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A Marine Archaeological Reconnaissance Using Side-Scan Sonar, Jamestown Island, Virginia, U.S.A.[1]

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ABSTRACT

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A detailed side-scan sonar survey of the shallow region immediately offshore of Jamestown Island, Virginia, specifically conducted for archaeological purposes, disclosed numerous anthropogenic or unexplained features including an outline of one feature having dimensions of many tens of meters. These items are of particular interest as Jamestown Island is the site of the earliest successful English settlement on North America. The major feature in the imagery was in an area thought a likely location for the fort constructed in 1607, the region having been drowned by the ensuing rise in sea level.

Subsequent investigations of the features depicted on the sonograms, first by waders and swimmers, later during a plane-table survey, retrieved seventeenth-century artifacts but were inconclusive in better identifying the major feature as other than a series of very subtle ridges with no immediately discernable underlying structure. Although providing no specific evidence, analysis of historical maps and charts suggests that this structure might be related to a recent pier that had been constructed slightly downstream from and in deeper water than the site of interest. The origin and history of the large, anthropogenic feature remain unknown and require further investigation.

ADDITIONAL INDEX WORDS: *Marine archaeology, side-scan sonar, Jamestown.*

INTRODUCTION

Jamestown Island, Virginia, (Figure 1) is the site of earliest, successful English settlement on North America. Jamestown was Virginia's capital from 1607 to 1698 when it essentially was abandoned after the fourth statehouse burned. Most of the island is owned and managed by the Colonial National Historical Park; the remainder of the property belongs to the Association for the Preservation of Virginia Antiquities (A.P.V.A.). In 1607, the Virginia Company established a settlement and fort on Jamestown Island. The obvious historic import of the fort has driven several researchers to search for the site.

Although there are artifacts and remnants of early seventeenth century structures on the island, there is no firm evidence as to the location of the original fort. The few written descriptions of the fort's site are so vague as to preclude absolute determination of its position. YONGE (1907) indicated a probable site that includes the existing remains of the Confederate fort on the A.P.V.A. property. In 1955, the National Park Service (SHINER, 1955) conducted a search for artifacts in the nearshore region adjacent the A.P.V.A. property. The project, using a large clam-shell dredging bucket operated from a barge-mounted crane, retrieved some artifacts but no evidence of the fort.

The post-Wisconsin rise of sea level contributes to the difficulty of locating the fort's physical place on the island as the site may have been eroded and/or flooded. In the nearly 400 years since initial European colonization, sea level has risen on the order of a meter (NICHOLS *et al.*, 1991). Hence, any structures or artifacts that were near the shoreline or on very low-lying ground now may be in the shallow waters immediately offshore of the island or may have been destroyed by the processes of erosion. If there, the structures have been subject to movement, burial, and abrasion secondary to the active nearshore processes. BYRNE and ANDERSON (1977) indicate that the hundred

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[1] Contribution 1823 of the Virginia Institute of Marine Science.

