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Amphibians and Reptiles of the Eastern Shore of Virginia National Wildlife Refuge and Fisherman Island National Wildlife Refuge

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ABSTRACT

I conducted an inventory of amphibians and reptiles in 2006 at Eastern Shore of Virginia National Wildlife Refuge (ESVNWR) and Fisherman Island National Wildlife Refuge (FINWR), Virginia to document their occurrence, describe their associated habitats, and provide refuge staff with conservation and management recommendations. Forty species (12 frogs, 4 salamanders, 8 turtles, 4 lizards, and 12 snakes) were expected to occur at ESVNWR and FINWR on the basis of published distribution patterns. The proportion of expected species documented was 67% for frogs, 0% for salamanders, 88% for turtles, 25% for lizards, and 75% for snakes. Low encounter rates with secretive species, variation in regional distribution patterns, and history of intensive land use at ESVNWR likely contributed to the low species richness for salamanders and lizards. Only five species of reptiles were documented at FINWR. I summarize numerous life history and natural history observations on all species accumulated during the inventory on each refuge and suggest additional research that would benefit the region's herpetofauna.

Key words: Amphibians, biogeography, ecology, *Malaclemys terrapin*, natural history, reptiles, inventory, endangered species, resource management.

INTRODUCTION

Although some of the national wildlife refuges in the United States have conducted field research on their existing flora and fauna (e.g., Buhlmann & Gibbons, 2006), many have never completed baseline species inventories. Where information exists, it is often incomplete and inaccurate as is also the case with many national parks (Mitchell, 2000b). For refuge managers to effectively maintain the biological diversity and ecological health of their refuges, they must have a basic knowledge of the natural resources that occur there, as well as an understanding of those factors that may threaten them. Many of the wildlife refuges in the eastern United States are located on land formerly used for agriculture and other intensive human uses. Such lands have changed from farmland through ecological succession to a mosaic of habitats. Restoration on refuges has usually been limited to construction of waterfowl ponds and maintenance of fields of grasses and other plants for waterfowl forage (JCM pers. obs.). Amphibians and reptiles are seldom included in management plans, although many species have responded well to restoration activities and the natural succession that has been allowed to occur (Cook, 2008). Thus, national wildlife refuges provide important habitats for these two groups of vertebrates and in many places offer refugia from surrounding inhospitable land use.

The Eastern Shore of Virginia National Wildlife Refuge (ESVNWR) lies on the southern tip of the Delmarva Peninsula and is bordered on the east by the Atlantic Ocean and on the west by the Chesapeake Bay. Prior to European colonization, the Eastern Shore supported a deciduous mixed hardwood forest (Wesler et al., 1981). During the exploration and early settlement period of the 17th and 18th centuries, forests were cleared for agriculture for production of grain and livestock and, to a lesser extent, tobacco. The majority of the farmland on the current refuge became Fort John Custis Army Base in 1940, and later became the Cape Charles Air Force Base. Aerial photographs show that

land on the western portion of the base was farmed from the 1960s to 1990 (Mata, 1997). The U.S. Fish and Wildlife Service acquired the land in the 1980s and ESVNWR was established officially in 1984 (U.S. Fish and Wildlife Service, 2005). The refuge administered a cooperative farming program on approximately 30 ha from 1984 to 1990 for sorghum, millet, milo, and sunflower that were planted and rotated with legumes (i.e., red clover) for wildlife consumption (http://training.fws.gov/library/CCPs/eastshoreVA_index.htm, accessed 6 June 2006). Farming was discontinued on the refuge in 1990 and the fields were left fallow.

The earliest documentation of the existence of Fisherman Island is in navigational charts of the Chesapeake Bay published in 1815. Thus, it is apparently of modern origin. In 1886, the federal government purchased the island from its owner William Parker for an immigrant quarantine station but it was used only once in the treatment of yellow fever victims from the ship *Despa* in 1893. Soldiers from the Fourth Company of the Virginia Coastal Artillery National Guard were stationed on the island to protect the entrance of the Chesapeake Bay at the advent of World War I in 1914. The U.S. Navy used the island as a harbor defense unit and, with the entry of the United States into World War II, as a submarine detection base. In 1943, long cables (still present) from structures on the island controlled the movement of nearly 300 underwater mines, Four radar-controlled 90-millimeter guns were also installed by the Army. The artillery station was deactivated in 1944 and the land was transferred from the Army to the Navy, which maintained a LORAN radar navigation station on the island until 1969. Fisherman Island National Wildlife Refuge (FINWR) was established in 1969 and transferred to the Department of the Interior in 1973 (U.S. Fish and Wildlife Service, 2005).

A primary goal of the amphibian and reptile inventory on these two refuges was to provide a reliable species list for each based on a combination of published literature, museum records, and fieldwork. This paper summarizes species occurrence, habitat use, and natural history observations for these vertebrates on ESVNWR and FINWR.

