YMA
1991

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Virginia Cooperative Fish and Wildlife Research Unit
106 Cheatham Hall, Virginia Tech
Blacksburg, Virginia 24061

Memo

To: Tom Pride, YMA

From: Dick Neves, VCFWRU

Subject: Draft report

Date: June 25, 1991

I have reviewed the draft report on the NFHR and find it to be in good order. In addition to some minor editorial comments, I recommend the following:

1. Nomenclature should follow Turgeon et al. (1988), which contains the binomials approved by AMU and AFS.
2. The number of federally endangered species in SW Virginia is now 12, not 9 (p. 14).
3. Reference to Imlay (1973) and Havlik and Marking (1987) would improve the credibility of pp. 6-7.
4. Citation of Neves and Odom (1989) should be included because of data for NFH RM 86.9.

I assume that the interpretation of Hg data will occur elsewhere in the RI report. Perhaps a copy of that report will be available for review by outside agencies in early 1992. I hope these comments are of use to you.

/cwl

Young-Morgan & Associates

14 June 1991

Dr. Richard Neves
Virginia Cooperative Fish and Wildlife Research Unit
Dept. of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute
Blacksburg, Virginia 24061

RE Review of North Fork Holston River Mussel Report, YMA Job #0302.

Dear Dr. Neves:

Enclosed please find (1) copy of YMA's mussel report for the North Fork Holston River submitted for your review/comments. The mussel report will eventually be a chapter in the Remedial Investigation (RI) Report for the Saltville Waste Disposal Site. A detailed review of the history of the site, location, maps, etc., will be included in the introduction of the RI Report and are, therefore, not presented in the mussel report. We will be submitting the first draft of the RI Report to EPA in October 1991.

Thanks again for taking time to review and comment on this work. Please call myself (703-676-3450) or Don Hubbs (615-790-0003) with any questions or comments.

Sincerely,

Young-Morgan and Associates

Tom Pride

Tom Pride

Consultants in the Environmental and Applied Earth Sciences

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INTRODUCTION

Various mussel population studies over the past 100 years have been reported for portions of the North Fork Holston River and certain of its tributaries. Historical surveys focused on the qualitative presence of unionid species above and below the former Olin chlorine plant site during the period of plant operations (1895 to 1972) and following the closing of the plant in 1972. This report presents a summary of the historical status of North Fork Holston River (NFHR) mussels and describes surveys performed at selected reaches of the NFHR in August 1988 and in the summer and fall of 1990.

Historical Review

The exploitation of freshwater mussels for the pearl and button industry of the 1800's through the early 1900's has been well documented (e.g., Coker, 1919; Ellis, 1931). Use of mussels for the pearl button industry was identified as a leading cause of nationwide declines in mussel diversity. In some streams, such as the Clinch and Duck Rivers, certain species were fished exclusively for pearls. In most major rivers, however, both commercially and non-commercially valuable mussels were taken in hopes of acquiring as many pearl products as possible. "Pearling" and the production of novelties were actively pursued using freshwater mussels as early as 1830. However, the pearl-button industry and the

resulting by-products trade did not utilize freshwater species until 1891 (Coker, 1919).

Clammers began operating in southwest Virginia and northeast Tennessee in the early 1900's. In 1912, 96 tons of shells were taken from the Clinch River and 50 tons from the Powell River (Coker, 1919). Coker (1919) identifies the Holston River in Tennessee as a minor mussel stream but does not mention the tonnage of shells taken. Some reports indicate that clammers moved up the tributaries of the Holston River as beds became depleted in the mainstream.

The earliest, most complete description of the mussel fauna on the North Fork Holston River was compiled by Ortmann (1918) using information from his own surveys (1912, 1913, 1915), from those of Adams (1900, 1901) and from Peterson (1917). He listed 16 species of mollusks at Saltville, Smyth County, Virginia, and 37 species below Saltville (Tables 1 and 2). He made no collections above Saltville. In 1968, Stansbery (1972) found no species of mussel from below Saltville to the confluence with the South Fork Holston River. Also in 1968, Stansbery and Clench (1974) found 11 species at Saltville and in 1971 they identified an additional 6 species from the same area. The same 17 species were also identified above Saltville (Table 3).

