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Journal

Parks Stewardship Forum, 40(1)

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Publication Date

2024

DOI

10.5070/P540162925

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How protecting shark teeth can lead to finding dolphins: George Washington Birthplace National Monument as a case study in developing and implementing paleontological resource monitoring

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ABSTRACT

George Washington Birthplace National Monument (GEWA) is a National Park Service (NPS) unit located in the Northern Neck of Virginia, situated on low bluffs overlooking the Potomac River. This small park unit, focused primarily on cultural and historical resources, may seem at first glance to be an unlikely candidate for notable paleontological resources. However, the bluffs are composed in large part of the fossiliferous early–middle Miocene-age Calvert Formation, and these bluffs and the adjacent shoreline have long been known by locals and rockhounds as places to find fossil shark teeth and other fossils. Following initial contact in the late 1990s and early 2000s, the NPS Paleontology Program has worked closely with GEWA since 2014 on the dual aims of stemming illegal fossil collecting and monitoring non-renewable paleontological resources in the face of rising river levels, increasing storms, and other effects of climate change. The working relationship is a case study for managing fossil resources facing similar challenges. Fossil theft has declined since the project began, as measured by decreasing bluff vandalism left by fossil removal. The benefits of establishing and maintaining a close relationship with park staff are superbly illustrated by the March 2020 recovery of two specimens of Miocene dolphins at imminent risk of loss to wave erosion or unauthorized collection. Plans are in progress to expand this collaborative work with the help of regional institutions.

INTRODUCTION

The classic image of a paleontological site is dry, sparsely vegetated, rocky badlands, perhaps with tents and an awning for shade, a dusty and weather-beaten truck, and picturesque field crew complete with broad-brimmed hats and rock hammers. Fossil discoveries are not limited to places that resemble this image, though. Some of the best fossil sites in the eastern United States are bluffs along rivers, estuaries, and other bodies of water, where shallow marine Cenozoic strata have been exposed.

George Washington Birthplace National Monument (GEWA), located on the Northern Neck of Virginia (Figure 1), was established January 23, 1930, to commemorate the Washington family plantation where George Washington was born in 1732. GEWA is first and foremost a place of cultural and historic resources, but a wide variety of natural resources are also present within its 223 federally owned hectares (551 acres). Among these is a significant occurrence of marine fossils in rocks of the early–middle Miocene Calvert Formation.

GEOLOGICAL AND PALEONTOLOGICAL BACKGROUND

GEWA faces the Potomac River on the north and northeast. This shoreline is marked for most of this stretch by a

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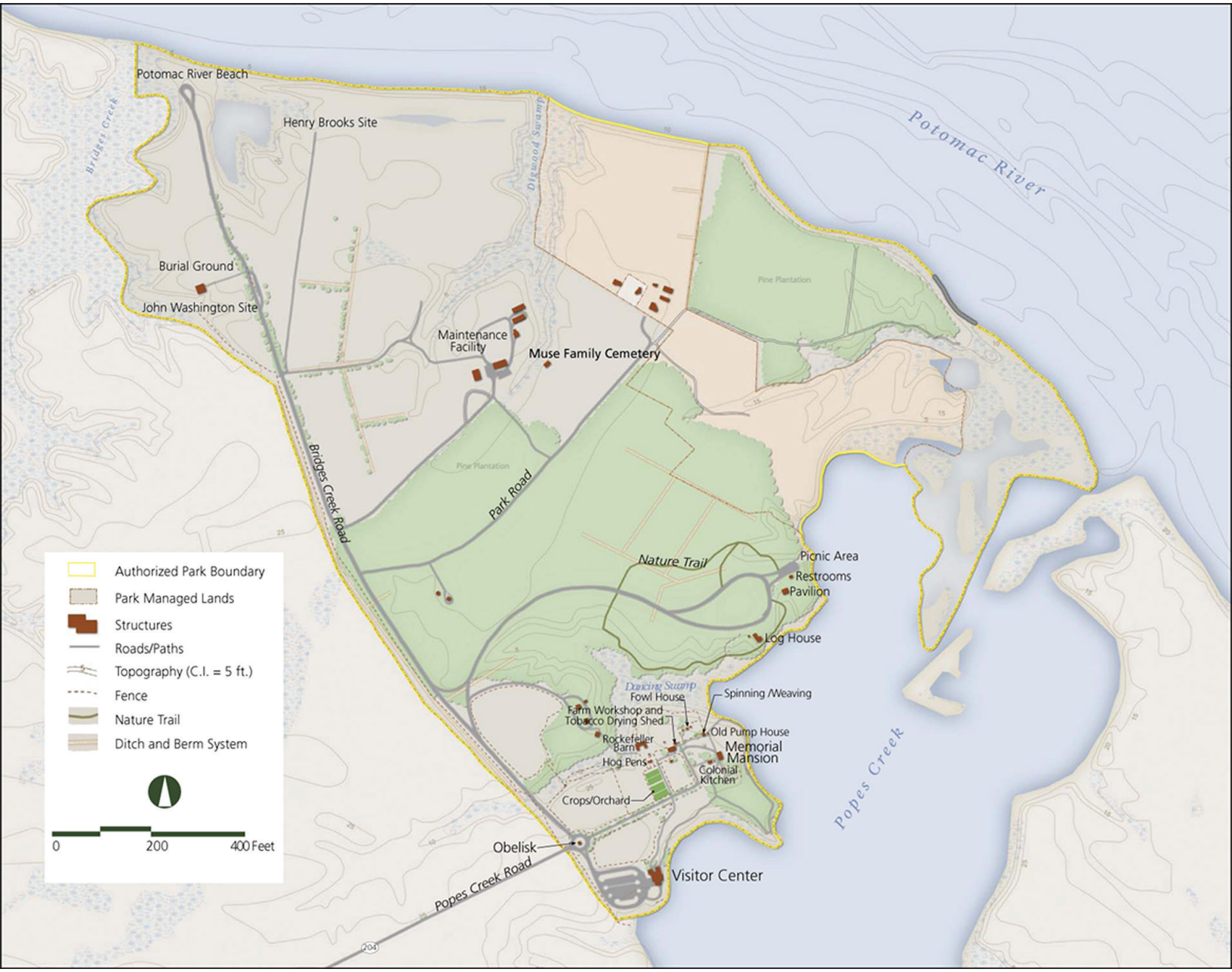


