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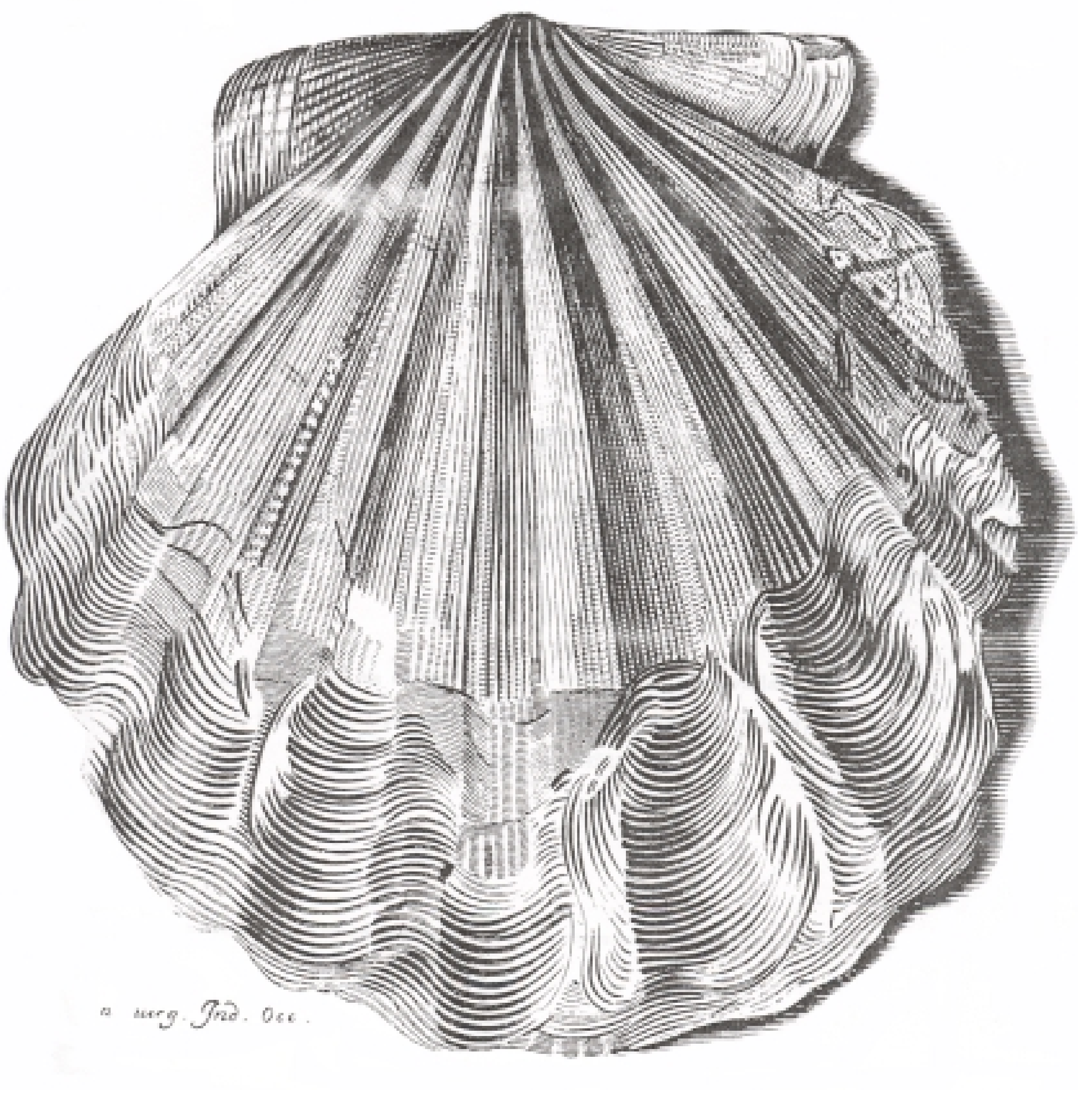
Northeast Coastal and Barrier Network

Paleontological Resource Inventory and Monitoring
Northeast Coastal and Barrier Network



Paleontological Resource Inventory and Monitoring
Northeast Coastal and Barrier Network

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On the Cover:
Martin Lister's 1687 figure (shown) and description of the mollusk *Chesapecten jeffersonius* is the first such publication of fossil material from North America. *Chesapecten jeffersonius* is just one of hundreds of mollusk species found within Colonial National Historical Park. See page 9 for more information. Image from Ward and Blackwelder, 1975.

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INTRODUCTION

Paleontological resources, fossils, are any remains of life preserved in a geologic context. These fossils are non-renewable resources that possess great scientific and educational values.

Establishment of baseline paleontological resource data is essential for the appropriate management of fossils found within National Park Service (NPS) areas. Although more than 160 NPS areas have been identified with paleontological resources, only a small percentage of these parks have adequate baseline paleontological resource data.

In conjunction with the NPS Geologic Resources Division and NPS Inventory and Monitoring Networks, paleontological resource inventories have been initiated in dozens of parks servicewide. This report represents paleontological resource inventory and monitoring data compiled for the parks within the Northeast Coastal and Barrier Network (CBN).

The CBN was formed to address coastal ecosystem resource issues throughout the northeast. The network contains eight NPS areas in five states, Assateague Island National Seashore (Maryland and Virginia), Cape Cod National Seashore (Massachusetts), Colonial National Historical Park (Virginia), Fire Island National Seashore (New York), Gateway National Recreation Area (New York and New Jersey), George Washington Birthplace National Monument (Virginia), Sagamore Hill National Historic Site (New York), and Thomas Stone National Historic Site (Maryland) as shown in Figure 1. These parks together cover 141,000 acres and host about 18 million visitors each year. The parks were set aside for a variety of historical reasons from preserving sites of the earliest American settlements at Colonial NHS through the urban recreational setting of Gateway NRA. While some parks such as Cape Cod NS and Assateague Island NS were set aside in part to preserve natural features, none of the parks' enabling legislation mention paleontological resources.

Figure 1. Map of CBN park areas.

The CBN contains a variety of geologic features including barrier islands, beach deposits, and glacial deposits. Barrier islands, such as Assateague Island NS and Fire Island NS, and beaches, such as those found at Gateway NRA and George Washington Birthplace NM, are very transient geological features. These coastal features are created and destroyed through relentless wave action and erosion. These islands and beaches also are usually very young, geologically speaking, with ages ranging from recent to tens of thousands of years old. The erosive character of such features, coupled with their young age, often precludes their inclusion in discussions of paleontological resources. Glacial deposits, such as those found at Sagamore Hill NHS or Cape Cod NS, are also not frequently associated with paleontological material.

Even though none of the parks were set aside specifically for paleontological resources, and many are made up of transient and erosional geological features, six CBN parks are known to contain, or may contain, paleontological resources. These fossils range from microfossils such as foraminifera and pollen to a large number and variety of mollusks and sharks teeth. Large marine mammal fossils have also been found. Taken together, fossils from the CBN contribute much to a greater understanding of past life on earth. One fossil in particular is of historical significance. The mollusk *Chesapecten jeffersonius*, found near Yorktown in Colonial NHS, represents the first fossil ever figured and described from North America in 1687. The original fossil itself may have been collected from within the current boundaries of Colonial NHS.

Continued paleontological resource inventories will continue to expand our knowledge of the history of life represented throughout the National Park Service. Although more than 160 parks have already been identified as containing paleontological resources, much of what we know about life on earth remains to be discovered.

Jason Kenworthy
Vincent L. Santucci
July 2003

ASSATEAGUE ISLAND NATIONAL SEASHORE

Assateague Island National Seashore (ASIS) was established September 21, 1965. The park preserves a 60-kilometer (37-mile) barrier island including beaches, migratory waterfowl, and wild ponies. The 9,021- acre Chincoteague National Wildlife Refuge, administered by the United States Fish and Wildlife Service (USFWS), is also contained within the park.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

Barrier islands, such as Assateague, are very transient geological features. These coastal features are created and destroyed through relentless wave action and erosion. These islands also are usually very young, geologically speaking, with ages ranging from recent to tens of thousands of years old. The erosive character of these islands, coupled with their young age, often precludes their inclusion in discussions of paleontological resources. Nevertheless, these islands can be sources of fossil material and fossils are known to occur at ASIS.

Formal geological and paleontological scoping sessions have not been completed for ASIS. Likewise, a formal paleontological inventory has not been undertaken at ASIS. However, there has been limited work on the paleontological resources of the seashore.

The Maryland Geological Survey's Geologic Map of Worcester County (Owens and Denny, 1978) identifies two types of units exposed on Assateague Island, barrier sand and tidal marsh deposits.