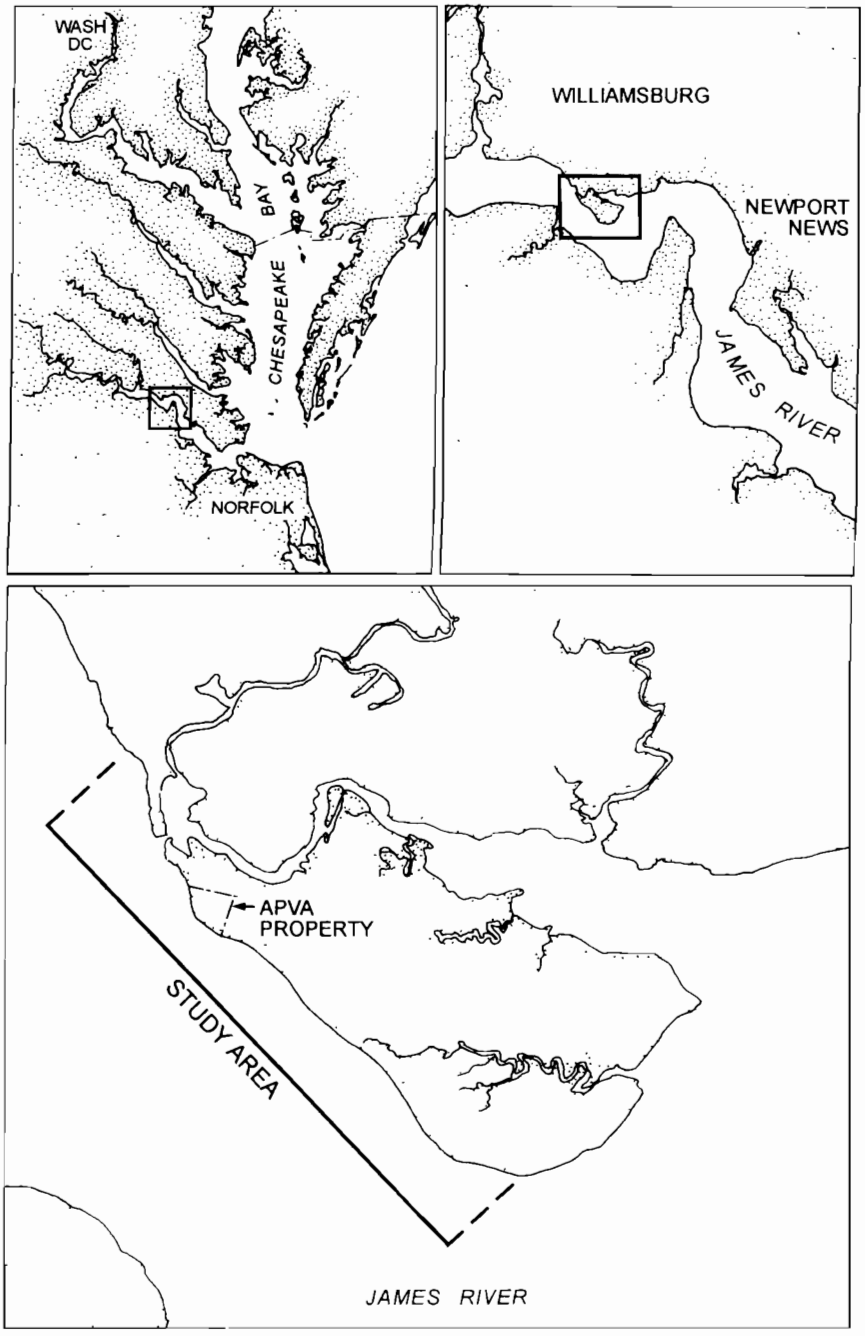

Figure 1. A general location map of the Jamestown Island study area.

year average rate of shoreline erosion on Jamestown Island exceeds 0.3 m (1 ft) per year. The problem is exacerbated by the generally high turbidity of the waters of the James River. Visibility usually is in the range of centimeters, prohibiting visual searches of the bottom either by divers/snorkelers or from the air. Lastly, construction of a seawall along part of the island just after the turn of the present century and various repair and dredging projects have contributed to the disruption of the natural setting.

This paper describes a recent examination of the riverbed adjacent to a portion of Jamestown Island in an attempt to identify the location of the fort. We used remote sensing techniques, specifically side-scan sonography, in an effort to overcome the turbidity problem. The reconnaissance was followed by a blind but tactile search of the bottom by swimmers and waders in areas of interest as identified on the sonographs and, later, by a systematic plane-table survey of a section of the nearshore.

METHODS

Geophysical surveys were performed on March 21 and 22 and July 23, 1991, aboard an 8.5 m (28 ft) outboard workboat from the Virginia Institute of Marine Science. A 105 kHz, EG&G SMS-960 side-scan sonar produced real-time sonograms depicting an area 100 m (330 ft) each side of the system's towed transducer-vehicle, or fish. Using the depth of water immediately under the fish and assuming a very nearly level bottom (not always a valid assumption although the manufacturer states that at bottom slopes up to 15° the error is less than 3 percent), the sonar system performs the necessary calculations to make the slant-range correction and thus produce a laterally correct depiction of the area. Longitudinal, along track scaling is accomplished by manually entering the vessel's speed-over-the-bottom as determined by other means. The final paper sonogram is at a scale of 1:10,000 (1 mm on the sonogram equals 1 m on the river bottom).