FIGURE 1. Park map of GEWA, Virginia (modified from NPS map). COURTESY RIJK MORAWE

bare vertical bluff approximately 4 m (13 ft) tall at its highest (Figure 2), laterally interrupted by drainage such as Digwood Swamp. The bluff face is composed of about 3 m (10 ft) of Calvert Formation overlain by 1 m (3 ft) or so of Quaternary deposits, some laced with mollusk shells constituting a widespread Indigenous shell midden. The bluffs historically have been accessible from a beach at the northwest corner of the park, although storm damage and the rising level of the Potomac have led to closure of most of this area to the public in recent years.

The Calvert Formation is an extensively fossiliferous shallow marine formation. It is generally divided, in ascending order (oldest to youngest), into the Fairhaven, Plum Point, and Calvert Beach Members (Ward and Andrews 2008). Ward and Powars (1989) attributed the exposure at GEWA to the lower Plum Point Member. In the Colonial Beach 7.5′ Quadrangle, which includes GEWA, the formation is described as mostly composed of fine to very fine quartz-rich sand, with lesser amounts of clay and silt (Newell et al. 2006). The few meters visible at GEWA are a fraction of the formation's actual vertical extent, which is typically on the order of 43 m (140 ft) thick. Bedding is thick to absent (massive). At GEWA, the formation is typically light brown to moderately dark bluish gray (Figure 3), but over the course of a year exposed surfaces can take on a vibrant array of colors (rusty red, yellow, forest green, etc.) due to staining (Figure 2).



FIGURE 2. The Calvert Formation bluffs at GEWA become colorfully stained during the year. JUSTIN TWEET

Deposition of the Calvert Formation has been described as muddy inner to middle shelf deposition alternating with heavily fossiliferous shoreface and inner shelf sands (Godfrey and Smith 2010). In the GEWA area, the lower Plum Point Member is interpreted as having been deposited in a protected embayment roughly north of the modern Potomac River, and in an inner shelf setting south of it (Gibson 1982, 1983). The prevailing climate during deposition of the formation is thought to have been warmer than the present, with subtropical to warm tropical estuarine and shallow marine waters (Gottfried et al. 1994), and a warm temperate coastal flora on land, comparable to that found today on the coasts of South Carolina and Georgia, or along the Gulf of Mexico from Florida to Texas (Berry 1916). Fossils of wood and land mammals represent terrestrial remains that were washed to sea (Vogt and Eshelman 1987). The age of the Calvert Formation is generally considered to be early–middle Miocene, but absolute dating has proven difficult. It may encompass deposition from about 22 or 21 Ma (million years ago) to about 14 or 13 Ma, with substantial internal hiatuses (Gottfried et al. 1994; Wijnker and Olson 2009). Microfossils found near GEWA suggest an age near the end of that range, close to 15 Ma in the early–middle Miocene (Weems et al. 2017).

