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Freshwater Mussel Surveys
Of The Pee Dee River Basin in South Carolina

Prepared For:

The Nature Conservancy-South Carolina Chapter

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January 3, 2006

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1.0 INTRODUCTION

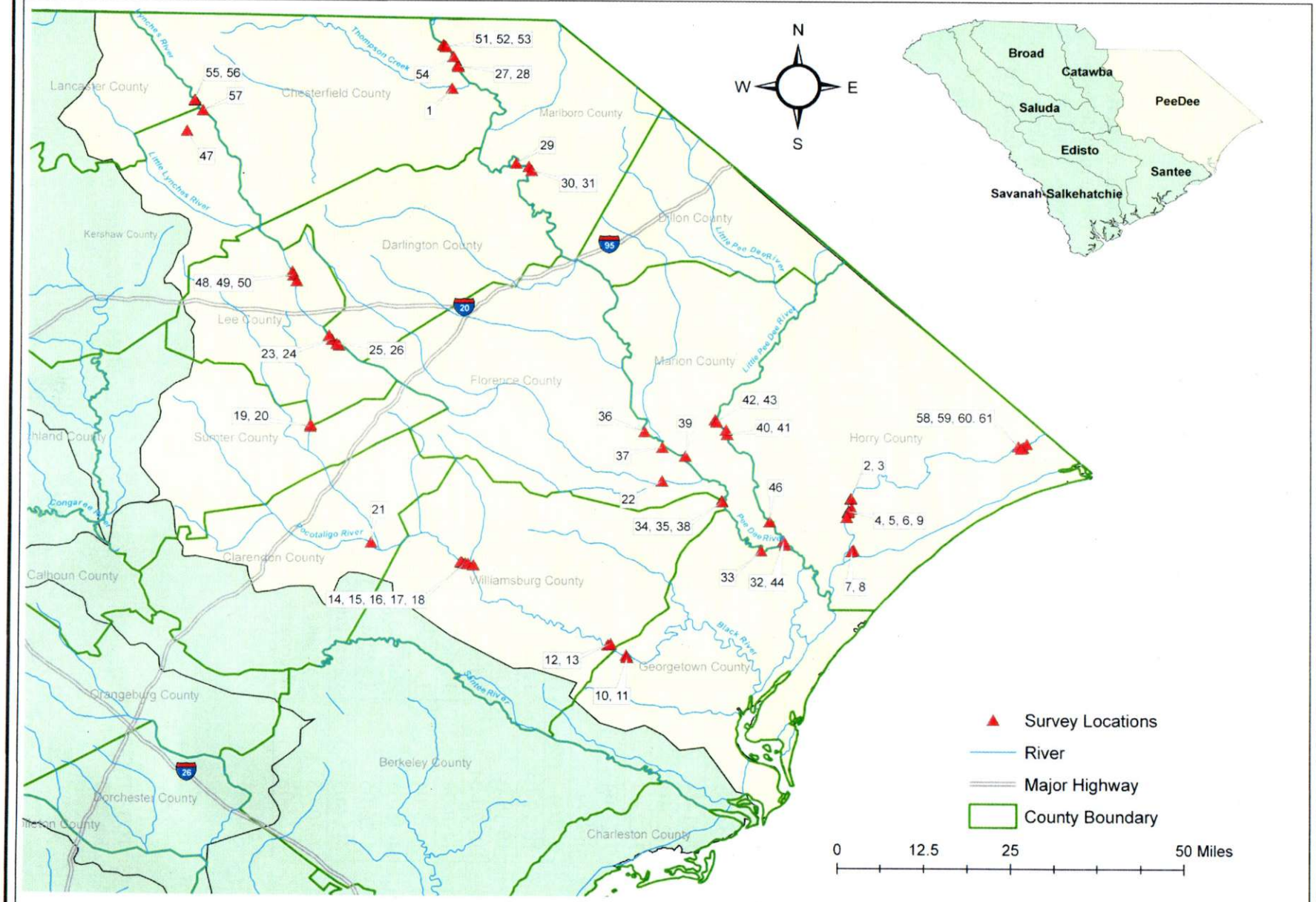
The freshwater mussel fauna of North America (the richest in the world) consists of approximately 297 species and subspecies (Turgeon et al. 1988), with much of the higher classification of taxa still unresolved. The greatest species diversity occurs in the southeastern United States (Neves 1993). The cumulative effects of the modification of aquatic habitats through impoundment, channelization and dredging, along with sedimentation and water pollution has resulted in dramatic declines in the freshwater mussel of North America. Williams et al. (1993) considers 72% of this fauna to be extinct, endangered, threatened, or of special concern, and only 24% as stable.

The Pee Dee River Basin is a major drainage of the Atlantic slope in the southeastern United States. The 10,755 sq mile drainage area incorporates portions of Virginia, North Carolina and South Carolina. A total of 3,425 sq. miles occurs within the lower piedmont and coastal plain in the northeastern portion of South Carolina, making it the second-largest river basin in the state. With the exception of a series of hydroelectric reservoirs on the main-stem in North Carolina, the lower portion of the basin is generally free-flowing, with extensive forested buffers that are relatively free of urban development. Knowledge of the mussel fauna in the lower portion of the basin has been limited to scattered locales, largely in smaller tributaries, and shallow water habitats. Very little information existed for the deep water habitats throughout the basin. In an attempt to update and fill in major gaps in the knowledge of the mussel fauna in this basin The Catena Group, Inc. (TCG) was retained by the South Carolina chapter of The Nature Conservancy (SCTNC) to conduct a qualitative assessment of the Unionid fauna in the lower Pee Dee River and its major tributaries; The Black, Lynches, Pocotaligo, Little Pee Dee, and Waccamaw Rivers, in South Carolina. In addition to sites surveyed for this project, other sites in the Pee Dee River Basin in South Carolina were also surveyed by the Catena Group during this period of time and these results are also included in this report.

Selection of survey locations were based on pre-survey evaluations to avoid areas recently searched, to avoid areas affected by Intracoastal Waterway dredging, and to specifically target areas flowing through calcareous geology. In the field, specific survey locations were selected based on accessibility and the locations that provided the greatest habitat type variability. Surveys were conducted at 61 sites throughout the Pee Dee River system in South Carolina from June 2004 to August 2005 (Figure 1). All habitat types at each survey location were evaluated, including the use of SCUBA to sample the deepwater habitats.

2.0 SURVEY EFFORTS

Mussel surveys efforts for this qualitative assessment were performed at 61 survey sites in the previously mentioned water bodies in June, July, August, October, and November 2004, and April, July, and August 2005. Site numbers were assigned to each site chronologically. All habitat types (riffle, run, pool, slack water, etc.) contained within



The Catena Group

Date: January 2006

Scale: As Shown

Job No.: 3131

Title:

Freshwater Mussel Survey Site Locations

PeeDee River Basin, South Carolina

Client:

South Carolina Chapter of The Nature Conservancy

Figure

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each site were sampled. Visual and tactile methods were employed at each site, primarily using SCUBA, with mask/snorkel and batiscope (glass-bottom buckets) used to a lesser extent. The Catena Group (TCG) led all of the survey efforts. TCG survey participates include Tim Savidge (TS), Tom Dickinson (TD), Shay Garriock (SG), and Sharon Snider (SS). Eric Kruger (EK) of SCTNC was responsible for logistic coordination (providing boats, determining access points etc.) for all sites surveyed under the TNC-Catena Group contract, as well as serving as surface support for the survey divers, and supplementing survey efforts in shallow water habitats.

On some occasions, additional volunteer survey collection and surface support efforts were graciously provided by individuals from several organizations. These include John Fridell (JF) and Lora Zimmerman (LZ) of the US Fish and Wildlife Service, Jennifer Price (JP) with the South Carolina Department of Natural Resources, David Wilkins (DW) and Arnold Postel (AP) with the South Carolina Aquarium, and Jeff Burleson (JB).

The individual dates and water bodies surveyed by these personnel and volunteers are shown in Table 1. Site numbers in Table 1 were assigned sequentially to each survey location and are shown in figure 1 and referenced throughout the report.

Table 1. Survey Dates by Water Body and Survey Team

Survey Date	Water Body(s) Surveyed (Site #)	Survey Team
6-1-04	Thompson Creek (1)	TS, TD
7-1-04	Waccamaw River (2-6)	TS, TD, EK, DW, AP, JB
7-2-04	Waccamaw River (7-9)	TS, TD, EK
7-20-04	Black River (10-13)	TS, TD, EK, JF
7-21-04	Black River (14-18)	TS, TD, EK, JF, JP
7-22-04	Black River (19-20)	TS, TD, EK, JF, JP
7-22-04	Pocotaligo River (21)	TS, TD, EK, JF, JP
7-22-04	Lynches River (22)	TS, TD, SG, SS, JF
8-4-04	Lynches River (23-26)	TS, TD, EK
8-5-04	Great Pee Dee River (27-31)	TS, TD, EK, LZ
10-19-04	Little Pee Dee River (32)	TS, SG, EK
10-19-04	Great Pee Dee River (33-35)	TS, SG, EK
10-20-04	Great Pee Dee River (36-39)	TS, SG, EK
11-8-04	Little Pee Dee River (40-43)	TS, TD, EK
11-9-04	Little Pee Dee River (44-46)	TS, TD, EK,JP
4-25-05	Buffalo Creek (47)	TS, TD, EK
4-26-05	Lynches River (48-50)	TS, TD, EK, LZ
4-27-05	Great Pee Dee River (51-54)	TS, TD, EK, LZ
7-20-05	Lynches River (55-57)	TS, SG, EK
8-24-05	Waccamaw River (58-61)	TD, SG, EK

2.1 Methodology

A minimum of a two-person survey team was used for all of the surveys. At most of the survey sites, habitat was first evaluated by traversing the bottom of the stream channel to provide full coverage of the habitats present at the site. Survey efforts were then concentrated in the areas with the most suitable habitat, and highest concentrations of mussels. Some of the sites were not surveyed in this manner due to time constraints, current, or channel width. In these cases, only one side of the channel was surveyed. The speed at which the team proceeded upstream depended on stream width, survey conditions (depth, clarity, etc.), habitat characteristics and the presence of mussels. Timed searches were employed at each site. The amount of time spent in each waterbody was determined by survey conditions and safety concerns (cold water temperatures, strong currents, etc.). Survey distances varied between sites, as sites were chosen based on best suitable habitat for the target species and accessibility to these habitats.

Mussels were collected, identified, counted and returned to the substrate. Catch per unit effort (CPUE) for each mussel species found were calculated at each surveyed site. Searches were also conducted for relict shells. The presence of a shell was equated with presence of that species; however the shells found were not factored into the CPUE for each species. Representative photographs of each mussel species collected were taken when possible.

While conducting freshwater mussel surveys, aquatic snails, and occasionally crayfish were also observed, and/or captured. A relative abundance (Rare, Uncommon, Common, Abundant and Very Abundant) was assigned to each snail species observed at each site. Representative crayfish were collected at a few sites, and deposited in the North Carolina State Museum of Natural Sciences and identified by John Cooper.

3.0 RESULTS

At least 23 freshwater mussel species were located during the survey efforts. Table 2 lists the species found, number of sites where the species was located, highest recorded CPUE for the species, and the waterbody and site number where the highest CPUE was recorded. Species numbers and CPUE for each site are shown in Appendix A.

Table 2: Mussel Species Located

Species	# of Sites Where Found	Highest CPUE	Waterbody/Site # of Highest CPUE
Alasmidonta varicosa (brook floater)	2	1.6	Lynches River (58)
Elliptio angustata (Carolina lance)	30	58	Great Pee Dee River (35)
Elliptio cistelliformis (box spike)	7	144	Black River (10)

Elliptio complanata (eastern Elliptio)*	59	227.5 221.5	Waccamaw River (2)** Lynches River (23)
Elliptio congarea (Carolina slabshell)	41	233.5 165	Waccamaw River (2)** Waccamaw River (8)
Elliptio folliculata (pod lance)	10	19	Waccamaw River (58)
Elliptio icterina (variable spike)*	33	162 60	Waccamaw River (2)** Thompson Creek (1)
Elliptio nasutilus (lanceolate elliptio)	13	35.5	Waccamaw River (6)
Elliptio producta (Atlantic spike)	7	2	Great Pee Dee River (37)
Elliptio roanokensis (Roanoke slabshell)	13	20	Great Pee Dee River (37)
Elliptio sp.1(Pee Dee lance)	4	6.05	Great Pee Dee River (54)
Elliptio spp. (elliptio mussels)*	6	623	Waccamaw River (2)
Elliptio waccamawensis (Waccamaw spike)	16	395	Little Pee Dee River (46)
Lampsilis cariosa (yellow lampmussel)	11	10	Great Pee Dee River (31)
Lampsilis splendida (rayed pink fatmucket)	3	2	Pocotaligo River (21)
Lasmigona decorata (Carolina heelsplitter	1	1 shell	Lynches River (55)
Leptodea ochracea (tidewater mucket)	3	7	Little Pee Dee River (44)
Ligumia nasuta (eastern pondmussel)	2	1.5	Great Pee Dee River (34)
Pyganodon cataracta (eastern floater)	3	1.5	Great Pee Dee River (34)
Strophitus undulatus (creeper)	1	0.33	Great Pee Dee River (28)
Uniomerus carolinanus (Florida pondhorn)	16	4.4	Little Pee Dee River (45)
Utterbackia imbecillis (paper pondshell)	2	1	Great Pee Dee River (34)
Villosa delumbis (eastern creekshell)	18	3.5	Black River (15)
Villosa modioliformis/vibex (Atlantic Southern rainbow)	2	1	Pocotaligo River (21)

* in some instances E. complanata and E. icterina were recorded collectively as E. spp
** CPUE estimated based on a random subset of E. spp. collected at this site (Site 2)

Consistent habitat partitioning by species, as well as various forms within the *Elliptio complanata* and E. icterina complexes were noted throughout the study area. The

introduced Asian clam (*Corbicula fluminea*) was found at all of the survey locations. Although not quantified, it appeared to be the most common bivalve species found throughout the study area.

4.0 DISCUSSION

Brief discussion of site conditions, mussel distribution within each sites and species descriptions are provided below.

4.1 Habitat conditions and distribution of mussels at each survey site

In nearly all of the sites surveyed mussels were unevenly distributed in the stream, which is reflective of the distribution and quality of microhabitats within a particular stream segment. Brief summaries of the habitat and molluscan fauna of each stream site surveyed are provided below to accompany the detailed survey site results in Appendix A.