MATERIALS AND METHODS

Study Area

ESVNWR and FINWR are located on the lower end of the Delmarva Peninsula in Northampton County, Virginia (Fig. 1). ESVNWR encompasses 465.4 ha on the tip of the mainland and FINWR is a 749 ha barrier island at the mouth of the Chesapeake Bay. Removal of military structures was initiated when the ESVNWR was established to create habitat to support migrating birds and other wildlife. Residences, towers, a non-commissioned officer's club, tennis court, swimming pool, bowling alley, and over 100 military structures were removed or demolished. Most of the once-developed land has changed via natural succession, much of which has become seedling Loblolly Pine (*Pinus taeda*) and shrub habitat. Invasive plant species such as Japanese Honeysuckle (*Lonicera japonica*), Fescue Grass (*Festuca* spp.), Common Reed (*Phragmites communis*), and Kudzu (*Pueraria lobata*) have become established throughout much of the disturbed acreage of the former base and farmland. Other invasive species include Autumn Olive (*Elaeagnus umbullata*), Multiflora Rose (*Rosa multiflora*), Mustards, Fennel (*Foeniculum vulgare*), and *Lespedeza sp*.

ESVNWR is approximately 35% wooded, scrub-shrub, 65% open fields in various stages of succession, and salt marsh. The refuge supports a variety of mixed species grasslands, Loblolly Pine stands, mixed Loblolly Pine and hardwood (various oaks [*Quercus* spp.], hickories [*Carya* spp.], and Black Cherry [*Prunus serotina*]) stands, brackish marsh fringe on the eastern and southern edges, a large freshwater depression, one freshwater pond (North Pond), a freshwater slough and swamp, areas of mowed grass, paved and gravel roads, and several buildings, most of which were erected for the refuge. North Pond (ca. 1 ha) is usually permanent but fluctuates dramatically and occasionally dries completely. It is an artificial pond that fills only partially during rainfall events. The large freshwater depression adjacent to the Visitor's Center was a shallow pond but is drained and now supports sedges and grasses. It has standing water during and only for short periods after rain events. This pond is artificial and water may be pumped into it. There are several pools with varying salinity at the southern end of the mainland amongst Loblolly Pine stands. Common Reed has invaded the southernmost portion of the refuge. The freshwater slough and swamp within the southern portion of the mainland supports duckweed (*Lemma* spp.) and emergent shrubs (e.g., *Clethra alnifolia* [Pepperbush]).

FINWR is surrounded by *Spartina* marsh on all but the Chesapeake Bay side of the island, which is beach habitat. The upland portion of the island is sand with about 80% wooded and shrub and 20% open, sandy areas with scattered Beach Grass (e.g., *Panicum* spp.). Active dunes occur only in the northeast and southeast portions of the island. The rest of the upland habitat is stabilized dunes and most support several hardwood

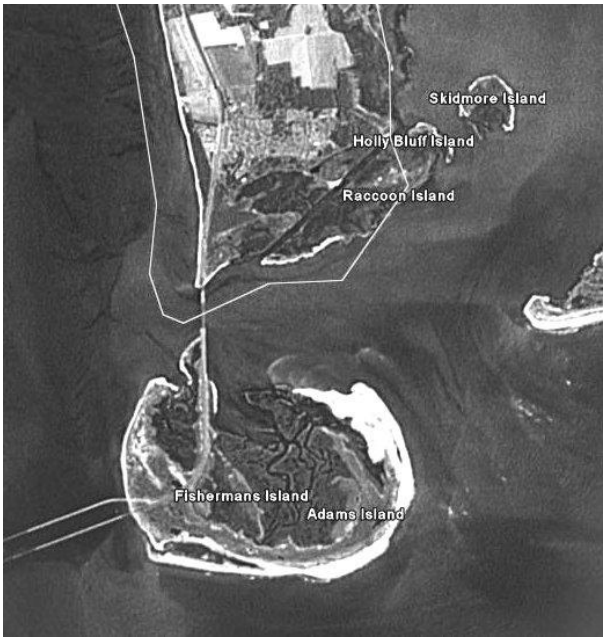

Fig. 1. Map illustrating the southern tip of the Delmarva Peninsula and associated islands that comprise the ESVNWR and FINWR. Map derived from Google Earth, Version 2009.

trees (e.g., *Morella* spp., *Prunus* spp., *Baccharis halimifolia* [Groundseltree]) that dominate the vegetation on the high side of the island. These trees and shrubs (e.g., *Amelanchier* [Serviceberry]) often occur as clumps and provide cover for birds and other wildlife. Belden & Field (2007) described the flora and vegetative communities of FINWR, indicating that 30% of the plants are invasive. U.S. Route 13 bisects the upland portion of the island on the northwestern end. Approximately 16.4 ha lie above the mean high water line. This southernmost barrier island in Virginia is separated from ESVNWR by Fisherman's Inlet, a half-mile-wide body of ocean water. Onshore sand bar movement (accretion) continues to expand the island's size, currently estimated at 749 ha. (http://training.fws.gov/library/CCPs/eastshoreVA_index.htm).

Habitats

I describe eight habitat types used by amphibians and reptiles on ESVNWR and FINWR. Common and scientific names of the flora follow Radford et al. (1968) and Stuckey & Gould (2000). The habitat codes are provided for each species below.

Grasslands (GRA) - Open fields dominated by grasses that are mowed on a regular to irregular basis or other land uses that have removed the forest canopy and created small to large patches of grass habitat. These areas include mixed grasses (Bermuda Grass [*Cynodon dactylon*], Velvet Grass [*Holcus lanatus*], Sweet Vernal Grass [*Anthoxanthum odoratum*], and Broomsedge [*Andropogon virginicus*]). Herbs include Horseweed (*Erigeron canadansis*), Pigweed (*Amaranthus hybridus*), Goldenrod (*Solidago* spp.), Fennel, Pokeweed (*Phytolacca americana*), Dog Fennel (*Anthemis* sp.), St. John's Wort (*Hypericum* sp.), Wood Sorrel (*Oxalis* sp.), and Dandelion (*Taraxacum officinale*) (B.D. Watts, pers. comm.). Other commonly found species include Wax Myrtle (*Morella cerifera*), patches of Black Raspberry (*Rubus occidentalis*), and Blackberry (*Rubus* spp.), Eastern Red Cedar (*Juniperus virginiana*), Japanese Honeysuckle, Multiflora Rose, Autumn Olive, Willow (*Salix* spp.), Sumac (*Rhus glabra*), and Common Nightshade (*Solanum* spp.).

