

C.4.2.2 Fish

Like other typical southeastern coastal plain rivers and streams, the Savannah River and its associated swamp and tributaries have a diverse fish fauna. Descriptions of the fishes of the Savannah River have been included in many ecological studies during the last 30 years. Matthews (1982) reviewed those studies published by the Academy of Natural Sciences of Philadelphia between 1951 and 1976. The results of fisheries studies in the portion of the river near the Savannah River Plant were reported by McFarlane et al. (1978a) and Dudley et al. (1977). Additionally, the Georgia Game and Fish Division (1982) reported on an electrofishing survey they conducted at 24 locations in the Savannah River between the New Savannah River Bluff Lock and Dam and Port Wentworth. Data on anadromous species, many of which are important in the Savannah River, were compiled by Rulifson et al. (1982).

Steel Creek studies

Studies of fish populations in the Steel Creek delta-swamp system and the Savannah River adjacent to the SRP showed a high species diversity (ECS, 1983a, 1983b, Smith et al., 1982b, 1983) (Tables C-10 and C-11).

The highest abundance and diversity of fish in Steel Creek occurred in deepwater areas where the tree canopy was eliminated during previous reactor operations and the vegetation was dominated by submergent and emergent macrophytes.

The use of the Steel Creek delta-swamp area by anadromous fish species (e.g., American shad and blueback herring) was minimal during 1982. Only 10 individuals of both species were collected. The appearance of American shad in Steel Creek was late in 1982 and the numbers were quite small. However, it appears that the shad spawning run in the Savannah River was smaller than in previous years; large year-to-year variations in abundance of anadromous fish species are quite common. In 1983, the American shad and blueback herring spawning run in Steel Creek occurred earlier than in 1982 (February through April for blueback herring and late March through May for American shad) (Smith et al., 1983). There was a greater utilization of the Steel Creek delta-swamp area by adult shad and blueback herring in 1983 as compared to 1982 (76 shad in 1983 versus 6 in 1982; 124 blueback herring in 1983 versus 4 in 1982). Two striped bass were collected in the delta-swamp area in 1983 while none were collected in 1982 (Smith et al., 1983).

During 1982, ichthyoplankton sampling revealed no evidence of spawning by shad, blueback herring, or striped bass in upper Steel Creek and the Steel Creek delta. However, ichthyoplankton of all three species was collected from the mouth of Steel Creek.

In 1983, Steel Creek yielded 518 fish larvae and 103 eggs in 23 ichthyoplankton collections made between March and August. The larvae were predominantly minnows, yellow perch, and sunfish and bass. Many blueback herring eggs were also collected. When compared to other creeks that were sampled ten or more times, Steel Creek ranked eighth in larval density of all species combined. This creek was distinctive in having minnows and yellow perch represent about 27 and 30 percent, respectively, of the fish larvae collected here. In all other streams of a similar size, these two species comprised no more than

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Table C-10. Scientific and common names of fish collected in the Steel Creek river-swamp, October 1981-July 1982^a

Scientific name	Common name
<u>Amblyopsidae</u>	
<u>Chologaster cornuta</u>	Swampfish
<u>Amiidae</u>	
<u>Amia calva</u>	Bowfin
<u>Anguillidae</u>	
<u>Anguilla rostrata</u>	American eel
<u>Aphredoderidae</u>	
<u>Aphredoderus sayanus</u>	Pirate perch
<u>Atherinidae</u>	
<u>Labidesthes sicculus</u>	Brook silverside
<u>Belonidae</u>	
<u>Strongylura marina</u>	Atlantic needlefish
<u>Catostomidae</u>	
<u>Erimyzon oblongus</u>	Creek chubsucker
<u>Erimyzon sucetta</u>	Lake chubsucker
<u>Minytrema melanops</u>	Spotted sucker
<u>Centrarchidae</u>	
<u>Centrarchus macropterus</u>	Flier
<u>Elassoma zonatum</u>	Banded pygmy sunfish
<u>Enneacanthus chaetodon</u>	Blackbanded sunfish
<u>Enneacanthus gloriosus</u>	Bluespotted sunfish
<u>Lepomis auritus</u>	Redbreast sunfish
<u>Lepomis gulosus</u>	Warmouth
<u>Lepomis macrochirus</u>	Bluegill
<u>Lepomis microlophus</u>	Redear sunfish
<u>Lepomis punctatus</u>	Spotted sunfish
<u>Micropterus salmoides</u>	Largemouth bass
<u>Pomoxis annularis</u>	White crappie
<u>Pomoxis nigromaculatus</u>	Black crappie
<u>Clupeidae</u>	
<u>Alosa sapidissima</u>	American shad
<u>Alosa aestivalis</u>	Blueback herring
<u>Dorosoma cepedianum</u>	Gizzard shad
<u>Cyprinidae</u>	
<u>Cyprinus carpio</u>	Carp
<u>Hyboganthus nuchalis</u>	Silvery minnow
<u>Notemigonus crysoleucas</u>	Golden shiner
<u>Notropis chatybaeus</u>	Ironcolor shiner
<u>Notropis cummingsae</u>	Dusky shiner
<u>Notropis emiliae</u>	Pugnose minnow
<u>Notropis hudsonius</u>	Spottail shiner
<u>Notropis leedsii</u>	Bannerfin shiner
<u>Notropis lutipinnis</u>	Yellowfin shiner
<u>Notropis maculatus</u>	Taillight shiner
<u>Notropis niveus</u>	Whitefine shiner
<u>Notropis petersoni</u>	Coastal shiner

Table C-10. Scientific and common names of fish collected in the Steel Creek river-swamp, October 1981-July 1982^a (continued)

Scientific name	Common name
<u>Cyprinodontidae</u>	
<u>Fundulus lineolatus</u>	Lined topminnow
<u>Esocidae</u>	
<u>Esox americanus</u>	Redfin pickerel
<u>Esox niger</u>	Chain pickerel
<u>Ictaluridae</u>	
<u>Ictalurus natalis</u>	Yellow bullhead
<u>Ictalurus nebulosus</u>	Brown bullhead
<u>Ictalurus platycephalus</u>	Flat bullhead
<u>Ictalurus punctatus</u>	Channel catfish
<u>Noturus gyrinus</u>	Tadpole madtom
<u>Noturus leptacanthus</u>	Speckled madtom
<u>Lepisosteidae</u>	
<u>Lepisosteus osseus</u>	Longnose gar
<u>Lepisosteus platyrhincus</u>	Florida gar
<u>Mugilidae</u>	
<u>Mugil cephalus</u>	Striped mullet
<u>Percichthyidae</u>	
<u>Morone saxatilis</u>	Striped bass
<u>Percidae</u>	
<u>Etheostoma fusiforme</u>	Swamp darter
<u>Etheostoma olmstedii</u>	Tesselated darter
<u>Perca flavescens</u>	Yellow perch
<u>Percina nigrofasciata</u>	Blackbanded darter
<u>Poeciliidae</u>	
<u>Gambusia affinis</u>	Mosquitofish
<u>Umbridae</u>	
<u>Umbra pygmaea</u>	Eastern mudminnow

^aAdapted from Smith et al. (1982b).

