D. B. Moore, Section Manager
Authorized Derivative Classifier

WSRC-TR--90-502

DE91 007248

EFFECTS OF OUTCROPPING GROUNDWATER FROM THE F- AND H-AREA SEEPAGE BASINS ON THE DISTRIBUTION OF FISH IN FOUR MILE CREEK (U)

by

M.H. Paller

C. Storey

Approved by: D.B. Moore, Section Manager
Environmental Sciences Section

Publication Date: October, 1990

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

SUMMARY

Four Mile Creek was electrofished during June 26 - July 2, 1990 to assess the impacts of outcropping ground water from the F- and H-Area Seepage Basins on fish abundance and distribution. Number of fish species and total catch were comparable at sample stations upstream from and downstream from the outcropping zone in Four Mile Creek. Species number and composition downstream from the outcropping zone in Four Mile Creek were similar to species number and composition in unimpacted portions of Pen Branch, Steel Creek, and Meyers Branch. These findings indicate that seepage basin outcropping was not adversely affecting the Four Mile Creek fish community.

INTRODUCTION

Included in the F- and H-Area Separations Facilities are two sets of seepage basins that received liquid nonradioactive and low-level radioactive effluents from 1955 - 1988 (Haselow et al. 1990). These basins are now being closed according to the Resource Conservation and Recovery Act (RCRA). The effluents discharged to the basins contained sodium hydroxide, nitric acid, low levels of radionuclides (mostly tritiated water) and a variety of dissolved metals (Looney et al. 1988, Haselow et al. 1990). Effluent from the basins has seeped into the ground, migrated through the subsurface strata, and outcropped into Four Mile Creek and adjacent wetlands. Recent surveys suggest that seepage basin discharge has resulted in elevated conductivity, total dissolved solids, nitrate, phosphate, sodium, potassium, and possibly cadmium levels in Four Mile Creek downstream from the seepage basins (Looney et al. 1988). In addition, gross beta and tritium levels are above either the proposed or established drinking water standards at one or more points in Four Mile Creek (Haselow et al. 1990).

The occurrence of elevated levels of several seepage basin constituents in Four Mile Creek water has raised concerns about possible impacts to aquatic organisms. Gladden (1988) reviewed the historical data from the upper reaches of Four Mile Creek to determine if outcropping effluent from the seepage basins was adversely affecting the instream communities. He concluded that there was no clear evidence of adverse impacts due to the seepage basin effluent but believed that the data were insufficient to evaluate possible local effects.

None of the studies reviewed by Gladden (1988) were specifically designed to assess potential impacts associated with outcropping ground water from the F- and H-Area Seepage Basins. To remedy this deficiency and provide additional information that may be needed for the closure of the seepage basins, a sampling program was designed to assess the abundance, distribution, and tissue contaminant levels of Four Mile Creek fish upstream and downstream from the seepage basins. An analysis of the effects of the seepage basin outcropping on fish distribution and abundance is presented in this report. The results of the tissue contaminant analysis will be presented as a separate report.

METHODS AND MATERIALS

Field methods

The sampling program included seven sample stations: six in Four Mile Creek and one in the upper reaches of Pen Branch. The sample station in Pen Branch was included

primarily to serve as a source of uncontaminated fish to establish background levels of potential tissue contaminants.

The locations of the sample stations are indicated in Table 1 and Figure 1. Sample stations 1 and 2 on Four Mile Creek were located upstream from the seepage basin outcropping; the rest were located downstream. At each of the sample stations, three 100 m stream segments having representative habitats were selected for electrofishing. Stream segments were at least 30 m from roads and bridges and were separated by at least 20 m. The stream segments at sample station 4 were separated by as much as 0.5 km because of the difficulty in finding areas that could be safely sampled in this portion of the stream. Thus, sample station 4 is shown as 4a and 4b in Figure 1.

