Freshwater Mussel Survey of Clinchport, Clinch River, Virginia: Augmentation Monitoring Site: 2006

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Introduction

Freshwater mussel populations have experienced dramatic declines across the country when comparing the current assemblages to historical accounts. Among the 297 species historically known from the U.S., nearly 70 % are presently classified as threatened, endangered or extinct (Neves 1999). Similarly, of the 81 freshwater mussel species recognized in Virginia, 37 (46%) are listed as threatened or endangered, with 32 occurring in the Clinch, Powell, and Holston river watersheds of Virginia's upper Tennessee River drainage.

Recent advancements in propagation techniques have led to widespread attempts to restore declining or extirpated populations by releasing cultured juvenile mussels or by translocating adult mussels. Many of these attempts have been made with little or no scientific control with regards to determining success or failure. Before implementing restoration activities, it is important to develop baseline information at the release point that includes habitat suitability, mussel assemblage, mussel density, mussel age class structure, host fish presence, and presence or absence of target species (Strayer and Smith 2003). All of these factors must be considered when determining the effectiveness of long-term mussel restoration activities.

In 2002, the Virginia Department of Game and Inland Fisheries (DGIF) developed a strategy to restore freshwater mussels at six reaches within the upper Tennessee River drainage. These reaches include four on the Clinch River, and one site each on the Powell and North Fork Holston rivers (Figure 1). The main restoration technique, termed augmentation, was to release translocated adults or propagated juveniles into reaches where valid species records exist after 1980. Within each augmentation reach, a site was selected to develop a baseline to gauge success of mussel restoration activities.

In previous years, sample sites have included the Clinch River at Clinchport (Clinch River Mile [CRM] 213.2), Scott Co., (2001); Slant (CRM 223.6), Scott Co., (2005, Eckert et. al 2008); and Cleveland Island (CRM 270.8), Russell Co., (2002). During 2004, two sites; the State Route 833 Bridge crossing (Powell River Mile [PRM] 120.3) and Fletcher Ford (PRM 117.3), were sampled in the Powell River, Lee County, Virginia (Eckert et. al 2007). The present study (2006) sampled the Clinch River at Clinchport (CRM 213.2) in Scott Co.

This is the first DGIF mussel survey at a site that was previously sampled. Some comparisons can be made between the 2001 and 2006 surveys. However, sampling conditions in 2001 were less than ideal, leading the authors to discount the results. The present study will be considered the baseline data against which future restoration efforts will be measured.

Objective

At Clinchport, Clinch River, specific objectives of this study were:

1. To map mussel distribution, richness, and relative abundance at available suitable habitat including the state endangered spiny riversnail (*Io fluvialis*).

2. To quantify sections of high density mussel aggregations at the site.

3. To identify ideal mussel habitat at the site for mussel augmentation.

4. Compare results of the present study to previous sampling events at Clinchport.

<u>**Study Area**</u>

The site known as Clinchport is found at the town of Clinchport immediately downstream of the confluence of the Clinch River and Stock Creek in Scott Co., Virginia and is located at CRM 213.2 (Figures 2 & 3). The site is approximately 1.0 km from the intersection of US 23 and Virginia 65. A swinging bridge, built in 1932, (VDOT structure #9017) crosses the Clinch River just downstream of the site. This site was selected as a representative of Virginia Freshwater Mussel Restoration Plan reach 2 which is defined as Clinchport downstream to the mouth of Dry Valley Branch, a distance of approximately six river miles. This area has been sampled several times previously (Table 1). Records from these samples can be compared to the current study.

<u>**Methods**</u>

Several factors should be considered when selecting a survey design. They include survey goals, target populations, available resources, site characteristics and general knowledge of mussel populations (Strayer and Smith 2003). When conducting a survey it is important to plan sampling techniques that will provide the most useful information possible. To ensure that the current mussel assemblage was accurately measured, multiple sampling techniques were employed. The use of multiple sampling techniques increases confidence in the validity of observed results (Strayer and Smith 2003).

<u>Initial site reconnaissance</u>

Prior to the initiation of a large scale quantitative mussel sample an initial site analysis is necessary. Early reconnaissance of a potential survey site includes snorkeling prospective areas to search for suitable habitat and the presence of live mussels. During these early site visits factors such as site accessibility and ease of sampling are considered. In addition, notes are taken about rare species collections in the event that they are not collected during future sampling.

Semi-Quantitative

The semi-quantitative portion of this survey included a systematic sample of the entire site length using 1-m^2 quadrats. The site was marked every 20 m with stakes and every 40 m with ropes. Ropes were marked every 5 m across the stream with flagging tape to provide lanes and a visual guide while sampling (Figure 4).

Each 20 m section was divided into lanes 5 m wide. Lanes were selected based on the average width of each section, starting with the center of the stream and moving 5 m left and right. One sampler was assigned to each lane, and the longitudinal position of the sampler within the lane was determined randomly. Sampling each lane begins by staggering the starting position of every other sampler, one starts at 1 m then the next at 3 m, while the third sampler begins at 1 m again. From the staggered starting point, a 1-m^2 quadrat was sampled every 4 m for a total of five quadrats sampled per sampler within each lane. By this design, 5 m^2 are sampled in an area that measures 100 m^2; a total of 5% of the overall habitat within each lane (Figure 5).

At every quadrat, depth, habitat type, visibility and dominant substrate class were recorded. Mussels on the surface were collected and then the large substrate was removed with the remaining substrate gently fanned to reveal additional mussels near the surface. Every mussel was identified, counted and measured. In addition, presence of the spiny riversnail was recorded.

By beginning the survey with this method, it is possible to delineate the areas of highest mussel density within the site. After determining the areas of highest density, quantitative sampling was conducted to assess the density of mussels within the mussel bed. Upon completion of the entire survey (semi-quantitative, quantitative, and qualitative), the semi-quantitative data was statistically analyzed to verify the location selection for quantitative sampling. Analysis of Variance was conducted (with multiple comparisons, $P < 0.05$) to find significant differences between sections sampled. Any significant difference indicates an area of higher mussel density which may be sampled quantitatively. Data from the semi-quantitative sample was graphed using spatial analysis in ArcMap 9.1 (ESRI) to visually highlight areas of higher density.

Quantitative

The area of highest mussel density during semi-quantitative sampling was selected for quantitative sampling. Quantitative sampling was used to estimate population size and age structure for monitoring purposes. The quantitative sampling approach involves random sampling within the selected area using 0.25-m^2 quadrats. A small grid was constructed using an x,y coordinate system. Within the small grid, 100-0.25-m^2 quadrats were randomly selected. Each quadrat was excavated using a Ferraro streambed sampler; these samplers are built with perforated aluminum, which allows flow through the sampler, while maintaining enough rigidity to handle a large volume of substrate (Figure 6). First, the mussels on the surface are removed, identified, counted, and measured, and then the substrate was excavated into the sampler; typical excavation depth was approximately 20 cm. Substrate from the quadrat was then placed in a set of nested sieves (2.54 cm, 1.27 cm, 0.64 cm) and washed to reveal subsurface mussels. The purpose of sieving substrate was to collect and identify juvenile mussels which are usually not collected in sampling without excavation; any mussel less than 30 mm was considered a juvenile. All subsurface mussels were identified, counted, and measured, and then the data were compiled to determine mean density and precision, target of which was 25%. The Dunn equation for precision, a modified Downing and Downing equation, [$N = ((2*SD)/ (P*X))^2$] was used because it is easy to manipulate and can provide both the precision of the mean and the number of samples needed to obtain the desired precision level (Dunn 2000). Upon completion of quadrat sampling the final precision was calculated.

<u>Qualitative</u>

Upon completion of the quantitative sampling, a qualitative sample was taken to determine additional species not found using earlier sampling methods. A qualitative sample is often more effective in detecting the presence of rare species than a quantitative sample (Strayer and Smith 2003). The qualitative sample was conducted systematically in 20 m sections in a similar fashion to the semi-quantitative sample. Samplers either snorkeled or used a view bucket and kept record of live and relic mussels during a 20 minute sample of each section. Observations were recorded at the end of each 20 m section and the total sample was compiled into an overall list of live and relic species observed.

<u>Incidental</u>

During any intensive multi-layered quantitative survey there are ample opportunities for samplers to encounter mussels outside of structured sampling. This includes mussels observed during preliminary site surveys, site preparation and mussels that are found near but outside of sampling quadrats. Species found live in this manner that are not otherwise collected in structured sampling will be recorded as incidental finds.

