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RESULTS OF FISHERIES INVESTIGATIONS IN DOUGLAS TAILWATER AUGUST 1987 - SEPTEMBER 1988

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INTRODUCTION

Releases from Douglas Dam during July, August, and early September are characterized by low dissolved oxygen (DO), increased hydrogen sulfide, and until fall 1987, no minimum flow. These factors, singly or in combination, represent significant stressors on aquatic biota in the 32.2 mile tailwater (figure 1). A cooperative effort involving the Tennessee Valley Authority (TVA), Tennessee Division of Water Pollution Control, and Tennessee Wildlife Resources Agency (TWRA) is underway to improve water quality in the tailwater. A five-year minimum flow demonstration began October 1, 1987. To achieve a 300 cfs minimum flow at Saffell Island, 2.5 river miles downstream from Douglas Dam, one turbine in the 3,200 to 4,000 cfs range is pulsed for 35 to 45 minutes every four hours. In addition to minimum flow, surface water pumps and oxygen diffusers in front of the hydro unit intakes are being evaluated as ways to increase DO in the tailwater (Hauser et al. 1988).

During this five-year demonstration water quality monitoring and biological investigations will document changes and responses to increased minimum flow and improved water quality. Objectives of the biological investigations are to document: (1) changes, characteristics, and diversity of the fish community of the tailwater (figure 1) using the Index of Biotic Integrity (IBI), (2) spawning locations and movement patterns of sauger in the tailwater, (3) reproduction of sauger and other species in the tailwater, and (4) fishermen distribution and creel throughout the tailwater.

A declining sauger fishery in the tailwater was reported by Tomljanovich et al. (1987). Initial sauger investigations in 1986 were focused on potential toxicity of the tailwater to eggs, larvae, and adults. Follow up studies attempted to determine location of spawning reaches. Using radio telemetry in spring 1987, Woodward et al. (1988) concluded that sauger tended to congregrate at the base of the dam (FBRM 32.2) and in the lower reach of the tailwater (FBRMs 5-10). In that study none of the tagged sauger migrated from the lower end of the tailwater to the upper end, though fish tagged at the base of the dam did move down to the lower reach. This suggested two sources of sauger recruitment for the tailwater and that spawning occurs in a limited reach of the tailwater. A radio telemetry investigation was begun in winter 1988 and was aimed at further understanding sauger movement in the tailwater. This report presents results of IBI surveys conducted in the Douglas tailwater during 1987 and 1988 and sauger investigations, larval fish sampling, and fishermen surveys conducted in 1988.

METHODS AND MATERIALS

Index of Biotic Integrity

The Index of Biotic Integrity (IBI) is a method introduced by Karr (1981) for obtaining a general assessment of environmental quality at a given site by making a total of 12 measures (metrics) of species richness and composition (metrics 1-6), trophic structure (metrics 7-9), and abundance and condition (metrics 10-12) of individuals in the fish community

(table 1). Actual values obtained for each of these metrics reflect the condition of the fish community and are scored against values expected under pristine conditions (i.e., best expected value). Three potential scores are available for each metric based approximately on the percentage groups indicated: 1 (0-32 percent of the best expected value), 3 (33-64 percent), or 5 (65 percent or more). The 12 metric scores attained for a given site are summed to produce an index ranging from 12 to 60. The resultant index corresponds to a classification ranging from "No Fish" to "Excellent" (table 2). An integral part of IBI is the judgment used to set scoring criteria for the 12 metrics. Scoring criteria, and consequently the final index, rely upon existing data from the study region as well as the knowledge and experience of biologists performing the analysis.

Scoring criteria for the fish fauna metrics were set for Douglas tailwater and are presented with the results. Scoring criteria for metrics 1 through 5 were set according to a checklist of species either occurring or expected to occur (table 3). This information was drawn from various sources including Harned (1979), Lee et al. (1980), and miscellaneous unpublished TVA data. Designations of trophic guilds and tolerance (metrics 6 through 9) were derived from ecological information presented by Pfleiger (1975), Smith (1979), Lee et al. (Ibid.), and from experience and knowledge of TVA biologists. Scoring criteria for these metrics were derived from TVA fish data produced during the Cumberlandian Mollusk

Conservation Program (CMCP). Criteria for scoring catch rate (metric 10) were based on TVA data from CMCP, 1987 Holston River Fisheries Evaluation, and 1986-1987 Fixed Station IBI. Scoring criteria for percentages of hybridized, diseased, or otherwise anomalous fish (metrics 11 and 12) were modified slightly from those used by Karr et al. (1986).

Three sites selected for sampling included FBRM 29.8 (Saffell Island), FBRM 15.0 (Seven Islands), and FBRM 8.0 (Campbell Island). Because Saffell Island is located nearest the dam, it is expected to show maximum benefits from increased minimum flow. This site was sampled in 1987, before minimum flow was initiated, to obtain baseline data. All three sites were sampled in August of 1988 to obtain additional baseline data and to check for any changes at Saffell Island that might be related to minimum flow. Sampling in August 1987 and 1988 was designed to coincide with time of lowest oxygen levels in the tailwater. Also, sampling was less difficult during periods of minimum discharge from Douglas Dam.

A variety of methods were used to sample all available habitats and species. A 20- by 6-ft seine of 3/16-in mesh was used to sample shallow backwaters, pools, and runs and was also used with a backpack shocker to sample riffles and runs. In each riffle sample, an area approximately 20 ft by 15 ft was shocked in a downstream direction to capture fish drifting or driven into the stationary seine. Backpack electrofishing and dip nets were used to capture fish from around logs, boulders,

undercut banks, and brush piles in shallow water. Ten-minute shocking runs were made at midstream and along the shorelines of deep pools with a boat-mounted, 230 volt DC generator. Data were recorded and samples processed following procedures described by Saylor et al. (1988).

Fish were collected from all discernible habitat types within riffle, run, and pool areas (i.e., sand and gravel, rubble, bedrock, vegetation, etc.). To standardize sampling and assure that a high percentage of species present were collected, predominant habitat types of run, riffle, and pool areas (over five feet deep) were sampled until a minimum of three consecutive seine hauls, or 15 minutes of shoreline backpack shocking, or 20 minutes of pool shocking produced no new species. Additional sampling was done if deemed necessary by the crew leader.

Fish from each sample were sorted by species, counted, and recorded (large schools of gizzard shad were estimated). Young-of-year fish, which can affect the accuracy of the IBI, were omitted from the analysis, but were noted on the data sheet. Because these young fish had not been present for a full year and were more likely to drift or be displaced than adult fish, they may not have reflected perturbation. Average catch per effort (one seine haul or five minutes of shocking) was used to express catch rate (metric 10). Before releasing or preserving the fish, they were examined for hybridization, injuries, disease, and poor condition. Subsamples (10 or more specimens) of large numbers of gizzard

shad were used to estimate proportions of anomalous fish. Apparent hybrids that could not be positively identified in the field were taken to TVA's Aquatic Biology Laboratory in Norris for closer examination. Temperature, dissolved oxygen, pH, and conductivity were measured on the day of sampling using a Hydro Lab Surveyor II and procedures in TVA's Natural Resource Engineering Procedures Manual, Vol. I.

Sauger Movement

Sauger movement in Douglas tailwater and upper Fort Loudoun reservoir was monitored using radio telemetry. Ten sauger captured in gill nets at FBRM 0.0 (Forks of the River) on January 19, 1988, and five captured on February 24 were fitted with externally attached radio transmitters and released at the capture site. Twenty additional sauger from these gill net collections were marked with TVA numbered spaghetti tags and released. Radio telemetry equipment and method of transmitter attachment are described in Woodward et al. (1988). Each transmitter had a unique frequency in the 48 MHz range (table 4). Transmitter-carrying fish ranged in total length from 394 to 502 mm and in weight from 663 to 2,250 g. Sex could not be determined from external characteristics. Transmitter signal reception was verified before and after releasing the fish using a programmable scanning receiver and loop antenna.

Nineteen searches for tagged fish were made between January 28 and May 14 (table 5). Five searches were made using aircraft, one from the

shoreline, and 13 from a boat. Ten boat and two plane surveys covered the entire tailwater and upper few miles of Fort Loudoun Reservoir. Two plane searches covered the entire Douglas tailwater and all of Fort Loudoun Reservoir, and two boat and one plane surveys included the 32-mile reach of Douglas tailwater. The remaining two searches included a smaller portion of the tailwater. Search methods are described in Woodward et al. (1988).