Fish were collected with a Smith Root Model 15-A backpack electrofisher. Electric current was directed around and in brushpiles, snags, stumps, beneath undercut banks, and in open water. Stunned fish were removed from the water using 6.35 mm mesh dip nets. All collections were made while moving upstream. Block nets were not used and only one pass was made in each stream segment. All fish were identified to species, measured (total length to nearest mm), weighed (nearest g), and briefly checked for disease, parasitism, and other anomalies in the field. Fish kept for tissue analysis were placed in clean plastic bags and frozen as soon as possible. Temperature, dissolved oxygen concentration, and conductivity was measured at mid-depth in the center of each stream segment just after the segment was electrofished. Notes were taken on physical habitat characteristics of each site. All field sampling was conducted during June 26 - July 2, 1990.

Data analysis

Catch per unit effort (CPUE) was calculated for each species in each sample segment by dividing the number of individuals collected from the segment by the length of the segment. Total CPUE for a segment was calculated by summing the CPUEs for all species collected from the segment. Mean CPUE for a sample station was calculated by averaging the CPUE values for the three segments within the sample station. The relative abundance (i.e., percent composition) of each species at each sample station was calculated by dividing the mean CPUE for each species by the mean total CPUE for all species collected from the sample station and multiplying by 100.

DESCRIPTION OF SAMPLE SITES

Station 1 was located in the uppermost headwaters of Four Mile Creek and consisted of a series of small pools connected by rivulets (Table 2). Stations 2, 3, and 4 were generally similar; all were moderate in width, depth and

Table 1. Sample station locations on Four Mile Creek (FMC) and Pen Branch.

Station	Location
1	FMC at powerline road (1.1 km upstream of road 4)
2	FMC at Road 4
3	FMC at Road C
4	FMC at Road 3 and Road A-7
5	FMC at west end of Banana Road near Leigh Road junction downstream of Road A
6	FMC at Cassels Pond, accessed via unpaved road off Road A-13 about 0.8 km S of Risher Pond Road intersection
7	Pen Branch at Road B