Site 1. Thompson Creek: This site is located close to its confluence with the Great Pee Dee River. This reach of Thompson Creek ranges from 10-12 meters wide and consists of a series of pools and gravel runs with moderate forested buffer and often steep, eroding stream banks. Four species were found at this site, with the variable spike (120 individuals) and the Carolina slabshell (108 individuals) being the most abundant. Mussels were generally concentrated in gravel riffle/run habitats in less than 2 feet of water, often existing in dense beds. Few individuals were found in pool habitats. Multiple size classes of all species found were observed.

Site 2. Waccamaw River: The Waccamaw River in this area is a wide, tidally influenced river with dark tannic water and predominantly sandy substrates in the channel. A moderate to wide cypress-gum swamp forest generally persists along both sides of the river. The majority of mussels found at this site were located with SCUBA in a sandy run to 10 feet deep. Mussels were generally abundant in this habitat with nearly 2500 elliptio mussels found in 4 person hours of search time. Due to the abundance of mussels located and very high ambient air temperature that could have been detrimental to survival during identification and data collection, a randomly selected subset of 200 *Elliptio spp.* was identified to species level. All of the other elliptio mussels were recorded simply as *E.* spp. Based on the subset, the Carolina slabshell, eastern elliptio and variable spike represented 37.5%, 36.5% and 26% respectively, of the 2,491 elliptio mussels found at this site. Based on these percentages, the estimated number of these species are 934, 909 and 648 individuals respectively. From these numbers, the CPUE for each species was estimated. With the exception of the eastern creekshell (1 individual) and the lanceolate Elliptio-*Elliptio nasutilus* (4 individuals) all other species found at this site were common to abundant. These two less common species were found in shallow water habitat near the mud river banks and bank root mats.

Site 3. Waccamaw River (oxbow): This site occurs in a slack up to 6 feet deep oxbow adjacent to the Waccamaw main channel. Substrate consists of mud and detritus. Large

accumulations of woody debris are scattered throughout the oxbow bottom. Mussels were generally uncommon at this site, being absent from areas containing large amounts of woody debris. The eastern elliptio (31 individuals) and the pod lance (25 individuals) were the most common species found, mainly concentrated in shallow water areas near the main channel of the Waccamaw River. The Florida pondhorn (2 individuals) and rayed pink fatmucket (1 individual) were also located at this site, being found in mud near the vegetated banks

Site 4. Waccamaw River: This site occurred in a run (to 6 feet deep) with predominately sand and detritus as substrate. Eastern elliptio (166 individuals) and Carolina slabshell (158 individuals) were most abundant, occurring at high densities in a sandy trough at the base of a bank. The pod lance (20 individuals) and Waccamaw spike (39 individuals) were also fairly common in these sandy trough habitats. The eastern creekshell (1 individual) and lanceolate Elliptio-*Elliptio nasutilus* (4 individuals) were found in low numbers in shallow water near the banks.

Site 5. Waccamaw River: This site occurred in a shallow run (to 5 feet deep) with dominant mud substrate mixed with detritus. Mussels were generally less common here than at other sites within the river, with the eastern elliptio (66 individuals) being the most common, having a CPUE of 33/phr. The next lowest CPUE for the eastern elliptio in the lower section of the Waccamaw River (excluding Oxbow channels) is 56.0 at Site 8. While numbers were low, species diversity (7 species) was comparable to other sites in the river.

Site 6. Waccamaw River cut through channel: This site consisted of a narrow cut – through channel of Thoroughfare Island within the river. Water level ranged from 1 to 4 feet deep and the substrate was predominantly sand and detritus. Relatively high abundance and species diversity (7 species) was recorded at this site. The eastern elliptio (288 individuals), Waccamaw spike (167 individuals) and box spike (125 individuals) are relatively abundant at this site, while the Carolina slabshell (2 individuals), eastern creekshell (1 individual) and the rayed pink fatmucket (1 individual) appear to be relatively rare.

Site 7. Waccamaw River Oxbow (Peachtree Lake): This site occurs in a deep (up to 188 feet) wide oxbow channel (lake) of the main stem Waccamaw River with a predominately mud substrate. Mussels were rare here, with one eastern elliptio comprising the only Unionid find. However, two aquatic snails, the pointed campeloma (*Campeloma decisum*), which was fairly common with a patchy distribution, and two individuals of the rare ridged lioplax (*Lioplax subcarinata*) were found here. This is the only location that the ridged lioplax was found during this study, and is one of only three locations of this species in ever recorded in South Carolina (SC DNR 2005). Nature Serve (2005) lists this species as S1 (Critically imperiled) in South Carolina; however, it has a global status of G5 (Globally Secure).

Site 8. Waccamaw River: This site occurs in a deep run in the main stem Waccamaw River with depths to 20 feet. Substrate is mostly sand with areas of quartz pea gravel in

the deepest troughs. Mussels were generally common, especially in the deep troughs, with 5 species of Elliptio found, the most abundant being the Carolina slabshell (165 individuals).

Site 9. Waccamaw River (Thoroughfare Creek): This site consisted of a mix of sandy substrate in the deeper (up to 14 feet) runs to mud substrate along banks and channel slopes. Four species of Elliptio were located throughout the site and 1 individual eastern creekshell was found in shallow water near the river banks. The Carolina slabshell (153 individuals) and eastern elliptio (118 individuals) were the most common species located, occurring primarily in the deep sandy runs.

Site 10. Black River (Cut-through channel): This shallow site (to four feet deep) consists of a run in a cut through channel of the floodplain swamp adjacent to a sharp bend in the river. The water was slightly tannic, but fairly clear at this site. Mussels were abundant and distributed throughout the channel, with the box spike (577 individuals) and eastern elliptio (481 individuals) making up the bulk of the 6 Elliptio species found. Three Florida pondhorn and one lanceolate Elliptio-*Elliptio nasutilus* were found in soft sediment in shallow water near the banks.

Site 11. Black River (Lester Creek): This site consists of a run in the main stem Black River with depths up to 6 feet deep. Substrate was dominated by sand, with areas of compact clay present. Mussels were often very dense in the compact clay substrate. Six Elliptio species were found, the most common being the eastern elliptio (337 individuals) and box spike (161 individuals), which were found throughout the surveyed reach. The variable spike (23 individuals), pod lance (14 individuals) and Carolina slabshell (1 individual) were fairly uncommon, and restricted to the sandy troughs. One individual lanceolate elliptio-*Elliptio nasutilus* was found in soft sediment in shallow water near the bank. The pointed campeloma has a patchy distribution in the surveyed reach, but was common where it was found.

Site 12. Black River: This site occurs in a sand/silt dominated run with a maximum depth of 12 feet and average depth of around 9 feet. Seven mussel species were found, six Elliptio species, and the Florida pondhorn (8 individuals). The Eastern elliptio 329 individuals) and variable spike 164 individuals) were the most common species found. One lanceolate elliptio-*Elliptio nasutilus* was found in shallow water near the bank.

Site 13. Black River: This deep (14 feet) run consisted of mostly coarse sand substrate with the occasional outcrop of soft, sedimentary bedrock present. The majority of mussels were found in the deep trough at the base of the slope of the right descending river bank. A total of 8 mussel species were located, the eastern elliptio being most abundant (489 individuals). One individual eastern creekshell and one lanceolate elliptio-*Elliptio nasutilus* were found in soft sediment in shallow water near the banks. This is the only site in this area of the Black River where the presence of the Waccamaw spike was established (one individual).

Site 14. Black River: This site occurs in a run with depths up to15 feet. Substrate is dominated by sand with clay present in some areas, particularlly in the banks. The majority of mussels were located in the deep troughs dominated by coarse sand. A total of 7 mussel species were found, the Carolina slabshell being the most common (107 individuals). The eastern creekshell was found here in shallow water habitat. This is the only site where both the pod lance and the Carolina lance were found. The Carolina lance appears to replace the pod lance in the deep run habitats at sites further upstream in the Black River. These two species are very similar, and the morphological differences may be related to environmental factors, rather than being separate species (See species discussion Section 4.2).

Site 15. Black River: This relatively shallow site (to 5 feet) occurs in a sand and quartz pebble run. Mussels are present throughout the site, although not abundant, with 5 species being found of which the eastern elliptio was most common (32 individuals). The site established the highest CPUE for eastern creekshell (4.8/phr) during all the surveys conducted for this study.

Site 16. Black River: This site occurs in a coarse sand and clay run in a broad bend of the river. The stream bottom slopes gradually from the left descending bank to a maximum depth of 10 feet, at the base of the steep bank on the right descending side of the river. Six species of mussels were found, with eastern elliptio and the variable spike being the most abundant (121 and 116 individuals respectively), as they were found throughout the site. The Carolina slabshell and Carolina lance were also found in large numbers (90 and 62 individuals respectively), but mainly restricted to the deep troughs. The eastern creekshell (14 individuals) and the Florida pondhorn (4 individuals) were found in shallow water habitats near the left bank. The 14 individuals of the eastern creekshell is the highest number found at any particular site in the entire study.

Site 17. Black River: This site occurs in a sand/clay run that has very similar characteristics as Site 16, with a maximum depth of approximately 8 feet. The majority of mussels were found in the deeper runs of the surveyed reach. Five species were found, the variable spike being the most abundant species found (72 individuals). The eastern creekshell (5 individuals) was found primarilly in shallow habitat, however 1 individual was found in a trough in 8 feet of water.

Site 18. Black River: This site occurs in a transition area of the river from a straight narrow run, to a wide, more ponded section of the river. The banks slope sharply to a depth of 10 feet within the narrow run which has a strong current and is dominated by coarse sand substrate. The wide section of the river is characterized as a deep (10 feet) pool, with shallow areas dominated by rooted emergent vegetation along the right descending bank. Due to time constraints, this site was only sampled for 30 minutes (2 person hours). The majority of mussels found at this site occurred in the deep run. Very few mussels were found in the pool habitats. A total of five mussel species were found with the Carolina slabshell being the most common (22 individuals). One individual eastern creekshell was found in the shallow habitats within the emergent vegetation.

Site 19. Black River Swamp: This survey site occurs within a large braided swamp complex near the town of Scotsville. The surveyed reach was shallow (less than 3 feet) with slack flow and a substrate of mostly detritus with areas of clay. Woody debris was very high and generally precluded the use of visual surveys. Elliptio mussels (171 individuals) were mainly concentrated in pockets of habitat dominated by a clay substrate, with comparatively less organic material than the majority of the surveyed reach. The Florida pondhorn (2 individuals) is the only other mussel species found in this reach. The crayfish *Procambarus (Scapulicambarus) troglodytes* is common in the survey reach.

Site 20. Black River Swamp: This site has very similar characteristics as Site 19. The surveyed reach is less than 3 feet deep with slack flow. As at Site 19, mussels *Elliptio spp.* (250 individuals) and the Florida pondhorn (4 individuals) were concentrated in fairly large numbers in pockets of suitable habitat. The crayfish *Procambarus (Scapulicambarus) troglodytes* was also observed at this site.

Site 21. Pocotaligo River (Brewington Lake): This site consists of a deep impounded section of the Pocotaligo River (Brewington Lake). The substrate is predominately organic mud, however pockets of sand and gravel are scattered throughout the surveyed reach. Maximum depth at this site is 25 feet. All but 1 (1 eastern elliptio) of mussels found at this site were located in less than 2 feet of water along the banks. Six mussel species were located. The lanceolate elliptio-*Elliptio nasutilus* was the most common (28 individuals) species found at this site. One individual each of the rayed pink fatmucket, Atlantic southern rainbow, and eastern creekshell were also found here.

Site 22. Lynches River: This location was surveyed for the SC Department of Transportation bridge replacement of the SC route 41/51 crossing of the Lynches River in Johnsonville. The results of this survey are included in this report since the survey was conducted within the study area for this project. The flow appeared slack on the surface, but was detectable and fairly strong to the divers using SCUBA. Maximum depth at this site is 25 feet. The dominate substrate of the site is mud, however, pockets of gravel/cobble habitat are scattered throughout, and most prevalent adjacent to the bridge pilings. Tactile searches were conducted in shallow areas along the river banks. A total of five mussel species were found with the eastern elliptio being the most common species found (78 individuals). Mussels were generally uncommon throughout the surveyed reach; however they were most prevalent in the pockets of gravel next to the bridge pilings in greater than 20 feet of water. Two species, the lanceolate elliptio-*Elliptio nasutilus* (8 individuals) and the rayed pink fatmucket (2 individuals) were located exclusively in shallow water along the muddy banks.

Site 23. Lynches River: This site occurred in a relatively shallow riffle and run habitat with a sand/gravel substrate. The majority of the reach was less than 3 feet deep with the deepest troughs approximately 6 feet deep. A wide forested buffer extended along the survey reach. A total of 4 mussel species were located at the site, the eastern elliptio (443 individuals) being the most abundant, and fairly evenly distributed throughout the site. The Carolina slabshell (90 individuals) and the Carolina lance (19 individuals) were

concentrated primarily in the deeper gravel-dominated trough adjacent to the right descending bank. One individual eastern creekshell was located in shallow habitat along the left bank.

Site 24. Lynches River: This site occurs in a deep run (maximum 12 feet deep) with sand and gravel substrate. Five species, the eastern elliptio (138 individuals), Carolina slabshell (8 individuals), Carolina lance (8 individuals) and the Pee Dee lance (1 individual) were found at this site. The eastern elliptio was found throughout the site, while the other species were found primarily in the deep troughs at the base of the streambanks. A narrow buffer bordered a rural area along the left descending bank in this reach.

Site 25. Lynches River: This site consists of a sand/gravel run with a maximum depth of 10 feet. A wide forested buffer extends along the surveyed reach. A total of four mussel species were found, with the eastern elliptio (141 individuals) being most abundant, and distributed throughout the site. The Carolina slabshell (48 individuals) and the Carolina lance (4 individuals) were found primarily in the deeper troughs. Several size classes of the Carolina slabshell were noted, including fairly small (young) individuals. One individual eastern creekshell was located.

Site 26. Lynches River: This site consists of a shallow sand/gravel riffle/run, with an average depth of 2 feet and a maximum of 5 feet in depth. A wide forested buffer extended along the surveyed reach. A total of 5 mussel species were located, the eastern elliptio (267 individuals) being most abundant. Four individuals of the eastern creekshell and one Florida pondhorn were located in shallow water along the banks at the site.

Site 27. Great Pee Dee River: This site consists of a large shallow cobble/gravel riffle area just upstream of the US 1 crossing of the Great Pee Dee River near Cheraw. This area of the Great Pee Dee is heavily influenced by the daily fluctuations in water level resulting from the hydroelectric operations at the Blewett Falls Lake dam upstream in North Carolina. As a result, river banks in the area are often heavily eroded and the shallow shoal searched at this site is exposed during times of minimum release from the dam. The maximum depth searched at this site was less than 4 feet. Only 2 live Carolina slabshell were found during the searches.

