

Fishes in Muddy Creek, Erie National Wildlife Refuge-
Seneca Division, with Emphasis on Host Species for Federal
and State-Listed Freshwater Mussels and State-Listed Fishes

Final Project Report for the Erie National Wildlife Refuge

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Abstract

Muddy Creek, Crawford County, PA is one of 10 major sub-basins of the French Creek watershed. The portion of Muddy Creek that flows through the Erie National Wildlife Refuge-Seneca Division provides habitat for 22 species of freshwater mussels, including two federally- and state-listed as endangered and one federal candidate species. The purpose of this project was to sample for fishes in the portion of Muddy Creek flowing through the Erie National Wildlife Refuge-Seneca Division to determine the presence and distributions of host fishes for federally- and state-listed freshwater mussels and of state-listed fishes. We collected 48 species of fish (3,221 individuals) including 24 of the 31 species in the French Creek watershed reported to serve as mussel hosts (1,023 individuals) and seven of the 24 state-listed fishes (177 individuals) thought to live in the French Creek watershed. We present new fish data, the associations of freshwater mussels and their host fishes at 19 sampling sites, and the listing status (by the Pennsylvania Natural History Program) of the sampled fishes and reported mussels.

Introduction

Muddy Creek, Crawford County, PA is one of 10 major sub-basins of the French Creek watershed. Semi-quantitative surveys conducted in 2003 in the portion of Muddy Creek that flows through the Erie National Wildlife Refuge-Seneca Division (ENWR) (Figure 1) confirmed that 22 species of freshwater mussels live in the study area (Table 1; Mohler et al., in press). Muddy Creek appears to be second only to the main stem of French Creek in providing habitat for the most diverse assemblage of freshwater mussels in Pennsylvania (WPCFCP 2002). Two species, the Clubshell Mussel (*Pleurobema clava*) and Northern Riffleshell (*Epioblasma torulosa rangiana*), are federal- and Pennsylvania-listed endangered species, and the Rayed Bean Mussel (*Villosa fabalis*) is a candidate for federal listing (PANHP 2006a, b). Successful reproduction is critical to the maintenance and recovery of several rare freshwater mussel populations known to occur in Muddy Creek in the ENWR (Mohler et al., in press), and their reproduction is dependent on the presence of the host fishes (Haas 2003, FMORB 2005) that carry the mussels' glochidia larvae during a critical developmental period.

The purpose of this project was to survey fishes in the portion of Muddy Creek that flows through the ENWR-Seneca Division and to determine the presence and distributions of host fishes for federal- and Pennsylvania-listed freshwater mussels and Pennsylvania-listed fishes. Fish were sampled at the same 20 sites sampled for mussels in 2003 by Mohler et al. (in press), and at five additional sites with varying stream habitat characteristics. However, we collected a combined sample of fish at two of Mohler et al.'s sites (19 and 20) that were close together near the confluence of Muddy and French

Creeks (Figure 1). This report gives new fish data for 25 sampling reaches in Muddy Creek, the associations of freshwater mussels and their host fishes at each sampling site, and the listing status of the sampled mussels (PANHP 2006a,b) and fishes (PANHP 2006a,c) in Pennsylvania.

Methods

Sampling sites (Figure 1) were accessed by canoe. A hand-held GPS unit was used to find the sites sampled by Mohler et al. (in press) in 2003. Four-person crews used two backpack electro-fishing units (one battery powered at a maximum of 5 A and 24 VDC, Halltech, Inc., Toronto, Ontario; the other powered by a gasoline generator at a maximum of 3 A and 120 VAC rectified to VDC, Smith-Root, Inc., Vancouver, WA) and two beach seines (13 ft x 5 ft, 21 ft x 7 ft; ¼ in mesh) to sample fish semi-quantitatively. Depending on water depth and conductivity, electro-fishing settings ranged from 1-5 A and 150-600 VDC and averaged 3-4 A and 250 VDC. The standard electro-fishing effort at each site was 30 min with power on. Cycles per second (Hertz) was varied from 30-90 to capture fish in a wide range of sizes.

A minimum of four and a maximum of 10 seine hauls were made at each site, with an average of five. To be counted, a haul had to produce at least six fish. Seines were pulled with, against and diagonally to the current depending on habitat type, current, in-stream wood and other obstacles. Distances from shore from which seines were pulled ranged from 2-10 m, with an average of 4 m. Seine hauls were most successful in higher currents and in backwater pools; many hauls were fouled by abundant in-stream wood.

