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RECOLONIZATION OF REACTOR COOLING WATER SYSTEM BY THE ASIATIC CLAM *CORBICULA FLUMINEA*

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RECOLONIZATION OF REACTOR COOLING WATER SYSTEM BY THE ASIATIC CLAM *CORBICULA FLUMINEA**

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ABSTRACT

Recolonization rates for the Asiatic clam *Corbicula fluminea* ranged from 3.0 to 5.6 metric tons per year in cooling water basins for a nuclear production reactor at the Savannah River Plant. However, a 10-month cleaning cycle for each basin (flow area, 6100 m^2) keeps the depth of the silt/clam layer low. With this cleaning frequency, *Corbicula* are not reaching heat exchangers at sufficient size or in sufficient numbers to restrict flow. Data are presented on the size/age distribution for clams recolonizing cooling water basins between cleanings.

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INTRODUCTION

The Savannah River Plant (SRP), built and operated for the Department of Energy by E. I. du Pont de Nemours and Company, was established in 1950 to produce plutonium-239 and tritium for national defense (Harvey and Randall, 1974). SRP occupies an 800-km^2 area of the Atlantic Coastal Plain near Augusta, Georgia, and is bordered on the south for 35 km by the Savannah River. The Savannah River is the principal source of cooling water for the nuclear reactors used to produce the plutonium and tritium.

The Asiatic clam *Corbicula fluminea* was first reported in the Savannah River near Augusta, Georgia in 1973 (Fuller and Powell, 1973). Labeled as a pest species by many industries, *Corbicula* are noted for their ability to restrict flow in water supply pipes and to clog ducts and screens. The affected industries are widespread and include water and sewage plants, power generating plants, and irrigation systems (Goss and Cain, Jr., 1975; McMahon, 1977). By 1975, sufficient numbers of *Corbicula* were present in cooling water from the Savannah River to clog the heat exchangers (Fig. 1) of P-Area nuclear production reactor, one of three (P, K, and C) at SRP. Clams were also found in the K- and C-Reactor cooling water systems.

The cooling water for P Reactor comes from two sources: the Savannah River and a cooling water reservoir, Par Pond (Fig. 2). The cooling water for K and C Reactors is pumped directly from the river through a system of pipes into large basins. Juvenile clams apparently enter the system with the river water and are transported 8 to 10 km through pipes before reaching the basins. *Corbicula* have been looked for but have not been found in Par Pond.

At K and C Areas, large volumes of river water are discharged into three 32-megaliter basins (Fig. 3) where some settling occurs before the water is pumped through heat exchangers in the reactor area. The floor area of each basin is approximately 6100 m^2. Due to infrequent cleanings and unexpected accumulations of *Corbicula*, the silt/clam substrate levels in P-Area basins were about 90 cm deep when heat exchanger pluggage occurred. The substrate levels in K-Area basins in 1976 were approximately 75 cm. The deposited silt and flow of river water provides suitable substrate and nutrients for *Corbicula* growth and reproduction. Silt and clams must be removed at regular intervals to prevent heat exchanger pluggage arising from high populations of clams in the basins. Current practice is to clean the basins every ten months.

A model has been developed to determine the growth rate of *Corbicula* in the cooling water basins at SRP (Pool and Tilly, 1978); their survival in chlorinated water has also been studied (Tilly, 1973). The objective of this paper is to characterize and provide a measure of the *Corbicula* population recolonizing the K-Area cooling water basins between cleanings (October 1976 - August 1977).

METHOD

At present, the clams are controlled by cleaning the reactor basins, pump wells, and emergency cooling system every ten months. Each cleaning occurs during reactor shutdown and involves draining the basins. The walls are washed down with fire hoses and the silt on the floor is removed. The emergency cooling system is also flushed completely at this time.

When the basins were cleaned, clams suspended in basin water were sampled with a 760-μ plankton net, 0.5 m in diameter and 1.5 m long, with a digital flowmeter mounted in the mouth of the net. The net was hand-held near floor drains as water levels dropped from 1.0 to 0.7 m. The sample was examined and clams were measured with the aid of a dissecting microscope.

