

Prepared in cooperation with the Pennsylvania Department of Transportation

# Freshwater Mussel Salvage and Relocation at the Pond Eddy Bridge, Delaware River, New York and Pennsylvania

Open-File Report 2018–1009

**Cover.** Photograph showing Delaware River at the Pond Eddy Bridge looking upstream on the Pennsylvania side of the river.  
Photograph by Jeffrey Cole, U.S. Geological Survey.

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**U.S. Department of the Interior**  
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## Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m <sup>2</sup> )	10.76	square foot (ft <sup>2</sup> )
	Flow rate	
cubic meter per second (m <sup>3</sup> /s)	35.31	cubic foot per second (ft <sup>3</sup> /s)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)



# Freshwater Mussel Salvage and Relocation at the Pond Eddy Bridge, Delaware River, New York and Pennsylvania

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## Abstract

In a study conducted by the U.S. Geological Survey, in cooperation with the Pennsylvania Department of Transportation, freshwater mussels were salvaged and relocated from the anticipated zone of impact for the Pond Eddy Bridge construction project in New York and Pennsylvania. Five 25-meter (m) by 25-m cells along the Pennsylvania bank of the Delaware River were sampled in three generally straight-line passes by four surveyors wearing snorkel gear for a total of 180 survey minutes per cell. All mussels encountered were collected and identified to species. A subset of individuals was marked with shellfish tags, weighed, and measured prior to relocation upstream from the zone of impact. A total of 3,434 mussels, including 3,393 *Elliptio complanata* (eastern elliptio mussels), 39 *Anodonta implicata* (alewife floaters), 1 *Strophitus undulatus* (creeper), and 1 *Pyganodon cataracta* (eastern floater), were salvaged and relocated. All non-eastern elliptio species were georeferenced using a high-resolution global positioning system unit; a subset of tagged eastern elliptio was placed in transects between georeferenced points. These mussels will be monitored to assess the effects of translocation on mortality and body condition at 1 month, 1 year, and 2 years.

## Introduction

Native freshwater mussels (hereafter mussels) are a critically imperiled fauna threatened by a variety of disturbances to aquatic ecosystems (Strayer and others, 2004). Mussels perform important ecological functions; therefore, there has been increasing interest in their conservation and restoration (Spooner and Vaughn, 2006; Vaughn, 2010). The Pennsylvania Department of Transportation (PennDOT) began construction to replace the bridge crossing the Delaware River from Pond Eddy, New York (Sullivan County) to Pond Eddy, Pennsylvania (Pike County) in 2016. Pond Eddy is located within the Upper Delaware River Scenic and Recreational River and, as such, is regulated by the National Park Service (NPS) under the Wild and Scenic Rivers Act (16 U.S.C. 1271–1287).

The Delaware River provides habitat for several populations of the Federally listed endangered *Alasmodonta heterodon* (dwarf wedgemussel) (Galbraith and others, 2016). In addition, populations of the New York State-listed *Alasmodonta varicosa* (brook floater) and critically imperiled (but unlisted) *Anodonta implicata* (alewife floater) have been found in the Delaware River. In summer 2011, a Phase 1 survey for dwarf wedgemussel was conducted in the designated zone of construction impact near the Pond Eddy Bridge, at which time no individuals of this species were found (Galbraith, 2012). The *Elliptio complanata* (eastern elliptio), *Strophitus undulatus* (creeper), and the alewife floater were the only species identified at this site.

Construction activities in or near water bodies can have significant negative effects on mussels through hydrological alterations and increasing siltation (Neves and others, 1997; Watters, 2000). As a result, there may be incidental take of mussels as a direct result of construction efforts or indirectly by way of habitat alteration in the immediate vicinity of construction sites. Because of the potential impact to mussels and their importance to water quality in the Upper Delaware River, the NPS decided that all species within the causeway's direct impact area would be salvaged and relocated. Specifically, mussels were only salvaged and relocated from the Pennsylvania bank of the river in locations with the highest densities of alewife floater. This area includes a stretch of river approximately 25 meters (m) wide along the Pennsylvania bank of the river, extending 75 m downstream and 50 m upstream from the existing Pond Eddy Bridge. The study was conducted by the U.S. Geological Survey (USGS), in cooperation with the Pennsylvania Department of Transportation; results of this salvage and relocation opportunity will be used to understand the short- and long-term effects of translocation on mussel survival and health.