Results

Semi-Quantitative

The semi-quantitative sample at Clinchport included 498-1-m^2 quadrats. The sample area was 171 m long, approximately 45 m wide at the island and 62 m wide above for a total sample area of 10,173 m^2 (Figure 7). Average depth of the site was 45.6 cm, ranging from 0 cm to 91 cm (Figure 8). Visibility was generally greater than one meter. Stream discharge was in decline from 440 CFS down to 366 CFS during the three days of sampling (Greg Johnson, USGS, pers comm.). Substrate was predominantly gravel (51%), and cobble (20%) with lower percentages of pebbles, boulder, sand, and mud.

A total of 297 mussels were collected to yield a mean density of 0.598/m^2 (Table 2). Eighteen species were collected alive with three species showing signs of recent recruitment (*Villosa vanuxemensis*, *Medionidus conradicus*, *Epioblasma brevidens*, length < 30 mm; 1.0% of individuals collected). Two mussel aggregations appeared to lie parallel to stream flow the larger near the left descending bank and the smaller near the right descending bank (Figure 9). The most abundant species were *Actinonaias ligamentina* (114), *Actinonaias pectorosa* (56) and *Cyclonaias tuberculata* (19).

Density of *Io fluvialis* was 1.02 snails/m^2 equaling 506 collected individuals. Spiny riversnail distribution showed that their highest density was found from markers 0-100 m along the right descending side of the stream (Figure 10).

Quantitative

During the Clinchport survey, two quantitative samples were taken. For reporting purposes, they will be referred to as the right ascending and left ascending sample because the two sites are linear on either side of the stream channel (Figure 11).

Right ascending sample

The grid for the right ascending quantitative sample was 80 m by 15 m and was located from transects 60-140 in lanes 40-55. Average depth in this quantitative sample area was 32.4 cm. In 120-0.25-m^2 quadrats, 64 mussels were collected for a density of 0.55/0.25 m^2 (Table 3) with a precision of 21.0%. Recent recruitment was seen in three species, *Epioblasma brevidens*, *Medionidus conradicus* and *P. fasciolaris* (6.25% of individuals collected). Of the mussels collected, 41% (26) were visible at the surface, 59% (38) were collected subsurface. Individuals of the most common species (*A. ligamentina*; 16 collected) were significantly larger on the surface compared to subsurface collections (P=0.001). A length frequency analysis of both *Actinonaias species* (*A. ligamentina* and *A. pectorosa*) showed equal lengths from 50 mm to 90 mm with several large individuals and few small individuals (Figure 12a).

Left ascending sample

The grid for the left ascending quantitative sample was 40 m by 15 m and was located from transects 100-140 in lanes 5-20. Average depth in this quantitative sample area was 50.4 cm. In 100-0.25-m^2 quadrats, 50 mussels were collected for a density of 0.50/0.25 m^2 (Table 4) with a precision of 24.6%. Recent recruitment was seen in one species, *E. brevidens* (2.0% of individuals collected). Of the mussels collected, 62% (31) were visible at the surface, 38% (19) were collected subsurface. The most common species (*A. ligamentina*; 15 collected) showed no significant difference in length of individuals collected surface vs. subsurface (P=0.087). A length frequency analysis of both *Actinonaias species* (*A. ligamentina* and *A. pectorosa*) showed a distribution of large old adults with no individuals smaller than 60 cm (Figure 12b).

Qualitative

A 33.5 person-hour visual search was conducted systematically from the downstream to upstream end of the survey site. This search yielded 23 species live and 7 represented by relic or fresh dead shell only for a total of 30 species (Table 5). This sampling added eleven species to our species list (6 live and 5 relic only). *Dromus dromas, Elliptio crassidens, Epioblasma triquetra, Fusconaia cor, Fusconaia cuneolus,* and *Ligumia recta* were all found live during the qualitative sample but had not been collected during the earlier quadrat samples.

Incidental

This site is frequently sampled qualitatively to collect broodstock for propagation. During recent qualitative samples and preliminary site preparation, a live *Hemistena lata* and *Cyprogenia stegaria* were found along with more than one young *Quadrula c. strigillata.* These species were not represented in the structured sampling but should currently be considered extant.

Clinchport 2001 Overview

No report has been compiled for data collected by VDGIF at Clinchport in 2001. To avoid a long series of unpublished data citations the data from 2001 will be summarized here and mentioned below in the discussion.

2001 Semi-quantitative

A total of 799-1-m^2 quadrats were sampled yielding 510 mussels and a density of 0.64/m^2. Twenty-three species were collected live during semi-quantitative sampling.

2001 Quantitative

Three separate quantitative samples were taken. The first sample included 60-0.25-m^2 quadrats finding 25 mussels for a density of 0.42/0.25 m^2. The second sample included 46-0.25-m^2 quadrats finding 66 mussels for a density of 1.43/0.25 m^2. It is believed that the second quantitative sample was taken at the same general area as the right ascending quantitative sample in the present study. The third and final sample included 40-0.25-m^2 quadrats finding 20 mussels for a density of 0.50/0.25 m^2. A grand total of 146-0.25-m^2 quadrats were sampled collecting 19 species live during quantitative sampling in 2001.

2001 Qualitative

A single 30 minute timed search totaling 5.5 person-hours was conducted, finding 17 live species and 3 represented by relic shell only (*Epioblasma f. gubernaculums, Potamilus alatus* and *Truncilla truncata*).

Discussion

Previous surveys have recorded 36 species live while the current study found 27 with 5 represented by relic shell only. Of previously known species from this location *Alasmidonta marginata, Epioblasma torulosa gubernaculum, Pleurobema coccineum, Pleurobema cordatum, Pleurobema oviforme, Quadrula intermedia,* and *Villosa perpurpurea* were not recorded in the present study. The present study collected *Dromus* *dromas* live and *Lemiox rimosus* as relic shell only, neither of which had previously been recorded at the site.

Results of the present study do not show a drastic decline in the mussel assemblage since 2001. Overall mussel density has only dropped from 0.64/m^2 to 0.598/m^2. These numbers are not directly comparable as the number of quadrats sampled varied significantly (799 versus 498); however, the overall density appears to be relatively stable over the time between samples.

In comparison with a nearby site, Speers Ferry (Clinch RM 211.1), densities are lower at Clinchport but general abundance stability appears the same. Semi-quantitative data from the present study (0.55/0.25m^2 and 0.50/0.25m^2) translates to a density of 2.20/m^2 and 2.0/m^2. Over 25 years of sampling (1979 to 2004), density at Speers Ferry has remained stable actually increasing from 3.70/m^2 to 4.70/m^2 (Ahlstedt et. al 2005).

The first and third 2001 quantitative sample were very consistent with data from the present study. However, the second quantitative sample was much higher, and it was believed to be collected at the same location as the 2006 right ascending sample. If these two quantitative samples overlapped, it shows a striking decline in density (1.43/0.25 m^2 down to 0.55/0.25 m^2) over the last five years.

The greatest difference between the two data sets is the number of mussel species collected by sampling type. In 2001, 23 live species were collected in 799-1-m^2 quadrats while the 2006 survey collected only 18 live in 498-1-m^2 quadrats. Quantitative (0.25-m^2 quadrats) sampling collected 19 species in 2001 in 146-0.25-m^2 quadrats while 14 were collected in 2006 in 220-0.25-m^2 quadrats. The largest disparity is between qualitative sampling data, 19 total species collected in 2001 and 30 collected in 2006.

These observed differences follow a logical path. More species were found in a larger effort of one meter quadrats in 2001, while a much greater qualitative sample collected far more species in 2006. The comparison that may most accurately reflect the trend in the population is the result of the semi-quantitative sampling. As rare species decreases in abundance the chance of collecting it in a quadrat decreases as well. The following species were collected in semi-quantitative sampling in 2001 and then were not collected in 2006 in the same manner: *E. capsaeformis, E. crassidens, F. cor, L. costata*, and *Q. c. strigillata* each being uncommon in the upper Tennessee River Basin. Two of these species (*L. costata* and *Q. c. strigillata*) were not collected live during any portion of the structured survey. It is worth mentioning again that the 2006 sample included 74 more 0.25-m^2 quadrats, greatly increasing the chance of finding rare species when compared to the 2001 survey. This evidence points to these rare species currently being in decline.

Not all results of the present study are negative. Only Ortmanns' 1913 collection (1918) recorded more live species than the present study (Table 1). Several species were collected in sub-adult size ranges (Figure 13), including *E. triquetra*, which hasn't been recorded at Clinchport since Ortmann (1918). Another positive sign is the fact that *E. brevidens* was the second most common species collected in the right ascending quantitative sample.