Quantitative samples from the walls, floors, and pump wells were washed through a U.S. Standard Number 10 sieve to collect the *Corbicula* present. Shell lengths of 100 clams from each sample were measured with a caliper across the widest part of the shell parallel to the hinge; this measurement was then used to determine the approximate age of each specimen (Gardner, et al., 1976).

RESULTS AND DISCUSSION

Flow was maintained on at least one of the three cooling water basins at all times. Under normal flow conditions, water is pumped from the pump wells to heat exchangers in the reactor area. Basins 2 and 3 were both drained on 1 September 1977, and were dry, when sampled six days later, except for small areas exposed to leakage. Basin 1 was drained on 28 September 1977, and was sampled during and immediately after draining. Basin 2, located between the other basins, contained essentially no silt and too few clams for a meaningful sample. About 50% of the floor area of Basin 3 was covered with silt up to 12.5 cm deep with an average depth of about 7.5 cm. Clam mortality, based on 5 sample areas (each 100 cm^2), ranged from 20 to 80% depending on the moisture of the substrate. Earlier notification would have permitted samples from Basin 3 during draining and would have made results more comparable with those from Basin 1. Mortality was only 5% for *Corbicula* collected from pump wells in Basins 2 and 3, and for those collected from Basin 1. About 40% of the floor area of Basin 1 was covered with silt up to 5.0 cm deep with an average depth of 2.5 cm.

Clam concentrations on the floors of Basins 1 and 3 (Table 1) were generally comparable except for the fifth sample from Basin 3 which was taken from a large mound of clams piled up by receding water. By using mean concentrations of *Corbicula*/m^2 and appropriate percentages of floor area covered by silt, clam populations in Basins 1 and 3, ten months after cleaning, were estimated to be 2.7 and 10.2 million, respectively (calculation excluding sample 5).

Size/age distribution data (Table 2) show that *Corbicula* in Basin 1 were smaller and younger than those in Basin 3. A higher percentage of juveniles and fewer one- and two-year old *Corbicula* in Basin 1 than in Basin 3 may be due to the source of cooling water. Basins 2 and 3 are supplied from the river water header; Basin 1 is supplied from a tie line header which has a section of pipe with stagnant water. This would suggest that the juveniles might be produced or raised in the tie line.

The silt substrate in the pump wells of Basins 2 and 3 generally contained higher concentrations of *Corbicula* (Table 1) than were found in basin floor samples. The reason is not known. Size/age distribution data for clams from the pump well (Table 2) are comparable to those observed for clams in Basin 3.

Wall scrapings in the K-Area basins did not yield any *Corbicula*. Samples (100-cm^2 areas) were collected at various depths and washed through a U.S. Standard Number 10 sieve.

Corbicula larvae, generally smaller than 250 μ, were not found in the K-Area basins. Shell lengths of 151 juveniles collected from 400 kiloliters (kL) of water during the draining of Basin 1 ranged from 380 to 1000 μ (1 kL = 264.18 gallons; 1 μ = 0.001 mm). These specimens were collected in a 715-μ plankton townet as the water level dropped from 1.0 to 0.7 m. This collection represents a concentration of about 0.4 clams/kL or 12,618 clams per basin volume.

An analysis of the size/age distribution data (Table 2) shows that *Corbicula* grow about 600 to 1100 μ/month during the first year. On this basis, the juveniles collected from Basin 1 were probably produced in late August or early September 1977, just prior to the draining of the basin. The *Corbicula* spawning season begins when the water temperature reaches 16 to 17°C and continues until temperature falls below this (Gardner et al., 1976), thus allowing a spawning season in the Savannah River usually from April through November. However, the origin of these clams can only be speculated. They could have entered the basins as larvae or as juveniles by transport through distribution pipes, or they could have been produced as larvae by adult *Corbicula* living on the floor of Basin 1.