Mixed hardwoods and pine (MHP) - Loblolly Pine and Virginia Pine (*Pinus virginiana*) comprise most of the coniferous forest elements of this habitat type. Dominant hardwood trees include White Oak (*Quercus alba*), Southern Red Oak (*Q. falcata*), Black Oak (*Q. velutina*), Willow Oak (*Q. phellos*), and Black Cherry. Understory trees include American Holly (*Ilex opaca*), Wax Myrtle, Dogwood (*Cornus florida*), Red Maple (*Acer rubrum*), Sweetgum (*Liquidambar styraciflua*), and Yellow Poplar (*Liriodendron tulipifera*). Several ephemeral pools (natural depressions in the landscape that hold water for varying times during the year, usually winter to summer) occur in this habitat type, varying in hydrology from short hydroperiods (weeks) to long hydroperiods (> 6 months) but usually drying out by the end of summer in most years.

Mixed pine (MPI) - Loblolly Pine is the most common pine species at ESVNWR, but some areas are largely composed of Virginia pine. In some areas, hardwood trees (Black Cherry, Red Maple) are scattered among the pines, usually as understory trees. Ground vegetation is sparse and includes Pennsylvania Smartweed (*Polygonum pensylvanicum*) and Partridge Berry (*Mitchella repens*).

Impoundments (IMP) - The only impoundments at ESVNWR are North Pond (Fig. 2), the depression pond adjacent to the Visitor's Center, and the shallow freshwater area immediately east and west of Wise Point Road. They all dry in drought years, although North Pond holds water long and often enough to allow frogs with long larval periods (e.g., *Lithobates catesbeianus*) to survive.

Fig. 2. North Pond on ESVNWR showing shallow water and the surrounding vegetation. This pond is ephemeral but supports a high diversity of amphibians and reptiles. Photo by J.C. Mitchell.

Swamp (SWP) - Swamp habitat in ESVNWR is most often flooded hardwoods in stream and bottomland areas. Mixed hardwoods such as Red Maple and Pepperbush, and fluctuating hydrologies characterize swamp habitats in this region. The primary swamp in the refuge is located adjacent to Wise Point Road below the road entrance gate (Fig. 3).

Vegetated Dune (VDU) – The dunes on FINWR support a variety of shrubs and grasses (Fig. 4). Vegetation on the primary dune ridge, which lies landward of the beach/foredune zone along crests of low ridges, is usually sparse or clumped and mainly colonized with grasses that have the ability to propagate via rhizomes and can withstand deep sand burial. The predominant species are American Beach Grass (*Ammophila breviligulata*), Running Panic Grass (*Panicum* sp.), and Salt Grass (*Distichis spicata*).

Fig. 3. Wetland at the southern end of the ESVNWR about 150 m N of the southern tip of Delmarva. Frogs heard or observed at this site were *Gastrophryne carolinensis*, *Hyla cinerea*, and *Hyla squirella*.

Fig. 4. Active dunes on FINWR illustrating the patchiness of the hardwoods and herbaceous vegetation. Photo by J.C. Mitchell.

Primary swales also have sparsely distributed shrubs, mainly Wax Myrtle and Bayberry (*Myrica pennsylvanica*). Plants have stabilized most of the dunes on the island except for the area near the entrance gate. This area has active dunes that support Black Cherry, Serviceberry, Prickly Pear Cactus (*Opuntia sp.*), Wax Myrtle, and patches of grasses.

Marsh (MAR) – The brackish marsh around most of FINWR and a portion of the ESVNWR is dominated by Cordgrass (*Spartina alterniflora*), Saltmeadow Cordgrass (*Spartina patens*), Hay, Black Rush (*Juncus gerardii*), and scattered Hightide Bush (*Iva frutescens*). The marsh is interspersed with mudflats and tidal channels of varying depths depending on tidal cycles.

Beach (BEA) - The beach on the Chesapeake Bay side of FINWR extends outward from the dunes and lacks vegetation. The intersection of these two zones is usually abrupt with the dunes rising sharply above the beach. The transition zone near the southern end of the island is less dramatic.