While recovering sub-adult mussels shows that conditions at the site remain adequate for juvenile recruitment, a discussion must follow about anthropogenic disturbances at the study site. The present study site is immediately below the confluence of the Clinch River at Stock Creek. The Stock Creek watershed contains mining activity and other human use impacts which adversely affects its’ water quality. While it may not be the source of these problems, fewer juvenile mussels and a lower overall density were recorded on the left ascending side of the river nearest the Stock Creek confluence.

Another recent anthropogenic impact is human activity along the right ascending side of the river. All terrain vehicles (ATV) have been observed driving along gravel bars and in the stream channel during periods of low flow. Prior to the present study large grooves, believed to be ATV tracks, could be seen in the substrate at the site. Shell fragments of multiple species of various size classes were also observed (Figure 14).

Considering all the various impacts to this site the mussel fauna still persists at a level near what it was in 2001. Several species can be collected at this site for propagation including *A. ligamentina*, *A. pectorosa*, *E. brevidens*, *E. capsaeformis*, *L. fasciola*, *L. ovata*, *P. fasciolaris*, *P. subtentum*, and *V. iris*. As a result of the recently observed disturbances, and in our opinion low probability of improvement or observing success at this site, we recommend that restoration activities at this site cease until further notice. This site may be suitable for restoration activities from a habitat stand point, but with additional anthropogenic stressors the chance of success is currently deemed too low to continue stocking of captive reared juveniles.

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Table 1. Previous mussel collections in the Clinch River at or near Clinchport.

Species	1899[1]	1913[1]	1979[2]	1988[2]	1994[2]	1999[2]	2001[3]	2004[2]	Present Study[4]
A. ligamentina	L	L	L	L	L	L	L	L	L
A. pectorosa	L	L	L	L	L	L	L	L	L
A. marginata	L	L							
A. plicata	L	L		L			L		L
C. tuberculata	L		L	L		L	L		L
C. stegaria			L	L			L		L
D. dromas									L
E. crassidens	L	L					L		L
E. dilatata	L	L	L	L		L	L	L	L
E. brevidens	L	L		L		L	L	L	L
E. capsaeformis	L	L	L				L	L	L
E. t. gubernaculum	L	L							
E. triquetra		L							L
F. barnesiana		L			L				R
F. cor	L	L					L	L	L
F. cuneolus		L		L			L		L
F. subrotunda	L	L	L	L			L		L
H. lata	L								L
L. fasciola	L	L			L	L	L	L	L
L. ovata		L	L	L			L		L
L. costata	L	L	L	L	L		L		R
L. rimosus									R
L. dolabelloides		L							L
L. recta		L					L		L
M. conradicus	L	L		L	L	L	L	L	L
P. cyphyus		L					L		L
P. coccineum		L							
P. cordatum							L		
P. oviforme		L							
P. alatus	L	L					R		R
P. fasciolaris	L	L	L			L	L	L	L
P. subtentum		L	L		L	L	L	L	L
Q. c. strigillata		L			L		L		L
Q. intermedia	L								
Q. pustulosa							L		L
T. truncata							R		R
V. iris		L			L		L		L
V. perpurpurea		L		L					
V. vanuxemensis					L				L
Live	**20**	**29**	**11**	**13**	**10**	**9**	**24**	**10**	**27**
Relic	**--**	**--**	**--**	**--**	**--**	**--**	**2**	**--**	**5**
Total	**20**	**29**	**11**	**13**	**10**	**9**	**26**	**10**	**32**

[1]Records from Ortmann (1918)
[2] Records courtesy of Steve Ahlstedt, USGS, Collection site Speers Ferry, CRM 211.1
[3] Previous DGIF mussel augmentation site survey at Clinchport June 5th-7th, 2001.
[4] Present study conducted at Clinchport from August 15th-17th, 2006.

Table 2. Total number and density of mussel species collected during semi-quantitative sampling of the Clinch River at Clinchport. Individuals measuring less than 30 mm were considered juveniles.

Species	Total Collected	Number of Juveniles	Percent of Collection	Density (per m^2)
Actinonaias ligamentina	114	0	38.4	0.229
Actinonaias pectorosa	56	0	18.9	0.112
Cyclonaias tuberculata	19	0	6.4	0.038
Ptychobranchus fasciolaris	18	0	6.1	0.036
Lampsilis fasciola	16	0	5.4	0.032
Amblema plicata	15	0	5.0	0.031
Epioblasma brevidens	15	1	5.0	0.031
Medionidus conradicus	15	1	5.0	0.031
Villosa iris	6	0	2.0	0.012
Elliptio dilatata	3	0	1.0	0.006
Epioblasma capsaeformis	3	0	1.0	0.006
Lampsilis ovata	3	0	1.0	0.006
Plethobasus cyphyus	3	0	1.0	0.006
Ptychobranchus subtentum	3	0	1.0	0.006
Villosa vanuxemensis	3	1	1.0	0.006
Fusconaia subrotunda	2	0	0.7	0.004
Quadrula pustulosa	2	0	0.7	0.004
Lexingtonia dolabelloides	1	0	0.4	0.002
Cyprogenia stegaria	0	0	0	0
Dromus dromas	0	0	0	0
Elliptio crassidens	0	0	0	0
Epioblasma triquetra	0	0	0	0
Fusconaia barnesiana	0	0	0	0
Fusconaia cor	0	0	0	0
Fusconaia cuneolus	0	0	0	0
Lasmigona costata	0	0	0	0
Lemiox rimosus	0	0	0	0
Ligumia recta	0	0	0	0
Pleurobema oviforme	0	0	0	0
Potamilus alatus	0	0	0	0
Quadrula c. strigillata	0	0	0	0
Total	**297**	**3**	**100**	**0.598**

Table 3. Total number and density of mussel species collected in the Clinch River at Clinchport in the right ascending quantitative sample. Individuals measuring less than 30 mm were considered juveniles.

Species	Total Collected	Number of Juveniles	Percent of Collection	Density (per 0.25m^2)
Actinonaias ligamentina	16	0	25.0	0.133
Epioblasma brevidens	13	2	20.3	0.108
Ptychobranchus fasciolaris	9	1	14.0	0.075
Actinonaias pectorosa	7	0	10.9	0.059
Medionidus conradicus	6	1	9.4	0.051
Cyclonaias tuberculata	4	0	6.2	0.033
Ptychobranchus subtentum	4	0	6.2	0.033
Elliptio dilatata	1	0	1.6	0.008
Fusconaia subrotunda	1	0	1.6	0.008
Lampsilis fasciola	1	0	1.6	0.008
Lampsilis ovata	1	0	1.6	0.008
Villosa iris	1	0	1.6	0.008
Amblema plicata	0	0	0	0
Cyprogenia stegaria	0	0	0	0
Dromus dromas	0	0	0	0
Elliptio crassidens	0	0	0	0
Epioblasma capsaeformis	0	0	0	0
Epioblasma triquetra	0	0	0	0
Fusconaia barnesiana	0	0	0	0
Fusconaia cor	0	0	0	0
Fusconaia cuneolus	0	0	0	0
Lasmigona costata	0	0	0	0
Lemiox rimosus	0	0	0	0
Lexingtonia dolabelloides	0	0	0	0
Ligumia recta	0	0	0	0
Plethobasus cyphyus	0	0	0	0
Pleurobema oviforme	0	0	0	0
Potamilus alatus	0	0	0	0
Villosa vanuxemensis	0	0	0	0
Quadrula c. strigillata	0	0	0	0
Quadrula pustulosa	0	0	0	0
Total	**64**	**4**	**100**	**0.55**

Table 4. Total number and density of mussel species collected in the Clinch River at Clinchport in the left ascending quantitative sample. Individuals measuring less than 30 mm were considered juveniles.

Species	Total Collected	Number of Juveniles	Percent of Collection	Density (per $0.25m^2$)
Actinonaias ligamentina	15	0	30.0	0.15
Actinonaias pectorosa	9	0	18.0	0.09
Lampsilis fasciola	6	0	12.0	0.06
Epioblasma brevidens	4	1	8.0	0.04
Ptychobranchus fasciolaris	4	0	8.0	0.04
Cyclonaias tuberculata	2	0	4.0	0.02
Elliptio dilatata	2	0	4.0	0.02
Lampsilis ovata	2	0	4.0	0.02
Medionidus conradicus	2	0	4.0	0.02
Ptychobranchus subtentum	2	0	4.0	0.02
Amblema plicata	1	0	2.0	0.01
Plethobasus cyphyus	1	0	2.0	0.01
Cyprogenia stegaria	0	0	0	0
Dromus dromas	0	0	0	0
Elliptio crassidens	0	0	0	0
Epioblasma capsaeformis	0	0	0	0
Epioblasma triquetra	0	0	0	0
Fusconaia barnesiana	0	0	0	0
Fusconaia cor	0	0	0	0
Fusconaia cuneolus	0	0	0	0
Fusconaia subrotunda	0	0	0	0
Lasmigona costata	0	0	0	0
Lemiox rimosus	0	0	0	0
Lexingtonia dolabelloides	0	0	0	0
Ligumia recta	0	0	0	0
Pleurobema oviforme	0	0	0	0
Potamilus alatus	0	0	0	0
Quadrula c. strigillata	0	0	0	0
Quadrula pustulosa	0	0	0	0
Villosa iris	0	0	0	0
Villosa vanuxemensis	0	0	0	0
Total	**50**	**1**	**100**	**0.5**

Table 5. Live and relic mussel species collected in the Clinch River at Clinchport during qualitative sampling, August 2006.

