DRY TORTUGAS NATIONAL PARK

SUBMERGED CULTURAL RESOURCES ASSESSMENT

LARRY E. MURPHY, Editor
SUBMERGED CULTURAL RESOURCES UNIT
NATIONAL PARK SERVICE

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FOREWORD

National Parks in South Florida do not exist in a vacuum. This document addresses the ecological whole of the region, an approach favored by Secretary of the Interior, Bruce Babbitt. Shipwrecks are one signature of the relationship between man and the ecosystem, a fact richly demonstrated in the array of sunken vessels around the Dry Tortugas.

This contribution to the NPS Submerged Cultural Resources series edited by Larry Murphy should be of interest to a wide spectrum of people. Managers of marine protected areas and cultural resources specialists are the targeted audience, but scientists working in any context should appreciate the methodological and theoretical depth of the document.

An "assessment" level report in this series is designed to provide a firm foundation for future research and stewardship of the archeological resources of a park. The emphasis is on submerged sites, particularly shipwrecks, but the systemic linkages between the underwater and terrestrial components of the archeological record in the Dry Tortugas is maintained throughout the text.

It is particularly instructive to note the level of site description and analysis undertaken without impact to the resource base. Then compare the level of these information returns with those resulting from highly invasive treasure hunting activities conducted in the same region. It should help clarify the rationale behind the adamant rejection in National Park Service policy of the practice of antiquity harvesting for profit on public lands.

The reader should also note the extensive cooperation with other agencies, academic institutions and volunteer groups evident in the conduct of this research project. These partnerships were critical to the successful completion of this report and are particularly appropriate to research programs where the resources being studied are part of a collective patrimony. We all have a stake in the future of Fort Jefferson and all of the Tortugas, wet or dry.

Daniel J. Lenihan, Chief
Submerged Cultural Resources Unit

ACKNOWLEDGEMENTS

This report represents the direct and indirect contributions of many people. Many colleagues' professionalism and enthusiasm is reflected in this assessment, and the volume could not have been completed without the joint effort and support of these people.

National Park Service (NPS) Chief Anthropologist Doug Scovill supported this work from its inception both with professional guidance and specific funding. Doug's long experience with cultural resource management programs and issues and his insistence that good research-oriented archeology can and must be done in the National Park System within a management framework guided this assessment's design and execution.

Edwin Bearss, NPS Chief Historian and early researcher of Fort Jefferson National Monument (NM) maritime casualties and history, contributed his particular knowledge. Cal Cummings, NPS Senior Archeologist and pioneer of Park Service underwater archeology programs, was a participant in the earliest archeology projects at Fort Jefferson NM, and he has maintained an active interest in Tortugas research. Cal contributed many ideas and suggestions to this report as it was being written. Doug, Ed and Cal also reviewed the draft and made numerous comments that enhanced the final version.

Dan Lenihan, Chief, Submerged Cultural Resources Unit (SCRU), contributed to every aspect of this publication from planning and execution to its research and management orientation. Dan and I first worked at Fort Jefferson together in 1974, and there we developed the long-range goal of a comprehensive park archeological survey and inventory.

Southwest Regional Director John Cook, personally familiar with new frontiers, has taken a particular interest in SCRU's mission to develop models for submerged cultural resource management and has strongly supported this work at Dry Tortugas National Park.

Associate Regional Director Rick Smith was involved with this report in a special capacity. As assistant superintendent of Everglades National Park (NP), he once had supervisory responsibility for Fort Jefferson NM. Rick assumed the task of ensuring this assessment addressed relevant management issues, and that it provided information in a form readily accessible to managers and interpreters.

The Submerged Cultural Resources Unit conducted its initial Fort Jefferson NM fieldwork at the request of Everglades National Park Superintendent Jack Morehead. Jack, one of the first NPS divers, knows firsthand the particular problems faced by managers responsible for submerged cultural resources, and he organized and led the 1985 investigations at the monument. Some of his ideas and concepts and some specific information requests he made then are contained in this document.

Everglades Superintendents Mike Finley and Bob Chandler both supported our field operations at Fort Jefferson NM. This assessment was discussed with both superintendents, and comments and requests they made have been included.

Rob Arnberger, assistant superintendent under both Mike Finley and Bob Chandler, worked directly with field operations. Rob, one of the growing number of diving park managers, visited various projects and took particular interest in the underwater interpretive approaches we experimented with

in 1989 and 1990. Rob contributed to the final version of the underwater trail guide for the Windjammer Site, and he was the first to test the underwater communication gear for guided interpretive trail swims. This report benefitted much from numerous insightful, on site conversations with Rob.

As this report goes to press, Wayne Landrum is at the helm of Dry Tortugas National Park and Dick Ring has become superintendent of Everglades NP. The support already shown from the earliest stages of this tenure is much appreciated.

Captains Cliff Green and Linda Vanaman of ACTIVA both took special interest in the field projects and are enthusiastic supporters of Dry Tortugas research. These two sailors know the Tortugas better than any, and their involvement in these projects above and below the water contributed directly to their success. Cliff and Linda reviewed the draft assessment and made numerous helpful comments and straightened out some obvious (to them) errors.

Everglades NP Public Relations Officer Pat Tolle has directly assisted logistics of each field project. Pat is one of the people that makes things happen, and she is a pleasure to work with under any circumstances.

Site Managers Bruce Rogers (1989) and Mike Eng (1990) both strained the limited resources of Fort Jefferson to support field operations. In addition, Mike reviewed the assessment draft and offered some helpful comments.

Although many NPS personnel at Fort Jefferson assisted in daily field operations, some made particular contributions beyond the hospitality Fort Jefferson is known for. Carolyn Brown-Wiley and Al Brown provided boat support, training and guidance to particular operational conditions in the park's waters. Both made the operations safer and more efficient by their participation. Carolyn discussed many aspects of this report, and it has benefitted by her observations and comments. Sarah Buckendorf assisted with administrative details. John Gibson, maintenance foreman, Bob Buckendorf and Tree Gotshall helped with numerous field repairs and kept some rather worn-out equipment working.

This report was supported directly by Southeast Archeological Center Chief Richard "Pete" Faust and his staff. Pete discussed each fieldwork project and contributed directly to this assessment by supplying information, arranging the assistance of Archeologist David Brewer, and by commenting on the assessment draft. Pete's support and comments have made an important contribution to this document.

Numerous archival sources and libraries were consulted during report research. Amalin Ferguson, Southwest Region librarian, and Peg Johnson, research librarian, both helped in many ways. They were nearly always able to cheerfully come up with even the most challenging, esoteric reference request. Thomas Hambright, librarian of the Monroe County Library, Key West, assisted Richard Gould and me during research visits in 1989. Steve Haller, curator of historic documents, San Francisco Maritime National Historical Park provided numerous references and researched the Windjammer Site.

The SCRU fieldwork in 1989 and 1990 involved many volunteer divers under the NPS "Volunteer-in-Parks" program. The NPS is one of the few government agencies that allows nonemployees to dive under their auspices for research purposes. Many hundreds of dives were conducted at Fort Jefferson NM under working conditions without a single incident. The successful safety record for this project can largely be attributed to Biscayne National Park Resources Management Specialist Rich Curry. Rich, as Southeast Region Dive Officer, constructed a workable set of certification parameters that allowed volunteer participation in his region and assisted in developing a project dive operations plan. His attention to dive safety issues and experience as a diving researcher contributed much to the SCRU projects at Fort Jefferson NM.

Many volunteers were involved in 1989 and 1990 field operations under my direction. It is a privilege to thank each one. During the 1989 reconnaissance Richard Gould, Brown University professor of anthropology, Jon Jolly of Jon B. Jolly, Inc., Seattle, Washington and Linda Stoll, superintendent of Pecos National Historical Park assisted during field operations. Pat Givens and Lucy Doyle of Fort Jefferson NM also assisted with preliminary site documentation.

In 1990 an expanded volunteer diver program was begun. Two approaches were utilized. One involved members of the Maritime Archaeology and Historical Society (MAHS), the other students under direction of Professor Richard Gould. A third field session involved Southwest Region personnel assisted by MAHS members.

The MAHS members under the direction of President Bill Eddy and University of Maryland Anthropology Professor John Seidel included Mel Larson, Pam Krim, Kevin Fuscus, Craig Heier, Mickey Ellsberg, Arun Vohra, Jim Smailes, Mike Wagoner, Steve Skolochenko and Richard Knudsen.

Richard Gould's team involved Donna Souza, field supervisor, Eugene Rowe, Charlotte Taylor, William Griffin, William May, Adam Smith, Susan Hurley-Glowa, Stephen Walker and Joseph Los. Most of these people were Brown University students.

The third session included Southwest Region archeologists Larry Nordby, Todd Metzger, Scott Travis, volunteer Jacquelyn Koenig and MAHS members Pam Krim, David Shaw, Thomas Berkey, Ray Merkin, Virginia Liberman, Edward Madden, Kazuko Cook and Bill Robey. Jim Bradford, Southwest Region, Division of Anthropology archeologist, was field director for the first and third sessions. Jim, long a noted southwest field archeologist, has become an accomplished maritime field archeologist drawing on his terrestrial experience. He contributed many report figures and photographs. Jim worked effectively and capably to organize, supervise and keep the project on track. A large measure of whatever success the fieldwork enjoys is a direct result of his efforts.

During the field season, Dr. Gary Davis, Channel Islands National Park research marine biologist; Dorothy Davis; Boston University marine biology graduate student Charles Mazel; photojournalist John Brooks and writer Joy Waldron visited the site. Results of Gary's visit form an important chapter in this volume.

Richard Gould has contributed in many ways to this publication including fieldwork, his chapter contribution and reviewing the draft report. Many of the volume's concepts and its structure reflect his approach and orientation to maritime archeology. Dr. Douglas Anderson, Brown University, also contributed much to the theoretical orientation of this volume.

W.A. "Sonny" Cockrell, Director, Warm Mineral Springs Project and report contributor reviewed and commented on the draft. Sonny's comments were especially useful because he directed the 1974 Fort Jefferson NM survey project, and he has been involved in submerged cultural resources management for more than 20 years. Sonny, who taught me about shipwrecks in the early

1970s, was the first to suggest their investigation within groups that reflect larger social processes.

This publication series has relied on many colleagues for peer review. Because an assessment like this one is meant to be a useful document to many audiences, reviewers with various experiences and backgrounds were asked for their comments. Many thoughtful and helpful comments were offered, each contributed to a better product. Some reviewers have already been mentioned. Others reviewers included: J. Barto Arnold, Texas Marine Archeologist; James Delgado, Director, Vancouver Maritime Museum; Ron Ice, Southwest Regional Archeologist; Patrick Labadie, Director, Canal Park Maritime Museum; Jack Morehead, Alaska Regional Director; Don Morris, Archeologist, Channel Islands National Park; Allen Saltus, Research Archeologist, Archaeological Research and Survey; John Seidel, Professor of Anthropology, University of Maryland, and Roger Smith, Florida Underwater Archeologist.

Besides reviewing the report draft, Larry Nordby, Chief, Branch of Cultural Research, Southwest Region, was the field director for the 1988 documentation project in which detachments of US Navy Mobile Diving and Salvage Unit 2 participated as part of Project SeaMark. He produced the detailed Windjammer Site map and assisted in the 1990 fieldwork. Larry's substantive comments and fieldwork have made a significant contribution to this report.

Frances Day, SCRU Cultural Resources Assistant, designed the publication and reviewed the volume for consistency. Jerry Livingston, Ernesto Martinez and Keith Ireland digitized the figures and developed procedures for revising and incorporating them into the text. SCRU Geodesist Tim Smith revised some figures with AutoCad. Dan Murphy edited the draft. Frank Pais, Peter Ripley and Kathleen Middlebrooks also contributed to the report's completion.

LEM

CHAPTER I

Introduction

Larry E. Murphy

This volume describes and assesses the known and potential archeological resources in Fort Jefferson National Monument. It also comprises an overview of existing archeological data, including a compilation of past work results, mostly unreported. Potential for prehistoric and historical sites and their context is discussed. Recommendations for future cultural resources research and management are made in the last chapter.

Fort Jefferson National Monument was redesignated Dry Tortugas National Park as

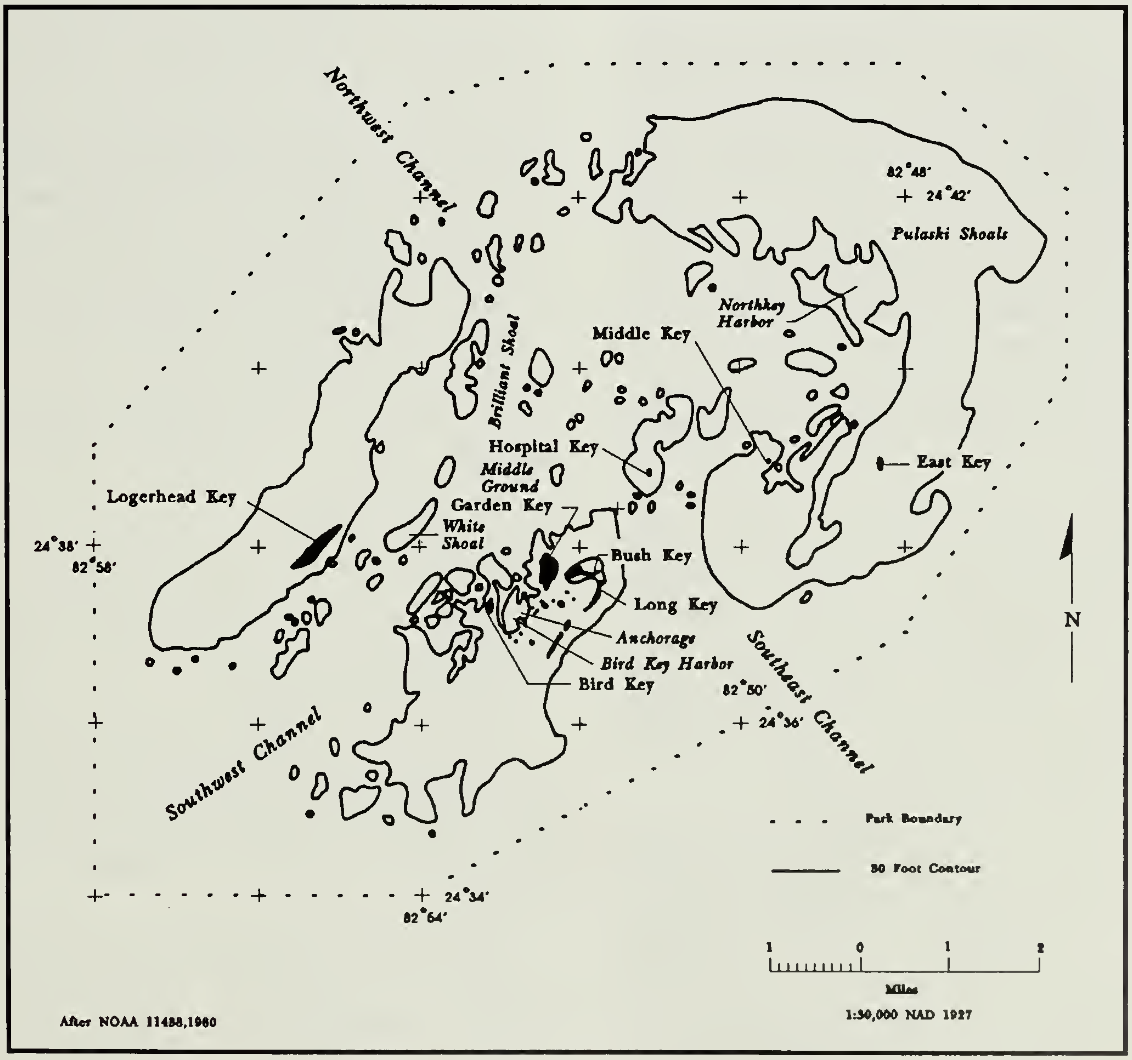


Figure 1.1. Fort Jefferson National Monument.

this report was readied for press. The old name is used throughout this volume because to change it would have proven almost impossible given the different nuances of use of these terms.

Fort Jefferson National Monument, located 68 miles west of Key West, Florida, encompasses seven small islands known as the Dry Tortugas within its 100-square-mile jurisdiction. Central to the area is Fort Jefferson, a masonry "third-system" fort with half-mile-long perimeter walls 50 ft high and 8 ft thick, located on Garden Key (Figure 1.1).

The Dry Tortugas are situated on the edge of the main ship channel between the Gulf of Mexico, the western Caribbean and the Atlantic Ocean. Gulf and Atlantic ship traffic must pass through the 75-mile-wide straits between the Gulf of Mexico and the Atlantic Ocean. Any ships traveling the more than 1,200 miles of United States Gulf coastline will pass close to the Tortugas. The Dry Tortugas pose a serious navigation hazard and have been the site of hundreds of marine casualties.

Most western Caribbean traffic also passes through the Straits of Florida, a situation that has changed little since the Spanish exploration and conquest period. Spanish interests centered on the larger Caribbean islands, Santo Domingo (Haiti and Dominican Republic), Puerto Rico, Cuba and on the continental land masses. Much Spanish activity was in the western Caribbean, which became their stronghold. Spain began western Caribbean fortification in 1567 in response to other nations' New World incursions.

The long history of the Dry Tortugas, which were discovered by Ponce de Leon in 1513 and discussed by the English as early as 1565, is reflected by the maritime archeological sites within its waters. The earliest known shipwreck site is from the 1622 Spanish plate fleet, however, it is reasonable to expect many earlier, presently undocumented casualties in the park. Marine casualties, wrecks and strandings, occurring frequently in the past, still occur here. High potential for a large wreck population and rich archeological record within park waters has been demonstrated by both historical research and the limited archeological fieldwork reported in this volume. Edwin Bearss (1971), who very early recognized the park's historical importance, located records for more than 200 ships sunk, stranded or damaged in the Tortugas.

The Tortugas' strategic importance has long been recognized. Fort Jefferson construction ratified the geopolitical importance of the Tortugas to the United States early in the nineteenth century. Fort Jefferson was a product of the coastal fortification buildup that took place as a planned development of United States coastal defense beginning after the War of 1812. Fort Jefferson was considered critical for protecting Gulf trade and ports. The fort, begun in 1846, was a strategic necessity to establish United States presence on the international Caribbean frontier and was a direct response to continuing United States concern about British Bermuda fortification, Spain's diminishing role and growing weakness, and the Mexican conflict in Texas. Principally, the fort was constructed to deny an enemy fleet carrying out blockading operations against the United States, access to the Tortugas' anchorages.

There are a number of historical themes and movements potentially represented in the Fort Jefferson National Monument archeological record. The earliest historical sites are likely related to Spanish and European explorations.

Beyond the discovery and exploration period, the consolidation of control and commercial development that followed close behind the explorers and adventurers is a primary theme that could be elaborated by Fort Jefferson National Monument archeological study. Prior to 1600, Spanish fleets returning to Spain from Vera Cruz sailed around the Gulf hugging the shore. This early route brought the fleet close to the Tortugas.

The competition between European maritime nations for Atlantic, Gulf and Caribbean control and domination will certainly have left material remains of war and commercial wrecks in the Tortugas. Today's international economic system is largely result of interaction among principal European maritime nations, much of which occurred near the sea lanes passing close to the Dry Tortugas.

A representative material record of Spanish development and decline as a world sea power, competition between the French, Dutch and British, and rise of the United States as a maritime power is found in the park's waters.

Development and commerce of the Gulf port cities are certainly well represented in the archeological record of Fort Jefferson National Monument. Ships from Tallahassee, Biloxi, Port Arthur, Corpus Christi, Pensacola, Mobile, New Orleans and Galveston were lost in the Dry Tortugas.

Local fishing and exploitation of the rich natural resources of the islands and surrounding waters, beginning with Ponce de Leon who named the islands for the many turtles captured there, should be seen in archeological remains. Indigenous Native American and Caribbean populations' use, as well as that of the growing United States will be reflected in the park archeological record.

Clandestine commercial operations of piracy, privateering, smuggling and slaving, which are poorly documented in archival sources of any nation, should be revealed in park archeological sites. Some clandestine activities are still going on, and they offer direct links with past activities.

The great trade between the Atlantic coast and the western rivers, all of which passed close to the Dry Tortugas, certainly left vessels, cargos and crew effects that have been scantily depicted in historical documents.

The archeological record of Fort Jefferson National Monument is rich, and its study will be rewarding. This report is the first comprehensive look at the monument's archeological potential, but it's just a start.

CHAPTER II

Dry Tortugas and South Florida Geological Development and Environmental Succession in the Human Era

Peter A. Stone

INTRODUCTION

Large geographic changes have occurred in the Dry Tortugas since the first human entry into South Florida. The Dry Tortugas area reflects extreme environmental changes during the human era: from peninsular mainland near the time of human entry, to rock islands, to open marine water, finally to the development of sand islands. Deposition continues in the current large submarine reef/bank/lagoon complex where a thick marine and freshwater sediment mantle has been laid.

Postglacial Development of the Floridian Coral-Reef Tract

Fringing coral reefs, which cover a significant portion of the Dry Tortugas, protect and generate much island sediment. Although the area is not predominantly coral reef per se, reefs play a dominant role in the Tortugas' geologic history and environmental sequence. Reefs occupy a similar position on the continental shelf and act essentially as an extension or outlier of the Florida reef tract fringing seaward of the Florida Keys. Other extensions and relicts occur between the Dry Tortugas and Key West on shoals near the Quicksands and the Marquesas Keys and along Biscayne Bay and the southeastern peninsula coast. These reefs have been studied more than those at the Dry Tortugas, but considerable reef origin and development information has transfer value. Especially useful are several major studies by Shinn and his associates (Shinn et al. 1977, 1989) that summarize numerous reef investigations. Lighty (1977; Lighty et al. 1978, 1982) adds information from more northerly reefs off the southern Atlantic shoreline. High information transfer value between these areas stems from dominance of sea level change as a physical control in all these areas; however, considerable differences in local factors limit extrapolations somewhat, for example, susceptibility to cold-water incursions from nearby shallows, which changed with sea-level rise. Following is a summary of overall Florida reef-tract coral reef development, mostly outside the Dry Tortugas, emphasizing specific characteristics with potential importance for archeological inferences. Syntheses by Shinn et al. (1977, 1989) are principal sources.

Carbonate geology dominates the extreme southern peninsula coast. Little quartz sand extends south of Miami or the Ten Thousand Islands, which has been the condition for a very long time. A 4,500 m well near the submerged Florida platform margin southwest of the Marquesas Keys encountered limestones throughout, the lowermost of Cretaceous age.

Despite the great age of the local limestone-forming environment, present reefs and carbonate banks are geologically very young. In contrast to their appearance and ancient relatives, these thick reefs and banks postdate human entry into southern Florida. Humans probably trod on dry land surfaces now beneath 10-14 or more meters of coral reef deposits lying 15 or more meters beneath the present sea level. Oldest of the still-living reefs investigated originated about 6000 B.P. (before present) on sites that were dry land up to about 8,000 years ago. Senescent or dead reefs lying along a line 100-300 m offshore the discontinuous living reefs in the Florida Keys and now 8-18 m below sea level are thought by Shinn et al. (1989) to be older; they were possibly drowned sometime between 10,000 B.P. and 6000 B.P. (note: interpolated dates from sea-level data are uncertain).

Reefs were not the only features on older surfaces to accumulate thick deposits; carbonate sand and coarser debris up to 10 m thick comprise some banks. Other areas have accumulated little or no sediment since much earlier in former Pleistocene interglacial times, and that material is now hardened into rock. Some rock areas that are essentially bare are covered with, and the surface obscured by, carbonate-producing organisms (colonial algae, coralline animals), but the debris they produce is swept away by currents. Fine grained or muddy (silty) sediments occupy some deeper areas, with accumulated thicknesses from a few centimeters to several meters. The shallow but protected Florida Bay area leeward of the Florida Keys also has accumulated several meters of mostly fine-grained carbonate sediments (Davies 1980; Davies and Cohen 1989).

A large and rapid rise in sea level caused by melting continental glaciers flooded Florida shelf areas that can now support coral reefs or accumulate other types of carbonate sediments. Similar glacial waning occurred with resultant sea levels higher than at present several times in the Pleistocene. The Sangamon interglacial prior to the present Holocene interglacial ended about 100,000 years ago and had sea levels 10 m above present levels. Coral reefs growing at that time now form the Key Largo limestone of the upper Florida Keys chain and lie submerged in nearby areas.

Other types of surface-forming limeston particularly oolitic Miami limestone, com from Sangamon sandy shoals. Nearly 100,00 years of emergence and subaerial exposu hardened these limestones and formed a harc recrystallized calcrete crust.

The present Holocene interglacial sedime deposition occurred on these Pleistocen surfaces after their resubmergence. Mo Holocene sediment is loose and unconsol dated, with several exceptions: 1) th semirigid intergrown mass of the some cor reef cores, 2) beachrock found in a fe limited areas and 3) slightly cemente "hardgrounds." Both bedrock topography an water depth influence Holocene coral re development. Water depth affects developme through wave and current exposure along wit proximity and direction of shoal areas whe cold water may be produced. Modern reefs a frequently located upon bedrock fro Sangamon-age ancient reefs. The linkage i part seems to be topographic, with ree forming at a break in slope. Elevated area including Sangamon-age dunes, are als represented beneath Holocene reefs, probabl in large part because elevated sites are le likely than nearby shallow depressions t contain a veneer of fine, loose sediments th interfere with coral colonization.

Probably little surficial sediment capped th reflooding marine limestone before reinunda tion (Shinn et al. 1989). Sediment typically i absent on presently emerged Bahamas an Caribbean islands, but marine sediments ma have accumulated in swales prior to attainme of depths (or distance from shallow an occasionally cold water, perhaps) necessar for coral growth. Possibly even fresh- c brackish-water sediments accumulated. I presently sand-filled, low spots in the bedroc are located in the Tortugas, they would b favorable sites for obtaining a sedimentar record of the last stages of the forme terrestrial environment. Corals are exclude from these low spots presumably because they cannot readily colonize fine sediments. Frequent occurrence of coral reefs upon ancient reefs, and carbonate sand deposits upon non-dune, lithified sands now hardened into limestone has led Shinn et al. (1989) to postulate general similarity of conditions today to those of around 125,000 years ago. Starkly different conditions characterized the intervening time.

Postglacial sea-level rise triggered development of modern depositional environments and allowed vast sedimentary accumulation during the South Florida human era. Rates of rise and former sea-level positions at various times are important in several ways. Deposition onset is dated at very few sites and depths, and, therefore, interpretations from elsewhere must be made by extrapolation and interpolation. Considerable disagreement exists locally for 5000 B.P. back to 14,000-16,000 B.P. or so. Far more data, and a degree of agreement among them, exist for the past 5,000 years and the last 4-5 m of rise (Scholl 1964; Kuehn 1980, Fig. 17; Shinn et al. 1989).

Dated sea levels are important to archeological inference. Unfortunately, there is no general agreement on sea-level position in South Florida during the human era. For example, Robbin (1984), using Florida Keys' data, recently has challenged the accepted general view and interprets much less depressed sea levels (to 100 m differences) for the period 14,000 to 7000 B.P. It is difficult to accept his interpretation (discussed below), but for the purposes of a purely geologic reconstruction, the problem is minor. Shinn et al. (1989) observe that all sea levels and stages above its minimum level existed no matter what the actual timing, and the deposits of main interest were within the shallower depth range and more recent time range (< 8000 B.P.). To archeology, however, timing of the rise and the maximum depth at the entry of humans into the region is critical.

Nearly all investigators agree on a rapid sea-level rise in the earlier postglacial period (terminal glacial and early Holocene times). Much of that rise took place beyond the present depth range of the Florida reef tract. Considering -20 m msl (meters below present mean sea level) as the maximum depth of interest in the local deposits, then the sea appears not to have reached it until very approximately 10,000 B.P. (using the curves of Blackwelder et al. 1979; Kuehn 1980; and with reference to date/depth data from peats off the east coast of Florida; e.g., Field et al. 1979). Coral reefs can match this Holocene rise in sea level by accretion, especially at the slower rates for mid- and late-Holocene times (Shinn et al. 1977).

Still, there are senescent reefs offshore living ones, and something caused them to drown. It appears that dramatic slowing of sea-level rise over the past several thousand years may have had more of an effect in limiting upward coral growth than the former rapid rise did in halting growth. Reefs can readily reach almost to the surface, where they greatly affect wave energies and currents to the leeward, and where they are highly exposed to wave damage and erosion during storms and hurricanes.

Shinn et al. (1989) outline important stages in Florida reef postglacial developments. Because bathymetry is used along with a semi-arbitrary extension of the sea-level curve back in time from the generally accepted post-6000 B.P. data, dates of earlier stages probably are not very accurate. However, information about former shoreline characteristics, no matter what their actual age of occurrence, is well founded.

When the sea stood very low, 100 m or more below present, such as at 15,000 B.P. or earlier, the shoreline lay at the base of a fairly steep, uniform bedrock slope. Freshwater seeps or springs, and possibly streams, discharged from this rock terrain. Freshwater sources probably existed near the slope base near sea level. Streams are much less likely than springs and seeps (see paleoenvironments of the mainland in the next section). By the time humans entered south Florida, no later than around 10-12,000 B.P. (Clausen et al. 1975, 1979; Cockrell and Murphy 1978b; Doran and Dickel 1988) the topographic relief was reduced by the rising sea, but a distinct rise in topography back from the shore and a steeply deepening offshore environment still existed. Shoreline springs may still have occurred, which would have been of interest to humans occupying a dry, elevated bedrock terrain. An elongated series of ridges now far offshore and forming the bases of major reefs existed as a series of offshore bedrock islands when they became surrounded and isolated by the transgressing sea, 10,000-8000 B.P. on the assumed curve.

With sea level 8.5 m below present around 8000 B.P. on the assumed curve, small, submerged bedrock islands remained at several sites that would later support distinct Florida Keys reefs. The depression forming present-day Hawk Channel between the modern offshore reefs and the relict bedrock Florida Keys began to flood, but the main shoreline still lay 3-7 km off the current shoreline. Above an elevation of 15 m below present sea level, the bedrock slope is considerably less than below, so the nature of the nearshore zone--both the land and the sea bottom--changed at that crossing. The relatively smooth shoreline of the steeper, deeper slopes became much more irregular as shallower slopes became encompassed, including the formation of embayments into the land area. At 6000 B.P., with sea level about 6 m below present (by this time there is much better control and presumably more accurate dates), the offshore bedrock islands were submerged. Hawk Channel between rocky shoals and the mainland was flooded, and lagoons formed on the rocky mainland.

At 4000 B.P., sea level stood about 3 m below present, and the mainland shoreline was 1-4 km seaward. The coastline had become very irregular by extensive flooding north and west of the present Florida Keys and in inlets between the keys. This initiated Florida Bay development. From an archeological perspective, the dominant result of coast dissection and flooding of expansive shallow, protected environments was formation and great expansion of diverse and productive intertidal and estuarine environments, which are extremely rich food sources.

By 2000 B.P., the Florida Keys shoreline was similar to today, with sea level about .5 m below present. Both Florida Bay and Biscayne Bay were highly developed. Since about 9000 B.P. and especially since 6000 B.P. for existing reefs, while the shoreline was retreating and diversifying, coral reefs and associated carbonate forming/depositing shallow marine environments were growing and evolving offshore.

A number of individual reef areas have been studied stratigraphically, from the lower east coast (Lighty 1977; Lighty et al. 1978, 1982), through the Florida Keys area including Southeast Reef in the Dry Tortugas (Shinn et al. 1977, 1989). These studies provide a context for interpretation and planning future Dry Tortugas research. Selected aspects with archeological significance related to position and timing of depositional onset, to accretion rates, and to geographic shifts in depositional environments are discussed here. Again, summaries by Shinn and his colleagues (Shinn et al. 1977, 1989) are principal references. Generally, a southward-westward progression is made in ordering the discussion.

The most northerly reef studied, extending from North Miami to Palm Beach, was examined at a transect off Hillsboro Inlet by Lighty (1977; Lighty et al. 1978, 1982). This now-dead tropical coral reef differs from reefs further south and west in that it is considerably older, dying before or around the onset of existing live coral reefs. Layers above the reef's base dated about 9400 B.P. and 8700 B.P. (the oldest about 10.5 m beneath the reef crest); coral from near the crest dated about 7100 B.P. Deeper, older samples were about 21 m below modern sea level and the shallower, younger samples from about 17 m deep. Elsewhere, the reef crest ranges to 30 m deep. This reef is located at a distinct break to steeper slope on the submerged shelf. Net reef accretion based on age and elevation differences (roughly 10 m elevation in 1,200-1,900 radiocarbon years) is an apparent 8.5-5.25 m per 1,000 years. Lighty and his colleagues attribute the reef's demise to turbidity, or as likely chilled winter water from the broad shallows that formed on the gently sloped shelf behind the reef as sea level rose. Tropical conditions are suggested for reef growth periods by specific coral taxa and associated biota.

Long Reef in Biscayne National Park provides a good example of how biotic and depositional environments have shifted through time. At the reef crest, coral (>1.5 m thick) overlies thick, loose carbonate sands (about 8 m thick) above a thin carbonate mud layer (about 0.5 m thick), all lying atop bedrock. The crest does not mark the location of the thickest or oldest portion of the reef, which lies slightly seaward. There, about two-thirds downward through the thickest coral accumulation (3.7 m under 4.6 m of water) the coral dates about 5600 B.P.

Likely the initial reef protected the leeward mud- and sand-depositing environments, and the coral colonized the sand by breakage and rubble from the seaward reef. At Elbow Reef off the upper Florida Keys, coral rubble accreted landward several meters during Hurricane Donna in 1960 in presently 4.5-12 m of water (Ball 1967). Patch reefs with more than 4 m of relief are scattered on sandy areas shoreward of Long Reef. Other reefs, such as Carysfort Reef off Key Largo, seem to have accumulated largely by in situ coral growth, there to within 2 m of the surface and 13 m thick.

At Bal Harbor, the control exerted by underlying bedrock topography is well evidenced. Coral reef has developed on cemented sand ridges, which are now bedrock, but absent on interdune swales, possibly due in part to loose sediments that inhibited coral polyp colonization. This reef began around 6300 B.P. (this date from near the base, about 16 m below modern sea level). It had grown at the coring site about 6 m thicker by around 4900 B.P.

The middle Florida Keys area provides other good evidence of strongly patchy or zoned depositional environments. There also, large areas of carbonate sand have accumulated in late-Holocene times. Reefs with "key" in their names (e.g., Sombrero Key Reef) were associated with vegetated islands in historical times (Romans 1775; Shinn et al. 1989), but these terrestrial environments no longer exist. Immediately landward of a distinct, thick coral reef, Robbin (1984) found shallow Pleistocene bedrock beneath Holocene-age peats and a very thin layer of sand. Surprisingly, the peat extends beneath the drowned reef-flat at Alligator Reef, which obviously overgrew or otherwise colonized the soft sediment on washed-in coralline rubble.

Looe Key Reef also exhibits the geographic shifting of distinct depositional environments, but in partial contrast to Long Reef, the deeper seaward reef portion is being covered in some areas by a moving sand body, with generally northerly winter storm activity likely the principal burial mechanism (Lidz et al. 1985). As at Long Reef, Looe Key Reef has transgressed shoreward, here above a sand- and rubble-filled depression. A predominant initial control by Pleistocene bedrock topography is demonstrated. The main reef began on a coralline bedrock ridge at the edge of a distinct drop-off. The ridge became the many bedrock islands after channel flooding between the ridge and the contemporary mainland, which is now the Florida Keys. This channel accumulated finer, looser sediments and rubble near the seaward reefs. A distinct topographic reef feature seems to be entirely of biological and sedimentological control, with currents also a factor. On older, deeper reef portions not covered by sand, spurs or seaward pointing, steep-sided to overhanging, deeply grooved coral ridges intervene. These spurs have grown upon thick carbonate sands without a bedrock control (Shinn et al. 1981).

Off Big Pine Key in the lower Florida Keys, two parallel reefs are located above more elevated bedrock formed from Pleistocene reefs and separated by a carbonate sand area underlain by bedrock derived from similar sands. This feature demonstrates both topographic controls and similarities to previous interglacial conditions (Shinn et al. 1977).

Archeological Implications of Reef and Sediment Accumulation Rates

Coral accretion, burial and lateral and temporal shifts in environment all have archeological implications. The more widely and intensively investigated Florida reef-tract portion provides data for archeological and paleoenvironmental assessment of the South Florida submerged shelf.

Coral Accretion - Radiocarbon dating of deep levels in coral reefs in the region allow estimation of long-term average reef accumulation rates. Shinn and his colleagues (Shinn et al. 1977, 1989) have collected and summarized most of the local information.

Individual coral growth rates also have been investigated by examination of seasonal growth rings. Hudson (1981) found growth of *Monastraea annularis* to be sometimes in excess of 11 mm per year on individual coral heads near Key Largo. This maximum average rate was from shallow, well exposed sites (<3 m deep near the reef margin). Nearshore patch-reef coral growth averaged more than 8 mm per year, and coral from deeper (>6 m) offshore sites was lower, but more than 6 mm per year. Other Florida coral taxa have shown roughly comparable growth rates: 2.4-16 mm per year (Hudson et al. 1989; Ghiold and Enos 1982; Landon 1975), which supports a centimeter-per-year rule-of-thumb. This growth rate obviously can bury colonized artifacts in a few decades. Coral overgrowth may be considerable on early shipwrecks in some areas of Fort Jefferson National Monument.

Average long-term reef accretion rates are considerably slower than outward growth of individual coral heads, yet are geologically very rapid compared especially to rates of mid- and late-Holocene sea-level rise. Shinn et al. (1989) notes the main differences between individual coral and reef growth are related to major reef growth interruptions, which may be frequent and prolonged. Interruptions can relate to stress from temperature, especially cold water; salinity increase, especially in shallow, baffled evaporating waters, or decrease from brackish run-off waters; fine sediment; disease and by mechanical hurricane damage. These factors represent the most probable reasons most Florida coral reefs have not grown to the surface and kept continuous pace with sea level. Note that some reefs and mainly algal-derived sand deposits do rise to low-tide level, or even above high-tide level in the case of sand islands. Measured reef growth rates also have geologic associations and archeological implications beyond simple burial rates, for example boring organism alteration and general cementation is greater in the slower accreting reefs.

Reef accretion rates calculated using a dated depth and assuming a zero age for the reef surface are lower than rates calculated between two dated depths. The former overall net rates to present are reported to range from 0.38-2.38 m per 1,000 years; the somewhat older interlevel net rates range from 1.56-4.85 m per 1,000 years; the highest from Southeast Reef in the Dry Tortugas. Slower rates assume reefs are still growing, when in fact erosion, or perhaps merely a rough equilibrium with the much slowed sea-level rise, may have characterized the past 1,000 years or more (Lidz et al. 1985). At these longer-term accretion rates, discovery-era artifacts could now be buried by more than 0.5 to almost 2.5 m of coral reef.

Burial - Paleoindian occupation surfaces, although likely present, are probably deeply buried. Ten meters or more of sediment have buried the submerged bedrock in places in late-Holocene times. For example, loose carbonate, sandy sediments behind Looe Key Reef accumulated overall at about 2 m per 1,000 years (Lidz et al. 1985). The overall average thickness for the area is 3-5 m (Shinn et al. 1989).

Normal currents and waves transport sands and coarser debris from their immediate formation sites, which are reef-forming corals and sand-forming colonial algae. Hurricanes are the most powerful transport agents, but northerly storms are also important, especially when the strong, slowly shifting winds approach from the open sea. Ball (1967) note that because local and regional topography play such a role in current and wave action, the high-energy events overall have about the same direction as prevailing tidal and wave actions.

It is expected that early inundated sites would be buried by at least a meter of sand by simple local deposition alone. Focused or episodic deposition from eroded areas could be greater. Nevertheless, while more than 10 m of sediment, including notably the semirigid reefs, has accumulated at some sites in the reef tract, and lesser but considerable sediment covers most of the submerged area, little or none has accumulated in the large total area.

Lateral and Temporal Shifts - Enormous environmental changes have occurred during the human era in the area of the now submerged shelf. The shoreline has moved many kilometers landward and at least tens of meters upward, although uncertainties in both directions result from the considerable uncertainties in sea-level positions for times prior to around 6000 B.P. During human occupation of the study area, open marine waters replaced dry, not necessarily arid but perhaps inhospitable, rock-surfaced land on the present shelf.

Major coral reefs center upon bedrock ridges and downward breaks in slope because of physical ecological linkages and controls expressed through topographic effects on currents and sedimentation. Some inferences, or perhaps just hints because the association is not infallible, can be made about underlying ancient surfaces from examination of recent sediments. For example, bases of steeper slopes would have been favorable sites for finding freshwater seeps in the past, and bedrock ridges would have formed the last occurring stable rock islands early or midway in the shelf inundation sequence. Consequently, sediment-filled depressions between ridges would be the most favorable sites for obtaining sedimentary evidence (e.g., peat, mud, pollen) of the late-stage bedrock mainland environment prior to marine flooding.

Lateral shifting of distinct sedimentary environments accompanying vertical accretion obscures confident or detailed predictions of local bedrock topography made from modern sediment surface observations. More important, deeper sediment types and archeological considerations, for instance, ability to excavate, cannot be predicted with precision in or near specific reef areas. Prediction is less problematic in wider, deeper muddy environments, or broad sandy environments that should be more homogeneous away from reef boundaries.

Most prehistoric surfaces are fairly deeply buried; most early historical surfaces may be considerably buried; and even many late-historical surfaces may be significantly overgrown, buried or obscured. Overgrowth and burial can involve ridged, hard, and difficult to remove corals and other organisms. Areas swept of sediments, or at least free from thick and rapidly developing accumulations, likely may also be poorly suited to retain any but dense or heavy, resistant artifacts.

All shallow-depth surfaces are subject to occasional severe wave attack and currents. Deeper water areas in general would have been less affected. Unfortunately, the slowly accreting, less disturbed, more easily explored, finer-sediment areas are perhaps the least likely areas for shipwrecks.

Geologic Features and Deposition Between Key West and the Dry Tortugas

More than 100 km presently separate the chain of Florida Keys from the Dry Tortugas. This area has not been intensively investigated until quite recently and still has relatively little stratigraphic or geochronologic data from cores. There are two principal data sources. Davis (1940, 1942) described the topography and vegetation of the low Marquesas Keys. Shinn et al. (1989, 1990) present very useful observational data and seismic profiling information supplanted by limited coring for the main shallow feature in the area.

Florida Keys noncoralline, oolitic limestone forms the subsediment bedrock at least as far as the Marquesas Keys and the Quicksands (see below); however, coralline bedrock occurs northwest of the Marquesas Keys and at the Dry Tortugas. Except for the terminuses of Key West and Dry Tortugas, coral reefs are poorly developed, but some do occur. One, New Ground Reef, northwest of the Marquesas Keys, has accumulated 7.6 m of carbonates above a high area of Pleistocene coralline bedrock. In the "Quicksands" area to the south, much bedrock was exposed as islands until sea level reached to within 7 m or so of the present level (Shinn et al. 1990, Fig. 4).

Prevailing easterly winds and waves run along the shelf and reef axis, here and along the lower Florida Keys, which likely cause a preferential westward movement of carbonate sand (Shinn et al. 1990). Calcareous sand production and accumulation is largely from *Halimeda* spp. (colonial algae), not from coral reefs. Lesser reef abundance is thought to relate to colder winter waters and Gulf nutrient-enriched, chlorophyll-colored water, as well as to shifting sands (Shinn et al. 1989, 1990). Near the Marquesas Keys at the Quicksands area, Hudson (1985) measured annual carbonate production in excess of 1,200 g/m^2 in a densely algal-vegetated area. (At a mineral density of 2.7 g/cm^3 and an assumed minimal porosity of 25 percent, this equates to almost 60 cm/1,000 yr vertical accretion, but relates only to the densely vegetated patches.) The Quicksands dominate a vast area (28 km x 4 km) where large, shifting ripples of sand waves as high as 5 m occur perpendicular to north-south tidal currents on sand deposits as thick as 12 m. Nearby reefs are separated from these sands by deeper sediment-free "hardgrounds." These sand waves move daily repeatedly burying and uncovering heavy objects. Except for Rebecca Shoal, deeper waters 18-24 km west of the Quicksands towards the Dry Tortugas generally lack reef growth and have accumulated fine-grained carbonate muds. About 8 m of mud and fine sand in 23 m of water were recently recorded in this area (Shinn et al. 1990, Fig. 6).

Deeper areas just east of the Dry Tortugas would have flooded and isolated the Dry Tortugas from the mainland early in the marine transgression, forming a bedrock island or islands at the site of the Dry Tortugas. Rapid to extremely rapid burial of historical artifacts, is probable in areas such as reefs, Hawk Channel extension, and especially Quicksands; but some deeper bedrock-type hardground areas that accumulate little sediment may contain resistant cultural remains at or near the surface, from perhaps as far back as early prehistoric times.

It is important to note for archeological purposes that nonbedrock "hardgrounds" can form the bottom in marine-carbonate environments where algae partially cement the top of granular marine sediments. These recent sediments could be mistaken for ancient bedrock in remote-sensing record interpretation. This mistake, however, is much less likely in physical examination.

Dry Tortugas Depositional Environments

The Dry Tortugas' islands mark the location of a mid- to late-Holocene age coral-reef and carbonate-banks complex on a shallow area of submerged Pleistocene bedrock shelf. The site is just beyond 100 km west of Key West and about 170 km north of Cuba. The ten fathom (60 ft, 18.3 m) isobath encompasses about 260 sq km (about 100 square miles) (Stoddart and Fossberg 1981). These islands were the scene of much shallow marine biological research early in this century by the former Carnegie Institution Tortugas Laboratory. There was, however, little research done on sediments, except for deeper lagoon and reef descriptions (Thorp 1935; Vaughan 1914). The early attribution of the Tortugas as an atoll is refuted by Brooks (1962) for dissimilarity with classical Pacific atolls, which are fringing subsiding volcanic islands or seamounts. Nevertheless, the term seems descriptive and useful, given the rounded, semienclosed ("horseshoe shaped," Jindrich 1972) complex that is partially ringed by fringing reefs and banks enclosing an interior area with deeper lagoons and banks.

Brooks' (1962) contention that seasonally shifting currents and wave actions are the main shaping agents is supported. Seasonal effects of shifting wave energies are dramatically shown for the sand islands (O'Neill 1976). The Tortugas' overall shape may be relict through Holocene recolonization of bedrock ridges from a Pleistocene interglacial "atoll" (Shinn et al. 1977).

The Tortugas complex as a distinct depositional unit is approximately 20 km long in its northeast-southwest axis and about 11 km across. Three main channels through the discontinuous fringing reefs and other carbonate shoals allow good circulation and swift currents (20-60 cm/sec, .39-1.18 kn) between the sea and the central lagoon (Jindrich 1972) (see Figure 1.1). Tidal currents in shoal waters reach 110 cm/sec; 2.17 kn.

Principal modern submerged geological investigators are Jindrich (1972) who describes depositional environments and processes and Shinn et al. (1977 reprinted in Halley 1979; see also Shinn et al. 1989), who investigated cores from one main coral reef. Shinn reports that cores have been taken from Pulaski Reef, Loggerhead Key and a site north of Ft. Jefferson. Jaap et al. (1989), Davis (1979 a & b) and Meeder (1979) describe the biologic communities that generate reef rock and sediments. As references indicate, the luxuriant local coral reef environment has received most scientific attention, but sandy and coarser (rubbly) carbonate shoals and islands of late-Holocene origin are also prominent.

Elongated ridge interconnections form a honey-comb pattern in parts of the interior lagoon, and some corals grow on interior shoals (Davis 1979a, 1982). Cold weather and disease stressed and widely killed these corals in 1977 (Porter et al. 1982; Shinn et al. 1989). Submerged sandy and rubbly environments, little investigated except near reefs, are derived both from mechanical disintegration and lagoon-ward transport of reef debris, and by colonial calcareous green-algae production, especially *Halimeda*.

Only brief mention is given here to the lagoonal sediments due to lack of data. Lagoonal sediments are finer, consisting of muddy carbonates because of deeper (to 18 m), quieter, protected waters and distance to source areas for coarser materials. They are relatively thin compared to the thick reef and sand-bank deposits. Thinness is judged indirectly by lagoon bathymetry and by bedrock elevation beneath the Dry Tortugas area in the few cores reported, which were located elsewhere on the thick deposits (Shinn et al. 1989; Jindrich 1972) (see Figure 2.1). This description of coral reefs and their development shows a direction for future research. There is a glaring need for further stratigraphic investigation of sand banks and emergent islands in any attempt to understand the Holocene origin and evolution of the Dry Tortugas complex. Some of the unreporte cores mentioned by Shinn et al. (1977), ma reveal such information.

Coral Reef Environment and Development

Jindrich (1972), working mostly on the ree and adjacent areas in the Garden Key segmer of the Dry Tortugas fringe, recognized thre main depositional environments: reef, ree bank, and lagoonal bank, each with area subdivisions. Each environment and sub environment has an intrinsic likelihood fo receiving and burying, or otherwise preservin or retaining, historical artifacts, and each ha characteristics enhancing or complicatin archeological exploration and excavation.

Reefs contain a rigid wave-resistant wall o the seaward side built in part or totally o coral. Reef banks have low energy, coral covered surfaces that rarely rise into th vigorous surf zone. Some protected ree banks rise to within 1-2 m of the surface Where reef banks face open waters, they ma actually be storm-degraded reefs, becaus erosion surfaces are not readily differentiate from accretionary surfaces (Jindrich 1972).

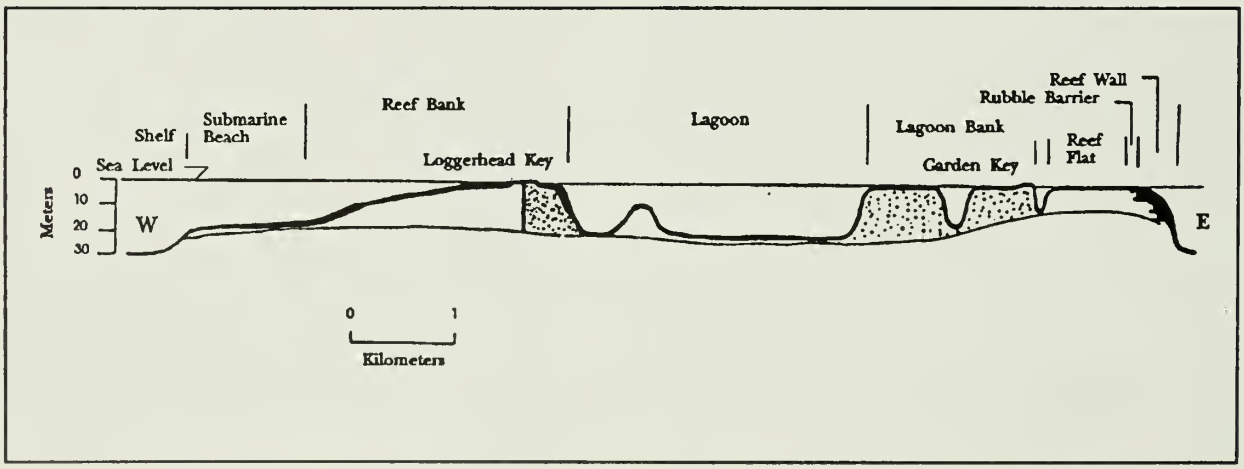


Figure 2.1. Cores and C14 dates collected from the Dry Tortugas (Shinn et al. 1977).

Lagoonal banks are raised features composed primarily of fragments, but these banks may have a coral covering and a fairly rigid surface. The Garden Key reef Jindrich (1972) examined most closely has a seaward-facing wall that dips roughly five degrees for 200-250 m, and at about 10 m depth dips abruptly to about 25 m depth (note that it is not a near-vertical "wall"). Coral-reef spurs 3-5 m wide and up to 15 m long rise near the seaward edge, with sand and rubble paving the floors of intervening grooves. The conch *Strombus gigas*, a common aboriginal food item, populates the upper reef wall. Coralline algae, which occur widely, covers many dead coral rock areas.

Shinn et al. (1977) cored a reef that revealed that an accretion of about 15 m in the last 6,000 years (Figure 2.2). This reef covered Pleistocene bedrock, but had also grown over Holocene-age granular sediments.

Sand Islands or Keys

Present islands are composed of modern sediment rather than ancient rock and are accretionary rather than relict. Despite descriptions of "rocky" islands in reports, with "boulders," "shingle" and "rubble" mentioned, rock is not dominant. Rock that is present includes two types: 1) large fragmental coral or coralline algae debris, deposited in substantial storms or 2) tabular beachrock formed in place by calcium carbonate cementation of calcareous sand and coarser debris (Ginsburg 1953; Multer 1971).

The Tortugas' keys differ fundamentally from those of Pleistocene-age bedrock, such

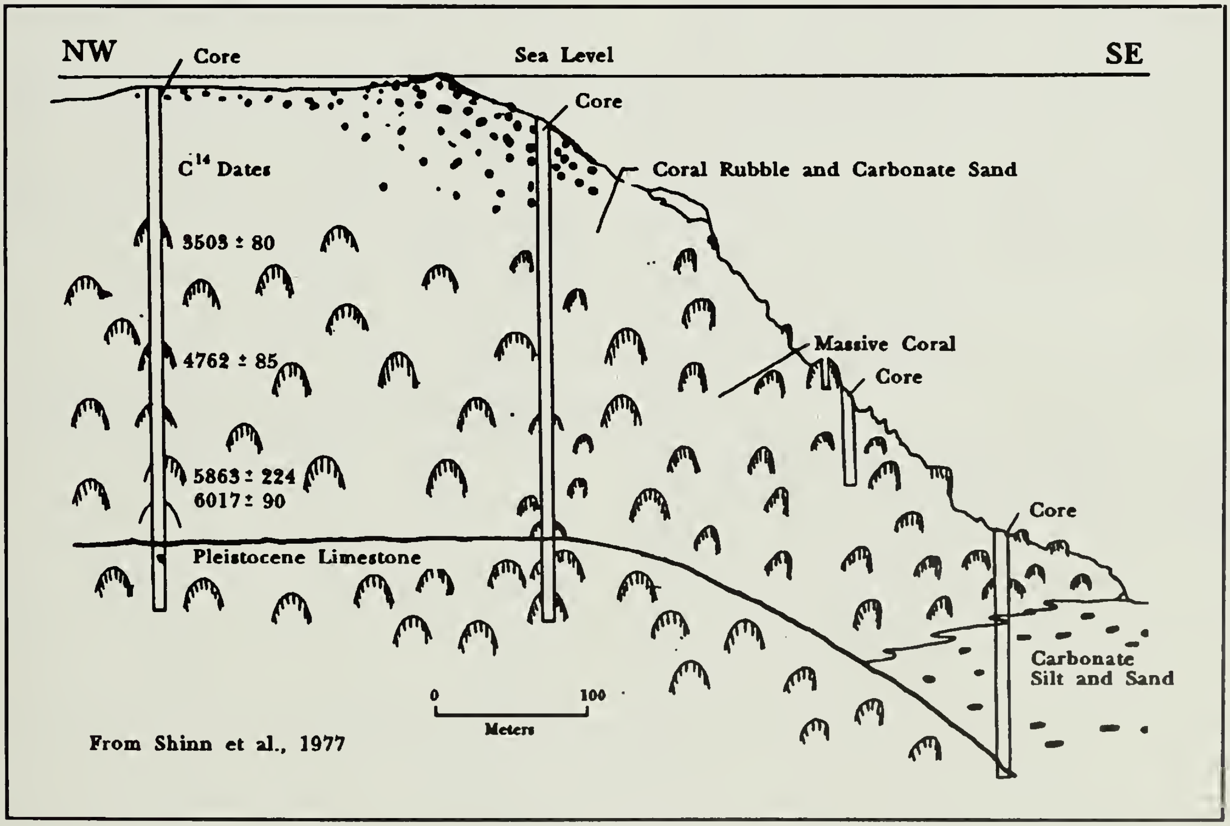


Figure 2.2. Generalized cross section through the Dry Tortugas (from Jindrich 1972).

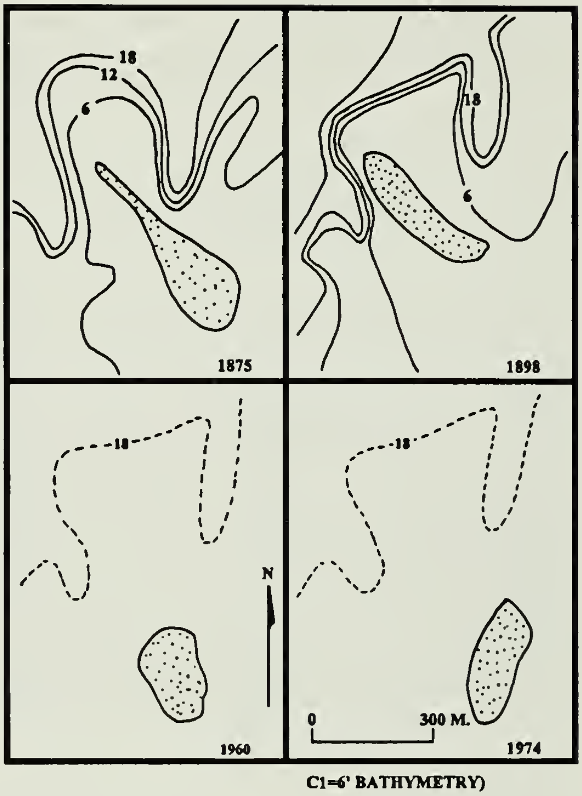


Figure 2.3. Historical morphology of East Key (from O'Neill, 1976).

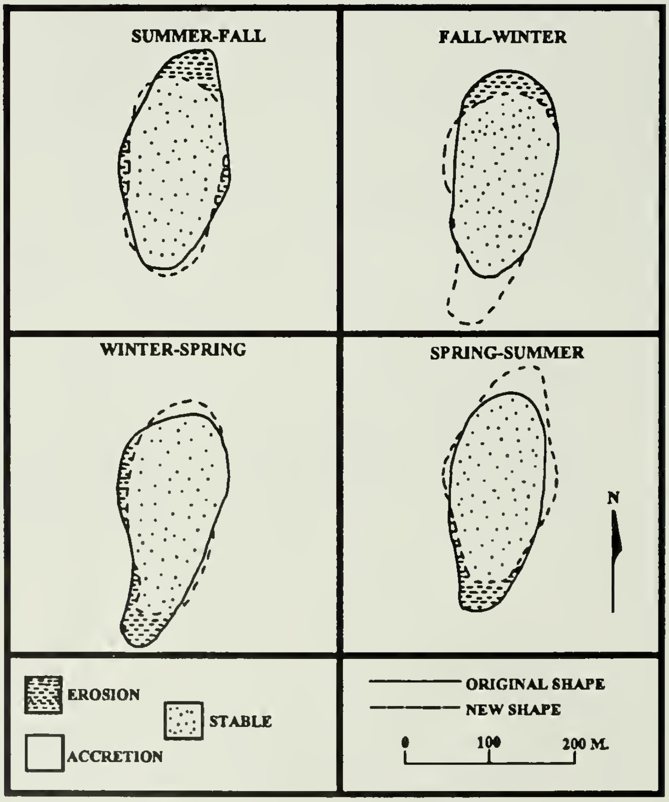


Figure 2.4. Seasonal morphology of East Key (from O'Neill, 1976).

as the oolitic lower Florida Keys or coralline upper Florida Keys. A few drill holes on Garden Key, Loggerhead Key and Southeastern Reef encountered bedrock 10-20 m below sea level (Hoffmeister and Multer 1968; Jindrich 1972; Shinn et al. 1977, 1989). The islands are neither composed of exposed Holocene-age coral reefs nor coral-growth-capped shoals, now at or slightly above sea level. Growing corals and in place (untransported) Holocene-age coral all lie below sea level. Similar sand keys elsewhere in the Caribbean may have useful comparative data for future investigations of Dry Tortugas' islands (e.g., Alcarn Keys, Mexico: Folk 1967; Fosberg 1962).

Ages of existing Dry Tortugas' sand islands and the local sand-island environment are unknown; it also is not known if similar islands preceded the present ones. Some speculation based on sedimentary and sea-level conditions can be applied to this question. The seven existing islands were reported in their approximate present locations in A.D. 1773, but three other islands also reported then have disappeared (Stoddart and Fosberg 1981). In addition, some existing islands were nearly eliminated in the interim period, presumably by hurricane wave attack, and these islands have subsequently recovered to emergent vegetated features. No new islands have formed. Stoddart and Fosberg (1981) have reviewed map records and identify other written descriptions and compilations, notably Robertson (1964); Jindrich (1972); O'Neill (1976) and Davis and O'Neill (1979).

Tortugas island topographic and vegetational dynamics are important to archeological interpretation. For example, the islands and the island environment may not be very old. Current islands have been subject to seasonal (interannual) and occasional, but not infrequent, moderate to substantial modification in shape, size, and probably even location, which is poorly documented. Major modifications are known to recur on time scales as short as decades and seem hurricane related (Figure 2.3). Shorter-term changes are thought to be related to seasonal shifts of prevailing wind and wave direction (Figure 2.4) (Jindrich 1972; O'Neill 1976; Davis and O'Neill 1979). Seasonal weather variations are discussed in Chapter VI.

The two larger islands, Loggerhead and Garden Keys, have fewer complications due to shifting at least since A.D. 1773, and by inference probably were more stable in earlier historical times (ca. A.D. 1515-1773). In essence, the other islands are active beach environments, including only temporarily vegetation-stabilized interior beach-ridge features.

Long-term preservation of recognizable archeological sites, topographic or vegetational features has been threatened frequently by storm waves throughout the past millennia. However, rising sea level and rapid accretion does give some hope for long-term preservation of older surfaces by deep burial. Although the present near-surface environment has been battered for several thousand years, older surfaces are now buried and protected within the islands by meters of sediment. But were they terrestrial surfaces?

If occupied surfaces exist, older ones may have had a better chance of surviving by being both crossed by sea level and buried more rapidly in the faster middle-Holocene sea-level rise, compared to that of the last few thousand years. Obviously, any site on a part of an island that is seasonally eliminated, or has ever been eliminated, is essentially destroyed, and its contents, if not very dense, are scattered. Dense objects may retain patterned spatial integrity as a buried storm-lag deposit (Murphy 1990c) while other artifacts may be buried elsewhere and recovered at seeming random fashion, or in a hydrodynamic rather than cultural pattern. An important point for archeological interpretation in this environment is not to overdraw the modern terrestrial conditions as analogs to the past, even to the historical past.

Present and past sand-island terrestrial environments and vegetation seem to have little of significance that would especially attract humans. Certainly, any mature plants recorded for the Dry Tortugas (Stoddart and Fosberg 1981 and their previous survey references) would have been readily available along the mainland coast. Marginally drinkable water is available only as a lens at shallow depth, on at least some larger islands (Loggerhead Key, 3 ppt salinity Halley and Steiner 1979).

Reconstruction of the islands' earlier geologic history will require stratigraphic analysis and drilling or coring. Specifically, attention should be directed to locating former terrestrial surfaces that were buried during vertical accretion by sea-level rise. Specific attention should also be directed to identifying zones evidencing subaerial exposure: buried soil zones, zones with carbonaceous matter that could be radiocarbon dated or beach-rock strata, also potentially datable (the calcareous cement should be quite reliable). Coring submerged banks, in addition to revealing accretionary history and rates, may give evidence of former islands, either where now extinct, or perhaps even where now-existing nearby islands once stood, if these features are laterally mobile. Lateral mobility over many hundreds of meters would not be at all surprising given the time length, available wave energies and sea level rise. Most important, the islands seem to be merely highly conspicuous areas (albeit drastically different environments) of much larger sand banks. Long-term changes in location of greatest emergence areas seem probable rather than unlikely, given the apparent absence of controls by older substrate topography. Future investigations, however, may reveal that some islands result from specific convergences of nearby carbonate production, currents and waves, and consequently may be somewhat fixed in position, at least recently during slow sea-level rise. Drowned and migrating barrier-type sand islands are well known elsewhere, as are mobile beach ridges in general and these features offer comparative data. Although little is known of the early sand island environmental history, much can be learned through coring and stratigraphic analysis.

Tortugas Paleoenvironmental Inferences from Mainland Data

Introduction; Types of Evidence and Linkages. Paleoenvironmental conditions at the peninsular tip, including the coastline and Florida Bay and Keys area must serve as a model for inferences to Dry Tortugas conditions during time(s) of emergence. Extrapolation is necessary because of the extreme paucity of Dry Tortugas paleoenvironmental data; however, this does not reduce the need for locally derived site-specific data through future research.

Available information on paleoenvironments and their succession in South Florida is provided mostly by abundant stratified, radiocarbon-datable and, most important, environmentally diagnostic, fresh- and brackish-water wetland sediments. These sediments are widespread in the regionally dominant wetlands. Basal sediment positions, ages and internal stratigraphies document regional environmental conditions, stages, and shifts during the human era. Direct linkages between sediment type and hydrological environmental factors, and indirect linkages through ecological controls on biota that either form or facilitate sediment formation, allow strong inferences to be made regarding the Holocene geologic record and previous conditions of surface-water hydrology. Fossil pollen in wetland or lake sediments reflects soil moisture conditions in nearby and regional sites that were unflooded and unburied. Vegetational remains, and the less-abundant faunal remains, inform directly about the human subsistence base around sites, or in particular types of depositional environments. Hydrologic inferences about climate are especially important; these can be extended further in interpreting conditions on contemporaneous, nonflooded peninsula soil surfaces that did not directly accumulate sediments or contribute a detailed pollen record.

Reconstructions are possible because of very strong interrelationships between surface-water hydrology and vegetation, and by regional occurrence of modern depositional environments that serve as analogs for most ancient sediment types. These analogs reveal environmental conditions of deposition. South Florida paleoenvironmental research is highly favored by this convergence of circumstances, although it has not progressed beyond a general regional reconstruction. Detailed examinations have been made for only a few of the many freshwater sites. Very shallow marginal marine environments or marine-dominated estuarine environments have been more extensively researched.

Sources and Prior Work

Relevant South Florida information paleoenvironmental reconstruction is scattered in many disciplines' literature. Little has been collected specifically for paleoenvironmental research, with some important exceptions: 1) stratigraphic pollen analyses of lake sediments by Watts (1969, 1971, 1975, 1980; Watts and Hansen 1988); 2) pollen and plant macrofossil analyses including wood taxonomy of several archeological sites (Warm Mineral Springs: Clausen et al. 1975; Little Salt Spring: Clausen et al. 1979; Brown 1981; Fort Center: Sears 1982); 3) late-Holocene vegetational succession of specific Everglades and coastal plant communities (various types in Everglades National Park area: Craighead 1969, 1971; tree-islands and marshes in the northeastern Everglades: Gleason et al. 1974, 1975, 1977, 1980). Archeological materials as a unique type of sediment also reveal important aspects of geologically recent environmental changes in a prescient article by Goggin (1948). Reviews, syntheses or regional treatments of late-Quaternary paleoenvironments containing extensive reference lists include: Gleason et al. (1974), Watts (1980), Watts and Hansen (1988), Stone and Brown (1983), Stone and Gleason (1983), Carbone (1980, 1983), Delacourt (1985), and Delacourt and Delacourt (1985).

Considerable additional information on vegetational and sedimentary environmental successions in specific areas comes from sedimentology-focused stratigraphic analyses, including floral and faunal identifications from macro- and microfossils: 1) coastal nearshore mangrove fringe and lagoons (Spackman et al. 1966, 1969, 1976; Taft and Harbaugh 1964; Scholl 1964; Scholl et al. 1969; Riegel 1965; Smith 1968; Cohen 1968; Wanless 1976, 1989; Kuehn 1980); 2) Florida Bay and Cape Sable specifically (Davies 1980; Davies and Cohen 1989; Roberts et al. 1977); 3) freshwater Everglades environments (Gleason 1972; Altschuler et al. 1983; and specific additional freshwater sites in works by Spackman, Riegel, Smith, and Cohen, see above). Peat as a soil has been examined in several wide-area surveys with stratigraphic information (Dachnowski-Stokes 1930; Allison and Dachnowski-Stokes 1932; Davis 1946). Various county and subcounty soils surveys include some significant stratigraphic data (e.g., peat/marl interlayering in Dade Co., Gallatin et al. 1958). Many other scattered data related to environmentally significant stratification in Holocene sediments occur in an eclectic array of sources: Quaternary geological, archeological, water resources, historical, agricultural, habitat management and others.

Increasing Separation from the Mainland

Interrelationship between the Dry Tortugas area and Florida mainland and coastal near-shore environments changed dramatically through the postglacial period. At first, the Dry Tortugas area was part of the emergent, and at that time much larger, Florida peninsular mainland. At the most general view, subsequent evolution was one of the Dry Tortugas area becoming divided and increasingly isolated from South Florida by open marine waters as sea level rose in postglacial times. Although it is entirely possible, perhaps probable, that no islands existed for an extended period or periods at the Dry Tortugas area, the Florida Keys Pleistocene limestone has remained emerged, first as a ridge and later as a series of island "stepping stones," to the mainland. The fairly deep channel between Rebecca Shoal and the Tortugas (deeper than -18 m msl) flooded early in the marine transgression and isolated the Dry Tortugas bedrock island(s) from the mainland. In the later stages, marine waters flooded Florida Bay, displacing freshwater marshes in many areas, and occupied the channel depressions between the present Florida Keys. The South Florida shoreline ecology facing the Dry Tortugas changed from more terrestrial with somewhat steeper coasts and offshore bottoms, to more island-like and backed by lagoonal environments such as the present shoreline along the southwestern shore.

Today's physical isolation of the Dry Tortugas area is the greatest of the human era. Increasing physical isolation must be balanced against an archeological assessment of the "technological" distances, which certainly decreased sharply in premodern times, and also must consider the possibility that no islands or "target" existed at some earlier times.

Late-Glacial and Postglacial Succession of Environments

Conditions at the Dry Tortugas area when it existed as elevated Pleistocene-limestone bedrock terrain, at first attached to the mainland and later as bedrock islands, can only be inferred from recorded or interpreted conditions on the mainland or Florida Keys. Presence of some organic debris, such as found by Shinn (1977, 1989), in minute pockets at the top of the uppermost, now buried, Pleistocene bedrock surface gives hope for future pollen analysis of the last terrestrial or coastal environments prior to inundation. Peat has been found under marine waters in reef and backreef areas of the Florida Keys, even beneath established coral reefs (Robbin 1984), and if found at the Dry Tortugas, will provide not only precise and datable sea-level indicators, but also fossil-pollen evidence of peat-forming and adjacent terrestrial vegetation. At present, there is no interpretable local evidence for such conditions at the Dry Tortugas.

