

**Surveys for the Endangered Maryland Darter
(August 2008 – September 2010)**

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Foreword

The work on which this report is based was a cooperative effort between the Maryland Department of Natural Resources' Monitoring and Non-Tidal Assessment Division, Dr. Richard Raesly of Frostburg State University, and Dr. Thomas Jones of Marshall University. Dr. Raesly was funded through an ESA Section 6 Grant, while the Maryland Department of Natural Resources and Dr. Jones were funded through endangered species recovery grants.

This report is one of three summaries of the efforts put forth by all partners to find the Maryland Darter from August 2008 to September 2010. See Raesly (2010) and Hern (2011) for additional analyses and summaries of data collected as part of this survey.

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Executive Summary

We conducted a status survey, the largest conducted to date, for the endangered Maryland Darter (*Etheostoma sellare*) from August 2008 to September 2010. The primary goal of this survey was to determine the continued existence of this species. We conducted fish surveys in four tributaries to the Susquehanna River including all sites where the species was historically collected. We also conducted the first targeted survey for Maryland Darter in the Susquehanna River mainstem below Conowingo Dam, an area long recognized as potential Maryland Darter habitat. We used multiple types of fish sampling gear, including backpack electrofishing, seining, snorkeling, trawling, and boat-mounted electrofishing. In most cases, we used a combination of these gears at individual sites to improve the probability of detecting this species. We also sampled all of the historical sites, including Swan Creek, Gashey's Run, and Deer Creek on multiple occasions.

We put forth approximately 460 man hours (mhrs) of effort in our searches. This includes approximately 240 mhrs of snorkeling, 206 mhrs of electrofishing/seining, and 14 mhrs of trawling. Despite this effort, we collected no Maryland Darters. In total, 54 species of fishes were collected during the surveys, including 29 species from Swan Creek, 20 from Gashey's Run, 46 from Deer Creek, 36 from Octoraro Creek, and 42 from the Susquehanna River. With the exception of the Maryland Darter, we collected all species of darter known to occur in the study area including Tessellated Darter (*Etheostoma olmstedi*), Banded Darter (*Etheostoma zonale*), Greenside Darter (*Etheostoma blennioides*), Shield Darter (*Percina peltata*), and Chesapeake Logperch (*Percina bimaculata*).

Following our survey, the likelihood that Maryland Darter remains extant is low. However, it is difficult to make definitive conclusions regarding the status of the Maryland Darter in the surveyed area due to substantial temporal and spatial variability in fish distributions. We recommend additional surveys be conducted for Maryland Darter in Deer Creek, Octoraro Creek, and the Susquehanna River mainstem. These surveys should be conducted on a monthly basis throughout all seasons of the year to improve probability of detection. These additional surveys will provide further data on which to base a status revision.

Introduction

Despite intensive efforts by ichthyologists over nearly 100 years, the Maryland Darter (*Etheostoma sellare*) has been collected only infrequently and, at one time, 50 years passed between collections (Table 1). As one of the world's rarest fishes, it is only known from the lower reaches of three streams, Swan Creek, Gashey's Run, and Deer Creek in Harford County, Maryland. In recognition of its rarity, the Maryland Darter was listed as federally-endangered in 1967 (U.S. Fish & Wildlife Service 1967). In 1984, a total of 2.8 miles in the lower portions of Deer Creek and Gashey's Run was officially designated as habitat critical to the survival of the species (U.S. Fish & Wildlife Service 1984). Following this designation, a species recovery plan was drafted in 1985 (U.S. Fish & Wildlife Service 1985) that listed measures necessary to protect, maintain, and enhance Maryland Darter habitats and populations. This plan also called for the collection of important information on the range, life history, and habitat requirements of the species. The acquisition of such information has been hindered by the scarcity of the species.

Table 1. Collection history of the Maryland Darter. All records are taken from Raesly (2010), agency reports, and other published literature.

Year	Location	Sampling Gear	Number of Specimens Collected/ Observed	Total Effort (manhours)	Catch Per Unit Effort (manhours)	Source
1912	Swan Creek	NR	2	NR	NR	Radcliffe & Welsh 1913
1962	Gasheys Run	NR	1	NR	NR	Knapp et al. 1963
1965	Gasheys Run	NR	1	NR	NR	Knapp 1976
1965-1977	Deer Creek	NR	77	NR	NR	Knapp 1976; Raesly 2010
1978	Deer Creek	Snorkeling	5	6	0.83	Carter 1979
1979	Deer Creek	Snorkeling	10	9	0.11	Foster & Early 1979/ Speir et al. 1979
1986	Deer Creek	Snorkeling	6	30.25	0.20	Stauffer & Arnold 1986
1987	Deer Creek	Snorkeling	3	48	0.06	Raesly 1991; 1992; 2010
1988	Deer Creek	Snorkeling	1	39.5	0.03	Raesly 1991; 1992; 2010

NR: Not reported

Although 72 specimens were collected from Deer Creek in 1965 (Knapp 1976), the Maryland Darter has never been observed in great abundance. It has not been collected from Swan Creek since 1912 or from Gashey's Run since 1965. This species was observed somewhat consistently in Deer Creek from 1965 to the mid-1980s, but the number of observed specimens per hour of sampling effort declined precipitously over the latter ten years of this period (Table 1). It was last observed in 1988 (Raesly 1992).

The last targeted survey for Maryland Darter was conducted in 1991, with no darters observed (Raesly 1992). This last effort and all previous surveys for the darter focused primarily on the three historical tributaries and, in some cases, other (e.g. Octoraro Creek) tributaries to the Lower Susquehanna River in Maryland and Pennsylvania (Foster and Early 1979; Stauffer and Arnold 1986; Raesly 1992). The Susquehanna River below Conowingo Dam, an area long recognized as potential Maryland Darter habitat (Knapp 1976; USFWS 1985; Neely et al. 2003), is a difficult area to sample effectively for small benthic fishes with traditional sampling gear (Neely et al. 2003; Freedman et al. 2009). Until recently, extremes in flow below Conowingo Dam, large boulder and bedrock substrates, and variable depths have precluded surveys for the Maryland Darter in this potential habitat. Neely et al. (2003) recognized the Susquehanna River as "the last remaining habitat that has not been thoroughly surveyed" for the species.