A survey of the river in 1957 from Saltville to its confluence with the South Fork indicated that no mussels were found for the first 70 miles and only 6 species were collected in the remaining section (TVA, 1980). Following the closure of the chlorine plant

in Saltville in 1972, the Tennessee Valley Authority (TVA) began a monitoring program to determine the recovery of fish and macroinvertebrate populations, including mussels, in the river. Ahlstedt (1979) also found no mussels along this same 70 mile reach between 1972 and 1975.

To enhance recolonization of the river below Saltville, TVA initiated a transplant program designed to recolonize the lower reaches with species known to be historically present. Between 1975 and 1978, a total of 2,887 mussels representing 16 species were transplanted from the Clinch River and the upper North Fork Holston River into four sites below Saltville (Table 4). A survey in 1980 by TVA (Ahlstedt, 1980) revealed that some of the transplanted mussels were still alive although there was no evidence of reproduction. The flood of 1977 evidently washed out the transplanted mussels at NFHRM 52.7 (personal communication, S. Alstedt, TVA, Norris, TN). Recovery rates for marked individuals at the remaining sites ranged from 0 to 44 percent. During the 1980 survey some native species (not transplanted) were observed to be abundant and reproducing in the lower North Fork Holston River. Those species included Lampsilis ovata, Lampsilis fasciola, Villosa iris, and V. vanuxemi.

In November 1982, TVA transplanted 1000 specimens of the endangered mussel Lemiox rimosus (Conradilla caelata), to the North Fork at NFHRM 4.8. Annual quantitative surveys of the transplant site have shown a steady decrease in mussel density. This decrease is attributed to both migration out of the transplant area and

mortality. It is unknown, however, which factor is the more significant. Muskrats are known to have preyed heavily upon the Lemiox during the first few years after transplanting (personal communication, S. Ahlstedt). Although gravid females commonly have been found during the surveys, there has been no evidence of reproductive success.

In 1981, Sheehan et al. (1989) and the Virginia Cooperative Fishery Research Unit translocated a total of 1,692 adult mussels of three species, Medionidus conradicus, Villosa nebulosa and V. vanuxemi at NFHRM 59.5, 68.6 and 73.9. As part of the same study, 50 specimens each of M. conradicus, V. nebulosa, and V. vanuxemi and 100 specimens each of Actinonaias ligamentina, A. pectorosa and Amblema plicata were translocated in 1985 at NFHRM 79.9.

The first set of transplanted populations was censused annually from 1983 to 1985. By 1985, the survival rate among all three species ranged from 2.0% to 11.0% of the total number. After 355 days, greater than 80% Amblema plicata and Actinonaias spp. from the second transplant set survived. The survival rate of Villosa nebulosa, V. vanuxemi and Medionidus conradicus, averaged about 49% after 328 days.

Sheehan et al. (1989) feel that natural mussel mortality may explain the low survival rates of transplanted mussels in the NFHR. They explain that periodically supplementing transplanted populations may be necessary "... until recruitment through reproduction is sufficient to replace the loss of breeding adults due to natural mortality."

Several mussel life-history/reproductive biology research projects have been conducted by Virginia Cooperative Fishery Research Unit personnel in the NFHR and Big Moccasin Creek, a large tributary of the North Fork entering below Saltville at NFHRM 10.2. Neves and Widlak (1988) described the occurrence of glochidia in stream drift, and the prevalence of glochidial infestations on host fishes in the North Fork Holston River from June 1981 to June 1982. Zale and Neves (1982a) found periods of glochidia in drift, and positively identified fish hosts for four mussel species of the subfamily Lampsilinae which occur in Big Moccasin Creek. The mussels and host fishes were as follows:

Mussel	**Fish Host**
Villosa nebulosa	Micropterus dolomieui (smallmouth bass) Ambloplites rupestris (rock bass)
Villosa vanuxemi	Cottus carolinae (banded sculpin)
Medionidus conradicus	Etheostoma rufilineatum (redline darter) Etheostoma flabellare (fantail darter)
Lampsilis fasciola	Micropterus dolomieui (smallmouth bass).

Zale and Neves (1982b) also examined histological sections of gonadal tissue from males and females of these same four species to reveal the active gametogenesis process and separate spawning periods of the four species. In light of the fact that Big Moccasin Creek is a major tributary of the NFHR, results of the studies in Big Moccasin Creek are almost undoubtedly applicable to the NFHR (personal communication, R. Neves, VPI, Blacksburg, VI).