The general South Florida postglacial environmental sequence inland from the shoreline has been one of increasing environmental wetness by freshwater, both surface and soil water. This is shown most strongly: 1) by the basal ages of abundant wetland sediments, times prior the onset of deposition being drier and below the wetness threshold for aquatic or wetland sedimentation, and 2) by the seasonal-wetland nature of sediments earliest (deepest) in the sequence. This sedimentary record comes primarily from the Everglades/Lake Okeechobee limestone basin, but important parts of the record come from smaller deposits in topographic depressions in the regionally prominent sandy sediments surrounding the main basin. Corkscrew Swamp in Collier County is notable for its long and reasonably continuous record of hydrologic and vegetational conditions (P. Stone, J. Meeder and M. Duever, unpublished data).

Very few sites from the enormous freshwater wetland-sediment area in South Florida have yielded basal ages greater than terminal-Pleistocene or earliest-Holocene times. The exception is the poorly understood "Lake" Flirt, a pond or deep marsh in Hendry County with nonbasal apparent dates (see below) as old as 32,000 B.P. (Brooks 1968; Stone and Johnson, unpublished data). Regional freshwater sedimentation onset marks Holocene interglacial environmental conditions (Watts 1975). Lake Annie, on the southernmost extension of a quartz-sand ridge that protrudes into South Florida northwest of Lake Okeechobee, began its current round of sedimentation about 13,010 B.P. (Watts 1975). The immediately underlying aquatic sediments yielded radiocarbon dates of about 33,300-44,300 B.P. (Watts 1980), but may be much older due to effects of slight natural contamination. (All finite radiocarbon dates of 20,000 B.P. or older should be viewed with suspicion, especially any associated with evidence of interglacial conditions (Morner 1971; Stapor and Tanner 1973)). A long sedimentation hiatus is very strongly suggested, encompassing at the least the time of the late-Wisconsin glacial extreme advance, which peaked about 18,000 B.P., far to the north of South Florida. Erosion or extremely slow deposition seems likely, even though Watts observed no overt sedimentary sign of exposure and drying. An abrupt shift in pollen flora assemblage proportions also argues for a significant hiatus below the 13,010 B.P. layer.

Near Lake Okeechobee, all nonsinkhole lakes investigated by Watts in peninsular Florida were apparently dry during this glacial extreme. Where underlying sediments occurred below the hiatus level at Mud Lake in Marion County, radiocarbon dates were old and indeterminant (>35,000 B.P.), and Watts thought the pollen flora represented interglacial conditions (Watts 1969, 1971, 1980). The last interglacial was around 100,000 or 125,000 B.P. Shealer Lake, in northern Florida between Gainesville and Jacksonville, has some sediments just older than the final glacial advance in a layer bounded by levels dated to around 18,000-24,000 B.P., but this lake sequence still evidenced a hiatus from about 18,000-14,000 B.P. (Watts and Stuiver 1980). Only Lake Tulane, near Avon Park on the sandy ridge, shows enticing evidence of holding water during this last glacial advance (Watts and Hansen 1988).

Environmental dryness prevailed in the later-Wisconsin glacial period, at least sufficient to prevent prolonged inundation in vast areas or depressions that are now marshes, swamps and even lakes. In modern lakes, water now stands 20 m higher than the hiatus level in the sediment profile, which indicates a water-table rise of at least this magnitude (Watts 1980). Greatly lowered sea level under the continual glaciation influence obviously had a major role in the substantial lowering of the water table by increasing hydraulic gradients for surface-water run-off and ground-water drainage. Sinkhole water tables, which form the focus of important mainland archeological sites, lay considerably below modern sea level in terminal-glacial or early postglacial times (Cockrell and Murphy

1978b; Clausen et al. 1979). Hydraulically, lowered water tables could only be accomplished under direct influence of lowered sea level.

Hydrologic base level control seems insufficient as a total explanation for the evidenced environmental conditions in the wider region, however. Earliest pollen assemblages, deposited soon after resumption of aquatic sedimentation in the deeper lake depressions, have strong suggestions of drier-aspect vegetation. This, in turn, suggests a decreased rainfall climatic regime relative to later times, including the modern, because much modern vegetation outside wetlands does not depend on tapping the water table by roots, but rather intercepts infiltrating rainwater as unsaturated-zone soil water. Plants are not likely phreatophytes, especially those on the high sandy terrains. At 30,000 B.P. at Lake Annie the conditions were very different than at present. The surrounding overdrained sandy ridges supported few pines. Instead, the plant types that now occupy only the highest and driest ridge tops, such as rosemary (*Ceratiola*), were much more prevalent than in later Holocene and modern times (Watts 1975, 1980). Shade-intolerant herbaceous plants also appear to have been common, though the broad environmental range and difficulties in identifying genera by pollen for the family *Compositae* limit the inference somewhat (Watts 1969, 1971). Pine is wind pollinated, and the very low percentage of this widely dispersed pollen shows a regional, rather than local, rarity of pines, especially compared to their present ubiquity outside regularly flooded sites.

The earliest sediment record in the era of reliable radiocarbon dating at Lake Annie (ca. 13,010 B.P.) is conveniently very roughly the same time as the earliest known human occupation of the region. These Holocene basal sediments also show pine to be much rarer than in all of late-Holocene times, including today, and show oak to have been much more common (Watts 1975). Oak is also wind pollinated, and therefore is evidenced on a wide-area basis from this one site. Oak species differ greatly in their ecological associations, from xeric sandhills to very moist lowlands (although not in flooded sites, typically), and this limits the inferences (Watts 1969). Codominance of xerophytic oaks with pines in historic times on dry, highly permeable, elevated, peninsular ridge acid-sands gives support to interpretation of a dry open forest or forest/herbaceous-prairie mosaic for the vegetation at the end of the Pleistocene glacial era and onset of Holocene interglacial conditions (Watts 1971).

The approximate Holocene era onset of postglacial conditions is usually given as 10,000 B.P. This is derived more from north-temperate or boreal area sequences, but several continuing South Florida wetland deposits date from about this time.

Sedimentation in the first half of the Holocene period at the more southern sites that have been investigated at Corkscrew Swamp and Everglades consisted mostly of freshwater marl or calcitic marsh muds. At the Windover Site near Titusville, Volusia County and the Bay West site near Naples, Collier County, peat or muck deposits initiated the archeological sequences (Doran and Dickel 1988; Kropp 1976). Deposition began in Buck Lake, near Lake Annie, about 8500 B.P. (Watts and Hansen 1988) and at the Bay West site deposition began around 7200 B.P. (Beriault et al. 1981). In the Everglades, deposition began prior to 6500 B.P. (Gleason and Stone 1975; Brooks 1974).

The long record at Corkscrew Swamp and the wide area of the Everglades best represent South Florida conditions. Marl evidences a seasonal-marsh environment--wetland, but drier than the peatland conditions of today in both areas. The oldest examples of peat or muck deposition without marls elsewhere in the region reflect somewhat wetter conditions at those sites. At the larger wetlands, marl deposition continued apparently steadily for thousands of years, until mid-Holocene times. However, the early mid-Holocene onset of peat or muck deposition at the Bay West site shows that local shifts, or else trends with crossing of hydrologic thresholds, took place within early Holocene times. Similar shifts are shown by areas of thin, calcitic Everglades mud that date somewhat prior to 6500 B.P. The 6500 B.P. date is from a bulk date on the entire thickness at Kreamer Island, in an extension of the Everglades at the south end of Lake Okeechobee (Gleason et al. 1975), and about the same date from a similar layer at the eastern lake shoreline (Brooks 1974). These thin marl areas began accreting within, not at the beginning of, early Holocene times. Elsewhere, in a small portion of the northeastern Everglades, much thicker marl occurs beneath peat (Davis 1946, Fig. 15), consequently this deposit's initiation must have been considerably earlier. Freshwater sediments as old as 6500 B.P. occur beneath marine sediments in Florida Bay (Davies 1980).

The early mid-Holocene sedimentary shifts presaged dramatic changes occurring around 5000 B.P. and have parallels in the pollen record. Lake Annie, similar to other Florida peninsula lakes such as Mud Lake and Scott Lake, shows an oak-dominated, woody vegetation containing much well-lighted ground cover, indicating a sparse forest or a forest with prairie-like openings. This situation characterizes much of the regional early Holocene period vegetation, which persisted from terminal-glacial times. Pines, presently regionally dominant, must have been few, but they dramatically increased in abundance starting very roughly 7000 B.P., toward their eventual dominance by the middle of the Holocene (Watts 1971, 1975, 1980). Changeover from oak to pine dominance has been ascribed to increased wetness, which is independently evidenced by wetland sediments, fire frequency with humans suspect and even to soil leaching (Watts 1980). The actual cause remains unproved, but recurring fire is necessary to maintain pine forests in the region, and many of South Florida's pinelands are marginally wet occurring in wide areas of low, slash-pine flatwoods environment off better drained coastal and axial ridges.

Wetland sedimentary evidence overall shows somewhat drier conditions than today, at least seasonally, for the early Holocene and an increase in wetness toward mid-Holocene times. The probable causes are discussed below in relation to the dramatic "explosion" of peatlands in the middle of Holocene times. Around 5500 B.P. at the earliest, and over wide areas by 4500 B.P., peat deposition succeeded marl deposition, or else initiated directly on limestone and sand surfaces. This occurred at both Corkscrew Swamp and the Everglades. The oldest Everglades dates come from former southern and northern extensions now beneath Florida Bay and southern Lake Okeechobee (Davies 1980; Gleason and Stone 1975). By 5000-4500 B.P., wide areas of Everglades and Corkscrew Swamps existed as peatland, and by 4000 B.P. many of the vast number of small isolated depressions that are surrounded by more terrestrial environments in the region had evolved to wetlands and begun to accrete peat or related muck. Some other southeastern United States lakes and sites similarly date from this mid-Holocene time, for example Scott Lake (Watts 1971) and a peat deposit (Gurr 1972) both in Polk County. At Okefenokee Swamp in southeastern Georgia, even though the earliest peat deposition was around 6500 B.P. (Spackman et al. 1976), almost certainly in the deeper areas of the depression, the initiation of widespread peat deposition in many areas began somewhat later around 5000 B.P. (Bond 1979; Stone and Johnson, unpublished data).

This wide-area initiation and peatlands expansion in the southeastern United States and southern Florida regions clearly evidences wetlands establishment and prolonged annual flooding. At present, such peat-forming marshes are flooded for more than half of each year, in some cases to near continuous flooding year-after-year (Olmsted et al. 1980, Figs. 5-7; Gleason et al. 1975). Some wet-mesic to marginal-wetland forests, especially bayhead vegetation, including some cypress forests accrete peat without prolonged flooding (Gleason et al. 1975; Spackman et al. 1976). These environments are dwarfed in importance by South Florida marshes, and their woody peats are unlikely to be confused with marsh peats.

There are two obvious outside physical controls that could have imposed regional peatland development: climate and rising sea level acting as the hydrologic base level. Hydrologic feedback mechanisms may also have played some role. Davis (1943, 1946) mentions dense, developing marshes retarding run-off, peats with high waterholding capacity retaining water, partial sealing of substrates by marl retarding infiltration, peat damming; to these could be added partial sealing of substrate by soil-horizon development in the widespread spodosols in the sand lands, particularly beneath low pinewoods.

Hydrologic feedback mechanisms do not intuitively seem to be the principal hydrologic factor in postglacial trends to increasing wetness. Sea-level rise substantially lowered hydrologic gradients for surface-water run-off and for ground-water drainage at low-elevation ites. For the presently emergent portion of the peninsula, this would have been most important since around 5000-6000 B.P., after sea level had quickly reached within 4-6 m of its present elevation. Obviously, the now submerged terrain offshore would have been affected earlier. Sea level, as hydrologic base level, would have been much less important as a factor for more elevated sites or sites at which a water table is perched above low permeability clay layers or semiperched (where vertical ground-water infiltration or drainage is greatly retarded even if not essentially precluded) above relatively low permeability mixed clayey sediments, or perhaps even in places above dense recrystallized limestone. In such situations, climate is likely the control on wetland initiation, especially when it occurs at roughly the same time at different elevations. Climate here specifically implies the rainfall regime. There is no evidence of a great temperature change, and in any case wetland initiation occurred in Holocene times when warmer and more heavily vegetated conditions would have increased, not decreased, evapotranspiration losses.

By 5000-6000 B.P., the close approach of sea level is deduced to have greatly affected the low lying Everglades hydrology at the basal elevations of the present peat deposit, especially in its former, now submerged, extensions to the south. Other low elevation deposits in Big Cypress Swamp, the sandy flatlands, and interridge swales in the coastal ridges would have been similarly influenced. By extension of this reasoning, however, climatic controls are implied for the initiation of lake or wetland sedimentation in the 14,000-10,000 B.P. time range, particularly at Lake Annie, the former Lake Okeechobee marsh and Corkscrew Swamp, when sea level was at least 20 m and possibly 70-80 m below its present level (Kuehn 1980; Robbin 1984; Blackwelder et al. 1979). The sea had risen greatly from its most depressed level around 18,000 B.P., so that base level control is not disproved, but tentatively, pending numerical geohydrologic modeling, sea level does not seem to be the main or singular control for wetland development. Similarly, widespread mid-Holocene wetlands development at various elevations from roughly -4 to +30 m relative to modern sea level strongly suggests a significant increase in annual rainfall. Examples are the low elevation Florida Bay and neighboring coastal environments, the midelevation Polk County deposit, and higher elevation Okefenokee Swamp, which is around 30-35 m msl.

A peculiarity in Florida's climate, especially in the south, favoring wetland development is strong rainfall seasonality that delivers much more water in the hotter months when evapotranspiration is highest. High-water time in freshwater areas of southern Florida is in the fall, not the early spring as it is to the north, and wetness rather than dryness prevails in the most active growing season.

Climate probably played a role in early Everglades development, even in mid-Holocene times. This is suggested by the apparent initiation of the oldest peats, (closely spaced data available only for the northeastern Everglades) on the less-permeable rock areas rather than at the topographically lowest rock areas (Gleason et al. 1974). Sand layers above the rock and below the peat weakens this inference, however (see Davis 1946, Fig. 14). By 4000 B.P., the largest regional deposits, and most investigated examples of the much more numerous small peat and muck deposits, had begun to accumulate in newly created long-hydroperiod wetland environments. Obviously, topographic depressions holding these deposits had long existed previously, excepting possibly some of the smallest ones (Meeder in Duever et al. 1979:83).

Local and regional pollen data show that pine predominated in the forest vegetation by 5000 B.P. (Riegel 1965; Watts 1975, 1980; Brown 1981; Nichols in Gleason et al. 1975, Core 5). Essentially modern environmental conditions were established in mid-Holocene times. It was not the modern or predevelopment landscape, however. Slower changes, occurring as long-term trends, continued with sea-level rise: outward expansion of existing wetlands best represented by peatlands; initiation of small wetlands as hydrologicthresholds were passed on scattered low sites; and the establishment of higher water tables and occasional flooding over wide, low flatland areas.

Evidence for episodic changes exists also for late-Holocene times, in coastal areas either in sea level or storminess (or perhaps in coastal exposure, without an outside influence), and in the freshwater hydrologic regime. Both would have affected the Dry Tortugas area, while storms would have been the main regional influence on the environment. Episodic here implies periods of rapid change, probably including some or all of the 14,000-10,000 B.P. shifts along with the mid-Holocene shifts, separated by intervening periods of relatively stable conditions, or at least slower change. Fluctuations with reversals provide the best evidence of episodes.

Sanibel Island is formed of four separate sets of beach ridges, each formed of adjacent, similarly oriented ridges (Missimer 1973). Shifts in orientation between the sets suggest changes in wave approach, but a curious increase and then decrease in beach ridge height in one set dated approximately 2400-1600 B.P. (but note the uncertainties in ridge dating, see Stapor and Mathews 1976), suggested to Missimer (1973, 1980) that sea level stood up to 1 m higher than present during that time. The dramatic effect that such a high stand should have had on the low-level southern and southwestern coastal fringes has no known sedimentary evidence. Other researchers (e.g., Scholl 1964; Scholl et al.

1969; Spackman et al. 1966, 1969, 1976; Riegel 1965; Smith 1968; Cohen 1968; Gleason 1972; Davies 1980; Kuehn 1980; Wanless 1976) suggest causes other than a high sea level stand because of the lack of supporting evidence in this well-investigated area. Perhaps wave energies were responsible, possibly climatically affected through increasing storminess or else incidentally caused by evolution of the bottom topographyand the adjacent shorelines under a changing, but still lower, sea level.

Investigators elsewhere in the southeastern United States have found evidence for fluctuations in the late-Holocene rise in sea level, but without incursions significantly above present levels (Colquhoun and Brooks 1986; Colquhoun et al. 1981; Brooks et al. 1989; for an alternative view, see Fairbridge 1974). While not overtly evidenced in South Florida, where certainly they would be expected, it is possible that such minor fluctuations, evidenced in various portions of the world, are obscured in the record that reflects overall net rise. Minor short-term incursions above present sea level could easily be mistaken for hurricane storm deposits (Scholl 1964; Scholl et al. 1969).

The freshwater sedimentary record is more clear on fluctuations and their likely climatic cause and influence, but the interrelations among shifts are not apparent. Substantial shifts are evidenced within the period very roughly 3000-2000 B.P. The northernmost Everglades muck deposit along the southern shore of Lake Okeechobee lying above the peats initiated deposition around 2800-2500 B.P. (Gleason et al. 1975, Core 11; Gleason and Stone 1975, and unpublished dates from Torrey Island). A rise in the level of Lake Okeechobee relative to the adjacent Everglades is the most likely explanation, and reencroachment of peat above the muck layer at its southernmost portion furthest from the lake indicates an undated reversal (Dachnowski-Stokes 1930). Perhaps the cause of lake-influenced expansion was increased rainfall to the north over the Kissimmee River basin, the principal lake tributary.

A widespread freshwater marl layer occurs within the southern or midlatitude Everglades peats (see Davis 1946; Gleason et al. 1974; Spackman et al. 1976; and Altschuler et al. 1983). The main layer dates about 3000-2000 B.P. for its deposition period (Gleason et al. 1975, Core 25; Gleason and Stone, in press) and has given slightly younger mean dates at another site (ca. 1800 B.P. for midperiod, Stone and Treadgold, unpublished data). Because modern marsh environments of freshwater marl deposition are seasonally drier than marshes where peats are forming, a roughly millennium-long, somewhat drier period is suggested. Minor marl layers above and below the main layer also occur (Altschuler et al. 1983) and evidence other shorter or less altered conditions. Goggin (1948) using South Florida archeological evidence observed that water levels had risen and, in some cases, shifted cyclically or at least episodically.

Even for late-Holocene times of essentially modern environmental conditions, the South Florida regional environment has experienced slow, small-magnitude long-term trends (e.g., 2-4 m rise in sea level in the most extreme examples, and 2+ m rise in water levels in Lake Okeechobee and the northern Everglades) as well as more dramatic shorter-term fluctuations in hydrology.

CHAPTER III

Dry Tortugas Physical Oceanography

Wilton Sturges

INTRODUCTION

This section is an overview of the eastern Gulf of Mexico physical oceanography, concentrating on the area near the Dry Tortugas. The focus is on currents that influence shipping, both now and historically, as well as present-day archeological studies.

The deep-water currents near the Dry Tortugas are dominated by the Loop Current. It is the major permanent current in the eastern Gulf; it is, to the Keys, as the Florida Current is to Miami. Figure 3.1 shows a typical path of the Loop Current, showing both a single day's observation and the average position for that year.

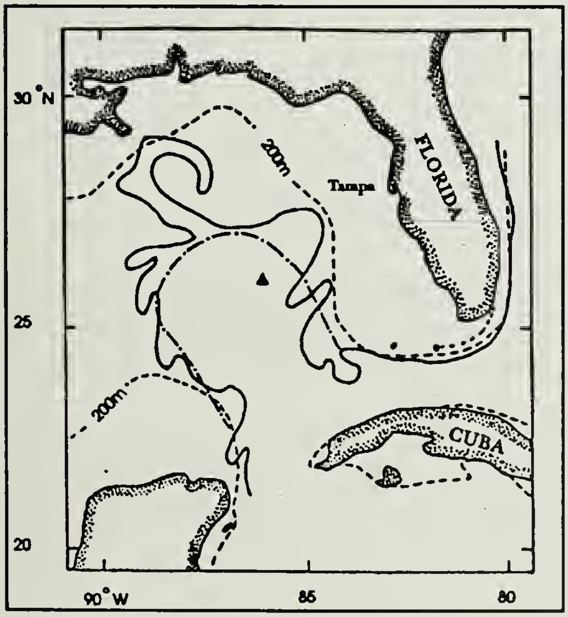


Figure 3.1. Position of the Loop Current on April 2, 1985, full curve, from satellite infrared data: dash-dot curve shows mean position of Loop Current from the full 1984-1985 satellite viewing season. The triangle near 26° N, 87° W shows the position of a NOAA meteorology buoy.

Snapshot observations such as shown in Figure 3.1 have been routinely available for roughly a decade from satellite infrared (IR) data. Data sets like this have made a major advance in our understanding of such highly variable current systems. The path in Figure 3.1 shows the main axis of the Loop Current as indicated by a strong contrast in the observed surface temperatures. Because the sea surface becomes uniformly warm in the summer, these data are usually available only from about October-May.

The following sections will describe the Loop Current and its variability in detail. The continental shelf currents will be described on the basis of theory and observations within the past few years. Currents in shallow water are driven primarily by winds, so some attention is given to those observations. Fortunately, the wind and tide-gauge records at Key West are quite good. Finally, complications of long-term level rise will be addressed.

Currents in Deep Water: The Loop Current

Before flowing along the United States east coast, the Gulf Stream waters flow through the Gulf of Mexico, making a large sweeping arc, or "loop," between Mexico and Key West. This flow pattern, shown in Figure 3.1, has led to the name "Loop Current," and its flow dominates the deep waters of the Gulf of Mexico. The Loop Current path has a great deal of variability. It is generally believed that the smaller, long thin features, having a width

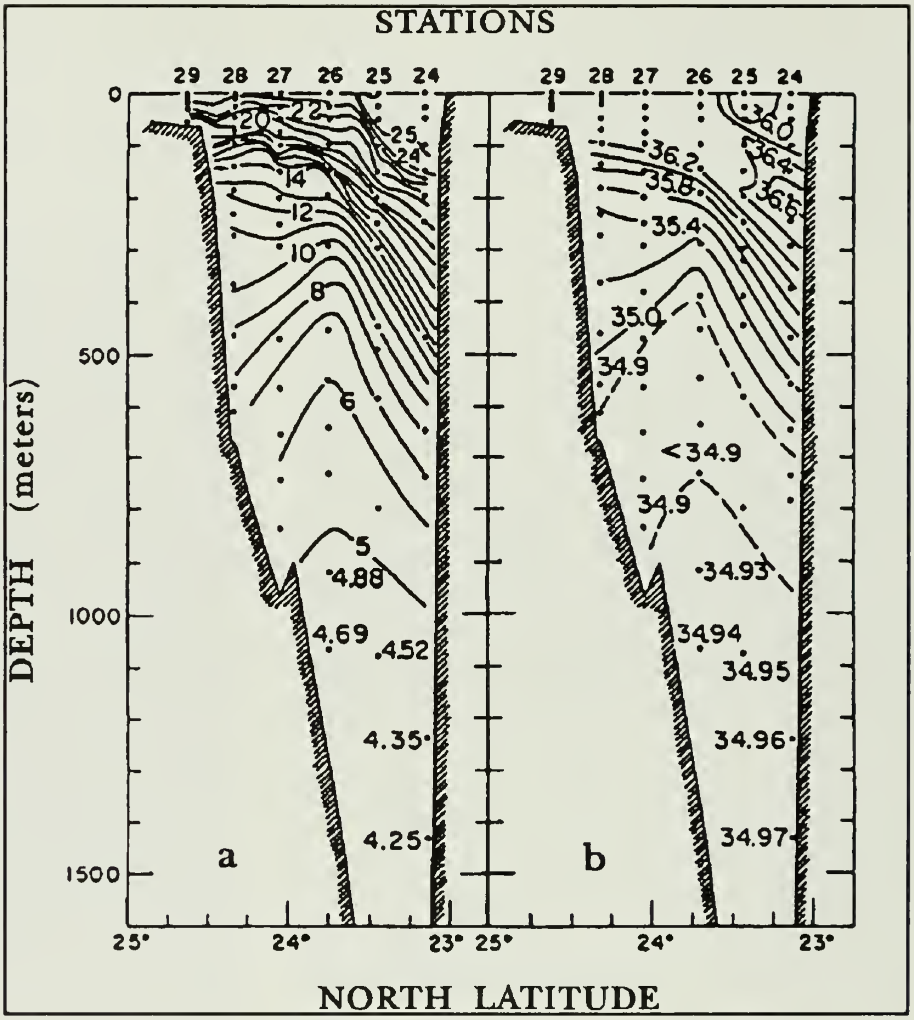


Figure 3.2. Vertical sections of temperature and salinity along a transect between Key West and Cuba. North is to the left. The station numbers (24-29) are shown across the top; temperature is shown in degrees C, salinity in parts per thousand (from Nowlin 1972).

of only 10-20 km are perhaps confined to near-surface phenomena. The larger variations, having scales of 100 km or more represent the full current, which penetrates to depths of about 1,000 m. The current's path, as detected by the IR signal, is the region of largest surface temperate gradient. This is shown in Figure 3.2, taken from Nowlin (1972). The left-hand side of this figure shows isotherms measured at a section from Key West to Cuba. The small dots are the observation points. Just to the left of station 25, it appears that the surface temperature changes from nearly 26° to about 23° in a narrow zone. This is the feature seen best from a satellite.

The region of sloping isotherms is where the current velocity is increasing from low values at depth to strong surface velocities of up to 4 kn or greater.

The same pattern of sloping contours is observed in salinity, as well, and is shown on the right. This high correlation between temperature and salinity is common in such current systems.

Over a period of many months, the Loop Current gradually extends farther and farther into the Gulf, until the loop closes back upon itself. At this point a large clockwise ring is detached, very much like the warm core rings shed from the Gulf Stream beyond Cape Hatteras (e.g., Maul 1977; Elliott 1982;

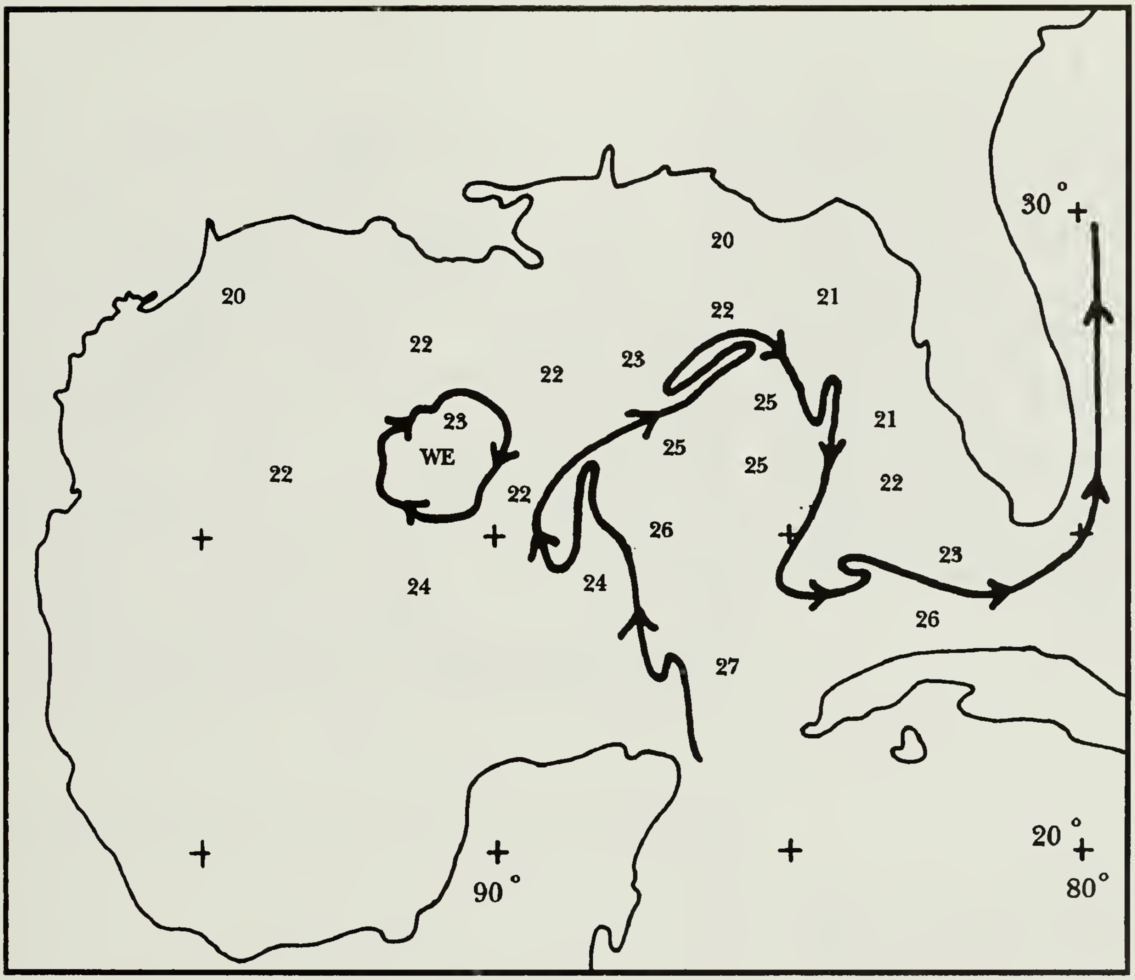


Figure 3.3. Position of the Loop Current from satellite IR data, January 2, 1982. The values 21-25, etc. indicate sea surface temperature. The approximately circular feature in the center of the Gulf marked "WE" represents a small anticyclonic, warm-core eddy or detached ring. (From NOAA/National Satellite Service, Washington.)

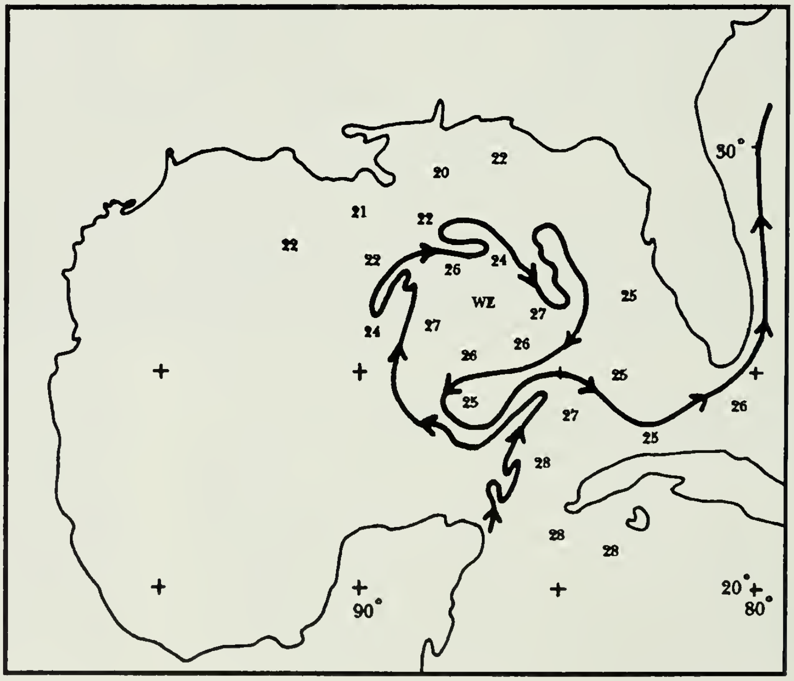
Hurlburt and Thompson 1980; Kirwan et al. 1988). This variability is known fairly well in terms of the amplitude of fluctuations (Vukovich 1988b). Predictability, however, is extremely poor. Some numerical models are available (e.g., Hurlburt and Thompson 1980), but these are not run in a prediction mode.

Rings are known to separate at irregular intervals of 6-18 months. The spectral energy at various frequencies increases toward lower frequencies, reaching a peak at approximately 12 months (Sturges and Evans 1983; Vukovich 1988a).

Figures 3.3-7 show a series of selected Loop Current patterns. Figures 3.3, January 2, 1982, and 3.4, May 10, 1983, show typical large intrusions and the associated waviness around the edges. Figure 3.5, December 13, 1983, shows a very large ring formation that appears to be about to separate from the main flow. These large separated

Figure 3.4. Position of the Loop Current from satellite IR data, May 10, 1983. The values 21-25, etc. indicate sea surface temperature. The approximately circular feature in the center of the Gulf marked "WE" represents a small anticyclonic, warm-core eddy or detached ring. (From NOAA/National Satellite Service, Washington.)

Figure 3.5. Position of the Loop Current from satellite IR data, December 13, 1983. The values 21-25, etc. indicate sea surface temperature. The approximately circular feature in the center of the Gulf marked "WE" represents a small anticyclonic, warm-core eddy or detached ring. (From NOAA/National Satellite Service, Washington.)



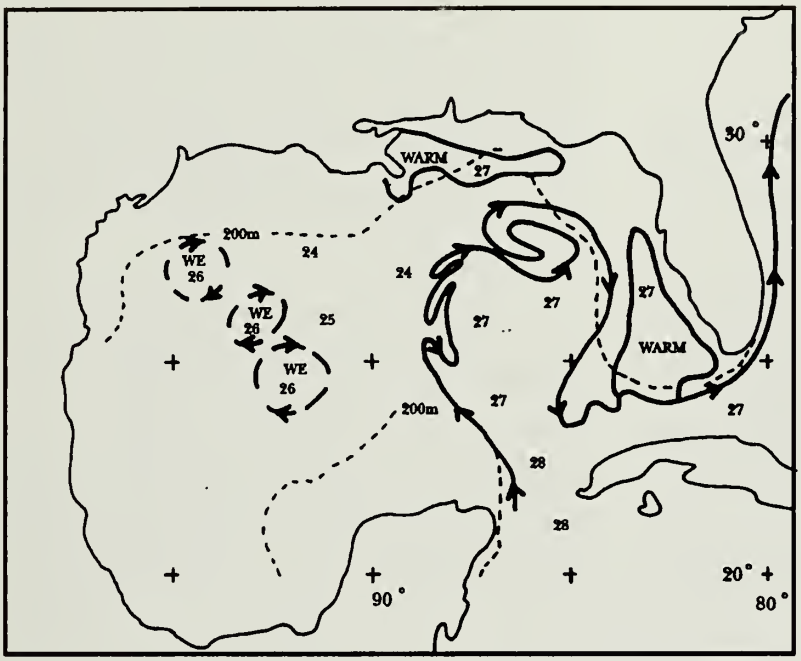


Figure 3.6. Position of the Loop Current from satellite IR data, May 9, 1984. The values 21-25, etc. indicate sea surface temperature. The approximately circular features in the center of the Gulf marked "WE" represent small anticyclonic, warm-core eddies or detached rings. (From NOAA/National Satellite Service, Washington.)

Figure 3.7. Position of the Loop Current from satellite IR data, May 14, 1985. The values 21-25 etc. indicate sea surface temperature. The approximately circular feature in the center of the Gulf marked "WE" represents a small anticyclonic, warm-core eddy or detached ring. (From NOAA/National Satellite Service, Washington.)

rings then propagate to the west at about 5 cm/sec.

Figure 3.6, May 9, 1984, shows a large warm surface water intrusion, presumably from the Loop Current, that has penetrated onto the shallow continental shelf waters. It is expected that such large features are not merely thin surface skin features, but extend down to perhaps 50 or 100 m depth, and have an associated velocity of approximately 1/2-1 kn (25-50 cm/sec). These features form what is generally referred to as "large scale turbulence" on the shelf.

Figure 3.4 suggests that the Loop Current edge is passing very near the Dry Tortugas. Figure 3.7, however, May 1985, which suggests that the edge is farther away seems to be more nearly "typical" of these plots. That is, after examining many of them, one comes to the subjective conclusion that Figure 3.7 is much more nearly the "typical" case than is Figure 3.4.

In order to make this idea quantitative, the Loop Current position was digitized along a north-south line just to the west of the Tortugas. These maps are available on an irregular basis, usually twice a week. Data points were interpolated with a cubic spline, and the results are shown in Figures 3.8-10 for three viewing seasons. This coordinate

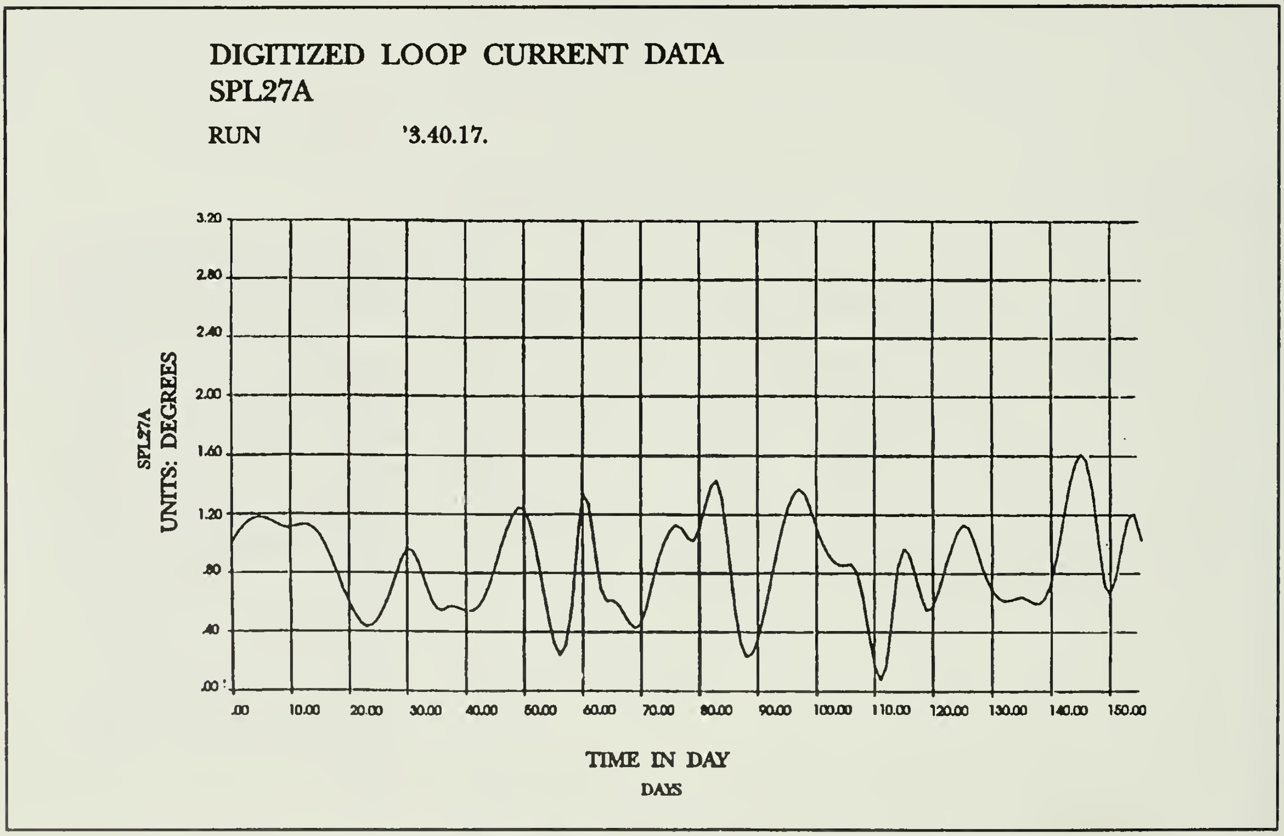


Figure 3.8. Fluctuations in the north-south position of the Loop Current edge near the Dry Tortugas, from satellite IR data as in Figures 3.3-7. The origin of the Y-coordinate system is at 23; the time axis begins on November 15, 1983. The position of the Loop Current was digitized on every available data map (usually twice a week) and a cubic spline was then fit through the data points.

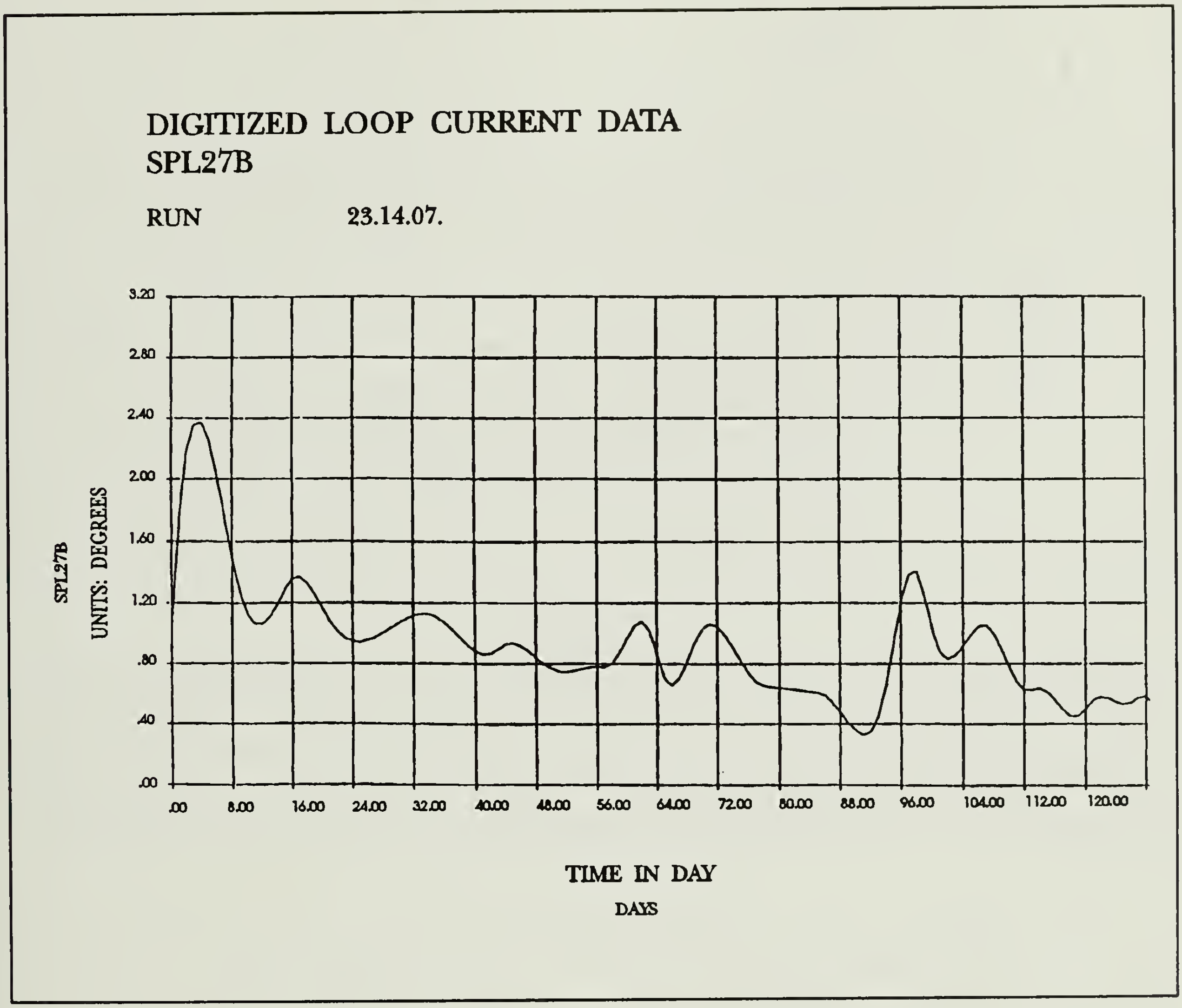


Figure 3.9. Fluctuations in the north-south position of the Loop Current edge near the Dry Tortugas, from satellite IR data as in Figures 3.3-7. The origin of the Y-coordinate system is at 23; the time axis begins on November 6, 1984. The position of the Loop Current was digitized on every available data map (usually twice a week) and a cubic spline was then fit through the data points.

system begins at 23°, so the Tortugas lie near 1.6° on the plots in these figures. The general result, based on this short record, is that the Loop Current seems to meander up this far north about once a year, but typically seems to be farther south.

A standard technique for examining variability of the kind shown in Figures 3.8-10 is spectral analysis. In this method, the energetic frequencies at which the fluctuations go back and forth are determined. The results are shown in Figures 3.11-13. The left-hand part of the figures shows the normal way the spectrum is plotted; on the right is given the so-called variance-preserving form. The plot on the left-hand shows energy of fluctuations versus frequency, and is a log-log plot. The second form is linear in the y (vertical) axis,

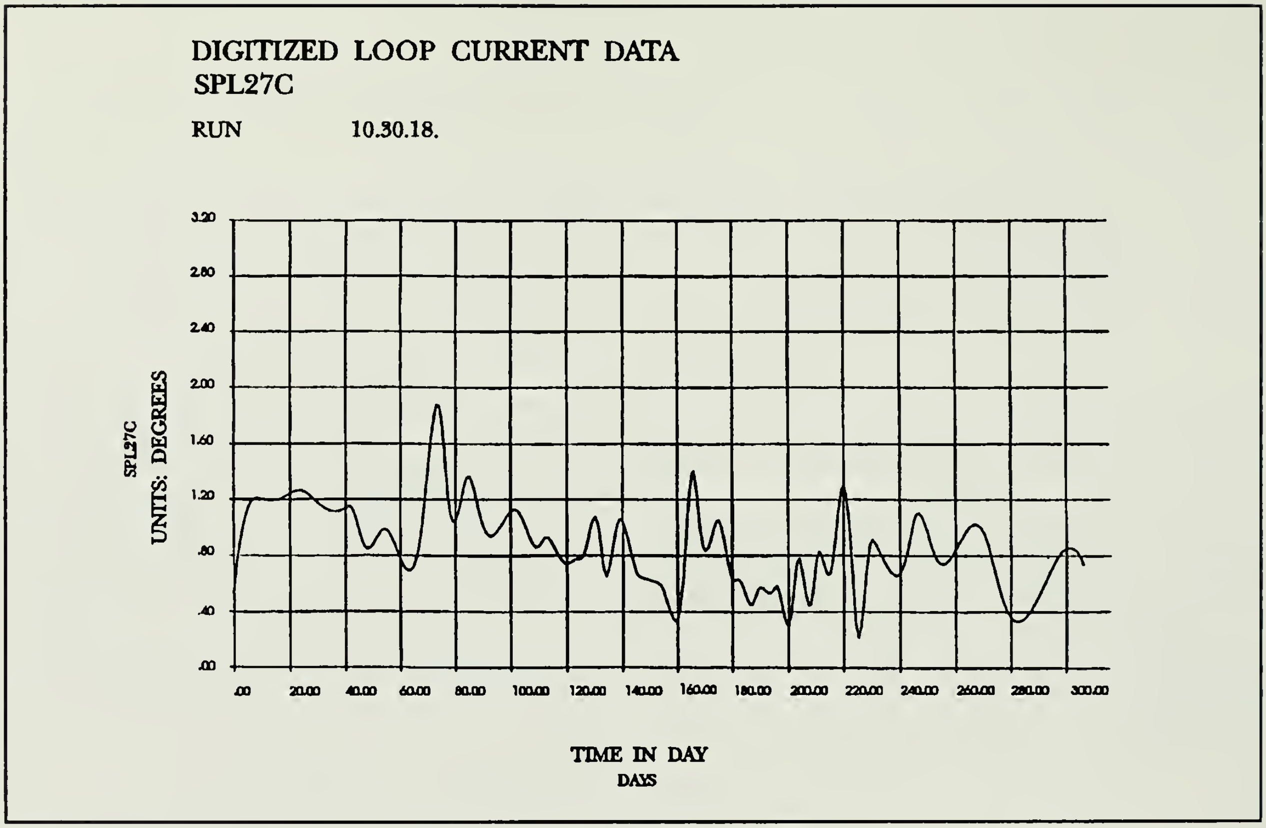


Figure 3.10. Fluctuations in the north-south position of the Loop Current edge near the Dry Tortugas, from satelllite IR data as in Figures 3.3-7. The origin of the Y-coordinate system is at 23; the time axis begins on September 26, 1985. The position of the Loop Current was digitized on every available data map (usually twice a week) and a cubic spline was then fit through the data points.

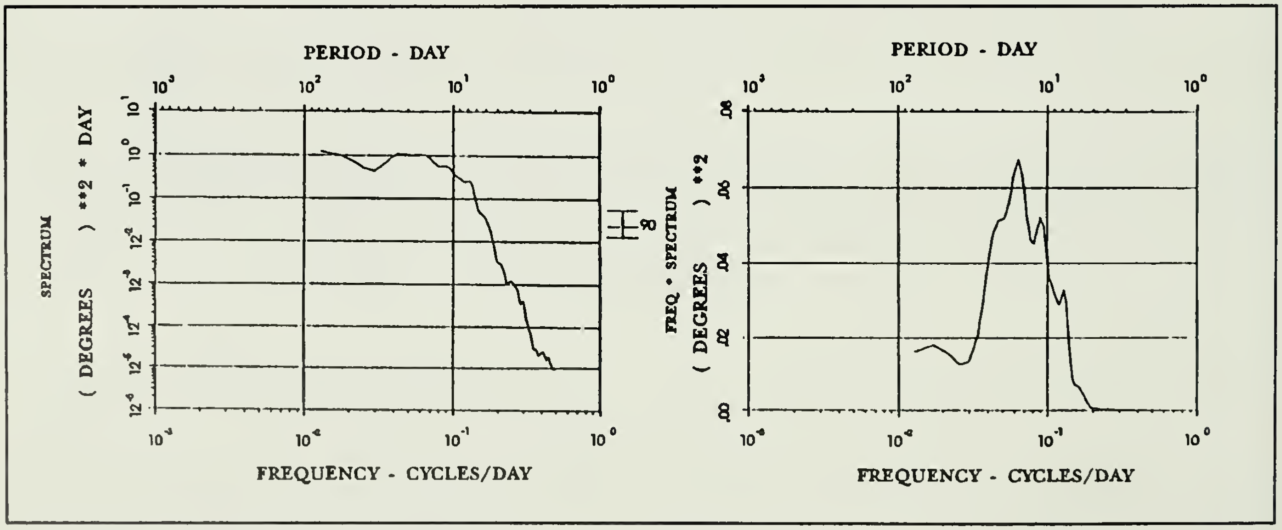


Figure 3.11. Spectrum of the complete data set of Figure 3.8, of the north-south Loop Current fluctuations near the Dry Tortugas, from the 1983-1984 viewing season. The plot on the left is the normal spectral density, and on the right is the variance preserving form. The 90 percent confidence limits for the left-hand figure are shown.

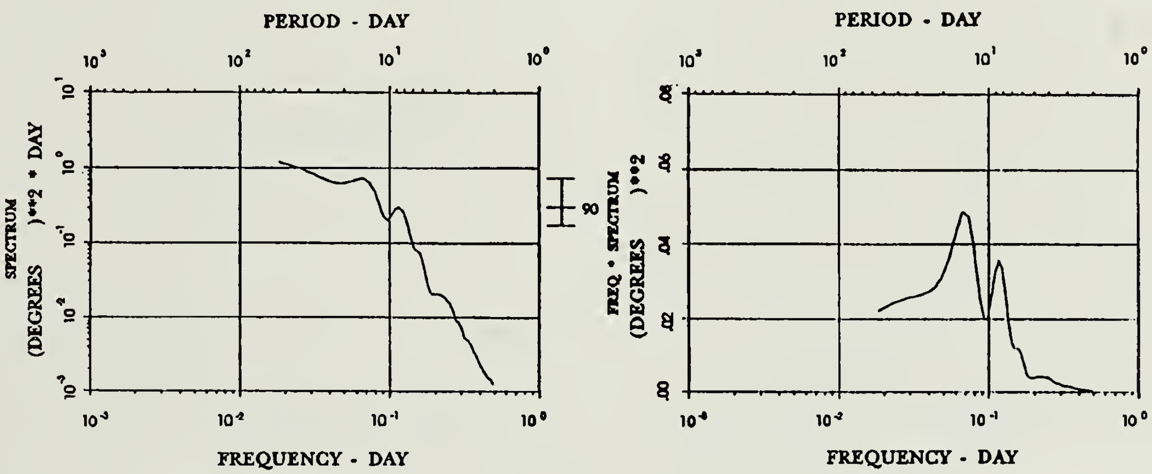


Figure 3.12. Similar to Figure 3.11, except this one shows the spectrum of the data from Figure 3.9, for the 1984-1985 viewing season.

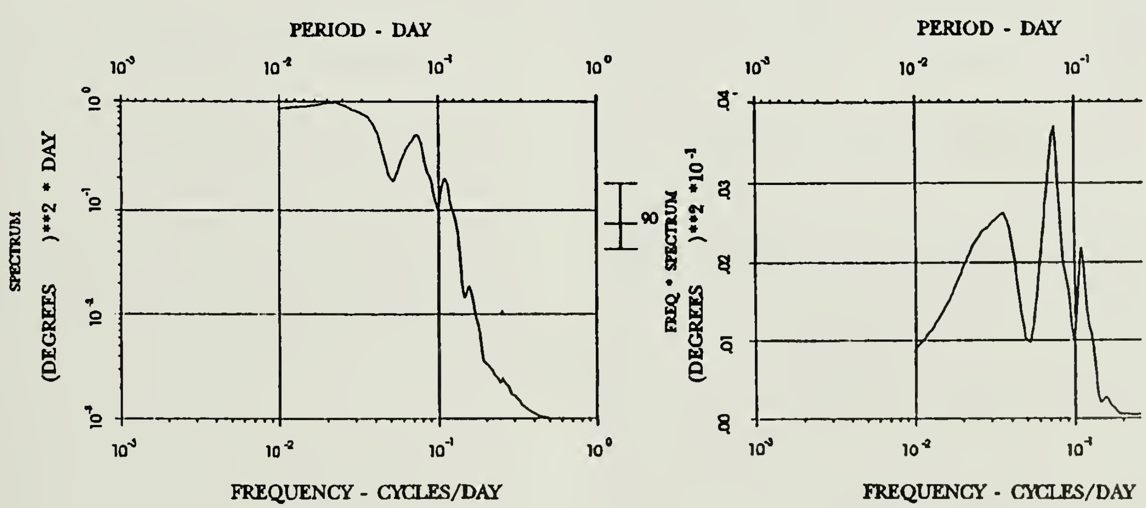


Figure 3.13. Similar to Figure 3.11, except this one shows the spectrum of the data from Figure 3.10, for the 1985-1986 viewing season.

These plots show that the peaks are mostly at periods of 8-16 days. This is the "wind-driven" frequency band. In other words, these fluctuations are being pushed back and forth by the local wind. The lower-frequency hump in Figure 3.13, near a period of 30 days, is probably a result of the eddy-like motions of the type shown in the IR data of Figure 3.6. This is the common belief, but the data from a single IR map are only suggestive.

Currents on the Continental Shelf

Tides

The standard US Atlantic Coast NOAA time tables list two tidal height locations in the Tortugas: Garden Key and Channel Key. They are both given relative to Key West, and it appears the Tortugas tides are quite similar to those in the larger surrounding area. The spring range of 1.7 ft is slightly less than at Key West.

The Tidal Current Tables, however, give no information for Tortugas locations. Florida Institute for Oceanography ship captains, who go into the Tortugas regularly on research cruises, report that the tidal currents in the narrow channels can be "quite strong," but there are several hours of slack water during which diving activity would be unhindered even during spring tides (R. Millander FIO; Walter Jaap, Fla DNR, personal communication 1989). It should be noted that these comments apply only to the tidal components and not to currents generated by other mechanisms, such as wind.

Figure 3.14 shows the variation in the tidal signal in the Gulf (from Zetler and Hansen 1972). Figure 3.15 shows a map of the K1 tidal component, one of the diurnal terms. The phase lines (solid) show that this component of the tide merely enters at the Straits of Florida (at a phase of 270°, relative to Greenwich), propagates around the basin, and

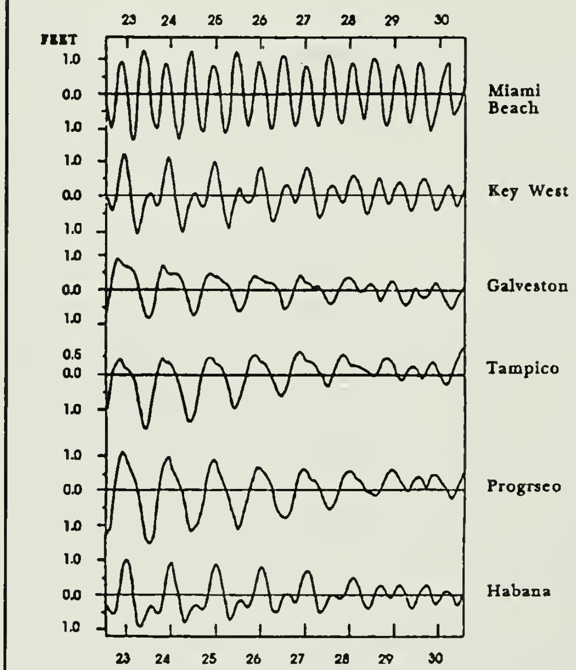


Figure 3.14. A plot of the shape of typical tidal height curves around the Gulf of Mexico. (from Marmer, copied from Zetler and Hansen 1972).

exits through the Yucatan Channel into the Caribbean Sea. The tidal heights (dashed contours) associated with this component are only 10-20 cm. The other diurnal terms will behave essentially the same way. It has been found, however, that the semidiurnal tidal components (periods near 12 hours) are nearly resonant with the tidal generating forces. The amplitudes are not very large because the basin is small in comparison with the open ocean. The irregular appearance of the Key West tide in Figure 3.14, as well as along the rest of the Gulf Coast, is the result of the tidal constituents drifting into and out of phase with each other and having similar amplitudes.

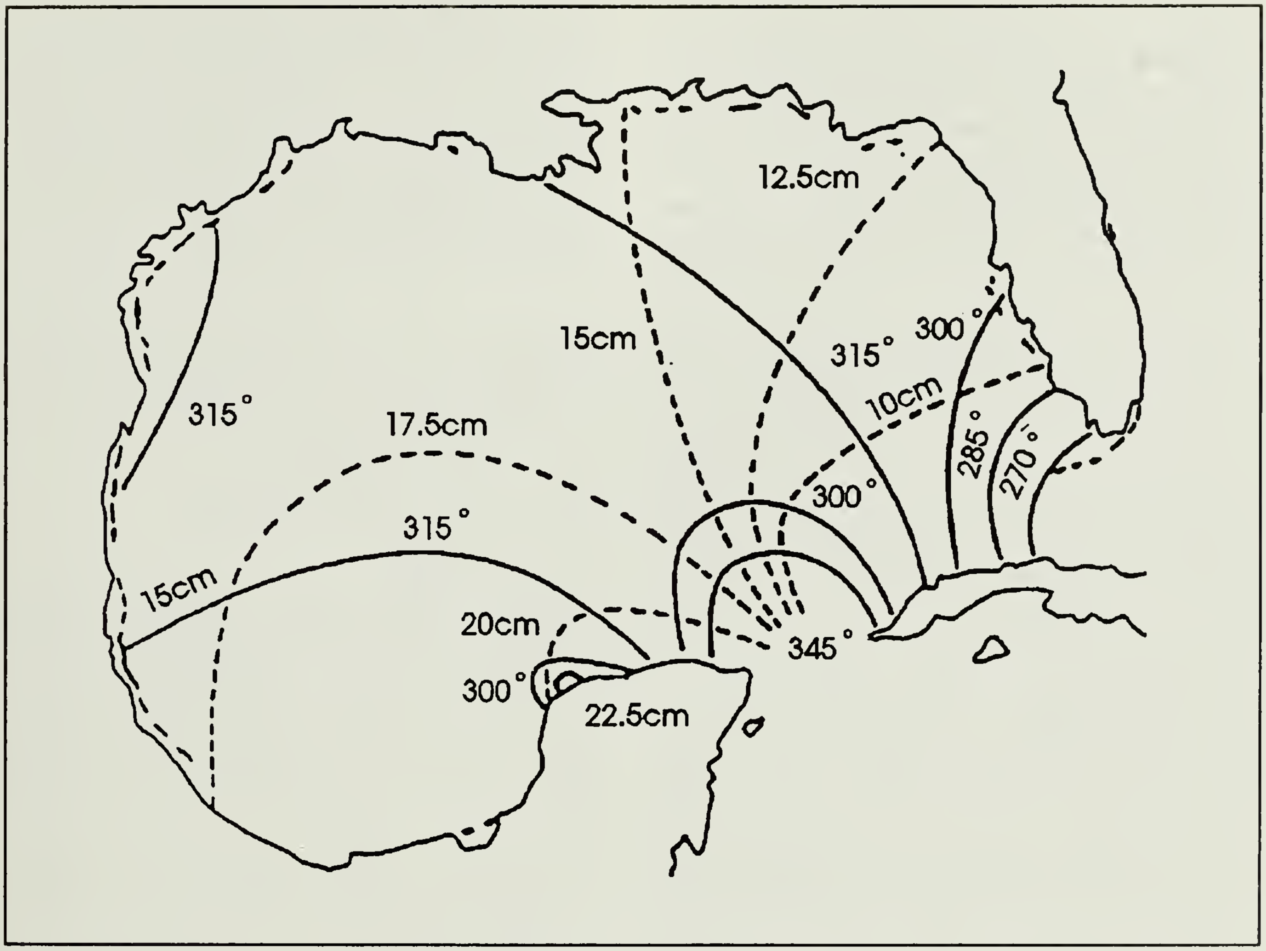


Figure 3.15. Phase and amplitude lines of the K tidal constituent in the Gulf (from Grace, copied from Zetler and Hansen 1972).

Inertial Motions

These motions have periods of approximately 28 hours at 25°. These are quite energetic on the west Florida shelf, and have been studied briefly (P. Hamilton in SAIC 1987). These currents are sporadic, usually driven by sudden wind events. They have amplitudes of typically one-half knot, but because their time scale is so short they are expected to contribute only "noise" to the problem at hand. The path of a particle in such a current would be approximately circular, of 5-10 km radius.

Wind-Driven Currents

These currents have been observed on some parts of the shelf, as discussed below, and well studied from a theoretical point of view (e.g., Clarke and van Gorder 1986; Mitchum and Clarke 1986). These are not the most energetic currents, but within this frequency band, the currents are probably as "predictable" if not more so than the wind that drives them. The analytical models have been fairly well confirmed (for present purposes) by comparison with data from moorings, from shallow water out to midshelf.

Figure 3.16 shows the locations of all known current-meter moorings on the west Florida shelf in the 1980s. At the shallowest moorings, such as No. 1, in only 13 m of water, there is very high coherence with wind in the long-shelf direction. We think we understand these motions. At mid-to-outer shelf depths to the north of the Tortugas, wind driven currents are smaller than the eddy motions and so become relatively less important. The cross-shelf velocities are usually smaller than the along-shelf velocities, and are difficult to predict without high resolution wind data.

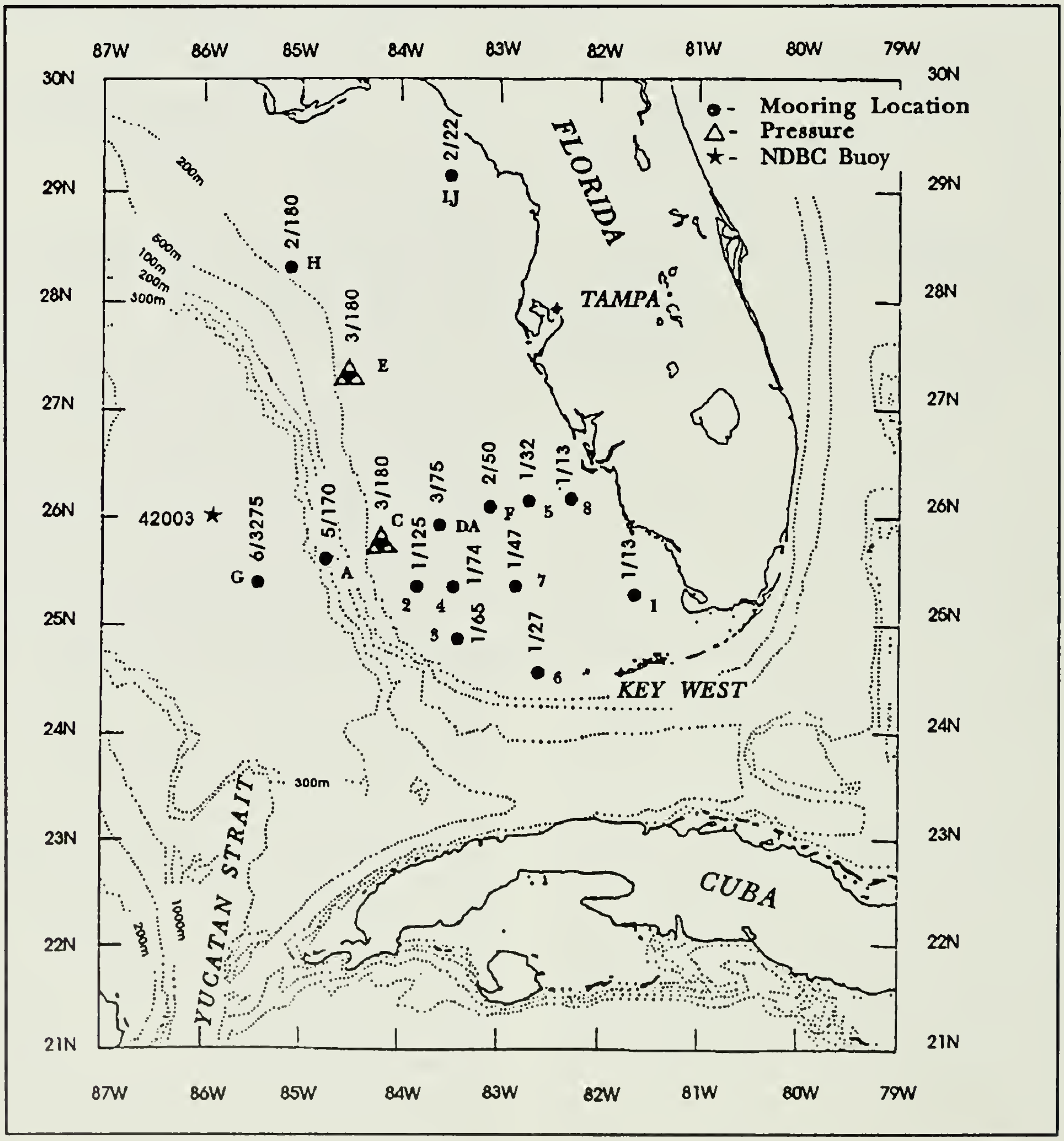


Figure 3.16. Map of all known current meter mooring locations on the west Florida shelf since 1982. The star (42003) shows the NOAA met buoy. The numbers by each mooring dot show the number of instruments on the mooring, followed by the water depth. Dots surrounded by a triangle indicate that a pressure gauge was at the bottom of the mooring (from SAIC 1987).

Away from shallow water near the coast, a rough rule of thumb is that the wind-driven currents are approximately 3 percent of the wind speed. When the winds are very strong, such wind-driven currents become appreciable. The winds will be examined in a later section. For a typical "strong" wind event of 5 m/sec, however, the wind-driven currents are thus approximately 15 cm/sec. The eddy-like currents and the effects of other factors, such as Loop Current intrusions, seem in general to be stronger.

Eddy Motions

The amplitude and durations of these motions have been studied by the 1983-1985 Minerals Management Service mooring program (Figure 3.16; SAIC 1987) to a sufficient degree for determining "typical" amplitudes. The data base is 2-3 years at a small number of locations. These eddy motions are as yet unpredictable. Some originate from large detached parcels of water near the south end of the shelf, as suggested in Figure 3.6; others may arise from Current Loop instabilities as it flows to the south and passes along the shelf edge (e.g., Niiler 1976). Cross-shelf (i.e., on-shore) amplitudes at midshelf (mooring D) have been observed to be as large as 25 cm/sec. The upper limit of speeds in the alongshore direction is rarely observed to be greater than approximately 1-1.25 kn. To be slightly more quantitative, one can use the longest available data set at midshelf, at mooring D (Figure 3.16) at the uppermost current meter. The mean currents there are 4 cm/sec to the south, but this value is not significantly different from zero. The root-mean-squared variability is 12.4 cm/sec in the along shelf (N-S) direction. An estimate of the mean plus 3 standard deviations (to the south) gives a flow of 41 cm/sec. Note that these velocities are observed at 17-30 m below the surface.

Because the eddy motions are so energetic, they contribute a great deal of uncertainty to the "mean" velocity to be expected at any particular time. As a result, the mean flow values are poorly known in the vicinity of the long-term moorings from the 1983-1985 mooring experiment, and scarcely at all anywhere else. As an example, suppose we wish to "forecast" the flow during any specific period. During a three-week period, we might expect currents that appear to be nearly steady for the entire time, as a result of unpredictable eddy motions; or the flow could be driven by wind-induced motions, reversing direction during the middle of the period of interest. Real flows are usually a combination of all these.

The mooring closest to the Tortugas in Figure 3.16 is mooring 6; the instrument there (as in all the moorings labeled 1-8) was a single current meter placed 1 m above the bottom. The currents observed at that location are shown as "stick plots" in Figure 3.17. The flow rarely exceeds 20 cm/sec. However, a speed of that magnitude at only 1 m above the bottom is a fairly strong flow. The flow at mooring 6 appears to be concentrated in the onshore-offshore direction, with almost no flow in the direction of the main flow of the Loop Current nearby. For completeness, the "stick plots" of velocity from moorings 1-8 for the full experimental period, together with the temperature records are reported below, Figures 3.17 and 3.22-26 (from SAIC 1987).

