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16. Abstract

Departments of transportation and other construction agencies are required to locate and conserve cultural resources located in the area of a construction project. Although most organizations have procedures for locating cultural resources on land, the relatively new field of underwater archaeology lacks clearly defined guidelines for preconstruction surveys for structures over water. The lack of specific guidelines complicates decisions by administrators who are unfamiliar with the issues concerning submerged cultural resources, but who are, nevertheless, required to consider them in planning projects. The increase in public interest in underwater archaeology and the recent passage of legislation protecting underwater historical sites indicate that greater attention will need to be directed toward consideration of these resources in construction projects.

This report reviews the relevant cultural resource legislation and it summarizes the origins, techniques, and working conditions of underwater archaeology. The differences between underwater and land archaeology are primarily related to the specialized technology required for underwater work and exploration; therefore, the methodology of underwater archaeology and the application of survey procedures are discussed in detail.

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FINAL REPORT

A METHODOLOGY FOR CONDUCTING UNDERWATER ARCHAEOLOGICAL SURVEYS

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

Departments of transportation and other construction agencies are required to locate and conserve cultural resources located in the area of a construction project. Although most organizations have procedures for locating cultural resources on land, the relatively new field of underwater archaeology lacks clearly defined guidelines for preconstruction surveys for structures in or over water. The lack of specific guidelines complicates decisions by administrators who are unfamiliar with the issues concerning submerged cultural resources but who are, nevertheless, required to consider them in planning projects. The increase in public interest in underwater archaeology and the recent passage of legislation protecting underwater historical sites indicate that greater attention will need to be directed toward consideration of these resources in construction projects.

This report reviews the relevant cultural resource legislation, and it summarizes the origins, techniques, and working conditions of underwater archaeology. The differences between underwater and land archaeology are primarily related to the specialized technology required for underwater work and exploration; therefore, the methodology of underwater archaeology and the application of survey procedures are discussed in detail.

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PURPOSE

Departments of transportation (DOT) and other government and private agencies responsible for construction projects are required to consider a number of cultural resource issues. Effective management of these issues requires an understanding of legislative requirements and archaeological techniques available for conducting preconstruction surveys. Underwater archaeology is a subdiscipline that uses very specialized techniques, which are unfamiliar to most DOT personnel. Increased public concern and the recent passage of legislation regarding submerged cultural resources indicate that the consideration of underwater historic sites will need to be included in the planning process for all construction projects in or over water. These projects include tunnels, bridges, piers, and ferry slips.

This report discusses the issues that confront government and private agencies in conducting underwater archaeological surveys. It summarizes the background, technology, and working conditions of underwater archaeology and proposes guidelines for conducting studies in compliance with the appropriate legislation. Where applicable, comparisons are made between land and underwater archaeology. Since the differences reside primarily in technique, the methodology of underwater archaeology is discussed in detail.

The study consists of a literature review and summary, methodology based on the results of several VDOT preconstruction underwater archaeological surveys, and a bibliography. Because of the controversial nature of the topic, authorities in underwater archaeology representing different factions of the discipline were consulted during the project and requested to review the final manuscript.

HISTORIC PRESERVATION LEGISLATIVE REQUIREMENTS

A number of state and federal laws regulating cultural resource management affect DOT construction projects. A summary of the relevant public archaeology laws is given in Appendix A.

The intent of the state and federal legislation is clearly the preservation and protection of archaeological resources. Consequently, the DOT is required not only to consider the impact of a proposed project on historically significant sites but also to locate all sites in the construction area.

Although the intent of the historic preservation legislation appears clear, its implications regarding DOT projects are less apparent. The legislation, which is designed to permit the necessary flexibility in managing individual projects and sites, allows a range of interpretations of the extent of the requirements for agencies such as the DOT (Bower, 1982; Kelly, 1988). For example, the extent of effort required to locate and identify historic sites may not be similarly interpreted by all archaeologists. Neither is there agreement in defining the direct and indirect adverse impact of projects for which an agency is accountable. Nevertheless, experience with the legislation has resulted in DOT policies for cultural resource protection that conform to the requirements for preconstruction archaeological surveys on land. Many state DOTs employ archaeologists for guidance on legislative requirements, for conducting of archaeological surveys, and for administering of contracted work. There continues to be some confusion, however, and DOT procedures are occasionally challenged.

To some extent, the lack of consensus among the archaeological community on the interpretation of historic preservation requirements is the result of changes and different orientations within the field. The cultural resource legislation has affected the definition of historically significant sites, the funding sources for archaeological research, and the selection of the archaeological excavations conducted in the United States. Although a number of traditional, academically based archaeologists persist, the legislation created a need for contract archaeologists to perform archaeological work for government and private agencies on a fee-for-service basis.

Contract archaeology is more complex than traditional noncontract archaeological research in that it imposes additional professional obligations. In addition to the goal of contributing to the advancement of knowledge in archaeology, contract archaeologists must satisfy the requirements and objectives of the sponsoring agency and balance the objectives of the agency and archaeological research to provide the maximum benefit to the public (Raab & Klinger, 1977). Cultural resource management studies conducted by contract archaeologists are directed toward expedience in salvaging threatened sites and satisfying legislative requirements. As such, they differ from traditional archaeology in which a particular site is located to excavate for research purposes, with the extent of effort determined independently of a contracting agency (Gardner, 1978).

Since DOTs are not primarily oriented toward cultural resource management, the requirements of historic preservation laws occasionally conflict with DOT goals (Bower, 1982), thereby resulting in expensive delays. Effective resolution of opposing objectives is necessary for the smooth and economical progression of DOT construction projects and the protection of historic sites. Because of the lack of consensus within the archaeological community, government agencies must define their own guidelines and limits in historic preservation for effective archaeological contract issuance and administration.

The relatively new subdiscipline of underwater archaeology has been plagued by a conflict of orientations since its establishment approximately 25 years ago (Gould, 1983). It is distinguished from land archaeology by technology and methodology that have undergone rapid evolution in the last decade. It is a very specialized field, which is not well understood even by many land archaeologists. Because of the expense and specialization of underwater archaeology, most of the technology will not be available within DOTs, and the work will have to be contracted. Effective contracting of underwater work requires an understanding of its applications and limitations. Many of the regulations and procedures for land archaeology can be applied to underwater surveys with some modification.

The protection of a historic site under the current cultural resource legislation is based on the eligibility of the site for inclusion in the National Register of Historic Places. The National Register, which is administered by the Department of the Interior, consists of a listing of historic sites that have met the criteria outlined by the legislation (included in Appendix B). There are several criteria for eligibility in the National Register, the most common qualification being that the site "has yielded, or may be likely to yield, information important in prehistory or history." In general, sites fewer than 50 years old are not eligible, although there are exceptions. As the legislation itself states, the wording of the criteria is designed for applicability to diverse resources. Legally, a site that fails to meet these criteria has no claim for protection and no additional investigation is required of the DOT. Consequently, the purpose of a preconstruction archaeological survey is identification of sites that are eligible for the National Register.

Infrequent use of the National Register for protection of historic shipwreck sites led to the production of a bulletin (Delgado et al., 1987) by the Department of the Interior that provides technical information on the planning, survey, and registration of historic ships. This bulletin describes the application of National Register criteria to a shipwreck site. The areas of significance to consider for shipwrecks are indicated in Appendix C. Shipwrecks are unique in their classification in the Register in that they may be considered as either sites or structures depending primarily on whether the wreck is intact or scattered.

Protection of marine sites has been afforded in the past through nomination to the National Register or, in some cases, by designating the site as a National Marine Sanctuary (Miller, 1985). New legislation passed by Congress in March 1988 provided an additional degree of protection to submerged cultural resources. Under the Abandoned Shipwreck Act, states are responsible for developing policies that protect underwater sites. This is to include the recovery of shipwrecks "consistent with the protection of historical values and environmental integrity of the shipwrecks and the sites."

HISTORY OF UNDERWATER ARCHAEOLOGY

Underwater archaeology, the study of man's past through the study of submerged artifacts, is a nascent discipline. In the broadest sense, underwater archaeology includes all sites covered by water, regardless of depth (Bass, 1966; Coles, 1984). The primary difference from its terrestrial counterpart lies in the specialized techniques of search, excavation, and conservation required by the aqueous environment. Its development has been closely linked with improved technology for underwater exploration in recent decades. Although some salvage-type recovery of artifacts was attempted with early diving equipment, the invention of scuba (self-contained underwater breathing apparatus) in 1942 permitted the development of underwater archaeology. Equipment for underwater exploration became easily accessible, relatively inexpensive, and (with the underwater mobility it allows) readily adaptable to systematic excavation. Exploration of wrecks and other archaeological sites was initially performed by divers for the purpose of treasure recovery. It was not until the 1960s that the systematic methods of land archaeology were applied to excavation of an underwater site by pioneers in marine archaeology such as Peter Throckmorton and George Bass (Bass & van Doorninck, 1971; Bass & Katzev, 1968; Throckmorton, 1969).

Underwater archaeology has drawn in its development from marine salvage, maritime history, terrestrial archaeology, and cultural resources management (Lenihan, 1983). Thus, many of the individuals involved with submerged cultural resources have different orientations, objectives, and approaches. Continued development of underwater archaeology has been troubled by disputes between the multiple opposing factions within the field and competition for the limited supply of submerged cultural resources.

Legal disputes between state archaeologists and treasure salvors for the management of shipwreck sites and recovered artifacts have intensified conflicts within the field. Because of pressure from state archaeologists and the enhanced value of well-documented finds, traditional treasure salvors have begun to employ underwater archaeologists to aid in the location and excavation of major treasure sites (Wade, 1981; Mathewson, 1985). Although this has the advantage of providing documentation of these sites (often, funding is not available for this purpose in the public sector), it has created further conflict within the underwater archaeological community primarily between state (and academic) archaeologists and commercial practitioners employed by the treasure salvors.

The difficulties of proposing stricter legislation have included selection of the sites to be protected, methods of enforcing the law, and conflicting opinions among those who would be affected by the law (e.g., treasure salvors; state, academic, and commercial archaeologists; and sport divers) (Miller, 1988). Efforts to control access to historic shipwrecks have caused consternation among the sport diving community, which often dives for recreation on shipwrecks that are not necessarily historic and which makes substantial amateur contributions to archaeology through the location of sites and volunteer diving on excavation projects. Several bills were proposed for stricter control of access to shipwrecks; they led to the passage in 1988 of the Abandoned Shipwreck Law, which places management of these sites under state control. The Department of the Interior is attempting to provide guidelines for state protection of shipwrecks, but the actual effect of the Abandoned Shipwreck Law on individuals and sites has yet to be seen.

UNDERWATER ARCHAEOLOGY AS A SUBDISCIPLINE OF ARCHAEOLOGY

When underwater archaeology is compared with land archaeology, similarities and differences are apparent. Both have the same goal: the scientific study of man's past as revealed through artifacts. The principal differences are related to the water environment of marine archaeology that imposes difficult but not overwhelming constraints. Underwater archaeology is the only subdiscipline of archaeology that is distinguished by technique as opposed to geographic area or subject matter (Lenihan, 1983; Bass, 1966). An underwater archaeologist must be competent in diving and archaeology. The underwater environment affects both the site and the working conditions.

Underwater Sites

Underwater archaeological sites are categorized somewhat differently than those on land. The four general types are refuse sites, submerged sites of previous human occupation, shrines (bodies of water, often springs, where objects were deposited as offerings), and shipwrecks (Goggin, 1960). Shipwreck sites are the most frequently studied and contain artifacts from a particular time period.

The other three types are similar to land sites in that they contain artifacts from a broad time period (Marx, 1975). Some important finds relating to North American Indian prehistory have been made at submerged refuse sites and shrines, particularly in the clear water springs of Florida and Mexico. Changes in sea level are believed to have resulted in the flooding of numerous coastal prehistoric sites (Wittkofski, 1981; Colquhoun et al., 1981; Blackman, 1971; Emery & Edwards, 1966). Studies of sea level in the mid-Atlantic coastal states indicate an initial rapid rise from glacial melt at a rate of several feet per century, with deceleration approximately 5000 years ago to 0.5 feet per century (Kraft, 1976). The total rise is estimated to be approximately 500 feet. Docks, forts, harbors, and other coastal installations were submerged by changing shorelines. Inundation sites from dams would also be included in the category of submerged sites of previous human occupation.