In summary, a diverse mussel fauna existed in the NFHR at the turn of the 20th century but had been extirpated from below Saltville to the confluence with the South Fork Holston River by the late 1950's. Recolonization and transplant efforts are being rewarded with limited success. A general decline in mussel diversity has been observed in the NFHR above Saltville.

Effects of Mercury and Salts on Mussels

The discharges associated with the alkali works in Saltville in the first half of the 20th century were composed of various inorganic salts and other unknown constituents. Operation of the chlorine and caustic soda plant (1951-1972) resulted in discharges containing mercury and various inorganic salts. The mechanisms of toxicity of these constituents are not well defined for mussels (Fuller, 1974) but some observations have been made regarding the relative toxicity of salts and mercury to mussels.

Ellis et al. (1930) reported the effects of potassium, sodium, magnesium and calcium salts on the blood chemistry of freshwater mussels. They found potassium salts (chloride, sulphate and carbonate) to be the most toxic, followed by sodium, magnesium and calcium. In all cases the mussels were very sensitive to changes in salt concentration of the water. As a result of the rapid physiological response of the blood to the change in salt concentrations, they concluded that the osmotic barrier separating the blood and environmental fluids is weak. In a similar study, Motley (1934) found potassium chloride to have an extremely adverse

effect on mussel heart rhythm when perfused externally. Internal perfusions of the salt solutions elicited an even greater adverse response. Motley also noted that calcium chloride and sodium chloride were slightly less toxic than potassium chloride.

Three potential sources of toxic salts have been identified in the NFHR. The naturally-occurring brine fields in Saltville drain into the NFHR opposite the former Chlorine Plant Site (NFHRM 82.8). The composition and salt concentrations of this stream are currently being investigated as part of the RI Study, but recent conductivity, total dissolved solids and chloride readings from the brinefield drain were relatively high (Olin, 1988; 1990). In a 1978-1979 study, Dames and Moore (1980) reported an average TDS level of 5,725 mg/L. Chloride, calcium and sodium concentrations averaged 2,789 mg/L, 205 mg/L and 1,600 mg/L, respectively. Under normal conditions, this stream was probably not toxic to mussel populations, as various species had historically been collected in the vicinity (Stansbery and Clench, 1974). It is possible that perturbations within the brine fields associated with the salt works may have elevated the salt concentrations in the stream to potentially toxic levels. However, such an increase in TDS levels probably would not be toxic enough to extirpate mussel populations for so many miles downstream in the NFHR.

A second historical source of possible elevated TDS levels is the discharges of the former alkali plant including the operations during the first half of the 20th century (prior to the chlorine plant operations and the use of the mercury electrode). Historical

records of the aesthetic quality of the discharges as far downstream as Holston (Adams, 1915) suggest a potential significant impact on the river fauna. After startup of the chlorine operations, TDS measurements from 1950 to 1956 revealed 1,000 to 2,000 tons of salt per day were discharged from the plant site. When TDS measurements were resumed in 1984, the low flow salt loads had been reduced to 100 tons per day (Jones and Stokes, Inc., 1990).

A current source of elevated TDS levels are the Ponds 5 and 6 effluent between NFHRM 81.7 and 81.6. Conductivity readings as high as 15,500 umhos/cm and TDS levels of 13,043 mg/L have been recorded at the Pond 5 discharge (Olin, 1991). High levels of calcium, potassium and sodium were found in the effluent between August 1983 and April 1985 (GCA, 1986). Olin Corporation currently is performing routine analyses on the discharge. The current estimated salt loading from the Pond 5 discharge is 2.5 tons per day at a flow of 60 gpm (personal communication, R. Brown, Jones and Stokes, Inc., Sacramento, CA).

Studies of mercury toxicity to mussels are lacking but Imlay's (1982) review of mussels as indicator organisms indicate that mercury accumulates in the shells and soft parts over a wide range of concentration levels. No information concerning the acute and chronic effects of mercury poisoning in mussels is available.

