

## Eagle Hill Institute

---

The Invasion of *Procambarus clarkii* (Decapoda: Cambaridae) into Maryland Streams following Its Introduction in Outdoor Aquaculture Ponds

Author(s): Jay V. Kilian, Jason Frentress, Ronald J. Klauda, Andrew J. Becker and Scott A. Stranko

Source: *Northeastern Naturalist*, Vol. 16, No. 4 (2009), pp. 655-663

Published by: [Eagle Hill Institute](#)

Stable URL: <http://www.jstor.org/stable/27744602>

Accessed: 07/05/2014 04:06

---

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.



*Eagle Hill Institute* is collaborating with JSTOR to digitize, preserve and extend access to *Northeastern Naturalist*.

<http://www.jstor.org>

## The Invasion of *Procambarus clarkii* (Decapoda: Cambaridae) into Maryland Streams Following its Introduction in Outdoor Aquaculture Ponds

Jay V. Kilian<sup>1,\*</sup>, Jason Frentress<sup>2</sup>, Ronald J. Klauda<sup>1</sup>, Andrew J. Becker<sup>1</sup>, and Scott A. Stranko<sup>1</sup>

**Abstract** - We provide locality data for stream populations of *Procambarus clarkii* (Red Swamp Crawfish) in Maryland. This non-native species is now established in 14 watersheds in the Coastal Plain, including all watersheds where it was historically raised in aquaculture ponds. Our surveys indicate that the introduction of Red Swamp Crawfish in Maryland has largely resulted from aquaculture, although the aquarium, biological supply, and live-bait industries are other potential vectors. The effects of Red Swamp Crawfish on the composition and diversity of stream fauna and flora in Maryland are unknown. The establishment of this species may have negative effects on native crayfishes, especially the congeneric *P. acutus* (White River Crawfish). These locality records provide baseline information for future monitoring of this non-native species and assessment of its effects on Maryland's stream ecosystems and native crayfishes.

### Introduction

Non-native crayfish introductions are considered the largest threat to North America's crayfish fauna, the second-most imperiled fauna on the continent (Lodge et al. 2000a; Stein and Flack 1997; Taylor et al. 1996, 2007). The documentation of non-native crayfish introductions into new areas is necessary to assess the effects of these species on ecosystem function and native crayfish diversity (Cooper et al. 1998).

*Procambarus clarkii* Girard (Red Swamp Crawfish), native to the south-central United States and northern Mexico, is the most widely cultured and distributed crayfish in the world (Huner 2002) and has been introduced on all continents except Australia and Antarctica, usually with negative consequences (Hobbs et al. 1989). The first known introduction of Red Swamp Crawfish in Maryland occurred in 1963 at the Patuxent National Wildlife Refuge in Laurel in the Patuxent River basin. Several individual crayfish were introduced to shallow water impoundments as a potential food source for wading birds (Matthew Perry, USGS-Patuxent Wildlife Research Center, Laurel, MD, 2006 pers. comm.).

Red Swamp Crawfish have also been introduced into outdoor ponds for the purposes of commercial aquaculture in Maryland. The Worcester

<sup>1</sup>Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment, 580 Taylor Avenue, Annapolis, MD 21401. <sup>2</sup>Oregon State University, Water Resources Science, 2075 Cordley Hall, Corvallis, OR 97331. \*Corresponding author - jkilian@dnr.state.md.us.

County Soil Conservation District initiated a crayfish aquaculture trial in 1981, during which seed-stock purchased from Louisiana was used to stock impoundments in the Pocomoke River (Pattys Branch) and Nanticoke River (Rewastico Creek) basins to examine the feasibility of crayfish culture in Maryland (Bruce Nichols, Hebron, MD, pers. comm.). The results of this trial indicated that sustained, profitable crayfish production could occur in Maryland. In 1983, the Mid-Atlantic Crawfish Association was established. With 250 members at its peak, this group of farmers and landowners promoted crayfish aquaculture in the Mid-Atlantic region. The original Louisiana seed-stock was used to stock Red Swamp Crawfish in outdoor ponds for commercial aquaculture on the Delmarva Peninsula and in Southern Maryland (Bruce Nichols, pers. comm.). It was also used to stock culture ponds on the University of Maryland Eastern Shore campus for research (David O' Neill, Community College of Baltimore County, Baltimore, MD, pers. comm.). Most of the stocking of Red Swamp Crawfish promoted by the Mid-Atlantic Crawfish Association occurred prior to the establishment of aquaculture permit regulations by the Maryland Department of Natural Resources (MDNR) in 1990. Many locations where Red Swamp Crawfish were introduced were not formally documented and are unknown. There are seven known locations where Red Swamp Crawfish were historically introduced into outdoor ponds for culture in Maryland; commercial aquaculture is still conducted at two of these locations.