Table C-11. Fish species collected during adult fisheries study, Savannah River Plant: August 1982, October 1982, and January 1983a

Scientific name	Common name
<u>Acipenser oxyrhynchus</u>	Atlantic sturgeon
<u>Lepisosteus osseus</u>	Longnose gar
<u>Amia calva</u>	Bowfin
<u>Anguilla rostrata</u>	American eel
<u>Alosa aestivalis</u>	Blueback herring
<u>Alosa mediocris</u>	Hickory shad
<u>Alosa sapidissima</u>	American shad
<u>Dorosoma cepedianum</u>	Gizzard shad
<u>Dorosoma pretenense</u>	Threadfin shad
<u>Esox americanus</u>	Redfin pickerel
<u>Esox niger</u>	Chain pickerel
<u>Cyprinus carpio</u>	Carp
<u>Hybognathus nuchalis</u>	Silvery minnow
<u>Hybopsis rubifrons</u>	Rosyface chub
<u>Nocomis leptcephalus</u>	Bluehead chub
<u>Notimogonus crysoleucas</u>	Golden shiner
<u>Notropis chalybaeus</u>	Ironcolor shiner
<u>Notropis emiliae</u>	Pugnose minnow
<u>Notropis hudsonius</u>	Spottail shiner
<u>Notropis leedsi</u>	Ochoopee shiner
<u>Notropis maculatus</u>	Taillight shiner
<u>Notropis niveus</u>	Whitefin shiner
<u>Notropis petersoni</u>	Coastal shiner
<u>Erimyzon sucetta</u>	Lake chubsucker
<u>Minytrema melanops</u>	Spotted sucker
<u>Moxostoma anisurum</u>	Silver redhorse
<u>Ictalurus brunneus</u>	Snail bullhead
<u>Ictalurus catus</u>	White catfish
<u>Ictalurus nebulosus</u>	Brown bullhead
<u>Ictalurus platycephalus</u>	Flat bullhead
<u>Ictalurus punctatus</u>	Channel catfish
<u>Noturus leptacanthus</u>	Speckled madtom
<u>Aphredoderus sayanus</u>	Pirate perch
<u>Fundulus notti</u>	Starheaded topminnow
<u>Gambusia affinis</u>	Mosquitofish
<u>Labidesthes sicculus</u>	Brook silverside
<u>Morone saxatilis</u>	Striped bass
<u>Acantharchus pomotis</u>	Mud sunfish
<u>Centrarchus macropterus</u>	Flier
<u>Lepomis auritus</u>	Redbreast sunfish
<u>Lepomis gibbosus</u>	Pumpkinseed
<u>Lepomis gulosus</u>	Warmouth
<u>Lepomis macrochirus</u>	Bluegill
<u>Lepomis marginatus</u>	Dollar sunfish
<u>Lepomis microlophus</u>	Redear sunfish
<u>Lepomis punctatus</u>	Spotted sunfish
<u>Micropterus salmoides</u>	Largemouth bass

Table C-11. Fish species collected during adult fisheries study, Savannah River Plant: August 1982, October 1982, and January 1983^a (continued)

Scientific name	Common name
<u>Pomoxis annularis</u>	White crappie
<u>Pomoxis nigromaculatus</u>	Black crappie
<u>Etheostoma olmstedii</u>	Tessellated darter
<u>Perca flavescens</u>	Yellow perch
<u>Percina nigrofasciata</u>	Blackbanded darter
<u>Agonostomus monticola</u>	Mountain mullet
<u>Mugil cephalus</u>	Striped mullet
<u>Trinectes maculatus</u>	Hogchoker

^aAdapted from ECS (1983a,b,c).

about 13 and 7 percent of the total larvae, respectively. In Steel Creek, densities of crappie larvae relative to other species were much lower than in the other large streams sampled.

Much more fish spawning occurred in Four Mile Creek in 1983 than in 1982, apparently because high river levels reversed stream flow enough to allow fish to enter the creek. A high density of larvae, mostly blueback herring, was observed on April 4, 1983. However, similar medium-sized streams that were sampled had higher larval densities and longer spawning periods than Four Mile Creek. Apparently, the elevated water temperature in this stream was a factor that limited spawning.

The diversity and abundance of fish in the thermally affected SRP streams was high only during periods of reactor shutdown (McFarlane, 1976). In addition, the fauna upstream of the thermal effluents was depauperate in both numbers and diversity. With the exception of the mosquitofish (Gambusia affinis), few fish lived in the streams when thermal effluent was present. During reactor shutdown, the streams return to ambient temperature and are invaded immediately by many fish from adjacent nonthermal areas. The diversity and abundance of species in the headwater tributaries of Four Mile Creek and Pen Branch upstream from reactor thermal effluents were reduced greatly in contrast to comparable areas in Upper Three Runs Creek or Steel Creek (McFarlane, 1976). Collection efforts have revealed that the first- and second-order tributaries of these streams were essentially devoid of fish.

To evaluate the potential for the entrainment of young stages of fish in the cooling-water systems, an ichthyoplankton sampling program was conducted in the river from March to August 1977 (McFarlane et al., 1978a). Fish eggs occurred in the collections during each month of the study. The greatest densities occurred in May. American shad comprised 96 percent of all fish eggs collected during the study. More than 1700 fish larvae representing at least 22 species were identified from the plankton collections. The greatest larval densities occurred in April. Clupeidae, primarily blueback herring, accounted for more than half of the larvae collected. Other abundant species were spotted sucker, black crappie, cyprinids, and channel catfish. The greatest number of

fish larvae were collected in Upper Three Runs Creek and in the 1G and 3G intake canals.