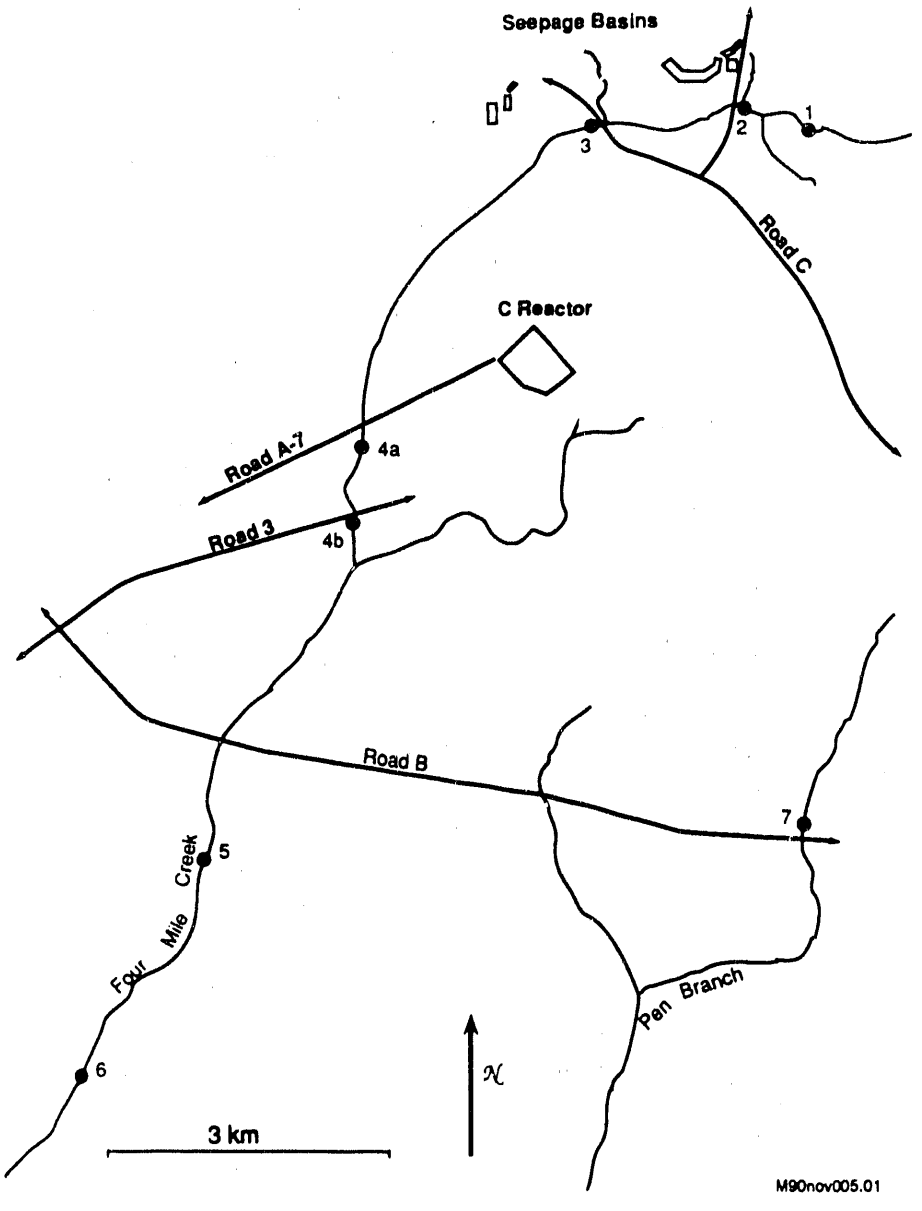

Figure 1. Map of Four Mile Creek and Pen Branch showing the location of the seven electrofishing sample sites.

Table 2. Description of sample sites in Four Mile Creek (Station 1-6) and Pen Branch (Station 7).

Station no.	Width (m)	Maximum depth (cm)	Current velocity	Temp. (°C)	Dissolved oxygen (mg/L)	Conductivity (umhos/cm)	Canopy cover	Substrate
1	0.2-1.5	50	very slow	24.8-28.7	2.0-5.1	60	100% hardwood	sand, silt, detritus sparse gravel
2	1.0-5.0	50	moderate	24.4-24.9	7.5	80	100% hardwood	sand, gravel, detritus
3	1.0-5.0	50	slow-moderate	27.6	5.9	100	70% hardwood	sand, silt, detritus aquatic plants
4	0.5-4.0	60	slow-moderate	24.5-24.8	7.3	83	100% hardwood	sand, silt, detritus snags, aquatic plants
5	1.5-7.0	150	slow-moderate	25.8-26.9	9.5	62	no canopy	sand, detritus, snags dense aquatic vegetation
6	5.0-15.0	180	slow-moderate	26.8-27.6	9.5	65	0-5% canopy	sand, dense aquatic vegetation
7	0.8-2.0	40	slow	23.0-24.6	6.0	90	100% hardwood	sand, detritus, gravel

current velocity and overhung by a hardwood canopy. Stations 5 and 6 were comparatively wide and surrounded by low growing aquatic vegetation rather than trees. Exposure to direct sunlight permitted the growth of submerged macrophyte beds at both sites. The marked differences in habitat between stations 2 - 4 and 5 - 6 is the result of the discharge of thermal effluent into Four Mile Creek until 1985. C-Reactor effluent, which entered Four Mile Creek downstream from station 4, resulted in death of the canopy vegetation and scouring and widening of the creek channel. The habitat observed at stations 5 and 6 during this study was a result of degradation due to past reactor operations followed by several years of recovery since C-Reactor was placed on standby status.