Field Sampling

I used various sampling techniques to conduct the inventory at ESVNWR and FINWR from March to October 2006. The techniques are described briefly here and in detail for amphibians by Heyer et al. (1994) and Mitchell (2000a), and for reptiles by Jones (1986), Mitchell (1994), and Blomberg & Shine (1996). Audio surveys were conducted during the day and also at night by listening for frog vocalizations at known wetland sites. Audio surveys conducted as part of this inventory were not time-constrained. Several species were detected opportunistically by driving roads during day

or night. I captured adult and larval anurans by sampling aquatic habitats with dipnets. I set unbaited standard minnow traps in shallow water with the upper portion set above the water surface to prevent drowning of air-breathing animals. Funnel openings were enlarged to 25-30 mm to increase capture success of adult frogs and semi-aquatic snakes. Minnow traps were also used in terrestrial habitats to capture snakes. Standard turtle hoop traps were set in wetlands and removed the next day. Traps used were (1) single funnel opening with nylon mesh on three 30-inch diameter steel hoops (nylon turtle nets) and (2) single funnel opening with nylon mesh on four 20-inch diameter fiberglass hoops (mini-hoop nets for catfish). Traps were baited with a can of sardines and set so that a portion was above the water surface to prevent turtles from drowning. When the probability of encounter was high (appropriate weather and season for the targeted species), I conducted visual encounter surveys (VES) by walking randomly through a selected habitat type, as well as turning logs and other surface objects to uncover animals. Binoculars were used to search water surfaces, logs, margins of wetlands, and basking sites for frogs, lizards, snakes, and turtles. Visual encounter surveys conducted as part of this inventory were not time-constrained.

I identified all captured amphibians and reptiles to species and released them at their capture sites. Common and scientific names follow Crother (2008). Most animals were measured (mm), weighed (g), and sexed. Body and tail measurements of amphibians were taken using plastic rulers, metric tapes, and calipers. I obtained body weights with Pesola® scales and an Ohaus Scout electronic field balance. Animals seen or heard in the field but not captured were recorded simply as observations.

RESULTS

Twelve species of frogs, four species of salamanders, eight species of turtles, four species of lizards, and twelve species of snakes were expected to occur on ESVNWR and FINWR based on available habitat types and species known to occur in Northampton County, Virginia (Mitchell, 1994; Conant & Collins, 1998; Mitchell & Reay, 1999; Roble et al., 2000; Roble 2001; White & White, 2002; Gibson, 2011) (Table 1). The list of species in the Comprehensive Conservation Plan (CCP) for these refuges includes 11 frogs, two salamanders, seven turtles (including four sea turtles), four lizards, and 11 snakes (Appendix D, U.S. Fish and Wildlife Service, 2008). Except for the species noted below, all amphibians and reptiles listed in the CCP were documented during this inventory. Three species of sea turtles (Green Sea Turtle [*Chelonia mydas*], Leatherback Sea Turtle [*Dermochelys coriacea*], Kemp's Ridley Sea Turtle [*Lepidochelys kempii*]) occasionally occur as rare strandings on Fisherman Island National Wildlife Refuge (Mitchell, 1994; Mitchell & Reay, 1999), but they were not encountered during my study.

During the 2006 inventory, I documented eight species of frogs and 17 species of reptiles (Table 1). Reptiles included seven species of turtles, one lizard, and nine species of snakes. No salamanders were found. Total capture success was 67% of the expected species of frogs in Northampton County and 71% for reptiles (88% for turtles, 25% for lizards, and 75% for snakes). Four species of frogs known to occur on the lower Eastern Shore were not encountered during this inventory (*Acris crepitans*, *Hyla chrysoscelis*, *Pseudacris kalmi*, *Scaphiopus holbrookii*). I documented all of the expected turtles except for the Spotted Turtle (*Clemmys guttata*) and the three species of sea turtles noted above. I encountered only one (*Scincella lateralis*) of the four expected lizards on ESVNWR and FINWR (*Plestiodon fasciatus*, *Plestiodon laticeps*, and *Sceloporus undulatus* were not found). The only expected snakes that were not captured during my inventory were the Northern Copperhead (*Agkistrodon contortrix mokasen*), Ring-necked Snake (*Diadophis punctatus*), and Eastern Gartersnake (*Thamnophis s. sirtalis*). Two species of turtles and three species of snakes were documented on FINWR, whereas eight species of frogs, six turtles, one lizard, and eight snakes were documented for ESVNWR (Table 1).

Species Accounts

Habitat codes included in the habitat descriptions above are used for brevity.

Anurans

Anaxyrus fowleri (Fowler's Toad) - GRA, MHP, MPI, IMP

Fowler's Toads were abundant on ESVNWR and observed April-September. Many individuals were observed on roads at night, in mowed grass areas, and in natural habitats throughout the refuge. Calling males were heard between 11 April and 27 June. Mating was observed on 9 June and 26 June. Eggs were observed in North Pond on 11 April and tadpoles were observed on 19 October. Sixteen tadpoles measured 9-13 mm total length and were in Gosner developmental stages 24-25.

Table 1. Checklist of the amphibians and reptiles of Eastern Shore of Virginia National Wildlife Refuge and Fisherman Island National Wildlife Refuge, Virginia. Expected (X) species are those known to occur in Northampton County (Mitchell & Reay, 1999; Roble et al., 2000; Roble, 2001; White & White, 2002; Gibson, 2011). Species that were confirmed by capture or observation in each refuge are noted as "O." Three species of sea turtles that are occasionally found on Fisherman Island are not included in this list.

