Workbook and Key
to the
Freshwater Bivalves
of
North Carolina

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North Carolina Museum of Natural Sciences

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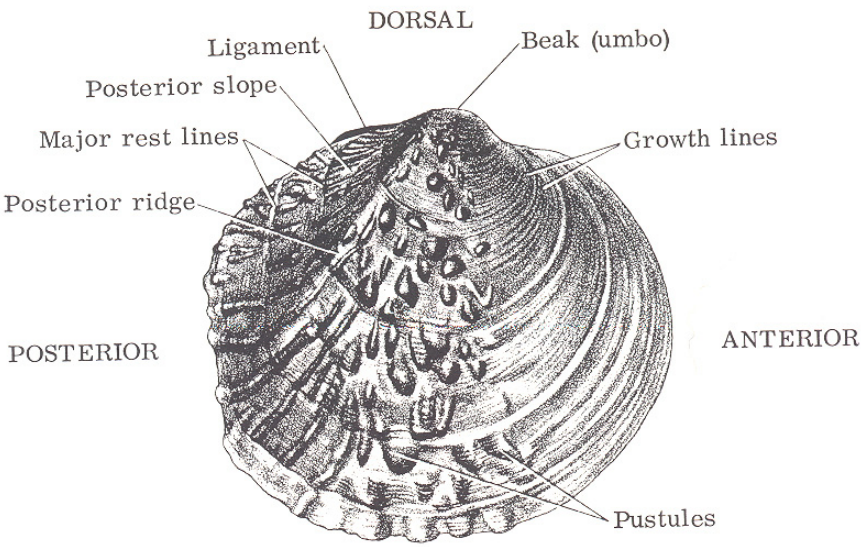

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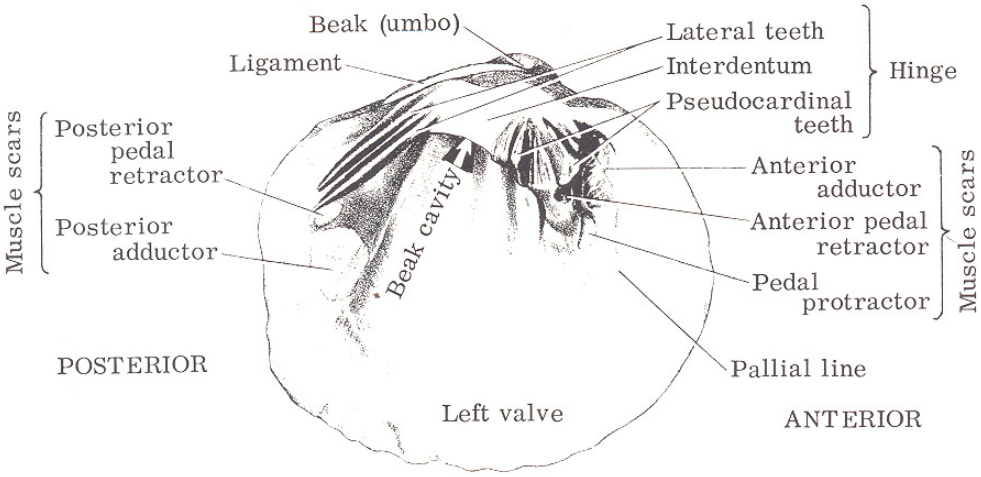

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Figure 1. Morphology of a freshwater unionid shell, illustrating structures and terminology. a. exterior of right valve; b. interior of left valve (Reproduced from Burch 1975:5, fig. 2).

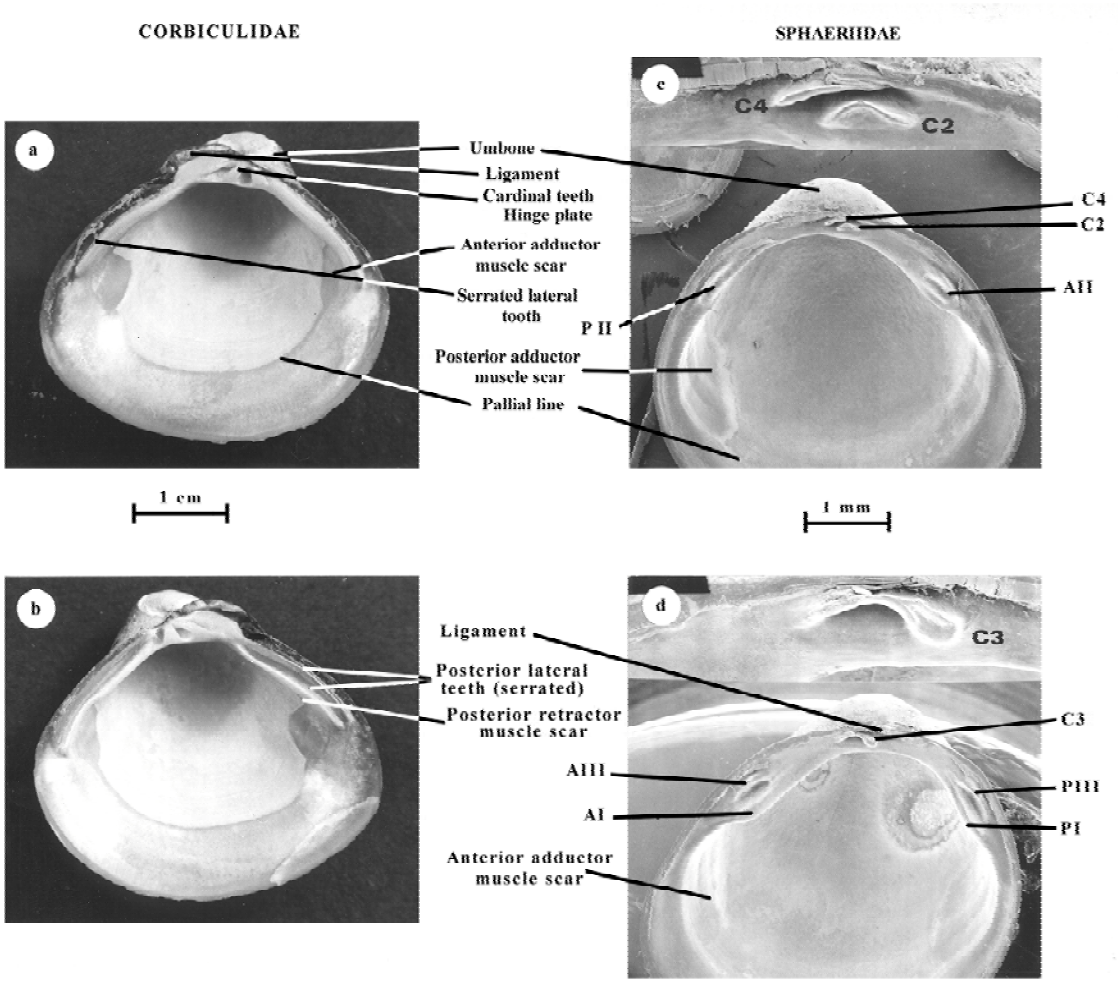

Figure 2. Internal shell features of left (a) and right (b) valves of *Corbicula fluminea* and of left (c) and right (d) valves of *Pisidium variabile*, representing the Sphaeriidae. C2, C3, C4 are the cardinal teeth; AI, AII, AIII are the anterior lateral teeth; PI, PII, PIII are the posterior lateral teeth. Reprinted from Mackie (2001) with the author's permission.

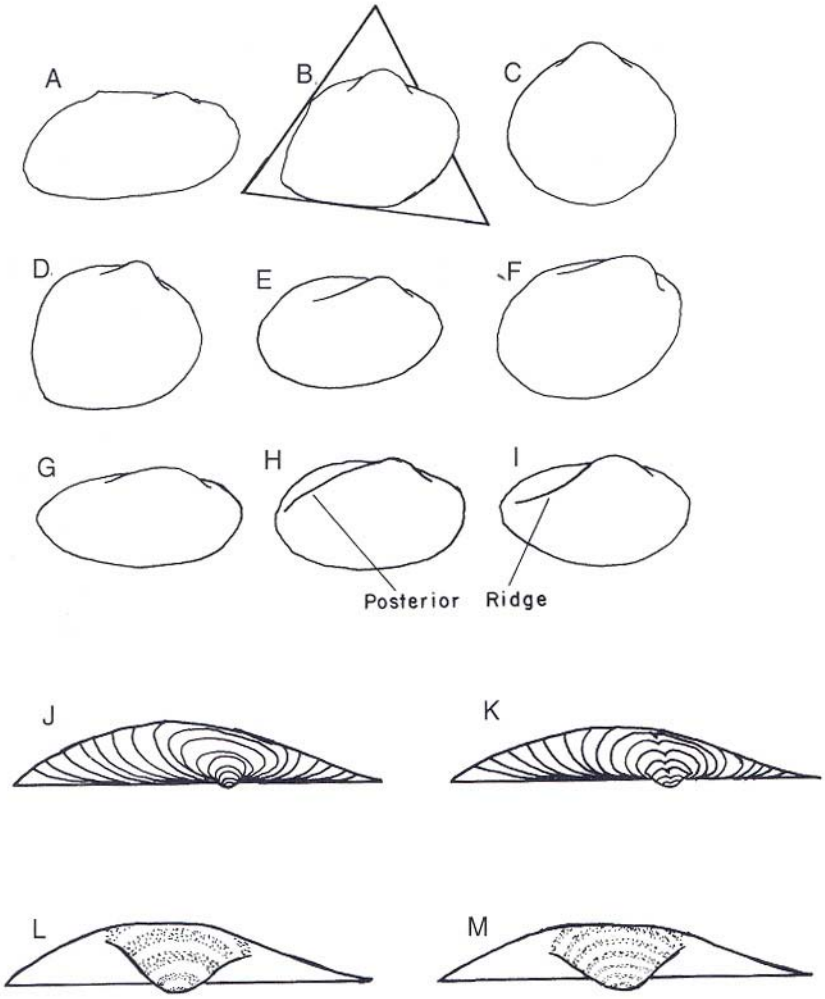

Figure 3. Illustrations of shell shape and beak sculpture. Shell shape descriptions: (A) rhomboidal; (B) triangular or trigonal; (C) round; (D) quadrate; (E and F) oval or ovoid; and (G) elliptical. Posterior shell-ridge morphology: (H) posterior ridge convex; and (I) posterior ridge concave. Concentric ridge structures of umbos: (J) single-looped concentric ridges; (K) double-looped concentric ridges; (L) coarse concentric ridges; and (M) fine concentric ridges. (Reproduced from McMahon and Bogan 2001).

Key to the freshwater bivalves of North Carolina

1 a. shell with a very sharp posterior ridge, shaped like a marine mussel, *Mytilus*, generally less than 30 millimeters, and attached to a hard substrate with byssal threads (pl. 10, fig. 58)[Not known from NC at this time].....***Dreissena polymorpha***

b. animal without byssal threads attaching adult animal to substrate, with or without teeth but not with above shape.....**2**

2 (1b) a. valves with cardinal teeth and two sets of lateral teeth (pl. 10, fig. 56, 57).....**3**

b. valves with one set of lateral teeth and pseudocardinal teeth or without teeth (Unionidae) **4**

3 (2a) a. valves with serrated lateral teeth (Fig. 2; pl. 10, fig. 56, 57).....***Corbicula fluminea***

b. valves with smooth lateral teeth (Fig. 2) [See Burch 1975b]..... **Sphaeriidae**

4 (2b) a. origin of shell is from rivers or lakes draining into the Atlantic Ocean **5**

b. origin of shell is from rivers or lakes draining into the Mississippi River Basin.....**31**

ATLANTIC COAST

5 (4a) a. shell with hinge teeth absent or greatly reduced.....**6**

b. shell with pseudocardinal teeth present, with or without lateral teeth **11**

6 (5a) a. umbo not projecting above the hinge-line **7**

b. umbo projecting above the hinge-line **8**

7 (6a) a. ventral margin slightly concave to straight (pl. 8, fig. 48) .....***Utterbackia imbecillis***

b. ventral margin rounded (pl. 2, fig. 7) .....***Anodonta couperiana***

8 (6b) a. beak sculpture double looped, shell uniformly thin.....**9**

b. beak sculpture consists of concentric bars.....**10**

9(8a) a. beak sculpture ridges all of the same height, common (pl.7, fig. 40) ....***Pyganodon cataracta***

b. beak sculpture ridges with pronounced bump or raised area in the bottom of the loop, introduced (pl. 7, fig. 41).....***Pyganodon grandis***

10 (8b) a. nacre usually orange in the beak cavity, pseudocardinal tooth area represented by a thickening near the umbo, ventral shell margin uniform thickness (pl. 8, fig. 43) ..... ***Strophitus undulatus***

b. Nacre bluish or white, hinge plate uniformly thin, teeth or swellings absent, ventral margin with a prominent thickened area along the anterior ventral margin below the pallial line (pl. 2, fig. 8) ..... ***Anodonta implicata***

11 (5b) a. shell with lateral teeth absent or reduced, neither functional nor interlocking **12**

b. shell truncated, with well developed lateral teeth **14**

12 (11a) a. shell elongate to elongate oval, inflated thin shell **13**

b. shell outline triangular, inflated but thin to thick shell, beak sculpture consists of large bars extending down onto the disk of the shell (pl. 1, fig. 4) ..... ***Alasmidonta undulata***

13 (12a) a. shell elongate, kidney shaped, periostracum greenish to brownish with obscured rays in adults (pl. 1, fig. 5) ..... ***Alasmidonta varicosa***

b. shell elongate oval, periostracum yellowish background with wavy green rays, Long Creek Catawba River basin, known only from the type lot, extinct (pl. 1, fig. 3) ..... ***Alasmidonta robusta***

14 (11b) a. right valve with two lateral teeth, small, rare (pl. 1, fig. 1) ..... ***Alasmidonta heterodon***

b. right valve with one lateral tooth **15**

15 (14b) a. shell with spines on the umbo and down on to the disc of the shell, but may be lost in adults, oval in outline and typically a yellowish brown periostracum **16**

b. shell lacks any evidence of spines **17**

16 (15a) a. shell from the Tar River basin (pl. 4, fig. 19) ..... ***Elliptio steinstansana***

b. shell from the Dan River drainage in the Roanoke River basin (pl. 7, fig. 37) ..... ***Pleurobema collina***

17 (15b) a. hinge plate in left valve with an additional small interdental or accessory tooth, giving the appearance of three pseudocardinal teeth, shell more or less compressed, shell shape rhomboid, periostracum dark green with numerous green rays, beak sculpture consists of prominent bars **18**

b. left valve without extra interdental tooth in left valve **19**

18 (17a) a. shell thick and maximum size114 mm, maximum height 68 mm, restricted to the Pee Dee and Wateree-Santee River drainages (pl. 5, fig. 29) ..... ***Lasmigona decorata***

b. shell relatively think, maximum size 62 mm, maximum height 33 mm, known from the Pamlico, Neuse, and Cape Fear River systems (pl. 6, fig. 31) .....***Lasmigona subviridis***

19 (17b) a. shell shape rectangular to broadly triangular shell, beak cavity shallow, species is from an area extending from the Roanoke River Basin south to the headwaters of the Savannah River Basin (pl. 4, fig. 23) .....***Fusconaia masoni***

b. shell shape oval, round or rhomboid..... **20**

20 (19b) a. shell shape rhomboid, or rectangular..... **21**

b. shell shape oval or round..... **24**

21 (20a) a. shell usually more than twice as long as high..... **22**

b. shell usually less than twice as long as high..... **28**

22 (21a) a. nacre color white, shell inflated..... **23**

b. nacre color typically some shade of purple, but ranges from white to salmon to purple, *Elliptio* [this genus contains basically three shell shapes, narrow and elongate: the ***Elliptio lanceolata*** complex; rectangular to elongate rectangular, with various degrees of inflation: the ***Elliptio complanata*** complex; those shells with short shell length, not too tall and inflated: the ***Elliptio icterina*** complex] [See Table 5 for species groups and figures for each species of *Elliptio*].

23 (22a) a. periostracum unrayed, shell thick, posterior end angled, periostracum mat or fuzzy, rectangular in shell shape (pl. 8, fig. 47) .....***Uniomerus caroliniana***

b. periostracum rayed in juveniles, posterior end tapered to a point in middle of posterior margin, periostracum not mat (pl. 6, fig. 34) .....***Ligumia nasuta***

24 (20b) a. adult shell typically <40 mm in length, with a fuzzy or mat textured dark brown to black periostracum (pl. 8, fig. 45) .....***Toxolasma pullus***

b. adult shell >40 mm in length, lacking the pronounced fuzzy periostracum..... **25**

25 (24b) a. shell shape oval to elongate oval, periostracum very shiny to mat with rays..... **26**

b. shell shape oval, periostracum dull yellow, without rays or with fine rays all over the shell, found in or near tidewater, nacre often a salmon color (pl. 6, fig. 32.....***Leptodea ochracea***

26 (25a) a. periostracum shiny yellow, with fine green rays when present restricted to the posterior slope (pl. 5, fig. 25) ..... ***Lampsilis cariosa***

b. periostracum mat to smooth but not shiny **27**

27 (26b) a. posterior ridge very sharp, maximum shell length <60mm, restricted to the Lake Waccamaw drainage (pl. 5, fig. 27) ..... ***Lampsilis fullerkati***

b. posterior ridge rounded, maximum size ca. 100 mm, inflated, wide spread, (pl. 5, fig. 28) ..... ***Lampsilis radiata***

28 (21b) a. periostracum greenish yellow, numerous green rays, shell relatively thin, oval to elongate oval, blade-like pseudocardinal teeth **29**

b. periostracum dark to black, shell thick, no green rays, shell shape oval to round (pl. 9, fig. 49) ..... ***Villosa constricta***

29 (28a) a. shell outline elliptical, numerous broad green rays, bluish white to pink or purple nacre (pl. 10, fig. 55) ..... ***Villosa vibex***

b. shell outline elongate oval, rays not broad, nacre bluish white or iridescent **30**

30 (29b) a. entire surface covered with narrow to very narrow green rays interrupted by growth lines (pl. 9, fig. 50) ..... ***Villosa delumbis***

b. numerous continuous dark green rays over most of the shell (pl. 9, fig. 54) ..... ***Villosa vaughaniana***

MISSISSIPPI RIVER BASIN

31 (4b) a. lacking lateral teeth or all evidence of any hinge teeth **32**

b. shell with both pseudocardinal and lateral teeth present **38**

32 (31a) a. shell with pseudocardinal teeth but lacking lateral teeth **33**

b. shell with greatly reduced or totally lacking both pseudocardinal and lateral teeth **36**

33 (32a) a. shell <25 mm, typically periostracum eroded off with periostracum restricted to narrow strip on shell margin, beak sculpture heavy bars extending down on the disc of the shell, upper Little Tennessee River basin (pl. 6, fig. 36) ..... ***Pegias fabula***

b. periostracum not eroded as above **34**

34 (33b) a. hinge plate in left valve with an additional small interdental tooth giving the appearance of a third pseudocardinal tooth, beak sculpture consists of six double looped concentric ridges shell smooth (pl. 5, fig. 30) ..... ***Lasmigona holstonia***

b. hinge plate in left valve without an additional small interdental tooth **35**

35 (34b) a. shell thin, inflated, shell shape elongate, posterior ridge rounded, periostracum shiny, some rays apparent even in adults (pl. 1, fig. 2) ..... ***Alasmidonta raveneliana***

b. shell thickened anteriorly, shell shape ovate, rectangular to triangular, posterior ridge often angular, somewhat inflated, periostracum slightly glossy, with narrow and wide green rays (pl. 1, fig. 6) ..... ***Alasmidonta viridis***

36 (32b) a. shell with pseudocardinal tooth consisting of a slight swelling or knob, lateral tooth consisting of a rounded ridge, beak cavity copper colored, umbo centrally located (pl. 8, fig. 43) ..... ***Strophitus undulatus***

b. hinge teeth completely absent **37**

37 (36b) a. umbo elevated well above the hinge line, shell shape variable, ranging from oval, elliptical to rhomboid, beak sculpture consists of double looped ridges with projections on the bottom of the loop (pl. 7, fig. 41) ..... ***Pyganodon grandis***

b. umbo level with hinge line or below the level of the hinge line, shell shape elongate, inflated, dorsal and ventral margins nearly straight and parallel, beak sculpture consists of 5-6 fine irregular concentric ridges (pl. 8, fig. 48) ..... ***Utterbackia imbecillis***

38 (31b) a. shell with sculpture on the external shell surface **39**

b. shell with no plications, undulations, ridges, pustules or nodules..... **42**

39 (38a) a. shell with prominent pustules or nodules and/or undulations, plications or ridges **40**

b. shell with only prominent, well-defined pustules, knobs or nodules distributed across the shell..... **41**

40 (39a) a. shell with undulations, ridges, or plications on the posterior slope, no pustules or nodules on the surface, shell elongate, with a rounded posterior ridge, inflated with a blue to blue-green nacre color (pl. 6, fig. 35) ..... ***Medionidus conradicus***

b. shell with undulations, ridges or plications on the posterior slope and pustules on the disc or umbonal area, shell oval, elongate with a well-developed diagonal posterior ridge, nacre color white (pl. 8, fig. 46)..... ***Tritogonia verrucosa***

41 (39b) a. pustules of uniform size, no broad green ray on umbo, periostracum of a uniform brownish, purple nacre, beak cavity deep and compressed (pl. 2, fig. 9)..... ***Cyclonaias tuberculata***

b. pustules generally large, often variable in size and shape, disc of the shell usually with a broad green stripe running down the disc of the shell with a variable number of pustules, varies from a very few to covering most of the shell, nacre color mostly white, beak cavity deep and open not compressed (pl. 7, fig. 42)..... ***Quadrula pustulosa***

42 (38b) a. shell shape round **43**

b. shell shape not round **46**

43 (42a) a. umbo central or nearly central in the dorsal margin **44**

b. umbo anterior of the center of the shell..... **45**

44 (43a) a. broad green ray extending from the umbo down only a short distance onto the disc of the shell, without pustules (pl. 7, fig. 42) ..... ***Quadrula pustulosa***

b. no broad green ray, shell with broad shallow to pronounced sulcus, fine green rays, shallow beak cavity, well developed hinge teeth, female shells with a swollen, extended or expanded portion of the posterior slope and posterior ventral margin of the shell (pl. 4, fig. 21).....***Epioblasma capsaeformis***

45 (43b) a. beak cavity deep compressed (pl. 4, fig. 24) .....***Fusconaia subrotunda***

b. beak cavity shallow and open, shell with green rays at least on the umbo area with a thick shell, heavy lateral teeth, very shallow sulcus or missing, shallow to no beak cavity (pl. 6, fig. 33).....***Lexingtonia dolabelloides***

46 (42b) a. shell shape not oval..... **48**

b. shell shape oval to oblong **47**

47 (46b) a. shell shape oval, inflated, rayed, thin to thick shell, posterior ridge rounded or sharp, nacre variously white to pink or salmon (pl. 5, fig. 26) ..... ***Lampsilis fasciola***

b. shell shape oblong to elongate oval, male shells are oval while female shells have a truncate posterior margin, purple nacre ranges from deep purple to copper (pl. 9, fig. 53) ..... ***Villosa vanuxemensis***

48 (46a) a. shell shape rectangular, triangular, or square with sulcus **49**

b. shell shape elongate, 2 to 4 times longer than high **50**

49 (48a) a. shell shape rectangular, with green rays on the umbo (pl. 4, fig. 22) ..... ***Fusconaia barnesiana***

b. shell shape triangular to broadly triangular (pl. 7, fig. 38) ..... ***Pleurobema oviforme***

50 (48b) a. thin shelled, shell inflated, periostracum usually rayed, adult shell length >50 mm, shell hinge thin, usually heavily rayed (pl. 9, fig. 51) ..... ***Villosa iris*** complex

b. thick shelled **51**

51 (50b) a. shell compressed **52**

b. shell inflated **53**

52 (51a) a. shell hinge massive, curved, nacre white, periostracum with interrupted green rays (pl. 7, fig. 39) ..... ***Ptychobranchus fasciolaris***

b. hinge lighter, straight, nacre purple to white, periostracum typically unrayed (pl. 3, fig. 13) ..... ***Elliptio dilatata***

53 (51b) a. periostracum smooth, color olive green with numerous rays, nacre white (pl. 9, fig. 52) ..... ***Villosa trabalis***

b. periostracum mat, color ranges from greenish to black without rays, nacre purple (pl. 8, fig. 44) ..... ***Toxolasma lividus***