Two other methods, to a lesser degree, also were used to capture fish. We experimented with mini-hoop nets (18 in diameter, 48 in long, ¼-in bar mesh) set overnight in pairs in areas with slow current, one facing upstream and the other downstream. We also counted identifiable, mostly large, fish observed escaping the electrical field or seine.

Fish were identified in the field using the keys of Cooper (1983), Smith (1985), Page and Burr (1991) and Knopf (2002). Fish that could not be identified were returned to SUNY Brockport and identified. Subsequently, lists of key features for these fishes were used in the field. We also recorded observations of amphibians and reptiles (Appendix 1).

Results and Discussion

Fishes

We sampled 48 fish species (3,221 individuals), including 24 of the 31 mussel hosts (1,023 individuals) and seven of the 24 Pennsylvania-listed fishes (177 individuals), reported in the French Creek watershed (WPCFCP 2002; Table 2, Appendix 2). We did not collect seven reported host species for mussels—northern pike (*Esox lucius*), bigeye chub (*Hybopsis amblops*), warmouth (*Lepomis gulosus*), largemouth bass (*Micropterus*

salmoides), white crappie (*Pomoxis annularis*), Tippecanoe darter (*Etheostoma tippecanoe*), and yellow perch (*Perca flavescens*). However, bigeye chub and largemouth bass were collected by Crisswell (2001) in Muddy Creek or adjacent French Creek.

Our results were consistent with Crisswell (2001) who collected 53 species in a similar study, including 23 mussel hosts and seven state-listed fishes (Table 2). We found eight fish species not collected by Crisswell and he found 15 species not collected by us. Our sampling intentionally focused on stream sections chosen by Mohler et al. (in press), with good habitat for mussels (Appendix 3) and, presumably, for their host fishes (Appendix 4), which probably accounted for not finding as many species as Crisswell who sampled a wider range of habitats in Muddy Creek and adjacent French Creek. We and Mohler et al. chose gravel to cobble substrates with relatively rapid water velocities (Table 3). Neither we nor Crisswell found the Tippecanoe darter, the only reported host fish for the Rayed Bean Mussel (FMORB 2005) found in Muddy Creek by Mohler et al.

We were surprised to collect moderate numbers of the PA-endangered eastern sand darter (*Ammocrypta pellucida*; $n = 75$, 2.3% of the 3,221 fish collected); the PA-threatened gilt darter (*Percina evides*; 47, 1.5%), longhead darter (*Percina macrocephala*; 11, 0.3%) and brindled madtom (*Noturus miurus*; 9, 0.3%); and the PA-candidate Ohio lamprey (*Ichthyomyzon bdellium*; 33, 1.0%). We caught one each of the PA-threatened bluebreast darter (*Etheostoma camurum*) and the PA-candidate bowfin (*Amia calva*) (Table 2, Appendices 2 and 5). We did not collect 17 of the 24 Pennsylvania-listed species reported to occur in the French Creek watershed (WPCFCP 2002, Table 2)—mountain brook lamprey (*Ichthyomyzon greeleyi*), American brook lamprey (*Lampetra appendix*), central mudminnow (*Umbra limi*), gravel chub (*Erimystax x-punctatus*), hornyhead chub (*Nocomis biguttatus*), blackchin shiner (*Notropis heterodon*), blacknose shiner (*Notropis heterolepis*), redbfin shiner (*Lythrurus umbratilis*), southern redbelly dace (*Phoxinus erythrogaster*), river redhorse (*Moxostoma carinatum*), northern madtom (*Noturus stigmosus*), mountain madtom (*Noturus eleutherus*), brook stickleback (*Culaea inconstans*), warmouth (*Lepomis gulosus*), Iowa darter (*Etheostoma exile*), spotted darter (*Etheostoma maculatum*), and Tippecanoe darter. However, Crisswell (2001) collected the hornyhead chub and northern madtom in Muddy Creek or adjacent French Creek.

Mussel and Fish Associations

We compared the relative abundance and potential associations of host fishes collected in this study with the mussel species collected at the same 19 sites by Mohler et al. (in press) in 2003 (Table 4, Appendix 6). Mohler et al. collected 22 species of mussels. As a measure of relative abundance and distribution, they found 10 of the 22 species of mussels at 13 or more of the 19 sites, seven species at 4-11 sites, and five species at 1-3 sampling sites (Table 4).

