Geologic Resources Inventory Scoping Summary Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial, Florida

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The Geologic Resources Inventory (GRI) provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a Geologic Resources Inventory report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

The National Park Service held a GRI scoping meeting for the park units of the Southeast Coast Network (SECN) during the week of April 20–24, 2009 at Jacksonville, Florida. These units included Canaveral National Seashore (CANA), Castillo de San Marcos National Monument (CASA), Cumberland Island National Monument (CUIS), Fort Caroline National Memorial (FOCA), Fort Frederica National Monument (FOFR), Fort Matanzas National Monument (FOMA), Fort Pulaski National Monument (FOPU), and Timucuan Ecological and Historic Preserve (TIMU). Timucuan Ecological and Historic Preserve and Fort Caroline National Monument, which is located within Timucuan Ecological and Historic Preserve, were discussed on April 20 and April 22. Bruce Heise (NPS GRD) facilitated the meeting and presented an overview of the GRI program. On April 20, Rich Spechler (USGS) presented an overview of collapse features found in the vicinity of TIMU and FOCA. A brief map discussion in the morning of April 22 was followed by an afternoon field trip, led by Richard Bryant (NPS TIMU, FOCA), that focused on geologic processes, features, and issues at the preserve. Randy Parkinson (RWParkinson Consulting) presented an overview of regional coastal geology, especially as it relates to Georgia. Participants at the meeting included NPS staff from the park, Geologic Resources Division (GRD), and Southeast Coast Network (SECN) and cooperators from the U.S. Geological Survey (USGS), Florida Geologic Survey (FGS), University of West Georgia (UWG), University of Georgia (UGA), Polk Community College (PCC), and Colorado State University (CSU) (see table 3).

This scoping summary highlights the GRI scoping meeting for Timucuan Ecological and Historic Preserve and Fort Caroline National Monument including the geologic setting, the plan for providing a digital geologic map, a summary of geologic resource management issues, a list of significant geologic features and processes, and a record of meeting participants.

Park and Geologic Setting

The 19,000-ha (46,000-ac) Timucuan Ecological and Historic Preserve includes Fort Caroline National Memorial, the Theodore Roosevelt Area, Kingsley Plantation, Cedar Point, and thousands of acres of woods, water, and salt marsh. TIMU is about 19 km (12 mi) south of Georgia and 12.3 km (9.5 mi) northeast of the center of Jacksonville. Thomas Creek and the Nassau River, which

flows into the Atlantic Ocean through Nassau Sound, delineate TIMU's northern boundary. St. Johns River marks the southern boundary except for a small part of the park that lies south of the river and includes the TIMU Visitor Center, TIMU Headquarters, Fort Caroline National Memorial, and the Theodore Roosevelt Area. Amelia Island is north of Nassau Sound, and Little Talbot Island lies between TIMU and the Atlantic Ocean. Kingsley Plantation was built on Fort George Island, a large island separated from Big Talbot Island to the north and Little Talbot Island by the Fort George River.

TIMU and FOCA, along with the entire state of Florida, lies on the Floridian Plateau, a physiographic province approximately 800 km (500 mi) long and 400 – 640 km (250 – 400 mi) wide. The plateau, which has existed for millions of years, includes both emergent land and submerged continental shelf. Areas on the plateau have been alternately covered by seawater and exposed as dry land many times in the past so that marine and terrestrial deposits have been deposited one on top of the other.

Pleistocene (1.8 million years to 10,000 years ago) to Holocene (10,000 years ago to present) beach ridge and dune deposits, Pleistocene - Holocene undifferentiated deposits, and Holocene sediments deposited in salt marsh, beach, marine, and lagoon environments compose the surface geology of TIMU and FOCA. Sedimentary rocks and undifferentiated sediments in the subsurface, to a depth of about 30 m (100 ft), include Quaternary sands, clay-rich and limestone layers from the Upper Miocene (11.6 – 5.3 million years ago) or Pliocene (5.3 – 1.8 million years ago), and mixed deposits from the Upper Oligocene (28.4 – 23.0 million years ago) to Miocene Hawthorn Group.