Table 1.List of Native Freshwater Unionid Bivalves of North Carolina

Alasmidonta heterodon (Lea, 1829) Dwarf Wedgemussel
Alasmidonta raveneliana (Lea, 1834) Appalachian Elktoe [Interior Basin]
Alasmidonta robusta Clarke, 1981Carolina Elktoe
Alasmidonta undulata (Say, 1817) Triangular Floater
Alasmidonta varicosa (Lamarck, 1819) Brook floater
Alasmidonta viridis (Rafinesque, 1820) Slippershell Mussel [Interior Basin]
Anodonta couperiana Lea, 1840 Barrel Floater
Anodonta implicata Say, 1829 Alewife Floater
Cyclonaias tuberculata (Rafinesque, 1820) Purple Wartyback [Interior Basin]
Elliptio cistellaeformis (Lea, 1863) Box Spike
Elliptio complanata (Lightfoot, 1786) Eastern Elliptio
Elliptio congaraea (Lea, 1831) Carolina Slabshell
Elliptio dilatata (Rafinesque, 1820) Spike [Interior Basin]
Elliptio folliculata (Lea, 1838) Pod Lance
Elliptio icterina (Conrad, 1834) Variable Spike
Elliptio judithae Clarke, 1981 Plicate Spike
Elliptio lanceolata (Lea, 1828) Yellow Lance
Elliptio marsupiobesa Fuller, 1972 Cape Fear Spike
Elliptio roanokensis (Lea, 1838) Roanoke Slabshell
Elliptio steinstansana Johnson and Clarke, 1983 Tar River Spinymussel
Elliptio waccamawensis Lea, 1863 Waccamaw Spike
Epioblasma capsaeformis (Lea, 1834) Oyster Mussel [Interior Basin]
Fusconaia barnesiana (Lea, 1838) Tennessee Pigtoe [Interior Basin]
Fusconaia masoni (Conrad, 1834) Atlantic Pigtoe
Fusconaia subrotunda (Lea, 1831) Longsolid [Interior Basin]
Lampsilis cariosa (Say, 1817) Yellow Lampmussel
Lampsilis fasciola Rafinesque, 1820 Wavyrayed Lampmussel [Interior Basin]
Lampsilis fullerkati Johnson, 1984 Waccamaw Fatmucket
Lampsilis radiata radiata (Gmelin, 1791) Eastern Lampmussel
Lampsilis radiata conspicua (Lea, 1872) Carolina Fatmucket
Lasmigona decorata (Lea, 1852) Carolina Heelsplitter
Lasmigona holstonia (Lea, 1838) Tennessee Heelsplitter [Interior Basin]
Lasmigona subviridus (Conrad, 1835) Green Floater [Atlantic/Interior Basin]
Leptodea ochracea (Say, 1817) Tidewater Mucket
Lexingtonia dolabelloides (Lea, 1840) Slabside Pearlymussel [Interior Basin]
Ligumia nasuta (Say, 1817) Eastern Pondmussel
Medionidus conradicus (Lea, 1831) Cumberland Moccasinshell
Pegias fabula (Lea, 1838) Littlewing Pearlymussel [Interior Basin]
Pleurobema collina (Conrad, 1836) James Spinymussel
Pleurobema oviforme (Conrad, 1834) Tennessee Clubshell [Interior Basin]
Ptychobranchus fasciolaris (Rafinesque, 1820) Kidneyshell [Interior Basin]
Pyganodon cataracta (Say, 1817) Eastern Floater
Pyganodon grandis (Say, 1829) Giant Floater [Interior Basin]
Quadrula pustulosa (Lea, 1831) Pimpleback [Interior Basin]
Strophitus undulatus (Say, 1817) Creeper [Atlantic/Interior Basin]
Toxolasma lividus Rafinesque, 1831 Purple Lilliput [Interior Basin]
Toxolasma pullus (Conrad, 1838) Savannah Lilliput
Tritogonia verrucosa (Rafinesque, 1820) Pistolgrip [Interior Basin]
Uniomerus carolinianus (Bosc, 1801) Florida Pondhorn

Utterbackia imbecillis (Say, 1829) Paper Pondshell [Atlantic/Interior Basin]
Villosa constricta (Conrad, 1838) Notched Rainbow
Villosa delumbis (Conrad, 1834) Eastern Creekshell
Villosa iris (Lea, 1830) Rainbow [Interior Basin]
Villosa trabalis (Conrad, 1834) Cumberland Bean [Interior Basin]
Villosa vanuxemensis (Lea, 1838) Mountain Creekshell [Interior Basin]
Villosa vaughaniana (Lea, 1838) Carolina Creekshell
Villosa vibex (Conrad, 1834) Southern Rainbow

Table 2. Distribution of Unionidae in North Carolina's Atlantic Slope River Basins
Within River Basin: X= Extant, H= Historic, S= in S. Carolina, ScH=SC historic, V= in Virginia

Species	**Savannah**	**Broad**	**Catawba**	**Pee-Dee**	**Lumber**	**Waccamaw**	**Cape Fear**	**White Oak**	**Neuse**	**Pamlico**	**Roanoke**	**Chowan**	**Pasquotank**
Anodonta implicata				X							X	X	
Anodonta couperiana	S						H						
Pyganodon cataracta	S	X	X	X			X		X	X	X	X	X
Utterbackia imbecillis		X	S	X			X		X	X	X	X	X
Strophitus undulatus		X	S	X			X		X	X	X	V	
Alasmidonta varicosa	S		X	X			X		X		X		
Alasmidonta heterodon									X	X			
Alasmidonta undulata	S			X			X		X	X	X	X	
Lasmigona decorata	S		X	X									
Lasmigona subviridis							H		X	X	X		
Fusconaia masoni	ScH		H	X			X		X	X	X[1]	V	
Pleurobema collina											X		
Elliptio complanata	S	X	X	X	X	X	X	X	X	X	X	X	
Elliptio cistellaeformis			X	X	X		X		X	X			
Elliptio mediocris					X				X	X			
Elliptio marsupiobesa				S	X		X		X				
Elliptio congaraea	S			X			X		X	X		V	
Elliptio waccamawensis						X							
Elliptio raveneli				X	X	X	X		X	X		V	
Elliptio icterina	S	X	X	X	X	X	X	X	X	X	X	V	
Elliptio lanceolata									X	X		V	
Elliptio angustata		X	X	X		X	X				X	V	

Species	**Savannah**	**Broad**	**Catawba**	**Pee-Dee**	**Lumber**	**Waccamaw**	**Cape Fear**	**White Oak**	**Neuse**	**Pamlico**	**Roanoke**	**Chowan**	**Pasquotank**
Elliptio producta	S		S	X		X	X						
Elliptio folliculate	S		S	X		X	X						
Elliptio shepardiana						X		X					
Elliptio viridula					X	X	X		X	X			
Elliptio emmonsii													
Elliptio roanokensis	S			X			X		X	X	X		
Elliptio steinstansana										X	X	X	
Uniomerus sp.	S	S	X	X	X	X	X			X			
Leptodea ochracea	ScH					X				H		X	
Toxolasma pullus	S			X		H	X		H		X		
Ligumia nasuta	S			X			X			H		V	
Villosa vibex	S						X				X	X	
Villosa delumbis	S		X	X		X	X						
Villosa constricta			X	X			X		X	X		X	
Villosa vaughaniana			X	X			X				X	V	
Lampsilis radiata radiate				X		X	X		X	X			
Lampsilis radiata conspicua				X					X				
Lampsilis fullerkati						X							
Lampsilis splendida	S					X	X						
Lampsilis cariosa	S					X	X		X	X		V	
Lampsilis n.s.				X					X	X			
Total taxa for River Basin	20	7	16	27	8	17	29	3	24	24	17	19	2

Prepared by J.M. Alderman, J.A. Johnson, and Brian T. Watson, January 31, 2002

[1]T. Savidge (Per. Comm. March 2002)

Table 3 Distribution of Extant Unionidae in North Carolina's Interior Basin
Within River Basin: X =Extant, H= Recently Extirpated, I=Introduced

Species	Hiwassee	Little Tennessee	Pigeon	French Broad	Watauga	New
Pyganodon grandis				X		
Strophitus undulatus				X		
Lasmgona holstonia	H	X[1]		X[2]		
Lasmigona subviridis					X	X
Elliptio dilatata	X	X		H		X
Elliptio complanata (Introduced)				I		
Alasmidonta raveneliana		X	X	X		
Alasmidonta viridis		X		X		
Cyclonaias tuberculata						X
Tritigonia verrucosa						H
Pleurobema oviforme	X	X		X		
Fusconaia barnesiana	X	X				
Fusconaia subrotunda	X			X		
Pegias fabula	X	X				
Villosa iris	X	X		H		
Villosa vanuxemensis	X					
Lampsilis fasciola	X	X	H	X		
Medionidus conradicus				H		
Epioblasma capsaeformis				H		
Ptychobranchus fasciolaris				H		
Toxolasma lividus				H		
Lexingtonia dolabelloides	?					
Villosa trabalis	?					

Prepared By J. M. Alderman, Judith A. Johnson, and Brian T. Watson, February 4, 2002
[1]W. McLaren (Pers. Comm., 1 July 2002).
[2]T. Savidge (Pers. Comm. March 2002).

Table 4. Status List of North Carolina freshwater bivalves

FEDERAL AND STATE ENDANGERED
Alasmidonta heterodon
Alasmidonta raveneliana
Elliptio steinstansana
Epioblasma capsaeformis
Lasmigona decorata
Pegias fabula
Pleurobema collina
Villosa trabalis

STATE ENDANGERED
Alasmidonta varicosa (effective July 1, 2002)
Alasmidonta viridis
Anodonta couperiana
Elliptio lanceolata (effective July 1, 2002)
Elliptio waccamawensis (effective July 1, 2002)
Fusconaia barnesiana
Fusconaia masoni (effective July 1, 2002)
Lampsilis cariosa (effective July 1, 2002)
Lasmigona holstonia
Lasmigona subviridis
Toxolasma pullus (effective July 1, 2002)
Villosa vaughaniana (effective July 1, 2002)

STATE THREATENED
Alasmidonta undulata
Anodonta implicata (effective July 1, 2002)
Elliptio roanokensis
Lampsilis fullerkati
Lampsilis radiata conspicua (effective July 1, 2002)
Lampsilis radiata radiata (effective July 1, 2002)
Leptocea ochracea (effective July 1, 2002)
Ligumia nasuta (effective July 1, 2002)
Strophitus undulatus
Villosa vanuxemensis

STATE SPECIAL CONCERN
Elliptio dilatata
Elliptio folliculata
Elliptio marsupiobesa
Lampsilis fasciola
Villosa constricta
Villosa iris

SIGNIFICANTLY RARE (Natural Heritage Program)
Cyclonaias tuberculata
Villosa delumbis

STATE EXTIRPATED
Epioblasma capsaeformis
Medionidus conradicus
Ptychobranchus fasciolaris
Quadrula pustulosa
Toxolasma lividus
Tritogonia verrucosa
Villosa trabalis

EXTINCT
Alasmidonta robusta

Table 5. A working list of the Elliptio of North Carolina.
A preliminary idea of the relationships of North Carolina *Elliptio*

***ELLIPTIO COMPLANATA* GROUP**
Elliptio complanata (Lightfoot, 1786) Eastern Elliptio [pl. 2, fig. 11]
Elliptio congaraea (Lea, 1831) Carolina Slabshell [pl. 2, fig. 12]
Elliptio judithae Clarke, 1981 Plicate Spike [p. 38]
Elliptio roanokensis (Lea, 1838) Roanoke Slabshell [pl. 3, fig. 18]
Elliptio steinstansana Johnson and Clarke, 1983 Tar River Spinymussel [pl.4, fig. 19]
Elliptio waccamawensis (Lea, 1863) Waccamaw Spike [pl.4, fig. 20]
Elliptio raveneli (Conrad, 1834) Carolina Spike*

***ELLIPTIO ICTERINA* GROUP**
Elliptio cistellaeformis (Lea, 1863) Box Spike [pl. 2, fig. 10]
Elliptio icterina (Conrad, 1834) Variable Spike [pl. 3, fig. 15]
Elliptio marsupiobesa Fuller, 1972 Cape Fear Spike [pl.3, fig. 17]

***ELLIPTIO LANCEOLATA* GROUP**
Elliptio folliculata (Lea, 1838) Pod Lance [pl. 3, fig. 14]
Elliptio lanceolata (Lea, 1828) Yellow Lance [pl. 3, fig. 16]
Elliptio angustata (Lea, 1831) Carolina Lance*
Elliptio fisheriana (Lea, 1838) Northern Lance*
Elliptio viridulus (Lea, 1863)*
Elliptio emmonsii (Lea, 1857)*
Elliptio nasutilus (Lea, 1863)*

***ELLIPTIO DILATATA* GROUP**
Elliptio dilatata (Rafinesque, 1820) Spike [Interior Basin] [pl. 3, fig. 13]

*These taxa are not treated here but, you will encounter in the literature on *Elliptio* from North Carolina.

CORBICULIDAE
Corbicula fluminea (Müller, 1776) INTRODUCED
Asian Clam

Plate 10, Figure 56, 57

General Distribution: The Asian Clam appears to have been introduced into North America sometime during or before the 1920s (Counts, 1986). It was first collected in the United States along the banks of the Columbia River in Pacific County, Washington, in 1938 (Burch, 1944), and since then it has invaded nearly every major river system in the country.

North Carolina Distribution: This introduced species is widespread in all rivers, most reservoirs and many lakes.

Description: The shell is fairly small, seldom exceeding 50 mm in length, very solid, ovate when young, and triangular in outline when mature. Beaks are high, full, directed inward, and elevated well above the hinge line, and centrally located. Thin, prominent concentric rings indicate growth periods. There are three cardinal teeth directly below the beaks in each valve, with two straight to slightly curved lateral teeth on each side in the right valve and one on each side in the left valve. The lateral teeth are serrated, a character distinguishing *Corbicula* from the Sphaeriidae. The beak cavity is deep. The periostracum is a light yellowish olive to cream-colored in immature clams, changing with age to tan, olive, and, finally, dark brown to black in old individuals. Very young individuals possess a characteristic dark stripe or band on the anterior slope of the valves. The nacre is white to a shiny light purple, darkest along the lateral teeth and in the beak cavity. The entire inner surface of adults is a very light purple and white, appearing highly polished outside the pallial line.

Life History and Ecology: Unlike our native freshwater mussels, the juvenile or larva (called a veliger) of the Asian Clam is free swimming and does not require a host for partial development. Oesch (1984) noted that in Missouri the spawning time of *Corbicula* generally is between May and September. The period of growth of the free-swimming veliger lasts about 7–10 days (McMahon and Bogan, 2001

The Asian Clam reaches its greatest population densities in a substrate of almost pure sand or one of mixed sand, silt, and mud. Although it thrives in rivers with slow to moderate current, typically at depths of less than three feet, *C. fluminea* may become abundant and grow to a large size in the quiet waters of small ponds. This small clam is highly resistant to desiccation and can survive for weeks in damp sand or mud.

Status: INTRODUCED

UNIONIDAE
Alasmidonta heterodon
(Lea, 1829)
Dwarf Wedgemussel

Plate 1, Figure 1

Synonymy:

Unio heterodon Lea, 1829; Lea, 1829:428, pl. 8, fig. 11

Type Locality: Schuylkill [River] and Derby [sic] Creek [mostly in Delaware County] P[ennsylvani]a

General Distribution: Clarke (1981:32, 34, Fig. 10) listed the distribution for the Dwarf Wedgemussel as occurring from the Neuse River basin, North Carolina, in the south, north to the Petitcodiac River Basin, New Brunswick, Canada. Distribution of *A. heterodon* is sporadic in the river basins between these two river basins.

North Carolina Distribution: This species occurs in the Neuse and Pamlico River basins in North Carolina (Clarke, 1981; Table 2).

Description: The shell is small, somewhat inflated and rather thin, thickened anteriorly, reaching a shell length of about 56 mm. Anterior margin sharply curved, ventral margin broadly curved to straight, and the posterior margin is roundly pointed near the base and broadly truncated above. The shells of males are more compressed and the shell shape is more ovate and elongate with a reduced posterior ridge, the posterior slope is not truncated. Female shells are more swollen around the posterior ridge and have a more distinct posterior ridge making the posterior slope appear truncated, thus making the whole shell appear more trapezoidal (Ortmann 1919:174). Posterior ridge well developed, extending to the posterior ventral margin and coming to a point. Beaks are low, rounded and projecting slightly above the hinge line, with beak sculpture consisting of a few well developed ridges or bars, running parallel to the growth lines, subsequent beak sculpture is double looped. This sculpture is visible only on young specimens.

Surface marked by uneven growth lines. Left valve has one or two compressed, pseudocardinal teeth, and may have one to three lamellar lateral teeth. Right valve with two compressed, pseudocardinal teeth and two lamellar lateral teeth that extend to the end of the ligament. This is the reverse of the rest of the species with lateral teeth. Interdentum marked by an accessory dentacle in the left valve and a corresponding depression in the right valve, beak cavity rather narrow and not very deep. Periostracum color varies from yellowish olive brown to green to black with some specimens with variable width, faint, reddish-brown rays. Nacre color is bluish white

Life History and Ecology: Fuller (1977:168) characterized the habitat of the Dwarf Wedgemussel as: “stable stream floors of sand and/or fine gravel, but like most other member of the subfamily Anodontinae, it has a considerable tolerance of sediment overlying formerly clean streambeds.” Ortmann (1919) found this species gravid in February to April in Pennsylvania. Clarke (1981b:31-32, fig. 9) described the glochidium of the Dwarf Wedgemussel as depressed, pyriform with a straight hinge, with a ventral hook, glochidial length 0.325mm and height 0.255 mm. Hoggarth (1999:36, 39, figs. 19a-f) commented that glochidium was asymmetrical in outline and listed the length as 330-338 µm and height as 258-268 µm. Michaelson and Neves (1995) listed three fish species, which serve as hosts

for the glochidia of the Dwarf Wedgemussel in laboratory studies: Tessellated Darter (*Etheostoma olmstedi*), Johnny Darter (*E. nigrum*) and the Mottled Sculpin (*Cottus bairdi*). Wicklow (1999) reported the Atlantic Salmon (*Salmo salar*) as a suitable host for the glochidia of this species.
Status: Endangered (Williams et al., 1993:10). This species is federally and state listed as endangered.

Alasmidonta raveneliana
(Lea, 1834)
Appalachian Elktoe

Plate 1, Figure 2

Synonymy:
Margaritana raveneliana Lea, 1834; Lea, 1834:106, pl. 17, fig. 50

Type Locality: French Broad and Swananoe [*sic*] rivers, North Carolina.

General Distribution: The Appalachian Elktoe is restricted to the tributaries of the Tennessee River in East Tennessee and western North Carolina.

North Carolina Distribution: This species is found in the Nolichucky River, Little Tennesee River basin and the French Broad River in western North Carolina (Clarke, 1981b, T. Savidge, Pers. Comm. March 2002)

Description: The Appalachian Elktoe is oblong, somewhat kidney-shaped in outline, moderately inflated, and thin-shelled but not fragile. The anterior margin is sharply rounded, and the posterior margin is broadly rounded, coming to a rounded point close to the posterior ventral margin. The ventral margin is nearly straight or slightly concave, and the dorsal margin is nearly straight posterior to the beaks. The posterior ridge is rounded and often double; the posterior slope is slightly concave, but not as acute as in the Elktoe *(Alasmidonta marginata).* The beaks are moderately full, rounded, and situated on the anterior third of the shell and slightly above the hinge line. Beak sculpture consists of a few fairly heavy straight or slightly double looped bars, which terminate at the posterior ridge. The Appalachian Elktoe reaches a maximum length of about 80 mm (Clarke, 1981b). Specimens > 120 mm have been seen in the Pigion and Little Rivers (T. Savidge, Pers. Comm. March 2002). The left valve has a single small, compressed, pyramidal pseudocardinal tooth; the lateral tooth is reduced to a swelling or ridge and is not an articulating tooth. The left valve also has a moderate-sized interdental projection. The right valve has a single small compressed pyramidal pseudocardinal tooth and a single reduced ridge along the hinge line in place of the lateral tooth. Beak cavity is quite shallow. Adductor muscle scars are shallow, becoming somewhat deeper and more distinct in large mature individuals. Dorsal muscle scars are present and consist of one or two short grooves. The pallial line is absent in some individuals, complete and distinct in others. The periostracum varies from yellowish brown in younger specimens to dark brown or black in adults with faint, often interrupted green rays. The surface is mostly smooth, but interrupted by concentric growth lines. There may be some fine plications on the posterior slope on juvenile specimens. Nacre color varies from a uniform bluish white to greenish, sometimes with a purplish tint, to salmon or pinkish in the center of the shell and beak cavity. (Parmalee and Bogan, 1998).

Life History and Ecology: *Alasmidonta raveneliana* may be locally common in some rivers, such as the Little Tennessee and Nolichucky in North Carolina, where it inhabits a sand and gravel substrate among cobbles and boulders and under flat rocks, usually in moderate current at depths of less than three feet. Ortmann (1921) reported that the breeding season ended in May, the species being bradytictic. Watters (1994) lists the fish host for the glochidia of *Alasmidonta raveneliana* as the Banded Sculpin *(Cottus carolinae).*

Status: Endangered (Williams et al., 1993:10). The U.S. Fish and Wildlife Service has developed a recovery plan for this species (U.S. Fish and Wildlife Service, 1996). This species federally and state listed as endangered. The U.S. Fish and Wildlife Service (2001) has proposed critical habitat for the Appalachian Elktoe.

Alasmidonta robusta Clarke, 1981
Carolina Elktoe

Plate 1, Figure 3

Synonymy:

Alasmidonta robusta Clarke, 1981: Clarke, 1981b:81-84, figs. 23, 27

Type Locality: Long Creek, a tributary of the Catawba River, Mecklenburg County, North Carolina.

General Distribution: Long Creek, tributary of the Catawba River, Mecklenburg County, North Carolina (Clarke, 1981b).

North Carolina Distribution: Long Creek, tributary of the Catawba River, Mecklenburg County, North Carolina (Clarke, 1981b).

Description: The Carolina Elktoe is known from five specimens. The length ranges from 42 to 66 mm; the height ranges from 26 to 42 mm; the width ranges from 18 to 33 mm. The holotype is 66 mm long, 43 mm high and 33.2 mm wide. The following abbreviated description is taken from Keferl and Shelly (1988). A more complete description can be obtained from Clarke (1981b). The shell of the Carolina Elktoe is thin and sturdy, the anterior margin is well rounded; the ventral margin broadly curved; the posterior end forms a round point below the center. The periostracum is glossy, pale greenish-yellow with broad greenish rays that diminish at the posterior ridge. The posterior slope is covered with corrugations that are perpendicular to the posterior margin of the posterior slope. The Carolina Elktoe has a large interdental projection in the left valve. See Keferl and Shelly (1988) for a comparison with *Alasmidonta varicosa* (Lamarck, 1819) (Adams et al., 1990).

Life History: Nothing is known of the about the specific habitat of the Carolina Elktoe. Long Creek, its only collection site, is a small creek with a fairly steep gradient and substrates that vary from mud to bedrock. The stream has numerous deep isolated pools separated by rapids over small rocks, boulders and bedrock. Host fish information on this species is unknown (Adams et al., 1990).

Status: According to Keferl and Shelly (1988), *Alasmidonta robusta* was not found in any part of the Catawba or Pee Dee river systems (Adams 1990). A thorough search of its only known locality yielded no specimens. Based upon current data this species is probably extinct. Clarke (1981b). Williams et al. (1993:10) listed it as extinct.

Alasmidonta undulata (Say, 1817)
Triangle Floater

Plate 1, Figure 4

Synonymy:
Monodonta undulata Say, 1817; Say, 1817: no pagination, pl. 3, fig. 3

Type Locality: Delaware and Schuylkill rivers [near Philadelphia, Philadelphia County, Pennsylvania]

General Distribution: extending from the Bosquet River of the lower St. Lawrence River Basin south to the Catawba River of North Carolina.

North Carolina Distribution: This species is found in the Chowan, Pamlico, Roanoke, Neuse, Cape Fear, and Pee Dee River basins (Clarke, 1981b; Table 2)

Description: Shell shape is subtriangular to ovate, solid, thicker anteriorly than in the posterior, shell is subinflated to inflated with maximum inflation at the middle of the shell, maximum shell length about 75 mm. Anterior shell margin rounded, ventral margin broadly rounded, posterior margin roundly pointed below the midline. Sexual dimorphism is not apparent. Posterior ridge present and rounded but often indistinct, the posterior slope somewhat compressed. Beaks are more or less full inflated and somewhat elevated above the hinge line, beak sculpture is extremely heavy, strong ridges that run parallel with the growth lines and composed of five prominent, single-looped, curved ridges that extend out onto the shell surface (Clarke, 1981b). Posterior slope sometimes marked by oblique ridges or corrugations. Periostracum is smooth and shiny.

Left valve with a single short, stumpy, sculptured pseudocardinal teeth. There is usually a well-developed interdental projection present. Right valve has two short stumpy often-sculptured pseudocardinal teeth. The interdental area is broad and flat, with the lateral teeth either short and vestigial or absent. The beak cavity is triangular, compressed and rather deep. Periostracum is yellowish, greenish, with broad, green or blackish rays of variable width in juvenile specimens, becoming black with age. Growth lines are rather indistinct. Nacre color is typically white anteriorly, but including salmon, pink or red, becoming iridescent posteriorly.