Savannah River fisheries program

The Biological Measurement Program in the Savannah River initiated in March 1982 was designed to provide additional data on the biological communities in the river that might be affected by the present and proposed activities at the Savannah River Plant. The long-term study of the river encompasses many factors including fish populations, meroplankton communities, and fish impingement at the SRP pumphouse intake screens. This section summarizes the results of the meroplankton and impingement sampling conducted from March through August 1982 and from February through July 1983 and electrofishing collections made in August and October 1982 and January 1983 (ECS, 1982, 1983a,b,c,d). A preliminary report (ECS, 1983d) describes portions of the 1983 results.

Meroplankton collections were made at nine transects and three creek stations during March through August 1982. The approximate locations of the sampling points are shown in Figures C-12 and C-13.

Larval fish populations in the region of the Savannah River sampled in 1982 were clearly dominated by the herring and shad family (Clupeidae). The herring and shad larvae combined made up almost 50 percent of all fish larvae collected (Table C-12). On 13 sampling dates between March 11 and August 29, 1982, a total of 2138 samples was collected. When these samples were sorted and analyzed, 10,205 ichthyoplankton were removed, identified and counted. Of this total, 50.7 percent were fish larvae and 49.3 percent were fish eggs.

In 1982, spawning for most Savannah River fishes occurred between early March and late July. On March 11-12, only 12 larval fishes were collected, which indicates that this sampling was prior to the main spawning period for most species. On March 25-26, 285 larval fish were collected. At that time, spotted suckers were the dominant larval form, constituting 42.8 percent of the total collection. On April 7-8, the minnows, which had not been taken in the prior collection, constituted almost 50 percent of the collection. Spotted suckers were again very abundant in April, making up 28.2 to 41.4 percent of the fish larvae collected. Minnows continued to dominate the collections from early April until May 20-21, when the number of unidentified clupeids increased to 43.0 percent of the total of 2268 larval fishes collected. Unidentified clupeids continued to dominate the larval collection through June, while minnows were almost absent from these collections. In July and August, the number of fish larvae collected was low.

During the survey, eggs of several important species (American shad, striped bass, and blueback herring) were identified. Eggs of these three species constituted 90 percent of the total eggs collected (Table C-13). Of the 5029 fish eggs collected during this study, 3550 were those of the American shad, about 71 percent of the eggs collected. McFarlane et al. (1978a) reported that over 96 percent of the fish eggs collected in their 1977 study were American shad. In the 1982 investigation, striped bass was the second most abundant fish egg collected. A total of 494 striped bass eggs was collected, which represents about 10 percent of all eggs collected during the study. Striped bass spawning had not been documented in the central Savannah River prior to 1982.

Table C-12. Number and relative abundance of larval fish collected at all stations in the Savannah River, March-August 1982^a and February-July 1983^b

Group	Total number collected		Percentage composition	
	1982	1983	1982	1983
Unidentified clupeids	1740	2957	33.6	6.9
Unidentified minnows	980	5557	18.9	13.0
Spotted sucker	825	1913	15.9	4.5
<u>Dorosoma</u> spp.	482	8234	9.3	19.3
Sunfish and bass	294	1778	5.7	4.2
Yellow perch	206	1658	4.0	3.9
Blueback herring	127	5648	2.5	13.2
American shad	110	653	2.1	1.5
Other	89	723	1.7	1.7
Unidentified suckers	88	321	1.7	0.8
Darter	88	1035	1.7	2.4
Carp	52	1370	1.0	3.2
Pirate perch	48	3105	0.9	7.3
Unidentified catfish	21	27	0.4	0.1
Sturgeon	15	10	0.3	<0.1
Gar	6	9	0.1	<0.1
Atlantic needlefish	4	6	0.1	<0.1
Swamp fish	1	7	<0.1	<0.1
Crappie		7257		17.0
Mud minnow		6		<0.1
Mosquito fish		4		<0.1
Pickereel		129		0.3
Silverside		160		0.4
Striped bass		88		0.2
Total	5176	42,655	100.0	100.0

^aAdapted from ECS, 1982.

^bAdapted from ECS, 1983d, which includes only daytime samples.

Table C-13. Number and relative abundance of eggs of each fish group collected in the Savannah River, March-August 1982^a and February-July 1983^b

Group	Total number collected		Percentage composition	
	1982	1983	1982	1983
Clupeidae				
American shad	3550	3612	70.6	50.7
Blueback herring	380	417	7.5	5.9
Percidae				
Perch and darters	87	309	1.7	4.3
Percichthyidae				
Striped bass	494	852	9.8	12.0
Other	<u>518</u>	<u>1928</u>	<u>10.4</u>	<u>27.1</u>
Total	5029	7118	100.0	100.0

^aAdapted from from ECS (1982).

^bAdapted from ECS (1983d), which includes only daytime samples.

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Fish larvae were generally distributed uniformly at the river stations and were dominated by shad, herring, and spotted sucker larvae (Table C-13). Fish eggs tended to be more concentrated in the middle portion of the river and often near the bottom. The intake canals had high densities of larvae and low densities of eggs. The eggs entrained into the canals probably settled to the bottom because of low-flow rates in the canal. Steel Creek and Upper Three Runs Creek contained numerous larvae and were sites for blueback herring spawning. High temperatures in Four Mile Creek precluded any extensive spawning in these waters.

Peak spawning activity occurred in May 1982. In May and June the abundance of fish eggs and larvae was significantly higher in nighttime collections than in daytime collections. Fourteen sturgeon larvae were also collected in 1982; both the Atlantic and shortnose sturgeon were represented (Table C-14).