The most interesting result was finding four reported host fishes highly associated (i.e., the only known, or a very abundant, host fish sampled at sites with the mussel) with five mussels, including two that are federally- and PA-listed endangered. The blackside darter (*Percina maculata*) is almost certainly the definitive host in Muddy Creek for the

endangered Clubshell Mussel (*P. clava*) and for the Snuffbox Mussel (*E. triquetra*) (Table 4). The banded darter (*Etheostoma zonale*) is probably the host for the endangered Northern Riffleshell (*E. torulosa rangiana*); the bluntnose minnow (*Pimephales notatus*) is probably the host for the Round Pigtoe (*P. sintonia*); and the fathead minnow is probably the host for the Cylindrical Papershell (*A. ferrusacianus*).

Reported host fishes collected at sites with the Elktoe (*Alasmidonta marginata*) and Giant Floater (*Pyganodon grandis*) appear to be widespread and abundant enough in Muddy Creek to support healthy populations of their associated mussels (Table 4). However, reported fish hosts collected at sites with the Three-ridge Mussel (*A. plicata*), Mucket (*Actinonaias ligamentina*), Spike (*Elliptio dilatata*), Plain Pocketbook (*Lampsilis cardium*), Fatmucket (*Lampsilis siliquoides*), and Squawfoot Mussel (*Strophitus undulatus*) do not appear to be widespread or abundant enough to support healthy populations of their associated mussels (Table 4).

Four mussels with no known hosts (Long-solid Mussel, *F. subrotunda*; Pocketbook, *Lampsilis ovata*) or a single host that is rare (bigeye chub; Rabbitsfoot Mussel, *Q. cylindrica*) or not reported in Muddy Creek (Tippecanoe darter; Federal candidate Rayed Bean Mussel, *V. fabalis*) were found in Muddy Creek by Mohler et al. (in press) (Table 4). These findings suggest a correlation between low abundance of these freshwater mussels and their host fishes, and that maintaining or enhancing conditions for host fishes will be important for maintaining or restoring these mussel species in Muddy Creek. However, widespread and abundant host fishes for other mussels in Muddy Creek were collected at the sites with the Long-solid, Pocketbook, Rabbitsfoot and Rayed Bean mussels. Unreported hosts, particularly the bluntnose minnow, northern hogsucker (*Hypentelium nigricans*), golden redhorse (*Moxostoma erythrurum*), and blackside darter (Table 4), may be used by these four mussels for dispersal of their glochidia larvae.

Reported host fishes were not collected at sites with four other mussel species, but widespread and abundant hosts reported for other mussels in Muddy Creek were collected at their sites. The bluntnose minnow, northern hogsucker, golden redhorse and blackside darter again were highly associated with the Creek Heelsplitter (*Lasmigona compressa*), Wavy-rayed Lampmussel (*Lampsilis fasciola*), Pocketbook (*Lampsilis ovata*), and Black Sandshell (*Ligumia recta*). In addition, no reported host fishes were found at sites with the Fluted-shell Mussel (*Lasmigona costata*) or Kidney Shell (*Ptychobranhus fasciolaris*), but many reported hosts for other mussels in Muddy Creek were collected at sites with these mussels (Table 4, Appendix 6).

The data reported here suggest several hypotheses of mussel-host fish relationships in the portion of Muddy Creek that flows through the ENWR-Seneca Division (Table 4). For example, we hypothesize that the abundant golden redhorse (not a reported host fish) may take the place of the closely related shorthead redhorse (*Moxostoma macrolepidotum*, a reported host) in Muddy Creek.

Finding some freshwater mussels in Muddy Creek without their known host fishes, suggests one of two possibilities: 1) unreported host species in Muddy Creek are serving

as mussel hosts, or 2) some mussel species are currently unable to complete their life cycles. Given the intensive fish surveys of the stream (Crisswell 2001, this study) it is unlikely that populations of additional host species capable of sustaining their associated mussels' life cycles have been missed. Given the low percent abundance of several mussels at the sampling sites in Muddy Creek (Table 4, Appendix 6), they may be having trouble reproducing if they are not using alternative hosts. Accordingly, two avenues of future research might be productive: 1) monitor mussel populations at 5-year intervals and focus on size-age distributions as evidence of successful reproduction (i.e., look for the presence of small, young mussels), and 2) conduct research to determine which fishes in Muddy Creek are actually serving as hosts for each mussel species.