Life History and Ecology: Ortmann (1919) lists the Triangle Floater as being gravid from July to September and April to June while Clarke (1981b) lists gravid females from 28 August to 24 October. Ortmann (1919) reported this species as common in smaller rivers and streams, going well into the headwaters, found mainly in quiet waters with some current, avoiding the riffles, living in coarser gravel and sand. It does not appear to like slack water but can be found in ponds and canals. Lellis (Pers. Comm. 1996) and the authors have observed this species deeply buried during the summer but sitting up on top of the substrate in January and February when water temperatures are at the coldest. Host fishes confirmed in the laboratory include the Blacknose Dace (*Rhinichthys atratulus*), Common Shiner (*Luxilus cornutus*), Fallfish (*Semotilus corporalis*), Largemouth Bass (*Micropterus salmoides*), Longnose Dace (*Rhinichthys cataractae*), Pumpkinseed (*Lepomis gibbosus*), Slimy Sculpin (*Cottus cognatus*), White Sucker (*Catostomus commersoni*), (Watters et al., 1999; from Nedeau et al., 2000:67).

Status: Special Concern (Williams et al., 1993:10). This species is listed as State Threatened in North Carolina.

Alasmidonta varicosa
(Lamarck, 1819)
Brook Floater

Plate 1, Figure 5

Synonymy:

Unio varicosa Lamarck, 1819; Lamarck, 1819:78

Type Locality: La rivière Schuylkill [Schuylkill] près de Philadelphie [Philadelphia Co. Pennsylvania] … aussi dans le lac Champlain

General Distribution: Lower St Lawrence River basin south in streams and rivers draining into the Atlantic to South Carolina (Clarke, 1981).

North Carolina Distribution: The Brook Floater is found in Roanoke, Neuse, Cape Fear, Pee Dee and Catawba River basins in North Carolina (Clarke, 1981b; Table 2).

Description: Shell shape is oblong, long rhomboid, thin-shelled, but slightly thickened anteriorly, slightly inflated with the maximum inflation at the posterior ridge, maximum length is about 70 mm. Anterior shell margin is abruptly curved, the ventral margin is long, and centrally gently concave, the posterior margin roundly biangulate below and obliquely flattened or flatly curved above. Female shells may be slightly more swollen in the area of the posterior ridge, but in many cases the sex cannot be determined based on shell characters. Posterior ridge is broad, rounded, and inflated. Posterior slope is flattened and slightly concave and covered with numerous, low corrugations or ridges. Beaks are narrow and bluntly pointed and located about 1/3 the distance from the anterior end and project only slightly above the hinge line. Beak sculpture is coarse, variable and composed of a few single-looped or occasionally double-looped ridges, mostly seen in juvenile specimens. Growth ridges are marked by concentric ridges, the periostracum is generally smooth except on the posterior slope.

Left valve with a single small rounded variously developed or reduced pseudocardinal tooth, some specimens also have an interdental projection or denticle, lateral teeth are vestigial or entirely absent. Right valve has a single small rounded or rudimentary pseudocardinal tooth. Beak cavity is open and shallow. Periostracum is yellowish but more often greenish and partly or completely covered with dark greenish rays in juveniles, becoming brownish with rays partially obscured to almost black in adult specimens. The periostracal color on the posterior slope is the same as the rest of the shell, not yellowish as in *Alasmidonta marginata*. Nacre color is whitish or bluish-white, often with salmon, pink or purple shades in the beak cavity (Ortmann, 1919; Clarke, 1981b).

Life History and Ecology: Ortmann (1919:191-192) reported gravid females from 9 August to 8 September and 3 May with glochidial discharge in May. Ortmann (1919) reported this species evenly distributed across eastern Pennsylvania except in the larger rivers and more common in smaller rivers and streams. Ortmann (1919:104) described the ecology of the Brook Floater as "It prefers strong currents and gravelly bottoms, thus being most frequently found in and near riffles." Lellis (Pers. Comm. 1996) has observed this species deeply buried during the summer but sitting up on top of the substrate in January and February when water temperatures are at the coldest. The Blacknose Dace (*Rhinichthys atratulus*), Golden Shiner (*Notemigonus chrysoleucas*), Longnose dace (*Rhinichthys cataractae*), Margined

Madtom (*Schilbeodes marginatus marginatus*) Pumpkinseed (*Lepomis gibbosus*), Slimy Sculpin (*Cottus cognatus*), and the Yellow Perch (*Perca flavescens*) have been identified in the laboratory as potential hostfish for the glochidia of this species (Wicklow and Richardson, 1995; Nedeau et al., 2000). **Status:** Threatened (Williams et al., 1993:10). This species is listed as State Endangered in North Carolina, effective July 1, 2002.

Alasmidonta viridis
(Rafinesque, 1820)
Slippershell Mussel

Plate 1, Figure 6

Synonymy:

Unio viridis Rafinesque, 1820; Rafinesque, 1820:293

Type Locality: Ohio River.

General Distribution: Upper Mississippi River drainage; Ohio, Cumberland, and Tennessee rivers; lower and middle sections of the St. Lawrence River systems: Lake Huron, Lake St. Clair, and Lake Erie drainages in Canada (Clarke, 1981a).

North Carolina Distribution: This species is known from the Little Tennessee , Mills and French Broad Rivers (Table 3).

Description:: The shell is small, rhomboid, moderately solid, and slightly inflated. Maximum shell length of adult specimens seldom exceeds 55 mm. The anterior end is rounded; the posterior end is squared or obliquely truncated. The posterior ridge is high, rounded, and usually ends as a blunt point at the base of the shell. Beaks are moderately swollen, only slightly elevated; sculpture consists of 5–6 irregular, heavy loops, the first one or two are diagonal to the hinge line, and the others are somewhat concentric. The surface has uneven growth lines, the rest periods appear as raised, dark-lined ridges. The pseudocardinal teeth in both valves are somewhat rudimentary, or they appear as elevated, triangular projections, usually doubled in the left valve. Lateral teeth are indistinct, being represented as a slight swelling of the hinge line. The beak cavity is relatively shallow; the interdentum is narrow or absent. The periostracum in young shells is a dull eggshell white, greenish or yellowish, with numerous wavy green rays; the colors are darker and the rays less distinct in old shells. The nacre is a dull white, and the posterior margin is slightly iridescent. (Parmalee and Bogan, 1998).

Life History and Ecology: A species of small creeks and shallow streams today, *A. viridis* once inhabited the shoals and riffles of large rivers such as the French Broad and Holston before impoundment. The Slippershell Mussel may typically be found living in a substrate composed of sand and fine gravel, although in stretches where there is a continuous current this small naiad will thrive in a mud and sand bottom among the roots of aquatic vegetation. Host fish for the glochidia include the Banded Sculpin *(Cottus carolinae)* and probably the Mottled Sculpin *(C. bairdi)* and Johnny Darter *(Etheostoma nigrum)* (Zale and Neves, 1982c; Watters, 1994). Baker (1928:186) states that the species in Wisconsin is "[p]robably bradytictic, with mature glochidia in the fall (September)." Individuals of this species have been observed spawning in January and February in the upper Little Tennessee River, North Carolina (Ahlstedt, pers. comm., 1994). Females lay on the substrate surface while spawning.

Status: Special Concern (Williams et al., 1993:10). This species is considered State Endangered in North Carolina, effective July 1, 2002.

Anodonta couperiana Lea, 1840
Barrel Floater

Plate 2, Figure 7

Synonymy:

Anodonta couperiana Lea, 1840; Lea, 1840:227, pl. 20, fig, 146

Type Locality:

McIntosh County, Georgia

General Distribution: The barrel floater is found from Florida's Apalachicola region to the Cape Fear drainage basin in North Carolina.

North Carolina Distribution: This species has been extirpated from one of its two known locations in North Carolina. The barrel floater was once known from the Greenfield Lake basin near Wilmington and the lower Cape Fear River (Adams et al., 1990). Vidrine (1980) documents this species from Bladen County (Adams et al., 1990). However, there are no recent records of the Barrel Floater in North Carolina (J. Alderman, Pers. Comm. July 2002).

Description: The barrel floater may reach over 100 mm in length. Like other *Anodonta,* this species also lacks pseudocardinal and lateral teeth. The shell of the barrel floater is similar to that of *Utterbackia imbecillis* in that the umbos do not extend above the dorsal margin. However, the barrel floater's height to length ratio is around 2 compared with 1.5 for *Utterbackia imbecillis*. The ventral margin of the barrel floater is broadly rounded and there are fine green rays on the periostracum (Adams et al., 1990).

Life History: According to Johnson (1970), the barrel floater is found in ponds and slow-flowing streams with mud or sand bottoms. The host fish for this species is unknown.

Status: Williams et al. (1993:10) listed as special concern. This species is listed as State Endangered.

Anodonta implicata Say, 1829
Alewife Floater

Plate 2, Figure 8

Synonymy:

Anodonta implicata Say, 1829; Say, 1829:340

Type Locality: Pond in Danvers [Essex Co.] Massachusetts. Changed by Johnson (1946:112, pl. 16, figs. 1, 2) when he selected a neotype to Agawam River (outlet of Halfway Pond), Plymouth [Plymouth Co.] Massachusetts.

General Distribution: North Atlantic Slope rivers from New Brunswick, Nova Scotia, and Quebec, Canada south to the Potomac River, Maryland, with a disjunct population in the Chowan River, North Carolina (Adams et al., 1990).

North Carolina Distribution: This species is found in the Chowan River, Roanoke and Pee Dee River systems in North Carolina (Shelley, 1983; Adams et al., 1990; Table 2).

Description: Shell shape is elliptical, oblong to ovate in outline, approaching sub cylindrical in cross-section, shell thickness rather solid, with a pronounced thickening of the anterior ventral margin from about the middle of the shell anterior, inflated, shell length reaching about 142 mm. Anterior margin of the shell is narrowly rounded, the ventral margin straight, with a straight dorsal margin, the posterior margin bluntly pointed slightly below the midline. The posterior ridge is rounded and generally double, ending posteriorly in a biangulation slightly below the midline. Beaks are moderately full and slightly raised above the hingeline, beak sculpture consists of 5-7 straight bars running parallel with the hingeline or slightly curved. The shell surface is marked by irregular growth lines, which may form ridges, surface varies from smooth almost shiny to rough. This is a typical *Anodonta* completely lacking any indication of pseudocardinal or lateral teeth. The beak cavity is open and relatively shallow. Periostracum is yellowish brown, greenish brown, to reddish brown becoming dark brown to black with age, immature specimens have fine green rays. Nacre color varies from white, salmon or purple and almost always darker in the beak cavity.

Life History and Ecology: The Alewife Floater is found living in ponds, overbank pools, streams and rivers in a variety of substrates including silt, sand and gravel. The distribution is closely tied to the distribution of its host fish. Nedeau et al. (2000) report this species is bradytictic, a long-term brooder, with eggs being fertilized in August and glochidia being released the next spring. The Alewife (*Alosa pseudoharengus*) has been reported as a host fish for this mussel (Davenport and Warmuth, 1965).

Status: Currently Stable (Williams et al., 1993:10). This species is considered State Threatened in North Carolina.

Cyclonaias tuberculata (Rafinesque, 1820) Purple Wartyback

Plate 2, Figure 9

Synonymy:

Obliquaria (Rotundaria) tuberculata Rafinesque, 1820; Rafinesque, 1820:103

Type Locality: Ohio River and its tributaries.

General Distribution: Upper Mississippi River drainage generally; Lake St. Clair drainage, and from Pennsylvania northwest to southern Michigan and northwestern Wisconsin (Mathiak, 1979), south to Iowa, Missouri, and Arkansas. In Canada, Lake Erie and the Sydenham River in southern Ontario (Clarke, 1981a). It occurs throughout the Tennessee and Cumberland river drainages.

North Carolina Distribution: This species is restricted to the New River, Allegheny County, in North Carolina (Table 3).

Description: The shell is compressed (among specimens in streams) to slightly inflated (among specimens in large rivers), solid, subquadrate to circular in outline. Mature individuals may attain a length of 130 mm. Beaks are depressed (in stream forms) to moderately swollen, rather prominent (in large river forms); sculpture consists of numerous fine, irregular, broken ridges, each made up of alternating zigzag bars and loops which continue down the valve until the nodules appear; there is often a shallow, narrow furrow or depression centrally on the umbonal area. A wing like depression above the low dorsal ridge, more extensive in stream forms. Center and posterior surfaces are covered with rounded or elongated tubercles that parallel the growth lines; tubercles are more numerous in stream forms. The anterior end and ventral margins are broadly rounded; the posterior end is occasionally rounded, usually squarely or obliquely truncated.

The left valve has two narrow but heavy, divergent pseudocardinal teeth, deeply serrated between, sometimes almost meeting anteriorly; the two lateral teeth are short, heavy, and slightly curved. The right valve has a single, massive, ragged, slightly triangular-shaped pseudocardinal tooth, usually with a small tubercular tooth on either side. The beak cavity is compressed and deep; the interdentum is wide and flat. The periostracum is a dull yellowish brown to dark brown; young shells occasionally have traces of greenish rays. The nacre varies from a uniform deep purple, often with a coppery tinge along the margin, to light purple with the center (within the pallial line) nearly white; the posterior margin is iridescent (Parmalee and Bogan 1998:68-69).

Life History and Ecology: This mussel typically inhabits a gravel/mud bottom, usually in areas of current or riffles; in water less than two feet in depth, but can occur at depths up to 20 feet. The species is tachytictic, and the reproductive period lasts from June to August. Initial studies by Hove et al. (1994) showed the Channel Catfish *(Ictalurus punctatus)* and Yellow Bullhead *(Ameiurus natalis)* as suitable hosts for glochidia of this mussel. Additional testing of the yellow bullhead confirmed it as a valid host species (Hove et al., 1994). Subsequently, Hove (1997) has reconfirmed the channel catfish as a host species and has added two new host species for the glochidia of the Purple Wartyback: the Flathead Catfish *(Pylodictis olivaris)* and the Black Bullhead *(Ameiurus melas)* (Parmalee and Bogan, 1998).

Status: Special Concern (Williams et al., 1993:11). This species is by the Natural Heritage Program as significantly rare in North Carolina.

Elliptio cistellaeformis (Lea, 1863)
Box Spike

Plate 2, Figure 10

Synonymy:
Unio cistellaeformis Lea, 1863; Lea, 1863:192

Type Locality: Neuse River, near Raleigh, North Carolina.

General Distribution: Restricted to the Atlantic river basins from the Catawba to the Pamlico River basins in North Carolina (Table 2).

North Carolina Distribution: This species is found in the Catawba, Pee Dee Lumber, Cape Fear, Neuse, Pamlico River basins in North Carolina (Table 2).

Description: "Shell smooth, oblong, very much inflated, flattened at the side, inequilateral, obtusely angular behind, rounded before; substance of the shell somewhat thick; beaks somewhat prominent; ligament rather short and dark brown; epidermis dark brown, without rays, with rather close marks of growth; umbonal slope swollen and rounded; posterior slope broad, flattened, scarcely carinate; cardinal teeth small, tuberculate, double in both valves; lateral teeth rather long, lamellar and nearly straight; anterior cicatrices distinct, large and will impressed; posterior cicatrices confluent, large and slightly impressed; dorsal cicatrices placed over the centre of the cavity of the beaks; cavity of the shell deep and wide; cavity of the beaks rather shallow and rounded; nacre white and iridescent: (Lea, 1863:19-20). The shell is very inflated with a very straight ventral margin.

Life History: The host fish for the glochidia of this species is unknown. It is found along the banks often among the tree roots.

Status: Williams et al. (1993:11) listed the status as unknown.

Elliptio complanata
(Lightfoot, 1786)
Eastern Elliptio

Plate 2, Figure 11

Synonymy:

Mya complanata Lightfoot, 1786; Lightfoot, 1786: 100, No. 2190

Comment: Johnson (1970) lists an extensive synonymy for this species. The taxonomy of this species in the southern end of its range becomes very confusing and many of the shell shapes have names but will not be dealt with here.

Type Locality: Maryland. Johnson (1948) restricted the type locality to: Potomac River, Washington, District of Columbia [approximately opposite Fairfax Co. Virginia].

General Distribution: Altamaha River Basin of Georgia, north to the St. Lawrence River Basin, west in the Interior Basin west to Lake Superior and parts of the Hudson Bay Basin.

North Carolina Distribution: This species is wide spread in the Atlantic Slope rivers in North Carolina from the Chowan south to the Broad River. It is introduced into the French Broad River in Buncombe County (T. Savidge, Pers. Comm. March 2002) (Table 2).

Description: Shell shape is trapezoidal to rhomboid or subelliptical, compressed to inflated, shell thickness varies from thin to solid, length 120 mm. Anterior margin is rounded, dorsal and ventral margins are roughly parallel, ventral margin is often straight, posterior margin broadly rounded ending at or near the base in a point or biangulation. Posterior ridge is broad and double and rounded to angular. The posterior slope is flat. Beaks are low and uninflated, beak sculpture consists of 5-6 ridges, the first two or three curved and subconcentric, the rest run parallel to the growth lines, nearly straight in the middle and curved up at both ends. Surface with irregular growth lines and varies from smooth to mat. Left valve has two ragged pseudocardinal teeth and two nearly straight lateral teeth. Right valve has a single pseudocardinal tooth and a single lateral tooth. Interdentum is essentially absent. Beak cavity is shallow. Periostracum is yellowish to brown and blackish, young specimens with indistinct greenish rays present. The rays generally disappear in older shells. Nacre varies from white, pink, salmon, to various shades of purple.

Life History and Ecology: Ortmann (1919:109) commented that the Eastern Elliptio "apparently has no ecological preferences, being found practically in any permanent body of water; in canals and reservoirs with quiet water and muddy bottom, as well as in large rivers with strong current and heavy gravel and rocks. In the small creeks it goes up very far into the headwaters". *Elliptio complanata* is tachytictic, gravid females have been found from late April through the middle of July. The females expelled their glochidia in conglutinates (Ortmann, 1919). The Banded Killifish (*Fundulus diaphanus*), Green Sunfish (*Lepomis cyanellus*), Largemouth Bass (*Micropterus salmoides*), White Crappie (*Pomoxis annularis*), and Yellow Perch (*Perca flavescens*) have been listed as hostfish for the glochidia for this mussel (Watters, 1994:103).

Status: Currently Stable (Williams et al., 1993:11).

Elliptio congaraea (Lea, 1831)
Carolina Slabshell

Plate 2, Figure 12

Synonymy:

Unio congaraeus Lea, 1831; Lea, 1831:72, pl. 6, fig. 4

Type Locality: Congaree River, South Carolina

General Distribution: This species is known from the Ogeechee River system in Georgia north to the Pamlico River system of North Carolina (Johnson, 1970; Table 2).

North Carolina Distribution: *Elliptio congaraea* is known from the Pamlico, Neuse, Cape Fear and Pee Dee River systems in North Carolina (Johnson, 1970; Table 2).

Description: "Shell rhomboid, subcompressed, rather thin to subsolid, somewhat inequilateral; beaks moderately full and slightly elevated; the sculpture consisting of parallel undulations, posterior ridge high and angled, double below, the greatest diameter of the shell being along its line; in front of it the shell is wedge-shaped; basal line nearly straight; posterior end obliquely truncated above, somewhat biangulate below; surface with irregular growth lines, wrinkled on the dorsal slope; epidermis dirty greenish-yellow or tawny, generally rayed, especially in young shells, scarcely shining; left valve with two ragged, subcompressed pseudocardinals and two delicate laterals; right valve with two pseudocardinals, the upper small, and one lateral; beak cavities not deep; muscle scars superficial; nacre purplish, often lurid in the shell cavities." (Simpson 1914:615).

Life History: The host fish for the glochidia of this species is unknown.

Status: Williams et al. (1993:11) listed as special concern. This species is not State listed in North Carolina at this time.

Elliptio dilatata
(Rafinesque, 1820)
Spike

Plate 3, Figure 13

Synonymy:
Unio (Eurynia) dilatata Rafinesque, 1820; Rafinesque, 1820:297

Type Locality: *Unio dilatatus:* no type locality published, but generally considered to be Ohio River.

General Distribution: Entire Mississippi River drainage from the St. Lawrence River and its tributaries south to northern Louisiana and west to the tributaries of the Red River, Oklahoma. Howells et al. (1996) report a single locality on the San Marcos River in Texas. With reference to Canada, Clarke (1981a:268) states that the Spike is "[c]ommon in the Great Lakes and their tributaries from Lake Michigan to Lake Erie; uncommon in Lake Ontario and in the St. Lawrence River."(Parmalee and Bogan, 1998).

North Carolina Distribution: The Spike is known form the Hiwassee, Little Tennessee, French Broad and New River basins in North Carolina (Ortmann, 1918; Table 3)

Description: The shell is compressed to slightly inflated, attenuate, solid, and thick. Mature individuals inhabiting impounded stretches of large rivers become especially large and develop extremely thick shells, many attaining a length of 120 mm. Beaks are depressed and flattened; sculpture consists of 4–5 pronounced loops, running parallel with the growth lines. The anterior end is broadly rounded, the ventral margin is straight or slightly curved, and the posterior end is sharply pointed and often compressed behind the strongly developed, rounded posterior ridge. Concentric rest lines are often prominent. The left valve has two triangular, divergent, compressed pseudocardinal teeth, usually roughened or finely serrated; the two lateral teeth are heavy, rough, widely separated, and the inner surface is usually rough. The right valve has a heavy, triangular pseudocardinal tooth; the lateral tooth is low, thick, and roughened. The interdentum is moderately wide; the beak cavity is usually very shallow or absent. Periostracum of young shells is light brown, greenish, or yellowish green, often faintly rayed; old valves are dark greenish brown to black. The nacre varies from white through salmon to deep purple (Parmalee and Bogan 1998:80).

Life History and Ecology: *Elliptio dilatata* is somewhat generalized relative to the size of rivers, which it inhabits, and depths at which it may occur. A firm substrate composed of coarse sand and gravel with moderately strong current appears to provide the most suitable habitat, but also can be found in soft mud. Baker (1928) indicated the species was tachytictic, the reproductive season occurring from mid-May to August. The Gizzard Shad *(Dorosoma cepedianum),* Flathead Catfish *(Pylodictis olivaris),* White Crappie *(Pomoxis annularis),* Black Crappie *(P. nigromaculatus),* and the Yellow Perch *(Perca flavescens)* have been listed by Fuller (1974) as host species for the glochidia. Under laboratory conditions Luo (1993) was able to infect the Rainbow Darter *(Etheostoma caeruleum),* Banded Sculpin *(Cottus carolinae),* and Rockbass *(Ambloplites rupestris)* with glochidia of the Spike (Parmalee and Bogan, 1998).

Status: Currently Stable (Williams et al., 1993:11). This species is listed as State Special Concern in North Carolina.

Elliptio folliculata (Lea, 1838)
Pod Lance

Plate 3, figure 14

Synonymy:

Unio folliculatus Lea, 1838; Lea, 1838:38, pl. 11, fig. 33

Type Locality: Savannah River, Georgia (Lea, 1838)

General Distribution: the Pod Lance ranges from the Savannah River north to the Waccamaw and Cape Fear River basins in North Carolina (Johnson, 1970; Table 2).

North Carolina Distribution: This species is found in the Cape Fear, Waccamaw and Pee Dee River basins. (Table 2)

Description: This is a narrow, uninflated, elongated naiad that in its lake form resembles a straight-edged razor. The umbo is flat and the dorsal and ventral shell margins are parallel to each other. The anterior-dorsal margin is angular in shape. The shell is covered by a rough dark-brown to black periostracum. The shell nacre of inner shell surface varies from bluish to pink. The hinge has pyramidal pseudo-cardinal teeth.

The original description by Lea (1838) is as follows: "Shell narrow-elliptical, very transverse, very inequilateral, subbiangular behind, rounded before, rather compressed, flattened at the side; substance of the shell rather thin; beaks scarcely prominent; ligament long and curved; epidermis very dark brown; cardinal teeth small and lobed; lateral teeth long and somewhat curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices in the center of the cavity of the beaks; cavity of the shell small; cavity of the beak very small; nacre purple and iridescent." (Adams et al., 1990).

Life History: As in all *Elliptio* species, the cream colored marsupium of the female extends along the ventral margin of the entire outer demibranch. Habitat depth ranged between 1.4-3.0 m in the lake. Host fish for the glochidia of this species is unknown.