This report presents the methods and results of mussel salvage and relocation from an area that will be directly impacted during construction of the new Pond Eddy Bridge across the Delaware River. The number of individual mussel species salvaged and relocated is presented. Size and weight of some relocated mussels are also presented.

## Methods of Salvage and Relocation

USGS surveyors worked on the Pond Eddy Bridge mussel salvage and relocation on June 9 and 10, 2016. Mussel salvage was conducted in five 25-m by 25-m cells along the Pennsylvania shoreline determined to be in the area of the proposed construction causeway (fig. 1). Cells were reconstructed from past surveys completed by Galbraith (2012) and marked with flagging tape on shore and anchored buoys in the water. Each cell was surveyed simultaneously by four individuals that snorkeled for 15-minute consecutive passes in generally straight-line transects, parallel to flow, along the length of each cell. All individual mussels encountered in each pass were collected. Surveyors also searched under moveable rocks to ensure that the maximum number of individuals was salvaged. Collected mussels were placed in mesh bags and held submerged near the shoreline until they could be processed for identification, measurement, and tagging (when necessary). If the number of individuals collected during the second pass exceeded 10 percent of the number of individuals collected during the first pass, a third 15-minute pass was completed for that cell. No more than three passes were done in each cell.

Following salvage, all mussels were identified to species. Rare species (alewife floater, creeper, and *Pyganodon cataracta* [eastern floater]) were weighed, measured, and tagged by affixing a small shellfish tag to the shell using superglue. All individual eastern elliptio mussels collected from cell 2 were weighed and measured because this cell contained the most individuals and the greatest variation in individual mussel body size. A haphazardly selected subset of the cell 2 eastern elliptio mussels was also tagged for future monitoring efforts.

A suite of potential relocation sites supporting both alewife floaters and eastern elliptios was identified prior to salvage with the closest potential relocation site located just upstream from the Pond Eddy Bridge, on the Pennsylvania bank of the river, upstream from the confluence of Mill Brook which enters on the New York bank of the river. An on-site snorkel assessment of this site conducted in June 2016, prior to salvage, revealed that it supported an ample number of both the alewife floater and eastern elliptio mussel. Salvaged mussels were hand placed in the substrate at the relocation site in an approximately 3,100-square-meter stretch of river (fig. 1), equivalent in area to that from which they were collected. A high-resolution global positioning system unit (Trimble GeoXH) was used to georeference each individual rare mussel relocated upstream, and tagged eastern elliptio mussels collected from cell 2 were placed in transects between georeferenced rare species for future monitoring. The remaining eastern elliptio mussels, collected from all cells, were hand placed haphazardly throughout the entire relocation area.