A total of 26 transects in the river and 2 in the SRP intake canals were sampled weekly from February 1 through July 31, 1983. The river transects were located between River Miles 187.1 and 29.6. The 1G and 3G intake canals are located at about River Miles 157.0 and 155.4, respectively. These stations were divided into three groups for the analysis of the results:

Lower Farfield (downstream from SRP): River Miles 29.6 to 120.0 (ten stations)

Nearfield (adjacent to SRP): River Miles 128.9 to 157.3 (13 river stations plus the two intake canal stations)

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EZ-5

Table C-14. Locations and dates where sturgeon larvae were collected in the Savannah River during 1982 and 1983^a

Date of collection	River Mile	Species
3/12/82	157.3	Shortnose sturgeon
3/26/82	157.3	Shortnose sturgeon
4/22/82	155.2	Atlantic sturgeon
4/22/82	155.2	Atlantic sturgeon
4/22/82	155.2	Atlantic sturgeon
4/22/82	157.0	Atlantic sturgeon
4/22/82	157.0	Atlantic sturgeon
4/22/82	150.8	Atlantic sturgeon
4/22/82	157.0	Atlantic sturgeon
5/21/82	155.4	Atlantic sturgeon
5/21/82	155.4	Atlantic sturgeon
5/21/82	157.0	Atlantic sturgeon
5/21/82	157.3	Atlantic sturgeon
8/12/82	157.3	Atlantic sturgeon
3/09/83	79.9	Shortnose sturgeon
3/22/83	155.4	Shortnose sturgeon
3/22/83	157.1	Shortnose sturgeon
3/22/83	155.3	Shortnose sturgeon
3/22/83	155.2	Shortnose sturgeon
3/23/83	97.5	Shortnose sturgeon
3/29/83	155.2	Shortnose sturgeon
4/26/83	129.1	Atlantic sturgeon
5/03/83	157.0	Atlantic sturgeon
5/10/83	155.4	Atlantic sturgeon
5/17/83	150.4	Atlantic sturgeon
5/18/83	69.9	Atlantic sturgeon
6/14/83	150.8	Atlantic sturgeon

^aAdapted from Matthews and Muska (1983). These include all sturgeon taken during day and night sampling.

Upper Farfield (upstream of SRP): River Miles 166.6 to 187.1 (three stations)

A total of 36,941 fish larvae and 6308 fish eggs were collected during this period. The most abundant taxa were the Clupeidae, a family that contains the anadromous species blueback herring and American shad, as well as the forage species Dorosoma sp. Crappie and minnow larvae were also abundant (Table C-12).

In general, during February, March, and April, densities of total ichthyoplankton (eggs and larvae combined) were highest in the lower reaches of the river and decreased in an upstream direction. May was a transitional month when densities were more uniform throughout the river. During June and July, densities were generally higher in the nearfield and upper farfield than in the areas downstream. The trend of generally higher densities nearer the river mouth

earlier in the year is largely because the lower Savannah River warmed more rapidly than the upper reaches and provided suitable spawning conditions for a longer period of time. However, such factors as the migratory movement of spawning adults might also play a role in these trends.

The seasonal pattern observed was the same throughout the stretches of river sampled: low densities occurred in February, increased to peak values in May, and declined to low levels in July.

The eggs and larvae of the American shad were collected in all three river areas. A total of 3557 eggs and 512 larvae of this species were taken. Highest densities were observed during May at River Mile 157.3. Mean densities for the 6-month collection period were higher above River Mile 89.3 than below. Thus, the region of maximum spawning of this species in 1983 included, but was not limited to, the SRP area.

Blueback herring eggs and larvae were also collected in all three river areas. The highest densities were observed in April at River Mile 97.5. During all months, densities of this species were greater in the lower farfield than in the nearfield and upper farfield areas.

A total of 852 striped bass eggs and 88 larvae was collected during the 1983 river study. Striped bass ichthyoplankton were prevalent only in May and June, although a few were found in April. During May, eggs and/or larvae were collected at all 10 lower farfield transects; at 10 of the 15 nearfield transects, the greatest densities occurring between River Miles 155.4 and 152.0; and at one of three upper farfield transects. During June, ichthyoplankton of this species was collected at only eight transects overall. Densities were highest at River Miles 129.1 and 166.6. Striped bass were found at only two transects in April, both in the nearfield area. Based on these results, it appears that the entire length of the Savannah River that was sampled (from River Mile 29.6 to River Mile 166.6) was used by the striped bass for spawning in 1983.

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Yellow perch larvae were collected in all three of the river areas sampled. Highest densities were observed in April between River Miles 97.5 and 141.7. Densities were also high in this area during other months. This maximum-density region included the section of river below and, in April, slightly above Steel Creek, which is a major producer of yellow perch ichthyoplankton.

Crappie were the second most numerous larvae in the collections; a total of 6126 were identified. No eggs of this species were identified. Crappie reached greatest densities in March and April. They were most numerous in the lower farfield during both months. Densities were somewhat lower in May and much lower during all other months.

Minnows, which are important as forage for predatory species, were present during all months sampled. A total of 5170 larvae were found. This species first appeared in significant numbers during March. During this month, mean densities of larvae (no eggs were identified as minnow) were highest in the lower farfield but were also high in the nearfield between Lower Three Runs Creek and River Mile 141.7. Minnow densities were much higher in April, but the same basic pattern of higher densities downstream of River Mile 141.7 was evident. Densities peaked in May, especially in the nearfield.

Ten sturgeon larvae were collected during the routine 1983 ichthyoplankton studies: four shortnose sturgeon (in March) and six Atlantic sturgeon (in April, May, and June). All were collected between River Miles 69.9 and 157.0. Three other shortnose sturgeon larvae were collected during other sampling in 1983 (Table C-14).

AY-3 During several months, some fish taxa exhibited somewhat higher densities in the intake canals than in the adjacent river. In March and May, crappie ichthyoplankton densities were higher in the canals than the nearby river, as were blueback herring in April and Dorosoma sp. in June. These data suggest that crappie, blueback herring, and Dorosoma were spawning in the intake canals in 1983. However, all three taxa exhibited comparable or higher densities elsewhere in the river, indicating that other locations were equally or more important as spawning sites.

Adult fish sampling stations for the 1982 studies were the same as those described for fish eggs and larvae. At the river stations, canal stations, and Upper Three Runs Creek, a 100-meter section of shoreline was measured and marked. On Four Mile Creek and Steel Creek, the lengths of the shocking transects were limited to less than 100 meters by fallen trees that blocked the creeks.

Electrofishing and hoopnet collections were made in each sample area on four occasions within a 12-day period in August and October 1982 and January 1983. The repeated sampling was conducted to obtain a more complete species list and to collect sufficient numbers of fishes for an estimate of their relative abundance. Most fish collected were returned alive to the river following analysis.