Site 28. Great Pee Dee River: This site consists of a 10 foot deep cobble/gravel run near the US 1 crossing in Cheraw. Occassional boulders and accumulations of coarse sand also occur within this run. A total of 7 mussel species were located, with the Carolina slabshell (182 individuals) being the most abundant species. One individual creeper, the only found at any site during survey efforts for this study, was located in a trough along the edge of the left descending river bank. The Pee Dee lance (3 individuals) was also found at this site, one of only three locations were it was found during the study. The rare Roanoke slabshell (10 individuals) and yellow lampmussel (2 individuals) were found in the pockets of coarse sand interspersed among the substrate. Water levels and velocity rose dramatically during the survey efforts at this site due to

release operations from the Blewett Falls Lake dam. Due to compromised survey conditions as well as diver safety, survey time was cut short at this site

Site 29. Great Pee Dee River: The next three sites occurred in the area of the US 401 crossing of the Great Pee Dee River south of Bennettsville. This site consists of run up to 13 feet deep, adjacent to a steeply sloping and eroding clay and mud river banks. The substrate is composed of shifting sand/peagravel, with mud along the banks. Mussels were rare and scattered, with the eastern elliptio (2 individuals), Carolina slabshell 3 (individuals), and yellow lampmussel (4 individuals) being located.

Site 30. Great Pee Dee River: This site consists of a sand and gravel run. The majority of the area searched was approximately 10 feet deep with a maximum depth of 15 feet. A narrow buffer extends along the river in this reach. Six mussel species were located primarily in the sand/gravel run at the base of the right descending bank, in fairly low numbers, with the Carolina slabshell (18 individuals) being the most common, followed by the eastern elliptio (7 individuals), yellow lampmussel (4 individuals), Roanoke slbshell (3 individuals), Carolina lance (3 individuals) and Atlantic spike (2 individuals). The gravel elimia (*Elimia catenaria*) was present, but uncommon with a patchy distribution at this site.

Site 31. Great Pee Dee River: This site consists of a sand/pea gravel run up to 15 feet deep, with a steep sloping, silt covered clay bank on the left descending side of the river and a gently sloping sandbar on the right. A narrow buffer extended along both sides of the river in this reach. A total of 6 mussel species were found at this site, but in relatively low numbers. The yellow lampmussel (10 individuals) found mostly on the sandbar and the Carolina slabshell (9 individuals) found in the deep run were the most common species at this site. This was the second highest abundance of the yellow lampmussel found at any site during the study, and was one of only 2 sites where young individuals were found. The Pee Dee lance (1 individual) was also found here.

Site 32. Little Pee Dee River: This site is located just upstream of the confluence with the Pee Dee River. The left descending bank slopes quickly to a depth of 32 feet. The substrate consists of sand and gravel over marl bedrock, with patches of exposed bedrock. The sloping banks consist of sandy mud. Seven total species were found at this site, with the variable spike (69 individuals) and the Carolina lance (56 individuals) being the most common species found. The majority of the mussels were found in the deep water in sand and gravel, with the exception of the eastern elliptio (12 individuals) and the E. nasutilus (3 individuals), which were found within the sloping bank. The yellow lampmussel (2 indiviuals) was found in sand in 32 feet of water. This species was generally found at depths less than 10 feet at all of the other sites where it was observed.

Site 33. Great Pee Dee River: Because of high current, only the left descending side of the river was surveyed. The bank drops quickly to a maximum depth of 17 feet. The substrate is primarily composed of coarse sand, and woody debris. The six species found at this site are generally uncommon, with the Carolina lance (24 individuals) being the most abundant. Mussels were found primarily in sand in a trough at the base of the slope,

with the exception of the eastern elliptio (16 individuals), which was found mostly in the bank.

Site 34. Great Pee Dee River: This site is located near the mouth of Clarks Creek. A large sand bar occurs in the river between an island in the river, and below the Clarks Creek confluence. The substrate adjacent to the right descending bank below Clarks Creek is composed of mud and sand. The sand bar and the muddy bank slope gradually toward the center channel which is dominated by shifting sand. Due to strong current, the area between the center of the channel and the left descending bank was not evaluated. Mussels have a very patchy distributions at this site, being fairly concentrated in small pockets, and being rare to absent in other areas. This site yielded the highest species diversity (12 species) of any site in the entire study area, with the eastern elliptio (55 individuals) being the most abundant species found. The yellow-lampmussel (11 individuals) was found primarily associated with the sandbar in fairly shallow water (6-8 feet). This is the most individuals of this species found at any one site in the entire study area. The eastern pondmussel (3 individuals), eastern floater (3 individuals), paper pondshell (2 individuals) and tidewater mucket (1 individual) were found in shallow water within the muddy banks on the right descending bank of the river. The Carolina lance (27 individuals), Carolina slabshell (8 individuals) and Roanoke slabshell (5 individuals) were found in the sandy substrates in deep water.

Site 35. Great Pee Dee River: Surveys were conducted in this deep (16 feet) sand and gravel run near on the opposite side of the river from Clarks Creek. The survey time was relatively short due to strong currents and low light levels, as the surveys were conducted around dusk. Due to the limited time, only the steeply sloping clay bank and the trough at the base of the slope were searched. Five mussel species were located, the Carolina lance (29 individuals) being the most abundant. Most of the mussels were found in deep sandy trough, with a few eastern elliptio (7 individuals) occurring in the sloping bank.

Site 36. Great Pee Dee River: This site consisted of a deep sandy run to 16 feet deep, with silt and mud sloping banks. Mussels were uncommon in the shifting sand substrate. Three species, the Carolina slabshell (7 individuals), eastern elliptio (3 individuals) and variable spike (3 individuals) were the only species found.

Site 37. Great Pee Dee River: A large marl outcrop located in a broad bend of the river, extending from the right descending bank to mid channel occurs at this site. Large accumulations of sand and mud occur over some areas of marl, while in other areas the bedrock is clean. The survey efforts of 1 diver were concentrated around the marl outcrop, while the other diver evaluated other habitats. A total of 9 species were found at this site, the second most of any site sampled in this study. The Carolina lance (56 individuals) and the Roanoke slabshell (40 individuals) were the most common species found. Mussels are abundant in areas with accumulated sediments and totally absent in the areas with no little to sediment. The maximum depth at the site is 16 feet.

Site 38. Great Pee Dee River: This site is located near the mouth of the Lynches River. A flooded wetland system borders the river at this location. The right descending side of

the river was surveyed. The stream bottom slopes gradually from the wetland to a depth of 15 feet. The substrate consists of sand, and mud. Large accumulations of detritus occur in some areas. The eastern elliptio (65 individuals) and variable spike (29 individuals) occurred mainly in the sloping bank, while the Carolina lance (35 individuals), Roanoke slabshell (15 individuals) and Carolina slabshell (12 individuals) were found primarily in sand in the deeper part of the river. One relict shell of the yellow lampmussel was also found.

Site 39. Great Pee Dee River: This site is located adjacent to a large sandy beach in a relatively narrow bend of the river, extending downstream to a straight run. The stream bottom slopes gradually from the beach to a depth of 14 feet. No mussels were found in the shifting sandy substrate. A few mussels, eastern elliptio (5 individuals), yellow lampmussel (2 individuals) and Roanoke slabshell (1 individual) were found in sandy mud adjacent to the right descending bank in the run below the sandy area.

Site 40. Little Pee Dee River: This site is located in a broad bend of the river. The stream bottom slopes very gradually from the right descending banks to the center of the channel. The left bank drops off quickly to a depth of 8 feet. A narrow trough of sand and gravel occurs at the base of the slope. Seven species were found at this site, with the Waccamaw spike (66 individuals) being the most abundant. Although mussels occur throughout the channel at this location, they are concentrated primarily along the left descending bank in rootmats, and the gravel trough. The 2 lanceolate elliptio-*E. nasutilus* found occurred in the shallow sandy area adjacent to the right bank. The eastern pondmussel (1 individual) was also found in the shallow along the bank, in a sandy-mud substrate. This is only 1 of 2 locations this species was found in the entire study

Site 41. Little Pee Dee River: This site occurs in a deep oxbow channel of the river that has very little flow. The area adjacent to the left bank was surveyed. The substrate slopes quickly from the bank to a depth of 14 feet and consists of mud with pockets of gravel and cobble. Four species, the eastern elliptio (3 individuals), Florida pondhorn (3 individuals), Waccamaw spike (1 individual) and the variable spike (1 individual) were found in low numbers. Surprisingly, no mussels were found in the gravel and cobble substrates, rather than were confined to the muddy banks.

Site 42. Little Pee Dee River: This site is located in a bend, followed by a straight run of the river. The substrate slopes fairly quickly from both sides of the river to a depth of 8 feet. Clay and sand comprise the substrate of the banks. A narrow trough of sand and gravel occurs at the base of each slope. Six species were located at this site, with the Waccamaw spike (86 individuals), followed by the Carolina lance (33 individuals) were the most abundant species found. Mussels occur throughout the channel at this location, but are concentrated primarily within the troughs and clay banks.

Site 43. Little Pee Dee River: This site is located in a bend of the river, with a sandy beach on the left descending bank. The substrate slopes gently from the beach to a maximum depth of 7 feet, and rises sharply along the right bank The channel is composed largely of shifting sand and gravel. Four species were located at this site, with the

Waccamaw spike (41 individuals) and Carolina lance (12 individuals) the most abundant. Mussels are generally uncommon and scattered throughout this location.

Site 44. Little Pee Dee River: This site is located near the midpoint of a narrow island in the middle of the channel. The substrate slopes gently from the left descending island shore to a depth of 8 feet. The substrate is composed of muddy sand. Four species were found. With the exception of the Waccamaw spike (54 individuals), mussels are generally uncommon but fairly evenly dispersed at this location. The tidewater mucket (7 individuals) was found primarily in soft substrate. This site yielded the highest CPUE and individual numbers for this species of all sites in the study area.

Site 45. Little Pee Dee River: This site is located a short distance downstream of Site 44, at the bottom of the mid-channel island. The substrate slopes gently from the shore to average depth of 6 feet on the left descending side of the island. A flooded cypress swamp system occurs on the right side of the river below the island. Pools up to 24 feet in depth occur adjacent to the swamp. The substrate is composed of muddy sand below the left side of the island and coarse sand in the center of the channel to the right descending bank. Seven species were found at this site with the Waccamaw spike (57 individuals) and Carolina lance (44 individuals) being the most common. The Carolina lance occurred mostly in sand in deeper water, while the Waccamaw spike was dispersed throughout the site. The tidewater mucket (5 individuals), Florida pondhorn (7 individuals) and laceolate elliptio-*E. nasutilus* (3 individuals) were found primarily in the shallow areas in soft substrate.

Site 46. Little Pee Dee River: This site is located in a straight shallow run. The substrate slopes gently from the shore to a maximum depth of 5 feet. The substrate is composed of compact sand. The Waccamaw spike (229 individuals) is very abundant at this site occurring equally within the banks under submerged rootmats and in the center of the channel in sand. The eastern elliptio (17 individuals) and Carolina lance (5 individuals) were found in lower numbers.

Site 47. Buffalo Creek: Surveys were conducted in Buffalo Creek en-route to planned surveys efforts and thus was added as an additional site. The surveyed area consisted of a gravel/sand run with a maximum depth of 2 feet, in a reach with stable banks and a wide natural buffer to adjacent rural areas. The water was very tannic, but fairly clear. No mussels were located in 1 hour of search time.

Site 48. Lynches River: This site occurs in a sand and gravel run, with a maximum depth of 8 feet, in an area with a wide forested buffer and stable banks. At least 5 mussel species were located during the survey efforts. *Elliptio spp.,* (104 individuals) was the most abundant mussel "species" collected at this site, and includes several forms of the *Elliptio complanta* and *E. icterina* complexes, with the *E. cistelliformis* form being the most common. These forms grade into each other, making separation difficult, therefore the forms were grouped into *E. spp.* The aquatic snail pointed campeloma (*Campeloma decisum*) was common with a patchy distribution in the surveyed reach.

Site 49. Lynches River: This site exists as a sand and gravel run in an area with a wide forested buffer and stable banks. The reach had a maximum of depth of 7 feet. At least 5 mussel species were located during the survey efforts. *Elliptio spp.*, (209 individuals) the most abundant mussel "species" collected at this site, includes several forms of the *Elliptio complanta* and *E. icterina* complexes, including *E. cistelliformis* and *E. raveneli*. The Carolina slabshell (13 individuals) was found primarily in sand at the base of the slope. Only very large (old) individuals of this species were located. These forms grade into each other, making separation difficult, therefore the forms were grouped into *E. spp.* The Atlantic spike (2 individuals), eastern creekshell (1 individual) and Carolina lance (1 individual) were uncommon at this site.

Site 50. Lynches River: This site occurs in a relatively narrow channel with swift flow that is constricted by a small island within a bend of the river. Both sides of the channel slope sharply to a depth of 12 feet. The substrate consists of sand and pea gravel. At least 3 mussel species were located during the survey efforts. *Elliptio spp.*, (59 individuals) the most abundant "species" collected at this site, includes several forms of the *Elliptio complanta* and *E. icterina* complexes. These forms grade into each other, making separation difficult, therefore the forms were grouped into *E. spp.* The Carolina lance (2 individuals) and Carolina lance (2 individuals) were uncommon. The aquatic snails, pointed campeloma (*Campeloma decisum*) and gravel elimia (*Elimia catenaria*) were also present in the surveyed reach.

Site 51. Great Pee Dee River: This site is located in the main channel of the Great Pee Dee River adjacent to Great Island. The river channel is a wide and shallow riffle in the area around Great Island with substrates consisting of mostly cobble and gravel. The survey reach was less than 3 feet deep at this site. Five mussel species were located at this site, the bulk of which were Carolina slabshell (416 individuals) of multiple size (age) classes. Other mussels at this site include the Carolina lance 20 individuals), Roanoke slabshell (8 individuals), eastern elliptio (6 individuals) and eastern creekshell (1 individual). Mussels were fairly evenly distributed across the site. The aquatic snails, pointed campeloma (*Campeloma decisum*), a mudalia (*Leptoxis sp.*), and gravel elimia (*Elimia catenaria*) were present in the surveyed reach.