RESULTS AND DISCUSSION

The fish assemblages in Four Mile Creek differed among sample stations. Station 1 was dominated by pirate perch, redbreast sunfish, and creek chubsuckers (Table 3). Stations 2-4, in contrast, were dominated by several types of shiners (dusky, yellowfin, or taillight) and sunfishes (dollar, spotted, or redbreast). Stations 5 and 6 were dominated by mosquitofish, redbreast sunfish, spotted sunfish, and yellow bullhead. CPUE also differed among stations (Table 4). The lowest CPUE in Four Mile Creek occurred at station 2 (44.7 fish/100 m) and the highest occurred at station 4 (149.7 fish/100 m).

One method of evaluating the impact of the seepage basin outcropping is to compare fish community structure above and below the outcropping zone. A decrease in species number or CPUE below the outcropping zone would be a possible indicator of adverse impact. A comparison of collections at stations 1 and 2 (above the outcropping zone) with stations 3 and 4 (below the outcropping zone) indicated that species number and total (i.e., all species summed) CPUE were higher below the outcropping zone than above (Figure 2, Table 4). On an individual species basis, four species decreased below the outcropping zone while nine increased. These differences are not indicative of adverse impact due to seepage basin outcropping and are more likely a result of habitat differences among stations.

While not a consequence of seepage basin operation, it is noteworthy that species number and total CPUE decreased downstream from station 4 (Table 4). Mosquitofish, a species commonly associated with thermal and post-thermal sites on the SRS (Aho et al. 1986), increased in abundance below station 4. These changes are likely a result of habitat alterations associated with past thermal discharge from

Table 3. Relative abundance (i.e., percent composition) of fish collected at six sample stations in Four Mile Creek and one sample station in the headwaters of Pen Branch. June 1990.

Species	Station number						
	1	2	3	4	5	6	7
American eel	0.0	0.0	0.0	0.2	1.1	0.0	0.0
eastern mudminnow	0.0	0.0	0.0	0.0	0.0	0.0	0.3
redfin pickerel	2.8	3.0	1.6	0.9	1.7	0.0	1.5
bluehead chub	0.0	0.0	1.2	6.0	1.1	0.2	4.3
golden shiner	1.9	0.0	0.0	0.0	0.0	0.0	0.0
ironcolor shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.2
dusky shiner	0.0	22.4	30.5	2.2	8.0	3.9	1.5
yellowfin shiner	0.0	0.0	17.6	41.9	1.1	0.0	72.4
taillight shiner	5.2	0.0	11.3	4.5	0.0	0.0	0.0
coastal shiner	0.0	0.0	0.0	0.7	1.7	0.2	0.0
creek chub	0.0	0.0	0.0	0.0	0.0	0.0	1.5
creek chubsucker	13.7	21.6	3.1	2.2	0.0	0.0	2.3
yellow bullhead	5.2	15.7	1.2	4.9	12.5	12.9	0.0
tadpole madtom	0.0	3.0	3.1	0.0	2.3	0.5	0.0
margined madtom	0.0	0.0	3.1	0.0	0.0	0.0	0.3
speckled madtom	0.0	0.0	0.0	0.0	0.0	0.0	0.2
pirate perch	36.5	7.5	5.9	2.7	2.3	6.3	4.0
lined topminnow	0.0	0.0	0.0	0.0	0.0	0.0	0.1
mosquitofish	0.5	0.7	2.7	0.4	18.2	39.4	0.3
redbreast sunfish	20.4	3.7	7.0	16.7	28.4	24.6	2.8
dollar sunfish	8.5	9.7	0.0	0.4	0.0	0.0	0.8
spotted sunfish	5.2	12.7	3.1	11.1	16.5	11.9	0.8
largemouth bass	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Savannah darter	0.0	0.0	8.6	1.1	0.0	0.0	0.0
tessellated darter	0.0	0.0	0.0	2.4	0.0	0.0	6.2
blackbanded darter	0.0	0.0	0.0	1.3	5.1	0.0	0.4
Total	99.9	100.0	100.0	99.8	100.0	99.9	99.9
Total number fish	211	134	256	449	176	411	952
Total number species	10	10	14	18	13	9	18