Fish Reproduction

Fish eggs and larvae were sampled with push nets and light traps in a pool between FBRMs 3.3 and 4.5, approximately two river miles downstream of the shoal where the previous year's study suggested sauger spawned. Samples were taken during dark hours on April 19 and 25, May 10 and 23, and June 6.

One push net sample was taken along each shoreline and two in midchannel. Each ten-minute net run sampled all strata from just above the bottom to the surface. A flow meter mounted in the net allowed calculation of volumes filtered and densities of fish (numbers per 1000 m^3) in the water column. Sampling procedures are described in Field Operations Biological Resources Procedures Manual, Number NROPS-FO-BR-23.5. Light traps are passive samplers made of a 14-in length of 12-in diameter PVC pipe. Features of this device include four openings (windows) containing angled walls made of clear plastic that

form four funnels leading to the inside of the cylinder. Chemical light sticks are placed in the center of the cylinder to attract larvae to the inside, where they become trapped. A catch cup is attached at the bottom for concentrating and removing the larvae at the end of the sample.

Three light traps were fished during the push net sampling to provide supplementary data on species present. One trap was placed near each shoreline within the push net sampling area and one on the shoal just downstream. Contents from each push net and light trap sample were preserved in formalin and taken to the laboratory for processing and identification as described in Field Operations Biological Resources Procedures Manual, Number NROPS-FO-BR-24.1.

Creel Survey/Pressure Count

Fishermen pressure counts were made on Douglas tailwater during November 1987 through September 1988 either by aerial survey or during creel surveys done from a boat (table 6). Seven aerial pressure counts were flown using fixed wing aircraft at low altitude during the mornings, preferably on Saturday with Sunday as an alternate. During the flight or float numbers of all bank and boat fishermen were recorded by location within the following tailwater areas: FBRMs 0-5, 5-10, 10-15, 15-20, 20-25, 25-30, and 30-32.2 (Douglas Dam).

Eighteen creel surveys were conducted by floating the entire 32-mile tailwater. Creel data were obtained only from the lower 30 miles, since

the TWRA was creeling fisherman at the base of the dam. However, fishermen at the dam could be seen from the boat launch site and were included in the pressure counts. When fishing pressure was light all bank and boat fishermen were interviewed; when fishing pressure was heavy, every other boat and every bank fisherman were creeled. Fishermen were asked what species they were fishing for, how long they had been fishing, and how many and what kind of fish they had caught. If they had caught any sauger, total length and scale samples (for age and growth analysis) were requested.

RESULTS AND DISCUSSION

Index of Biotic Integrity

Saffell Island, 1987--Water quality measurements, 35 minutes of backpack shocking, and 12 seine samples were completed at Saffell Island on August 6, 1987, and 90 minutes of boat shocking were done the following day. Despite zero turbine discharge approximately 50 cfs leakage provided a riffle. Water temperature was 22.5 C and DO was 2.5 to 1.7 mg/L (table 7). Conductivity and pH were within the range of expected values for unimpacted conditions. Measurements taken during July and August by personnel from TVA's Natural Resource Engineering section showed DO greater than 2.0 mg/L even during full discharge.

An IBI of 28 rated a "Poor" classification (table 8). Metric values and scoring (table 9) indicated a severely impacted fish fauna with problems

occurring primarily in species richness and composition and in trophic structure. Native species numbered far less than expected. Darters and intolerant species were absent, and number of sucker species was low. Tolerant and omnivorous species, particularly gizzard shad, were dominant. Specialized insectivorous minnows and darters were represented by only a few blackstripe topminnows.

Aside from these conspicuous disorders in the fish community, the number of sunfish species (less Micropterus sp.), and proportion of piscivores were only moderately below expectations. No hybrids were found, but eight fish were observed with lesions. Fish abundance was excellent, but was based primarily on large schools of gizzard shad in the pool area downstream of Saffell Island. The riffle area, which should have been the most productive fish habitat, had no fish. Catch rate was higher than at the three sites sampled in 1988.

Saffell Island, 1988--Ninety minutes of boat shocking on August 23, 1988, was followed three days later by water quality measurements, 10 minutes of backpack shocking, and 23 seine samples. Minimum flow increased the area of riffle and run habitat compared to the 1987 sampling. Water quality readings (table 7) were similar to those recorded during 1987. Dissolved oxygen had improved by approximately 1 ppm (3.7 mg/L on the surface) but was still far below levels suitable for survival of much of the native fauna.

The 1988 survey (table 8) showed no meaningful difference from 1987. A slightly lower index of 26 produced a classification between "Very Poor" and "Poor". Metric values and scores (table 9) indicated that the fish fauna continued to have serious problems in species richness and composition and in trophic structure. Minor differences in species occurrence included the addition of black crappie, which produced a high score (5) for metric 3 (number of native sunfish).

Hybridization and fish condition worsened in 1988. Proportion of gizzard shad x threadfin shad hybrids in the 1988 sample was slightly excessive (0.8 percent). Occurrence of fin damage, scale deformities, and lesions among fish sampled, especially gizzard shad, was also at an unhealthy level (4.8 percent). Other maladies included parasitism of sunfish by leeches and anchor worms.

Catch rate in 1988 (17.2) was sufficient to receive a high score but was considerably less than the catch rate of 1987 (32.2). Gizzard shad, the most abundant species collected in both years, showed the greatest decrease in numbers. Fish abundance remained extremely low in run and riffle habitats.

Seven Islands, 1988--Water quality measurements, 30 minutes of backpack shocking, and 37 seine samples were completed at Seven Islands on August 19, 1988, and 90 minutes of boat shocking the following day.

During this sampling, considerable flow occurred covering most of the river bed at this site. Almost all run and riffle areas, however, could be waded and sampled. Water temperature was 27 C and DO was 7.0-7.1 mg/l (table 7). The IBI of 22 (table 8) was classified "Very Poor" and was the lowest index for the study. Disorder in species richness and composition (table 9) was principally responsible. Metric values for numbers of native species, darter species, intolerant species, and proportion of tolerant species were slightly better than Saffell Island values but not great enough to increase metric scores. Number of sucker species and number of native sunfish species was unusually low. Other contributors to the low index were low catch rate; high incidence of leech infestation among sunfish and darters; and fin rot, lesions, and deformities.

Compared to Saffell Island, Seven Islands fish fauna exhibited signs of recovery in trophic structure, evidenced by modest improvement in the balance between the proportions of omnivores and specialized insectivorous minnows and darters. Proportion of piscivores continued to be moderately low. Absence of hybrids resulted in the only high score for the site.

Campbell Island, 1988--Water quality measurements, 25 minutes of backpack shocking, and 37 seine samples were completed at Campbell Island on August 16, 1988, followed one day later by 140 minutes of boat shocking. Flow at this site covered the river bed and made some run and riffle

areas impassible to waders; however, extensive areas of workable run and riffle were available.

Water temperature was cool (23.7 C), and DO was 4.9 to 5.0 mg/l (table 7). The cause of lower DO at this site compared to upstream at Seven Islands is unknown. At any rate, even periodic low DO could impact the fish fauna.

An IBI index of 34 is classified "Poor", although it was the highest index attained in the tailwater. Species richness and composition and trophic structure continued to suffer the most impairment. Numbers of native species, darter species, and intolerant species were only moderately low. Numbers of native sunfish and sucker species, however, were still exceptionally low, and proportion of tolerant species remained at an unhealthy level. Trophic structure showed moderate imbalance at all levels. Proportions of specialized insectivores and piscivores were somewhat low, and proportion of omnivores was slightly elevated.

Catch rate was somewhat less than normal for unimpacted conditions but indicated an improvement over fish abundance at Seven Islands. No hybrids were observed, and proportion of fish with anomalies was low, resulting in a score of 5 for each metric.

Sauger Movement

During the three and one half month tracking period, transmitter-tagged sauger were only found within 6.5 river miles upstream or downstream of

the release site at FBRM 0.0 (table 10). A typical movement pattern was to first move downstream a few river miles, reside there for a period of time, and then move upstream. This pattern was also found for sauger in the previous year (Woodard et al. 1988).