Since 1988, speculation has grown over the continued existence of this species. To date, there has been at least one petition to de-list Maryland Darter (USFWS 1996) and two prominent conservation

organizations, the International Union for the Conservation of Nature and the American Fisheries Society, have already designated it as Extinct and Presumed Extinct, respectively (Jelks et al. 2008; IUCN 2010). Despite this speculation, the status of Maryland Darter as Endangered remained unchanged in the most recent federal review of the species (USFWS 2007). However, this review did acknowledge that the regulatory mechanisms necessary to protect the darter under the Endangered Species Act are contingent on establishing its presence. This review called for additional years of intensive surveying to provide data on which to base a status revision.

Recognizing continued uncertainty surrounding the existence of Maryland Darter, the U.S. Fish and Wildlife Service recently provided funding to conduct a status survey. The primary goal of this survey was to determine the continued existence of this species. This survey, conducted from August 2008 to September 2010, was the first targeted effort for the species in 18 years. As with previous attempts to find this rare fish, this survey focused intensive effort in the three historical tributaries (Fig. 1). This survey differed from previous efforts, however, in focusing additional sampling effort in the Susquehanna River below Conowingo Dam; marking the first targeted survey for Maryland Darter in this large river habitat. This report summarizes the results of this status survey and provides recommendations for further efforts to find the species.



Figure 1. The area surveyed included the Susquehanna River and Octoraro Creek, and the three tributaries of Swan Creek, Gashey's Run, and Deer Creek where the Maryland Darter was historically collected.

Methods

Description of sampling gear

We used multiple types of fish sampling gear, including: backpack electrofishing, seining, snorkeling, trawling, and boat-mounted electrofishing in our attempts to find the Maryland Darter. In most cases, we used a combination of these gears at individual sites to improve our detection. These gears are described as follows:

Backpack electrofishing/seining: These two gears were used in combination to survey each of the four tributaries sampled during this effort. Seining was conducted using a three to four person crew. A 3 m × 1.5 m × 6 mm mesh seine was positioned perpendicular to stream flow and stream substrate within three meters upstream of the seine was disturbed by one or two people. A backpack electrofisher was used as substrate was disturbed to increase capture efficiency. This process was repeated throughout targeted riffle habitats in each of the tributaries during each site visit. During low flow periods when seining was not effective, backpack electrofishing was used to sample for fishes in shallow riffle and pool habitats.

Snorkeling: Snorkel surveys were conducted in Deer Creek, Octoraro Creek, and in the Susquehanna River. At times, these surveys were done along transects where divers, spaced an equal distance apart, swam parallel to each other in an upstream or downstream direction. Snorkeling was also conducted at specific sites in the Susquehanna River accessible by boat. At these locations, divers surveyed all available habitats adjacent to the anchored boat.

Trawling: We utilized a modified, electrified Missouri benthic trawl (2.44 m wide) for surveys within non-wadeable areas of the Susquehanna mainstem and Deer Creek. This technique has proven effective for detecting small-bodied benthic fishes in other large river habitats (Herzog et al. 2005; Freedman et al. 2009). We also used a non-electrified version of this trawl to increase our sampling effort in these large river habitats. These trawls are described in detail by Hern (2011). Trawls were deployed from the bow of a boat for up to two minutes moving in a downstream direction. Geographic coordinates, stream depth, and sample duration were recorded following each deployment.

Boat-mounted electrofishing: We used a 14-ft johnboat outfitted with a Smith-Root KVA electrofisher to sample non-wadeable portions of the Susquehanna River. Use of this gear was limited; only used on two occasions in the Susquehanna River.

Summary of sampling effort

Swan Creek: We sampled a large reach of this tributary that included multiple riffle/pool sequences from MD Route 132 (Old Post Road) downstream approximately 500 m (Fig 2). This is a portion of Swan Creek that traverses the Fall Line. Along this reach, riffle habitats shift from being predominantly high-gradient and cobble-dominated to low-gradient habitats characterized by fine gravel and sand/silt substrates. We sampled these habitats on four occasions using backpack electrofishing and seining from November 2009 to August 2010. The mouth of Swan Creek near Spesutia Island was also surveyed using trawling in August 2008. The trawl was deployed five times in this portion of Swan Creek.