An experiment in October 1977 estimated the transport of *Corbicula* from the raw water system into Basin 1. Immediately after the basin was drained, the walls and floor were washed with fire hoses to remove all clams. The basin was refilled on 6 October 1977, and the water was allowed to stand for two hours for the clams to settle before draining for the second time. Four *Corbicula* juveniles with shell lengths about 0.5 mm in length were found in a 129-kL plankton townet sample (mesh 715 μ) collected from Basin 1 as the water level dropped from 1.0 to 0.7 m. This calculates to about 0.03 clams/kL or 946 clams/basin volume. When the basin was completely drained, the basin floor contained very little silt and only a few clams near the inlet header and near the effluent drain. Six 1-m^2 floor samples yielded *Corbicula* concentrations of 0, 0, 4, 12, 2, and 0/m^2. One specimen was less than 1 year old, seven were about 1 year old, and ten specimens were approximately 2 years old. This experiment demonstrates how quickly a clean basin can be restocked with both juveniles and sexually mature clams from the river water header.

SUMMARY

The ten-month cleaning cycle is effective in preventing the buildup of silt/clam substrate in K-Area basins. The level in 1976 was about 75 cm; in both 1977 and 1978, silt/clam levels were <15 cm. Although clams are recolonizing Basins 1 and 3 at rates of 3.0 and 5.6 metric tons/year, clams apparently are not reaching the heat exchangers at sufficient size or in sufficient numbers to restrict the cooling water flow. A higher percentage of juvenile clams in Basin 1 (78%) than in Basin 3 (9.4%) may be due to Basin 1 receiving water from the tie line header which has a section that is not routinely flushed to remove clams.

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TABLE 1. Corbicula *concentrations in K-Area cooling water basins.*

Sample No.	*Number of Clams/m² of Sample Area*			
	Basin 1		*Basin 3*	
	Basin Floor		*Basin Floor*	*Suction Well*
	Sept. 1977	*Aug. 1978*	*Sept. 1977*	*Sept. 1977*
1	3002	23270	4380	11780
2	1076	11580	505	30380
3	656	7061	2130	18600
4	1431	15403	6230	-
5	430	4628	44780[1]	-

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[1] Sample 5 was collected from a mound of clams accumulated by receding water. The sample is not representative of clam concentrations in the basin.

TABLE 2. *Size distribution of* Corbicula *in the K-Area cooling water basin.*

Location	*Shell Length/Age Class (Percent of Population)*			
	<7.5 mm (<1 yr)	*7.5 - 13.5 mm (1 yr)*	*13.6 - 18.5 mm (2 yr)*	*18.6 - 28.0 mm (3 yr)*
186-1K Basin				
Floor, Sept. 1977	78.3	14.9	6.8	0.0
Water[1]	100.0			
186-3K Basin				
Floor	9.4	73.9	16.7	0.0
Suction Well	17.5	48.3	29.2	5.0
K-Area ECWS				
CW-39	1.0	37.0	39.0	23.0
RW-1	1.0	59.0	39.0	1.0

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[1] Shell lengths are <1 mm (151 specimens).