Species	0	20	40	60	80	100	120	140	160	Present Overall
Actinonaias ligamentina	L	L	L	L	L	L	L	L	L	L
Actinonaias pectorosa	L	L	L	L	L	L	L	L	L	L
Amblema plicata	L	L	L	L	L	L	L	L	L	L
Cyclonaias tuberculata	L	L	L	L	L	L	L	L	L	L
Cyprogenia stegaria										
Dromus dromas							L			L
Elliptio dilatata	R	R		L	L	L	L	R	R	L
Elliptio crassidens		R	R	R		L	R			L
Epioblasma brevidens	R	L	L	L	L	L	L	L	R	L
Epioblasma capsaeformis			R	L	R	L			R	L
Epioblasma triquetra							L		R	L
Fusconaia barnesiana		R								R
Fusconaia cor				L	R	R	R	R	R	L
Fusconaia cuneolus					L	R				L
Fusconaia subrotunda	R	L	R	L	L	L	R	R	L	L
Hemistena lata										
Lampsilis fasciola	R	R	L	R	R	L	L	L	L	L
Lampsilis ovata	R	L		L	R	L	L			L
Lasmigona costata						R	R	R	R	R
Lemiox rimosus								R		R
Lexingtonia dolabelloides			L							L
Ligumia recta	R	R	R	R	R	R	R	L		L
Medionidus conradicus	L	L	L	L	L	L	L	L	L	L
Plethobasus cyphyus		R	L	L	L	L	L	L		L
Pleurobema oviforme										
Potamilus alatus	R	R			R	R	R	R		R
Ptychobranchus fasciolaris	L	L	L	L	L	L	L		L	L
Ptychobranchus subtentum	R		L		L	R	R	R	L	L
Quadrula c. strigillata		R							R	R
Quadrula pustulosa	R	R	R	R	R	L				L
Truncilla truncata				R						R
Villosa iris	R	R	R	L	L	L	L	L		L
Villosa vanuxemensis				R	R		R	R	R	R
Live	**6**	**9**	**11**	**14**	**13**	**16**	**14**	**10**	**9**	**23**
Relic	**10**	**10**	**6**	**6**	**8**	**6**	**8**	**8**	**8**	**7**
Total	**16**	**19**	**17**	**20**	**21**	**22**	**22**	**18**	**17**	**30**

Table 6. Mussel species collected in the Clinch River at Clinchport based on type of sampling employed. Qualitative reflect all species collected live, fresh dead or relic; other samples are live collections only.

Species	Semi-Quantitative	Quantitative	Qualitative	Incidental*	Overall
Actinonaias ligamentina	X	X	X		X
Actinonaias pectorosa	X	X	X		X
Amblema plicata	X	X	X		X
Cyclonaias tuberculata	X	X	X		X
Cyprogenia stegaria				X	X
Dromus dromas			X		X
Elliptio dilatata	X	X	X		X
Elliptio crassidens			X		X
Epioblasma brevidens	X	X	X		X
Epioblasma capsaeformis	X		X		X
Epioblasma triquetra			X		X
Fusconaia barnesiana			X		X
Fusconaia cor			X		X
Fusconaia cuneolus			X		X
Fusconaia subrotunda	X	X	X		X
Hemistena lata				X	X
Lampsilis fasciola	X	X	X		X
Lampsilis ovata	X	X	X		X
Lasmigona costata			X		X
Lemiox rimosus			X		X
Lexingtonia dolabelloides	X		X		X
Ligumia recta			X		X
Medionidus conradicus	X	X	X		X
Plethobasus cyphyus	X	X	X		X
Pleurobema oviforme					
Potamilus alatus			X		X
Ptychobranchus fasciolaris	X	X	X		X
Ptychobranchus subtentum	X	X	X		X
Quadrula c. strigillata			X	X	X
Quadrula pustulosa	X		X		X
Truncilla truncate			X		X
Villosa iris	X	X	X		X
Villosa vanuxemensis	X		X		X
Totals	**18**	**14**	**30**	**3**	**32**

* Incidental records are reserved for rare and endangered species that were found live coincidentally.

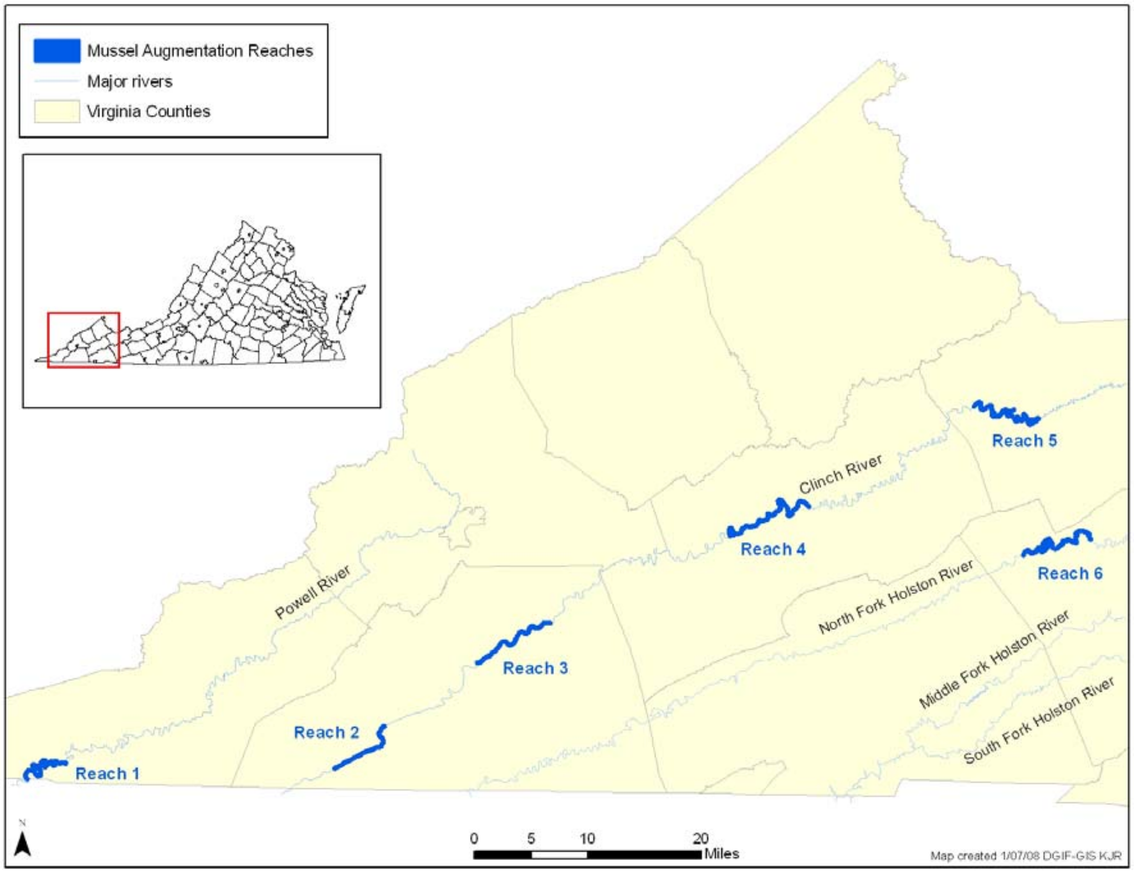


Figure 1. Stream reaches designated as augmentation reaches by the Virginia Department of Game and Inland Fisheries mussel restoration plan. Six reaches are divided between the Powell River (1), Clinch River (4) and North Fork Holston River (1).