The barrier sand is a light-colored, moderately to well-sorted feldspathic quartz sand. Grain sizes range from fine to very coarse. There are abundant broken shell fragments within the sand unit. Extensive cross bedding is present in the sands, resulting from wave action. The unit can be as much as 6 meters (20 feet) thick. Tidal marsh deposits at the base of the barrier sand have been radiocarbon dated to about 1,800±200 years, and the unit has been assigned a Holocene (recent) age.

The tidal marsh deposits are exposed all along the western shore of the island (bay side). The deposits consist primarily of clay or silt with abundant decayed/decaying organic matter. These deposits are highly unconsolidated and soupy. Tidal marsh deposits are extensively exposed in the Chincoteague area and generally are no thicker than 5 meters (15 feet). This unit has also been assigned a Holocene age.

While shelly material is common within the barrier sand, fossilized material is generally not found in either deposit. However, Richards (1936) reports on shells discovered in sands on the southern end of Assateague Island, near Chincoteague. Described as "worn and apparently fossils", these shells, all bivalves, include *Chione cancellata*, *Crassinella lunatula parva*, *Donax variabilis*, and *Arca ponderosa*. These species are not found in the area today, aiding Richards' diagnosis that the material is paleontological rather than recent. The material is most likely Pleistocene in age, and may date to the Peorian interglacial period (approximately 60,000 years ago).

The paleontological resources from Assateague Island are generaly limited to material occasionally found on the ocean beaches. Whether the materials have washed ashore or have been eroded from the body of the island is unclear. This material has been collected over the last 30 years by both park staff and visitors. The park's museum has 11 paleontological specimens including crabs, shells, oyster, coral, ammonites, and an angel wing (see Table 1). These specimens have not been identified to genus or species level, and no locality information is associated with the material. The fossils are generally quite fragmentary. For example, the crab specimens have been described as "imprints" while the angel wing shell looks "mineralized" and approximately 60% complete (C. Zimmerman, personal communication, 2003). The crab material is typical of East Coast beach deposits and may be either *Cancer irroratus* or *Callinectes sapidus* (W. Blow, personal communication, 2003). Warren Blow, Museum Specialist at the Smithsonian's National Museum of Natural History, works with Cenozoic crabs and would be willing to look at the park's specimens (see contact information below) and provide additional information/description if possible. None of the fossil specimens have been dated, but are probably Pleistocene in age (tens of thousands of years old). ASIS museum specimens represent the only collections of paleontological material accessioned into CBN park museums.

The Toms Cove Visitor Center has two additional fossils that are not accessioned into the park's museum collections. These fossils include a crab and a possible sea lion jaw. The crab fossil is relatively complete. The sea lion remains consist of a right mandible with one tooth presented. The fossils were in the Visitor Center's sandbox/touch room exhibit but have been removed due to excessive wear and tear (J. Collins, personal communication, 2003).

A park employee reports that a mammoth tusk washed up on the beach of NASA's Wallops Island facility in Virginia, about 13 kilometers (eight miles) west of ASIS. Similar material may wash up on the shores of the park (J. Collins, personal communication, 2003).

Although not the focus of formal interpretation, fossils are mentioned incidentally during interpretive programs to tell the story of barrier island rollover (R. Daigenault, written communication, 2003).

Accession Number	ASIS Catalog Number	Class	Description
ASIS-00086	ASIS-00004	Crustacea	Fossilized crab
ASIS-00086	ASIS-00005	Crustacea	Fossilized crab
ASIS-00086	ASIS-00006	Crustacea	Fossilized crab
ASIS-00088	ASIS-00008	Bivalvia	Fossilized shells
ASIS-00092	ASIS-00109	Mollusca	Fossilized oyster (large)
ASIS-00216	ASIS-00336	Unknown	Funnel shaped casting
ASIS-00249	ASIS-01650	Anthozoa	Fossilized Tableate coral
ASIS-00249	ASIS-01651	Anthozoa	Fossilized Tableate coral
ASIS-00249	ASIS-01652	Anthozoa	Fossilized Cup coral and Tetra coral
ASIS-00249	ASIS-01653	Ammonoidea	Fossilized Ammonite
ASIS-00260	ASIS-01664	Crustacea	Fossilized crab
ASIS-00269	ASIS-01673	Bivalvia	Fossilized angel wing shell

Table 1. Paleontological specimens from ASIS museum collections.

REFERENCES CITED

Owens, J.P. and C.S. Denny, 1978. Geologic Map of Worcester County. Maryland Geological Survey. 1:62,500.

Richards, H.G., 1936. Fauna of the Pleistocene Pamlico Formation of the Southern Atlantic Coastal Plain. Bulletin of the Geological Society of America 47: 1611-1656.

ADDITIONAL REFERENCES

Warren Blow has offered to identify the crab material from ASIS. The material can be shipped via Federal Express (US Postal Service mail is irradiated and should not be used to ship paleontological material) to:
Mr. Warren C. Blow
Department of Paleobiology
MRC-121
National Museum of Natural History
10th Street and Constitution Avenue NW
Washington, D.C. 20560-0121

DATA SETS:

DS-ASIS-XXX Assateague Island National Seashore Paleontological Archives. 5/1985 – present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

DS-ASIS-XXX Assateague Island National Seashore Files, Archive, Museum Records. 9/1965– present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Assateague National Monument; status: Active.

CAPE COD NATIONAL SEASHORE

Cape Cod National Seashore (CACO), established June 1, 1966 (authorized August 7, 1961) stretches 64 kilometers (40 miles) from Chatham to Provincetown on outer Cape Cod, Massachusetts. Within this 64 kilometers are extensive ocean beaches, dunes, woodlands, freshwater ponds, and marshes and a number of cultural sites including Marconi's Wireless Station site.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken for CACO. Paleontological or geological scoping sessions have likewise not been completed for the park. There are no collections of paleontological specimens in the park museum (H. Morrill, personal communication, 2003).

Geologically, Cape Cod is a glacial creation, now being shaped by the waves of the Atlantic Ocean. The Laurentide Ice Sheet advanced and covered the entire Cape Cod area approximately 25,000 years ago. After retreating a few thousand years later, the ice sheet left behind the extensive glacial tills and "kame-and-kettle" (small knolls and kettle ponds) topography found today. CACO is mostly composed of glacial outwash deposits. These deposits were created as the ice sheet melted and retreated. The streams flowing out of the ice sheet carried debris trapped within the ice. This material was subsequently deposited in formations similar to deltas. Small bluffs found throughout the Cape preserve the moraines and tills recording the retreat of ice sheets. The very northern tip of the seashore (Race Point/Long Point) and the extreme southeastern features (Nauset Beach) represent more recent beach deposits created through wave action and erosion acting on the glacial material and underlying bedrock. Although glacial or beach deposits are not frequently associated with paleontological material, fossils have been found within some of the transported glacial tills and kettle ponds of CACO.

Fossils within the glacial tills and intertill beds of Cape Cod were initially reported by Sayles (1939) and described in greater detail by Sayles and Knox (1943) and summarized here. The micropaleontology of the tills was studied from a number of localities in the park, near Nauset Beach Coast Guard Station (Sayles and Knox locality 12), near the site of the Pamet River Coast Guard Station (locality 16), and near Highland Light (locality 17). Samples from each locality contained microfossils. Sponge spicules were very abundant throughout. Diatoms were found in higher numbers within park deposits (up to 18 different species), compared to localities outside of the park (with two different species at most). These diatoms are important because they are used to reconstruct the preglacial environment of the sediment before it was bulldozed into place on Cape Cod by the advancing ice sheet. Absolute dating of the diatoms is not possible, however, the overall assemblage can be dated as post-Miocene to pre-Wisconsinan age (approximately 5.3 million-100,000 years ago). Within the blue clay and intertill beds, microscopic tree and shrub pollen, along with spores of mosses and ferns were the most common fossils found. A maximum of 19 different species or types were described at these localities. Like the diatoms, the pollen and spores can be used to reconstruct paleoenvironments. However, the pollen and spores reconstruct the time period between glacial periods due to their deposition in outwash clays and not the tills. These clays are similar to Pleistocene age (approximately 1.8 million-10,000 years ago) clays on Nantucket and Martha's Vineyard with respect to the fossils. All of the interbeds had small unidentifiable fragments of wood and additional carbonized material, which may represent seaweed. No foraminifera or other calcareous fossils were found. Overall, the microfossils, clay, and till deposits record at least four ice advances/retreats during the Wisconsinan glacial period (ending about 100,000 years ago).