The side-scan sonogram portrays the relative intensity of the acoustic energy received at the transducer as backscatter or reflection from an original sound pulse (EG&G, 1983; Hobbs and Dame, 1992). A dark area on the sonogram indicates a strong return; a light area indicates a weak return. The strength of return is a function of the type of material on the bottom of the seafloor and of the local relief. Coarse sediments or hard bottoms produce stronger returns than fine sediments or very soft bottoms; slopes facing the transducer yield relatively stronger returns.

Analysis of the sonograms also can provide a quantitative estimate of the scale of relief of bottom features. The length of the (acoustic) shadow behind a bottom feature is related to the height the feature extends above the bottom. This relationship (H_o/L_s, Height of object/Length of shadow) is identical to the relationship H_f/R_s (Height of the fish above the bottom/horizontal Range or distance of the end of the shadow from the fish). Thus $H_o = (H_f/R_s)L_s$ (EG&G, 1983).

During the first survey, loran-C was used for position information; GPS (Global Positioning System) was used for the second. In both cases, position data were read from the instrument's display coincident with an annotation mark on the sonogram and manually logged. The log of position data provided the information for the construction of maps of the tracklines (Figure 2). Although the loran position data are most satisfactory in terms of repeatability, locally, its accuracy in terms of registration with a map datum is poor. Therefore, it was necessary to shift or adjust the loran data such that the loran-derived positions of specific, identified points coincided with the true map positions. There was no similar problem with the GPS. Indeed, GPS derived positions of known locations coincided within the limits of plotting with the mapped positions of those sites. The match of the groins and seawall and the offshore break in slope between water roughly 1 meter deep and nearly 3 meters deep was a good demonstration of the effectiveness of the side-scan sonar system in such extremely shallow water.

Analysis of the sonograms identified several features of possible archaeological interest. We returned to Jamestown Island and attempted to "dive" on those features. Because of the great turbidity of the water, attempts at visual observation were fruitless. The swimmers instead waded across the target areas, retrieved items from the bottom, and noted qualitative variations in bottom texture. Finally, one region of the nearshore adjacent to the northern end of Jamestown Island was surveyed with plane-table and alidade. Because there was no immediate means of preservation and conservation, all artifacts except for four items (portions of a bottle, a brick, and two rocks) were left in the water where they were found.

