanus,* since 1972 has failed to result in successful spawns, in spite of high survival, good growth, and rapid maturity by the introduced subspecies.

The objectives of this study were to elucidate the interactions of blue tilapia and largemouth bass through analysis of lake data on population changes and reproductive state, and to test, by an experiment in ponds, the hypothesis that high populations of tilapia inhibit reproduction of bass.

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