The majority of current underwater archaeological work is concentrated on shipwrecks, from which a vast amount of cultural information can be derived. Unlike many land archaeological sites, sunken vessels represent a "time capsule" from a particular era that may be precisely dated. Ships have been viewed anthropologically as surprisingly complete microcosms of their culture of origin (Lenihan, 1983; Cederlund & Ingelman-Sundberg, 1973). Space on ships is limited and therefore restricted to cultural items of need or value. Ship design and outfitting represent a society's response to the requirements of trade, travel, exploration, and military threats. The cargo of a wrecked vessel offers clues to the identity, priorities, and trade contacts of its culture of origin. In addition, valuable information on the techniques and materials of early shipbuilding can be gleaned from shipwreck sites.

Underwater archaeological sites have several important features. Part of their attraction for archaeologists lies in the superb preservation of artifacts that is possible under water. Artifacts on shipwrecks may be exposed to disruption during the sinking, but under most circumstances, the site stabilizes quickly after deposition on the bottom. As long as artifacts exist in a stabilized condition covered with sediment, deterioration is minimal. Land sites are subjected to the effects of freeze-thaw, animal disturbance, plant processes such as tree falls and root growth, erosion, environmental effects of wind and storms, and other perturbations not present under water (Murphy, 1983; Hole, 1961; Wood & Johnson, 1978). A greater range of artifacts is often present at underwater sites. The artifacts at many sites on land consist of broken shards, whereas virtually intact glass, ceramics, and other fragile objects can be recovered at underwater sites. The water effectively preserves organic materials such as fabrics, foodstuffs, and even human tissues in some cases (Barkman & Franzen, 1972; Vreeland, 1978; Cockrell, 1973). Underwater artifacts are sequestered at the time of sinking and do not remain available for the use or disposal by a subsequent era. The precise dating of artifacts possible at underwater sites is another valuable asset archaeologically. Shipwreck sites have minimal contamination with artifacts from other time periods, although sites in bays and harbors have a greater amount of contamination than those located farther from populated areas.

Factors in Site Preservation

Certain characteristics of a site promote the preservation of submerged artifacts. One of the most important factors is the covering of silt. A protective layer of silt settles on most wrecks as they contact the bottom, and the silt continues to accumulate over time (Bascom, 1971, 1976). In many cases, particularly under a thick layer of silt, an oxygen-free environment is created, inhibiting the microbial and chemical processes that lead to the degradation of organic materials (Muckelroy, 1978). Wood that is covered by sand or silt is also protected from the effects of wood-eating marine animals, such as the shipworms *Limnoria lignorum* and *Teredo navalis*.

The cold, still water and mud bottoms of inland waters can result in dramatic wreck preservation. Wooden vessels in fresh and brackish waters are better preserved since shipworms are present only in salt water. Bay and riverine environments also lack the extreme water conditions that cause massive structural damage of ships sunk during storms (Peterson, 1972).

Deep water also improves the preservation of hulls and artifacts. Factors contributing to the excellent preservation of sunken artifacts at great depths include the absence of shipworms, pressures that may inhibit bacterial growth, and the slowing of biological and chemical activity from the cold temperatures and the low oxygen content of the water (Bascom, 1976).

Working Conditions of Underwater Archaeology

Divers work in an alien environment that requires specialized equipment and personal adaptation. The restrictions imposed on divers under water have special significance for an archaeologist working in this environment. One of the major restrictions on the underwater archaeologist is reduced visibility. Visibility of 100 to 150 feet is unusually good under water and is most likely to be found in areas such as the Caribbean, the Mediterranean, and the arctic. In contrast, visibility in rivers, lakes, and bays is commonly 10 feet or less; in some places, there is no visibility. The low visibility is caused by suspended silt and small marine organisms in the water, and like a foggy atmosphere, it cannot be appreciably illuminated with lights. In dark water, a diver's "observations" must be made entirely by sense of touch.

Reduced visibility has significant effects on the application of traditional land techniques to underwater archaeology. Reduced visibility prevents the archaeologist from obtaining a visual overview of the site. Work is performed in a small area at a time, often within a grid matrix. Measuring is more difficult because of limited visibility, and the problem is compounded by the viscosity of the water, currents, and reduced dexterity. Visual estimations of distance are distorted under water since objects appear one-third larger and closer than they really are. The use of underwater sonic measuring devices and long-range optical instruments such as theodolites or alidades has been possible only at certain sites. Most measuring is done with tapes or graduated rods. Photographic documentation is also impeded by low visibility.

Underwater archaeologists are further limited by the physiological effects of working under increased ambient pressure. The physiological restrictions of safe diving affect both the time spent under water and the depth at which work can be conducted. When the human body is placed under higher pressures as in the underwater environment, nitrogen gas is taken up by the tissues. The gas must be liberated slowly without causing significant bubbles in the tissues and the blood stream, or the diver will develop decompression sickness, also called the bends, which is a painful and sometimes fatal condition. Decompression sickness is avoided by adherence to the time and depth schedules of decompression tables (such as those developed by the U.S. Navy) and a controlled ascent at a rate of 60 feet per minute. Decompression tables were developed on a theoretical basis but have proven fairly safe in application.

As an example of the dive table limitations, a diver working on an archaeological site at a depth of 60 feet on his first dive, will be able to stay at that depth for 60 minutes or less for a "no-decompression" or "no-stop" dive (to avoid having to stop under water during the ascent to control the formation of nitrogen bubbles). If the dive lasts longer, he will have to stop at 10-foot intervals from the surface for the length of time designated by the tables. Eighty minutes at 60 feet requires a 7-minute stop at 10 feet. On a dive 2 1/2 hours later that day, the diver still has a penalty from the previous dive: this time, a no-stop dive to 60 feet is limited to 24 minutes or less. At greater depths the restrictions become more severe: the no-stop time for the first dive of the day at 120 feet is 15 minutes. Decompression times can be lengthy: decompression from an 80-minute dive at 120 feet would total 105 minutes.

Decompression diving is not considered a safe recreational diving practice. The arrangements for a decompression dive increase the task load on the diver and the tables are less reliable at extreme exposures of time and depth. Deeper and longer exposures are possible with specialized diving techniques such as the use of mixed gas as a breathing medium and saturation diving (Miller, 1979). These require more equipment, training, and expense than standard scuba diving practices and are beyond the scope of this discussion.

Another physiological limitation affecting underwater archaeologists at depth is nitrogen narcosis, a temporary "drunkenness" that results from breathing the nitrogen in air while in a pressurized environment. This condition can seriously and dangerously impair a diver's safety and ability to work. Individuals are affected differently, but in general, the effect is negligible until a depth of 100 feet is attained, when the narcotic effect becomes roughly comparable to the effect of two martinis. The threat of nitrogen narcosis, combined with the decompression table restrictions at greater depths, is the reason that most archaeological diving has been done at sites in 100 feet of water or less.

Other restrictions on the underwater archaeologist include cold temperatures, weightlessness, slowing of movements, decreased dexterity, and reduced ability to communicate. Water conducts heat away from the body more rapidly than air, so that immersion, even in warm water, will eventually result in the chilling of the diver. Divers wear thermal protection consisting of wet or dry suits to extend the length of time they can comfortably remain under water and to slow the onset of hypothermia. The viscosity of the water slows movements and can reduce manual dexterity (especially when combined with heavy wet suit gloves). Studies have shown that manual dexterity decreases markedly under water and with increasing depth. A standard dexterity test took 28 percent longer at 10 feet under water and 49 percent longer at a depth of 100 feet than at the surface (Baddeley, 1966). This further slows the progress of work under water. Immersion in water also produces weightlessness, causing the diver who pushes against or strikes an object under water to be propelled in the opposite direction, thus increasing the difficulty of handling tools. Communication between divers is hampered by the inability to talk under water. Messages can be written on slates, or underwater intercoms are occasionally used, but communication is nevertheless slowed using these methods.

Diving is personnel intensive. A number of divers are needed to work continuously at the underwater site during a work day because the exposure allowed each individual is limited. Diving alone is not considered safe. A dive team consists of a team of surface personnel in addition to the divers in the water. *Task overloading* is an expression used by divers to refer to the confusion and ineffectiveness experienced during a dive that places demands on the diver beyond his ability to cope. In general, more experienced divers are able to perform complicated tasks efficiently under water, whereas a novice may be at his limit monitoring gauges and attending to personal safety. Any underwater team is limited by the level of achievement of the divers.

Underwater archaeology can be very expensive. Estimates of cost compared to land sites range from 8 to 32 times higher on submerged sites in terms of the project cost distributed over the number of hours of work on site (Muckelroy, 1978). The expense is related to the relative slowness of underwater work, the restricted work schedule of divers resulting from decompression limitations, the cost of the equipment, and the dependence of the project on good weather conditions.

THE HISTORY OF VIRGINIA'S WATERWAYS

Since Virginia is a coastal state with numerous rivers, lakes, and reservoirs, a variety of underwater sites could be affected by VDOT projects. A brief summary of Virginia's maritime history will underscore its significance and the likelihood of the existence of numerous submerged cultural resources within the state.

Prehistory, or the unrecorded era prior to the arrival of Europeans in North America, is an era about which archaeologists have much to learn. There are indications from shoreline sites (Wittofski, 1981) and submerged sites along the Chesapeake Bay (Peck, 1978) that regions in proximity to the coastal waters of Virginia were extensively used by the American Indians beginning approximately 4,000 years ago (Koski-Karell, 1987). Sites have been identified in association with rivers and swamps in the western part of the state dating from the Late Archaic periods (5,000 to 3,000 years ago) and the Early and Middle Woodland periods (3,000 to 1,200 years ago) (Gardner, 1978, 1979a, 1979b). The technology for detection of submerged prehistorical sites is poorly developed, but many sites of early habitation were probably inundated during the gradual rise in sea level (Colquhoun et al.,1981; Emery & Edwards, 1966; Wittkofski, 1981).

In 1607, the first permanent English settlement in the Western Hemisphere was established at Jamestown on the James River. Maritime transportation played an important role in the development of the colonies by linking them with Europe and with each other. Pioneer settlements of the Shenandoah Valley occurred in the

1700s. Although streams in western Virginia would have rarely been used for transportation, homesteads would have been frequently associated with them for water supply (Gardner, 1978).

The waterways of Virginia have been extensively used during military conflicts. During the Revolutionary War, numerous conflicts occurred in the Chesapeake Bay area, and the major naval battle of the war occurred on the neighboring York River. During the Civil War, Confederate blockade running was prevalent on Virginia's waterways, and some of the principal naval battles of the war occurred on the James River between ironclad ships. In World War II, a number of ships were sunk offshore by patrolling German submarines. The prominent economic and military role of Virginia's ports has continued to the present. As a result of this busy shipping activity, approximately 2,000 shipwrecks are estimated to have occurred off the Virginia coast (U.S. Congress, 1987).

UNDERWATER ARCHAEOLOGY IN VIRGINIA

Considering Virginia's rich cultural history, it is not surprising that significant underwater archaeological discoveries have occurred. Three underwater sites in Virginia encompassing 13 shipwrecks dating from the Revolutionary and the Civil War have been identified as eligible for the National Register. A brief history and description of these sites is included to indicate the submerged cultural resource potential in Virginia waters.

The sites of yet undiscovered shipwrecks and other cultural resources in Virginia waters will share characteristics with sites already located in the state. The water conditions usually restrict visibility to less than 10 feet. Most sites are covered by a quantity of soft sediment, leading to very good preservation but increasing the effort required for excavation. The majority of sites encountered in VDOT surveys will be in fresh or brackish water, which also promotes good preservation. Currents in larger rivers can be swift, causing difficulties for divers, backfilling excavated areas with sediment, and disturbing exposed artifacts. The depth of most Virginia rivers is less than 30 feet, but some major waterways have depths approaching 100 feet, thereby limiting the time a diver could remain on the bottom.