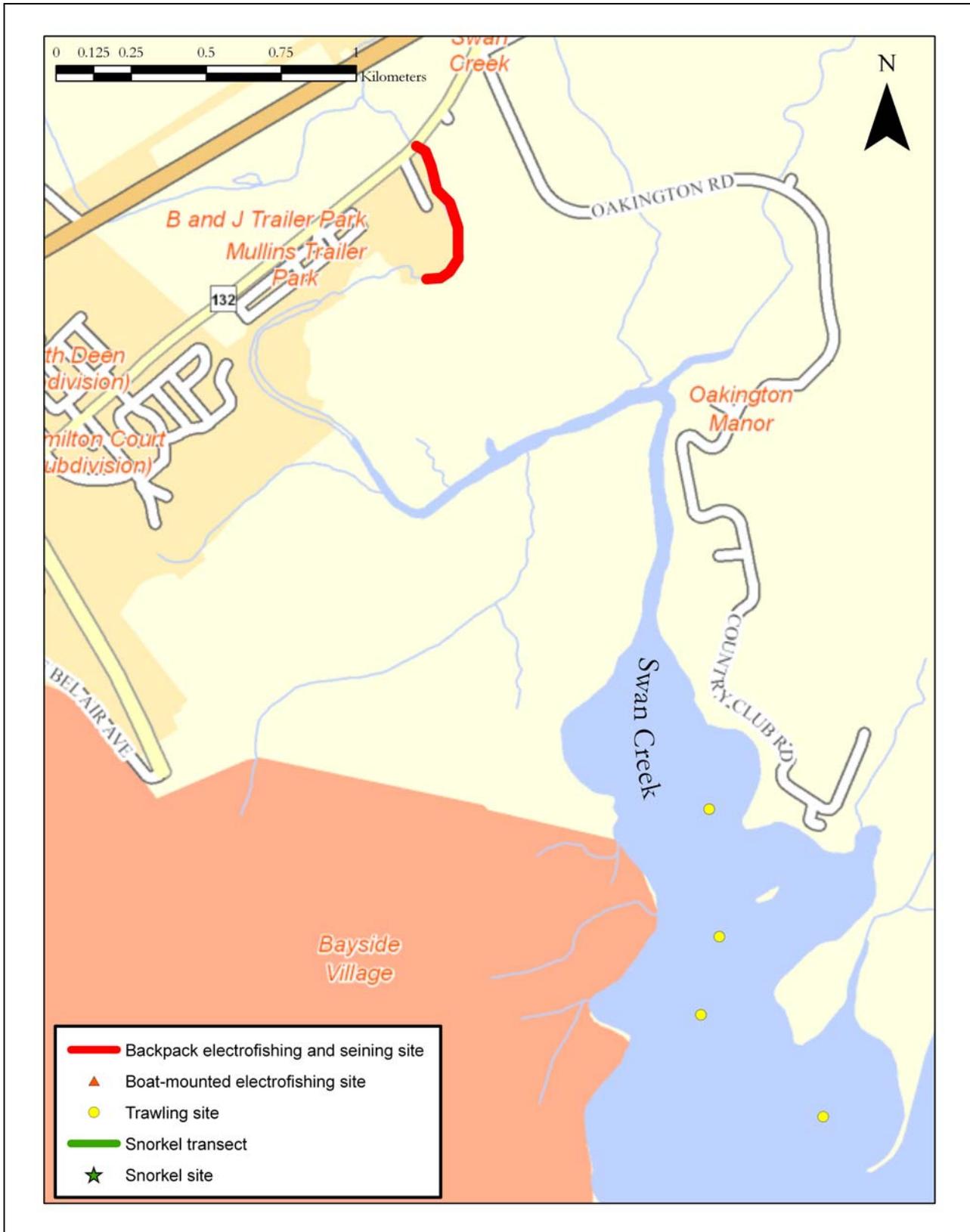


Figure 2. Surveys for the Maryland Darter in Swan Creek from November 2009 to August 2010.

Gashey's Run: We focused our surveys in this tributary in the vicinity of Oakington Road where Maryland Darter was collected historically (Fig. 3; Knapp et al. 1963). We collected fishes using backpack electrofishing and seining on four occasions from November 2009 to August 2010. These surveys focused on riffle habitats from Oakington Road upstream approximately 700 m (Fig. 3).

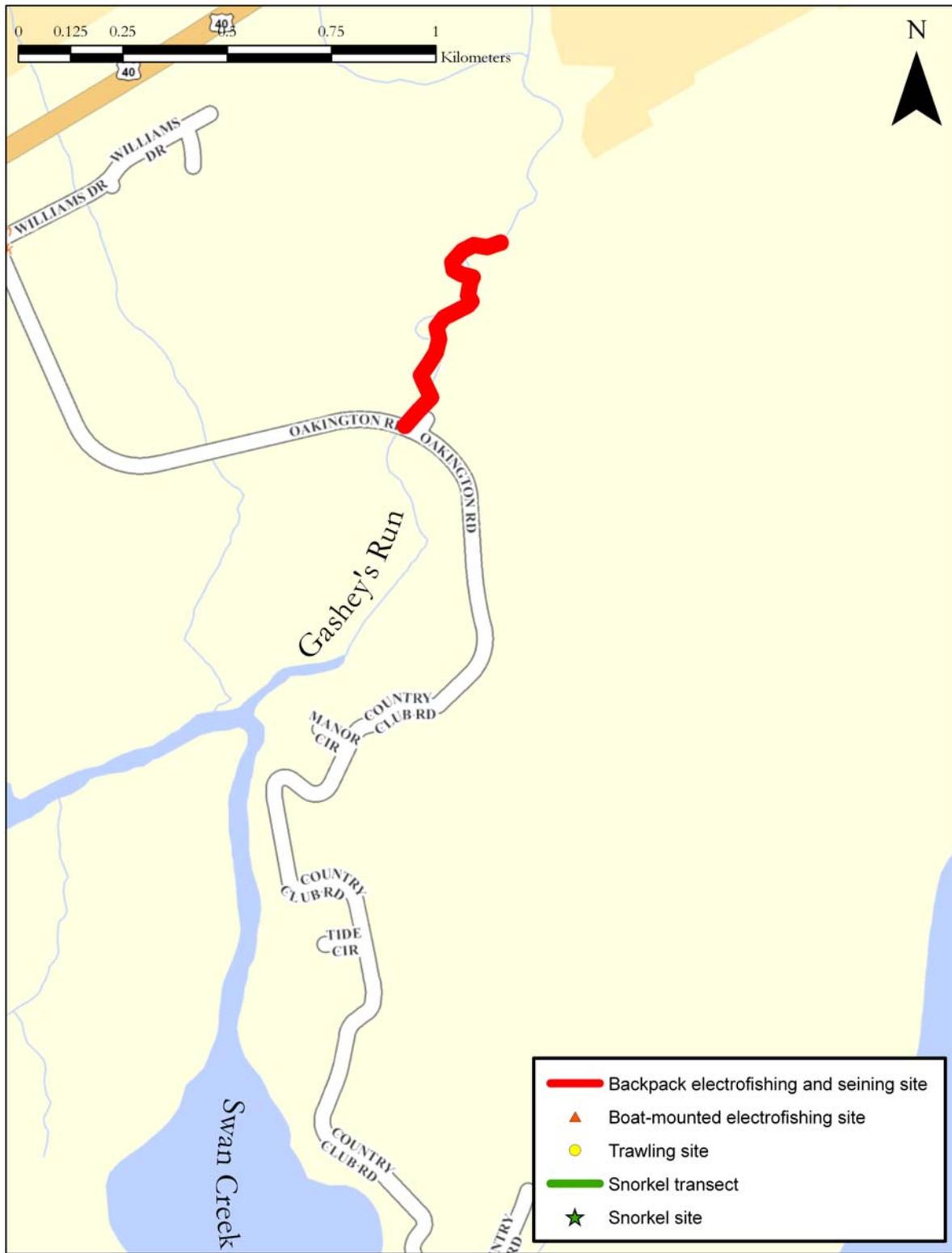


Figure 3. Surveys for the Maryland Darter in Gashey's Run from November 2009 to August 2010.