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Table 1. Live freshwater mussels found in Muddy Creek, Erie National Wildlife Refuge-Seneca Division, their Federal and Pennsylvania listing status, and their reported host fishes.

Table 2. Fishes reported in the French Creek watershed and their Pennsylvania listing status.

Table 3. In-stream habitat observations for 24 sampling sites in Muddy Creek, Erie National Wildlife Refuge-Seneca Division.

Table 4. Live freshwater mussels and their reported host fishes collected at the same sampling sites in Muddy Creek, Erie National Wildlife Refuge-Seneca Division.

Appendix 1. Amphibians and reptiles observed in Muddy Creek, Erie National Wildlife Refuge-Seneca Division.

Appendix 2. Fish catches in Muddy Creek, Erie National Wildlife Refuge-Seneca Division, May-June, 2005.

Appendix 3. Habitats and distributions of live freshwater mussels found in Muddy Creek, Erie National Wildlife Refuge-Seneca Division.

Appendix 4. Habitats and distributions of host fishes and Pennsylvania-listed fishes collected in Muddy Creek, Erie National Wildlife Refuge-Seneca Division.

Appendix 5. Pennsylvania and Federal species listing codes and status definitions.

Appendix 6. Percent abundance of freshwater mussels and their host fishes sampled in Muddy Creek, Erie National Wildlife Refuge-Seneca Division.

Table 1. Live freshwater mussel species found in Muddy Creek, ENWR-Seneca Division, by Mohler et al. (in press), their Federal and Pennsylvania listing status, and their reported host fishes. Most information about potential host fishes was found at Freshwater Mussels of the Ohio River Basin, <http://www.marietta.edu/~bio/mussels/1stpg.html> (Biology Department website, Marietta College, Ohio). Fishes collected in this study are in bold print. For Federal and Pennsylvania listing definitions, see Appendix 5 and PANHP (2006a, b).

Common/Scientific Name	Host Fishes for Transport of the Glochidia Larvae of Unionid Mussels
Mucket <i>Actinonaias ligamentina</i>	White bass, rock bass, bluegill, green sunfish , largemouth bass ¹ , smallmouth bass, black crappie , white crappie, yellow perch, sauger
Elktoe <i>Alasmidonta marginata</i>	White sucker, northern hogsucker, shorthead redhorse, rock bass , warmouth
Three-ridge Mussel <i>Amblema plicata</i>	Shortnose gar, northern pike, white bass, rock bass, green sunfish , warmouth, pumpkinseed, bluegill , largemouth bass ¹ , white crappie, yellow perch
Cylindrical Papershell <i>Anodontooides ferrusacianus</i>	White sucker, common shiner, spotfin shiner, fathead minnow, bluegill , largemouth bass ¹ , black crappie, mottled sculpin
Spike <i>Elliptio dilatata</i>	Gizzard shad, flathead catfish, rock bass, black crappie , white crappie, rainbow darter , yellow perch, sauger, banded sculpin
Northern Riffleshell <i>Epioblasma torulosa rangiana</i> Federally Endangered PA Endangered	Brown trout, banded darter, mottled sculpin
Snuffbox Mussel <i>Epioblasma triquetra</i>	Logperch, blackside darter
Long-solid Mussel <i>Fusconaia subrotunda</i>	No known hosts
Plain Pocketbook <i>Lampsilis cardium</i>	Bluegill , largemouth bass ¹ , smallmouth bass , white crappie, yellow perch, sauger, walleye
Wavy-rayed Lampmussel <i>Lampsilis fasciola</i>	Smallmouth bass

Table 1. Continued.	
Pocketbook <i>Lampsilis ovata</i>	No known hosts (perhaps similar to Plain pocketbook)
Fatmucket <i>Lampsilis siliquoidea</i>	White sucker, common shiner , white bass, rock bass, bluegill, pumpkinseed , largemouth bass ¹ , smallmouth bass, black crappie , white crappie, yellow perch, sauger, walleye
Creek Heelsplitter <i>Lasmigona compressa</i>	Spotfin shiner , yellow perch
Fluted-shell Mussel <i>Lasmigona costata</i>	Bowfin , northern pike, common carp, bluegill , largemouth bass ¹ , yellow perch, walleye
Black Sandshell <i>Ligumia recta</i>	bluegill , largemouth bass ¹ , white crappie, sauger, walleye
Clubshell Mussel <i>Pleurobema clava</i> Federally Endangered PA Endangered	Central stoneroller, logperch, blackside darter
Round Pigtoe <i>Pleurobema sintoxia</i>	Spotfin shiner, bluntnose minnow, bluegill
Kidney Shell <i>Ptychobranthus fasciolaris</i>	No known hosts
Giant Floater <i>Pyganodon grandis</i>	Too many to list, and many species found in Muddy Creek
Rabbitsfoot Mussel <i>Quadrula cylindrica</i>	Bigeye chub ¹
Squawfoot Mussel <i>Strophitus undulatus</i>	Creek chub , plains killifish, green sunfish , largemouth bass ¹
Rayed Bean Mussel <i>Villosa fabalis</i> Federal Candidate	Tippecanoe darter