Collapse Features (Rich Spechler)

Groundwater from Floridan aquifers is the primary water source for the Jacksonville area and most of Florida. Consequently, the aerial extent of the aquifers and groundwater quality are very important. In mapping the aquifers in the TIMU and FOCA vicinity using seismic reflection techniques, the U.S. Geological Survey (USGS) discovered a variety of paleo collapse features (sinkholes) that formed sometime in the geologic past and which may affect groundwater quality. These features are quite large, ranging up to 610 m (2,000 ft) in diameter, and are buried to depths of 610 m (2,000 ft) although one feature located off the coast is as shallow as 150 m (500 ft).

Elevated levels of chloride in groundwater are associated with the collapse features. For example, water quality sampling on Fort George Island reported a chloride level of approximately 400 milligrams per liter (mg/L) at a site suspected to be connected to a significantly large paleo collapse feature. The Environmental Protection Agency (EPA) recommends a maximum of 250 mg/L of chloride before blending. Researchers suspect that fractures radiating from the collapse structures may breach confining beds or the collapse features may tap zones of unflushed sea water, allowing chloride influx in the aquifers. In the vicinity of Fort Caroline National Monument, elevated chloride levels have been detected in groundwater, although a collapse feature has yet to be located.

Mapping these collapse features may be of interest to park management because once a well is contaminated, it can't be recovered. Many reports addressing Florida's groundwater are available from the Water Resources Division of the USGS. Two references applicable to TIMU and FOCA include:

- Phelps, G. G. and Spechler, R. M. 1997. *The relation between hydrogeology and water quality of the lower Floridan Aquifer in Duval County, Florida, and implications for monitoring movement of saline water*. Water Resources Investigation 96-4242. Reston, VA: U.S. Geological Survey.
- Spechler, R. M. 1994. *Saltwater intrusion and quality of water in the Floridan aquifer system, northeastern Florida*. Water Resources Investigation 92-4174. Reston, VA: U.S. Geological Survey.

Regional Coastal Geology (Randy Parkinson)

Five major northeast-southwest trending geologic zones define the landscape in the southeastern United States. From northwest to southeast, these geologic zones include the Appalachian Plateau, Ridge and Valley, Blue Ridge, Piedmont, and Coastal Plain provinces. With the exception of the Coastal Plain province, these zones record a history of continental collision at a time when all the major landmasses came together to form the supercontinent, Pangaea. When Pangaea began to split apart in the Early Triassic, approximately 250 million years ago, rifting began along the eastern seaboard that would eventually widen to become the Atlantic Ocean.

The Coastal Plain formed approximately 100 million years ago to less than 1,000 years ago from sediments transported into the region from the other provinces and by south-flowing longshore currents. A "Fall Line," an abrupt change in elevation recognized today on topographic maps by a series of waterfalls, separates the low-lying Coastal Plain from the rolling topography and foothills of the much older Piedmont Province. As the Coastal Plain formed, terrigenous (land derived) sediments dominated deposition north of the fall-line. In contrast, the offshore Florida Platform formed from calcium carbonate (limestone). A northeast-southwest trending channel located across the neck of the Florida Peninsula isolated the Florida Platform from the terrigenous sediments of the Coastal Plain. Terrigenous sediments eventually filled the channel and spilled over onto the peninsula.

Marine terraces on the Coastal Plain mark the location of various shorelines through time. A stable sea level is a rare geologic event. About seven paleo-coastlines can be mapped on the Georgia plain, for example. Over the past 250 million years, sea level has oscillated by as much as 300 m (980 ft). Global controls on sea level include the available volume of the ocean basins and the volume of sea water in those basins. Fluctuations in relative sea level continue to influence Coastal Plain geomorphology. Locally, subsidence and compaction of sediments may influence the local rise and fall of sea level.

Glacial and interglacial periods have an indirect effect on sea level by influencing the volume of sea water in the ocean basins. Once the last Pleistocene glaciers melted, the north Atlantic coastlines, once depressed under thousands of feet of ice, began to rebound so that the rising land surface currently keeps pace with the relative rise of sea level.

Rivers flowing from the melting glaciers carried large volumes of sediment to mid-latitude coastlines, including coastlines from Georgia to north Florida. Atlantic coastlines in central and southern Florida illustrate a transition from a mix of carbonate and clastic (broken fragments of

preexisting rock) sediments to coastlines dominated by carbonates. For example, Canaveral National Seashore contains about 50% clastic sediments and 50% carbonate sediments whereas Miami contains mostly carbonate beaches and the Florida Keys are 100% carbonate.