Deer Creek: Given that most historical observations of Maryland Darter occurred in Deer Creek, we focused a great deal of effort in the lower 2.8 km of this tributary (Fig. 4). Most effort was focused in the riffle habitat below Stafford Road bridge where the Maryland Darter was last observed. This riffle was surveyed using backpack electrofishing and seining on seven occasions in October and November 2009 and June, July, August, and September 2010. Snorkeling was conducted in this riffle on five additional occasions from June to August 2010. Snorkeling was also used to survey this tributary from Stafford Road bridge to approximately 300m above the Deer Creek Pumping Station along Craigs Corner Road in July and August 2010. We sampled the riffle habitat approximately 1 km below Stafford Road in June 2010 using backpack electrofishing, seining, and snorkeling. The mouth of Deer Creek was snorkeled on one occasion in July 2010. We also conducted trawling in the lower reach of Deer Creek from its mouth upstream approximately 1 km in July 2010. The trawl was deployed 18 times in this portion of Deer Creek.

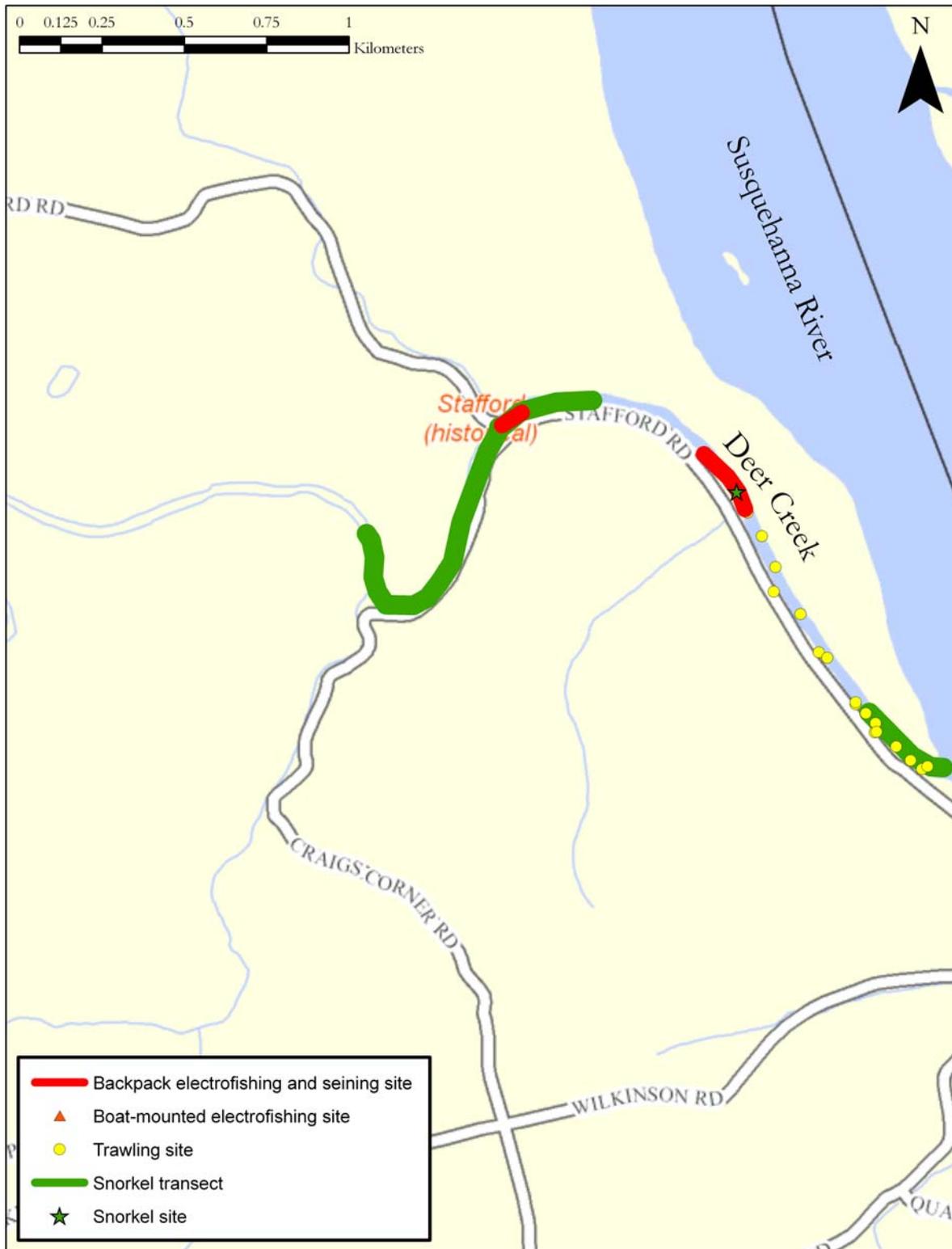


Figure 4. Surveys for the Maryland Darter in Deer Creek from October 2009 to September 2010.

Octoraro Creek: We surveyed this tributary to the lower Susquehanna River in Cecil County due to its proximity to historical localities and similarity to Deer Creek in habitat and fish assemblage. We sampled this tributary using backpack electrofishing and seining from the MD Route 222 bridge to the railroad bridge (Fig. 5), a reach approximately 320 m in length. This reach was sampled on four occasions from November 2009 to July 2010. The lower portion of Octoraro Creek from its mouth to the Route 222 bridge, a reach 600 m in length, was snorkeled on two occasions in July 2010.



Figure 5. Surveys for the Maryland Darter in Octoraro Creek from November 2009 to July 2010.