In order to determine the recovery of mussel populations in the NFHR, Young-Morgan and Associates (YMA) performed a qualitative reconnaissance survey of the river in August 1988 and both

qualitative and quantitative sampling in the summer and fall of 1990. The following is a description of these surveys.

The main objective of the current study is to determine the effect of past and present discharges from the Saltville Site on the NFHR mussel community. The mussel sampling program, as proposed in the RI/FS Sampling Plan (Olin, 1989), was designed to address two current data gaps: (1) the present status of the mussel population in the NFHR, and (2) the mercury concentration in the bivalve population, specifically Corbicula fluminea, in the NFHR.

As part of the mussel sampling program, a qualitative reconnaissance survey of the river was performed in August 1988 and both a qualitative and quantitative study was performed in the summer and fall of 1990. Mussel sampling during 1990 included surveys of TVA and VPI transplant sites and collection of Corbicula for mercury analysis.

MATERIALS AND METHODS

In 1988, a qualitative reconnaissance survey was performed to facilitate sample location selection for the 1990 study design. Samples of mussels were collected at 14 sites on the NFHR. Two of the sites were below the former plant site, the remaining 12 were from above Saltville to the headwaters of the river. Considerations in sample site selection included relative proximity to historical sampling locations and likelihood of collecting live mussels. Habitat types included riffles, runs, undercut banks, log jams and shallow pools. Collections were made by handpicking mussels from

the substratum. Live mussels were identified to the specific level when possible. Questionable identifications were photographed for later verification and returned to the substratum or retained for analysis. Identification was based solely on external shell characteristics.

The purpose of the 1990 survey was to document the present status of the mussel fauna above and below the Saltville Site. During the 1990 survey, qualitative sampling was performed at 19 sites approximately two to three miles apart, 16 of which were below Saltville (NFHRM 82.8-53.2). Six sites were also quantitatively surveyed: NFHRM 91.5, 88.5, 85.6, 61.0, 56.4 and 53.2. Quantitative surveys were not conducted at the other 13 sites due to the low numbers of mussels found during qualitative sampling. Quantitative collections were made by marking two 10m x 20m areas at each site. Forty $0.25m^2$ grids were then sampled within each area for a total sampling area of $20m^2$. The total amount of habitat disturbed at each site was 5 percent or less, while the large number of grids enhanced the statistical quality of the data and decreased the possibility of overlooking a rare mussel within the sampling area (Green and Young, 1990).

Attempts were made to collect Corbicula from thirteen sites (NFHRM 53.2, 56.4, 58.2, 60.7, 63.8, 66.3, 71.0, 74.0, 76.7, 81.3, 85.6, 88.5 and 91.5) for total and methylmercury analysis. A recently published protocol from the United States Fish and Wildlife Service suggested collecting live Corbicula and holding them for a 72-hour depuration period to remove any contaminated

sediments from the gut. To determine any difference in mercury levels in purged and non-purged specimens, approximately 400 Corbicula were collected from NFHRM 81.3 and split into two equal samples. One sample was immediately frozen on dry ice, causing the valves to open. The tissue was removed and shipped on dry ice to the laboratory for analysis. The second sample was placed in baskets with 0.25 inch openings and suspended in an aquarium containing reconstituted water. After three days, the Corbicula were removed, the tissue extracted and shipped on ice to the laboratory for analysis. Comparison of the single composite for each treatment (Table 10) indicated no difference in mercury concentrations for purged vs. non-purged organisms. For this reason, none of the Corbicula in later samples were purged prior to sample preparation.

Where found, Corbicula were collected from each bank and mid-stream at each site. Substratum at each sampling point was shovelled into a box sieve and the Corbicula were removed by hand, placed in labelled plastic bags and frozen on dry ice. They were later shucked, homogenized and submitted to the laboratory for mercury analysis.

Sediment for mercury analysis also was collected at each Corbicula collection location. Each sediment sample was placed in a labelled plastic bag, frozen and delivered to the laboratory. Comparisons will be made with Corbicula and sediment mercury levels.

Finally, relic mussel shells were collected and identified

from the NFHR during 1989 and 1990. Identification of formerly productive locations should provide useful information for future transplant efforts and evaluation of habitat suitability, although caution should be used when using data obtained from relic mussels.