Concurrent with the physical surveys we re-

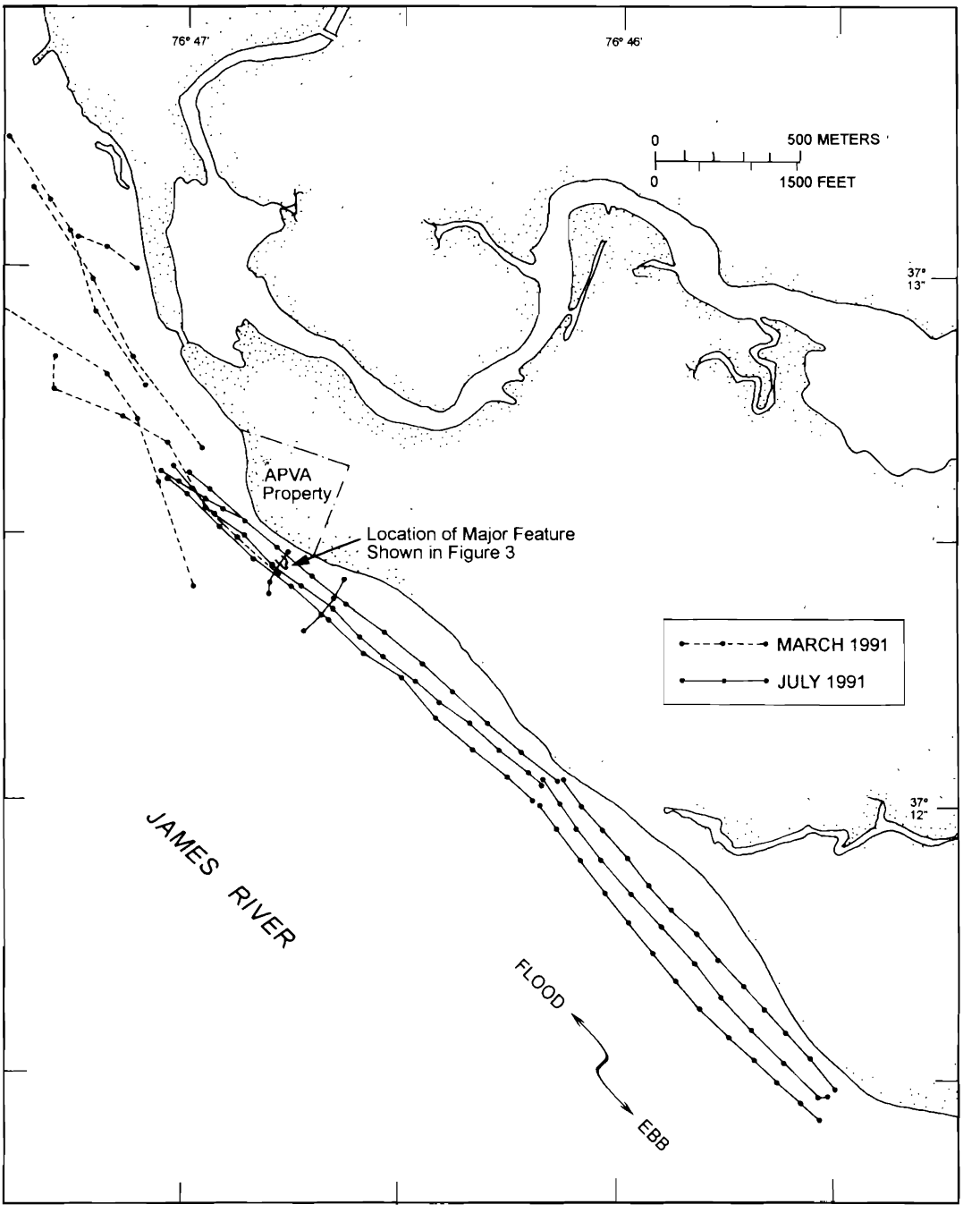

Figure 2. A map of the side-scan track lines.

Table 1. *Historical maps and charts of Jamestown Island, Virginia used in the preparation of marine archaeological study.*

Date	Source	Description	Scale	Comment
1855	USCS*	#530	1:10,000	Little detail, little use
1873	USCS	#1290	1:20,000	T-sheet, acetate reproduction, also shows NAD 1927
1892	Corps†	"North End . . ."	1:4,800	Shows 1873–75 and 1892 shoreline, quite helpful
1894	Corps	"West End . . ."	1:1,200	Incomplete copy, good shoreline information, shows old ditch
1899	Corps	"North West . . ."	1:1,200	Incomplete copy
1905	Corps	"Sketch . . ."	1:2,400	Shows seawall stages, proposed dredging area, quite helpful
1941	unknown (Corps?)	none	1:3,000	Indicates location of modern boundaries
1944	USC&GS	"Yorktown"	1:20,000	Topo map, acetate copy
1948	USC&GS	H-7641	1:10,000	soundings, includes 1:1,000 insert of Jamestown Wharf area
unk	unknown (Corps?)	none	1:2,400	Post seawall, 1 foot topo interval, piers, helpful

*U.S. Coast Survey

†Corps indicates that chart or map is in the archives (library) of the Norfolk, VA, District of the U.S. Army Corps of Engineers and may have been prepared by or for the Corps in conjunction with a civil works project

viewed the available literature for references to the early European habitation of Jamestown (YONGE, 1907; HATCH, 1949, 1989; RILEY and HATCH, 1955; COTTER and HUDSON, 1957; among others). We also obtained partial copies of late nineteenth and early twentieth century survey maps of the area from the files of the Norfolk District of the U.S. Army Corps of Engineers. Other historical maps and charts were available in the archives of the Virginia Institute of Marine Science (Table 1). Several of these materials were processed on a scale-changing office-copier to yield copies at a common scale, which then were compared with one another and with the survey data. Comparison generally was accomplished by matching the plotted, surveyed boundary lines of the A.P.V.A. property which appear on many maps and by matching various specific sites appearing on the maps.