Key to sample station locations:

1 Four Mile Creek 1.1 km upstream from Road 4
2 Four Mile Creek at Road 4
3 Four Mile Creek at Road C
4 Four Mile Creek at Road A-7
5 Four Mile Creek downstream of Road A
6 Four Mile Creek at Cassel's Pond (just upstream of delta/swamp)
7 Pen Branch at Road B

Table 4. Mean (standard error) electrofishing catch per unit effort (CPUE expressed as number fish per 100 m) at six sample stations in Four Mile Creek and one sample station in the headwaters of Pen Branch. June 1990.

Species	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7
American eel	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.3 (0.3)	0.7 (0.3)	0.0 (0.0)	0.0 (0.0)
eastern mudminnow	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	1.0 (0.6)
redfin pickerel	2.0 (1.0)	1.3 (1.3)	1.3 (0.8)	1.3 (0.7)	1.0 (0.6)	0.0 (0.0)	4.7 (1.2)
bluehead chub	0.0 (0.0)	0.0 (0.0)	1.0 (0.6)	9.0 (3.5)	0.7 (0.7)	0.3 (0.3)	13.7 (3.2)
golden shiner	1.3 (0.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
ironcolor shiner	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.7 (0.3)
dusky shiner	0.0 (0.0)	10.0 (1.0)	26.0 (15.0)	3.3 (3.3)	4.7 (4.7)	5.3 (3.0)	4.7 (4.2)
yellowfin shiner	0.0 (0.0)	0.0 (0.0)	15.0 (4.5)	62.7 (2.7)	0.7 (0.3)	0.0 (0.0)	229.7 (40.9)
taillight shiner	3.7 (1.9)	0.0 (0.0)	9.7 (0.9)	6.7 (1.9)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
coastal shiner	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	1.0 (1.0)	1.0 (1.0)	0.3 (0.3)	0.0 (0.0)
creek chub	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	4.7 (2.2)
creek chubsucker	9.7 (3.3)	9.7 (3.8)	2.7 (1.5)	3.3 (2.4)	0.0 (0.0)	0.0 (0.0)	7.3 (3.5)
yellow bullhead	3.7 (1.2)	7.0 (3.0)	1.0 (0.6)	7.3 (2.3)	7.3 (2.8)	17.7 (5.7)	0.0 (0.0)
tadpole madtom	0.0 (0.0)	1.3 (0.9)	2.7 (1.7)	0.0 (0.0)	1.3 (0.7)	0.7 (0.7)	0.0 (0.0)
margined madtom	0.0 (0.0)	0.0 (0.0)	2.7 (0.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	1.0 (0.6)
speckled madtom	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.7 (0.3)
pirate perch	25.7 (13.2)	3.3 (0.7)	5.0 (2.1)	4.0 (0.6)	1.3 (0.7)	8.7 (3.3)	12.7 (4.4)
lined topminnow	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.3 (0.3)
mosquitofish	0.3 (0.3)	0.3 (0.3)	2.3 (1.2)	0.7 (0.7)	10.7 (5.4)	54.0 (9.0)	1.0 (0.6)
redbreast sunfish	14.3 (2.8)	1.7 (0.3)	6.0 (1.0)	25.0 (6.7)	16.7 (6.8)	33.7 (18.4)	9.0 (6.5)
dollar sunfish	6.0 (1.5)	4.3 (1.2)	0.0 (0.0)	0.7 (0.7)	0.0 (0.0)	0.0 (0.0)	2.7 (0.9)
spotted sunfish	3.7 (0.9)	5.7 (1.7)	2.7 (1.5)	16.7 (6.4)	9.7 (2.7)	16.3 (5.5)	2.7 (0.7)
largemouth bass	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.3 (0.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Savannah darter	0.0 (0.0)	0.0 (0.0)	7.3 (0.9)	1.7 (0.9)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
tessellated darter	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	3.7 (1.9)	0.0 (0.0)	0.0 (0.0)	19.7 (6.1)
blackbanded darter	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2.0 (1.2)	3.0 (1.2)	0.0 (0.0)	1.3 (0.3)
Total CPUE	70.3 (22.4)	44.7 (1.9)	85.3 (24.3)	149.7 (17.3)	58.7 (13.0)	137.0 (27.2)	317.6 (62.9)
Total species	10	10	14	18	13	9	18