Water Temperature

From the satellite IR maps shown in preceding sections, we see that the surface temperature in the open Gulf reaches the high 20s (centigrade) in the summer and the lower 20s in the winter. The coldest temperatures, however, are found near the coast when cold winter air cools the shallow water. Figure 3.18 (Goulet and Haynes 1979) shows the

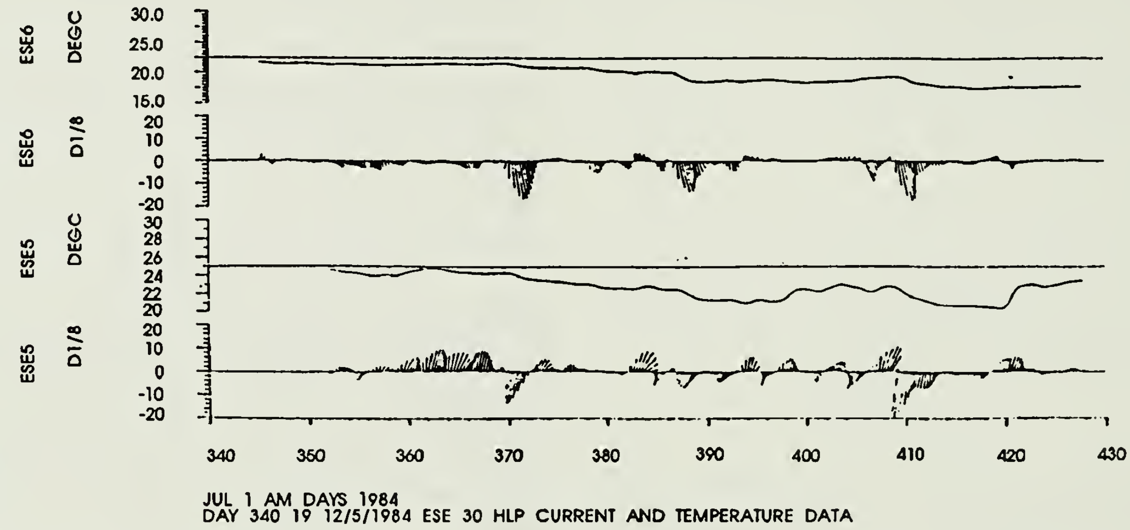


Figure 3.17. Plots of a data segment from moorings 5 and 6 (positions shown in Figure 3.16). For each mooring, the upper trace shows temperature; the lower trace shows stick plots of velocity. The sticks point in the direction toward which the current is flowing. The data have been filtered with a 40-hour low-pass filter. (The designation ES&E means that the moorings were installed by Environmental Science & Engineering, Gainesville, FL.)

temperature around the edge of the Gulf as a function of time of year (X axis) and a function of position (Y axis). The long-term mean is on the left, and the deviations for a single year are on the right. It appears that the monthly value at a single position may depart from the long-term mean by as much as 5°.

The Key West temperature reaches its mean yearly minimum in February (Figure 3.18). As the monthly departures can be several degrees, however, it would appear that a minimum mean monthly temperature could occur in a given year from December through March and still be within the statistics shown here.

In recent years, a valuable source of temperature data has been the Ship of Opportunity program. The cruises between 1983-1985 have been conveniently compiled by Waddel et al. (1986). This was a time of very active Ship of Opportunity data acquisition in the Gulf. This report shows XBT sections from various ship tracks, and includes information not only of the type shown in Figure 3.17 but also the vertical variation of temperature as well. A brief study of this report suggests that, first, from the perhaps dozen sections that come close to the Tortugas, the temperature in the upper layers is consistent with the data of Figure 3.18; and second, the report (having more than 600 pages) is not organized so as to allow easy extraction of information relating to the Tortugas, although a computer sort of the original data is possible.

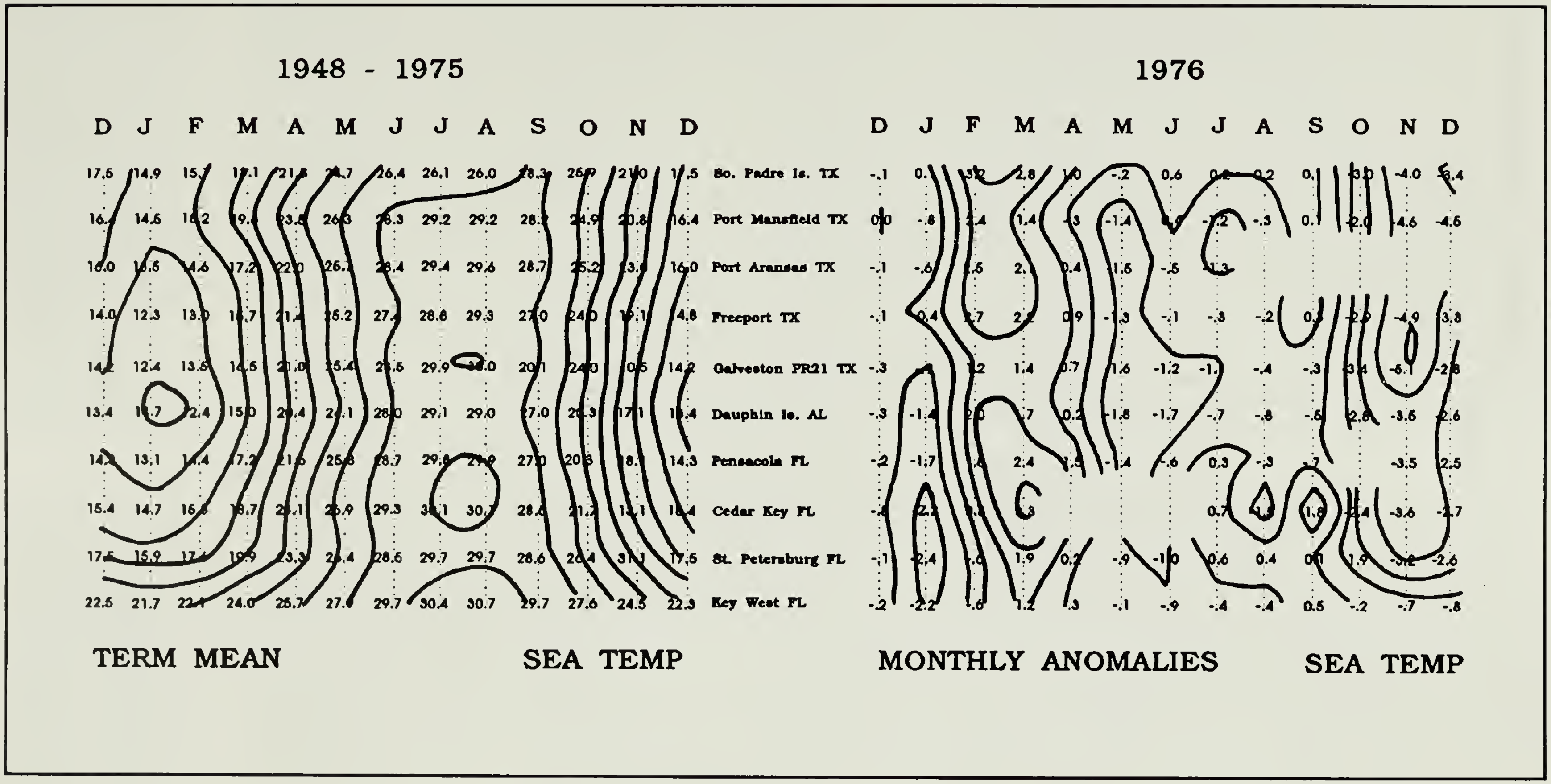


Figure 3.18. Sea surface temperatures at tide gauges around the Gulf, from Goulet and Haynes (1979). The plot on the left shows the long term monthly mean temperatures, as measured at tide gage stations; geographical position is along the Y-axis and month of the year along the X-axis. The monthly anomaly is shown on the right.

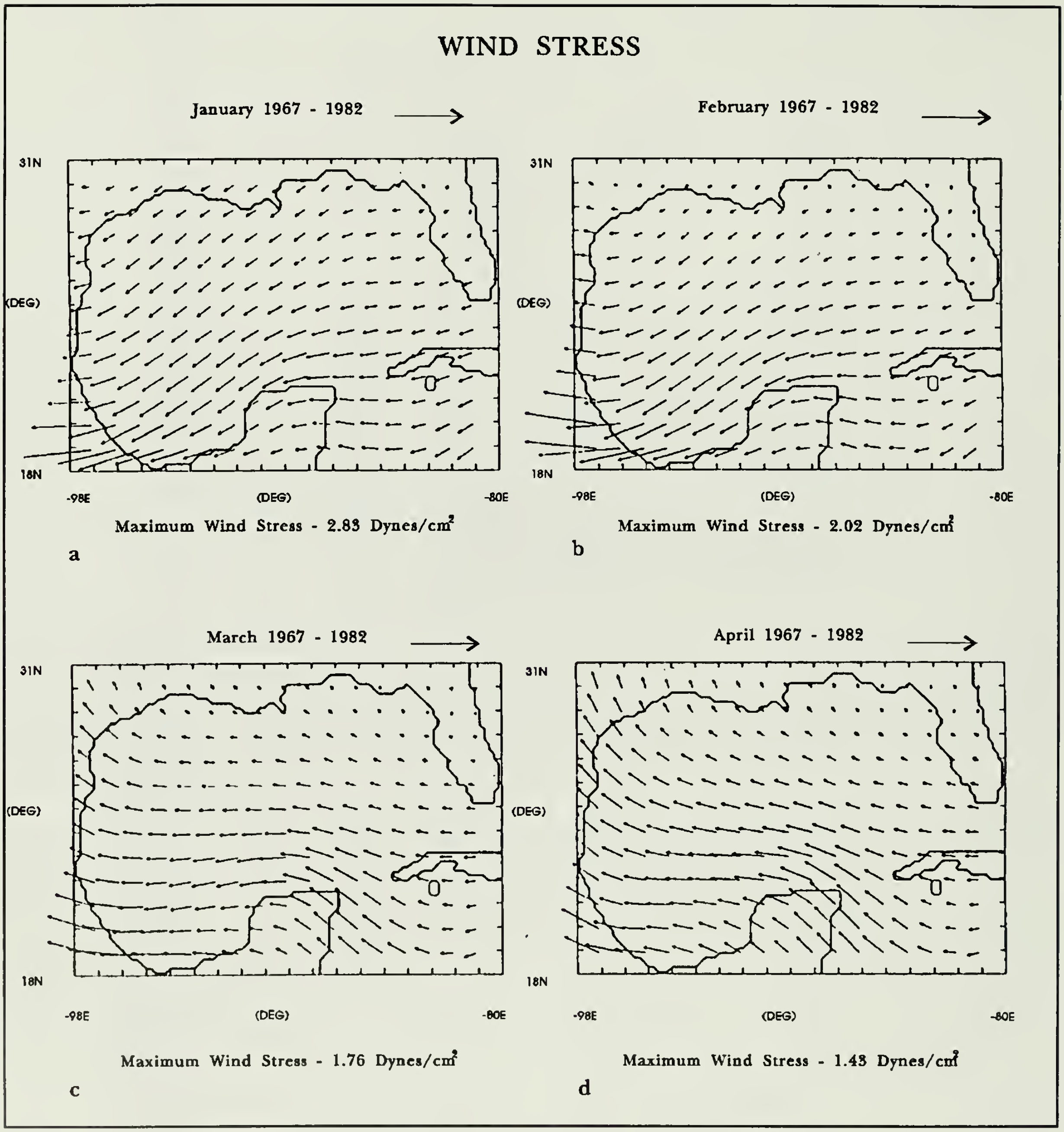


Figure 3.19. Monthly mean winds over the Gulf of Mexico. These winds are computed from the observed surface pressure data and corrected by comparison with met buoys (from Rhodes et al. 1989).

Some Relevant Meteorology

Meteorology of the eastern Gulf of Mexico is dominated by two large-scale processes: first, the prevailing trade winds from the east, and second, the transient frontal systems that are more characteristic of higher latitudes. The prevailing winds are shown most clearly by the usual mean monthly maps; a new set of improved wind data from Rhodes, Thompson

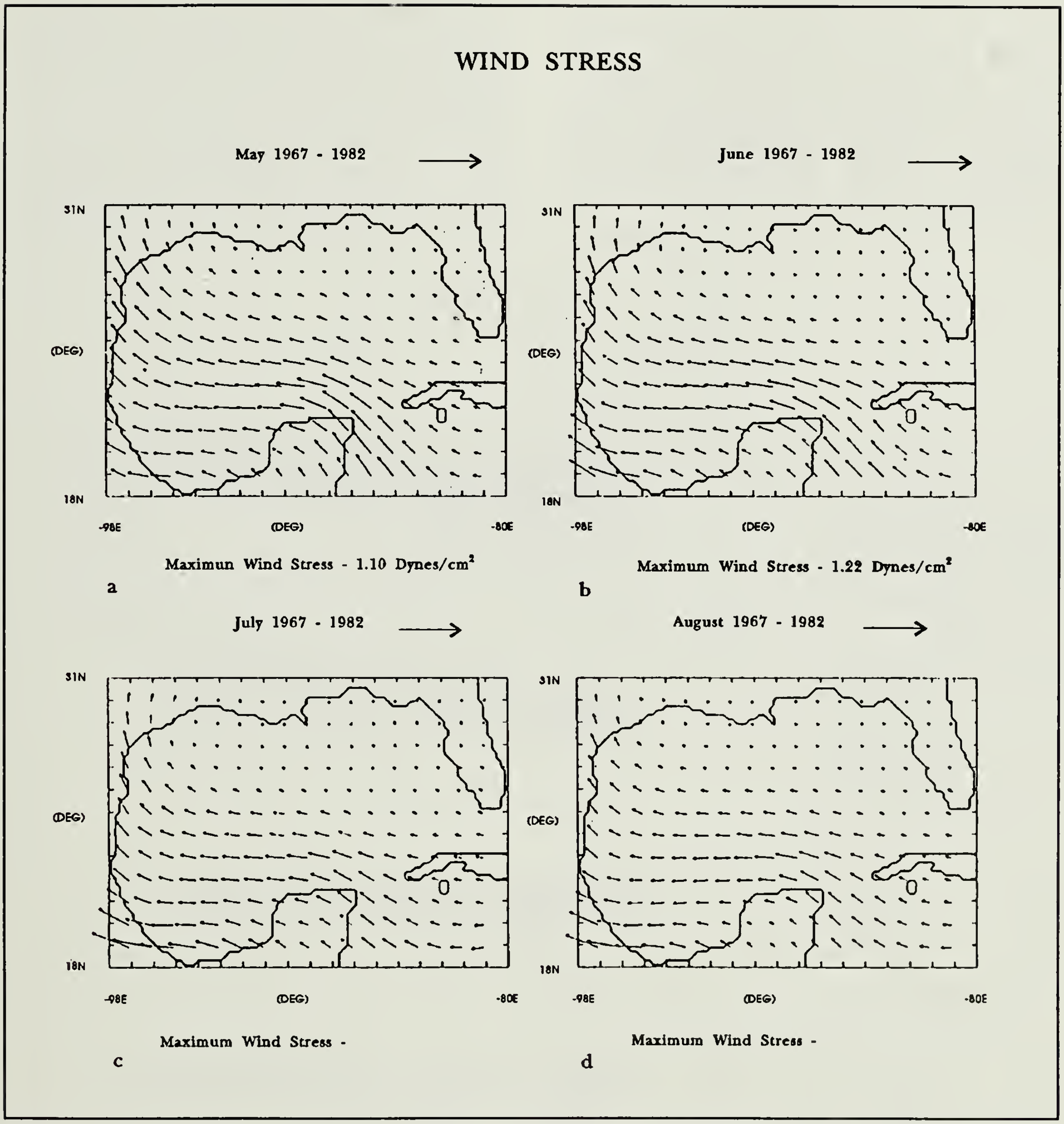


Figure 3.20. Monthly mean winds over the Gulf of Mexico. These winds are computed from the observed surface pressure data and corrected by comparison with met buoys (from Rhodes et al. 1989).

and Wallcraft (1989), computed from the pressure field, is shown in Figures 3.19-21.

These figures show the "mean conditions" that are typical if one is interested in conditions averaged over the passage of many frontal systems. Because these winds are based on correction factors from the three meteorological buoys in the central Gulf, some aspects of the mean winds are significantly different from the older wind charts. The curl of the wind stress is changed, and the largest changes overall are near the Yucatan Peninsula. The differences over the west Florida shelf, however, are more subtle, and involve slight changes of direction from month to month.

To see the effects of the passage of frontal systems, the most direct manner seems to be to examine the wind data directly. Figures 3.22-26 show plots of the winds observed at Key West. Note that in the third panel of Figure 3.22 the prevailing winds out of the southeast have been plotted in the oceanographic convention; that is, the head of the arrow is on the x axis. The most noticeable

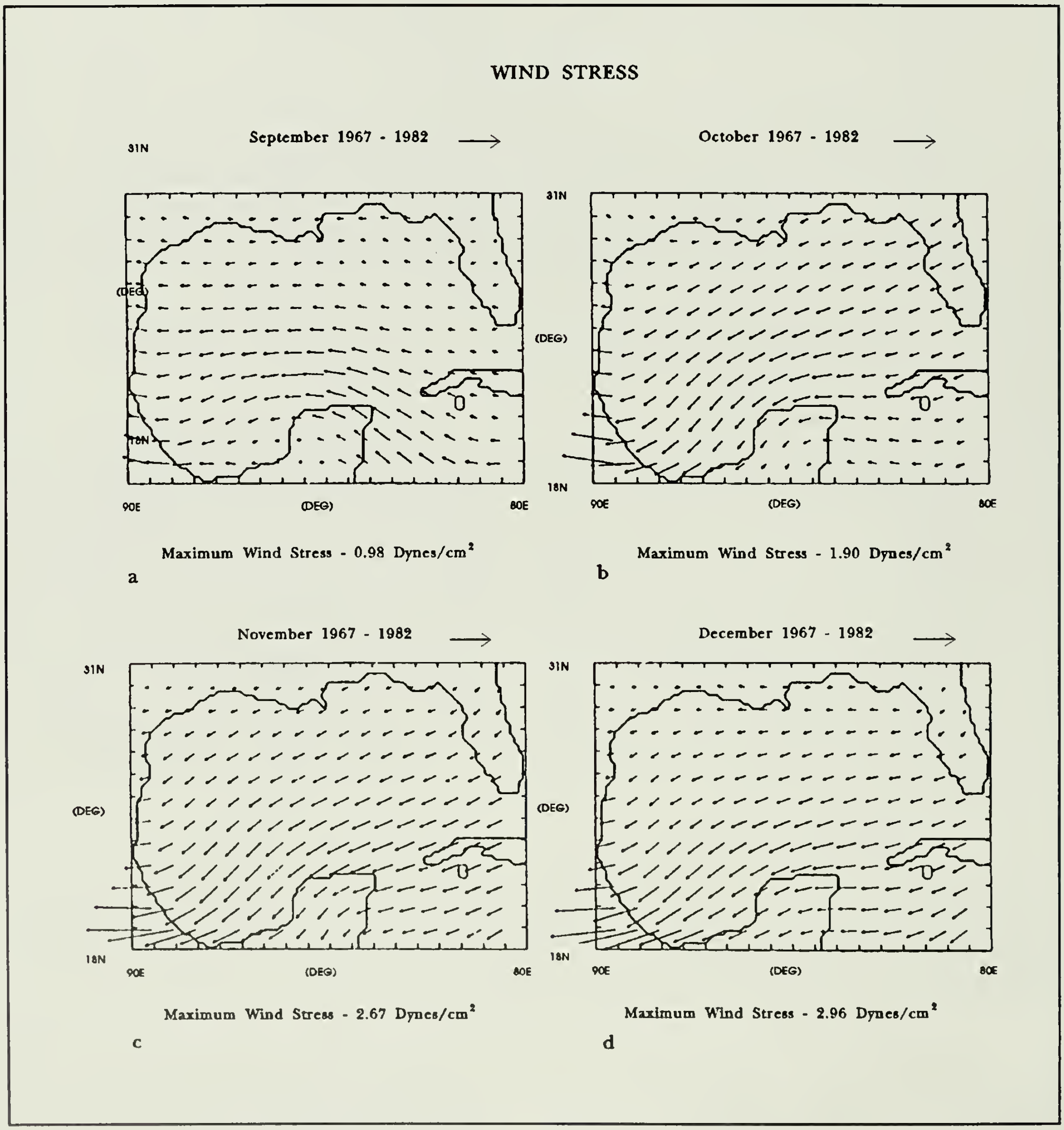
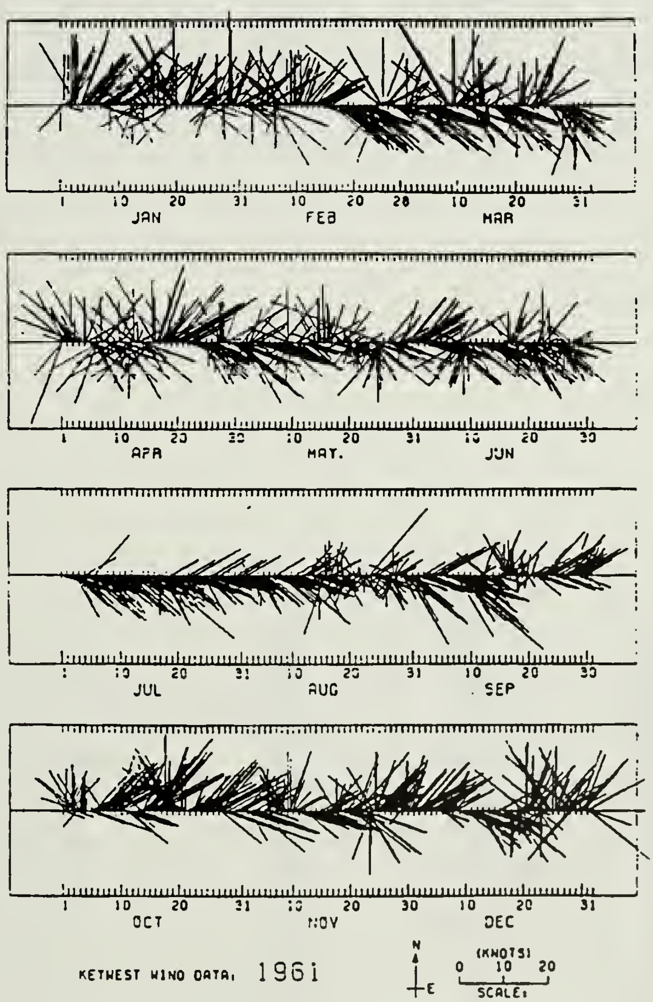


Figure 3.21. Monthly mean winds over the Gulf of Mexico. These winds are computed from the observed surface pressure data and corrected by comparison with met buoys (from Rhodes et al. 1989).

Figure 3.22 the prevailing winds out of the southeast have been plotted in the oceanographic convention; that is, the head of the arrow is on the x axis. The most noticeable feature of these plots at first (or third) glance is the enormous variability. While the "mean winds" may be true, on the average, they are quite unlikely to be representative of the wind field on any given day.

It is fortunate that the Tortugas are close to the weather station at Key West. The winds and tide data from Key West are among the best records available. The data are conveniently available for further calculations, as necessary.



Figures 3.22-26. A selection of stick plots showing winds at Key West, Florida. Because of the difference between data archiving conventions between meteorologists and oceanographers, these plots have the opposite sign convention from the current meter stick plots: the wind in these figures flies from the end of the stick toward the plot axis. The prevailing winds in July, for example, are out of the southeast, blowing toward the northwest.

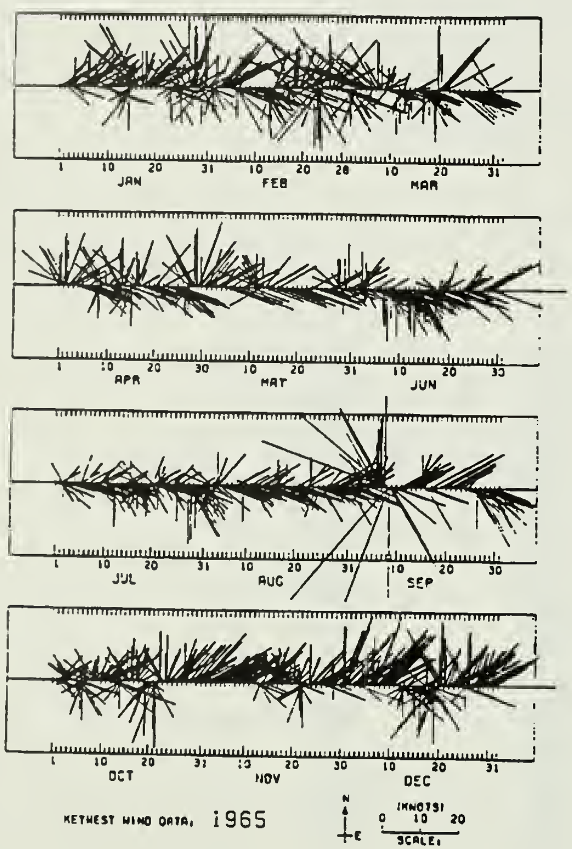


Figure 3.23. A selection of stick plots showing winds at Key West, Florida.

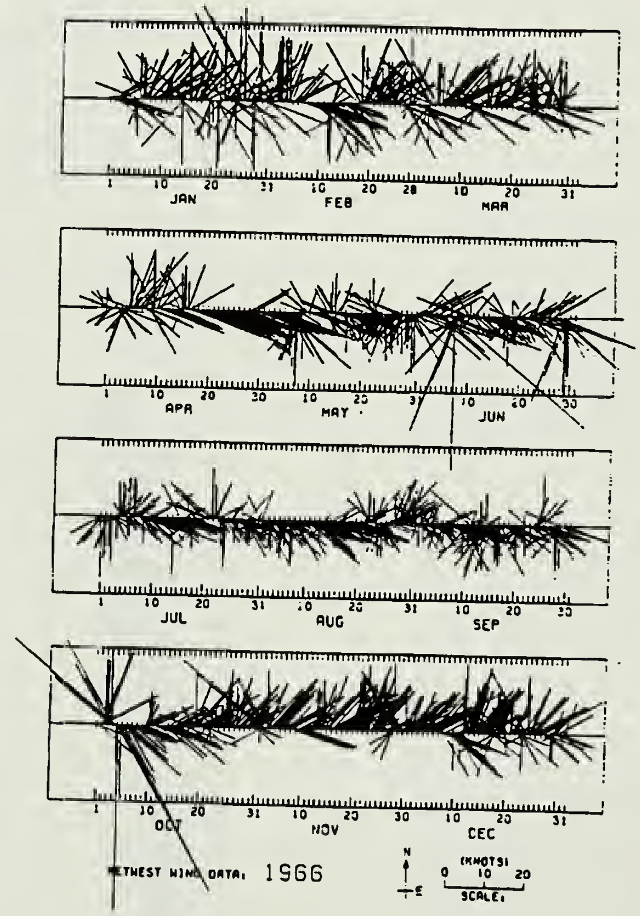


Figure 3.24. A selection of stick plots showing winds at Key West, Florida.

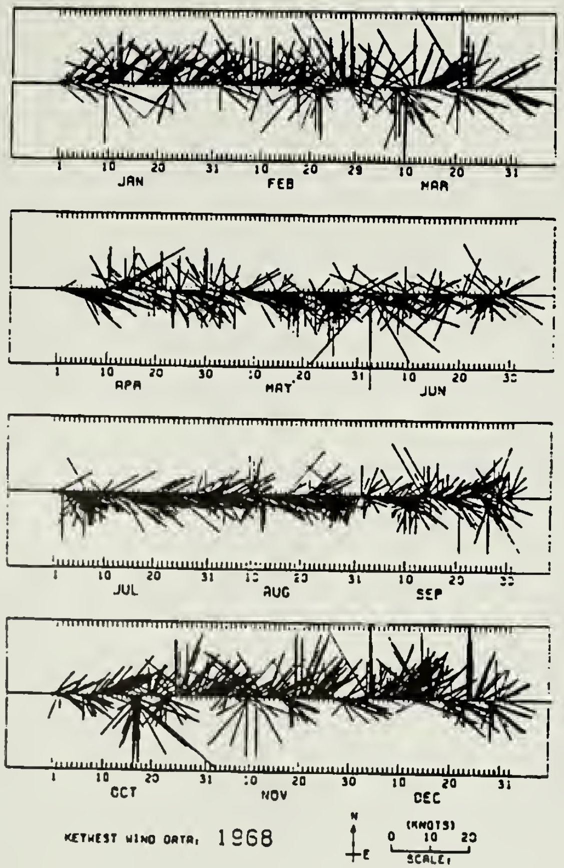


Figure 3.25. A selection of stick plots showing winds at Key West, Florida.

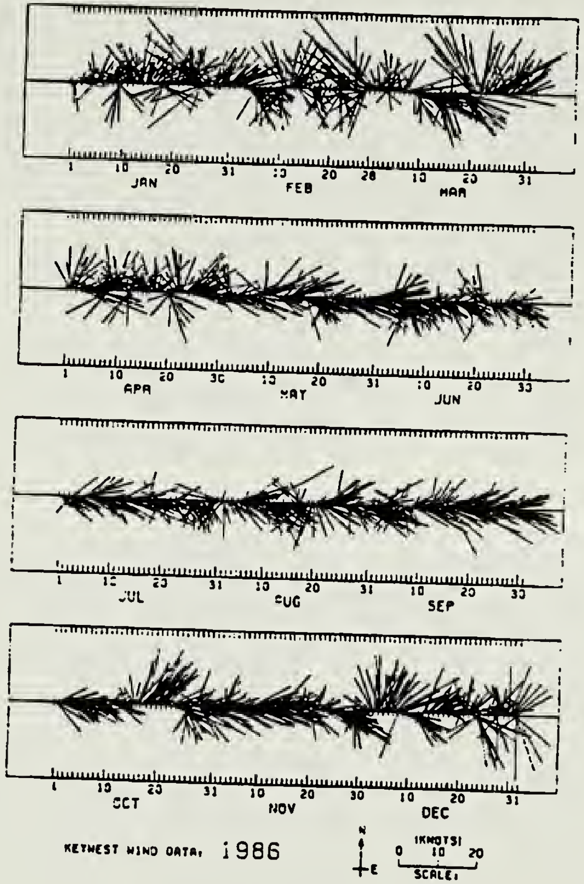


Figure 3.26. A selection of stick plots showing winds at Key West, Florida.

Hurricanes

There is a recent comprehensive meteorological study of Gulf hurricane data sponsored by the Minerals Management Service (Ford et al. 1988). Maps are available that show all known historical storm tracks for storms with winds greater than 34, 64 and 100 mph. Most maps show a totally blackened Gulf of Mexico; the 100 mph map has some white area peeking through. That is, the hurricane tracks go everywhere. Calculations have been done, and maps plotted, to show the percentage likelihood that a storm of given strength will pass say within 139 km of a chosen point in 100 years. For the area near the Tortugas, these values are roughly 55 percent for winds over 34 knots, about 30 percent for winds over 64 knots.

Long-Term Sea-Level Rise

Figure 3.27 shows the mean yearly trend of sea level from tide data at Key West since 1910 (Hicks 1983). The long-term trend of the data is 2.2 +/- 0.2 mm/yr; 2 mm/yr or 20 cm/century. If this trend were constant, that is 1 m +/- 10 percent in 5 centuries.

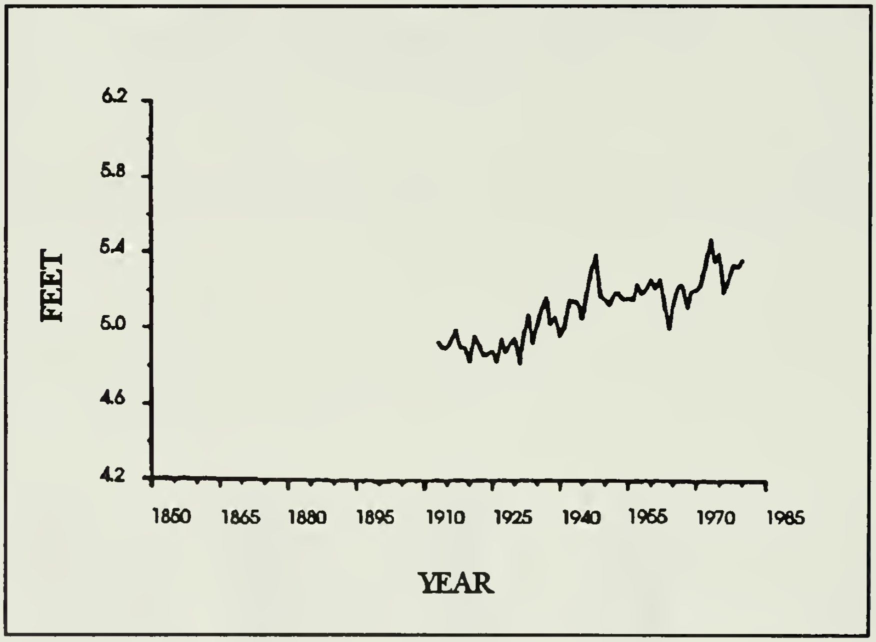


Figure 3.27. Long-term trend of sea level at Key West (from Hicks). The yearly mean data have been smoothed with a low-pass filter, and not adjusted to constant atmosphe ric pressure. Note that the Y-axis is in feet; the absolute value, however, is essentially arbitrary.

Local effects of winter storms on beaches can be greater, but these would be highly localized. The importance of long-term sea-level rise, of course, is that it happens everywhere at middle and lower latitudes. There is nothing anomalous at the Key West tide gauge; the trend seen there is completely consistent with the trend observed across the southwestern US.

It would be a gross mistake, to extrapolate the observed trend over 70 years to time scales longer than a century. We know that the observed rise of sea level is partly the result of local tectonics, and partly the result of continuing response of the mantle from the last ice age. There are a few tide gauge stations that have records going back into the late 1800s. Observations from those few stations (Sturges 1987) suggest that the long-term trend from glacial unloading, about 12 cm/century, is the only clear feature; the rest--including the apparent trend shown in the Key West data since 1910--may be related to large scale, time-dependent variability rather than to a reliable long-term trend.

Discussion

It is possible to make a few random speculations in answer to the question, "is there anything unusual about the Dry Tortugas that would make this area the likely site of a high proportion of shipwrecks?" There are, indeed, several anomalous combinations of ocean currents and winds. While plausibility and causality are sometimes handmaidens, the prudent reader will remember that the operative word here is speculative.

The Tortugas lie in the transition zone between the fairly steady trade winds and the irregular meteorology of frontal passes characteristic of higher latitudes. Such a transition could catch an unsuspecting mariner by surprise.

The prevailing winds at these latitudes are out of the east. In surprising contrast, the Loop Current flows out of the west, past the Tortugas. This is a most unusual current structure. Away from land boundaries, both the Gulf Stream and the North Equatorial Currents tend to flow with the wind.

To make a passage from the northern Gulf around the tip of the Florida peninsular, it might seem possible, if the charts were poor, merely to skirt the edge of the keys, such as Key West. That is, if a ship travelling to the east had unexpectedly been carried to the north by the Loop Current, a captain without sufficient knowledge might try to sail directly toward Key West without making his course adequate to miss the Tortugas.

And, finally, Murphy's law of fluid similarity: low-lying islands move into the path of ships like trees attract kites.

CHAPTER IV

Relationship of Dry Tortugas Natural Resources to Submerged Archeological Sites

James T. Tilmant

The Dry Tortugas are of keen interest to archeologists because their geographical location and natural features have made them the focus of much human activity since their discovery. This activity has left a rich deposit of archeological remains on land and underwater. The small island group and surrounding coral reef formations, first named "Las Tortugas" by Ponce de Leon in 1513, served as a key Gulf of Mexico military defense post during the following four centuries. The Tortugas reef formations have always provided protected anchorage for vessels plying the Florida Straits, fishing the productive shelf waters, or caught in tropical storms. Today the Dry Tortugas are used extensively by recreational boaters on short-term outings from the mainland or Florida Keys, and those travelling to and from the Yucatan Peninsula.

Since the early nineteenth century, the Dry Tortugas have been recognized for their magnificent natural resources including tropical coral reef formations, sea-grass beds, fisheries and pelagic bird nesting. The Dry Tortugas became a national bird sanctuary in 1918 after discovery of significant pelagic bird nesting areas there. A presidential order in 1935 proclaimed the Dry Tortugas a national monument to protect its historic and natural resources.

Because of their location on the edge of the Florida Straits, the Tortugas have been the site of numerous maritime casualties from passing vessels and those using local resources. Despite modern navigational aids, such as the Loggerhead Key Lighthouse established in the 1850s and LORAN, wrecks and groundings continue within the monument. Some recent mishaps include sinking of the 45-ft vessel CAPTAIN BLEIGH east of East Key in April 1990 and grounding of the 475-ft MV MAVRO VETRANIC on Pulaski Shoal in November 1989.

This chapter presents the history of natural science research in the Dry Tortugas, describes the area's natural resources and discusses their relationship with submerged cultural resources and the role of biological assessments in archeological site evaluation.

HISTORY OF NATURAL RESOURCE STUDIES

Early Dry Tortugas scientific expeditions include visits by Louis and Alexander Agassiz during 1850 and 1851, the research vessels BIBB in 1869, BLAKE in 1877 and 1878, and ALBATROSS in 1885 and 1886. The University of Iowa sponsored the C.C. Nutting expedition of 1893. The Agassizs published several papers (1852, 1869, 1880, 1883, 1885, 1888) containing information acquired during Dry Tortugas visits, including a detailed map of the islands and benthic marine communities (A. Agassiz 1882).

In 1902, the Brooklyn Institute of Arts and Sciences sent an expedition under the direction of A.G. Mayer to the Dry Tortugas (Mayer 1902). Mayer recommended that a permanent marine research station be established at the

Tortugas. In 1904, the Carnegie Institution built a laboratory on Loggerhead Key, and A.G. Mayer became its director. During the next forty years, many of the world's leading tropical marine and coral reef scientists studied at the Tortugas Laboratory. Their work, constituting some of the most noteworthy on reef geology and biology, include classic studies of marine algae (Taylor 1928), sponges (deLaubenfels 1936), corals (Mayer 1914; Wells 1932; Yonge 1935a, 1935b; Cary 1914, 1918a, 1918b), fishes (Longley and Hildebrand 1941) and reef development (Vaughan 1910, 1914). A fire destroyed the Tortugas Laboratory in 1937. All that remains today on Loggerhead Key is a stone memorial to A.G. Mayer, a small boat house and foundation ruins.

Between 1932 and 1977, only one publication about the Dry Tortugas marine resources appeared in the scientific literature (Brooks 1962). However, in the early 1960s a group of ornithologists, headed by Dr. William Robertson of the National Park Service (NPS), began a long-term study of sooty and noddy tern nesting on Bush Key. This study, involving annual tagging and monitoring of nesting birds, has resulted in numerous publications over the last 30 years that have been summarized by Robertson (1964).

In 1975, NPS initiated the Tortugas Reef Atoll Continuing Transect Studies (TRACTS), whose objective was to develop a bench-mark marine-resource description of Fort Jefferson National Monument using modern techniques of in situ submarine habitat observation and sampling (Davis 1982). Basic TRACTS data combined with those of the Carnegie Laboratory studies will be important to defining and evaluating long-term change. During 1975 and 1976, cooperative studies were made by investigators from the Smithsonian Institution (Fort Pierce Bureau), Harbor Branch Foundation, US Geological Survey, US National Park Service, Florida Department of Natural Resources Bureau of Marine Research, University of Michigan and University of Texas. Contributions from this program include reports on reef geology (Shinn et al. 1977; Halley 1979), fish assemblages (Thompson and Schmidt 1977; Jones and Thompson 1978), coral community structure at Bird Key Reef (Jaap 1987) and a benthic community map showing the coral reef, sea grass and sediment distribution over the entire area (Davis 1979b). Davis later (1982) compared his map with A. Agassiz's of 1882. An example of the long-term importance of the TRACTS studies is Dustan's (1985) comparison of Carysfort Reef off Key Largo with Long Key Reef (Bird Key Reef) at the Dry Tortugas.

Since the initial TRACTS work, the NPS in cooperation with other agencies and universities has periodically conducted additional Tortugas biological assessments and reef community documentation. Most significant among these is a 1976 assessment of reef fish assemblages, a 1977 sponge survey, documentation of a massive shallow water coral kill by an extreme cold front in 1977 and sampling of coral and reef fish communities during 1989 and 1990 (NPS unpublished data, on file South Florida Research Center).

DESCRIPTION OF NATURAL RESOURCES

The Dry Tortugas are located in the eastern Gulf of Mexico approximately 117 km west of Key West, Florida (bounded by coordinates 24°33' - 24°44' N and 82°46' - 82°58' W). The Tortugas are an elliptical, atoll-like, coral reef formation, approximately 27 km long and 12 km wide with a southwest-northeast axis (NOAA-NOS Chart 11438) (see Figure 1.1). Three major bank reef systems, Pulaski Shoal to the northeast, Loggerhead Shoal to the west, and Long Key/Bird Key

Shoal to the southeast, comprise the atoll's outer extent. These reefs are separated by 10-20-m-deep channels on the northwest, southwest, and southeast. The banks surround a 12-33-m-deep lagoon containing numerous patch reefs and shoals. Water depth over the bank reefs is 2-3 m, while depths immediately adjacent to the Dry Tortugas reefs range from 11-29 m.

Islands

The Dry Tortugas contained eleven islands when originally mapped and reported. These included Loggerhead Key, Sandy Key, Bird Key, Garden Key (site of Fort Jefferson), Bush Key, Long Key, Hospital Key, Middle Key, North Key, Southwest Key and East Key (Robertson 1964). By the time the Carnegie Laboratory was established in the early 1900s, there were only eight major keys in existence with North, Sandy and Southwest Keys submerged. Following denudation by hurricanes in 1910 and 1919, Bird Key washed away in the 1930s (Robertson 1964). When Davis mapped the Tortugas in 1976, he reported only the seven remaining islands, although the total land area within these islands roughly approximated the total land area reported by A. Agassiz in 1882 (Davis 1982). Davis observed that Middle Key was frequently awash, and Hospital Key occasionally submerged on spring tides during the 1970s. Since 1986, Bird Key reef has accreted sediment, and it is now above sea level continuously, although no vegetation has developed on the island. Loose calcareous sands resting on Pleistocene reef formations comprise all Dry Tortugas islands (Halley 1979, see Chapter II).

Geology

Although the Dry Tortugas resemble an atoll, they are not in Darwin's classic Indo-Pacific definition (1842). Pacific atolls developed through volcanic land mass subsidence, whereas the Dry Tortugas reef formations sit atop an ancient reef formation (Key Largo Limestone) of Pleistocene origin that once extended from Soldier Key (near Miami) to the Tortugas (Hoffmeister 1974; Shinn et al. 1977).

Shinn et al. (1977) reported on several cores obtained by drilling through the present (Holocene) reefs at the Dry Tortugas. Five cores were drilled in a transect across Bird Key Reef (Long Key Reef) and other cores were obtained from Pulaski Reef, Loggerhead Key and at a site north of Fort Jefferson near the center of the atoll. The thickest reef section encountered was on Bird Key Reef where reef crest Holocene accumulations exceeded 13 m thick. Near the present reef base in 24 m of water, Holocene deposits are only 8 m thick. The underlying Pleistocene bedrock matched the Key Largo limestone formation farther north along the Florida Keys and contained the same coral fauna as the present Holocene reefs (Shinn et al. 1977). This observation prompted Shinn et al.'s conclusion that the Tortugas reefs have been built upon an atoll-like Pleistocene reef formation similarly shaped as the present reef. With the Holocene transgression, corals became established on and around the topographic rim and continued keeping pace with rising sea level during the past 10,000 years.

One of the Tortugas corings most significant findings was absence of the coral *Acropora palmata*, long considered the major Caribbean Holocene reef-builder (Shinn et al. 1977). Although three small living colonies of this coral occur on the south side of the 2 m channel across Bird Key Reef into Garden Key near the northern end of that reef, no *A. palmata* was found in the cores or in coral rubble comprising the reef crest and flat. *A. palmata* presence on other Florida and

Caribbean reefs perhaps has enabled those reefs to keep pace with rising sea level.

An unusual coral rubble and carbonate sand abundance within the first 5 m beneath the reef crest on Bird Key Reef indicated to Shinn et al. (1977) that the Tortugas reef did not grow upward in the manner traditionally ascribed to reef growth, but rather as a mechanical accumulation. Perhaps sand and rubble accumulation at the reef crest, probably during hurricanes, is responsible for the reef's ability to keep pace with sea-level rise despite absence of *A. palmata* (Shinn et al. 1977). Similar situations are likely to occur on the other major Tortugas reef banks. This unusual unconsolidated sediment accumulation within a rapidly growing (expanding) reef system may be a major formation process that covers and encases historical artifacts at Tortugas shipwreck sites.

Benthic Communities

Davis' (1979) detailed benthic community map and his later descriptions (1982) provide a good indication of the present Dry Tortugas natural marine resources. Davis (1982) reported that, in 1976 "living" coral reef occupied less than 4 percent of the bottom above the 10-fathom (18 m) depth at the Dry Tortugas. Included in his living coral-reef classification were stony (Scleractinian) coral-dominated areas of the three major banks, larger staghorn areas such as those found west of Loggerhead Key and large coral-head buttresses (patch reefs) occurring within the lagoon and adjacent the major bank-reef systems. The most extensive reef type at that time was the staghorn coral (*A. cervicornis*) reefs that accounted for about 55 percent of scleractinian coral cover. Nearly half this reef type was concentrated in a single 220-ha reef on northwest Loggerhead Shoal at 6-14 m depths in an area of strong northeast-southwest tidal currents perpendicular to ridges of this coral. Jaap (1987) described coral cover within the rugged, deeper spur-and-groove habitat of Bird Key Reef, which matches Davis' (1982) "stony-coral dominated" zone. Within this zone, *Montastrea annularis, Siderastrea siderea* and *M. cavernosa* dominate.

In shallower water between the deeper stony-coral zone and lagoonal grass beds, the major Tortugas banks and shoals Tortugas are dominated by a hard-bottom community of sea fans, plumes, and whips (octocorals) occurring on exposed limestone. The numerous shallow patch reefs within the lagoon are also topped by octocoral-dominated growth. Davis estimated that approximately 17.4 percent of the Dry Tortugas was occupied by hard-bottom octocoral communities in 1976. Small and low-profile stony corals common within this zone include *Diploria clivosa, Siderastrea radians, Millepora alcicornis, Favia fragum* and *Porities astreoides* (Jaap 1987).

On the shallowest portions of the major banks' southeastern sides, Davis reported finding small, partially intertidal, algal-dominated communities. Fleshy algae of the genera *Laurencia, Dictyota, Sargassum, Padina* and *Zonaria*, and calcareous green algae such as *Halimeda, Avrainvillea, Penicillus* and *Udotea* were the dominate species. A narrow, intertidal coral-rubble ridge extending south-southwest of Long Key was dominated by the crustose coralline algae, *Goniolithon spp.*, and included in Davis' "Algal Community" classification. Overall, Davis' algal communities occupied less than 1 percent of the total benthic area.

Tropical coral-reef benthic algae can be categorized into four major groups: crustose coralline algae that encrust coral, reef rock and other limestone skeletal material; filamentous and fleshy algae, which occur as sparse vegetation and dense vegetation; algae on unconsolidated sediments, which are erect macro-algae of the order *Siphonales* and mats of blue-green algae; and excavating or boring algae (Humm 1984).

The crustose coralline algae, blue-green mats and boring algae are of primary archeological interest. Crustose coralline algae form thin or massive crust, with or without erect branches, and are calcified throughout. When living, they are usually a red shade in low light, but may be yellow-brown in surface light. Dead, they are chalk-white, but soon become greenish as a result of establishment of limestone-boring green and blue-green algae that lend color to the outer 5 mm of skeleton (Humm 1984). The mat-forming blue-green algae community is composed primarily of filamentous species that play a significant role in trapping and binding fine sediments. Among the least conspicuous algae are those possessing the ability to bore into limestone by dissolving it as they grow. To the unaided eye, they are visible as a greenish tinge or discoloration at the surface of dead coral, mollusk shells, or other limestone material (Humm 1984). Boring algae belong to three taxonomic groups: most are blue-green (*Cyanobacteria*), some are green (*Chlorophyta*), and the remaining are *Xanthophyta* (no common name).

Sea grasses, occupying nearly 30 percent of the bottom in 1976, occur primarily within the lagoonal area surrounded by the banks (Davis 1982). The sea-grass community ranges from barely subtidal on Bird Key (Long Key) Bank to depths of 15 m in the northeastern lagoon. Sea grasses occur on sediments ranging from fine sands in the deeper areas to coarse sand and *Porities* coral rubble on shallow flats.

Sea-grass beds adjacent to coral reefs often provide a foraging area for resident reef fish and macro-invertebrates whose grazing reduces blade density adjacent to the reef. From the air, there often will be a halo appearance around or adjacent to a reef. This same phenomenon can occur around submerged cultural resources that provide structure and relief to an otherwise flat sea-grass surface, which attracts a concentration of reef organisms that feed on the surrounding sea grass. Sea grasses typically grow in an alligotrophic (nutrient limited) system and respond to increased nutrient availability by increased productivity and plant vigor. Often shipwrecks will provide a source of slow nutrient input as the wreckage ages and deteriorates, consequently there may be an area of increased sea-grass blade density and/or plant height over the wreck site. Again, this sea-grass bed anomaly can often be detected from aerial observation.

Bare sand and rubble areas occupied nearly half the seabed above the 10-fathom isobath at the Dry Tortugas in 1976 (Davis 1982). Channel bottoms and aprons at outer reef bases are bare sand without conspicuous vegetation or coral growth. Davis (1982) reported that coarse sand and coral rubble, stretching southwest to northeast, separated the staghorn coral reef from the shallower hard-bottom octocoral community and coral-head buttresses west of Loggerhead Key. Davis believed this zone was the result of occasionally severe winter-storm generated surf that he observed breaking over the staghorn reef onto the octocoral zone. He cited large overturned *Diploria* and *Siderastrea* coral heads as evidence of extreme winter storm and hurricane wave energy impinging on that area of usually quiet waters.

Sponges are an important coral-reef benthic faunal component that often play a major role in encrustation, and/or deterioration of shipwrecks and artifacts. Although not usually dominant, sponges are common in most reef zones and can be especially abundant in certain situations. Benthic fauna substrate analysis on selected upper Florida Keys patch reefs indicated a sponge component ranging from 1.2 percent to 9.2 percent of the surface area sampled (Jaap and Wheaton

1977). A NPS Dry Tortugas sponge survey found a total of 85 sponge species, not including microscopic or boring species within the family *Clionidae* (Schmahl 1984).

Of all Dry Tortugas benthic communities, those on hard bottoms in depths less than 4 m are probably of most interest to archeologists because shipwrecks and historical artifacts are most likely to be found in or close to these locations. The primary community occupying this zone is the octocoral-dominated shoals, although some major isolated coral buttresses also occur in shallow water.

Fish and Invertebrate Fauna

Coral reefs have a higher overall density of living organisms per square-meter-of-surface-area than any other habitat; it would not be possible to describe here the extensive multitude of marine macro-invertebrates and fish species occurring on Tortugas reefs. However, some of the more common macro-invertebrates likely to be seen around submerged Tortugas sites include various polycheate worms, spiny lobster (*Panulirus argus*) and other decapod crustaceans, echinoderms (sea urchins, sea stars and brittle stars), tunicates and numerous mollusk species.

Longley and Hildebrand (1941) provided a systematic account of all fishes they captured or observed during 25 years of Tortugas investigations. They listed 442 species, of which 300 were closely associated with coral reefs. Species diversity within small coral reef areas can be extremely high. Bohnsack (1979) recorded a mean number of species ranging from 10-23 on isolated natural coral heads less than 330 x 210 x 150 cm in size off Big Pine Key, Florida. During recent Tortugas surveys, Tilmant and Kemmel (1990) recorded averages ranging from 43-70 fish species visible within a 5 m radius of an observer sitting at randomly selected reef for a 15 minute period. Relatively high species diversity can be expected on Tortugas archeological sites. A few species most likely to be seen because they are extremely common or are often attracted to artificial structures are: Gray (Mangrove) Snapper (*Lutjanus griseus*); White Grunt (*Haemulon plumieri*), Bluestripe Grunt (*H. sciurus*), and Tomtate (*H. aurolineatum*); Ocean Surgeon (*Acanthurus bahianus*) and Blue Tang (*A. coeruleus*); Slippery Dick Wrasse (*Halichoeres bivittatus*), Clown wrasse (*H. maculipinna*), Bluehead Wrasse (*Thalassoma bifasciatum*); Threespot (*Stegasties planifrons*) and Bicolor Damselfish (*S. partitus*); and Stoplight Parrotfish (*Sparisoma viride*).

There is at least one species of reef fish that seems to occur frequently on shipwreck sites but that the author has seldom observed elsewhere on Florida reefs. This is the Cottonwick (*Haemulon melanurum*). This species has been observed on several early shipwrecks in Biscayne National Park, but was not recorded during five years of sampling surveys on nearby patch reefs. There is no explanation for this species' affinity for shipwrecks.

Community and Reef Stability

Coral reef ecosystems are among the earth's oldest and most complex living systems. Overall, most coral reef accretion rates are extremely slow, and reefs require a long geologic period to develop significant structure (Shinn et al. 1977). Because of these characteristics, the coral reef ecosystem is geologically stable. However, from a community composition standpoint, new evidence reveals coral reefs are a highly dynamic, often perturbed system that can vary dramatically in dominant species and functional processes over relatively short time periods (Connell 1978). Environmental perturbations that may be responsible for such changes include hurricanes, unstable substrate, temperature changes, water mass movement, turbidity and human influences. The coral reef's complexity reflects both perturbation frequency and geological stability (Connell 1978).

Within the Dry Tortugas, species composition of live reef-building corals has changed dramatically during several periods. Perhaps the earliest recorded natural reef perturbation in Florida was the 1878 "black-water" phenomenon that caused massive fish kills and extirpated extensive coral fields from shallow flats at the Dry Tortugas. According to the original Tortugas supply vessel ACTIVA's log, the water was "very dark, like cypress water" (Feinstein et al. 1955). The black water was believed to have been caused by an unusually large fresh water surface runoff from the Everglades (Mayer 1902; Jaap 1987). Mayer (1902) reported that species of *Madrepora* (*Acropora*) were nearly eliminated from the Dry Tortugas reefs during the black-water event.

Some indication of coral reef community alterations can be seen by comparing historical reef studies. When Agassiz (1883) mapped the Tortugas benthic communities in 1881, he recorded Elkhorn coral (*Acropora palmata*) as the dominant coral along a major portion of the Long Reef crest (Bird Key Reef). However, by 1932 when Taylor and Wells were working at the Tortugas, *A. palmata* was found only along the seaward edge of the Bird Key Reef rampart and the seaward end of the Five-Foot Channel in depths of 2.4-4.0 m (Jaap 1987). These colonies were reported as flourishing, with some of them as much as 8 ft high and 15 ft across. All that remained of this dominant coral by the time Davis mapped the Tortugas in 1976 were two small patches less than 600 sq m near the Five-Foot Channel on the northern end of Bird Key Reef (Davis 1982).

When Davis mapped the Dry Tortugas, there were extensive shallow water staghorn coral (*Acropora cervicornis*) stands in the Tortugas. The most extensive was the "staghorn reef" on the northwest side of Loggerhead Bank. Davis (1977) reported a concern about anchor damage within these massive staghorn reefs. When Agassiz constructed his map, he showed only linear ridges of gorgonian-dominated rubble within Davis' staghorn reef zone. In late January 1977, an extreme cold front passed through south Florida killing between 90-95 percent of the *A. cervicornis* within the Tortugas (Davis 1982, Tilmant unpublished data). Today (1990), there is once again only gorgonian-dominated rubble within Davis' northwest Loggerhead Key staghorn reef zone.

While Davis (1982) found several significant changes in coral distributions and community composition between his map and the detailed map of Agassiz (1883), the total area percentage covered by coral reef community (both stony corals and gorgonian dominated hard bottom) and the general reef formation distribution had not changed significantly. This, along with the geological investigations that have been done at the Tortugas, suggests that there is indeed geological stability in the Tortugas Reef formations, although the biological communities may be rather dynamic.

Davis (1982) concluded that Dry Tortugas reef form and structure have been determined by prevailing physical environmental conditions. Major bank shapes, which form the atoll-like Dry Tortugas morphology, have been determined by prevailing westerly currents. Bank reefs on the southeastern, windward reef side complex reflect the moderate wave energy generated by mild summer trade winds, while massive coral buttresses and hard-bottom octocoral areas along the northern rim appear to reflect regular high-energy winter storms (Shinn 1977; Davis 1982).

Growth Rates of the Reef and Its Prominent Species

Two aspects of coral-reef growth are of importance to underwater archeological investigations. These are the overall growth rate of the reef formation (net sedimentation rates occurring at the reef surface) and growth rate of individual encrusting organisms on exposed artifacts.

Rate of Reef Formation

Coral reef development progresses through the integration of biological, chemical and physical processes (Jaap 1984). Annual skeletal calcium carbonate accretion in the more massive corals form the reef's skeleton and structural integrity. Dominant Tortugas reef-building corals are those of the genera *Montastraea, Diploria* and *Siderastrea.*

However, soon after the first coral and algal colonies settle and start to grow, skeletal breakdown by biological and physical agents begins producing sediments that also become part of the reef. Finer sediments filter into voids between corals and into borings in the reef; coarser fractions fill the interstitial spaces within the reef framework. Carbonate reef-tract sediments are predominately algal and coral skeletal material (Ginsburg 1956). Sedimentary material becomes incorporated into the reef framework through binding to the platform by crustose coralline algae and through the in situ geochemical cementation by high magnesium calcite cements. Ginsburg and Schroeder (1973), among others, have provided detailed accounts of the coral-reef marine cementation process.

Reef accretion rates based on south Florida carbon-dated borings (Table 4.1) have ranged from 0.65-8.5 m/1,000 yr (Shinn et al. 1977, 1981; Shinn 1980). At these rates, shipwrecks settling to the reef surface in the late 1600s may be incorporated into the reef and as much as 2.5 m below the reef surface.

Loose carbonate sediments, picked off the reef by storm surges, and sediments produced by calcarious algae within the grass beds surrounding the reef are deposited in depressions, behind reef barriers and in deeper water. Sandy-sediment accumulation rates behind Looe Key Reef off the Florida Keys were recently measured at 2.0 m/1,000 yr (Lidz et al. 1985). However, unconsolidated sediments within such areas are subject to continual shifting and movement, often covering and exposing hard substrate and artifacts laying upon them.

Table 4.1. Age and growth rate of recent Florida reefs (Shinn et al. 1977; Shinn 1980)*

Reef	Base Age (YBP) (with confidence limits)	Accretion (m)	Growth Rate (m/1,000yr)
Long Key	5,630 +/- 120	5.0	0.65
Carysfort	5,250 +/- 85	7.3	0.86-4.85
Grecian Rocks	5,950 +/- 100	9.5	6-8
Bahia Honda	7,160 +/- 85	4.6-8.2	1.14
Looe Key	6,580 +/- 90	7.3	1.12
Bird Key	6,017 +/- 90	13.7	1.36-4.85

* As presented in Jaap (1984).

Growth of Reef Organisms

A second aspect of coral reef development of archeological importance is the growth rate of individual coral species or other common marine organisms that typically colonize exposed artifacts and ocean floor surfaces. Individual coral species' growth rates have been investigated by means of marker dyes and analysis of seasonal variations in skeletal material density.

Scleractinian (stony) coral taxa found within Florida waters vary widely in growth rates depending on location, exposure, depth and other factors. Rates ranging from 0.3-3.7 cm/yr have been reported (Hudson et al. 1989; Hudson 1981; Glynn 1973). *Octocoralla* (soft corals) growth rates have been much less studied. Highsmith (1979) reported growth rates of 3-5 cm/year for sea plumes of the genera *Gorgonia*.

Sponges and algae are two other common colonizers on exposed artifacts and substrate. Uncalcified filamentous and fleshy algae typically occur in dense abundance, but are not good indicators of age or duration of substrate exposure because of grazing impact. Often these algae will develop in cropped forms 1-2 mm high on a seasonal or intermittent basis. The most distinctive and characteristic algal group inhabiting exposed artifacts will usually be the crust-forming coralline algae. Colonization, succession and growth rate of tropical crustose coralline algae were unknown until Adey and Vassar (1975) reported that crust margins grew 1-2 mm/mo, and accretion rates were 1-5 mm/yr for Virgin Island plants.

Although sponges will commonly be one of the most abundant reef organisms found colonizing exposed submerged artifacts, little information is available on their ecology or life histories. Virtually all algae research has focused on taxonomy. Common Florida Keys reef-sponge growth rates have not been reported. It is suspected that growth rates probably vary greatly because pumping activity and respiration of these filter feeders are known to vary with sediment conditions and light availability (Reiswig 1974; Gerrodette and Flechsig 1979).

BIOLOGICAL INFLUENCES ON SUBMERGED CULTURAL RESOURCES

Encrustation

On healthy, actively growing coral reefs, suitable substrate upon which larval organisms can settle become established, and growing room is at a premium. Newly submerged shipwrecks or artifacts provide a substrate that is usually rapidly colonized by the abundant planktonic larvae needing settling space in a coral reef community. Following the grounding of the M/V MAVRO VETRANIC on Pulaski Reef at the Dry Tortugas in November 1989, filamentous green algae had colonized the newly exposed carbonate substrate to a visible green "turf" within a few weeks.

Usually, filamentous algae are first to invade any new available substrate. In studies using clear, artificial substrates, colonizers were principally filamentous brown and green algae of the genera *Griffordia*, *Cladophora* and *Enteromorpha* during the first 6-8 weeks (Wanders 1977). After 10-15 weeks, these were replaced by larger filamentous and parenchymatous species. Within six months, calcarious algae are likely to appear. Calcarious algae heavily encrusted research study-plot markers placed on the Tortugas reef within a year. *Batophora* is usually one of the most prominent calcarious genera to first encrust foreign objects introduced into the marine environment.

Significant coral reef algae biological controls are competition for space with other epibenthic sessile organisms and the grazing impact of herbivorous fish and invertebrates.

On recently exposed substrates, benthic algae may be the first colonizers, but under normal grazing pressure, they are usually replaced by sponges, tunicates, corals and bryozoans over a longer period of time.

Most exposed submerged artifacts found within Fort Jefferson National Monument will have had a long history of colonization and may be supporting a relatively well-developed coral-reef community. Davis (see Chapter XX) reports observing 14 of the 50 corals known to occur in the Tortugas on the Windjammer wreck (FOJE 003) within the monument. This site also has an abnormal concentration of predators and grazers because of increased substrate availability.

Typically, artifacts will be supporting well-developed communities dominated by organisms of the phylum *Cnidaria*, which includes jellyfish, sea anemones, corals and hydrozoans. An often dominant substrate colonizer is the hydrozoan *Millepora* or fire coral. Fire corals are quite common throughout the western Atlantic tropical reef areas and occur in two main growth forms: *M. alcicornis*, a digitate branching form, and *M. complanata*, a truncated-blade form. Both are aggressive encrusting organisms that may rapidly encase exposed artifacts or exposed shipwreck surface areas. Scientific *Millepora* growth-rate studies are lacking, but after settlement, annual rates may be as high as 10 cm (Jaap 1984).

Boring

Many marine organisms colonizing newly submerged and exposed substrate have the capability to bore into soft or calcarious substrate, these include marine worms, sponges, algae and hydrozoans. These organisms can often cause extensive damage to exposed artifacts. Among the least conspicuous and most often overlooked are boring algae. Boring algae belong to three taxonomic groups: most are blue-green (*Cyanobacteria*), some are green (*Chlorophyta*), and some are *Xanthophyta* (Humm 1984).

Sponges are a major force in the coral reef bioerosional process (Goreau and Hartman 1963; Rutzler 1975), and they may play a significant role in attacking exposed organic substrates on shipwrecks or other artifacts. The boring sponges are classed mostly in the family Clionidae (genus *Cliona*), but species of the *Adocidae* (*Siphonodictyon*) and the *Spriastrellidae* (*Spheciospongia*, *Anthosigmella*) also excavate coral limestone skeletons (Schmahl 1984).

ASSESSMENTS AND MONITORING OF BIOLOGICAL RESOURCES AT SUBMERGED CULTURAL SITES

Need for Biological Assessments

It is important to conduct biological assessments and subsequent submerged cultural resource site monitoring for several purposes. Once a site is discovered, a detailed biological assessment may be able to greatly assist in dating artifacts and determining time of deposition. In addition, an assessment may be important to determine what impact the cultural resource is having on adjacent communities; determine potential impact to natural resources if the cultural site was to be excavated, recovered, moved or preserved in situ; or to determine if the cultural resource is being further exposed or encased within sediment or reef structure due to storm events or reef surface structural changes.

Investigation of biological, hydrological and sedimentary characteristics of a historic shipwreck in the Biscayne NP Legare Anchorage is an example of the value of environmental assessments (Tilmant et al. 1982). Shipwreck and artifact analysis revealed the wreck was an eighteenth-century warship of considerable historical importance.

Archeologists evaluating the site during the first few months after its discovery believed the area was being threatened by continued erosion, further exposing the wreck to human disturbance and destruction by natural forces. A commercial treasure hunter's illegal excavations prior to NPS control seemed to be causing erosion. A detailed biological description, and sedimentological and hydrological characterization of the site was necessary to evaluate management options of salvage, recovery of surface artifacts or in situ preservation.

Physical and biological data gathered during a three-month sampling period clearly showed a net sediment loss of 2.1 cm during the study period. However, close inspection along artifact-sediment interfaces did not support high rates of continuous sediment loss over long periods. All exposed material was either heavily colonized with algae, sponges, tunicates, bryozoans and other encrusting organisms, or in the case of wooden beams, highly infiltrated with teredo worms and other boring organisms. A star coral (*Madracias madracias*) exceeding 19 cm in diameter was noted on an exposed cannon. Another star coral (*Favia fragnum*) 4 cm in diameter was observed only 3 cm from the sediment surface. Although these species' growth rates have not been reported, similar species (*Porities, Favia* and *Montastrea*) grow anywhere from 0.63-3.70 cm/yr (Glynn 1973; Hudson 1981). Sea plumes (known to grow between 3-5 cm/yr) up to 50 cm in height also were found on exposed artifacts. Other corals on exposed artifacts included an *Oculina diffusa* and a *Porities porities*, both exceeding 70 cm in width and a brain coral measuring 35 cm in diameter. These encrusting organisms' size and location indicate most of the wreck site had been exposed continuously for at least the last 40 years, and perhaps longer.

In addition to the above biological data, numerous skeletal remains of small corals, worm tubes, coralline algae and gastropods were observed in open sandy areas surrounding the wreck. Presence of these remains suggests the sandy substrate surrounding the wreck had been exposed and recovered periodically in the past. The main conclusion of the physical and biological site assessment was that the wreck is located in an area of relatively unstable surface sediments that experiences periodic shifting and buildup within relatively narrow overall limits in response to storm events and wave conditions. Recent, or continually increasing long-term exposure of the site is not likely.

Assessment Methods

The best approach to a detailed biological assessment lies in establishing a grid network over the entire area and mapping biological features in relation to grid cells. A detailed grid survey insures that all significant features and organisms present will be enumerated and precisely positioned. Key locations necessary to establish the grid can be permanently marked so the grid can be rapidly reestablished and all organisms relocated. This approach allows investigators to easily and accurately assess artifact loss or movement, as well as changes occurring in the physical and biological attributes of the site over time.

The author and his coworkers have found a 10 m grid interval provides sufficient detail and is of a cell size that can be easily surveyed and mapped. The grid system can be rapidly established underwater by first laying two parallel lines marked in 10-m segments along the major site axis. One line should be laid near each extremity. The baselines can then be easily used to guide laying the remaining grid lines as the survey progresses across the site.

Whenever possible, it is desirable to obtain low-level aerial site photography. Benthic communities are often distinct in aerial views, which allows tracing on to photo overlays to form base maps and to reference the grid system. In addition, aerial photos, and subsequent community analysis, can often provide a good indication of additional buried material at the site through recognition of changes in grass density, morphology of sand areas or benthic community composition and structure.

Underwater surveys should be conducted within each visually distinct benthic community to obtain quantitative and qualitative community descriptions. Within sea-grass communities, .1 m plots at 1 m intervals along randomly laid line-transects work well to enumerate grass species and blade density. Two transects of 10 plots each are usually sufficient to obtain a statistically reliable estimate of mean grass density. Coral communities are best surveyed utilizing .25 m x .25 m plots placed at 1 m intervals along 20 m transects. Within the sample plots, all corals, sponges and other macro fauna should be enumerated and recorded. In addition, all exposed artifacts, or wreckage substrate, should be individually mapped at a scale that allows recording of all encrusting macro-organisms. At several selected grid locations, permanent "sediment surface" reference stakes should be established to document changes in site exposure. Copperweld survey markers driven into the substrate, or pvc stakes cemented in place, with a clear reference mark work well for measuring sediment surface level changes over time.

Other factors that may need to be assessed or monitored at a cultural site include sediment composition through core sample analysis; overall surface sediment thickness, which can be done with deep probes (a high-pressure water drill works well); water currents and sediment transport potential (particle size and wave dynamics of surface sediments). Each factor plays a role in determining necessary and prudent management actions regarding site protection and preservation.

SCLEROCHRONOLOGY

Sclerochronology is the marine counterpart to the more commonly known dendrochronology--the study of tree rings for archeological dating. The relatively new science of sclerochronology involves examination of stony coral density bands and offers great potential for dating submerged sites. Variations in the density of calcium carbonate skeletal material laid down by a stony coral colony as it grows has been shown to occur on a seasonal basis (Knutson et al. 1972). Density banding, most clearly visible in radiographs of a coral colony cross sectional, appears to be the result of the seasonal variations in light and temperature (Buddemeier and Kinzie 1976).

Two distinct types of high-density banding were found in *Montastrea annularis* from Florida reefs (Hudson et al. 1976): consistently spaced, thin high-density annual bands and occasional, wide high-density "stress" bands. The higher density bands are related to known cold weather/water or other stress-causing natural events and are believed to represent periods of unusually slow coral growth because of unusual conditions.

Stony corals, found on exposed artifacts, may serve to help document the time of submergence through a sclerochronological analysis. Although it will not be known how long after deposition of the material the coral began to grow, this approach will allow documentation of a minimum time period of exposure to the marine environment and provide a reliable relative dating tool.

CHAPTER V

Dry Tortugas Prehistoric Cultural Resources Potential

Wilburn A. Cockrell

INTRODUCTION

This chapter's objective is to evaluate the Dry Tortugas' potential for prehistoric sites, materials, structures, watercraft and other cultural resources on land and underwater. This evaluation is in a regional context encompassing the Florida Keys, south Florida and the Caribbean, and is designed to contribute to a research design that includes site location and evaluation methods and techniques appropriate for inclusion on the National Register of Historic Places (Figure 5.1).

At present, from both the writer's limited research in the Dry Tortugas as Florida State Underwater Archeologist (1972-1983), and review of the Florida Master Site File, there are no recorded prehistoric cultural resources in this small cluster of keys. Uplands prehistoric sites potentially exist, but no formal archeological survey has yet been undertaken. It is highly improbable that prehistoric peoples never visited these keys, given the islands' proximity to areas known to have been occupied or utilized, yet it is quite possible that visitors or inhabitants left little or no readily identifiable archeological evidence. Given centuries of exposure to weathering ranging from annual freezes in the terminal Pleistocene to hurricanes in the Holocene (Millás 1968), it is also possible that traces were left, but have long since become undetectable to traditional survey approaches.