¹Collected by Crisswell (2001) in Muddy Creek or adjacent French Creek.

Table 2. Fishes reported in the French Creek watershed (from WPCFCP 2002, Appendix G) and their Pennsylvania listing status (see Appendix 5 and PANHP 2006a, c). Species in bold print were caught in Muddy Creek flowing through the ENWR-Seneca Division during this study. Species in non-bold print were caught by Crisswell (2001). PA listing status: PE = endangered; PT = threatened; PC = could become PE or PT in future.

Common Name	Scientific Name	Mussel Host?	Sites	N	2001	PA Status
LAMPREYS		PETROMYZONTIDAE				
Ohio lamprey	<i>Ichthyomyzon bdellium</i>		9	33		PC
Mountain brook lamprey	<i>Ichthyomyzon greeleyi</i>					PT
American brook lamprey	<i>Lampetra appendix</i>					PC
GARS		LEPISOSTEIDAE				
Longnose gar	<i>Lepisosteus osseus</i>					
BOWFINS		AMIIDAE				
Bowfin	<i>Amia calva</i>	Yes	1	1		PC
TROUTS		SALMONIDAE				
Brown trout	<i>Salmo trutta</i>	Yes	1	1		
Brook char	<i>Salvelinus fontinalis</i>					
MUDMINNOWS		UMBRIDAE				
Central mudminnow	<i>Umbra limi</i>				X	PC
PIKES		ESOCIDAE				
Grass pickerel	<i>Esox americanus vermiculatus</i>		5	7	X	
Northern pike	<i>Esox lucius</i>	Yes				
Muskellunge	<i>Esox masquinongy</i>				X	
MINNOWS & CARPS		CYPRINIDAE				
Central stoneroller	<i>Campostoma anomalum</i>	Yes	11	37	X	
Redside dace	<i>Clinostomus elongates</i>		3	5	X	
Common carp	<i>Cyprinus carpio</i>	Yes	1	1	X	
Tonguetied minnow	<i>Exoglossum laurae</i>					
Brassy minnow	<i>Hybognathus hankinsoni</i>					
Bigeye chub	<i>Hybopsis amblops</i>	Yes			X	
Streamline chub	<i>Erimystax dissimilis</i>				X	
Gravel chub	<i>Erimystax x-punctatus</i>					PE
Hornyhead chub	<i>Nocomis biguttatus</i>				X	PC
River chub	<i>Nocomis micropogon</i>				X	
Golden shiner	<i>Notemigonus crysoleucas</i>		2	3	X	
Comely shiner	<i>Notropis amoenus</i>					

Table 2. Continued.