Two of the 15 tagged fish were not found after being released. Of the remaining 13 fish, 11 were first located downstream of the release point (table 10). Four of these 11 fish were never found in the French Broad River upstream of the release site. A fifth individual moved upstream, then returned downstream. The six remaining fish moved upstream into the French Broad River to reside between FBRMs 1.0 and 6.5. Two individuals were initially found upstream after being tagged. One consistently but slowly moved from FBRM 0.0 to FBRM 4.0 between January 27 and April 25.

No fish were located after April 25. Spawning should have been completed by this time, and the fish probably had returned to Fort Loudoun Reservoir. Also, by this time batteries in the tags could have expired.

Results of this tagging study confirmed the previous year's findings, that sauger did not migrate upstream beyond the first two major shoal areas of the tailwater. The preferred reach of river was between FBRMs 4.0 and 5.6. Also, as in the previous year, none moved into the Holston River.

Fish Reproduction

Push net and light trap sampling for fish eggs and larvae yielded 12 and 10 taxa, respectively (table 11). Push nets captured 3,742 larvae compared to 162 with light traps. Light traps were most effective at capturing darters (91 percent of total light trap catch), particularly Tennessee snubnose darters. Shad (Clupeidae) and white/yellow bass larvae (Morone) comprised 69 and 25 percent respectively of push net samples. Darters comprised 3 percent of the total number, and remaining species comprised less than 1 percent. No sauger larvae were taken in either light trap or push net samples.

Egg densities in push net samples ranged from 12 to 2,169 per 1,000 m^3, and larval densities from 31 to 2,251 individuals per 1,000 m^3 (table 12). Densities were greatest on May 10 for both eggs and larvae. Eggs and shad larvae showed a similar trend in abundance during the sampling period, suggesting that the majority of the unidentifiable eggs were shad eggs. White/yellow bass densities were greatest on the first and second sample dates. Highest catch per effort in light traps was 5.7 fish per hour for all taxa (table 13).

Size of larvae, known larval fish growth rates, and flow rate can be used to help determine where hatching occurred. All shad larvae were 3 to 5 mm total length, and all white/yellow bass were 3 mm, or near their hatching size (table 11), indicating these larvae most likely hatched in Douglas tailwater and not in Douglas Reservoir.

Creel Survey/Pressure Count

Twenty-seven pressure counts recorded a total of 1,199 fishermen on Douglas tailwater between November 28, 1987, and September 24, 1988. Of this total, 785 individuals were fishing from boats and the remaining 414 from the shoreline. Number of fishermen ranged from 0 on February 4 to 128 on May 7, with highest counts occurring between early April and mid-May (figure 2). This period of the year coincides with the presence of sought-after, migratory species, principally white bass and sauger.

Fishing pressure was clustered at the upper and lower ends of the tailwater (figure 3). Forty-seven percent of the boat fishermen were observed in the lower ten river miles and 29 percent in the upper seven river miles. Similarly, 46 percent of bank fishermen were observed in the lower 10 river miles and 29 percent in the upper two river miles. These two areas coincided with access for boaters and bank fishermen. Shallow water over shoal areas restricts boaters from utilizing some reaches of the tailwater that do not have a launching ramp.

Forty-nine percent (584) of the fishermen counted were creeled. They were either fishing specifically for one of nine species (target species) or any species they could catch (table 14). The most sought after species was white bass (38 percent of fishermen) followed by any species (24 percent), crappie (12 percent), catfish (9 percent), sauger (6 percent), black bass (5 percent), sunfish (4 percent), skipjack

herring (less than 1 percent), carp (less than 1 percent), and striped bass (less than 1 percent). The most successful fishermen (success defined as catching at least one individual of a target species) were those fishing for sunfish (83 percent of fishermen), white bass (67 percent), any fish (64 percent), black bass (58 percent), and sauger (53 percent).

A total of 1,466 target fish were caught by the 584 anglers creeled. Total fishing time was 1,365.7 hours, yielding an average catch of 1.1 target species per hour. Highest catch per hour for a target species was for sunfish (1.8) followed by white/yellow bass (1.5) and any species (1.4). The remaining species were caught at a rate of less than one fish per hour (table 14). Nontarget species were caught incidental to the target species. Total number of target and nontarget fish caught by the 584 anglers was 2,296 fish for a catch rate of 1.7 fish per hour.

Catch distribution throughout the tailwater (table 15) reflects angler distribution (figure 3). Creel data taken at the stilling basin by the TWRA are not included in this report. Monthly catch data (table 16) reflects the monthly pressure count pattern in figure 2. Forty-nine percent of the fish were caught in April and 20 percent in May, demonstrating the strong seasonal nature of the fishery and its dependence upon migratory species.

SUMMARY AND CONCLUSIONS

IBI analysis showed a strongly disturbed, altered fish community in Douglas tailwater under present water quality and flow regimes. No improvement in the fish fauna was detected at Saffell Island (FBRM 29.8) from 1987 to 1988. Indices of 28 in 1987 and 26 in 1988 classified this site as "Poor" and "Very Poor to Poor", respectively. Serious problems existed in species richness and composition and trophic structure.

Relatively high catch rates were were due mainly to an over-abundance of tolerant and omnivorous fish typically associated with a stressed environment. The slight difference in the two IBIs was due to higher proportions of hybrid fish and proportions of fish with disease and parasites in the 1988 sample. While minimum flow (initiated in October 1987) appeared to increase the amount and variety of fish habitat, DO (2.5 to 3.7 mg/l during sampling) probably was inadequate to support most native fish species.

IBI surveys at Seven Islands (FBRM 15.0) and Campbell Island (FBRM 8.0) during 1988 indicated that severe impacts have occurred to the native fish that would typically inhabit the 22 river miles encompassed by the sample sites. Seven Islands produced the lowest IBI (22) of the study, and rated a classification of "Very Poor". Compared to findings from Saffell Island, there were slight improvements in species richness and composition and trophic structure. These advances were negated by abnormally low fish abundance and an excessive proportion of anomalous fish.

Campbell Island exhibited only marginal improvement from upstream sites, attaining an IBI of 34. Although this site received the highest index of the tailwater, it rated the same "Poor" classification as Saffell Island and was characterized by a badly disturbed fish fauna. Problems persisted mostly in species richness and composition, although modest gains were evident in numbers of native species, darter species, and intolerant species. Trophic structure was moderately unbalanced at all levels. Fish abundance was also somewhat below expectation. Fish health and level of hybridization were normal.

Minimum flows initiated in 1987 appeared to enhance fish habitat at all three sites, evidenced by extensive run and riffle areas and increased availability of shoreline cover. Fish in the first few miles of tailwater downstream from the Dam, including Saffell Island, should benefit most from minimum flows. However, poor water quality may remain a limiting factor for many species in this immediate tailwater reach. Furthermore, moderately low DO (4.9 - 5.0 mg/L) and cool water temperatures (23.7 C) at Campbell Island suggested continued water quality impairment at this station some 24 miles below Douglas Dam.

Continued improvements in physical habitat and water quality should result in recovery of some riverine fish fauna. This recovery may require a minimum of two years and will probably be detected first in the lower reaches of the tailwater, where a combination of acceptable flows and water quality are most likely to be first attained.

For the second consecutive year radio tagged sauger did not migrate upstream beyond the lower reach of Douglas tailwater. Because sauger are known to migrate relatively long distances and even travel through navigation locks, it is concluded that the lower shoal and pool area of Douglas tailwater contains preferred spawning habitat for this species.

The source(s) of sauger that are present in the stilling basin of Douglas Dam during late winter and spring is still unresolved. One probable source is recruitment of adults to the tailwater via dam passage. If a significant proportion of sauger in the tailwater are from Douglas Reservoir, the observed decline in the tailwater fishery may be directly related to mechanisms within the reservoir which affect spawning success and survival of egg, larval, and juvenile sauger.

Absence of sauger eggs and larvae in larval fish samples in 1988 does not rule out a successful spawn. Probability of catching sauger larvae is low based on: (1) relatively limited sampling done in Douglas tailwater and (2) past TVA larval fish sampling experience at several locations, including the spawning site of a relatively large population of sauger (Hevel, personal communication). Nevertheless, successful spawning was documented for other percids (darters) and for several other species, particularly white/yellow bass and shad. These results indicate water quality is not limiting to all fish reproduction. The question still remains if other factors are limiting sauger reproduction, including flows, substrate, and predation on eggs and larvae.