Over 2400 fishes in 55 species have been collected to date. The adult fish community was dominated by spotted sucker, bowfin, redbreast sunfish, catfish, and flat bullhead (Table C-15).

The numbers of fishes taken in the river station collections by both electrofishing and hoop netting were similar in August and October and more variable in January. Fishes congregated in the heated discharge areas in the colder months and were absent from them during warm months.

Intake canal collections generally contained smaller fishes than the river collections and were dominated by centrarchids.

Creek station collections differed markedly from each other. Steel Creek had the highest fish density in October while the heated Four Mile Creek had the highest density in January. Upper Three Runs Creek had fish densities similar to river stations.

These data were consistent with the results of electrofishing collections made by the Georgia Game and Fish Division (1982) in the Savannah River. The Georgia study listed redbreast sunfish, striped mullet, spotted sucker, and bluegill as the most abundant fishes, exclusive of miscellaneous minnows. McFarlane et al. (1978a) listed redbreast sunfish, bluegill, and spotted sucker as the three most common species, exclusive of minnows.

Table C-15. Relative abundance of fishes collected by electrofishing in the Savannah River, August 1982, October 1982, and January 1983^a

Species	Percentage abundance		
	August 1982	October 1982	January 1983
Longnose gar	0.6	0.5	4.0
Bowfin	5.5	13.6	15.1
American eel	4.2	3.6	0.3
Blueback herring	0.0	2.4	0.0
American shad	3.9	0.0	0.0
Gizzard shad	2.9	1.9	4.5
Threadfin shad	0.0	0.0	2.3
Redfin pickerel	0.0	0.7	5.4
Chain pickerel	1.3	1.3	3.4
Carp	1.6	0.3	1.4
Golden shiner	0.0	0.0	0.3
Spotted sucker	15.3	13.5	22.7
Silver redhorse	1.3	0.9	1.4
Flat bullhead	1.0	0.0	0.3
Channel catfish	0.0	0.2	0.0
Pirate perch	0.0	0.9	0.0
Flier	0.0	0.0	0.9
Redbreast sunfish	18.8	22.4	7.1
Pumpkinseed	0.0	0.0	0.3
Warmouth	0.6	1.2	0.0
Bluegill	4.5	11.2	2.6
Dollar sunfish	0.0	1.4	0.0
Redear sunfish	15.0	3.3	7.7
Spotted sunfish	1.3	7.1	4.8
Largemouth bass	7.1	7.9	8.5
White crappie	0.0	0.7	0.3
Black crappie	0.6	0.7	3.7
Striped mullet	11.7	1.5	1.1
Yellow perch	2.3	2.0	2.0
Hogchoker	0.6	0.8	0.0

^aAdapted from ECS (1983b,c).

The Savannah River fisheries program was expanded in February 1983 to collect samples of fish eggs and larvae from the river and its major tributaries from Augusta to near Savannah. The results of the river portion of the study are given above. The information obtained from the sampling of the tributary creeks is given below.

A total of 27 creeks were sampled for ichthyoplankton from 5 to 23 times during the February through-July 1983 period. Five of these creeks drain portions of SRP: Beaver Dam Creek, Upper and Lower Three Runs Creeks, Four-Mile Creek, and Steel Creek. The remainder lie upstream or downstream of the site.

AY-2,
EZ-1,
EZ-5

A total of 5714 fish larvae and 810 fish eggs were collected. Spirit Creek (River Mile 182.8) had the highest number of ichthyoplankton with 1530 eggs and larvae taken in 19 samples. The high number at this location was due to the unusually high number of eggs (primarily Dorosoma sp.) collected during May and June.

Steel Creek yielded 518 fish larvae and 103 eggs in 23 collections. The larvae were predominantly minnows, yellow perch, and sunfish and bass. Many blueback herring eggs were also collected. When compared to other creeks that were sampled ten or more times, Steel Creek ranked eighth in larval density of all species combined. This creek was distinctive in having minnows and yellow perch represent about 27 and 30 percent, respectively, of the fish larvae collected. In all other streams of a similar size, these two species made up no more than about 13 and 7 percent of the total larvae, respectively. In Steel Creek, densities of crappie and larvae relative to other species were much lower than in the other large streams sampled.

Seasonal trends in larval abundance in Steel Creek indicated peaks in density in March and April that were due to high numbers of yellow perch. Peaks in May and June were caused by sunfish and minnows. The maximum density occurred on May 3, 1983. This sample period coincided with a sharp reduction in river level; the high density probably reflects a large number of sunfish larvae in the water draining from the swamp.

Seasonal trends in larval density in Steel Creek were compared to seasonal trends in mean larval density at the six similar large creeks. Spawning peaks occurred both earlier and later in the season in Steel Creek than at the other locations. Larval density was generally higher than the mean of the other creeks.

There was much more fish spawning in Four Mile Creek in 1983 than in 1982, apparently because high river levels reversed stream flow sufficiently to allow fish to enter the creek. A high density of larvae, mostly of the blueback herring, was observed on April 4, 1983. However, similar medium-sized streams that were sampled had higher larval densities and longer spawning periods than Four Mile Creek. Apparently, the elevated water temperatures in this stream were a factor that limited spawning.

Beaver Dam Creek was sampled 13 times and larvae were collected on all but one date. The larvae were predominantly sunfish and silversides.

The seasonal trend of ichthyoplankton abundance in four select creeks (Ebenezer, Briar, Steel, and Spirit) was evaluated from weekly samples between February and May, 1983 (ECS, 1983d). Densities of ichthyoplankton were relatively constant in Steel Creek, whereas densities fluctuated markedly in the other creeks (Figure C-14). Blueback herring spawning was greatest in Briar Creek, with high densities occurring over a 4-week period. Steel Creek had a high density of blueback herring on one sampling date (Figure C-15). Yellow perch larval density was higher in Steel Creek than in any of the other three creeks (Figure C-16).

Steel Creek fisheries program

The purpose of the 1982-1983 fish population studies in Steel Creek was to determine the use of the Steel Creek swamp and delta area by fishes and to characterize the fish community in terms of species use and relative abundance. Although some species known to occur within the Savannah River drainage are on the Federal or state lists of threatened and endangered species, no such fish have been collected in Steel Creek. Fish listed among South Carolina's commercially and recreationally important species have been collected. The commercially important species are primarily anadromous.