In 2006, we examined the role of aquaculture as a source of introduction of Red Swamp Crawfish in Maryland streams. We conducted targeted surveys in streams adjacent to all seven aquaculture facilities. We also collected data on stream crayfishes at sites sampled as part of the Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS). These surveys documented populations of this non-native species in streams and rivers on Maryland's coastal plain. The goals of this report are to 1) compile all known records of Red Swamp Crawfish to document its current distribution in Maryland, and 2) to discuss the likely vectors responsible for the introduction of this species. Documentation of these records will prove useful for examining changes in the distribution of this species over time.

### **Methods**

Locations of aquaculture ponds where Red Swamp Crawfish were cultured were provided by MDNR Fisheries Service personnel, crayfish farmers, and researchers (Richard Bohn, MDNR Fisheries Service, Annapolis, MD, pers. comm.; Bruce Nichols, pers. comm.; David O' Neill, pers. comm.; Matthew Perry, pers. comm.). We sampled 16 sites in non-tidal streams adjacent to seven aquaculture ponds. Crayfishes were collected using dip-nets. Crayfish burrows in stream banks were excavated by hand. Dip-netting was supplemented with backpack electrofishing at sites where dip-netting was not

considered sufficient to provide a representative sample of crayfish species present. All crayfishes captured were identified to species. One record of Red Swamp Crawfish from a stream adjacent to an aquaculture pond in the Nanticoke River was provided by David O' Neill of the Community College of Baltimore County.

Crayfish sampling was also conducted at 172 sites as part of the annual Maryland Biological Stream Survey. Backpack electroshockers (Smith-Root Model 12; Haltech Model HT-2000) were used to sample non-tidal stream sites. Non-wadeable rivers and freshwater impoundments were sampled using a jonboat outfitted with a Smith-Root Model KVA electrofisher. Boat electroshocking was supplemented by seining (1.5 m x 3.0 m, 0.3-cm mesh; 1.8 m x 7.6 m, 0.6-cm mesh) in shallow, heavily vegetated shoreline habitats at three sites sampled in the tidal Potomac River. All crayfishes collected at each MBSS site were field-identified to species. All Red Swamp Crawfish specimens collected in 2006 were preserved in alcohol and are currently stored at the MDNR in Annapolis, MD.

## Results

Non-native Red Swamp Crawfish were collected at 35 sites in 14 watersheds (Maryland 8-digit HUC) in the coastal plain on the western shore of Chesapeake Bay and on the Delmarva Peninsula (Fig. 1, Appendix 1). Populations were documented in streams adjacent to all known ponds where