Site 52. Great Pee Dee River (Island Channel): This site is located in the larger island channel of the Great Pee Dee River adjacent to Great Island. Habitat in the island channel is characterized as a long, very shallow riffle, with substrates consisting of mostly cobble and gravel. The survey reach was less than 2 feet deep at this site. Four mussel species were located at this site, the bulk of which were Carolina slabshell (94 individuals) of all multiple size (age) classes. The aquatic snails, pointed campeloma (*Campeloma decisum*), a mudalia (*Leptoxis sp.*), and gravel elimia (*Elimia catenaria*) were present in the surveyed reach.

Site 53. Great Pee Dee River (Island Channel-Westfield Creek): This site is located in the smaller island channel of the Great Pee Dee River adjacent to Great Island near the confluence with Westfield Creek. The island channel near the confluence is characterized by very shallow (< 2feet) riffle/run and deeper (3-4 feet) pool habitats, with

substrates consisting of mostly cobble and gravel. Seven mussel species were located at this site, the bulk of which were Carolina slabshell (85 individuals) of multiple size (age) classes. The eastern creekshell (4 individuals), Atlantic spike (3 individuals), Roanoke slabshell (1 individual) and yellow lampmussel (1 individual) appeared to be uncommon to rare at the site. The pointed campeloma and gravel elimia were present in the surveyed reach.

Site 54. Great Pee Dee River: This site is located in the main channel of the Great Pee River upstream from the US 1 crossing, in the same general reach of the river as Site 27 and Site 28. A deep (12 feet) run consisting of mostly bedrock, cobble and gravel along the left descending bank of the channel was surveyed. Seven mussel species were located at this site, the bulk of which were Carolina slabshell (124 individuals). The Pee Dee lance (7 individuals) was found underneath rocks on the river bottom. Six of the 7 individuals were found at this site under 1 rock. This is the largest number found and highest CPUE for this species of any site within the study. Other rare mussels at this site include the Roanoke slabshell (2 individuals), eastern creekshell (1 individual), and Atlantic southern rainbow (1 individual). Aquatic snails found at this site include the pointed campeloma (*Campeloma decisum*), a mudalia (*Leptoxis sp.*), and gravel elimia (*Elimia catenaria*).

Site 55. Lynches River: This site occurs just above the SC 265 bridge crossing and is characterized by a shallow (2.5 feet) run/ pool habitat with mostly sand substrate and gradually sloping clay banks. A moderate forested buffer extends along the surveyed reach. Water was highly turbid during the survey efforts, making visual surveys difficult. At least 3 live mussel species, elliptio mussels (92 individuals), Carolina lance (3 individuals) and eastern creekshell (3 individuals) were located during the survey efforts with shells of the brook floater (4 shells), eastern floater (1 shell) and the federally Endangered Carolina heelsplitter (1 shell) also being located. This is the only site that the Carolina heelsplitter was found. Elliptio mussels, the most abundant mussel "species" collected at this site, includes several forms of the *Elliptio complanta* and *E. icterina* complexes, including *E. cistelliformis* and *E. raveneli*. These forms each grade into each other, making separation difficult, therefore the forms were grouped into *E. spp.* The pointed campeloma (*Campeloma decisum*) was common with a patchy distribution throughout the survey reach.

Site 56. Lynches River: This site consists of a long, shallow cobble/gravel riffle just above, and contiguous with Site 55. Areas searched were mostly less than 1 foot deep. The area has a wide natural buffer with stable banks. Three mussel species, elliptio mussels (28 individuals), the brook floater (4 individuals) and the Carolina lance (1 individual) were found at this site, despite very poor survey conditions (high turbidity). Two of the brook floaters found were very small (young individuals). This site and Site 55 were the only two locations this species was found during the study. The gravel elimia was common in the surveyed reach.

Site 57. Lynches River: This site consists of a shallow, sand/pea gravel run with a moderate buffer to the surrounding timber and rural land use. The substrate was

unconsolidated and very unstable. Areas searched were generally under 2 feet deep. Only one individual eastern elliptio was collected during the survey efforts.

Site 58. Waccamaw River: This site occurs upstream of the SC 9 crossing in the area of Worthams Ferry. This area of the river has a wide floodplain, with extensive natural bottomland and swamp forest buffering this black water system. This site occurs in a relatively sharp bend of the river and consists of a moderately deep (to 8 feet) run and slack water area with gently sloping silt and clay banks to deeper sand dominated trough areas. At least 8 mussel species were located, with elliptio mussels (242 individuals) followed by box spike (60 individuals), pod lance (45 individuals) and Waccamaw spike (32 individuals) being the most abundant The elliptio mussels found at this site includes several forms of the *Elliptio complanta* and *E. icterina* complexes. The eastern creekshell (6 individuals) and lancelolate elliptio-*Elliptio nasutilus* (3 individuals) were present, being found primarily in shallow water in softer substrate.

Site 59. Waccamaw River: This site occurs in a broad bend in the river upstream of the SC 9 crossing of the river, and is characterized by run/pool habitat. Mud banks gently sloped to the sandy river bottom around 8 feet in depth. At least 7 mussel species were located. Elliptio mussels (266 individuals) were the most abundant mussel "species" collected at this site, and include several forms of the *Elliptio complanta* and *E. icterina* complex. These forms each grade into each other, making separation difficult, therefore the forms were grouped into *E. spp.* The eastern creekshell (2 individuals) and lancelolate elliptio-*Elliptio nasutilus* (28 individuals) were found primarily in shallow water in softer substrate.

Site 60. Waccamaw River: This site consists mainly of a sandy run with some slack-flow areas in depths up to 8 feet. Steep clay banks occur on both sides of the river at this location At least 6 mussel species were found, with elliptio mussels (425 individuals) being the most abundant "species" collected at this site, which includes several forms of the *Elliptio complanta* and *E. icterina* complexs. These forms grade into each other, making separation difficult, therefore the forms were grouped into *E. spp.*.

Site 61. Waccamaw River: This site encompasses a sand run with slackwater areas and sloping silt banks. This area was also turbid as a result of earlier rains. A total of 6 mussel species were found, with elliptio mussels (281 individuals) being the most abundant "species" collected at this site, which includes several forms of the *Elliptio complanta* and *E. icterina* complexs. These forms grade into each other, making separation difficult, therefore the forms were grouped into *E. spp.* The eastern creekshell (1 individual) and lancelolate elliptio-*Elliptio nasutilus* (4 individuals) were present, being found primarily in shallow water in softer substrate.

4.2 Mussel species found during the surveys

At least 23 species of freshwater mussels were found during these survey efforts. Brief descriptions of each of these species are provided below. The original species descriptions, or Bogan (2002) and Bogan and Alderman (2004) should be consulted for

more detailed descriptions of each species. Representative photographs of these species are included on the provided data CD, as available.

Alasmidonta varicosa (brook floater)- Described by Lamarck (1819) from the Schuylkill River in Philadelphia County, Pennsylvania, this species ranges from the lower St. Lawrence River basin south to the Atlantic drainages of South Carolina. While still common in some areas, the species has experienced significant declines throughout its range. Shells of the brook floater are long rhomboid in outline, with a yellowish to greenish smooth perisotracum. Shell surfaces are partly to completely covered with dark greenish rays, becoming obscured with age. The posterior slope of the shell is flattened and slightly concave with numerous, low corrugations or varicose ridges. Williams et al. (1993) list this species as endangered, and it is considered a species of Special Concern in South Carolina (SCDNR 2005).

This species typically occurs in gravel riffle-dominated habitats, which is not present in the majority of sites surveyed during this study. Four live individuals were found at Site 58 (Lynches River) in a long shallow riffle in strong current. The water was very turbid during the site visit. Surveys conducted during better water clarity would likely yield greater numbers of this species. Fresh-dead shells (3) of this species were found at Site 57 (Lynches River), which is a run/pool section of the river contiguous with this riffle site.

Elliptio angustata (Carolina lance)-This species was described from the Cooper River, South Carolina (Lea 1831). The shell is more than twice as long as high coming to a posterior point, below the midline between the dorsal and ventral margins. The dorsal margin is straight and essentially parallel to the ventral margin. Umbos are slightly elevated with beak sculpture consisting of strong ridges. Johnson (1970) synominized this species and over 20 other named species of lance-shaped elliptio mussels into *Elliptio lanceolata*. Recent genotypic and phenotypic analysis suggests that some of these formally described species are valid, including "true" *Elliptio lanceolata* (type locality-Tar River). The Carolina lance ranges from the Ogeechee, Georgia north to the Potomac River in Maryland and Virginia. Williams et al. (1993) list this species as Special Concern, although it is not currently ranked in South Carolina (SCDNR 2005).

This species was found at 30 sites within the study area, almost exclusively in deep run habitats dominated by coarse sand/pea gravel, and fairly swift flow. It was most commonly associated with the Carolina slabshell. This species is very similar in appearance to the pod lance (E. folliculata) differing only by being more inflated, broader, and being more pointed at the posterior end. The pod lance appears to occupy similar habitats as the Carolina lance in the lower reaches of the river basin (Waccamaw River, lower sections of Black River). It is unclear whether these are two separate species, or one species with marked clinal variation within its range. Both species (forms) were found together at only 1 site (Site 14-Black River). The Carolina lance was found at sites in the Black River upstream of this site, while the pod lance was found at downstream sites.

Elliptio cistelliformis (box spike)-This species was described from the Neuse River near Raleigh, North Carolina (Lea, 1863). Its range extends from the Catawba River drainage to the Tar/Pamlico drainage (Bogan 2002). Johnson (1970) synonomized this species with Elliptio complanata, however it is distinguished by its smooth, oblong very inflated shell with swollen umbos and a straight ventral margin, lending it to it's box-like shape. It is generally more common in the lower portions of river systems, often being tolerant of tannic, swampy systems. (Williams et al., 1993) listed its status as unknown.

This species was recorded at 7 sites, where it was clearly distinguishable from other forms of E. complanata. At some sites within the Lynches River, the box spike was lumped into E. spp. as gradation between forms, and time constraints made separation difficult. It was typically found in low flow, tannic water habitats, and was most abundant at Site 10 (Black River), in a cut-through channel of a floodplain swamp.

Elliptio complanata (eastern elliptio)-This species was described as Mya complanata from the Potomac River in Maryland (Lightfoot 1786). Shell characteristics are highly variable. Shell shape is typically trapezoidal to rhomboid, and compressed to inflated. The usually straight ventral margin is mostly parallel with the dorsal margin and the posterior margin is broadly rounded. Shell thickness varies from thin to solid. This species is widely distributed along the Atlantic Slope from Altamaha River Basin in Georgia north to the St. Lawerence River Basin, and west to Lake Superior and parts of the Hudson Bay Basin. It can be found in a variety of habitats from large rivers and, lakes to small headwater streams. The species is widespread and common throughout its range and considered "Stable" (Williams et al. 1993). It is not ranked in South Carolina (SCDNR 2005).

This species occurred at all but 2 of the 61 sites surveyed in this study. Several forms of this species occurred throughout the study area, and often within a particular site. At several sites, it was lumped along with E. icterina forms into *E. spp*. (see *E.* spp. discussion below). This species generally occupied multiple habitat types within a particular site. However, due to time constraints, and not being the focus of this study, efforts to correlate different forms with different habitat types were not attempted. It is unclear whether the variations in shell morphology within the study area, as well as within particular sites represent ecophenotypic variation, or whether they represent distinct species.

Elliptio congaraea (Carolina slabshell)-This species was described from the Congaree River, South Carolina by Lea (1831). The range of this species extends from the Ogeechee River, Georgia north to the Chowan River, North Carolina. The shell is rhomboid and subcompressed with moderately full beaks. The front of the shell is wedge-shaped, with the posterior end obliquely truncate above and biangulate below. The posterior slope usually has numerous cross corrugations or wrinkles. The periostracum is greenish-yellow or tawny. Williams et al. (1993) and the SCDNR (2005) list this species as Special Concern.

This species was found at 41 sites within the study area, usually occurring in deep run habitats dominated by coarse sand/pea gravel, and fairly swift flow. However, in the upper sites in the Great Pee Dee River it was often found in high numbers in shallow riffles. Daily water level fluctuations of greater than 2 feet regularly occur in this portion of the river as a result of the release operations at Blewett Falls Lake in North Carolina. This may suggest that the swift flow has more influence on distribution of this species than water depth. It was most commonly associated with the Carolina lance. In general, the majority of Carolina slabshell found were large (old) individuals. Sites where several small (young) individuals were observed include Site #s 1,2,4,8, 16, 25 and 51.

Elliptio folliculata (pod spike)-This species was described from the Savannah River, Georgia by Lea (1838). The range of this species extends from the Ogeechee River, Georgia north to the Cape Fear River basin, North Carolina. The shell is narrow and uninflated, resembling a straight-edged razor. The dorsal and ventral shell margins are parallel to each other and the anterior-dorsal margin is angular in shape. The umbos are flat and scarcely prominent. The periostracum is dark-brown to black and nacre color varies from bluish to pink. Williams et al. (1993) list this species as Special Concern, although it is not currently ranked in South Carolina (SCDNR 2005).

This species was observed at 10 sites within the Waccamaw River and lower portions of the Black River, typically in sandy run habitats. This species closely resembles the Carolina lance, which was typically found further upstream within the basin. See description above of *E. angustata*, for further discussion of this species.

Elliptio icterina (variable spike)-Described from the Savannah River near Augusta Georgia (Conrad 1834), this highly variable species has been represents a complex of nearly 50 species (Johnson 1970). The shell shape is oblong, subelliptical, or subrhomboid, with a prominent posterior ridge, and moderately elevated beaks. The periostracum is usually smooth and greenish yellow to tawny-brown. This species is considered common and Currently Stable throughout its range (Williams et al. 1993) and it is not currently ranked in South Carolina (SCDNR 2005).

Several forms of this species occurred throughout the study area, and often within a particular site. At several sites, it was lumped along with E. complanata forms into *E. spp*. (see *E.* spp. discussion below). This species generally occupied multiple habitat types within a particular site. However, due to time constraints, and not being the focus of this study, efforts to correlate different forms with different habitat types were not attempted. It is unclear whether the variations in shell morphology within the study area, as well as within particular sites represent ecophenotypic variation, or wheter they represent distinct species.

Elliptio nasutilus (lanceolate elliptio)- Johnson (1970) synonymized over 20 named species of lance-shaped elliptio mussels into *Elliptio lanceolata* (yellow lance). Recent genotypic and phenotypic analysis suggests that some of these formally described species are valid, including "true" *Elliptio lanceolata* (type locality, Tar River). The true yellow lance is a Federal Species of Concern. The lanceolate elliptio found in the Pee Dee

system described below is not the yellow lance, rather it more closely resembles what was described from the Cape Fear River Basin in North Carolina as *Unio=Elliptio nasutilius* (Lea 1863). The shell is more than twice as long as high coming to a posterior point that is turned upward above the midline between the dorsal and ventral margins. The dorsal ridge is strongly angled. The periostracum is usually yellowish-green with darker green rays, becoming black with age. This species is very similar to, if not the same as the northern lance (*E. fisherianus*), which was described from the Chester River in Maryland. Futher taxonomic and genetic research is needed on this group to determine species phylogeny. Because of taxonomic uncertainty, the status of this species is undetermined.