Pressure count and creel data indicated that Douglas tailwater is an important fishery resource, particularly seasonally during April and May, when migratory fish are present. Improvement in summertime water quality, especially in the upper tailwater should lead to increased abundance of non-migratory game fish and increased fishing pressure.

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Table 1. Metric scoring criteria used in calculating Index of Biotic Integrity*. Criteria are set using values expected under unaltered or pristine conditions for the lower French Broad River.

Species richness and composition	Scoring 1	3	5
1. Number of native species.	<26	26 - 50	>50
2. Number of darter species.	<5	5 - 8	>8
3. Number of native sunfish species (excluding Micropterus sp.).	<3	3 - 4	>4
4. Number of sucker species.	<5	5 - 8	>8
5. Number of intolerant species.	<2	2 - 3	>3
6. Percentage of individuals as tolerant species.	>20%	20% - 10%	<10%
Trophic structure			
7. Percentage of individuals as omnivores.	>30%	30% - 15%	<15%
8. Percentage of individuals as specialized insectivorous minnows and darters.	<25%	25% - 50%	>50%
9. Percentage of individuals as piscivores.	<2%	2% - 5%	>5%
Fish abundance and condition			
10. Catch rate (average number per seine haul or five minutes of shocking).	<9	9 - 16	>16
11. Percentage of individuals as hybrids.	>1%	1% - Tr**	<Tr
12. Percentage of individuals with poor condition, injury, deformity, disease, or other anomaly.	>5%	5% - 2%	<2%

*Each is assigned a score as follows: 1-poor, 3-intermediate, 5-the best to be expected. The IBI for a given site is the sum of those values.
**A value between 1 and 0.5.

Table 2. Classifications for indices of biotic integrity used in assessing fish communities along with general descriptions of their attributes (Karr et al. 1986).

Class	Attributes	IBI Range
Excellent	Comparable to the best situations without influence of man; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with full array of age and sex classes; balanced trophic structure.	58-60
Good	Species richness somewhat below expectation, especially due to loss of most intolerant forms; some species with less than optimal abundances or size distribution; trophic structure shows some signs of stress.	48-52
Fair	Signs of additional deterioration include fewer intolerant forms, more skewed trophic structure (e.g., increasing frequency of omnivores); older age classes of top predators may be rare.	39-44
Poor	Dominated by omnivores, pollution-tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.	28-35
Very Poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular.	12-22
No fish	Repetitive sampling fails to turn up any fish.	

Table 3. Native fish species expected to occur in the lower French Broad River under unimpacted conditions.

Scientific Name	Common Name
Ichthyomyzon bdellium	Ohio lamprey
I. castaneus	Chestnut lamprey
Lampetra appendix	American brook lamprey
Lepisosteus oculatus	Spotted gar
L. osseus	Longnose gar
Alosa chrysochloris	Skipjack herring
Dorosoma cepedianum	Gizzard shad
D. petenense	Threadfin shad
Hiodon tergisus	Mooneye
Campostoma anomalum	Central stoneroller
Hybopsis aestivalis	Speckled chub
H. amblops	Bigeye chub
H. insignis	Blotched chub
H. monacha	Spotfin chub
H. storeriana	Silver chub
Nocomis micropogon	River chub
Notropis atherinoides	Emerald shiner
N. chrysocephalus	Striped shiner
N. coccogenis	Warpaint shiner
N. galacturus	Whitetail shiner
N. leuciodus	Tennessee shiner
N. photogenis	Silver shiner
N. rubellus	Rosyface shiner
N. spilopterus	Spotfin shiner
N. telescopus	Telescope shiner
N. volucellus	Mimic shiner
N. whipplei	Steelcolor shiner
Phenacobius uranops	Stargazing minnow
Pimephales notatus	Bluntnose minnow
P. vigilax	Bullhead minnow
Carpiodes carpio	River carpsucker
C. cyprinus	Quillback
C. velifer	Highfin carpsucker
Cycleptus elongatus	Blue sucker
Hypentelium nigricans	Northern hog sucker
Ictiobus bubalus	Smallmouth buffalo
I. niger	Black buffalo
Minytrema melanops	Spotted sucker
Moxostoma anisurum	Silver redhorse
M. carinatum	River redhorse
M. duquesnei	Black redhorse
Moxostoma erythrurum	Golden redhorse
M. macrolepidotum	Shorthead redhorse
Ictalurus furcatus	Blue catfish

Table 3. Continued.

Scientific Name	Common Name
I. melas	Black bullhead
I. natalis	Yellow bullhead
I. punctatus	Channel catfish
Noturus eleutherus	Mountain madtom
Pylodictus olivaris	Flathead catfish
Fundulus catenatus	Northern studfish
F. notatus	Blackstripe topminnow
Labidesthes sicculus	Brook silverside
Ambloplites rupestris	Rock bass
L. cyanellus	Green sunfish
L. gulosus	Warmouth
L. macrochirus	Bluegill
L. megalotis	Longear sunfish
Micropterus dolomieui	Smallmouth bass
M. punctulatus	Spotted bass
M. salmoides	Largemouth bass
Pomoxis annularis	White crappie
P. nigromaculatus	Black crappie
Etheostoma blennioides	Greenside darter
E. camurum	Bluebreast darter
E. jessiae	Blueside darter
E. kennicotti	Stripetail darter
E. maculatum	Spotted darter
E. ruflineatum	Redline darter
E. simoterum	Tennessee snubnose darter
E. zonale	Banded darter
Percina aurantiaca	Tangerine darter
P. burtoni	Blotchside logperch
P. caprodes	Logperch
P. evides	Gilt darter
P. macrocephala	Longhead darter
P. sciera	Dusky darter
P. shumardi	River darter
Stizostedion canadense	Sauger
S. vitreum	Walleye
Aplodinotus grunniens	Freshwater drum
Cottus carolinae	Banded sculpin

Table 4. Transmitter frequency, fish size, and capture/release date of sauger fitted with radio tags at French Broad River Mile 0.0.

Transmitter Frequency (MHz)	Length (mm)	Weight (g)	Date Tagged
48.081	398	663	02-24-88
48.190	494	1,402	01-19-88
48.209	410	766	02-24-88
48.230	502	1,403	01-19-88
48.252	437	860	01-19-88
48.272	472	1,207	01-19-88
48.362	427	896	01-19-88
48.500	413	737	01-19-88
48.531	410	731	01-19-88
48.549	394	726	01-19-88
48.571	411	666	02-24-88
48.669	417	833	02-24-88
48.691	560	2,250	01-19-88
48.710	420	782	02-24-88
48.754	445	1,070	01-19-88

Table 5. Dates and locations of searches for radio-tagged sauger in Douglas tailwater, January - May 1988.

Date	River Miles Searched	Search Method
1-27-88	FBRM 0.0 (TRM 652.0)	Shoreline
1-28-88	Douglas Dam to TRM 649.0	Boat
2-04-88	Douglas Dam to TRM 651.2	Boat
2-09-88	Douglas Dam to Ft. Loudoun Dam	Airplane
2-25-88	Douglas Dam to Ft. Loudoun Dam	Airplane
2-27-88	Douglas Dam to TRM 649.0	Boat
3-05-88	Douglas Dam to TRM 651.0	Boat
3-12-88	Douglas Dam to FBRM 0.0	Boat
3-20-88	Douglas Dam to FBRM 0.0	Airplane
3-26-88	Douglas Dam to TRM 649.0	Boat
4-02-88	Douglas Dam to TRM 651.0	Airplane
4-09-88	Douglas Dam to TRM 649.5	Boat
4-15-88	FBRM 5.5 to TRM 643.4	Boat
4-23-88	Douglas Dam to TRM 649.0	Boat
4-25-88	FBRM 0.0 to FBRM 5.9	Boat
4-30-88	Douglas Dam to TRM 649.0	Boat
5-05-88	FBRM 10.0 to TRM 635.0	Airplane
5-07-88	Douglas Dam to TRM 649.0	Boat
5-14-88	Douglas Dam to FBRM 0.0	Boat

Table 6. Schedule of pressure counts and creel surveys conducted on Douglas tailwater between November 1987 and September 1988.