RESULTS

Mussel surveys

Fifteen species of unionid mussels were collected during the 1988 qualitative survey. Four species were collected below Saltville, 10 at Saltville and 13 above Saltville. Also, 22 specimens of Sphaerium fabale (Family Sphaeriidae) were collected above Saltville. Villosa vanuxemi was the most abundant species collected, followed by V. nebulosa. Both were collected at 10 of the 14 sites, making them the most frequently occurring species. A specimen of Lasmigona holstonia was collected near Ceres (NFHRM 128). This is the first recorded occurrence of this species from the NFHR. Table 5 lists the live mussels collected.

Sixteen Actinonaias ligamentina and 11 A. pectorosa were collected from NFHRM 79.9 in 1988. The 27 specimens were part of the transplanted mussels placed by Sheehan et al. and the Virginia Cooperative Fishery Research Unit in 1985. Six of these mussels were submitted for mercury accumulation analysis with concurrence of the Virginia Cooperative Fishery Research Unit. Results of the mercury analysis are shown in Table 6.

In 1990, 12 species of live mussels were found during the qualitative survey. Four species were found below Saltville with

three of the species being the same as those found in 1988. Eleven species were collected above Saltville, with eight being the same as those found in 1988. V. vanuxemi and L. fasciola were the most frequently occurring species; both were found at six of the 19 sites. All live mussels found below Saltville were downstream of NFHRM 63.8. The live mussels collected in 1990 are listed in Table 7.

Results from the 1990 quantitative survey are shown in Table 8. NFHRM 91.5 had the largest number of species (10) and the highest overall density (17.7 mussels/m^2). The lowest density of the six sites (0.4 mussels/m^2) occurred just upstream of Saltville at NFHRM 85.6. Overall mussel density of the three quantitative sites below Saltville ranged from 0.55 to 1.05 mussels/m^2.

No live or fresh dead mussels were found at the TVA (NFHRM 78.0) or VPI (NFHRM 59.5, 68.6, 73.9 and 79.9) transplant sites during the 1990 survey. Although relic shells were found at some of these sites, none of the shells had translocation markings. It is likely that most, if not all, of the transplanted mussels are dead. According to Sheehan et al. (1989), the mussels transplanted by VPI "...were in the last half to last quartile of their maximum life expectancy of about 13 years." It could take several years to determine if any of these mussels were reproductively successful as their glochidia would have been widely dispersed.

A general comparison of historical and recent mussel surveys is presented in Tables 1 through 3 although slight differences may exist between the various studies. An attempt was made during

recent studies to sample in close proximity to previous sampling sites, but changes in habitat, the inability to locate the exact location of previous sites and differences in collection techniques and personnel must be recognized. Site replication was also hampered by the poor documentation of specific locations and catch per unit effort in some historical reports.

Nine species of freshwater mussels occurring in southwest Virginia are currently listed as endangered by the U.S. Department of Interior: Fusconaia cuneolus, F. cor, Quadrula intermedia, Q. sparsa, Pleurobema plenum, Lemiox rimosus (Conradilla caelata), Dromus dromas, Epioblasma torulosa gubernaculum, and E. florentina. While four of these species had been recorded previously from the NFHR, only one was found during the YMA survey. A single specimen of Fusconaia cor was located at Saltville (NFHRM 84.5) in 1988. In 1990, four specimens of F. cor were found at NFHRM 88.5 and three at NFHRM 91.5.

Several sites on the NFHR produced a number of relic shells. Although determination of the post-mortem age of shells is difficult, the age of shells collected in 1989 and 1990 appears to be from less than one year to greater than twenty years. Table 9 lists the relic shells found during the 1989 and 1990 surveys.

Corbicula study

Corbicula were not present at several sites for various reasons: 1) high stream velocity, 2) lack of available substrate, and 3) smothering effects from silt and/or precipitate coatings (e.g., NFHRM 81.3 right bank below Ponds 5 and 6 outfalls). During

the initial collection on July 8-20, 1990, sediment and/or Corbicula were not collected at NFHRM 81.3, 58.2, 56.4 and 53.2 due to high water, poor visibility, and/or inclement weather. Collections were made at these sites on August 10, 1990. Results of the total mercury and methylmercury analysis for Corbicula are shown in Table 10. No mercury was detected in any of the upstream Corbicula samples. The highest total and methylmercury levels (x = 0.45 mg/kg and 0.51 mg/kg, respectively) were found in Corbicula from NFHRM 53.2, the site furthest downstream from the former chlorine plant location. The highest sediment mercury levels were at NFHRM 81.3 and 74.0 (4.1 mg/kg). Sediment mercury concentrations generally decreased or remained approximately the same downstream of NFHRM 74.0.