Emerald shiner	<i>Notropis atherinoides</i>		1	1		
Striped shiner	<i>Luxilus chrysocephalus</i>		6	20	X	
Common shiner	<i>Luxilus cornutus</i>	Yes	3	7		
Blackchin shiner	<i>Notropis heterodon</i>					PE
Blacknose shiner	<i>Notropis heterolepis</i>					PE
Spottail shiner	<i>Notropis hudsonius</i>		1	2		
Silver shiner	<i>Notropis photogenis</i>		17	162	X	
Rosyface shiner	<i>Notropis rubellus</i>		3	7	X	
Spotfin shiner	<i>Cyprinella spiloptera</i>	Yes	3	7	X	
Sand shiner	<i>Notropis stramineus</i>		21	600	X	
Redfin shiner	<i>Lythrurus umbratilis</i>					PE
Mimic shiner	<i>Notropis volucellus</i>				X	
Southern redbelly dace	<i>Phoxinus erythrogaster</i>					PT
Finescale dace	<i>Phoxinus neogaeus</i>					
Bluntnose minnow	<i>Pimephales notatus</i>	Yes	19	103	X	
Fathead minnow	<i>Pimephales promelas</i>	Yes	16	103	X	
Eastern blacknose dace	<i>Rhinichthys atratulus</i>		13	90	X	
Longnose dace	<i>Rhinichthys cataractae</i>		15	33	X	
Creek chub	<i>Semotilus atromaculatus</i>	Yes	7	85	X	
Pearl dace	<i>Margariscus margarita</i>					
Silverjaw minnow	<i>Notropis buccatus</i>		18	235	X	
SUCKERS	CATOSTOMIDAE					
Quillback	<i>Carpionodes cyprinus</i>					
White sucker	<i>Catostomus commersonii</i>	Yes	11	62	X	
Northern hog sucker	<i>Hypentelium nigricans</i>	Yes	24	237	X	
Silver redhorse	<i>Moxostoma anisurum</i>				X	
River redhorse	<i>Moxostoma carinatum</i>					PC
Black redhorse	<i>Moxostoma duquesnei</i>				X	
Golden redhorse	<i>Moxostoma erythrurum</i>	Yes	23	170	X	
Shorthead redhorse	<i>Moxostoma macrolepidotum</i>				X	
N. AMER.						
CATFISHES	ICTALURIDAE					
Yellow bullhead	<i>Ameiurus natalis</i>		3	3	X	
Brown bullhead	<i>Ameiurus nebulosus</i>		3	4		
Stonecat	<i>Noturus flavus</i>					
Brindled madtom	<i>Noturus miurus</i>		4	9	X	PT
Northern madtom	<i>Noturus stigmosus</i>				X	PE
Mountain madtom	<i>Noturus eleutherus</i>					PE
TROUT-PERCHES	PERCOPSIDAE					
Trout-perch	<i>Percopsis omiscomaycus</i>					

Table 2. Continued.

TOPMINNOWS	FUNDULIDAE					
Banded killifish	<i>Fundulus diaphanous</i>					
NEW WORLD SILVERSIDES	ATHERINOPSIDAE					
Brook silverside	<i>Labidesthes sicculus</i>				X	
STICKLEBACKS	GASTEROSTEIDAE					
Brook stickleback	<i>Culaea inconstans</i>				X	PC
SUNFISHES & BASSES	CENTRARCHIDAE					
Rock bass	<i>Ambloplites rupestris</i>	Yes	14	23	X	
Green sunfish	<i>Lepomis cyanellus</i>	Yes	2	2	X	
Pumpkinseed	<i>Lepomis gibbosus</i>	Yes	3	5	X	
Warmouth	<i>Lepomis gulosus</i>	Yes				PE
Bluegill	<i>Lepomis macrochirus</i>	Yes	4	4	X	
Smallmouth bass	<i>Micropterus dolomieu</i>	Yes	2	2	X	
Largemouth bass	<i>Micropterus salmoides</i>	Yes			X	
White crappie	<i>Pomoxis annularis</i>	Yes				
Black crappie	<i>Pomoxis nigromaculatus</i>	Yes	1	1	X	
PERCHES	PERCIDAE					
Eastern sand darter	<i>Ammocrypta pellucida</i>		16	75	X	PE
Greenside darter	<i>Etheostoma blennioides</i>		23	289	X	
Rainbow darter	<i>Etheostoma caeruleum</i>	Yes	8	14	X	
Iowa darter	<i>Etheostoma exile</i>					PE
Fantail darter	<i>Etheostoma flabellare</i>		12	57	X	
Spotted darter	<i>Etheostoma maculatum</i>					PT
Johnny darter	<i>Etheostoma nigrum</i>		24	409	X	
Variagate darter	<i>Etheostoma variatum</i>		7	11	X	
Banded darter	<i>Etheostoma zonale</i>	Yes	15	78	X	
Bluebreast darter	<i>Etheostoma camurum</i>		1	1		PT
Tippecanoe darter	<i>Etheostoma tippecanoe</i>	Yes				PT
Logperch	<i>Percina caprodes</i>	Yes	2	2	X	
Gilt darter	<i>Percina evides</i>		14	47		PT
Longhead darter	<i>Percina macrocephala</i>	Yes	6	11	X	PT
Blackside darter	<i>Percina maculate</i>	Yes	22	146	X	
Walleye	<i>Sander vitreum vitreum</i>					
Yellow perch	<i>Perca flavescens</i>	Yes				
SCULPINS	COTTIDAE					
Mottled sculpin	<i>Cottus bairdi</i>	Yes	3	4	X	

Table 4. Live freshwater mussels (Mohler et al., in press) and their reported host fishes (this study) collected at the same sampling sites (n = 19) in Muddy Creek, ENWR-Seneca Division. See Table 2 for scientific names of fishes. PE = PA Endangered, E = Federally Endangered; C = Federal Candidate, s = number of sites where mussels and their reported host fishes were collected, f = number of reported host fishes collected at sites with associated mussels, % = average percentage in their communities of mussels and reported host fishes collected at sites with the mussel. Most information on mussel hosts found at Freshwater Mussels of the Ohio River Basin, Biology Dept. website, Marietta College, Ohio, <http://www.marietta.edu/~bio/mussels/1stpg.html>.