RESULTS

The side-scan sonar surveys depicted many features and several unexplained targets. Physical location of these features was aided, in some instances, by their depiction on two or more of the overlapping sonograms and by the excellent control provided by the GPS. A subset of these features in the vicinity of the A.P.V.A. holdings and the Civil War era fortifications were especially interesting.

The most obvious and striking feature is the large "structure" clearly evident in Figure 3. This feature with its straight lines and right angles and the suggestion of an opening in its downstream extremity generated much discussion and speculation. Analysis of the width of the light (shadow) zone of the lines indicates that the relief is approximately 10 cm. The scale of the relief was confirmed by the waders who noted linear zones in the bottom that were somewhat firmer than the surrounding material and that graded to an elevation slightly above adjacent areas. Unfortunately, the subsequent plane-table and alidade survey was unable to confirm or deny the presence or configuration of the feature.

Another item noted on the sonograms was a "boat shaped" or "pointy-ended" feature near the very northern end of the island. In the wading survey, the area was identified as having cobbles on the bottom, as opposed to the regional fine

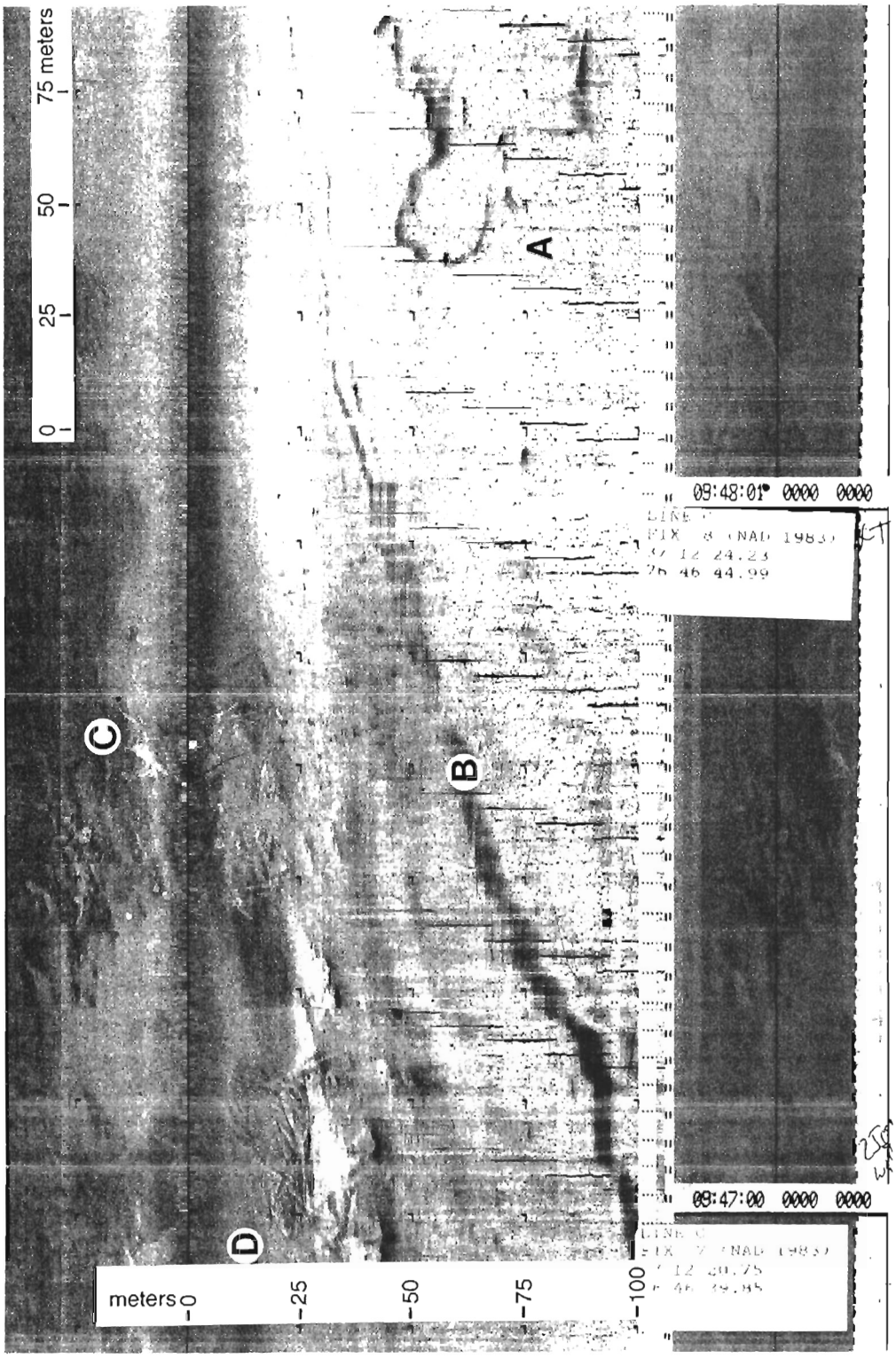

Figure 3. A photograph of the portion of the sonograph depicting the "major feature," labeled "A" on the figure. "B" is the relative steep slope marking the transition from relatively relatively shallow to relatively deep water. Features "C" and "D" perhaps are indications of remnants of the piers shown in Figure 4.

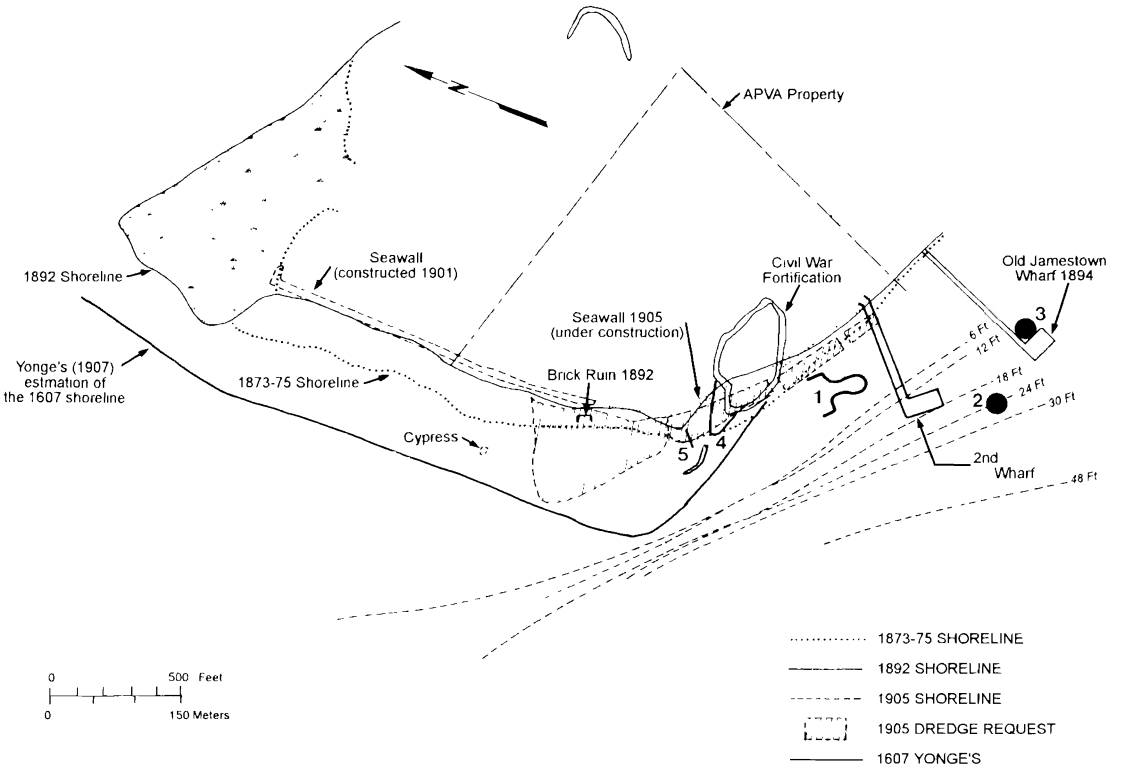

Figure 4. A composite of features and shoreline positions from several earlier maps and charts including some features from the side-scan sonograms. "1" is the approximate location and configuration of feature "A" on Figure 3. Items "2" and "3" near the piers mark the approximate positions of "C" and "D" from Figure 3. YONGE's (1907) estimation of the location of the 1607 fort is shown by "4," and extension of the Civil War era fortification. "5" is the approximate site of a masonry mass described by YONGE (1907).

sand. Also fragments of a brick and a bottle, both identified as probably seventeenth century, were recovered from this site.