The Steel Creek area of the Savannah River swamp was divided into six sampling areas (Figure C-17) to determine habitat utilization by resident and anadromous fish (Smith et al., 1982a,b, 1983). The lower Steel Creek channel between the swamp and the Savannah River was also sampled. Sampling for anadromous fish began on January 30, 1982, and continued through 1983.

Fish of various sizes were collected for most species. The collections should be representative of both relative abundance and species composition of the swamp fish community. A total of 5313 fish representing 55 species were collected from the Steel Creek-river-swamp system from November 1981 through July 1982. A total of 1000 individuals representing 31 species was collected by fyke nets in Steel Creek from February through May of 1983 (Smith et al., 1982b) (Table C-16).

Figure C-18 shows the mean number of fish collected per 50-meter transect in the Steel Creek swamp area. The order of rankings of mean number of fish collected in each area were $B_1 > A_1 > B_2 > C > A_2$, with more fish collected in Area B_1 than in all other areas.

Areas B_1 and B_2 also appear to be important as spawning and/or nursery areas for resident fishes in the swamp. Young-of-year fishes were captured almost exclusively in these areas, although no spawning activity was ever observed. Young-of-year fish dispersed into other areas as they increased in size through the summer.

No major run of anadromous fish was detected in the Steel Creek area during 1982; a total of six American shad and four blueback herring was collected with fyke nets from February through April. To determine if the nets were an effective method for capturing clupeids, portions of lower Steel Creek were electrofished on selected dates; few fish were collected. Conversations with fishermen at the confluence of Steel Creek and the Savannah River also suggested that a major run did not occur in 1982 and that this year was atypical (Smith et al., 1982a). There was greater utilization of the Steel Creek delta-swamp area by adult shad and blueback herring in 1983 when compared to 1982 (76 shad in 1983 versus 6 in 1982; 124 blueback herring in 1983 versus 4 in 1982). Two striped bass were collected in this area in 1983 while none were collected in 1982 (Smith et al., 1983).

The 1982-1983 sampling provided information on which areas of the Steel Creek system are used by these species. The majority of fish were collected in lower Steel Creek channel with some fish being collected from the fast water

Table C-16. Total number of fish (by species) collected with fyke nets in Steel Creek and Upper Three Runs Creek, February-May 1983^a

Species	Steel Creek		Upper Three Runs Creek
	Upper net	Lower net	
Bowfin	14	11	9
American eel	2	2	8
Atlantic needlefish	0	1	0
Lake chubsucker	2	0	0
Spotted sucker	8	3	4
Flier	0	4	25
Redbreast sunfish	0	2	6
Warmouth	0	0	1
Bluegill	1	0	9
Redear sunfish	0	2	3
Spotted sunfish	12	0	0
Largemouth bass	1	0	0
Black crappie	4	3	14
Hickory shad	21	10	20
American shad	35	41	5
Blueback herring	48	76	209
Gizzard shad	74	64	97
Carp	0	1	0
Golden shiner	1	3	5
Chain pickerel	1	0	1
White catfish	3	0	5
Yellow bullhead	6	0	0
Brown bullhead	4	1	0
Flat bullhead	4	3	2
Channel catfish	34	6	15
Unidentified Ictalurid	1	0	0
Longnose gar	223	319	228
Florida gar	12	23	49
Striped mullet	6	7	1
Striped bass	1	1	2
Striped bass (hybrid)	0	0	4
Total	518	583	722

^aAdapted from Smith et al. (1983).

areas of the swamp. Other migratory fish that were collected included the Atlantic needlefish and striped mullet.

C.5 ENDANGERED AND THREATENED SPECIES

The Endangered Species Act of 1973 (Public Law 93-205) is administered by the U.S. Fish and Wildlife Service in conjunction with cooperating states and

other Federal agencies, and affords protection to some 300 species of native American plants and animals. A species can be federally listed under either of two categories, endangered or threatened, depending on its status and the degree of the threat posed to it. Endangered refers to a species or subspecies that is in danger of extinction throughout all or a significant portion of its range. Threatened means any species or subspecies that is likely to become endangered in the foreseeable future throughout all or a significant portion of its range. When a species is proposed for the endangered or threatened status, areas essential to its survival or conservation are also proposed as "critical habitat," when appropriate. Compliance with the Endangered Species Act requires Federal agencies to consult with the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service on potential impacts and mitigation and to conduct a biological assessment of any listed or proposed species that might be present in the area of the proposed action.

In addition to the Federal list, the State of South Carolina also recognizes and affords protection to fauna in accordance with the South Carolina Non-game and Endangered Species Conservation Act of 1974. However, the State does not afford protection to flora other than federally protected species.

TC | The following section addresses those species that are protected by Federal and state law. These include 3 plants, 1 bivalve, 1 fish, 1 reptile, 11 birds, and 2 subspecies of mammals (Table C-17). Species with historic ranges that include the Savannah River Plant are mentioned briefly even though they are unlikely to occur in the impact area. Where possible, emphasis is given to the vicinity of L-Reactor, Steel Creek and its delta, and the Savannah River. (For listings of unprotected taxa such as those of "special concern" or "peripheral," consult Forsythe and Ezell (1979) and Rayner et al. (1979).)

C.5.1 Flora

Two endangered and one proposed endangered species of vascular plants are listed by the U.S. Department of the Interior (USDOI, 1983) for South Carolina. None have been identified on the SRP site or near Steel Creek during field studies conducted over the past 25 years.

Termed the rarest orchid in America, the small whorled pogonia (Isotria medeoloides) is currently proposed by the Fish and Wildlife Service as an endangered species; only 16 populations, which include 150 to 175 individual plants, are estimated to exist within its phytogeographical range, which extends from Canada to Georgia (Norkin, 1980). The only population known to exist in South Carolina is in the Sumter National Forest, where its habitat includes second-growth deciduous or deciduous/coniferous forests having an open canopy, sparse shrub and herbaceous layers, and proximity to streams, roads, or rights-of-way.

The persistent trillium (Trillium persistens), a member of the lily family, is known only from a 6.5-kilometer area of northern Georgia and South Carolina (Finnley, 1979a). Its preferred habitat consists of hemlock-dominated or yellow-poplar-dominated cove forests with an understory of great laurel (Rhododendron maxima) of varying density. The occurrence of this plant anywhere on the SRP site is doubtful (Rayner, personal communication with G. P. Friday).