Summary

Although mussel diversity is less than that reported at the turn of the century, mussel populations below Saltville are increasing. Whereas Stansberry and Clench (1972) reported no mussels, current surveys show a minimum of four species naturally occurring below Saltville. The transplanted mussels also may be reproducing due to availability of suitable habitat and improved water quality, but it may be several years before their reproductive success is known.

By comparing data from the present study to that of Stansberry and Clench (1974), there appears to be a slight decline in mussel diversity both at and above Saltville. This apparent decrease is

currently unexplained but may be due to a loss or reduction of host fish species, disturbance of habitat, or poorer water quality.

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TABLE 1

MUSSEL SURVEYS ON THE NORTH FORK HOLSTON RIVER AT SALTVILLE*

Species	Ortmann**, 1918	Stansbery & Clench, 1974	YMA, 1988
Actinonaias ligamentina			x
Actinonaias pectorosa	x	x	
Alasmidonta marginata	x		
Alasmidonta viridis	x	x	
Fusconaia barnesiana	x	x	x
Fusconaia edgariana		x	x
Lampsilis fasciola	x	x	x
Lampsilis ovata	x	x	x
Lasmigona costata	x	x	x
Lexingtonia dolabelloides	x	x	x
Medionidus conradicus	x	x	x
Pegias fabula	x	x	
Pleurobema oviforme	x	x	
Ptychobranchus fasciolaris		x	
Ptychobranchus subtentum	x	x	
Strophitus undulatus	x	x	
Toxolasma lividus	x	x	
Villosa iris nebulosa	x	x	x
Villosa vanuxemi	x	x	x
total species	16	17	10

x = mussel species present

* NFHRM 82.5 to 85.0

** includes collections made by Peterson in 1917.

TABLE 2
MUSSEL SURVEYS ON THE NORTH FORK HOLSTON RIVER BELOW SALTVILLE

Species	Ortmann*	Stansbery & Clench, 1974	YMA, 1988	YMA, 1990
Actinonaias ligamentina	x		x	
Actinonaias pectorosa	x			
Alasmidonta marginata	x			
Amblema plicata	x			
Conradilla caelata	x			
Cyclonaias tuberculata	x			
Elliptio dilatatus	x			
Fusconaia barnesiana	x			
Fusconaia cor	x			
Fusconaia cuneolus	x			
Fusconaia pilaris	x			
Lampsilis fasciola	x		x	x
Lampsilis ovata	x		x	x
Lasmigona costata	x			
Lexingtonia dolabelloides	x			
Medionidus conradicus	x			
Pegias fabula	x			
Plethobasus cyphus	x			
Pleurobema oviforme	x			
Potamilus alata	x			
Ptychobranchus fasciolaris	x			
Ptychobranchus subtentum	x			
Quadrula cylindrica	x			
Quadrula intermedia	x			
Strophitus undulatus	x			
Toxolasma lividus	x			
Truncilla capsaeformis	x			
Truncilla haysiana	x			
Truncilla interrupta	x			
Truncilla lenior	x			
Truncilla torulosa	x			
Truncilla triquetra	x			
Villosa fabalis	x			
Villosa iris nebulosa	x		x	x
Villosa perpurpurea	x			
Villosa recta	x			
Villosa vanuxemi	x			x
total species	37	0	4	4

x = mussel species present

* includes collections made by Adams in 1900, 1901 and Ortmann in 1912, 1913.