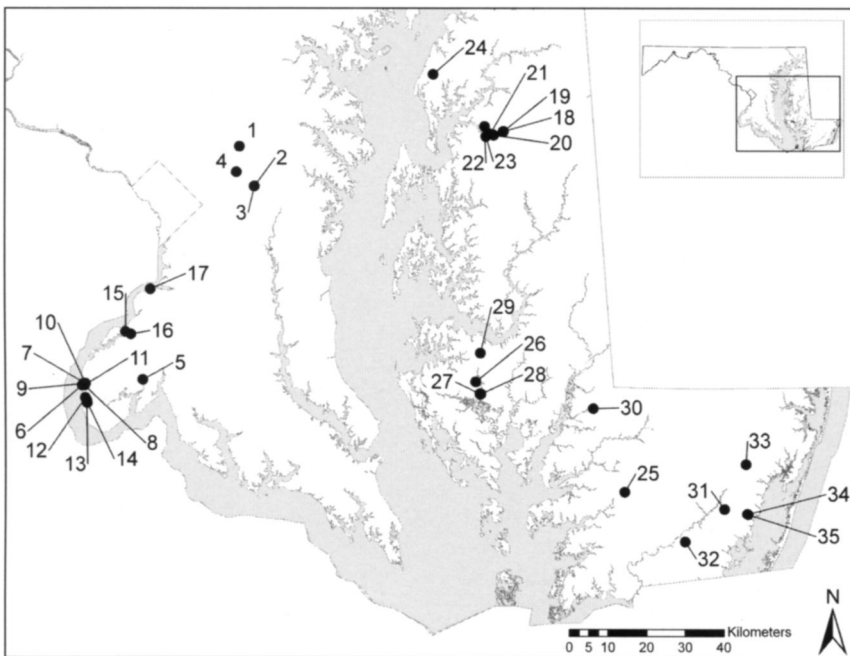


Figure 1. Stream sites where Red Swamp Crawfish were collected.

Red Swamp Crawfish were once cultured and in portions of the Patuxent, Potomac, and Chester rivers (Fig. 2).

### Discussion

The most important vectors responsible for the introduction of non-native crayfishes throughout North America are the aquaculture, aquarium, biological supply, and live-bait industries (Lodge et al. 2000b). The results of this study indicate that the introduction of Red Swamp Crawfish in Maryland has largely resulted from aquaculture. This species is now established in streams adjacent to all aquaculture ponds where it was introduced for commercial culture or for aquaculture-related research.

The vector or vectors responsible for the introductions of Red Swamp Crawfish in the Potomac and Chester Rivers are unknown. Although no aquaculture facilities in the Potomac River or Chester River basins are or were registered with the MDNR Fisheries Service, these introductions may have resulted from undocumented aquaculture in these areas. It is also likely that these populations are the result of the inadvertent introduction of Red Swamp Crawfish as bait, or intentional release by aquarium hobbyists. The population documented in the Western Branch watershed of the Patuxent River was approximately 70 river km from the original introduction site in the Patuxent National Wildlife Refuge. This population could have

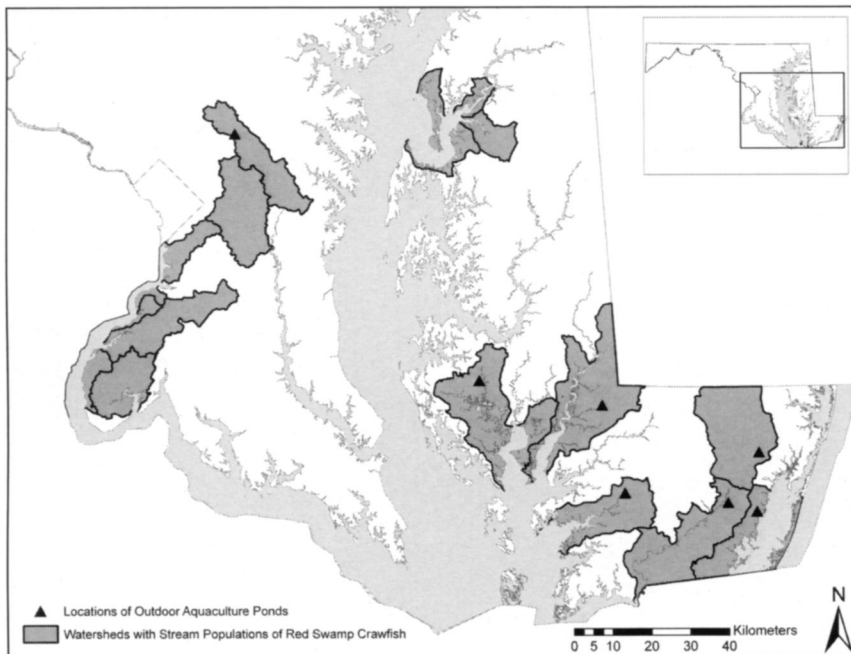


Figure 2. Maryland watersheds (8-digit HUC) with established stream populations of *Procambarus clarkii* (Red Swamp Crawfish) and locations of aquaculture ponds where this species was originally introduced.

originated from the downstream dispersal of Red Swamp Crawfish within the Patuxent River or from a separate introduction event.