A wide variety of fossils has been found in the Calvert Formation. Within GEWA, the authors have observed: pieces of wood, ranging in size from chips smaller than a fingernail to flattened trunks more than 45 cm (18 in) across



FIGURE 3. Stains are worn away during the winter. Winter weather also often blows down trees and leaves debris at the foot of the bluffs. JUSTIN TWEET

(Figure 4A); shells of bivalves and snails, generally represented by natural molds and casts (Figure 4B); shark teeth; bones and associated partial skeletons of ray-finned fish ("fish smears"); bone fragments and small whole bones of mammals (Figure 4C); and invertebrate burrows and zones of bioturbation (Figure 4D). The Calvert Formation sediments in GEWA are also diatomaceous (Ward and Powars 1989), but management actions specific to microfossils have not been proposed.

PALEONTOLOGICAL RESOURCE MANAGEMENT

Situation

The fossils of GEWA are vulnerable to a variety of threats falling under two broad categories: direct anthropogenic actions and natural processes. The anthropogenic threats are primarily unauthorized collection and vandalism. Unauthorized collection ranges from casual spontaneous collection of shark teeth from the shore to sophisticated intentional removal of fossils using typical paleontological tools and collecting techniques (Figure 5A). Vandalism is typified by visitors carving graffiti into bluffs, and in such cases damage to fossils is usually coincidental. Damage from natural processes is a consequence of the dynamic shoreline system. The bluffs and their fossils are vulnerable to storms, erosion due to processes associated with the Potomac River, bluff collapses due to tree falls or natural

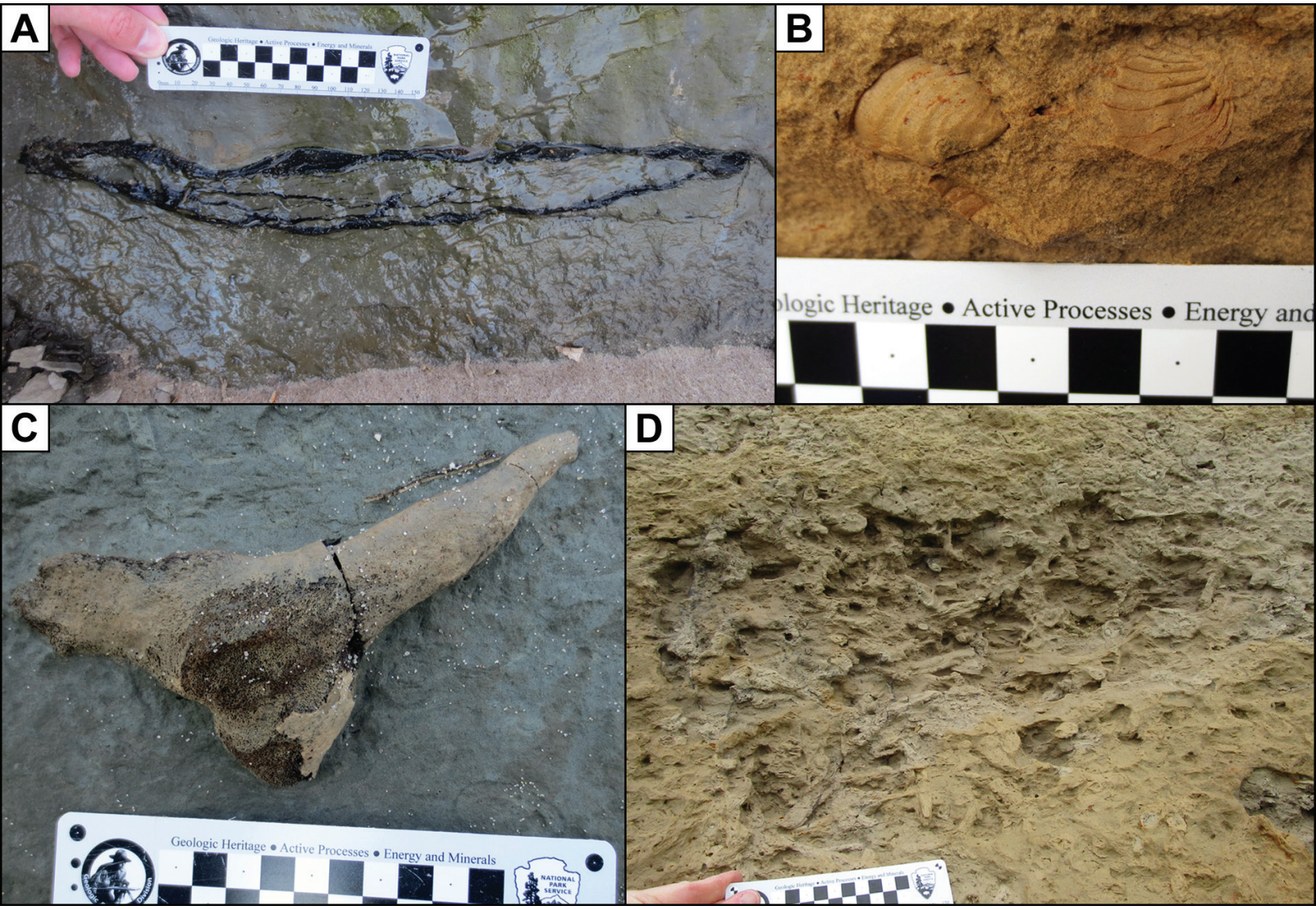


FIGURE 4. Various types of fossils in the bluffs at GEWA. (A) A flattened trunk. (B) Shells. (C) Bone. (D) Invertebrate burrows. JUSTIN TWEET