Susquehanna River: We conducted trawling in the Susquehanna River mainstem in August 2008, November 2009, and July 2010. Areas of the river that could be effectively trawled were located from 380 m below the mouth of Octoraro Creek to Havre de Grace. The majority of trawling was conducted in the vicinity of the mouth of Deer Creek; an area characterized by riffle/run habitat and cobble, boulder, and bedrock substrate (Fig. 6). We pulled a total of 131 trawls, including 92 with the electrified trawl and 39 with the non-electrified trawl. Snorkeling was also conducted at 14 sites in the Susquehanna in July and August 2010. The Susquehanna River at the mouth of Deer Creek was snorkeled on five occasions during that time. Additionally, we conducted snorkeling along a 50 m × 5.2 km transect of the Susquehanna River in July 2010. The transect extended along the right descending bank of the river from the park access at the base of Conowingo Dam downstream to Rock Run. Along this transect, divers recorded fishes observed in 100 m intervals (Hern 2011). We also conducted boat-mounted electrofishing at four sites in the Susquehanna mainstem and Furnace Bay, a small embayment of the Susquehanna River near Perryville in July 2010 (Fig. 6).

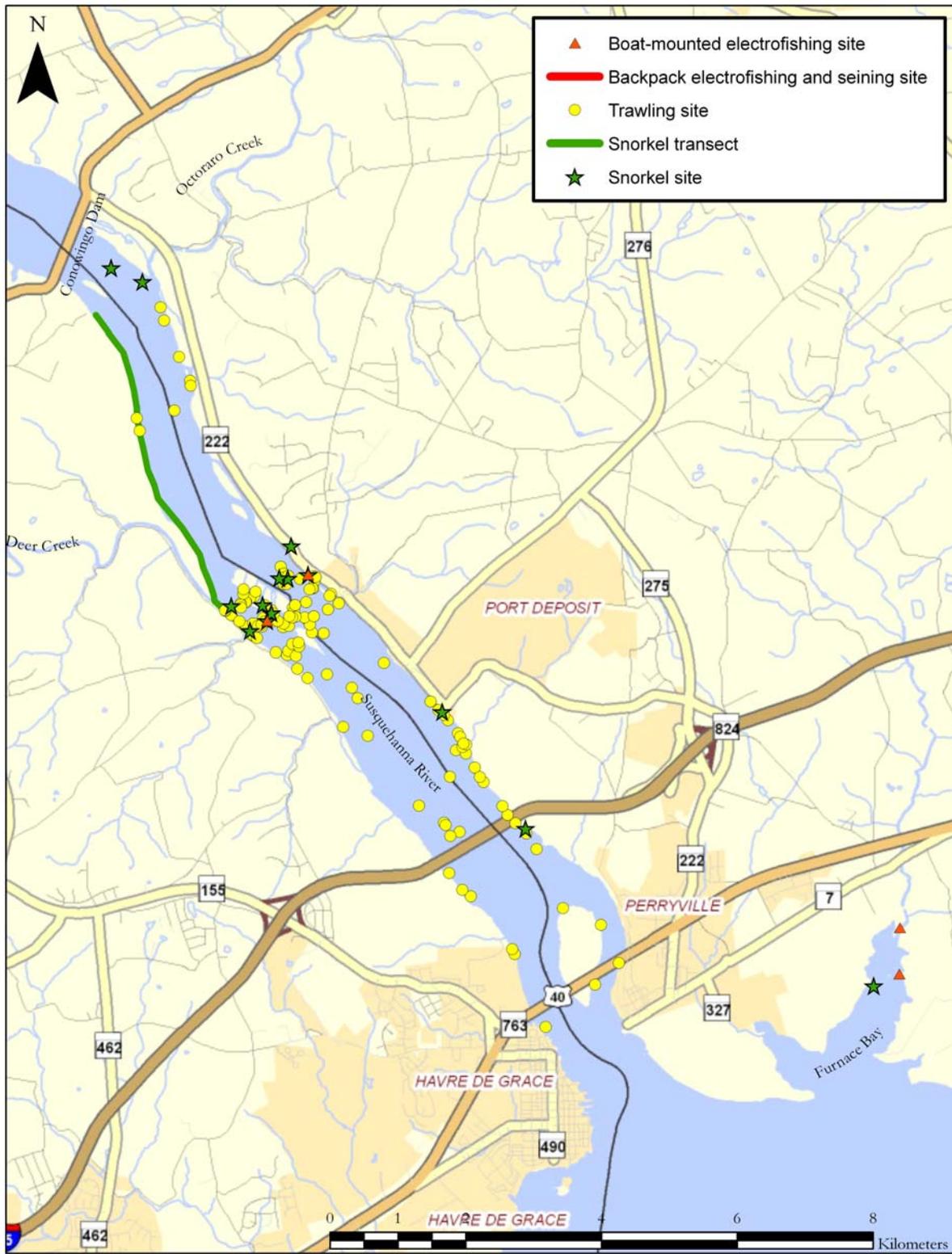


Figure 6. Surveys for the Maryland Darter in the Susquehanna River from August 2008 to July 2010.

Results

Approximately 460 man hours (mhrs) of effort were used to search for the Maryland Darter. This includes approximately 240 mhrs of snorkeling, 206 mhrs of electrofishing/seining (mean/site = 10.0 mhrs), and 14 mhrs of trawling. Despite this effort, we collected no Maryland Darters. In total, 54 species of fishes were collected during the survey, including 29 species from Swan Creek, 20 from Gashey's Run, 46 from Deer Creek, 36 from Octoraro Creek, and 42 from the Susquehanna River (Table 2).

The use of multiple types of sampling gear at sites in the four tributaries and the Susquehanna River mainstem improved our ability to assess the species present at each site and to detect numerically rare species. Although species detection varied by sampling gear type (Raesly 2010; Hern 2011), the predominant gear used during this survey, including backpack electrofishing and seining, snorkeling, and trawling, were effective at collecting small benthic fishes; 19 benthic species were caught in the study areas. With the exception of Maryland Darter, we collected all species of darter known to occur in the study areas including Tessellated Darter (*Etheostoma olmstedii*), Banded Darter (*Etheostoma zonale*), Greenside Darter (*Etheostoma blennioides*), Shield Darter (*Percina peltata*), and Chesapeake Logperch (*Percina bimaculata*) with the combined use of these gears.