Generally the species was found in a sand substrate at greater than one-meter depths in Lake Waccamaw waters (Porter, 1985). Specimens from Big Creek and Waccamaw River were collected in conditions similar to that from Lake Waccamaw except that some downstream Waccamaw River specimens were extracted from a clay bank in a semi-swift flowing river segment. On the other hand, the Orton Pond canal habitat was a muddy high-sided bank with considerable vegetation near by in sluggishly moving water

This species, like most *Elliptio* sp., is believed to be tachytictic (short-term breeder). Of the few specimens collected in Lake Waccamaw waters during the 1978-1981 sampling period (Porter, 1985), gravid conditions were seen only in June, 1980 and August, 1980. Since then, gravid specimens have been collected in July (1986) from a canal exiting Orton Pond, Brunswick County, North Carolina (Adams et al., 1990)

Status: Williams et al. (1993:11) listed as special concern. This species is listed as Sate Special Concern in North Carolina.

Elliptio icterina (Conrad, 1834)
Variable Spike

Plate 3, Figure 15

Synonymy:
Unio icterinus Conrad, 1834; Conrad, 1834:41, pl. 6, fig. 5

Type Locality: Muddy shore, Savannah River opposite Augusta [Richmond Co.] Georgia (Johnson, 1970).

General Distribution: St. Marys River of Florida north to the Chowan River system in Virginia (Johnson, 1970; Table 2).

North Carolina Distribution: This species is found in from the Broad River basin north to the Roanoke River basin (Johnson, 1970; Table 2).

Description: "Shell oblong, subelliptical or subrhomboid, convex, solid, inequilateral; beaks moderately full and elevated, their sculpture a number of strong concentric ridges; posterior ridge prominent, somewhat double, ending behind in a narrow faint biangulation at or below the median line; surface nearly smooth; epidermis greenish-yellow to tawny or tawny-brown, usually showing dark rest marks, scarcely rayed, shinning; pseudocardinals subcompressed to solid, rough; laterals long, curved; muscle scars large, impressed; nacre white often silvery, a little thicker in front." (Simpson, 1914:665).

Life History: No host fish are known for the glochidia of this species.

Status: Williams et al. (1993:11) listed as currently stable.

Elliptio judithae Clark, 1986
Neuse Slabshell

Not figured

Synonymy:

Elliptio judithae Clark, 1986; Clarke, 1986:78-96

Type Locality: The holotype is from the Neuse River at Seven Springs, Wayne County, North Carolina. Paratypes are from the Neuse River above the U. S. Route 301 bridge near Smithfield, Johnston County, and at Milburne, 7 miles east of Raleigh, in Wake County. (Adams et al., 1990).

General Distribution: Restricted to the Neuse River, North Carolina.

North Carolina Distribution: Known definitively only from the Neuse River at Milburne (Wake County), Smithfield (Johnston County), and Seven Springs (Wayne County). Conchologically similar shells collected from the Tar River below Rocky Mount probably belong to this species. (Adams et al., 1990).

Description: The Neuse Slabshell is a freshwater mussel with an appressed, elliptical shell. Specimens up to about 85 mm in length have been collected. Height of the shell is about 48% of the length and the valves are thin. The shell is sculptured with plicate ridges, each about 1.5 mm to 3.0 mm wide, and the periostracum is glossy. The shell is generally yellowish to dark brown with faint, narrow green rays. The hinge teeth are complete, the pallial line distinct, and the nacre pale purple. Morphs of other *Elliptio*s may share some of these characteristics, however, soft-part anatomy of *Elliptio judithae* will serve to distinguish it from such specimens. *E. judithae* has coronate incurrent papillae and irregularly-developed brachial septa, characters not known to be shared by any other *Elliptio*. A complete description and photographs of the species can be found in Clarke (1986) (Adams et al., 1990).

Life History: Nothing is known of the life history and ecology of the species. Its fish host is unknown. The holotype was collected in water 0.15 m deep on a sand bar in the middle of the Neuse River, which was about 100 m wide at the site.

Status: Williams et al. (1993) did not list this species but assumed it was a synonym of *Elliptio roanokensis.*

Remarks. Recently, J. M. Alderman collected a gradating series of specimens of *Elliptio roanokensis* from the Tar River near Tarboro, North Carolina, and found that the smaller specimens bore striking conchological and soft-tissue similarity to *E. judithae*. This raises the possibility that our species concept of *E. judithae*, as defined by Clarke (1986), needs to be reassessed (Adams et al., 1990).

Elliptio lanceolata (Lea, 1828)
Yellow Lance

Plate 3, figure 16

Synonymy:

Unio lanceolatus Lea, 1828; Lea, 1828:266, pl. 3, fig. 2

Type Locality: Tar River at Tarborough [Edgecombe County], North Carolina (Johnson, 1970).

General Distribution: The yellow lance is known from the Tar, Roanoke, James, and Rappahannock drainages (A. Gerberich, pers. comm.) (Adams et al., 1990).

North Carolina Distribution: the Yellow Lance is restricted to the Pamlico and Neuse River systems (Table 2).

Description: This elongate, freshwater mussel grows to approximately 86 mm long. Shells are over twice as long as tall. The periostracum is usually bright yellow over the entire surface in younger individuals. Older individuals may have a brown discoloration at the posterior end of the shell. (Uniformly brown individuals are also found; however, yellow and brown individuals are not found at the same stations.) The nacre may range from salmon to white to an iridescent blue color. The posterior ridge is distinctly rounded and curves dorsally toward the posterior end. Rays are usually never present; however, one individual has been observed with three wide, prominent green rays on the posterior third of the shell in the Tar River Drainage Basin (Adams et al., 1990). Brownish growth rests are clearly evident on the periostracum. The pallial line and adductor muscle scars are distinct. The posterior adductor muscle scars are less impressed than the anterior adductor muscle scars. The lateral teeth are long - two on the left valve and one on the right valve. Two pseudocardinal teeth are on each valve. On the left valve one is before the other with the posterior tooth tending to be vestigial. On the right valve, the two pseudocardinal teeth are parallel with the more anterior one rather vestigial. (Adams et al., 1990)

Life History: *Elliptio lanceolata* prefers clean, coarse to medium size sands as substrate. On occasion, specimens are also found in gravel substrates. This species is found in the main channels of drainages down to streams as small as three feet across. Gravid females have been found in the Tar River Drainage Basin in June (Alderman, unpubl. data). As verified by Tankersley (1988), the glochidia are hookless. The fish host for this species has not been determined.

Status: Williams et al. (1993:11) listed as endangered. The existence of the Yellow Lance in the Roanoke Drainage Basin has not been verified in recent years. In the Tar River, this species has declined (Alderman 1988) since A. Clarke (1983) completed his survey for the Tar River spiny mussel (Adams et al., 1990). This species is listed as State Endangered effective July 1, 2002.

Elliptio marsupiobesa Fuller, 1972

Cape Fear Spike

Plate 3, Figure 17

Synonymy:

Elliptio marsupiobesa Fuller, 1972; Fuller, 1972:1-10

Type Locality: Cape Fear River, 0.1 miles downstream from Carvers Creek, Cumberland County, North Carolina.

General Distribution: *Elliptio marsupiobesa* is only known from the Cape Fear River, North Carolina.

North Carolina Distribution: *Elliptio marsupiobesa* is only known from the Cape Fear River in Cumberland and Bladen counties

Description: The Cape Fear spike may reach about three inches in length. The anterior third of the shell is considerably thicker than the posterior third, and the shell appears to significantly thicken as individuals grow. The shell is distinctly wedge shaped without sexual dimorphism. The swollen posterior ridge is keeled and the posterior slope is narrow and concave. Adults have one or two radial grooves on the posterior slopes. Growth rests are clearly expressed in the shells. The periostracum of young individuals is smooth with a shiny, yellow-brown color. Green rays may be present on the posterior half of the shell. Older individuals are a dark brownish-black with roughened margins and posterior slopes. (Adams et al., 1990).

Life History: As provided by Fuller (1972), the Cape Fear spike was found in muddy, loose, sandy substrates below logjams. It was not found in firm, sandy substrates. Fuller (1972) found gravid females around the middle of June. Nothing is known about the fish hosts or ecology of the species (Adams et al., 1990).

Status: Williams et al. (1993:1) listed as currently stable. This species is listed as State Special Concern.

Elliptio roanokensis (Lea, 1838)
Roanoke Slabshell

Plate 3, Figure 18

Synonymy:

Unio roanokensis Lea, 1838; Lea, 1838:27, pl. 8, fig. 21

Type Locality: Roanoke River, between Tarboro, North Carolina and Norfolk, Virginia.

General Distribution: According to Walter (1954) the Roanoke Slabshell ranges from the Connecticut River in Massachusetts to the Savannah River in Georgia.

North Carolina Distribution: This species is found in the Cowan, Roanoke, Pamlico, Neuse, Cape Fear and Pee Dee River systems (Table 2).

Description: Individual Roanoke Slabshells grow to greater than 150 mm total length. In North Carolina it is one of our largest freshwater mussel species. Of 13 specimens recently examined from the Tar River, the height to length ratio ranged from .458 to .544, and the width to length ratio ranged from .212 to .283. The posterior ridge varies from being well defined to being uniformly rounded. The periostracum is generally smooth except near the margins of the shell. Growth rests are distinct. Color of the periostracum is usually a yellow-reddish-brown, which darkens with age. Narrow greenish rays are often present from the anterior end of the shell to the posterior ridge. The rays are less distinct in larger individuals. The nacre is usually purple(Adams et al., 1990).

Life History: Little is known of the life history and ecology of this species. In the Tar River, the Roanoke Slabshell is usually found associated with the deeper channels near shore in relatively fast flowing water. The substrate consists of coarse to medium sized sands and small gravel (Alderman, unpubl. data) (Adams et al., 1990).

Status: Williams et al. (1993:11) listed as special concern. This species is listed as State Threatened.

Remarks: Johnson (1970) considered the Roanoke Slabshell to be one of the many forms of *Elliptio complanata* found throughout the southern Atlantic Slope Region. However, the Roanoke Slabshell has a centrally plicate shell, certain of the incurrent papillae being subdivided into smaller papillae, and irregularly developed branchial septa. These characteristics distinguish the Roanoke Slabshell from *Elliptio complanata*. Clarke (1986) described *Elliptio judithae* from the Neuse River. His description of the species matched that of smaller individual Roanoke Slabshells (Adams et al., 1990).

Elliptio steinstansana
Johnson and Clarke, 1983
Tar River Spinymussel

Plate 4, Figure 19

Synonymy:
Elliptio steinstansana Johnson and Clarke, 1983; Johnson and Clarke, 1983:289-298

Type Locality: Near Tarboro in Edgecombe County, North Carolina

General Distribution: This species is found in the Pamlico and in the lower Neuse River basins of North Carolina (Johnson and Clarke, 1983, J. Alderman, Pers. Comm.).

North Carolina Distribution: The Tar River Spinymussel is restricted to the Tar River basin and one site on a tributary in the lower Neuse River Basin (Johnson and Clarke, 1983; Alderman, 1988; J. Alderman, Pers. Comm.).

Description: This small, subrhomboid mussel grows to approximately 60 mm long. Short spines (up to 5 mm long) are found on most specimens. As many as 12 spines have been found on juveniles; however, adults tend to lose some of their spines as they mature. In general, spines arranged in a radial row slightly anterior of the posterior ridge on one valve are symmetrically positioned with the spines on the opposite valve. Some individuals may have two rows of spines on each valve. The smooth, orange-brown to dark brown periostracum may be rayed in younger individuals. The shell is significantly thicker toward the anterior end, and the nacre is usually pink in this area. The posterior end of the shell is thinner with an iridescent bluish white color. Two or more linear ridges, originating within the beak cavity and extending to the ventral margin, can be found on the interior surface of the shell. The distance between these ridges widens toward the ventral margin. Johnson and Clarke (1983) provide additional descriptive material.

Life History: It appears that the Tar River Spinymussel's preferred habitat includes the following: relatively fast flowing, well oxygenated, circumneutral pH water; relatively silt-free, uncompacted, gravel/coarse sand substrate; sites prone to significant swings in water velocity (Adams et al., 1990). The Tar River spiny mussel is probably a tachytictic reproducer with gravid females present at some time from April through August (Widlak 1987). The glochidia have not been described and the fish host is unknown.

Status: Williams et al. (1993:11) listed as endangered. This species is federally and state listed as Endangered. The U.S. Fish and Wildlife Service has developed a recovery plan for this species (U.S. Fish and Wildlife Service, 1992).

Elliptio waccamawensis
(Lea, 1863)
Waccamaw Spike

Plate 4, Figure 20

Synonymy:
Unio waccamawensis Lea, 1863; Lea, 1863:193

Type Locality: Lake Waccamaw, North Carolina

General Distribution: This species is restricted to the Waccamaw basin in North Carolina and South Carolina (Johnson, 1970; Heard, 1975; Adams et al., 1990).

North Carolina Distribution: The Waccamaw Spike is restricted to the Waccamaw Lake and River in North Carolina (Johnson, 1970; Porter and Horn, 1984a; Adams et al., 1990, Table 2).

Description: This naiad has a moderately inflated elliptical shell with a prominent angular ridge on its posterior slope. The ventral margin is straight. The umbo has a trapezoidal beak sculpture. Pseudo-cardinal teeth are present on the hinge and variable in shape. There is a white to bluish nacre on the inner shell surface. A light to dark brown smooth periostracum covers the outer shell surface.

"Shell smooth, triangular, inflated, flattened at the sides, very inequilateral, subbiangular behind, rounded before; valves thin; beaks prominent; epidermis brownish green or olivaceous, obscurely rayed; cardinal teeth very small, compressed, oblique, double in both valves; lateral teeth long, lamellar and straight; nacre bluish white and iridescent." (Lea, 1863) (Adams et al., 1990).

Life History: Glochidia are suboval, hookless and marginally bilaterally asymmetrical in shape. Its hinge varies from straight to slightly concave in appearance. Dimensions, as reported in Porter and Horn (1980) are: length = 0.210 mm; height = 0.217 mm; hinge length = 0.144 mm; hinge length/length ratio = 0.69; height/length ratio = 1.04; and hinge length/height ratio = 0.66. This is a short-term breeder (tachytictic). Time of its reproductive cycle does vary from season to season. Marsupia have been observed from April into August. Glochidia have been found in May through July. Host fish for the glochidia are unknown.

The 1978-1981 survey (Porter, 1985) found large numbers of *E. waccamawensis* throughout the lake including in the deepest depths where the substrate is peat. Average density of the species in the lake was 22.79/m^2. Highest recorded density was 132.3/m^2. Densities of *E. waccamawensis* were positively correlated with light penetration and pH; densities were negatively correlated with: sediment pheo-pigment and mean sediment size (Ø units). *Elliptio waccamawensis* densities were lower within beds of the emergent plants Maidencane and Spatterdock than in areas not containing Maidencane and Spatterdock (Adams et al., 1990).

Status: Williams et al. (1993:11) listed as special concern. This species is listed as State Endangered effective July 1, 2002.

Epioblasma capsaeformis
(Lea, 1834)
Oyster Mussel

Plate 4, Figure 21

Synonymy:

Unio capsaeformis Lea, 1834; Lea, 1834:31, pl. 2, fig. 4

Type Locality: Cumberland River, Tennessee.

General Distribution: Found throughout the Tennessee River system in Virginia, Tennessee, North Carolina, and northern Alabama, and in the Cumberland River system in Kentucky and Tennessee (Johnson, 1978).

North Carolina Distribution: This species is known historically from the French Broad River in Ashville, Buncombe County (Ortmann, 1918).

Description: The shell is elliptical or irregularly obovate in outline and of medium size: maximum length is about 70 mm. Valves are subsolid and somewhat inequilateral. Beaks are moderately full and elevated, located slightly anterior of the middle of the shell in males and within the anterior third of the shell in females; the sculpture is feeble, consisting of 2–4 faint parallel loops discernible only in very young juveniles. The surface of the shell is covered with irregular growth lines. The hinge ligament is short. The dorsal shell margin is straight, and the anterior end is regularly rounded; the posterior end of males is slightly protruding; females are more broadly rounded. The ventral margin in males is slightly curved; in females, it is straight and anterior to the sulcus, but behind the sulcus there is a pronounced, rounded marsupial swelling extending well below the base. Marsupial swelling is thin, slightly inflated, often offset from the rest of the shell by an anterior and posterior sulcus, sometimes toothed along the margin. Male shells are almost regularly elliptical, with a double posterior ridge, slightly biangulate behind. Female shells are obovate with a distinct thin, slightly inflated marsupial swelling, darker than the rest of the shell.

The left valve has two small, triangular, subcompressed pseudocardinal teeth, a narrow interdentum, with two short, slightly curved lateral teeth. The right valve has a single stout, triangular, subcompressed pseudocardinal tooth, sometimes with a small tooth on either side, a narrow interdentum, and a single short, slightly curved lateral tooth. The beak cavity is shallow; anterior adductor muscle scars are small, well-impressed; posterior adductor muscle scars are longer and shallow. The pallial line is distinct anteriorly, fading posteriorly. The periostracum subshiny, yellowish green, with fine green rays over entire shell. The marsupial swelling of the female is usually dark green, sometimes almost black. The nacre color is bluish white to creamy. (Parmalee and Bogan, 1998).

Life History and Ecology: The Oyster Mussel can be found living in shallow riffles in fast water less than three feet in depth in a gravel and sand substrate. S. A. Ahlstedt (pers. comm., 1992) noted that the Oyster Mussel females, when releasing glochidia, move up onto the surface with the ventral margin uppermost, the mantle margins being visible at some distance. Ortmann (1924:53) observed that the “pad” of the mantle margin in females collected from the Duck River was “grayish to blackish, and never of the peculiar bluish or greenish-white so often seen in upper Tennessee specimens.” The Oyster Mussel is a long-term brooder (bradytictic): gravid individuals have

been observed from early spring into fall. Fish species identified as hosts for the glochidia include the Spotted Darter *(Etheostoma maculatum),* Redline Darter *(E. rufilineatum),* Dusky Darter *(Percina sciera),* Banded Sculpin *(Cottus carolinae)* (Yeager, 1987; Neves, 1991), and Wounded Darter *(E. vulneratum)* (Yeager and Saylor, 1995) (Parmalee and Bogan, 1998).
Status: Endangered (Williams et al., 1993:11). The Oyster mussel is federally and State listed as endangered. Adams et al. (1990) presumed this species is extirpated in North Carolina.

Fusconaia barnesiana (Lea, 1838)

Tennessee Pigtoe

Plate 4, Figure 22

Synonymy:

Unio barnesianus Lea, 1838; Lea, 1838b:31, pl. 10, fig. 26

Type Locality: Cumberland River, Tennessee.

General Distribution: Cumberland and Tennessee River systems (Simpson, 1914).

North Carolina Distribution: This species is known only from the Hiwassee and Little Tennessee River basins (Table 3).

Description: The shell of *Fusconaia barnesiana* is highly variable in outline, dimension, color, and pattern, factors that resulted in the recognition of three subspecies, which may in reality reflect a headwaters-to-big-river cline and individual variations.

Shells of *Fusconaia barnesiana* are strong, occasionally very thick and heavy, oval, and somewhat truncated to triangular in outline, especially in *F. b. bigbyensis.* Mature specimens may reach a length of 90–95 mm. The posterior ridge is usually distinct but typically rounded; the anterior and ventral margins are broadly rounded, while the posterior margin is straight. Beaks are only slightly inflated to rather high and full. The surface is usually evenly roughened with fine, uneven growth lines.

The left valve has two erect pseudocardinal teeth; the more dorsal one is often short and triangular, and the anterior tooth is elongated and bladelike. The two lateral teeth are moderately long and straight; in some individuals they are relatively short, slightly curved, and widely separated. The right valve has a large, erect, elongated pseudocardinal tooth, usually with a smaller low tooth on either side; the lateral tooth is long and straight, sometimes with a second low tooth present. Often the pseudocardinal teeth project ventrally at a 90° angle from the lateral teeth. The beak cavity is shallow to nearly wanting; the interdentum is usually wide. Muscle scars are deeply impressed. The periostracum of juveniles is a dull yellowish olive or brown with a satiny appearance, becoming dark brown to blackish with age. Some individuals are marked with a few to many dark green rays. The nacre color is white, and some specimens have a faint salmon wash (Parmalee and Bogan, 1998).

Life History and Ecology: The Tennessee Pigtoe is probably tachytictic, spawning in late spring and being gravid into midsummer, based on data for other species of *Fusconaia (F. cor* and *F. cuneolus)* found living in the same rivers and under the same habitat conditions as *F. barnesiana* (Neves, 1991). Host fish for the glochidia unknown (Parmalee and Bogan, 1998).

Status: Special Concern (Williams et al., 1993:11). This species is listed as State Endangered, effective July 1, 2002.

Fusconaia masoni (Conrad, 1834)
Atlantic Pigtoe

Plate 4, Figure 23

Synonymy:
Unio masoni Conrad, 1834; Conrad, 1834:34, pl. 5, fig. 2

Type Locality: Savannah River, Augusta, [Richmond Co.] Georgia (Johnson, 1970).

General Distribution: The Atlantic Pigtoe ranges from the Ogeechee Drainage Basin, Georgia north to the James Drainage Basin, Virginia. In North Carolina, this species was once found in every Atlantic drainage except the Cooper- Santee and Waccamaw drainage basins (Johnson 1970).

North Carolina Distribution: This species is known from the Catawba, Pee Dee, Cape Fear, Neuse, Pamlico, and Roanoke River basins (Aarons Creek) (Johnson, 1970; Table 2).

Description: Atlantic Pigtoes are sub-rhomboidal except in individuals from headwater areas. Such individuals tend to be more elongate. The posterior ridge is very distinct, and the umbos extend well above the dorsal margin. The periostracum is yellow to dark brown and parchment like. The nacre ranges from an iridescent blue, to salmon, to white, to orange. Pseudocardinal and lateral teeth are well developed except for the anterior pseudocardinal tooth in the right valve, which is vestigial. All four demibranchs serve as marsupia in gravid females. As the glochidia mature, the demibranchs and adductor muscles develop a bright orange-red to red color. Additional species descriptions can be found in Johnson (1970) and Fuller (1973).

Life History: The preferred habitat for the Atlantic Pigtoe is a yielding substrate composed of coarse sands and gravel at the downstream edge of riffle areas. In such habitats, which are becoming increasingly rare since sedimentation significantly affects such areas, as many as five live individuals have been found in a one-meter square area. This species is less common in sands, cobble, and mixed substrates of sand, silt, and detritus. Little is known about other aspects of its life history or ecology (Adams et al., 1990). Watters and O'Dee (1997) identified the Bluegill (*Lepomis macrochirus*) and the Shield Darter (*Percina peltata*) as potential fish hosts for *Fusconaia masoni* glochidia.

Status: Williams et al. (1993:11) listed as threatened. This species is listed as State Endangered, effective July 1, 2002.

Fusconaia subrotunda (Lea, 1831)
Long-solid

Plate 4, Figure 24

Synonymy:
Unio subrotundus Lea, 1831; Lea, 1831:117, pl. 18, fig. 454

Type Locality: Ohio

General Distribution: Ohio, Cumberland, and Tennessee River systems (Simpson, 1914:893).

North Carolina Distribution: This species is reported from the Hiwasssee and French Broad rivers (Ortmann, 1918; Table 2).

Description: The big river form of *Fusconaia subrotunda* has a shell that is oval to broadly elliptical or oblong in outline, solid, and inflated. Beaks are high, full, and turned forward over the lunule; sculpture consists of a few subnodular ridges or wrinkles. The anterior margin is broadly rounded, and the ventral and posterior margins are slightly curved to nearly straight; lacking a distinct posterior ridge, the dorsal slope is evenly curved. The shell surface is generally sculptured with low, wide, concentric ridges. Mature individuals may reach a length of 130 mm. Shells of the medium-sized to small river forms, *Fusconaia subrotunda kirtlandiana* are more compressed and Ortmann (1919) noted that the two forms graded into one another and the separation was artificial. The left valve has two low, heavy triangular pseudocardinal teeth, widely separated with deep striations; the two lateral teeth are moderately long and straight. The right valve has a heavy, triangular serrated pseudocardinal tooth usually with a low tooth or roughened area on either side. The lateral tooth is broad, serrated, and often doubled for most of its length. Muscle scars are deeply impressed, the interdentum is usually wide, and the beak cavity is deep and somewhat compressed. The periostracum is a dull straw yellow to greenish brown, becoming blackish in old individuals. Some may show subtle green rays, primarily on the umbos. The nacre is pearly white and iridescent posteriorly (Parmalee and Bogan 1998:120-121).

Life History and Ecology: The small to medium-sized river forms of *Fusconaia subrotunda* typically are found in currents, usually in riffle areas, at a depth of less than two feet. The big river form, such as specimens formerly inhabiting the Ohio, Allegheny and Monongahela rivers lived at depth, in strong current, and on a gravel substrate. The more compressed small river form was widespread living in gravel and sand substrates with good current (Ortmann, 1919). The Longsolid, like other species of *Fusconaia* for which the breeding season is known, is probably tachytictic, the females becoming gravid during the summer. Host fish for the glochidia is unknown.

Status: Special Concern (Williams et al., 1993:11).