The tactile investigation of the bottom at other sites shown on the sonograms demonstrated that many of the isolated dark patches were portions of the bottom that were colonized by dense populations of the fresh-water clam *Rangia cuneata*. The swimmers were unable to determine if the clams were selectively colonizing on anthropogenic artifacts or not. Similarly, the swimmers were unable to determine if any of the other side-scan targets had cores that might be of import.

As previously noted, the plane-table survey was inconclusive. The surveyors were able to locate small targets from the sonographs as well as to find other items on the riverbed. Although some were obviously modern, others were of indeterminate and obviously colonial ages. Items noted included old pilings, planks, logs, areas of gravel and cobbles, a (barrel?) hoop, and rubble. Nothing, including mapped changes of elevation, was firmly indicative of specific past use.

Analysis and comparisons of the various maps (Table 1) provided further information. The older, larger scale (1:1,200 and 1:2,400) maps provided valuable information on the migration of the shoreline between 1873 and the construction of the seawall in the early 1900's (Figure 4). The 1905 map indicates that the immediate nearshore region—the areas between the groins—had been dredged suggesting that these areas would not provide a surfeit of artifacts. Indeed the plane-table survey found the intra-groin regions, although the site of much rubble, were essentially barren of artifacts.

The map of the "North-Western End of Jamestown Island, Virginia," dated 1899, at an original scale of 1 to 1,200, also depicts the shorelines in 1893, referencing a survey of Mr. Shirley Carter,

and of February, 1891. This map also indicates the location of a "magazine" just offshore of the 1891 shoreline about halfway between the existing remains of the Confederate fort and the upstream boundary of the A.P.V.A. property. The same structure appears as a "brick ruin" adjacent to the 1892 shoreline and inside the 1873 shoreline on the 1 to 4,800 map of 1892. This structure is in the area identified for dredging on the 1905 map. The lone cypress, still present and a significant landmark today, is first shown approximately 75 m (250 ft) offshore of the seawall on the 1905 map.

None of the maps offer specific explanations of any of the features, especially the anthropogenic structure in Figure 3 depicted on the side-scan sonographs. Analysis of the maps, however, present some possible interpretations. The deeper water features appear likely to be associated with the outer ends of the two major piers. The thin, shaft-like features on the sonogram perhaps being old pilings remaining on the riverbed from the destruction of the wharf in 1956.

The other feature possibly explained by the maps is the major target shown on Figure 3. Although both inshore and upstream of the location of the pier-head, the feature on the sonogram is roughly similar in size and shape to the outer end of the wharf. Even though there is no reasonable explanation for this structure to have been moved to shallow water, where it would present a real hazard to navigation, the similarities of form cannot be ignored.

DISCUSSION AND CONCLUSION

The project to investigate the shallow, nearshore in the vicinity of Jamestown Island, Virginia, has provided mixed results. It has very easily demonstrated the utility of side-scan sonar in very shallow water. The sonography has imaged structures not otherwise visible and has evidenced both excellent correlation with physical, ground-truth surveys and strong repeatability. Unfortunately, the amalgam of the side-scan sonar surveys with in-the-water tactile and plane-table surveys, and co-analyses of historical charts and maps has neither explained a major and exciting feature on the shallow riverbed nor located the site of the original fort of the 1607 settlement of Jamestown. We are left with a large, but unexplained, anthropogenic feature in the very shallow waters offshore of Jamestown Island. Further physical, archaeological, and historical studies of this feature and the surrounding area are essential if we are to determine its origin. Such studies also would provide additional data to use in assessing the nature of the earliest English settlement on North America.

The geophysical investigation has proven itself to be a valuable method of reconnaissance for shallow archaeological sites. Even including "ground truthing" of selected targets, the method allows a rapid, low impact, non-destructive, and inexpensive first look at areas of interest.

The area of probable dredging immediately offshore of the seawall, depicted on turn of the century charts, indicates that any artifacts originally on the bottom there likely have been destroyed.

ACKNOWLEDGEMENTS

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