Inundated prehistoric cultural resources potential is much greater given the far larger target area of the submerged shelf that surrounds the keys and extends outward to a depth of as much as 60-100 m, which is the present depth of the submerged Pleistocene shoreline at ca. 12,000 B.P. (Coastal Environments, Inc. 1977; Widmer 1988) (Figure 5.2). (NOTE: To facilitate date comparisons, all citations, unless contained in a quotation or "Figure," are B.P., i.e., years Before Present, normally 1950. Here "present" is rounded to 2000 A.D. to facilitate computations; a fifty year "error" is insignificant over a 12,000 year period. This would be an error only if the date being adjusted were an absolute and exact date, which of course it is not.) Terrestrial sites, now inundated, could have been established in the survey area, and it is also quite possible that other prehistoric evidence could have been deposited and subsequently preserved on the shelf surrounding the keys.

For more than forty years, archeologists have been speculating about the existence and nature of offshore, nearshore, and inland sites inundated as a result of rising sea levels (Goggin 1964; Rouse 1951:238-240; 1956; Lazarus 1965). Studies or literature reviews for inundated site potential may be found in Gluckman (1982), Cockrell (1974a), Coastal Environments, Inc. (1977), Cockrell and Murphy (1978a; 1978b), Cockrell (1980), Ruppé (1980; 1988), Cockrell (1981), Garrett (1983), Masters and Flemming (1983), Kellogg (1988) and Murphy (1990b).

In addition to these reviews and long-standing speculations on the potential for finding and excavating inundated sites, there have been some successful nearshore projects. The writer and Larry Murphy have studied a drowned terminal Pleistocene site (Douglass Beach Site 8SL17) off the Florida east coast

Figure 5.1. Caribbean region.

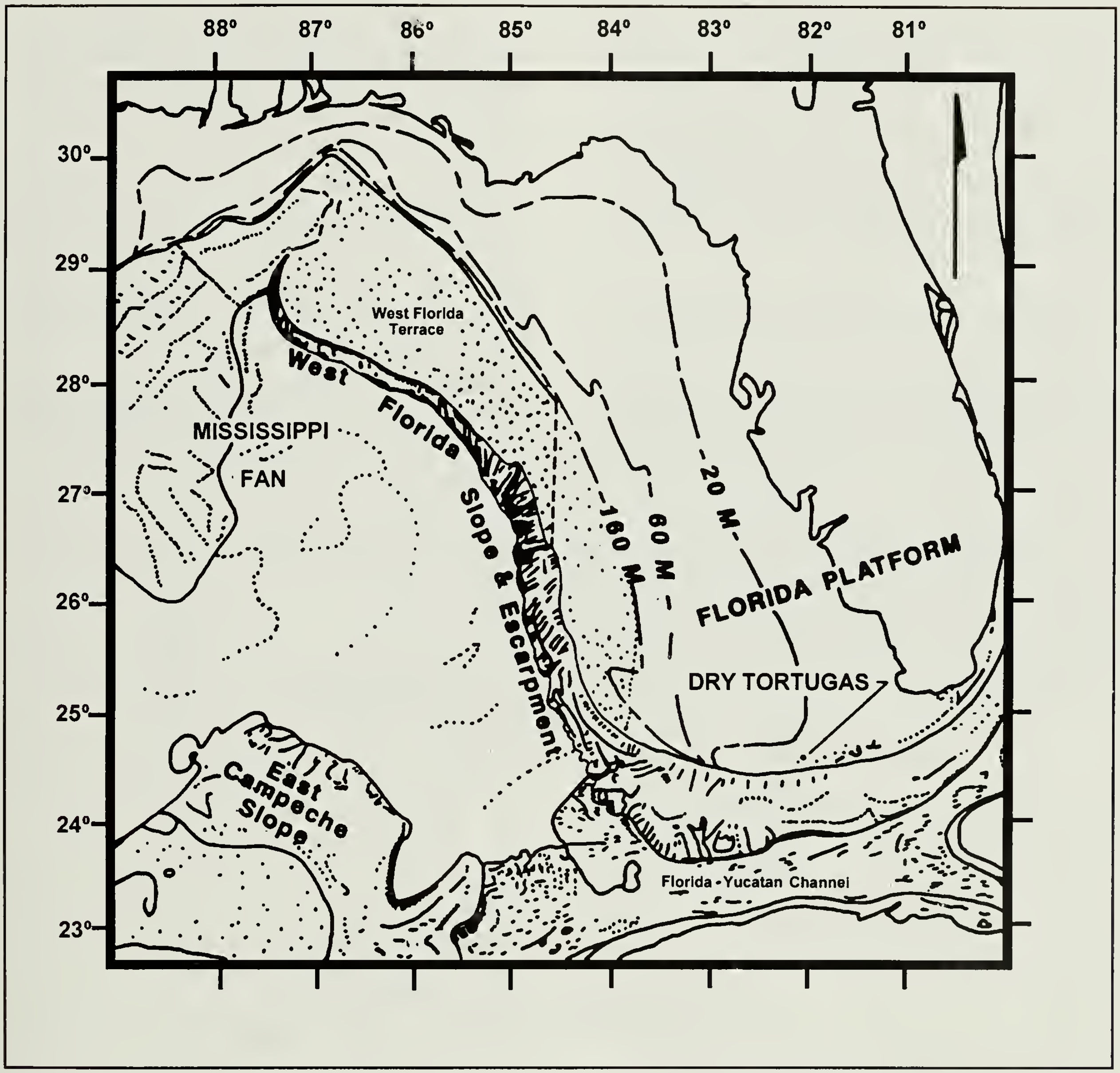


Figure 5.2. Submerged land forms and bathymetry.

(Cockrell and Murphy 1978a, 1978b; Murphy 1990b). Ruppé and Koski continue to conduct research on a 2000 to 3000 B.P. drowned site (Venice Beach 8So26) off the Florida west coast (Ruppé 1980; Koski 1988). For inland submerged sites, Clausen worked extensively in the 1970s in and around the cenoté at Little Salt Springs (8So18) recovering extensive materials from ca. 7000 B.P. and some earlier materials (Clausen et al. 1979), although some researchers question the earliest dates and associations.

Another drowned site, Warm Mineral Springs (8So19), historically known as Salt Springs, is only 3.2 km southwest of Little Salt Springs (Figure 5.3). It was visited briefly by Goggin in the early 1960s (1962) and by Clausen in 1971 (Clausen et al. 1979). Intermittent multidisciplinary investigations conducted there since 1972 (Cockrell 1988; Wood 1988) have produced a continuum of historical and archeological materials from 11,000 B.P., including extinct Pleistocene megafauna, to the present.

Evidence for Aboriginal Watercraft

Other nonhabitation evidence possible in the study area includes aboriginal watercraft, which are frequently found in Florida and are currently being reported to the Florida State Museum in Gainesville. Aboriginal watercraft are known in Florida as early as 3000 B.P. (Garrett 1983:28), and inferred to exist in the Caribbean at least as early as Rouse's "Meso-Indian" stage, which roughly equates to Florida's "preceramic Archaic" stage (Rouse 1960:10,12), with a temporal span from ca. 8500 B.P. to ca. 5000-4500 B.P. (Milanich and Fairbanks 1980:19).

James A. Ford makes an eloquent argument for transoceanic transport of peoples

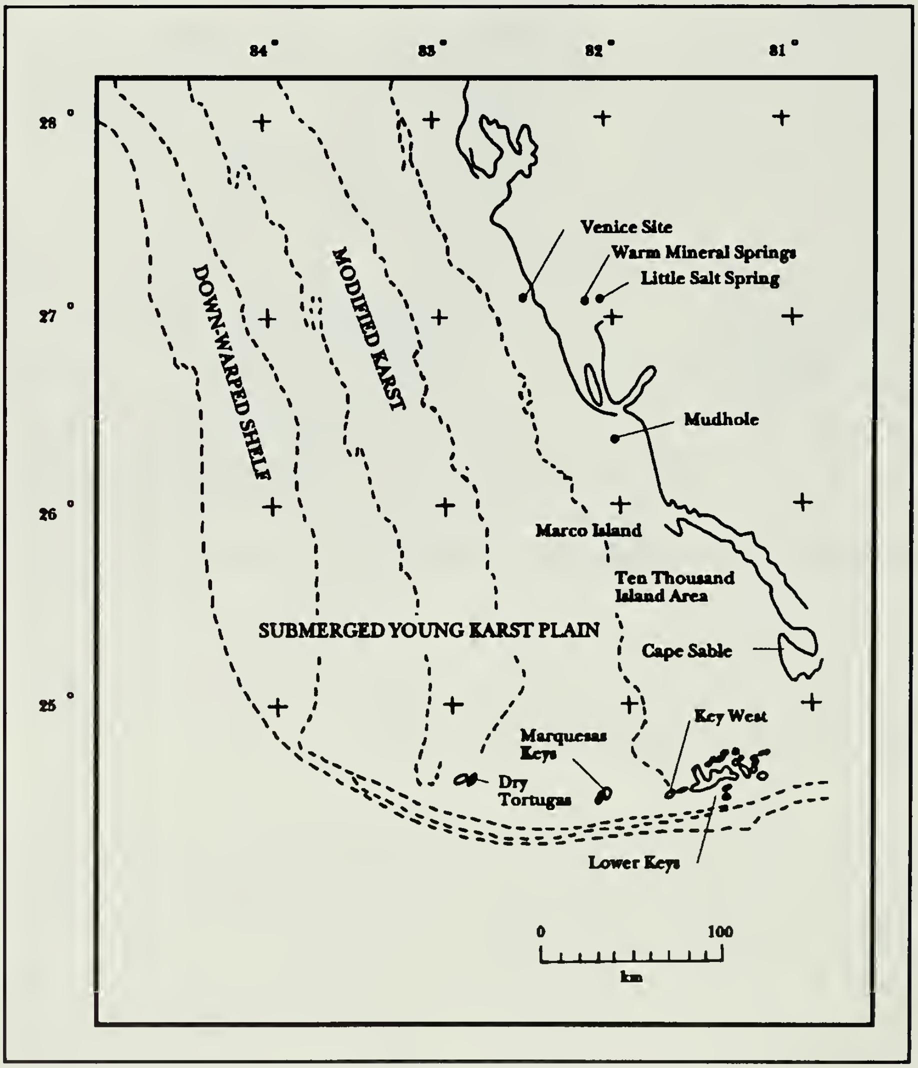


Figure 5.3. Early Florida west coast sites.

and ceramic technology to South America at about 5000 B.P. (Ford 1969:183), and then to Stallings Island, at the mouth of the Savannah River, by ca. 4400 B.P. (Figure 5.1). Crusoe (1972:63), in support of Ford's thesis, presents evidence that "ancient mariners" brought ceramic technology via water to North America by approximately 4000 B.P. In 1971, one radiocarbon sample from an early single-component fiber-tempered site on Marco Island was dated at ca. 5000 B.P., or five hundred years earlier than the earliest Stallings Island date (date on file at Division of Historical Resources, Tallahassee).

This early long-distance transport of ceramic technology, as well as other cultural evidence, with no intermediate evidence of any sort indicating overland travel, argues strongly for water transport over considerable distances. In addition, once a lower sea level is postulated, there is a far greater cumulative land mass area available to early travelers, effectively shrinking water distances between points in North and South America and the Caribbean basin (Cockrell 1986:49).

Florida prehistoric watercraft are also inferred from "toy" wooden canoes such as those found by Cushing at the Key Marco site (8Cr48) (Cushing 1897), and the extensive southwest Florida canals reported by Goggin (1964:87) and recently reviewed by Luer (1989). Goggin and Sturtevant (1964:195) later stated the Calusa canals "...are considered to be ceremonial in nature..." (1964:195). Widmer (1988:6) agrees that the canals are "apparently without economic function" and are "ceremonial in nature." This conclusion, even if correct, does not preclude canal use by prehistoric watercraft.

Finally, the first Europeans' reports of the region (1492 for the Caribbean, and at least prior to Ponce de Leon's 1513 Florida expedition (Smith 1944:62)) and shortly thereafter contain observations of aboriginal use of non-European watercraft (Smith 1944:29,44; Connor 1964). Rouse (1966: 235-236) reviews prominent sightings and other evidence of large seagoing watercraft, including Columbus' 1502 report of a large trading canoe that must have held 40 people, as well as a 96 ft x 8 ft Arawak craft observed in Jamaica, which was "... supplied with both oars and sails" (1966:236). Rouse notes that the Caribs had similar canoes, but without sails, and that there is no information about the nature of Ciboney canoes. McKusick (1960) in "Aboriginal Canoes of the West Indies" reviews historical documents with both Carib and Arawak watercraft accounts. Various other accounts of interisland interaction exist, and the vast archeological and ethnological evidence of transmission of ideas, peoples and material culture over water for millennia forms a self-evident inferential body of data demonstrating watercraft existence.

Additional Sites

In addition to preserved watercraft, other materials are being discovered in varying states of preservation in submerged contexts, primarily in anaerobic water, peat or muck, thus demonstrating potential for other cultural materials' existence in the study area (Purdy 1988).

Submerged structures, such as fish weirs, have been found in North America (Cockrell 1980:145), and could have been used in the study area. That structural wood could remain preserved in a marine context has been documented most recently in a 3000 B.P. context in 2.5 m of water in the Venice Beach Site (8So26) on the west coast of Florida (Koski 1988:26). A feature consisting of a ring of stakes dated at 4600 B.P. (Murphy 1990b: 27) was reported for 8SL17 offshore the Florida East Coast.

SEA LEVEL

The relative Pleistocene-Holocene sea level rise, whether and to what degree oscillations occur, and the curve's shape depicting the rise have been subject to considerable expert attention. Several excellent studies have reviewed the literature (Fairbridge 1974; Coastal Environments, Inc. 1977; Science Applications, Inc. 1979; Garrett 1983; Widmer 1988; Murphy 1990b). A plethora of data is available, but there is no universal agreement on many points. However, some consensus occurs on the maximum lowering during the last 12,000 years. The range of opinion clusters between 100-60 m below present sea level (Figure 5.4 and Table 5.1). Most authorities agree that eustasy, rather than isostasy, accounts for most or all of the rise.

There is widespread agreement that the global warming that ultimately resulted in the terminal Pleistocene-Holocene rise occurred ca. 12,000-14,000 years B.P.; there is also general agreement that the rise was geologically quite rapid. Widmer devotes considerable attention to this rapid rise (Table 5.2) and its natural and cultural effects (1988 passim) in the southwest Florida area. The present-day optimum, or the time at which the rising sea level slowed and essentially stabilized at

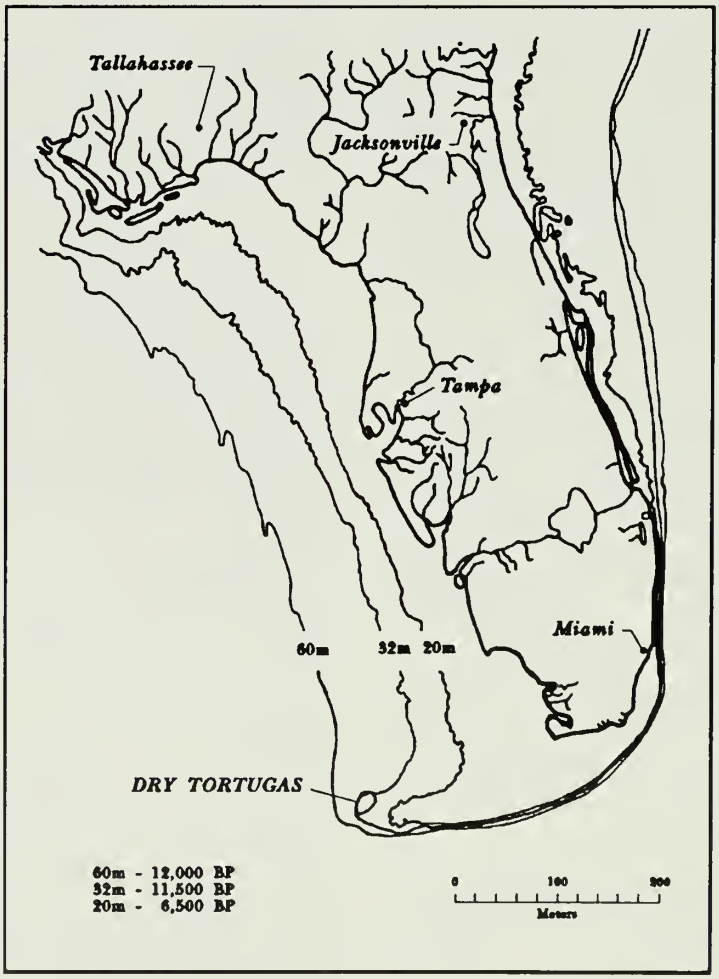


Figure 5.4. General Florida sea levels (after Ruppe 1980:44).

Table 5.1. South Florida Geological Chronology

Date	My Usage	Gagliano's	Sea Level	Geological Characteristics
Present			0.0 m	
				Origin of modern coastal configuration & Big
	Late			Cypress Swamp, sedimentation = sea-level rise, sea
	Holocene	Interval K	-1.5 m	level slows dramatically
2700 B.P.				
		Interval J	-2.7 m	Water table rises to surface, formation of coastal
4000 B.P.				zone, peat formation and sedimentation begins,
	Middle		-4.0 m	origin of Lake Okeechobee, Everglades, Caloosa-
	Holocene		-12.0 m	hatchee River
5500 B.P.				
		Interval I	-20.0 m	
7000 B.P.				
		Interval H4	-25.0 m	
8500 B.P.				
		Interval H3	-45.0 m	
9000 B.P.				
		Interval H2	-60.0 m	Surface water restricted to cenotes, water table -11
10,500 B.P.	Early			to -26 m, dunes become stable
	Holocene	Interval H1	-80.0 m	
12,000 B.P.				
		Interval G	Rising sea	
15,000 B.P.				
	Late	Intervals		Maximum exposure of Florida Peninsula, maximum
	Wisconsin	E & F	-100.0 m	extent of glacial ice
18,000 B.P.				
		Intervals		Lowered water table, no flowing rivers, no surface
	Late	C & D	Falling	sediment, beginning of climatic deterioration, onset
	Wisconsin		Sea	of glaciation
		Interval B		
30,000 B.P.				
	Sangamon	Interval A	+ 7.0 m	Sangamon (Pamlico) sea inundates south Florida
73,000 B.P.				

Table 5.2. Sea-Level Transgression for Southwest Florida

Date B.P.	Sea Level	Rate of Sea Level Rise Per 100 Yrs (1,2)	Rate of Shoreline Transgression Per	
			Year 1	Year 2
15,000	- 128.0 m	-	-	-
14,000	- 125.0 m	0.84 m	-	-
13,000	- 115.0 m	-	-	-
12,000	- 95.0 m	2.0 m	8.3 m	3.4 m
11,000	- 73.0 m	-	-	-
10,000	-55.0 m	2.2 m	30.4 m	11.6 m
9,000	-45.0 m	1.5 m	37.5 m	21.0 m
8,000	-30.0 m	-	-	-
7,000	- 12.0 m	-	-	-
6,000	- 4.0 m	-	-	-
5,000	- 4.0 m	-	-	-
4,500	- 4.0 m	0.213 m	-	-
4,000	- 2.75 m	0.151 m	-	-
3,500	- 2.0 m	0.107 m	-	-
3,000	- 1.8 m	0.075 m	-	15.2 m
2,500	1.2 m	0.053 m	-	-
2,000	- .90 m	0.038 m	-	1.6 m
1,500	-	0.027 m	-	-
1,000	-	0.019 m	-	0.3 m
500	-	0.017 m	-	-
0	-	-	-	-

(1) Rate from Milliman and Emery (1968)
(2) Rate from Kuehn (1980)

Adapted from Widmer (1988)

current levels, is agreed on in general, but informed estimates range from as early as 6000 B.P. (Fairbridge 1974:228) to as late as 4000 B.P. (Murphy 1990b:18). While most contend that no transgressions, or rises above current level, have occurred since then, the "Fairbridge Curve" shows "important oscillations" in the last 6000 years (Fairbridge 1974:226-229). Fairbridge also reinterprets data obtained by Scholl and others (Scholl et al. 1969) and concludes they may show repeated transgressions since 6000 B.P.

While such precision regarding temporal events and transgressions is demonstrably critical to Widmer's thesis on prehistoric coastal adaptation, it is of less critical importance to the Dry Tortugas prehistoric study, as the research objectives differ. The goal here is to determine whether potential for cultural resources, as defined at the beginning of this chapter, exits, whether taphonomic events would allow them to still occur in any discernible form, and to stipulate a strategy for their location, examination and analysis.

The targeted temporal frame begins ca. 12,000 B.P. (see Meltzer 1989, for a discussion of earliest dates for people in North America), thereby excluding depths below 60-100 m from consideration as possible habitation sites. Because there is general agreement that at ca. 4000-6000 B.P. the sea level reached present-day optimum, there is a 6,000-8,000-year window during which prehistoric peoples could have occupied now submerged lands surrounding the Dry Tortugas. Factors such as population densities, settlement and subsistence behavior, and regional and local environments are critical elements in the equation, but the existence of once-dry land during a time period when people were available to occupy it is not the only required element. The element of culture must be considered; human behavior is the other critical factor in determining site location.

PREHISTORIC WATERCRAFT

Given these limiting factors, sites and structures can be fairly safely predicted to lie in discrete areas. Predicting location of submerged watercraft away from the immediate vicinity of a site is much more difficult. Even if transportation routes could be known or assumed on the basis of proximity to settlements inferred from intersettlement transport models, postdepositional events such as floatation and transportation by sea or wind currents would result in widespread dispersal. Precise locational modelling remains extremely tentative.

All known prehistoric watercraft found in Florida have been in anaerobic mud and peat at the bottom of ponds and bogs adjacent to habitation sites and in rivers. While the Dry Tortugas geomorphological history makes it highly unlikely that rivers were located in the study area within the last 12,000 years, it is nevertheless possible that, if sites did exist (given that at least for the last few millennia the people in the area almost certainly had watercraft, as noted earlier), there is the potential for watercraft loss and subsequent preservation in areas immediately adjacent to habitation sites. A notable example of a prehistoric situation that would fit this model was reported by Cushing after his excavation of the Court of the Pile Dwellers on Key Marco (1897). Directly adjacent to a habitation site in a lagoon he recovered well-preserved organic remains, primarily wood, including the "toy" canoes mentioned earlier. He surmised that a hurricane and subsequent fire had deposited the remains in the water where they became waterlogged, sank and were ultimately covered by "muck" and preserved. While he found no functional watercraft, an analogous situation could allow similar preservation in the study area.

For the foregoing reasons it is important to survey the spatially and temporally neighboring cultures for insights into settlement and subsistence behavior. Thus far, it has been demonstrated that it is possible for submerged cultural resources to exist, and that it is possible to identify and study them. In order to produce a survey design for the Dry Tortugas, it is advisable to next evaluate adjacent areas, defined for the present purpose as the nearby islands of the Florida Keys, the Bahamas, south Florida and the Caribbean.

REGIONAL SPATIAL-TEMPORAL FRAMEWORK

Archeologists have long used heuristic devices to order data. In order to proceed, it will be helpful to arrive at operational definitions for developmental-temporal-spatial constructs that are frequently, and not always clearly, used by prehistoric archeologists dealing with North American, Meso-American and Caribbean cultures. As these devices are artifices of convenience constructed and imposed (sometimes forcefully) on data, it is necessary to use and modify them in ordering data or addressing a specific problem, and to ignore or discard them when not relevant. In a classic discussion of this topic, J.O. Brew wrote, "We need have no fear of changing established systems or designing new ones, for it is only by such means that we can progress" (reprinted in Deetz 1971:105).

In Willey and Phillips' *Method and Theory in American Archaeology* (1958), the authors used a "Historical-Developmental Approach" and postulated five "stages" to order New World archeological data. These stages generally, but not always, had a temporal reality; however, they were based on the assumption that cultures may develop in complexity through time, and that cultural manifestations might be effectively studied by classifying them in this manner. North American prehistoric peoples fall into the first three of five stages: the Lithic stage, the earliest and least complex peoples; the Archaic stage, "the stage of migratory hunting and gathering cultures continuing into environmental conditions approximating those of the present" (1958:107); and the Formative stage, defined by "... presence of agriculture, or any other subsistence economy of comparable effectiveness, and by the successful integration of such an economy into well-established, sedentary village life" (1958:146). It is important to remember that this is not a deterministic model, and that cultures do not necessarily move inevitably from a less complex to a more complex stage. This is not an evolutionary model.

Rouse, for the 1954 symposium "Settlements and Society: A Symposium in Archeological Inference," faced similar problems and followed Julian Steward's 1947 articulation of an interestingly parallel construct in "Settlement Patterns in the Caribbean Area" (Rouse 1956:165ff). Rouse states that:

> One of the characteristics of the Caribbean area, as here defined, is that it was occupied by tribes on different levels of cultural development, who sometimes lived side by side. In the time of Columbus these included (1) Indians who subsisted by hunting, fishing, and gathering without the practice of agriculture and who generally lacked pottery; (2) tribes which practiced agriculture and made pottery but which had a relatively simple social organization and religion; and (3) agricultural, pottery-making Indians with chiefs, social classes, and elaborate forms of religion, characterized by the presence of priests, temples, and idols. It has become customary to call the Indians of group 1 'Marginal', those of group 2, 'Tropical Forest'; and those of group

3, 'Circum-Caribbean'" [1956:165] (Figure 5.5).

In the Caribbean, "the Ciboney were of the Marginal type, and were the first peoples in the Antilles" (Rouse 1966:234). Marginal sites were camps, occupied by small, independent bands (Rouse 1956:172). In central Cuba, the "sub-Taino" were Tropical Forest, while the Taino in eastern Cuba were Circum-Caribbean (Rouse 1956:165) (Figure 5.6). The latecomers to the Antilles were the Caribs, a Tropical Forest type, who came into the Lesser Antilles as aggressors, but ultimately had their language displaced by Arawak (Rouse 1966:234-235). The Greater Antilles Arawaks were Circum-Caribbean, probably moving from Venezuela's north coast into the Antilles by 1000 B.P.

These peoples of differing cultural complexity and settlement patterns were coeval at the ethnographic present. This is not a temporal model, although the Marginal pattern developed first, followed by the Tropical Forest pattern and the complex Circum-Caribbean was the latest. This conceptual model is included here because of its parallels to the Willey and Phillips historical-developmental model, which, in a modified form, is to be used in the remainder of this discussion. In addition, the Steward/Rouse model casts useful insights on the study area, which is on the northern periphery of the Caribbean, but also directly adjacent to south Florida, where Milanich and Fairbanks observe, "There is some evidence to suggest that the extreme southern third of Florida (outside of the Lake Okeechobee Basin) remained in what was basically an Archaic stage until the coming of the Spanish" (1980:20). The point emphasized here is that in the study area and environs, prehistoric peoples of differing stages of cultural complexity, with resultant differing settlement and subsistence behavior, occupied neighboring, sometimes overlapping, or sometimes quite similar ecological niches, and they had varying interaction systems. Therefore, at the same temporal horizon, particularly during the later millennia of the target 4000 to 12,000 B.P. era, it is possible to have coeval groups with different settlement/subsistence behaviors operating in the survey area, i.e., the shelf surrounding the Dry Tortugas.

Interestingly, Rouse, with Cruxent, utilizes a primarily temporal and developmental, rather than behavioral, model in the paper "Early Man in the West Indies" (Cruxent and Rouse 1969) (Figure 5.7). Rather than "stages", the authors use "ages": Paleo-Indian, Meso-Indian and Neo-Indian. The Paleoindian occupations were identified "...by the absence of ground-stone artifacts; the only stone artifacts were made of flaked flint" (1969:73). Temporally, they postulate Paleoindian sites in Hispaniola as early as 7000 B.P., with Meso-Indian sites being coeval on the eastern coast of Venezuela (Figure 5.8). The Meso-Indians "... knew nothing of pottery; they made their distinctive artifacts by grinding stone and by chipping flakes of flint. They did not know farming and fed themselves instead by fishing and gathering shellfish and wild vegetable foods" (1969:73). The Neo-Indians were latecomers, arriving in the Greater Antilles about 1700 B.P., and the Bahamas about 1000 B.P. (Figure 5.9). Their culture is characterized by pottery, and they were of Cariban and Arawakan linguistic stock (1969:71-72). At the time of first European contact, the Neo-Indians had displaced the earlier West Indian (Meso-Indian) population, who "...existed only as remnants in western Cuba, in a few small Cuban offshore islands and in southwestern Hispaniola" (1969:72). This Cruxent and Rouse paper makes two innovative statements. First, relating to sea level change, they suggest that the Paleo-Indians' purposeful movement from island to island was made less difficult as a result of

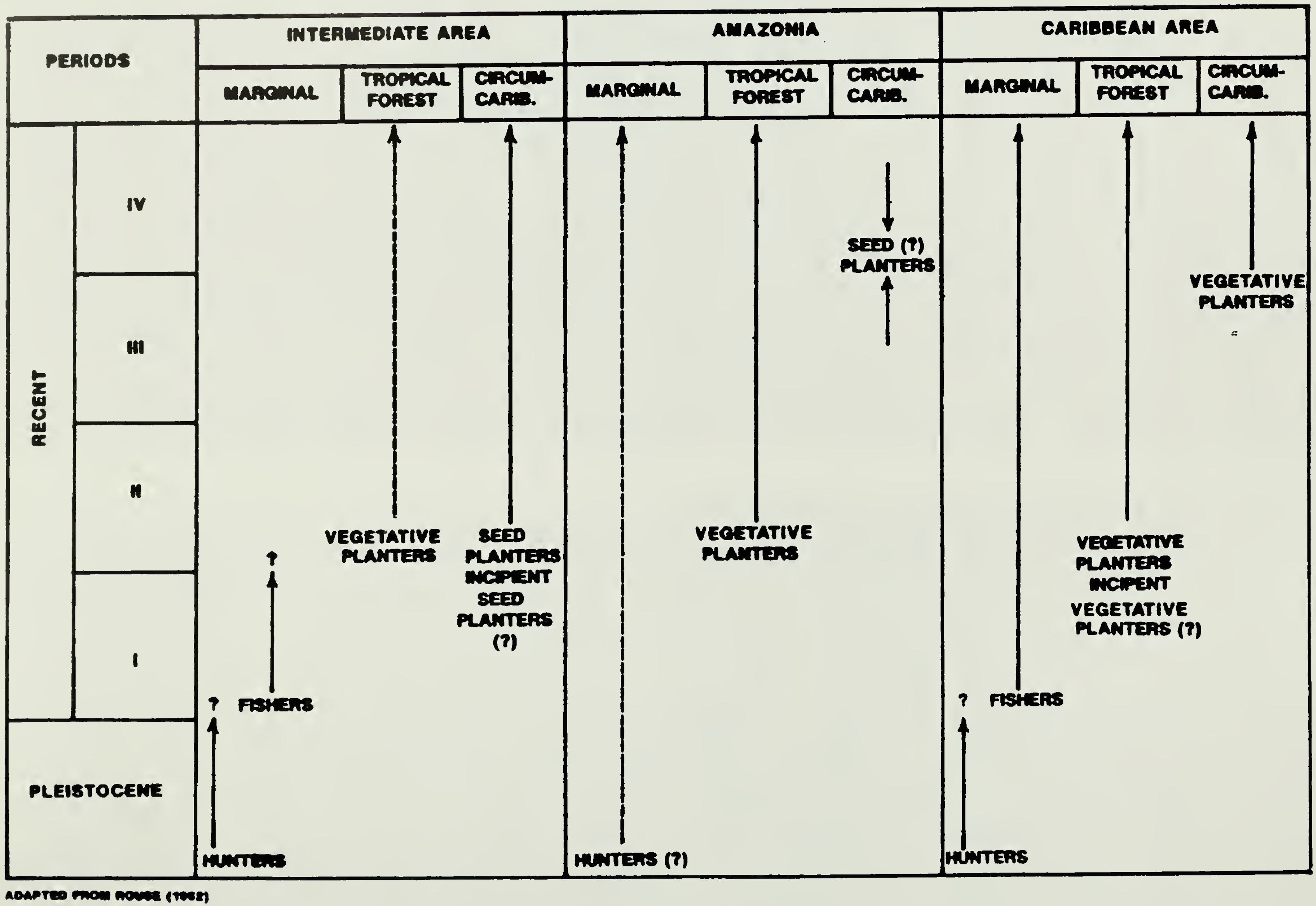


Figure 5.5. Rouse's spatial-temporal framework adapted from Rouse (1962).

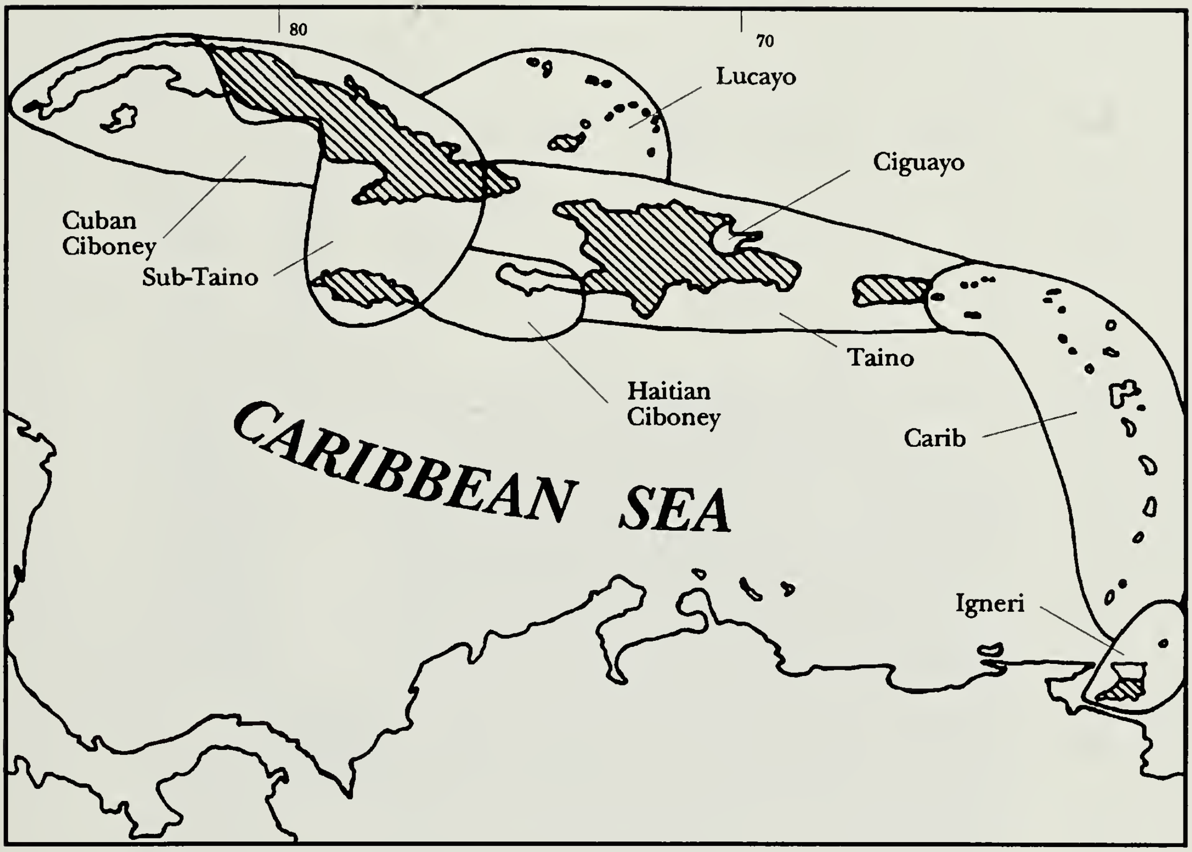


Figure 5.6. Caribbean culture areas (after Rouse 1956).

lowered sea level that created many more islands in the Caribbean chain. Second, they state that, "It seems entirely possible that various Paleo-Indians were using rafts for coastwise travel in very early times. The first Americans need not have been restricted to overland routes for their movements, as many have supposed" (1969:81).

Having been favorably exposed to the Willey-Phillips model in the early 1960s, I made the choice to utilize a combination of their construct and Goggin's "Traditions" (Goggin 1964:108ff) for a master's thesis (Cockrell 1970) dealing with late Archaic stage and early Formative stage settlement and subsistence at Marco Island on Florida's southwest coast. After beginning research at the Warm Mineral Springs site, which was first thought to be a very early Archaic stage site, it became evident that the site was quite old, and possessed characteristics of the Willey-Phillips Lithic stage and the Cruxent-Rouse (and others) Paleoindian concept. Beginning in 1974, as well as subsequent papers, the three stages are used to order data relating to Warm Mineral Springs in particular, and North American drowned terrestrial sites in general (Cockrell 1974a, 1980, 1981). For present purposes, it is useful to conditionally define the stages with bracketing dates, while nevertheless restating Rouse's (1956), Cruxent and Rouse's (1969), and Milanich and Fairbanks' (1980) points about the documented or suspected cases of proximate coevality of

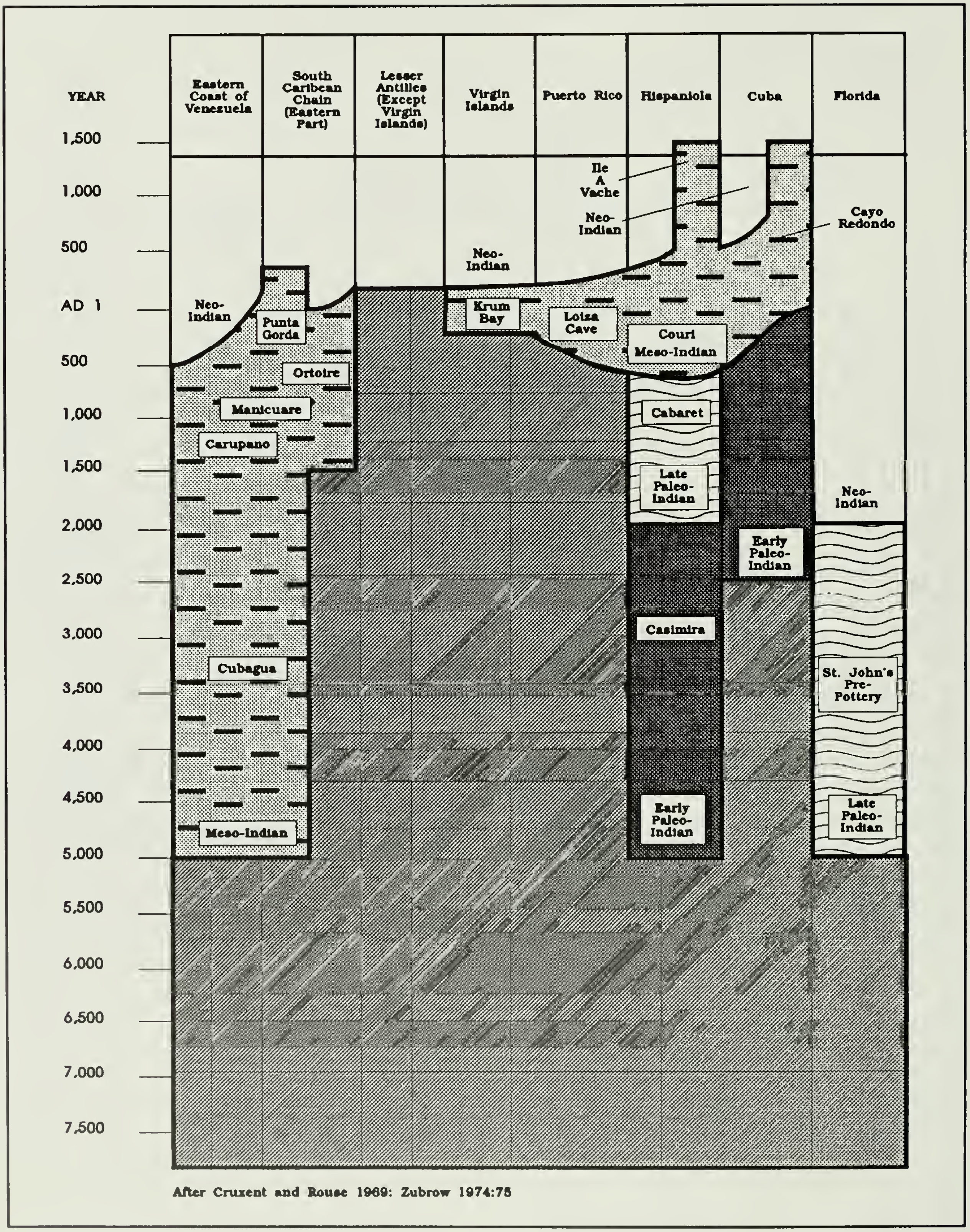


Figure 5.7. Cruxent and Rouse Caribbean spatial-temporal model.

Figure 5.8. Principal early circum-Caribbean sites.

Figure 5.9. Principal Neo-Indian circum-Caribbean sites.

cultural groups from different stages. The dates for the stages mark their first appearance, with the exception, of course, the obvious conclusion of the Formative stage at the ethnographic present.

The Paleoindian stage is generally recognized as the earliest Americans, erroneously termed "Big Game Hunters" at a time of more limited data. The earliest widely accepted Paleoindian dates are around 12,000 B.P. (Meltzer 1989). The people are of a recognizable physical type, in the rare instances where skeletal material has been recovered. They frequently possess distinctive artifact types; for example, Paleoindian "projectile points" are characteristically basally and laterally ground. Thus far, evidence points to small groups, and a generalized rather than specialized subsistence pattern.

The Archaic stage has a loosely defined early date. Milanich and Fairbanks use 8500 B.P. (Figure 5.10). Due to the scarcity of sites from this era, it is possible that this time could be moved, more likely toward a more recent rather than earlier date. It is more probable that the beginning date will be widened to reflect the fact that the Archaic did not "begin;" knowledge of the mechanics of culture change dictates rather the new stage as "becoming," i.e., a process occurring at varying rates at varying places. It is most probable that whether Paleoindians and Archaic peoples were different people doing different things, or the same people doing different things, groups from the two stages were for a time approximately coeval, just as the Caribbean peoples from differing "ages" and "groups" were. The early Archaic tool types are readily recognizable, with the absence of basal and lateral grinding of "projectile points."

By the middle Archaic, a very real change becomes evident in Florida and the Southeastern United States. Larger sites, several with up to 200-300 burials, occur indicating a more intensive subsistence adaptation, and the beginnings of settlements at least seasonal, if not longer-termed, in nature. By the late Archaic, fiber-tempered ceramics appear (it is possible that in a limited area, sand-tempered ceramics show up at nearly the same time), and their appearance at about 6000 B.P. in coastal South America and shortly thereafter in the Southeastern United States marks the beginning of the late Archaic. Clearly, fiber ceramics occur at Stallings Island by 4400 B.P., and certainly in Florida by 4000 B.P., perhaps as early as 6000 B.P.

The final stage, the Formative, is easily recognized at its inception by the replacement of fiber-tempered pottery with sand-tempered ceramics; the generally recognized date for this event is ca. 2500 B.P. This obviously was not an overnight event, nor would all groups have changed their material culture at the same time or at the same rate. A great deal of cultural change is evident, but the ceramics provide an easily recognizable marker. Again, we would expect peoples from the two stages to exhibit proximate coevality. It will be recalled that Milanich and Fairbanks suggested that in the extreme southern third of Florida, the Archaic-stage peoples continued their existence until the ethnographic present.

James Ford, in "A Comparison of Formative Culture in the Americas," defines the Formative somewhat differently, "...as the 3,000 years (or less in some regions) during which the elements of ceramics, ground stone tools, handmade figurines, and manioc and maize agriculture were being diffused and welded into the socioeconomic life of the people living in the region extending from Peru to the eastern United States" (1969:4-5). This stage is defined as beginning ca. 6000 B.P. (Ford 1969:183). Crusoe (1972:60), in an extensive consideration of Ford's trans-Caribbean contact theory, declares that "...early New World village life was based upon a primary aquatic oriented subsistence

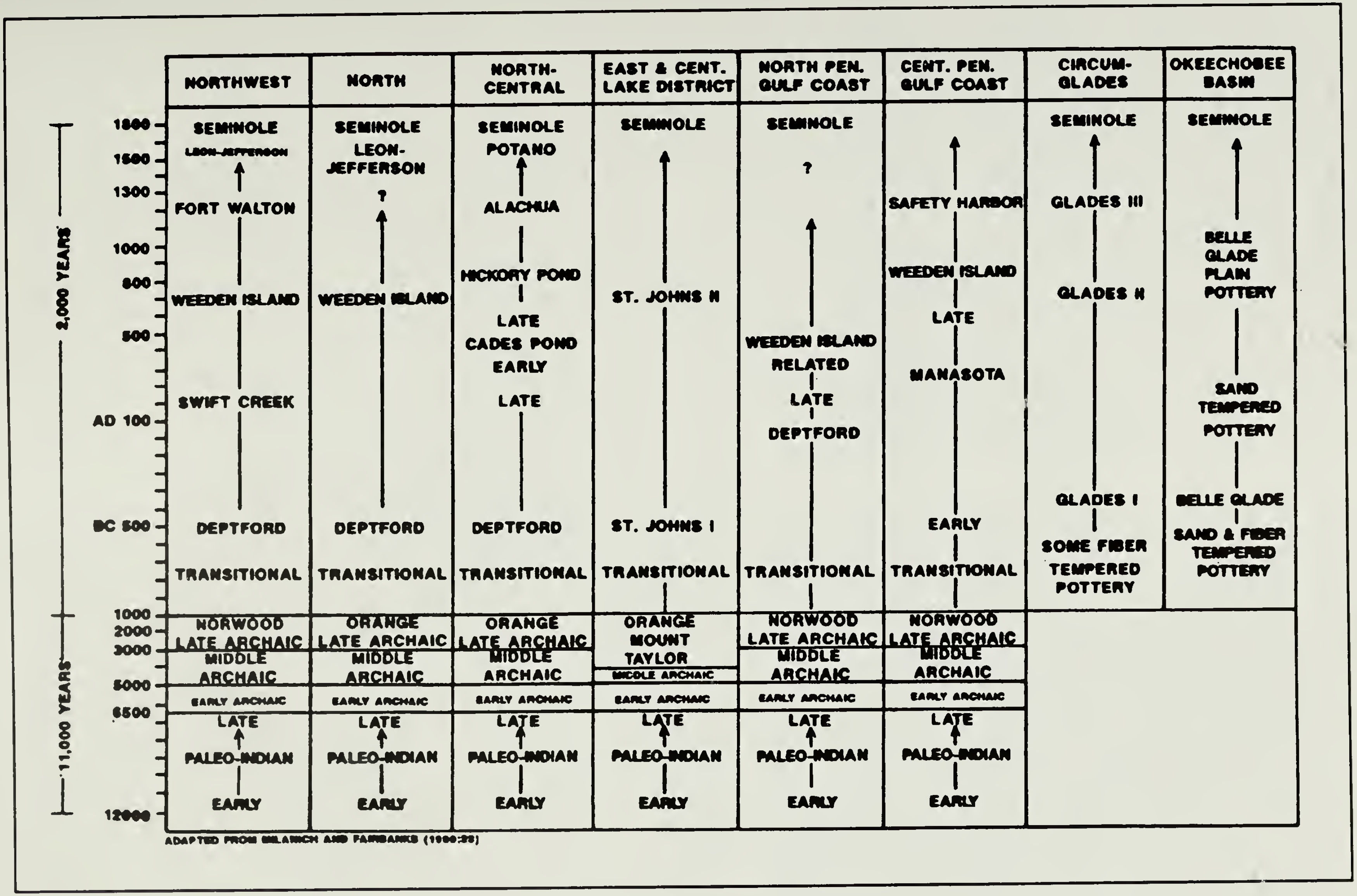


Figure 5.10. Florida prehistoric cultural stages (adapted from Milanich and Fairbanks 1980:23).

pattern and not upon a primary village farming efficiency pattern."

While noting that there are physical characteristics distinguishing Paleoindian peoples from those who are clearly Archaic (Morris 1975), there is no present evidence to (radiocarbon dated, along with Burial #1 at Warm Mineral Springs, at 10,240 B.P.), it is quite easy to suppose that this tool, which so greatly increased hunting internal changes demonstrate whether these differences are result of new genetic material, or a result of in resident populations, or both. As the change occurs after the introduction of the spear -thrower into the area efficiency, was a contributing factor in a number of subsequent changes in the people and their culture (Cockrell 1980).

FLORIDA-CARIBBEAN REGION

Following is a review of cultural/historical information in the Florida-Caribbean area (Figure 5.11). A regional context was the framework for this study and includes prehistoric sites in south Florida, Florida Keys, the Caribbean and the Bahamas. The Bahamas, although not properly in the Caribbean, are included because of their proximity to south Florida and the Florida Keys; culturally, the Bahamas are affiliated with the Caribbean (Hoffman 1970) rather than with Florida.

In 1948, Goggin (1964) defined the lower one-third of the Floridian peninsula as the Glades archeological region, a term he equated with Glades culture area (Figure 5.12). After

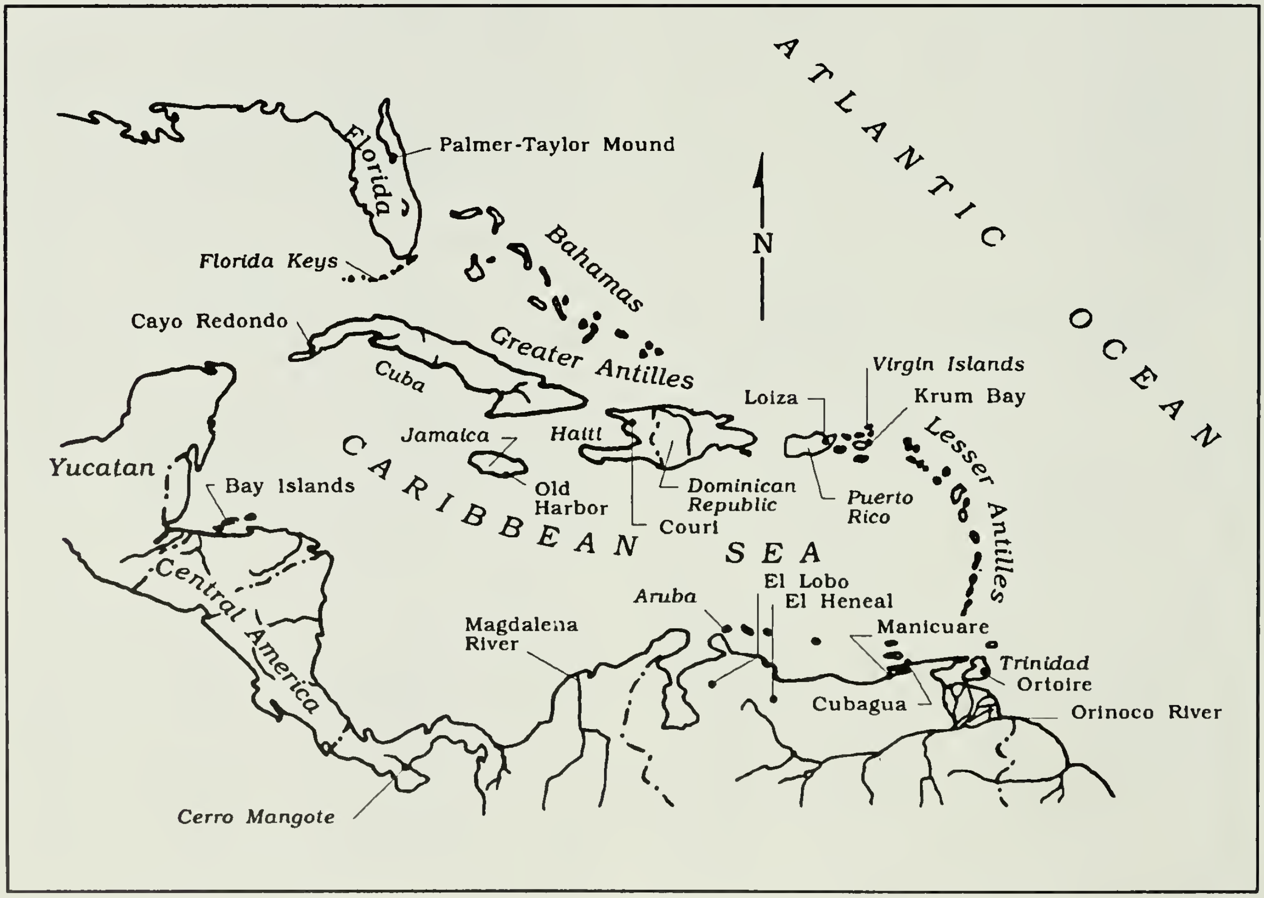


Figure 5.11. Florida-Caribbean region and principal sites.

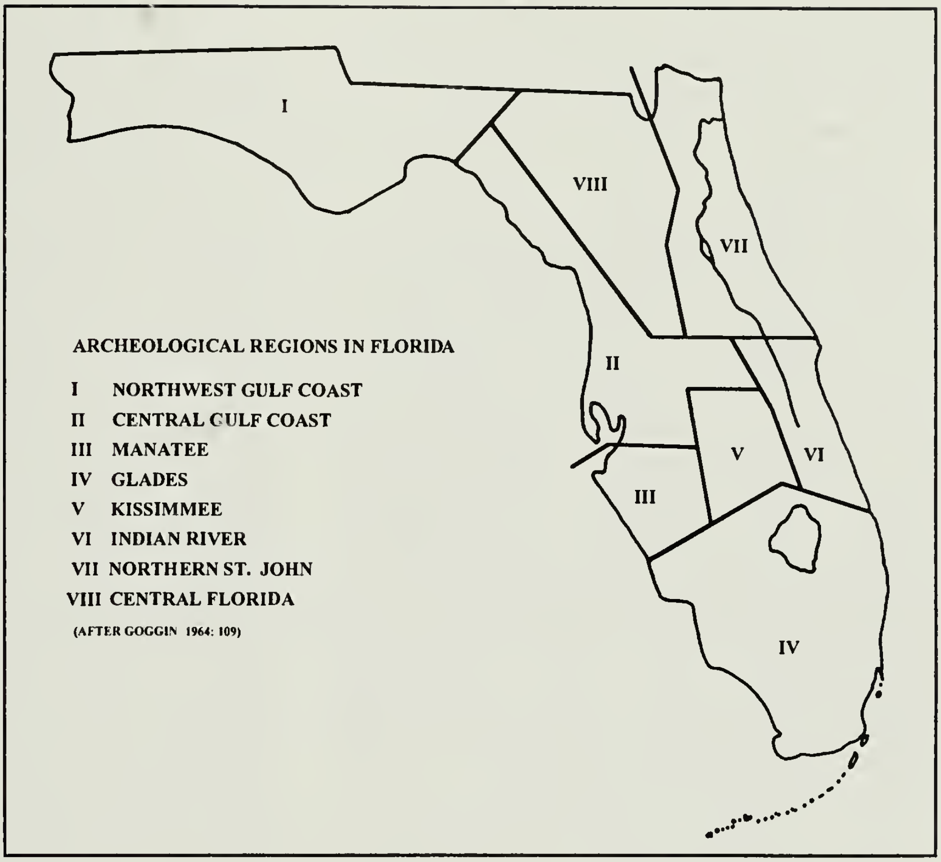


Figure 5.12. Goggin's Florida archeological regions, 1964.

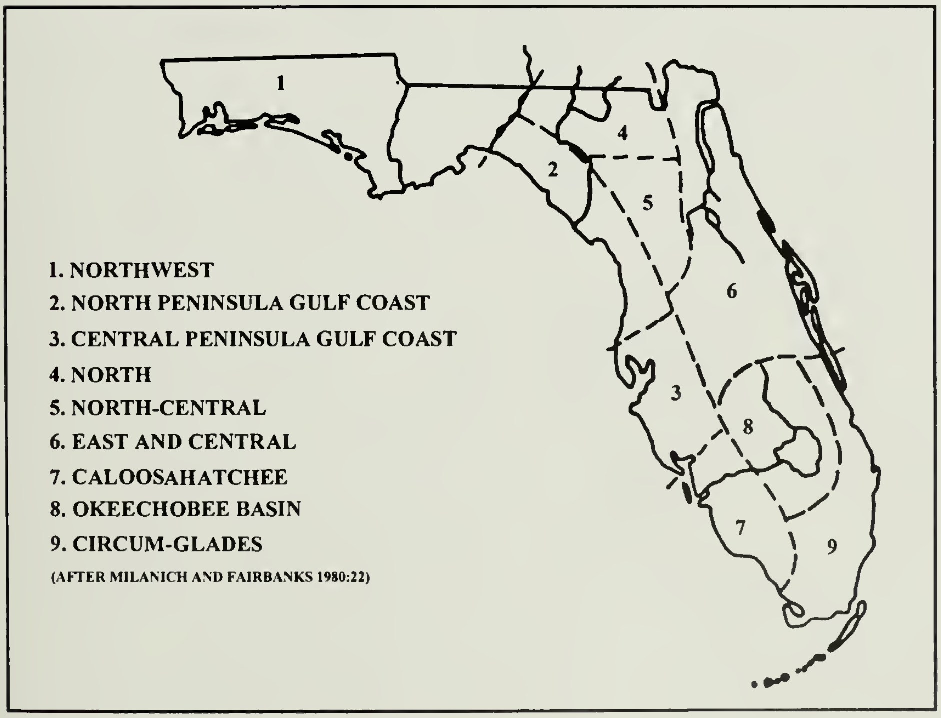


Figure 5.13. Milanich and Fairbank's Florida archeological regions, 1980.

thirty years research, the same area is now viewed as three distinct areas: the Caloosahatchee, the Okeechobee Basin, and the Circum-Glades (Figure 5.13; Milanich and Fairbanks 1980).

Archeological research in the past two decades has demonstrated a longer occupation for South Florida than traditionally thought. In 1948, Goggin's earliest south Florida dates were estimated at ca. 1300 B.P. (1964), the beginning of the Glades Period (Figure 5.14), or the beginning of the Formative stage, to use the terminology proposed earlier. Three decades later, Milanich and Fairbanks published their update on culture periods in Florida, and the Central Peninsula Gulf Coast culture area is depicted as going back to the early Paleoindian stage at ca. 14,000 B.P. This early date is from Little Salt Springs (Figure 5.15) and dates a land tortoise and stick association. The data probably are valid, and the site probably was utilized by humans at or about that time, but I would feel more comfortable with more solid evidence. Warm Mineral Springs, as noted, has produced dates of ca. 10,000 to 11,000 B.P. for human and stratigraphically related extinct Pleistocene megafauna. Of particular import to the Dry Tortugas study is the remarkable preservation of organic remains recovered from anaerobic peat and mud at both sites. These examples demonstrate that, given a certain set of conditions, both plant and animal remains can remain in excellent condition even after several thousand years of submersion. These are not the only examples of this preservation level. Across the state, in southeast Florida, Carr (P.C.) has reported finding extinct Pleistocene megafauna in clear human association.

The early Archaic remains enigmatic and little known, and may require reexamination and redefinition, as noted earlier, although Murphy (1990b) suggests an early Archaic component at the Douglass Beach Site on Florida's lower east coast. Murphy reported a date of 4800 B.P. for the Douglass Beach Site, and after extensive analysis of materials from this submerged site, assigned it to the early to middle Archaic (1990b:36).

The middle Archaic has become better known, particularly due to research already discussed on the Little Salt Springs component. Work at Marco and Horrs Islands has expanded our knowledge of the late Archaic, when ceramics became established in the area (Cockrell 1970; McMichael 1982; Widmer 1988). Late Archaic sites (also termed Pre-Glades in this area by Cockrell (1970) and Widmer (1988) after Goggin's 1948 usage (Goggin 1964)) are not uncommon in the Caloosahatchee and Circum-Glades culture areas, and are recognized by presence of Orange Series fiber-tempered pottery. Some of these sites, when a type of ceramics often described as "semi-fiber tempered" occurs, are labelled Transitional period, a term coined by Bullen (1970), and followed by Widmer (1988:68). This construct does not seem applicable in south Florida (Cockrell 1970; McMichael 1982:78). Sears encountered semi-fiber tempered pottery at Fort Center, northwest of Lake Okeechobee, and simply ignored Bullen's Transitional period (Sears 1982:24). Sears estimated the pottery to date the lowest part of the site, and posited a 3000 B.P. date. Unfortunately for the clarity of the archeological record, some people in southeast Florida, following a trend started by amateur archeologists (e.g., Mowers and Williams 1972) influenced by Bullen, have enshrined the Transitional concept, and it is now a part of the South Florida archeological literature. From extensive personal observations, their usage of "Transitional period" means simply that they found one or more sand-tempered potsherds with some fibrous cast in the paste. The concept is overused, poorly understood, and probably culturally meaningless as currently used.

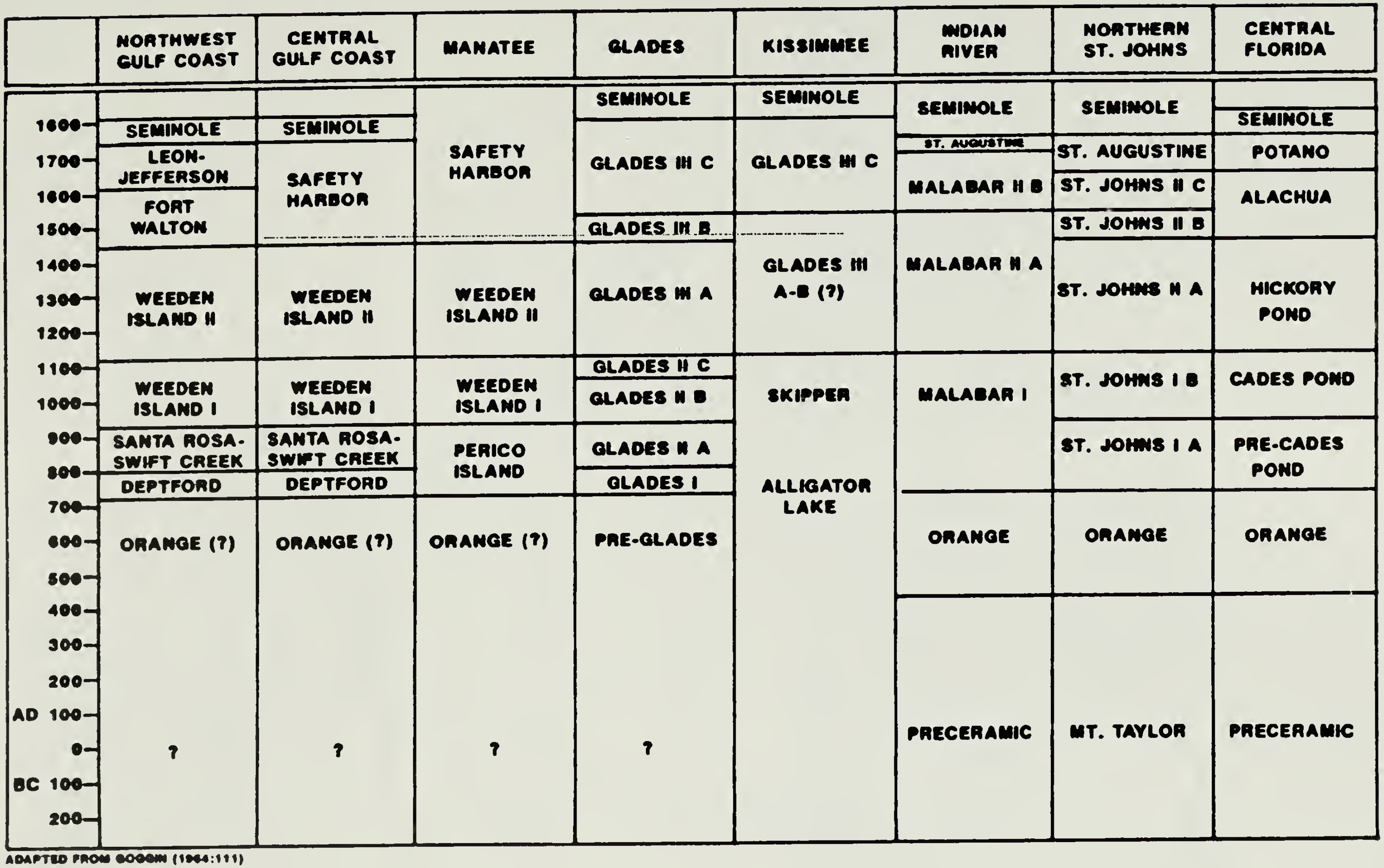


Figure 5.14. Goggin's Florida archeological periods (adapted from Goggin 1964:111).

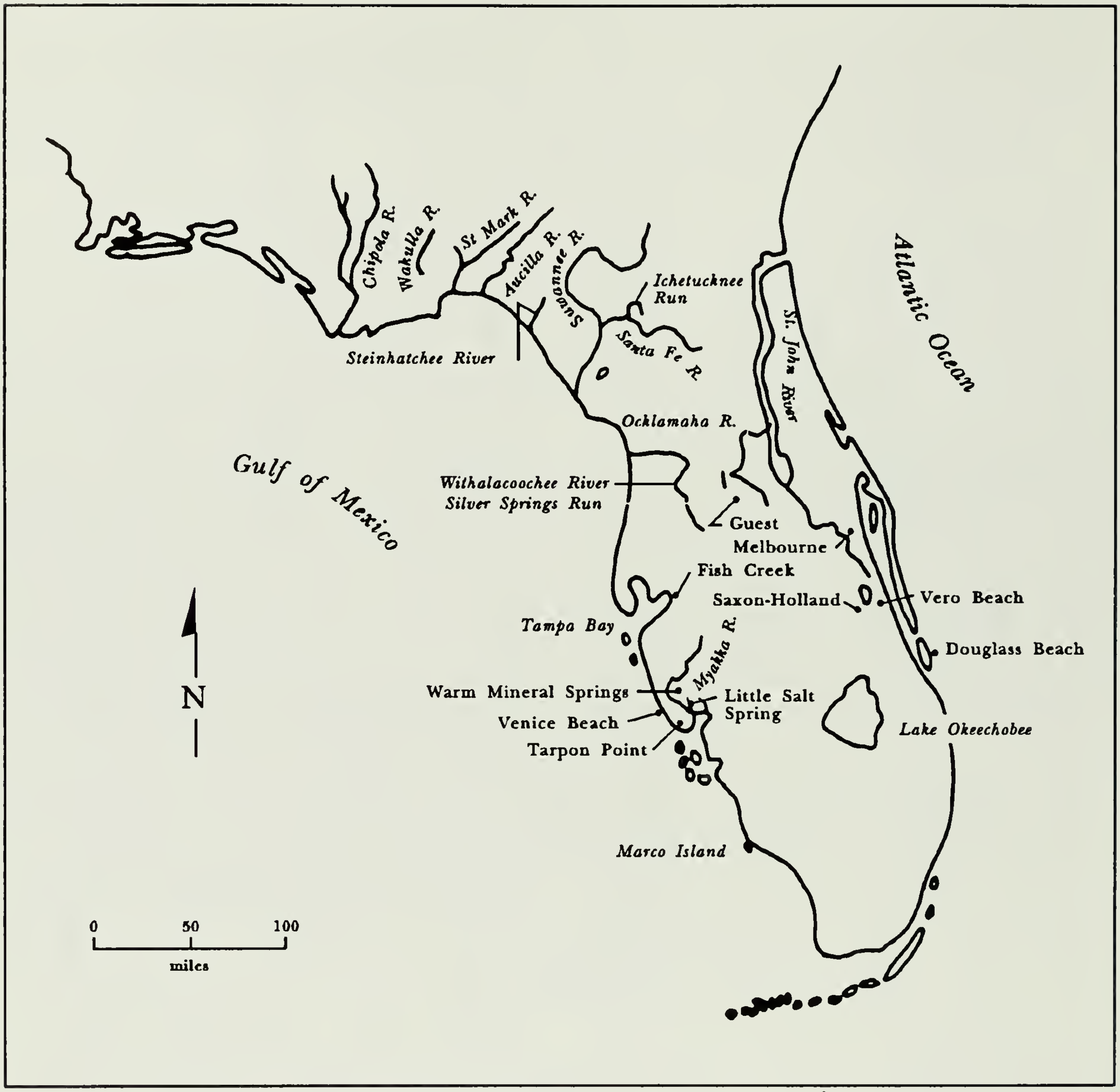


Figure 5.15. Principal early Florida archeological sites.

The Formative stage is well-represented in south Florida, as witnessed by numerous sites, some of them quite large, such as the midden at Caxambas Point on Marco Island, which was ca. 33 ha in extent and over 9 m in depth. There are burial mounds in the earlier sites (Cockrell 1970), and ceremonial structures, including temple mounds, in the later sites (Widmer 1988). There are a number of exotic earthworks, some thought to be ceremonial by earlier researchers (Goggin and Sturtevant 1964), but Sears contends that those earthworks at Fort Center are actually raised agricultural plots and housemounds, while declining to generalize about other well-known complexes in the area.

Of particular interest to this study are the very well-preserved ceremonial and utilitarian wooden carvings recovered from an artificial pond at the Fort Center complex, demonstrating again that the peoples of this region were excellent woodcrafters, and that in certain situations involving anaerobic peat or muck, exceptional organic preservation is possible. In addition to the large number of extensive sites, there are numerous small black-dirt middens scattered throughout interior and coastal Florida, most probably representing seasonal hunting and gathering stations rather than year-round camps.

We have numerous eyewitness accounts of aboriginal peoples at and immediately following European contact. These historical accounts and the attendant linguistic data, limited as they are, provide a rich adjunct to the archeological record. It may well be that linguistic evidence holds the key to demonstrating a strong south Florida-coastal South America contact in prehistoric times (Sears P.C.). Accounts from the sixteenth and seventeenth centuries have already been cited to show extensive watercraft usage during this period.