Lampsilis cariosa (Say, 1817)
Yellow Lampmussel

Plate 5, Figure 25

Synonymy:

Unio cariosus Say, 1817; Say, 1817:no pagination, pl. 3, fig. 2

Unio crocatus Lea, 1841; Lea, 1841:31

Type Locality: Delaware and Schuylkill rivers; [Susquehanna River] Wilkes Barre; [Luzerne County; all Pennsylvania] Johnson (1947) restricted the type locality to Schuylkill river, near Philadelphia, Pennsylvania.

General Distribution: The Yellow Lampmussel extends from the Ogeechee River Basin, Georgia, north to Nova Scotia and Cape Breton Island, and westward in the St. Lawrence River Basin to the lower Ottawa River drainage and the Madawaska River (Johnson, 1970).

North Carolina Distribution: This species is known from the Pee Dee, Waccamaw, Cape Fear, Neuse, and Pamlico basins (Johnson, 1970; Table 2).

Description: Shell shape is obovate, shell thickness begins as thin in juveniles becoming thicker with age, moderately inflated, shell length 120 mm. Anterior margin is rounded, ventral margin slightly curved, posterior margin bluntly rounded. Male shells elliptical and somewhat elongate in outline with the ventral margin evenly convex. Female shells are subovate to obovate in outline with the ventral margin expanded near the posterior margin, sloping up to a very bluntly rounded posterior margin. Posterior ridge is poorly developed and rounded, posterior slope slightly convex to flat. Beaks moderately swollen but not elevated much above the hingeline, located anterior of the middle of the shell, beak sculpture consist of about five poorly defined bars, the first ridge concentric with the remainder slightly double-looped. Periostracum is waxy and shiny.

Left valve with two compressed pseudocardinal teeth, the posterior tooth low and immediately under the umbo, two delicate lateral teeth. Right valve has a single compressed pseudocardinal tooth, and a single lamellar lateral tooth. The pseudocardinal teeth tend to become more stumpy and ragged with age. Interdentum is practically absent, the beak cavity is open and moderately deep. Periostracum is waxy yellow, often with a trace of green in it, rays are either absent or restricted to the posterior slope or slightly in front of it. The rays are variable in width, but usually thin, sharp and dark green to black, contrasting with the yellow of the background. Older specimens become brownish and loose much of the luster. Nacre color bluish-white, often tinged with cream or salmon.

Life History and Ecology: Ortmann (1919) observed that gravid females were seen in August, with glochidia appearing only in late August. The species is bradytictic, releasing glochidia in the following spring or early summer. The Yellow Lampmussel is found in medium to larger rivers often in sand in bedrock cracks, but also is found in silt, sand, gravel, and cobble substrates. Wick and Huryn (2002) have identified the Yello Perch (*Perca flavescens*) and the White Perch (*Morone americana*) as host fish for the Yellow Lampmussel in Maine.

Status: Threatened (Williams et al., 1993:12). This species is listed as State Endangered, effective July 1, 2002.

Lampsilis fasciola
Rafinesque, 1820
Wavyrayed Lampmussel

Plate 5, Figure 26

Synonymy:

Lampsilis fasciola Rafinesque, 1820; Rafinesque, 1820:299

Type Locality: Kentucky River.

General Distribution: "Great Lakes drainage in the tributaries of lake Michigan, Lake Huron, Lake St. Clair and Lake Erie, and Ohio–Mississippi drainage south to the Tennessee River system" (Clarke, 1981a).

North Carolina Distribution: The Wavyrayed Lampmussel occurs in a large number of medium-sized rivers including the Hiwassee, Little Tennessee, Pigeon, and French Broad rivers (Ortmann, 1918, Table 3).

Description: The shell is elliptical or subovate, fairly thin to solid and heavy; it is generally inflated, especially so as a marsupial swelling in some females. Mature individuals may reach a length of 90–100 mm. The anterior end is broadly rounded; the ventral margin is straight to slightly curved; the posterior end is rounded (in some females) to bluntly pointed (in males). The posterior ridge is broadly rounded; the posterior-dorsal margin is occasionally compressed, appearing alate. Beaks are full, depressed, and only slightly elevated above the hinge line; sculpture consists of several indistinct, fine, wavy ridges. The surface is shiny, usually with numerous raised rest lines.

The left valve has two triangular, short, thick, rather widely separated pseudocardinal teeth; the two lateral teeth are short, thick, nearly straight, and widely separated. The right valve has a large, coarsely serrated, heavy, erect pseudocardinal tooth, sometimes with a suggestion of a smaller tooth on either side as slightly roughened, raised areas; the lateral tooth is wide, short, and elevated. The interdentum is narrow or absent; the beak cavity is wide and moderately deep. The periostracum is light yellow or yellowish green, the beaks often tinged with reddish brown; the surface is densely patterned with green rays of varying widths, characteristically wavy in appearance, and often interrupted at the lines of growth. The nacre is white or bluish-white as a result of iridescence, especially posteriorly (Parmalee and Bogan, 1998).

Life History and Ecology: *Lampsilis fasciola* is a species typical of small to medium-sized rivers, usually occurring at depths of three feet or less. This mussel appears tolerant of habitat conditions unfavorable to many species, and, under favorable circumstances, including moderate current and a stable substrate composed of mud, sand, and gravel, it may become quite abundant locally. In spite of the extensive range and local abundance of the Wavyrayed Lampmussel, its reproductive period remains unknown, although there is some evidence to suggest it is bradytictic. In their detailed study of fish hosts of four species of Lampsiline mussels, Zale and Neves (1982a) found that glochidia of *Lampsilis fasciola* parasitized only Smallmouth Bass *(Micropterus dolomieu).* Brian Watson, in experimenting with potential fish hosts for the glochidia of this mussel, was able to get glochidia to parasitize and transform on Largemouth Bass *(Micropterus salmoides)* (S. A. Ahlstedt, pers. comm., 1996; Parmalee and Bogan, 1998).

Status: Currently Stable (Williams et al., 1993:12). This species is listed as State Special Concern.

Lampsilis fullerkati Johnson, 1984
Waccamaw Fatmucket

Plate 5, Figure 27

Synonymy:
Lampsilis fullerkati Johnson, 1984; Johnson, 1984:305-319

Type Locality: Lake Waccamaw, North Carolina.

General Distribution: Restricted to the Waccamaw basin in North Carolina and South Carolina (Johnson, 1984).

North Carolina Distribution: Restricted to the Waccamaw basin (Johnson, 1984).

Description: "Shell small, seldom exceeding 60 mm in length. Outline elongated rhomboidal to long elliptical. Valves subinflated, thin, inequilateral. Anterior end regularly rounded; posterior end slightly biangulate and pointed toward the base in the male; female broadly rounded and somewhat expanded in the postbasal region. Ventral margin straight, slightly curved, or occasionally arcuate roughly parallel to the almost straight dorsal margin, which forms an angle with, or merges imperceptibly with the obliquely descending margin. Posterior ridge high somewhat angular, usually with a faint second ridge above it ending behind in a broad point in the male. Umbos rather sharp but not full or high, located in the anterior quarter of the shell, their sculpture not observed. Periostracum rather smooth with delicate growth lines, generally yellowish or brownish green, with rather fine dark greenish rays of varying width often visible over the entire surface.
Left valve with two stumpy pseudocardinal teeth, one in front of the other, often of almost equal height. Hinge line short and narrow, two short almost straight lateral teeth. Right valve with one triangular pseudocardinal, and a vestigial one before it; one lateral tooth. Beak cavities very shallow, with a few dorsal muscle scars. Anterior and posterior adductor muscle scars and pallial line distinct. Nacre purplish often lurid and spotted, somewhat iridescent." (Johnson, 1984).
The rays and lessened sharp angular ridge on the posterior shell slope of *L. fullerkati* help separate it from *E. waccamawensis* (the latter generally is without rays on its posterior surface).

Life History: Glochidia have valves that are bilaterally symmetrical, hookless and purse shaped. There are eyespots near the ventral border. The hinge line is straight with the umbos extending slightly above the hinge line giving this line sometimes a false convex appearance. Dimensions, as reported in Porter and Horn (1980) (under *Lampsilis* sp.) are: length = 0.222 mm; height = 0.276 mm; hinge length = 0.120 mm; hinge length/length ratio = 0.76; height/length ratio = 1.24; and hinge length/height ratio = 0.44.
Average habitat depth for this naiad was 2.07 m with a range of 0.4-3.5 m
This species is a typical lampsilid bradytictic (slow term or winter) breeder (Porter, 1985, Porter and Horn, 1983). Evidence of breeding condition (female gills containing a swollen marsupia) by this lampsilid were observed in Lake Waccamaw waters during the 1979-1981 investigative period (Porter, 1985): April, June 1979; March, June, September, December 1980.

Status: Williams et al. (1993:12) listed as threatened. This species is listed as State Threatened in North Carolina.

Lampsilis radiata radiata (Gmelin, 1791)
Eastern Lampmussel
Lampsilis radiata conspicua (Lea, 1874)
Carolina Fatmucket

Plate 5, Figure 28

Synonymy:
Mya radiata Gmelin, 1791; Gmelin, 1791:3220
Unio conspicuus Lea, 1872; Lea, 1872:156

Type Locality: Ortmann (1919:296) reported the locality of Malabar listed by Gmelin (1791) as incorrect and noted Lamarck (1819) had listed it from Saratoga Lake in New York and recommended "if there should not be any other earlier record, we might select this as the type locality." Simpson (1914) listed Virginia as the type locality. Johnson (1970) restricted the type locality to Potomac River, District of Columbia (approximately opposite, Farifax Co., Virginia). We use the Saratoga Lake, NewYork as the type locality.

General Distribution: The Eastern Lampmussel occurs discontinuously north from the Pee Dee River of South Carolina to the St. Lawrence River Basin, extending west to Lake Ontario.

North Carolina Distribution: The Eastern Lampmussel is found in the Pee Dee, Waccamaw, Cape Fear, Neuse, and Pamlico basins (Johnson, 1970, Keferl and Shelley, 1988; Table 2). The Carolina Fatmucket is found in the headwaters of the Yadkin-Pee Dee and Neuse river basins in North Carolina (Table 2).

Description: Shell shape is subelliptical to subovate in outline, shell valves are thick and solid, shell valves vary from hardly inflated to quite inflated, shell length is 93 mm. Anterior end rounded, ventral margin straight to gently curved, posterior margin rounded. Male shells elongate and not expanded posteriorly, while female shells are expanded in the postbasal area, but the amount of swelling is variable and some females are difficult to distinguish from male shells. Posterior ridge low to absent, the posterior slope is broad. Beaks are rather sharp but are not full or very high, beak sculpture consists of delicate, doubly looped sculpture, periostracum roughed by close concentric wrinkles. Left valve has two pseudocardinal teeth, the posterior one located under the beak, and two straight lateral teeth. The right valve has two separate pseudocardinal teeth, the upper is smaller and compressed, and has a single straight lateral tooth. Interdentum is lacking, beak cavity is shallow, compressed. Periostracum is yellowish or brownish green with dark green or black rays over the entire surface, rays are not well defined. Nacre color is white, may be tinged with pink or salmon or may be completely pink or salmon.

Life History and Ecology: Ortmann (1919) reported gravid females with eggs on 22 August and gravid females with glochidia on 20 August. He seemed to think the species is bradytictic, possibly with overlapping ends to the breeding season. Ortmann (1919) reported the Eastern Lampmussel from the Delaware River in fast current in gravel substrate and in a sandy substrate in the lake like portion of the lower Delaware River. Strayer and Jirka (1997:60) recorded this species from creeks, lakes and rivers. The authors have found the Eastern Lampmussel in sand substrate with good current. The Black Crappie, (*Pomoxis nigromaculatus*) Largemouth Bass (*Micropterus salmoides*), Pumpkinseed (*Lepomis gibbosus*), Rock bass (*Ambloplites rupestris*), Smallmouth

Bass (*Micropterus dolomieu*), and Yellow Perch (*Perca flavescens*) have been identified as hostfish for the glochidia of this mussel (Watters, 1994; Tedla and Fernando, 1969).
Status: Currently Stable (Williams et al., 1993:12). Both the Eastern Lampmussel and the Carolina Fatmucket are listed as State Threatened, effective July 1, 2002.

Lasmigona decorata (Lea, 1852)
Carolina Heelsplitter

Plate 5, Figure 29

Synonymy:

Unio decoratus Lea, 1852; Lea, 1852:257, pl. 13, fig. 6

Type Locality: Abbeville District, South Carolina

General Distribution: Historically the Carolina Heelsplitter was recorded from the Abbeville District in South Carolina, and around Mecklenburg County in North Carolina (Clarke, 1985). Johnson (1970) assumed that the records from the Abbeville District, South Carolina were in the Savannah River system. However, it is more likely that the Carolina Heelsplitter was in the Saluda River drainage instead (Clarke, 1985, Keferl and Shelley, 1988) (Adams et al., 1990).

North Carolina Distribution: Keferl and Shelley (1988) did not find any evidence of *L. decorata* in the Saluda River drainage. Keferl and Shelley (1988) did find the species living in Waxhaw Creek (Catawba River drainage) Union County, North Carolina; Goose Creek (Pee Dee River system), Union County, North Carolina; and Lynches River (Pee Dee River system), Lancaster and Chesterfield counties, South Carolina. At the present time living specimens of the Carolina Heelsplitter have been found from just six localities in three different drainages of three different river systems.

Description: The Carolina Heelsplitter can reach a length of 118 mm, with a height of 68 mm and a width of 39 mm. Based on some specimens collected by Keferl and Shelley (1988) from three different streams and rivers, the mean length is 78 mm, the mean height is 43 mm and the mean width is 27 mm. The shell is an ovate trapezoid. The dorsal margin is straight and may end with a slight wing. The umbo is flattened. The beaks are depressed and project a little above the hinge line. The beak sculpture is double looped. The unsculptured shell can have a yellowish, greenish or brownish periostracum. The Carolina Heelsplitter can have greenish or blackish rays. The lateral teeth may or may not be well developed, in most cases they are thin. The pseudocardinal teeth are lamellar and parallel to the dorsal margin, and there is a slight interdentum. The nacre varies from an iridescent white to a mottled pale orange. (Adams et al., 1990).

Life History: Historically the Carolina Heelsplitter was collected in creeks, streams, a river and ponds. The ponds were probably millponds. Keferl and Shelley (1988) found *L. decorata* living in two small streams and one small river. All specimens found were in shaded areas, either in a ponded portion of a small stream, or in runs along steep banks with a moderate current. All specimens were found in less than three feet of water during low waters of summer and fall. The substrates included soft mud, sand, muddy-sand, and sandy gravel. Almost nothing is known about the life history and ecology of *Lasmigona decorata*. Living specimens of *L. decorata* have been collected in late June, August and late October and none had any glochidia. The fish host(s) has not been determined. (Adams et al., 1990).

Status: Williams et al. (1993:13) listed as endangered. This species is federally and state listed as Endangered. The U.S. Fish and Wildlife Service (1997) has developed a recovery plan for this species. The U.S. Fish and Wildlife Service (2002) has designated critical habitat for the Carolina Heelsplitter.

Lasmigona holstonia (Lea, 1838)
Tennessee Heelsplitter

Plate 5, Figure 30

Synonymy:
Margaritana holstonia Lea, 1838; Lea, 1838b:42, pl. 13, fig. 37

Type Locality: Holston River.

General Distribution: Upper Tennessee River drainage; headwaters of the Coosa River (Simpson, 1914).

North Carolina Distribution: This species is known from Valley Creek, Cherokee County, North Carolina, Hiwassee River basin (Clarke, 1985), Mills River, French Broad River basin (T. Savidge, Pers. Comm. March 2002), and Iotla Creek, Little Tennessee River basin (W. McLaren, Pers. Comm. 4 July 2002).

Description: The shell is somewhat elongated, rhomboid, and moderately inflated; some very young juveniles are more oblong and compressed. Beaks are full but not high, projecting only slightly above the hinge line; sculpture consists of 4–5 strong, double-looped ridges; the last loop is low and almost straight. The anterior margin is broadly rounded, while the ventral margin is straight; the posterior end is broadly pointed to squared; the posterior ridge is pronounced but broadly rounded, in some specimens appearing doubled. The shell is thin but not fragile. Mature specimens seldom exceed 75 mm in length. The surface is roughened with irregular, recessed, darkened rest lines. The right valve has a single compressed, but moderately heavy, pseudocardinal tooth; the left valve has two low, compressed pseudocardinal teeth, angled anteriorly and, in both valves, nearly parallel with the hinge line. Lateral teeth appear as a thickening of the hinge line in each valve. The periostracum is an almost uniform dull greenish brown or yellowish brown, and most shells become a dark brown or black with age. The nacre is bluish white, often with a pale salmon wash in the beak cavity area. (Parmalee and Bogan, 1998).

Life History and Ecology: *Lasmigona holstonia* is a species most often found inhabiting small shallow streams and headwater creeks with some current, and it may become locally abundant in stretches of substrate composed of sand and mud. The reproductive period is unknown, but it is probably bradytictic. Steg and Neves (1997) identified the Banded Sculpin (*Cottus carolinae*) and the Rock Bass (*Ambloplites rupestris*) with the possible additional hosts are Central Stone Roller (*Campostoma anomalum*), Striped Shiner (*Luxilus chrysocephalus*) and Warpaint Shiner (*Luxilus cocogenis*) as host fish for the glochidia of the Tennessee Heelsplitter.

Status: Special Concern (Williams et al., 1993:13). This species is listed as State Endangered.

Lasmigona subviridis
(Conrad, 1835)
Green Floater

Plate 6, Figure 31

Synonymy:

Unio subviridis Conrad, 1835; Conrad, 1835a:4 (appendix), pl. 9, fig. 1

Type Locality: Schuylkill River, Juniata River, creeks in Lancaster County, Pennsylvania.

General Distribution: New and Greenbrier rivers of the upper Kanawha River drainage, Virginia and West Virginia. Upper Savannah River system of South Carolina north to the Hudson River system, and westward through the Mohawk River and the Erie Canal to the Genesee River of New York (Johnson, 1980; Clarke, 1985).

North Carolina Distribution: This small species is known from the Watauga and New river basins in western North Carolina and the Roanoke (Dan River), Tar, Neuse, and Cape Fear River basins in eastern North Carolina (Walter, 1954; Clarke, 1985; Shelley, 1987; Adams et al., 1990;T. Savidge, Pers. Comm. March 2002; Tables 2,3)

Description: The shell is thin and slightly inflated; it is subovate, narrower in front, higher behind, and the upper margin forms a blunt angle with the posterior margin (Ortmann, 1919). The posterior ridge is low, rounded, and appears more as a slight swelling than as a ridge. Beaks are low and not extended beyond the hinge line; sculpture consists of 4–5 nodulous bars, the first two concentric, the others deeply double-looped (Johnson, 1970). Mature individuals reach a length of about 60 mm. The lateral teeth, one in the right valve, two in the left, are long, straight, and thin. The left valve has two lamellate pseudocardinal teeth, and the right valve has one; pseudocardinals are directed forward of the beak and nearly parallel with the hinge line. The periostracum is a dull yellow or tan to brownish green, with variable concentrations of dark green rays. The nacre is a dull bluish white, often with mottled shades or tints of salmon in the general beak cavity area (Parmalee and Bogan 1998:145).

Life History and Ecology: Ortmann (1919:124) noted that *Lasmigona subviridis* is “adverse to very strong current, and prefers more quiet parts, pools or eddies with gravelly and sandy bottoms, and it also goes into canals, where it seems to flourish.” Pockets of sand and gravel among boulders provide a habitat for this mussel although it appears to be uncommon and localized. Ortmann (1919) stated that this species is normally hermaphroditic, and that it is bradytictic, with the reproductive season extending from August to May. Barfield and Watters (1998) reported direct development for the juveniles of the Green Floater. This is the only recently confirmed non-parasitic development for a North American unionid.

Status: Threatened (Williams et al., 1993:13). This species is listed as State Endangered.

Leptodea ochracea (Say, 1817)
Tidewater Mucket

Plate 6, Figure 32

Synonymy:

Unio ochraceus Say, 1817; Say, 1817: no pagination, pl. 2, fig. 8

Comment: The generic placement of *Unio ochraceus* Say, 1817 is unsettled (see Bereza and Fuller, 1975; Morrison, 1976; Porter and Horn, 1980; Kat, 1983, Adams et al. 1990). Stiven and Alderman (1992) presented an analysis of some populations of *Lampsilis* and used *Elliptio complanata* as the outgroup. In this study, *Leptodea ochracea* fell outside of the *Lampsilis* and *Elliptio* clades, suggesting *L. ochracea* does not belong in the genus *Lampsilis*. Smith (2000) has proposed moving this species to the genus *Ligumia* based on anatomical and larval characters. We (Bogan, unpubl.) have noted major anatomical differences in anal position and characters between *Ligumia recta* (type species of *Ligumia*) and *Ligumia nasuta,* which raise the question of the monophyly of *Ligumia*. This data coupled with the observation of Davis and Fuller (1981) that *L. recta* and *L nasuta* are not closely related based on their immunological analyses, leads us to retain *L. ochracea* in its recent placement in *Leptodea* until DNA tests provide a clearer indication of *L. ochracea*'s generic placement.

Type Locality: Delaware and Schuylkill Rivers. Johnson (1947) restricted the type locality to the Schuylkill River, near Philadelphia, Pennsylvania.

General Distribution: Atlantic Coast rivers from Cape Breton, Nova Scotia, Canada south to the Savannah River, Georgia.

North Carolina Distribution: The Tidewater Mucket is known from the Waccamaw, Pamlico, Roanoke, and Chowan River basins (Adams et al., 1990; Table 2). Walter (1956) reported it from the Neuse. Alderman (Pers. Comm. July 2002) suggests this species is extirpated from the Pamlico River.

Description: Shells of the Tidewater Mucket are relatively small, length 75 mm., elliptical to ovate in outline with a thin to subsolid, strong, subinflated shell. Anterior margin rounded, ventral margin evenly rounded, posterior margin evenly rounded. Male shells are more elliptical with the posterior margin somewhat pointed. Female shells are more ovate and the posterior margin is truncated. Posterior ridge is well developed ending in a blunt point about half way up from the base on the posterior margin. Beaks are moderately swollen and raised above the hingeline, beak sculpture consists of a few straight, strong ridges with the later ridges becoming weakly double-looped. Periostracum is slightly shiny to mat.

Left valve with two small compressed pseudocardinal teeth located in front of the beaks, two thin, distant lateral teeth. Right valve has two triangular compressed pseudocardinal teeth, and a single thin lateral tooth. The hingeline is narrow and rounded in the middle. The beak cavity is open and moderately deep. Periostracum is dull, not a bright yellow but grayish, greenish, or brownish olive and the rays have a different character. The rays are sometimes absent but when present are indistinct and blackish and grayish or greenish, rather fine and are found across the shell or most of the shell. The rays become obscure on the posterior slope. Nacre is white to reddish pink.

Life History and Ecology: The Tidewater Mucket is gravid in the autumn and releases glochidia in the spring (Ortmann, 1919). Ortmann (1919) reported *L. ochracea* as occurring in estuaries, ponds and canals with muddy bottoms Host fish unknown. At least one of the host fish species is probably an anadromus species in light of the Tidewater Mucket's tidewater distribution.

Status: Special Concern (Williams et al., 1993:13). This species is listed as State Threatened in North Carolina, effective July 1, 2002.

Lexingtonia dolabelloides (Lea, 1840) Slabside Pearlymussel

Plate 6, Figure 33

Synonymy:

Unio dolabelloides Lea, 1840; Lea, 1840:288

Type Locality: Holston River, Tennessee.

General Distribution: Tennessee River system, from Lee and Tazewell counties, southwestern Virginia to Mussel Shoals (formerly), Alabama.

North Carolina Distribution: This species was probably known historically from the French Broad, Little Tennessee or the Hiwassee River basins. It was not covered by Adams et al. (1990).

Description: Although generally subtriangular in outline, this mussel exhibits considerable variability in shell shape. The majority of individuals possess a wide, flat disc, extending from the beak to the ventral margin. Valves are moderately inflated and very solid; large, mature specimens may reach a length of 85 mm. Beaks are prominent with the umbonal area arched forward and located near the anterior end. The anterior end of the shell is obliquely truncate above and rounded to the base; the posterior slope is truncated. The ventral margin of the shell is curved, and the dorsal slope is strongly curved. The posterior ridge is narrowly rounded but distinct, although not as elevated as the radial swelling in front of it. The surface of the shell is often irregularly and concentrically sculptured as a result of pronounced growth rings. Beak cavities are shallow; muscle scars are deep, and the pallial line is well impressed anteriorly. Sculpture consists of 6–8 fine, rather crowded, irregular, and wavy bands, which are distinct anteriorly, becoming indistinct in the middle. The left valve possesses two pseudocardinal teeth; the upper tooth is triangular, and the lower tooth is bladelike, separated from two short, curved lateral teeth by a broad interdentum. The right valve has a triangular pseudocardinal tooth, occasionally with a smaller tooth before and behind it. There is typically a single large lateral tooth, although occasionally a vestigial tooth below is present. The periostracum is greenish yellow (in juveniles) to tawny or brownish with a few broken green rays or blotches in some specimens, especially young individuals. The nacre color is white or, more rarely, straw-colored. (Parmalee and Bogan, 1998).