Date	Day	Pressure Count	Creel Survey	Survey Method
11-28-87	Sat	X		Aerial
11-29-87	Sun		X	Float
12-19-87	Sat	X	X	Float
01-16-88	Sat	X	X	Float
01-28-88	Thu	X		Float
02-04-88	Thu	X		Float
02-27-88	Sat	X	X	Float
03-05-88	Sat	X	X	Float
03-12-88	Sat	X	X	Float
03-20-88	Sun	X		Aerial
03-26-88	Sat	X	X	Float
04-02-88	Sat	X	X	Float
04-09-88	Sat	X	X	Float
04-23-88	Sat	X	X	Float
04-30-88	Sat	X	X	Float
05-07-88	Sat	X	X	Float
05-14-88	Sat	X	X	Float
05-21-88	Sat	X		Aerial
06-04-88	Sat	X	X	Float
06-18-88	Sat	X		Aerial
06-25-88	Sat	X	X	Float
07-09-88	Sat	X	X	Float
07-16-88	Sat	X	X	Float
07-24-88	Sun	X		Aerial
08-06-88	Sat	X	X	Float
08-28-88	Sun	X		Aerial
09-24-88	Sat	X		Aerial

Table 7. Hydro Lab readings taken in conjunction with four IBI samples in Douglas tailwater.

Site/ Sample date	Depth (M)	Temperature (C)	pH (S.U.)	Conductivity (umhos/cm)	DO (mg/L)
Saffell Is.	0.3	22.6	6.7	142	2.5
(FBRM 30)	1.0	22.5	6.4	142	2.0
8-06-87	2.0	22.5	6.3	142	1.8
	2.1	22.5	6.3	142	1.7
Saffell Is.	0.3	23.4	6.3	212	3.7
(FBRM 30)	1.0	23.0	6.5	214	2.6
8-26-88	2.0	22.8	6.5	213	2.5
	2.4	22.8	6.5	213	2.5
Seven Is.	0.3	27.0	7.6	196	7.1
(FBRM 15)	0.5	27.0	7.6	206	7.0
8-18-88					
Campbell Is.	0.3	23.7	7.1	196	5.0
(FBRM 8)	0.6	23.7	7.0	196	4.9
8-16-88					

Table 8. Fish collected during Douglas tailwater IBIs with species designations as tolerant (1), intolerant (2), introduced (3), omnivore (4), specialized insectivore (5), and piscivore (6).

Common name	Saffell Island 1987	Saffell Island 1988	Seven Islands 1988	Campbell Island 1988
Spotted gar (6)	-	-	3	1
Longnose gar (1 & 6)	-	-	-	1
Gizzard shad (1 & 4)	1,000	641	49	115
Threadfin shad	-	7	17	2
(hybrid shad)	-	1	-	-
Common carp (1, 3 & 4)	73	41	13	29
Bigeye chub (5)	-	4	-	-
Speckled chub (5)	-	-	-	44
River chub (1 & 4)	-	-	1	67
Whitetail shiner	-	-	-	2
Spotfin shiner (1)	-	7	15	102
Steelcolor shiner	-	-	-	2
Bluntnose minnow (4)	-	-	1	6
Blacknose dace	-	-	-	1
Northern hog sucker (2)	-	-	5	88
Smallmouth buffalo	23	26	8	4
Black buffalo	4	5	-	-
River redhorse	-	-	-	2
Golden redhorse	-	-	-	2
Shorthead redhorse	2	-	-	-
Blue catfish (6)	2	2	-	-
Channel catfish (4)	-	-	1	5
Mountain madtom (2 & 5)	-	-	-	1
Mosquitofish (1 & 3)	-	-	1	4
Brook silverside (5)	-	-	-	2
Blackstriped topminnow (5)	5	-	-	-
White bass (3 & 6)	5	4	-	1
Yellow bass (3 & 6)	10	-	-	2
Rock bass (6)	-	-	6	7
Redbreast sunfish (3)	14	20	17	56
Green sunfish (1)	1	1	-	-
Warmouth	12	5	-	-
Bluegill	28	10	17	14
Redear sunfish (3)	2	1	1	1
Smallmouth bass (6)	-	-	1	-
Spotted bass (6)	2	-	5	22
Largemouth bass (6)	3	10	-	-
White crappie (6)	2	3	-	-

Table 8. continued.

Common name	Saffell Island 1987	Saffell Island 1988	Seven Islands 1988	Campbell Island 1988
Black crappie (6)	-	2	-	-
Redline darter (5)	-	-	22	162
Tennessee snubnose darter (5)	-	-	50	18
Banded darter (5)	-	-	10	2
Logperch (5)	-	-	2	8
Snail darter (3 & 5)	-	-	-	5
Banded sculpin	3	-	52	25
Freshwater drum	-	2	6	9
Total	1,191	792	303	812

Table 9. Values, scores, and indices for Douglas tailwater IBI sites, 1987 and 1988.

Metrics	Saffell Island 1987 value	score	Saffell Island 1988 value	score	Seven Islands 1988 value	score	Campbell Island 1988 value	score
1. Total number of native fish species.	13	1	14	1	19	1	30	3
2. Number of darter species.	0	1	0	1	4	1	5	3
3. Number of native sunfish species (less *Micropterus* sp.).	4	3	5	5	2	1	2	1
4. Number of sucker species.	3	1	2	1	2	1	4	1
5. Number of intolerant species.	0	1	0	1	1	1	2	3
6. Percentage of individuals as tolerant species.	90.2%	1	87.1%	1	26.1%	1	39.2%	1
7. Percentage of individuals as omnivores.	90.1%	1	86.1%	1	21.5%	3	27.3%	3
8. Percentage of individuals as specialized insectivorous minnows and darters.	0.4%	1	0.5%	1	27.7%	3	30.4%	3
9. Percentage of individuals as piscivores.	3.0%	3	3.3%	3	4.9%	3	4.2%	3
10. Catch rate (average number per unit of sampling effort).	32.2	5	17.2	5	5.0	1	11.6	3
11. Percentage of individuals as hybrids.	0.0%	5	0.8%	3	0.0%	5	0.0%	5
12. Percentage of individuals with disease, injury, deformity, and other anomalies.	0.6%	5	4.8%	3	6.6%	1	1.9%	5
IBI INDEX*		28		26		22		34

*See Table 2 for classification.

Table 10. Location of radio-tagged sauger on 19 search days between January 27 and May 14, 1988 on Douglas tailwater and upper Tennessee River.

Transmitter Frequency (MHz)	Date																	
	Jan 27	Jan 28	Feb 04	Feb 09	Feb 25	Feb 27	Mar 05	Mar 12	Mar 20	Mar 26	Apr 02	Apr 09	Apr 15	Apr 23	Apr 25	Apr 30	May 05	May 07	May 14
48.081	-	-	-	-	-	-	-	-	-	652.5	651.0	-	651.2	-	-	-	-	-	-
48.190	-	649.7	651.6	-	-	651.2	-	-	-	-	-	-	1.0	-	-	-	-	-	-
48.209	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48.230	-	-	-	-	-	651.1	1.8	-	-	-	651.5	-	-	-	-	-	-	-	-
48.252	-	-	-	-	-	651.5	1.8	1.6	3.5	5.0	-	-	5.6	-	-	-	-	-	-
48.272	-	649.3	651.2	-	-	0.2	1.8	2.3	1.8	4.8	-	-	-	-	-	-	-	-	-
48.362	-	-	651.9	651.9	0.0	2.1	2.5	2.8	3.0	4.7	-	-	-	-	-	-	-	-	-
48.500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48.531	-	-	-	651.6	-	651.5	-	-	-	650.9	651.0	-	646.0	-	-	-	-	-	-
48.449	-	651.2	-	650.6	-	-	-	6.5	4.3	5.5	-	-	-	-	-	-	-	-	-
48.571	-	-	-	-	-	649.4	-	-	-	-	-	-	-	-	-	-	-	-	-
48.669	-	-	-	-	-	-	-	-	-	0.1	-	-	651.2	-	-	-	-	-	-
48.691	-	651.8	652.0	652.0	0.0	2.1	4.0	4.5	4.0	4.5	-	4.0	4.9	-	4.9	-	-	-	-
48.710	-	-	-	-	-	651.0	651.0	-	-	-	-	-	-	-	-	-	-	-	-
48.754	0.0	0.0	0.1	0.4	-	1.5	1.7	2.0	2.0	3.5	-	4.0	4.0	-	4.0	-	-	-	-

Note: River miles 646 to 652 are Tennessee River and river miles 0.0 to 6.5 are French Broad River.