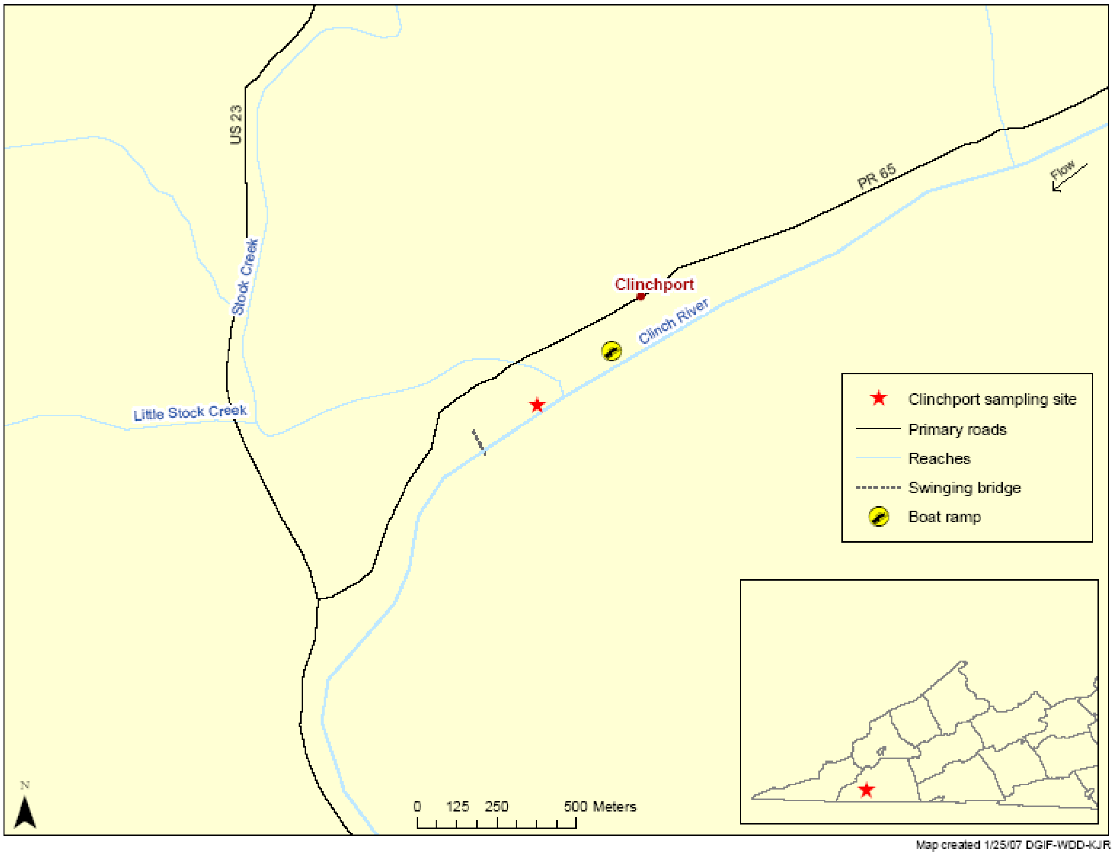


Figure 2. Location of present study with relation to the town of Clinchport, Stock Creek, and a DGIF boat ramp in Scott County, Virginia.

Figure 3. Elevated view of the Clinch River at Clinchport, Scott County, Virginia. Site of the present study in 2006. Ropes with flagging provide a visual guide for samplers moving upstream.

Figure 4. Overhead view of a survey site. Ropes are stretched every 40 meters with flags every 5 meters to delineate lanes and serve as a visual guide. Black lines show one lane.

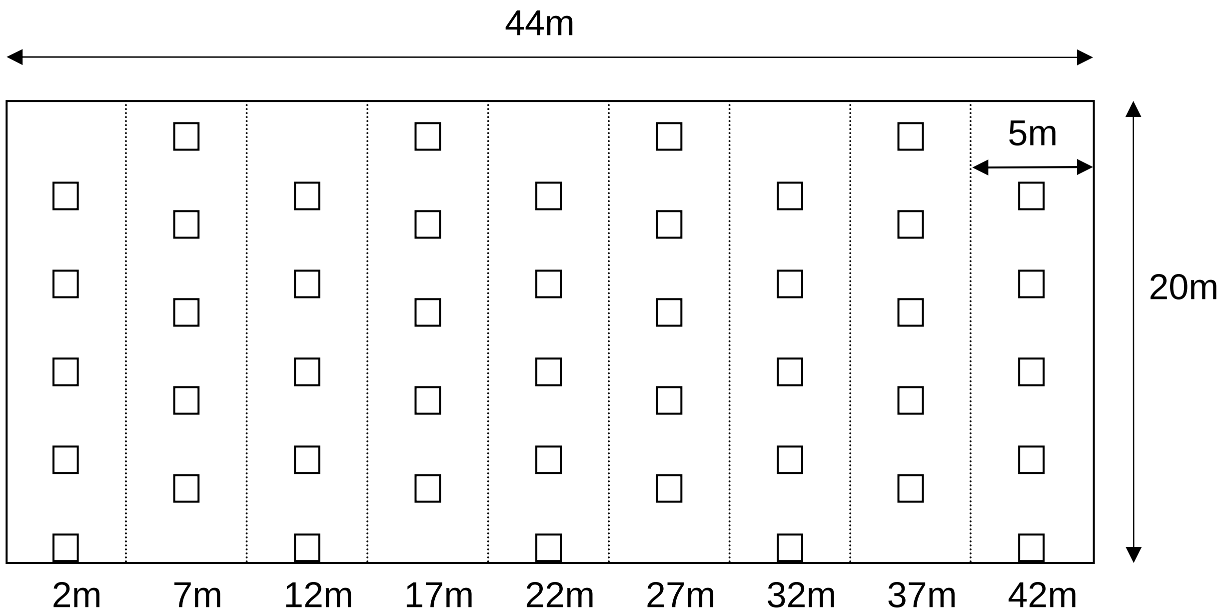


Figure 5. Representation of semi-quantitative sampling method at a site 44m wide. Squares indicate sampling location and lines show lane boundaries. Each lane is 5m wide and 20m long. Five samples are taken representing 5% of overall habitat. Starting position of samplers alternates between 1m and 3m.

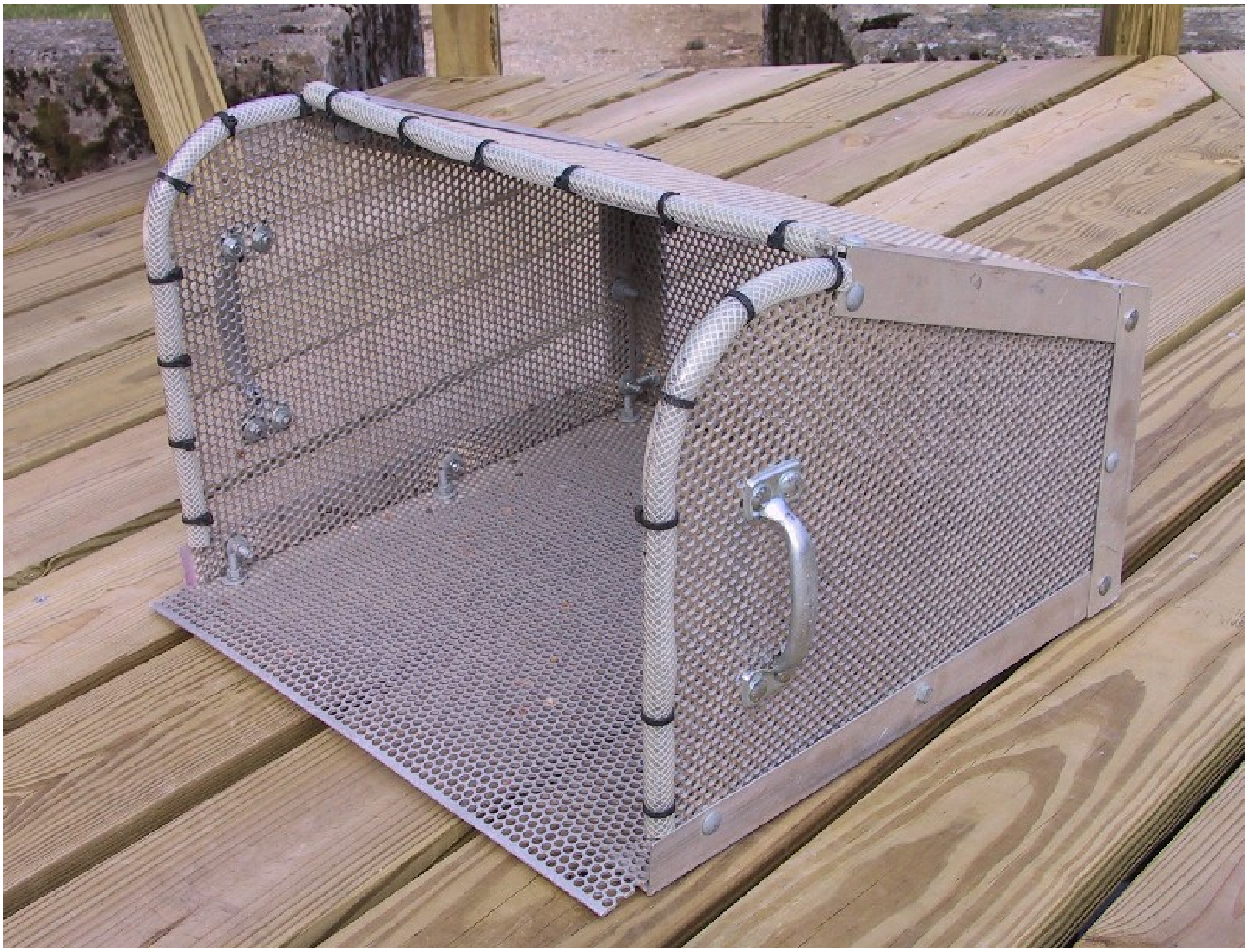


Figure 6. The Ferraro streambed sampler. This sampler is made with perforated aluminum and was designed to hold all substrate excavated from a 0.25 m^2 quadrat.