Life History and Ecology: *Lexingtonia dolabelloides* once occurred in shoal areas of the Tennessee River as well as in small to medium-sized streams and rivers, such as the Clinch, Powell, Duck, and Hiwassee (the form *L. d. conradi*). Ortmann (1918) arbitrarily separated the big river species, *L. dolabelloides,* from the headwater form, *L. d. conradi,* on the basis of the shell diameter and length; specimens with a diameter, which is 50% of the length or greater are *dolabelloides* and those less than 50% are *conradi.* A moderately strong current and a substrate composed of sand, fine gravel, and cobbles appear to provide the most suitable habitat for this species. It is probably tachytictic; Ortmann (1921) recorded finding unripe glochidia early in July. Six species of minnows have been found naturally infested with glochidia: Popeye Shiner *(Notropis ariommus),* Rosyface Shiner *(N. rubellus),* Saffron Shiner *(N. rubricroceus),* Silver Shiner *(N. photogenis),* Telescope Shiner *(N. telescopus),* and Tennessee Shiner *(N. leuciodus)* (Kitchel, 1985; Kitchel in

Neves, 1991) (Parmalee and Bogan, 1998).
Status: Threatened (Williams et al., 1993:13). *Lexingtonia dolabelloides* has been proposed as Endangered for inclusion in the federal list of *Endangered and Threatened Wildlife and Plants.* The Slabside Pearlymussel is restricted to thinly scattered or isolated populations in primarily the Clinch, Powell, Elk, Duck, and Hiwassee rivers in Tennessee, the North Fork and Middle Fork Holston rivers in Virginia, and the Paint Rock River in Alabama (Parmalee and Bogan, 1998).

Ligumia nasuta (Say, 1817)
Eastern Pondmussel

Plate 6, Figure 34

Synonymy:

Unio nasuta Say, 1817; Say, 1817: no pagination, pl. 4 fig. 1

Type Locality: Delaware and Schuylkill [rivers near Philadelphia, Philadelphia Co. Pennsylvania]

General Distribution: The Eastern Pondmussel occurs from the Pee Dee River Basin, North Carolina, north to the St. Lawrence River Basin, westward through the Mohawk River and Erie Canal and west to Lake Erie in Pennsylvania, Ohio and Michigan (Johnson, 1970).

North Carolina Distribution: The Eastern Pondmussel is known form the Pee Dee, Cape Fear, Pamlico, Roanoke, and Chowan River basins (Adams et al., 1990; Table 2).

Description: Shell shape elongated, subelliptical, thin to subsolid and is more or less compressed, shell length 102 mm. Anterior margin rounded, ventral margin broadly curved, posterior margin is rounded and drawn out into a posterior angle or blunt point near the midline of the shell. Sexual dimorphism in the shells is well marked. The posterior margin of the male shell tapers evenly to a blunt point, while the ventral margin has a uniform curve. The female shell has the ventral margin expanded in the postbasal region, becoming a broad rounded projection, behind which the ventral margin turns upward abruptly. Posterior ridge well developed, distinct and angled near the beak, becoming rounded posteriorly. Posterior slope is slightly concave near the beaks, becoming flatter near the posterior margin of the shell. Beaks are low, hardly raised above the hinge line and located in the anterior quarter of the shell, beak sculpture consists of 5 –7 fine bars, subconcentric becoming double looped. Periostracum is subshiny with irregular growth lines and sometimes marked by a few nearly vertical ribs below the posterior ridge.

Left valve has one or two compressed, subtriangular, pseudocardinal teeth, two delicate, long lateral teeth Right valve has one, sometimes two compressed pseudocardinal teeth and a long lamellar lateral tooth. The interdentum is lacking and the beak cavity is shallow. Periostracum is dark olive green to brownish and often with faint dark green, straight and narrow rays present, especially in juvenile specimens. The rays may be completely absent. Nacre is bluish white, some with salmon in the beak area, iridescent posteriorly.

Life History and Ecology: The Eastern Pondmussel was reported gravid from mid-September through early July, discharging glochidia in June and July (Ortmann, 1919:272). Ortmann (1919:274-275) reported this species from fine sand substrates, in deep water with a mud and vegetable debris, at the edge of a riffle in gravel. He reported it from Lake Erie at Presque Isle Bay living in sandy, gravelly and muddy substrates in one to 15 feet of water and occurring in the beach-pools of Presque Isle in sandy and sand/mud substrates. Hostfish are unknown, but its close relative *Ligumia subrostrata* has been documented as using several centrarchid species as hostfish (Watters, 1994).

Status: Special Concern (Williams et al., 1993:13). This species is listed as State Threatened in North Carolina, effective July 1, 2002.

Medionidus conradicus
(Lea, 1834)
Cumberland Moccasinshell

Plate 6, Figure 35

Synonymy:

Unio conradicus Lea, 1834; Lea, 1834:63, pl. 9, fig. 23

Type Locality: No locality given in the original description Johnson (1977:165) lists it as "no locality [Caney Fork of the Cumberland River, Tennessee]," apparently supplying this locality as the type locality.

General Distribution: The Cumberland Moccasinshell is a Cumberlandian species endemic to the Tennessee and Cumberland River drainages.

North Carolina Distribution: It was reported historically from the French Broad River, Buncombe County (Ortmann, 1918).

Description: The shell is usually elongate and elliptical in outline, becoming arcuate in adults; it is relatively thin, but becomes thicker with age. The Cumberland Moccasinshell is a small species, seldom exceeding 60 mm in length. Shells are rounded anteriorly with a posterior ridge ending in a rounded point at the posterior end. The ventral margin is straight, becoming incurved in adult specimens. Valves are subinflated and subsolid. The male shell is generally more arcuate and broader in the posterior area. Female shells are generally somewhat more inflated along the middle of the ventral margin; this area may be faintly radially grooved. Beaks are only slightly inflated and elevated, being marked by fine, irregular corrugated ridges often tending to double loops. The posterior slope is marked by wrinkles or corrugations, which often extend onto the anterior portion of the shell. The left valve has two short, stumpy pseudocardinal teeth and two slightly curved lateral teeth. The right valve has a single short, stumpy pseudocardinal tooth and a single lateral tooth. The beak cavity is very shallow, often lacking. Anterior adductor muscle scars are deep, and the posterior scars are only slightly impressed. The pallial line is impressed anteriorly where the shell is thicker. The periostracum is slightly shiny, tawny to yellowish green in color, and covered with weak, broken dark green rays, which break into arrowhead-shaped markings. The nacre color is bluish to dirty white and may be iridescent posteriorly (Parmalee and Bogan, 1998).

Life History and Ecology: The Cumberland Moccasinshell inhabits a substrate composed of sand and gravel, often living in cracks in the bedrock or under flat rocks. Usually it occurs at depths of less than three feet in moderate to strong current. Wilson and Clark (1914) and Ortmann (1918, 1924, 1925) noted that this mussel is typically a small stream inhabitant. Zale and Neves (1982b) identified the Fantail Darter *(Etheostoma flabellare)* and the Redline Darter *(E. rufilineatum)* as hosts for the glochidia; Stern and Felder (1978) list the Warmouth *(Lepomis gulosus)*. Luo (1993) was able to infect the Rainbow Darter *(Etheostoma caeruleum)* and Striped Darter *(E. virgatum)* with glochidia of the Cumberland Moccasinshell under laboratory conditions. The breeding season for *M. conradicus* begins with gravid females occurring from early September on with glochidia present in mid-September; they are not discharged until mid- to late May (Ortmann, 1921). The glochidia appear in river drift from January to May and June, but are absent in July and August; they reappear in river drift in

September through early November (Zale and Neves, 1982a, b).
Status: Williams et al. (1993:13) listed as Special Concern. It is considered extirpated in North Carolina (Table 4).

Pegias fabula (Lea, 1838)
Littlewing Pearlymussel

Plate 6, Figure 36

Synonymy:
Margaritana fabula Lea, 1838; Lea, 1838b:44, pl. 13, fig. 39

Type Locality: Stones River, Tennessee. Cumberland River, Tennessee (Simpson, 1914).

General Distribution: Tennessee and Cumberland River systems, formerly widespread from southern Kentucky (Rockcastle County) and southwestern Virginia (Lea, Russell, Smyth, Tazewell, and Washington counties), through the tributary stream system of the Tennessee and Cumberland rivers in East Tennessee and southwest to Lauderdale County, Alabama (Ortmann, 1925) (Parmalee and Bogan, 1998).

North Carolina Distribution: This species is known from the Hiwassee and Little Tennessee River basins (Table 3).

Description: The Littlewing Pearlymussel is a small species: adults rarely exceed 35 mm in length. Valves are thickened anteriorly with a sharp posterior ridge, in front of which is a wide radial depression that ends in a basal sinus. There is another ridge above the posterior ridge, making the shell decidedly biangulate and truncate behind. Valves of the female possess a wider posterior slope behind the ridge and a more truncated posterior end than do those of the male. Beak sculpturing consists of heavy, subconcentric ridges, these being most prominent and persistent on the posterior ridges.
The left valve has an irregular triangular pseudocardinal tooth under the beak, sometimes with a vestige of another in front of it. Lateral teeth appear as short, faint, irregular ridges. The right valve has a single triangular pseudocardinal tooth in front of the beak. Beak cavities are rather deep and compressed; anterior muscle scars are deeply impressed. The periostracum is usually eroded away in mature individuals; a few dark brownish or olive green rays are apparent along the base of the shell in young specimens. The nacre is whitish on the anterior ventral third, flesh-colored or salmon in the beak cavities. The shells exhibit sexual dimorphism, one of the characters, which separates *Pegias* from species belonging to the genus *Alasmidonta* (Simpson, 1900, 1914; Stansbery, 1976) (Parmalee and Bogan, 1998).

Life History and Ecology: This very small unionid inhabits cool, clear, high-gradient streams. It is usually found lying on top of or partially imbedded in sand and fine gravel between cobbles in only 6 to 10 inches of water, often just at the head of riffles. Ortmann (1914) collected a gravid female of this species in mid-September, suggesting that *Pegias fabula* is bradytictic, a winter breeder. Ahlstedt (in Neves, 1991:271) states that "[f]ish hosts are unknown for this species; however, based on field observations, the Banded Sculpin, *Cottus carolinae,* and Redline Darter, *Etheostoma rufilineatum,* may be likely hosts. These fish were observed under large flat rocks and were present on gravel shoals where live specimens of *Pegias fabula* were found." Layzer and Anderson (1992) identified the host fish for *Pegias fabula* as the Greenside Darter *(Etheostoma blennioides)* and Emerald Darter *(E. baileyi).*

Status: Williams et al. (1993:13) listed as endangered. This species is federally and state listed as Endangered. Adams et al. (1990) list it as extirpated in North Carolina.

Pleurobema collina
(Conrad, 1837)
James Spinymussel

Plate 7, Figure 37

Synonymy:
Unio collina Conrad, 1837; Conrad, 1837:65, pl. 36, fig. 2

Type Locality: North River, a branch of James River, Virginia.

General Distribution: The James Spinymussel is found in the James River basin in Virginia and the Dan River drainage of the Roanoke River basin (Simpson, 1914; T. Savidge, Pers. Comm.).

North Carolina Distribution: This species is restricted to the Dan River drainage of the Roanoke River basin in North Carolina (T. Savidge Pers. Comm.)

Description: "Shell rhomboid, convex, subsolid, inequilateral, with moderately full, high beaks, their sculpture a number of strong, slightly double-looped ridges; posterior ridge full, rounded, ending behind at the base of the shell in a rounded point; growth lines elevated into slight, concentric ridges; besides this sculpture there are generally one or two sharp, prominent tubercles or spines placed on a line running from the beaks to a little behind the central base, though these are sometimes entirely wanting [as many as nine spines on one valve in the Dan River, North Carolina (T. Savidge, March 2002); epidermis smoky, greenish-brown, showing the rest marks, subshining; left valve with two subcompressed, irregular pseudocardinals and two straight, delicate laterals; right valve with a compressed pseudocardinal, with a vestigial one in front of and behind it, with one lateral; beak cavities shallow; nacre bluish-white, slightly thicker at the anterior end." (Simpson, 1914:501).

Life History: Hove and Neves (1994) reported the Blacknose Dace (*Rhinichthys atratulus*), Bluehead Chub (*Nocomis leptocephalus*), Central Stoneroller (*Campostoma anomalum*), Rosefin Shiner (*Lythurus ardens*), Rosyside Dace (*Clinostomus funduloides*), Satinfin Shiner (*Cyprinella analostana*), Mountain Redbelly Dace (*Phoxinus oreas*) as hosts for the glochidia for the James Spinymussel. They reported that the mussel "occupied sediment of cobble and sand in reaches with slow to moderate currents." The females were gravid between 23 May and 9 August. *Pleurobema collina* was found living in second and third order streams at depths of 0.3 to 2 meters (Hove and Neves, 1994).

Status: Williams et al. (1993:13) listed as endangered. This species is federally listed as Endangered.

Pleurobema oviforme
(Conrad, 1834)
Tennessee Clubshell

Plate 7, Figure 38

Synonymy:

Unio oviformis Conrad, 1834; Conrad, 1834:46, 70, pl. 3, fig. 6

Type Locality: Tennessee. Haas (1969a) records the Holston River as the type locality.

General Distribution: Tennessee and Cumberland River drainages (Ortmann, 1925).

North Carolina Distribution: The Tennessee Clubshell is known from the Hiwassee, Little Tennessee, and French Broad rivers (Ortmann, 1918; Table 2).

Description: The shell is solid, obovate, elliptical to nearly rhomboid in outline, and slightly to moderately inflated. Ortmann (1925:341) commented that "[i]n the Tennessee at the Mussel Shoals it is represented by the more swollen *holstonense,* and in the headwaters it passes into the compressed *argenteum*." Beaks are only moderately full, high, turned forward, and extend only slightly beyond the hinge line; the beak cavity is shallow, and the interdentum is wide. The anterior end is broadly rounded, and the ventral margin is slightly curved; the posterior end is bluntly pointed and sometimes somewhat truncated. The posterior ridge is low, rounded, and often indistinct. Old individuals may attain a length of 90 mm, although the majority of adults seldom exceed 70 mm in length.

Pseudocardinal teeth, two in the left valve, one with vestiges of two others in the right, are stout, triangular, deeply serrated, and erect; they project ventrally from the hinge line at nearly a 90° angle; the one in the right valve is directed more posterior-ventrally. Lateral teeth, two in the left valve, one in the right, are erect, heavy, long, and straight. Muscle scars are large and deeply impressed. The surface is roughened by evenly spaced, concentric, often darkened rest lines. The periostracum is a dull straw yellow, greenish yellow, or gray brown, typically patterned with narrow and/or wide broken green rays, primarily on the umbonal and disc areas. The nacre is a silvery or bluish white. (Parmalee and Bogan, 1998).

Life History and Ecology: Viable populations of *Pleurobema oviforme* in Tennessee typically may be found in small, shallow (less than two feet in depth) streams and rivers with good current and a substrate of coarse gravel and sand. The breeding season of this species is unknown, although it may be tachytictic; Kitchel (1985) reported peak densities of glochidia during mid-July. Weaver et al. (1991) have shown, under both natural and laboratory conditions, that the Whitetail Shiner *(Cyprinella galactura),* Common Shiner *(Luxilus cornutus),* River Chub *(Nocomis micropogon),* Central Stoneroller *(Campostoma anomalum),* and Fantail Darter *(Etheostoma flabellare)* may serve as host fish for glochidia of the Tennessee Clubshell (Parmalee and Bogan, 1998).

Status: Special Concern (Williams et al., 1993:13).

Ptychobranchus fasciolaris (Rafinesque, 1820) Kidneyshell

Plate 7, Figure 39

Synonymy:
Obliquaria (Ellipsaria) fasciolaris Rafinesque, 1820; Rafinesque, 1820:203

Type Locality: Muskingum River, Ohio.

General Distribution: Ohio, Tennessee, and Cumberland River systems; Lower Peninsula of Michigan, Kansas, Arkansas, Oklahoma, and Louisiana (Simpson, 1914); Pennsylvania west to Illinois, south to Tennessee.

North Carolina Distribution: Ortmann (1918) reported this species from the French Broad River (Table 2).

Description: The shell is elongate, elliptical, and compressed; it is solid, heavy, and thick in old individuals. The anterior end is rounded, and the posterior end is bluntly pointed. The posterior-dorsal ridge is prominent but rounded. Senile individuals may reach a length of 150 mm, although the majority of mature individuals seldom exceed 120–130 mm. Beaks are flattened, compressed, and low; sculpture consists of several fine, indistinct, wavy ridges. The surface is marked with numerous, usually prominent, coarse rest lines. The left valve has two low, thick, heavy, serrated triangular pseudocardinal teeth; the two lateral teeth are nearly straight, short, heavy, and usually widely separated. The right valve has a heavy, somewhat compressed, and pyramidal elevated pseudocardinal tooth, sometimes with a low, roughened tubercular tooth on either side; the lateral tooth is wide, heavy, elongated, and serrated. The interdentum is long and wide; the beak cavity is shallow. The periostracum is yellow or yellowish green, becoming a dark chestnut brown in old shells; most individuals are patterned with dark green rays that are usually wide, often wavy, and usually interrupted or broken. Some individuals lack rays. The nacre is pearly white, and the posterior half or third is iridescent (Parmalee and Bogan 1998:202).

Life History and Ecology: The Kidneyshell appears tolerant of a variety of habitat conditions, although rivers with moderately strong current and a substrate of coarse gravel and sand, usually firmly packed. It is often found on the edges of weed beds with good current. *Ptychobranchus fasciolaris* may be found at depths of less than three feet up to those as great as 18 to 24 feet in large rivers (reservoirs) such as the Ohio River. Ortmann (1919) records the species as bradytictic; the breeding season in Pennsylvania begins in August with the discharging of glochidia taking place in June through August. Host fish for the glochidia are unknown.

Status: Currently Stable (Williams et al., 1993:14). Ortmann (1918) listed this species as widely distributed but nowhere abundant. Adams et al. (1990) presumed it to be extirpated in North Carolina. This species is presumed extirpated in North Carolina.

Pyganodon cataracta (Say, 1817)
Eastern Floater

Plate 7, Figure 40

Synonymy:

Anodonta cataracta Say, 1817; Say, 1817: no pagination, pl. 3, fig. 4

Type Locality: Deep part of milldam, Johnson (1970) restricted the locality to: deep part of milldam [presumably near Philadelphia, Philadelphia Co. Pennsylvania].

General Distribution: The Eastern Floater extends from the Alabama-Coosa River drainage, the Coctawhatchee and upper Apalachicola River basins, and on the Atlantic slope from the Altamaha River Basin of Georgia north to the lower St. Lawrence River Basin, possibly extending west to Michigan (Johnson, 1970).

North Carolina Distribution: This is a wide-ranging species and is found in North Carolina from the Broad River basin north to the Pasquotank River Basin (Johnson, 1970; Table 2).

Description: Shell shape is ovate, subelliptical and elongate, shells of juveniles not much inflated but much more inflated in adult shells, shells are uniformly thin, often with a low post dorsal wing, shell length 135 mm. Anterior margin evenly rounded, ventral margin is broadly rounded and the posterior margin comes to a tapered point about in the midline. Posterior ridge is moderately developed, often with an indication of being biangulate. Ortmann (1919) observed that the female shells of this species may exhibit swelling of the valves posterior to the middle, however, not all females exhibit this character. Beaks are usually full and elevated above the hingeline, beak sculpture consists of 5-7 double-looped ridges without the nodulous point on the loops as found in *Pyganodon grandis*. Periostracum is usually smooth. The Eastern Floater has no hinge teeth or any indication of swellings in this area. The beak cavity is open and relatively shallow. Periostracum is light to dark green, rarely becoming brownish or black, often quite brightly colored, with concentric light and dark bands and with dark green rays most distinct on the disc of the shell, broad green rays on the posterior slope are often well developed, giving the area a much darker color. Nacre is bluish-white.

Life History and Ecology: Ortmann (1919:155) discussed the variability of shell thickness and shape in *Pyganodon cataracta* and recognized thee generalized shell forms: "the pond-forms being generally thinner, while the creek-forms are thicker… *A. cataracta* is also quite variable in the convexity of the valves; and the inflation, if present, is restricted to the disk, and does not extend to the umbos." He (Ortmann, 1919:155) remarked "The various forms of *A. cataracta* … are all connected by intergrades, and they seem to be special reactions to special environmental conditions, although we are not in all cases sure what are the essential features of the environment, which are active." Ortmann (1919:158) reported the ecology of the various shell forms of the Eastern Floater as: the pond-form in small ponds with muddy bottoms, the creek-form in small rivers and creeks with gravel substrates, in good current, including riffles or in quiet pools in gravel, sand or mud, the short high form is found in the bigger rivers on muddy substrates. Ortmann (1919) reported the Eastern Floater as gravid from early August through late April, with glochidia being discharged in April and no charged females reported for May. The Common Carp (*Cyprinus carpio*), Bluegill (*Lepomis macrochirus*),

Pumpkinseed (*Lepomis gibbosus*), Threespine Stickleback (*Gasterosteus aculeatus*), White Sucker (*Catostomus commersoni*), and Yellow Perch (*Perca flavescens*) have been listed as potential hostfish for the glochidia of this species (Watters, 1994; Gray et al., 1999).
Status: Currently Stable (Williams et al., 1993:14). This species is considered currently stable.

Pyganodon grandis (Say, 1829)
Giant Floater

Plate 7, Figure 41

Synonymy:

Anodonta grandis Say, 1829; Say, 1829:341

Type Locality: Fox River of the Wabash River, Indiana.

General Distribution: This common mussel is found throughout the Mississippi and Missouri River drainages, the St. Lawrence drainage and the Canadian Interior Basin from western Ontario to Alberta (Burch, 1975), in the Gulf of Mexico drainage area of Louisiana and Texas (Clarke, 1973), and in the Red River drainage, Texas and Oklahoma.

North Carolina Distribution: The Giant Floater has been reported from the French Broad River (Table 2) and has been introduced into Jordan Lake of the Cape Fear River.

Description: The shell is variable, usually elongated, ovate, often somewhat elliptical or rhomboid, thin to moderately solid, and inflated to swollen in the beak area. The anterior end is broadly rounded, but the posterior end is rather bluntly pointed; the dorsal margin usually forms a sharp angle with the posterior end. Beaks are swollen, typically flush with the hinge line or moderately elevated; sculpture consists of 4–5 heavy bars, the first two concentric, the rest strongly double-looped. Individuals may become extremely large under ideal habitat conditions; mature specimens may reach a length of 130–140 mm. Both valves are edentulous; the hinge line is usually slightly thickened. The beak cavity is shallow. There are pronounced fine concentric ridges on the surface indicative of rest periods. The periostracum is yellowish green and occasionally faintly rayed in young shells and dark green or brown to black in old shells, often with the umbonal area a lighter ash brown. The nacre is a dull white, somewhat iridescent, and occasionally tinged or washed with cream, pink, or salmon (Parmalee and Bogan, 1998:207-208).

Life History and Ecology: *Pyganodon grandis* occurs in western Pennsylvania rivers possessing a substrate of sand and gravel, but it, like all closely related species within the genera *Anodonta* and *Utterbackia* that are found in the state, reaches its greatest abundance and individual size in reservoirs, backwaters, lakes, and ponds having a mud bottom with little or no current. The diversity of fish hosts for the glochidia of this floater (e.g., gar, *Lepisosteus* sp.; catfish, *Ictalurus* sp.; sunfish, *Lepomis* sp.; freshwater drum, *Aplodinotus grunniens,* according to Oesch, 1984; Watters, 1994) may well be the primary factor contributing to its extensive geographical range, abundance, and adaptability. Baker (1928a) reported the bradytictic reproductive period for *Pyganodon (Anodonta) grandis* in Wisconsin as extending from August to April or May. Ortmann (1919) reported similar dates for Pennsylvania but noted the species discharges glochidia in early spring (April) and that for Pennsylvania was very late.

The greatly inflated shell and elevated beaks that are more or less centrally located on the dorsal margin of *Pyganodon g. corpulenta* [Ortmann (1919) used *Anodonta grandis footiana* for this form restricted to Lake Erie in Pennsylvania] are characters that appear to clearly distinguish this form or subspecies from the somewhat more compressed and elongated shell of *Pyganodon g. grandis.* Some researchers (e.g., van der Schalie and van der

Schalie, 1950) considered these naiads to be distinct species, and, although the shells of these two subspecies appear quite different, certain local populations suggest a cline or intermediate form on the basis of shell obesity and position and elevation of the beaks. Stream gradient (current) and type of substrate may be the primary factors in influencing shell characters of these subspecies.