Tessellated Darter was the most widespread and abundant darter collected. It was the most collected darter in the Susquehanna River, collected in 81 of 131 trawls (62%), and present in all four tributaries. We collected the introduced Greenside Darter and Banded Darter in Deer Creek, Octoraro Creek, and the Susquehanna River. Shield Darter, a Watch-List species, and Chesapeake Logperch, a Threatened species in Maryland (Code of Maryland Regulations 2010 08.03.08.06), were both collected in Deer Creek, Octoraro Creek, and the Susquehanna River. Three individual Chesapeake Logperch were also collected in Swan Creek on 8 November 2009, representing the first record of the species in this tributary (Raesly 2010). This threatened species was observed frequently, primarily in schools, during snorkel surveys in the Susquehanna River from approximately 500m below Conowingo Dam to the I-95 bridge. It appeared to be a habitat generalist; found in shallow, fast-flowing riffles and in deep, tidally-influenced pools over a variety of substrate types.

Our survey of the Susquehanna River mainstem using trawling and snorkeling verified that this area provides habitat suitable for darters throughout its length from Conowingo Dam to the tidal flats near Havre de Grace. Bedrock and boulder substrate in the upper reach from Conowingo Dam to the mouth of Deer Creek create prevalent riffle/run habitats with a variety of depth and current velocities. Five darter species including Tessellated Darter, Banded Darter, Greenside Darter, Shield Darter, and Chesapeake Logperch were observed in abundance in this area. Extreme fluctuations in flow that characterize this portion of the river likely affect populations of these species. In July 2010, we observed individuals of two darter species (i.e., Tessellated Darter and Chesapeake Logperch) stranded in shallow pools following a rapid reduction in release from Conowingo Dam (Hern 2011). Strandings during mid-summer undoubtedly lead to thermal-induced mortality and may increase susceptibility of these fishes to predation. Although high-flow events also likely affect these species, large boulders and bedrock crevices prevalent in the area likely provide refuge during these periods. The lower tidal portion of the Susquehanna River also proved suitable for darters. Tessellated Darter and Chesapeake Logperch were common over fine gravel and sand/silt substrate and in vegetated habitats that characterize this area. Given that five darter species were found in the river, and at least two of these species occurred throughout its length, it is plausible that, at least at one time, this large river provided suitable habitat and refuge for the Maryland Darter.

Table 2. Fishes collected from the study area sampled for the Maryland Darter from August 2008 to September 2010.

Common Name	Scientific Name	Susquehanna Mainstem	Deer Creek	Swan Creek	Gashey's Run	Octoraro Creek
Petromyzontidae						
Sea Lamprey	<i>Petromyzon marinus</i>		X			X
Anguillidae						
American Eel	<i>Anguilla rostrata</i>	X	X	X	X	X
Clupeidae						
Unidentified Shad	<i>Alosa</i> sp.	X				
Gizzard Shad	<i>Dorosoma cepedianum</i>	X	X	X	X	
Ictaluridae						
Yellow Bullhead	<i>Ameiurus natalis</i>					X
Brown Bullhead	<i>Ameiurus nebulosus</i>	X	X	X	X	X
Channel Catfish	<i>Ictalurus punctatus</i>	X	X	X		X
Margined Madtom	<i>Noturus insignis</i>	X		X		X
Flathead Catfish	<i>Pylodictis olivaris</i>	X	X			
Salmonidae						
Brown Trout	<i>Salmo trutta</i>		X			
Catostomidae						
White Sucker	<i>Catostomus commersoni</i>	X	X	X	X	X
Creek Chubsucker	<i>Erimyzon oblongus</i>	X	X	X	X	
Northern Hogsucker	<i>Hypentelium nigricans</i>	X	X	X		X
Golden Redhorse	<i>Moxostoma erythrurum</i>		X			
Shorthead Redhorse	<i>Moxostoma macrolepidotum</i>	X	X			X
Cyprinidae						
Central Stoneroller	<i>Campostoma anomalum</i>					X
Rosyside Dace	<i>Clinostomus funduloides</i>		X	X		
Satinfin Shiner	<i>Cyprinella analostana</i>	X	X	X		X
Unidentified Minnow	<i>Cyprinella</i> sp.	X	X			
Spotfin Shiner	<i>Cyprinella spiloptera</i>		X	X	X	X
Common Carp	<i>Cyprinus carpio</i>	X				
Cutlips Minnow	<i>Exoglossum maxillingua</i>		X	X		X
Eastern Silvery Minnow	<i>Hybognathus regius</i>			X		
Common Shiner	<i>Luxilus cornutus</i>		X	X	X	X

Table 2 (continued).

Common Name	Scientific Name	Susquehanna Mainstem	Deer Creek	Swan Creek	Gashey's Run	Octoraro Creek
River Chub	<i>Nocomis micropogon</i>	X		X		X
Golden Shiner	<i>Notemigonus crysoleucas</i>				X	
Spottail Shiner	<i>Notropis budsonius</i>	X	X		X	X
Swallowtail Shiner	<i>Notropis proce</i>	X	X	X	X	X
Rosyface Shiner	<i>Notropis rubellus</i>	X	X			X
Bluntnose Minnow	<i>Pimephales notatus</i>	X	X			
Blacknose Dace	<i>Rhinichthys atratulus</i>	X	X	X	X	X
Longnose Dace	<i>Rhinichthys cataractae</i>		X			X
Creek Chub	<i>Semotilus atromaculatus</i>		X	X	X	
Fallfish	<i>Semotilus corporalis</i>	X				X
Umbridae						
Eastern Mudminnow	<i>Umbra pygmaea</i>				X	
Fundulidae						
Banded Killifish	<i>Fundulus diaphanus</i>	X	X	X	X	X
Mummichog	<i>Fundulus heteroclitus</i>	X	X			
Cottidae						
Blue Ridge Sculpin	<i>Cottus caeruleomentum</i>		X			
Atherinidae						
Inland Silverside	<i>Menidia beryllina</i>	X	X			
Percidae						
Greenside Darter	<i>Etheostoma blennioides</i>	X	X			X
Tessellated Darter	<i>Etheostoma olmstedii</i>	X	X	X	X	X
Banded Darter	<i>Etheostoma zonale</i>	X	X			X
Yellow Perch	<i>Perca flavescens</i>	X	X			
Chesapeake Logperch	<i>Percina bimaculata</i>	X	X	X		X
Shield Darter	<i>Percina peltata</i>	X	X			X
Walleye	<i>Sander vitreum</i>	X	X			
Moronidae						
White Perch	<i>Morone americana</i>	X	X	X		
Striped Bass	<i>Morone saxatilis</i>	X				X

Table 2 (continued).