water piping through root voids and other zones of weakness, physical contact from fallen trees and branches rubbing against the bluffs, and so on. Bluff erosion is significant and rapid at GEWA: Per Hardaway et al. (2009), overall net shoreline change was –0.3 m/yr (–1 ft/yr) for 1937–2007. These natural processes have been exacerbated by climate change. A particularly visible effect of this is the rise in the level of the Potomac River; when the authors began monitoring at GEWA in 2014, it was possible to walk on dry beach for much of the route under favorable tidal conditions. As of 2023, ankle-deep water is much more prevalent even at optimal tidal conditions. Much of the beach downstream from the public access is closed to visitors as of spring 2023 due to bluff instability.

Early History of Paleontological Resource Management at GEWA

As a small park unit with a cultural/historical focus, GEWA typically has not prioritized natural resources without a direct connection to its mission. Fossil collection appears to have been overlooked for many years, with some anecdotal reports indicating a belief among the public that collection was permitted. For example, a member of the online avocational paleontology community "The Fossil Forum," observed in 2012 that fossil collection was illegal at the site, but that locals described collecting there as "legal" 15 years before. The forum member also noted that a summer 2011 hurricane brought up numerous fossils (http://www.thefossilforum.com/index.php?/topic/30808-virginia-teeth-sites/&do=findComment&comment=341161post #2; only visible to logged-in members). The hurricane referenced is presumably Hurricane Irene, which affected the area in late August 2011. The reference to 15 years prior suggests that there was little official attention as late as the mid-1990s. The park's attention increased beginning in the