Only two populations of the endangered bunched arrowhead (Sagittaria fasciculata) have been confirmed--one in Henderson County, North Carolina, and the second in Greenville County, South Carolina. The latter population occupies a transmission line right-of-way along the headwaters of a river (Finnley, 1979a). The habitat of this plant is somewhat unique and consists of nearly level seepage areas that have a year-round, continuous supply of gently flowing cold water. The existence of this species on or near Savannah River Plant is very doubtful.

C.5.2 Fauna

C.5.2.1 Mussels

TC | Listed as endangered by the State, the brother spike mussel (Ellipio fraterna) has been identified only in the Chattahoochee and Savannah Rivers from sandbars beneath 0.3 to 0.6 meter of water (Britton and Fuller, 1980). The 1972 discovery of this bivalve in the Savannah River approximately 15 river miles downstream from the mouth of Steel Creek was the first documented collection in 130 years. The distribution and ecology of this species, particularly in the Savannah River, are poorly understood.

C.5.2.2 Fish

AY-3 | The shortnose sturgeon (Acipenser brevirostrum) is listed by the Federal Government as an endangered species in the United States (USDOJ, 1983). The species is found only on the east coast of North America in tidal rivers and estuaries. Prior to 1982, the shortnose sturgeon had not been reported in the middle reaches of the Savannah River in the vicinity of the Savannah River Plant. However, shortnose sturgeon larvae were found in ichthyoplankton samples collected in the Savannah River above Upper Three Runs Creek and 3G pumphouse intake canal as part of the Savannah River Biological Measurement Program (ECS, 1983a). As a result, DOE initiated a consultation process with the National Marine Fisheries Service (NMFS) to comply with the Endangered Species Act of 1973 (ESA, Public Law 93-205, as amended). Based on the results of this consultation process, the NMFS concurred in DOE's determination that the population of the shortnose sturgeon in the Savannah River would not be adversely affected (Oravetz, 1983).

C.5.2.3 Amphibians

TC | No amphibians inhabiting the SRP are currently listed as endangered or threatened.

C.5.2.4 Reptiles

Listed as endangered by USDOJ (1983) and by the State, the American alligator (Alligator mississippiensis) is locally common on the Savannah River Plant; it breeds in Par Pond and the Savannah River swamp (Gibbons and Patterson, 1978). The ecology of this species has been examined intensively on the Savannah River Plant, and is presented in Section C.3.1.

Formal consultation on the American alligator was held under the Endangered Species Act in September 1982 with representatives of DOE-SR, Du Pont, NUS Corporation, the Savannah River Ecology Laboratory (SREL), and the U.S. Fish and Wildlife Service (FWS). In a biological opinion, FWS judged that protection of the lagoons at SRP Road A should provide sufficient mitigation for the American alligator potentially impacted by L-Reactor restart. Protection of these lagoons has been completed.

Because of the delayed restart schedule for L-Reactor, the Fish and Wildlife Service requested reconsultation. DOE has subsequently reinitiated the consultation process, and has transmitted the most recent information and impact projections for this species (Sires, 1983, 1984a). DOE is awaiting a decision on its conclusion that the impacts resulting from the delayed restart of L-Reactor will not jeopardize the continued existence of the species.

AB-4

C.5.2.5 Birds

The Cooper's hawk (Accipiter cooperii) is listed as threatened by the State, and has been documented on the Savannah River Plant during Christmas bird counts (Angerman, 1979, 1980).

The winter range of the golden eagle (Aquila chrysaetos), an endangered raptor of South Carolina, includes Savannah River Plant. The number of breeding birds in the mountains of the eastern United States has declined significantly recently, but management efforts should enhance its survival (Forsythe and Ezell, 1979). Its presence on the SRP site has not been confirmed, but it might overwinter in the Savannah River swamp.

According to the most recent information, the ivory-billed woodpecker (Campephilus principalis) is probably extinct (Gauthreaux et al., 1979). There have been no confirmed reports of this large woodpecker on the SRP site and it is extremely unlikely that it exists. Its preferred habitat is dense, isolated mesic or swamp hardwood forests.

The endangered Kirtland's warbler (Dendroica kirtlandii) is apparently very habitat-specific, and has never been found to nest anywhere except in northern lower Michigan; specifically, it nests among dense stands of young jack pine on Grayling sand (Senecal, 1981). It winters in the Bahama islands and could possibly occur on the SRP site as a transient, although its presence has never been confirmed.

The summer or breeding range of the swallow-tailed kite (Elanoides forficatus), an endangered hawk of South Carolina, includes Savannah River Plant,

but its presence has never been confirmed. Its preferred habitat includes swamps, marshes, river banks, and open forests (Robbins et al., 1966).

The endangered peregrine falcon (Falco peregrinus) has been extirpated as a naturally occurring breeding bird in the eastern United States. Since the 1950s, captive breeding of peregrines and subsequent releases by Cornell University have spearheaded recent management efforts to reestablish this raptor (Finnley, 1979c). This species is reported regularly during migration and winter in South Carolina (Gauthreaux et al., 1979), but it has not been reported on the Savannah River Plant.

The bald eagle (Haliaeetus leucocephalus), an endangered species, has declined dramatically in number in recent years. During the 1980-1981 season, 20 active bald eagle nesting territories were observed in South Carolina (Kearney, 1981). The bald eagle has been observed over Par Pond (Patterson, 1981), but its presence near L-Reactor and Steel Creek is unknown.

TC | The wood stork (Mycteria americana) is designated as endangered by South Carolina and the Fish and Wildlife Service. As many as 386 individuals were observed in 1983 feeding in the Savannah River swamp of Savannah River Plant. This species is discussed in greater detail in Section C.3.2.

The osprey (Pandion haliaetus), which is listed as threatened by the State, has been observed on Savannah River Plant (Du Pont, 1982) but is considered an occasional migrant. It typically does not breed or winter in South Carolina (Robbins et al., 1966), but might use the swamp and riverine habitats on the Savannah River Plant briefly during migration.