Scientific name	Common name	Northampton County	ESVNWR	FINWR
Frogs				
Acris crepitans	Northern Cricket Frog	X		
Anaxyrus fowleri	Fowler's Toad	X	O	
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad	X	O	
Hyla chrysoscelis	Cope's Gray Treefrog	X		
Hyla cinerea	Green Treefrog	X	O	
Hyla squirella	Squirrel Treefrog		O	
Pseudacris crucifer	Northern Spring Peeper	X	O	
Pseudacris kalmi	New Jersey Chorus Frog	X		
Lithobates catesbeianus	American Bullfrog	X	O	
Lithobates clamitans	Northern Green Frog	X	O	
Lithobates sphenocephalus	Southern Leopard Frog	X	O	
Scaphiopus holbrookii	Eastern Spadefoot	X		
Salamanders				
Ambystoma opacum	Marbled Salamander	X		
Hemidactylium scutatum	Four-toed Salamander	X		
Notophthalmus viridescens	Red-spotted Newt	X		
Plethodon cinereus	Red-backed Salamander	X		
Turtles				
Caretta caretta	Loggerhead Sea Turtle	X		O
Chelydra serpentina	Common Snapping Turtle	X	O	
Chrysemys picta	Eastern Painted Turtle	X	O	
Clemmys guttata	Spotted Turtle	X		
Kinosternon subrubrum	Eastern Mud Turtle	X	O	
Malaclemys terrapin	Diamond-backed Terrapin	X	O	O
Pseudemys rubriventris	Red-bellied Cooter	X	O	
Terrapene carolina	Eastern Box Turtle	X	O	
Lizards				
Plestiodon fasciatus	Common Five-lined Skink	X		
Plestiodon laticeps	Broad-headed Skink	X		
Sceloporus undulatus	Eastern Fence Lizard	X		
Scincella lateralis	Ground Skink	X	O	
Snakes				
Agkistrodon contortrix	Northern Copperhead	X		
Carphophis amoenus	Eastern Worm Snake	X	O	
Coluber constrictor	Northern Black Racer	X	O	O
Diadophis punctatus	Northern Ring-necked Snake	X		
Heterodon platirhinos	Eastern Hog-nosed Snake	X	O	
Lampropeltis getula	Eastern Kingsnake	X	O	
Nerodia sipedon	Northern Watersnake	X	O	
Opheodrys aestivus	Rough Greensnake	X		O
Pantherophis alleghaniensis	Eastern Ratsnake	X	O	O
Storeria dekayi	Northern Brownsnake	X	O	
Thamnophis sauritus	Northern Ribbonsnake	X	O	
Thamnophis sirtalis	Eastern Gartersnake	X		

The largest male was 62 mm SVL and weighed 24.7 g and the largest female was 73 mm SVL and weighed 35.2 g. However, the heaviest female was 72 mm SVL and weighed 41.5 g. The smallest mature male measured 49.5 mm SVL and weighed 13.8 g. The smallest presumably mature female measured 51 mm SVL and weighed 15.5 g. The largest five immature females were 45-49 mm SVL and weighed 7.9-12.8 g. The smallest Fowler's Toad captured was 26 mm SVL and weighed 1.6 g on 28 June. One female was missing her right rear foot. A 72 mm female died while trying to consume a 55 mm total length, 1.6 g grasshopper on 26 June. She also contained 2 small beetles, a small caterpillar, and 3 isopods (pill bugs).

Gastrophryne carolinensis (Eastern Narrow-mouthed Toad) - GRA, MHP, MPI

Narrow-mouthed Toads were commonly heard calling throughout the late spring and summer months. They called from small bodies of water in pine and cedar lowlands, as well as in ditches near the southern end of the refuge. A female was found under a board in a grass field on 9 June. Adults were heard calling 27 May - 27 June throughout ESVNWR. Choruses were present at several locations in shallow wetlands immediately east and west of Wise Point south to nearly the tip of the mainland. Amplexus was observed on 9 and 27 June. The largest male was 28 mm SVL and 1.5 g; the largest female was 32 mm SVL and 2.6 g.

Hyla cinerea (Green Treefrog) - GRA, MHP, MPI, IMP, MAR

Green Treefrogs were abundant on ESVNWR. Juveniles and adults were commonly seen on the sides and windows of houses and other structures. Adults were heard calling from trees and vegetation in and around North Pond and usually throughout ESVNWR south to the tip of the mainland from 18 May to 7 September. The largest adult male was 50 mm SVL and 6.3 g, and the largest adult female was 52 mm SVL and weighed 6.8 g (gravid). Amplexus was observed on 26 and 27 June. One male observed at North Pond on 25 March 2006 had three unidentified leeches attached to its abdomen (Fig. 5).

Hyla squirella (Squirrel Treefrog) - GRA, MHP, MPI, IMP

Squirrel Treefrogs were documented on the Delmarva Peninsula for the first time with discovery of a very large population in ESVNWR (Mitchell & Denmon, 2007). This species is abundant and found in all habitat types on the refuge. Several were found on windows of houses. Some called from small bodies of water in pine and cedar lowlands, as well as in ditches near the southern end of the refuge and from hardwood trees. Adults were heard calling 27 May - 7 September throughout ESVNWR south to the tip of the mainland. Mating behavior was observed on 9 June. The largest male was 35 mm SVL and 2.8 g, and the largest female was 36 mm SVL and 2.8 g (gravid). Metamorphs were observed on 19 October at North Pond.

Fig. 5. A male *Hyla cinerea* with three unidentified leeches on its abdomen found at North Pond on ESVNWR.

Lithobates catesbeianus (American Bullfrog) - GRA, IMP

The deepest portion of North Pond was the only location where this highly aquatic species was heard calling on 26 June. The next day a large (133 mm SVL, 284 g) female was caught on a paved road on ESVNWR during a heavy rainstorm.

Lithobates clamitans melanota (Northern Green Frog) - GRA, IMP, SWP

Adult Green Frogs were observed calling in North Pond on 26 June and 7 September in thick vegetation. Tadpoles were captured in the swamp/slough near the southern end of the mainland on 19 May. Some of these had rear legs indicating they were the 2005 breeding

cohort and would metamorphose in 2006. Only one male was captured (66 mm SVL, 23.7 g).