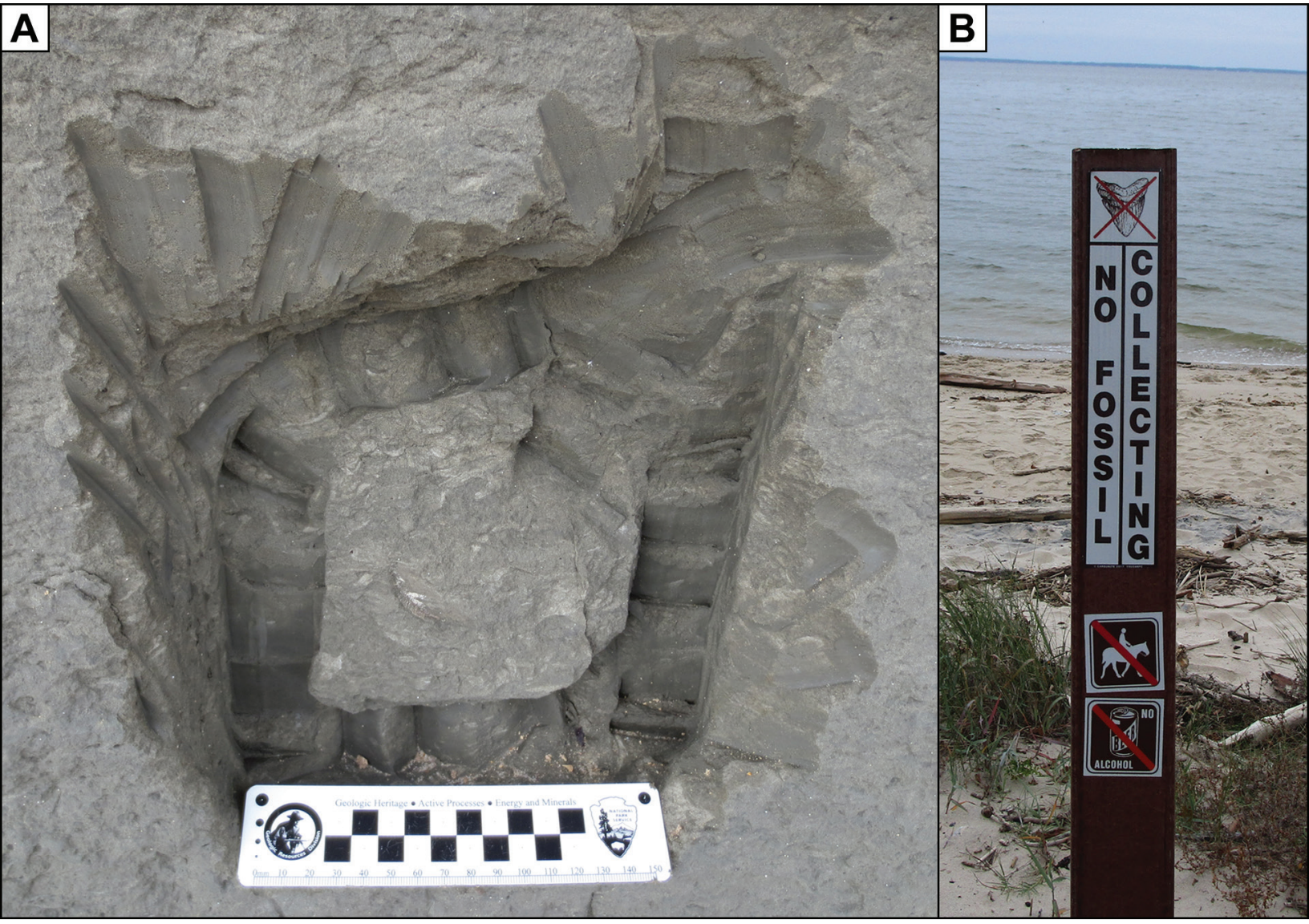


FIGURE 5. (A) An example of a collecting hole left by an experienced collector using a pedestal technique. In past years a half-dozen or more pits would be encountered while monitoring. (B) One of two signs at the beach stating that fossil collecting is not permitted. JUSTIN TWEET

early 2000s (see below). Avocational exploration goes back much further. For example, an item in a 1967 issue of the journal *Rocks and Minerals* (Wertz 1967: 446) includes the following note: "[Richmond Gem and Mineral Society] Members Howard Urbach and Peter McCrary went to Westmoreland State Park and to Wakefield National Park to collect vertebrate fossils of the Calvert formation." "Wakefield National Park" refers to GEWA, which has occasionally been misidentified under this name or "Wakefield National Monument" in non-NPS documents (perhaps due to confusion with the Wakefield National Memorial Association, which helped lead the campaign to establish GEWA). It can be safely assumed that avocational collection began before then, as shark tooth collection is a popular outdoor hobby in the region and several other sites in the vicinity are noted for shark teeth (e.g., Westmoreland State Park and Stratford Hall). Over the decades, a culture of collection became engrained at GEWA's beach.

Collaboration

In 1999 GEWA divided its joint law enforcement and resource management position into separate positions and hired a dedicated resource manager (Bruggeman 2006). This was Rijk Morawe, who had a background in geology and became interested in the park's fossils, including making a small collection of teeth and bones for GEWA over the first years of the 2000s. In the same period the present article's second author Vincent L. Santucci, then the chief ranger at Fossil Butte National Monument in Wyoming, was in the early stages of a project to produce

paleontological resource summaries for all 32 NPS Inventory & Monitoring (I&M) networks. He and paleontology intern Jason Kenworthy began corresponding with Morawe, initially resulting in one of the most detailed park chapters in the early network summaries, including a discussion of the issue of recreational collecting (Kenworthy and Santucci 2003). Santucci and Kenworthy were invited to GEWA in July 2006 to participate in a meeting on the park's general management plan, during which they also met with Morawe and inspected the bluffs. Although contact continued over the next few years, and GEWA featured in a short article on unauthorized collecting from NPS shorelines (Brunner et al. 2010), circumstances did not favor a more substantial relationship between GEWA and the NPS Paleontology Program until 2014.

In 2014, GEWA management and Santucci began plans to prepare a paleontological resource monitoring protocol. To do this, lead author Justin Tweet made his first visit to GEWA in October 2014. The timing was very convenient, as Tweet and Santucci had recently completed a revised version of the Northeast Coastal and Barrier (NCBN) I&M Network paleontological resource summary, including a much expanded chapter on GEWA (Tweet et al. 2014). By this time, Morawe had moved on to Organ Pipe Cactus National Monument and the Paleontology Program's primary contact at GEWA was now Amy Muraca, chief of cultural resource management. Tweet, Muraca, and NCBN data manager Dennis Skidds, a frequent visitor to the park for shoreline monitoring, inspected the bluffs and discussed the state of paleontological resources at GEWA. On this first visit Tweet took photographs and GPS points on the assumption that a monitoring program would involve repeat visits to the same sites over multiple years, similar to the model in Clites and Santucci (2012). This assumption was quashed by a second visit in March 2015, which showed that winter weather and unauthorized collectors had removed all trace of the fossils observed five months earlier. A different strategy was clearly needed.