Worst case scenarios of relative sea level rise along the Atlantic coast projected in 2007 are now considered to be the "lower limit" of 2009 predictions. Using various sea level models, resource managers may wish to incorporate "trigger points" and "adaptation strategies" into management policy. These trigger points may signal a potential shift in habitat, depositional environments, or other natural processes that may initiate a significant change to the estuarine ecosystem.

Geologic Mapping for Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial

During the scoping meeting, Stephanie O'Meara (CSU) briefly displayed some of the main features of a GRI digital geologic-GIS map, which includes source map notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic-GIS map model using ESRI ArcGIS software. Final digital geologic-GIS map products include GIS data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, an Adobe Acrobat PDF help document that captures ancillary map data, and an ESRI ArcGIS ArcMap document file that displays the map, and provides a tool to access the PDF help document directly from ArcMap document. Final data products are posted at http://science.nature.nps.gov/nrdata/. The data model is available at http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain park lands (fig. 1). Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process of selecting maps for management begins with the identification of existing geologic maps (table 1) and mapping needs in the vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data or develop a plan to obtain new mapping, if necessary.

Map coverage is available for all of the quadrangles of interest for TIMU and FOCA from updated geomorphic digital data expected to be published by the Florida Geological Survey (FGS) in January 2010. Harley Means (FGS) stated the new geomorphic map will incorporate updated mapping and will provide more detail than the existing geologic map of Florida (Scott et al. 2001).

Richard Bryant (NPS TIMU, FOCA) stated that the FGS digital data should prove useful to general park resource management issues. However, more-detailed geologic, geomorphic, or geo-technical mapping would likely be needed on a site specific basis for more comprehensive park resource management. The GRI would not necessarily be the entity to fund such future mapping.

The GRI will evaluate the quality of the FGS digital data and distribute an image of the map to Richard Bryant and Linda York (NPS SERO) to determine if the data is adequate for TIMU and

FOCA park resource management. In all likelihood the GRI will use this new mapping to produce digital geologic map coverage for TIMU and FOCA.

Table 1. GRI Mapping Plan for Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Amelia City	Intersects TIMU park boundary	Unpublished Geomorphic Map of the State of Florida, Florida Geological Survey, 2010	digital	The digital map has not been finalized, and requires review by GRI, the park and others	Obtain GIS data from Florida Geological Survey in early 2010 and evaluate data quality and distribute map image to the park and others to assess the usefulness to the park
Hedges					
Italia					
Jacksonville Beach					
Mayport	Intersects TIMU & FOCA park boundaries	Unpublished Geomorphic Map of the State of Florida, Florida Geological Survey, 2010	digital	The digital map has not been finalized, and requires review by GRI, the park and others	Obtain GIS data from Florida Geological Survey in early 2010 and evaluate data quality and distribute map image to the park and others to assess the usefulness to the park
Eastport					
Arlington	Near TIMU &FOCA park boundaries	Unpublished Geomorphic Map of the State of Florida, Florida Geological Survey, 2010	digital	The digital map has not been finalized, and requires review by GRI, the park and others	Obtain GIS data from Florida Geological Survey in early 2010 and evaluate data quality and distribute map image to the park and others to assess the usefulness to the park