Key to sample station locations:

1 Four Mile Creek 1.1 km upstream from Road 4
2 Four Mile Creek at Road 4
3 Four Mile Creek at Road C
4 Four Mile Creek at Road A-7
5 Four Mile Creek downstream of Road A
6 Four Mile Creek at Cassel's Pond (just upstream of delta/swamp)
7 Pen Branch at Road B

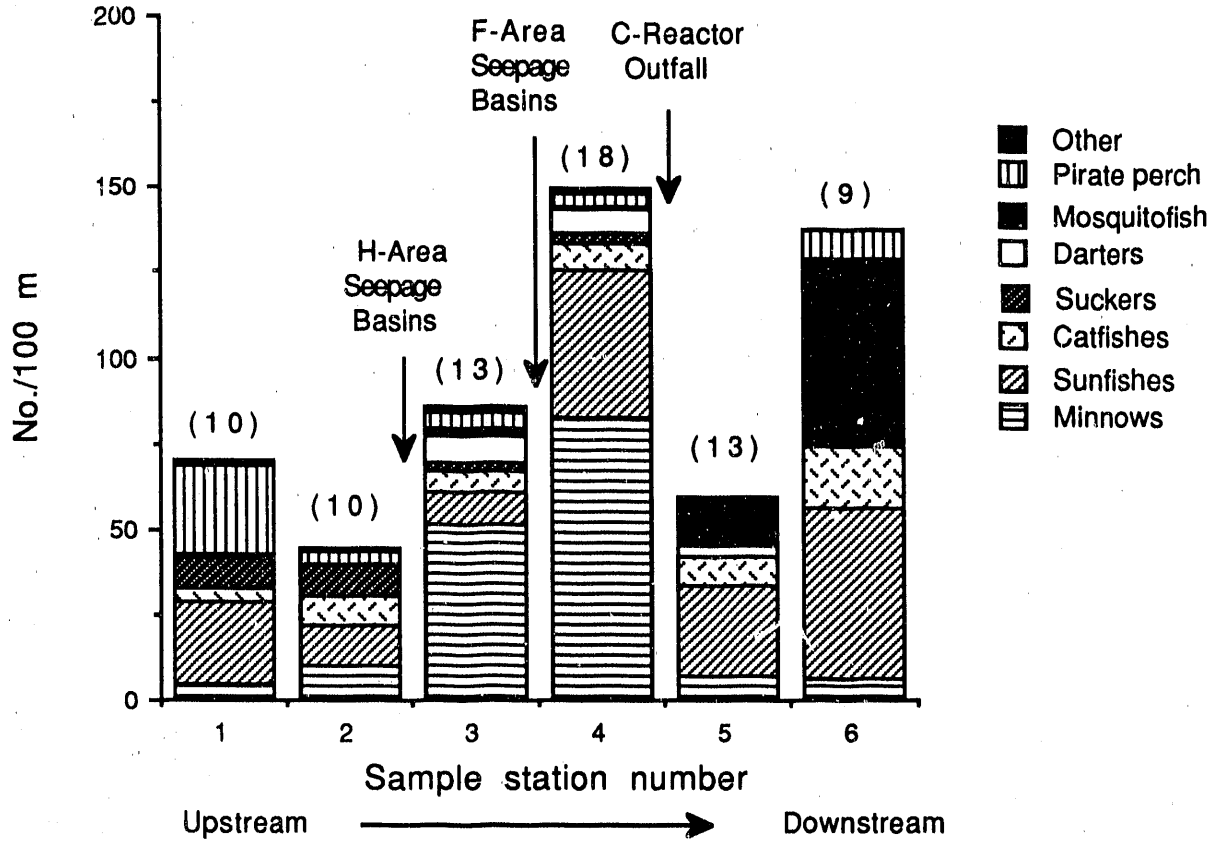

Figure 2. Mean electrofishing catch per unit effort (expressed as no. fish/100 m) at sample stations in Four Mile Creek. Parentheses indicate number of fish species collected at each location.

C-Reactor. Decreases in species number and CPUE at these stations suggest that recovery from C-Reactor operation is not yet complete.

The fish community below the outcropping zone can also be evaluated by comparing it to the fish communities in nearby unimpacted streams of similar size and generally similar habitat. Three unimpacted stream reaches (upper Meyers Branch, upper Steel Creek, and upper Pen Branch (station 7)) were used in this comparison. Data from Meyers Branch and Steel Creek were obtained from Aho et al. (1986). Because of differences in sampling methodology, CPUE cannot be directly compared between the study of Aho et al. (1986) and this study. Therefore, only species number and relative abundance are shown in Figure 3. Species number at stations 3 and 4 in Four Mile Creek was comparable to species number in the other streams. Relative abundance at stations 3 and 4 was generally similar to that in the other streams except that sunfishes constituted a slightly higher percentage of the community and minnows a slightly lower percentage.