Florida Keys archeology (Figure 5.16) is perhaps less understood than any other in Florida. There has been scant professional work done there, and very little has been published. A thorough review of the Florida Master Site File will be necessary prior to field testing the Dry Tortugas model. The writer has done limited survey on Key Largo, Lignumvitae Key, and Indian Key; prehistoric sites were observed on the first two, and Baker (1982:104) reports a small midden on the third. Irving Eyster, a long-time keys resident and amateur archeologist and known as a reliable informant and observer, was interviewed regarding his recollections and

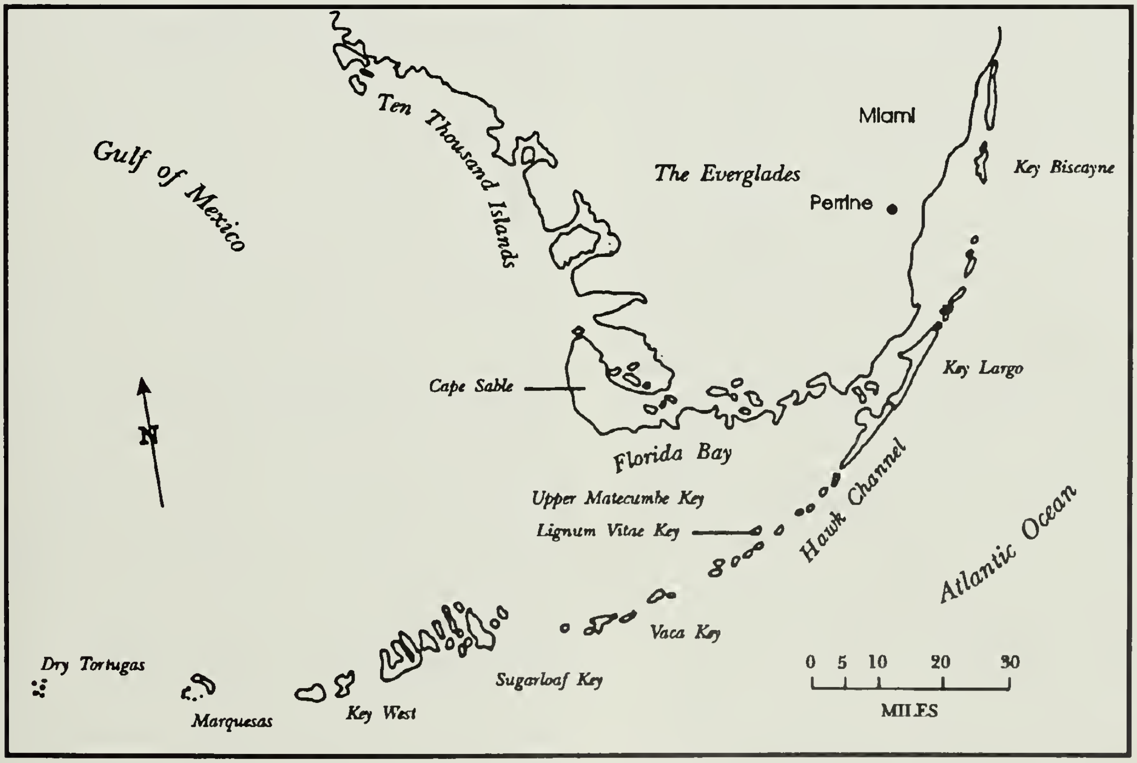


Figure 5.16. Florida Keys area.

experiences, and this interview will be used in this section (Eyster 1982).

Goggin published two articles on the keys and did his master's thesis on Matecumbe Key ceramics (unpublished). Goggin and Sturtevant published "Excavations on Upper Matecumbe Key, Florida" in 1949 and this is still the only major publication on the prehistoric archeology of the keys. Milanich and Fairbanks (1980:237-238) review the sparse knowledge of the keys Indians. They state that the keys evidently were first occupied ca. 1150 B.P. peninsular Florida peoples. They say that nothing is known about their language. Subsistence was primarily marine-based with supplemental terrestrial foods.

Fortunately, it is possible to expand this picture somewhat. Eyster (1982) provides additional material for review. He states he recovered fiber-tempered pottery from the Key Largo site (8Mo25), with a "corrected" radiocarbon date of ca. 3600 B.P., and that the upper date range for the site was ca. 800 B.P. He says he knows of no other Archaic and no Paleoindian sites in the keys. However, in a comment about sea-level rise, he stated that after Hurricane Donna he saw shell underwater which "... looked very much like rough celts and that sort of thing" (1982:112). On the topic of fresh water in the keys, he stated that historically there was fresh water on "Old Matecumbe," and that he had seen the wells there and at other locations in the keys; he mentions a spring on Key Largo where "...at low tide the water would spurt out about three feet high" (1982:111). He notes that there are more than 100 prehistoric sites in the keys, and mentions several, from 8Mo25 in Key Largo near the mainland, to 8Mo2 in Key West, adding that there was probably one major site to each large island.

Garrett (1983:96-8), in a report on cultural resources on national wildlife refuges, reviews four refuges in the keys. She notes one site (8Mo25) in the Crocodile Lake Refuge and claims a high site potential for this refuge. In the middle keys, at the National Key Deer Refuge, she lists four known prehistoric sites, and again lists high potential for significant sites. The Great White Heron and Key West Refuges are in the lower keys. No known sites are listed, and there the prehistoric site potential is ranked low.

Staff of the Florida Master Site File was contacted in August 1989, and requested to search the files for prehistoric sites located in the Marquesas or the Dry Tortugas; none are recorded in either island group. All known prehistoric sites thus are on and between Key Largo and Key West.

Ethnographic Information

The remaining source on prehistoric peoples of the keys is historical documentation; as in previously discussed areas, eyewitness accounts exist. A valuable document is Jutro's unpublished Ph.D. thesis on Lignumvitae Key (Jutro 1975). Jutro notes freshwater wells dug in the nineteenth century, and Matecumbe's former abundance of freshwater, as well as natural depressions and sinkholes. (These were observed by the writer on Key Largo, Big Pine Key and Indian Key, functioning as natural catchments, in each case reported by local informants to have previously been limited potable water sources.) Jutro addresses the confusion surrounding the tribal identity of the keys Indians, and reviews historical accounts that have led those who have misunderstood or misused them to conclude that the keys Indians were Tequesta or Calusa. Jutro provides a sound demonstration that the keys Indians at contact were called the Matacumbes (1975:10-14).

Around 1545 Fontaneda was shipwrecked in the keys and held captive for 17 years (Smith 1944). His account of south Florida

Figure 5.17. Early historical Indian towns (adapted from Smith 1944).

and the keys Indians is a wonderful and useful source document. He discusses the keys Indians, the Calusa, the Lucayos (or Yucayos), the Tequesta, the Ais, the Jeaga and even the Apalachee. He names two keys Indian towns, Luchiyaga, in the middle keys, and Jarugunve, in the lower keys (Figure 5.17); unfortunately, their description is so vague, and the place names varied so much through the years, that the towns may never be identified archeologically even if they survived development. (See Jutro 1975:Chapter III, for an excellent review of the confusion surrounding early keys place names).

Fontenada provided a good description of the Dry Tortugas:

> To the west are "islands without trees; these islands are of sand and in times past must have been keys (cayos) that were worn away by the sea and have remained as sand flats without trees. They are seven leagues in circuit and

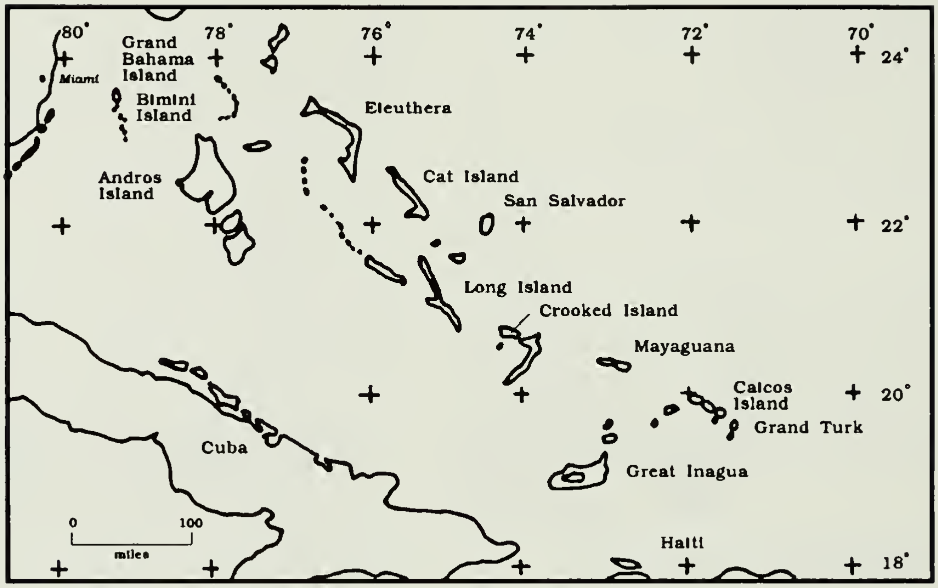


Figure 5.18. The Bahamas.

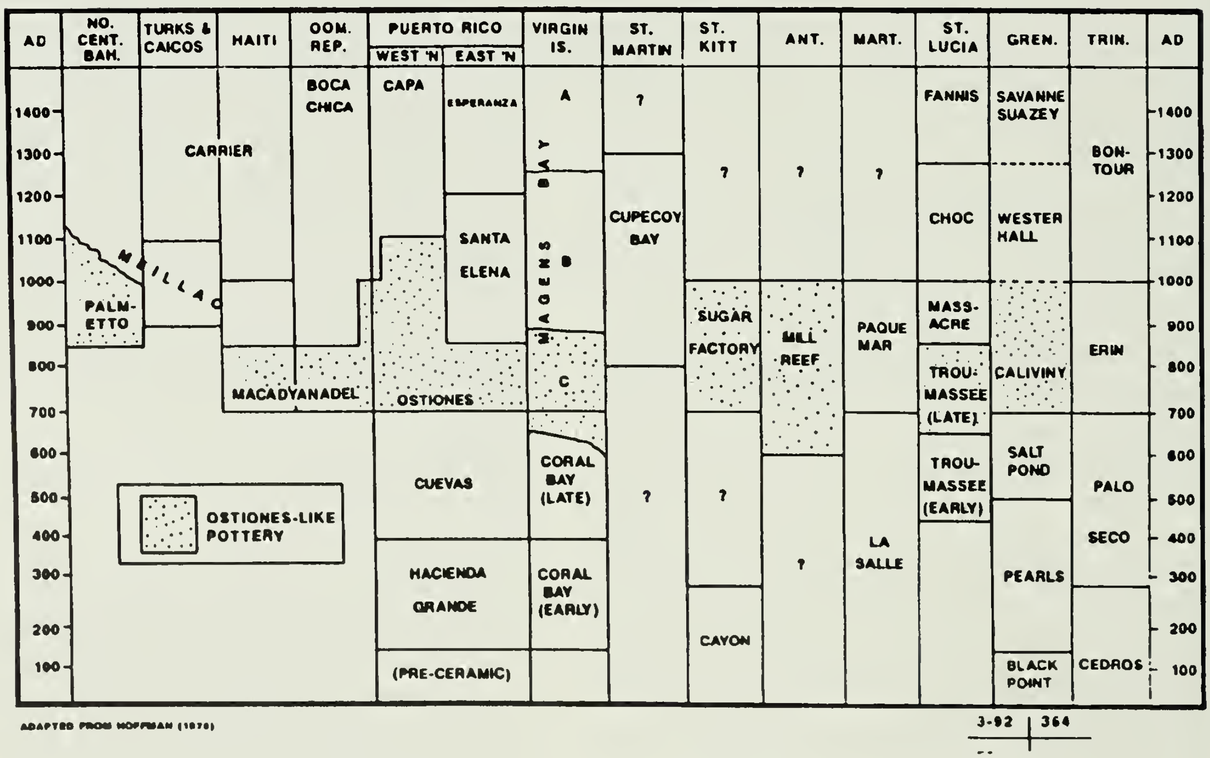


Figure 5.19. Hoffman's (1970) Bahamas archeological sequence.

are called Islas Tortugas, there being many turtles that come at night to lay eggs in the sand" [Sauer 1971:219]

The Bahamas, as noted earlier, are in the Atlantic Ocean (Figure 5.18), but archeologists consider them as Caribbean (Hoffman 1970). Hoffman's excavations on San Salvador and MacLaury's (1970) on Cat Island link both islands archeologically to Hispaniola. Hoffman's Palmetto Grove site dates ca 1100-750 B.P., while MacLaury's Cat Island dates 1000-500 B.P. Hoffman gives no indication for sites at an earlier horizon (Figure 5.19). McKusick says the ethnographic present peoples, the Lucayans (Fontaneda's Lucayos or Yucayos), were related to the Greater Antilles Arawak, and that "Their culture was less advanced than the Taino development, presumably due to the marginal agricultural conditions which existed in the Bahamas" (1960:4). Little is known of prehistoric watercraft in this peripheral area, but McKusick cites Columbus' account of "boats or canoes" in the Bahamas. Columbus said they ranged in size from one-person craft to those holding 40-45 (McKusick 1960:8). In noting that the Bahamian canoes had no sails, McKusick contends that, while the island Caribs had sails after 1650, they learned of their use from the Europeans.

The Caribbean has been extensively surveyed, particularly by Irving Rouse. In "The Entry of Man into the West Indies" (1960) he states, "Only a single well-documented group of Paleoindian remains is known for the entire Caribbean area, Mesoamerica excluded" (1960:6). He is referring to the El Jobo complex in Venezuela, and says that Cruxent found El Jobo-type points in association with mastodon, glyptodon, megatherium, and other extinct animals, with a date of 16,000 B.P. This complex is not known from the offshore islands or the "West Indies proper." (Note: Current literature contains some references to extinct ground sloths in caves associated with humans in the Antilles, but a check of primary sources makes such claims suspect.) Recall that later (1969) Cruxent and Rouse postulate Paleoindians in Hispaniola at ca.7000 B.P. and in Cuba at ca. 4500 B.P. (Figure 5.7). Rouse includes the northeastern coast of Venezuela in the Caribbean Region (Figure 5.20).

While the Yucatan peninsula is only peripheral to the Caribbean, and to the problem at hand, the peninsula is a limestone plateau characterized by Karst topography, similar to Florida, but at a greater height above sea level. For the past three years cave divers from Florida have been making expeditions to Yucatan to explore drowned caves. One diver, associated with Florida State University's Academic Diving Program, shot very clear videotapes and still film of an intriguing phenomenon: a submerged cave with wondrously exotic drip and flowstone formations that had an apparently natural basin with charcoal in it (Turner p.c.). To my knowledge, no one has molested the site, and the people who found it are strong conservationists, so they disturbed nothing. The point to be made here is that we have well-documented cultural resources in drowned Karst features in Florida, and an intriguing possibility of such in Yucatan. The Dry Tortugas lie on a platform between the two points, and the *Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf* (Coastal Environments, Inc. Vol. I: 1977) states that, "Off Key West, at the outer edge of the [Pourtales] plateau, large sinkholes have been discovered at a depth of -250 m. These holes, averaging 1 km in diameter and 140-170 m in depth, are evidence that the Pourtales Plateau was once subaerially exposed...." (Coastal Environments, Inc. Vol.I:137). A depth of 250 m below sea level obviously puts these sinkholes out of the range of prehistoric peoples. What is demonstrated is that

Figure 5.20. Rouse's (1960) Caribbean archeological regions.

sinkholes do exist in the region in the underlying limestones. Hoffmeister (1974) and Shinn et al. (1979) describe Dry Tortugas geology, and while the stratigraphy of the post-Pleistocene surface deposits are of recent marine origin affected by surface elements, the underlying Pleistocene formations are of approximately the same ages and of similar origins from peninsular Florida, the keys and Yucatan.

DRY TORTUGAS PREHISTORIC CULTURAL RESOURCE POTENTIAL

Very limited dry land area was available to Formative and late Archaic peoples. An uplands area of the now submerged surrounding shelf to a depth of ca. 25 m was available at the beginning of the Archaic stage, while Paleoindian stage peoples at 12,000 B.P. would have had access to a vast area, delimited by the 60-100-m isobath (depending on which model sea level curve is used).

For at least the past 15,000 years, the uplands area of the Dry Tortugas has been shrinking at a greater or lesser rate, with only minor shift in the past 2,000 years. The sea level change data are still not as precise as archeologists need for them to be, and the shape, rate and oscillations of the curve of the rise should continue to be viewed and used with caution. In the end, the archeological data from submerged sites will provide the definitive evidence, as submerged habitation sites are self-evident proofs of associated drowned shorelines; by definition the shoreline was lower than the habitation site. Dating the site dates the shoreline; peat, shells, reefs and other methods used to establish sea level curves generally do not furnish the precision needed to formulate and answer the types of questions archeologists often want to ask. (See Kellog 1988 for a discussion of these problems.)

In the uplands area, personal casual observations have produced no sites, and the Florida Master Site File has no records of prehistoric sites in the Dry Tortugas or the neighboring Marquesas group. No other prehistoric cultural resources are recorded in the literature, and historic records reviewed for this paper have not alluded to aboriginal occupation or utilization of the islands, although they are frequently mentioned as landmarks. It is possible that further ethnohistoric research will produce documents containing observations of such activities; this possibility should be explored.

Potable water is a requirement for habitation sites, whether it is available onsite or is transported to the site. We speak of the "Dry" Tortugas, and the keys are indeed "dry" at present and historically. Halley and Steinen (1979), however, refer to ground water availability on Loggerhead Key, noting that although the water is saline " ... it could sustain life for an indefinite period." This is a 1979 observation, at a period when annual rainfall can be as low as 65-75 cm a year. As well, portions of the key are now covered with Australian pines, an exotic introduced in the twentieth century, which can significantly increase evapotranspiration (1979:84). In addition, nearby Cluett Key has freshwater ponds after heavy rains (1979:86-87). The huge amounts of freshwater produced during hurricanes would saturate the porous keys and provide potable water for some time after the storms.

The temporal span for this study is at least 12,000 years, and lowered sea levels during that time would significantly affect ground water availability during that period, with effects not always being easily predicted, due to lack of control of all relevant variables. Of course a lowering of 100 m of sea level would lower the ground water, but it would also ensure that the porous limestones were not saturated with salt water when the rains came; cenotes, aquacludes and other geological phenomena could provide the mechanism for potable water retention. The need for potable water obviously exercises controls on settlement patterns, but the nature of the control is not always readily apparent. For the Dry Tortugas it is not sufficient to simply conclude that potable water was unavailable. Complex factors are operable: it may be that potable water will be inferred only as a result of sites being located during the proposed study.

Other factors governing the potential for uplands sites are subsistence patterns. It has been shown that the peoples from surrounding areas were maritime oriented for at least the last 6,000 years; it is also documented that these peoples would avail themselves of terrestrial food resources. The Dry Tortugas clearly possess the former, and would have possessed the latter at a time of lower sea level. It seems clear that the study area's uplands could have been used by prehistoric peoples. The question of whether their cultural remains can be located or even inferred is partially governed by the postdepositional history of the subject matter; natural or cultural events from 12,000 B.P. to the present can preserve, leave unaffected or destroy critical evidence.

This section on the uplands potential has concentrated primarily on sites. Other cultural resources such as structures or material, if they existed, would probably have been discovered by now, given the limited area and lack of ground cover or wet, anaerobic situations conducive to preservation. Watercraft, for the same reasons, are not likely to be located in the uplands area.

Submerged prehistoric cultural resources potential is far greater than for the uplands for essentially two major reasons: first, there was a far greater land area, with its necessarily expanded surrounding littoral zone (Figures 5.2-5.4), and second, the 12,000 year time span witnessed, cumulatively, large numbers of potential inhabitants or transients who could have occupied or utilized the area's terrestrial and/or marine resources, or who could have lost, discarded or abandoned watercraft or other materials that could have been preserved in some identifiable form.

The earliest peoples, the Paleoindians, or Rouse's Marginal pattern peoples, were generalists, and exhibited highly efficient subsistence behavior; they were efficient gatherer-hunters and in the region from the earliest times in the case of the Paleoindians, and until the ethnographic present in the case of the Marginal pattern peoples. Their terrestrially deposited evidence could be, given our limited data, on virtually any part of the surrounding shelf to a depth of 100 m. Structures such as fish weirs would of necessity always be slightly lower than the cultural group's coastline at any given time. Watercraft, as noted earlier, could have been lost anywhere, but depressions with a potential for a postdepositional preservative environment hold greater potential.

Potential for Archaic terrestrially deposited cultural resources is good. Larger numbers of peoples were in the region and, as noted, they possessed water transport methods. Their rapid expansion, both in area and population, was discussed earlier. At the beginning of the Archaic at ca. 8500 B.P., the sea level was ca. 25 m below present (using Widmer's model, derived from primary sources discussed earlier, Table 5.1). By the Middle Archaic, at ca. 7000 B.P., the Archaic peoples were living in villages, burying in established cemeteries, and had become highly efficient gatherers, when the coastline was ca. 20 m below present sea level (Table 5.1).

Widmer presents a complex and well-reasoned hypothesis based on rapid sea-level rise between ca. 15,000 B.P. and ca. 5500 B.P. when the rise curve flattened at approximately 6 m below present sea level. He maintains that the rise was sufficiently rapid and the curve was of a shape so as to prevent the formation and development of a littoral zone which would support a "...large, dense human population" (1988:187). He uses this conclusion to argue that "...only occasional, sporadic, generalized or perhaps seasonal specialized use of the coastal zone would be expected in south Florida during this time" (1988:187). Acceptance of this conclusion requires acceptance of his model sea-level curve as conclusive and accurate, which is unlikely at this stage of our knowledge. Even if his data and conclusions are valid, the now-submerged shelf around the Dry Tortugas would have possessed a coastline that these Archaic peoples would certainly have exploited and also used for access via water travel to other areas for purposes of exchange or subsistence. Even if correct, his hypothesis still allows for coastal utilization by smaller groups on a more limited basis. In addition, there were interior areas away from the littoral zone that Archaic peoples are known to have exploited efficiently. Widmer's construct has an uncomfortably large number of uncontrolled, or even uncontrollable, variables for it to be accepted as conclusive at this stage of knowledge about both the nature of the sea level-change, and the nature of southwest Florida Archaic peoples. It is a well-constructed, reasonable hypothesis, but need not be accepted as representing reality. Far too few data are available: it should be viewed as a good testable model and a theoretical framework for manipulating an increasingly complex body of data.

By the late Archaic, sea level had risen to approximately the present day optimum, thus eliminating possibilities for drowned terrestrial sites occurring after this time. The occurrence of watercraft and other materials from this and later times has already been discussed.

For the uplands area, the first step is a literature search; this has been done and no prehistoric cultural resources are known, although it is possible that further ethnohistoric research will provide accounts of aboriginal presence at the ethnographic present. A thorough standard walkover survey should be undertaken, utilizing test excavations, shovel testing, and coring, as judged appropriate. Remote sensing techniques such as aerial or satellite imaging would probably not be particularly helpful on the uplands area, but would have obvious applications on submerged areas.

Older evidence could be buried beneath later detritus; Shinn et al. (1979) recorded 13 m of submerged Holocene reef rubble overlying marine Pleistocene bedrock on Southeast Reef near Fort Jefferson. They also cored on Loggerhead Key, but did not publish their results in this volume. Nevertheless, their data are intriguing, as they demonstrate that there is bedrock near enough to the surface to demonstrate that there was land at this spot during the time under consideration. Their brief report thus supports the possibility that strata containing prehistoric cultural resources could lie in areas above bedrock. If the Dry Tortugas and the surrounding platform were simply projections of marine Pleistocene bedrock from the deep seabed with no overlying Holocene strata, the possibility for finding evidence of prehistoric peoples would be very slim; as it is, there is a good possibility that evidence is there. The task is to devise strategies for finding and recognizing the evidence.

It would be appropriate to radiocarbon date uplands strata on the various keys in order to define and isolate test excavation target strata from the past 12,000 to 15,000 years. In addition, sedimentary and geochemical core and bulk sample analyses should be performed to discern human activity evidence, as well as to determine the strata's depositional and postdepositional history. Murphy's modification of the Gagliano model for such analysis successfully demonstrated the procedure's effectiveness on Douglass Beach site samples. He was able to determine whether sediments within a stratum had suffered mechanical disturbance, and to discern cultural activity (Murphy 1990b). Location of prehistoric cultural materials such as artifacts, human refuse, structural evidence, burials and other traditionally recognized archeological materials would obviously achieve the survey's goal. Negative evidence, i.e., finding nothing, or even learning that there is no potential for finding anything on the uplands or submerged areas, either because data were never there or were there and subsequently destroyed, is still significant evidence. The results would still be scientifically valuable, if not particularly satisfying.

Surveying for the earliest submerged sites should properly begin at the appropriate drowned shoreline and proceed to shallower depths. At any given time, deepest areas would be the target population's littoral zone, while shallower depths, up to the present day shoreline and onto the uplands, would constitute their "interior." Because Paleoindian sites could be found on any now-submerged areas they had access to, their sites could be found out to their deepest shoreline; likewise for the Archaic. We should, however, focus on those depths having higher probabilities for site location. For locating the earliest submerged sites, the survey should begin at a depth of 100 m. However, since disagreement exists in the literature, and some authorities contend that the 12,000 B.P. coastline is at a depth of only 60 m, it would seem that practical factors dictate beginning the search at the shallower depth. One such practical factor is the extreme likelihood that even if the target shoreline is at a depth of 100 m, the population density at that time would have been so small that even a survey on a comparable easily accessible uplands area utilized by Paleoindians would probably produce no identifiable data.

The economical outlay of time and funds has to be a consideration; the area to be surveyed within a 100-m curve is perhaps double the area of the 60 m postulated plateau (Figure 5.3). Diving technology limitations and human safety are other considerable factors. Human physiology, diving technology and safety must obviously be considerations. Realizing that much of the underwater survey can be most efficiently done remotely, it will still be essential to put diving scientists and technicians down. With recent advances in special gas-mix technology, 60 m is a relatively safe and routine scientific dive, while 100-m dives, even on special mixtures, are far more difficult and dangerous. Of course, having reviewed these practical considerations, the study's goal has to be kept in mind; if the data needed to address the research concerns are in 100 m of water, then we should utilize the necessary technology to get there, either remotely or in person. However, absent persuasive evidence of the pressing need to be there, and realizing that continued funding of a project of this magnitude requires positive results, it seems that prudence, as well as good science, dictates beginning at the shallower level, establishing the data base, reformulating hypotheses as the need occurs, and then going deeper or shallower as the data dictate.

After having identified the Paleoindian shoreline target littoral zone, and realizing the site scarcity at that horizon, a potentially more productive middle-Archaic target littoral zone should be identified. As with the Paleoindian stage sites, submerged Archaic sites could occur from the deepest Archaic coastline for littoral zone sites to the shallowest depths for interior sites. The ca. 12-m depth is where most authorities would place the ca. 6,000 to

5500 B.P. shoreline; adding 3 m to the inshore and 3 m to the offshore side of this line establishes a middle-Archaic littoral target zone of 9-15 m in depth as a beginning point. The middle Archaic was a time of population expansion and increased efficiency in subsistence technology, and sites of this stage might be larger and, therefore, have a higher potential for being located. The next step is to plot this band on the bathymetric charts, and then select sample areas. Random sampling this target band is not appropriate, as bottom and subbottom topography must be addressed in order to identify (1) natural features, including but not limited to ridges and hollows, lagoons and ponds, solution features, watercourses, potential submarine springs; and (2) possible cultural features, such as shell beds, rock deposits and depressions, all of which would indicate potential loci of coastal middle Archaic or even interior Paleoindian settlement and subsistence activities.

The technology required to conduct such investigations is well-established, albeit frequently expensive and cantankerous. After establishing accurate bathymetric charts, either by consulting existing ones or doing supplemental surveys, the next step should be the subbottom survey, again to establish bottom topography with the possibility of also identifying submarine springs. Aerial or satellite remote sensing can be used for general survey, mapping, site survey and could possibly reveal submarine springs as well.

Following topographic feature analysis, and selection of areas to be sampled, actual excavation should begin. Unless suspected or documented submerged prehistoric cultural resources have been located in the initial stages, the preliminary approach should be through coring, with cores being subjected to multiple analytic techniques. Such techniques should include visual examination and palynological, botanical (especially if peat is encountered), malacological, faunal, sedimentary, geochemical and radiocarbon analyses.

After digesting the analyses, it is probable that areas with varying degrees of potential for containing cultural resources can be identified. The higher probability areas may then be selected for a more intensive scrutiny, such as more coring, or actual hand excavation, using standard underwater archeological excavation and recording techniques.

At any time in the study process, participating scientists will need to be able to dive on, and access by remote sensing techniques such as remote-operated vehicles (ROVs), loci in the study area to answer specific questions, or simply to engage in unselective seabed examination. This will allow the constant rethinking, reexamination and reformulation necessitated by such a pioneering study.

To conclude, there is great potential for the existence of prehistoric cultural remains in the Dry Tortugas. For at least 12,000 years people have been on the mainland of the Americas surrounding the Caribbean. Some of those people were in south Florida by that early time, and in later millennia larger numbers of people occupied the entire region, and their numbers and cultural complexity grew until the ethnographic present. Lowered sea level near the end of the Pleistocene uncovered vast areas of dry uplands exposing an area of the Floridian peninsula and the Florida Keys twice as large as at present. For some time it has been contended that early peoples expanded their activities into that area, only to retreat before the rising Holocene waters. We now know that this did indeed occur. It is now known that cultural remains can stay remarkably well-preserved over millennia, given certain conditions. And it is now known that these remains can be located and recovered.

CHAPTER VI

Environmental Factors Affecting Vessel Casualties and Site Preservation

Larry E. Murphy and Randolph W. Jonsson

Environmental factors have contributed directly to vessel losses at Fort Jefferson National Monument, and they have produced postdepositional alterations to submerged and terrestrial sites. A consideration of environment is fundamental to site interpretation and is necessary to account for the number and kind of marine casualties within the study area, and the level of site preservation and integrity.

Historical research indicates the Dry Tortugas have been the focus of numerous marine casualties, and for centuries they have been recognized as a primary Gulf and Florida Straits navigation hazard. The Tortugas can be seen as a "ship trap" because of their proximity to principal Gulf of Mexico shipping routes and then extensive unnavigable shallow water and associated reefs. Formation of a ship trap requires a combination of natural and cultural variables that have yet to be completely isolated and defined. Among the most obvious variables would certainly be trade routes, which are dependent on sociocultural factors; density of vessel traffic; weather factors, including wind, waves and currents; presence of navigation aids including warning devices and charts; and navigation technology. This chapter focuses on natural processes that have influenced the wreck collection within the monument.

Environmental factors are important to developing a predictive model for wreck concentrations useful for stratifying the study area in various zones, including areas most likely to contain a high site density, and those most likely containing sites of a particular type and preservation level. Stratification contributes directly to cost-effective remote sensing survey.

GENERAL CLIMATE

Southwest Florida, including the study area, is classified as tropical. The average monthly temperature is above 18° C, with no notable winter season (Garrett 1983:5). Mean daily temperature ranges from 21.3° C in January to 29.1° C in August. Infrequent cold spells, exceptionally approaching 0° C, may occur during winter "northers."

Annual precipitation is about 83 cm/year with the wet season from May to October averaging 58 cm/yr and the dry season, November through April, averaging less than 25 cm/yr (Davis 1942:144). September is usually the wettest month. Monument rainfall in 1990 was just over 76 cm (NPS 1990 weather data).

The Dry Tortugas have an average rainfall only about 12 cm less than Key West. The reason that the Dry Tortugas are "dry" is not because of lack of rainfall. Tortugas' aridity results from a combination of poor water retention by the coarse calcareous soil, and a high evaporation rate from nearly constant winds and intense sunlight. Davis (1942:146) observed that rainfall decreases and soil coarseness increases as one moves westward from Key West to the Tortugas. While there is no fresh water in the Dry Tortugas, a brackish water lens has been documented on Loggerhead Key.

The mean sea-level pressure in the Gulf region ranges from a low of 1,018 mb in September to a high of 1,021 mb in January. Less than 10 percent of observations depart from the mean by as much as 5 mb in summer or 10 mb in winter (Jordan 1973:IIA-1).

Wind

Examination of the historically documented vessel casualties in the study area indicate that storm-generated wind contributes to vessel loss. Prevailing winds dominate sailing vessel navigation, and storm winds are direct cause of many casualties in the Dry Tortugas.

The Tortugas lie within the influence of the northeast trade winds, which blow easterly throughout the year. These constant winds have given rise to the terms "windward" and "leeward," commonly applied in Caribbean navigation to note a point relatively to the eastward or westward (Green 1877:1).

March through September, the eastern Gulf is in the western side of the Bermuda high-pressure cell that has a gentle clockwise (anticyclonic) wind flow. During October through May, northeasterly winds prevail in the eastern Gulf. November through February, the eastern Gulf winds are predominately from the northwest and north. During the summer months, flow is southerly. Principal Gulf winter influences are continental cold-air masses, while in the spring and summer, tropical air masses arrive from the south and southeast (Jordan 1973:IIA-2; Mineral Management Service 1982:126). The mean wind speed for Fort Jefferson for 1990 is in Figure 6.1.

The 1877 US Hydrographic Office Caribbean navigation guide (Green 1877:1-4) gives a good general Tortugas wind pattern description particularly pertinent to mariners, and the following discussion is from that publication.

Trade wind diurnal variations are called land and sea breezes, which are locally variable. Sea breeze generally begins about

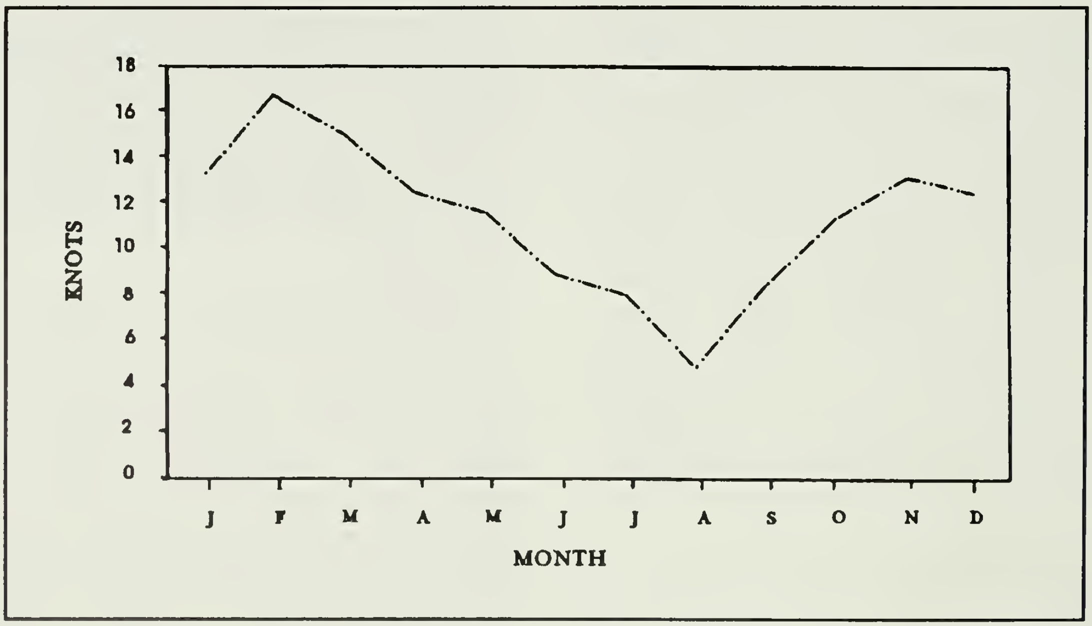


Figure 6.1. Mean Dry Tortugas wind speed 1990.

9:00 A.M. and blows onshore until sunset, when there is usually a calm. Evening land breezes are offshore, blowing strongest just before dawn. The land breeze usually does not occur in the Bahamas area, where the trades diminish during the night. Sailing vessels usually went to sea in the Caribbean at early daylight.

During the rainy season, the wind inclines toward the southeast with periods of calm and squalls, which bring most of the rain. While Fort Jefferson was under construction, the rainy season was also called the "sickly season" because of the prevalence of fevers.

During the dry season, the wind moves more to the northeast and increases in strength, sometimes blowing a strong gale for two or three weeks, especially during December, January and February. Occasionally, strong north and northwest winds interrupt the trades, usually from November to April. These periodic storms are called "northers." July to October is the hurricane season. Besides hurricanes and northers, intense thunderstorms can be hazardous to mariners. These three storm types will be discussed separately below.

Thunderstorms

Thunderstorms can be very serious in the Gulf-Caribbean region. The southeast Florida Gulf coast has a mean average of between 60 and 100 thunderstorm days a year. About 66 percent of the thunderstorms occur between June and September, and only about 7 percent between November and February (Figure 6.2) (Jordan 1973:IIA-7).

Tropical thunderstorms form when large masses of moist, unstable air rise to high altitudes. In the tropics, this occurs when major wind systems converge, forming storm-cell systems that can be particularly violent. Winds exceeding 100 km/hr can be generated during regional thunderstorms (Millás 1968:xvi). Thunderstorms frequently produce tornadoes and waterspouts. Severe gales are produced when rapidly descending cool-air downdrafts fan out along the storm-cell base. A vessel caught in an intense

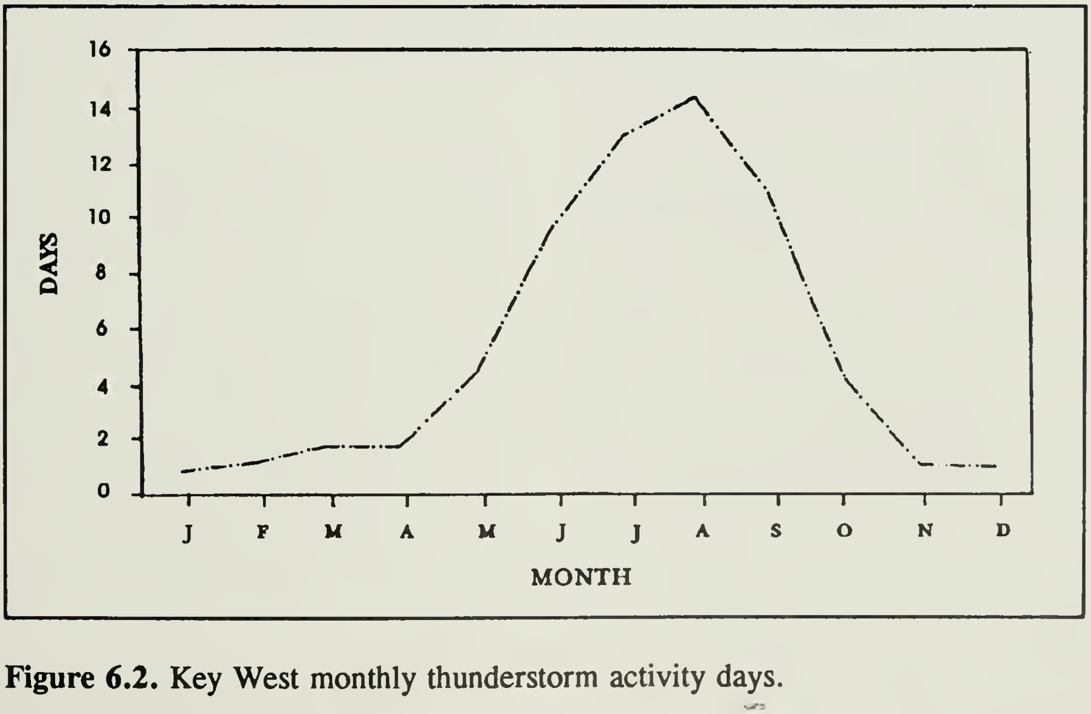


Figure 6.2. Key West monthly thunderstorm activity days.

thunderstorm could easily suffer damage and be blown off course onto the Tortugas reefs.

Northers

The first documentation of a Caribbean norther was by Columbus. On November 9, 1492, Columbus recorded cold weather and heavy seas along the Cuban coast (Millás 1968:25).

Numerous Key West Admiralty Court Wreck Reports list strong northerly winds or "northers" as contributing factors for marine casualties. Northers occur when polar air masses move south from the cold continental interior out over warm Gulf waters. When heated by convection from below, these cold air masses develop strong, gusty north winds, substantial cloud cover and rainfall. Typically, from November to March, 30 or more such cold front intrusions can directly affect the Tortugas area (Figure 6.3). Majority of cold fronts produce winds ranging from 28-37 km/hr. About 30 percent have winds in excess of 62 km/hr and about 15 percent have winds as high as 90 km/hr (Department of Interior 1979:II-20; MMS 1982:128). Cold weather periods lasting several days, with temperatures occasionally approaching 0° C, can be attributed to northers (Stoddart and Fosberg 1981:3). Northers generate high seas and rough conditions that contribute to vessel losses in the Tortugas. Northerly winds can occur in any month, but are most frequent in the winter. Figure 6.3 depicts northerly wind days for 1990.

The 1877 mariner's guide to the Caribbean relates the meteorological changes indicating an approaching north gale (Green 1877:2):

> Always heralding their approach by a heavy bank of clouds in the NW, and preceded by a light air from the contrary direction, accompanied by a falling barometer, they commence with a violent squall, gradually settling down into a fresh gale, which hauls to the NE and E, ending with fine weather.

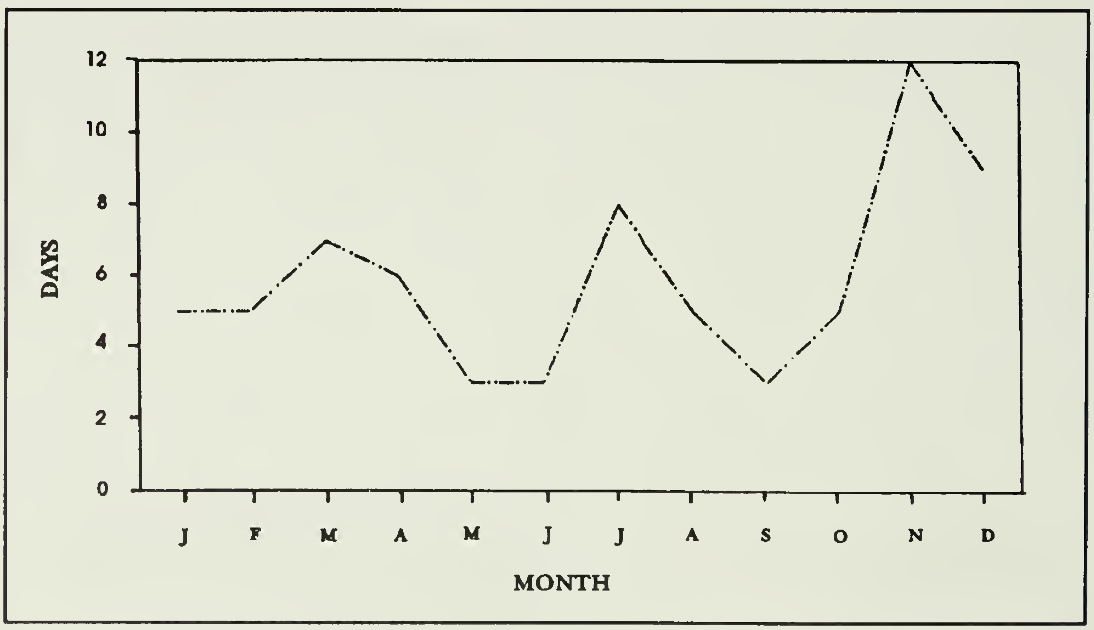


Figure 6.3. Dry Tortugas days with northerly winds.

Hurricanes and Tropical Storms

The Gulf is particularly favorable for turbulent weather because of its extensive coastal regions and nearly complete enclosure by land. The Gulf of Mexico and adjacent coastal areas are part of the Atlantic tropical cyclone basin.

Hurricanes are tropical cyclones, which revolve counterclockwise in the northern hemisphere. Cyclones are designated hurricanes when their winds exceed 119 km/hr, and they are the most destructive meteorological phenomenon known. Windspeeds have been clocked in excess of 400 km/hr and storm surges 12 m above sea level. Hurricane size may range from 100 km to 2,000 km. Although recorded hurricanes that have struck the study area are about half these levels, these maximums indicate the range of possibility.

Tropical cyclones with winds between 61 km/hr and 119 km/hr are classed as tropical storms, while weaker circulations are known as tropical depressions or disturbances (Gentry 1984:516). A hurricane can form from a tropical depression in four to eight days. Once formed the system can last a few hours to three weeks, with a majority dissipating in five to ten days.

Several conditions necessary for tropical cyclone and hurricane formation frequently combine in the western Atlantic and Gulf of Mexico. Some conditions are: 1) sea water temperature greater than 26° C, with sufficient surface area to supply overlying atmosphere with water vapor; 2) convectively unstable air with no strong inversions to prevent high cloud growth; 3) high middle-troposphere humidity; 4) minimum vertical wind shear (wind constant for great height); and 5) cyclonic wind rotation in the lower troposphere (Schlatter 1988:234).

The first recorded hurricane is probably that by Columbus in June 1494 (Millás 1968:7). Millás has analyzed historical documents recording more than 170 Caribbean hurricanes between 1494 and 1800. His study found that the hurricane season lasts from mid-May through November, with nearly 73 percent occurring during August, September and mid-October (Millás 1968:xiv).

Florida's position between the Gulf and the Atlantic makes it the most exposed area of the United States to hurricanes. Hurricanes approach from the Atlantic to the east, the Caribbean to the south, and Gulf of Mexico to the west. From 1875 to 1958, 125 hurricanes have struck Florida, an average of 1.7 storms per year (Ichiye et al. 1973:1-3). Southeast Florida leads the nation in major hurricane strikes between 1899 and 1980 (NOAA 1981:28). Hurricane and tropical storm monthly frequency from 1886-1980 is depicted in Figure 6.4.

Millás' frequency data correspond with more recent findings. Gentry (1984:511) found that approximately 18 percent of cyclones affecting Florida occur in August, 31 percent in September and 30 percent in October, most before October 20. About 10 percent of the cyclones occur in June and 7 percent in July. Probability that a major storm will hit the general Tortugas area in any one year is also provided by Gentry (1984:511). The probability is 18 percent for a tropical cyclone, 13 percent for a hurricane and 2 percent for a great hurricane, which means storms with winds exceeding 201 km/hr.

Just as there is predictable hurricane seasonality, hurricane frequency appears to follow predictable longer cycles. Leal (1991:5) reports periods of hurricane intensity resulting from increased summer rainfall in the western Sahel region of West Africa. During

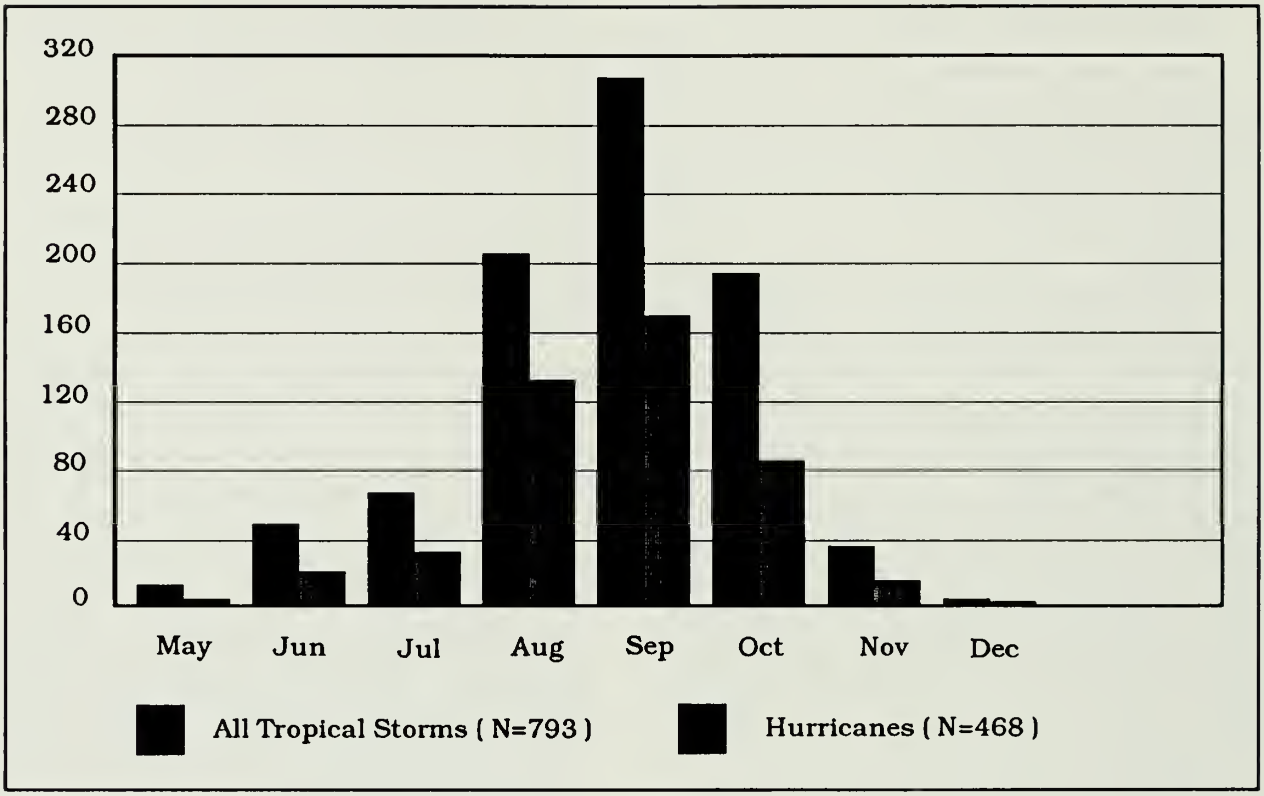


Figure 6.4. Comparison of total number of tropical storms and hurricanes by month.

years of Sahel drought, hurricane activity diminishes. About every 20 years higher than average tropical Atlantic temperatures supply moisture for increased Sahel rainfall facilitating formation of organized tropical disturbances. Severity of the 1988 and 1989 hurricanes corresponds with the recently ended eighteen-year drought period in the Sahel and portends increasingly intense hurricanes during the next few years.

Hurricanes pose a serious threat to mariners, and the 1877 mariner's guide provides a recommended course of action (Green 1877:3-6):

> As the centre, or vortex is approached, the wind increases in violence and the furious gusts become more frequent; the mercury in the barometer falls steadily, rising again as the storm-centre recedes. The confused cross-sea at the centre is tremendous, and very few vessels could there escape serious disaster. The most important requisite therefore in experiencing one of these tempests is to keep the ship as far as possible away from the centre. As the wind blows in a nearly circular course ... it is evident that the centre will always bear eight points from the direction of the wind ... To cross in front of a hurricane would be a most perilous undertaking, but, ... if a vessel finds herself in the right-hand semicircle of the storm, she should heave to on the starboard tack; if in the left-hand semicircle, then the port tack is better, as in each case as the

wind shifts the ship will come up instead of breaking off and consequently will run far less risk of being taken aback.

The National Oceanic and Atmospheric Administration compiled major tropical cyclone storm tracks for the period 1871-1980 (NOAA 1981). For the years 1871, when the Hurricane Warning Service was established, to 1935 (an arbitrary end date), cyclones have struck or passed near the Dry Tortugas on the following dates: 6/1/1871; 10/19/1876; 08/17/1881; 10/10/1885; 08/17/1886; 09/24/1894; 10/01/1895; 09/10/1897; 09/05/1900; 10/17/1906; 10/17/1910; 08/09/1914; 11/15/1916; 10/10/1919; 10/20/1924; 09/17/1926; 08/12/1928; 05/27/1934; 09/03/1935. This list is not exhaustive as historical research by Edwin Bearss (1983) located reports of additional storms of sufficient strength to damage Fort Jefferson (discussed below).

A search of the 241 marine casualties in the Fort Jefferson data base indicates that only two casualties, both occurring in the 1910 storm, can be directly attributed to these storms. The two vessels stranded by the 1910 storm, LAKE WINONA and FRED W. WELLER, recorded the lowest barometric pressure of this storm, 929.2 mb (27.44"). This is the lowest reading recorded in a hurricane between 1900-1973 (Ho et al. 1975:5).

Between 1871 and 1935, 107 vessel casualties are documented for the Tortugas. Twenty-seven have sufficient information to determine they were storm related. Based on this rather small sample, it appears that in the Dry Tortugas more marine casualties result from northers and thunderstorms than cyclones.

Hurricane Storm Surge

Although hurricanes and cyclones may not have been responsible for many Tortugas marine casualties in the last 100 years, high waves and storm surges have certainly impacted archeological sites in the study area. While storm surge impact is well documented for occupied areas, its effect on archeological sites is less well known. It is likely that the majority of Tortugas archeological sites have been affected by hurricane waves, currents and surges. The difficulty lies in determining just how great that influence has been, or will be.

Every hurricane landfall produces a storm surge, which can be the most dangerous aspect of a hurricane. Typically, the longer a storm remains in the Gulf, the higher the surge (MMS 1982:129). Surge results from proximate sea level changes caused by interaction of several processes, including local low barometric pressure with highs offshore, bottom friction on waves and storm-carried water mass, and high winds. The highest surge is usually on the on-shore wind side of the storm (Gentry 1984; Bascom 1980:87-91). Surges as high as 5.5 m above normal have been recorded in the Florida Keys (Gentry 1984:512).

Great differences in water height in the short period of a hurricane can cause severe coastal erosion and unusual deposition. Dunn and Miller (1964:221) observe that hurricane-driven waves have washed away 9-15 m of beach in a few hours. Reef-faced shores receive some protection from wave damage, but adjacent subtidal offshore areas are subject to extreme damage (Britton and Morton 1989:37). Hurricane surge and waves are the primary processes that have altered the islands, as discussed in the historical geography chapter (Chapter II).

Hurricanes are the most effective sediment movement processes, but northeasters also are efficient sediment transporters. Hurricane driven seas have been observed moving enormous quantities of sand and boulder-size coral rubble in the Florida Keys (Shinn et al. 1989:27-8). Hurricane sediment transport in the lower keys is related to the east-west platform margin tilt, which means primary transport is to the west. Shinn notes that most hurricanes approach Florida from the southeast. Consequently, the first and strongest winds hitting the Tortugas would be from the northeast, which would tend to move sediment offshore.

Tropical cyclone and hurricane impact has been a significant factor during Fort Jefferson's history. At least 11 major storms or hurricanes are known to have affected Fort Jefferson construction:

October 11, 1846 - A hurricane altered Garden Key (Manucy 1936; Bearss 1983:40). Maj. Hartman Bache surveyed Garden and Bush Keys in January 1846. Lt. Horatio Wright found that the island migrated toward the south and waves were reported to have washed over the island when he arrived a few months later.

1852 - A hurricane undermined the breakwater (Manucy 1936).

August 27-28, 1856 - Government vessel ACTIVA sunk by hurricane (Bearss 1983: 171).

1865 - Hurricane knocks down the walls of officers' quarters (Bearss 1983:262,288).

October 20, 1870 - Damage to government boats and wharfs; small buildings swept away and 25 tons of coal were lost (Bearss 1983: 333).

October 6, 1873 - Damage to parade ground buildings, some buildings and cattle pens swept away (Bearss 1983:318).

September 13, 1875 - Damage to the lighthouse tower and two officer's quarters' chimneys were toppled (Bearss 1983:343). The track of this hurricane is plotted in NOAA 1981:37.

August 1886 - Hurricane damaged buildings and tore porches off parade ground quarters and nearly leveled the wharfs (Bearss 1983:374). This probably occurred August 17, based on this hurricane's track plot (NOAA 1981:48).

1888 - Storm collapses a 15-in Rodman platform on the parapet (Bearss 1983:376). This could have resulted from a September 23 storm or a hurricane on August 16 (NOAA 1981:50).

1904 - Tropical storm damages the coal docks, probably on September 18 (NOAA 1981:66).

October 14-17, 1910 - Damaged coal docks, levelled some out buildings and tore down the north dock approach (Snell 1983:416-417). The track of this storm passed directly over the Tortugas on October 17 (NOAA 1981:72).

Historical evidence has provided some idea of storm surge impact on Tortugas Islands and structures. How these processes affect shallow water shipwrecks and other submerged sites is not known and so far uninvestigated. What appears at first to be a devastating impact, may not be. Most of the wrecks that have been investigated so far at Fort Jefferson National Monument have associated wooden structure and are relatively compact sites, indicating less severe storm impact than might be expected. Investigation of natural site-formation processes on the Tortugas' shallow-water wreck collection will greatly augment what is known about wreck and submerged site formation and preservation in general.

Hurricanes also damage marine life and reefs. Intense hurricanes are capable of bringing cold water to the surface that can persist for weeks. Surface water cooling as much as 9° F was recorded from hurricane Hilda in 1964 (Jordan 1973:IIA-9).

Other Weather Phenomena

Fog

In extreme south Florida areas, there are fewer than 10 fog days a year, with diminishing frequency southward. These fogs usually dissipate after sunrise and heavy daytime fog is seldom observed (Ichiye et al. 1973:1-3). Fog reducing visibility below one-half mile is very rare in the Dry Tortugas. It is unlikely that fog would be a factor in Tortugas marine casualties.

Low Visibility from Heavy Rain

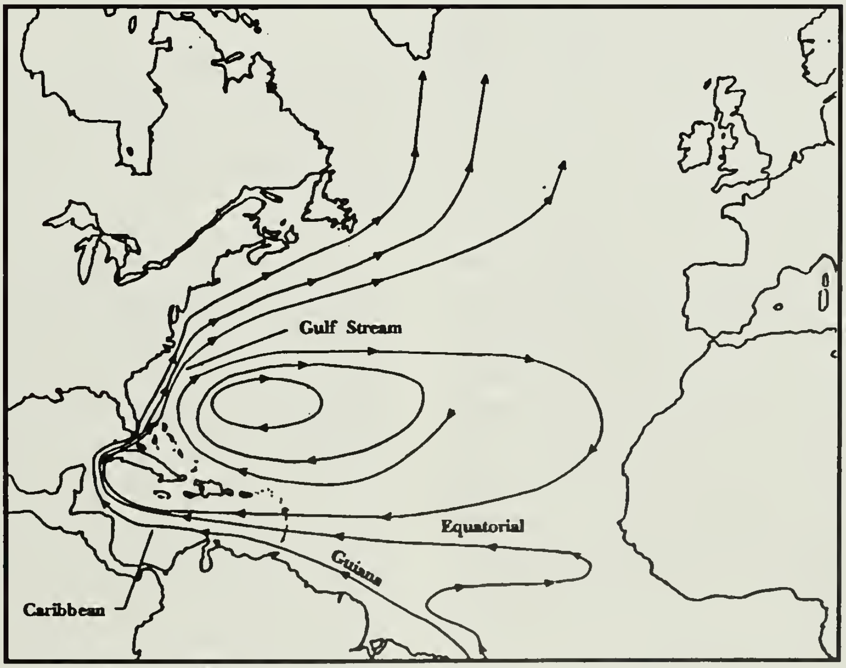
Reduced daytime visibility in the Tortugas can result from very heavy rain, which might contribute to marine casualties.

Tides

Gulf of Mexico tides usually do not exceed 0.7 m. The tidal regime for the southwest Florida Plateau is mixed, having both diurnal and semidiurnal tidal components (MMS 1987:25).

Current

Current can be viewed on at least three levels: global, regional and local. On the global level, as depicted in Figure 6.5, the major Atlantic currents and prevailing winds provide a natural circulatory route from Spain to the Caribbean and back. Oceanic currents



From O'Brien 1973:11B-28

Figure 6.5. Principal North Atlantic and Caribbean currents.

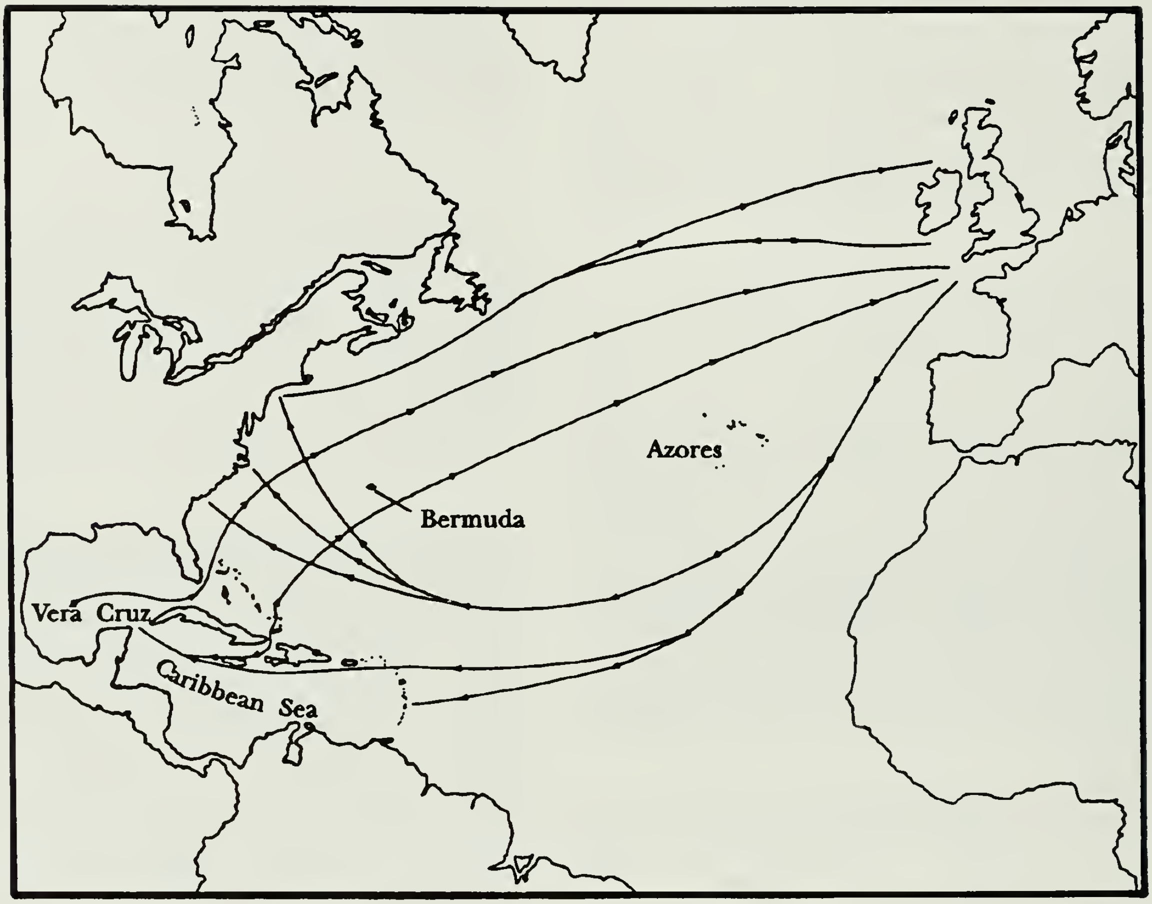


Figure 6.6. Principal sea routes (after Rosler and Imray 1869).

were critical factors in maritime exploration and European global expansion. The North Equatorial Current, along with the prevailing easterly trade winds, provides a direct sailing route from Spain to the Antilles. The swift Gulf Stream provides egress through the Florida Straits up along the Atlantic seaboard to the Carolinas, where prevailing westerlies and the North Atlantic currents return to European shores. This natural oceanic system structured European, especially Spanish, maritime activities for centuries.

Regional current systems are those of the Caribbean, Gulf of Mexico, and Gulf Stream, which flows through the Florida Straits. The Atlantic northeast trade winds drive the Caribbean Current that flows westward from the Equatorial Current (Figure 6.5). The Caribbean Current crosses the Caribbean Sea and continues through the Yucatan Channel into the Gulf of Mexico forming the Loop Current (Jones 1973:IIB-4). Gulf circulation is dominated by the Loop Current, which is discussed in detail in Chapter III.

The eastern Gulf, including the Tortugas, is the most dynamic area of the Gulf of Mexico. The lower Florida peninsula separates two adjacent environs with a typically strong flow of ocean water from the Gulf into the Atlantic. This strong current system tends to remain very close to land areas in the Florida Keys (MMS 1982:139) and augments local currents.

Local currents of the Dry Tortugas have not been studied in detail. While global and regional current patterns have affected Tortugas sites by influencing maritime activities conducted in the vicinity, local currents directly affect both cultural and natural site formation. The lack of data on local Dry Tortugas currents reinforces the necessity of a multidisciplinary approach to the cultural resource inventory in Fort Jefferson National Monument. Detailed knowledge of local current regimes is necessary for site interpretation, as well as biological assessment.

Waves

The discussion of wind and storm activity above suggest that moderate seas dominate the eastern Gulf most of the year. Wave patterns, like most weather, do show a seasonality, generally being more severe in the winter than summer.

Summaries of wave data for the eastern Gulf collected by the US Navy (reported in Jordan 1973) show 60-65 percent wave height below 3 ft between October and April, 10-15 percent greater than 5 ft and about 1 percent of the time exceeding 12 ft. May through August the waves are less than 3 ft 80-90 percent of the time, 2-6 percent more than 5 ft and much less than 1 percent of the time more than 12 ft.

Predominate wave directions are from the east and northeast September through February, and from east and southeast March through August. Waves from the north and northwest, especially in the fall and winter, tend to be the highest. Wave periods of five seconds or less occur 61-74 percent of the time and predominate in summer. Wave periods greater than nine seconds occur about 5-6 percent of the year (Jordan 1973:IIA-3).

The highest waves are associated with cyclones. Hurricane waves can exceed 10 m (Jones 1973). Generally, offshore waves are higher than those in near-coast areas. The Tortugas would have higher waves than many coastal areas because of the long fetch in nearly every direction.

Swells follow a pattern similar to waves. September to April 72-80 percent of the swells are less than 6 ft and 3-6 percent are more than 12 ft. May to October 93-96 percent of the swells are less than 6 ft and less than 2 percent are more than 12 ft. Minimum swell is noted in June and July (Jordan 1973:IIA-3).

Wave action affects initial shipwreck site deposition and is a principal postdepositional process. Muckelroy (1978:176-182) classes wave action as a "scrambling device" along with currents. Other than Muckelroy there has been little investigation of wave impact on shipwrecks.

Bascom (1980) presents a useful account of wave action, and this discussion draws from that reference. As ocean waves and swells enter shallow water, their systematic circular motions become turbulent in the surf zone. Bottom sediments are suspended, with the size of sediment suspended and the duration of suspension being a function of particle size and weight and of wave energy, which is in turn a function of wave height and length. Bigger waves have more energy and consequently suspend larger particles for a longer time. When waves diminish, heavier particles come out of suspension first. The depth of sediment disturbance below the seabed is also related to wave height and length. The deepest level below the seabed disturbed by waves is called the wave base. Because of these processes, heavier objects tend to be quickly buried at the wave base when sufficient sand is present (Murphy 1990c:53).

Waves can move materials on the seabed, but because most artifacts are heavy relative to even large suspended particle size, they tend not to be moved much after initial deposition, but rather migrate downward. Lighter materials tend to be transported in the direction of waves, currents and littoral drift, but they, too, eventually become stabilized. Because there is a size and weight limit for materials transported under a certain set of conditions, and the principal movement direction can usually be discerned, wave and current impact can be roughly estimated, and eventually accurately predicted.

Wave impact is typically viewed as an overwhelmingly destructive force on shallow-water shipwrecks, however, recent work indicates that it is not as destructive as commonly believed (Murphy 1990c). Muckelroy (1978:176-182) found the level of site disturbance was closely related to particular environmental conditions, which indicates the importance of geomorphological and oceanographic research to wreck interpretation. Fort Jefferson shipwrecks occur in many different environments, and the level of integrity and preservation is a function of environmental variables. Analysis of environmental variables' influence on site preservation will be an important part of multiple-site research at Fort Jefferson National Monument.

Some other environmental factors affecting artifact movement or stabilization are: the nature of initial site deposition (whether or not it was storm deposited, storm intensity and extent of initial site scatter); storm occurrence prior to site stabilization; bottom slope and composition (whether solid or scattered reef, amount and depth of sand cover); growth rate and nature of pioneering reef organisms that may contribute to stabilization; and chemical and electrochemical environment that affects artifact encrustation rate. These factors, and other unrecognized variables, if tested and controlled for in a multidisciplinary study of the Fort Jefferson sites, will be important to developing a reliable model for submerged site formation processes in the monument as well as other areas. Such a model, if sufficiently refined to allow prediction, will enhance cost-effective submerged site evaluation and survey design in other NPS areas. One of the contributions model development and testing has is the generation of (usually statistical) laws of natural site transformation underwater, which would have general applicability (Schiffer 1987:8-11).

At this stage, some speculation about the nature of site integrity and preservation can be made about various Fort Jefferson areas known to contain historical sites. Environmental factors must be considered in the survey design, which is discussed in a later chapter. Temporal and spatial distribution and composition of Tortugas' historically documented wrecks are detailed in Chapter IX. Summarily, there are basically two wreck populations in the monument: vessels passing the Tortugas en route and vessels bound for the Tortugas for either sanctuary or participation in local activities.

En route vessels will be found primarily on the outer shoal perimeter. Vessels involved directly with the Tortugas will be found near the 10-20-m-deep channels, within sheltered anchorages or on the interior island perimeters. Because of protection and limited fetch, waves within the sheltered portions will be much lower and shorter than those on the outer perimeter. Consequently, interior wrecks should generally be less dispersed than perimeter wrecks. However, because a principal preservation variable is depth of sand, the shallower of these sites may be on hard reef, which would allow more dispersal.

Outer perimeter wrecks will reflect the impact of numerous variables. Principal bank-reef systems that form the perimeter are: Pulaski Shoals to the northeast, Loggerhead Shoal to the west and Long Key/Bird Key Shoal to the southeast (see Figure 1.1). The highest and longest waves occur on the perimeter, especially on the north. If the vessel was storm deposited, the wreck scatter may be shallow and widely dispersed, or the wreck may fall into deeper water on the reef face, which could enhance site integrity. The vessel could also be damaged on an outer shallow patch reef and sink in somewhat deeper water inside the reef.

Wrecks can be found in water much shallower than the vessel's draft because high waves can carry the vessel into much shallower water than would normally float the vessel. Complex wreck scatter can be formed by a vessel holing in a high-wave trough and then being carried further inland to disperse in shallow water, or alternately breaking apart and dispersing in heavy waves. The hull, or large sections of structure, can ground and initially survive, only to be broken up by later storms, for example apparently the case with FOJE 003. If the vessel was grounded through navigation error and broken up by later storms, the dispersal pattern would vary as a function of postdepositional wind and wave direction, intensity and duration.

Bottom topography is an important variable to all wrecks within the monument. The best preservation is expected in areas of deep sand. However, sand is not necessary to preserve wooden structure. For example, most wrecks examined so far have wooden structure such as FOJE 008, 011, 029 and the Coast Guard Dock Ballast Pile, which represent both interior and perimeter sites. Sand bottom extent is presently unknown for the Tortugas. However, sand of varying depths has been observed in the grooves between reefs, in channels and anchorages, and in patches within living reefs. Grasses can effectively stabilize material in relatively shallow sand, and coralline algae and encrustation can cement artifacts to bare rock. Basic investigation of biological questions, for example the minimum sand depth necessary to support grass cover, are important to site prediction and interpretation and argue for a multidisciplinary approach.

Live reefs cover less than 4 percent of the monument's area (Davis 1982), which means that most wrecks probably occur in areas with little live coral. However, the introduction of a shipwreck produces protected substrate that is colonized by reef organisms (see Chapter XX). Growth of reef-building organisms coupled with artifact encrustation processes help stabilize cultural materials, even in high-energy areas.