The kettle ponds of Cape Cod National Seashore have also been the subject of paleontological research. Portnoy and others (2001) describe of the geologic forces behind the formation of the kettle ponds of Cape Cod, which are summarized here. Granitic outwash sands deposited approximately 17,000 to 14,000 years ago form the setting for these kettle ponds, part of the park's "kame and kettle" topography (Portnoy, et al., 2001). Ice blocks that were left behind as the Laurentide glacier retreated formed the depressions now known as kettle ponds. These ponds now serve as important sources of information about the postglacial paleoecology of Cape Cod. Sediment cores in the ponds have been radiocarbon dated and microscopically examined for pollen, diatom/algae, and cladocera (water fleas) fossils. Charcoal deposits have also been studied (Portnoy, et al., 2001). The plant and charcoal fossils can be used to reconstruct the past vegetation, fire disturbances, water level, and climatic change of the area around the ponds. Diatom and cladocera fossils are important indicators of within-pond changes of pond shape, pH, salinity, and other pond systems through time (Portnoy, et al., 2001). Winkler (1985) studied these features for Duck Pond and Winkler (1988) used fossil diatoms to reconstruct the pH of Duck Pond (Wellfleet) over the last 12,000 years. Winkler and Sanford (1995) and Portnoy and others (2001) present more in-depth results from research in a number of kettle ponds throughout CACO.

Many ponds in the park have significant sedimentation records and paleontological materials. These deposits are often continuous for over 10,000 years and were documented in Duck Pond (Wellfleet) (over 11,710 years), Dyer Pond (approximately 12,530 years), Great Pond (Wellfleet) (over 11,700 years), Great Pond (Truro) (13,800 years), and Williams Pond (approximately 9,500 years). Duck Pond (Wellfleet), Dyer Pond, and Great Pond (Truro) had substantial pollen and charcoal deposits providing records of vegetation change over the last 14,000 years. The earliest assemblages include tundra species, poverty grass (*Hudsonia*) and spruce-willow parklands (Portnoy, et al., 2001). Pollen of spruce, jack pine, and green alder has been found in sediments dating to between 12,000 and 10,500 years old. Heath family (Eriaceae) pollen has been discovered in sediments from between 11,000 and 10,000 years ago. Conifer pollen including jack pine and white pine is common in sediments from about 10,500 through 9,000 years old. Pollen assemblages younger than 9,000 years old display the oak and pitch pine barrens vegetation typical of the Cape today (Portnoy, et al., 2001). In addition, Duck Pond (Wellfleet) and Great Pond (Truro) had "litter" deposits at the bottom of the cores. Duck Pond litter included aquatic mosses, cattail fruits, sedges, *Potentilla*, and *Epilobium* (all about 12,000 years old). Litter from Great Pond (Truro) included twigs from a dwarf willow (one had an intact bud, several others had *in situ* scale insects), black spruce needles, *Najas* seeds, *Nitella* oospores, cattail seeds, and St. John's-wort seeds. These fossils are very well preserved and have been dated to approximately 13,000 years old (Portnoy, et al., 2001).

Allen (1920) reports the discovery of bison maxilla with two deciduous milk teeth found in glacial till on Town Cove, near Orleans. While located a few miles west of the park boundary, this discovery may indicate the presence of similar material from deposits within the park.

The Wellfleet glacial till deposits of the Cape, just west of the park, have produced silicified (petrified) wood (Cretaceous or Tertiary in age), pieces of a shelly sandstone (Eocene in age), and sharks teeth (Tertiary in age) (Oldale, 1992).

COOPERATIVE PROJECTS

- Paleoecology and Modern Water Quality of CACO kettle ponds study undertaken by NPS/CACO staff and scientists from University of Wisconsin (Madison) Center For Climatic Research (Portnoy, et al., 2001).

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Oldale, R.N., 1992. Cape Cod and the Islands: The Geologic Story. East Orleans, Massachusetts: Parnassus Imprints. 208 pp.

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Winkler, M.G. 1997. Late Quaternary Climate, Fire, and Vegetation Dynamics. pp. 329-346 *in* Clark, J.S., H. Cachier, J.G. Goldammer, and D.J. Stocks (editors). Sediment Records of Biomass Burning and Global Change. Berlin, Germany: Springer-Verlag.

DATA SETS

DS-CACO-XXX Cape Cod National Seashore Paleontological Archives. 5/1985 – present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

COLONIAL NATIONAL HISTORICAL PARK

Colonial National Historical Park (COLO) was proclaimed July 3, 1930 and established December 30, 1930. The park preserves a number of features and places prominent in early American history. Jamestown Island was the site of the first permanent English settlement in North America. The culminating battle of the American Revolution, and subsequent surrender of British forces, occurred at Yorktown in 1781. Cape Henry Memorial marks the approximate site of the first landing of Jamestown colonists in 1607. The Colonial Parkway winds 37 kilometers (23 miles) between Yorktown and Jamestown Island, connecting the two units of the park. The road also passes through the colonial town of Williamsburg. Yorktown National Cemetery is the site of thousands of Civil War interments.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken at Colonial National Historical Park. Paleontological or geological scoping sessions have likewise not been completed for the park and there are no collections of paleontological material in the park's museum. While formal inventories and collections have not been conducted by the park, there are extensive paleontological resources known from COLO. In fact, the first figured and described fossil from North America may have been collected from Yorktown Formation sediments in what is now COLO.

Johnson (1972) maps the Upper Pleistocene Norfolk Formation throughout the Beaverdam Creek area south of Yorktown and in very small area southeast of Moore House near the park boundary. This name is no longer used, however, and Mixon and others (1989) map the area as the "middle" Pleistocene Shirley Formation and the "middle" (?) Pleistocene Chuckatuck Formation.

The Shirley Formation is made up of sand, gravel, silt, and clay, representing surficial deposits of river terraces (Mixon, et al., 1989). Organic material is common in the Shirley Formation including *in situ* tree stumps and leaves and seeds of cypress, oak, and hickory trees. Additional fossils are reported in the Shirley Formation in the lower James River and Rappahanock River area, including *Crassostrea virginica*, *Mulinia*, *Noetia*, and *Mercenaria*, among other mollusks. An *Astrangia* (coral) fossil was dated from the Shirley Formation and yielded an approximate age of 184,000 years before present (Mixon, et al., 1989).

The Chuckatuck Formation is made up of sand, silt, and clay, with minor amounts of peat, representing surficial deposits of mid-level coast-parallel plains and equivalent river terraces (Mixon, et al., 1989). The Chuckatuck is not particularly fossiliferous, although *Ophiomorpha* burrows have been reported (Mixon, et al., 1989).

The late Pliocene or early Pleistocene Windsor Formation is well exposed throughout the Yorktown area of COLO, especially at the Zook marl pit located just northeast of the intersection of Virginia Routes 238 and 639. The Windsor Formation contains a lower cross-bedded sand and bedded silt member and an upper silty-clay, sandy-silt, and clayey sand member (Johnson, 1972). The only fossils *in situ* within the Windsor Formation are vertical knobby burrows similar to those formed by *Calianassa major* (modern ghost shrimp) (Johnson, 1972). Mollusk molds formed in the minerals goethite, hematite, and limonite are found in the lower beds of the Windsor Formation. These molds are most likely from Yorktown Formation mollusks, reworked into the younger beds of the Windsor Formation (Johnson, 1972).

The lower and upper Pliocene Yorktown Formation (approximately 4.5-3 million years old) is exposed throughout the coastal plain of Virginia and North Carolina. Within COLO, the Yorktown Formation was exposed mainly along the banks of the York River. Additional exposures were found near the mouths of creeks feeding into the York and along the banks of Yorktown Creek and Ballard Creek in particular. The impact of erosion control measures on the exposures of the Yorktown Formation is mentioned at the end of the COLO summary. Overall, the Yorktown Formation is a marine unit composed of silts, sands, and crossbedded coquinas (shell hash). The formation is abundantly fossiliferous. The vast majority of the fossil material described from the Yorktown Formation is molluscan, and many of the taxa were named based on material from the immediate Yorktown area.

The Yorktown Formation has been the subject of a voluminous amount of geological and paleontological research. Much of the early work describing the Yorktown Formation took place within current park boundaries or within close proximity to them. However, exact locality information is sometimes not clear. Some of this early work is very significant historically.

Ward and Blackwelder (1975) speak to the extraordinary significance of a fossil from the Yorktown area in that it represents the first description and figure of a fossil from North America, published by Martin Lister in 1687! The story behind this unique fossil is summarized below.