Yorktown Shipwrecks

In September, 1781, the British fleet at Yorktown under the command of General Cornwallis was blockaded within the Chesapeake Bay by the arrival of French naval forces commanded by Admiral de Grasse. In an effort to protect the British military post at Yorktown from amphibious assault by the French, a number of ships were scuttled immediately offshore. Additional vessels were lost during intermittent encounters between the allied French and American forces and the British prior to Cornwallis' surrender. As many as 34 vessels were unaccounted for in the records following the battle (Sands, 1983). Some of the submerged vessels were salvaged by the French soon after the battle, but many remained unrecovered. Subsequently, various salvage attempts were undertaken to recover the submerged artifacts. A major salvage effort occurred in 1934, when the officials at the Yorktown National Monument authorized a search to provide artifacts for the newly founded Mariner's Museum (Ferguson, 1939). Interest in the site increased in the 1960s and 1970s with the availability of scuba equipment. In order to protect the wrecks from unauthorized exploration, the Virginia Historic Landmarks Commission nominated the area of the York River known to contain the Revolutionary War shipwrecks for inclusion in the National Register. The area was officially listed in 1973 and became the first underwater archaeological site to be included in the National Register. In 1975, a team of underwater archaeologists led by Dr. George Bass explored the remains of a wreck from which sport divers had recovered numerous artifacts. They found conditions greatly different from the Mediterranean Sea where most previous underwater archaeology projects had been performed. Heavy currents, low visibility, sharp oyster shells, jellyfish, and logistical difficulties hindered the excavation (Sands, 1983; Bass, 1976). Later that year, a remote sensing survey of the York River was conducted in an attempt to locate the Revolutionary War wrecks. Nine shipwrecks dating from Cornwallis' siege of Yorktown in 1781 were identified in shallow water in the York River (Johnson et al., 1978; Broadwater et al., 1975; Andahazy et al., 1976; Broadwater, 1980). Following the survey, specific site investigation began. Most of the excavation to date has been concentrated on a single submerged vessel that is particularly well preserved. A wet cofferdam was constructed around the wreck in order to control the working environment at the site, and numerous artifacts have been recovered (Broadwater, 1988).

The C.S.S. Florida and the U.S.S. Cumberland

In 1980, a private, nonprofit organization and the Virginia Research Center for Archaeology began searching the James River for the remains of the C.S.S. Florida and the U.S.S. Cumberland (Margolin, 1987). The Florida was sunk under mysterious circumstances in 1864. The Cumberland was lost in 1862 after an encounter with the C.S.S. Virginia (the Merrimack) in one of the historic battles that established ironclad ships in naval history. It was during this battle that the Virginia lost her battering ram and was undoubtedly weakened prior to her famous battle with the U.S.S. Monitor the following day.

Two warships dating from the third quarter of the nineteenth century were located in the James River with the aid of historical reports, a local waterman, and a recording fathometer (described below) (Margolin, 1987). Preliminary surveys and artifacts recovered added credence to the hypothesis that the two vessels were indeed the Cumberland and the Florida. Both sites have been nominated for inclusion in the National Register of Historic Places.

Chickahominy Shipyard

The Chickahominy Shipyard was established in 1777 at the mouth of the Chickahominy River as the shipyard for the state of Virginia's navy. Two ships were built at the shipyard, and at least eight others were repaired or outfitted there (*The Daily Press*, 1979). British troops seized and burned the shipyard in 1781.

The remains of the site were nominated for inclusion in the National Register in 1978 and listed later that year. It is unique as a shipyard site in the only state that maintained its own navy. The site encompasses the foundation remains of the shipyard superintendent's and workers' residences, warehouses, ship launching slips, and two submerged colonial shipwrecks. Underwater archaeological artifacts recovered have included nails, cannon balls, barred shot, ballast, and rigging blocks (McCartney & Luccketti, 1978). Further archaeological investigation at the site is expected to reveal information about colonial shipbuilding techniques unavailable from other known sources.

PHASES OF ARCHAEOLOGICAL INVESTIGATION

Three phases of archaeological investigation have been described by the Virginia Historic Landmarks Commission Research Center for Archaeology (1985). The phases represent investigations of differing intensity. Although individual sites are unique, the phases provide a standardized framework for conducting archaeological investigations. The phases are defined in terms of land sites as summarized below.

A phase I investigation consists of an archival search and a preliminary field survey of the project area to discern the nature and extent of archaeological resources present. The land-based field search generally consists of pedestrian search patterns and in rural areas, the shoveling of small, sample pits to the depth of the subsoil (Kelly, 1988). A survey of the entire project area is required to fulfill the legal requirements for a phase I survey. If a phase I survey documents the absence of archaeologically significant sites or that cultural resources in the area will not be adversely affected as a result of a proposed project, a recommendation may be filed by the principal investigator on the project that no further work be conducted. In general, however, a phase I survey gives inadequate data to document this position, so a phase II investigation must be performed.

Phase II investigations are more intense than phase I studies, although they also consist of literature investigation and test pits. The test pits are larger than those used for phase I surveys, with the excavated soil sifted through mesh screens (Kelly, 1988). The objective of a phase II investigation is to obtain sufficient evidence to determine the archaeological significance of historic sites in the study area and their eligibility for inclusion in the National Register. Under current legislation, further study is not required for archaeological sites that are not eligible for the National Register. If the proposed project could have an adverse impact on sites that are eligible for the National Register, suggestions should be made concerning mitigation measures such as avoidance of the area or intensive data recovery.

Phase III investigations consist of intensive data recovery for sites eligible for the National Register that are endangered by a project. This type of study is typically performed as a last resort when avoidance of the site is not feasible. The methodology of a phase III investigation varies greatly with the site and depends on decisions made through the collaboration of the project sponsor with state and federal agencies.

The phase system of archaeological surveys is broadly stated and can be readily applied to underwater investigations.

Phase I

Phase I investigations can be divided into two areas, phase IA and IB. A IA investigation is a literature search examining the cultural impact and archaeological potential of the body of water to be surveyed. Because of the difficulties involved in conducting underwater surveys, an adequate archival search is of the utmost importance (Jenney, 1983; Frederick, 1982; Mazel, 1985). This step adds focus to the later underwater survey and facilitates the identification of located sites. The literature survey should concentrate on the following issues: sites of settlements along the waterway, the use and significance of water transportation and shipping, watercraft employed, location of docks and anchorages, temporal changes in the shoreline, present and historical navigational charts identifying the location of navigational hazards and wrecks, ships reported lost in the vicinity, significance of the area in military confrontations, location and results of previous underwater archaeological investigations in the area, and known submerged cultural resources (Koski-Karell, 1987). The area likely to be affected by a proposed DOT project should be carefully compared with the results from the phase IA survey to determine what cultural resources might be encountered.

The phase IB underwater survey consists of a systematic search of the study area. For efficiency of time and labor, this generally involves a remote sensing scan of the area, with subsequent examination by divers of targets that suggest the presence of cultural resources. Underwater archaeological survey teams employ a variety of remote sensing instruments. Several of the instruments, the proton magnetometer, side-scan sonar, and sub-bottom profiler, consist of a towed submersible transducer-receiver that is connected by a cable to an electronic monitor in the survey vessel. The monitor's recorder provides permanent documentation of the findings. In remote sensing surveys, the device is towed along a series of parallel transects. Transects are spaced at a uniform distance determined by the known sensitivity of the survey instrument. A critical component of any underwater survey technique is an accurate and reproducible navigational system for the consistent spacing of transects, the documentation of site localization, the correlation of searches at separate times or with different instruments, and the relocation of the site at a later time.

Phase II

A phase II investigation focuses on possible sites identified in the phase IB survey that may be affected by a proposed DOT project. The objective of this phase is to obtain adequate background and field data to permit definitive statements concerning the historical significance of a particular site and its eligibility for inclusion in the National Register. Careful surveying of sites identified during phase I should result in detailed field observations and sketches as well as sample artifacts for identification of the cultural resource. Careful documentation of the literature pertinent to the site is necessary to ascertain its historical significance. To discern the implication of the deposit for the DOT project, the size and boundaries of the archaeological site should be defined. Disintegrating remains of shipwrecks can cover a large area particularly in water less than 40 feet deep (Jenny, 1983).

Scattered wreck sites, where the ship's structure has been lost and artifacts are distributed over a large area, are the most common and challenging type of submerged archaeological site. The goal of the archaeologist in this setting is to document the locations of the artifacts and attempt to identify archaeologically significant patterns in their distribution. Visual surveying of the site may be performed by divers, but the visible remains may not indicate the extent of the wreck. Underwater metal detectors and proton magnetometers can contribute significant pre-excavation information through the location of metallic elements associated with the cultural resource. The ferrous and nonferrous content of the wreck from these surveys may yield information on the identification, preservation, and significance of a site (Hall, 1972). The distribution of these metallic components is generally indicative of the distribution of other elements of the shipwreck (Clausen, 1966; Hall, 1972; Arnold & Weddle, 1978). If the site has historic merit and will potentially be destroyed as a result of a DOT project, a phase III investigation may be recommended for a sample area of the site.

The condition of the cultural resource and evidence of site disturbance should be estimated. Underwater resources are subject to a number of damaging effects. For example, the condition of a wreck depends on water conditions at the site, the damage it sustained during the sinking, its structural integrity, and subsequent environmental and human interference. Shallow wrecks that are hazards to navigation are disrupted by the Navy or Coast Guard. Some wrecks sustained damage from World War II torpedoes and mines or the effects of anchors, trawling, or nets.

The identification and dating of a site are very important for assessing its archaeological merit and determining methods for its excavation. Often, the documented records from the literature of ship size, tonnage, cannon, and cargo can be correlated with the measured keel size of the wreck, the amount of ballast, and the location of cargo and ballast on the wreck for identification of the wreck (Marx, 1975). A number of methods can be used to date underwater sites. Artifacts recovered from the site, especially coins and ceramics, can be useful for dating purposes. A method of dating was developed on the Yorktown wrecks that involved the microscopic examination and counting of the number of layers of encrustation on the glass bottles to pinpoint their date of submersion (Bass, 1966).

The report of the phase II investigation will contain the estimated effect of a proposed project on the significant sites and suggestions for mitigative measures. Optimal mitigation is the avoidance of the significant sites identified, and the feasibility of this course must be carefully considered by the archaeologist and DOT project directors. Alternatively, an intensive data recovery program may be necessary.

Phase III

A phase III investigation is an intensive data recovery effort at archaeological sites eligible for listing in the National Register that will be adversely affected by a project's activities. The primary goal of an early archaeological survey of a proposed site is avoidance of this level of investigation by suggesting alternate sites for a construction project. A sample phase III excavation should be considered prior to commitment to a large-scale rescue excavation, particularly of a scattered wreck site (Muckelroy, 1975). If a recovery program is necessary, its goals and extent are formulated through discussion between the project sponsor and appropriate state and federal agencies. Generally, complete recovery of the site will not be possible, so specific research questions should be carefully formulated to provide objectives to guide the investigation.

SURVEY METHODS

Methods of underwater surveying have been rapidly advancing in the last 10 years, paralleling advances in underwater archaeology. Each project is unique and requires a survey methodology designed for its particular characteristics (Bass, 1966). The methods for identification of historic sites are more developed than for prehistorical sites, most of which have been found by chance (Koski-Karell, 1976). Archaeological surveys may be conducted by employing divers or a number of specialized instruments used in geophysical oceanographic surveys that have been adapted for the identification of historic sites. Remote instrument surveys permit rapid coverage of large areas.

Navigation

Accurate navigation is critical for all archaeological surveying by remote instrumentation. Precise navigation ensures that the survey area is adequately covered, provides information for subsequent return to targets, and allows comparison between surveys obtained at different times or with different instruments. Methods may vary depending on whether the location is near a shoreline or is an offshore, open-water area. In proximity to the shore, buoys and shoreline range markers may be installed to guide the boat traverses. If the helmsman maintains alignment with paired range markers on shore, a reasonable degree of accuracy can be maintained. Electronic methods can be used, but radio interference is often encountered close to shore. Optical methods such as a laser positioning system are accurate (within 1 foot) and relatively inexpensive (Koski-Karell, 1987).

Offshore searches require the use of electronic navigational systems. Government-sponsored long-range systems such as LORAN C are occasionally used. However, greater accuracy is achieved with the establishment of privately operated stations for the archaeological survey, such as the Raydist, Shoran, and Decca systems. These provide accurate intermediate-range location for surveys within approximately 30 miles of shore (Bascom, 1976). Satellite-based navigation and positioning systems including the private system Starfix are very accurate (U.S. Congress, 1987). Local electronic systems that reference the ship's position to the sea floor provide the most accurate navigational data at remote ocean locations.

Remote Sensing Surveys

Proton Magnetometer

The most effective remote sensing device in underwater archaeology is the proton magnetometer (Koski-Karell, 1987; Clausen, 1966; Clausen & Arnold, 1976). The instrument detects local disturbances in the earth's magnetic field ("magnetic anomalies") that are caused by the proximity of magnetic metals such as iron and steel. The character of the anomaly is not influenced by water, air, sand, silt, or coral and is detectable by the proton magnetometer even when buried below the sediment (Shomette & Eshelman, 1981). Other items such as ballast stones and pottery that contain magnetic material may also be located with the instrument. Although several types of magnetometers are available, the proton magnetometer is the most appropriate for archaeological surveys because it is sensitive to the magnetic anomalies normally associated with cultural deposits.