TABLE 3

MUSSEL SURVEYS ON THE NORTH FORK HOLSTON RIVER ABOVE SALTVILLE

Species	Stansbery & Clench, 1974	YMA, 1988	YMA, 1990
Actinonaias ligamentina			x*
Actinonaias pectorosa	x		x
Alasmidonta viridis	x		
Fusconaia barnesiana	x	x	x
Fusconaia cor	x		x
Lampsilis fasciola	x	x	x
Lampsilis ovata	x	x	
Lasmigona costata	x		
Lexingtonia dolabelloides	x	x	x
Medionidus conradicus	x	x	x
Pegias fabula	x		
Pleurobema oviforme	x	x	x
Ptychobranchus fasciolaris	x		x
Ptychobranchus subtentum	x	x	x
Strophitus undulatus	x		x*
Toxolasma lividus	x	x	x*
Villosa iris nebulosa	x	x	x
Villosa vanuxemi	x	x	x
total species	17	11	14

x = mussel species present

* fresh dead

TABLE 4

MOLLUSK TRANSPLANTS BY TVA ON THE NORTH FORK HOLSTON RIVER, 1975–1978

	Number Transplanted							
	Mile 6.3				Mile 9.3	Mile 52.7	Mile 78.0	
Species	1975	1976	1977	1978	1978	1975	1977	Total
Actinonaias ligamentina	100	98	152	171	101	205		827
Actinonaias pectorosa	85	223	198	150	126	21	14	817
Amblema costata	15			4	1	10		30
Cyclonaias tuberculata	9	12		8	5	6		40
Elliptio dilatatus	13	17		13	4	3		50
Epioblasma capsaeformis		10		3		5		18
Fusconaia barnesiana	15	67		30	22	19		153
Lampsilis fasciola					3		2	5
Lampsilis ovata				8	1			9
Lasmigona costata		36	24	20	15	12		107
Medionidus conradicus				8	1			9
Potamilus alata	36			3		15		54
Ptychobranchus fasciolaris		14		2	2	1	4	23
Ptychobranchus subtentum		143	105	72	64	6	322	712
Quadrula cylindrica	8	3		1		3		15
Villosa nebulosa		18						18
Io fluvialis (Snail)				270	446			716
							Total	3,603

From Ahlstedt, 1979

TABLE 5

MUSSELS COLLECTED BY YMA
NORTH FORK HOLSTON RIVER, AUGUST 1988

	River Mile														
			Saltville								Nebo		Spring Branch	Ceres	
Species	11.5	73.9	84.5	85.0	88.7	91.0	91.5	98.0	~106	~108	~120	~125	~127	~128	
Actinonaias ligamentina	x		x	x		x	x								
Pleurobema oviforme							x		x	x	x				
Fusconia cor			x												
Lasmigona costata				x											
Lasmigona holstonia														x*	
Lampsilis fasciola		x	x	x				x	x	x					
Lampsilis ovata	x		x		x										
Lexingtonia dolabelloides			x	x	x		x								
Medionidus conradicus			x				x	x	x	x	x				
Fusconaia barnesiana				x		x		x				x		x	
Ptychobranchus subtentum								x							
Toxolasma lividus											x		x	x	
Villosa iris													x		
Villosa nebulosa		x	x	x			x	x	x	x	x	x		x	
Villosa vanuxemi			x	x			x	x	x	x	x	x	x	x	
Sphaerium fabale												x			

* New record for NFHR

TABLE 6

NORTH FORK HOLSTON RIVER MUSSEL TISSUE MERCURY CONCENTRATIONS, AUGUST 1988

Tag ID	Hg Concentration mg/kg
785 RED	0.233
785 RED (Duplicate)	0.237
797 RED	0.160
912 RED	0.192
899 RED	0.435
899 RED (Duplicate 1)	0.303
899 RED (Duplicate 2)	0.473
753 RED	0.241
Orange	0.204
Orange (Duplicate)	0.203

All mussels transplanted by Sheehan et al. (1989) at NFHRM 79.9.

TABLE 7

LIVE MUSSELS FOUND DURING 1990 NFHR SURVEY

Species	North Fork Holston River Mile						
	91.5	88.5	85.6	60.7	58.2	56.4	53.2
Actinonaias pectorosa	x	x					
Fusconaia barnesiana	x	x	x				
Fusconaia cor	x	x					
Lampsilis fasciola	x	x	x	x		x	x
Lampsilis ovata							x
Lexingtonia dolabelloides	x	x					
Medionidus conradicus	x	x	x				
Pleurobema oviforme	x	x					
Ptychobranchus fasciolaris	x	x					
Ptychobranchus subtentum		x					
Villosa iris nebulosa	x	x	x			x	x
Villosa vanuxemi	x	x		x	x	x	x
Total Number of Species	10	11	4	2	1	3	4

No live mussels were found at the following locations: NFHRM 81.3, 80.0, 78.0, 76.7, 73.9, 73.0, 72.2, 68.6, 66.7, 65.2, 63.8 and 59.4.