Lithobates sphenocephalus (Southern Leopard Frog) - GRA, MHP, MPI, IMP

Southern Leopard Frogs called from North Pond on 22 March, 11 April, 18 May, and 7 September. One calling male was observed perched above the water line by holding the stiff stems of an aquatic plant; they are usually sitting in shallow water. Egg masses were observed on 11 April (fresh and hatching) and tadpoles occurred in the pond on 19 May, 26 June, and 19 October. Six tadpoles measured 18-26 mm total length and were in Gosner developmental stage 25. One metamorph with tail was observed on 19 May. The largest male was 60 mm SVL and 16.9 g, and the largest female was 61 mm SVL and 17 g.

Pseudacris crucifer crucifer (Northern Spring Peeper) - GRA, MHP, MPI, IMP, SWP

Spring Peepers were first heard calling on ESVNWR on 22 March from North Pond and the depressional wetland adjacent to the Visitor's Center. Tadpoles were observed on 11 April in North Pond. The largest individual captured was a female (28 mm SVL, 1.9 g).

Turtles

Caretta caretta (Loggerhead Sea Turtle) - BEA

One Sea Turtle crawl was observed on the beach at FINWR on 5 July 2006 on the northeast side of the island. Skeletal elements are occasionally seen on the bayside.

Chelydra serpentina serpentina (Common Snapping Turtle) - IMP

Two Snapping Turtles were captured in turtle traps on 18 May in North Pond. A very large male (~300 mm CL) was observed in North Pond on 26 June. The largest captured male had a maximum CL of 182 mm, maximum PL of 128 mm, and weighed 1250 g.

Chrysemys picta picta (Eastern Painted Turtle) - IMP

Painted Turtles were common in North Pond but found nowhere else in ESVNWR. Eight were captured during the day and night while they rested on the bottom of the pond in shallow water (<0.5 m) in vegetation or in small indentations in the soft substrate. One 153 mm CL, 402 g female was found crossing a dirt road on 27 June at 1242 EDT; she had already nested. Of the 31 adults captured, 12 were males (mean CL = 138.8±15.8 mm, 101.3-157.1; mean PL = 127.3±13.0 mm, 98.0-141.7; mean body mass = 329.2±89.8 g, 148-485) and 19 were females (mean CL = 160.0±6.9 mm, 147.0-171.5; mean PL = 147.8±6.3 mm, 135.6-155.7; mean body mass = 531.6±58.3 mm, 402-600, n = 18). Two immature females (108 mm CL, 99 mm PL, 173 g, and 97 mm CL, 93 mm PL, 131 g) were judged to be in their fourth year of growth based on counts of lines of arrested growth. One mature male (101 mm CL, 98 mm PL, 148 g) was in his third year of growth. The only hatchling captured was 28.4 mm CL, 26.4 mm PL, and 5.7 g. A portion of two of the marginals on one female had been chewed by a predator, another female was missing her right foreleg and her left rear leg, and one male had a damaged left rear foot. The shell of a juvenile apparently killed by a predator was found at North Pond on 11 April.

Kinosternon subrubrum subrubrum (Eastern Mud Turtle) - GRA, MHP, MPI, IMP

Mud Turtles are apparently terrestrial for long periods of time at ESVNWR, as none was observed during day or night forays in North Pond until 18 May when five were captured in turtle traps. A heavy rainstorm during the morning of 9 June triggered movement of 25 individuals (11 males, 14 females) into the pond that night. Several were observed in the northern portion of the pond adjacent to a Loblolly Pine forest that had been repeatedly checked several times that day and early evening. A total of 37 individuals was caught, 20 males (mean CL = 93.5±4.1, 84.1-98.6; mean PL = 80.6±3.7 mm, 71.6-85.2; mean body mass = 146.7±19.1 g, 101.0-170.0) and 17 females (mean CL = 91.5±5.7 mm, 82.8-101.7; mean PL = 83.6±6.1 mm, 71.1-93.6; mean body mass = 146.1±22.0 g, 111-185). The smallest male was 86 mm CL, 73 mm PL, and 109 g and the smallest female was 83 mm CL, 77 mm PL, and 123 g. No juveniles were encountered. The shell of an apparently predator-killed adult was found at North Pond on 11 April. One adult male had a slightly kyphotic shell.

Malaclemys terrapin terrapin (Diamond-backed Terrapin) - VDU, MAR, ROAD

Diamond-backed Terrapins appear to be common on FINWR. Numerous nests were observed on the island, primarily in the active dune area, after being destroyed by Raccoons (*Procyon lotor*) and possibly

other predators. Fifteen roadkills and six live adult females were found on U.S. Rt. 13 during the 2006 inventory. Sixteen adult females were observed on the beach, along the sand road bisecting the island, and in the dunes. Active females presumably seeking or returning from nest sites were observed between 27 May and 21 July. The largest female captured measured 206 mm CL and 191 mm PL, less than the largest reported for Virginia for carapace length (213 mm) but larger than the largest known plastron length (189 mm) (Mitchell, 1994). The smallest adult female measured 169 mm CL. Numerous Pillbugs (*Armadillilium vulgare*) were observed in several fresh egg shells left over from being eaten by predators on Fisherman Island, presumably eating the last of the albumin (Fig. 6).