The proton magnetometer sensor is a torpedo-shaped instrument that is usually towed submerged behind the survey vessel. It is connected by a cable to an electronic monitor on the ship that records and displays readings at 1- to 3-second intervals. The survey vessel covers the entire survey area with traverses 50 feet apart towing the magnetometer fewer than 20 feet above the bottom (Clausen & Arnold, 1976). Courses too closely spaced are inefficient and increase the number of insignificant anomalies identified; transects too widely spaced produce incomplete data. The speed of the vessel during the survey determines the spacing of the timed readings along the traverse. Most magnetometers employed in archaeological surveys are sensitive to a magnetic field deviation of less than 1 gamma. Strip-chart records are a permanent documentation of magnetometer data. Significant anomalies can be buoyed during the magnetometer survey, or the site can be revisited by means of navigational readings.

Most sunken vessels contain quantities of metals in their structure or cargo. A Civil War blockade runner, for example, could contain as much as 100 tons of iron (Marx, 1975). Shipwreck sites containing cannons and anchors are also identifiable, at distances as far as 400 to 500 feet from the instrument. In the area of a shipwreck, anomalies greater than 100 gammas represent clusters of large ferromagnetic targets, such as anchors and armament (Clausen & Arnold, 1976). These same targets, located singly, produce readings in the 15 to 35 gamma range. Anomalies of 10 to 15 gammas are caused by small metal artifacts such as spikes and small fittings. "Noise" on the strip chart record can be caused by radar interference, tidal surge, and movement of the sensor head or the boat. Noise appears as large deflections or spikes, and it can prevent the detection of small anomalies.

Metal debris from recent years is also detected by the instrument and can lead to confusion concerning which anomalies require further investigation. A large amount of scattered debris of recent vintage would preclude a useful magnetometer study. A particular concern in DOT archaeological surveys is the effect of a large deposit of magnetic materials, such as a bridge, in the study area. Some methods have been developed to improve the usefulness of the proton magnetometer in proximity to large bridges (Koski-Karell, 1987). Survey courses oriented perpendicular to the bridge reveal a predictable increase on approach to the bridge. Anomalies that occur unrelated to the predictable magnetic gradient caused by the bridge suggest a separate deposit of cultural material. The sensor head will be more sensitive to submerged archaeological relics if deployed immediately above the bottom. Other limitations of magnetometer searches include the natural occurrence of iron in some rock formations and an absence of ferrous materials at the cultural resource site, such as a wreck from the prehistory era (Mazel, 1985).

Clustering, certain configurations, and large amplitude magnetometer readings suggest a deposit of artifacts from sunken vessels. Anomalies caused by shipwrecks tend to be large, with steep gradients from the baseline (Arnold & Clausen, 1975). However, significant historic sites may fail to produce a large anomaly since the magnetometer signal measures the local disturbance in the earth's magnetic field, which is not necessarily proportional to the amount of ferrous material at the site (Kimmel et al., 1984). Analyzing parallel transects using computer-generated contour maps is an extremely efficient method of evaluating magnetic data (Arnold & Clausen, 1975). The method employs navigational and magnetometer data to yield a two- or three-dimensional rendition of the survey area. The locations of anomalies along parallel traverses are readily identified as a group of positive readings, although the size of the anomalies may not be remarkable.

Side-Scan Sonar

Like the proton magnetometer, the side-scan sonar towfish transmits signals to an electronic monitor through a towing cable. Side-scan sonar operates by emitting high-frequency sound waves laterally from the towfish. Sound waves that encounter objects along the bottom are reflected back to the transducers in the towfish, thereby producing an image of the bottom. The intensity of these sonar images depends on the distance of the object from the towfish and the quality of its reflecting surface, both of which affect the quantity of sound waves reflected to the towfish. In most underwater archaeological surveys, the side-scan sonar is operated at a frequency of 100 kilohertz (kHz). An extensive lateral range of 150 to 300 feet is one of the important advantages of this instrument.

The side-scan sonar has some limitations. The speed of the survey vessel must be less than three nautical miles an hour to avoid blurring the side-scan sonar images. Dramatic images can be produced of intact submerged vessels located in areas with smooth bottom conditions, but bottom irregularities interfere with the scanning. Rock outcroppings and other irregularities can be confused with historically significant underwater sites (Rosencrantz et al., 1972; Mazel, 1985). Narrow irregular rivers and creeks are not amenable to survey with a side-scan sonar (Shomette & Eshelman, 1981). Natural riprap, plant debris, and complete coverage of sites by bottom sediment restrict its use in narrow riverine environments. Rough seas may also produce unreadable side-scan records because of blurring caused by movement of the sensor head (Kimmel et al., 1984).

Bathymetric Sonar Recorder (Fathometer)

The bathymetric sonar recorder (depth sounder) is a scanning instrument that measures water depth beneath a vessel and displays it on a visual monitor. The sequence of depth readings produced when a vessel is moving provides a profile of water depth and of the bottom topography along a transect. Discrete elevations of the bottom profile may be associated with wrecks or other large cultural deposits. Depth readings may be used during a survey transect to position the towfish of a proton magnetometer or side-scan sonar in safe, but effective, proximity to the bottom.

Sub-bottom Profiler

The sub-bottom profiler is a sonar device designed to penetrate sediment. It emits a conical beam of low frequency sound waves (3.5 to 7 kHz) aimed below the towed transducer. The sub-bottom profiler has proved to be of limited usefulness in cultural resource investigations. It can be employed in specialized applications such as delineating bottom characteristics and obtaining information for sedimentary stratigraphy studies of inundated sites (Schurer & Linden, 1984). It is also useful to survey the extent and geography of identified sites (Mazel, 1985). However, the distance between survey transects must be closer than with some other sensing devices since the sub-bottom profiler produces a high resolution vertical profile that does not extend far laterally (Schurer & Linden, 1984). Its inability to penetrate gravel and its unreliable readings near gassy deposits usually present in the decaying organic matter at the bottom of rivers, estuaries, or bays prevent its application to surveys of these areas (Anuskiewicz, 1978).

Underwater Metal Detectors

Underwater metal detectors, like their land counterparts, may be used to identify a variety of metals including silver, gold, and bronze. They are available in a hand-held form comparable to many land models or as a towfish with an electronic monitor, similar to other remote sensing instruments. The limitation of underwater metal detectors lies in their restricted range of less than 10 feet, which renders them impractical for large surveys. However, they may be very useful at sites identified with other instruments because divers can conduct localized searches with the metal detector to identify the types of metal present and their distribution.

Remotely Operated Vehicles

Remotely operated vehicles (ROVs) are tethered, remote-controlled submersibles. They are usually equipped with lights, closed-circuit television, and other electronic equipment. ROVs have been used in archaeological work to investigate wrecks in deep water, such as in the recent Titanic expeditions (Ballard, 1987). Use of these instruments is limited by several factors: the turbidity of the water (this blurs or obscures the camera images), current in excess of 1 knot (they have limited propulsion capability), and the high cost of the instruments.

Diver-Conducted Surveys

Almost every underwater archaeological survey will require diver participation either to examine target sites identified with remote sensing instrumentation or to conduct the entire survey. Surveys conducted at extreme depths (greater than 150 feet) where diver contribution is limited by the constraints of safety and efficiency are the exception. If using divers is unsafe because of extreme depth or similar restrictions, ROVs may be used to obtain information about particular sites.

In examining targets localized during the remote instrumentation survey, the function of the diver is to determine the identity and configuration of each site, to formulate a preliminary evaluation of the target's historical significance, and in some cases, to perform limited artifact recovery. Many magnetic anomalies and side-scan targets represent recent debris; divers are able to discern which sites require further investigation. The objective of this portion of the survey is to identify sites that will require avoidance or other mitigative measures during the construction project.

Generally, the archaeological team returns to dive on the targets located during the remote sensing survey. Sites are identified by navigational coordinates and/or buoyed floats distributed during the search. The divers use scuba gear for most of these surveys because of the convenience and the freedom of movement the equipment allows under water. They descend at the sites and localize the source of the anomaly using a search pattern if necessary. The divers may use 2- to 3-foot metal probes and/or underwater metal detectors to identify submerged objects, or they may use small-scale dredging equipment or air hoses to perform a localized excavation to expose submerged objects for identification. The divers attempt to determine the historical significance of the site and obtain documentation of their findings. Documentation may include underwater sketches and maps, carefully recorded field observations, photography, and recovery of sample artifacts. Because the phase IB survey is an overview, divers may wait until phase II to conduct a definitive survey of a site.

Divers may conduct the entire underwater survey for small study areas, surveys in very shallow water where the use of a vessel and towed sensor would be impractical, and sites where extensive metal debris such as pipelines or bridge piles would render magnetometer readings inaccurate. A variety of diver search patterns can be modified to each application. Selection of a search pattern is determined by the number of divers, water visibility, and currents. These search patterns are a systematic means of surveying an area. Large areas are subdivided into grid sections marked by anchored buoys, and each section is surveyed by divers using an appropriate search pattern. Divers use probes or underwater metal detectors to identify artifacts covered by bottom sediment. Though simple, this method is very effective in identifying sites (Shomette & Eshelman, 1981), and with practice, the object struck by a metal probe can be identified as stone, metal, or wood (Marx, 1975). When looking for sites in hard sediment or in sediment deeper than 4 feet, an air probe may be useful. A length of 1-inch diameter plumber's pipe is fastened to an air compressor, and the air stream is directed into the sediment to facilitate penetration by the probe. Coring tubes can also be used to sample sites (Ruppe, 1978). A metal tube is driven into the sediment by divers using sledge hammers until the tube strikes bedrock. The end is plugged, and the pipe containing the sample is retrieved using a lift bag. The sample is examined on the surface for the presence of wood or other fragments. This procedure can result in damage to artifacts and therefore must be used with caution. Sites that warrant further investigation are identified with marker buoys or navigational coordinates.

Search Patterns

The most popular search pattern is the circular search (see Figure 1). A buoy line with a highly visible, graduated marker line extending from it is attached to an anchor at the center of the search area. The diver swims a series of concentric circles holding a taut line attached to the anchor weight. Each circle begins and ends at the marker line. The distance between each circle is determined by underwater visibility. Several divers can participate in the search at one time by taking positions along the line. The circle search method is difficult to perform in a strong current.

Another swimming search pattern is the arc search (see Figure 2). This is particularly applicable to areas with heavy current, but it is well suited also to searching along shorelines, where the anchor point can be on shore. The diver swims laterally, describing an arc. When he reaches a lateral boundary, such as a

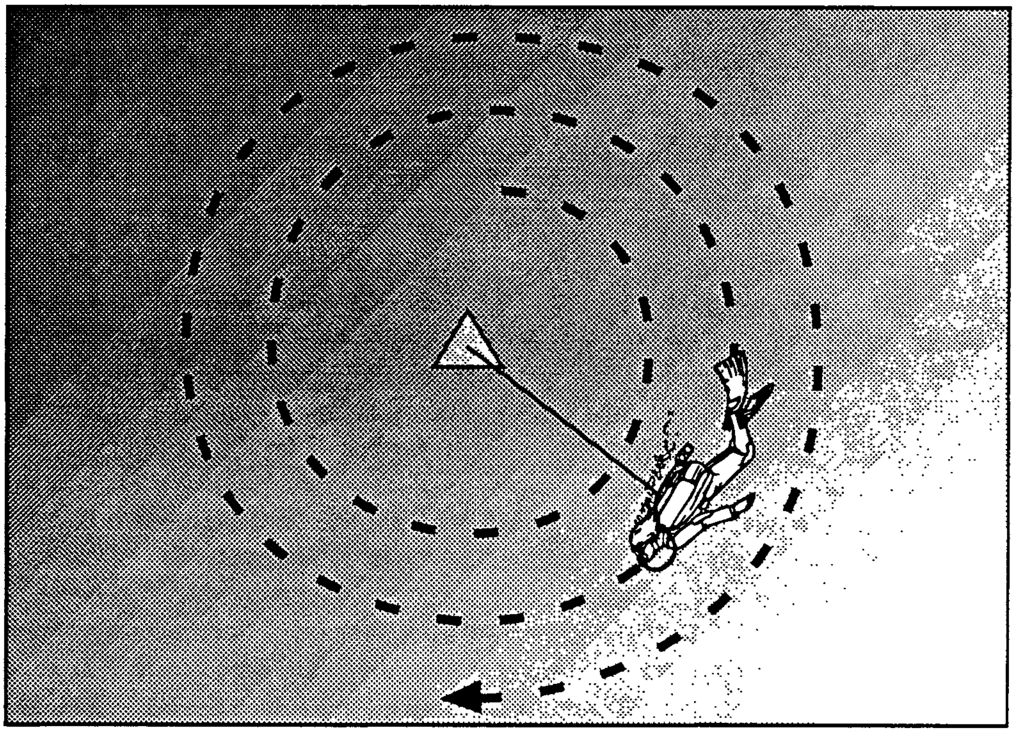

Figure 1. The circular search pattern.