The only permissible CPUE comparison is between Four Mile Creek (stations 3 and 4) and Pen Branch Creek at Road B (station 7) since sampling methods were similar at these stations. Total CPUE was considerably higher at Pen Branch than at Four Mile Creek (Table 4); however, the high total CPUE at Pen Branch was largely due to high catches of one species, yellowfin shiner. If this species is subtracted from the catch, total CPUE is quite similar between streams (70.3 at station 3 in Four Mile Creek, 87.0 at station 4 in Four Mile Creek, and 87.9 at station 7 in Pen Branch). Yellowfin shiner are a mobile, schooling species; and the high catch at Pen Branch may represent a fortuitous encounter with a large school. It is also possible, however, that yellowfin shiner are truly more abundant in Pen Branch than in Four Mile Creek because of subtle habitat differences between the streams or because of temporary fluctuations in reproductive success.

CONCLUSIONS

There is no indication that outcropping groundwater from the F- and H-Area Seepage Basins is adversely affecting the abundance and distribution of fish in Four Mile Creek. There is an absence of adverse changes in community structure below the outcropping zone, and community structure in this region is generally comparable to community structure in other relatively unimpacted SRS streams. These results are not surprising in light of the nature and concentrations of the seepage basin constituents found in Four Mile Creek. Total dissolved solids, nitrate, phosphate, sodium, and potassium either are not directly toxic to fish or are toxic at far higher concentrations than found in Four Mile Creek (see Looney et al (1988) and Haselow et al.(1990) for a discussion