Table 11. Species list, percent composition, and length frequencies of fish larvae sampled with push nets and light traps at French Broad Mile 4.0, 1988.

Taxon	Size class (mm)															Totals	Percent Comp.
	3	4	5	6	7	8	9	10	11	12	13	14	15	16-20	20		
Push Net Samples																	
Unidentifiable fish larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0.75
Clupeidae	86	2510	3	0	0	0	0	0	0	0	0	0	0	0	0	2599	69.45
Gizzard shad	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.03
Mooneye	0	0	0	0	0	0	2	1	1	2	0	0	0	0	0	6	0.16
Carp	0	0	1	14	8	1	0	0	0	0	0	0	0	0	0	24	0.64
Buffalo	0	0	0	0	2	2	2	1	0	0	0	0	0	0	0	7	0.19
Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
White/yellow bass	954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	954	25.49
Unidentifiable darter	0	0	0	11	55	40	11	2	0	0	0	0	0	0	0	119	3.18
Greenside darter	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.03
Tennessee snubnose darter	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	2	0.05
Banded sculpin	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0.03
																3,742	
Light Trap Samples																	
Cyprinidae	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0	6	3.70
Carp	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	1.23
Buffalo	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	1.23
Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.62
Lepomis sunfish	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.62
Largemouth/spotted bass	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	1.23
Unidentifiable darter	0	0	0	0	3	30	23	4	2	1	0	0	0	0	0	63	38.89
Greenside darter	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.62
Tennessee snubnose darter	0	0	6	15	5	12	5	14	11	4	5	0	1	3	2	83	51.23
Banded sculpin	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0.62
																162	

Table 12. Densities of fish eggs and larvae in push net samples from French Broad River Mile 4.0 on five nights in 1988.

Taxon	Density (Number per 1000 m^3)				
Sample date	4/18	4/25	5/10	5/23	6/07
Eggs					
Unidentifiable fish eggs	35.5	10.1	2168.9	1457.8	181.4
Clupeidae	0.0	1.7	0.0	0.0	0.0
White/yellow bass	1.9	0.0	0.0	0.0	0.0
Total density	37.4	11.8	2168.9	1457.8	181.4
Larvae					
Unidentifiable fish larvae	0.0	47.2	0.0	0.0	0.0
Clupeidae	9.4	862.4	2093.0	1428.6	15.3
Gizzard shad	1.9	0.0	0.0	0.0	0.0
Mooneye	0.0	0.0	5.1	5.2	0.0
Carp	0.0	0.0	18.5	22.3	0.0
Buffalo	0.0	6.7	1.7	0.0	3.8
White/yellow bass	525.3	987.0	55.6	89.3	3.8
Unidentifiable darter	61.7	25.3	77.5	37.8	5.7
Greenside darter	0.0	1.7	0.0	0.0	0.0
Tennessee snubnose darter	0.0	1.7	0.0	0.0	1.9
Banded sculpin	1.9	0.0	0.0	0.0	0.0
Total density	600.2	1931.0	2251.4	1583.2	30.5
Total vol. filtered (m^3)	535	594	593	582	524
Water temperature (C)	14.1	17.8	20.0	20.3	21.0

Table 13. Catch per hour of fish larvae in light trap samples from French Broad River Mile 4.0 on five nights in 1988.

Taxon	Catch rate (Number per hour)				
Sample date	4/18	4/25	5/10	5/23	6/07
Cyprinidae	0.0	0.0	0.1	0.0	0.4
Carp	0.0	0.0	0.1	0.1	0.0
Buffalo	0.0	0.0	0.1	0.0	0.1
Redhorse	0.0	0.0	0.0	0.0	0.1
Lepomis sunfish	0.0	0.0	0.0	0.0	0.1
Largemouth/spotted bass	0.0	0.0	0.0	0.0	0.2
Unidentifiable darter	0.3	0.2	2.7	1.6	1.6
Greenside darter	0.0	0.1	0.0	0.0	0.0
Tennessee snubnose darter	0.4	0.3	2.6	3.6	1.5
Banded sculpin	0.1	0.0	0.0	0.0	0.0
Total catch	0.8	0.6	5.6	5.3	4.0
Total effort (hrs)	9.0	9.4	8.5	10.4	11.4

Table 14. Results of Douglas tailwater creel conducted between November 1987 and August 1988. Data include targeted species only.

	Target Species (species specifically sought by fisherman)*										
	Any Species	Skipjack Herring	Carp	Catfish	Striped Bass	White Bass	Black Bass	Bluegill/ Sunfish	Crappie	Sauger	Total
Total anglers	140	4	4	52	3	221	31	24	71	34	584
(percent)	(24)	(<1)	(<1)	(9)	(<1)	(38)	(5)	(4)	(12)	(6)	(100)
Successful anglers†	89	2	1	17	0	147	18	20	33	18	345
(percent)	(64)	(50)	(25)	(33)	(00)	(67)	(58)	(83)	(46)	(53)	(959)
Target-hrs fished	290.0	6.1	5.0	92.6	1.5	497.5	95.3	61.8	157.1	158.4	1,365.7
Target catch††	397	5	2	16	0	743	27	109	107	60	1,466
Target catch/hr.	1.4	0.8	0.4	0.2	0.00	1.5	0.3	1.8	0.7	0.4	1.1

* Example of fish not included in table: white bass caught by fisherman fishing only for sauger.
† Those anglers that caught 1 or more target fish.
†† Total number of target fish caught.

Table 15. Results of Douglas tailwater creel survey conducted between November 1987 and August 1988. Numbers denote catch of major species by five-mile intervals.

	French Broad River Miles						
	0-5	5-10	10-15	15-20	20-25	25-30	30-Dam*
Skipjack	138	311	10			1	
Carp	5	5				1	
Catfish	5	12	5		5		
White/Yellow Bass	514	351	3		12	258	
Bluegill/Sunfish	60	42	50	49	56	31	
Black Bass	33	6	9	14	18	22	
Crappie	35	12	1	1	17	74	
Sauger	34	42	-	-	3	-	
Other	33	5	-	-	1	12	
Total	857	786	78	64	112	399	

* Creel data were taken by Tennessee Wildlife Resource Agency and were not available for this report.

Table 16. Results of Douglas tailwater creel survey conducted between November 1987 and August 1988. Data indicate catch of major fish groups by month.

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug
Skipjack	-	-	-	-	-	280	159	1	2	18
Carp	-	1	-	-	-	8	1	1	-	-
Catfish	-	-	-	-	-	7	4	2	2	12
White/yellow bass	-	-	-	7	34	658	181	25	192	41
Bluegill/Sunfish	4	1	-	-	5	56	63	96	45	18
Black bass	1	-	-	-	3	36	22	3	28	9
Crappie	1	-	-	-	24	33	22	5	55	-
Sauger	-	10	-	1	14	39	11	1	3	-
Other	-	-	-	-	1	15	2	4	3	26
Total	6	12	0	8	81	1,132	465	138	330	124