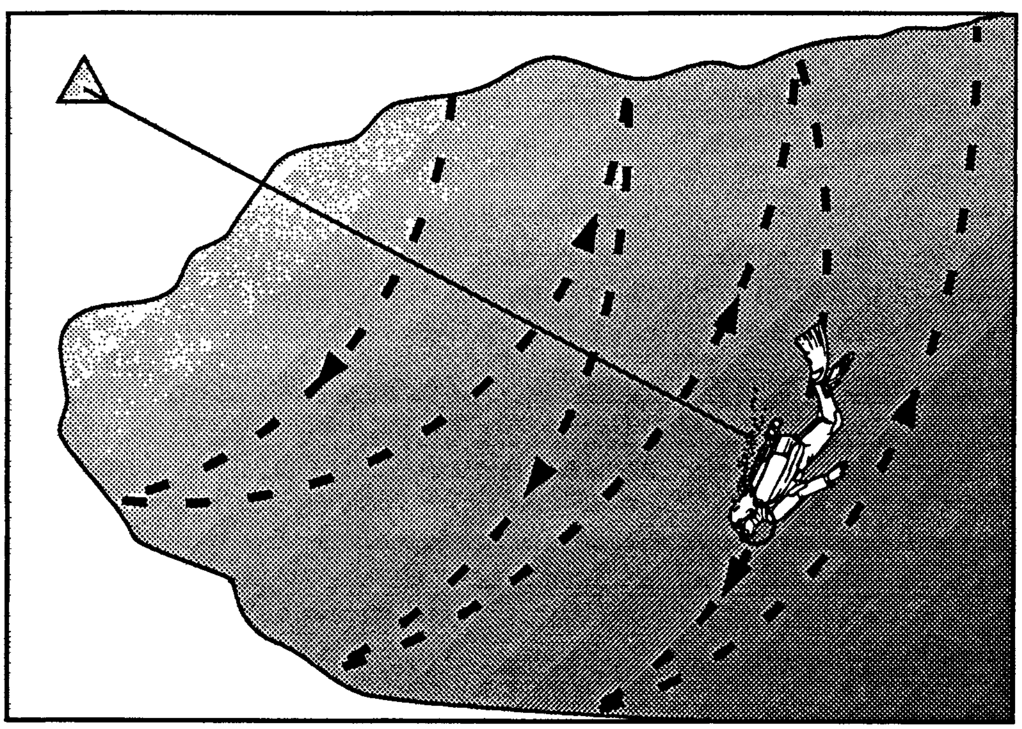

Figure 2. The arc search pattern.

current he cannot swim against or the shoreline, he releases a length of line (determined by visibility) and swims an arc in the reverse direction.

Underwater Photography

Underwater photography is an excellent method of documentation of an underwater archaeological site. In turbid water, its use is compromised since a camera takes clear pictures underwater at distances one-third or less of the visibility available to the diver. Techniques in underwater photography have advanced rapidly in recent years, and several methods have been developed for obtaining acceptable photographs in limited visibility. Fine wide-angle lenses for underwater cameras have been developed that are capable of obtaining clear pictures at a short focal length. Clear water within a container may be interposed between the camera and the subject (McGeehan, 1983). This method is effective for photographing small areas. The size of the clear water box limits the target area, and boxes of larger size are difficult to maneuver by divers under water. Photomosaic techniques have proved very useful for documenting an entire site (Cederlund & Ingelman-Sundberg, 1973). Precise optics and positioning minimize the distortion between segments. Underwater video is also available for site documentation in relatively clear water (Murphy, 1978).

Excavation

A summary of the methods used in archaeological excavation is given below. In general, underwater archaeologists attempt to apply the principles of land archaeology to underwater sites. The overlay of sediment is removed using air or water. Artifacts buried in the sediment may be extracted more easily under water than on land. Rather than digging them out, gentle fanning will often displace the accumulated silt. When a large amount of soil covering the excavation site must be moved, an airlift can be used to draw up the sediment and deposit it elsewhere.

A graduated matrix of metal or plastic bars is frequently assembled and placed over the site to subcompartmentalize it and to provide a locational reference. A new, extremely rapid and accurate mapping technique is the sonic high accuracy ranging and positioning system (SHARPS). The SHARPS system consists of three electron transmitter-receivers that detect signals from a hand-held electronic gun. The archaeologist activates the instrument during survey of the underwater site, and points are recorded by a computer on the support ship for mapping of the site and artifact location.

Excavations are usually of the open type because underwater sediments do not lend themselves to trench excavation. The excavation proceeds by layers, with each tier carefully drawn and mapped before artifact removal. Stratigraphy, or layering of artifacts and sediment, is less evident in underwater sites than on land since heavy objects sink into the soft sediment. However, three dimensional artifact location has yielded significant findings on many wreck sites (Muckelroy, 1975). Artifacts are brought to the surface with lift bags, carried by hand, or drawn up with ropes or in baskets by surface personnel. Fragile items can be packed in boxes of sediment before being conveyed to the surface.

Conservation

The conservation process includes the documentation, analysis, cleaning, and stabilization of recovered artifacts (Hamilton, 1978; Leigh, 1971). It is one of the most important, but often neglected, steps in the recovery of artifacts. Submerged relics may exist in an astonishing state of preservation when discovered. Exposure to sea water, or worse, air, after years of protection under a layer of sediment results in rapid deterioration. Organic materials should be left under their protective covering of sediment until they are to be retrieved and conservation can be initiated, or they will rapidly begin to deteriorate. Most objects must remain in containers of water until the conservation process begins. Unfortunately, simply covering exposed artifacts at the site with sediment or plastic has not proved adequate to delay the process of decay. It is for this reason that a partial or sample excavation of a wreck can be very destructive.

Conservation of marine artifacts is a relatively new science and is continually evolving. Not infrequently, the conservator learns as he attempts to preserve (Barkman & Franzen, 1972; Marx, 1975). Careful experimentation with new techniques may yield more effective, economical, or enduring methods. Conservation methods should be reversible to allow different methods to be used later if necessary (Hamilton, 1976; Barkman & Franzen, 1972). Conservation often creates budget difficulties because it can be a lengthy and expensive process.

Provision must be made for the conservation of all artifacts obtained in a phase II or III investigation prior to recovery. Failure to make these arrangements in advance is irresponsible and may result in serious deterioration of the retrieved objects (Throckmorton & Throckmorton, 1973; Muckelroy, 1978; Hamilton, 1978; Miller, 1985). Conservation of artifacts recovered in association with VDOT projects may be performed by a contractor or by the available state facilities. With prior arrangements, the Mariner's Museum and the Virginia Council for Archaeology, organizations with considerable experience in the preservation of underwater artifacts, may assist with the necessary conservation measures.

The conservation of an object may entail reproducing it, stabilizing the object in its current state, restoring it to its former appearance, or reconstructing it, depending on its condition (Peterson, 1974; Townsend, 1972). Techniques of conservation vary with the material, but even artifacts of the same material may require different treatment depending on condition, planned analysis, and eventual disposition. This is a complex subject only briefly described here for illustrative purposes.

Wood and metal artifacts pose the most difficult conservation problems. Wood that has been immersed for a long period will warp, crack, and powder if it is merely allowed to dry. Instead, the water must gradually be replaced by a substance (typically polyethylene glycol) that strengthens and protects the wood structure. A fungicide is also necessary to prevent decay. The treatment occurs in immersion vats with recirculators or in a container with a set of intermittent sprayers. The process occurs gradually, with increasing concentrations of polyethylene glycol, and may take up to five years of careful attention.

Metals vary in their response to sea water. Size of the metal mass, type of metal alloy, and the proximity of other metal objects that may provide cathodic protection all affect the degree of corrosion of a particular object (Peterson, 1972). Larger metal objects or groups of objects tend to be better preserved than smaller objects or metal sheets. Gold is unchanged, and bronze and copper remain relatively stable following immersion. Silver coins may change into wafers of silver sulfide. Some metals, such as iron, form "concretions" consisting of sea water minerals, deteriorating metal, and materials such as sand, marine organisms, and other artifacts that were nearby during the process (Muckelroy, 1978; Hamilton, 1978). Concretions are generally brought to the surface intact after their original locations on the site are mapped. Most of the work with these artifacts is done in the conservation laboratory. It is difficult to predict the condition or the location of artifacts within concretions. If possible, the concretions should be X-rayed to locate the metal within. The metal may have disappeared, leaving a hollow space behind. In these cases it may be possible to obtain a cast of the lost metal object by injecting latex, plaster, or even lead into the hollow in the concretion that serves as a mold. Artifacts are removed from encrustations by mechanical cleaning. Hammers and chisels are used to dissect along cleavage planes for large objects, and pneumatic chisels and scribes are used for smaller, fragile artifacts (Hamilton, 1978). The location of artifacts within the concretions are carefully recorded. After the artifacts are removed from the concretions, they must promptly undergo conservation treatment. There are a number of methods possible for preserving metal; the most commonly used is electrolytic conversion (Oddy, 1975).

Archaeological Reports

A detailed report is required following an archaeological investigation. Specific guidelines, modeled after those of the National Park Service, are delineated by the Virginia Division of Historic Landmarks for land sites and apply equally well to underwater surveys. The guidelines specify the format of the report and require a thorough account of the investigation that was performed. For underwater investigations, the preparer should include all of the relevant information that is requested for land sites. Additional information should include a detailed description of survey methods used. All anomalies should be reported including position, gamma intensity (strength), characteristics (dipolar, orientation, duration, etc.), and correlations between different survey modes. Recommendations should be made regarding additional investigations and minimizing the impact of the project on cultural resources in the area.

ADMINISTRATIVE APPROACHES

It is evident from state and federal legislation that state DOTs are responsible for the identification and location of cultural resources that may be affected by agency-sponsored projects. This is no less true for submerged than for land sites. It is therefore incumbent on these agencies to conduct a survey adequate to locate underwater sites that may be included in a project area.

A number of state and federal agencies have hired archaeologists to conduct in-house archaeological surveys and to ensure quality control of contracted work. Some government agencies, such as the Army Corps of Engineers, employ staff archaeologists that are experienced in underwater archaeology, but most agencies' archaeologists are trained in land techniques and have little knowledge of this subdiscipline. The technical specialization and expense of underwater archaeology, however, mandate informed administration of underwater surveys by construction agencies.

Phase investigations of underwater cultural resources may be conducted very similarly to the procedure currently in effect for VDOT land surveys involving a combination of in-house and contracted efforts. In this approach, an initial project assessment is conducted by in-house VDOT archaeologists in the Environmental Division. Projects requiring an environmental assessment (EA) or an environmental impact statement (EIS) are generally contracted but are actively supervised by VDOT archaeologists (Kelly, 1988). Most phase I surveys are performed by the VDOT staff, with phase II primarily contracted. Mitigative measures for sites eligible to be placed on the National Register affected by VDOT projects on land have usually involved phase III data recovery by a contracted archaeologist.

Mitigation measures most commonly include site avoidance or data recovery. Avoidance has been an uncommon mode of mitigation for land VDOT projects (Kelly, 1988). An alternative uncommonly employed on land is burial of the site under fill soil (Kelly, 1988). Its limitation for terrestrial sites relates to concern that leachate in the fill soil could damage the site and reduce the information available at a future excavation. Considering the unique protective qualities of sediment coverage for underwater archaeological sites, the method may have more application for underwater sites.

The expense of excavation for underwater sites should reemphasize the importance of avoidance as a mitigation measure. Early surveys and careful planning are needed for projects with in-water components. The expense and specialization of underwater technology preclude most agencies from conducting their own archaeological studies. Similar to the VDOT approach to land surveys, initial investigation and phase I literature searches could be performed by the DOT staff, with phase IB, II, and III underwater surveys contracted under agency supervision.