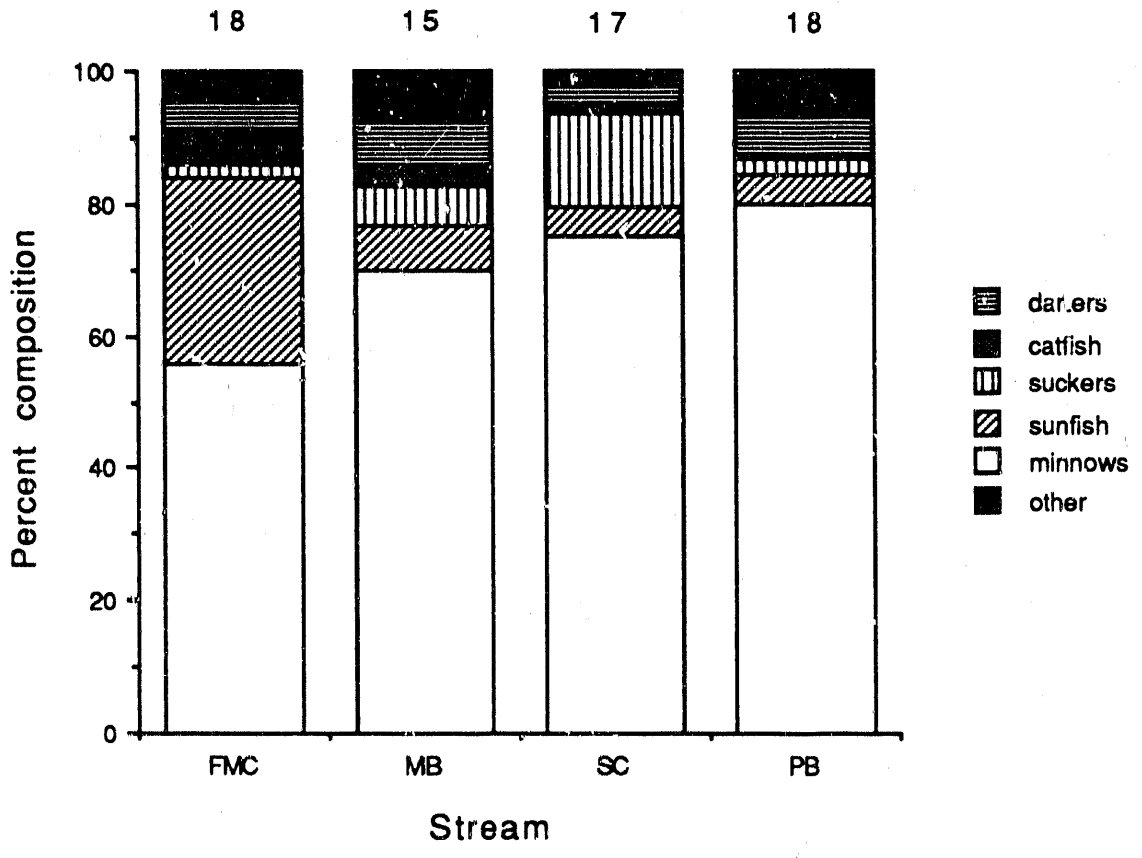

Figure 3. Percent composition and number of species in Four Mile Creek (station 6, FMC), Meyers Branch (MB), Steel Creek (SC), and Pen Branch (station 7, PB).

of contaminant concentrations in Four Mile Creek and USEPA 1976 for a discussion of the toxicity of many of these materials).

REFERENCES

Aho, J.M., C.S. Anderson, K.B. Floyd, and M.T. Negus. 1986. Patterns in fish assemblage structure and dynamics in waters of the Savannah River Plant. SREL-27, UC-66e. Savannah River Ecology Laboratory, Aiken, SC.

Gladden, J.B. 1989. Evaluation of stream biological communities in nonthermal reaches of Four Mile Creek. DPST-88-324, Rev. 1. E.I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, SC.

Haselow, J.S., M. Harris, B.B. Looney, N.V. Halverson, and J.B. Gladden. 1990. Analysis of soil and water at the Four Mile Creek seepline near the F&H Areas of SRS(U). WSRC-RP-90-0591. Savannah River Laboratory, Aiken, SC.

Looney, B.B., J.E. Cantrell, and J.R. Cook. 1988. Sampling and analysis of surface water in the vicinity of the F- and H- Area seepage basins. DPST-88-229. E.I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, SC.

USEPA (United States Environmental Protection Agency). 1976. Quality criteria for water. EPA-440/9-76-023. National Technical Information Service. Springfield, VA 22161.

END

DATE FILMED

02 / 22 / 91