Elliptio producta (Atlantic spike)-This species was described from the Savannah River, Georgia by Conrad (1836). The range of this species extends from the Savannah River, Georgia north to the Potomac River Basin in Maryland and Virginia. The Atlantic spike was once synonymized with *Elliptio lanceolata* (Johnston 1970) but is now considered a separate species. The anterior shell margin is rounded and the posterior margin roundly pointed with the most posterior point slightly above the midline of the shell. The periostracum is often shiny, dark reddish brown to greenish brown generally with out rays. Shell nacre is variable shades of purple. Williams et al. (1993) list this species as Special Concern, although it is not currently ranked in South Carolina (SCDNR 2005).

This species was found in very low numbers (mximum 4 individuals) at 7 sites throughout the study area. Because it occurred in so few numbers, apparent habitat preferences of this species were not able to be determined.

Elliptio roanokensis (Roanoke slabshell)-The Roanoke slabshell was described from the Roanoke River (exact location unknown) by Lea (1838). The reported range of this species extends from the Connecticut River in Massachusetts south to the Savannah River in Georgia (Walter 1954)). Based on shell morphologies, Johnson (1970) synominized this and 100 other species into the *Elliptio complanata* complex, however it is now widely recognized as being a valid species. The periostracum is generally very smooth, often with placations (furrows) and reddish yellow in color. Shells of this species reach lengths exceeding 150 mm. Williams et al. (1993) list this species as Special Concern, although it is not currently ranked in South Carolina (SCDNR 2005).

This species was found at 13 sites, within the study area, all in the Great Pee Dee River. It was usually found in deep run habitats dominated by coarse sand/pea gravel, and fairly swift flow. It was most commonly associated with the Carolina lance and Carolina slabshell. There was little evidence of recent recruitment of this species at most sites where it occurred, as nearly all of the individuals found very large (old). Although its presence in the lower reaches of the Great Pee Dee River had been presumed, this study provided the first documentation of this.

Elliptio sp. 1 (lanceolate elliptio #1/Pee Dee Lance)-This undescribed lance appears to be morphologically distinct from other lance forms described here and preliminary analysis has indicated that it is genetically distinct from other lances. This large lance can exceed

150 mm. It is often a distinct "boomerang" shape with a concave ventral margin and equi-distant convex dorsal margin. Like other lances, it is more than twice as long as high, approaching more than three times as long as high. Perisotracum is generally dark brown to black in older specimens. It has currently been observed in the Cape Fear River basin in North Carolina and the Pee Dee River basin in North and South Carolina (personal observations). Because of taxonomic uncertainty, the status of this potential "new"species is undetermined.

This species was found at 4 sites in the study area. It appears to occur in the upper portions of the basin, and seems to be more common in the Great Pee Dee River, further upstream in North Carolina (personal observations). It was fairly uncommon at sites where it was found during this study, being most abundant (7 individuals) at site 54 (Great Pee Dee River). All of these individuals were found under rocks (6 under 1 rock) in a bedrock dominated run of the river.

Elliptio spp. (elliptio mussels)-Mussels in the genus Elliptio were the most common species found in all of the streams containing a mussel fauna. Based on shell morphologies, Johnson (1970) synonymized nearly 150 named species into two complexes: *E. complanata* and *E. icterina* respectively (102 and 47). Many of these species were described in the Carolinas. Preliminary genetic research suggests that some of these may be valid species. In some of the streams surveyed for this project there appeared to be several forms of Elliptios, with gradation between each form, making separation difficult. In these instances they were lumped into 1 group (*Elliptio* spp.).

A number of distinct "forms" of *E. complanata* and *E. icterina* were consistently noted during this study. Unfortunately time constraints did not allow for, nor did the scope of this study intend to separate each form at each site, and assign a former species name to the elliptio fauna found. However, some general observations were made:

E. complanata complex. In the areas with moderate to strong current, the *E. complanata* complex was represented by shell morphologies similar to those described for *E. complanata*, *E. yadkinesis* (Lea 1834-72), *E. subparallelus* (Lea 1834-72), and *E. oblongus* (Lea 1834-72). In more quiet waters in softer substrates, forms resembling *E. infulgens* (Lea 1874) and *E. beaverensis* (Lea 1834-72) were observed.

E. icterina complex. Forms similar to *E. icterina*, *E. ablatus* (Lea 1863), *E. micans* (Lea 1834-72) and *E. raveneli* (Conrad 1834) comprised the *E. icterina* complex observed in the study area. The *E. raveneli* form was particularly prevalent in the Lynches River.

Elliptio waccamawensis (Waccamaw spike) - The Waccamaw spike was described from Lake Waccamaw by Lea (1863). The previously reported range for this species restricted it to Waccamaw Lake and River in North Carolina and the Waccamaw River in South Carolina. The surveys conducted for this assessment also documented the species presence in the Little Pee Dee, Great Pee Dee, and Black Rivers in South Carolina. This species has a moderately inflated elliptical shell with a prominent angular ridge on its posterior slope: the ventral margin is straight. The perisotracum is light to dark brown

and the nacre is bluish white and iridescent. Williams et al. (1993) list this species as Special Concern, and it is considered critically imperiled in South Carolina (SCDNR 2005).

This species was observed at 16 sites in the study area, in a variety of habitat conditions, reaching its highest apparent densities in sandy substrates. Prior to this study, the Waccamaw spike had only been recorded from the Lake Waccamaw in Columbus County, North Carolina, and in the Waccamaw River in North Carolina and South Carolina. The discoveries in the Little Pee Dee River (Sites 40-46), Great Pee Dee River (Sites 33-34) and Black River (Site 13) mark significant increases in the known distribution of this species.

Lampsilis cariosa (yellow lampmussel)-This species was described from the Schuykill River near Philidelphia (Say 1817). Its range extends from the Ogeechee River in Georgia north to Novia Scotia. The waxy-yellow shell is obovate in outline, with a rounded anterior margin and slightly curved posterior margin and is rarely rayed. Like other members of this genus, this species is sexually dimorphic, with the shells of the male being more elongate, and the females more rounded, particularly in the posterior margin. This species is a Federal Species of Concern and is proposed as State Endangered in South Carolina (Bogan and Alderman 2004). Williams et al. (1993) list this species as endangered, and it is considered special concern in South Carolina (SCDNR 2005).

This species was found at 11 sites, in fairly low numbers (maximum 11 at site 34), in sandy substrate. With the exception of Site 32 (Little Pee Dee River, where it was found in 32 feet of water, it was typically found in fairly shallow water (<4 feet). The majority of individuals found were fairly large (old). Small (young) individuals were found only at sites 31 and 34. The sites in the lower portions of the Great Pee Dee and the site in the Little Pee Dee extend the known range of this species in the basin.

Lampsilis splendida (rayed pink fatmucket)-This species was described from the Altamaha River, Georgia by Lea (1838). The species is closely related in morphology and known ecology to the eastern lampmussel (*Lampsilis radiata*) and it is believed that individuals classified as rayed pink fatmucket may represent geomorphologic variation of the same species. The rayed pink fatmucket occurs from the Altamaha River north to the Cape Fear River basin and range for the eastern lampmussel extends from the Pee Dee River basin north the St. Lawrence River basin. The rayed pink fatmucket has an oval elongate shell shape and it is generally greatly inflated. As with other members of the genus, the species is sexually dimporphic: in the male, the posterior end is bluntly pointed, and in the female, it is more broadly rounded. The outer surface of the shell can be smooth to more commonly roughened by close concentric wrinkles. Perisotracum color ranges from yellowish-green to reddish-brown often with variable dark rays. Nacre color ranges from bluish white to light purple, but is most often a deep pink. Williams et al. (1993) and South Carolina's Comprehensive Wildlife Conservation Strategy (SCDNR 2005) list this species as Special Concern.

This species was found in shallow habitats in low numbers (maximum 2 at sites 21 and 22) at 3 sites in the study area. This species may have been under-detected at some of the sites, as most of the survey efforts focused on deep water habitats.

Lasmigona decorata (Carolina heelsplitter)-The Carolina heelsplitter (*Lasmigona decorata*), originally described as *Unio decoratus* by (Lea 1852), synonymized with *Lasmigona subviridis Conrad*, (Johnson 1970), and later separated as a distinct species (Clarke 1985), is a federally Endangered freshwater mussel, historically known from several locations within the Catawba and Pee Dee River systems in North Carolina and the Catawba, Pee Dee, and Savannah River systems in South Carolina. The Carolina heelsplitter is characterized as having an ovate, trapezoid-shaped, unsculptured shell. The outer surface of the shell ranges from greenish brown to dark brown in color, with younger specimens often having faint greenish brown or black rays. The shell's nacre is often pearly white to bluish white, grading to orange in the area of the umbo (Keferl 1991). The hinge teeth are well developed and heavy and the beak sculpture is double looped (Keferl and Shelly 1988). Morphologically, the shell of the Carolina heelsplitter is very similar to the shell of the green floater (Clarke 1985), with the exception of a much larger size and thickness in *L. decorata* (Keferl and Shelly 1988). Williams et al. (1993) and the South Carolina Wildlife Initiative Plan (2005) list this species as Endangered.

One fresh-dead shell of this species was found at site 55 (Lynches River), confirming its present in this reach of the river. The Carolina heelsplitter is primarily found in habitat within the Carolina slatebelt. Most of the survey efforts of this study were focused in areas outside of this geologic region.

Leptodea ochracea (Tidewater mucket)-The tidewater mucket was described from the Schuykill River near Philidelphia (Say 1817). Its range extends from Cape Breton, Nova Scotia Canada, south to the Savannah River, Georgia. The dull yellow to greenish shell is ovate to elliptical in outline, with evenly rounded anterior, ventral and posterior margins. Like members of the genus *Lampsillis*, this species is sexually dimorphic, with the shells of the male being more elongate, and the females more rounded, particularly in the posterior margin. The shells usually have fine greenish to grey rays across most of the shell. This species is reported to be fairly small in size (75 mm), however the average size of the individuals found in the Roanoke River was 85 mm with a maximum of 102 mm. Williams et al. (1993) list this species as Special Concern, although it is not currently ranked in South Carolina (SCDNR 2005).

This species was found at 3 sites in the study area, confirming its extant presence in South Carolina, and documenting it to occur in the Pee Dee River Basin. In parts of its range, this species can be locally common (personal observations), but was found in fairly low numbers in this study. This can likely be explained by the fact that few slack-water habitats were searched.

Ligumia nasuta (eastern pondmussel)-This species was described from the Schuykill River near Philidelphia (Say 1817). Its range extends from the Savannah River Basin in

Georgia north to the St. Lawrence River Basin, Canada and westward through the Mohawk River and Erie Canal to Lake Erie in Pennsylvania, Ohio and Michigan (Bogan and Alderman 2004). The elongate subelliptical shell reaches a length of 102 mm. The anterior margin is rounded, and the ventral margin is broadly curved. The posterior margin is rounded and slopes to a blunt posterior point near the midline of the shell. Like members of the genus *Lampsilis*, this species also is sexually dimorphic with the shells of the male being more elongate, and the females more rounded, particularly in the posterior margin. The periostracum is dark olive with dark narrow green rays. Williams et al. (1993) list this species as Special Concern, although it is not currently ranked in South Carolina (SCDNR 2005).

This species was found in low numbers at only two locations in the study area, confirming its expected presence in the lower portions of the basin. It was found in shallow water along the stream banks in soft substrate at both locations.

Pyganadon cataracta (eastern floater)-Described by Say (1817) in the deep part of a milldam, presumably near Philadelphia, this species is wide ranging in the Atlantic drainages from the lower St. Lawrence River Basin south to the Altamaha River Basin, Georgia, and in the Alabama-Coosa River drainage, and the Apalachicola and Coctawhatchee River Basins, Florida. The shells of this species are uniformly thin, and are lacking any hinge teeth. The shell shape is ovate, subelliptical and elongate, with an evenly rounded anterior margin and a broadly rounded ventral margin. The periostracum is light to dark green with broad green rays on the posterior slope. Ortman (1919) recognized three generalized shell forms, the pond form, the creek/small river form and the big river form, that were related to environmental conditions. The pond form occurs in small ponds with muddy substrates, and is characterized by very thin elongate inflated shells. The creek form occurs in riffle-pool habitats in gravel substrates, and is much thicker and more compressed. The big river form is generally short and inflated and occurs in soft substrates. This species is considered common and currently Stable throughout its range (Williams et al. 1993).

This species was found at 3 sites in the study area, two in the lower portion of the Great Pee Dee River, and 1 in the upper Lynches River. The "big river form" was found at the two sites (Sites 34 and 37) on the Great Pee Dee River, while the creek form was observed at the upper Lynches River site (Site 55)..

Strophitus undulatus (creeper)-This species was described from the Schuykill River near Philadelphia (Say, 1817). Its range extends throughout much of the Interior River Basin and Atlantic Slope regions. The shell is elliptical to rhomboid in outline and somewhat inflated. The anterior end is rounded, and the posterior end is bluntly pointed. The periostracum is yellowish green to brown, with dark green rays. This species occupies a variety of habitats, from high-gradient small streams, to larger rivers. Williams et al. (1993) and the South Carolina's Comprehensive Wildlife Conservation Strategy (2005) list this species as Special Concern.

The only site where this species (1 individual) was observed was in the upper portion (of this study) of the Great Pee Dee River (Site 28), near the transition zone between the Piedmont and Coastal Plain physiographic provinces. In North Carolina and South Carolina, this species typically occurs in fairly shallow water in Piedmont, or inner coastal plain habitats (personal observations). Its' absence, or extreme rarity from the shallow riffle pool habitats in the upper portions of the Great Pee Dee River may be attributable to the extreme fluctuations in flow regime in this section of the river caused by the releasing operations at Blewett Falls Dam. During the course of a 24 hour period, shallow riffle habitats in this section of river can fluctuate from being exposed, with minimal flow, to being inundated by very high flows (personal observations). The shell of the creeper is fairly thin and fragile, and not completely airtight; thus, it may be more vulnerable to desiccation if exposed, as well as be susceptible to breaking if it becomes dislodged from the substrate during high flows.