Contract Archaeology

Cultural resource management efforts can produce significant archaeological contributions (Shiffer & House, 1977; Gardner, 1978; King, 1971). The majority of the work in underwater archaeology in the United States and some of the most significant advances in the field have been through cultural resource management programs at the state or federal level (Lenihan, 1983). Regional surveys have been the main thrust of cultural resource management programs in the National Park Service and the construction-oriented government agencies. In considering the eligibility of each site encountered for the National Register, a wide variety of sites are subjected to research scrutiny (Sharrock & Grayson, 1979). The survey method yields valuable regional information about historical shipping activities with minimal site disturbance (Murphy, 1983). Changing trends in noncontract underwater archaeology are highlighting the important role of regional surveys as well. This is similar to the conservation movement in land archaeology that uses surveys to locate and inventory sites with excavation reserved for selected sites (Gould, 1983).

Recently, underwater archaeologists have been questioning the wisdom of widespread excavation of wreck sites for a number of reasons. Excavating a cultural resource site by definition destroys it (Lenihan, 1983; Lipe, 1974; Judge, 1979). It has been commented that the activities most damaging to a wreck site are treasure hunting and archaeological excavation, although archaeological excavation provides the "compensation" of a report (Lenihan, 1983). Unexplored wreck sites are in limited supply, and their number is rapidly dwindling. Furthermore, as new underwater archaeological methods are developed, improved methods of excavation and conservation will undoubtedly extend current capabilities for data gathering and artifact conservation (White, 1987; Miller, 1985; Throckmorton, 1985). Much can be learned from excavation of selected sites, but serious consideration should precede the complete disarticulation of a site. Even during the excavation, considerable disintegration of the fragile organic wreck components occurs (Throckmorton, 1985).

Some feel that the detailed exploration of a single archaeological site is a questionable application of limited public funds (Lenihan, 1974; Anuskiewicz, 1978). Underwater archaeological excavation can be expensive and complicated (Wade, 1981). The estimated cost of raising and restoring the Monitor, for example, is $40 million (White, 1987). Whenever possible, conservation and avoidance is the preferred choice for DOT cultural resource management. Encountering a site during a project may obligate the DOT to certain recovery measures, but the avoidance of such a budget-straining event is the goal of preconstruction archaeological surveys. From the standpoint of the effective use of public funds, each site must be individually evaluated for its potential contribution to archaeological knowledge prior to its excavation. Although much is known about some aspects of marine and cultural history, data on other periods are lacking, and public-funded efforts in underwater archaeology should be directed toward rectifying these deficits rather than duplicating available information.

Cultural resource management of sites encountered in agency surveys needs to be individualized based on the anticipated impact of the project on the site, the estimated value and condition of the site, and feasible mitigation. Certain sites may not yield enough information to justify the effort and expense of extensive excavation.

Research-oriented concepts and questions should provide the framework for any excavation that is required (Raab & Klinger, 1977; Throckmorton, 1985). This approach encourages directed research that contributes to the archaeological data base. Total data recovery even of a site that will be destroyed is not feasible or useful (Shiffer & House, 1977).

The role of a DOT archaeological survey team is to obtain information on the location, identification, and condition of sites in the survey area. The decision concerning appropriate mitigation measures for unavoidable sites is made by state archaeologists and government officials. Should excavation be the only mitigation alternative available, there are resources within the state that may be able to assist. In Virginia, agencies such as the Virginia Institute of Marine Science, the Virginia Marine Resources Commission, the Virginia Historic Landmarks Commission,and the Mariner's Museum have professionals with experience in underwater excavation and conservation methods. In consideration of the vulnerability of recovered submerged artifacts to rapid deterioration, arrangements for conservation should be approved by the State Historic Preservation Officer prior to excavation.

Archaeologically Significant Sites

The criteria for defining an archaeologically significant site have been a matter of considerable debate among archaeologists. In general, any site that provides information about man's past, especially if it is not obtainable from other sources, has potential archaeological significance (Marx, 1975). The problem faced by federally funded agencies is that significance is a dynamic concept. Agencies are required to anticipate whether a site has the potential of attaining significance. Sites identified in a project area must be considered to be of value until preliminary investigation reveals otherwise. The most convenient method for assessment of the archaeological significance of sites identified during an agency preconstruction survey is by use of the National Register criteria.

Numerous considerations are included in the National Register criteria. The system provides consistent guidelines, familiar to most archaeologists, for assessment of a site. These criteria can be adapted to the evaluation of underwater sites as indicated in the *National Register Bulletin* No. 20 (Delgado et al., 1987). Such consistency facilitates the recognition of significant sites by those untrained in the subdiscipline of underwater archaeology. It also provides a framework for justification of agency decisions regarding site significance.

Survey Methodology

A standard approach that will apply to all applications cannot be formulated since the methods used to survey each project site need to be individualized. In each case, the proposed approach should be designed and discussed with the State Historic Preservation Officer. Several factors must be considered in the selection of an underwater survey methodology. These include the size of the survey area, the water conditions, the methodology chosen for the study, and the type of project proposed.

The most common methods that will be used are remote sensing surveys in combination with the evaluation of sites by divers. Effective underwater archaeological surveys of large areas often employ a combination of instruments to optimize particular characteristics of each device. A popular combination is the proton magnetometer, the side-scan sonar, and the bathymetric depth recorder (Koski-Karell, 1987; Arnold, 1976; Kimmel et al., 1984). Computer analysis is often used for large surveys (Arnold, 1976) to allow comparison of information from different types of remote survey instruments and between adjacent lanes of the search area. Diver investigations of sites identified by remote instrument surveys should provide an adequate survey for the presence of cultural resources (Cummings & Lenihan, 1974). Diver searches with hand-held probes or coring instruments are effective in small areas or where the use of remote sensing instruments is not feasible (Marx, 1975; Ruppe, 1978).

Sites that project above the bottom contour represent the most easily locatable sites. Considerable survey information can be obtained with side-scan sonar. Some government agencies use this method exclusively or as an early screening method. It is commonly employed for areas that will be used for the deposit of dredged material.

Remote surveys using only a proton magnetometer with an investigation of identified anomalies by divers are also used by some construction agencies. The magnetometer is a good survey instrument, although it may result in a large number of anomalies that are difficult to interpret before diver evaluation. It has the advantage that it identifies sites buried under sediment, which renders it useful for sites in the project area where the bottom sediment will be disrupted.

The environment of some construction sites precludes the use of certain survey methods. These include the limitations of a magnetometer where a large amount of ferromagnetic debris is present and the difficulty of obtaining a meaningful side-scan sonar profile in areas with irregular bottom profiles or in narrow riverine environments (see "Survey Methods" section). Where a remote sensing survey is not feasible, search patterns may be conducted by divers with probing instruments or hand-held magnetometers or metal detectors.

Considerable debate has centered on whether all anomalies located during the remote surveys should be examined in a cultural resource management study. Hundreds of anomalies may be identified; examination of all of them is expensive, labor intensive, and time-consuming. A cost assessment of a magnetometer anomaly investigation was performed approximately 10 years ago on one survey project. The careful examination of an anomaly cost 1 percent or less of site excavation cost, and 35 percent of anomalies investigated were historical sites (Arnold,1976). The probability that anomalies represent sites of significant cultural material depends on the historical potential of the area, the amount of contaminating ferromagnetic debris in the area, and other factors. It has been argued that examination of all anomalies is unnecessary and that selective sampling supplies sufficient information (Anuskiewicz, 1978). The decision to investigate a site could depend on the character of the anomaly and the probability, determined from the phase IA investigation, of culturally significant deposits in the area. However, it must be noted that the goal of the survey is to identify any cultural deposit in the project area and that the character of the anomaly does not always correspond to its significance. If selective sampling is chosen, it must be based on information clearly predictive of the location of archaeological sites. Surveys for VDOT projects have been challenged in the past by outside contractors for failure to examine all sites (Koski-Karell, 1984). Despite the expense of an initial survey, it is less than the potentially staggering cost of rescue excavation and project delays.

It is difficult to identify an individual anomaly as representing a significant cultural resource (Kimmel et al., 1984). The character of an anomaly is dependent on many factors, including noise, mass, orientation, and metal content. However, small or poorly defined anomalies are as likely to be associated with significant cultural resources as the others; so as many anomalies should be investigated as possible (Kimmel et al., 1984). The Army Corps of Engineers criteria for investigating anomalies could be adopted for VDOT surveys. A minimal 5 to 10 gamma pulse over several seconds on relatively noise-free readings or a duration and pattern distinct from the noise background is considered potentially indicative of a submerged cultural resource. Anomalies 5 gammas or less located on only one survey lane are eliminated from further analysis.

A grouping of anomalies on the basis of similar characteristics is a useful guide for subsequent reconnaissance: group 1, a wreck is visible on side-scan sonar; group 2, proton magnetometer anomalies that are associated with above bottom components on side-scan sonar; group 3, large anomalies with significant size, duration, and form; group 4, small anomalies suggestive of a single source; and group 5, poorly defined, small anomalies (Kimmel et al., 1984). The grouping system cannot be used to indicate the significance of each anomaly since a target from any group is as likely to be archaeologically significant as any other. The categories do, however, indicate the relative ease of location of the target and its recovery by divers, which facilitates the planning of further efforts.

Survey Area

One of the most important issues preliminary to an underwater survey for a construction project is determination of the area that may be adversely affected by the project. The effect of construction in the area is more difficult to assess for underwater than for land sites. Even the effects of the environment on an underwater site are not well understood (Murphy, 1983). Studies have shown that conditions remain fairly stable on the bottom of a body of water despite turbulence and wave action at the top (Muckelroy, 1978). Therefore, under most water conditions, disturbance of sites by activity on the surface such as barge motors would not be anticipated. An activity that adds overburden to a site may have a minimal effect since silt and sand actually protect submerged artifacts. However, denuding a site through propwash or dredging can lead to its rapid deterioration (Lenihan, 1983). In general, the survey area should encompass the full extent of the bottom that will be directly disturbed during construction.

The size of the survey area depends on the configuration of the proposed project and the anticipated effects of construction on the surrounding area. If the proposed area is a tunnel, the entire corridor must be surveyed. In the case of a bridge with a few piers in the water, evaluation of several discrete locations may be justified unless a survey of the entire corridor is cost-effective and desirable for other reasons. Usually a dredged channel in the project area need not be surveyed because archaeological sites in the channel would have been previously disrupted during the dredging process.

CONCLUSIONS AND RECOMMENDATIONS

Departments of transportation, like other government agencies, are regulated by legislation protecting cultural resources in the area of a construction site. This protection extends to cultural resources underwater as well as on land. The agency is required to conduct preconstruction surveys to locate the cultural resources in the area and minimize any disruption caused by the project.

The techniques of underwater archaeology are relatively new, unique, and unfamiliar to many agency officials responsible for project administration. Compared with land archaeological methods, underwater archaeological procedures are extremely expensive. Consequently, underwater archaeological preconstruction surveys should be conducted early in the project before the final route is determined and alternate alignments are still feasible. Avoidance of the cultural resource site is the optimum mitigative measure for projects that extend over water both for conservation of the site and financial considerations. If a salvage underwater excavation becomes necessary because a National Register eligible site will be destroyed during the project, specific goals and questions should be formulated, and the excavation must be coordinated through close cooperation between agency officials, contractors, and the state historic preservation officer.

Each project site requires a survey methodology designed for its particular characteristics. The literature search preceding the survey will indicate the type and location of cultural resources in the project area. The extent of the survey and the methodology employed will depend on the disruption of the bottom sediment anticipated during the project and the applicability of various survey tools to the site. A combination of several survey techniques may be desirable to optimize the information obtained. A frequently used combination for a comprehensive survey is the proton magnetometer, the side-scan sonar, and the bathymetric depth recorder.

REFERENCES

Andahazy, W. J., Everstine, D. G., and Hood, B. R. (1976). Magnetic search for shipwrecks from the Battle of Yorktown. *Sea Technology* 17: 19-22.

Anuskiewicz, R. J. (1978). The Exhorbitant Cost of Underwater Remote Sensing and Research: A Public and Federal Government Cultural Research Management Dilemma. In *Beneath the Waters of Time: The Proceedings of the Ninth Conference on Underwater Archeology*, ed. J. B. Arnold, III, 183-185. Austin, Texas: Texas Antiquities Committee.

Arnold, J. B., III. (1976). *An Underwater Archeological Magnetometer Survey and Site Test Excavation Project off Padre Island, Texas*. Texas Antiquities Committee Publication No. 3. Austin, Texas.