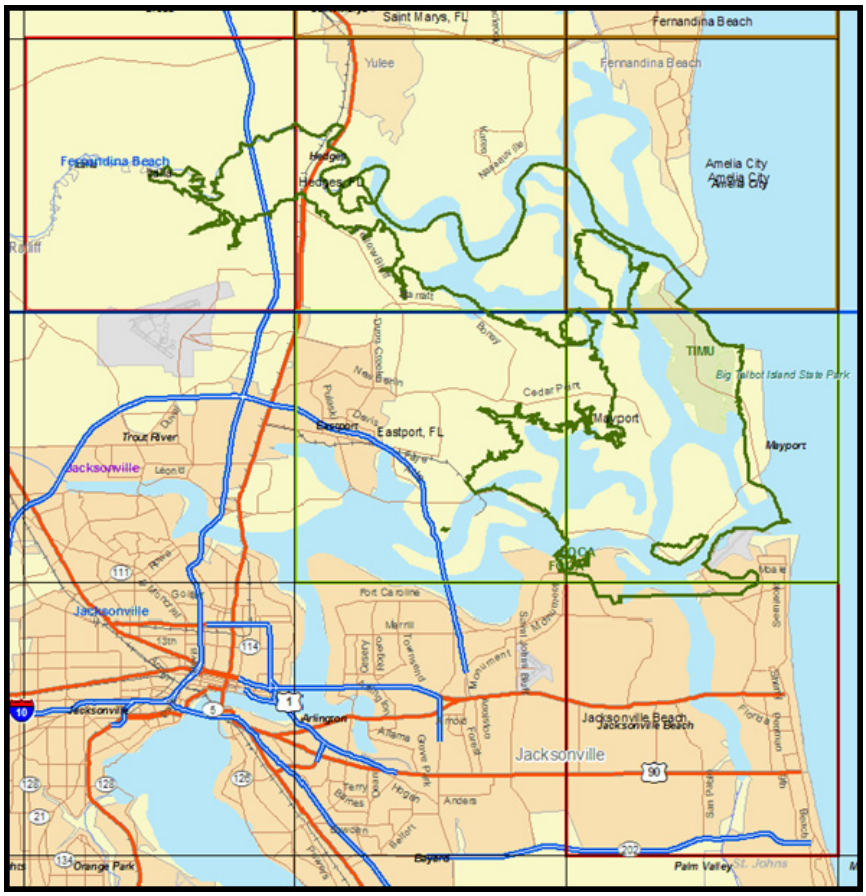

Figure 1. Area of interest for Timucuan Ecological and Historical Preserve and Fort Caroline National Memorial. The 7.5-minute quadrangles are labeled in black; names and lines in blue indicate 30-minute by 60-minute quadrangles, whereas names and lines in purple indicate 1x2 degree quadrangles. Green outlines indicate national preserve and memorial boundaries. The Arlington 7.5-minute quadrangle, south of the Eastport 7.5-minute quadrangle and west of the Jacksonville Beach 7.5-minute quadrangle, was added to the area of interest at the scoping meeting by Richard Bryant (NPS TIMU, FOCA).

Geologic Resource Management Issues

Potential closure of the mouth of the Fort George River due to accumulated sediment was the principal geologic resource management issue discussed during the field trip to Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial. Other issues included bank erosion, dredging and spoils piles, and potential disturbed lands reclamation issues.

Fort George River Issue

Accumulated sediment threatens to close the mouth of the Fort George River. This issue can be traced back to the late 1800s when two jetties were installed at the inlet to the St. Johns River and Little Talbot Island began expanding to the south. The northernmost jetty blocks the southerly transport of sand, which forces the mouth of the Fort George River to the north (fig. 2). The sand bars that have formed near the bridge in figure 2 were not present ten years ago. Simpson Creek, a tributary to Fort George River, is clogging with sediment due to the jetty. One storm may be all it takes to completely clog the river's mouth with sediment, closing the inlet. If the Fort George River closes, the salinity and water quality of the adjacent marshes will change and heavy metals may

accumulate. The river will become a lake with very poor water quality. The solution is to remove the jetty, but that is beyond the control of the park. Alternate solutions involve dredging of sand with possible bypassing to a point south of the St. Johns River.