TC | The endangered and nonmigratory red-cockaded woodpecker (Picoides borealis), first listed in 1970, is estimated to number less than 10,000 individuals (Finnley, 1979b). Also habitat-specific, this woodpecker nests in cavities in living upland pine trees averaging 75 years of age. The nearest colony to Steel Creek is approximately 0.8 kilometer from SRP Road A-19 (Du Pont, 1982). Because upland stands of mature conifers will not be affected by thermal discharge from L-Reactor, no indirect adverse impacts will occur to this species due to habitat degradation. The U.S. Fish and Wildlife Service has issued a biological opinion that the red-cockaded woodpecker will be unaffected by L-Area operations.

The endangered Bachman's warbler (Vermivora bachmanii), one of the rarest and least known of North American warblers, might be extinct. If the species still occurs in the United States, it probably is restricted to swamplands of South Carolina's coastal plain (Gauthreaux et al., 1979). Systematic surveys of the I'On Swamp, its last confirmed sighting, have been unsuccessful; its presence has never been recorded on the Savannah River Plant.

C.5.2.6 Mammals

Two subspecies of the cougar (Eastern cougar (Felis concolor cougar) and the Florida panther (Felis concolor coryi)) have historic ranges which include South Carolina. While the swamp bottomlands could provide habitat for

individuals of either subspecies, there is no indication that either the Eastern cougar or the Florida panther occurs at Savannah River Plant.

C.6 AREAS OF SPECIAL CONCERN

Areas of special concern include environments that are recognized by a government agency or the scientific community as having unique or exceptional value as natural resources. This category includes (1) wetlands, (2) critical wildlife habitat, (3) state and national forests, (4) state and national game management areas (i.e., sanctuary, reserve, refuge, or preserve), (5) prime agricultural land, (6) designated natural areas, and (7) wild and scenic rivers. Of the areas listed above, only wetlands will be impacted by the proposed action. A description of the wetlands is given in Section C.2, above.

C.7 COMMERCIALY AND RECREATIONALLY VALUABLE BIOTA

The utilization of fish and wildlife resources in South Carolina for commercial or recreational purposes is regulated by the South Carolina Wildlife and Marine Resources Department. This agency designates game species and season's creel and bag limits, and essentially regulates the fish and wildlife resources throughout the State.

Although the ecosystems of the Savannah River Plant support many populations of game and fish, commercial exploitation is prohibited and recreational use is restricted to controlled hunts of the white-tailed deer and feral hog. Despite restricted public access, poaching has been reported near the site's boundary and in the Savannah River swamp.

Commercially valuable plant biota on the Savannah River Plant include approximately 175,000 acres of timber that are managed by the U.S. Forest Service. The commercial value of timber on the Savannah River Plant that was managed and sold by the Forest Service was 1.7 million dollars in 1982; this included pine and hardwood sawtimber, pine pulpwood, and cordwood hardwoods. Approximately 71 percent of the timber sales consisted of pine pulpwood. The long-term trend in planting activities has been an increase in the number of loblolly pine and a decrease in slash pine. The latter is more susceptible to injury from ice glazing and has not been planted since 1970. Over 1,530,000 seedlings of loblolly pine and 160,000 seedlings of longleaf pine were planted in 1980 (USDA, 1983).

DY-1

Public hunting of deer and feral hogs on the SRP site has been managed by the Forest Service since 1966 to minimize deer-car accidents and to maintain habitat quality. Beginning in 1981, the planning and management responsibility of these hunts was given to E. I. du Pont de Nemours & Co.

The annual number of hunter-days increased from 700 in 1966 to 6325 in 1980; paralleling this trend was an increase from 198 deer killed in 1966 to 961 in 1980. The harvest of feral hogs ranged from 10 in 1972 to 32 in 1980. There also has been a relatively consistent decline in the number of deer-car

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accidents. In the late 1960s and early 1970s, deer-car accidents ranged in the 50s; only 11 incidents were reported in 1980.

Other game species that have commercial and recreational value but that are protected from hunting include the bobcat, fox, mink, muskrat, opossum, otter, rabbit, raccoon, skunk, squirrel, migratory waterfowl, bobwhite quail, mourning dove, wild turkey, Wilson's snipe, and woodcock.

The Savannah River supports both commercial and sports fisheries. Table C-18 lists the species and catches of fish taken commercially from the river from 1970 to 1979. Many of these fisheries are confined to the marine and brackish waters of the coastal regions of South Carolina and Georgia. Table C-19 lists the total weight of shellfish caught in the lower Savannah River and adjacent coastal waters between 1972 and 1979.

The only commercial fishes of significance near the Savannah River Plant are the American shad (*Alosa sapidissima*), the channel catfish (*Ictalurus punctatus*) and the Atlantic sturgeon (*Acipenser oxyrinchus*). These species, except for sturgeon, are exploited to a limited degree by nonprofessional local fishermen. There is no fishery specifically for hickory shad (*Alosa mediocris*) in South Carolina or Georgia; however, many are taken each year incidental to the catch of American shad (Ulrich et al., 1978).

Sport fishermen are the principal consumers of river fishes, primarily sunfish and crappie. Striped bass, which is classified as game fish in South Carolina and Georgia (Ulrich et al., 1978), is a favorite quarry of fishermen in the Augusta area.

Commercial and recreational fisheries for blueback herring (*Alosa aestivalis*) exist in South Carolina (Ulrich et al., 1978) but none are taken commercially in Georgia because of State netting restrictions.

Although species of commercial or sports importance in the Savannah River might use SRP streams, fishing or other exploitation of commercial species is not allowed on the site.

Anglers in the freshwater section of the Savannah River fish predominantly for bream and largemouth bass. Based upon electrofishing studies, the relative abundance of bream in the freshwater section of the river is high, as is the actual angler success rate. The lesser abundance of largemouth bass in the freshwater section results in a relatively low angler harvest of this species (Figure C-19).

Anglers in the estuarine section of the Savannah River fish predominantly for sea trout and striped bass. Electrofishing results indicate that these two species are not very abundant in the estuary. Actual angler success rates for these species are low (Figure C-20).

The Fisheries Section of the Georgia Department of Natural Resources recently published the results (Table C-20) of a fisheries study conducted on the Savannah River during the period July 1, 1981, to June 30, 1982 (Georgia Game and Fish Division, 1982). The study consisted of a creel survey of sports anglers and an electrofishing study. Together these studies provide data on the fish species most sought by anglers and on the probabilities of catching those species.