In summary, Loggerhead Key, North Key Shoals and to a lesser extent Pulaski Shoals are high probability areas for vessel casualties resulting from northers. The southern shoals, from East Key through Garden Key Shoals and the southeast side of Loggerhead, are likely to pick up vessels driven by strong southeast cyclonic winds. Thunderstorms and pilot errors would be more random and less attributable to these larger storm patterns.

The most intact wrecks will generally be found in the interior of the Tortugas group and the most scattered will be on the perimeter. However, local conditions can produce a high state of preservation and integrity anywhere in the island group. We currently do not have sufficient data to predict preservation and integrity levels based on site location. Consequently, at this point we cannot identify areas most likely to contain sites with the highest information potential, although this is a critical factor for National Register determination, as well as necessary for future research planning. Completion of an extensive survey, inventory and evaluation of a wreck population like that of the Tortugas will go a long way toward providing a model that will provide predictability for other areas.

CHAPTER VII

Historic Contexts

Larry E. Murphy

Fort Jefferson National Monument historical sites are an international heritage as well as an important representation of United States historical development. This chapter develops a general interpretive framework based on established United States Department of Interior (USDOI) historic contexts for the international collection of Dry Tortugas sites. This framework is intended to provide a basis for site significance evaluation, and to serve as a field guide to ascertaining probable submerged site function--that is, what category is most likely represented by a site, which can assign each site a property-type as defined by the Secretary of Interior's guidelines (USDOI 1983b). It is expected that this approach will be modified and amplified considerably as a comprehensive site survey and numerous site evaluations are conducted.

Historic context development has long been part of USDOI preservation planning. Historic property significance evaluation for planning and management purposes is typically conducted within historic themes (USDOI [NPS-28] 1985:Ch. 2, p. 1). The Secretary of Interior's Archeology and Historic Preservation Standards and Guidelines (USDOI 1983b) establish historic context as an integral part of research for preservation planning purposes. Contexts are intended to describe an area's significant, broad developmental patterns. A basic assumption of these guidelines is that decisions about identification, evaluation, registration and treatment of historic properties are most reliably made when information is collected and organized within historic contexts.

> General Approach...A single historic context describes one or more aspects of the historic development of an area, considering history, architecture, archeology, engineering and culture; and identifies the significant patterns that individual historic properties represent...The goal of preservation planning is to identify, evaluate, register and treat the full range of properties representing each historic context, rather than only one or two types of properties. Identification activities are organized to ensure that research and survey activities include properties representing all aspects of the historic context. Evaluation uses the historic context as the framework within which to apply the criteria for evaluation to specific properties or property types (USDOI 1983b:44718).

This chapter provides an interpretive framework based on principal historic themes recognized by the National Historic Landmarks (NHL) Program (USDOI 1987a). Thematic classifications were initiated in 1936 by the National Park Service Advisory Board, which stated, "classification of resources is intrinsic to an understanding of a body of knowledge about those resources and is fundamental to the comparative analysis necessary in making judgments of relative significance" (USDOI 1987a:i). The purpose of thematic classification is to provide a basic outline of US history, prehistory and cultural endeavors against which parks and landmarks are evaluated to determine properties' representativeness within the National Park System. Currently (1987 revision), there are 34 US historic themes, divided into subthemes and facets.

Historical contexts provide a reasonable organizational framework for the vast historical record potentially relevant to the Dry Tortugas. A hierarchical structure is useful for developing archeological inferences, and determining historical significance of the complex maritime material record within the study area. Different geographical scales include activity involving the Dry Tortugas directly, such as exploration, fishing, wrecking, anchorage; Fort Jefferson supply and construction; regional activity, such as Gulf navigation and transport; Caribbean trade and ascendancy of US markets and transportation; and international themes, including navigation and interaction of all nations involved in Caribbean and Gulf trade, warfare and privateering; and finally clandestine and poorly documented activities such as smuggling, piracy and salvage. Consequently, sites within Fort Jefferson National Monument may have local, regional, national or international context and significance. Rather than including a comprehensive historical narrative in this assessment, the approach here is to delineate specific themes on various levels that represent Dry Tortugas historical activity.

Historic context used as a framework for maritime sites interpretation is just beginning. The approach is untested, but it may have general methodological applicability. For example, recently the Texas Antiquity Committee developed an historic context overview for Texas shipwrecks (Arnold 1989) as part of the revision and expansion of the Texas State Historic Preservation Plan concerning shipwrecks. Arnold notes that "The determination of a site's significance is often a ticklish matter. Examination of a site relative to its historic context can facilitate this determination and make the historic context a valuable functional tool" (Arnold 1989:12).

Some historic contexts relevant to Fort Jefferson site interpretation are just mentioned here. Others, which pertain to known casualties, are more developed. Based on the long Dry Tortugas maritime history, more thematic contexts are presented than might be finally represented once a comprehensive survey and evaluation is completed. This chapter, which is experimental, is intended to include most currently listed potentially applicable contexts.

Mobility of ships requires a modified application of NHL themes. Dry Tortugas archeological sites reflect many different activities designated by the thematic classifications. However, some categories have to be stretched a bit to include specific maritime activities represented by probable sites in Fort Jefferson National Monument. Dry Tortugas sites also reflect international activities that extend beyond NPS thematic classification. Primary modification of the NPS thematic framework, besides addition of themes, subthemes and facets, is the inclusion of activities, some treated as processes, that do not fall within a particular historical period. For example, piracy is treated as a particular facet of the subtheme "Shipping and Transportation" under Theme XII "Business." It is not limited to a particular period, but rather is an activity that occurred at varying intensities at various times.

The format for the remainder of the presentation is a discussion of particular categories (subthemes are designated by letters, facets by numbers) presented in the USDOI National Historic Landmarks publication (1987a); modifications to the NHL categories; related NHL properties (1987b); likely vessel characteristics involved; archeologically or historically documented sites in the study area (property types); and other archeological site examples useful for comparative purposes, which includes appropriate sites from the National Maritime Initiative Shipwreck Inventory (USDOI 1990).

Theme I: Cultural Developments: Indigenous American Populations

A. The Earliest Inhabitants

1. The Early Peopling of North America
3. The Early Peopling of the Caribbean
13. Archaic Adaptations of the Southeast
14. Archaic Adaptations of the Caribbean
19. Early Man and Late Pleistocene Environmental Adaptations

B. Post-Archaic and Pre-Contact Developments

16. Post-Archaic Adaptations of Eastern Coastal Regions
17. Caribbean Adaptations
23. Other-Late Prehistoric Specialized Maritime Adaptations

C. Prehistoric Archeology: Topical Facets

2. Prehistoric Technology
8. Prehistoric Economics/Trade
15. Prehistoric Transportation and Travel
20. Submerged Prehistoric Period Archeological Resources
23. Paleoecology

D. Ethnohistory of Indigenous American Populations. This theme encompasses the period 1500-1830; the latter date represents the time when southeastern Native American groups had been displaced. Recently, the NPS Southeast Region developed a NHL Theme Study (NPS Southeast Region Office nd.) that included a discussion of thematically related sites that provide specific context for this subtheme.

1. Native Cultural Adaptations at Contact

j. Native Adaptations to Southeastern Environments
k. Native Adaptations to Caribbean Environments

2. Establishing Intercultural Relations

d. Guiding Explorers Across New Territories: exploration and Menendez' 1566 passage through the Marquesas Islands
h. New Native Military Alliances (Menendez-Calos 1566)
i. Trade Relationships

3. Varieties of Early Conflict, Conquest or Accommodation

b. Forced and Voluntary Population Movements (Keys Indian removal and extermination)

Theme II: European Colonial Exploration and Settlement

Subtheme A: "Spanish Exploration and Settlement" includes all Spanish activities until conclusion of the Spanish-American War in 1898. After that period Spanish maritime activities would be included within other categories, such as international trade.

Facet 1: Gulf and Caribbean Exploration

Related Sites: Florida: Martin Site (8Le853B/8Le282) - Winter encampment of de Soto expedition (1539-40).

Puerto Rico: Mona Island Passage - Important seafaring landmark since earliest European exploration and discovery. Caparra - First capital, founded by Ponce de Leon in 1508, abandoned 1521.

Virgin Islands: Columbus Landing Site - Associated with 1493 discovery of St. Croix (1960 NHL).

Facet 2: Spanish Occupation and Defense, including naval operations.

Related Sites: Alabama: Apalachicola Fort Site - Northernmost Spanish colonial outpost on the Chattahoochee River. Built in 1690 to prevent British inroads among the Lower Creek.

Arkansas: Arkansas Post - Site of both French and Spanish eighteenth century colonial occupations along the Arkansas River (1969 NHL).

Florida: British Fort ("Negro Fort" 1975 NHL Property) - Established by English and Spanish during the War of 1812 as a haven for runaway slaves. Fort was destroyed by the US in 1816. Cathedral of St. Augustine established in 1594. Fort San Carlos de Barrancas (Bateria de San Antonio) eighteenth century brick fortification that was an outpost of the Spanish Caribbean empire, captured by Andrew Jackson in 1814 (1960 NHL). Fort San Marcos de Apalache - Established in 1660 to control the Florida west coast, captured by Andrew Jackson in 1818 (1966 NHL). Gonzales-Alvarez House - Eighteenth-century Spanish townhouse (1970 NHL). Llambias - Dwelling dating to the first Spanish Period (pre-1763) and containing British and Spanish details (1970 NHL). St. Augustine Town Historic District - Oldest continuously occupied settlement in US (1970 NHL). San Luis de Apalache - Seventeenth-century Spanish mission province of Apalache. Burned by British colonial troops in 1702 (1960 NHL). Fort Mose (8Sj40) - Site of Black freedman established by Spanish in 1738. Fountain of Youth Park (8Sj31) - Created by Pedro Menendez de Aviles 1565. Santa Rosa de Siguenza - Established 1722 after French forced out of northwest Florida and destroyed by hurricane in 1752. Spanish Colonial Coastal Defense Complex - Seventeenth and eighteenth century coastal fortifications, includes San Francisco de Pupo (8Cl10), Fort Picolata (8Sj67) and Fort Matanzas (8Sj44A).

South Carolina: St. Elena - Sixteenth century fort and township, Spanish Florida capital 1566-1587.

Puerto Rico: El Fuerte de San Jeronimo del Boqueron - Main defensive fort of eastern San Juan Island. Constructed in 1591 attacked by English 1595, 1598, 1797 and by Dutch in 1625. Fuerte del Conde de Mirasol - Constructed in 1845 to protect Vieques, Conde de Mirasol harbor and the largest masonry fort outside San Juan.

Facet 3: Spanish privateering, smuggling and slaving.

Facet 4: Spanish Commerce and Merchant Shipping

Related Sites:

Subtheme B: "French Exploration and Settlement" includes activities until the transfer of Louisiana to the US in 1803.

Facet 1: Gulf and Caribbean Exploration

Facet 2: Gulf Coast Occupation and Defense, including naval operations

Related Sites: Alabama Sites: Fort Toulouse/ Fort Jackson Sites - Established in 1717 and was significant in extending French influence into Southeast interior; Fort Louis de la

Mobile - Site of first French colonial settlement (1702-1711) in the Mobile area. Bienville's establishment of military post and village secured France's claim to the northern Gulf coast. Recent archeological work has confirmed this site's location. Dauphin Island - Numerous French colonial sites located. Fort Tombecbee - Eighteenth century French colonial military and trading post in Alabama interior.

Arkansas: Arkansas Post (1960 NHL) - Site of both French and Spanish eighteenth century colonial occupations along the Arkansas River.

Louisiana: Fort de la Boulaye (1960 NHL) - Established to hold French claim to Mississippi River mouth in 1701.

Facet 3: French Privateering, Smuggling and Slaving

Related Sites: Lafitte's Blacksmith Shop (1970 NHL) - Traditionally associated with Jean and Pierre Lafitte.

Facet 4: French Commerce and Merchant Shipping

Related Sites: Louisiana: Natchitoches Historic District (1984 NHL) - Established by French in 1714 as Red River trading center.

Mississippi: Fort St. Pierre Site (22Wr514) founded in 1718 to control Yazoo River Basin trade, destroyed in Natchez War of 1729.

Subtheme C: "English Exploration and Settlement" includes activities from Cabot's voyage in 1497 through colonization.

Facet 1: Gulf and Caribbean Exploration

Facet 2: Gulf Coast Occupation and Defense, including naval operations

Related Sites: Florida: Fort Pensacola (8Es1150), British fort from 1763-1783. Attacked by Spanish in 1781 as part of US Revolutionary War.

Facet 3: British Smuggling, Privateering and Slaving

Facet 4: Gulf and Caribbean Commerce and Merchant Shipping

Related Sites: Florida: Panton, Leslie Trading Co. Site (8Es534B) British trading company that worked with British and later Spanish colonial governments for Indian trading concessions.

Charleston Historic District (1960 NHL) - Largest and most prosperous eighteenth century seaport south of Philadelphia.

Subtheme D: Other European Exploration and Settlement. Deals with the earliest European voyages to the present territory of the US including Dutch and Swedish activity.

Facet 1: Gulf and Caribbean Exploration

Facet 2: Gulf and Caribbean Occupation and Defense

Related Sites: Virgin Islands: Fort Christian (1977 NHL) - Built in 1680 to protect second Danish occupation of St. Thomas and secured Charlotte Amalie Harbor. Blackbeard's Castle (Skytsborg) - Constructed about the same time as Fort Christian, only defensive tower of its kind known in Lesser Antilles. Hassel Island - Ruins of fortifications, shipping and coaling facilities related to nineteenth century

Charlotte Amalie, including Shipley's Battery 1807-1809 British Napoleonic War battery. Fort Sale - Midseventeenth century earthwork Dutch coastal fort to protect St. Croix, became main French defense after 1650. Frederick's Fort - Constructed 1718, destroyed in 1733 Slave Revolt. Rebuilt in 1736.

Facet 3: Smuggling, Privateering and Slaving

Related Sites: Cinnamon Bay Plantation and Frederick's Fort associated with 1733 Slave Revolt.

Facet 4: Commerce and Merchant Vessel Operation

Related Sites: Virgin Islands: Zufriedenheit Site - Archeological representation of sugar-making facilities dating from seventeenth-early twentieth centuries. Represents earliest Danish plantation attempts in Virgin Islands. Whim Plantation - 1790s plantation. Adrian Plantation - Earliest St. John plantation (1718) and island's largest sugar producer. Annaberg Plantation - Well preserved sugar plantation. Cinnamon Bay Plantation - Associated with the 1733 Slave Revolt. Reef Bay Plantation - Last working sugar plantation on St. John.

Theme III: Development of the English Colonies, 1688-1763. This focus is on the physical, military and political development of Great Britain's North American colonies during the eighteenth century.

Theme IV: The American Revolution

Subtheme F: The Naval War

Theme V: Political and Military Affairs, 1783-1860. This theme addresses the related activities during the period of US development into a growing nation capable of pursuing its interests by military action.

Subtheme E: War of 1812, 1812-1815

Subtheme H: Manifest Destiny 1844-1859

Subtheme K: The Army and Navy. This would include the building of Fort Jefferson.

Theme VI: The Civil War includes war-related and unrelated political and social activities of both the Union and Confederacy.

Subtheme D: Naval Action

Theme VII: Political and Military Affairs, 1865-1939. This theme includes related activities from the Civil War's end to the beginning of World War II. The period was characterized by the South's reconstruction, increasing influence of corporations, a "war" with Spain, the increasing stature of the US as a world power, especially with the entry of the country into World War I. The period was also characterized by massive immigration and isolationism after the war, rise in living standards, the Great Depression and increased national government involvement in economic and social affairs.

Theme VIII: World War II

Subtheme D: The Home Front. German U-boats operated in the Gulf of Mexico, northwestern Caribbean, Bahamas and along Florida's east coast in 1942 and sporadically in 1943. During June 1942 in this area, U-boats destroyed more shipping than they had sunk in any single month in all other theaters combined. U-boats sank 58 ships of about 300,000 gross tons between May and September 1942 (Cronenberg 1990:163; Morison 1947:142-4).

The response to the U-boat threat was increased patrols from Key West-based military ships and planes and the organization of merchant ship convoys for the Gulf sea lanes. Only two U-boats are recorded sunk in the Gulf during the 1942 campaign, one in the Florida Straits, U-157 (Cronenberg 1990:174). At war's end, there were 12 Type XXI U-boats in operation and another 121 launched. The Type XXI subs were the most refined produced by Germany. Early in 1946, a Three-Power agreement provided Britain, France and the US with 10 German U-boats, all others were destroyed. One Type XXI sub assigned to the US was U-2513; launched in late 1944 or early 1945 this sub had not been commissioned. U-2513 was commissioned into the US Navy where it was used for submarine tactics development until 1949. U-2513 was sunk during a Navy weapons test by destroyer ROBERT A. OWENS (DDK-8217) on October 7, 1951, off the Dry Tortugas at 24°53'N, 83°15'W in 228 feet of water. Although the sub was dived by Navy divers after sinking, the site has apparently not been located by divers since that time (Keatts and Farr 1986:159-162).

Theme IX: Westward Expansion of the British Colonies and the US, 1763-1898 includes the period between the Proclamation of 1763 and the end of the Spanish American War.

Subtheme A: British and US Exploration of the West

Facet 3: Scientific and Topographic Surveys

Subtheme B: The Fur Trade

Facet 1: Old Northwest and Mississippi Valley Fur Frontier, 1763-1815. Furs were brought down the Mississippi River and loaded aboard coastal and oceanic vessels for trade.

Subtheme D: Western Trails and Travelers

Subtheme E: California Gold Rush

Theme X: The Farmers' Frontier

Subtheme 4: Settling and Farming in the Great Plains, 1862-1900

Theme XI: Agriculture

Subtheme B: Plantation Agriculture, 1607-1860. South and Virgin Islands

Theme XII: Business

Subtheme A: Extractive or Mining Industries

Facet 4: Timber and Lumber

Facet 5: Fishing and Livestock

Subtheme B: Manufacturing Organizations

Facet 2: Transportation Equipment

Subtheme D: Trade

Facet 1: Export-Import

Facet 5: Commodity Markets

Subtheme F: Insurance

Facet 1: Fire and Marine

Subtheme L: Shipping and Transportation

Subtheme M: Supporting Institutions

Subtheme N: Piracy and Its Suppression

Theme XIII: Science

Subtheme B: Earth Science

Facet 1: Physical Geography

Facet 3: Hydrology

Subtheme C: Biological Sciences

Facet 2: Zoology

Theme XIV: Transportation

Subtheme B: Ships, Boats, Lighthouses and Other Structures

Theme XV: Communication

Subtheme B: Mail Service

Theme XVI: Architecture

Subtheme Z: Naval Architecture. The National Maritime Initiative has added this subtheme and began a NHL Theme Study, "The Maritime Heritage of the United States." The first phase recognized large historic vessels and developed an American maritime vessels typology.

Theme XVII: Technology (Engineering and Invention)

Subtheme B: Transportation

Subtheme E: Military (Fortifications, Weapons). Documentation of Fort Jefferson construction and support details is important for augmenting what is known of this fort in particular and the construction and operation of "third system forts" in general. There is clear need of archeological documentation of these activities.

Subtheme F: Extraction and Conversion of Industrial Raw Materials

Subtheme G: Industrial Production Processes

Subtheme H: Construction. Construction of Fort Jefferson as the largest masonry structure in the Western Hemisphere and completely supported by shipping would augment this theme.

CHAPTER VIII

Documentation for Dry Tortugas Historical Archeology

Larry E. Murphy

There has been very little terrestrial archeology done in the Dry Tortugas (see Chapter X). Nevertheless, the potential exists for material examination of events and processes known to have occurred on the islands within Fort Jefferson National Monument (NM). Primary and secondary historical documentation presented here centers on events likely to have left archeological residues and indicates areas that should be archeologically examined prior to any impact activities within and around Fort Jefferson.

LOGGERHEAD KEY

The principal features are the lighthouse and its support structures. On the island's north end are foundations, trash and other

Plate 8.1. Loggerhead Key light and Coast Guard dock today. The trees are Australian pines (*Casuarina*), which are twentieth-century exotics. USN photo by W. Krumpelman.

features associated with the Carnegie Institution research station that operated from 1904-ca. 1944 (Mayer 1910; Langley 1927).

September 8, 1867. During a yellow fever epidemic, Company K, 5th US Artillery was moved to the island from Fort Jefferson. On September 21, Company L was moved there from Bird Key (Manucy 1938).

1873. The Fort Jefferson command was evacuated to Loggerhead Key during a yellow fever outbreak (Bearss 1983:336). Duration is not clear for either the 1867 or 1873 occupations.

GARDEN KEY

1824-25. Commodore Porter reconnoitered the Dry Tortugas and noted the islands were "liable to changes from gales of wind" (Bearss 1983:3). The lighthouse, which was constructed in 1825, was not mentioned.

May 1829. Commodore John Rogers made a four-day stop to examine the Tortugas anchorage (Bearss 1983:3).

October 3, 1829-January 1830. Lt Josiah Tattnall conducted a survey of the islands. From October 3-20, Tattnall surveyed the area and may have stayed aboard sloop FLORIDA. On October 20, he went to Havana and returned to the Tortugas on the October 22. He dispatched FLORIDA to Pensacola for supplies. From October 22 to the end of December, Tattnall and five others surveyed the harbor and islands. The Tattnall survey crew may have camped on the islands or could have utilized the lighthouse or keeper's quarters.

Mid-October 1844. Capt John G. Barnard reconnoitered the Florida reef, including the Dry Tortugas (Bearss 1983:12).

November 1845-January 1846. Maj Hartman Bache surveyed Garden and Bird Keys. It is not clear how long Bache was in the Tortugas or where he stayed (Bearss 1983:10).

Fort Jefferson is, of course, the largest and most important feature, however, evidence of other structures and activities lie underground and in shallow water. The reason that Garden Key, rather than larger Loggerhead Key, was chosen as the fort site is that it is the largest island close to Tortugas Harbor.

Activities, Structures and Features Inside Fort Jefferson

October 1846. Lt Horatio Wright, Superintending Engineer, arrived at Dry Tortugas aboard ACTIVA and observed eight islands. Garden Key had been significantly altered by hurricane from what Bache charted. The island had migrated from north to south. During the hurricane, waves washed over the island, flattened some lighthouse buildings and damaged one of the wharfs (Bearss 1983: 40-41). Wright apparently had a steam engine and machinery for a pug mill (a mill for mixing and extruding clay) (Bearss 1983:38).

1846. Construction activities began. Orders were given to fence the Lighthouse Board property (Bearss 1983:28). The property consisted of a lighthouse, built in 1825 (Manucy 1943b:304), a lighthouse keeper's residence, and likely some out-buildings. The lighthouse keeper's residence has been described as a "Swiss-like structure with a large veranda, before which stood two old cocoa-nut palms" (Holden 1887). This site was the scene of James Fenimore Cooper's novel *Jack Tier*.

The fort scarp (walls) were built around the lighthouse, which was in the angle of Bastion C, with the lighthouse keeper's quarters at the

Plate 8.2. Garden Key and Fort Jefferson today. Aerial view looking east toward Bush Key. Long Key is to the top, north coal docks to the left, south coal docks right. Photo by John Brooks.

light base (Manucy 1936). A single grave is inside the fort, that of the wife of a lighthouse keeper (Anon. 1941:6).

May 1846. Before arrival of contracted temporary buildings, eleven slaves were hired from their owners and were engaged in strengthening the wharf and removing a wreck from in front of the landing (Bearss 1983:44).

October 1847. Beginning of permanent structure construction with officers' quarters and three detached kitchens. The kitchens were laid at reference 4 ft above water level, instead of 0 ft, and with concrete foundations rather than brick. The foundations had "enrockment" placed to shield against the surf, and fill was placed in the foundations and a coral barrier erected (Bearss 1983:46-47).

1847. The first permanent fort construction work began in the fall when about twenty slaves began digging foundations for the three-storied officers' quarters in what would be the fort's parade ground (Manucy 1943a: 307). The officers' quarters foundations can be seen in Plate 8.2 above. They are the rectangular feature to the lower left.

The first blacks arrived on May 26, 1847 and became the principal heavy laborers. Originally, their owners were paid $20.00 per month per slave; rations, quarters and medical care were furnished. Slaves operated under this system until 1855, when all laborers were paid a basic wage of $1.12 per day (Manucy 1943b:308-309).

1848. A 69-ft 3-in x 44-ft section of the three-story officers' quarters was raised and enclosed. The structure had stone plinths and curb stones (Bearss 1983:47).

1849. A "light piazza" was built on the east front of the frame barracks (Bearss 1983:59). Experiments with a tremie funnel for pouring cement underwater were conducted on a platform constructed on south Garden Key shoal (Bearss 1983:80).

1850. Wooden cisterns, although they had been covered with pitch, were rotting in place, and a cistern was begun as a foundation for the 66-ft x 53-ft building planned for offices and a chapel on the parade ground. The large area would be divided into 15 separate cisterns (Bearss 1983:124-125).

1854. Parade ground leveled, sand from the counterscarp cofferdam and sand from Long Key was added to fill the pond in the island's center and raise the parade three feet (Bearss 1983:127). Fill and features surveyed in 1854 are shown in Figure 8.1.

1855. Fort drainage system was begun with subfloor outlet culverts in the scarp of the curtains near the flank angles. Three outlets would serve the fort. A 2-ft-diameter, cylindrical exit was installed through the scarp. Six-inch iron pipe was installed for cistern conduits. Two-inch diameter composition pipe was installed at the cistern floor level. Five privy vaults (two doubles and one single) and brick privies with slate roofs were constructed over a double and single privy (Bearss 1983:119-121).

Stone flagging was determined better than bricks for casemate floors. The stones under traverse circles could be 3-6 in thick (Bearss 1983:134,152).

1858. Carpenters fitted temporary quarters in front four casemates (Manucy 1936).

1860. Black assistant to the blacksmith was making spearheads (Manucy 1936).

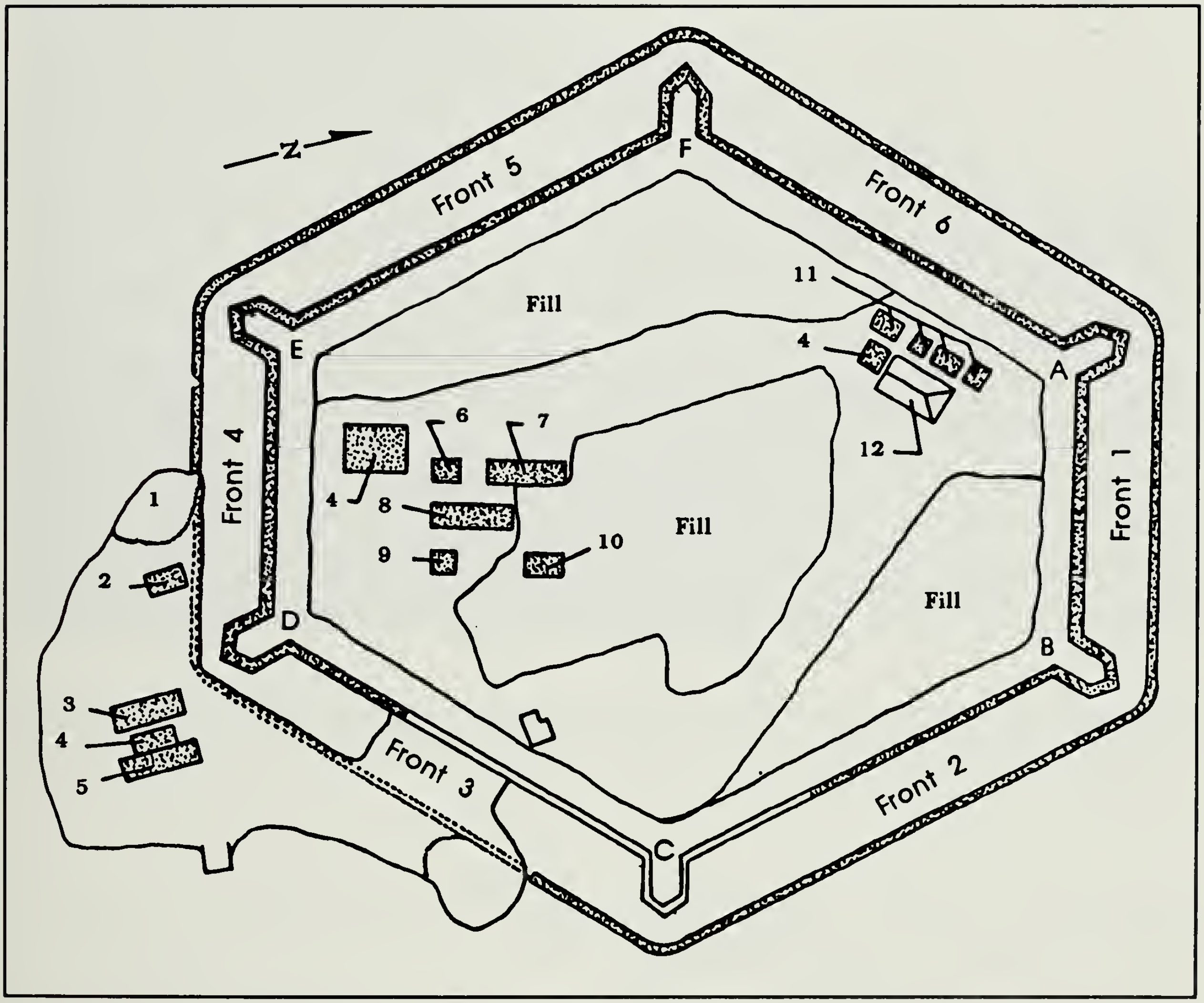
1861. Chief Engineer states no guns are at the fort; the walls are 30 ft high and the lower tier is ready for guns to be mounted (Meigs 1861a:4). On April 15, 1861, Col Harvey Brown (1861:376) listed the armament at Fort Jefferson in a letter to the Secretary and the General-in-Chief, Washington:

> 13 8-inch columbiads and a field battery, and 104 barrels gunpowder, 608 shells, 150 shot, and a vessel now at the wharf is unloading 30 8-inch columbiads and 24 twenty-four pounder howitzers with carriages, implements, complete with 250 barrels of powder 2,400 8-inch shells, 600 round shot and a proportioned quantity of fixed ammunition.

A contemporary sketch (Figure 8.2) indicates buildings at the southwestern end of the parade ground, including bakery, lime house, blacksmith and carpenter shop (Manucy 1936, from July 1861 sketch).

Recommendation was made to excavate the parade ground to 18 in below low water and backfill with "clay puddle" to low water and then "silicious sand" (Bearss 1983:185). Not clear if this was done (unlikely).

First of many alterations to terreplein barbettes (Bearss 1983:197).



1. Coral piles
2. Stable
3. Mess hall and kitchen
4. Masonry cistern
5. Workmen's quarters
6. Bakery
7. Storehouse
8. Limehouse
9. Smithy
10. Carpenter's shop
11. Kitchens
12. Officers' quarters

Figure 8.1. Fort Jefferson buildings, 1854. After district engineer's drawing 9/30/1854 (Bearss 1983).

Plate 8.3. The sally port today. The lower casemates and uncompleted upper tier and terreplein are visible. The light segments in the curtain wall are recent repairs. NPS photo by Larry Murphy.

Parade ground magazines begun (Bearss 1983:205).

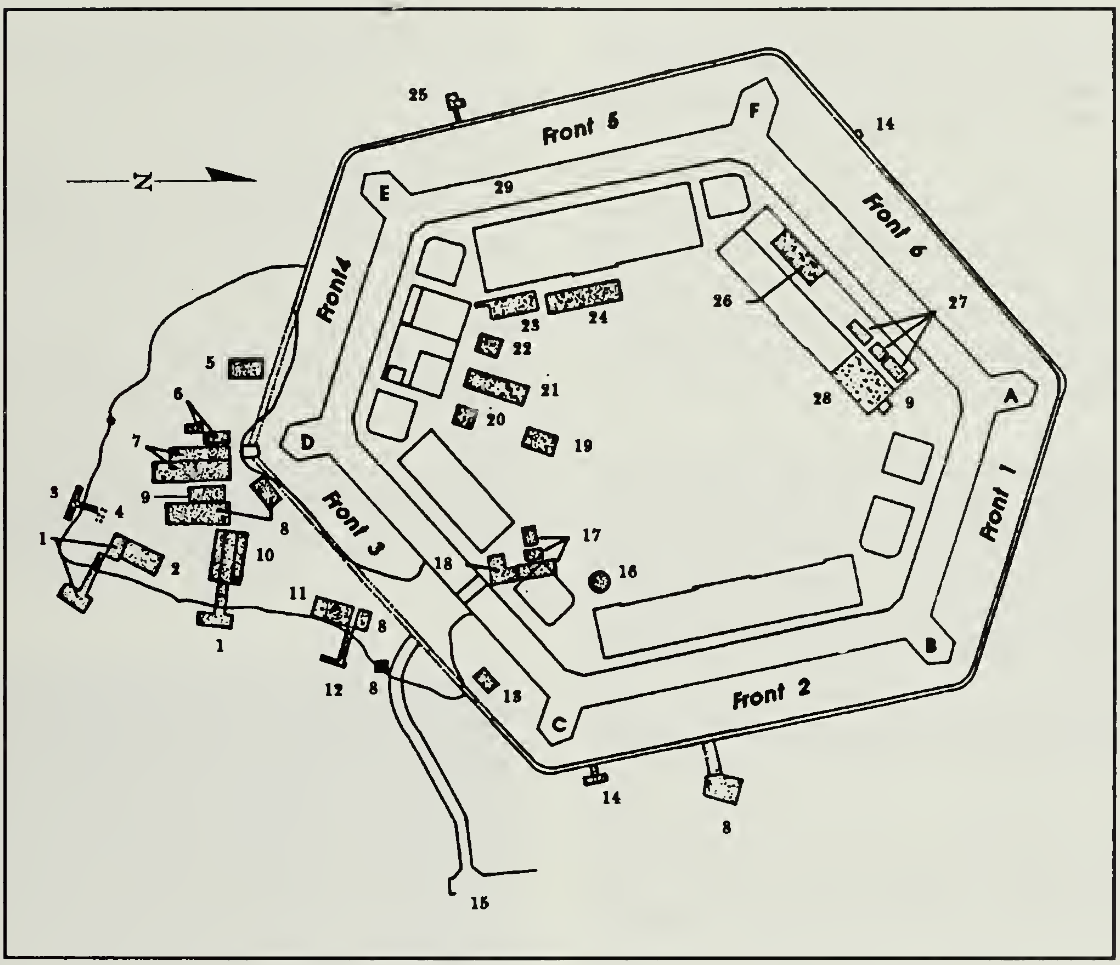
A horse railway from the wharf to the parade was approved. Small four-wheel carts were to be used with open carts and iron tanks for slop and refuse (Bearss 1983:211).

First water-distilling apparatus (made by Normandy) of 500-gallon capacity arrived from New York City, and a second soon arrived. A third of 5,000-gallon capacity is ordered (Bearss 1983:221). A Lighthall condenser reported in use in 1865. The Normandy condenser was repaired (Bearss 1983:279). These condensers were necessary because the water diverted from the terrepleins was unfit for use from lime and salt contamination.

<u>1863</u>. Several magazines and the hot-shot furnace were finished (Manucy 1943a:316). Bearss (1983:252) notes all 52 service magazines completed, as well as barracks foundations.

Stronger traverse stones were shipped. Curtains one and two were laid on bricks, concrete was specified for others (Bearss 1983:265).

<u>1864</u>. Barbette magazines on the terreplein were finished (Manucy 1943b:316). Wharfs were repaired, piles were driven and one



1. Wharf
2. Cattle pens
3. Workmen's privy
4. Saw pit
5. Hospital
6. Hospital steward's lodging
7. Engineer workmen's mess
8. Engineer workmen's barracks
9. Cistern
10. Cement house
11. Carpenter's shop
12. Small boat landing
13. Boat house
14. Soldiers' privy
15. Proposed wharf
16. Lighthouse tower
17. Lightkeeper's dwelling and kitchens
18. Soldiers' barracks (was engineer storehouse)
19. Commissary for carpenter's shop
20. Blacksmith
21. Soldiers' barracks (was limehouse)
22. Bakery
23. Soldiers' barracks (was lumber shed)
24. New soldiers' barracks
25. Lightkeeper's structure (?)
26. New lumber shed
27. Kitchens
28. Permanent officers' quarters
29. Soldiers' mess

Figure 8.2. Fort Jefferson buildings, 1861. After district engineer's sketch 8/6/1861 (Bearss 1983).

planked (Bearss 1983:253). Three steam engines driving a 20-in Worthington pump, 2 screw-pumps and 4 12-in pumps in operation in ditch dewatering (Bearss 1983:256).

1865. Sewers completed, foundation of small detached magazine laid, four barrack's kitchens and two double officers' quarters' kitchens completed. Cattle pen removed from the center of the parade to Long Key (Bearss 1983:257-258).

At the Pensacola forts and Fort Pulaski, the vulnerability of masonry forts to rifled cannon was demonstrated, so alterations to the barbettes began here (Bearss 1983:261), including preparation of bastion platforms for 15-in, center-pintle Rodmans.

1866. Wood shot-platforms built on terreplein (Bearss 1983:278).

1867. Blacksmith and two stone cutters working. The multiple storied quarters had iron floor beams. Quartermaster and commissary stores were in first-floor casemates (Manucy 1938). In that year, soil from the mainland was dumped on the parade ground to provide a garden (Manucy 1938; Report of Surgeons 1870).

Most troops were quartered in the second tier casemates that were boarded up on the parade ground side, and reached by wooden stairs leading to a makeshift landing and entry doors on the second level. The post hospital was in two unplastered rooms in the north end of the soldiers' barracks (Manucy 1938).

Company K was moved to the center of Bastion C at the eastern angle of the fort and extended over casemates north and along front two and southwest to the prisoners living in front three casemates (Manucy 1938). Company K reported quartered in the casemates on the fort's south side above the unfinished moat (Manucy 1938 from Mudd's notes on the yellow-fever epidemic).

Additional hospital quarters were set up in four casemates on the ground tier of front two, directly opposite the barracks hospital and under Company L (Manucy 1938).

Three temporary wooden buildings, a blacksmithy, paint shop and dwelling, belonging to the Corps of Engineers were planned for removal from the parade ground (Bearss 1983:293). However, these apparently remained until April 1870 when they were

Plate 8.4. Example of second tier brickwork in the communication passage. NPS photo by Randy Jonsson.

razed. At that time, the dwelling was referred to as a bakery (Bearss 1983:335).

In an attempt to combat sickness, an order was given that troops would be quartered in tents on the parade during the summer months (Bearss 1983:335).

1868. Fort privies were not being used; ones at the "margin of the shoal" are specified (Bearss 1983:298).

Sand from the 4-ft 6-in-deep ditch excavation paralleling front three and four was used to fill parapet interior (Bearss 1983:302).

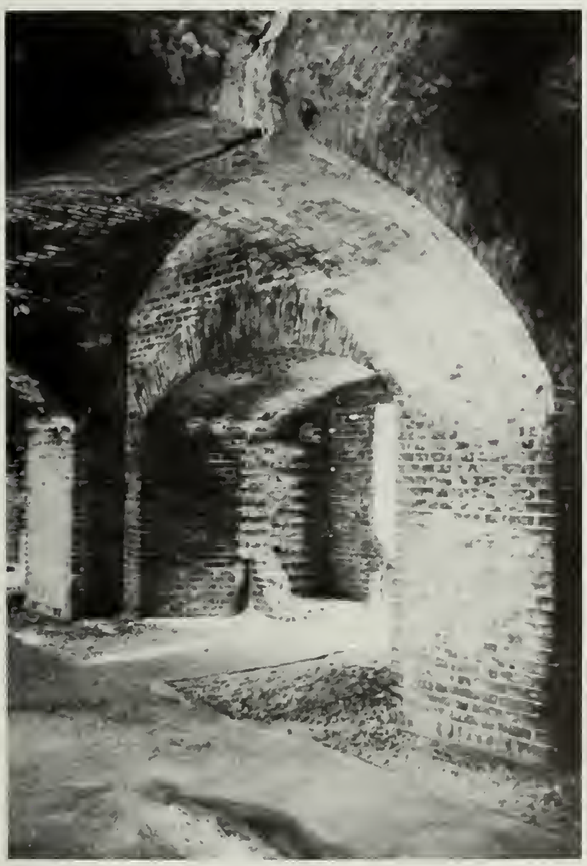


Plate 8.5. Example of second tier brickwork in casemate. NPS photo by Randy Jonsson.

1870. A plan was formulated to modernize Fort Jefferson, which would include mounting the largest possible rifled cannon to defend against modern English ironclads (Bearss 1983:319-327).

1875. Traverse magazine alterations completed. Five barbette platforms were modified for 4-in pintles for 15-in Rodmans. Eight traverse magazine roofs were embanked with sand and timbers (Bearss 1983:331).

On September 13, a hurricane damaged the 1825 lighthouse tower and toppled two officers' quarters chimneys (Bearss 1983:343).

1876. All framed buildings, except the lighthouse keeper's quarters, were removed from parade ground; the wrought-iron lighthouse was installed on Bastion C; the 1825 lighthouse tower was razed (Bearss 1983:346-347).

1878. Fifteen cartloads of rubbish were removed from privies (Bearss 1983:353).

1885. The frame building housing the condenser was in ruins; its large chimney had partially collapsed (Bearss 1983:367).

1895. The following buildings were reported in the parade ground: officers' quarters 44 ft x 288 ft, barracks 38 1/2 ft x 337 ft, lighthouse keeper's quarters, ordnance-sergeant's quarters, an unfinished magazine and numerous kitchens (Bearss 1983:385).

1912. A fire burned the lighthouse keeper's quarters, outhouses and Marine (enlisted) barracks. The fire may have begun in the keeper's outhouse (Snell 1983:421; Manucy 1943b:330).

1913-14. Bureau of Supplies was given authority by the Secretary of the Navy to sell all condemned property at Garden Key, except for 10 large cannon, which had been sold by the Bureau of Ordnance prior to the last Navy takeover. The contractor for the condemned property was Boston Iron and Metal Company, which removed items selectively and left the remainder as junk (Snell 1983:423).

1915. Several thousand bricks from the enlisted barracks' (burned in 1912) kitchens were taken to the Key West Station (Snell 1983:424).

1916. Public Works Officer's report lists a two-story brick building 31 1/2 ft x 20 ft 3 in with a wood kitchen 31 1/2 ft x 11 ft and two smaller brick buildings in poor condition (Snell 1983:425).

1934. Salvage of fort's metal was being done by Sherman Adler and M.B. Bostwick, who apparently employed 50-75 men camped at the fort for about 60 days. Plans were to salvage between 800-1,000 tons of scrap for sale in the US and Europe (Key West Citizen June 14, 1934).

Activities, Structures and Features Outside the Fort

1846. Horatio Wright and George Phillips built a temporary shelter on Garden Key (Manucy 1943a:307).

Materials were ordered for eight temporary buildings, but the firm went bankrupt before they could be delivered. Materials were rebid. Buildings included a blacksmith shop, carpenter shop, barracks, kitchens and mess room, bakery, stable and storehouse (Manucy 1936, from Annual Report of Operations 1847).

Midsummer 1846. Materials and workmen arrived to construct temporary buildings under contract. Five buildings were completed by September: Carpenter's shop, blacksmithy, limehouse barracks, and combination mess hall and kitchen. The bakehouse was missing its large boiler kettle, the stable's upper floor and weatherboarding had not been finished, only the storehouse frame was up, and 5 of the 22 wooden cisterns were not positioned (Bearss 1983:31,35,45,123). Dimensions of these buildings were:

- 2-story storehouse, 80 ft x 25 ft - burned May 15, 1857 (Bearss 1983:172).
- 1-story lime and cement house, 80 ft x 25 ft
- 1-story carpenter's shed, 40 ft x 25 ft
- 1-story blacksmithy, 25 ft x 25 ft
- 1-story bakery, 25 ft x 30 ft
- 2-story stable, 40 ft x 25 ft
- 2-story barracks, 80 ft x 25 ft, 4 rooms
- 1-story mess hall and kitchen, 75 ft x 25 ft, kitchen in the middle of the structure, with the mess tables in either end to separate mechanics and laborers.

1848. A 34-ft x 28-ft pierhead was built, rebuilt in 1853 and in service through 1855 (Bearss 1983:95).

1849. Excavation of counterscarp, which went to 6 1/2 ft below water level, began (Manucy 1936). Planks, 2 in thick and 5 ft long were used for sheet piling during construction of counterscarp. Pumps and windmills were used for dewatering. A steam engine and rotary pump were received for dewatering (Bearss 1983:102-103).

1850. Quarters completed, including a three-story section 66 ft x 44 ft and three detached kitchens (Manucy 1936).

1851. First concrete poured in the foundation of the main walls (Manucy 1943a:308). A cofferdam and wind-powered pumps were used to dewater the ditch.

1852. Chapel foundation completed and used as a cistern (Manucy 1936). An enrockment was placed along the weather-front breakwater (front 5), which was undermined in a hurricane (Manucy 1936; Bearss 1983:106). Funds ran out in May. Before then, a shed was erected over the steam engine and boiler (Bearss 1983:92), location unknown.

The foundations of Bastions A, B and F and curtains 1 and 6 were constructed and faced with a "very superior quality of hard-burned, pressed bricks" from North Danvers, Massachusetts (Bearss 1983:115).

1854. Two cisterns built, each 40 ft x 6 ft x 6 ft and positioned outside the fort, one between the temporary barracks and kitchen, the other at the rear wall of the officers' quarters. These cisterns used some existing foundation walls in their construction (Bearss 1983:125-126).

1855. Grillage (a construction of timbers and crossbeams forming a foundation support in sandy soil) and foundations for the fort wall piers were begun. The sewer was begun, mess hall kitchens and an old stable enlarged and adapted as quarters for workmen. A new wharf extended from front two (Manucy 1936). A bridge was built from the parade through the casemate for a plank roadway. This new pierhead was 40 ft x 30 ft, with a 12-ft approach (Bearss 1983:95).

The counterscarp had only one gap, on front two, which was used to facilitate landing lumber on the parade ground (Bearss 1983: 104).

1857. The storehouse burned with an estimated loss of $7,000 (Manucy 1936).

A frame one-story building was built near the mess hall for use as a store (Bearss 1983:173).

1861. A contemporary description indicates that some wooden buildings were located outside the fort to the south. These structures included the workmen's barracks, kitchens and mess room, storehouse and stable (Manucy 1936 from photostatic sketch dated July 1861) (Figure 8.2).

A proposal made to build a concrete wharf to mount an iron crane, which had been obtained earlier (Bearss 1983:186). It is not clear if this was done.

A boathouse was constructed for protection of engineers' boats (Bearss 1983:224).

Recommendations for batteries to be erected on several keys were made, but were apparently cancelled, however, this is not clear (Bearss 1983:219-220).

A letter from Col H. Brown to Maj L.G. Arnold (1861a:371-2) reveals orders to reinforce the Tortugas Harbor with Navy vessels and build temporary shore batteries, each containing at least three pieces of heavy caliber artillery in closed works containing bomb-proof magazines. Sufficient garrison shelter was to be provided (temporary sheds of lumber) with the guns *en barbette*. Construction would be of material at hand, sand and fasces or gabions. Probable occupation sites are Bird Key, Sand Key, Loggerhead Key, East Key, Middle Key and Bush Key. Work was to begin immediately, prior to approval of plans, with the first site Bird Key. Brown ordered 20-24 heavy guns with barbette carriages and platforms of timber for these batteries (Brown 1861:372). The documents are not clear as to what extent any of this construction was actually done.

1862. Walls were completed to 50 ft high (Manucy 1943b:315). A shed near the parade ground center used to store hundreds of lime barrels, burned. Afterward, trenches along parade fronts one, five and six were dug and used to slake the salvaged lime, which was at least partially utilized (Bearss 1983:284).

1865-66. A large construction crew was present using about 50 barrels of cement a day. About 70 percent of the delivered bricks were rejected (Bearss 1983:288).

1869. Spoil from ditch excavation of fronts three and four was dumped on the parade ground or over the counterscarp (Bearss 1983:307). The wharf was repaired, and included a 100-ft walkway and a 70-ft x 50-ft building containing a slaughter house (Bearss 1983:332).

1870. On October 20, 1870, a hurricane wrecked two government boats, carried away two small wharves. The 100-ft walkway leading to one of the wharfs was damaged. The slaughter house and enlisted men's privy was carried to sea, casemate laundress' quarters wrecked, the coal pen damaged and 25 tons of coal were lost (Bearss 1983:333).

Recesses were cut into the breast-high wall on the parapet to accommodate full traverse chassis for 10-in Rodmans. Eleven eccentric traverses placed on temporary wood platforms (Bearss 1983:311).

1871. An Andrews pump was in use for dewatering the ditch west of sally port (Bearss 1983:314).

1872. Counterscarp was completed and water began circulating around the fort (Bearss 1983:316).

1873. On October 6, a hurricane damaged parade ground buildings, including tearing off barracks roofs, destruction of hospital kitchen, bakehouse and oven were damaged, enlisted men's sink outside the fort was swept away, as was the cattle pen, slaughterhouse and stable (Bearss 1983:318).

Presence of yellow fever prompted a report that buildings outside the fort near the wharfs should be demolished. Six buildings were razed in 1874 (Bearss 1983:337-440)

1878. A visiting general recommended that the military burials on Bird and Sand Keys, along with the single Garden Key burial be removed to Fort Barrancas National Cemetery (Bearss 1983:355). It is not clear if this was done.

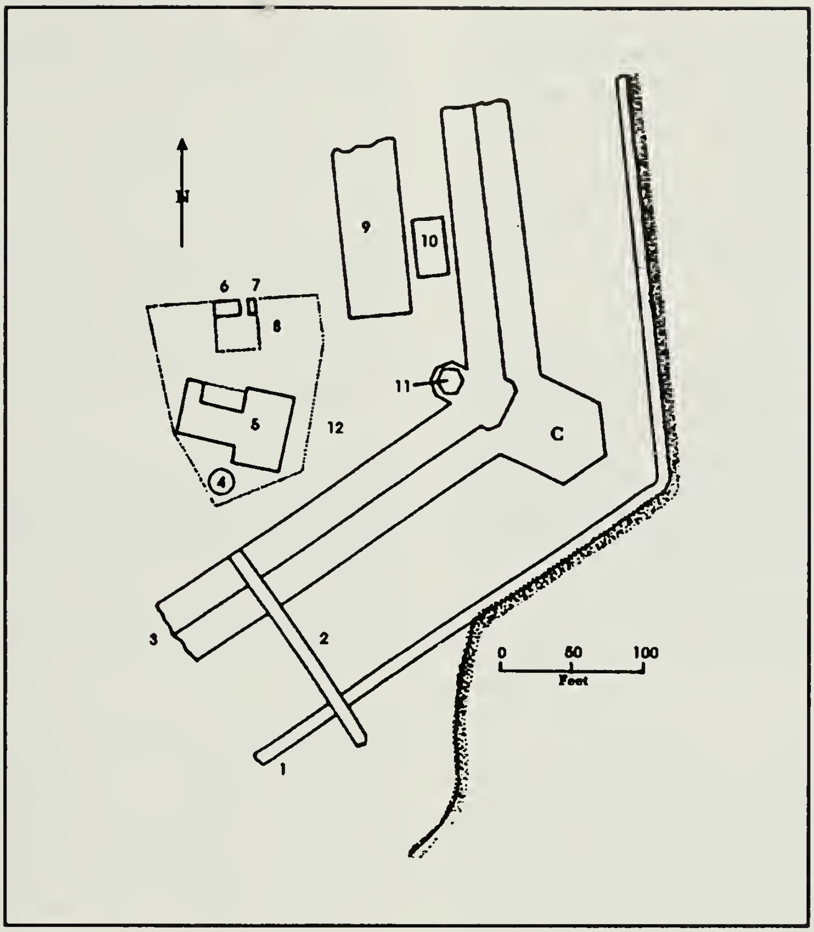
1883. Although the fort mounted 132 guns, it was pronounced defenseless against ironclads (Bearss 1983:361).

1886. Wharf noted as deteriorated and unsafe, six Rodman platforms were useless, the sally port doors could not be moved because of rust (Manucy 1938:326; Bearss 1983:361, 370).

An August hurricane damaged buildings, piazzas were torn off, walkways accessing the parapet magazines were blown down and the wharf was nearly destroyed (Bearss 1983:374).

1887. Holden (1887) mentions "an old abandoned building which once bore the name of Hospital, but latterly it was more like a curiosity shop. Quaint old balconies and verandas were on the old hospital and away up in the peak or gable end was a balcony look-out." Parade ground features and structures present in 1887 are depicted in Figure 8.3.

Only one building, a shed, was standing outside the fort (Bearss 1983:375).



1. Counterscrap
2. Walkway
3. Wall
4. Brick cistern
5. Keeper's dwelling (wood)
6. Chicken house
7. Privy
8. Fence
9. Hospital quarters (brick)
10. Kitchen (brick)
11. Light tower (iron)
12. Fence

Figure 8.3. Light station buildings. Surveyed March 5, 1887 (Bearss 1983).

1888. A storm collapsed a 15-in Rodman platform on the parapet (Bearss 1983:376).

The Lighthouse Service erected a wharf, buoy and blacksmith sheds on a spit west of Engineers' Wharf (Bearss 1983:376). The location of these structures is in Figure 8.4.

1889. Army transferred the fort to the Treasury Department. Excluded were the lighthouse tower, keeper's quarters, lighthouse wharf, buoy and coal sheds (Bearss 1983:379). Quarantine station was established, sulphur fumigation and steam disinfecting equipment, tents for soldiers, a new wharf and a warehouse were constructed (Manucy 1943a:327). The lighthouse keeper and family were housed in a parade building near the sally port. The quarantine shed was 100 ft long (Bearss 1983:382)

Shot and shell were sinking into the parade ground (Bearss 1983:378).

1892. 120-ft x 32-ft wharf was built and connected to the fort by a bridge near the sally port. The wharf was covered by a 120-ft x 24-ft shed containing a steam chamber and disinfecting plant that included a 30,000-gallon tank, storeroom, sulphur furnace, boiler fan and engine. There was also a 2,500-gallon tank to wash vessels in mercury bichloride and a hoist for ballast and coal. A site was cleared for a 250-ton coal bin, and car and rail for coal transport (Bearss 1983:383-384).

1894. A 150-ton coal shed was erected on the wharf gangway. A diver, the first recorded at work in the Dry Tortugas, cut away the pilings of the lighthouse wharf, which collapsed in 1893 (Bearss 1983:384).

1895. The following structures were reported outside the fort: near the 1894 coal dock was a frame coal shed, formally a carpenter's

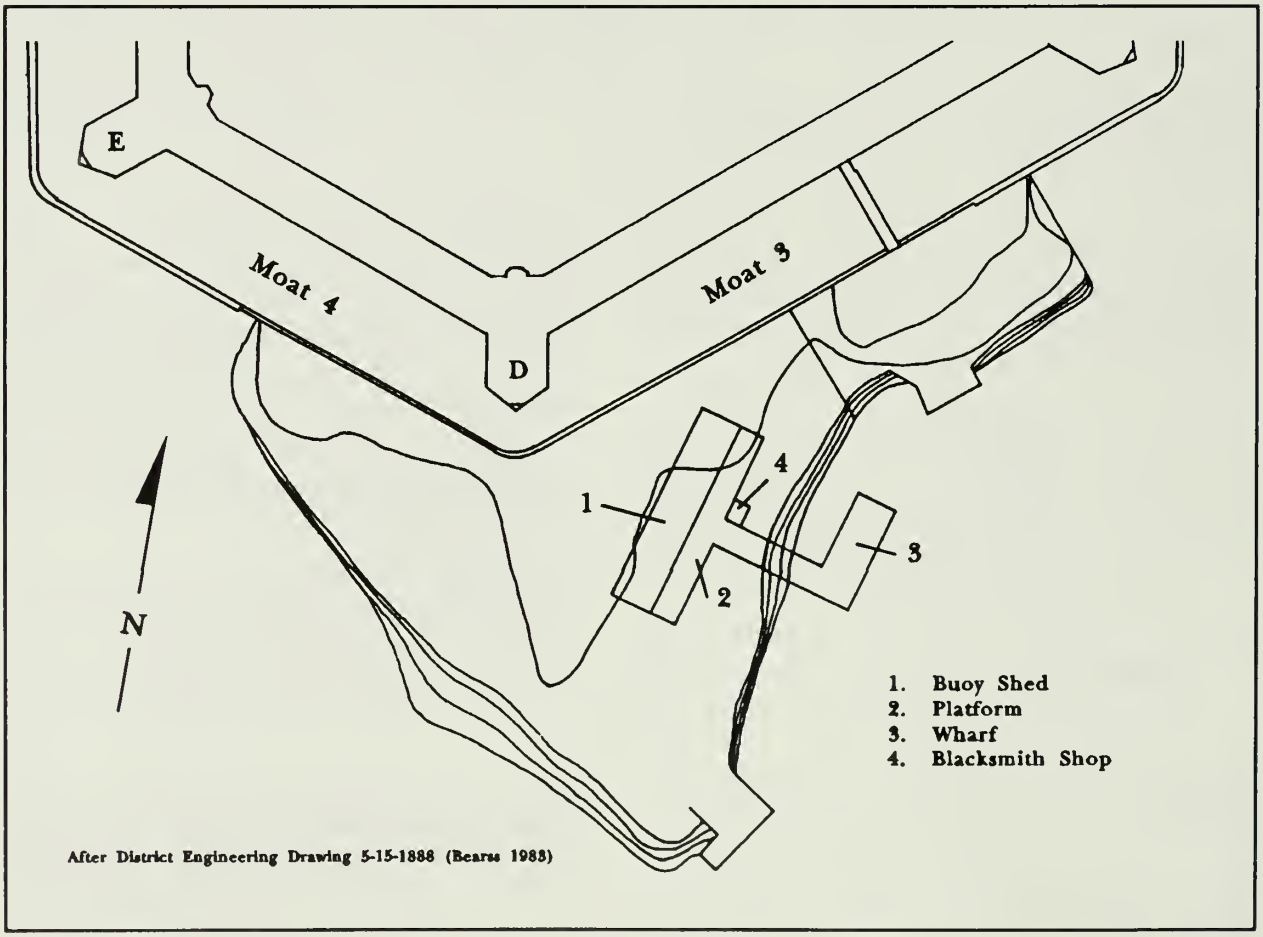


Figure 8.4. Location of lighthouse establishment structures. After district engineer's drawing May 15, 1888 (Bearss 1983).

shop, concrete cistern on the southeast spit, a 50-person dormitory for the disinfection crew 50 feet from the drawbridge (Bearss 1983: 386).

Mooring piles were placed in front of the wharf, the carpenter's shop foundation was renewed, the 18-ft x 36-ft cistern was serviced, 500 ft of 1 1/2-in galvanized pipe were taken from the parade cistern to connect the Engineers' cistern and wharf tank (Bearss 1983:386).

1898. A cable was laid between Garden Key and Key West (Bearss 1983:389). US Navy reported using the harbor for the "White Fleet." Twenty-three naval vessels in and out of Tortugas Harbor (Manucy 1943b:329).

The two moat openings were opposite the southeast bastion or between it and the quarantine wharf, and the other was at the northwest angle of the wall. These were gated in 1898. A steam launch could enter the western opening (Snell 1983:427).

1899. Channel dredging and construction began on coaling docks. Marines were stationed and camped in tents on the parade ground. A new condensing plant was finished capable of distilling 60,000 gallons a day. Wireless antennae masts were installed (Manucy 1943a:329). Extensive dredging allowed vessels drawing up to 30 ft to approach the wharf (Bearss 1983:393).

The Union Bridge Company, the Alabama Bridging and Jetty Co. and Babcock and Wilcox Co. were engaged in various contracts (Bearss 1983:393). The Union Bridge Co. and Brown Hoisting and Conveyor Machine Co. were the prime contractors (Snell 1983:408).

1900. Dry Tortugas transferred to the Navy, which requested the quarantine station be removed (Bearss 1983:394; Snell 1983:407).

All the Bureau of Yards and Docks' construction records of the Dry Tortugas Coaling Station were destroyed (Snell 1983:408).

1901. July, the Dry Tortugas Coal Depot was completed and turned over to the Navy Bureau of Equipment for operation (Snell 1983:409).

1902 All ordnance removed except for 11 guns: 8 24-pounders, 1 6-pounder, 1 24-pounder, 1 10-pound mortar (Snell 1983:412).

A distilling plant was completed (Snell 1983:413).

1904. A hurricane damages coal docks. Dredging ceases (Manucy 1943b:330). Between August 1898 and March 1906, $318,624 spent on dredging (Snell 1983:409).

1904-1912. Coal depot received 19,984 tons of coal (Snell 1983:410).

1905. Distilling plant removed to Guantanamo, Cuba (Snell 1983:415).

1907. Coal depot operations ceased (Manucy 1943b:330).

1910. October 14-17 hurricane damaged coal docks, including breaking up the blacksmith shed, levelling wharf sheds, tearing up the approach to the north dock and bringing down the Weather Bureau tower. The north pier jetty was gone, the south jetty missing sections (Snell 1983:416-417).

1916. The south coal shed may have been removed to the Philadelphia Navy Yard. Weight of material was estimated at 400,000 pounds (Snell 1983:426).

1917. Wireless station reestablished (Manucy 1943b:331).

1935. Fort Jefferson transferred to the National Park Service as a national monument (Manucy 1943a:331).

Fort Jefferson Construction Supplies

The freight rates from the southern ports were high in relation to northern rates. In 1854, the overseer remarked in the Annual Report of Operations that there was a scarcity of freighters handling lumber and bricks (Manucy 1936). One obvious problem is that vessels bringing supplies to the fort had to return empty (Bearss 1983:65).

Early in 1847 lumber, iron and other supplies came from Mobile (Manucy 1943a: 310). By September, stockpiling of materials had begun for the permanent structures, including stone, lime cement, glass, iron, etc. (Bearss 1983:46). Little more than bricks and lumber was available from southern suppliers (Manucy 1936).

Bricks

1847. Northern bricks had been used in the officers' quarters (Bearss 1983:67).

1850. Supervising engineer visited Pensacola and Mobile brickyards. He found the Pensacola bricks superior and recommended their use for exposed surfaces, with northern bricks forming rear courses next to the concrete core (Bearss 1983:66-67).

1851-2. North Danvers, Massachusetts, bricks used for Bastions A, B and F and curtains 1 and 6 (Bearss 1983:115).

1853. The first order for southern bricks was placed. Companies in Pensacola (particularly Bacon and Abercrombie), Mobile, New Orleans, Charleston and Savannah pressed millions of bricks for the fort before the Civil War (Manucy 1836; 1943:310). Bearss records first contract with Abercrombie and Raiford, Baldwin County, Alabama, in 1854 for bricks of 90 cu in of Escambia clay, shaped bricks began the same year. Benner and Tift of Jacksonville received a contract in 1854 (Bearss 1983:74,77).

Pensacola bricks averaged 90 cu in, whereas northern bricks averaged less than 60 cu in (Bearss 1983:73).

1859. Machine-made bricks were attempted by Bacon and Abercrombie, but the experiment was considered a failure (Manucy 1936; Letter, Bacon and Abercrombie to Lt H.G. Wright April 14, 1859). The principal producer was the Pensacola firm.

February 1861. Bacon and Abercrombie notified fort of refusal to supply any more bricks and lumber. Danver, Massachusetts, bricks were unsuccessfully sought; a Brewer, Maine firm supplied some, two million were ordered (Bearss 1983:226-227).

Cement

Cement came from, or at least was shipped from, New York (Manucy 1943b:310).

1861. 21,000 barrels ordered (Bearss 1983:228).

Stone

Granite came from New York (Manucy 1943b:310) and Vermont (Manucy 1936; Annual Report of Operations: Fort Jefferson Material Book pp.3, 5, 34, 36, 58, 61, 77-116).

1855. Flagging for casemate floors, 3-6 in thick, was specified. Orders for flagging and granite traverse circles arrive in 1856 (Bearss 1983:134,152,157). Flagging was laid 16 ft from the scarp in the lower casemates by 1859 (Bearss 1983:154).

Granite tongue-hole lintel stones for casemate guns were ordered; pintle holes would be drilled on site (Bearss 1983:135-136). Granite sole stones, which sit atop the lintel stones were specified for embrasures (Bearss 1983:165). Apparently, these began arriving in 1856.

1863. 150 stones shipped to reinforce traverse stones (Bearss 1983:265).

Lumber

1849. Moody and Byrne of Jacksonville supplied lumber (Bearss 1983:65).

1850-51. Lumber was supplied by Moody and Boultier of Jacksonville. They received the 1853 contract but were unable to deliver. Two of their vessels chartered to transport lumber were lost at sea, location unknown (Bearss 1983:71).

Iron

1856. Decision was made to add Totten iron-and-brick embrasures to third system forts (Bearss 1983:163). The embrasures had wrought iron around the opening and were faced with 3/8- or 1/2-in boiler plate 9 in wide. Embrasure irons were received and being positioned by February 1858 (Bearss 1983:169).

1861. Irons for 2 30-ft long hot-shot furnaces were ordered (Bearss 1983:215).

1862. Iron ordered for casemate traverse irons, 6 in wide, 1/2 in thick with a radius of 16 ft 9 1/2 in (Bearss 1983:229).

1863. Iron beams used in upper floors of barracks (Bearss 1983:251). One-inch thick iron used for 15-in Rodman traverse circles on bastions (Bearss 1983:266).

Lime

In 1851, lime was used in all mortar above the lower tier level, not less than 1 barrel of lime to 1 of cement, in large masses it was 2 barrels (unslaked) lime to 1 of cement (Bearss 1983:84).

Coral Aggregate

Collected at low tide on the outlying reefs in scows of 375 cu ft capacity (Bearss 1983:211).

Armament

April 25, 1861. Four mountain howitzers with prairie carriages and ammunition taken aboard ATLANTIC for Fort Pickins (Meigs 1861a: 395).

1873. Some 15-in Rodmans mounted (Manucy 1943a:326).

January 1887. Eleven 10-in Rodman guns received, but none mounted. Unmounted guns on hand: 33 10-in Rodmans, 12 24-pounders, 1 10-columbiad, 6 18-pound howitzers,4

300-pound Parrotts and 2 24-pound howitzers (Manucy 1938).

Various Occupations, Including Prisoners and Regiments Documented at Fort Jefferson

Before 1846. Cuban fishermen collected thousands of bird eggs here (Annual Report of Smithsonian Institution 1917:473-477).

May 1846. Eleven slaves hired from their owners by supervising engineer (Bearss 1983:44). Slaves were used for labor until 1863. The Emancipation Proclamation of September 1862 did not apply to US Government territory, which included Key West and Dry Tortugas (Bearss 1983:281).

1847. Rules promulgated preventing direct contact with fishing boats for health reasons. Quarantine was required in the outer harbor. No person was to land without permission and all personal property had to be removed from the islands. No one was allowed to build any structures, and the Tortugas Islands could not be used for drying, salting or curing fish (Bearss 1983:56-57). Presumably, some of these activities had been going on.

1853. Forty-six people on the roll, including 15 white laborers and 17 black laborers (Bearss 1983:62-63).

1854. Rolls indicate no more than 60 people at Garden Key for the summer (Manucy 1936). One death from yellow fever, burial unrecorded (Bearss 1983:54).

1857. Number of workers doubled, high point in numbers of construction workers before 1861: 299 workers in December, including 148 white laborers, 58 slaves, 68 masons, 7 carpenters, 2 smiths, 2 stone cutters, a physician, overseer, 8 crew and 4 utility men (Manucy 1936 from letters to General Totten). Principal white laborers were Irish (Manucy 1936).

1860. Apparently, all Union soldiers arrived after December 1860. In a December 23, 1860, letter to President Buchanan, Gen Winfield Scott, stated: "There is only one feeble company at Key West for the defense of Fort Taylor, and not a soldier in Fort Jefferson to resist a handful of filibusters or a rowboat of pirates" (Shinn 1910:5).

January 1861. Sixty-six officers and men of the 2nd US Artillery, C Company arrived from Fort Independence, Boston aboard JOSEPH WHITNEY (Bearss 1983:183).

September 4, 1861. Fifty-Three soldiers charged with mutinous conduct from the 13th and 79th New York Infantry Regiments arrived aboard WILLIAM H. WALL (Bearss 1983:231).

Average wartime complement was about 500, peak population during this period was 1,400 (Manucy 1943a:314-315).

April 1861. Two companies from the 6th New York, Wilson Zouaves, arrived at the fort (Shinn 1910:12). Their uniforms were burned, and they were given regular uniforms (Shinn 1910:21).

July 1861. B and E Companies from the 1st US Artillery arrived (Shinn 1910:12; Bearss 1983:223). Company K, 1st Artillery leaves for Fort Pickens.

September 1861. The first prisoners (33) arrived (Manucy 1943a:316).

1862. One thousand men manned the fort (Manucy 1943b:314)

1863. One hundred free blacks were recruited from New Orleans (Bearss 1983:281).

1865. Eight hundred eighty prisoners at the fort (Bearss 1983:283).

1866. Arrival of 82 US Colored Infantry to replace the 110th New York garrison (Bearss 1983:259).

1867. There were 113 prisoners, 345 soldiers and officers of Companies D, L, K, M and I of the 5th US Artillery present. In March, 50 prisoners were released and D Company was transferred. Number of prisoners averaged about 50 for the year, average of 15 in engineer force. Entire force was about 400 for the year (Manucy 1938; 1943:321).

Thirty-Eight people died during yellow fever epidemic. Their burial place is unknown (possibly Sand Key) (Manucy 1938).

1868. Only two companies of artillery present (Bearss 1983:296).

1869. Four companies of the 3rd US Artillery replaced the 5th Artillery (Bearss 1983:305).

1873. Fourteen deaths from yellow fever were recorded (Bearss 1983:336). The burial place is unknown.

1878. Two companies of the 5th Artillery sent to Fort Jefferson to escape yellow fever outbreak in Key West (Bearss 1983:357).

1880. Only War Department personnel at the fort were the keeper and ordnance sergeant (Bearss 1983:359).

1887. "Garrison consists of four companies of the Fifth US Artillery...prisoners quartered in the casemates above the moat. The sally port is the only entrance; and here is a draw bridge and heavy gates, over which are the cells where the [Lincoln assassination] conspirators are incarcerated" (Holden 1887).

1888. Army left the fort (Bearss 1983:376).

1898. Companies A and C, 5th US Infantry, occupied Fort Jefferson and camped in the parade ground (Bearss 1983:390).

1901. Marine guard was in place for Coal Depot security. This was reduced to a "sergeant's guard" in 1905 (Snell 1983:411, 414).

1906. All but two Navy personnel were withdrawn (Snell 1983:415).

1912. Lightkeeper and family left Garden Key after a fire destroyed their quarters (Snell 1983:422).

1934. Fifty to seventy-five men involved in metal salvage operations at the fort for 60 days (Key West Citizen 6/14/1934).