Common/Scientific Name Locations & Percent Abundance	Reported Host Fishes at Sites	Comments and Hypotheses for Mussel Hosts
Mucket <i>Actinonaias ligamentina</i> 15 sites; 18.6% Mostly site 5 and downstream	rock bass (9s, 14f, 1.0%) bluegill (2s, 2f, 0.2%) smallmouth bass (2s, 2f, 0.1%)	H: unknown fishes may be important hosts
Elktoe <i>Alasmidonta marginata</i> 8 sites; 1.7% Mostly site 7 and downstream	white sucker (2s, 5f, 0.4%) northern hogsucker (8s, 77f, 9.7%) golden redhorse (8s, 49f, 5.8%) rock bass (5s, 9f, 1.3%)	The golden redhorse may be an important host in place of the shorthead redhorse (<i>Moxostoma macrolepidotum</i>) H: suckers are the likely hosts
Three-ridge Mussel <i>Amblema plicata</i> 16 sites; 25.4% Mostly site 5 and downstream	rock bass (10s, 18f, 1.1%) green sunfish (2s, 2f, 0.1%)	H: unknown fishes may be important hosts
Cylindrical Papershell <i>Anodontoides ferrusacianus</i> 3 sites; 4.0%	common/striped shiner (2s, 10f, 1.4%) fathead minnow (3s, 51f, 6.3%) mottled sculpin (2s, 3f, 0.4%)	The spotfin shiner is a reported host, but was not collected at sites with this mussel H: fathead minnow is the likely host

Table 4. Continued.		
Spike <i>Elliptio dilatata</i> 16 sites; 7.8% Throughout the study reach	rock bass (9s, 17f, 1.0%) rainbow darter (5s, 9f, 0.5%)	H: unknown fishes may be important hosts
Northern Riffleshell (PE, E) <i>Epioblasma torulosa rangiana</i> 2 sites; 0.3%	banded darter (1s, 4f, 1.3%)	H: probably <u>the</u> important host; although not collected at one mussel site, it was found at 16 other sites
Snuffbox Mussel <i>Epioblasma triquetra</i> 11 sites; 1.9% Mostly site 7 and downstream	blackside darter (10s, 59f, 5.0%)	H: probably <u>the</u> important host
Long-solid Mussel <i>Fusconaia subrotunda</i> 4 sites; 1.2% Mostly site 15 and downstream	No hosts reported	Other reported hosts at sites with this mussel: bluntnose minnow (3s, 11f, 2.9%) fathead minnow (3s, 6f, 1.5%) northern hogsucker (4s, 30f, 10.5%) golden redhorse (4s, 34f, 10.5%) H: suckers are the most likely hosts
Plain Pocketbook <i>Lampsilis cardium</i> 14 sites; 5.6% Throughout the study reach	bluegill (2s, 2f, 0.2%) smallmouth bass (2s, 2f, 0.1%)	H: unknown fishes likely are more important hosts
Wavy-rayed Lampmussel <i>Lampsilis fasciola</i> 5 sites; 10.6% All between sites 4-10	Smallmouth bass is reported host; none collected at these sites	Other reported hosts at sites with this mussel: bluntnose minnow (3s, 15f, 2.2%) fathead minnow (4s, 10f, 1.6%) white sucker (2s, 4f, 0.7%) northern hogsucker (5s, 53f, 8.2%)