Martin Lister described and figured an unnamed scallop-like shell in his “Historiae Conchyliorum, Liber III” (History of the Mollusks, Third Book). This fossil has had an interesting history since this first description more than 315 years ago. Initially, Lister misinterpreted the locality where the shell was collected. The fossil was labeled “a virg.” which Lister interpreted as “from the Virgin Islands”, hence his addition of “Ind Occ”, meaning Indies Occidentale, or West Indies, to the label (Ward and Blackwelder, 1975). However, fossils of this type are not known from the Virgin Islands (L. Ward, personal communication, 2003). Paleontologist Thomas Say, in 1824, recognized the shell as probably coming from the Atlantic Coastal Plain of the United States, instead of the Virgin Islands, and named it *Pecten jeffersonius* (now assigned to *Chesapecten jeffersonius*; Ward and Blackwelder, 1975). However, Say was also confused as to the exact locality of additional *Chesapecten jeffersonius* material. He incorrectly described the material as coming from Miocene deposits on the Saint Mary’s River in Maryland. Given the abundance of *Chesapecten jeffersonius* throughout southeastern Virginia, the “a virg.” most likely meant “from Virginia” (Ward and Blackwelder, 1975). Recognizing the historical significance and the abundance of the fossil, the Virginia General Assembly named *Chesapecten jeffersonius* the state fossil of Virginia in 1993. A copy of Lister’s figure for *Chesapecten jeffersonius* is presented as Plate 1 in Ward and Blackwelder (1975) and is figured on the cover of this report.

While the exact collecting locality of the original specimen is not known, it is from the Yorktown Formation, based on numerous additional finds of *Chesapecten jeffersonius*. The specimen figured by Lister may be from the Kings Creek area, currently located within the U.S. Naval Weapons Station adjacent to Yorktown (G. Johnson, personal communication, 2003). The Colonial Parkway crosses Kings Creek where it joins the York River, within exposures of the Yorktown Formation. If the collection was made near the mouth of Kings Creek, the locality may fall within current boundaries of COLO. Alternatively, the specimen may have been collected in the Indian Field Creek area, the mouth of which is also within current COLO boundaries (L. Ward, personal communication, 2003).

Ward (1993) and Campbell (1993) describe much of the other early work on the Yorktown Formation. References for many of these publications are listed under the “additional references” section at the end of this report.

Lister’s significant description of *Chesapecten jeffersonius* in 1687 was the first description of paleontological material from the area. Lister did not actually visit the area, although many of his specimens were collected from a number of different naturalists working in the Yorktown vicinity (L. Ward, personal communication, 2003). The first description of the Yorktown area by a geologist was in 1824, when Scottish geologist John Finch visited the region and made collections of approximately 50 fossil mollusks (L. Ward, personal communication, 2003). Finch distributed these fossils to a number of prominent scientists at the Academy of Natural Sciences in Philadelphia including Timothy Abbott Conrad, Samuel G. Morton, Isaac Lea, Thomas Say, and J. Green. Say received the majority of the specimens, about 30 fossils (L. Ward, personal communication, 2003). Say described most of these fossils, including *Chesapecten jeffersonius*, in 1824. However, Say and the other scientists (Conrad in 1832 and Lea in 1833) all mistakenly listed the collecting locality for Finch’s fossils as coming from Saint Mary’s River, Maryland (Ward, 1993; Campbell, 1993). Finch and the authors never corrected this error. Therefore many of the original specimens collected from the area (now many of which are housed in the British Museum, London) are listed as coming from Maryland (L. Ward, personal communication, 2003). Conrad returned to the area around Yorktown repeatedly from the 1830s through the 1860s, describing and naming a large number of mollusk fossils (Ward, 1993; Campbell, 1993).

A number of authors during the mid- to late-1800s and early 1900s attempted to catalog and classify Yorktown Formation mollusks from throughout the Coastal Plain of Virginia.

The authors included, among many others, H.C. Lea in 1846 and 1849, d'Orbigny in 1850-1852, Conrad in 1862, Meek in 1864, Meyer in 1888, Shaler in 1890, Dall in 1890-1903, Olsson in 1914 and 1916, and Gardner in 1948 (Campbell, 1993). However, a large number of these publications, especially the earlier ones, contain various taxonomic and/or stratigraphic errors and omissions (summarized in greater detail by Campbell, 1993). These errors are in addition to the erroneous locality information introduced by Lister and Finch. Campbell (1993) goes on to warn all those who "deal casually with the Yorktown faunas" of these discrepancies present throughout a widely scattered literature base.

In 1890, Gilbert Dennison Harris made the first intensive geologic description of the Yorktown Formation, in the area of Yorktown Proper. His elegantly handwritten manuscript was originally unpublished, but has been reproduced by Ward (1993). This "new edition" includes copies of the original pages and drawings along with updated information. Dall and Harris in 1892 also reproduced a portion of Harris' 1890 manuscript. Harris, in addition to his geologic observations, described in detail the fossil fauna he discovered and collected from the cliffs along the banks of the York River. Harris collected fossils from eight localities along the York River. Seven are most likely within current COLO boundaries and range from Temple Place (Moore House), throughout the bluffs at Yorktown and a few miles upstream from the town, and up to Bellefield (Bellfield). These locations produced a diverse assemblage of gastropods and bivalves. Harris named many of the layers (beds) he studied after the predominant, or most characteristic, fossil species from each respective bed including: *Turritella* (gastropod), *Crepidula* (gastropod), *Striarca centenaria* (bivalve), *Tellina* (bivalve), and *Yoldia limatula* (bivalve). Harris also describes areas of "shell marl" and "fragmentary series" (probably coquina) where the shell material is extraordinarily abundant, but very fragmented. Ward (1993) a complete listing of fossils collected by Harris, all are now curated in the Smithsonian Institution's National Museum of Natural History. Overall, Harris collected 72 species of gastropods and 69 species of bivalves. Harris also collected a few specimens of brachiopods and *Balanus* (barnacles).

Harris also described and produced a detailed sketch, reproduced in Ward (1993), of the Yorktown Formation (then known as the "Miocene Beds") exposed from Wormley Creek to Kings Creek. This is significant in that it is one of the only existing sketches and descriptions of the river shoreline from before erosion control features (riprap) were installed in the mid 1950s.

Clark and Miller (of the Maryland and Virginia Geological Surveys) formally applied the name Yorktown Formation to the "Miocene Beds" as the Yorktown Formation rocks were known in 1906.

In 1836, William Barton Rogers, first state geologist of Virginia, briefly described the Yorktown bluffs from Wormley Creek (about one mile southwest of Moore House) to several miles above Yorktown proper. Nearly all of this shoreline is currently administered by COLO (Ward, 1993).

W.C. Mansfield, in 1944, suggested dividing the entire Yorktown Formation into two zones based on mollusk assemblages. The lower Zone 1 contains 105 molluscan species while the upper Zone 2 contains an astounding 507 molluscan species (Campbell, 1993).

Johnson (1972) mapped the geology of the Yorktown area and presented a faunal list from the Yorktown Formation collected from the area. Two localities including the bluffs near Moore House and the Zook marl pit are within COLO boundaries. Johnson also identified two species of Scaphopoda (tusk-shelled mollusks), 39 species of gastropods, 46 species of Pelecypods (bivalves), two species of annelid worms, barnacle and decapod fragments, echinoid spines and plates

Ward and Blackwelder (1980) revised much of the stratigraphy of Chesapeake Group formations of which the Yorktown Formation is the youngest. They renamed strata equivalent to Mansfield's Zone 1, the Sunken Meadow Member of the Yorktown Formation. They divided Mansfield's Zone 2 into three members, from oldest (bottom) to youngest (top) they are the Rushmere Member, the Morgarts Beach Member, and the Moore House Member.

The Sunken Meadow Member is a coarse-grained, poorly-sorted, very shelly sand with 27 different species of mollusks (Ward and Blackwelder, 1980). The Rushmere Member is a fine-grained, well-sorted shelly sand, containing a molluscan assemblage very similar to the Moore House Member, described below. The Morgarts Beach Member is a very fine grained sandy to silty clay with some silty sand beds. The quieter-water environment represented in this member contains a molluscan assemblage similar to the Moore House Member, but the fossils are generally less abundant (Ward and Blackwelder, 1980). The Moore House Member is named for exposures still visible along the shoreline of the York River near Moore House within COLO boundaries. The Moore House consists of sandy shell beds and a prominently cross-bedded shell hash (coquina) locally well cemented to form a relatively hard rock. Cornwallis Cave was excavated into the Moore House Member and dramatically displays the crossbedded nature of the coquina (Ward and Blackwelder, 1980; Santucci, et al., 2001). The molluscan assemblage of the Moore House Member contains 71 different species.

Ward and Blackwelder assigned type sections to the Yorktown Formation. Even though Clark and Miller originally named the formation for exposures along the York River (most likely within COLO boundaries), they did not define a type section. Now that most of the exposures originally studied and named are inaccessible due to riprap, the type section of the Yorktown Formation is found near Rushmere, Virginia along the James River (Ward and Blackwelder, 1980).