## Results of Salvage and Relocation

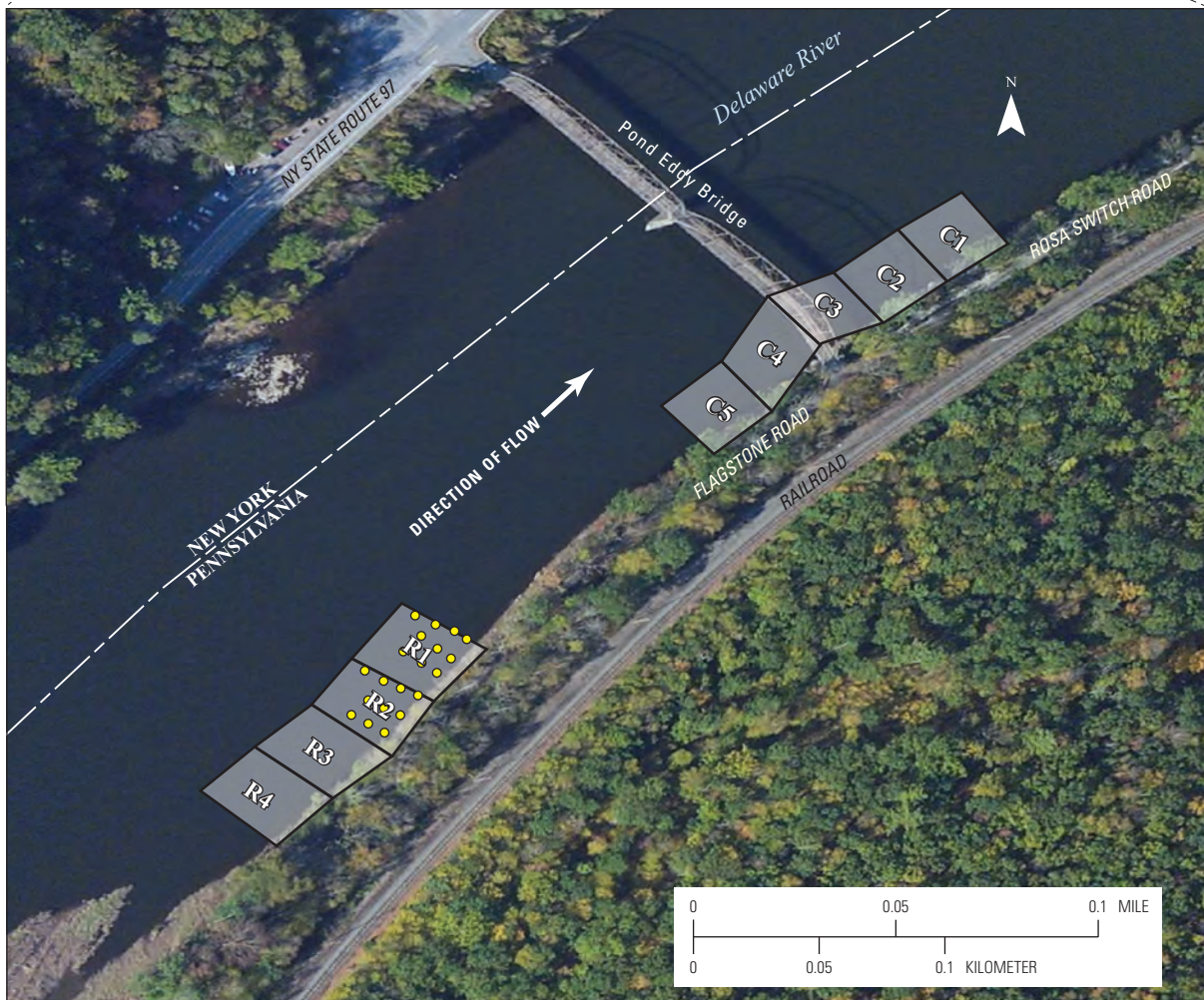
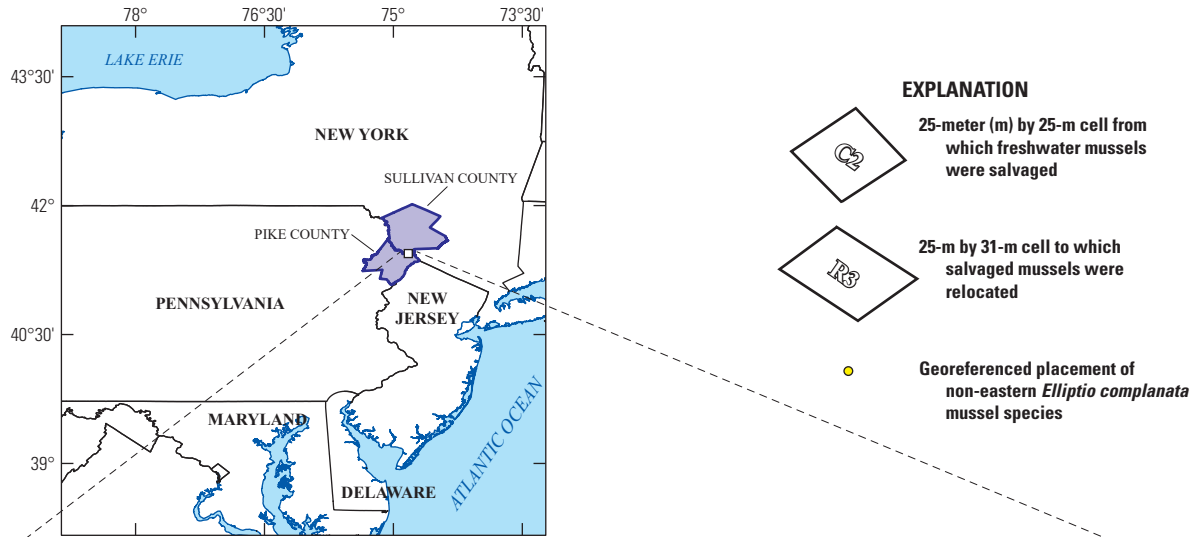
The number of individual mussels salvaged from consecutive passes generally decreased (table 1), but the number of mussels salvaged in the second pass was never less than or equal to 10 percent of the first pass; therefore, a third pass was completed for each cell resulting in a total of 180 minutes of survey time per cell. A total of 3,434 mussels were salvaged and relocated from the five cells (table 2), including 39 alewife floater (size range: 36–90 millimeters (mm)), 3,393 eastern elliptio (size range: 9–88 mm), 1 eastern floater (60 mm), and 1 creeper (59 mm).