Uniomerus carolinianus (Florida pondhorn) - Described by Bosc (1801-1804) from "the Carolinas," this species ranges from Ocmulgee River in Georgia north to the Chowan River in Virginia. Shells are usually inflated rhomboid, to long rhomboid that reach lengths to 114 mm. The species generally exhibits a dark brown to black periostracum with a slightly roughened, satiny sheen. Teeth of the left valve contain two subequal pseudocardinals, often with a vestigal tooth above them, and one lateral tooth. This species is considered common and Currently Stable throughout its range (Williams et al. 1993).

The Florida pondhorn was found at 16 sites in the study area. The majority of the sites where it was found occur in the lower part of the basin. It was generally found in shallow habitat in soft sediments, in fairly low numbers (Maximum of 8 at site 12). The low numbers at these sites is likely partially attributable to study design, as the majority of survey time with this study was focused on deeper habitats.

Utterbackia imbecillis (paper pondshell)-Described from the Wabash River in Indiana (Say 1829), this mussel occurs throughout the Mississippi River and Great Lakes drainages, as well as sporadically along the Atlantic slope. It has an extremely thin shell that is oblong and inflated. The dorsal and ventral margins are nearly straight and parallel. The periostracum is greenish yellow with fine green rays. This species is considered common throughout its range (Williams et al. 1993).

This species was found at two sites (34 and 37) in low numbers (2 and 1 individuals respectively). This species typically occurs in lentic habitats, or ponded conditions in lotic habitats, which were generally not habitats targeted by this study.

Villosa delumbis (eastern creekshell) - This species, described by Conrad (1834) from small streams near the Cooper River South Carolina, ranges from Ocmulgee River, Georgia north to the Cape Fear River in North Carolina. It has a generally thin shell that is ovate in outline. Like other members of this genus, this species is sexually dimorphic, with the shells of the male being more elongate, and the females more rounded and swollen, particularly in the posterior margin. The periostracum is yellow with numerous

green rays that are broken along the prominent growth lines. Williams et al. (1993) consider this species to be stable; however it is considered Significantly Rare (SR) in North Carolina.

The eastern creekshell was found at 18 of the 61 sites in this study, predominately in shallow water habitats, with a variety of substrates. The maximum number of individuals found at any site was 14 (Site 16). Like is the case with the Florida pondhorn, the relatively low numbers of this species found is likely partially attributable to search efforts, as the majority of survey time with this study was focused on deeper habitats.

Villosa modioliformis (*V.vibex*) (Atlantic southern rainbow) - This species, described by Conrad (1834) from "Santee canal" in South Carolina as *Unio modioliformis* was synonymized with *Villosa vibex* by Johnston (1970). The holotype for *Villosa vibex* was described from the Black Warrior River, of the Mobile River Basin, in the Gulf of Mexico drainage, thus it is unlikely that V. vibex from the Gulf of Mexico drainages is the same species as the specimens from South Carolina described as *V. modioliformis.* For these reasons, the name used for this report is *V. modioliformis*. Further genetic analysis is expected to support these species as being genetically distinct. This species has a thin to subsolid shell that is elliptical to elongate obovate in outline. Like all *Villosa,* this species is sexually dimorphic. Periostracum is greenish yellow to olive brown, the surface covered with broad, unbroken to slightly wavy dark green rays usually over the entire shell surface. Nacre color is bluish white, often becoming iridescent posteriorly. Williams et al. (1993) consider this species to be stable, and it is not currently ranked in South Carolina (SCDNR 2005).

Prior to this study, this species was only historically known to occur in the Pee Dee River Basin (Bogan and Alderman 2004). It was found at two very different sites in this study. One individual male was found in shallow water in soft sandy substrate in the Pocataligo River (Site 21), a site characterized by slack-water conditions. In the Great Pee Dee River (Site 54), one female was found in a relatively deep (14 feet) swift flowing run in rocky substrate. On the Atlantic slope, this species is more often found in smaller waterbodies than the majority of those surveyed in this study.

5.0 CONCLUSIONS

These surveys provide new and updated information for the lower portions of the Pee Dee River basin, which was lacking prior to these efforts. The majority of these surveys provide new location information for the species found due to the fact they many of these streams had not been previously evaluated for Unionid fauna. Significant extensions of known ranges of many species such as the Roanoke slabshell, Waccamaw spike, yellow lampmussel, rayed pink fatmucket, tidewater mucket, eastern pondmussel, creeper, paper pondshell and Atlantic southern rainbow were documented with the survey efforts. These range extensions are depicted graphically in Appendix B.

Twenty seven species of freshwater mussels are reported to occur in the Pee Dee River Basin (including the Waccamaw River) in North and South Carolina, more than in any

other river basin in the two states (Bogan and Alderman 2004). This study confirms the high species diversity (for Atlantic Slope drainages) of this river basin, as at least 23 species were recorded. Three of these species, the box spike, Pee Dee lance, and laceolate elliptio-*Elliptio nasutilus* are not reported by Bogan and Alderman (2004), which would bring the total number of species in the basin to 30. It is very possible that the E. complanata and E. icterina complexes are represented by several species, which would further raise the number of species known from the basin.

Seven species reported from the basin were not found during this study. These include the Atlantic pigtoe (*Fusconaia masoni*), alewife floater (*Anodonta implicata*), Savannah liliput (*Toxolasma pullus*), eastern lampmussel (*Lampsilis radiata*), triangle floater (*Alsmidonta undulata*) and Carolina creekshell (*Villosa vaughniana*), which are known from the basin only in North Carolina, as well as the notched rainbow (*Villosa constricta*). The notched rainbow and Carolina creekshell are primarily found in smaller streams than those surveyed for this study.

In general, diverse and viable mussel populations occur throughout most of the surveyed portions of the basin. Variations in mussel diversity and apparent density occurred between sites within a general reach of the basin (i.e. lower Great Pee Dee River, Upper Great Pee Dee River, lower Black River etc.). The stability of substrate appeared to be the most important factor determining distribution of mussels in all of the sites surveyed. The presence of marl outcroppings in the Great Pee Dee and Little Pee Dee seemed to correlate with high numbers of mussels. Much of the habitat in the center of the channel of the larger water bodies (particularly Great Pee Dee River) is of poor quality for freshwater mussels due to unstable, shifting sediment. The best mussel habitat in these rivers is often restricted to narrow troughs, usually within the thalweg adjacent to river banks.

The highest diversity located at a site during the survey efforts (12 species) occurred at Site 34 (Great Pee Dee River). This site consists of a wide variety of available habitats, including soft sediments of stable depositional areas below the confluence of Clarks Creek, clay/sand banks, gradually sloping sandbars and deep consolidated sand troughs.

Consistent habitat partitioning by species was observed at most sites throughout the survey efforts (discussed earlier in species accounts, Sec. 4.2). For example, the eastern creekshell and lanceolate Elliptio (*Elliptio nasultilus*) were almost always found in shallow soft sediment near the river banks, while the Carolina slabshell, Carolina lance, pod lance and Waccamaw spike were generally found only in deeper troughs with faster flow. At many of the sites, certain species such as Carolina slabshell, Roanoke slabshell and Carolina lance were not detectable or detectable in low numbers in shallow water habitats. This demonstrates that a combination of survey methodology, including the use of SCUBA is necessary to perform adequate inventories of the mussel fauna in this basin.

The finds of the survey efforts conducted during this study provide a current baseline of the Unionid fauna present in a variety of habitats in the larger water bodies of the lower Pee Dee River Basin in South Carolina. As a result this information will be useful in

helping direct priorities for aquatic habitat conservation and preservation activities, as well as in providing background for future study opportunities involving Unionid fauna in the basin.

6.0 RECOMMENDATIONS

As stated earlier, this study provides baseline information of mussel diversity in the larger water bodies in the Pee Dee River Basin in South Carolina. With the exception of Thompson Creek (Site 1), Buffalo Creek (Site 47) and the upper sites of the Lynches River (Sites 55-57), smaller water bodies were not sampled. Although prior to this study more survey data existed in smaller tributaries than in the larger rivers, there are still significant gaps in data from small streams in this basin in South Carolina. Species such as the notched rainbow, Carolina creekshell and possibly Atlantic pigtoe and Savannah liliput, which were not located during this study are more likely to be found in smaller waterbodies. Additionally, species such as eastern creekshell and the Atlantic southern rainbow, which were found in this study in relatively low numbers, would likely be found in greater numbers in smaller streams. A comprehensive basin-wide approach similar to the one taken for this project is thus recommended for the smaller water bodies of the basin.

The major impetus for this study was to identify priority areas in the basin freshwater mussel habitat conservation. As stated earlier mussels are distributed throughout the basin, and any conservation of aquatic habitats would be beneficial to this resource. Criteria that should receive top consideration include sites that are large and contiguous, preferably on both sides of the water body, and preferably branched (include tributaries as well as main-stem). One area that would be worthy of protection efforts is the Great Pee Dee River and Clark's Creek (Site 34), due to the high habitat and species diversity in this area. The upper Lynches River (Sites 55-56) is also worthy of consideration due to the presence of the Carolina heelsplitter and brook floater, as well as other species likely to occur at this site, but not detected due to poor survey conditions (creeper, Carolina creekshell etc.).

In general, the Waccamaw River and Little Pee Dee River had the highest densities of mussels, and appeared to have the most consistent distributions of mussels within sites. Protection of these areas would also benefit this resource; however, given their nature, the expansive swamp forests within these areas are likely currently protected to some degree.

The results of this study suggest several potential research topics that would be useful to meet conservation goals of the mussel resources in the Pee Dee River Basin:

1). Long term population monitoring: Although not quantifiably examined during this study, observations indicate that the release operations at Blewett Falls Dam have and are continuing to impact the freshwater mussel fauna in the Great Pee Dee River. Long term qualitative and quantitative monitoring of the mussel populations is needed to adequately address this concern. Some sites to consider would be the "best" (most diverse and

dense) sites identified in the Great Pee Dee River during these survey efforts (Sites 34, 37, 51).

2). Habitat partitioning by mussels: Various general observations were made on habitat partitioning by species throughout the study area (see site descriptions and species accounts). Quantitative research is expected to support these observations.

3). Taxonomic/Genetic Research: As discussed in the species accounts section, several named species of elliptio mussels have been synonomized into two species complexes (*E. complanata* and *E. icterina*). Further research is needed to determine on these complexes, as it is believed by many mussel researchers that several distinct species may exist in these complexes. It is therefore possible that species diversity is even greater in the Pee Dee River Basin than is currently believed.

4). Fish Host Identification: The fish hosts for several mussel species are still unknown. Laboratory and field research is needed in this area, as understanding life cycles is a critical component of species conservation.

5). Archeological Research of Mussels in Basin: Much has been learned of mussel faunas in other river basins, by examining archeological material. If archeological freshwater mussel material is available, research comparing current species composition with the archeological material would enhance the scientific community's understanding of this resource, and thus help facilitate conservation initiatives.

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APPENDIX A: Detailed Results

SITE	DATE	WATERWAY	SCIENTIFIC NAME	#	CPUE (#/ph)
1	6/1/04	Thompson Creek	*Elliptio angustata*	17	8.5
		34.66129°N, -79.88844°W	*Elliptio complanata*	25	12.5
			Elliptio congaraea	108	54
			Elliptio icterina	120	60
2	7/1/04	Waccamaw River	*Elliptio complanata*	909*	227.25
		33.80414°N, -79.05505°W	*Elliptio congaraea*	934*	233.5
		**Elliptio spp. at this site represents*	*Elliptio folliculata*	44	11
		the total number of Elliptio	*Elliptio icterina*	648*	162
		complanata, congaraea, and	*Elliptio spp.**	2491	622.75
		icterina found at this site. The #s	*Elliptio waccamawensis*	58	14.5
		and CPUE for each species are	*Elliptio nasutilus*	4	1
		estimated based on a randomly			
		selected subset of 200 from this	*Villosa delumbis*	1	0.25
		total number.			
3	7/1/04	Waccamaw River Oxbow	*Elliptio complanata*	31	24.8
		33.80490°N, -79.05371°W	*Elliptio congaraea*	1	0.8
			Elliptio folliculata	25	20.0
			Lampsilis spledida	1	0.8
			Uniomerus carolinianus	2	1.6
4	7/1/04	Waccamaw River	*Elliptio complanata*	166	83
		33.78380°N, -79.05296°W	*Elliptio congaraea*	158	79
			Elliptio folliculata	20	10
			Elliptio icterina	3	1.5
			Elliptio waccamawensis	39	19.5
			Elliptio nasutilus	4	2
			Villosa delumbis	1	0.5
5	7/1/04	Waccamaw River	*Elliptio complanata*	66	33
		33.77603°N, -79.06091°W	*Elliptio congaraea*	2	1
			Elliptio icterina	9	4.5
			Elliptio waccamawensis	2	1
			Elliptio nasutilus	4	2
			Uniomerus carolinianus	1	0.5
			Villosa delumbis	1	0.5
6	7/1/04	Waccamaw River cut through	*Elliptio cistelliformis*	125	62.5
		Channel	*Elliptio complanata*	288	144
		33.77780°N, -79.05889°W	*Elliptio congaraea*	2	1
			Elliptio waccamawensis	167	83.5
			Lampsilis spledida	1	0.5
			Elliptio nasutilus	71	35.5
			Villosa delumbis	1	0.5
7	7/2/04	Waccamaw River Oxbow	*Elliptio complanata*	1	1
		(Peachtree Lake)	*Lioplax subcarinata*	2	2
		33.69773°N, -79.04903°W			