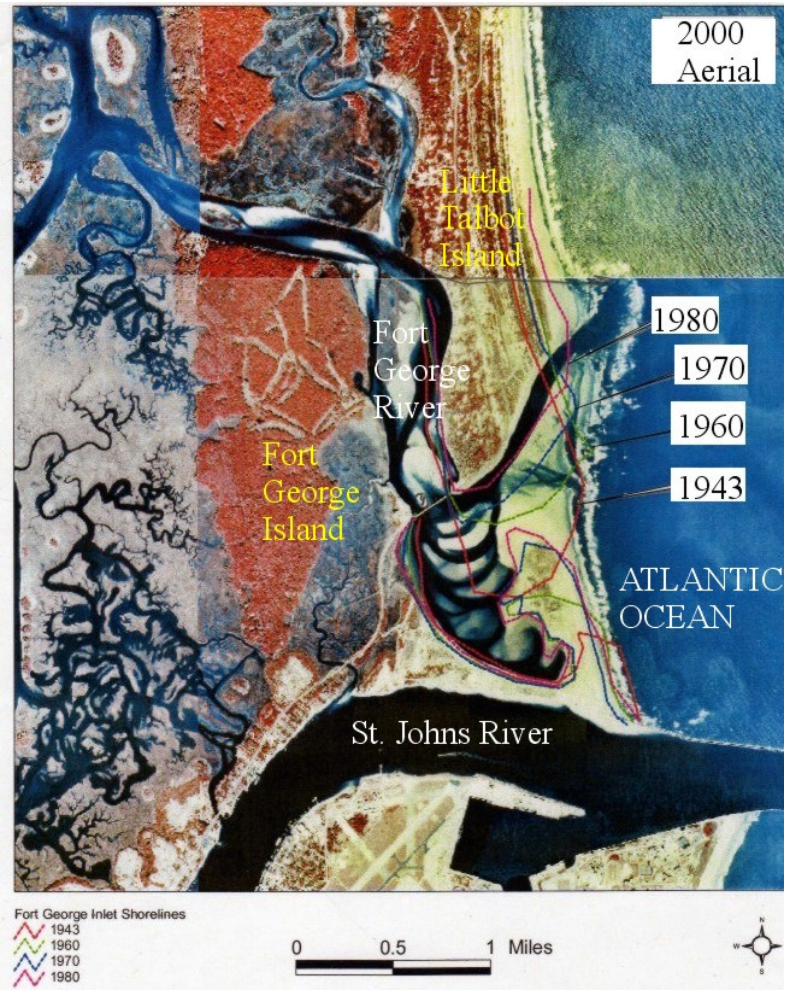

Figure 2. Aerial photograph showing how the Fort George River inlet has changed over time.

Other Issues

Bank erosion. At Fort Caroline National Memorial, the "training wall" (i.e. seawall) and rip rap along the shore have failed. Boat wake and currents from the 1.5 m (5 ft) tidal range cause erosion and slumping of the steep bank. Due to deterioration of the training wall at Fort Caroline, shoreline erosion has resulted in the abandonments of hiking trails and may possibly damage the fort model in the future. Minor erosion also occurs on either end of the training wall at the Kingsley Plantation Visitor Center.

Dredging of St. Johns River (both continued and increased depth proposal). The St. Johns River undergoes constant dredging to maintain 12 m (40 ft) through TIMU. This has resulted in changes to salinity, speed of salt water movement upstream, sediment budgets and numerous other

alterations to the estuary. In addition, there are several proposals to further deepen the channel to allow commercial vessels. The proposals call for depths up to 18 m (60 ft).

Spoil site east of Ribault Monument. Rising 21 m (68 ft) from the riverbank, Ribault Monument is the highest point on the St. Johns River. The Jacksonville Port Authority (JPA) owns the barren spoil site, which is clearly visible to the east of the viewing area. Periodically, when the channel is dredged, the volume of spoil material becomes an issue. In the past, the NPS rejected a proposal by the JPA to raise the dikes 7.6 m (25 ft). Because the dikes could not be raised, the existing spoils had to be removed in order to create room for subsequent dredge operations. About 20,000 dump truck loads hauled away the spoil sand. In addition, the creek flowing between the bluff and the spoils pile is eroding the bank at the base of Ribault Column.

Disturbed lands. Decades ago, sand from a borrow pit northeast of the park Headquarters building on Mount Pleasant Road was quarried for roads and golf courses in the area. The pit may become a reclamation issue. However, it is stable at the present time.

Three other sites typically seen as candidates for reclamation are not considered so at TIMU/FOCA. The tee-box for the 9th hole of the old golf course on Mt. Cornelia marks one site. To construct the tee-box, the top of the hill was flattened. However, the course was abandoned in 1990, and vegetation quickly reclaimed and naturally restored the area.