## Limitations of the Study and Future Monitoring

The number of mussels salvaged from the five cells was substantially greater than the number of individuals located during Phase 1 surveys completed by Galbraith (2012) (table 3). Specifically, there were almost 8 times the number of eastern elliptio and 4 times the number of alewife floaters collected in the 2016 salvage compared to those located in the 2011 Phase 1 survey. River flows during the Phase 1 survey were substantially (32–39%) higher than during the salvage, which may have affected the surveyor's success in finding mussels. In particular, river discharge measured at USGS streamgage 01434000 (fig. 1) ranged from 128.8 to 156.7 cubic meters per second ( $\text{m}^3/\text{s}$ ) and from 86.6 to 95.1  $\text{m}^3/\text{s}$  during the Phase 1 survey and salvage, respectively. Even though both ranges of discharge are considered "suitable" for mussel surveys, the difference may be partially responsible for the differences in surveyor success. Another more likely explanation for differences in surveyor success and mussel detection between the 2 survey years is variations in sampling methodology.

A substantial portion of the salvaged mussels were found buried in clumps under large rocks beneath the substrate that was not surveyed during the 2011 Phase 1 surface assessment (Galbraith, 2012). The Phase I survey was completed with minimal disturbance to the existing substrate, as is standard for such surveys, focusing primarily on surface mussels, with the condition that if listed species were found, follow up quadrat surveys with excavation would be completed. Since most of the salvaged mussels were found buried in large clumps beneath the substrate, performing some level of "excavation" during the Phase I sampling may have produced a better estimate of actual mussel density at the site. This in turn would have resulted in a more precise estimate of the time necessary to salvage all mussels from the impacted site to depletion, and a greater number of mussels being relocated than these





Base from U.S. Geological Survey digital data  
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**Figure 1.** Pond Eddy Bridge site located at the mainstem Delaware River between New York and Pennsylvania.

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**Table 1.** Total number of salvaged mussels from the Delaware River at the Pond Eddy Bridge site, New York and Pennsylvania, June 9–10, 2016. Mussels were collected from a total of five 25-meter (m) by 25-m cells in three successive passes.