Arnold, J. B., III, and Clausen, C. J. (1975). A magnetometer survey with electronic positioning control and calculator-plotter system. *International Journal of Nautical Archaeology and Underwater Exploration* 4: 353-366.

Arnold, J. B., III, and Weddle, R. (1978). *The Nautical Archeology of Padre Island: The Spanish Shipwrecks of 1554.* New York: Associated Press.

Baddeley, A. D. (1966). The influence of depth on the manual dexterity of free divers. *Journal of Applied Psychology* 50: 81-85.

Ballard, R. D. (1987). Epilogue for Titanic. *National Geographic* 172: 454-463.

Barkman, L., and Franzen, A. (1972). The Wasa: Preservation and Conservation. In *Underwater Archaeology, A Nascent Discipline*, 231-242. Paris: UNESCO.

Bascom, W. (1971). Deep-water archaeology. *Science* 174: 261-269.

Bascom, W. (1976). *Deep Water, Ancient Ships.* Garden City, N.Y.: Doubleday & Co., Inc.

Bass, G. F. (1966). *Archaeology Underwater.* London: Thames and Hudson.

Bass, G. F. (1976). The Cornwallis Cave Shipwreck. Richmond, Virginia: Virginia Historic Landmarks Commission.

Bass, G. F., and Katzev, M. L. (1968). New tools for underwater archaeology. *Archaeology* 21: 165-173.

Bass, G. F., and van Doornick, F. H. (1971). A Fourth century shipwreck at Yassi Ada. *American Journal of Archaeology* 75: 27-37.

Blackman, D. J., ed. (1971) *Marine Archaeology, Proceedings of the Twentythird Symposium of the Colston Research Society.* London: Butterworths & Co.

Bower, R. W. (1982). *Legal aspects of historic preservation in highway and transportation programs.* Report No. NCHRP 138. Washington, D.C.: Transportation Research Board.

Broadwater, J. D. (1980). The Yorktown Shipwreck archaeological project: results from the 1978 survey. *International Journal of Nautical Archaeology and Underwater Exploration* 9: 227-236.

Broadwater, J. D. (1988). Yorktown shipwreck. *National Geographic* 173: 804-823.

Broadwater, J. D., Sands, J. O., and Watts, G. P., Jr. (1975). Report of an archaeological survey of several shipwreck sites near Yorktown, Virginia. Richmond, VA: Virginia Historic Landmarks Commission.

Cederlund, C. O., and Ingelman-Sundberg, C. (1973). The excavation of the Jutholmen wreck, 1970-1971. *International Journal of Nautical Archaeology and Underwater Exploration* 2: 301-327.

Clausen, C. J. (1966). The proton magnetometer: its use in plotting the distribution of the ferrous components of a shipwreck site as an aid to archeological interpretation. *The Florida Anthropologist* 14: 2-3.

Clausen, C. J., and Arnold, J. B., III. (1976). The magnetometer and underwater archaeology. *International Journal of Nautical Archaeology and Underwater Exploration* 5: 159-169.

Cockrell, W. A. (1973). Remains of early man recovered from spring cave. *Archives and History News* 4:2.

Coles, J. (1984). *The Archaeology of Wetlands*. Edinburgh: University Press.

Colquhoun, D. J., Brooks, M. J., Michie, J., Abbott, W. B., Stapor, F. W., Newman, W., and Pardi, R. R., (1981). Location of archaeological sites with respect to sea level in the southeastern United States. *Striae* 14: 144-150.

Cummings, C., and Lenihan, D. (1974). Submerged cultural resources on the outer continental shelf. In *Underwater Archeology in the National Park Service, A Model for the Management of Submerged Cultural Resources*, ed. D. Lenihan, 89-95. Washington, D.C.: Department of the Interior.

Daily Press. (1979). Yard site added to Register. August 14.

Delgado, J. P., and a National Park Service Maritime Task Force. (1987). Nominating historic vessels and shipwrecks to the National Register of Historic Places. *National Register Bulletin* No. 20. Washington, D.C.: NationalPark Service.

Emery, K. O., and Edwards, R. L. (1966). Archaeological potential of the Atlantic Continental Shelf. *American Antiquity* 31: 733-737.

Ferguson, H. L. (1939). Salvaging Revolutionary relics from the York River. *William and Mary Quarterly Historical Magazine* 19: 257-271.

Frederick, J. (1982). *Diver's Guide to River Wrecks*. Milwaukee, Wisconsin: Rowe Publ. Co.

Gardner, W. M. (1978). Comparison of ridge and valley, Blue Ridge, Piedmont, and Coastal plain archaic period site distribution: an idealized transect (preliminary model). Paper read at the 8th Middle Atlantic Archeological Conference, Rehoboth Beach, Delaware.

Gardner, W. M. (1979a). Paleoindian settlement pattern and site distribution in the Middle Atlantic. Paper read at the 1978-79 Anthropological Society of Washington Meetings, Washington, D.C.

Gardner, W. M. (1979b). Euroamerican settlement pattern in the Shenandoah Valley. Paper read at the 9th Middle Atlantic Archeological Conference, Rehoboth Beach, Delaware.

Goggin, J. M. (1960). Underwater archaeology: its nature and limitations. *American Antiquity* 25: 348-354.

Gould, R. A. (1983). Looking below the surface: shipwreck archaeology as anthropology. In *Shipwreck Anthropology,* ed. R. A. Gould, 3-22. Albuquerque, New Mexico: University of New Mexico Press.

Hall, E. T. (1972). Wreck prospecting by magnetometer. In *Underwater Archaeology, a Nascent Discipline.* Paris: UNESCO.

Hamilton, D. L. (1976). The conservation of metal objects from underwater sites; a study in methods. Texas Antiquities Committee, Publ. No. 1. Austin, Texas.

Hamilton, D. L. (1978). Conservation procedures utilized for the sixteenth century Spanish shipwreck materials. In *The Nautical Archaeology of Padre Island: The Spanish Shipwrecks of 1554,* J. B. Arnold, III, and R. Weddle, 417-440. New York: Academic Press.

Hole, F. D. (1961). A classification of pedoturbations and some other processes and factors of soil formation in relation to isotropism and anisotropism. *Soil Science* 91: 375-377.

Jenny, J. (1983). *Advanced Wreck Diver's Manual.* Milwaukee, Wisconsin: Rowe Publ. Corp.

Johnston, P. F., Sands, J. O., and Steffy, J. R. (1978). The Cornwallis Cave Shipwreck, Yorktown, Virginia: Preliminary Report. *International Journal of Nautical Archaeology and Underwater Exploration* 7: 205-226.

Judge, W. J. (1979). Minimal impact archaeology: a plea for a formalized ethic. In *1979 Proceedings of the American Society for Conservation Archaeology,* ed. C. R. Cummings, 1-9.

Kelly, V. (1988). *VDOT Compliance with Section 106 of the National Historic Preservation Act.* Charlottesville, Virginia: Virginia Transportation Research Council.

Kimmel, R., Wall, R., and Israel, S. (1984). *A Phase I remote sensing cultural resources reconnaissance of Wolf Trap and Rappahannock Shoals alternate disposal areas, Chesapeake Bay, Virginia, Baltimore Harbor and Channels 50 foot study.* Norfolk, Virginia: Army Corps of Engineers.

King, T. F. (1971). A conflict of values in american archaeology. *American Antiquity* 36: 255-262.

Koski-Karell, D. (1984). Letter to author January 20, 1984.

Koski-Karell, D. (1976). Underwater surveys and the proton magnetometer. *Quarterly Bulletin of the Archeological Society of Virginia* 30: 192-193.

Koski-Karell, D. (1987). *Phase IA Underwater Cultural Resources Background Investigation for the York River Crossing Study.* Arlington, Virginia: Karell Archeological Services.

Kraft, J. C. (1976). Geological reconstructions of ancient coastal environments in the vicinity of the island field archaeological site, Kent County, Delaware. *The Pre- European Archaeology of Delaware, Transactions of the Delaware Academy of Science* 5:83-118.

Leigh, D. (1971). Reasons for preservation and methods of conservation. In *Marine Archaeology, Proceedings of the Twentythird Symposium of the Colston Research Society*, D. J. Blackman, 203-218. London: Butterworths & Co.

Lenihan, D., ed. (1974). *Underwater Archeology in the National Park Service: A Model for the Management of Submerged Cultural Resources.* Washington, D.C.: Department of the Interior.

Lenihan, D. J. (1983). Rethinking shipwreck archaeology: a history of ideas and considerations for new directions. In *Shipwreck Anthropology,* ed. R. A Gould, 37-64. Albuquerque, New Mexico: University of New Mexico Press.

Lipe, W. D. (1974). A conservation model for American archaeology. *The Kiva* 39: 213-244.

Margolin, S. G. (1987). Civil war legacy beneath the James. *Archaeology* Sept./Oct. 50-57, 84.

Marx, R. F. (1975). *The Underwater Dig, An Introduction to Marine Archaeology.* New York: Henry Z. Walck, Inc.

Mathewson, R. D., III. (1985). *Archaeological Treasure: The Search for Nuestra Senora de Atocha.* Key West, Florida: Seafarers Heritage Library.

Mazel, C. (1985). Technology for marine archaeology. *Oceanus* 28: 85-89.

McCartney, M., and Luccketti, N. (1978). National Register of Historic Places Inventory Nomination Form for Chickahominy Shipyard Archaeological Site, as presented to the Virginia Historic Landmarks Commission.

McGeehan, D. D. (1983). *Underwater Photography for Bridge Inspections.* Charlottesville, Virginia: Virginia Transportation Research Council.

Miller, J. W., ed. (1979). *NOAA Diving Manual.* Washington, D.C.: Department of Commerce.

Miller, E. M. (1985). The Monitor National Marine Sanctuary. *Oceanus* 28: 68-71.

Miller, E. M. (1988). A time for decision on submerged cultural resources. *Oceanus* 31: 25-34.

Muckelroy, K. W. (1975). A systematic approach to the investigation of scattered wreck sites. *International Journal of Nautical Archaeology and Underwater Exploration* 4: 174-190.

Muckelroy, K. W. (1978). *Maritime Archaeology.* New York: Cambridge University Press.

Murphy, L. (1978). Specialized methodological, technological, and physiological approaches to deep water excavation of a prehistoric site at Warm Mineral Springs, Florida. In *Beneath the Waters of Time: The Proceedings of the Ninth Conference on Underwater Archaeology,* ed. J. B. Arnold, III, 123-126. Austin, Texas: Texas Antiquities Committee.

Murphy, L. (1983). Shipwrecks as a data base for human behavioral studies. In *Shipwreck Anthropology*, ed. R. A. Gould, 65-89. London: Butterworths & Co.

Oddy, W. A. (1975). A review of procedures for the conservation of cast and wrought iron found on the sea-bed. *International Journal of Nautical Archaeology and Underwater Exploration* 4: 367-370.

Peck, D. W. (1978). Artifacts from submerged areas of the Chesapeake Bay coastline. *Maryland Archeology* 14: 1-10.

Peterson, C. (1974). The nature of data from underwater archaeological sites. In *Underwater Archeology in the National Park Service, A Model for the Management of Submerged Cultural Resources,* ed. D. Lenihan, 62-65. Washington, D.C.: Department of the Interior.

Peterson, M. L. (1972). Materials from post-fifteenth century sites. In *Underwater Archaeology, a Nascent Discipline*, 243-250. Paris: UNESCO.

Raab, L. M., and Klinger, T. C. (1977). A critical appraisal of "significance" in contract archaeology. *American Antiquity* 42: 629-634.

Rosencrantz, D. M., Klein, M., and Edgerton, H. E. (1972). The uses of sonar. In *Underwater Archaeology, a Nascent Discipline*, 257-270. Paris: UNESCO.

Ruppe, R. J. (1978). Underwater site detection by use of a coring instrument. In *Beneath the Waters of Time: The Proceedings of the Ninth Conference on Underwater Archeology*, ed. J. B. Arnold, III, 119-121. Austin, Texas: Texas Antiquities Committee.

Sands, J. O. (1983). *Yorktown's Captive Fleet.* Charlottesville, Virginia: University of Virginia Press.

Schurer, P. J., and Linden, R. H. (1984). Results of a sub-bottom acoustic survey in a search for the Tonquin. *International Journal of Nautical Archaeology and Underwater Exploration* 13: 305-309.