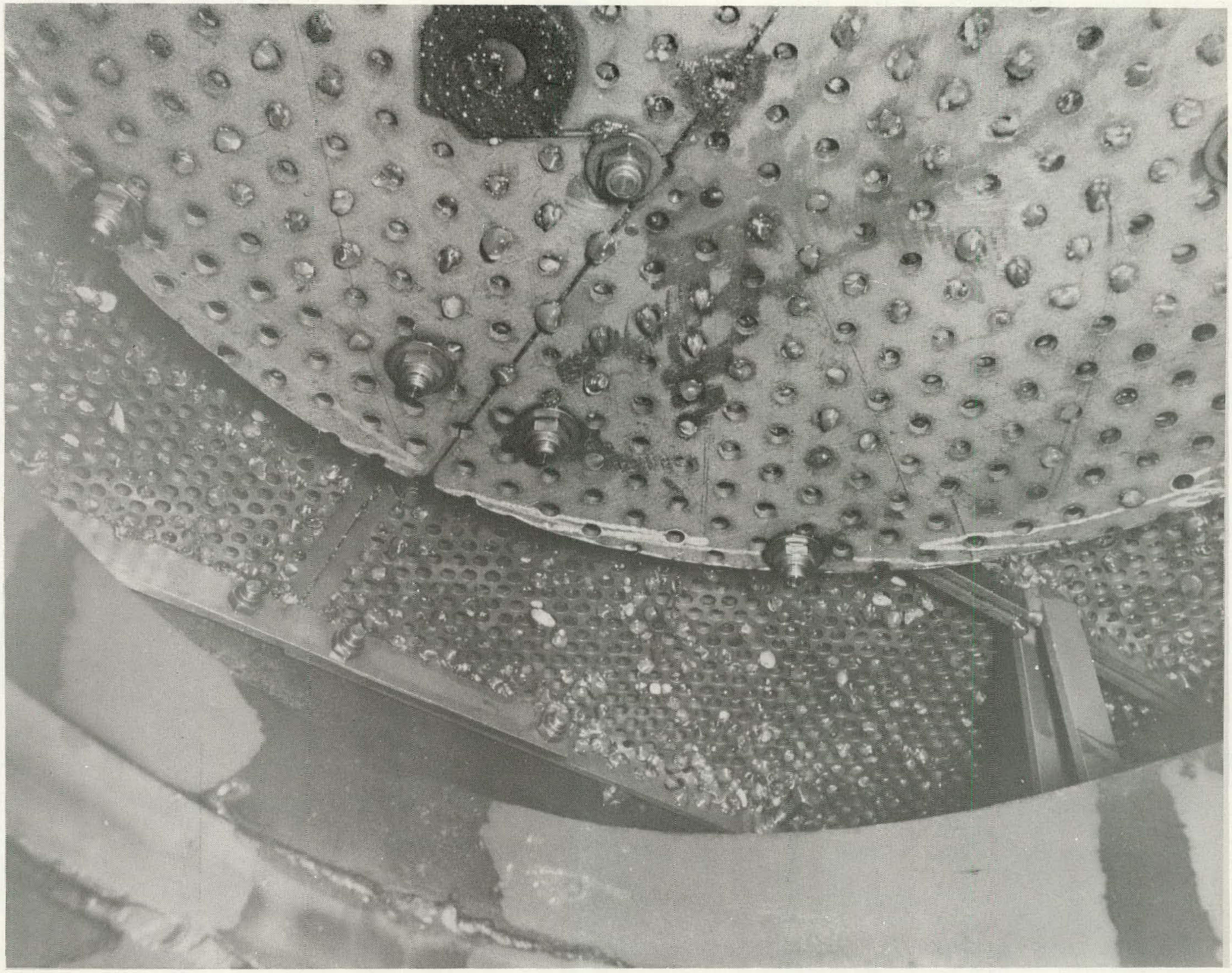

FIG. 1. *Heat exchanger openings are clogged by the Asiatic Clam* Corbicula fluminea.