SITE	DATE	WATERWAY	SCIENTIFIC NAME	#	CPUE (#/ph)
8	7/2/04	Waccamaw River	*Elliptio cistelliformis*	1	1
		33.69435°N, -79.05242°W	*Elliptio complanata*	56	56
			Elliptio congaraea	165	165
			Elliptio folliculata	19	19
			Elliptio waccamawensis	3	3
9	7/2/04	Waccamaw River	*Elliptio cistelliformis*	43	28.67
		(Thoroughfare Creek)	*Elliptio complanata*	118	78.67
		33.76593°N, -79.06330°W	*Elliptio congaraea*	153	102
			Elliptio folliculata	14	9.33
			Villosa delumbis	1	0.67
10	7/20/04	Black River (Cut-through	*Elliptio cistelliformis*	577	144.25
		channel)	*Elliptio complanata*	481	120.25
		33.47609°N, -79.52233°W	*Elliptio congaraea*	3	0.75
			Elliptio folliculata	11	2.75
			Elliptio icterina	17	4.25
			Elliptio nasutilus	1	0.25
			Uniomerus carolinianus	3	0.75
11	7/20/04	Lester Creek (Black River)	*Elliptio cistelliformis*	161	40.25
		33.47190°N, -79.52045°W	*Elliptio complanata*	337	84.25
			Elliptio congaraea	1	0.25
			Elliptio folliculata	14	3.5
			Elliptio icterina	23	5.75
			Elliptio nasutilus	1	0.25
12	7/20/04	Black River	*Elliptio cistelliformis*	25	8.33
		33.49749°N, -79.56011°W	*Elliptio complanata*	329	109.67
			Elliptio congaraea	8	2.67
			Elliptio folliculata	38	12.67
			Elliptio icterina	164	54.67
			Elliptio nasutilus	1	0.33
			Uniomerus carolinianus	8	2.67
13	7/20/04	Black River	*Elliptio cistelliformis*	5	1.67
		33.49977°N, -79.55438°W	*Elliptio complanata*	489	163
			Elliptio congaraea	3	1
			Elliptio folliculata	1	0.33
			Elliptio icterina	5	1.67
			Elliptio waccamawensis	1	0.33
			Elliptio nasutilus	1	0.33
			Uniomerus carolinianus	1	0.33

SITE	DATE	WATERWAY	SCIENTIFIC NAME	#	CPUE (#/ph)
14	7/21/04	Black River	*Elliptio angustata*	12	4
		33.66776°N, -79.86349°W	*Elliptio complanata*	58	19.33
			Elliptio congaraea	107	35.67
			Elliptio folliculata	1	0.33
			Elliptio icterina	69	23
			Uniomerus carolinianus	1	0.33
			Villosa delumbis	2	0.67
15	7/21/04	Black River	*Elliptio angustata*	5	4
		33.66875°N, -79.86615°W	*Elliptio complanata*	32	25.6
			Elliptio congaraea	5	4
			Elliptio icterina	3	2.4
			Villosa delumbis	6	4.8
16	7/21/04	Black River	*Elliptio angustata*	62	15.5
		33.66586°N, -79.85699°W	*Elliptio complanata*	121	30.25
			Elliptio congaraea	90	22.5
			Elliptio icterina	116	29
			Uniomerus carolinianus	4	1
			Villosa delumbis	14	3.5
17	7/21/04	Black River	*Elliptio angustata*	18	7.2
		33.66481°N, -79.85095°W	*Elliptio complanata*	55	22
			Elliptio congaraea	36	14.4
			Elliptio icterina	72	28.8
			Villosa delumbis	5	2
18	7/21/04	Black River	*Elliptio angustata*	1	0.5
		33.66237°N, -79.84048°W	*Elliptio complanata*	18	9
			Elliptio congaraea	22	11
			Elliptio icterina	12	6
			Villosa delumbis	1	0.5
19	7/22/04	Black River (Swamp)	*Elliptio spp.*	171	68.4
		33.95097°N, -80.18016°W	*Uniomerus carolinianus*	2	0.8
20	7/22/04	Black River (Swamp)	*Elliptio spp.*	250	100
		33.95508°N, -80.17992°W	*Uniomerus carolinianus*	4	1.6
21	7/22/04	Pocotaligo River	*Elliptio complanata*	8	8
		(Brewington Lake)	*Lampsilis spledida*	2	2
		33.70913°N, -80.05224°W	*Elliptio nasutilus*	28	28
			Uniomerus carolinianus	1	1
			Villosa delumbis	1	1
			Villosa vibex	1	1
22	7/22/04	Lynches River	*Elliptio complanata*	78	7.8
		33.84001°N, -79.44880°W	*Elliptio icterina*	8	0.8
			Lampsilis spledida	2	0.2
			Elliptio nasutilus	8	0.8
			Uniomerus carolinianus	1	0.1

SITE	DATE	WATERWAY	SCIENTIFIC NAME	#	CPUE (#/ph)
23	8/4/04	Lynches River	*Elliptio angustata*	19	9.5
		34.13405°N, -80.13666°W	*Elliptio complanata*	443	221.5
			Elliptio congaraea	90	45
			Villosa delumbis	1	0.5
24	8/4/04	Lynches River	*Elliptio angustata*	8	2.67
		34.14248°N, -80.14294°W	*Elliptio complanata*	138	46
			Elliptio congaraea	8	2. 67
			Elliptio sp. 1 (Pee Dee lance)	1	0.33
25	8/4/04	Lynches River	*Elliptio angustata*	4	1.33
		34.12203°N, -80.12177°W	*Elliptio complanata*	241	80.33
			Elliptio congaraea	48	16
			Villosa delumbis	1	0.33
26	8/4/04	Lynches River	*Elliptio angustata*	8	5.33
		34.12511°N, -80.12684°W	*Elliptio complanata*	267	178
			Elliptio congaraea	13	8.67
			Uniomerus carolinianus	1	0.67
			Villosa delumbis	4	2.67
27	8/5/04	Great Pee Dee River	*Elliptio congaraea*	2	0.67
		34.71051°N, -79.87679°W			
28	8/5/04	Great Pee Dee River	*Elliptio angustata*	2	0.67
		34.70670°N, -79.87533°W	*Elliptio complanata*	14	4.67
			Elliptio congaraea	182	60.67
			Elliptio roanokensis	10	3.33
			Lampsilis cariosa	2	0.67
			Elliptio sp.1 (Pee Dee lance)	3	1
			Strophitus undulatus	1	0.33
29	8/5/04	Great Pee Dee	*Elliptio complanata*	2	1
		34.50468°N, -79.75515°W	*Elliptio congaraea*	3	1.5
			Lampsilis cariosa	4	2
30	8/5/04	Great Pee Dee	*Elliptio angustata*	3	2.4
		34.49788°N, -79.72878°W	*Elliptio complanata*	7	5.6
			Elliptio congaraea	18	14.4
			Elliptio producta	2	1.6
			Elliptio roanokensis	3	2.4
			Lampsilis cariosa	4	3.2
31	8/5/04	Great Pee Dee River	*Elliptio complanata*	1	1
		34.48988°N, -79.72289°W	*Elliptio congaraea*	9	9
			Elliptio producta	1	1
			Elliptio roanokensis	5	5
			Lampsilis cariosa	10	10
			Elliptio sp. 1 (Pee Dee lance)	1	1

SITE	DATE	WATERWAY	SCIENTIFIC NAME	#	CPUE (#/ph)
32	10/19/04	Little Pee Dee River	*Elliptio angustata*	56	28
		33.70717°N, -79.19145°W	*Elliptio complanata*	12	6
			Elliptio congaraea	6	3
			Elliptio icterina	69	34.5
			Elliptio waccamawensis	2	1
			Lampsilis cariosa	2	1
			Elliptio nasutilus	3	1.5
33	10/19/04	Great Pee Dee River	*Elliptio angustata*	24	24
		33.69498°N, -79.24248°W	*Elliptio complanata*	16	16
			Elliptio congaraea	8	8
			Elliptio icterina	5	5
			Elliptio roanokensis	5	5
			Elliptio waccamawensis	2	2
34	10/19/04	Great Pee Dee River	*Elliptio angustata*	27	13.5
		33.79809°N, -79.32521°W	*Elliptio complanata*	55	27.5
			Elliptio congaraea	8	4.0
			Elliptio icterina	20	10.0
			Elliptio roanokensis	5	2.5
			Elliptio waccamawensis	2	1.0
			Lampsilis cariosa	11	5.5
			Elliptio nasutilus	1	0.5
			Leptodea ochracea	1	0.5
			Ligumia nasuta	3	1.5
			Pyganodon cataracta	3	1.5
			Utterbackia imbecillis	2	1
35	10/19/04	Great Pee Dee River	*Elliptio angustata*	29	58
		33.79830°N, -79.32379°W	*Elliptio complanata*	7	14
			Elliptio icterina	1	2
			Elliptio roanokensis	2	4
			Lampsilis cariosa	1	2
36	10/20/04	Great Pee Dee River	*Elliptio complanata*	3	3
		33.94337°N, -79.48558°W	*Elliptio congaraea*	7	7
			Elliptio icterina	3	3
37	10/20/04	Great Pee Dee River	*Elliptio angustata*	56	28
		33.91060°N, -79.44826°W	*Elliptio complanata*	9	4.5
			Elliptio congaraea	12	6
			Elliptio icterina	26	13
			Elliptio producta	4	2
			Elliptio roanokensis	40	20
			Lampsilis cariosa	1	0.5
			Pyganodon cataracta	2	1
			Utterbackia imbecillis	1	0.5

SITE	DATE	WATERWAY	SCIENTIFIC NAME	#	CPUE (#/ph)
38	10/20/04	Great Pee Dee River	*Elliptio angustata*	35	42.02
		33.79715°N, -79.32492°W	*Elliptio complanata*	65	78.03
			Elliptio congaraea	12	14.41
			Elliptio icterina	29	34.81
			Elliptio roanokensis	15	18.01
			Lampsilis cariosa	1 shell	
39	10/20/04	Great Pee Dee River	*Elliptio complanata*	5	5
		33.89216°N, -79.40085°W	*Elliptio roanokensis*	1	1
			Lampsilis cariosa	2	2
40	11/8/04	Little Pee Dee River	*Elliptio angustata*	14	10.53
		33.93827°N, -79.31394°W	*Elliptio complanata*	8	6.02
			Elliptio congaraea	1	0.75
			Elliptio waccamawensis	61	45.86
			Elliptio nasutilus	2	1.50
			Ligumia nasuta	1	0.75
			Uniomerus carolinianus	2	1.50
41	11/8/04	Gunter Lake (Oxbow of	*Elliptio complanata*	3	5.17
		Little Pee Dee River)	*Elliptio icterina*	1	1.72
		33.94759°N, -79.31591°W	*Elliptio waccamawensis*	1	1.72
			Uniomerus carolinianus	3	5.17
42	11/8/04	Little Pee Dee River	*Elliptio angustata*	33	23.24
		33.96891°N, -79.33929°W	*Elliptio complanata*	11	7.75
			Elliptio congaraea	1	0.70
			Elliptio producta	3	2.11
			Elliptio waccamawensis	86	60.56
			Uniomerus carolinianus	5	3.52
43	11/8/04	Little Pee Dee River	*Elliptio angustata*	12	17.91
		33.96419°N, -79.33576°W	*Elliptio complanata*	4	5.97
			Elliptio producta	3	4.48
			Elliptio waccamawensis	41	61.19
44	11/9/04	Little Pee Dee River	*Elliptio angustata*	16	16
		33.71550°N, -79.19498°W	*Elliptio complanata*	8	8
			Elliptio waccamawensis	54	54
			Leptodea ochracea	7	7
45	11/9/04	Little Pee Dee River	*Elliptio angustata*	44	27.85
		33.71544°N, -79.19485°W	*Elliptio complanata*	17	10.76
			Elliptio icterina	11	6.96
			Elliptio waccamawensis	57	36.08
			Elliptio nasutilus	3	1.90
			Leptodea ochracea	8	5.06
			Uniomerus carolinianus	7	4.43

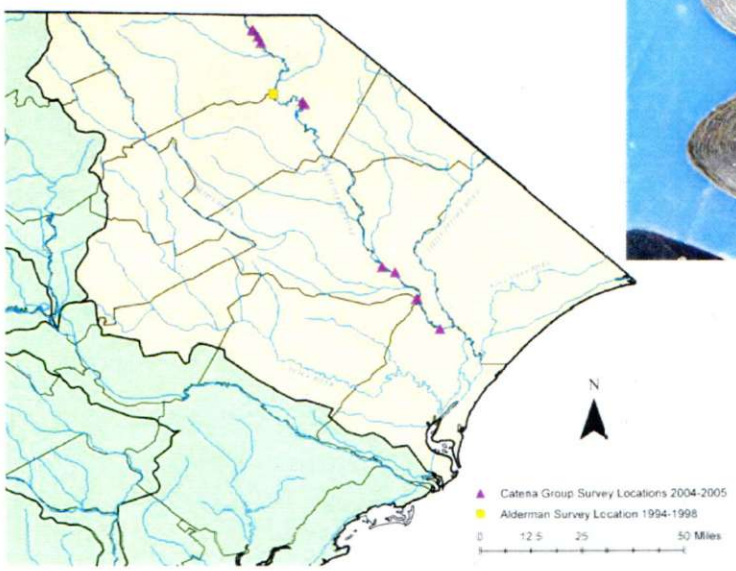
SITE	DATE	WATERWAY	SCIENTIFIC NAME	#	CPUE (#/ph)
46	11/9/04	Little Pee Dee River	*Elliptio angustata*	5	8.62
		33.75594°N, -79.22427°W	*Elliptio complanata*	17	29.31
			Elliptio waccamawensis	229	394.83
47	4/25/05	Buffalo Creek	None		
		34.56939°N, -80.43911°W	34° 34.1634 -80°26.3466		
48	4/26/05	Lynches River	*Elliptio angustata*	7	3.18
		34.27605°N, -80.21973°W	*Elliptio complanata*	6	2.73
			Elliptio congaraea	6	2.73
			Elliptio spp	104	47.27
			Uniomerus carolinianus	2	0.91
49	4/26/05	Lynches River	*Elliptio angustata*	1	0.37
		34.26792°N, -80.21720°W	*Elliptio congaraea*	13	4.87
			Elliptio producta	2	0.75
			Elliptio spp.	209	78.28
			Villosa delumbis	1	0.37
50	4/26/05	Lynches River	*Elliptio angustata*	2	1.20
		34.25600°N, -80.21057°W	*Elliptio congaraea*	2	1.20
			Elliptio spp.	59	35.33
51	4/27/05	Great Pee Dee River	*Elliptio angustata*	20	5
		34.75272°N, -79.90696°W	*Elliptio complanata*	6	1.5
			Elliptio congaraea	476	119
			Elliptio roanokensis	8	2
			Villosa delumbis	2	0.5
52	4/27/05	Great Pee Dee River – Island Channel	*Elliptio angustata*	13	13
			Elliptio complanata	2	2
		34.75114°N, -79.90386°W	*Elliptio congaraea*	94	94
			Elliptio roanokensis	3	3
53	4/27/05	Great Pee Dee River - Island Channel (Westfield Creek)	*Elliptio angustata*	14	4.67
			Elliptio complanata	10	3.33
		34.74826°N, -79.90114°W	*Elliptio congaraea*	85	28.33
			Elliptio producta	3	1
			Elliptio roanokensis	1	0.33
			Lampsilis cariosa	1	0.33
			Villosa delumbis	4	1.33
54	4/27/05	Great Pee Dee River	*Elliptio angustata*	35	30.17
		34.72788°N, -79.88587°W	*Elliptio complanata*	8	6.90
			Elliptio congaraea	124	106.90
			Elliptio icterina	1	0.86
			Elliptio roanokensis	2	1.72
			Elliptio sp. 1 (Pee Dee lance)	7	6.03
			Villosa delumbis	1	0.86
			Villosa modioliformis	1	0.86