Common Name	Scientific Name	Susquehanna Mainstem	Deer Creek	Swan Creek	Gashey's Run	Octoraro Creek
Centrarchidae						
Rock Bass	<i>Ambloplites rupestris</i>	X	X			X
Redbreast Sunfish	<i>Lepomis auritus</i>	X	X	X	X	X
Green Sunfish	<i>Lepomis cyanellus</i>	X	X	X	X	X
Pumpkinseed	<i>Lepomis gibbosus</i>	X	X	X	X	X
Bluegill	<i>Lepomis macrochirus</i>	X	X	X	X	X
Unidentified Sunfish	<i>Lepomis</i> sp.	X	X			
Smallmouth Bass	<i>Micropterus dolomieu</i>	X	X	X		X
Largemouth Bass	<i>Micropterus salmoides</i>	X	X	X	X	X
Sciaenidae						
Spot	<i>Leiostomus xanthurus</i>	X		X		

Conclusions

This was the single largest survey ever conducted for the Maryland Darter, with more effort put forth than all surveys for the darter since 1978 combined (Fig. 6). It is also the most spatially and temporally comprehensive survey conducted to date; with all historical tributaries and the Susquehanna River mainstem sampled on multiple occasions in multiple seasons. The absence of Maryland Darter from this survey is consistent with declines in catch per unit effort observed in surveys conducted since 1978 (Fig. 6). Given the breadth of this survey, the use of multiple sampling gear types, repeated surveys of historical localities (e.g. Stafford Road riffle), and the success at collecting all other darter species known in the study area, the probability that the Maryland Darter remains extant is low. However, its absence from our collections is not irrefutable proof that it is gone.

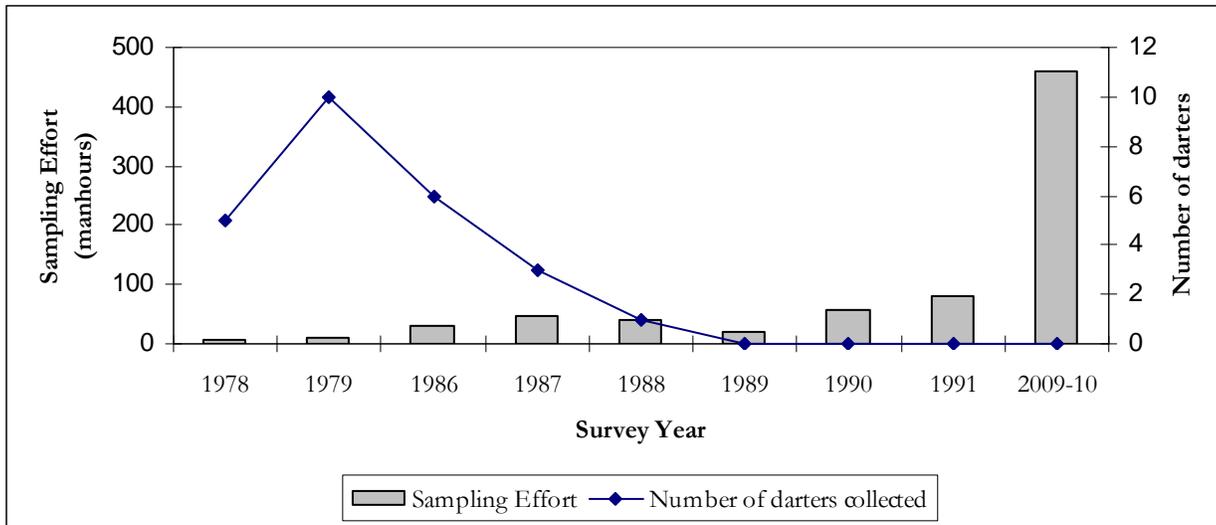


Figure 7. Trends in sampling effort and numbers of Maryland Darters collected during the past nine surveys conducted since 1978. This collection history was compiled from: Carter (1979), Foster & Early (1979), Speir et al. (1979), Stauffer & Arnold (1986), and Raesly (1991; 1992; 2010).

Unsuccessful attempts to collect a species over long periods of time have been erroneously used as evidence for extinction (Miller et al. 1989; Helfman 2007). There are many examples of species mistakenly declared extinct, including large, seemingly conspicuous species like the Alabama Sturgeon (*Scaphirhynchus suttkusi*; Mayden and Kuhajda 1996), and smaller, inconspicuous species like the Snail Darter (*Percina tanasi*; Miller et al. 1989). A gap of fifty years since the last observation has been suggested as a minimal benchmark to use when determining the extinction of a species (Harrison and Stiassny 1999; Helfman 2007). Even a benchmark of 50 years may not be conservative enough (Helfman 2007). Mattheison (1959) mistakenly declared Maryland Darter extinct following 50 years of failed attempts to collect it from Swan Creek. It was rediscovered three years later (Knapp et al. 1963). In their analysis of 25 North American fishes inaccurately reported as extinct, Miller et al. (1989) found that on average 62 years passed between their reported extinction and their rediscovery (Helfman 2007). It is not unusual for long periods of time to pass between observations of rare species (Etnier 1994). It has only been 23 years since Maryland Darter was last observed.

Proving extinction of fishes is made difficult by their inconspicuous nature, complex life histories that are often not well understood, and their use of habitats that are difficult to access and sample (Harrison and Stiassny 1999). A small population of a rare species is very difficult to detect in large rivers and creeks (Etnier 1994). Their use of habitats can be highly variable through time and their distribution within habitats can be highly localized. Although we put forth a lot of sampling effort in the Susquehanna River mainstem, the total amount of habitat that we sampled was small in comparison to that which was available. Given the expansive size and variety of habitats present in this area, detecting a very small population of Maryland Darter would require substantial effort. Even in small tributaries, detection of rare species can be difficult. In a separate analysis of fish data collected during this survey, Raesly (2010) noted the temporal and spatial variability in species detected across all sites visited in the four tributaries. Several species were observed only once or infrequently in sites sampled multiple times during the survey. Raesly (2010) also noted variability in species detected even within microhabitats of a single riffle. The variability that occurs in fish distributions at each site over time and among microhabitats can reduce detection of rare species. This variability makes it difficult to make definitive conclusions regarding the status of the Maryland Darter.