Over the next few years, Tweet and Santucci collaborated with GEWA staff and Skidds to prepare a more effective and comprehensive monitoring protocol. The eventual protocol (Tweet and Santucci 2017) was based around several major considerations, particularly: rapid erosion and turnover of material at the bluff face; widespread distribution of fragmentary material rather than fossils being found in distinct confined localities; and the desire to facilitate monitoring by GEWA staff without requiring long preparation, excessive equipment, or an extensive paleontological background. Rather than attempt to monitor specific localities, the protocol is intended as a snapshot of the condition of paleontological resources that may be compared over years. The bluff-bearing shoreline is divided into three roughly equal segments, and observers walk them and, using tallies, record instances of several types of fossils (wood, bone, teeth, shell impressions), natural holes left by eroded bones, and holes left by unauthorized collecting. Unusual finds, such as multiple bones in a small area, and evidence of theft are recorded with geospatial points and photographs. For fossils, this recording allows for follow-up, while for collecting, this is intended to build up a picture of preferred areas.

At the same time, GEWA staff sought to implement new ways of discouraging collecting. For example, when doing outreach to schools, chief ranger Tim Sveum (now at Fort Sumter and Fort Moultrie National Historical Park) would bring fossil teeth in evidence bags, so he could explain that collecting was illegal. Blending concepts from Badlands National Park and Grand Canyon National Park, lead interpretive ranger Kait Weston proposed creating a trading card that would be distributed to visitors during ranger contacts as an alternative to collecting teeth from the beach. This has not been implemented to date due to her subsequent departure. Signage is also clearly posted at the beach (Figure 5B).

BENEFITS

The frequent contact between GEWA and the Paleontology Program, including periodic training, has been crucial for creating and maintaining "buy-in" by park staff concerning the significance,

management, and monitoring of the paleontological resources, transcending staff turnover. For his part, Tweet has been a participant in other GEWA projects, including the creation of the GEWA resource stewardship strategy summary (GEWA 2018) and a 2022 climate change vulnerability workshop. Increased focus on reducing unauthorized collection has paid off: while Santucci and Kenworthy observed at least a dozen dig pits on their 2006 visit with Morawe, and Tweet used to see a half-dozen such holes on his visits, he has not seen any definite dig pits on visits since 2019 (the holes that he has seen can be attributed to branches or roots on downed trees being pushed into the bluffs by the water).

The most significant single event to come from the GEWA/Paleontology Program collaboration and the paleontological resource monitoring strategy being implemented has been the discovery and recovery of dolphin fossils from the bluffs. In mid-February 2020, Sveum alerted Santucci and Tweet to the presence of an exposed series of bones discovered by law enforcement ranger Wesley Spurr. After GEWA management decided to permit a salvage collection of the specimen, Santucci contacted paleontologists from nearby museums, including the Calvert Marine Museum and National Museum of Natural History. On March 16, approximately a month after the initial contact and with the COVID-19 shutdown looming, a collecting party including GEWA staff, Santucci, and scientists from the Calvert Marine Museum under paleontologist Stephen J. Godfrey arrived at GEWA and collected not only the specimen reported by Sveum, but a second specimen observed nearby (Figure 6). The two specimens pertain to extinct long-nosed dolphins of the family Eurhinodelphinidae. (See Santucci 2020 for more details.) Following preparation, the initial specimen has been identified as skull material, vertebrae, and ribs, and the second specimen as a nearly complete skull. Unusually, this skull is surrounded by finger-sized invertebrate burrows (Figure 7).

FIGURE 6. Stephen J. Godfrey (Calvert Marine Museum) excavating a dolphin skull at GEWA, March 16, 2020. VINCENT L. SANTUCCI





FIGURE 7. Part of the snout of the prepared dolphin skull with associated burrows. JUSTIN TWEET

CHALLENGES

There are several challenges in maintaining the strong working relationship. One of the most significant is logistics: Both the NPS Paleontology Program and GEWA face limited resources in terms of staffing, time, and money. Complicating the issue is location: Tweet is based out of the Twin Cities of Minnesota, so any visits must be planned weeks in advance. On two occasions he has come to GEWA for site visits on dates selected for anticipated favorable low tides, only to have to abandon field monitoring due to adverse weather conditions. The COVID-19 pandemic prevented travel to either train staff or make the monitoring walk for several years. Another challenge is maintaining staff interest and participation in the face of turnover in a small park unit. This necessitates occasional retraining to bring everyone up to speed.

The most significant long-term challenge is climate change. Increasing storms and rising water levels accelerate bluff weathering overall and amplify the effects of individual weather events. The overall rise of the Potomac can be assumed to have played a part in reducing unauthorized collection and vandalism by making more of the bluff inaccessible to the causal visitor for longer periods of time. In effect the downstream beach closure is being enforced by the presence of water that is at least ankle-deep most of the time, along with areas of clustered fallen trees impeding passage along the shore. These beneficial aspects are outweighed by accelerated natural erosion and increased difficulty of access for monitors, though. Over time the emphasis of paleontological resource management and monitoring at GEWA will likely tilt increasingly toward mitigating natural processes, including post-storm assessments and salvage collecting.