SITE	DATE	WATERWAY	SCIENTIFIC NAME	#	CPUE (#/ph)
55	7/20/05	Lynches River	*Alasmidonta varicosa*	3 shell	
		34.63301°N, -80.42159°W	*Elliptio angustata*	3	0.95
			Elliptio spp.	92	29.11
			Lasmigona decorata	1 shell	
			Pyganodon cataracta	1 shell	
			Villosa delumbis	3	0.95
56	7/20/05	Lynches River	*Alasmidonta varicosa*	4	1.6
		34.63423°N, -80.42345°W	*Elliptio angustata*	1	0.4
		.	*Elliptio spp*	28	11.2
57	7/20/05	Lynches River	*Elliptio complanata*	1	0.22
		34.61272°N, -80.40543°W			
58	8/24/05	Waccamaw River	*Elliptio cistelliformis*	60	34.29
		33.91571°N, -78.70599°W	*Elliptio congaraea*	12	6.86
			Elliptio folliculata	45	25.71
			Elliptio spp.	242	138.29
			Elliptio waccamawensis	32	18.29
			Elliptio nasutilus	3	1.71
			Uniomerus carolinianus	3	1.71
			Villosa delumbis	6	3.43
59	8/24/05	Waccamaw River	*Elliptio congaraea*	9	5.14
		33.91360°N, -78.69640°W	*Elliptio folliculata*	40	22.86
			Elliptio spp.	266	152
			Elliptio waccamawensis	14	8
			Elliptio nasutilus	28	16
			Uniomerus carolinianus	1	0.57
			Villosa delumbis	2	1.14
60	8/24/05	Waccamaw River	*Elliptio cistelliformis*	29	16.57
		33.92112°N, -78.68850°W	*Elliptio folliculata*	20	11.43
			Elliptio spp.	425	242.86
			Elliptio waccamawensis	16	9.14
			Uniomerus carolinianus	6	3.43
			Villosa delumbis	1	0.57
61	8/24/05	Waccamaw River	*Elliptio folliculata*	11	4.4
		33.91077°N, -78.69965°W	*Elliptio spp.*	281	112.4
			Elliptio waccamawensis	13	5.2
			Elliptio nasutilus	4	1.6
		.	*Uniomerus carolinianus*	8	3.2
			Villosa delumbis	1	0.4

APPENDIX B: Significant Range Extension Maps

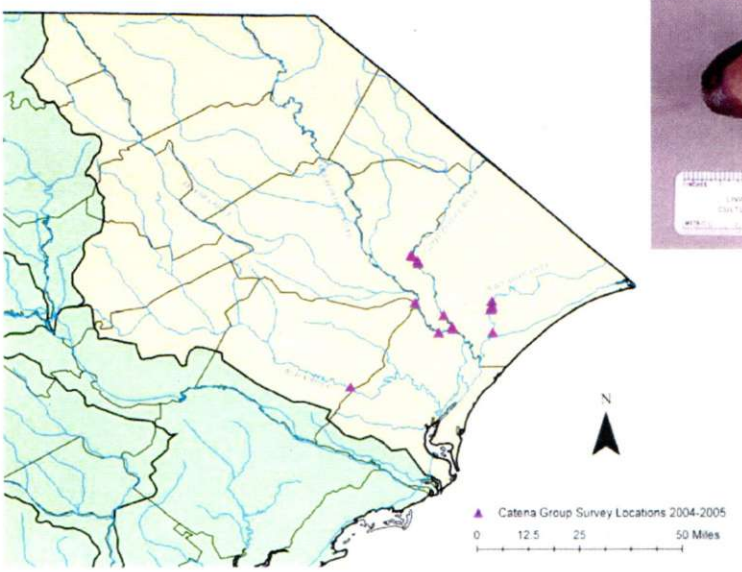
Elliptio roanokensis (Roanoke slabshell) Lea, 1838

-deep thalweg troughs, anadromous fish host?



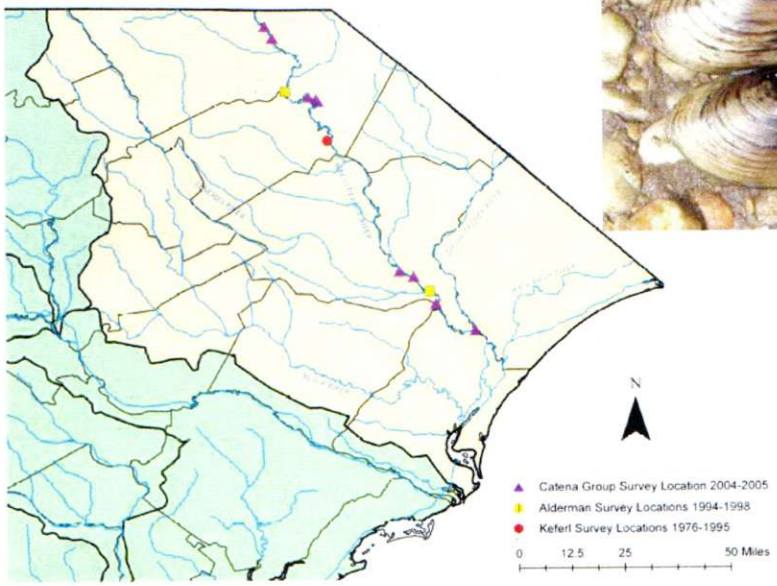
Elliptio waccamawensis (Waccamaw spike) Lea, 1863

-concentrated in sandy-mud substrates, dense in Little Pee Dee

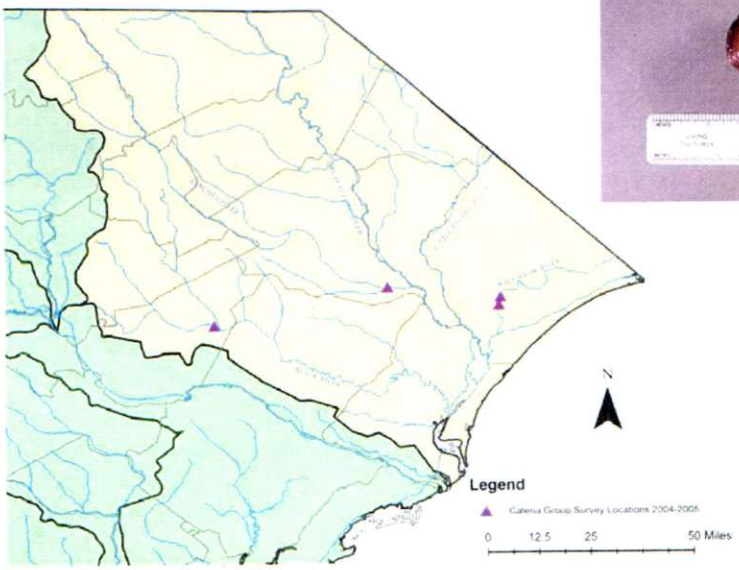


Lampsilis cariosa (yellow lampmussel) Say, 1817

-generally in softer (silt, sand, mud) sediments
-to 30 feet

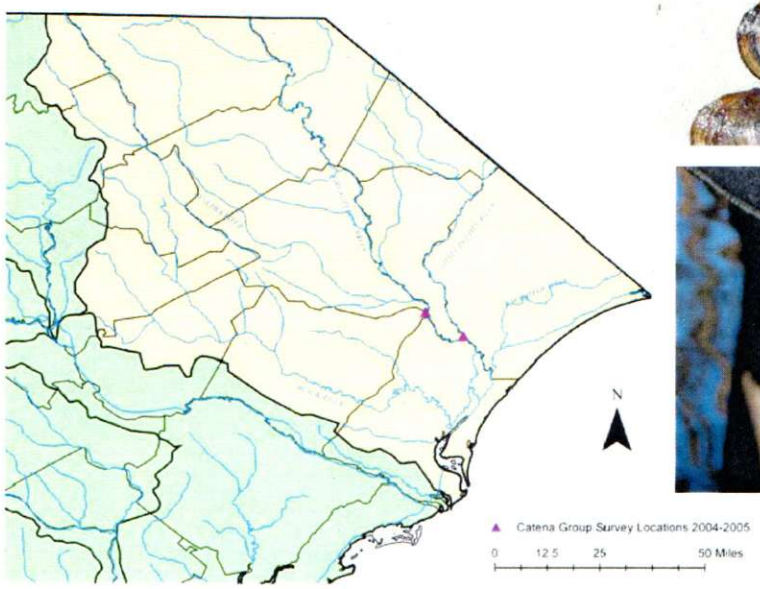


Lampsilis splendida (Rayed Pink Fatmucket) Lea, 1838

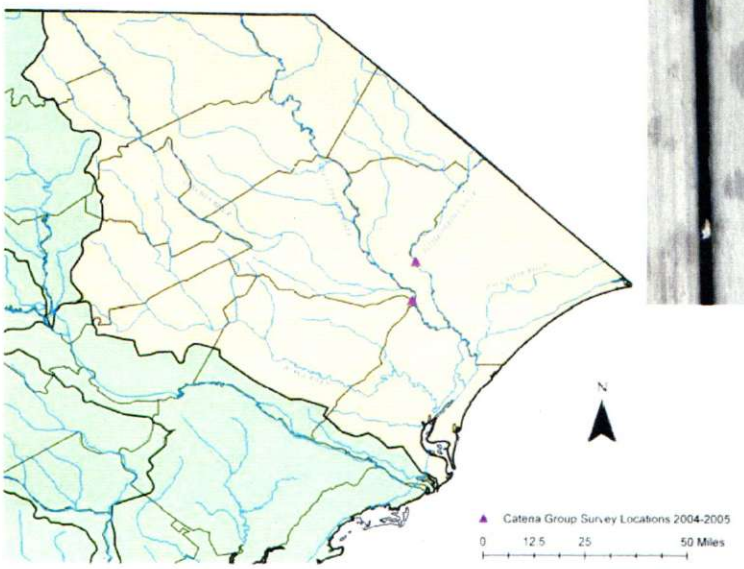


Leptodea ochracea (Tidewater mucket) Say, 1817

-deep soft sediment slopes

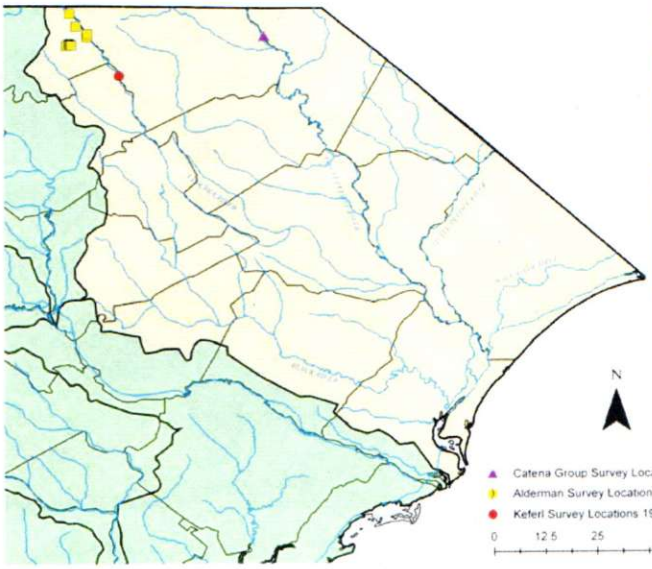


Ligumia nastuta (Eastern pondmussel) Say, 1817

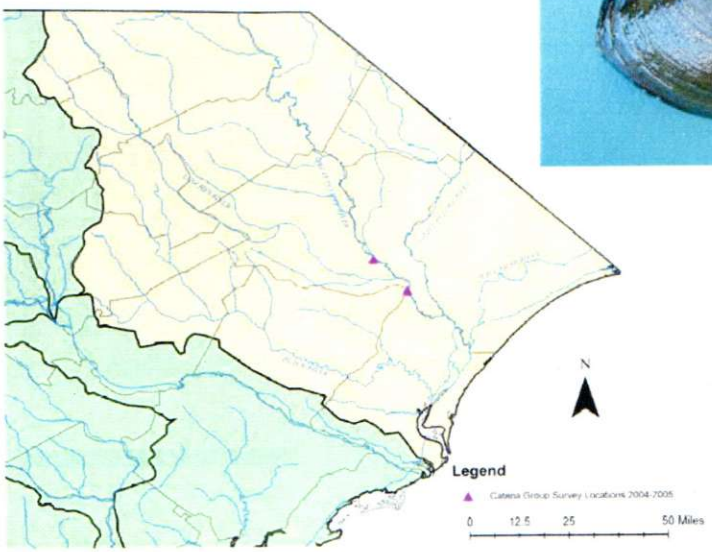
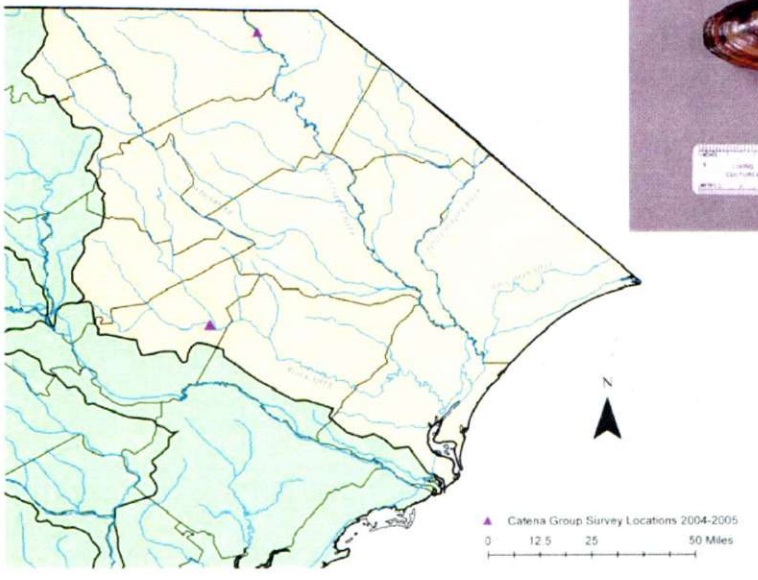


Strophitus undulatus (Creeper) Say, 1817

-preference for Piedmont



Utterbackia imbecillis (paper pondshell) Say, 1829



Villosa modioliformis Lea, 1834
(synonomized with *V. vibex*-Southern rainbow-Conrad, 1834)