Pseudemys rubriventris (Red-bellied Cooter) - MHP

One adult female Red-bellied Cooter was observed walking through the refuge near the Headquarters Building on 24 August. There is no permanent water on ESVNWR, so this observation is likely of a transient individual from a permanent pond north of the refuge.

Terrapene carolina carolina (Eastern Box Turtle) - GRA, MHP, MPI

Box Turtles are apparently common on ESVNWR. Two were observed near buildings and two were caught in Hav-a-Hart® traps set for Raccoons. Two small individuals were 74 mm CL each and 69 mm and 76 mm PL. The first was determined to be in its second and the other in its third year of growth based on lines of arrested growth. The largest adult captured was a 127 mm CL, 126 mm PL, 422 g female.

Fig. 6. Pillbugs (*Armadillilium vulgare*) presumably feeding on the albumin inside the egg shells of *Malaclemys terrapin* after the fresh eggs have been eaten by a predator on FINWR.

Lizards

Scincella lateralis (Ground Skink) - GRA, MHP

One adult female was found on a resident sidewalk on 21 April on ESVNWR and another was observed under a log in mixed hardwoods and pine woods on 28 June.

Snakes

Carphophis amoenus amoenus (Eastern Worm Snake) - MHP

One adult female was found inside a moist log in mixed hardwoods and pine at the northern end of ESVNWR near the Headquarters Building on 28 June.

Coluber constrictor constrictor (Northern Black Racer) - GRA, MHP, MPI, VDU

Black Racers are common at ESVNWR in grassy areas and also occur in the shrub zones on FINWR. One was observed active at 1257 EDT on 9 June in a Cattail (*Typha* sp.) pool. The largest individual caught on the mainland was a 1078 mm total length and 400 g male. A 1370 mm total length, 316 g adult female was captured in one of 60 minnow traps set overnight among Myrtle shrubs and grasses on Fisherman Island on 28 June.

Heterodon platirhinos (Eastern Hog-nosed Snake) - GRA, MHP, MPI

One blotched, adult female Eastern Hog-nosed Snake (647 mm total length, 164 g) was caught in a minnow trap set along an abandoned building in a grassland area on ESVNWR.

Lampropeltis getula getula (Eastern Kingsnake) - GRA, MHP

A large, adult male (1320 mm total length) was killed on 12 October by a vehicle on the access road in ESVNWR. Habitat was mixed pines and hardwoods on the east side of the road and grasslands on the west side.

Nerodia sipedon sipedon (Northern Watersnake) - GRA, MHP, IMP

Northern Watersnakes were observed in North Pond on 19 May and 26-27 June. The largest one caught was

a 975 mm total length, 405 g female. One juvenile measured 284 mm total length and weighed 9.1 g.

Opheodrys aestivus (Rough Greensnake) - VDU

Rough Greensnakes are known to occur on FINWR and probably on ESVNWR as well. Only one of these cryptic snakes was observed during this inventory, on Fisherman Island on 8 September. An adult specimen in the former Virginia Commonwealth University Herpetological Collection (now in the North Carolina Museum of Natural Sciences) was collected from Fisherman Island on 21 March 1982.

Pantherophis alleghaniensis (Eastern Ratsnake) - GRA, MHP, MPI, VDU

Eastern Ratsnakes are common on both refuges. Dates of observation on ESVNWR were 19 May, 9 June, and 9 July. One was caught in an unused shed, another in grassland, and a third in Loblolly Pine woods. One adult was observed in shrub and grass habitat on FINWR on 12 September. The largest female was 1280 mm total length and weighed 410 g. The latter, captured on 9 July, had consumed 3 Northern Bobwhite (*Colinus virginianus*) eggs measuring on average 25.1 x 31.8 mm and weighing 10.5 g. No males were captured. The dorsal blotch pattern on one large female (1256 mm total length, 431 g) was visible without body distention, whereas no blotches were visible in the other three large females (1280 mm, 1173 mm, 1142 mm).

Storeria dekayi dekayi (Northern Brownsnake) - GRA, MHP

An adult female was found dead on 7 November 2006 adjacent to a dormitory yard on ESVNWR. Local habitat was mowed lawn and shrub regrowth with Bayberry, Multiflora Rose, Fennel, and Japanese Honeysuckle.

Thamnophis sauritus sauritus (Northern Ribbonsnake) - GRA, MHP, IMP

An adult male (827 mm total length, 36.2 g) was observed foraging in the rain on the night of 27 June in the shallow Cattail and grass wetland adjacent to North Pond.