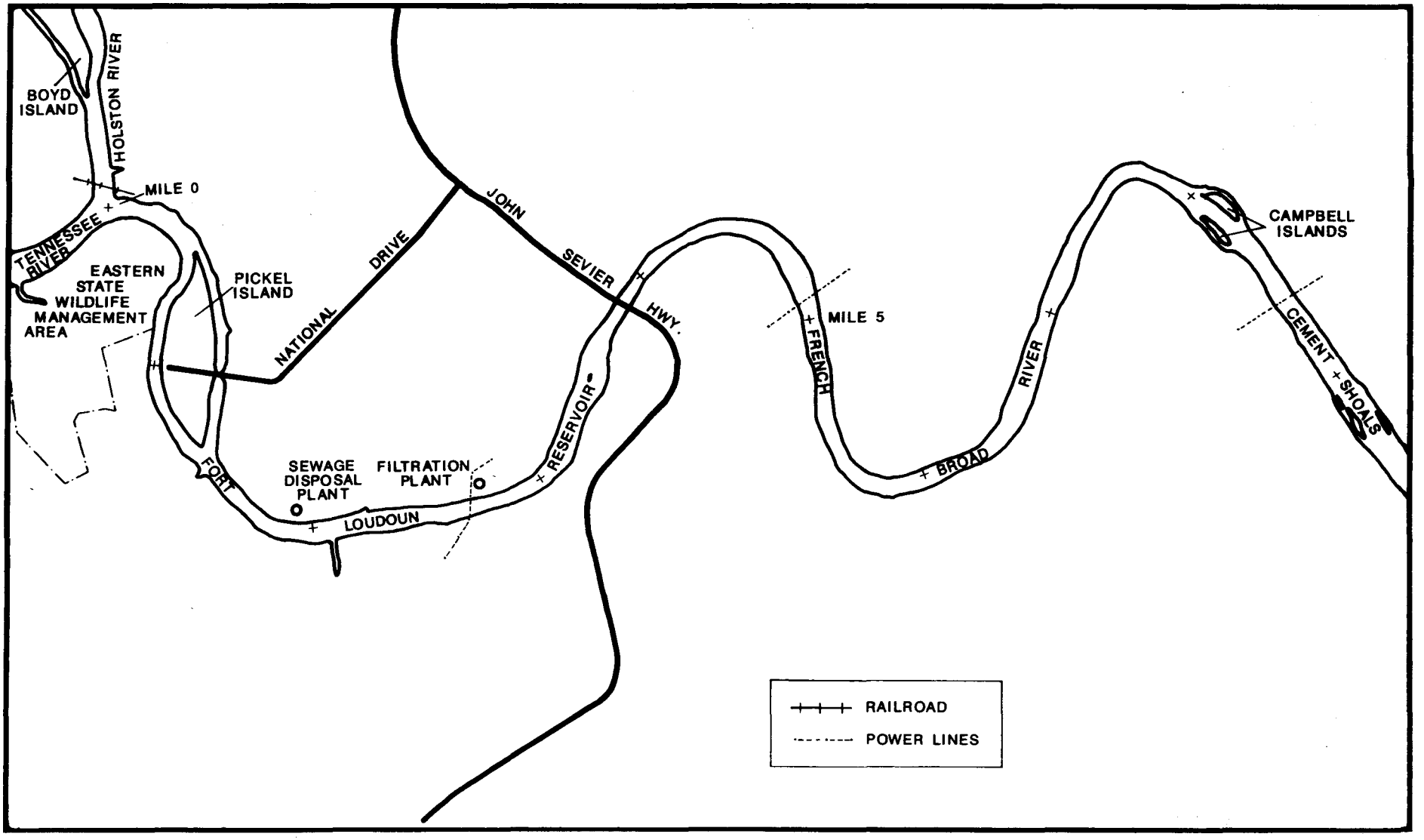

Figure 1. Douglas tailwater.

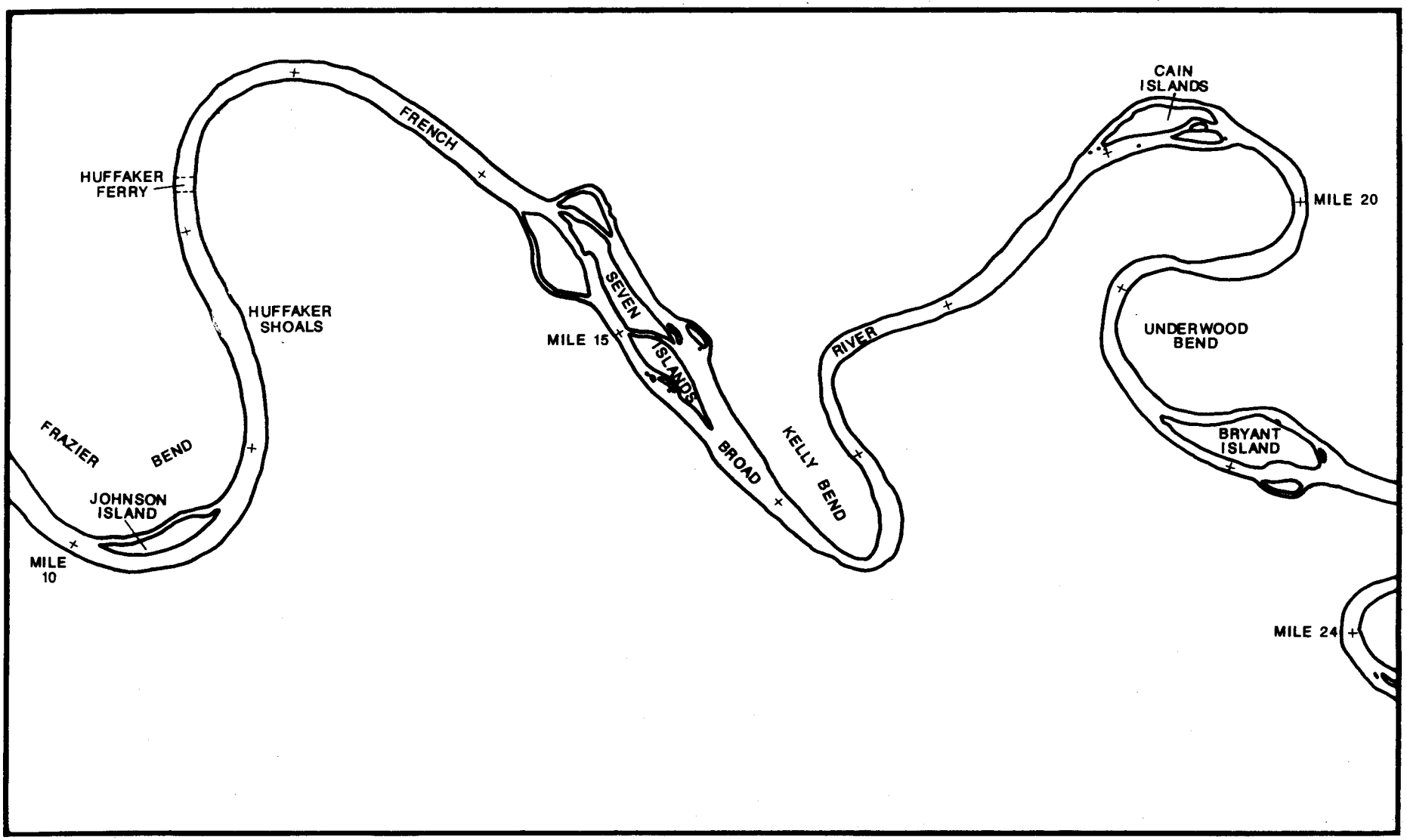

Figure 1. Douglas tailwater (continued).