The effects of Red Swamp Crawfish on ecosystem function and the composition and diversity of aquatic fauna and flora in Maryland are unknown. Many transplants of this species throughout the world have resulted in crop damage, damage to levees and dams as a result of burrowing activity, or changes to regional flora and fauna (Hobbs et al. 1989, Holdich 1988, Lowery and Mendes 1977). The establishment of this species in Maryland waters may have negative effects on native crayfishes, especially the congeneric *P. acutus* Girard (White River Crawfish). Red Swamp Crawfish, the more aggressive of the two species, may likely out-compete White River Crawfish for shelter or other limited resources, and ultimately displace the native species (Gherardi and Daniels 2004) as appears to have occurred in portions of North Carolina (Cooper and Armstrong 2007). Native displacement by non-native crayfishes is a phenomenon that has been documented extensively (Capelli 1982, Capelli and Munjal 1982, Holdich 1988, Lodge et al. 2000a, Schwartz et al. 1963), prompting many states to establish regulations on the import, culture, and sale of these potentially damaging species (Lodge et al. 2000b). In Maryland, an aquatic nuisance species list drafted in 2006 seeks to limit the import and transport of several problematic invasive species (COMAR 2006). Non-native crayfishes on this list include Red Swamp Crawfish, *Orconectes virilis* Hagen (Virile Crayfish), and *O. rusticus* Girard (Rusty Crayfish). The establishment of stream populations of Red Swamp Crawfish as a result of the aquaculture of this species in outdoor ponds has major management implications and should be considered in decisions involving the culture of this and other non-native species in other states.

Efforts to eradicate Red Swamp Crawfish have been extensive and costly in other areas of the country (Barbaresi et al. 2004, Hobbs et al. 1989), and future attempts will likely prove futile in Maryland and could harm native species. Pesticide application is likely to harm non-target species (Bills and Marking 1988, Olden et al. 2006), and toxicants may be ineffective on Red Swamp Crawfish individuals in protected burrows. Other approaches such as trapping would be labor-intensive and may also be ineffective. Red Swamp Crawfish is likely to spread into new watersheds in Maryland's coastal plain. Changes in the physical and chemical characteristics of streams that occur above the Fall Line may prevent it from invading the piedmont of Maryland. Its spread on the coastal plain will likely be limited by saltwater.

The new records presented here improve our understanding of the distribution of this non-native species and establish a baseline for future crayfish surveys in Maryland. Since the culture of Red Swamp Crawfish generally results in the establishment of breeding populations in surrounding water bodies (Hobbs et al. 1989, Lodge et al. 2000a), it is likely that additional extant populations of Red Swamp Crawfish exist in Maryland watersheds

beyond those that are reported here. Undocumented stocking of Red Swamp Crawfish mentioned above is likely to have occurred in watersheds not surveyed during 2006. Additional surveys are necessary to determine the distributional limits of Red Swamp Crawfish throughout Maryland. Also, the effects of this species on native crayfishes and other aquatic fauna and flora are unknown and require further research and additional monitoring.

#### Acknowledgments

We thank David O'Neill for providing his records and history of Red Swamp Crawfish culture at UMES and John Cooper for providing information on Maryland crayfishes and information on Red Swamp Crawfish in North Carolina. We thank Arnold Norden for sharing his knowledge of Maryland crayfishes. We are also grateful to Bruce Nichols, Matthew Perry, Ralph Andrews, and Eric May for providing invaluable information on the history of crayfish aquaculture in Maryland. We also thank Rebecca Chalmers, Karl Hellman, Richard Raesly, Gerald Mack, Joseph Smith, Virginia Eaton, Rachel Gauza, Matthew Kline, Matthew Sell, Aaron Gates, Ryan Utz, Ann Roseberry-Lincoln, Mark Southerland, Chris Millard, and Dan Boward for their efforts in crayfish data collection. This study was funded in part by State Wildlife Grant funds provided to the state wildlife agencies by US Congress, and administered through the Maryland Department of Natural Resources' Natural Heritage Program.