Botanical References

At the time the fort was used as a prison, there may have been few plants. Samuel Arnold, one of the Lincoln conspirators, reported: "On our arrival the island was entirely destitute of vegetable matter, with exception of some few bushes of small growth, natural to the soil, and about a dozen Cocoa nut trees planted many years back" (Manucy 1943b:95). There were date palms, guavas, tamarinds, oleanders and gumbo limbo trees (Anon. 1941:6).

Plants Mentioned in 1868

An early description of the fort (Anon. 1868, which was reprinted in Century magazine in 1887) gives an idea of the interior appearance:

> 2 coconut palms at early lightkeeper's house, upon entering the fort, the stander is surprised to see a pleasant parade-ground of fine Bermuda grass... and large groups of evergreen mangroves and buttonwoods. Towering above all are the elegant plumes of the cocoa palm...and as we approach headquarters, a beautiful group of mangroves is seen, furnished with shady seats and lounging places where the ever acceptable hammock swings invitingly ...
>
> Across the parade ground is a cottage, vine-clad and cozy ...any time of the year is the same display of rich foliage and flowers...jasmines, Thunbergias, morning glories and cypress vies. ...four-o-clocks are quite like shrubs...at the end of the veranda [of the cottage on across from the officer's quarters] is a group of splendid bananas...on the brick wall of the house is the night-blooming cereus...here is a banyan or wild fig... on the fence grows one of the curious "air-plants" -orchids...Gum-trees, castor-oil plants, date palms and the curious palm-like tapioca plant are here...those large clumps of maritime lilies are perfectly at home in the salt sand-soil and give confidence to the tender gladiolus and crocus and dyeletras. ...marigolds, larkspurs and hollyhocks have been cheering us all winter, the great vine that covers much of the cottage is an Ipomoea - is a native here and is surnamed Bona Nox or good-night [Holden 1887].

"Pusly" grew in unfrequented places inside the fort and was used as a vegetable (Manucy 1938).

Faunal and Food References

Ponce de Leon reported to have killed 170 turtles, 14 seals, and sea birds and eggs (Sauer 1971:27; Manucy 1936).

A canary, rabbits and a goat were mentioned (Holden 1887). Two mules (Arnold 1861:347). Cattle were brought for Punta Rassa, near Tampa. A full-grown bullock seldom dressed 300 pounds of meat; fresh meat averaged 3 issues in 10 days. Ration records for 1861-68 record beef, ham, pork, cans of lobster, clams and oysters, flour, corn meal, hominy, beans, rice, dried apples, cans of milk, potatoes, tomatoes, peas, onions, assorted cans of preserves, syrup and molasses, brown and white sugar, salt, pepper, vinegar, ketchup, hops, lard, coffee and tobacco (Manucy 1936; 1943:321-322).

Mosquitos were a problem after fort construction; they bred in the cisterns (Manucy 1938).

Draft animals were used to raise concrete in wheelbarrows to the terreplein (Bearss 1983:211).

EAST KEY

Captain Benner, the Tortugas lightkeeper is reported to have recovered "something over a thousand dollars of silver money at East Key" (Holden 1887).

BUSH KEY

1846. The first supervising engineer noted that the eastern and northern shores of Bush Key would be a good source of coral aggregate. By at least 1848, crews were boating coral from the island (Bearss 1983:58).

Beginning in early 1850. Whenever laborers were not otherwise engaged, they boated coral from Bush Key. Four scows, each handling 448 cu ft per load were used. It took seven laborers all day to collect one load (Bearss 1983:42, 58).

By 1854. Most of the coral had been collected from this key (Bearss 1983:42,78-79).

There is mention of a "slaughter house on the key opposite the fort" (Holden 1887), which is most likely Bush Key.

SAND KEY - HOSPITAL KEY

1846. Lieutenant Wright, first supervisor, notes that the best sand for mortar was found on Sand Key (Bearss 1983:42).

1862. A hospital was built to isolate small pox patients. It was a "little shack" with the capacity of only 10 patients. In 1867, three tents were pitched there to accommodate 26 yellow fever victims (Manucy 1938).

1867. On September 1, a hospital was reestablished on Sand Key in the frame structure that had housed patients in 1862. This was discontinued by Dr. Mudd, who moved patients to the four lower gun tiers behind the barracks (Bearss 1983:291). Hospital abolished by Dr. Mudd during the yellow fever epidemic of 1867 according to Samuel Arnold, one of the Lincoln conspirators incarcerated there at the time (Manucy 1943b:99).

1872. Graves of yellow fever victims may have been on Sand Key (Manucy 1943a:325).

BIRD KEY

1861. A frame isolation hospital was built on Bird Key (Bearss 1983:225).

A lunette-shaped earthwork with its principal face parallel to the northeast front of Fort Jefferson is built on Bird Key (Bearss 1983:224).

1862. Forty soldiers quarantined with small pox in hospital (Bearss 1983:225). Although plans were produced for a permanent fort on Bird Key, none was begun.

1866. "Scattered graves of Union soldiers who have died at this post during the war" noted, and hogs were transferred from Long Key (Bearss 1983:258).

1867. Company L moved there from the fort September 4 during yellow fever epidemic (Manucy 1938).

1895. A 30-ft x 34-ft hospital, 8-ft x 16-ft kitchen and 6-ft x 10-ft outhouse was constructed as a lazaretto, but was not fully equipped until 1897 when a small landing and boardwalk were added. A seaman died in 1898 (Bearss 1983:387-389).

1899. A small "hurricane-proof" hospital was built at the lazaretto (Bearss 1983:393). This structure may have had a solid concrete foundation and could be the foundation visible in Plate 12.21.

LONG KEY

Most of the sand used in the concrete and brick masonry was boated from Long Key because of its superior cleanliness (Bearss 1983:78). Sand was used to fill the Fort Jefferson parade in 1854 (Bearss 1983:127).

1856. "About half of Long Key" washed away in the hurricane of August 27-28. Several hundred feet disappeared from the western end and a 600-700-ft cut was opened in the center. A flat boat was lost (Bearss 1983:171).

1866. Hogs transferred to Bird Key. Cattle pen removed from parade ground and relocated on Long Key (Bearss 1983:258).

VESSELS INVOLVED DIRECTLY WITH THE TORTUGAS

ACTIVA. 112-ton schooner, sailed from New York in 1846 carrying the first expedition to Dry Tortugas to begin fort construction (Manucy 1936). ACTIVA was purchased by the Corps of Engineers (Bearss 1983:38). The master purchased many items for fort construction (Bearss 1983:62). The vessel was recoppered in 1850 in New York City (Bearss 1983:52). This vessel apparently supported Fort Jefferson activities until 1856, when it was lost near the Marquesas Keys (Manucy 1936). Bearss (1983:171) reports ACTIVA was at anchor in the Marquesas' lee at the storm's beginning, but parted anchor and sailed for Fort Jefferson during the hurricane of August 27-28, 1856. The vessel was lost in sight of Garden Key light (most likely within the monument's waters).

ATLANTIC. US transport steamship that served as headquarters for Col Harvey Brown in 1861 of Key West (Brown 1861:371-372).

B.K. EATON. While en route from New York to Dry Tortugas with 1,046 cement barrels and 1,047 lime casks, burned by Confederate privateer (Bearss 1983:229).

CRUSADER. US steamer brought reports to the fort from Mobile in 1861 (Meigs 1861b:5). Conveyed personnel between the fort and Key West (Arnold 1861:347).

DAGMAR. Steamer purchased by Marine-Hospital Service for support of the Fort Jefferson station in 1892 (Bearss 1983:383).

FOSTER. Steam tug that replaced DAGMAR in 1894 (Bearss 1983:385).

HORACE BEALE. Towed by JOSEPH WHITNEY while bringing armament to the fort (Arnold 1861:347; Shinn 1910:10).

J.C. CHAMBERS. Grounded on a shoal near Southwest Key on February 14, 1862 and released the next day (Bearss 1983:232).

JOHN HOWELL. A schooner burned en route to Fort Jefferson [location unknown] with 49,000 bricks and 389 barrels of lime. $15,000 in gold had been recovered by the survivors (Bearss 1983:64).

JOSEPH WHITNEY. Steamer (Meigs 1861b:1) brought personnel to fort in 1861. Brought six 8-in columbiads, four field pieces and ammunition to the fort in January 1861 from Ft. Taylor (Arnold 1861:347). This vessel was owned by the Merchants and Miners Transportation Co. of Boston and chartered by US Government for troop transport (Shinn 1910:6). The vessel cleared Boston January 14 for the Tortugas carrying two companies of troops, 750 barrels of provisions and 320 tons of coal.

MACEDONIA. Sloop-of-war, landed at Fort Jefferson January 29, 1861 (Shinn 1910:10).

MARIGOLD. Steamer. Part of the East Gulf Blockading Squadron cruising northward and eastward of the Tortugas in 1863 (Bailey 1863:531).

MATCHLESS. Schooner. On August 25, 1867, sailed into the fort with a yellow fever victim aboard (Manucy 1938). This was a quartermaster vessel (Bearss 1983:313).

MOHAWK. US steamer (Meigs 1861b:2). This vessel captured a bark and a brig fitted out in New Orleans for the slave trade (Meigs 1861b:5). Guarded Fort Jefferson while the first shipment of armaments were being unloaded (Arnold 1861:347; Bearss 1983:181).

NELLY BARRETT. Schooner carrying freight to Fort Jefferson; sunk in the October 1865 hurricane (Bearss 1983:289).

ORIENTAL. Schooner leased as engineer tender in 1868 (Bearss 1983:303).

RICHMOND. Sloop-of-war. Transferred members of C Company from Fort Jefferson to Fort Pickens in 1861 (Shinn 1910:21).

SALVOR. Steamer. Owner was threatened by citizens of Tampa for taking cattle to Fort Jefferson in 1861 after hostilities erupted (French 1861:405).

ST. LOUIS. Dispatched to Fort Jefferson by H.A. Adams, senior officer present on blockade duty off Pensacola. This was prompted by a request of Army Commander Col Harvey Brown (letter from H. Brown to Captain Adams April 22, 1861, and report of Adams to Secretary of Navy Gideon Wells April 22, 1861)

THOMAS A. SCOTT. US transport. Dr Mudd tried to escape aboard this vessel, apparently in 1865 (Manucy 1943a:318).

TORTUGAS. Replaced ACTIVA in 1857. The 110-ton vessel cost about $6,700 (Manucy 1936). Vessel was armed in 1861 (Bearss 1983:222). The schooner sank at the quartermaster dock in Key West during the October 1865 hurricane (Bearss 1983:289).

UNION. In 1847, seven blacks stole this schooner. The vessel was becalmed a few miles from shore; those aboard abandoned the vessel in a small boat (Manucy 1936; letter D.W. Whitehurst to Lt H.G. Wright, July 12, 1847).

Unnamed mail steamer. Meigs (1861b:3) mentioned his route aboard mail steamer: Apalachicola, Saint Marks, Cedar Keys, Tampa Key West and to Fort Jefferson. It is not clear if separate passage was obtained to the fort. He mentions only having semi-monthly mail.

Various barges and scows (Bearss 1983:250). Much more historical research is needed to determine small craft use and losses within the monument.

VICTOR. A small craft that was beached in 1847 by blacks who stole UNION. VICTOR was rowed to the becalmed UNION; the crew escaped in a small boat (Manucy 1936; letter D.W. Whitehurst to Lt H.G. Wright, July 12, 1847).

WILLIAM HITCHCOCK. Wrecked January 20, 1849. Most of the workmen at Fort Jefferson were called to Admiralty Court to testify. The vessel grounded on Garden Key and was refloated and towed to Key West (Bearss 1983:103).

WYANDOTTE. Vessel captured in Dry Dock at Pensacola by Confederate forces (Meigs 1861b:2).

This chapter can be considered a first cut at the historical research that is needed for the background for interpretation of archeological features likely to be located on the terrestrial portions of Fort Jefferson NM. This research serves as a model of what can be expected from systematic historical archeological investigation on and around the monument's islands based on primary and secondary documentation. It is obvious that much more historical research is needed as this discussion opens numerous questions about other activities, such as fishing, birding and salvage operations, which are scarcely mentioned. However, one conclusion that can be drawn at this early stage of investigation is that any disturbance on any of the land areas within Fort Jefferson NM is likely to encounter significant archeological remains.

CHAPTER IX

Fort Jefferson National Monument Documented Maritime Casualties

Larry E. Murphy and Randolph W. Jonsson

INTRODUCTION

It is useful to discuss documented Dry Tortugas ship casualties as a collection. Unlike most wreck history presentations, which deal with individual wrecks, this discussion focuses on casualties as a geographically defined site population. Relationships of selected attributes are examined to discern maritime activity patterns. This approach leads to questions and observations relevant to developing broad interpretations of the monument's ship-related sites in a regional context.

Unlike most other parks with water jurisdiction, specific historical research has been conducted on maritime casualties within Fort Jefferson National Monument. Individual sites are not discussed here because most have been documented and reported by Edwin Bearss (1971). Recent historical research building on Bearss' work has located additional casualties, and a computer maritime casualty database has been developed that formed the basis for this chapter.

While there is a significant body of documentation for Fort Jefferson National Monument sites, it is far from complete. Currently documented casualties include only one identified shipwreck site, FOJE 003, the AVANTI or Windjammer Site on Loggerhead Key. Although incomplete, the current historical record offers a reliable indication of what can be expected from a complete area survey and is important for planning and research purposes.

The documentary record is a useful planning and management tool. Study area stratification for survey purposes based on recorded marine casualties may prove cost efficient. Survey methodology and intensity can be varied throughout the study area relative to documented casualty density. For example, intensity can be increased in areas where early wrecks or small vessel types are expected and diminished in areas of few casualties. Management decisions may be affected by number of documented wrecks even prior to survey completion, such as where to more closely monitor visitor diving operations.

Principal research questions concerning shipwreck related sites within the monument center on the nature of the wreck population and an explanation of how it came to be structured in the way that it appears to be. Shipwreck distribution is not amenable to typical archeological settlement pattern models and explanations. An understanding of maritime behavior represented in the study area sites depends on explanations that consider specifically maritime natural and cultural factors that are tied to the widest possible context.

Most shipwreck research to date has been site-specific, wherein a wreck is evaluated as a single site with minimal concern for general context. This is a reasonable approach when one notes the ship was certainly not intending to wreck, and probably was frantically trying to avoid the very place where it is now found.

The basic site-specific research limitation is that it has rarely lead to discussion of much beyond site descriptions and generally ignores past cultural processes and systems. Most site specific reports tell us much about the present and very little about the past.

The collective approach taken here assumes that shipwrecks represent general cultural processes of which they were a part prior to wrecking. If natural and cultural processes affecting maritime activities reflect patterned regularities, sites resulting from them will be patterned and will best be interpreted in a wide sociocultural context. Shipwreck locations are viewed here as the nonrandom result of many complex, interrelated environmental and cultural factors, not simply random accidents (Muckelroy 1978: 219-200; Hulse 1981; Murphy 1989b:5). Testing these assumptions by interpreting and explaining observed variations in the Dry Tortugas site collection form the basic research domain for future park research.

Interpretation and explanation of the monument's sites begins with examination of documented casualties as a group for associations, relationships and patterns. Examination of patterns and anomalies is basic to developing research questions directed toward understanding the processes that have structured the archeological record. Such study begins with historical pattern recognition, which is facilitated by computer database manipulation.

There are 241 vessel casualties documented for the Dry Tortugas and immediate vicinity. In order to access and analyze these wrecks, a computerized database was produced. The Maritime Archaeological and Historical Society (MAHS) of Arlington, Virginia was contracted to conduct historical research in the National Archives to augment the Bearss study (1972) and to develop a computer database inventory. The initial data entry form was developed in consultation with the NPS Submerged Cultural Resources Unit. Members of MAHS entered data from Bearss and other sources. Upon receipt of the database and software program from MAHS, the entry form was altered, the data reviewed and corrected, and additional materials added, which brought the casualty list to its present level.

Database software is Q&A, a dBase III-compatible program. dBase III is both the NPS standard and the NPS Maritime Initiative database, so compatibility with them was important. Q&A was selected for this park-specific application because it is somewhat easier to use and easier to program than dBase III, and it has a feature that allows manipulation by ordinary language useful for personnel unfamiliar with dBase query requirements. The database is a changing document that allows cumulative update. Some minor contradictions between figures reported in this chapter and the current database result from this ongoing update. (Graphics have been generated from a separate program.)

In addition to the computer database, a set of paper files has been produced that contain vessel documentation, registrations, operational background and Dry Tortugas casualty information. Unfortunately, many vessels are poorly documented. For instance, of 241 casualties, only four are documented before 1800, 69 do not have cargo documented, 18 have unknown rig and only 92 have hull-dimension information. Such historical research should be a high priority for future cultural resource projects, especially for park interpretation.

The computer database allows quick sorting on field combinations in whatever order desired. Ability to manipulate a fairly large body of information readily allows recognition of patterns, generation of questions and examination of relationships that have both managerial and research applications.

Database fields were selected for compatibility with historical information. For example, the field "Type of Casualty" is based on those found in the *Merchant Vessels of the US* (US Bureau of Customs 1867-1967), which began including a list of "Loss of American Vessels" in 1906. This list classifies losses in six categories: foundered, stranded, collision, burned, abandoned and "all others." The Fort Jefferson database uses these categories, although here few are listed in categories other than foundered or stranded. The "Loss" list also reports gross tonnage, year built, persons on board, lives lost, nature of casualty, date and place, which are also database fields. Additional fields in the park database include dimensions, rig, builder, home port, destination port, cargo, value and salvage.

The park database lists all casualties documented for the Dry Tortugas, whether total losses or not. The reason for this is that stranded vessels often leave archeological remains, so their record is important for site interpretation, and overall casualty patterns are important for broad maritime archeological inferences. Inferences drawn from complete and coordinated documentary and archeological research inform on many levels, including variables of wreck and salvage behavior and more generally, the conduct of maritime activities in the Tortugas, Gulf and Caribbean regions over time.

The currently documented 241-casualty population contains 235 events where it is known if the vessel was a total loss or not. Of the 235, 94 are documented as lost vessels. Another 37 casualties lost partial cargo; but six were carrying solely lumber, sugar, cotton or molasses, which would be unlikely to leave many archeological remains. This gives a minimum of 125 historically documented shipwreck-related sites likely to be located during archeological survey.

Salvage activities resulting in complete vessel and cargo recovery involve an additional 83 vessels. Salvage activity at these locations may have left archeological remains and other evidence. These remains could include unrecovered ship apparel such as ballast (for example FOJE 031, see Chapter XII), anchors and cable, salvage gear, reef grounding scars and wreck disturbance. Setting of kedge or salvage anchors was a common practice during a stranding and salvage, and these, or the stranded hull bottom, could have affected archeological materials already in situ on the sea bottom. Salvage activity is an important cultural site-formation process that has received little discussion or research, but will have to be considered during Dry Tortugas site interpretation.

Casualty frequency is basic to pattern determination. The primary question is whether casualties are simply a function of ocean travel, that is, a certain number of vessels will be lost as a normal consequence of combined risk variables, principally weather and pilot error. If that is the case, then correlation between losses and amount of shipping should be more or less constant over time, and variations would tend to be gradual. Variation could be explained by the use of bigger vessels, technological and navigational aids development or perhaps naval conflict. Any short-term anomalous variation from general trends naturally requires an explanation, and can unlikely be attributable to solely natural contingencies.

Casualties in ten-year increments have been graphed for 215 Tortugas vessels, with the four pre-1800 vessels grouped together (Figure 9.1 and 9.2). Percentages by decade are presented in Figure 9.2. As can be readily observed, there is no smooth variation over time that could be attributable to general shipping parameters. The five-year increments are very irregular (Figure 9.3). Decade fluctuations are somewhat smoother than the five-year periods, but neither appears to follow any general pattern. In fact, some periods predicted to produce more casualties, such as wartime 1860s and 1940s, do not show expected increases --both show less than periods immediately before and after.

In 1866, the same year mandatory merchant vessel registration began, the US government started compiling the *Merchant Vessels of the United States*, which lists vessels in service. This has been published annually since 1867, first by the Bureau of Customs (until 1967), currently by the Coast Guard. This list is a basic merchant vessel documentary source, and it has contributed to the database. This list also provides comparison data on number and variation of US merchant vessels against which the Tortugas sites can be analyzed. An obvious question is whether the Tortugas casualties are representative of regional (Gulf of Mexico) trends. As can be seen in Figure 9.4, which is from the "Loss List" of the *Merchant Vessels of the US* and includes all US vessel casualties documented between 1906-1936, there is only gross correlation between strandings and founderings, the two most common casualties. There appears to be a general decline in both during this period, which correlates with the Tortugas pattern of Figure 9.3.

A regional comparison was developed for shipwreck frequency by decade. Gulf of Mexico shipwreck frequency data were collated by Garrison et al. (1989:II-99) as a part of the reevaluation of archeological resource management zones for Minerals Management Service, who oversee offshore oil and gas leasing. Garrison notes a general increase in shipwrecks overtime with under reporting in earlier periods. This general increase does not correlate with the US total trend or the Tortugas data above. Unfortunately, available Gulf data only pertain to shipwrecks, presumably total losses. A comparison between Gulf of Mexico "shipwrecks" and Tortugas database casualties (whether total losses or not) is Figure 9.5.

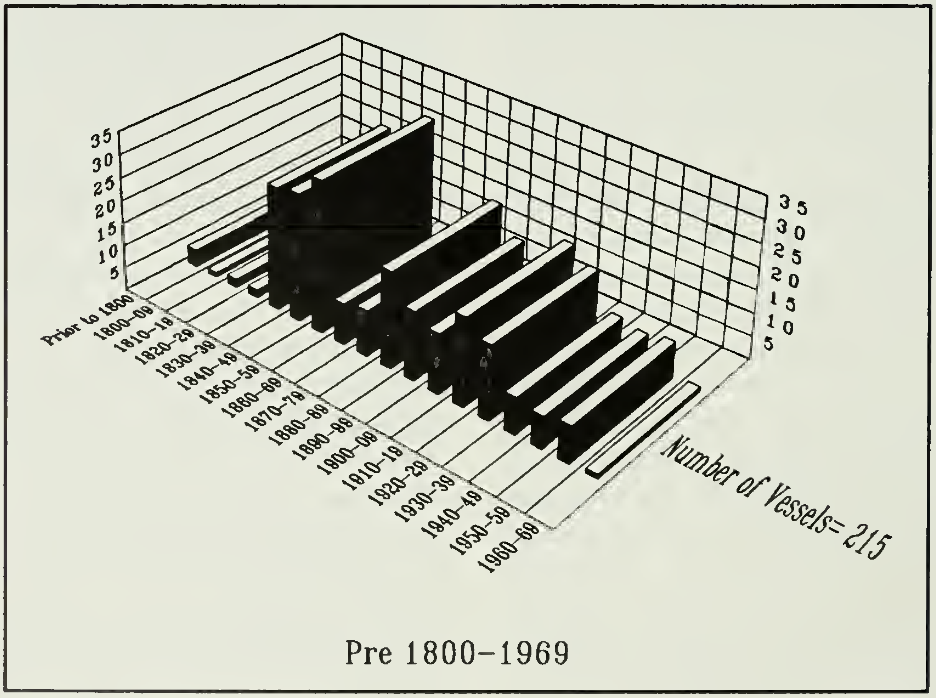


Figure 9.1. Casualties at ten-year intervals, pre-1800 to 1969.

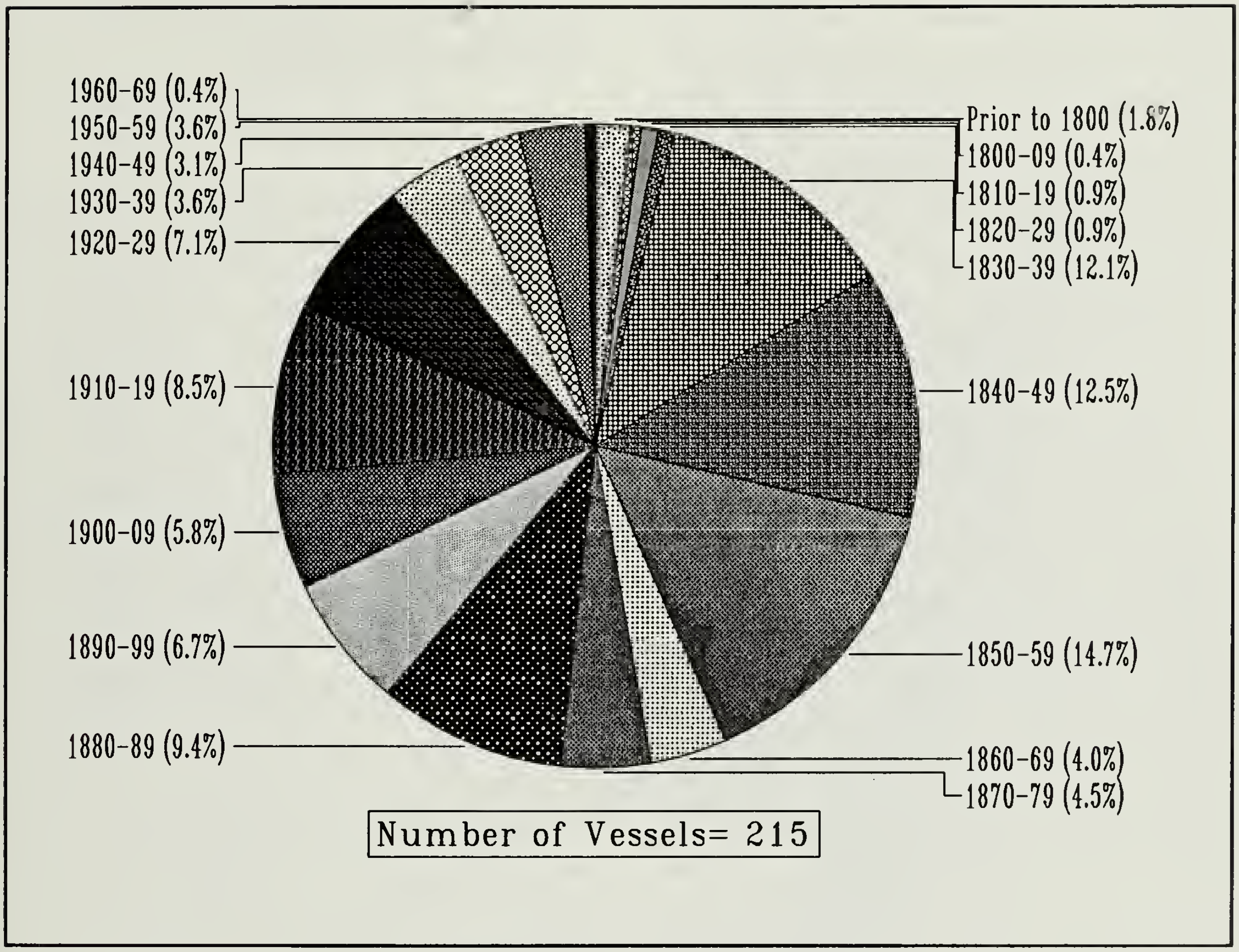


Figure 9.2. Percentages of casualties at ten-year intervals.

Weather

The role of weather is important to understanding the nature of recorded casualties. General weather patterns have been discussed in another chapter (see Chapter VI). The basic question here is to what extent can weather be considered the primary factor of Dry Tortugas casualties?

Sufficient database information exists for 43 Dry Tortugas casualties to determine whether or not storms were a contributing factor. Of these, 32 are storm related, with 15 casualties resulting in vessel loss and six others with partial cargo loss. For this small sample, storm-related casualties resulted in vessel or cargo loss 65 percent of the time, which indicates that when weather is a factor, the casualty tends to be serious.

If weather is a primary consideration, then there should be seasonal correlation with numbers of casualties. More casualties would be expected during periods of poorest weather, which is typically during winter months in the study area. There are 206 vessels in the database that include the month in which the casualty occurred. These data are presented in Figure 9.6. The months with the most casualties are January and April, with September, November and December close behind. The five months of September through January account for 51 percent of all casualties, with November, December and January accounting for 35 percent. There does seem to be some correlation, although not as strong as would be expected if weather were the primary casualty determinate. Total losses, of which 82 document month of occurrence, follow the general casualty pattern (Figure 9.7). Fifty-three percent occur in the five-month period September through January, with 37 percent occurring in November, December and January.

Another view of weather can be considered by using monthly casualty frequency variables for different areas, Figure 9.8. Interior lagoonal sites of Bird Key, Garden Key and North Key were combined, Southwest and Loggerhead Reef were combined and Pulaski and East Key were combined. A comparison shows a general similarity, but with some variation. Most Pulaski casualties occur in the winter-spring season, while at Bird Key they occur in the fall and winter, as do those of Southwest Reef. There is sufficient variation between these areas to require going beyond weather as a satisfactory explanation. Clearly more research is needed on the role of weather in accounting for wreck casualty variation within the maritime sites of the study area.

Human Error

Weather is just one of a complex set of operative variables, including pilot error. Investigating causal variables that contribute to wreck concentrations may prove one of the most productive research areas in maritime archeology. Indications are that pilot error is not random, as might be expected. Pilot error is a difficult factor to analyze and quantify reliably; it can be seen as an idiosyncratic mistake or a cultural factor. Because there are no means to investigate the former, analysis of pilot error must include a wide range of sociocultural factors, including risk assessment and tolerances, which are affected by competition and seasonality.

Shipping Seasonality

Gulf product seasonality and concomitant shipping demands also structure the park's wreck population. The area variation noted above may be influenced by competitive pressures of Gulf trades. For example, historically cotton transportation peaked during November to May, with late spring and summer shipments being at the low point of the yearly production cycle, which picked up at the September harvest (Daggett 1988: 126-128). Cotton vessels, which comprised a large portion of Gulf trade, were minimally represented in the summer months while owners detailed their vessels to other trades. Database casualties support this observation: of 25 vessels with cotton cargoes and casualty month recorded, none occur during June, July or August. The high overall casualty and loss rate during April will require further research to explain. It certainly cannot be satisfactorily attributable to weather alone, and may be a result of competitive pressures of trade seasonality.

Rigs

The documented casualty population is composed mostly of sailing vessels, principally schooners, brigs and ships. Overall, engine powered vessels are only about 13 percent of total casualties. Schooners had fore-and-aft rigs, generally two masts, later three and sometimes four. Brigs were square-rigged with two masts. Full-rigged ships carried three masts, all square rigged. Barks became common in the 1830s and also carried three masts, the first two square-rigged, the third fore-and-aft. Barks usually fell between ships and brigs in size. Ships and barks are New

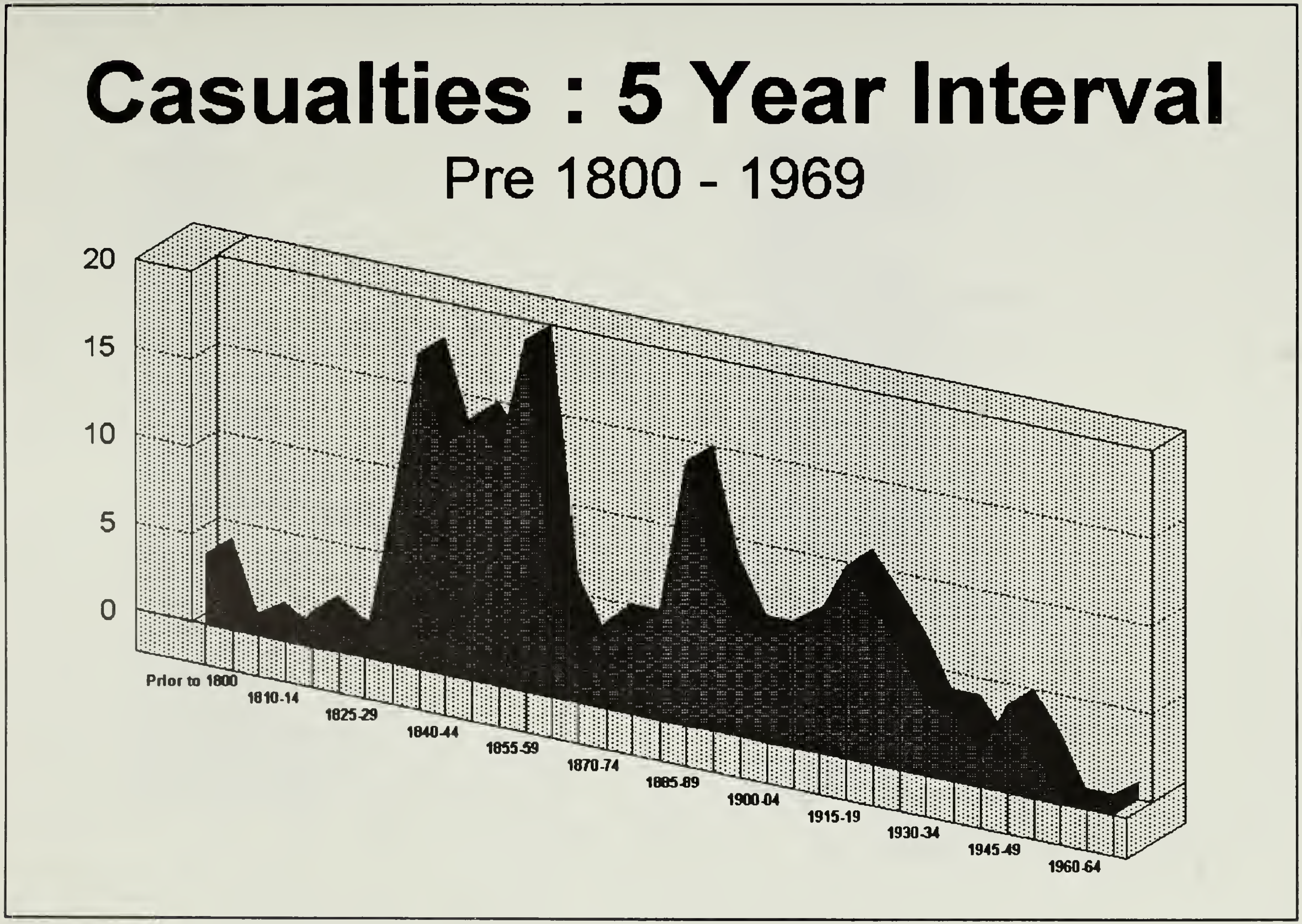


Figure 9.3. Casualties at five-year intervals, pre-1800 to 1969.

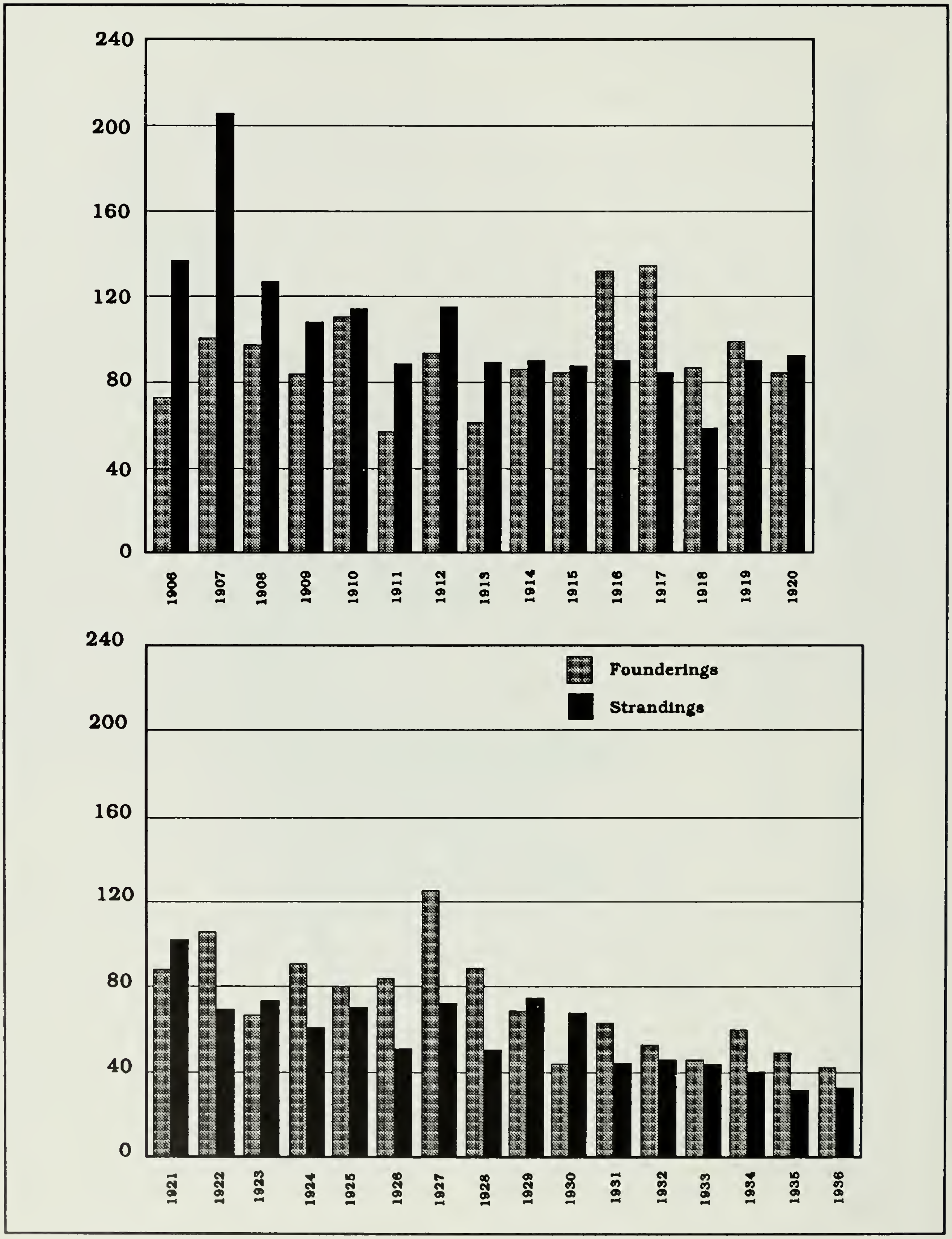


Figure 9.4. US merchant vessel casualties all locations, 1906-1936.

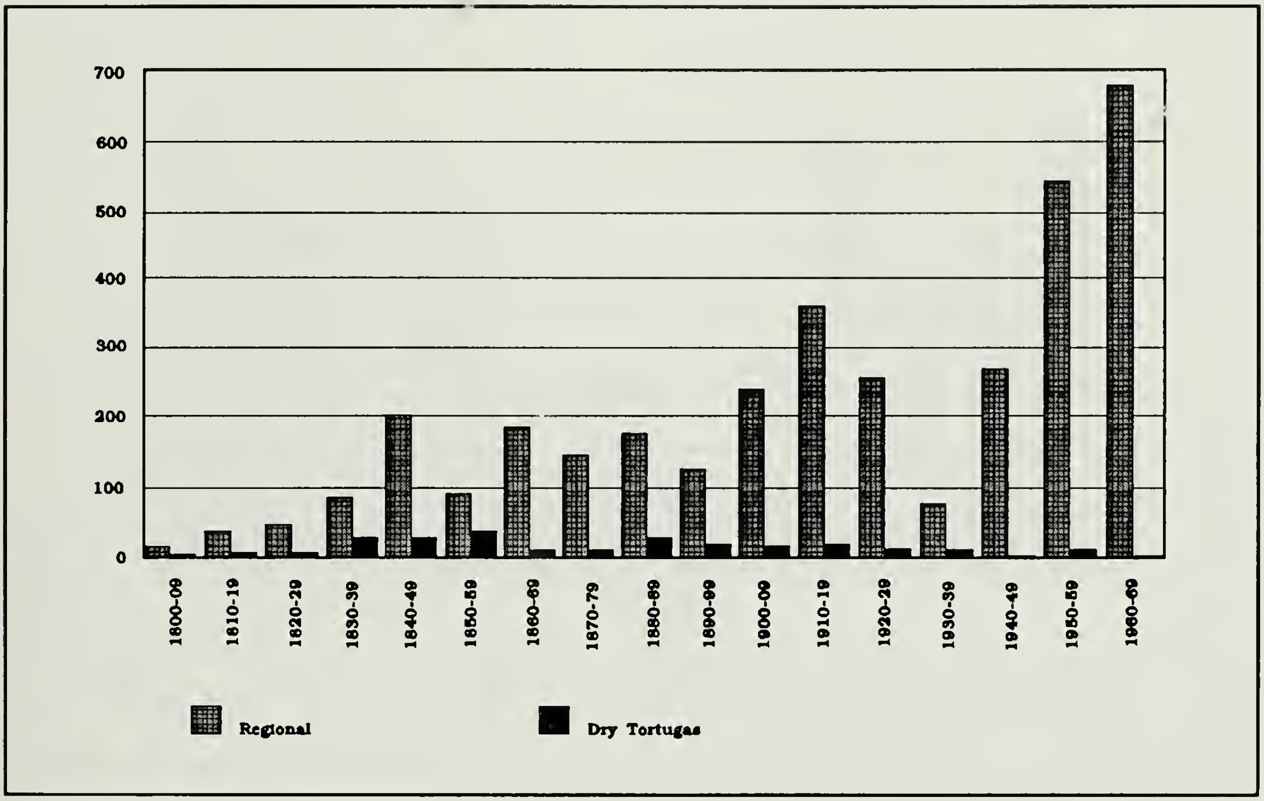


Figure 9.5. Casualty frequency by decade 1800-1969--regional versus Dry Tortugas.

normally the largest vessels. In the first quarter of the nineteenth century, registered York-built vessels can are representative of period vessel size. Ships averaged 373 tons, with a range of 176-899 tons, brigs 250 tons with a range of 174-324 tons, and schooners averaged 87 tons with a range of 27-173 tons (Albion 1938:13-14). Vessels of all sizes grew over time, with ships growing fastest.

There are 215 database casualties with documented rigs. A comparison of total casualties by rig is in Figure 9.9. Most casualties are schooners (36.7 percent), twice as many as any other rig. Both barks and brigs number about half that of schooners (17.7 percent) with ships comprising 13.5 percent.

Of the 94 vessels documented as total losses in the Dry Tortugas, 87 have known rigs. Again schooners comprise the largest group, 33 percent, with ships, barks and brigs each 14 percent of vessels lost (Figure 9.10).

Rig popularity and use changed through time prompted by many factors including economical and technological ones. For example, the bark rig became very popular after the financial depression of 1854-1857, because it was almost as fast as a full-rigged ship, but more economical. Ships outnumbered barks in the first half of the century, but barks were more numerous at the end of the century (Cutler 1958:7). Brigs and schooners generally operated in the same trades, with schooners possessing a competitive advantage of requiring fewer crew-per-vessel-ton.

The monument's casualty population reflects these changes. Tables 9.1 and 9.2 indicate the changing pattern of losses by rig over time.

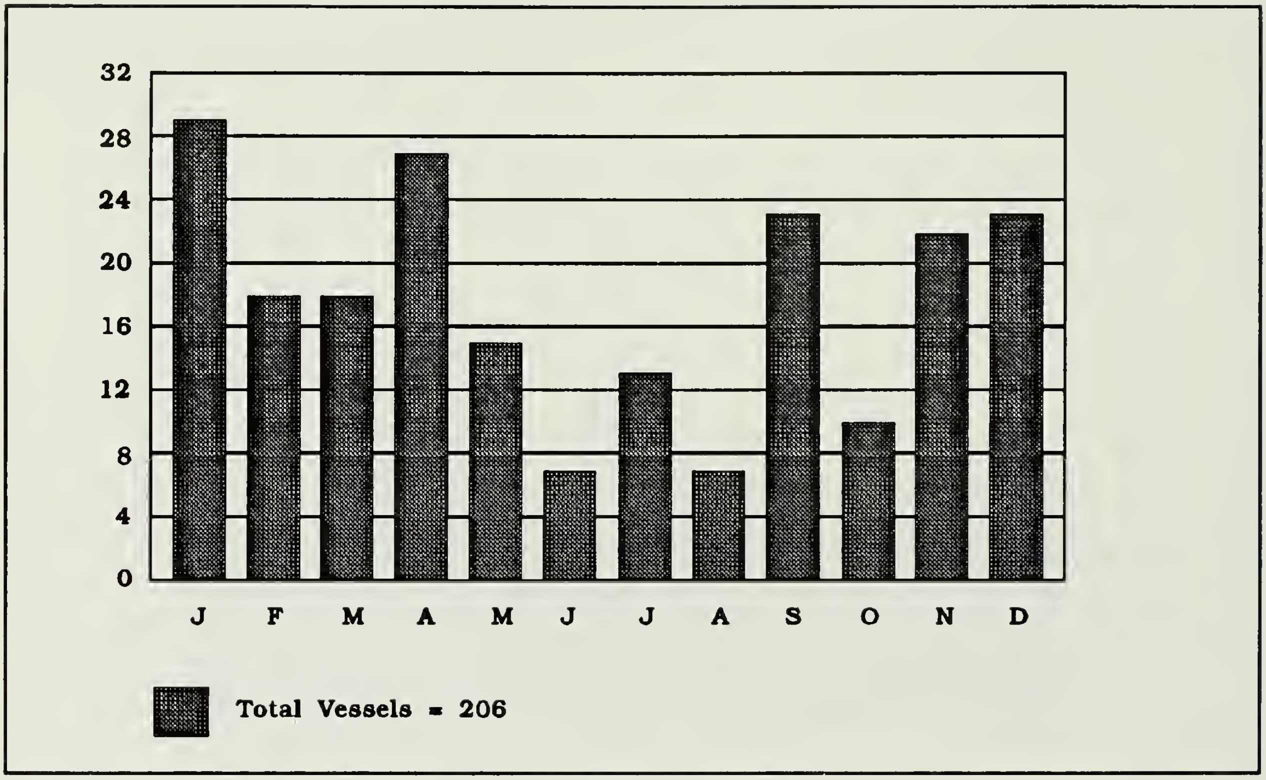


Figure 9.6. Total casualties by month.

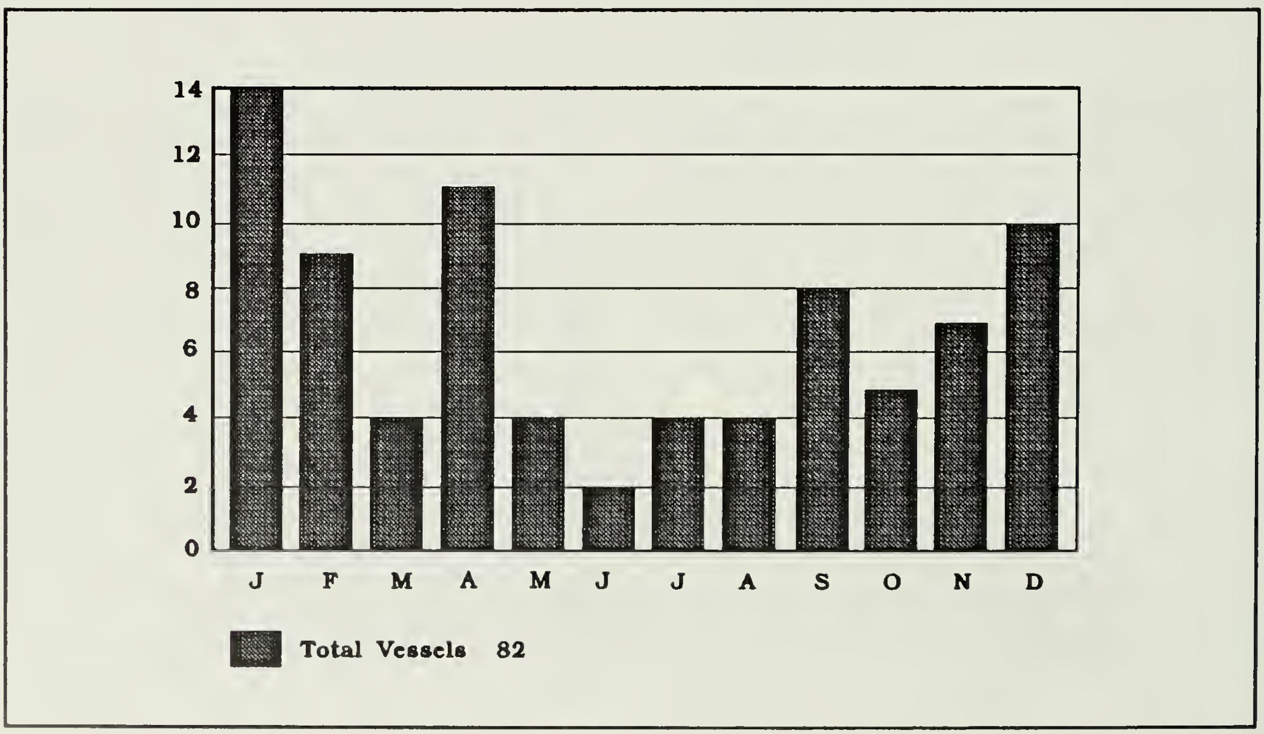


Figure 9.7. Total vessels lost by month.

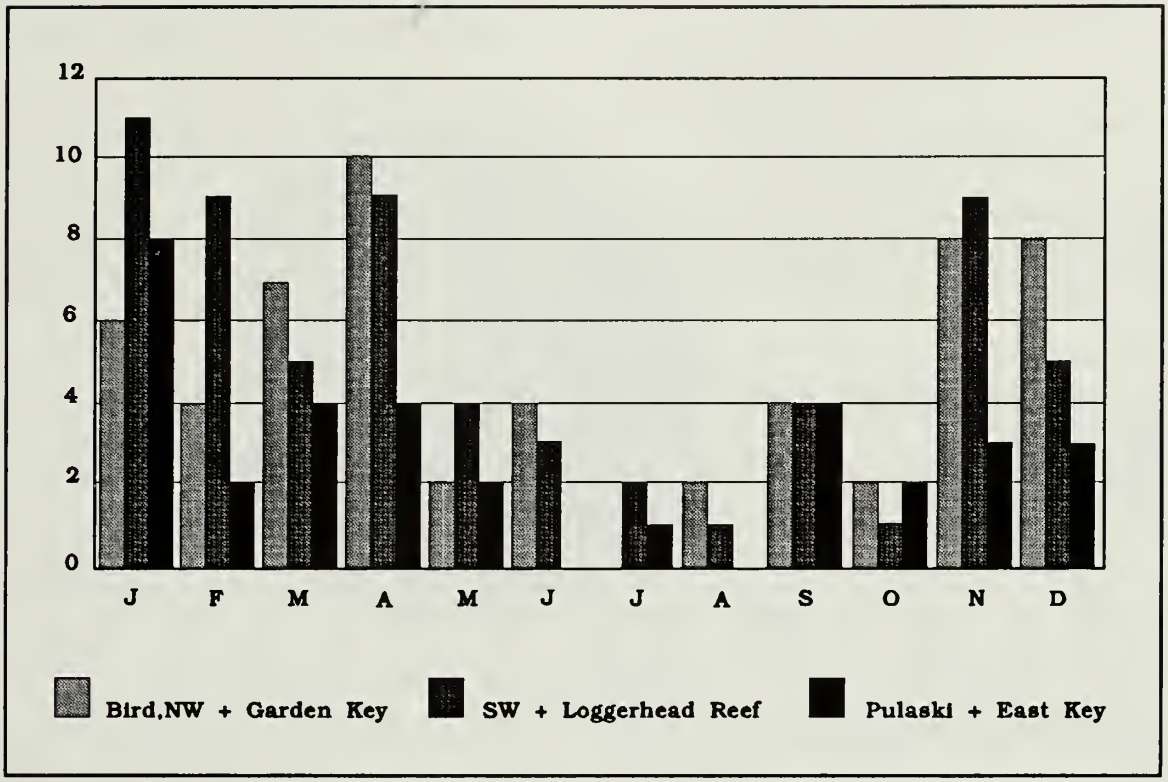


Figure 9.8. Monthly losses by location.

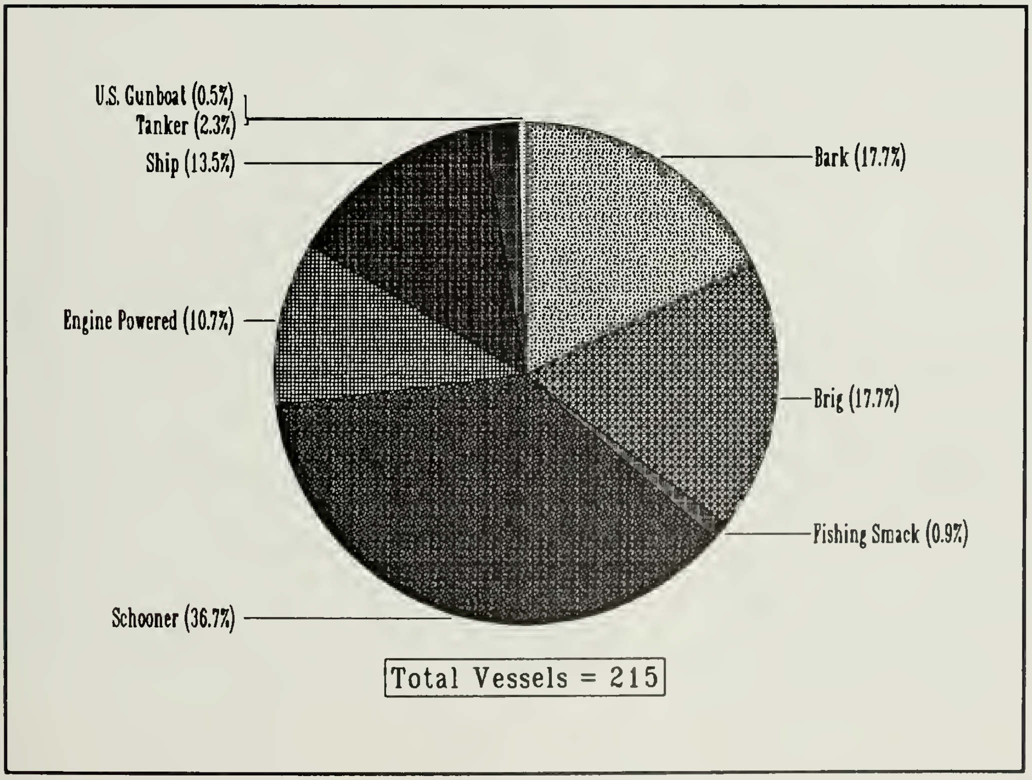


Figure 9.9. Casualties by rig.

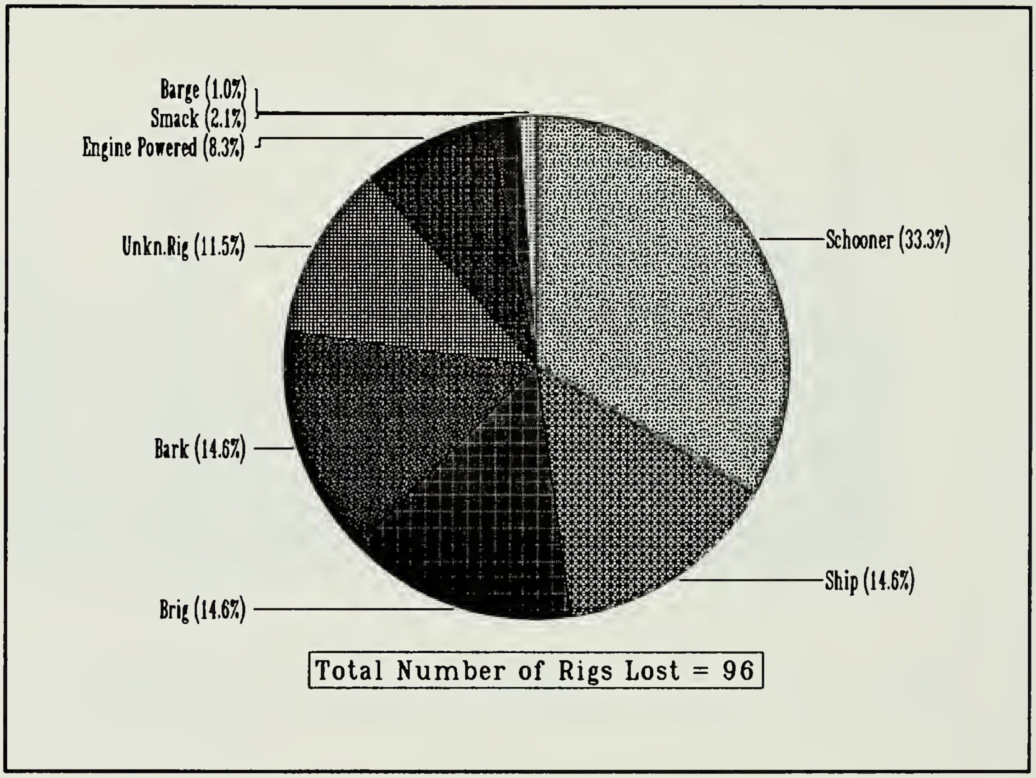


Figure 9.10. Vessel losses by rig.

Table 9.1. Dry Tortugas Casualties by Rig

	Before 1860	After 1860	After 1900
Barks	19	17	2
Brigs	34	8	0
Schooners	22	55	34
Ships	26	3	1

Table 9.2. Tortugas Losses by Rig

	Before 1860	After 1860	After 1900
Barks	5	8	1
Brigs	8	7	0
Schooners	8	24	17
Ships	12	3	1

These figures reflect what is documented by contemporary observers regarding the increasing popularity of schooners in the Gulf and coastal trade. Brigs competed with schooners with diminishing success through the nineteenth century, with few used in the Gulf trade by the 1880s. Ships and larger barks were more heavily involved in international trade and were generally larger vessels. For example, up to 1860, coastal-trade lumber was shipped aboard schooners, which carried about 100,000 board feet. Generally, barks, brigs and ships, which carried as much as 500,000 board feet were used for ports farther away than the West Indies (Eisterhold 1972:270). Of the 69 schooner casualties with destination port documented, only four were bound for European ports, and all around 1900 when few square-riggers were available.

Vessel Age at Time of Casualty

The normal use-life of a nineteenth century merchant ship was about 20 years (Table 9.3) (Albion 1938:98). Some authorities put the overall average at 10 years in 1900, when losses, accidents and deterioration are considered (US Census Bureau 1902:210). The shipwreck database records age at time of casualty for 61 sailing vessels ranging from less than one year to 44 years. Eighteen of these vessels (29.5 percent) were older than 20 years. Thirty-eight percent of vessels lost were older than 20 years. The following average ages for casualty and loss relative to rig comes from the database information.

Table 9.3. Average Age for Tortugas Casualties and Losses

Rig	No	Range	Av Casualty	No	Range	Av Loss
Bark	14	3-34	15	9	3-28	14
Brig	6	5-25	14	5	10-25	16
Schooner	33	1-44	15	20	1-44	19
Ship	7	2-32	10	4	8-32	14

It would not be useful to speculate much on these figures, particularly because they reflect only about 25 percent of the database. However, a correlation between age at time of casualty, rig and cargo gives a perspective of trades for vessels older than 20 years. There are 16 vessel casualties older than 20 years where sufficient information is available to determine cargo. Of these 16 vessels, nine are schooners, five are barks, one is a brig and one a ship. There is no correlation of rig with cargo, other than that all were carrying bulk cargoes. The oldest vessels seem to be involved in the lumber trade. For vessels younger than 30 years, three were in ballast, one in the lumber trade, all others were carrying rock, cotton, grain or railroad iron. All seven vessels older than 30 years were in the lumber trade or fishing.

Home Ports

Home ports provide a perspective on how regional shipping economies were structured in the past. The database contains information on 77 vessel homeports. Table 9.4 presents these data.

Dominance of northern shipping is readily apparent. It is interesting that foreign shipping exceeds southern vessels, another indicator of the southern transportation weakness. The post-1860 growth of foreign shipping is notable and reflects a major shift of nineteenth century practices. In 1826, American vessels carried 92.5 percent of US foreign commerce, which diminished to 9.3 percent by 1900 (US Census Bureau 1902:210).

Cargo

Examination of recorded cargo reveals the general nature of the study area's maritime trade and suggests what can be expected from archeological remains. Eight categories were selected for cargo analysis. The broadest is agricultural products, which includes grain, molasses, honey, wine--basically everything except cotton.

Cotton is a separate category because of its singular importance in the Gulf trade. The

Table 9.4. Fort Jefferson Vessel Casualty Homeports

North		South		Foreign	
< 1860	> 1860	< 1860	> 1860	< 1860	> 1860
20	30	3	9	1	14

principal cotton shipping port was New Orleans, which periodically rivalled New York for dominance in export tonnage. Until railroad development, most southern cotton was transported by vessels leaving Gulf ports bound for the northeastern US and European cotton market centers. No schooners carrying cotton bound for a foreign port are documented as casualties.

Construction materials include everything related except lumber and timber. General merchandise is self explanatory. Much general merchandise was being imported into Gulf ports, especially from the northeast US, during the nineteenth century. Oil and coal were combined as a logical, though small, category.

Cargoes of 172 casualties are documented in the database and presented in Figure 9.11. Lumber, agricultural products and cotton dominate, followed by construction materials and general merchandise. The same trend holds for the 103 vessels with known cargo that are reported to have partial or total cargo losses in the Dry Tortugas (Figure 9.12), with percentages of losses in Figure 9.13. The basic trend is export of agricultural products and import of manufactured goods for the Gulf ports. Based on cargo destinations, more than 60 percent of Dry Tortugas vessels lost were inbound.

Documented agricultural products for Dry Tortugas casualties include grain for Buenos Aires, coffee for New Orleans, hogs for Havana and sugar and molasses bound for northeastern ports. Phosphate rock, although not technically an agricultural product, was included in this category for general analytical purposes because of its southern origin and use as a fertilizer. Destination ports for phosphate were mostly European and northeastern US ports, with the exception of one Cuban load.

About half the cotton cargoes also included other goods, primarily agricultural produce or lumber products such as staves. Primary cotton destinations were European and northeastern ports, such as Great Britain, Ireland, Belgium, Germany, Austria, New York and Boston.

General merchandise was most often inbound to Gulf ports, principally to New Orleans and Mobile, with a single load of barbed wire bound for Velasco, Texas. The other few destination ports for general merchandise were Caribbean and South American ports, Bremen, Germany and New York.

Lumber and lumber products, which rarely were mixed with other cargoes, were bound for northeastern US ports, especially New York, and Caribbean ports, such as Puerto Rico, Santo Domingo and Havana and European ports like Queenstown and Belfast, Ireland; Cardiff, Wales; Greenock, Scotland; Great Yarmouth, England; Harlingen, Netherlands and Genoa, Italy.

Many casualties with construction material cargoes were Fort Jefferson bound. Examples of other destinations and cargoes are lime bound for Apalachicola and paving stones for New Orleans.

Most vessels recorded in ballast were headed for Florida ports principally

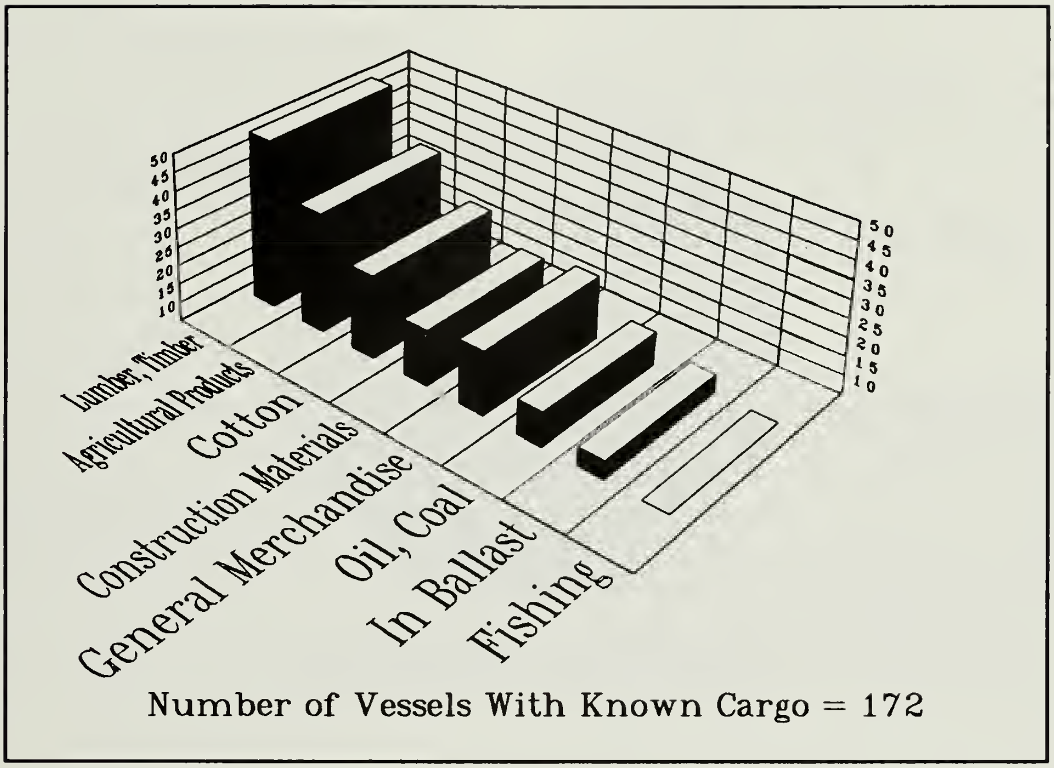


Figure 9.11. All cargo casualties.

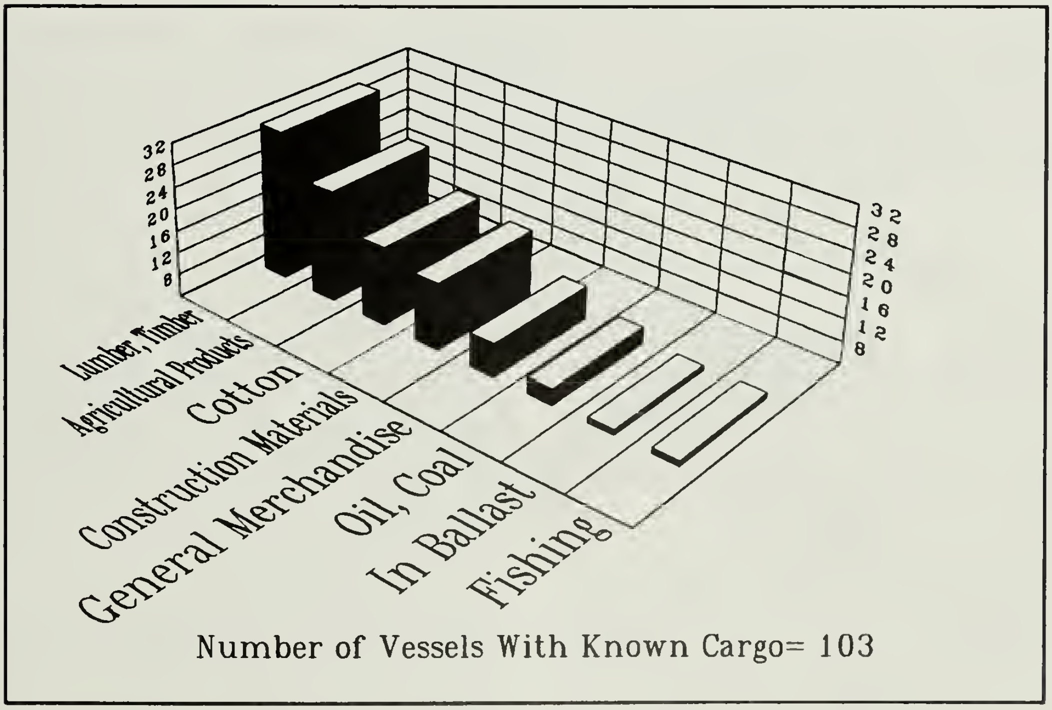


Figure 9.12. Wrecks with partial or total cargo loss.

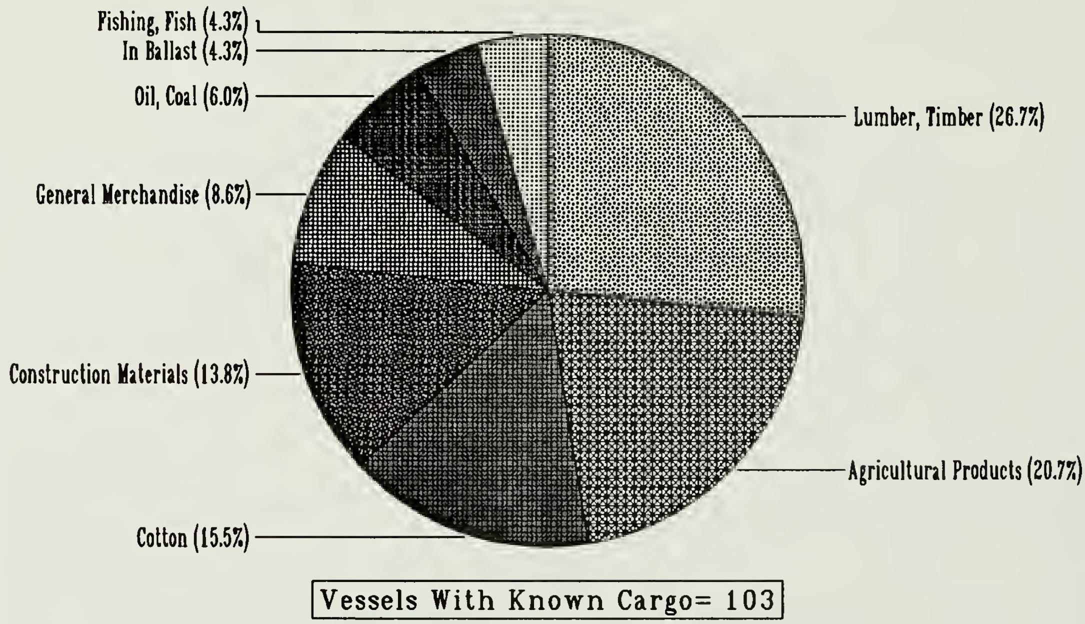


Figure 9.13. Percentages of wrecks with partial or total cargo loss.

Appalachicola, Charlotte Harbor, St. Joseph or Jacksonville, all lumber ports.

Oil was bound for a wide diversity of ports, including Boston, Montevideo, Veracruz and Paulsboro, New Jersey.

Spatial Patterning

Maritime sites are not uniformly distributed throughout Fort Jefferson NM. The first question is, of course, how the casualty population and potential sites vary. Spatial distribution is fundamental to any explanatory hypotheses of why variation occurs.