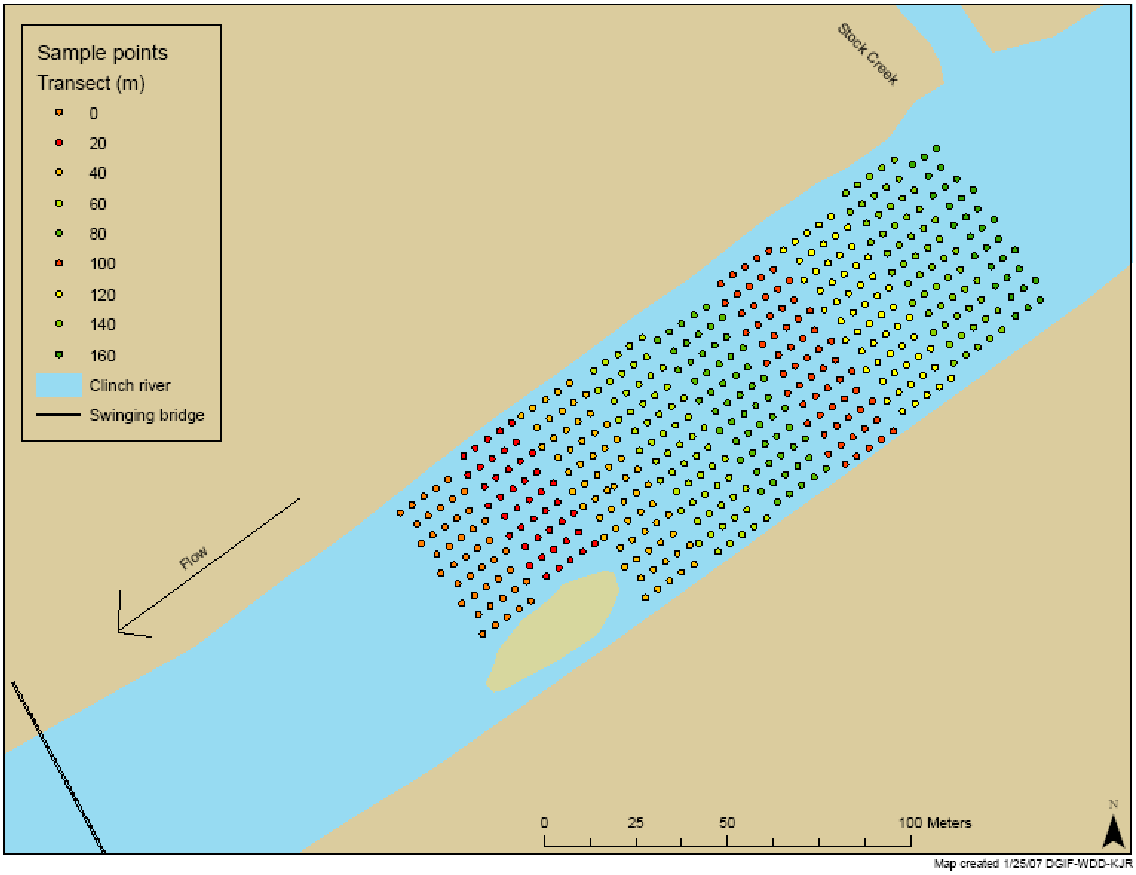


Figure 7. Location of 1m quadrats sampled during semi-quantitative sampling at Clinchport.

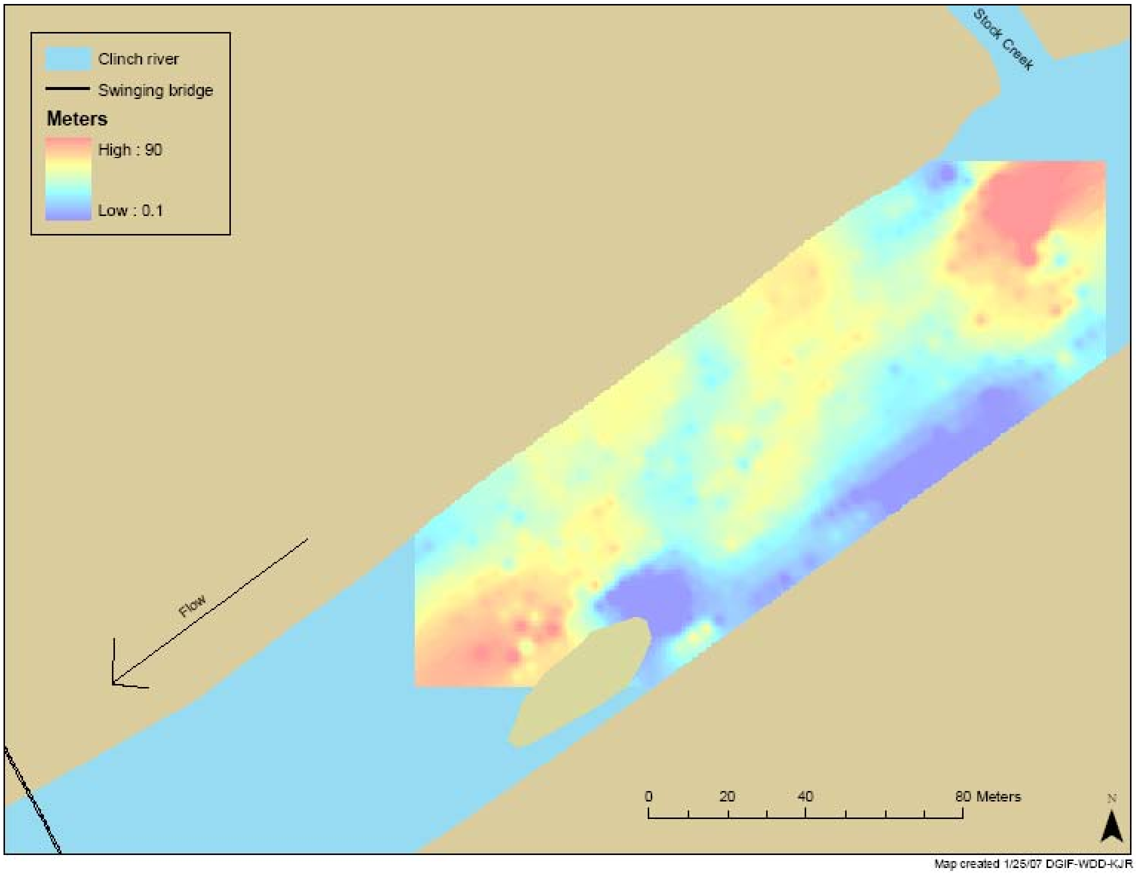


Figure 8. Depth profile of the Clinch River at Clinchport, August 2006. Stream discharge approximately 300 cubic feet per second.