The Stout Floater attains a maximum size and abundance in impounded sections of large rivers, such as Allegheny and Ohio rivers. Quiet, mud-bottomed sections of rivers and lakes provide ideal habitat for this floater; it may be found at depths that vary from one foot to 20 feet or more.

Status: Currently Stable (Williams et al., 1993:14). This species is considered stable in North Carolina.

Quadrula pustulosa (Lea, 1831) Pimpleback

Plate 7, Figure 42

Synonymy:

Unio pustulosus Lea, 1831; Lea, 1831:76, pl. 7, fig. 7

Type Locality: Ohio; Alabama River. Ortmann (1919) lists only the Ohio River as the type locality.

General Distribution: The entire Mississippi River drainage, from New York and Pennsylvania west to the Dakotas, and south to eastern Texas and Louisiana.

North Carolina Distribution: Lea described *Unio pernodosus* from specimens sent by B.W. Budd with locality data of North Carolina. Ortmann (1918) considered *U. pernodosa* a synonym of Quadrula pustulosa but was skeptical of this record. The occurrence of this species needs to be verified in North Carolina (Adams et al., 1990).

Description: Shells of this common mussel, which seldom exceed 80 mm in length, are rounded to somewhat quadrate, solid, and moderately to greatly inflated. Beaks are high, full, and turned forward; sculpture consists of 3–4 coarse ridges. The anterior end is rounded, while the posterior end is squarish or sharply truncated. The posterior ridge is prominent and rounded. The posterior two-thirds of the surface is usually densely covered with rounded tubercles or pustules, occasionally with a few low, narrow ridges on the posterior slope. Some individuals may be totally lacking in pustules or possess only a very few. The pseudocardinal teeth, two in the left valve and one in right, are triangular, elevated, and roughened (divergent in the right). In the left valve, the anterior pseudocardinal tooth is bladelike, more elevated, and the larger of the two. The lateral teeth, one in the right valve and two in the left, are short, slightly curved, and heavy. Muscle scars and the pallial line are deeply impressed. The beak cavity is deep and somewhat compressed. The periostracum is yellowish green or brown in young shells, often with a broad broken green ray extending from the umbo toward the ventral margin; it is dark brown to black in old shells. The nacre is white and iridescent posteriorly (Parmalee and Bogan, 1998).

Life History and Ecology: Like the Mapleleaf, *Quadrula pustulosa* is rather generalized in habitat preference and can maintain abundant and viable populations in shallow to deep sections of large reservoirs, as well as in small to medium-sized free-flowing rivers. It is usually found in a substrate consisting of coarse gravel, sand, and silt. However, in Pennsylvania the Pimpleback was restricted to the larger rivers and Ortmann (1919) reported it from "deep, strongly flowing waters, with a gravelly bottom." The Pimpleback is tachytictic, being gravid from about mid-June to mid-August. The Shovelnose Sturgeon *(Scaphirhynchus platorynchus),* Black Bullhead *(Ameiurus melas),* Brown Bullhead *(A. nebulosus),* Channel Catfish *(Ictalurus punctatus),* Flathead Catfish *(Pylodictis olivaris),* and the White Crappie *(Pomoxis annularis)* are listed by Fuller (1974) as host fish for glochidia of this mussel. (Parmalee and Bogan, 1998).

Status: Currently Stable (Williams et al., 1993:14). The Pimpleback has not been seen in North Carolina in recent time and is presumed extirpated in the state.

Strophitus undulatus (Say, 1817)

Creeper [formerly the squawfoot]

Plate 8, Figure 43

Synonymy:

Anodonta undulata Say, 1817; Say, 1817:pl. 3, fig. 5

Type Locality: None given for *Anodonta undulata* Say, 1817. Johnson (1970:367) restricted the type locality to Schuylkill river, near Philadelphia, Philadelphia Co. Pennsylvania. For *Alasmodonta edentula* Say, 1829: Wabash River, Indiana.

General Distribution: Canadian Interior Basin in the Red River–Nelson River system from western Ontario to eastern Saskatchewan, and throughout the Great Lakes–St. Lawrence northern drainage system (Clarke, 1981a). Entire Mississippi River drainage from Minnesota to central Texas, Pennsylvania to Tennessee; Atlantic coastal drainage from Nova Scotia to the upper Savannah River system of South Carolina.

North Carolina Distribution: The Creeper is widely distributed in the Atlantic slope drainages including the Broad, Pee Dee, Cape Fear, Neuse, Pamlico, and Roanoke. It is reported from the French Broad of the Tennessee River basin (Johnson, 1970; Table 2).

Description: The shell is elliptical, somewhat rhomboid, solid, compressed, and thin when young, moderately inflated and thick in mature and old individuals. The anterior end is rounded, and the posterior end is bluntly pointed and often obliquely truncated. The posterior ridge is broadly rounded and either compressed or quite pronounced (especially in old shells). Shell length is usually less than 110 mm. Beaks are depressed, only slightly elevated above the hinge line; sculpture consisting of 3–4 heavy concentric bars, somewhat oblique to the hinge line, rounded anteriorly, and angled posteriorly. The pseudocardinal tooth in the left valve is represented by an elongated, low thickening of the hinge line below the beak; the pseudocardinal tooth in the right valve appears as a low, thick swelling anterior to the beak. Lateral teeth are absent or suggested by a thickened hinge line. The beak cavity is shallow. The periostracum is yellowish or greenish, marked by greenish, often wavy rays; old shells are dark brown or black and usually rayless. The nacre is white or bluish white and iridescent around the margins, the center, and occasionally along the pallial line where it may also be cream-colored or salmon (Parmalee and Bogan, 1998).

Life History and Ecology: *Strophitus undulatus* appears adaptable to a variety of aquatic habitats, from the high-gradient small streams to the main channel of the upper Allegheny River in finer sediments to large gravel, usually deeply buried. It typically inhabits depths of no more than three or four feet. This species appears to spend the summer and fall buried beneath the surface and is found up on the surface of the substrate during the coldest parts of the year along with *Alasmidonta undulata*, *Alasmidonta varicosa* (AEB Pers. Obs. and W. Lellis, Pers. Comm. January, 1995). It has been shown experimentally that the glochidia of this species may develop on the fins and skin of the Largemouth Bass *(Micropterus salmoides)* and the Creek Chub *(Semotilus atromaculatus)* (Baker, 1928) and that the Rio Grande Killifish *(Fundulus zebrinus)* and Green Sunfish *(Lepomis cyanellus)* may serve as natural hosts for the glochidia of this mussel (Fuller, 1978). In addition, Hove (1995) has identified seven fish as

definite hosts for the glochidia of the Creeper: Spotfin Shiner *(Cyprinella spiloptera),* Fathead Minnow *(Pimephales promelas),* Yellow Bullhead *(Ameiurus natalis),* Black Bullhead *(Ameiurus melas),* Bluegill *(Lepomis macrochirus),* Largemouth Bass *(Micropterus salmoides),* and Walleye *(Stizostedion vitreum).* The Common Shiner (*Luxilus cornutus*), Fallfish (*Semotilus corporalis*), Golden Shiner (*Notemigonus crysolucas*), Longnose dace (*Rhinichthys cataractae*), Slimy Sculpin (*Cottus cognatus*), and Yellow Perch (*Perca flavescens*) have been added recently as potential hosts for the Northeastern United States populations of the Creeper (Wicklow and Beisheim, 1998; Watters et al., 1999; Gray et al., 1999). Wicklow and Beisheim (1998) reported the larvae of the Northern Two-Lined Salamander (*Eurycea bislineata*) served as potential hosts for the glochidia of the Creeper. However, the Creeper is one of the few freshwater mussels able to complete its life cycle without a fish host; the glochidia undergo a complete development in the female before being expelled (Lefevre and Curtis, 1910). Having direct development of the glochidia, resulting in the elimination of the parasitic stage on fish, is probably a primary factor in the species' wide distribution and local abundance. It is bradytictic, the reproductive period extending from July to April and May (Baker, 1928). Ortmann (1919) noted that the interim between breeding seasons occurs in Pennsylvania from the end of May to early July.

Status: Currently Stable (Williams et al., 1993:14). This species is listed as State Threatened in North Carolina as it appears to be declining throughout its range.

Toxolasma lividus
Rafinesque, 1831
Purple Lilliput

Plate 8, Figure 44

Synonymy:
Toxolasma lividus Rafinesque, 1831; Rafinesque, 1831:2

Type Locality: Rockcastle River [Kentucky].

General Distribution: The Purple Lilliput is known from the Ohio River Basin west of Pennsylvania, including Ohio, Michigan, Illinois, Indiana, and Kentucky. It occurred in the Tennessee and Cumberland River drainages in Tennessee, Virginia, and Kentucky. Oesch (1984) reported the Purple Lilliput from streams in southern Missouri. Also known from the Arkansas River in Arkansas and Oklahoma.

North Carolina Distribution: recorded from Hot Springs on the French Broad River, Madison County, North Carolina. Ortmann (1918) accepted the record but did not examine the specimens. Johnson (1970) suggested the specimens may be *Villosa vanuxemensis* (Adams et al., 1990).

Description: The Purple Lilliput is short, solid, inflated, and elliptical in outline, with a distinct lunule. Shell length seldom exceeds 35 mm. The anterior end is uniformly rounded; the dorsal margin is nearly straight; the ventral margin is straight; the posterior margin has a sharp point above and is broadly rounded below. The posterior ridge is low and rounded. The male shell is short and elliptical to almost rhomboidal in outline with a bluntly rounded posterior margin. The female shells are shorter and somewhat more inflated and have an angular marsupial swelling at the posterior ventral margin. Beaks are full and elevated; sculpture consists of irregular ridges, which curve upward behind and become nodulous at the posterior ridge. The beak cavity is open and shallow, and the interdentum is narrow or absent.

The left valve has two erect, triangular, compressed pseudocardinal teeth and two long, nearly straight lateral teeth. The right valve has a large elongate pseudocardinal tooth, often with a vestige of another above, and a long lateral tooth often with a vestigial lateral or small shelf below it. Adductor muscle scars are impressed; the pallial line is impressed anteriorly. The periostracum has irregular growth lines; color varies from dark brown to black and is rayless. The nacre color is usually a deep purple, lighter beyond the pallial line, but sometimes it is a creamy white, becoming iridescent posteriorly. (Parmalee and Bogan, 1998).

Life History and Ecology: Ahlstedt (in Neves, 1991) reported the Purple Lilliput from small to medium-sized rivers in mud, sand, and gravel substrates. This species has also been found on shallow, rocky gravel points or sandbars in Wheeler Reservoir, Alabama. Ortmann (1921) reported gravid females in May and July. Watters (1994) listed the Green Sunfish *(Lepomis cyanellus)* and Longear Sunfish *(L. megalotis)* as fish hosts for the glochidia of *Toxolasma lividus* (Parmalee and Bogan, 1998)

Status: Special Concern (Williams et al., 1993:14). This species is considered extirpated in North Carolina (Table 4).

Toxolasma pullus (Conrad, 1838)
Savannah Lilliput

Plate 8, Figure 45

Synonymy:

Unio pullus Conrad, 1838; Conrad, 1838:100, pl. 55, fig. 2

Type Locality: Wateree River, South Carolina (Johnson, 1970).

General Distribution: The range of the Savannah Lilliput is from the Altamaha River System in Georgia to the Neuse River System in North Carolina (Johnson, 1970).

North Carolina Distribution: This species is known from the Pee Dee, Waccamaw, Cape Fear, and the Neuse River basins (Johnson, 1967; Fuller, 1977; Porter and Horn, 1980; Shelley, 1987; Adams et al., 1990).

Description: *Toxolasma pullus* has a small, oval or elliptical shell. A large specimen would be 30 to 35 mm long, with a height of 19-20 mm and a width of 15-16 mm. The shell is somewhat inflated. The shells are sexually dimorphic. The females have a broader more truncated posterior end, whereas the males have a narrower rounded posterior end and a point below the median line. The ventral margin is curved in males and straight in females. The posterior ridge is double, sometimes broadly rounded, but usually angular. The umbos are prominent. The periostracum is satiny and coarse because of the numerous closely spaced growth lines. The periostracum is most frequently blackish. Johnson (1970) reports that the periostracum is sometimes brownish, greenish or olivish and with obscure very fine green rays. The left valve has two triangular pseudocardinal teeth. The right valve has a fairly large triangular tooth. The nacre is bluish white with a pink to purplish iridescence at the posterior end (Adams et al., 1990).

Life History and Ecology: The Savannah Lilliput lives in still shallow water near the banks of streams and ponds in mud or sand (Johnson, 1970). I have always found the Savannah Lilliput near the shore in less than 6 inches of water usually in a sandy or silty sand substrate. They seem to exist in small colonies. They are easiest to find when the water is low and still dropping. Nothing is known about the life history of the Savannah Lilliput (Adams et al., 1990).

Status: Williams et al. (1993:14) listed as threatened. This species is listed as State Endangered, effective July 1, 2002. This species may be extirpated from the Neuse River and Lake Waccamaw (J. Alderman, Pers. Comm. July 2002).

Tritogonia verrucosa (Rafinesque, 1820) Pistolgrip

Plate 8, Figure 46

Synonymy:

Obliquaria verrucosa Rafinesque, 1820; Rafinesque, 1820:48, pl. 81, figs. 10–12

Type Locality: Ohio River.

General Distribution: Generally throughout the Mississippi River drainage, from western Pennsylvania west to southern Minnesota, south and west to Oklahoma and Texas; the Cumberland, Tennessee, and Alabama River systems (Ortmann, 1919).

North Carolina Distribution: The Pistolgrip is known only from the New River basin, a tributary to the Ohio River (Table 3).

Description: The shell is solid and an elongated rhomboid in outline, rather compressed but with a distinct, elevated, and rounded posterior ridge. In the same population, shells of old males may reach a length of 160 mm, while those of females may reach 120 mm. Shell size varies greatly in this species and is apparently dependent upon local habitat conditions. The anterior end is broadly rounded, and the ventral margin is slightly curved; the posterior end is squarely or obliquely truncated in the male, more compressed and expanded into a broad wing in the female. Although sexual dimorphism is usually apparent in the shells of mature specimens, it is not well defined in many individuals. Ortmann (1919:45) commented that "the female shell is on the average more flattened and compressed than that of the male." The entire shell surface, with the occasional exception of the posterior ridge and slope, is densely covered with rather small, low tubercles. The posterior slope is usually sculptured with several parallel-elevated ridges or plications. Beaks are compressed to slightly swollen, barely elevated above the hinge line.

The left valve has two solid, triangular, divergent, roughened pseudocardinal teeth; the two lateral teeth are long and straight. The right valve has a large, heavy, triangular, serrated pseudocardinal, with a small tubercular tooth on either side. The lateral tooth is solid, high, straight, and finely striated. The interdentum is narrow; the beak cavity is moderately deep. The anterior pallial line and muscle scars are deeply impressed, the posterior scars weakly so. The periostracum is a dark olive or yellowish tan, unrayed, becoming brown to black in old shells. The nacre is white and iridescent posteriorly. (Parmalee and Bogan, 1998:235).

Life History and Ecology: Because of its apparent adaptability to a variety of habitat conditions, *Tritogonia verrucosa* may be found living at river depths of one foot up to 20 feet and in a substrate composed of coarse gravel, sand, and/or mud. Under favorable conditions, including a stable substrate and moderate current, the Pistolgrip may become locally numerous. The species is tachytictic, and the reproductive period occurs from April to August (Ortmann, 1919; Utterback, 1915–1916). Howells (1996) reported the Flathead Catfish *(Pylodictis olivaris)* to be a suitable fish host for this species. Pepi and Hove (1997) have added the Yellow Bullhead *(Ameiurus natalis)* to the list of host fish for the glochidia of this species (Parmalee and Bogan, 1998).

Status: Currently Stable (Williams et al., 1993:14). The Pistolgrip is considered extirpated in North Carolina (Table 4).

Uniomerus caroliniana
(Bosc, 1801)
Florida Pondhorn

Plate 8, Figure 47

Synonymy:
Unio caroliniana Bosc, 1801; Bosc, 1801:142, pl. 23, fig. 2

Type Locality: " en Caroline", the Carolinas.

General Distribution: The Florida Pondhorn ranges along the South Atlantic Slope from the Ocmulgee River, Georgia north to the Chowan River basin of Virginia (Johnson, 1970).

North Carolina Distribution: This species is found in the Catawba, Yadkin, Lumber, Waccamaw, Cape Fear, Neuse, Pamlico, and Roanoke River basins in North Carolina (Johnson, 1970; Table 2).

Description: " Shell medium to large reaching 114 mm in length. Outline rhomboid or long rhomboid. Valves subinflated or inflated, subsolid. Anterior end regularly rounded or slightly truncated, posterior end usually somewhat produced. Ventral margin slight incurved. Dorsal margin slightly curved, generally forming a sharp angle with the almost straight posterior margin. Hinge ligament long and narrow, located posteriorly of the umbos. Posterior ridge rounded, ending in a point or feeble biangulation at the base of the shell, sometimes rendering older specimens a bit arcuate. Posterior slope often with two radial sulci. Umbos low to slightly elevated, located in the anterior quarter of the shell, their sculpture consisting of five or six heavy ridges that form a rounded angle on the posterior ridge, in front of which they tend to be corrugated. Periostracum generally black and slightly roughened, but with a satiny sheen over most of the surface. Sometimes the surface is smooth and shiny, especially in the umbonal area, and may then be brownish-yellow or yellowish mixed with green, not rayed.
Left valve with two ragged subequal pseudocardinal often with a vestigial tooth above it; one lateral tooth. Beak cavities compressed, but with several scars deep, posterior ones faint. Pallial line distinct. Nacre white, bluish white or pinkish to lurid purple." (Johnson , 1970:341)

Life History: Johnson (1970) reported *Uniomerus* living in smaller streams and ponds on buddy bottoms. The host fish for this species is unknown.

Status: Williams et al. (1993:14) listed as currently stable.

Utterbackia imbecillis (Say, 1829)
Paper Pondshell

Plate 8, figure 48

Synonymy:

Anodonta imbecillis Say, 1829; Say, 1829:355

Type Locality: Wabash River.

General Distribution: The Paper Pondshell is found throughout the Mississippi River and Great Lakes drainages, from southern Michigan south to Georgia and northern Florida (Clench and Turner, 1956), west to Kansas, Oklahoma, and Texas, and southwest to extreme northeastern Mexico. It also occurs sporadically along the Atlantic Coast as far north as Eastern Pennsylvania (Fuller and Hartenstine, 1960).

North Carolina Distribution: The Paper Pondshell occurs in the Broad, Catawba, Yadkin, Cape Fear, Neuse, Pamlico, Roanoke, Chowan, and Pasquotank River basins (Johnson, 1970, Table 2).

Description: The shell is thin, oblong, and inflated. Juveniles, however, are greatly compressed. In especially favorable habitat, individuals may exceed 100 mm in length and become extremely inflated, almost circular in cross section at the beaks. The posterior ridge is moderately angled; the dorsal and ventral margins are nearly straight and parallel. The anterior end is rounded; the posterior end is rather pointed. Beaks are flattened and usually flush with the hinge line; sculpture consists of 5–6 fine, irregular, often broken, somewhat concentric ridges, which are somewhat wavy, forming indistinct double loops. Rest periods are usually marked by distinct concentric ridges, edged with black. Both valves are edentulous; the hinge line is only very slightly thickened. The periostracum is yellowish or greenish with numerous fine green rays. The nacre is bluish white or silvery, and the outside margins and posterior end are iridescent; the shallow beak cavities are often cream or light yellowish brown (Parmalee and Bogan, 1998).

Life History and Ecology: *Utterbackia imbecillis* is found in backwaters, ponds and impoundments and thrives in a mud and fine sand substrate. Once it becomes established in a farm pond, borrow pit, or drainage canal, the Pond Mussel may become quite numerous. The species is probably bradytictic; Ortmann (1909) suggested that it is an autumn breeder in Pennsylvania, noting gravid individuals in May and June. According to Sterki (1898), this species is hermaphroditic, and Baker (1928) indicated that the parasitic developmental stage of glochidia on fish is often omitted. However, Tucker (1927) listed the Green Sunfish *(Lepomis cyanellus)* as a host for the Paper Pondshell, and Fuller (1978) reported the Creek Chub *(Semotilus atromaculatus)* as another. Stern and Felder (1978) also recorded the Western Mosquitofish *(Gambusia affinis),* Warmouth *(Lepomis gulosus),* Bluegill *(L. macrochirus),* and Dollar Sunfish *(L. marginatus)* as host fish for the Paper Pondshell in Louisiana. Watters (1994), citing Trdan and Hoeh (1982) and others, added the Banded Killifish *(Fundulus diaphanus),* Largemouth Bass *(Micropterus salmoides),* Pumpkinseed *(Lepomis gibbosus),* Rockbass *(Ambloplites rupestris),* and Yellow Perch *(Perca flavescens)* to the list of host fish. Hove et al. (1995), based on laboratory experiments, added the Spotfin Shiner *(Cyprinella spiloptera)* and Black Crappie *(Pomoxis nigromaculatus)* to the list of fishes parasitized by glochidia of the Paper Pondshell. Watters (1997) had identified

26 exotic fish species, the tadpoles of the bullfrog and northern leopard frog, adult African clawed frogs, and larval tiger salamanders as surrogate hosts for the glochidia of *Utterbackia imbecillis.* (Parmalee and Bogan, 1998).
Status: Currently Stable (Williams et al., 1993:14). This species is considered stable in North Carolina.

Villosa constricta (Conrad, 1838)
Notched Rainbow

Plate 9, Figure 49

Synonymy:

Unio lienosus var. *constrictus* Conrad, 1838; Conrad, 1838:91, pl.49, fig. 4

Type Locality: North River, Rockbridge County, Virginia

General Distribution: The Notched Rainbow occurs from the James River basin south to the Catawba River basin of North Carolina (Johnson, 1970, Table 2).

North Carolina Distribution: This species is found in the Catawba, Pee Dee, Cape Fear, Neuse, Pamlico, Roanoke, and Chowan River basins in North Carolina (Johnson, 1970; Table 2).

Description: " Shell rather small and short, subelliptical, subsolid, subcompressed; beaks not elevated, their sculpture evenly doubly-looped ridges; surface nearly smooth or marked with irregular concentric growth lines; rather shining, yellowish-green, or bottle-green, feebly rayed; hinge somewhat solid; there are two pseudocardinals in the left valve and one and a faint second in the right; one straight lateral in the right valve and two in the left; anterior muscle scars separate, somewhat impressed; posterior scars faint; nacre bluish, sometimes purplish in the center, slightly thicker in front. The female shell is pointed behind a little more than midway up form the base, and between this point and the small marsupial swelling the outline is generally a little emarginated. The male shell is often subrhomboid, the posterior point being generally less than midway up for the base." (Simpson, 1914:111).

Life History: The breeding season for the Notched Rainbow begins in August and ends in June. The glochidia are subspatulate in outline this species is found in sand in rather good current (Johnson, 1970). The host fish for the glochidia of this species is unknown.

Status: Williams et al. (1993:14) listed as special concern.

Villosa delumbis (Conrad, 1834)
Eastern Rainbow

Plate 9, Figure 50

Synonymy:

Unio delumbis Conrad, 1834; Conrad, 1834: 35, pl. 5, fig. 3

Type Locality: Small streams near Cooper River, South Carolina.

General Distribution: The Eastern Rainbow is found from the Ocmulgee River drainage of the Altamaha River basin in Georgia north to the Cape Fear River basin of North Carolina (Johnson, 1970, Table 2). The record from the Neuse is probably a new species of *Lampsilis* (J. Alderman, Pers. Comm. July 2002).

North Carolina Distribution: This species' range includes the Catawba, Pee Dee, Waccamaw, and Cape Fear River basins (Johnson, 1970; Table 2).

Description: "Shell long ovate, very thin and fragile, ventricose; ligament margin slightly elevated; anterior side rather narrow; posterior margin rounded; beaks only moderately full; margin of the ligament slope rounded, very oblique; within bluish, highly iridescent; cardinal teeth lamellar; cavity capacious." (Simpson, 1914:52). The female shell is very enlarged on the posterior end while the male is oval in shell outline. The periostracum is yellow marked by numerous green rays, interrupted by the prominent growth lines.

Life History: Johnson (1970) reported this species living in mud or soft sand, rich in vegetation, in small creeks and rivers. The host fish for the glochidia of this species is unknown.

Status: Williams et al. (1993:14) listed as currently stable.

Villosa iris (Lea, 1829)
Rainbow

Plate 9, figure 51

Synonymy:

Unio iris Lea, 1829; Lea, 1829:439, pl. 11, fig. 18

Type Locality: Ohio.