DISCUSSION

Amphibians and reptiles are highly seasonal animals whose activity patterns respond to changes in climate, temperature, and precipitation. Thus, a complete inventory of amphibians and reptiles can be a challenge for short-term surveys. Two of the four frog species (*Acris crepitans*, *Hyla chrysoscelis*) not encountered during this inventory are known to occur at the lower end of the Delmarva Peninsula (Mitchell & Reay, 1999; White & White, 2002). The other two anurans (*Pseudacris kalmi*, *Scaphiopus holbrookii*) inhabit northern Northampton County but may not occur at the lower end. The lack of any of the expected salamanders suggests that habitats on the refuge may not be suitable. All of the expected turtles are represented in the refuge except for *Clemmys guttata*, which requires ephemeral freshwater marshes and pools that apparently are not present there. They are known to occur on Hog Island (Conant et al., 1990; Mitchell, 1994), but their existence there may be historical. The putative record for the Eastern Six-lined Racerunner (*Aspidoscelis sexlineata*) in Northampton County in Mitchell & Reay (1999) is incorrect and was included inadvertently. *Plestiodon fasciatus* and *Plestiodon laticeps* are known from northern parts of Northampton County and*Sceloporus undulatus* has been documented in two sites near the ESVNWR (Mitchell, 1994; Mitchell & Reay, 1999). Thus, lack of observations of these diurnal, and often conspicuous, lizards in pine stands on the refuge was unexpected. Copperheads (*A. contortrix*) are known from the northern end of the county, and Ring-necked snakes and Eastern Gartersnakes (*T. sirtalis*) have been documented from the middle portion of the county (Mitchell, 1994; Mitchell & Reay, 1999; Roble, 2001). Historical land use in the lower portion of the Peninsula now occupied by present day ESVNWR may have played a role in determining their absence. However, each of these species may be found with additional inventory effort and, perhaps most likely, by opportunistic encounters. Snakes in general can be especially difficult to discover because many are secretive and occur in limited numbers (Gibbons et al., 1997). Leiden et al. (1999) demonstrated with multiple techniques that 66% of the total snake species expected were caught in the first 75 days of sampling, but that an additional 325 days of sampling would be required to collect 90% of the total number expected. One snake species was not discovered for 22 years on the Savannah River Site, an area that has been intensively studied for over 40 years (Whiteman et al., 1995; Gibbons et al., 1997).

An important factor to consider in amphibian conservation on ESVNWR is their movement between aquatic breeding sites and the terrestrial environment. Production of metamorphic frogs in breeding sites and their emergence into the terrestrial environment is a major energetic link between these two habitats

(Gibbons et al., 2006). Dispersal of these metamorphs occurs over long distances from which they return to their natal breeding sites or colonize other breeding sites (Semlitsch, 2008). Thus, maintenance of viable populations of these amphibians requires protection and management of all breeding sites in the area and the terrestrial habitat. Evaluation of breeding site location, terrestrial habitat for periods outside of the breeding period, and dispersal corridors should be included in any species management plan. Habitat conservation strategies for amphibians should also include the maintenance and preservation of a core habitat composed of breeding pools or ponds and the terrestrial habitat around them (>200 m), surrounded by an additional buffer zone of 100-200 m (Semlitsch & Jensen, 2001).

Threats to amphibians and reptiles at ESVNWR include mortality from vehicular traffic, human disturbance or killing, subsidized predators (e.g., raccoons that benefit from human shelter and discarded food [Mitchell & Klemens, 2000]), miscellaneous hazards that trap animals, crab pot mortality of *M. terrapin*, and habitat loss or alteration. Removal of animals by humans for personal purposes or the commercial pet trade constitutes an unknown level of threat because there are no data to evaluate this impact. Habitat loss is not considered a major threat at ESVNWR or FINWR. Future plans for alteration of areas of refuge land that may include habitat loss should be reviewed thoroughly and losses prevented when possible. Specific areas to which to pay special attention include all impoundments, breeding sites, swamps, and the pine-hardwood forests.

Vehicular traffic on all roads remains a threat to amphibians and reptiles crossing them. This includes U.S. Route 13 that bisects Fisherman Island and the roads within ESVNWR. Many frogs and several snakes were killed by vehicles in 2006. An evaluation of the magnitude of these threats should be undertaken and measures implemented to reduce the mortality of these animals. Road mortality is especially an issue with *Malaclemys terrapin*.

Several other local environmental issues affect the amphibians and reptiles on ESVNWR and FINWR. Trash in the form of plant and bird netting, netting from fisheries activities that washes up on the Fisherman Island beach, rip-rap, and other items that may trap reptiles and amphibians should be removed and discarded safely (Mitchell et al., 2006b). Mowing of grass areas to short heights is a potential hazard to frogs and some reptiles, particularly *Terrapene carolina*. Blade height should be no lower than 6 inches (Mitchell et al., 2006a). Invasive plants and introduced species pose mostly unknown threats to amphibians and reptiles. Giant Reed is well known to choke out native vegetation and modify habitats used by these vertebrates (Paton, 2005). Introduced animals include invertebrates and domestic and feral cats. The latter are usually not considered an introduced species but were introduced into North America by early colonists (Mitchell & Beck, 1992). Assessments of each invasive and introduced species should be undertaken with respect to amphibian and reptile management.

Long-term habitat management at ESVNWR would be beneficial to amphibians and reptiles if management issues and potential construction impacts were viewed within the context of the refuge's landscape matrix (Mitchell et al., 2006a). Any change to mixed hardwood and pine forests, impoundments, freshwater wetlands, tidal marshes, and dunes at ESVNWR and FINWR, for example, may have consequences to small snake assemblages and *T. carolina* populations. Many individuals of the latter species are long-lived and have low reproductive rates (30-100 years old; Dodd 2001). Mowing is a weekly, if not daily, activity at ESVNWR. Such operations are well-known to kill Box Turtles and other reptiles, such as large snakes.

The natural history of amphibians and reptiles has received little to no attention in most national wildlife refuges. Although my short-term inventory of these vertebrates on ESVNWR and FINWR has provided some information on their natural history, more research into their population dynamics would greatly benefit the development of a comprehensive natural habitat management plan. A management plan for amphibians and reptiles on these two refuges would help to ensure that these areas are maintained in sufficient natural conditions to allow the long-term persistence of the native herpetofauna.

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