McLean (1957) summarized the field collections made by Denise Mongin (Laboratoire de Geologie, Institut Catholique, Paris, France) in 1955 from the bluffs at Moore House within COLO. Mongin collected 66 species from a wide variety of fossils including foraminifera, ostracodes, and mollusks. These fossils are curated in the Institut Catholique museum.

Palmer (1958) reported on an interesting specimen of *Turritella pilsbryi* (gastropod; assigned to *Turritella bipertita* by Campbell, 1993) found with more than 100 young embryos inside the adult shell. The finding of this viviparous (gives birth to live young) specimen is significant in that determining the sex and/or life habit of a fossil is usually impossible. This specimen was found about 14 kilometers (nine miles) north of Yorktown along the York River, and may be within Colonial Parkway right of way. Other similar viviparous specimens have been found in Miocene-age rocks at Plum Point, Maryland (Palmer, 1958).

Campbell (1993) attempted to comprehensively describe the history and taxonomy of all Pliocene-aged mollusks from both the Yorktown and Chowan River formations in Virginia. In this monograph he described a total of 572 molluscan species and subspecies from those formations, the vast majority from the Yorktown Formation. Campbell (1993) also addressed new ideas about the depositional environments of the Yorktown Formation and suggests revisions to the four members named by Ward and Blackwelder (1980). Campbell mentioned the importance of localities not along the riprapped shoreline of the York River, such as the Zook pit (located with COLO boundaries), to future studies of the Yorktown Formation. Campbell also speaks to the significance of the Virginia Yorktown fauna as a whole. The Virginia Yorktown molluscan fauna is of importance to many other Neogene (Miocene and Pliocene) fossil assemblages from the western Atlantic from Massachusetts to the Caribbean, hence it is cited in many of the significant works. The Yorktown fauna is thus a very important part of the more than 1,550 molluscan species identified from the Pliocene of Massachusetts to Florida (Campbell, 1993). Because of the continuous stratigraphy and well-exposed outcrops (before the installation of riprap), the Yorktown Formation faunal assemblage provided stratigraphic context for Yorktown-aged fossils found in other formations throughout the Atlantic Coastal Plain.

Collections of Yorktown Formation fauna are housed in a number of museums around the world. For example, many of Say's described fossils are housed at the British Museum in London. Mongin's specimens are at the Institut Catholique in Paris, while many other early specimens are found in other European museums and collections. Harris' significant collection from the 1890s was made while he was working for the U.S. Geological Survey, hence his collections are at the Smithsonian's National Museum of Natural History in Washington, DC (NMNH; although specimen numbers are prefixed USNM). All together the NMNH houses a huge number (more than 500) of Yorktown Formation mollusk species (Campbell, 1993). Johnson's specimens are curated at the College of William and Mary in Williamsburg. Campbell (1993) also lists collections housed at the American Museum of Natural History (New York), the Academy of Natural Sciences (Philadelphia), the Museum of Comparative Zoology (Harvard), the Wagner Free Institute (Philadelphia), and the Paleontological Research Institute (Ithaca). Specimens described in Ward's 1975 and 1980 publications are curated at the NMNH and the Virginia Museum of Natural History.

Apart from the immense diversity of mollusk fossils, there are a number of other paleontological resources from the Yorktown Formation, both in and around COLO boundaries.

Extensive work on the microfauna, including foraminifera (small single-celled organisms with chambered exoskeletons called 'tests') and ostracodes (bivalved, generally microscopic aquatic crustaceans) of the Yorktown Formation has been conducted and reported in a number of papers.

McLean (1956) described 108 species of foraminifera from the York-James Peninsula. Much of the material is well preserved, although not necessarily abundant. Two of McLean's localities, Yorktown Bluffs and Moore House Beach, are within COLO boundaries. A third locality near the mouth of Felgates Creek (McLean refers to "Felgaters" Creek) may be within COLO boundaries of the Colonial Parkway, or just outside COLO administered land. The Yorktown Bluffs locality produced seven different species or forms of foraminifera including one previously undescribed species. The Moore House Beach locality contained a much more diverse assemblage with 50 species or forms represented, including 11 previously undescribed species. The Moore House Beach foraminifera were collected from excavations along the base of the embankment, and then four feet and six feet above the base. The Felgates Creek assemblage of foraminifera contained seven species or forms, two of which were previously undescribed. The overall assemblage of foraminifera suggest a shallow to moderately deep marine environment (McLean, 1956). This foraminiferal material is curated at the Paleontological Research Institution in Ithaca, New York. Dowsett and Wiggs (1992) studied foraminifera from the Moore House Member and Mogarts Beach Member, exposed near Moore House within COLO. Their study identified 18 different species of foraminifera present at this locality. The Moore House Member, in particular contains well-preserved and abundant forams. Common specimens include *Neogloboquadrina* and *Globigerinoides ruber*. Slightly less common were specimens of *Globigerinoides obliquus* and *G. sacculifer*. Foraminifera are important indicators of paleoenvironment. The assemblage collected from the Mogarts Beach Member within COLO indicates an approximate sea surface temperature ranging from 18.7°C (65.7°F) in winter to 25.9°C (78.6°F) in summer (Dowsett and Wiggs, 1992).

McLean (1957) followed up his 1956 work on the foraminifera of the Yorktown Formation with a description of the ostracoda of the York-James Peninsula. McLean described 30 species of ostracodes from throughout the Peninsula. The Yorktown Bluffs, Moore House Beach, and Felgates Creek (again, McLean refers to "Felgaters" Creek) localities listed in this 1957 paper are the same as those utilized in 1956. Yorktown Bluffs and Moore House Beach are within COLO boundaries, while the Felgates Creek locality is near, if not inside, present-day COLO boundaries. The Yorktown Bluffs locality did not produce any ostracodes. The Moore House Beach locality however produced 17 different species of ostracoda. Of these 17, one species, *Murrayina barclayi*, was previously unknown and was only described form the Moore House Beach locality. The Felgates Creek locality produced four species. The overall ostracode assemblage indicates relatively shallow water conditions.

Sabol (1960) reported on the ostracodes and foraminifera of the Cobhams Wharf area, located approximately three kilometers (two miles) south of Jamestown Island on the south bank of the James River. Sabol (1960) described 15 species of ostracods, McLean (1957) also collected nine of these species at the Moore House

Beach locality. Sabol's collection of foraminifera yielded 25 different species, 14 of which were also collected at the Moore House Beach locality within COLO as reported by McLean (1957).

Additional microfossils are reported from the Yorktown including fragments of bryozoans (McLean, 1956; Sabol, 1960; Johnson, 1972), brachiopods (Johnson, 1972), echinoid spines and fragments (McLean, 1956; Johnson, 1972), numerous barnacle plates (Sabol, 1960; Johnson, 1972), sponge spicules (Sabol, 1960; Johnson, 1972), and a small coral (Sabol, 1960; Johnson, 1972).

Clarke and Fitch (1975) reported the discovery of fossil cephalopod statoliths (small calcium carbonate or aragonite deposits in the ear, responsible for equilibrium) from a number of formations throughout the country, including the Yorktown in Virginia. Sabol (1960) notes the occurrence of statoliths in the Cobham Wharf area on the south bank of the James River, south of Jamestown Island. Fossil statoliths, also known as otoliths, may be present within COLO boundaries based on these discoveries in the immediate area.

Vertebrates have been reported from the Yorktown Formation. However much of the material is most likely from the Sunken Meadow Member of the Yorktown Formation, as vertebrate fossils are rarely found in the younger members of the Yorktown Formation (L. Ward, personal communication, 2003). For example, both McLean (1956) and Johnson (1972) report discoveries of fish bones within Yorktown sediments. Berry and Gregory (1906) reported on a discovery of walrus from the "beach at Yorktown, Virginia". The jaw material found was significant in that the authors named a new genus and species, *Prorosmarus alleni*, from the material. (Berry and Gregory, 1906). Baum and Wheeler (1977) reported on vertebrae of the whale *Balaenotus* sp. found on the south bank of the James River directly across from Jamestown Island at the end of Virginia Route 636. Additional whale material was found approximately 16 kilometers (10 miles) west of Jamestown Island near Sunken Meadow Pond on the south bank of the James River (Baum and Wheeler, 1977). Johnson (1972) reported what may be an *Orycterocetus* (sperm whale) tooth found within the R.L. Brandt & Sons gravel pit about 6.5 kilometers (four miles) southeast of Moore House near Fish Neck. While not within COLO boundaries, these discoveries indicate the possibility for similar material to be located within the park. Additionally, Ward (personal communication, 2003) indicated that whale material was discovered during the early summer of 2003 during an archeological survey at a fort near Indian Field Creek.