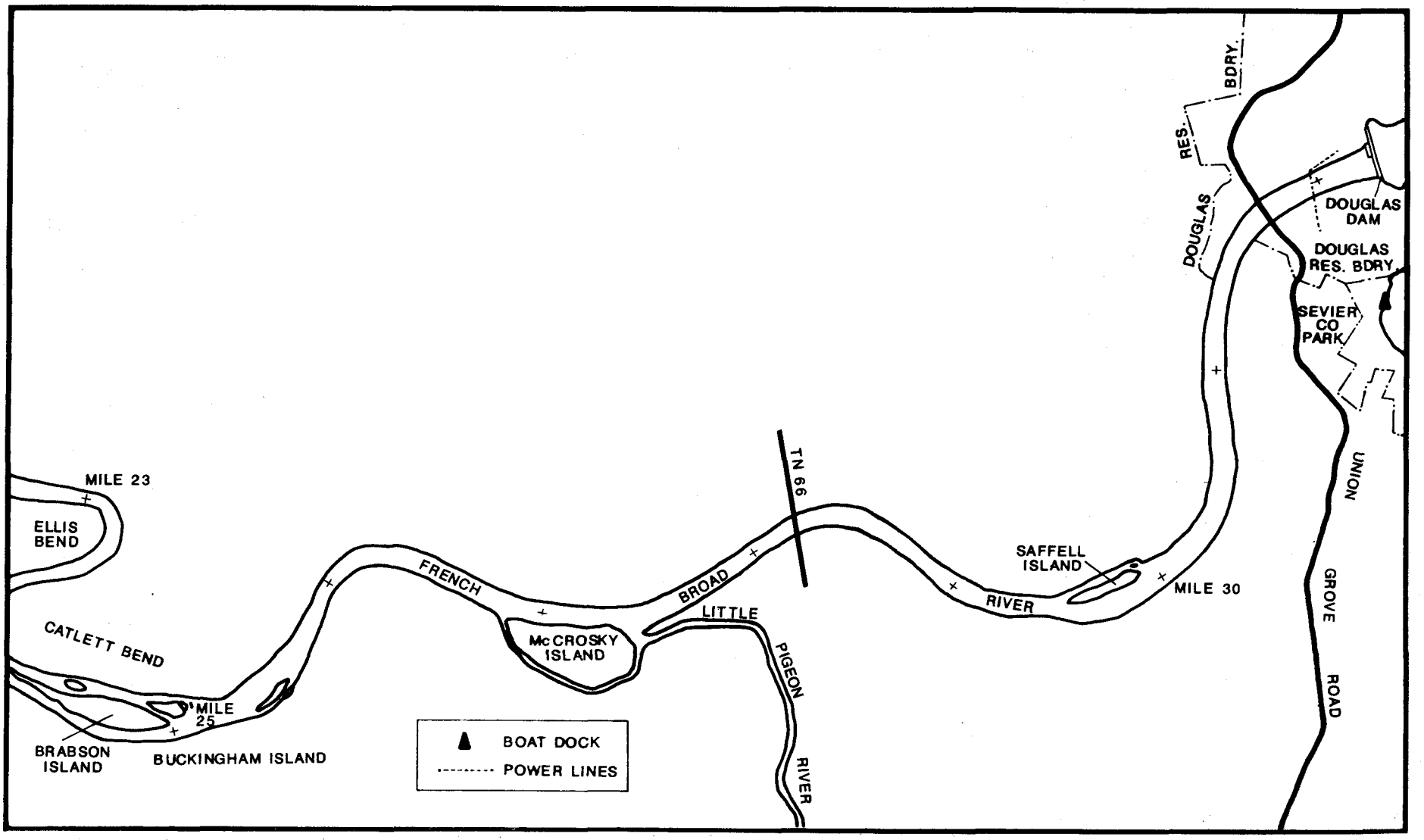

Figure 1. Douglas tailwater (continued).

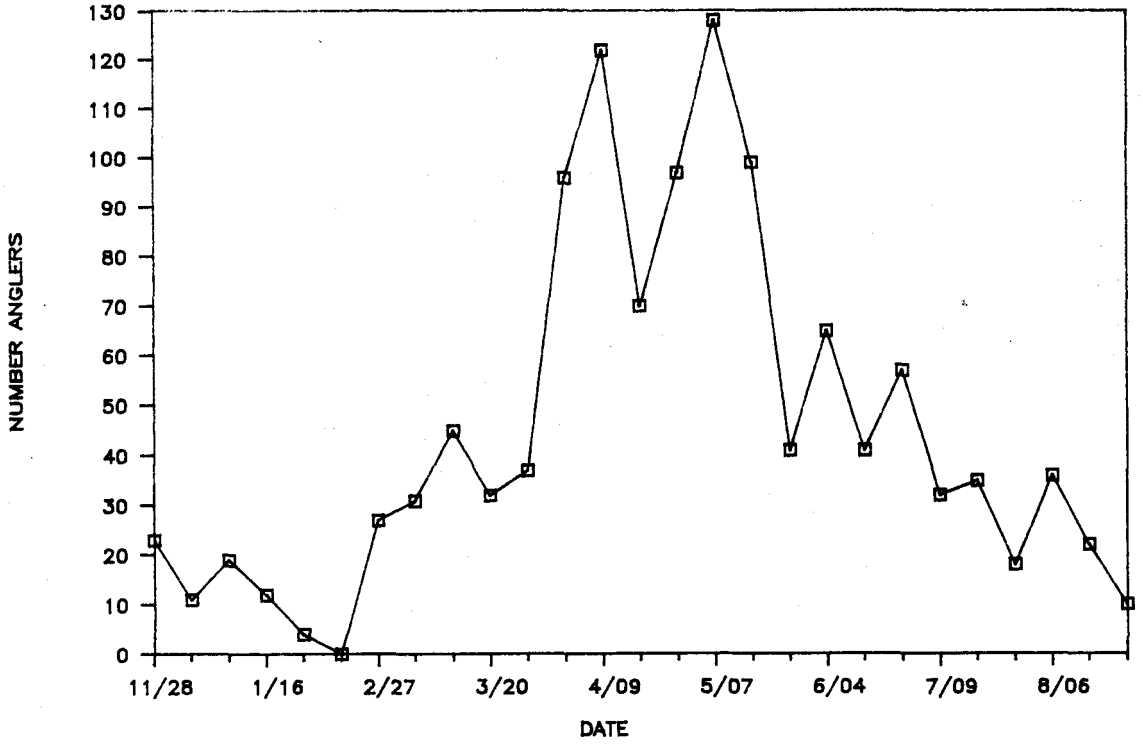

Figure 2. Total number of boat and bank fishermen on Douglas tailwater during 27 pressure counts conducted between November 28, 1987 and August 8, 1988.

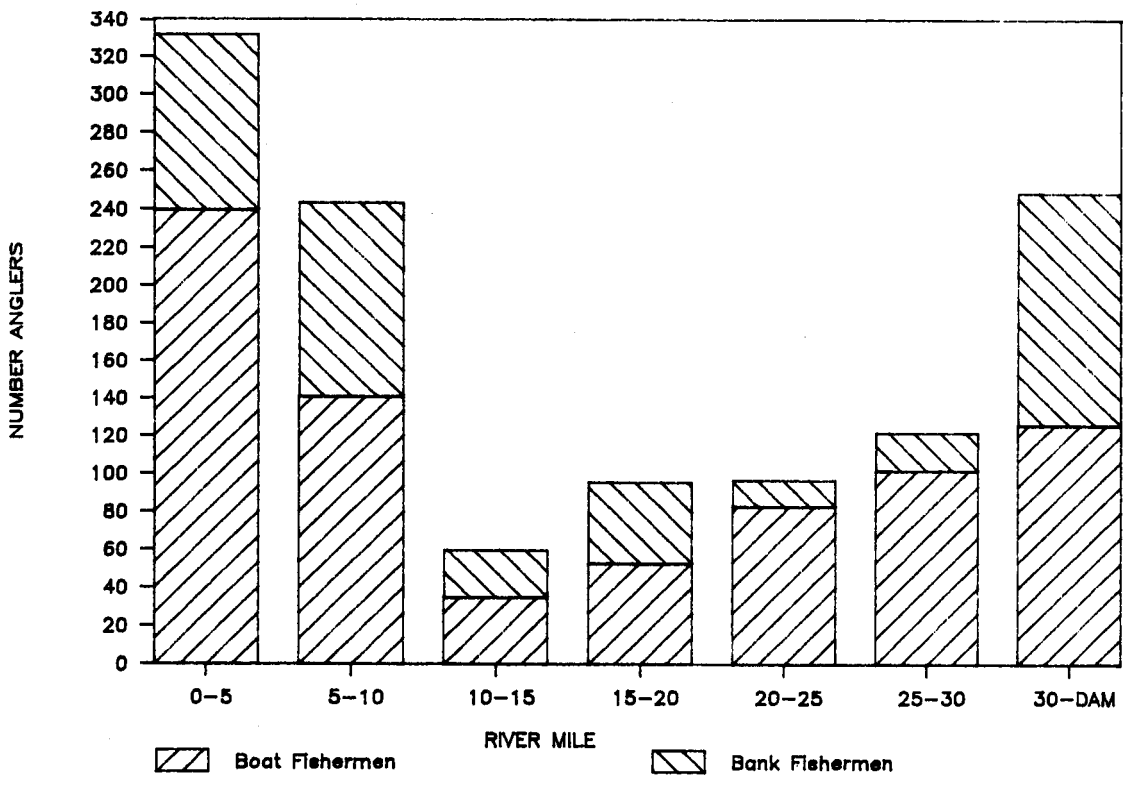

Figure 3. Distribution of fishermen on Douglas tailwater during 27 pressure counts conducted between November 28, 1987 and September 24, 1988.