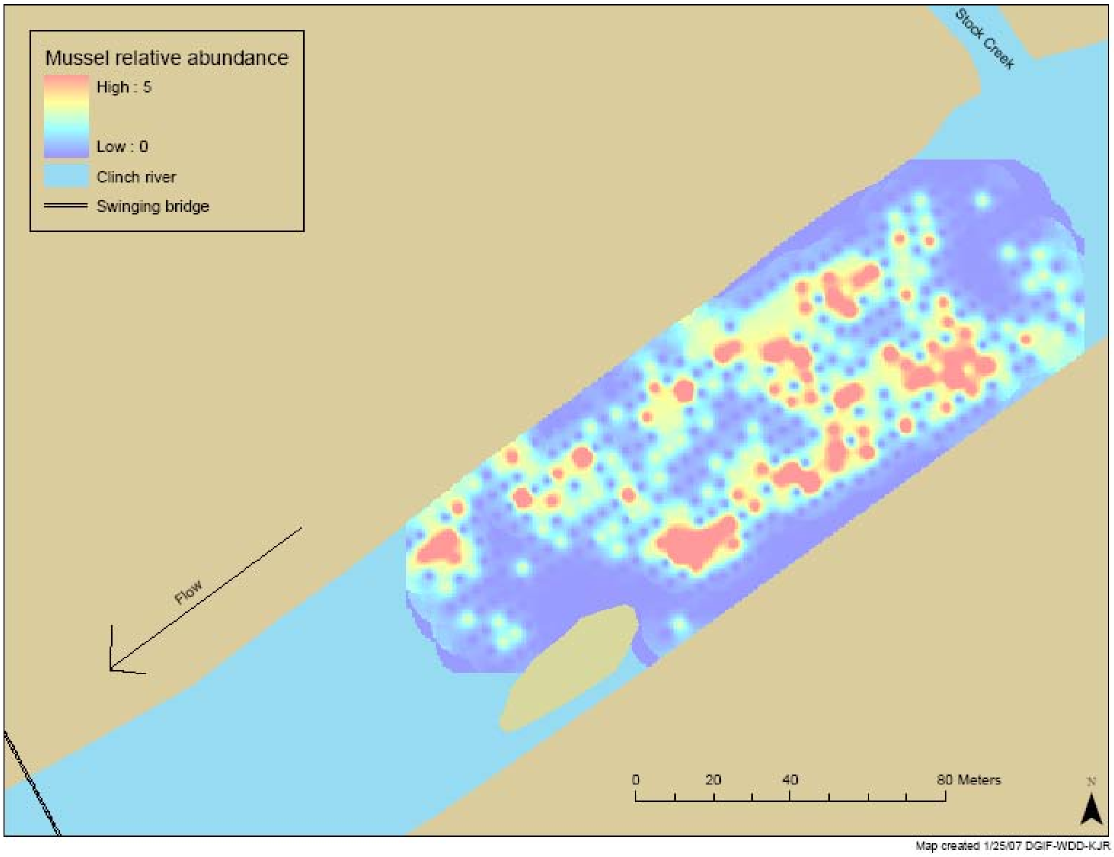


Figure 9. Relative abundance and location of mussels collected at Clinchport during the present study.

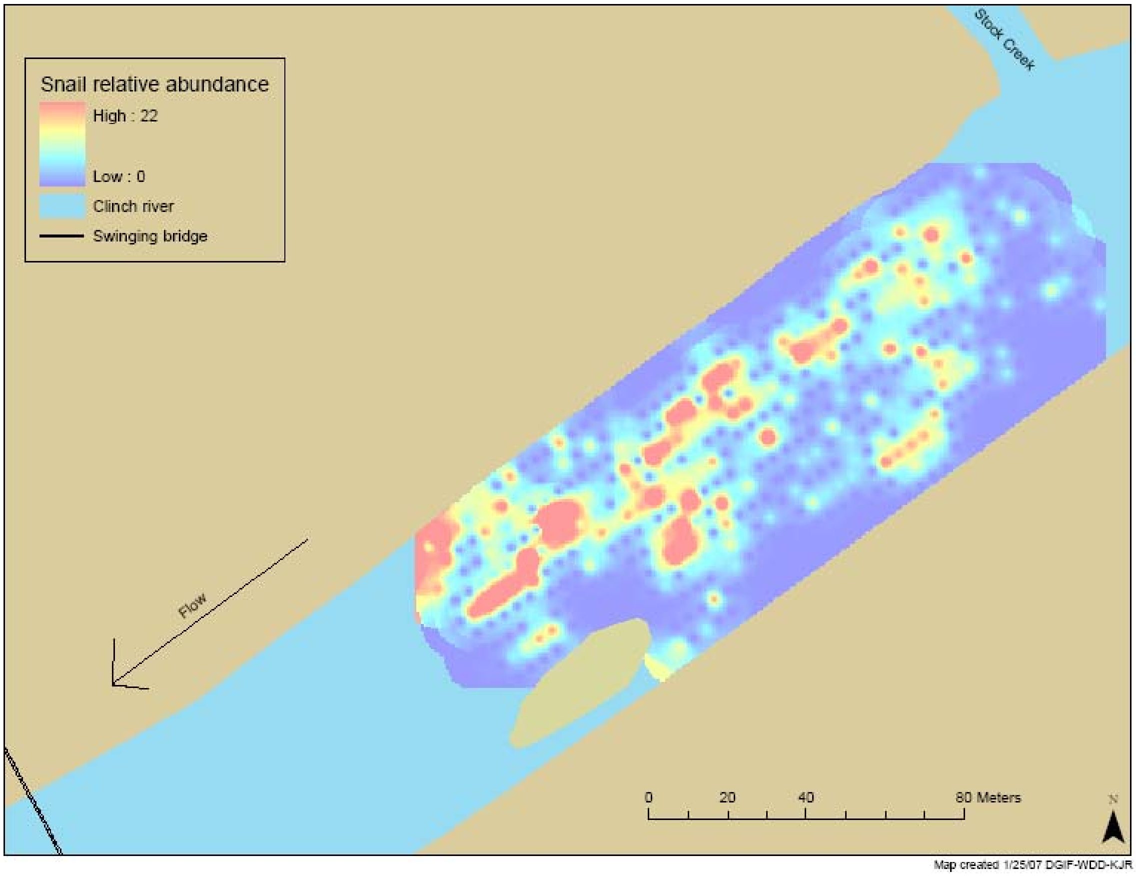


Figure 10. Relative abundance and location of spiny riversnail, *Io fluvialis*, collected during the present study.

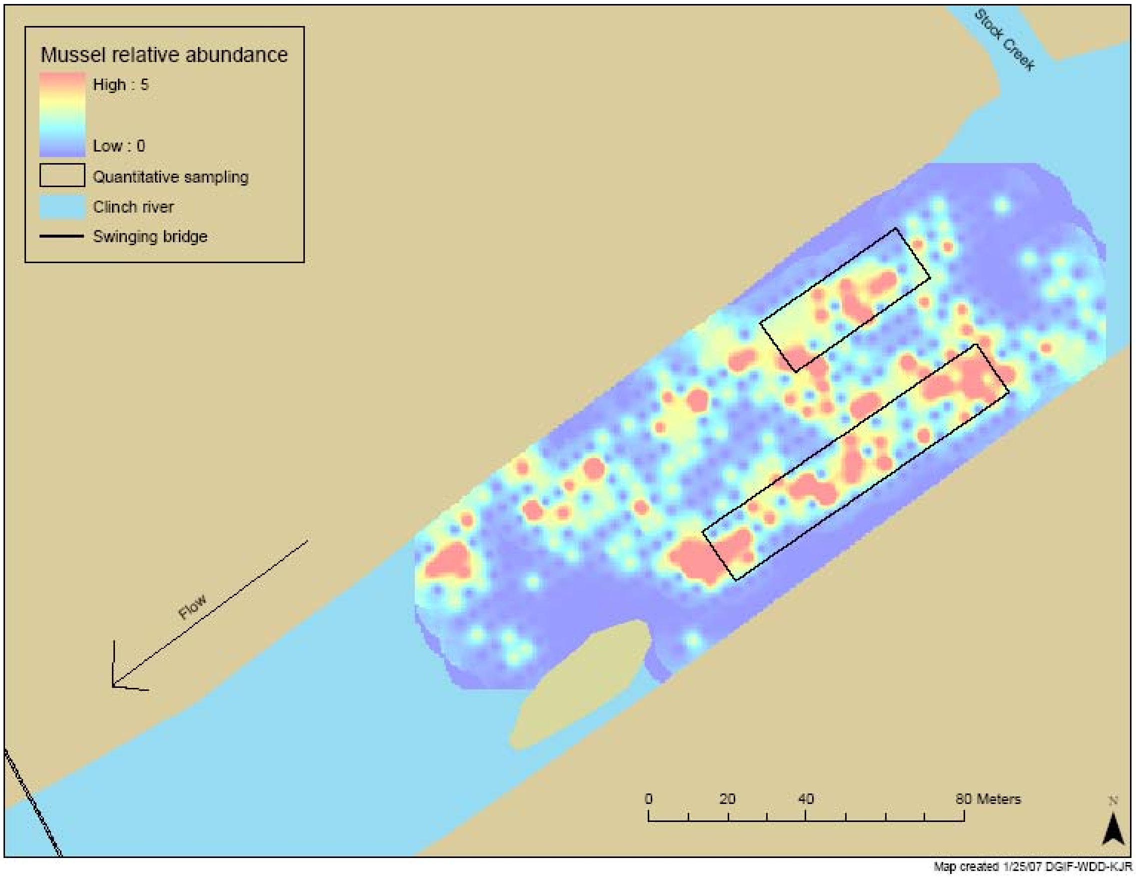
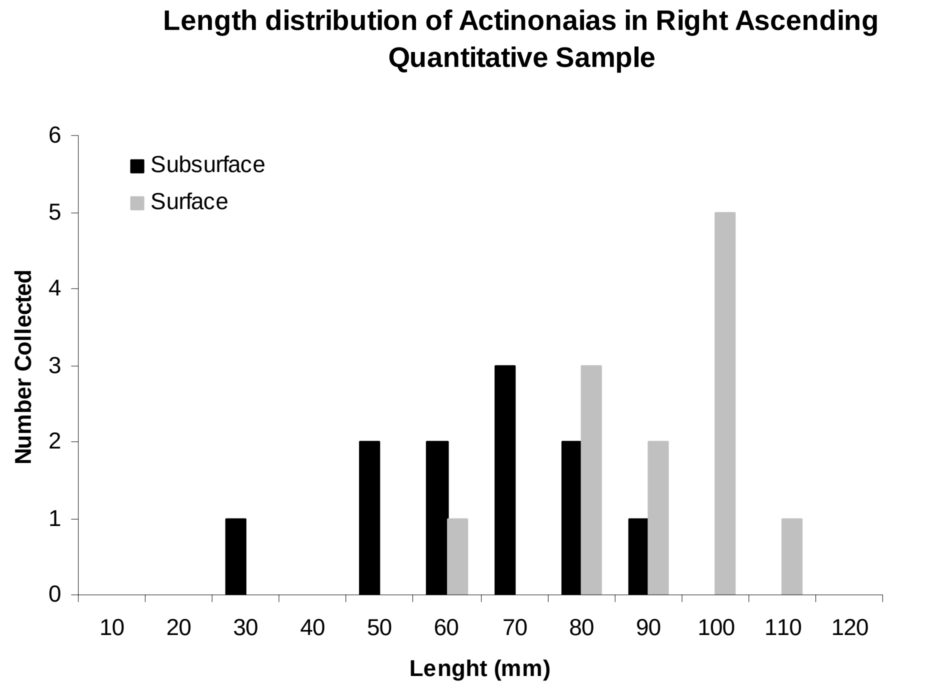