TABLE 8

NUMBER OF MUSSELS PER SQUARE METER
NORTH FORK HOLSTON RIVER, JULY 1990

Species	North Fork Holston River Mile					
	91.5	88.5	85.6	60.7	56.4	53.2
Actinonaias pectorosa	0.3	0.45				
Fusconaia barnesiana	0.4	0.05	0.05			
Fusconaia cor	0.3	0.2				
Lampsilis fasciola	0.4	0.4	0.05	0.45	0.5	0.35
Lampsilis ovata						0.05
Lexingtonia dolabelloides	1.7	0.95				
Medionidus conradicus	3.1	0.6	0.05			
Pleurobema oviforme	1.4					
Ptychobranchus fasciolaris	0.3	0.8				
Ptychobranchus subtentum		0.05				
Villosa iris nebulosa	5.6	0.3	0.25		0.25	0.25
Villosa vanuxemi	4.2			0.1	0.3	0.1
Overall Density (no./m^2)	17.7	3.8	0.4	0.55	1.05	0.75

TABLE 9

RELIC SHELLS FROM THE NORTH FORK
HOLSTON RIVER, OCTOBER 1989 AND NOVEMBER 1990

Species	North Fork Holston River Mile														
	79.9	78.0	76.0	73.1	72.5	71.4	70.7	68.9	68.6	67.2	66.8	66.6	66.0	65.3	59.4
Actinonaias pectorosa	x							x	x	x		x	x	x	
Elliptio crassidens										x					
Elliptio dilatatus						x		x	x				x	x	x
Fusconaia barnesiana				x	x	x				x			x	x	
Fusconaia cor															x
Lampsilis fasciola	x		x		x				x			x			x
Lampsilis ovata	x				x			x	x	x			x	x	
Lasmigona costata							x				x				
Medionidus conradicus															x
Pluerobema oviforme									x	x			x		
Ptychobranchus fasciolaris				x											
Ptychobranchus subtentum	x			x					x						
Villosa nebulosa	x	x						x			x				
Villosa vanuxemi									x		x	x			x

TABLE 10

CORBICULA AND SEDIMENT MERCURY CONCENTRATIONS
NORTH FORK HOLSTON RIVER, JULY 1990

Site	Mile	Sample Location		
		Right*	Midstream	Left*
1	91.5	NP	NP	NP
2	88.5	<0.20 (<0.20) 0.49	<0.20 (<0.20) 0.76	<0.20 (<0.20) 0.72
3	85.6	<0.20 (<0.20) 1.1	<0.20 (<0.20) 0.69	NP
4	81.3	NP	NP	see note below** 4.1
5	76.7	NP	NP	NP
6	74.0	0.30 (0.49) 4.1	NP	NP
7	71.0	0.31 (0.43) 3.4	NP	0.36 (0.60) 3.6
8	66.3	NP	NP	NP
9	63.8	0.34 (0.32) 3.4	NP	<0.20 (<0.20) 1.7
10	60.7	<0.20 (0.48) 1.7	NP	NP
11	58.2	<0.20 (<0.20) 0.93	<0.20 (<0.20) 1.3	<0.20 (<0.20) 1.1
12	56.4	<0.20 (<0.20) 1.2	<0.20 (0.44) 0.98	<0.20 (<0.20) 1.3
13	53.2	0.35 (0.47) 1.1	0.37 (0.47) 0.86	0.62 (0.60) 0.96

* Facing downstream
Value on left is MeHg concentration (mg/kg); value in parentheses is total Hg concentration (mg/kg); value on bottom is sediment Hg concentration (mg/kg).
Sediment collected only where Corbicula were present.
NP = no Corbicula present.
Sediment Hg concentration on dry basis, dried at <60 for 36 hours, screened with #35 mesh prior to analysis.
** Methylmercury for both purged and non-purged = 0.11 mg/kg, total mercury for purged = 0.16 mg/kg, total mercury for non-purged = 0.13 mg/kg.