[#, number; %, percent]

Cell	Pass	# Alewife floater	# Eastern elliptio	# Eastern floater	# Creeper	Total # mussels	% of first pass
1	1	6	245	0	0	251	100.0
	2	3	197	0	0	200	79.7
	3	6	177	0	0	183	72.9
2	1	4	241	0	0	245	100.0
	2	1	203	0	0	204	83.3
	3	2	197	0	0	199	81.2
3	1	1	218	0	1	220	100.0
	2	3	201	0	0	204	92.7
	3	2	169	0	0	171	77.7
4	1	1	255	0	0	256	100.0
	2	1	286	1	0	288	112.5
	3	1	232	0	0	233	91.0
5	1	2	234	0	0	236	100.0
	2	4	276	0	0	280	118.6
	3	2	262	0	0	264	111.9
TOTAL		39	3,393	1	1	3,434	

**Table 2.** Weight and length of salvaged mussels from the Delaware River at the Pond Eddy Bridge site, New York and Pennsylvania, June 9–10, 2016.

[g, gram; mm, millimeter; n, total number of individuals; Avg, average; SD, standard deviation; SE, standard error; Min, minimum; Max, maximum; N/A, not applicable]

Species	n	Weight (g)					Length (mm)				
		Avg	SD	SE	Min	Max	Avg	SD	SE	Min	Max
Alewife floater	39	22.91	10.39	1.66	3.20	56.75	76.7	79.6	12.7	36	90
Eastern elliptio <sup>1</sup>	761	15.80	12.08	0.44	0.05	63.60	53.2	14.4	0.5	9	88
Eastern floater	1	17.28	N/A	N/A	N/A	N/A	60.0	N/A	N/A	N/A	N/A
Creeper	1	24.35	N/A	N/A	N/A	N/A	59.0	N/A	N/A	N/A	N/A

<sup>1</sup>Data represent a subset of total salvaged individuals.

**Table 3.** Total number of mussels from the Delaware River at the Pond Eddy Bridge site, New York and Pennsylvania, found during Phase 1 of the Pond Eddy mussel surveys conducted in 2011. Surveys were completed in the same five 25-meter (m) by 25-m cells where salvage efforts were conducted in the present study.

[#, number]

Cell	# Alewife floater	# Eastern elliptio	# Eastern floater	# Creeper	Total # mussels
1	2	94	0	0	96
2	1	109	0	0	110
3	0	44	0	0	44
4	3	76	0	1	80
5	3	86	0	0	89
TOTAL	9	409	0	1	419

efforts achieved. Future evaluation of sampling methodologies required at bridge construction sites is warranted. The results from these surveys indicate that combined surface and subsurface techniques are necessary to accurately estimate mussel abundance.

Owing to the unexpected number of mussels requiring salvage, surveyors were unable to collect all mussels from each cell to depletion within the allocated time and budget. Although the number of eastern elliptio generally decreased with successive passes, it never declined to less than 70 percent of the first pass, indicating that a large number of mussels likely remain in these cells and within the area directly impacted by bridge construction. There was no clear trend in the number of alewife floaters salvaged: similar numbers of individuals were collected during all three passes. Significant additional salvage time and effort would be required to reduce the mussel populations in each cell to less than 10 percent of the first pass. Representatives from PennDOT, NPS, and USGS had several consultations after the initial salvage to determine whether additional survey passes were warranted to salvage mussels to depletion. The NPS concluded that additional survey passes were not necessary.

Relocated individuals will be monitored as part of a long-term USGS study to assess the effects of translocation on the mortality and body condition of relocated mussels 1 month, 1 year, and 2 years after relocation. Monitoring mussel populations remaining in the zone of impact is beyond the scope of this study; however, there is some indication that mussels remaining in this area may be important for recolonization following completion of bridge construction (Villegla, 2005).

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