The second site is Heckscher Drive, which effectively acts as a dike blocking the mouth of Cedar Point Creek and other creeks that once drained into St. Johns River. In 1988, the NPS wanted to open the dike and build bridges over the creeks, but results from a study by the University of Florida showed that since construction of the road, the creeks have re-plumbed themselves and any restoration would produce more harm than good. Dredging the St. Johns River has dramatically changed the sediment and vegetation patterns. The NPS has stopped asking the Army Corps of Engineers to consider re-opening the creeks, but homeowners would like to see the creeks reopened in order to flush the marsh area.

The St. Johns River is the third potential reclamation site, but the river has been changed so much over the years that restoration to an "original" condition would be difficult to achieve, or define. For example, dredging has affected the river's velocity, water quality, and sediment load. Grass beds that once grew near the shore and buffered wave action are gone. Yesterday's marshlands became today's spoils areas.

Features and Processes

The field trip for Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRI report. Please note that the National Park Service monitoring manual (R. Young and L. Norby, editors. *Geological Monitoring*. Special paper. Geological Society of America, Boulder, CO.) is currently in press and will contain information on monitoring of geologic

features and processes found in NPS coastal units. These features at Timucuan Ecological and Historic Preserve and Fort Caroline National Memorial are summarized in table 2.

Table 2: Features and processes

Field Trip Stop	Features and Processes
1. Fort Caroline National Memorial	Training wall and influence of waves and tides Mass wasting (slumping) along bluff Trail made with local material: broken shells and sand
2. Drive to Ribault Monument	Fresh water pond from Spanish era. Rare to find fresh water lakes
3. Ribault Monument	View of surrounding landscape: channel, spoil site, training wall at Blount Island, Heckscher Drive Discussion of artesian wells. Prior to city water, wells used for water supply. Now used for irrigation at fort. Florida Aquifer can't supply all the domestic need so suppliers want to take water from St. Johns River
4. Little Talbot Island bridge (Highway A1A 105)	Sand flats Dunes (note: remnant dune exposed at the north end of Big Talbot Island; approximately 8-9 m, 25-30 ft, high) Channel bars Ripples Channel meanders Historical shorelines
5. Ribault Club on Fort George Island	Point bar building in the river Vegetated sand bar
6. Mt. Cornelia (9th tee of old golf course)	Remnant dune about 30-60 m (100-200 ft) long and 60 m (200 ft) wide (not fill) – possible old barrier island? Reclaimed by vegetation Gopher tortoise burrow
7. Kingsley Plantation Visitor Center	Seawall, rip rap Minor erosion of bank "Tabby" constructed slave cabins: tabby cement from local oysters
8. Heckscher Drive at Cedar Point Creek	Discussion of Heckscher dike, dredging, wetlands, and creek

Larry West (NPS SECN) suggested consulting the recently published Paleontological Resource Inventory and Monitoring report for the SECN to review the paleontological resources in the monument (Tweet et al. 2009). According to the report, no fossils have been uncovered at Fort Caroline National Memorial, but at TIMU, specimens have been found in archeological contexts and are currently in storage at the Florida Museum of Natural History (FLMNH) and the Southeast Archeological Center (SEAC). Oyster shells found on Fort George Island dated to be about 3,700 years old are stored in the collections of the Environmental Archaeology Program at the FLMNH, of the University of Florida, at Gainesville. Eleven specimens, or parts of specimens, were found at other archeological sites on TIMU and are stored at SEAC. They have yet to be identified. Fossils may also be found in the TIMU tabby structures.

References

Scott, T.M., K. M. Campbell, F. R. Rupert, J. D. Arthur, T. M. Missimer, J. M. Lloyd, J. W. Yon, and J. G. Duncan. 2001. *Geologic map of the state of Florida*. Scale 1:750,000. Map Series 146. Tallahassee, FL: Florida Geological Survey.

Tweet, J. S., V. L. Santucci, and J. P. Kenworthy. 2009. *Paleontological resource inventory and monitoring: Southeast Coast Network*. Natural Resource Technical Report NPS/NRPC/NRTR – 2009/197. Fort Collins, CO: National Park Service, Natural Resource Program Center.

Table 3. Scoping Meeting Participants

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EDR	TIMU	Prone		(see photo below)

Figure 3. Eastern diamondback that was saved by H. Means on April 23, 2009, in TIMU. The diamondback was estimated to be approximately 1.2 m (4 ft) long. Photo courtesy of H. Means, Florida Geological Survey.