While extraordinarily abundant, and extraordinarily varied, paleontological resources have been described from the Yorktown Formation within COLO, there is little future potential for additional finds at the classic localities. The best exposures of the Yorktown Formation were along the south bank of the York River. This bank, however, was riprapped in the 1950s to slow erosion. This riprap completely covers many of the fossiliferous exposures making them inaccessible (L. Ward, personal communication, 2003; Ward, 1993). McLean (1956) also commented on the loss of paleontological collecting and research sites due to bank conservation practices throughout the York-James Peninsula.

While riprap obscures some of the classic collecting localities, there is still potential for unauthorized collection of paleontological resources. In fact, Burns (1991) published a popular guide to collecting fossils in the Mid-Atlantic region. The book describes a collecting locality located within COLO, along the south bank of the York River at the mouth of Indian Field Creek. Unauthorized fossil collectors may be visiting this location and may be removing fossils from the park. However, collections made below high mean tide are technically out of COLO boundaries (C. Rafkind, personal communication, 2003).

The Yorktown area and Yorktown Formation of COLO has been the subject of the majority of geological and paleontological research within the park. However, Johnson and Hobbs (2001) do report on the geology of the Jamestown area. The marsh, estuary, and beach sediments found on the surface of Jamestown Island are relatively young, dating from the late Pleistocene and Holocene. These sediments have been assigned to the late Pleistocene Tabb Formation and the Kennon formation (an informal name). These young surficial units cover nearly 305 meters (1,000 feet) of Miocene and older sediments not exposed on the surface. Fossils found in the Jamestown Island area are mainly pollen and phytoliths (small mineral deposits formed within plants). Spores and foraminifera are also found and contribute to paleoecological reconstruction of the Jamestown area. These various types of microfossils, taken together, date back approximately 37,000 years and contain a nearly continuous record to present day (Johnson and Hobbs, 2001). Palynological (pollen) studies were conducted near Great Dismal Swamp 70 kilometers (44 miles) south-southeast from Jamestown Island. However, Johnson and Hobbs (2001) reported that because of limited elevation change between the two sites, paleoclimatological data is applicable to the Jamestown area. Grafton Pond (18 kilometers (13 miles) east of Jamestown), Kingsmill Creek (within COLO), and the Back River Marsh (within COLO) were other palynological survey sites, where geological core samples were obtained. Phytoliths (mineral deposits that form within plants) from four families of grasses in addition to oak and pine trees were studied from cores obtained in Back Water Marsh area and date from 5,000 years before present. Protistans including foraminiferids and thecaemobinids were described from the Middle James Estuary and range in age from 6,000 years to modern day. Overall, the microfossil record is not complete, but indicates that during the late Pleistocene, the Jamestown areas was covered with a boreal (northern) forest with spruce, fir, and cool climate pines (Johnson and Hobbs, 2001). Between 11,000 and 8,000 years before present, these northern species declined. Oak, hickory, temperate climate pines, and sweet gum, among others then flourished (Johnson and Hobbs, 2001).

COOPERATIVE PROJECTS

- Johnson and Hobbs' investigation of the geology of the Jamestown Island was performed within COLO, supported by College of William and Mary and Colonial Williamsburg Foundation (Johnson and Hobbs, 2001).

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DATA SETS

DS-COLO-XXX Colonial National Historical Park Paleontological Archives. 5/1985 – present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

DS-COLO-XXX Inventory of Paleontological Resources Associated with National Park Service Caves. 1997-2001. (field notes; photographs; publication). Originated by Santucci, Kenworthy, and Kerbo; status: Inactive.

DS-COLO-XXX Smithsonian Institution National Museum of Natural History Collections. 1890s-present. (museum specimens; associated specimen notes; collections records; field notes). Originated by NMNH Staff; status: Active.

FIRE ISLAND NATIONAL SEASHORE

Fire Island National Seashore (FIIS) was established on September 11, 1964 to preserve beaches and dunes along the southern reach of Long Island, New York. The park also preserves Fire Island Light House and the estate of William Floyd, a signer of the Declaration of Independence.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken at Fire Island National Seashore. Paleontological or geological scoping sessions have likewise not been completed for the park and there are no collections of paleontological specimens in the park's museum collection.

Barrier islands, such as Fire Island, are very transient geological features. These coastal features are created and destroyed through relentless wave action and erosion. These islands also are usually very young, geologically speaking, with ages ranging from recent to tens of thousands of years old. The modern Fire Island is approximately 8,000 years old (M. Bilecki, personal communication, 2003).

The beaches of Fire Island are primarily composed of sand eroding from glacial moraines. These moraines, the remains of the bulldozing action of glaciers, were deposited approximately 50,000 years ago as part of what is now known as the Ronkonkoma moraine (P. Stoffer, personal communication, 2003). Good exposures of the Ronkonkoma moraine are found near Montauk Point at the extreme northeast point of Long Island, about 80 kilometers (50 miles) from the northeast boundary of FIIS. The Ronkonkoma contains abundant metamorphic material including garnets and large quartz pebbles, transported to Long Island from the Connecticut area by glaciers. Fossils are extraordinarily rare in metamorphic rocks, and coupled with the young age of the island, none have been reported from the FIIS area (P. Stoffer, personal communication, 2003; B. Mader, personal communication, 2003; G. McDonald, written communication, 2003). Offshore deposits that have produced paleontological material on the beaches of Gateway National Recreation Area (GATE; approximately 56 kilometers (35 miles) southwest of Fire Island) are not known to be present in the Fire Island area (B. Mader, personal communication, 2003).

Gateway National Recreation Area

Gateway National Recreation Area (GATE) provides a wide range of recreational and educational opportunities to residents of New York and New Jersey with its location just outside of New York City. The park, established on October 27, 1972, contains over 26,000 acres of marshes, wildlife sanctuaries, recreations and athletic facilities, miles of sandy beaches, historic structures, old military installations, airfields, a lighthouse and adjacent waters around New York harbor.

Baseline Paleontological Resource Inventories

There have been no formal paleontological inventories undertaken for GATE. Paleontological or geological scoping sessions have likewise not been completed for the park. There are no specimens of paleontological material accessioned into GATE museum collections.

Beaches are very transient geological features. These coastal features are created and destroyed through relentless wave action and erosion. Beaches also are usually very young, geologically speaking, with ages ranging from recent to tens of thousands of years old. The erosive character of beaches, coupled with their young age, often precludes their inclusion in discussions of paleontological resources. However, extensive fossil resources have been reported in GATE.

The main fossil bearing unit in the Gateway area is equivalent to the Gardiner's Clay. The Gardiner's Clay is a poorly consolidated unit lying beneath Wisconsinan Age (approximately 75,000-100,000 years old) glacial deposits throughout the southern portion of Long Island. The unit is most likely Pleistocene in age (approximately 100,000 years old) and may represent a large storm deposit or high standing seas between glacial advances during the Wisconsinan glacial period (P. Stoffer, personal communication, 2003; Stoffer and Messina, 1996). The Gardiner's Clay is an offshore deposit in the area around GATE, up to 12 or 15 meters below the surface of the water (40 or 50 feet). The unit does outcrop in the Jamaica Bay area, however, it is poorly exposed due to its unconsolidated nature (P. Stoffer, personal communication, 2003). The unit is also believed to extend beneath Sandy Hook (Stoffer and Messina, 1996). Although primarily an offshore underwater unit, fossil material from the Gardiner's Clay washes up on a number of GATE's beaches due to submarine erosive processes. Fossil material is recovered from four beaches in the national recreation area: Rockaway Beach, Fort Tilden, Staten Island, and throughout Sandy Hook (P. Stoffer, personal communication, 2003; Stoffer, 1996).

The fossil assemblage from the Gardiner's Clay sampled at these beaches is estuarine in nature and quite extensive, including a wide variety of invertebrates such as oysters, scallops, gastropods, barnacles, and coral (Stoffer, 1996; Stoffer and Messina, 1996). Foraminifera are also abundant (Stoffer and Messina, 1996). Crab material has been discovered as well (P. Stoffer, personal communication, 2003; D. Phillips, personal communication, 2003). Concretions have produced specimens of two species of crab, *Cancer irroratus* and *Callinectes sapidus* (Stoffer, 1996). Vertebrae and teeth of fish and marine mammals are reported as well (Stoffer, 1996). A crocodilian tooth was found at Fort Tilden (Stoffer, 1996). Phil Stoffer has extensive personal collections of material found on the beaches of Gateway (P. Stoffer, personal communication, 2003).

Some of the paleontological material displays unusual taphonomy. For example, casts of clams and other invertebrates have been found in a coal-like material (Stoffer, 1996). A similar type of material, described as "black rocks", is reported from material dredged out of New York Harbor near the beaches of GATE (D. Linck, personal communication, 2003). This material may also contain similar invertebrate casts. Most materials clearly identifiable as fossils are found in hard concretionary material (carbonate-cemented sand (P. Stoffer, personal communication, 2003).