Sharrock, F. W., and Grayson, D. K. (1979). Significance in contract archaeology. *American Antiquity* 44: 327-328.

Shiffer, M. B., and House, J. H. (1977). Cultural resource management and archaeological research: the Cache River Project. *Current Anthropology* 18: 43-53.

Shomette, D. G., and Eshelman, R. E. (1981). The Patuxent River submerged cultural resource survey Drum Point to Queen Anne's Bridge, Maryland. *Maryland Historic Trust Manuscript Series* No. 13.

Throckmorton, P. (1969). Ancient ship yields new facts and a strange cargo. *National Geographic* 135: 282-300.

Throckmorton, P. (1985). Marine Archaeology. *Oceanus* 28: 2-12.

Throckmorton, P., and Throckmorton, J. (1973). The Roman wreck at Pantano Longarium. *International Journal of Nautical Archaeology and Underwater Exploration* 2: 243-266.

Townsend, S. P. (1972). Standard Conservation Procedures. In *Underwater Archaeology: A Nascent Discipline*, 251-256. Paris: UNESCO

U.S. Congress, Office of Technology Assessment. (1987). *Technologies for Underwater Archaeology and Maritime Preservation--Background Paper,* OTA-BP-E-37. Washington,D.C.: U.S. Government Printing Office.

Virginia Historic Landmarks Commission Research Center for Archaeology. (1985). *Guidelines for Preparing Archaeological Resource Management Report.* Richmond, Virginia.

Vreeland, J. M. (1978). Fibers and fabrics of the 1554 shipwreck (41 KN 10). In *The Nautical Archaeology of Padre Island: The Spanish Shipwrecks of 1554,* ed. J. B. Arnold, III and R. Weddle, 417-440. New York: Academic Press.

Wade, N. (1981). Galleon yields gold, silver, and archaeology. *Science* 212: 1486-1487.

White, D. F. (1987). 125 Years after her famous battle at sea: can we salvage the Monitor? *Parade Magazine*, December 20.

Wittkofski, J. M. (1981). A summary of cultural resources and environmental variables of the Virginia Eastern Shore. Paper read at the Middle Atlantic Area Session of the Middle Atlantic Archaeological Conference in Ocean City, Maryland.

Wood, R. W., and Johnson, D. L. (1978). A survey of disturbance processes in archaeological site formation. In *Advances in Archaeological Method and Theory* Vol. 1, ed. M. B. Schiffer. New York: Academic Press.

APPENDIX A

FEDERAL AND STATE ARCHAEOLOGY LEGISLATION

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FEDERAL AND STATE ARCHAEOLOGY LEGISLATION

The following is a summary of the current Federal and Virginia State legislation that pertains to cultural resource management by construction–oriented agencies (Brace & Klein, 1981; McGimsey, 1972; Kelly, 1988).

Federal Legislation

- The Antiquities Act of 1906 was enacted to protect historic places by authorizing the President to set those located on federal land aside as national monuments. The act does not extend to the protection or acquisition of sites on nonfederal land nor to the review of federal projects that affect historic sites.
- The Historic Sites Act of 1935 declares the national policy of preservation of historic sites that have national significance. It authorizes the Secretary of the Interior to acquire and maintain historic sites of national significance. The National Historic Landmark Program was initialed by this Act.
- The Reservoir Salvage Act of 1960 provides for the preservation of historical and archaeological data (as described in the Historic Sites Act of 1935) that might be "irreparably lost or destroyed as the result of flooding, the building of access roads, the erection of workmen's communities, the relocation of railroads and highways, and other alterations of the terrain caused by erection of a dam," or as amended, of any federally assisted or licensed activity.
- The National Historic Preservation Act of 1966 is the most comprehensive historic preservation legislation. One significant aspect of this act is that it extends protection to historic sites of not only national but also local significance. It establishes a National Register of Historic Places under the Secretary of the Interior. Criteria for inclusion in the Register are found in Appendix B. Section 106 of the Act, as amended, protects historic properties from disturbance by federal projects. Any federal action that will affect a district, site, structure, or object included in, nominated to, or eligible for inclusion in the National Register must be reviewed by the Federal Advisory Council on Historic Preservation. A State Historic Preservation Officer (SHPO), designated by the governor, reviews documented DOT archaeological conclusions prior to approval of a project. The FHWA is responsible for DOT compliance with Section 106 of this act for federal–aid projects.
- The Department of Transportation Act of 1966 forbids federal approval of transportation projects using land associated with a historic site eligible

for or included in the National Register unless there is no feasible and prudent alternative location for the construction project. Every effort must be made in that instance to minimize the disturbance to the site.

- National Environmental Policy Act of 1969 (NEPA) provides for federal protection of "historic, cultural, and natural aspects of our national heritage." Its protection is extended through the Environmental Impact Statement requirement of Section 102 of the Act. NEPA was extended by Executive Order No. 11593, "Protection and Enhancement of the Cultural Environment." The Order stated a federal policy of locating and nominating sites for inclusion in the National Register.
- The Archaeological and Historic Preservation Act of 1974 authorizes federal agencies to survey and recover archaeological data endangered by projects under federal jurisdiction. The act further provides for funding compensation for project delays through the Department of the Interior.
- The Archaeological Resources Protection Act of 1979 clarifies issues in the Antiquities Act of 1906 and prohibits disturbance of archaeological resources on federal land without a federal permit.
- The Protection of Historic and Cultural Properties Act of 1979 consists of the regulations issued by the Advisory Council on Historic Preservation to ensure compliance with the National Historic Preservation Act.
- The Criteria for Comprehensive Statewide Historic Surveys and Plans was issued in 1977 by the Heritage Conservation and Recreation Service to provide for the designation of a State Historic Preservation Officer by the governor of each state for compliance with the National Historic Preservation Act.
- Abandoned Shipwreck Act of 1987 gives the states the responsibility for a range of underwater resources, including abandoned shipwrecks. It establishes a policy of requiring states to allow for recovery of underwater artifacts "consistent with the protection of historical values and environmental integrity of the shipwrecks and the sites." State of Virginia Laws have been enacted in Virginia protecting land and underwater archaeological sites. A citation in the Code of Virginia, passed in response to the federal Historic Preservation Act, created the Landmarks Committee to conduct surveys of state or nationally significant structures. The committee has the power of eminent domain. Within the Landmarks Committee, a Research Center for Historical Archaeology was established at The College of William and Mary under the direction of an archaeologist to perform archaeological research for the state.
- The Virginia Antiquities Act establishes a policy in Virginia of identification, evaluation, preservation, and protection of sites and objects of antiquity with historic value that are located on state–controlled land. The state reserves the right of field investigation and ownership of artifacts located on state–controlled land sites or zones and provides for permits to be issued for archaeological excavation. The Department of Conservation

and Historic Resources may designate state archaeological sites or zones on any property except for certain local government restrictions.

- The 1986 Appropriations Act applies to state–funded projects that may disturb archaeological or historic sites. Under this act, the VDOT is required to account to the Department of Conservation and Historic Resources for adverse impact on state–owned historic properties already listed on the Virginia Landmarks Register.
- The Road and Bridge Specifications of Virginia requires the suspension of a construction project when historic or prehistoric sites of archaeological significance are encountered. Protection and excavation of the sites are provided for if necessary.
- The Underwater Properties Act passed in 1976 is legislation specifically protecting underwater archaeological sites. The Virginia Marine Resources Commission and the position of State Underwater Archaeologist was established by the act. Under Article 10–261–5, underwater historic property is defined as "any submerged shipwreck, vessel, cargo, tackle, or underwater archaeological specimen, including any object found at underwater refuse sites or submerged sites of former habitation, that has remained unclaimed on the state–owned subaqueous bottom and has historic value as determined by the Department of Conservation and Historic Resources." Underwater historic property is owned by the State, and its preservation and protection is the responsibility of all state agencies. All recovery operations on historic underwater sites require a permit. Excavations must be conducted so that the "maximum amount of historic, scientific, archaeological, and educational information may be recovered and preserved in addition to the physical recovery of items."

References

Brace, P., and Klein, J. (1981). *Archaeological Resources and Urban Development, A Guide to Assess Impact*. HUD–0003045. Washington, D.C.: Government Printing Office.

McGimsey, C. R. (1972). *Public Archeology*. New York: Seminar Press.

Kelly, V. (1988). *VDOT Compliance with Section 106 of the National Historic Preservation Act*. Charlottesville, Virginia: Virginia Transportation Research Council.

APPENDIX B

NATIONAL REGISTER CRITERIA

Definitions and National Register Criteria as Appearing in the Code of Federal Regulations

36 C.F.R. Part 60 (1987) – National Register of Historic Places sec. 60.1 Authorization and expansion of the National Register.

(a) The National Historic Preservation Act of 1966, 80 Stat. 915, 16 U.S.C. 470 et seq., as amended authorizes the Secretary of the Interior to expand and maintain a National Register of districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, engineering, and culture. The regulations herein set forth the procedural requirements for listing properties on the National Register.

sec. 60.3 Definitions

(c) Determination of Eligibility. A determination of eligibility is a decision by the Department of the Interior that a district, site, building, structure, or object meets the National Register criteria for evaluation although the property is not formally listed in the National Register. A determination of eligibility does not make the property eligible for such benefits as grants, loans, or tax incentives that have listing on the National Register as a prerequisite.

(l) Site. A site is the location of a significant event, a prehistoric or historic occupation or activity, or a building or structure, whether standing, ruined, or vanished, where the location itself maintains historical or archeological value regardless of the value of any existing structure.

(m) State Historic Preservation Officer. The State Historic Preservation Officer is the person who has been designated by the Governor or chief executive or by State statute in each State to administer the State Historic Preservation Program, including nominating eligible properties to the National Register and otherwise administering applications for listing Historic Properties in the National Register.

(p) Structure. A structure is a work made up of interdependent and interrelated parts in a definite pattern of organization. Constructed by man, it is often an engineering project in large scale.

sec. 60.4 Criteria for Evaluation.

The criteria applied to evaluate properties (other than areas of the National Park System and National Historic Landmarks) for the National Register are listed below. These criteria are worded in a manner to provide for a wide diversity of resources. The following criteria shall be used in evaluating properties for nomination to the National Register, by NPS [National Park Service] in evaluating National Register eligibility of properties. Guidance in applying the criteria is further discussed in the "How To" publications, Standards & Guidelines sheets of the National Register. Such materials are available upon request.

National Register criteria for evaluation. The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and

(a) that are associated with events that have made a significant contribution to the broad patterns of our history; or

(b) that are associated with the lives of persons significant in our past; or

(c) that embody the significant characteristics of a type, period, or method of construction, of that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entitity whose components may lack individual distinction; or

(d) that have yielded, or may be likely to yield, information important in prehistory or history.

APPENDIX C

COMMON AREAS OF SIGNIFICANCE FOR HISTORIC VESSELS

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COMMON AREAS OF SIGNIFICANCE FOR HISTORIC VESSELS

To be considered significant, a shipwreck must meet one of the four major criteria as illustrated below (excerpted from Delgado et al., 1986).

A. Association with significant events in the "broad patterns of history"

Category	Examples
Agriculture	Trade and commerce vessels
Commerce	Merchant vessels
Communications	Telegraph and cable–laying vessels; early ship–to–shore transmissions
Engineering	Technological advances (hull design, propulsion systems, etc.
Exploration/ Settlement	Exploration and early vessels involved in expansion
Government	Nonmilitary vessels such as dredges, survey boats, and lightships
Industry	Great Lakes ore freighters and Alaskan fishing boats
Invention	Experimental vessels
Law	Vessels associated with landmark legal cases
Literature	Vessels associated with noted literary figures
Military	Warships and support craft
Recreation	Yachts, luxury ships, and racing boats
Science	Research vessels
Social/Humanitarian	Hospital ships and life boats
Theater	Showboats, ships used in motion pictures
Transportation	Ferries

B. Association with significant historical persons

C. "Distinctive characteristics of a type, period, or method of construction," or a vessel that represents the work of a master.

Architecture	Good example of a specific type of naval architecture Representative of historic ship designer's work
Art	Vessels with distinctive design features or ship–board decorations
Engineering	Significant design, propulsion, or engines

D. Likely to yield information important to history. Regarding vessels, this may include the information obtained from the physical remains of the vessel concerning its use, construction, or function.

Reference: Delgado, J.P. and a National Park Service Maritime Task Force. (1987). *Nominating Historic Vessels and Shipwrecks to the National Register of Historic Places.* National Register Bulletin No. 20. Washington, DC: National Park Service.