THE FUTURE

The challenges outlined above inform the ways that GEWA and the NPS Paleontology Program are looking to adapt and sustain their collaboration. Monument visits and discussions over the past few years have been focused on practical solutions. In March 2023 Tweet made a visit to the park to provide paleontological resource management training to staff, with the ultimate goal of staff being able to carry out monitoring and preliminary find documentation as necessary, when conditions are optimal. This is much more efficient and effective than the previous model of Tweet or someone else from the NPS Paleontology Program arranging a visit weeks in advance and hoping that weather and river conditions will not turn unfavorable in the days immediately before the visit. Another proposed change is the development of an annual programmatic permit issued to park staff, with NPS Paleontology Program staff and nearby subject-matter experts included as additional researchers. This would provide faster responses for salvage operations, and will also strengthen GEWA's ties to the wider paleontological community. Collaborating with an institution such as the Calvert Marine Museum would also be beneficial for the curation of any specimens, as GEWA lacks the facilities, equipment, staff, and expertise to curate paleontological collections.

George Washington Birthplace National Monument is a surprising paleontological gem in the National Park System, and the relationship between the park and the NPS Paleontology Program is one of the latter's most successful collaborations. Santucci and Tweet look forward to many more years of collaboration and discovery!

ACKNOWLEDGMENTS

Over the past two decades, Santucci and Tweet have met and worked with many of the staff at GEWA and the occasional interested visitor from nearby Fredericksburg & Spotsylvania National Military Park. An alphabetical list includes: Christine Almassy, Evert Bono, Deanna Brown, Kelly Brownson, Melissa Cobern, Bobby Dickinson, Michelle Douglass, Bill Ethridge, Solim Garcia, Scott Hill, Chris Kennedy, David Lassman, Deborah Lawton, Rijk Morawe, Amy Muraca, Elizabeth Ottarson, Jennifer Pflugfelder, Sean Reier, Wesley Spurr, John Storke, Tim Sveum, Andrew Therrien, and Kait Weston. We particularly wish to acknowledge our primary contacts, beginning with Rijk Morawe, to Amy Muraca, to Tim Sveum, and now to Elizabeth Ottarson. Any omissions are unintentional and regretted. Others who have contributed to this collaboration over the years include Tim Connors and Jason Kenworthy (NPS Geologic Resources Division); Erika Rocks, Dennis Skidds, and Sara Stevens (Northeast Coastal and Barrier I&M Network); Jim Comiskey (NPS Northeast Region); Stephen J. Godfrey, John Nance, and the paleontological staff of the Calvert Marine Museum; David Bohaska (National Museum of Natural History); Erica Clites (University of California Museum of Paleontology); and Robert Weems (US Geological Survey).

REFERENCES

Berry, E.W. 1916. *The Physical Conditions Indicated by the Flora of the Calvert Formation*. Professional Paper 98-F. Washington: US Geological Survey. https://doi.org/10.3133/pp98F

Bruggeman, S.C. 2006. *George Washington Birthplace National Monument: Administrative History 1930-2000*. Williamsburg, VA: College of William & Mary.

Brunner, J., J. Kenworthy, and V. Santucci. 2010. Unauthorized fossil collecting from National Park Service shorelines: Servicewide policy and perspectives. In *Rethinking Protected Areas in a Changing World: Proceedings of the 2009 George Wright Society Conference*, S. Weber, ed. Hancock, MI: George Wright Society, 319–323.

Clites, E.C., and V.L. Santucci. 2012. *Protocols for Paleontological Resource Site Monitoring at Zion National Park*. Natural Resource Report NPS/ZION/NRR—2012/595. Fort Collins, CO: National Park Service.

GEWA [George Washington Birthplace National Monument]. 2018. *Resource Stewardship Strategy Summary: George Washington Birthplace National Monument, Virginia*. GEWA 332/144896. Colonial Beach, VA: National Park Service.

Gibson, T.G. 1982. Depositional framework and paleoenvironments of Miocene strata from North Carolina and Maryland. In *Miocene of the Southeastern United States: Proceedings of a Symposium*. T.M. Scott and S.B. Upchurch, eds. Special Publication 25. Tallahassee: Florida Geological Survey, 1–22.

Gibson, T.G. 1983. Stratigraphy of Miocene through lower Pleistocene strata of the United States central Atlantic Coastal Plain. *Smithsonian Contributions to Paleobiology* 53: 35–80.

Godfrey, S.J., and J.B. Smith. 2010. Shark-bitten vertebrate coprolites from the Miocene of Maryland. *Naturwissenschaften* 97(5): 461–467. https://doi.org/10.1007/s00114-010-0659-x

Gottfried, M.D., D.J. Bohaska, and F.C. Whitmore, Jr. 1994. Miocene cetaceans of the Chesapeake Group. *Proceedings of the San Diego Society of Natural History* 29: 229–238.