#### Literature Cited

- Barbaresi, S., G. Santini, E. Tricarico, and F. Gherardi. 2004. Ranging behavior of the invasive crayfish, *Procambarus clarkii* (Girard). *Journal of Natural History* 38:2821–2832.
- Bills, T.D., and L.L. Marking. 1988. Control of nuisance populations of crayfish with traps and toxicants. *Progressive Fish Culturist* 50:103–106.
- Capelli, G.M. 1982. Displacement of Northern Wisconsin crayfish by *Orconectes rusticus* (Girard). *Limnology and Oceanography* 27:741–745.
- Capelli, G.M., and B.L. Munjal. 1982. Aggressive interactions and resource competition in relation to species displacement among crayfish of the genus *Orconectes*. *Journal of Crustacean Biology* 2:486–492.
- Code of Maryland (COMAR). 2006. 08.02.19.00. Maryland Department of Natural Resources. Annapolis, MD.
- Cooper, J.E., and S.A. Armstrong. 2007. Locality records and other data for invasive crayfishes (Decapoda: Cambaridae) in North Carolina. *Journal of the North Carolina Academy of Science* 123:1–13.
- Cooper, J.E., A.L. Braswell, and C. McGrath. 1998. Noteworthy distributional records for crayfishes (Decapoda: Cambaridae) in North Carolina. *Journal of the Elisha Mitchell Scientific Society* 114:1–10.
- Gherardi, F., and W.H. Daniels. 2004. Agonism and shelter competition between invasive and indigenous crayfish species. *Canadian Journal of Zoology* 82:1923–1932.
- Hobbs III, H.H., J.P. Jass, and J.V. Huner. 1989. A review of global crayfish introductions with particular emphasis on two North American species (Decapoda, Cambaridae). *Crustaceana* 56:299–316.

- Holdich, D.M. 1988. The dangers of introducing alien animals with particular reference to crayfish. *Freshwater Crayfish* 7:15–30.
- Huner, J.V. 2002. *Procambarus*. Pp. 541–584, In D.M. Holdich (Ed.). *Biology of Freshwater Crayfish*. Blackwell Science Ltd., Oxford, UK. 702 pp.
- Lodge, D.M., C.A. Taylor, D.M. Holdich, and J. Skurdal. 2000a. Nonindigenous crayfishes threaten North American freshwater biodiversity: Lessons from Europe. *Fisheries* 25(8):7–20.
- Lodge, D.M., C.A. Taylor, D.M. Holdich, and J. Skurdal. 2000b. Reducing impacts of exotic crayfish introductions: New policies needed. *Fisheries* 25 (89):21–23.
- Lowery, R.S., and A.J. Mendes. 1977. *Procambarus clarkii* in Lake Naivasha, Kenya, and its effects on established and potential fisheries. *Aquaculture* 11:111–121.
- Olden, J.D., J.M. McCarthy, J.T. Maxted, W.W. Fetzer, and M.J. Vander Zanden 2006. The rapid spread of Rusty Crayfish (*Orconectes rusticus*) with observations on native crayfish declines in Wisconsin (USA) over the past 130 years. *Biological Invasions* 8:1621–1628.
- Schwartz, F.J., R. Rubelmann, and J. Allison. 1963. Ecological population expansion of the introduced crayfish, *Orconectes virilis*. *Ohio Journal of Science* 63(6):266.
- Stein, B.A., and S.R. Flack. 1997. 1997 species report card: The state of US plants and animals. The Nature Conservancy, Arlington, VA.
- Taylor, C.A., M.L. Warren, Jr., J.F. Fitzpatrick, Jr., H.H. Hobbs III, R.F. Jezerinac, W.L. Pflieger, and H.W. Robison. 1996. Conservation status of crayfishes of the United States and Canada. *Fisheries* 21:25–38.
- Taylor, C.A., G.A. Schuster, J.E. Cooper, R.J. DiStefano, A.G. Eversole, P. Hamr, H.H. Hobbs III, H.W. Robison, C.E. Skelton, and R.F. Thoma. 2007. A reassessment of the conservation status of crayfishes of the United States and Canada after 10+ years of increased awareness. *Fisheries* 32:372–388.



**Appendix 1.** Collection records of *Procambarus clarkii* (Red Swamp Crawfish) summarized by river basin and watershed (Maryland 8-digit Hydrologic Unit).