In light of our findings, we recommend further electrofishing/seining, and snorkel surveys in Deer and Octoraro creeks and additional trawling and snorkel surveys in the Susquehanna River. These surveys should be conducted on a monthly basis throughout all seasons of the year to improve probability of detection. These further efforts will aid in determining whether or not the Maryland Darter is still extant.

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Literature Cited

- Carter, W.R. 1979. Maryland darter investigation, 17 September 1979. Memorandum to Mr. Charles Frisbie, Maryland Darter Recovery Team. Annapolis, Maryland.
- Etnier, D.A. 1994. Our southeastern fishes: What have we lost and what are we likely to lose. *Proceedings of the Southeastern Fishes Council* 29:5-9.
- Foster, J.W.S., III and R.S. Early. 1979. Notes from observations of the Maryland darter, *Etheostoma sellare*, at riffle below Stafford bridge, Deer Creek, on May 8, 1979. Memorandum to Mr. Charles Frisbie, Maryland Darter Recovery Team. Annapolis, Maryland.
- Freedman, J.A., T.D. Stecko, B.D. Lorson, and J.R. Stauffer, Jr. 2009. Development and efficacy of an electrified benthic trawl for sampling large-river fish assemblages. *North American Journal of Fisheries Management* 29:1001-1005.
- Harrison, I.J., and M.L.J. Stiassny. 1999. The quiet crisis: A preliminary listing of the freshwater fishes of the world that are extinct or "missing in action". *In: Extinctions in Near Time: Causes, Contexts, and Consequences*. Edited by : R.D.E. MacPhee. Kluwer Academic/Plenum Publishers, New York. 394pp.
- Helfman, G. S. 2007. *Fish conservation: A guide to understanding and restoring global aquatic biodiversity and fishery resources*. Island Press , Washington, DC. 584pp.
- Hern, T.R. 2011. *Rediscovering the Maryland Darter (Etheostoma sellare)*. Masters Thesis. Marshall University. Huntington, West Virginia.
- Herzog, D.P., V.A. Barko, J.S. Scheibe, R.A. Hrabik, and D.E. Ostendorf. 2005. Efficacy of a benthic trawl for sampling small-bodied fishes in large river systems. *North American Journal of Fisheries Management* 25:594-603.
- IUCN 2010. *IUCN Red List of Threatened Species. Version 2010.4*. <<http://www.iucnredlist.org>>. Downloaded on 15 May 2011.
- Jelks, H.L., S.J. Walsh, N.M. Burkhead, S. Contreras-Balderas, E. Diaz-Pardo, D.A. Hendrickson, J. Lyons, N.E. Mandrak, F. McCormick, J.S. Nelson, S.P. Platania, B.A. Porter, C.B. Renaud, J. J. Schmitter-Soto, E.B. Taylor, and M.L. Warren, Jr. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. *Fisheries* 33:372-407.
- Knapp, L.W., W.J. Richards, R.V. Miller, and N.R. Foster. 1963. Rediscovery of the percid fish *Etheostoma sellare* (Radcliffe and Welsh). *Copeia* 1963:445.

- Knapp, L.W. 1976. Redescription, relationships, and status of the Maryland darter, *Etheostoma sellare* (Radcliffe and Welsh), and endangered species. *Proceedings of the Biological Society of Washington* 89:99-117.
- Mattheison, P. 1959. *Wildlife in America*. Viking Press, New York. 304pp.
- Mayden, R.L. and B.R. Kuhajda. 1996. Systematics, taxonomy, and conservation status of the endangered Alabama sturgeon, *Scaphirhynchus suttkusi* Williams and Clemmer (Actinopterygii, Acipenseridae). *Copeia* 1996:241-273.
- Miller, R.R., J.D. Williams, and J.E. Williams. 1989. Extinctions of North American fishes during the past century. *Fisheries* 14:22-38.
- Neely, D.A., A.E. Hunter, and R.L. Mayden. 2003. Threatened fishes of the world: *Etheostoma sellare* (Radcliffe & Welsh) 1913 (Percidae). *Environmental Biology of Fishes* 67: 340.
- Radcliffe, L. and W.W. Welsh. 1913. Description of a new darter from Maryland. *Bull. U.S. Bur. Fish.* 32:29-32.
- Raesly, R.L. 1991. Population status of the endangered Maryland darter, *Etheostoma sellare* (Radcliffe and Welsh) in Deer Creek. Final Report. Submitted to Maryland Department of Natural Resources, Natural Heritage Program. Middletown, Maryland.
- Raesly, R.L. 1992. Population status of the endangered Maryland darter, *Etheostoma sellare* (Radcliffe and Welsh). Final Report. Submitted to Maryland Department of Natural Resources, Natural Heritage Program. Frederick, Maryland.
- Raesly, R.L. 2010. Maryland Darter Survey (October 2009 – September 2010). Final Report. Submitted to Maryland Department of Natural Resources, Natural Heritage Program. Annapolis, Maryland.
- Stauffer, J.R., Jr., and D.E. Arnold. 1986. Survey to locate additional populations of the endangered Maryland darter (*Etheostoma sellare*). Final Report. Submitted to the U.S. Fish and Wildlife Service, Annapolis, Maryland.
- U.S. Fish & Wildlife Service. 1967. Native fish and wildlife: Endangered species. *Federal Register* 32: 4001.
- U.S. Fish & Wildlife Service. 1984. Designation of critical habitat for the endangered Maryland darter. *Federal Register* 49: 34228-34232.
- U.S. Fish & Wildlife Service. 1985. The Maryland darter recovery plan. USFWS, Newton Corner, MA. 39pp.
- U.S. Fish & Wildlife Service. 1996. Endangered and threatened wildlife and plants; 90-day finding for a petition to de-list the Maryland Darter (*Etheostoma sellare*). *Federal Register* 61: 5971-5972.
- U.S. Fish & Wildlife Service. 2007. Maryland darter (*Etheostoma sellare*) 5-year review: Summary and evaluation. Chesapeake Bay Field Office. Annapolis, Maryland.