Dredging operations in the harbor frequently bring to the surface additional paleontological specimens along with archeological resources. The fossil material is of the same assemblage found washing up on the beaches (D. Linck, personal communication, 2003).

Interestingly, most of the crab material appears to be from juveniles. This abundance of juvenile material may support the idea that the Gardiner's Clay represents a severe storm deposit. This storm, if active during spring months, would have buried the crabs during their juvenile stage under a large amount of sand. Other organisms would have succumbed to a similar fate (P. Stoffer, personal communication, 2003).

Stoffer and Messina (1996) have produced a website entitled "Geology and Geography of the New York Bight". The website contains a wealth of information about the New York Bight area, with much of the work was conducted within the boundaries of GATE. The website, in addition to describing the modern beach features and dynamics, includes pictures of fossils commonly found in the area and descriptions of the stratigraphic units found throughout the New York Bight. Stoffer has prepared a more comprehensive manuscript detailing geology and paleontology from throughout the New York City area. This manuscript may be posted on the USGS website in the near future (P. Stoffer, personal communication, 2003).

Due to the abundance of the fossil material (as well as archeological material) on the beaches of GATE, unauthorized fossil collecting and beachcombing have been popular activities within GATE's boundaries (D. Linck, personal communication, 2003; P. Stoffer, personal communication, 2003). Highlands, New Jersey, located on the shore to the southwest of Sandy Hook, is an area of intensive fossil collecting outside of the park.

COOPERATIVE PROJECTS

- The Geology and Geography of the New York Bight website (created 1996) by Phil Stoffer and Paula Messina was produced with assistance from GATE.

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DS-GATE-XXX Gateway National Recreation Area Collections. 1990s. (fossil specimens; associated specimen notes; field notes). Originated by Phil Stoffer; status: Inactive.

GEORGE WASHINGTON BIRTHPLACE NATIONAL MONUMENT

George Washington Birthplace National Monument (GEWA) was established on January 23, 1930 to preserve the birthplace of the United States' first President. The park, located on the Potomac River, contains a memorial mansion, gardens, and the tombs of several generations of Washingtons.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken at George Washington Birthplace National Monument. Paleontological or geological scoping sessions have likewise not been completed for the park and there are no collections of paleontological specimens in the park's museum. While the park has not made formal inventories and collections, there are extensive paleontological resources known from GEWA.

The Calvert Formation is the main fossiliferous deposit within George Washington Birthplace. The Calvert Formation has been known as a major source of fossil material for one hundred years after the original descriptions by George Burbank Shattuck in 1902 and 1904.

The marine sediments of the Middle and Lower Miocene Calvert Formation are extensively exposed throughout the Chesapeake Bay area, with exceptional exposures in Maryland at Calvert Cliffs State Park. While there are limited exposures of the Calvert Formation within the boundaries of GEWA, large quantities of fossils from this formation wash onto the beaches within the park. The Calvert Formation is exposed near the Bridges Creek Landing area, adjacent to northwest boundary of GEWA (R. Morawe, personal communication, 2003). Excellent exposures of the Calvert Formation are found at Westmoreland State Park approximately five miles down river from GEWA (W. Newell, personal communication, 2003). Mixon and others (1989) do not map extensive exposures of the Calvert in the immediate vicinity of GEWA, however the unit is exposed locally along the banks of the Potomac River and Popes Creek (R. Morawe, written communication, 2003).

On the coastal plain of Virginia the Calvert Formation consists of two to seven sequences of beds that fine upward. The sequences consist of a basal sand usually very fine to fine grained, often olive-gray in color. The sand can be silty or clayey and ranges from sparsely to abundantly shelly (Mixon, et al., 1989). The upper portions of the sequence contain rich diatomaceous clay-silt (Mixon, et al., 1989).

Sharks teeth are common throughout the Calvert Formation and, in turn, are the most common fossil found on the beaches of GEWA (R. Morawe, personal communication, 2003). In addition to being quite abundant, there is also quite a variety of species represented. The most frequently discovered sharks teeth include specimens from *Galeocerdo contortus*, *Galeocerdo triqueter* (both tiger sharks), *Hemipristis serra* (requiem, or snaggletooth, shark), *Oxyrhina desorii* (mackeral shark), *Sphyrma prisca* (hammerhead shark), and *Odontaspis elegans* (sand shark), all of which are now extinct (McLennan, 1971). While these are reported for the Calvert Cliffs area in Maryland, the presence of teeth from *Hemipristis serra*, *Oxyrhina desorii*, and *Otodus obliquus* (another mackeral shark) has been noted at GEWA (R. Morawe, written communication, 1999). In addition, teeth from sand, mako, silky, and white sharks have been found at GEWA (R. Morawe, personal communication, 2003). Large hand-sized specimens of *Carcharodon* (the giant white shark) may have been recovered from GEWA beaches (R. Morawe, written communication, 1999). Field work by Dave Bohaska of the Smithsonian Institution in January of 1989 uncovered a broken *Carcharodon* tooth while excavating a partial porpoise skull (see marine mammal section below) near GEWA (Bohaska field notes, 1989). Bohaska (field notes, 1989) also reports finding teeth of *Galeocerdo contorus* and *Hemipristis*, along with two unidentified specimens during other marine mammal excavations.

Fossilized remains of turtles and rays are also described from the Calvert Formation in Maryland, and similar fossils may be discovered in Virginia (McLennan, 1971). In fact, Bohaska (field notes, 1989) reports finding leatherback tortoise shell fragments during his 1989 excavations near GEWA.

Among the largest fossils found in exposures of the Calvert Formation near GEWA are those of marine mammals such as whales, sea cows, and dolphins (R. Morawe, personal communication, 2003). The Smithsonian Institution's National Museum of Natural History has a number of cetacean (whale and dolphin) specimens collected from the area immediately surrounding GEWA. Fragmentary bones of marine mammals could potentially wash up on the beaches at GEWA.

Dave Bohaska (personal communication, 2003) has collected material from a number of sites near GEWA. In 1989, Bohaska's field crew excavated a long beaked porpoise skull found on a beach located on private property northwest of GEWA. Additional excavations 30 meters (100 feet) downstream yielded another partial porpoise skull along with ribs and vertebrae. Cetothere whale material was collected approximately 457 meters (1,500 feet) upriver from the beach parking lot at GEWA, about 366 meters (1,200 feet) below the porpoise material. Skeletal remains collected from the cetothere include mandible, ribs, and vertebrae (Bohaska, 1989). In 1996, Bohaska returned to the GEWA area to collect a partial sirenian skeleton later identified as *Metaxytherium* (dugong). The specimen was originally discovered by the Richmond Gem and Mineral Society about 235 meters (770 feet) upstream from range station #17, near Bridges Creek Landing, just outside GEWA boundary (Bohaska, 1996). The excavation yielded several vertebrae and ribs, now in the Smithsonian's collection. Additional material including a small porpoise mandible was found upriver. A large jaw fragment and teeth of *Orycterocetus crocodilinus* (sperm whale) was discovered and excavated in 1977 1.6 kilometers (one mile) west of GEWA boundary (USNM 183078 specimen notes). A maxillary fragment of a sperm whale was discovered in 1975 at Church Point, west of GEWA. Myrick (1979) studied Rhabdosteidae (dolphins) including specimens found in the Calvert Formation near Church Point.

Fossils of land animals have also been found in the Calvert Formation. Tapirs, mastodons, rhinoceros, horses, and dogs have been found occasionally from Calvert Cliffs, Maryland (McLennan, 1973). While it may seem odd to find land animal fossils in a marine unit, streams probably transported the material from terrestrial environments, where the creatures lived, to the sea after death. In Virginia, *Amphicyon* (bear dog) skull material, including a jaw fragment with tooth, was excavated in 1970 from the cliffs at "Wakefield", most likely just outside of GEWA (USNM 26405 specimen notes). This material is significant because it is very rare to find skull bones of predators such as *Amphicyon* in the Calvert Formation (D. Bohaska, personal communication, 2003). A peccary dentary identified as "*Cynorca proterva*" was discovered near Church Point in Westmoreland County (USNM 214942 specimen notes) a few miles northwest of GEWA and mentioned by Wright and Eshelman (1987). The distal end of a left tibia (leg bone) of a tayassuid (peccary) was collected in 1978 above the beach at "Wakefield" (USNM 321259 specimen notes). These discoveries, all accessioned into the Smithsonian collections (USNM numbers listed here are catalog numbers), indicate that additional land animal fossils could be found in the GEWA area.