Site	River basin	Watershed (8-digit)	Location	Latitude (NAD83)	Longitude (NAD83)	Collection date
1	Patuxent	Patuxent River upper	Goose Pond outlet stream	39°01'46"	76°47'55"	26 July 2006
2	Patuxent	Western Branch	Tributary to Collington Branch	38°56'09"	76°45'17"	15 July 2006
3	Patuxent	Western Branch	Tributary to Collington Branch	38°56'10"	76°45'17"	15 July 2006
4	Patuxent	Western Branch	Tributary to Lottsford Branch	38°58'11"	76°48'29"	15 July 2006
5	Potomac	Nanjemoy Creek	Mill Run	38°29'01"	77°05'09"	18 July 2006
6	Potomac	Potomac Middle Tidal	Tributary to Mallows Bay	38°28'15"	77°15'31"	10 May 2006
7	Potomac	Potomac Middle Tidal	Tributary to Mallows Bay	38°28'30"	77°15'26"	09 June 2006
8	Potomac	Potomac Middle Tidal	Tributary to Mallows Bay	38°28'14"	77°15'34"	12 June 2006
9	Potomac	Potomac Middle Tidal	Tributary to Mallows Bay	38°28'27"	77°15'45"	25 June 2006
10	Potomac	Potomac Middle Tidal	Tributary to Mallows Bay	38°28'29"	77°15'22"	25 June 2006
11	Potomac	Potomac Middle Tidal	Potomac River	38°28'15"	77°15'57"	25 July 2006
12	Potomac	Potomac Middle Tidal	Tributary to Wades Bay	38°26'30"	77°15'23"	08 June 2006
13	Potomac	Potomac Middle Tidal	Tributary to Wades Bay	38°26'11"	77°15'09"	08 June 2006
14	Potomac	Potomac Middle Tidal	Tributary to Wades Bay	38°25'48"	77°15'03"	07 June 2006
15	Potomac	Mattawoman Creek	Mattawoman Creek	38°35'47"	77°08'14"	22 Aug 2006
16	Potomac	Mattawoman Creek	Mattawoman Creek	38°35'26"	77°07'17"	22 Aug 2006
17	Potomac	Potomac Upper Tidal	Bryan Point	38°41'46"	77°03'59"	21 Aug 2006
18	Chester	Corsica River	Three Bridges Branch	39°03'34"	76°00'43"	18 July 2006
19	Chester	Corsica River	Three Bridges Branch	39°03'36"	76°00'39"	18 July 2006
20	Chester	Corsica River	Three Bridges Branch	39°03'07"	76°02'24"	26 Sept 2006
21	Chester	Corsica River	Three Bridges Branch	39°03'16"	76°03'02"	31 July 2006
22	Chester	Corsica River	Alder Branch	39°04'18"	76°04'00"	24 July 2006
23	Chester	Corsica River	Gravel Run	39°02'56"	76°03'47"	31 July 2006
24	Chester	Lower Chester River	Swan Creek	39°11'38"	76°13'07"	26 July 2006
25	Nanticoke	Manokin Branch	Manokin Branch	38°12'57"	75°39'55"	03 Aug 2006

Site	River basin	Watershed (8-digit)	Location	Latitude (NAD83)	Longitude (NAD83)	Collection date
26	Nanticoke	Fishing Bay	Roadside ditch at Egypt Road	38°28'33"	76°06'04"	21 June 2006
27	Nanticoke	Fishing Bay	Blackwater National Wildlife Refuge	38°26'51"	76°05'21"	21 June 2006
28	Nanticoke	Fishing Bay	Blackwater National Wildlife Refuge	38°26'51"	76°05'11"	21 June 2006
29	Nanticoke	Fishing Bay	Tributary to Little Blackwater River	38°32'34"	76°05'12"	21 June 2006
30	Nanticoke	Nanticoke River	Rewastico Creek	38°24'39"	75°45'16"	1989*
31	Pocomoke	Lower Pocomoke River	Pattys Branch	38°10'18"	75°22'19"	29 Aug 2006
32	Pocomoke	Lower Pocomoke River	Bachelors Branch	38°05'50"	75°29'22"	26 Aug 2006
33	Pocomoke	Upper Pocomoke River	Old Mill Branch	38°16'32"	75°18'21"	23 Oct 2006
34	Atlantic	Chincoteague Bay	Tributary to Pawpaw Creek	38°09'44"	75°17'55"	26 June 2006
35	Atlantic	Chincoteague Bay	Tributary to Scarboro Creek	38°09'32"	75°18'10"	26 June 2006

\*Record provided by David O'Neill, Community College of Baltimore County, MD.