Hardaway, C.S., Jr., D.A. Milligan, K.P. O'Brien, and C.A. Wilcox. May 2009 (revised October 2009). *Status, Evolution, and Storm Vulnerability Assessments of the Shoreline at George Washington Birthplace National Monument*. Gloucester Point, VA, and Philadelphia: Virginia Institute of Marine Science, College of William & Mary, and National Park Service. https://doi.org/10.21220/m2-4s18-vv25

Kenworthy, J.P., and V.L. Santucci. 2003. George Washington Birthplace National Monument. In *Paleontological Resource Inventory and Monitoring: Northeast Coastal and Barrier Network*, J.P. Kenworthy and V.L. Santucci, eds. Denver: National Park Service, 25–29.

Newell, W.L., O.P. Bricker, and M.S. Robertson. 2006. *Geologic Map of the Colonial Beach South 7.5′ Quadrangle, Virginia*. 1 sheet, scale 1:24,000. Open-File Report 2005-1025. Reston, VA: US Geological Survey. https://doi.org/10.3133/ofr20051025

Santucci, V.L. 2020. Fossil discovery in the shadow of Washington's birthplace. *Park Paleontology News* 12(1). Online article, available at https://www.nps.gov/articles/fossil-discovery-in-the-shadow-of-washington-s-birthplace.htm (accessed 8 May 2023).

Santucci, V.L., and A.L. Koch. 2003. Paleontological resource monitoring strategies for the National Park Service. *Park Science* 22(1): 22–25.

Santucci, V.L., J.P. Kenworthy, and A.L. Mims. 2009. Monitoring *in situ* paleontological resources. In *Geological Monitoring*. R. Young and L. Norby, eds. Boulder, CO: Geological Society of America, 189–204. https://doi.org/10.17704/1944-6178-36.2.245

Tweet, J.S., and V.L. Santucci. 2017. *A Protocol for Paleontological Resource Monitoring at George Washington Birthplace National Monument*. Natural Resource Report NPS/GEWA/NRR—2017/1526. Fort Collins, CO: National Park Service.

Tweet, J.S., and V.L. Santucci. 2020. *Paleontological Resource Monitoring: George Washington Birthplace National Monument: 2019 Monitoring*. Natural Resource Data Series NPS/GEWA/NRDS—2020/1252. Fort Collins, CO: National Park Service.

Tweet, J.S., V.L. Santucci, and T. Connors. 2014. George Washington Birthplace National Monument. In *Paleontological Resource Inventory and Monitoring: Northeast Coastal and Barrier Network*. J.S. Tweet, V.L. Santucci, and T. Connors, eds. Natural Resource Technical Report NPS/NCBN/NRTR—2014/897. Fort Collins, CO: National Park Service, 181–207.

Vogt, P.R., and R.E. Eshelman. 1987. Maryland's Cliffs of Calvert: A fossiliferous record of mid-Miocene inner shelf and coastal environments. In *Northeastern Section of the Geological Society of America*. D.C. Roy, ed. Centennial Field Guide 5. Boulder, CO: Geological Society of America, 9–14. https://doi.org/10.1130/0-8137-5405-4.9

Ward, L.W., and G.W. Andrews. 2008. *Stratigraphy of the Calvert, Choptank, and St. Marys Formations (Miocene) in the Chesapeake Bay Area, Maryland and Virginia*. Memoir 9. Martinsville, VA: Virginia Museum of Natural History.

Ward, L.W., and D.S. Powars, leaders. 1989. Tertiary stratigraphy and paleontology, Chesapeake Bay region, Virginia and Maryland. Washington, American Geophysical Union, Field Trips for the

28th International Geological Congress, Field Trip 216. https://doi.org/10.1002/9781118667385.ch1

Weems, R.E., L.E. Edwards, and B. Landacre. 2017. Geology and biostratigraphy of the Potomac River cliffs at Stratford Hall, Westmoreland County, Virginia. In *From the Blue Ridge to the Beach: Geological Field Excursions Across Virginia*. C.M. Bailey and S. Jaye, eds. Field Guide 47. Boulder, CO: Geological Society of America, 125–152. https://doi.org/10.1130/2017.0047(05)

Wertz, R.C., ed. 1967. Current events of the Eastern Federation of the Mineralogical and Lapidary Societies. *Rocks and Minerals* 42(6): 444–448. https://doi.org/10.1080/00357529.1967.11765342

Wijnker, E., and S.L. Olson. 2009. A revision of the fossil genus *Miocepphus* and other Miocene Alcidae (Aves, Charadriiformes) of the western North Atlantic Ocean. *Journal of Systematic Palaeontology* 7(4): 471–487. https://doi.org/10.1017/S1477201909990022