<p>Table 4. Continued.</p>		<p>golden redbreast (5s, 47f, 7.6%) rock bass (3s, 3f, 0.5%)</p> <p>H: suckers are the most likely hosts</p>
<p>Pocketbook <i>Lampsilis ovata</i> 1 site; 0.1%</p>	<p>No hosts reported</p>	<p>Other reported hosts at sites with this mussel: bluntnose minnow (1s, 7f, 13.0%) northern hogsucker (1s, 6f, 11.1%) golden redbreast (1s, 5f, 9.3%) rock bass (1s, 3f, 5.6%)</p> <p>H: any may be an important host</p>
<p>Fatmucket <i>Lampsilis siliquoidea</i> 17 sites; 14.6% Throughout the study reach</p>	<p>common/striped shiner (6s, 19f, 0.6%) white sucker (8s, 25f, 0.9%) rock bass (10s, 18f, 1.0%) bluegill (3s, 3f, 0.2%)</p>	<p>H: unknown fishes may be important hosts</p>
<p>Creek Heelsplitter <i>Lasmigona compressa</i> 4 sites; 1.0%</p>	<p>spotfin shiner is reported host is; none collected at these sites</p>	<p>Other reported hosts at sites with this mussel: bluntnose minnow (4s, 45f, 7.8%) fathead minnow (2s, 2f, 0.5%) northern hogsucker (4s, 48f, 8.6%) golden redbreast (3s, 27f, 6.8%) rock bass (3s, 5f, 0.9%) blackside darter (4s, 21f, 4.0%)</p> <p>H: bluntnose minnow, suckers</p>

Table 4. Continued.		and blackside darters likely hosts
Fluted-shell Mussel <i>Lasmigona costata</i> 15 sites; 9.6% Mostly site 5 and downstream	Reported hosts are bowfin, common carp, bluegill, largemouth bass; none collected at these sites	Many other reported mussel hosts at the sites with this mussel
Black Sandshell <i>Ligumia recta</i> 6 sites; 1.1%	Reported hosts are bluegill and largemouth bass; none collected at these sites	Other reported hosts at sites with this mussel: bluntnose minnow (5s, 50f, 7.4%) fathead minnow (4s, 7f, 1.5%) northern hogsucker (6s, 92f, 11.0%) golden redbreast (5s, 31f, 4.5%) rock bass (4s, 7f, 1.4%) H: bluntnose minnow and suckers are likely hosts
Clubshell Mussel (PE, E) <i>Pleurobema clava</i> 8 sites, 2.8% Mostly sites 6-10 and 18-20	blackside darter (8s, 56f, 5.6%)	Probably <u>the</u> important host fish
Round Pigtoe <i>Pleurobema sintoxia</i> 13 sites, 4.0% Throughout the study reach	spotfin shiner (1s, 4f, 0.4%) bluntnose minnow (11s, 61f, 3.7%)	Bluntnose minnow probably <u>the</u> important host fish
Kidney Shell <i>Ptychobranhus fasciolaris</i> 13 sites; 3.5% Throughout the study reach	<i>No hosts reported</i>	Many reported mussel hosts at the 13 sites
Giant Floater <i>Pyganodon grandis</i> 14 sites; 6.7% Mostly site 7 and downstream	Many reported hosts	Many reported mussel hosts at the 14 sites

Table 4. Continued.		
<p>Rabbitsfoot Mussel <i>Quadrula cylindrica</i> 3 sites; 0.9%</p>	<p>Reported host is bigeye chub (found in Muddy Creek or adjacent French Creek by Crisswell 2001); none collected at the sites</p>	<p>Other reported hosts at sites with this mussel: fathead minnow (3s, 8f, 2.1%) northern hogsucker (3s, 52f, 12.4%) golden redhorse (3s, 23f, 6.5%) rock bass (1s, 1f, 0.3%) banded darter (3s, 11f, 3.0%) blackside darter (3s, 26f, 6.5%)</p> <p>H: suckers and darters may be the important hosts</p>
<p>Squawfoot Mussel <i>Strophitus undulatus</i> 18 sites; 15.2% Throughout the study reach</p>	<p>creek chub (5s, 71f, 1.7%) green sunfish (1s, 1f, 0.3%)</p>	<p>H: unknown fishes are likely to be important hosts</p>
<p>Rayed Bean Mussel (C) <i>Villosa fabalis</i> 3 sites; 3.8%</p>	<p>Reported host is Tippecanoe darter; none collected at the sites</p>	<p>Other reported hosts at sites with this mussel: fathead minnow (3s, 8f, 2.1%) northern hogsucker (3s, 52f, 12.4%) golden redhorse (3s, 23f, 6.5%) rock bass (1s, 1f, 0.3%) banded darter (3s, 11f, 3.0%) blackside darter (3s, 26f, 6.5%)</p> <p>H: suckers and darters may be the important hosts</p>