Figure 11. Clinchport mussel abundance and location. Box indicates sites selected for quantitative sampling.

A



B

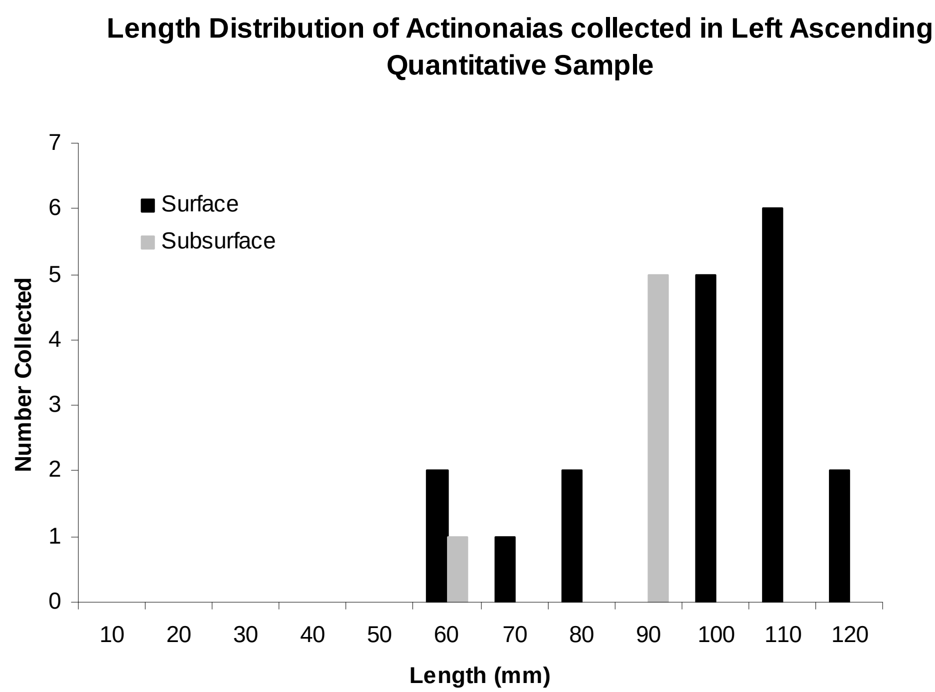


Figure 12. Length frequency diagram of *Actinonaias pectorosa* and *Actinonaias ligamentina* collected during two quantitative samples of the Clinch River at Clinchport, 2006. Right ascending sample (A) taken from right ascending portion of the stream, while left ascending sample (B) was taken from left ascending side.

Figure 13. Sub-adult specimen collected during qualitative sampling at Clinchport, 2006. Starting clockwise from top left species include: *P. fasciolaris, L. fasciola, L. ovata*, *E. triquetra*, *E. brevidens*, *E. capsaeformis*, *M. conradicus*, and *V. iris* (center).

Figure 14. Shell fragment collected in the Clinch River at Clinchport during 2006. It is believed that mussel was crushed by ATV traffic that was evident in the streambed during low flow conditions of 2006. The shell is a federally endangered *E. brevidens* female.

Appendix 1. Scientific name, common name, Virginia wildlife action plan tier, state and federal status of species mentioned in this report.

Species Name	Common Name	WAP Tier	State*	Federal*
Actinonaias ligamentina	mucket	**---**	-----	-----
Actinonaias pectorosa	pheasantshell	**---**	-----	-----
Alasmidonta marginata	elktoe	**III**	**SSC**	**SOC**
Amblema plicata	threeridge	**---**	-----	-----
Cyclonaias tuberculata	purple wartyback	**---**	-----	-----
Cyprogenia stegaria	fanshell	**I**	**SE**	**FE**
Dromus dromas	dromedary pearlymussel	**I**	**SE**	**FE**
Elliptio crassidens	elephantear	**IV**	**SE**	-----
Elliptio dilatata	spike	**---**	-----	-----
Epioblasma brevidens	Cumberland combshell	**I**	**SE**	**FE**
Epioblasma capsaeformis	oystermussel	**I**	**SE**	**FE**
Epioblasma t. gubernaculum	green blossom	**I**	**SE**	**FE**
Epioblasma triquetra	snuffbox	**II**	**SE**	**SOC**
Fusconaia barnesiana	Tennessee pigtoe	**II**	**SSC**	-----
Fusconaia cor	shiny pigtoe	**I**	**SE**	**FE**
Fusconaia cuneolus	finerayed pigtoe	**I**	**SE**	**FE**
Fusconaia subrotunda	longsolid	**III**	-----	**SOC**
Hemistena lata	crackling pearlymussel	**I**	**SE**	**FE**
Io fluvialis	spiny riversnail	**III**	**ST**	**SOC**
Lampsilis cardium	plain pocketbook	**---**	-----	-----
Lampsilis fasciola	wavyrayed lampmussel	**---**	-----	-----
Lampsilis ovata	pocketbook	**IV**	-----	-----
Lemiox rimosus	birdwing pearlymussel	**I**	**SE**	**FE**
Lexingtonia dolabelloides	slabside pearlymussel	**II**	**ST**	**FC**
Ligumia recta	black sandshell	**III**	**ST**	-----
Medionidus conradicus	moccasinshell	**---**	-----	-----
Plethobasus cyphyus	sheepnose	**II**	**ST**	**FC**
Pleurobema coccineum	round pigtoe	**---**	-----	-----
Pleurobema cordatum	Ohio pigtoe	**III**	**SOC**	**SE**
Pleurobema oviforme	Tennessee clubshell	**III**	-----	**SOC**
Potamilus alatus	Pink heelsplitter	**---**	-----	-----
Ptychobranchus fasciolaris	kidneyshell	**---**	-----	-----
Ptychobranchus subtentum	fluted kidneyshell	**II**	-----	**FC**
Quadrula c. strigillata	rough rabbitsfoot	**I**	**SE**	**FE**
Quadrula pustulosa	pimpleback	**IV**	**ST**	-----
Truncilla truncata	deertoe	**IV**	**SE**	-----
Villosa iris	rainbow	**---**	-----	-----
Villosa vanuxemensis	mountain creekshell	**IV**	-----	-----

* FE=Federally Endangered, SOC=Federal Species of Concern, FC=Federal Candidate, SE=State Endangered, ST=State Threatened, SSC=State Species of Concern.