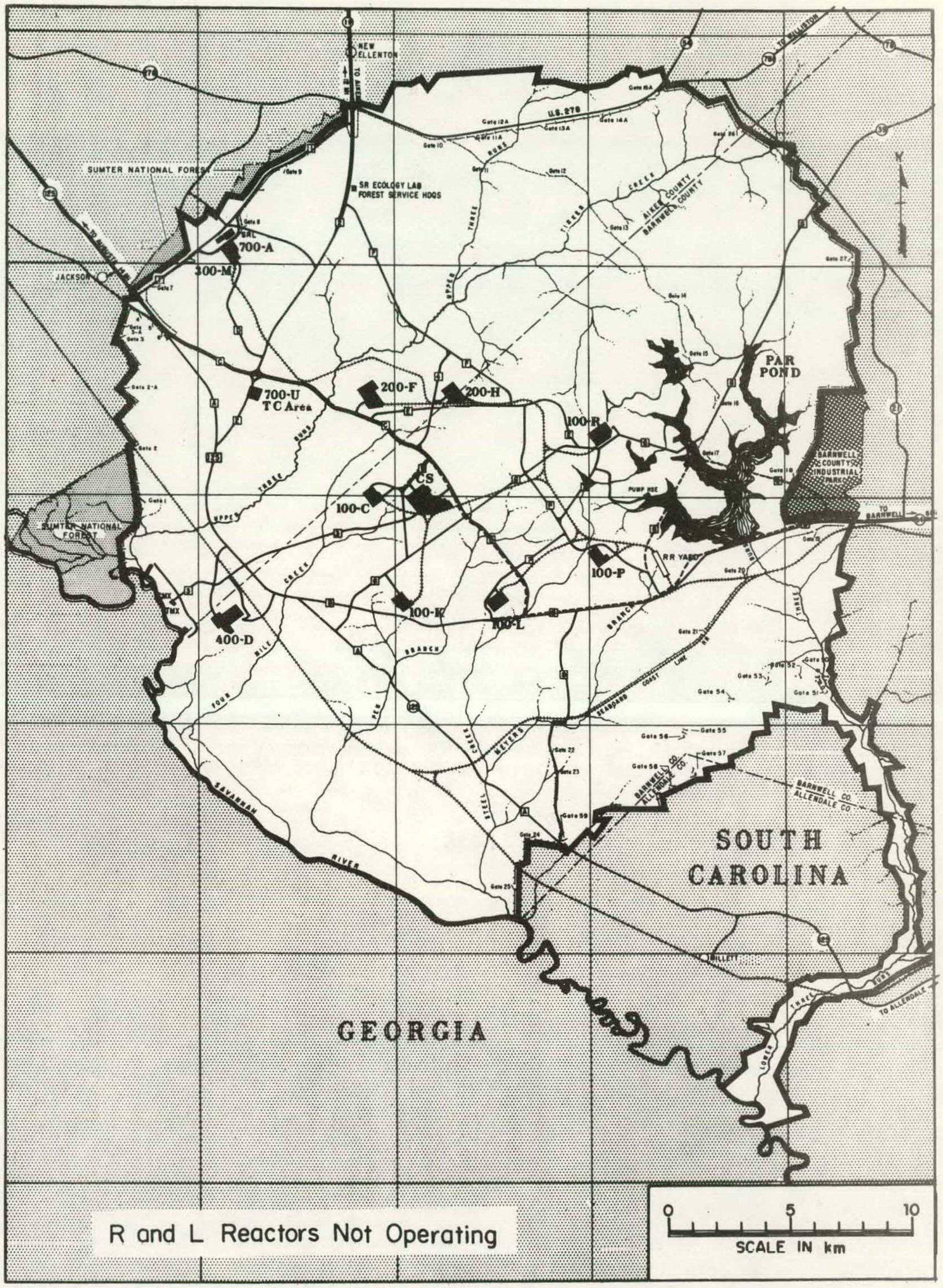

FIG. 2. *Production Areas and cooling water sources on the Savannah River Plant.*

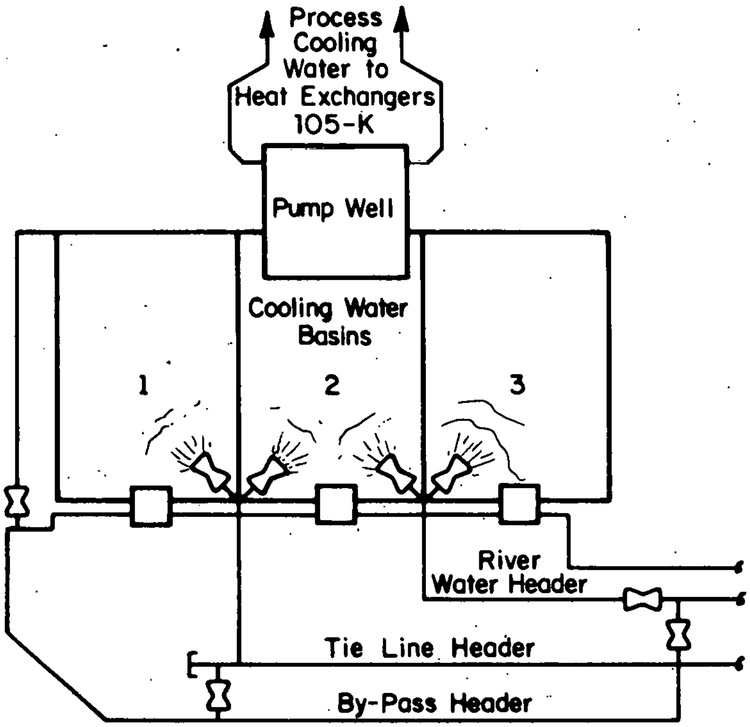

FIG. 3. *K-Area cooling water system.*