General Distribution: The Rainbow is found throughout the Tennessee, Cumberland, and Ohio River basins, the upper Mississippi River, and the St. Lawrence River system from Lake Huron to Lake Ontario including their tributaries (Burch, 1975; Clarke, 1981a).

North Carolina Distribution: The Rainbow is reported from the Hiwassee, Little Tennessee, and historically from the French Broad rivers (Ortmann, 1918; Dawley, 1965; Table 3).

Description: The Rainbow shell outline is elongate elliptical to long ovate, subcompressed to somewhat inflated; the shell is thicker anteriorly, becoming quite thin posteriorly. The anterior end is evenly rounded, the dorsal margin is almost straight to slightly convex, and the ventral margin is also almost straight to broadly curved. The posterior ridge is low and rounded. The male shells are more sharply pointed posteriorly, while the female shell is expanded posteriorly, producing a marsupial swelling and thus becoming more broadly rounded. Beaks are low and compressed; sculpture consists of 4–6 bars, the first concentric, the rest irregular, interrupted ridges, tending to become double-looped. The beak cavity is open and shallow with a few dorsal muscle scars. The maximum shell length attained is about 75 mm. The left valve has two triangular, somewhat compressed, slightly sculptured pseudocardinal teeth, which run parallel with the hinge line, and two long, straight, thin lateral teeth. The right valve has one subcompressed pseudocardinal and one long, straight, and thin lateral tooth. The anterior adductor muscle scar is well impressed; the posterior adductor muscle scar is quite shallow. The pallial line is impressed anteriorly. The shell surface is covered with faint growth lines. The periostracum is yellowish to greenish yellow with numerous dark green rays varying from narrow to wide, complete to interrupted. The nacre color varies from white to salmon, pink and purple, and is iridescent posteriorly (Parmalee and Bogan, 1998:247).

Life History and Ecology: Ortmann (1919) reported *Villosa iris* as bradytictic with glochidia from July to May. The Rainbow lives in riffles and along the edges of emerging vegetation, such as *Justicia* beds, in gravel and sand in moderate to strong current. It becomes most numerous in clean, well-oxygenated stretches at depths of less than three feet. Watters (1994) lists the following fish hosts for the glochidia of *Villosa iris:* Largemouth Bass *(Micropterus salmoides),* Smallmouth Bass *(M. dolomieu),* Spotted Bass *(M. punctulatus),* Suwannee Bass *(M. notius),* Rockbass *(Ambloplites rupestris),* and Western Mosquitofish *(Gambusia affinis*). O'Connell and Neves (1999) examined the immunological response of host fish Rockbass (*Amboplites rupestris*) and non-host fish, Carp (*Cyprinus carpio*) and Goldfish (*Carassius auratus*) to the glochidia of the Rainbow documenting specific humoral defense factors that reacted immunologically to glochidia tissue (Parmalee and Bogan, 1998).

Status: Currently Stable (Williams et al., 1993:14). This species is listed as State Special Concern (Table 4).

Villosa trabalis (Conrad, 1834)
Cumberland Bean

Plate 9, Figure 52

Synonymy:

Unio trabalis Conrad, 1834; Conrad, 1834:27, 72 pl. 3, fig. 5.

Type Locality: Flint River, Alabama.

General Distribution: The small Cumberland Bean is restricted to the upper Cumberland River system in Kentucky, formerly the main channel of the Tennessee River upstream from Muscle Shoals, Alabama, and in streams of the upper Tennessee River drainage in Tennessee and Virginia (Parmalee and Bogan, 1998).

North Carolina Distribution: This species was probably part of the fauna as is treated as such. However, Ortmann (1918) observed that this species was absent from the eastern tributaries to the Tennessee River in Tennessee.

Description: Shells of the Cumberland Bean are solid and elongate with inflated, inequilateral, and irregularly oval valves. The anterior end is rounded, and the ventral margin slightly rounded to straight, converging with the posterior-dorsal surface in a rounded point. The posterior ridge is somewhat full and rounded. The male shell is slightly narrowed at its center and is drawn out posteriorly; this elongation is obliquely truncated above and ends in a rounded point below. Female shells are higher and more evenly ovate and only slightly truncated behind and above the posterior ridge. The ventral margin is rather evenly curved. Beaks are high, situated near the anterior end where the shell is thickest, and sculptured with a few coarse, double-looped ridges. Female shells reach a slightly larger size than males, attaining a maximum length of about 55 mm.

The left valve has two solid triangular pseudocardinal teeth, a narrow interdentum, and two long, straight, relatively heavy lateral teeth. The right valve has three pseudocardinals: the central tooth is large, sculptured, and triangular, while the anterior and posterior teeth are much reduced. The single lateral tooth is long, sometimes with a vestige of a second tooth below. The beak cavity is shallow with a few dorsal scars. Adductor muscle scars and the pallial line are well impressed. The periostracum is a dingy olive green with numerous faint wavy green rays. The surface is marked by irregular growth lines. The nacre color is a bluish white or white with a bluish or greenish iridescence posteriorly (Parmalee and Bogan, 1998).

Life History and Ecology: The Cumberland Bean has been collected in small rivers and streams in a typically gravel or sand and gravel substrate with fast current in riffle areas. The animal is bradytictic. Probable host fish for *Villosa trabalis* have been determined, based on laboratory experiments, as the Arrow Darter *(Etheostoma sagitta),* Barcheek Darter *(E. obeyense),* Fantail Darter *(E. flabellare),* Johnny Darter *(E. nigrum),* Rainbow Darter *(E. caeruleum),* Snubnose Darter *(E. simoterum atripinne),* Sooty Darter *(E. olivaceum),* Striped Darter *(E. virgatum),* and Stripetail Darter *(E. kennicotti).* However, the Arrow Darter is not found within the known range of *Villosa trabalis* and the Johnny Darter and Rainbow Darter both produced very few juveniles per fish (Layzer and Anderson, 1991, 1992, J. B. Layzer, pers. comm., 1997) (Parmalee and Bogan, 1998).

Status: Williams et al. (1993:15) listed as endangered. This species is federally listed as endangered. It is presumed to be extirpated in North Carolina.

Villosa vanuxemensis (Lea, 1838)
Mountain Creekshell

Plate 9, figure 53

Synonymy:

Unio vanuxemensis Lea, 1838; Lea, 1838b:36, pl. 11, fig. 31

Type Locality: Cumberland River, Tennessee.

General Distribution: *Villosa vanuxemensis* is a Cumberlandian species restricted to the Tennessee and central Cumberland River basins (Ortmann, 1918, 1924). Upper Coosa River system (Conasauga River, northern Georgia)(Parmalee and Bogan, 1998)

North Carolina Distribution: The Mountain Creekshell is reported from the Hiwassee River basin (Table 3).

Description: The Mountain Creekshell varies in outline from elliptical to somewhat obovate, the shell being rather solid and inflated. The anterior end is broadly rounded, the dorsal margin is straight to convex, and the ventral margin is broadly rounded to almost straight. The posterior ridge is slightly developed. Male shells are elongated elliptical in outline with the posterior margin rather sharply pointed, the point occurring in about the middle of the posterior margin. The female shell is marked by a prominent marsupial swelling along the posterior ventral margin; the shell is truncated beyond this to a point about two-thirds the way up the posterior margin. Shells in old females have a strong constriction posterior to the marsupial swelling. Beaks are low, sculpture consists of several ridges drawn up in the middle. The beak cavity is open and shallow. Maximum shell length rarely exceeds 70 mm.

The left valve has two short, compressed triangular pseudocardinal teeth and two slightly curved, thin lateral teeth. The right valve has one short, compressed pseudocardinal and one curved, thin lateral tooth. The anterior adductor muscle scar is well impressed, while the posterior adductor muscle scar is shallow. The pallial line is impressed anteriorly. The periostracum varies from a tan or olive to dark brown, becoming black with age; rays are indistinct or absent. The nacre color varies from a light lavender or pinkish purple, to shades of copper or very dark purple (Parmalee and Bogan, 1998).

Life History and Ecology: The Mountain Creekshell is found in gravel and sand substrates in riffles and along the edges of *Justicia* beds in very clean water at depths of less than three feet. It, along with *V. iris,* is a species most often encountered in small headwater creeks and streams. *Villosa vanuxemensis* is bradytictic, holding glochidia from September to their release in May (Ortmann, 1921). Watters (1994) lists the following fish hosts for the glochidia of *Villosa vanuxemensis*: Banded Sculpin *(Cottus carolinae),* Black Sculpin *(C. baileyi),* Mottled Sculpin *(C. bairdi),* and the Slimy Sculpin *(C. cognatus)* (Parmalee and Bogan, 1998).

Status: Special Concern (Williams et al., 1993:15). This species is listed as State Threatened in North Carolina (Table 4).

Villosa vaughaniana (Lea, 1838)
Carolina Creekshell

Plate 9, Figure 54

Synonymy:

Unio vaughanianus Lea, 1838; Lea, 1838:5, pl. 3, fig. 5

Type Locality: Sawney's Creek, near Camden (Kershaw County), South Carolina.

General Distribution: .The only published record found for the Carolina Creekshell is Sawney's Creek (Catawba River system), near Camden, South Carolina, its type locality. It is known from creeks in the Pee Dee River basin in North Carolina (Adams et al., 1990).

North Carolina Distribution: The Carolina Creekshell has been collected recently from creeks in the Catawba, Pee Dee, and Cape Fear River basins (Adams et al., 1990; J. Alderman, Pers. Comm. July 2002).

Description: With the exception of the original description by Lea in 1838, the only other description found for *V. vaughaniana* was in Simpson (1914). The description in Simpson (1914) is accurate, but it was based on two female specimens. The following description of the Carolina Creekshell is based upon twenty specimens (male and female) from Densons Creek, Montgomery County, North Carolina.

The somewhat inflated shell is elliptical in the male and obovate in the female. The largest male was 60 mm long, 33 mm high and 22 mm wide. The largest female was 54 mm long, 30 mm high and 20 mm wide. The anterior margin of both sexes is rounded. The posterior end is pointed about 2/3 of the way from the ventral margin. In the male, the posterior margin below the point is a gradual curve and above the point it is straight in older males, but a gradual curve that blends with the dorsal margin in younger individuals. In the female, there is a distinct posterior basal swelling. There can also be a slight constriction between the basal swelling and the posterior point. The ventral margin in males is generally a gentle curve, but in females, it is usually straight. The beaks extend a little above the dorsal margin. The shell is moderately shiny with strong irregular growth lines. The periostracum is a greenish yellow to a dark brownish yellow with numerous, continuous dark green rays covering most of the shell. The overall appearance of the shell can sometimes be a uniform dark brown, but actual color is a dark brownish yellow with numerous dark green rays.

The left valve has two moderately large, triangular, serrated pseudocardinal teeth. The anterior tooth is more pointed and directed slightly towards the anterior end. When the left valve is viewed from the dorsal side both pseudocardinal teeth protrude noticeably. The right valve also has two pseudocardinal teeth. The larger posterior tooth is either like a thick blade or is pointed; it is also usually parallel to the dorsal margin. There are two well-developed lateral teeth in the left valve and one in the right valve. The nacre is shiny, iridescent white or bluish-white, frequently with a pale salmon shade deepening toward the ventral margin. Some specimens do not show any salmon shading (Adams et al., 1990).

Life History: Most of the Carolina Creekshells Alderman collected were found near the bank in the shaded pools of small streams. They were usually in muddy or silty gravel and in shallow water. Gravid females were found on August 23, 24 and 26, 1987 in Second Creek, Goose Creek and Lick Creek of the Pee Dee River system. In the streams examined this species was not usually associated with *V. constricta,* which was

usually found in shallow running water (Adams et al., 1990).
Status: Williams et al. (1993:14) listed as special concern. This species is listed as State Endangered in North Carolina, effective July 1, 2002.

Villosa vibex (Conrad, 1834)
Southern Rainbow
Plate 10, Figure 55

Synonymy:
Unio vibex Conrad, 1834; Conrad, 1834:31, pl. 4, fig. 3

Type Locality: Black Warrior River, south of Blount's Springs [Blount County], Alabama.

General Distribution: Gulf Coast drainages from the Pearl River, Mississippi, east across peninsular Florida, north to the Savannah River system and up the South Atlantic Coast to the Cape Fear River Basin of North Carolina (Johnson, 1970).

North Carolina Distribution: The Southern Rainbow was found in the Waccamaw and Cape Fear River basins (Johnson, 1970; Table 2).

Description: Shells vary from thin to subsolid, being elliptical to elongate obovate in outline. The anterior and posterior margins are evenly rounded, and the ventral margin is straight to slightly curved in males and often arcuate in females. The dorsal margin is straight. The shell varies from slightly compressed to inflated. Male shells are often subrhomboid with a bluntly pointed posterior margin, while female shells are slightly inflated with a broadly rounded posterior margin. The posterior ridge is broadly rounded. Beaks are only moderately inflated and slightly elevated above the hinge line; sculpture consists of a few double-looped ridges. The shell length of adults averages about 60 mm but may reach 100 mm.

The left valve has two slightly compressed pseudocardinal teeth, the anterior tooth being longer and higher; the two lateral teeth are rather short and delicate. The right valve has a single pseudocardinal tooth, sometimes with a dorsal vestigial tooth and a single short lateral tooth. The beak cavity is fairly shallow and open. Adductor muscle scars are shallow, not impressed; the pallial line is lightly impressed. The periostracum is smooth and shiny, but interrupted by irregular growth lines. Color varies from a greenish yellow to olive brown, the surface covered with rather broad, unbroken to slightly wavy dark green rays over the entire surface. Some individuals have the rays restricted to the posterior area or are occasionally rayless. The nacre color is a bluish white, often becoming iridescent posteriorly (Parmalee and Bogan, 1998).

Life History and Ecology: Johnson (1972:238) reported that *Villosa vibex* "[l]ives in small rivers, creeks, and lakes, in mud or soft sand, particularly where rich in vegetable detritus." In the Conasauga River in Tennessee, the Southern Rainbow occurs at depths of less than three feet, usually in stretches with moderate current. Haag et al. (1997) have shown through laboratory fish host identification experiments that the Redeye Bass *(Micropterus coosae),* Spotted Bass *(M. punctulatus),* and Largemouth Bass *(M. salmoides)* may serve as hosts for the glochidia of this mussel. No information on the breeding season for this species was encountered, but it is assumed to be bradytictic, holding glochidia from September to May, as is the case in other members of the genus *Villosa* (Parmalee and Bogan, 1998).

Status: Currently Stable (Williams et al., 1993:15). Porter (1985) did not report this species from Lake Waccamaw nor did Adams (1990) find it in Greenfield Lake.

GLOSSARY OF BIVALVE TERMS

Alate - with an extension or wing on the dorsal edge of the shell.
Angular (subangulate) - having either the anterior or posterior margins forming a relatively acute (sharp) angle.
Anterior - front or forward.
Arcuate - bent in a bow or arched.
Beak - the raised portion of the dorsal margin of a shell; formed by the embryonic shell around which the rest of the shell develops distally in a concentric manner.
Beak cavity - the cavity on the inside of each valve leading into the beak, under the interdentum.
Beak sculpture - raised ridges or undulations on the umbo.
Biangulate - having two angles.
Bradytictic - mussels which are long-term breeders; females retain glochidia in their gills typically over the winter.
Byssus, byssal threads - a bundle of tough threads secreted by the byssal gland in the foot of a bivalve, used to anchor the bivalve to some hard substrate.
Cardinal teeth - teeth located between the lateral teeth in Corbiculidae and Sphaeriidae.
Chevron - shaped like a wide-angled V.
Clinal variation - the graded variation in morphology exhibited by a species in mollusks from headwater areas to the mouth of the highest order stream.
Compressed (subcompressed) - flattened out or pressed together.
Concentric - having a common center, such as ridges or loops radiating from the beak of a mussel valve.
Conspecific - pertaining to individuals or populations of the same species.
Corrugated - marked by wrinkles or ridges and grooves.
Crescentic - shaped like the figure of the crescent moon with a convex and a concave edge.
Decorticate - to remove the outer covering, in mollusks the epidermis.
Disc - the middle or central portion of the exterior of a valve; distinct from the posterior slope or other areas immediately adjacent to the margin of the valve.
Discoidal - round and flat like a disc.
Dorsal - the top or back; in mussels, the hinge area.
Edentulous - lacking both pseudocardinal and lateral teeth.
Effuse - spread out broadly.
Elliptical (subelliptical) - elongated, having the form of an ellipse.
Elongate - long or extended.
Emarginate - having a shallow notching at the margin.
Endangered - this status at the state level includes peripheral forms which may be common in another part of its range, but whose continued existence within the political boundaries of the state is in danger of extirpation. At the national level, this status means the organism is in danger of extinction, and included on or being considered for the U.S. List of Endangered Fauna and Endangered and Threatened Plant Species of the United States, under the Endangered Species Act of 1973 (Cooper et al., 1973:x).
Epidermis - exterior or outside (corneous) layer of the shell.

Extinct - a species which has no living representatives; all individuals are no longer extant.
Extirpated - the extinction of a species within a portion of its range.
Form - an animal with questionable taxonomic status; that is, one exhibiting variation but the extent or degree is not well enough known to determine whether it is a species, subspecies or simply individual or population variation.
Fusiform - tapering toward each end.
Gills - a thin plate-like paired structure within the mantle cavity, which serves as a respiratory organ in aquatic mollusks and in female unionids all of the gills or certain portions of the gills serve as the marsupium.
Globose - globe-like, spherical.
Glochidium (plural - glochidia) - the bivalve larvae of unionids which are generally parasitic on the gills of fish.
Gravid female - a female that has embryos in the marsupium.
Growth lines - compact lines of temporarily arrested growth or rest periods appearing on the epidermis of the shell as a raised or darker concentric line.
Hinge ligament - an elastic, elongate, corneous structure that unites the two valves dorsally along the hinge plate.
Holotype - single specimen designated as the "type" by the author in the publication of a new species level taxon. Inequilateral - in a bivalve, having the two ends unequal, i.e., one end is wider or thicker than the other.
Inflated (subinflated) - moderately to greatly inflated.
Interdentum - a flattened area of the hinge plate between the pseudocardinal and lateral teeth.
Iridescent - showing colors like those of a rainbow.
Lachrymose - term describing teardrop-shaped pustules.
Lateral teeth - the elongated, raised and interlocking structures along the hinge line of the valve.
Lectotype - one of a series of syntypes that, subsequent to the publication of an original description of a species level taxon, is selected (by publication) to serve as the type specimen for that taxon.
Lunule - depressed area immediately anterior to the umbo.
Marsupial swelling - a section of the posterior ventral margin of the female unionid shell which is enlarged or inflated to provide space for expansion of the marsupium with the development of the glochidia.
Marsupium (marsupial pouch) - in unionids, a brood pouch for eggs and developing glochidia, formed by a restricted portion of the outer gill, the complete outer gill or all four gills.
Muscle scar - the area of attachment of a muscle to the inside of the shell; e.g., the anterior adductor muscle scar is the location of attachment for the anterior adductor muscle.
Nacre - the interior iridescent, thin layer of a mussel shell.
Naiad - formerly a tribe of Mollusca nearly equivalent taxonomically to the family Unionidae, often used as a synonym of unionid.
Nodule (subnodulous) - a small rounded mass of irregular shape.
Oblique - slanting; angled, but not horizontal or vertical.

Obovate - (subobovate) - ovate.
Orbicular (suborbicular) - having the form of an orb; circular or nearly circular in outline.
Oval, Ovate (subovate) - egg-shaped, broadly elliptical.
Pallial line - an indented groove or line approximately parallel with the ventral margin of a bivalve shell that marks the line of muscles attaching the mantle to the shell.
Paratype - each specimen of a type series other than the holotype designated in the original publication of the taxon.
Periphery - the external boundary on a surface, edge.
Periostracum - see epidermis.
Plications - parallel ridges on the surface of the shell.
Posterior - hind or rear.
Posterior ridge - a ridge on the exterior of a mussel shell, extending from the umbo to the posterior margin.
Posterior slope - the area across the dorsal portion of the valve extending from the umbo to the posterior margin, often above the posterior ridge.
Pseudocardinal teeth - triangular-shaped hinge teeth near the anterior -dorsal margin of the shell.
Pustule - small, raised structure on the external or outside surface of the shell (see also tubercle).
Quadrate (subquadrate) - square, or nearly square in outline.
Radial furrow - a groove or depression; in naiads a groove running from the umbo area toward the shell margin.
Radiating - proceeding outward from a central point.
Rare- seldom appearing, occurring widely separated in space; extremely few in number.
Rectangular - a shape with four sides possessing four right-angles.
Rest mark - see growth lines.
Rhomboid (subrhomboid) - having generally four distinct sides, two sides being longer than the others.
Semicircular - a partial or incomplete circle.
Serrated - notched or grooved.
Sexual dimorphism - a condition in which males and females of the same species are morphologically different, usually indicated by an expanded posterior marsupial area in the female in contrast to a more pointed or bluntly rounded area in the male.
Sinus - a character of some unionids that have a depression above or below the posterior ridge.
Solid (subsolid) - shells that are thick and heavy.
Special Concern - This status covers cases where the organism exists in small populations over a broad range, may be over exploited which may pose a threat, the organism are especially vulnerable to specific pressures, or any other reasons identified by experienced researchers (Cooper et al., 1973:x).
Species - group of interbreeding natural populations that are reproductively isolated from all other such groups.
Striae - impressed or raised lines on a shell.
Striate - having striae.

Subspecies - a geographically defined aggregate of local populations within a species that differ morphologically and/or physiologically from other aggregations of local populations within that species.
Sulcus (plural - sulci) - a longitudinal furrow or depression.
Sympatric - pertaining to populations of two or more closely related species that occupy identical or broadly overlapping geographical areas.
Syntype - one of a series of specimens of the same taxon that formed the material studied by the original author to describe a new species level taxon, form which no type specimen (holotype) was designated.
Tachytictic - mussels which are short-term breeders; i.e., glochidia are found in the gills of the female only during the summer.
Taxon - any formal taxonomic unit or category of an organism; e.g., a species or genus.
Threatened - This status at the state level includes forms that are likely to become Endangered in the foreseeable future if certain conditions are not met. This includes forms that exhibit a considerable decrease in numbers beyond normal populations fluctuations or a documented range contraction, but are not yet considered Endangered. At the national level this applies to the Endangered Species Act of 1973 (Cooper et al., 1973:x).
Trapezoid (subtrapezoid) - a shape having four distinct sides with two sides parallel.
Triangular (subtriangular) - a shape having three sides and three angles, like a triangle.
Truncate (subtruncate) - having the end squared off.
Tubercle (tuberculate) - small, raised, rounded knob on the outside of the shell.
Tuberculate - having tubercles on the outside of the shell.
Type - a designated specimen or specimens of an organism that serves as the basis for the original name and description of any species level taxon.
Umbo/umbone - the dorsally raised, inflated area of the bivalve shell.
Unionids - refers to any member of the freshwater bivalve mollusks that belong to the superfamily Unionoidea.
Undulation - pattern with waves; raised ridges or bars.
Valve - the right or left half of a mussel (or unionid) shell.
Ventral - the underside or bottom.

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Website with pictures and information on the status of the federal and state listed freshwater bivalves of North Carolina. Constructed by John Alderman and Judith Johnson, NC Wildlife Resources Commission

Tom Watters Electric Elliptio Land
http://www.biosci.ohio-state.edu/~molluscs/OSUM2/elliptio_land.htm
This is part of the website for the Ohio State University Museum of Zoology, Mollusk Collection, this is the only website with a variety of pictures of some of the *Ellipto*.

Freshwater Mollusk Conservation Society
http://ellipse.inhs.uiuc.edu/fmcs/
Society formed for the conservation of freshwater mollusks with good links to other sites.

Illinois Natural History Mollusk Collection
http://www.inhs.uiuc.edu/cbd/collections/mollusk.html
This site has a lot of information on mollusk collections around the world, curators of those collections, and links to the freshwater mollusk bibliography.
Compiled by Kevin Cummings and Chris Mayer.

Freshwater Mollusk Bibliography
http://ellipse.inhs.uiuc.edu/mollusk/
This website is a searchable database of over 10,000 articles, book chapters, theses, dissertations and gray literature reports dealing with freshwater mollusks. Compiled by Kevin Cummings, Arthur Bogan, G. Thomas Watters, and Chris Mayer.

USGS Florida Caribbean Science Center/ Non-indigenous species
http://www.fcsc.usgs.gov/Nonindigenous_Species/nonindigenous_species.html
This site has great pictures, distribution maps and information on the major aquatic invasive species.

USGS zebra Mussel Information
http://nas.er.usgs.gov/zebra.mussel/
Good source of maps showing the invasion of North America by both the zebra and quagga mussels.

Conchologists of America
http://coa.acnatsci.org/conchnet/
Amateur shell collectors website with loads of good information and links.

If these websites do not answer your questions go to the web browser www.google.com and type in a key word with great results. These sites are active at this time, July 9, 2002.