An extensive variety of mollusks, mostly gastropods and pelecypods, are found throughout the Calvert Formation and may wash up on the beaches of GEWA. As an example of the abundance of mollusks, 408 species of Mollusca are reported from Calvert Cliffs, Maryland (McLennan, 1973). *Chesapecten coccymelus*, *Crassatella melinus*, and *Ecphora tricostata* are typical of the formation in Virginia, although they probably represent a very small fraction of molluscan diversity (Mixon, et al., 1989).

Well-preserved foraminifera are also reported from the Calvert Formation throughout the coastal plain of Virginia including the genera *Siphogenerina* and *Uvigerina* (Teifke, 1973). Diatoms are very common as well, evidenced by the diatomaceous clay-silt layers described by Mixon and others (1989).

Extensive collections of Calvert Formation material in the area around GEWA have been made by the Smithsonian Institution's National Museum of Natural History. Approximately 800 cataloged specimens at the museum come from Calvert Formation exposures in Westmoreland County, Virginia (M. Brett-Surman, written communication, 2003). The American Museum of Natural History has a baleen whale collected near GEWA (D. Bohaska, personal communication, 2003).

Fossil sharks teeth have been discovered in association with an archeological site and shell midden within GEWA (R. Morawe, personal communication, 2003). The site is associated with prehistoric components dating to the Middle (2,500-1,100 years ago) and Late (1,100-400 years ago) Woodland periods and contains remains of multiple occupations (Harwood, 2002). Native Americans may have utilized the sharp fossils as tools to remove meat from shellfish.

While the Calvert Formation is more fossiliferous, the Sedgefield Member of the Upper Pleistocene Tabb Formation is exposed throughout GEWA (Mixon, et al., 1989). The Sedgefield Member is pebbly to bouldery, and contains a clayey sand and a fine to medium grained shelly sand, fining upward into clayey silt. This unit represents surficial deposits of rivers and coast-parallel plains deposited during interglacial times of high sea level. (Mixon, et al., 1989).

Fossils have been discovered in the Sedgefield Member, and may be found in the park. The coral *Astrangia* has been discovered and yields an average date of 71,000±7,000 years before present giving an estimate for the age of the Sedgefield Member (Mixon, et al., 1989). The mollusk genera *Mercenaria*, *Anadara*, *Polynices*, and *Ensis*, among others have also been reported (Mixon, et al., 1989). Mixon and others also note the occurrence of *Crassostrea* (a type of oyster) biostromes. These biostromes are laterally extensive carbonate deposits that may be reef-like structures or sheets of transported material. In addition, channel fill deposits, found locally in the Sedgefield, have yielded peat deposits with *in situ* tree stumps (Mixon, et al., 1989).

Fossils are not interpreted formally at GEWA, however a site bulletin has been produced describing the fossils commonly found within the park.

The material washing up on the beaches of GEWA is transported by relentless wave action along the Potomac River. These erosional forces not only expose paleontological material, but also carry it further downstream. This process provides a rather unique challenge for inventorying fossils at GEWA in that what is exposed on the beach one day may be buried or washed away days later. On the other hand, new material is constantly washing up along the beaches. This process is accelerated by storm events. These erosive mechanisms not only impact paleontological resources, but also the physical boundaries of GEWA. An estimated one to three feet of beach is lost each year to Potomac River erosion (R. Morawe, personal communication, 2003). This calls into question jurisdiction over paleontological resources discovered just off the GEWA shoreline. The Maryland state line is defined as mean low tide on the Virginia side of the Potomac. GEWA boundaries were established as such in 1930. However, over the last 73 years, the shoreline has retreated significantly and the original 1930 boundary line is now off shore. For example, the *Metaxytherium* (dugong) specimen collected by Bohaska outside of GEWA was excavated under extraordinarily low tide. Similar materials may be found directly off the GEWA shoreline under similar conditions.

In addition to significant natural impacts on fossils from GEWA, there are significant human impacts as well. Fossil collecting on the beaches of GEWA is a popular recreational activity due to the abundance and variety of fossils that can be found. The constant "renewal" of material washing up on the beaches, coupled with the fact that GEWA provides the only free public access beach with fossils in the local area may also fuel the popularity of fossil collecting on GEWA land (R. Morawe, personal communication, 2003). Collecting any fossil material on any National Park Service land is illegal. Collecting is allowed at Westmoreland State Park, although this activity is limited to "in plain view" fossils, no digging is allowed (S. Pflickinger, personal communication, 2003). Likewise, public access beaches at Calvert Cliffs State Park in Maryland allow personal collecting, but no digging or excavating into the actual cliff face (McLennan, 1973).

GEWA will be adding a museum building to their facilities in the near future with some space dedicated to natural resources. Therefore, future collections of paleontological material may be possible (R. Morawe, personal communication, 2003).

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DS-GEWA-XXX Smithsonian Institution National Museum of Natural History Collections. 1970s-present. (museum specimens; associated specimen notes; collections records; field notes). Originated by NMNH Staff; status: Active.

SAGAMORE HILL NATIONAL HISTORIC SITE

Sagamore Hill National Historic Site (SAHI) was established on July 25, 1962 to preserve the home of Theodore Roosevelt, where he lived from 1886 until his death in 1919. The shingle-style Queen Anne home was built in 1885 from a plan sketched by Roosevelt himself.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken for SAHI. Paleontological or geological scoping sessions have likewise not been completed for SAHI. There are no collections of paleontological material in the park museum.

Quaternary glacial moraine deposits, resulting from the bulldozing action of advancing glaciers, of the Harbor Hill moraine at SAHI are currently not known to contain any paleontological resources (P. Stoffer, personal communication, 2003). The moraine dates from approximately 25,000 years ago and contains material from the Connecticut area. While fossils have not been discovered within the boundaries of SAHI, fossil leaves have been found associated with lignite (Cretaceous in age) in Caumsett State Park located about eight kilometers (five miles) northeast of SAHI (P. Stoffer, personal communication, 2003). Mammoth bones are also found occasionally between glacial moraine deposits in the surrounding area (P. Stoffer, personal communication, 2003).

THOMAS STONE NATIONAL HISTORIC SITE

Thomas Stone National Historic Site (THST), established on November 10, 1978, preserves Haberdeventure, a Georgian mansion built in 1771 near Port Tobacco, Maryland. The house was the home of Thomas Stone, a signer of the Declaration of Independence and a delegate to the Continental Congress. THST is administered through George Washington Birthplace National Monument (GEWA).

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES

There have been no formal paleontological inventories undertaken for Thomas Stone National Historic Site. Paleontological or geological scoping sessions have likewise not been completed for the park, and there are no known reports of paleontological material from within the boundaries of the park. There are no fossil specimens in the park's museum collections.

The predominant geologic formation exposed at THST is the Pliocene Brandywine Formation (Glaser, 1984). The Brandywine most likely represents deposits of the ancestral Potomac River due to its fluvial (river) sediments. Fossils are not known from the Brandywine (Glaser, 1984).

Two fossiliferous formations do occur within park boundaries of THST. These formations are exposed along the banks and draws of Hoghole Run, which feeds into Port Tobacco Creek near the town of Port Tobacco southeast of THST. The lower (older) formation is the Eocene Nanjemoy Formation and is exposed along the deepest cuts of Hoghole Run, within THST boundaries. Fossils are reported from the Nanjemoy, in particular the mollusk *Venericardia* (Glaser, 1984). The Nanjemoy most likely was deposited in relatively shallow marine waters 55-34 million years ago (Glaser, 1984). The uppermost (youngest) formation is the Miocene Calvert Formation. The Calvert Formation is a very fossiliferous unit producing spectacular mollusks, shark's teeth, and marine mammal fossils. These marine fossils are best known from a famous locality along the Maryland Coast, called Calvert Cliffs. Similar fossils wash up on the shores of the Potomac River at George Washington Birthplace National Monument in Virginia (see section on GEWA in this paper). Along the banks of Hoghole Run, the Calvert Formation may produce molds and casts of mollusks with burrows disturbing the original bedding (Glaser, 1984). The Calvert Formation was probably deposited in a restricted marine basin in relatively deep water approximately 5.3-1.8 million years ago (Glaser, 1984). Both of these units may be exposed in the deep draws, located within THST, feeding into Hoghole Run (R. Morawe, personal communication, 2003). Paleontological resources may therefore be found within the Nanjemoy or Calvert formations exposed in these draws on THST lands. A brief field investigation in April 2003 by Morawe and Kenworthy yielded one potential fossil bone fragment in a stream leading to Hoghole Run. Neither the Nanjemoy Formation nor the Calvert Formation units are well exposed due to heavy vegetation cover. Further field investigations will be necessary to determine if additional paleontological material is present within THST boundaries.

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