The database contains 215 casualties with known locations. The largest group is the general designation "Dry Tortugas." Figure 9.14 shows casualties by frequency and location. Figure 9.15 depicts relative percentages of casualties by location. Southwest and Loggerhead Reefs are combined because these names appear to have been used interchangeably in documents. Hospital and Middle Keys were grouped because of proximity and few recorded events. Total-loss frequency and location are in Figure 9.16 ordered by decreasing frequency. There is fairly close correlation between total casualties and total losses except for Pulaski Shoal, which has relatively more casualties than losses. These Pulaski casualties are successfully refloated strandings. North Key casualties are similar, but not as pronounced as Pulaski. Relative percentages for total losses by location is Figure 9.17.

A more detailed look at location variation was generated for all casualties focusing on vessel rig type. The 215 total casualties were separated by area to determine patterning relative to rig. Total casualties were used because the greater number of events should be more reliably indicative of overall patterns. The question was: do casualties vary as a function of rig for different locations? Figures 9.18 through 9.22 present graphs depicting percentage of total casualties for each rig for each location.

Some general observations can be made from examination of vessel rig and location variables. The "Dry Tortugas" category is probably indicative of the general pattern: roughly 50 percent schooners, 15 percent ships and brigs, about 10 percent barks and 13 percent engine-powered vessels. This is not significantly different than the summation of casualties by rig (Figure 9.18). Each area does have particular characteristics and will be discussed separately. The statements are only speculative at this point and are offered for hypothesis construction and testing.

Bird Key is the only location with no engine-powered casualties documented, although one is known archeologically (FOJE 029, the Bird Key Harbor Brick Wreck). The area has predominately square-rigged vessel casualties, with smaller vessel types the majority. These casualties were most likely using nearby anchorages, or were shallow draft enough to be blown over surrounding reefs.

Garden Key has a majority of schooners, followed by engine-powered vessels and brigs, and again large square-rigged vessels are in the minority. These vessels were most likely either using the anchorage for shelter or conducting some sort of local business.

East Key has 85 percent square-rigged vessels; no schooners are reported. This area has the second largest percentage of engine-powered vessels, and large, square-rigged

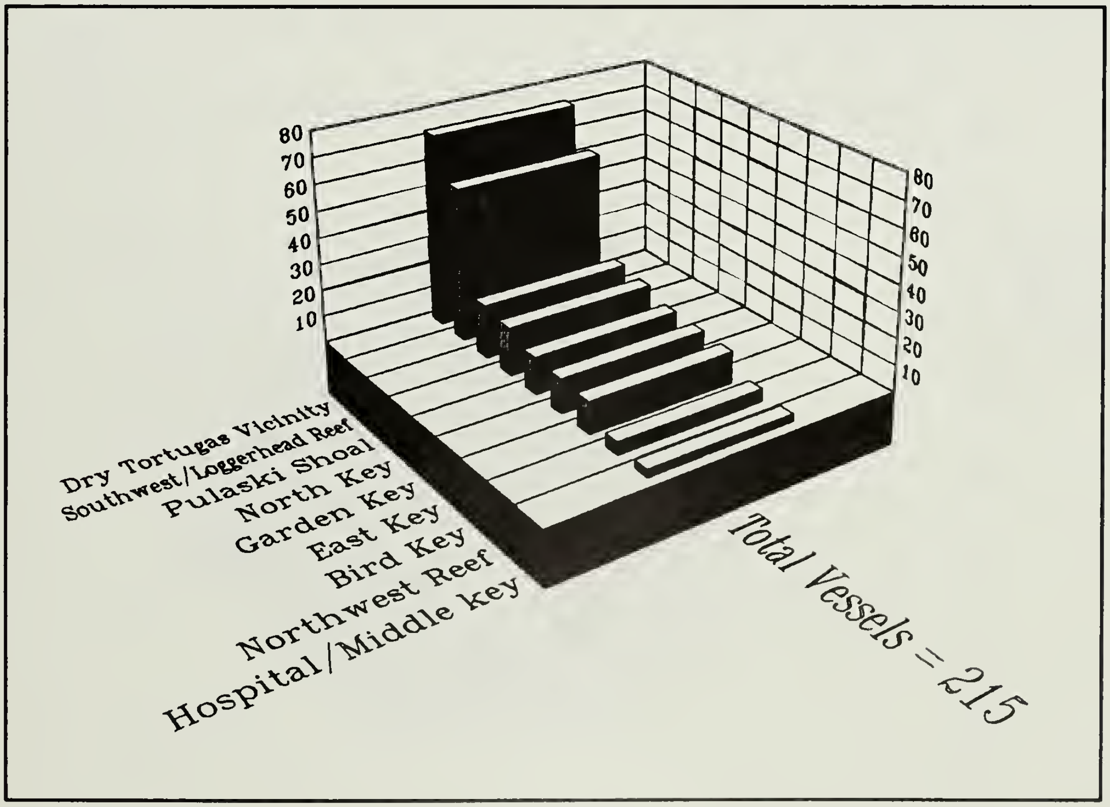


Figure 9.14. Casualties by major location.

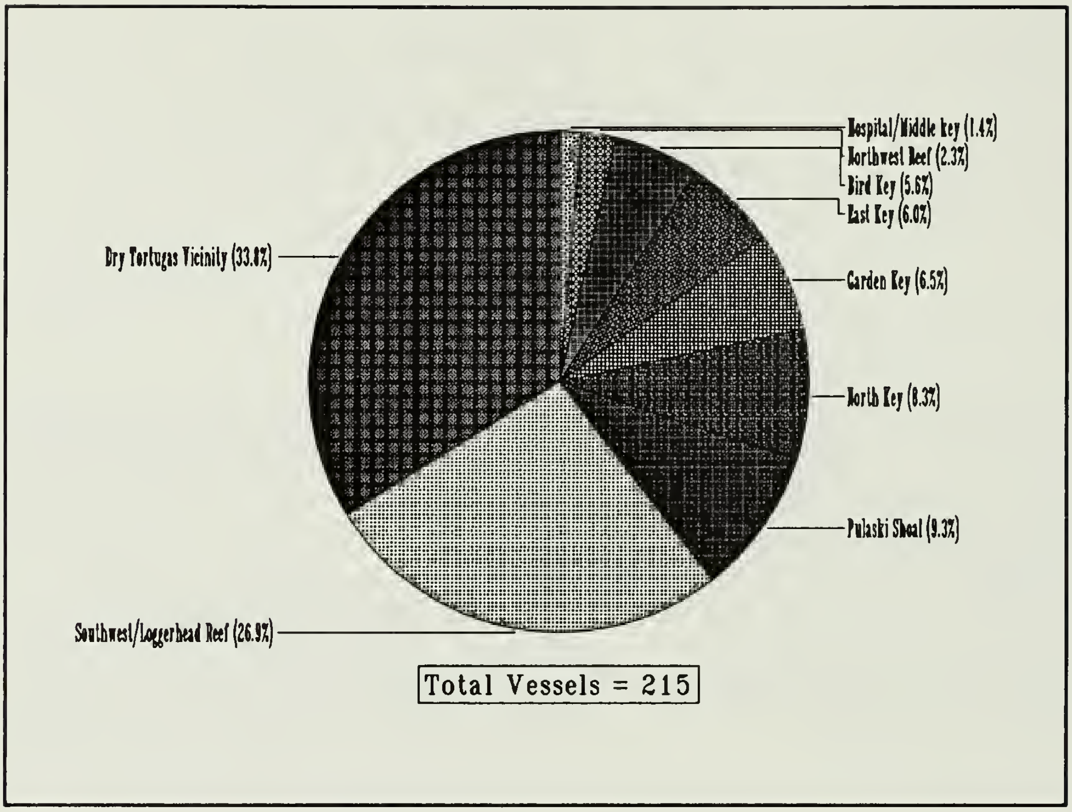


Figure 9.15. Percentages of casualties by major location.

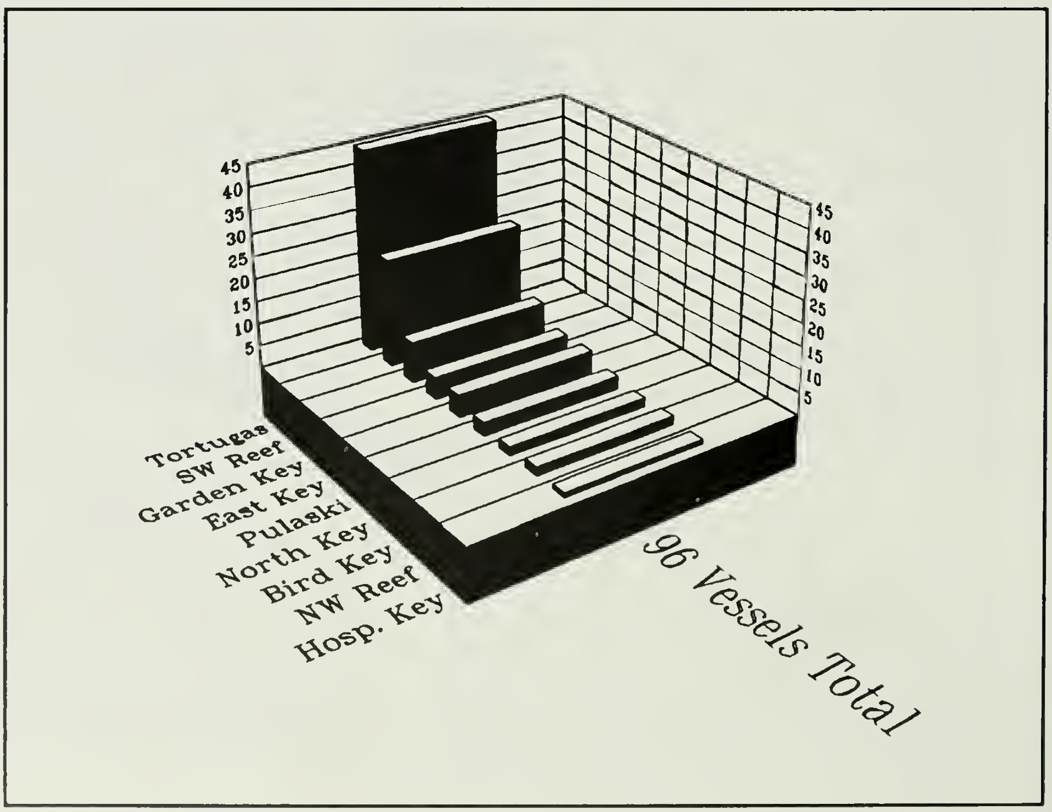


Figure 9.16. Vessel losses by location.

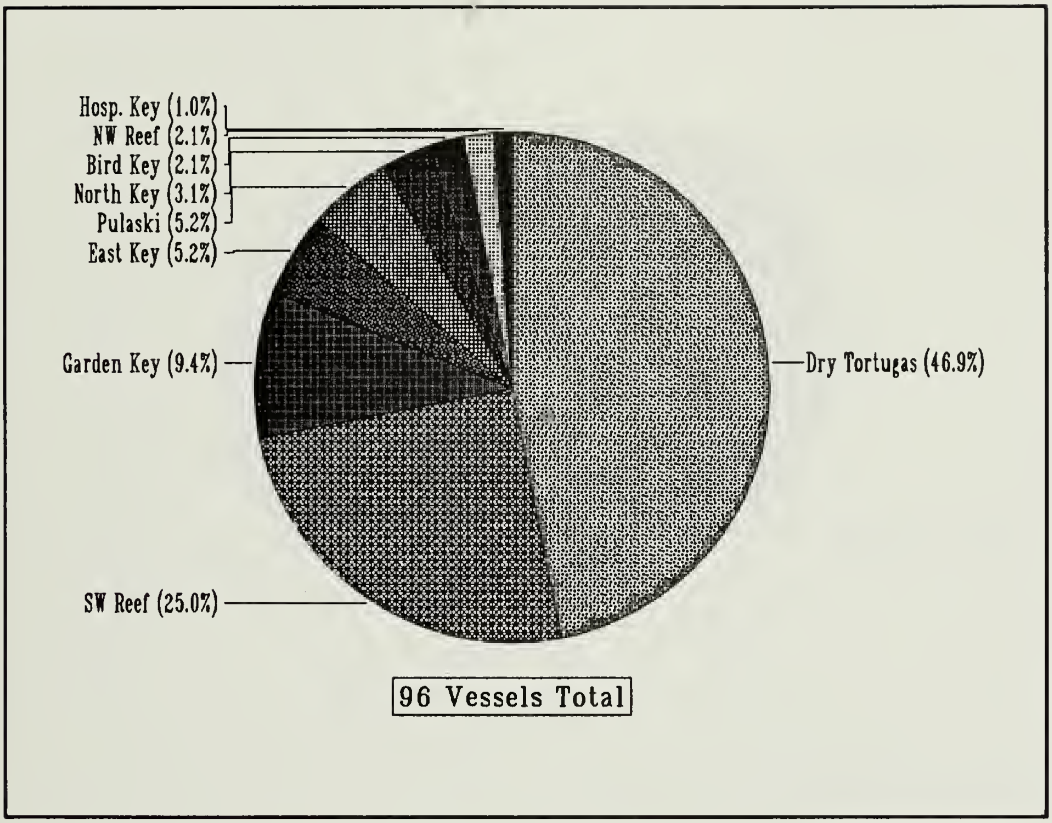


Figure 9.17. Percentages of vessel losses by location.

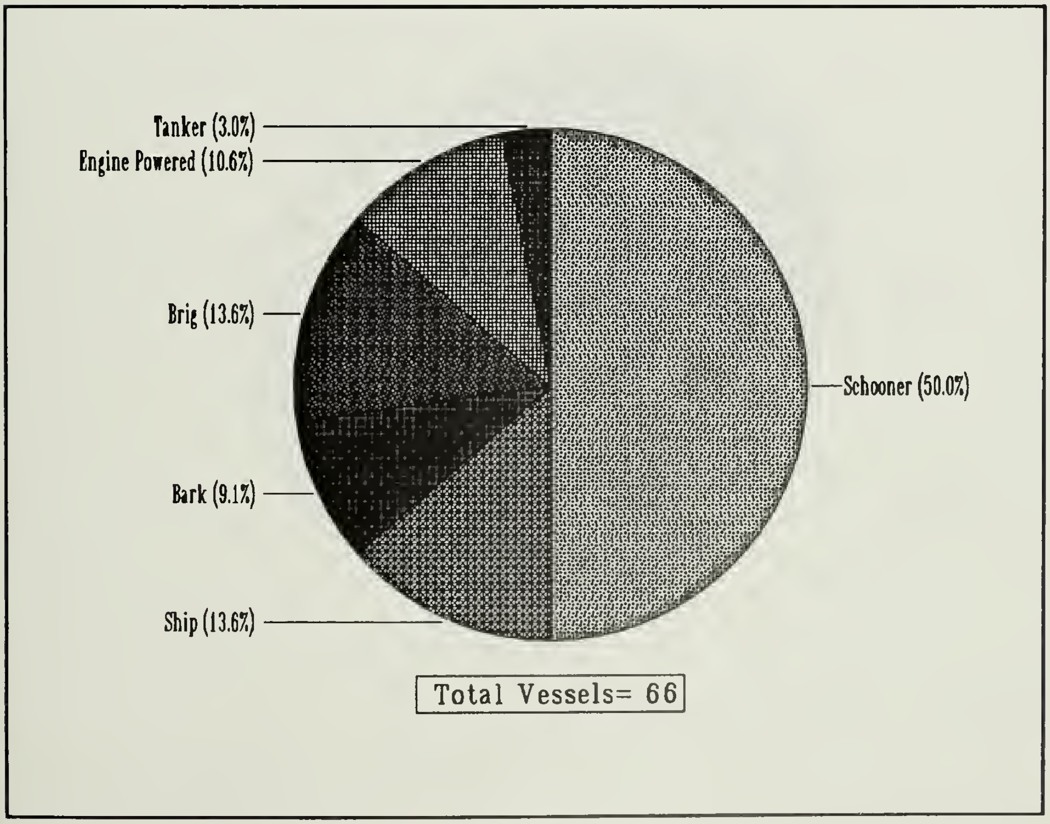


Figure 9.18. Dry Tortugas rig casualties.

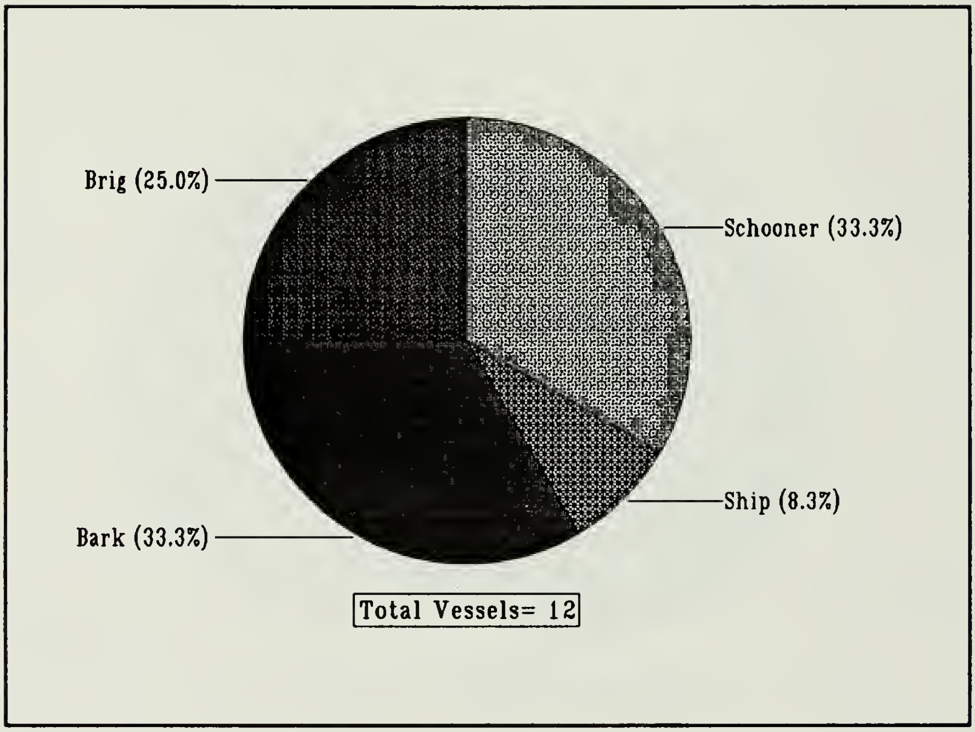


Figure 9.19. Bird Key rig casualties.

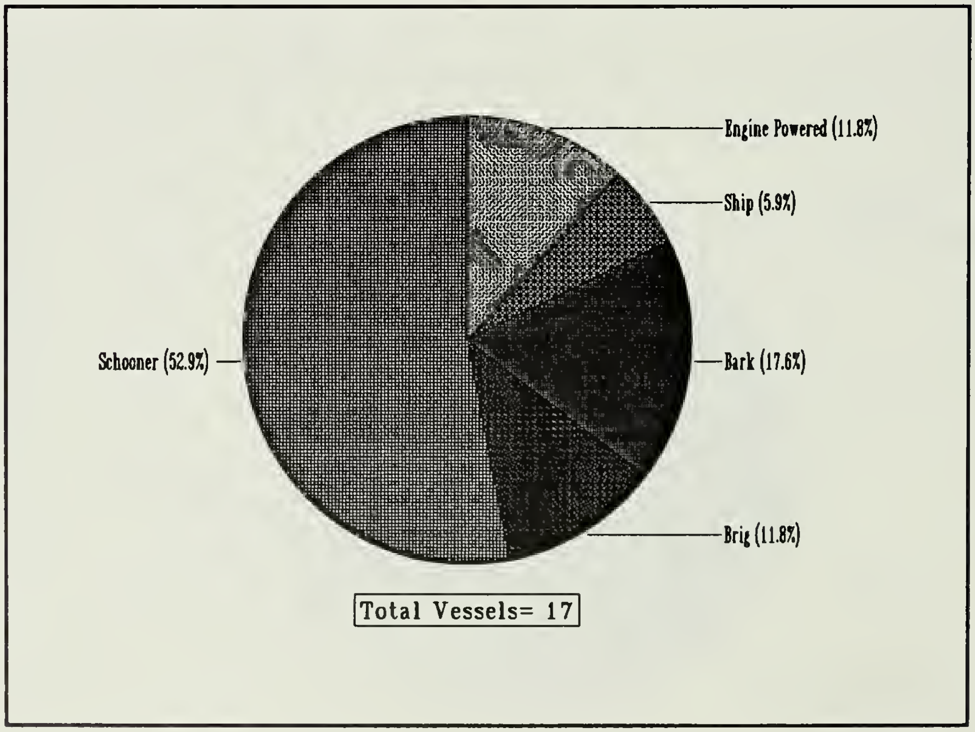


Figure 9.20. Garden Key rig casualties.

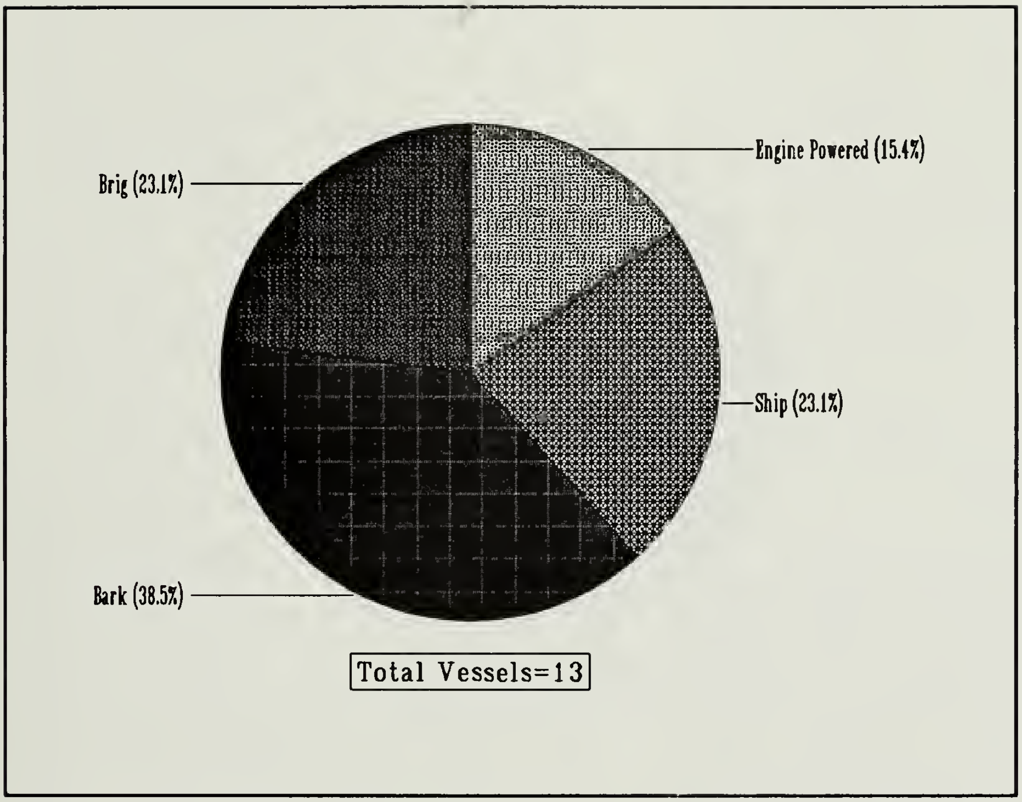


Figure 9.21. East Key rig casualties.

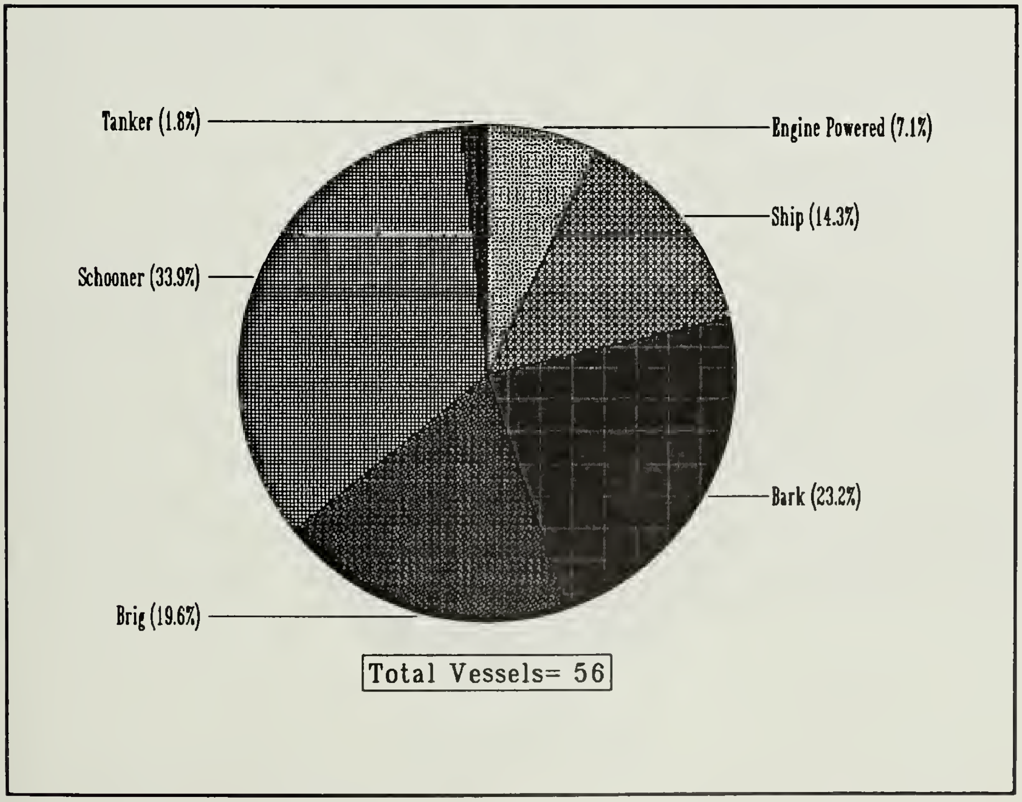


Figure 9.22. Southwest Reef rig casualties.

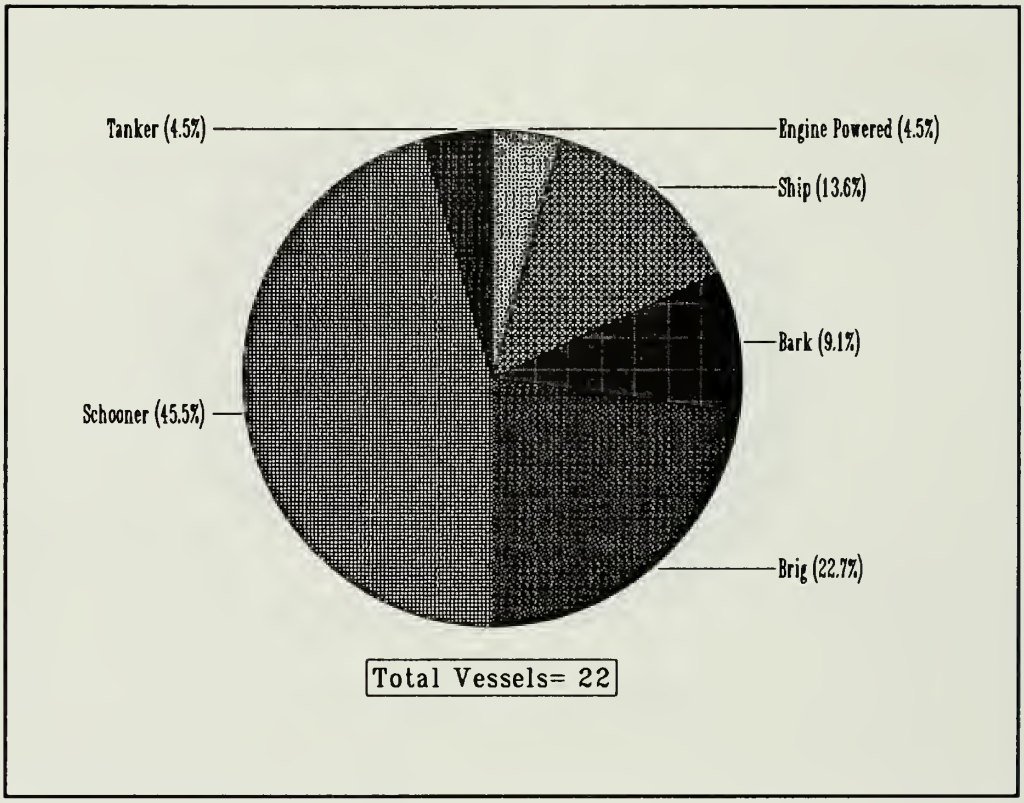


Figure 9.23. North Key rig casualties.

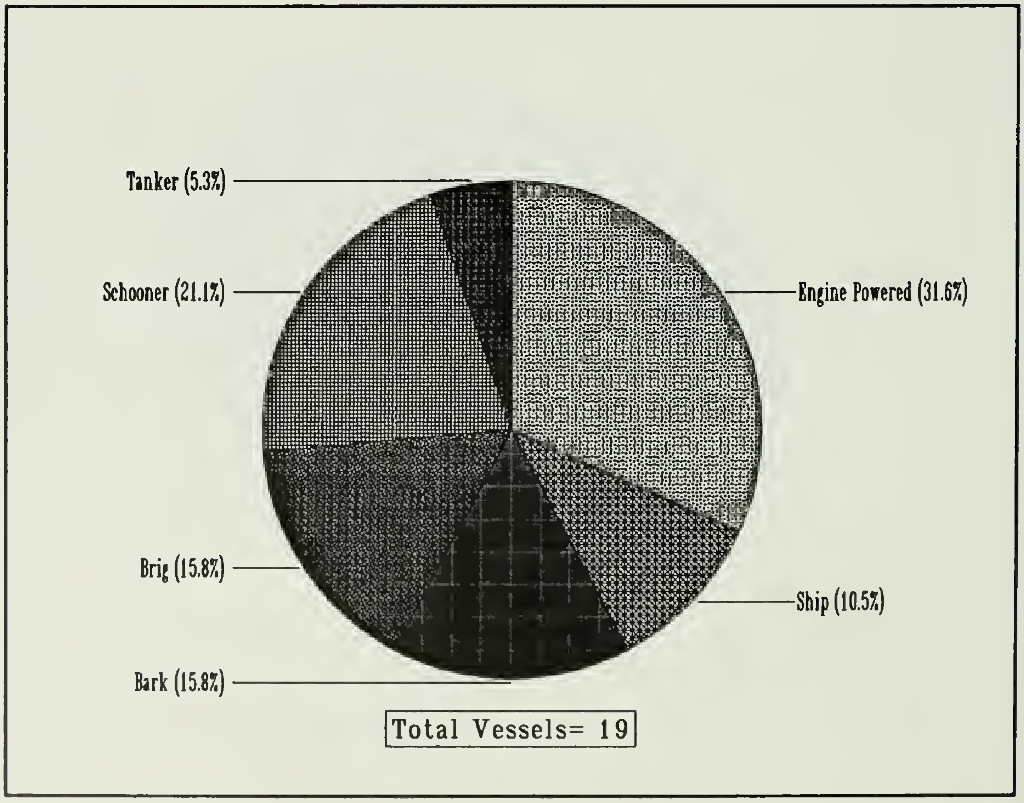


Figure 9.24. Pulaski Shoal rig casualties.

vessels are the majority. East Key resembles Pulaski Shoals in rig type, and probably reflects vessels utilizing Rebecca Channel as a short-cut between the Tortugas and Marquesas Keys to the east.

Southwest Reef (including Loggerhead Key Reef) has the most vessel casualties reported. Large square-rigged vessels are most numerous, followed by schooners and brigs. Loggerhead and Southwest Reef casualties are vessels passing the Tortugas in transit.

A wide cargo diversity is documented for 57 Southwest Reef casualties. Only 15 (26%) of the casualties were inbound to Gulf ports. The remaining casualties are divided between US and foreign ports. US port destinations comprise 43 percent of the total (25) and foreign ports nearly 30 percent (17). Most inbound vessels were carrying general merchandise, construction materials or in ballast. US and foreign-bound vessels carried mostly cotton and lumber.

North Key had more schooner and brig casualties, which make up about 70 percent and outnumber engine-powered vessels and large-square-riggers. These were mostly smaller vessels, perhaps seeking sheltered anchorage. Most cargoes lost on North Key were outbound, mostly lumber, agricultural products and cotton. Fewer than 20 percent were general merchandise.

Pulaski Shoal has the largest percentage of engine-powered vessel casualties, which with large-square rigged vessels makes up about 63 percent of total casualties, with schooners and brigs the minority. This is almost exactly opposite of North Key, and is similar to East Key. Pulaski Shoal casualties appear to be larger vessels that were perhaps using Rebecca Channel between the Marquesas and Tortugas as a short-cut to save rounding Dry Tortugas.

Nineteen Pulaski Shoal casualties have documented cargoes. These cargoes are also diverse, from lumber and phosphate rock to general merchandise. Vessel destinations are mostly outbound; only four cargoes to New Orleans and one to Apalachicola are recorded inbound to Gulf ports. It would seem, based on this small sample, that outbound vessels tended to use Rebecca Channel more than those inbound for Gulf ports.

CONCLUSIONS

This is an initial examination of documented variables of the Fort Jefferson ship casualty record. There are many more combinations and relationships that could be utilized. As historical and archeological research continues, other variables will become useful to understanding and ultimately explaining the maritime archeological record represented within the monument. Comprehensive examination of these data contributes to archeological and historical research question formulation directed toward a more reliable understanding of why shipwreck concentrations vary, and what are the operative structuring principles.

One conclusion particularly relevant for future research in Fort Jefferson National Monument is that much more can be learned historically and archeologically from maritime sites if they are approached as a group, rather than as discrete, disparate sites. Localized shipwrecks and related-site concentrations are complex, and they require examination of a wide range of data to isolate causal factors and their interaction in forming the collection of monument maritime sites.

CHAPTER X

Chronological Overview of Archeological Research 1969-1983 and Terrestrial Projects 1989 and 1990

David M. Brewer

INTRODUCTION

Archeological research at Fort Jefferson National Monument (NM) is a relatively recent affair. From its designation as a National Monument in 1935 to the mid-1960s, there is no record of interest in the archeological values of the fort or surrounding waters. At some point in the early 1960s, when visitor use became heavy enough to warrant fort development as a tourist attraction, historic architects examined fort structures and made recommendations, including a brief comment that the abandoned enlisted men's barracks and officers' quarters were unsafe for visitors. This offhand remark resulted in a decision by then-National Park Service (NPS) Director Conrad Wirth to demolish these buildings despite the area manager's protests. Historic preservation, then gaining a foothold across the country as a result of legislation such as the Historic Preservation Act of 1966, required evaluation of government holdings and land affected by government funding for historic and archeological significance. As a result, attention was directed to resource assessment in and around Fort Jefferson.

Advent of recreational diving increased visitor impact on this unspoiled, remote section of the Florida barrier reef. Unfortunately, it also attracted attention of treasure hunters to whom the numerous Dry Tortugas historic shipwrecks represented a potential opportunity for easy wealth. Vandalism in search of imagined gold and silver resulted in destruction of the real treasure--information about our historical and cultural heritage. It was for this reason that archeological assessment has concentrated on the monument's underwater resources; they are less visible, yet vulnerable. As can be seen from the past work, Fort Jefferson NM archeology is only just beginning.

1969

Prospectus and Initial Reconnaissance (Southeast Archeological Center [SEAC] Accession 185)

In 1969, George Fischer, then an archeologist with the NPS, Washington, D.C., Division of Archeology, wrote a prospectus to conduct underwater archeological research at Fort Jefferson NM. A bit ambitiously, he proposed conducting a multistage, comprehensive underwater archeological project for locating, identifying, evaluating and studying shipwreck sites around Fort Jefferson (Fischer 1969:2). A preliminary six-week shakedown study was planned for summer 1969, with subsequent investigations being carried out during 1970 and 1971. The proposed research plan included: 1) study of USGS aerial photos and subsequent complete visual survey of shallow waters; 2) a systematic deep-water magnetometer survey near shoals, reefs and channels; 3) accurate plotting of sites with minimum subsurface testing to recover only enough artifacts to determine nationality and time period; 4) development of a shipwreck priority list based on historic significance and/or vulnerability to disturbance or destruction; 5) prioritized archeological investigation and site mapping; 6) planning and practice of in-field preservation and conservation, with preparation for the long-term; and 7) carrying through with curation (Fischer 1969:9-10).

This project was innovative for the time because it planned for an overall view towards an interdisciplinary and general approach to archeology conducted underwater. Oceanography and marine biology were to be incorporated in ecological studies of marine bottom communities. Underwater photography, then in its infancy, was to be used for data collection, including proposed use of underwater video as well. Land survey and potential testing of terrestrial sites were planned for some of the barren keys. There was even the rudimentary suggestion of an interpretive prospectus for public accessibility including the use of an in situ transparent shell covering a site, with fixed diving bells and underwater audio to provide narrative and the use of wet and dry submersibles for tours. Closed circuit television was considered for the impaired (Fischer 1969:17).

Four people conducted the shakedown survey April 13-19, 1969: George Fischer and Zorro Bradley from the National Park Service's Division of Archeology; Mendel Peterson, Smithsonian Institution military historian and Emmy Boynton, a Bahamas archeologist. This initial survey evaluated wrecks reported by park personnel and resulted in a recommendation that a well-preserved, iron-hulled motor-vessel wreck, loaded with brick located south of the fort in 6 ft of water, be utilized by the park for interpretive snorkeling. A large test excavation was also carried out on the east side of the moat 100 ft north of the entrance bridge. This test excavation was dug from the fort wall across the moat to the moat wall, with no artifacts discovered. It did reveal, however, that a fine sediment buildup had filled in the moat. Finally, a walkover survey by Bradley and Boynton for prehistoric sites yielded no observed surface materials on Garden or Loggerhead Keys. Bush Key was not visited because of Sooty Tern nesting, and Hospital Key was observed from the air only.

1970

Returning briefly in December 1970, Fischer, Bradley and Jerome Petsche, also from NPS, surveyed East Key and Hospital Key, where they noted building bricks and a monument stone, apparently associated with the yellow fever hospital that gave the key its name. They also located and explored a wreck, 150-200 ft long and lying at 5-10° magnetic, in the northeast sector of Bird Key Harbor. Later, while working in the fort moat, they excavated along a crack in the fort wall west of Bastion 6 to see how far below the water surface it extended and found it went all the way to the foundation. A single brick fragment with a maker's mark was recovered. Plans were made for a systematic excavation for the summer of 1971.

1971

The 1971 investigation had three goals: a controlled moat excavation, architectural evaluation of the fort's submerged walls and a shipwreck survey. "When Fischer returned to conduct the full-scale excavation, he brought a full contingent of divers, archeologists, and other specialists, and much in the way of specialized equipment" (Lenihan 1974a:46).

Fischer was overall project director. Open-water survey supervisor was Carl Clausen, State of Florida underwater archeologist, and Calvin Cummings, superintendent of Gran Quivira National Monument, directed moat investigations. National Park Service historian Edwin Bearss conducted post-project historical research and produced the comprehensive report *Shipwreck Study - The Dry Tortugas* (1971), which listed hundreds of wrecks, strandings and groundings, and is still recognized as the definitive monument history of maritime casualties.

Moat Excavation

Concerning the moat excavation procedures:

> A grid system was constructed above the surface which could be rigidly secured in place. A base line was established through the exact center of the Sally port (Figure 10.1) and running southeast lengthwise down the middle of the bridge and across the moat. The grid was in squares, ten feet per side with point 00 located at the outside end southeast of the bridge, and seven-and-a-half feet southwest of a brass National Park Service corner marker. The north-south line is set back two feet on top of the moat wall. At the fort side 70 feet is even with the

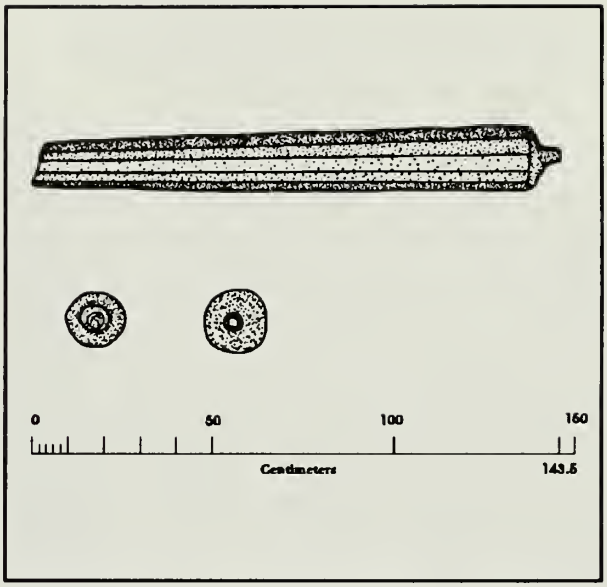


Figure 10.2. Sixteenth century cannon, recovered in 1971.

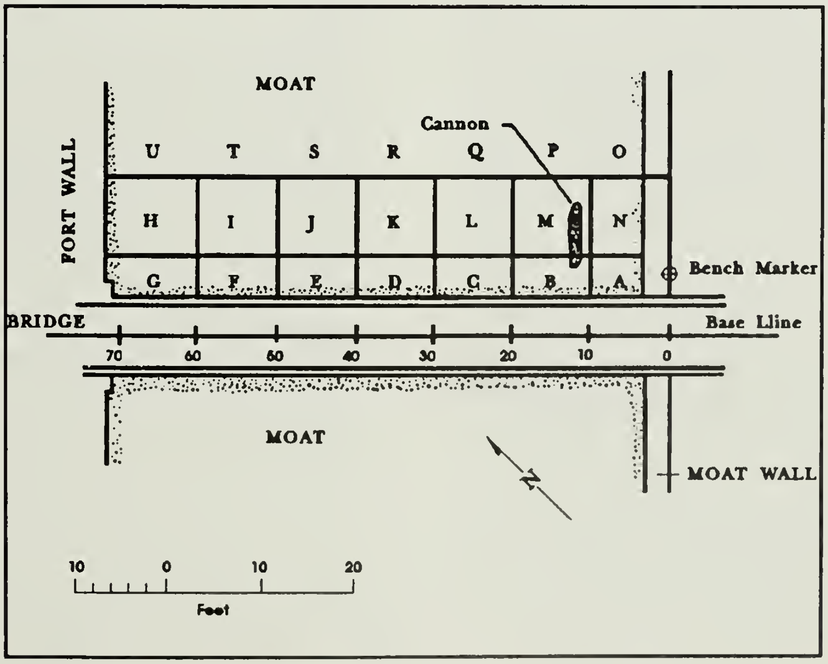


Figure 10.1. Test area number 1, 1971 moat excavations.

> wall at the bottom of the moat, but almost three feet short of the wall at bridge level [Lenihan 1974a:4].

A cannon (Figures 10.1 and 10.2) recovered by Lee Wood, NPS, in April 1969, was noted within the initial gridded moat area. Cliff Green, captain of NPS supply vessel ACTIVA, remembered the cannon coming from "just west or southwest of the south end of Loggerhead Key" (Fischer field notes, 1971:n.p.). The cannon had been placed in the moat to keep it stable until proper conservation treatment could be arranged. Harold Peterson, NPS chief curator, in a letter to George Fischer (3/22/74) stated that after some study, he believed it to be "a 2-pounder falcon dating from the third quarter of the sixteenth century. Originally it would have been nearly six feet long." He also thought that at the time it was the earliest cannon recovered from Florida waters.

The area adjacent to the entrance bridge had been chosen "because of the likelihood of historic objects being deposited by troops returning to the fort through the sally port" (Lenihan 1974a:46). However, other than a single bottle and some glass and metal fragments, the "hypothesis that a rich sprinkling of historical material would be found near the sally port was not borne out" (Lenihan 1974a:49). After completing the entrance bridge excavations, the moat investigation was moved, because...

> One of the researchers discovered while perusing some old documents that the kitchen area had been located at Bastion #4, and an alternate theory was proposed that this area should be heavily spotted with debris and that there should be a proportional lessening of the occurrence of material remains as one progressed away from the bastion. This alternate hypothesis was borne out as indicated by the fact that a large number of bottles covering about a 60-90 year range in age plus a number of other items were recovered with the predicted frequency distribution. An observation made here was that medical-type bottles were found in consistently closer proximity to the bastion than whiskey and wine bottles. Further testing would be necessary to conclusively indicate whether this is a direct function of the superior aerodynamic properties of alcoholic beverage containers of the nineteenth century over contemporaneous medicine bottles. Or perhaps the bottles' deposition is instead related to the more vigorous and enthusiastic state that the contents of the former type of container put the cultural actors in, over the contents of the latter [Lenihan 1974a:49].

The large bottle collection from the 1971 Fort Jefferson moat and swimming beach investigations was the subject of an independent descriptive study by James Thomson (1975), who concluded:

> Little can be added to Lenihan's description concerning the distribution of alcoholic containers as compared to those carrying medicines. I had thought that the preponderance of "refreshment" bottles would be located on the western side of the fort where the soldiers might have drank and conversed while the sun was setting, but most have been plotted on the north east side at Bastion 4 [Thomson 1975:n.p.].

Architectural Evaluation

Divers working near the kitchen area discovered evidence of construction methods used on the large, supportive foundation

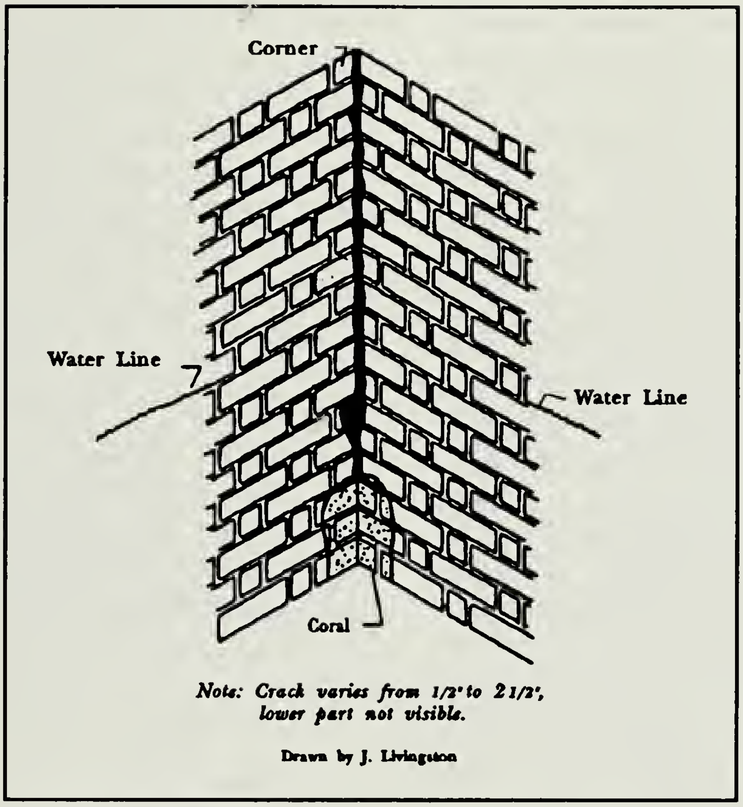


Figure 10.3. Example of 1971 wall crack survey drawings.

"belts" spanning the moat. Investigators developed a hypothesis for how the fort's foundation was constructed:

> They were comprised of burlap packaged sand, tied together or bound through looped brass wire, twisted, covered with steel mesh, sealed with a cheese-like material, and then capped and spanned with concrete. They may have been built at low tide, the gap between pumped dry and the brick foundations for the wall constructed. Construction would then have continued until the sea wall was of sufficient height to allow building of the coffer dams within. In other words, the fort foundation and walls may have been built within the sealed "moat" after it had been pumped dry, a section at a time [Lenihan 1974a:50].

Following the 1971 moat investigations, Jerry Livingston, Midwest Archeological Center Scientific Illustrator, drew a series of foundation wall cracks discovered during moat investigations (Figures 10.3 and 10.4, Livingston 1971). The most significant point about the submerged moat architecture, as described by Lenihan, was that cracks observed above the water surface did not generally extend much below the low-water level (1974a:50). Submerged wall preservation was attributed to constant water level and relative temperature, which apparently preclude atmospheric erosion and expansion-contraction forces: "a finding of considerable significance in regard to future preservation of masonry forts of this style and period" (Lenihan 1974a:50).

Open-Water Survey

The open-water survey, under Carl Clausen's direction, combined two survey techniques. The general approach was intensive saturation magnetometer survey using a buoy grid-system tied to bearings and horizontal angles taken on visible points, primarily navigation buoys and the Loggerhead and Fort Jefferson lighthouses.

A secondary survey method consisted of random runs taken when the grid was being moved from one area to another, while the magnetometer continued running outside the formal grid. Any anomalies encountered were treated the same, however, being buoyed, positioned by bearing and angles, investigated by divers and mapped (Fischer 1973:3-4). A Varian V4937-A proton-precession magnetometer, with a one-half gamma sensitivity, digital readout and strip-chart recorder, was the survey instrument. The machine was owned and operated by Martin Meylach of Miami, under NPS contract. Areas of most interest and intensive, systematic survey were reef areas near Loggerhead and Long Keys, because these had been targeted as being "where historical documentation and archeological precedent in analogous situations

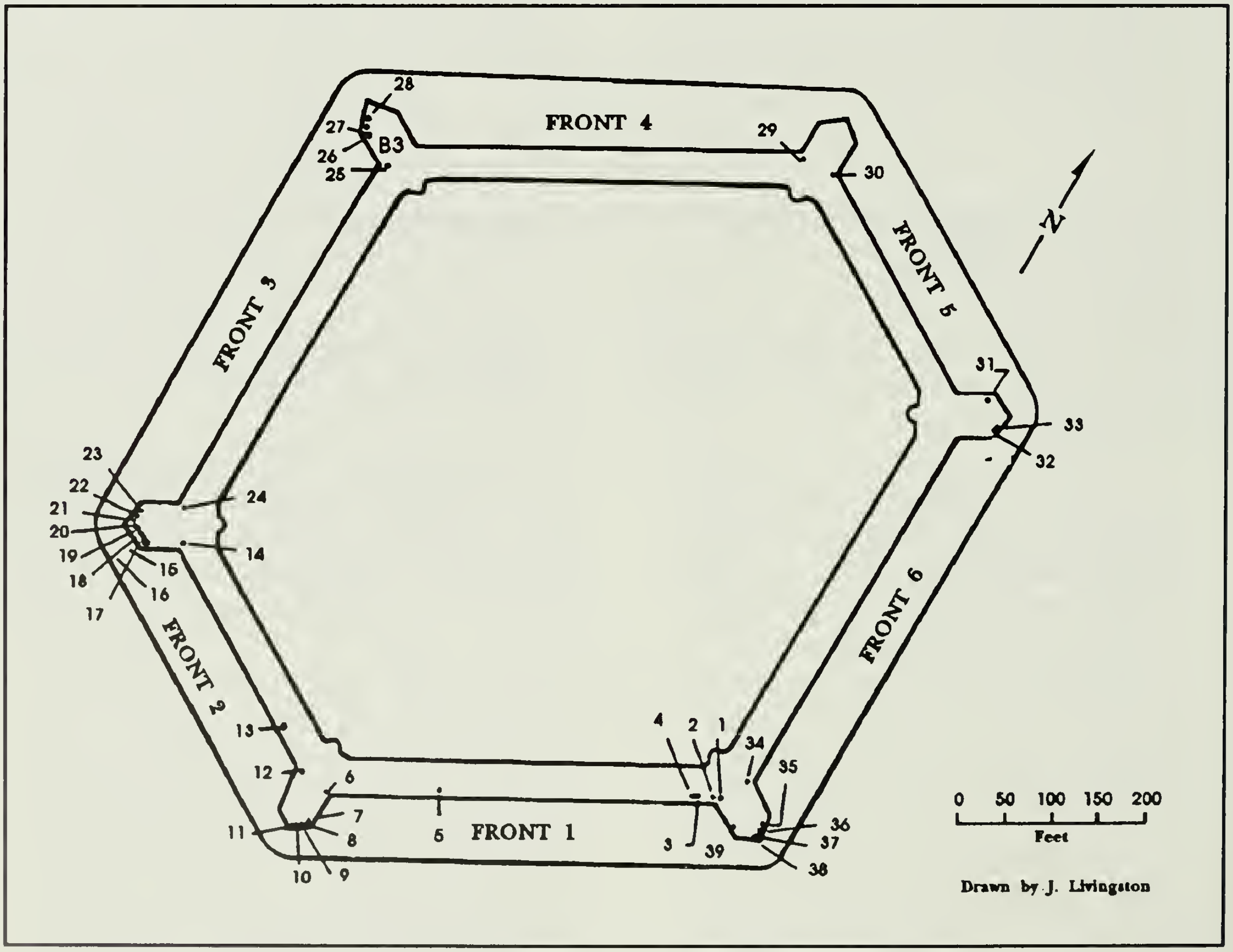


Figure 10.4. Area covered by 1971 wall crack survey.

indicated most wrecks would be found" (Fischer 1973:3).

Five gridded areas were surveyed: Survey areas number 1, 2 and 3, each approximately 1,000 ft x 4,000 ft, were contiguous and southeast of Long Key; survey areas number 4 and 5, areas approximately 2,000 ft x 6,000 ft, were located southwest of Loggerhead Key. "Magging runs were carried out at 75-ft intervals" within the grid areas (Fischer 1973:5). Random sample areas were: north and northwest of Loggerhead Key for 2 1/2 nautical miles; southwest end of Loggerhead Reef outside survey area number 4; portions of the reef southwest of Long Key; portions of shoal areas at East Key; and the 15-ft depth line from East Key to Pulaski Shoal Light (Meylach 1971a:1). All areas sampled as a result of magnetometry were in waters 25 ft deep or less (Meylach 1971a:2).

> As a supplement to the magnetometer survey an aerial photographic survey was also conducted of the Loggerhead Reef area. Besides contributing... to the immediate survey goals this was also intended as a feasibility demonstration to determine the utility of aerial photography in support of marine archeological surveys in general [Fischer 1973:4].

Two historical sites were discovered using aerial photographic survey techniques in August 1971 by Alan Marmelstein of Earth Satellite Corporation, Washington D.C. (Fischer 1973:5). These discoveries validated use of aerial wreck detection in these waters.

Sixteen sites were recorded as a result of open-water survey efforts through 1969-1971, twelve sites were classified as shipwrecks, and four sites as artifact concentrations associated with shipping activities. All were given field site-designations and plotted on a basemap. A draft report (Fischer 1973) covered the general results. A final report was not completed because the project was considered ongoing; however, the volume of data present in the field notes and the professional range of the researchers involved continues to make a final report desirable, even considering the length of time since the project occurred.

The NPS Division of Archeology, Washington D.C., let a contract to the State of Florida in 1971 to "conduct survey and testing of historical shipwrecks in the Pulaski Light and East Key vicinities, and such other areas as may be deemed necessary by the Service, at Fort Jefferson National Monument..." (Contract No. 14-10-9-900-379, 6/4/71). A change in personnel in the State's Underwater Archeological Research Section, however, caused delays in carrying out the continued survey and evaluation until 1974 when the new state underwater archeologist could begin work.

1974

State of Florida Contract Survey (SEAC Accession 433)

The 1974 survey project consisted of a six-person crew headed by State Underwater Archeologist Wilburn Cockrell, and took place from May 7-23, 1974, although inclement weather precluded any work until May 14. Terms of the NPS Washington office contract included: 1) establishment of priority areas (based on previous surveys, historical research, and a study of aerial photographs); 2) survey by metal-sensing, diver observation, and other methods, of those areas not covered by earlier survey activities and mutually agreed to be most productive on the basis of earlier research; 3) testing of discovered sites using standard archeological techniques, with a definitive sample removed from each site tested; and 4) all materials recovered to be cleaned, described and preserved.

The initial survey site area, selected on the southwest portion of Loggerhead Reef, was changed to the west (lee side) because of inclement weather. "This section was precisely demarcated by corner buoys positioned through radio contact with transit operators on Loggerhead Key and on the terreplein of Fort Jefferson on Garden Key" (Cockrell et al. 1974a). Thus, there were three transit stations: one set up on each end of Loggerhead Key (Stations 1 and 3) and one three miles east on Garden Key (Station 2). These transit stations were used to triangulate the search area corners, whereas only Stations 1 and 3 were used to shoot in magnetic anomalies recorded in the search area. A buoy system was used for navigation during the survey.

Seventeen magnetic anomalies were recorded and investigated by divers. Of these, 11 were reported to be modern metal debris, four had no material visible above the substrate, and two were reported as historical shipwreck materials. Of the two shipwreck scatters, one was in the immediate area as the Iron Ring Wreck discovered in 1971 (Field Site No. 83: FOJE 009, a.k.a. the Spanish Wreck, and the alleged ROSARIO site). In the accompanying documentation to the report, there are Florida Master Site File forms documenting five sites listed as shipwrecks discovered during this survey. Of these five sites, four are described as containing modern materials.

The remaining site (8Mo252), if not entirely composed of the same materials reported in the 1971 site sheet for Field Site No. 83, is in the same location. The materials described as recovered in 1974 include a bronze rudder gudgeon, square nails, iron shot, a brass coin and animal vertebrae. Other items observed were a wooden beam, gears, an anchor, ballast and fittings. The evidence presented does not justify an alternate site location from that of FOJE 009 (1971 Field Site No. 83), until it can be demonstrated that there are two (or more) wreck sites at this location. Nonetheless, the site was recorded separately (FOJE 028) based on the survey crew's in-field interpretation that the items recovered represent a site of more recent vintage than that of FOJE 009. The four magnetic anomalies recorded on Florida Master Site File forms are also recorded as separate sites (FOJE 024, 025, 026 and 027).

None of the material recovered from this project is available, either having been "lost in conservation" or simply lost, although photos of the material are on file (SEAC Accession 433). Field notes and supporting documentation are currently in the possession of the State of Florida's Bureau of Archeological Research.

Aerial Remote-Sensing (SEAC Accession 432)

The positive results of the 1971 aerial remote sensing experiment prompted a continuing study funded by the NPS to operationally support additional aerial shipwreck survey in Fort Jefferson and other NPS lands (Marmelstein 1975:2). During the May 1974 state survey, George Fischer and Alan Marmelstein returned to Fort Jefferson to continue aerial photography reconnaissance and interpretation for archeological sites. They flew over the south end of Loggerhead Key on their initial approach to Fort Jefferson and noted the island's south end had changed in shape since 1971--in only three years. They also flew over the Bird Key Harbor Brick Wreck (FOJE 029) and established ranges for that site (Fischer field notes 1974:3).

Prior to the 1974 fieldwork, Marmelstein reviewed high-quality aerial photography of Loggerhead Reef available at the National Ocean Survey Archives. While at Fort Jefferson, Marmelstein used this aerial imagery to relocate such prominent features as the Nine-Cannon Wreck (FOJE 008), the

ROSARIO site (FOJE 009), and other wreck sites, including several Civil War period "brick wrecks" in the Bird Key Harbor area (Marmelstein 1975:5-6).

Land Wreck Discovery

A September 1974 storm, which occurred after the state survey crew had departed, eroded a section of the southeast tip of Loggerhead Key and exposed approximately 30 ft of wooden ship structure (Stark 10/2/74). Four iron fasteners and a small wood fragment were sent to SEAC along with some photos of the exposed wreck site. No bronze or other metal fittings were observed. To date, no other record mentioning this site has been located, and it has not been listed on the park archeological site inventory.

1975

Catchment System, Drain Field 106 Compliance (SEAC Accession 434)

In 1975, during fort catchment-system rehabilitation, a drain field was to be installed to an already existing septic tank (Richards 1975:1). In a short report on the line excavations, Park Technician Steven Richards, who was acting as the archeological monitor, noted that:

> One line runs from the presently occupied apartments, along the inner side of the walk, makes a right angle at the generator station and empties into the first cell of the cistern. The second line of the catchment system runs along the fort wall from two unoccupied apartments near the west powder magazine, to the generator station, where it also makes a right angle, but empties into the third cell of the cistern.
>
> The drain field for the septic tank runs between the Superintendent's apartment and the cistern, toward the parade ground. One line runs 24' toward the parade ground (south). The other lies to the west, 40' in the direction of the cistern [1975:1].

Along the second catchment-system line, the original plans had been changed, with two 45° angles put in near the generator station to avoid a trash dump of metal objects. The drain-field pipe had also been laid outside the originally planned trenchline because it would have hit "a line of bricks, 100 ft long and 30 ft from the present walk" (Richards 1975:1). Richards surmised that "the line of bricks was probably used to delimit the area of a lumber shed from the 1890s...[because] A photograph from 1898 shows a lumber building in this area of about the above proportions, although the line of bricks is not shown" (1975:1). He recommended avoidance of these two features until they could be studied further. A project map accompanies the two-page report showing the changes to the original proposed catchment and drain field lines.

1976

Mapping of the Bird Key Harbor Brick Wreck (No SEAC Accession #)

As part of Florida State University's (FSU) Academic Diving Program, which sponsored a Scientist-In-The-Sea (SITS) course on diving research applications, student Trisha Logan planned and carried out a mapping exercise on the Bird Key Harbor Brick Wreck (FOJE 029). The result was a map produced from two on-site datum points ("one near the center of the wreck on the starboard side ... and a second datum point near the bow"), and angle and distance measurements along a plane table, or alidade, to various points on the exposed wreck (Logan 1976:n.p.). Using these mapped-in points, as well as photographs and sketches, a simple site map was constructed.

1981

SEAC/FSU Site Investigations, October 1981 (SEAC Accession 580)

Nondestructive documentation of two sites first located in 1971, FOJE 008, the Nine-Cannon Wreck (1971 Field Site No. 82) and FOJE 009, the Spanish Wreck or ROSARIO site (1971 Field Site No. 83), was carried out by SEAC in cooperation with the FSU Academic Diving Program October 5-12, 1981.

> The primary objectives for the operation were twofold: to train and give experience to FSU students in remote-sensing survey and on-site data collection techniques associated with shipwreck archeology; [and] to locate, photodocument and map the surface materials associated with a shipwreck in the Fort Jefferson National Monument [Johnson 1982a:43].

Photomosaic and Mapping of FOJE 008

Data collection efforts centered on FOJE 008, the Nine-Cannon Wreck, as the shipwreck documentation training site. "No site disturbing activities were permitted, and no subsurface testing was conducted" (Johnson 1982a:43). Besides relocating and replotting the site location, 38 exposed artifacts were mapped. A huge site photomosaic of more than 1,000 photos was shot, with each archeological feature plotted and photographed individually. The nine cannons, for which the site was named, were visually inspected and diagnostic physical measurements taken. These cannon were identified as six 9-pounders, two 6-pounders, and one 4-pounder, of contemporary mideighteenth century vintage, and probably British, although a definite cultural affiliation was not firmly established at that time (Johnson 1982a:43). A basemap was drawn from site measurements (Figure 10.5).

Discovery of FOJE 017 the Ludert-Cooper Site

The Spanish Wreck site (Iron Ring site, FOJE 009), first noted in the 1971 open-water survey, was relocated by magnetometer survey. A large number of ladrillos (ceramic fire tiles) marked the site. During visual inspection of the site environs, a "nest" of seven built-up, breech-loading wrought-iron swivel guns was discovered within 200 m of FOJE 009. This site was documented separately, with each gun measured and drawn in situ.

Designated the Ludert-Cooper site (FOJE 017), its relationship to FOJE 009 was unclear; nevertheless, certain clues indicated a probable relationship. This site was unknown to the NPS prior to the October 1981 field investigation. It was subsequently plotted on the monument's archeological base map. Individual artifacts were mapped in place, and approximately 20 artifacts were recovered. Ninety percent of these artifacts were ceramics, primarily Spanish olive-jar fragments dating to Goggin's Middle Period (1550-1800). A wrought-iron swivel gun was recovered, its construction date estimated as probably sometime during the late sixteenth century (Johnson 1982a:43).

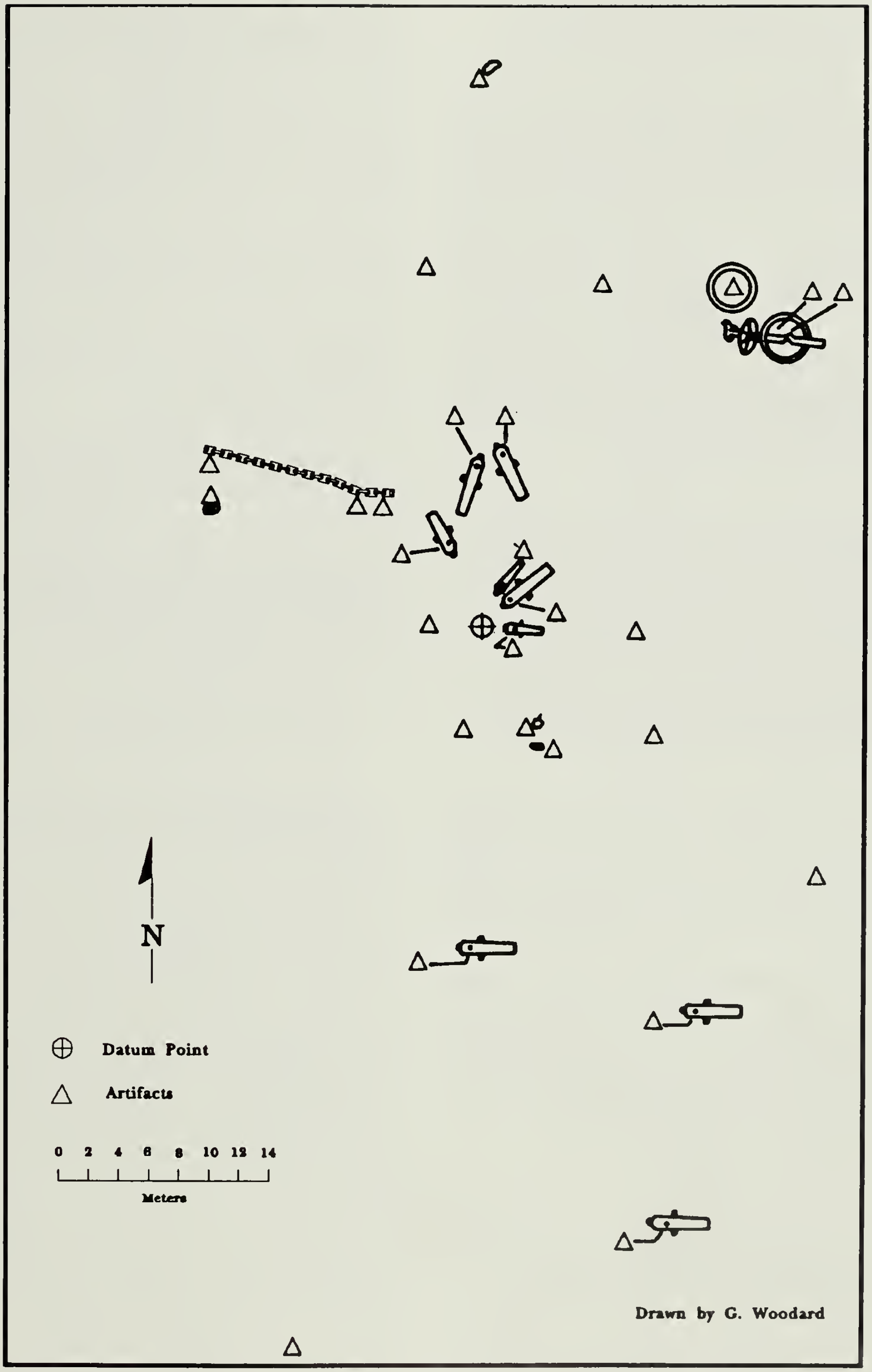


Figure 10.5. Sketch map, Nine-Cannon Wreck, FOJE 008, 1981.

Discovery of FOJE 018 the Two-Cannon Site

While carrying out magnetometer survey during the SEAC-FSU project, another new site was discovered, the Two-Cannon site (FOJE 018). The site, located approximately 200-250 m offshore west of the Loggerhead Key Lighthouse, consisted of only two cannons; no other artifacts were observed in association. These cannons were plotted, measured and photographed. The investigators noted they "reveal a probable dump site or site of secondary deposition rather than a shipwreck site" (Johnson 1982a:43).

> Preliminary indications reveal that both cannons are probably 4-pounders of consistent vintage, probably mid-18th to early 19th with an average caliber size of 17 or 18, an indication that the guns are of more recent vintage than those on the Nine-Cannon Site (FOJE-UW-8) [Johnson 1982a:43].

They were neither recovered nor buried and should still be exposed. The 1981 investigation results were written up in a brief summary as Appendix D to the 1982 investigations report.

The FOJE 008 photomosaic has not been assembled. As a scientific (and legal) document establishing the site's condition as it existed in 1981, completion of this particular photographic record should be done.

1982

SEAC/FSU Site Investigations, July 1982 (SEAC Accession 594)

The SEAC, again supported by FSU's Academic Diving Program, returned to Fort Jefferson National Monument for three weeks in July 1982 to conduct further archeological studies on southwest Loggerhead Key sites. This project was designed to thoroughly assess FOJE 009, the Spanish Wreck site, discovered in 1971. Identification as a "Spanish" wreck was based on materials recovered there during the 1971 field investigations, including "Spanish bricks, two iron rings (possibly mast hoops), forged-iron ship's fastenings, rock ballast, and a typically Mexican tripod metate" (Johnson 1982b:2). "No (intrasite) provenience documentation for material recovered was recorded at the time of investigation (1971)" (Johnson 1982b:iv).

A second objective was to determine if there was any relationship to the swivel gun "nest," FOJE 017, discovered the previous year [1981], which had yielded culturally diagnostic ceramics and the temporally diagnostic ordnance that established definite Spanish cultural affiliation of the late sixteenth or early seventeenth century.

Mapping and Testing of FOJE 009

The original grid over FOJE 009, delimited by presence of ladrillos and egg-rock ballast, consisted of 299 10-m square units. Inspection of this gridded area produced an artifact distribution map from which a smaller grid of 50 10-m square units was chosen as for intensive investigation (Figure 10.6). Within the 50 10-m squares, a number of 1-m-square test-excavation units were planned. Using a stratified, random sampling method (wherein the northeast 1-m- square corners of randomly chosen 10-m squares from 20 m x 50 m strata were tested), a total of 27 test units was selected for excavation by dredge screening. These test units comprised a .54 percent sample of the intensive investigation area tested for subsurface wreck components, features or artifacts. Units were excavated to an average of 40 cm below the seabed to a generally sterile substrate of finely compacted "marl," or clay-like strata. About half (55.6

percent) the test units yielded cultural material including ballast stone, unidentifiable iron fragments and fragmented brass pieces (Johnson 1982b:14) from which samples were recovered. All diagnostic artifacts were recovered. Excavated material consisted of unidentified wood, a brass fastener fragment, a fire-tile fragment, two glass fragments, an unidentified iron fragment, eight ballast stones, an iron-buckle concretion, several brass fragments, a ceramic fragment (whiteware?) and an iron fastener (Johnson 1982b:20). Two anchors, heavily encrusted, were also observed.

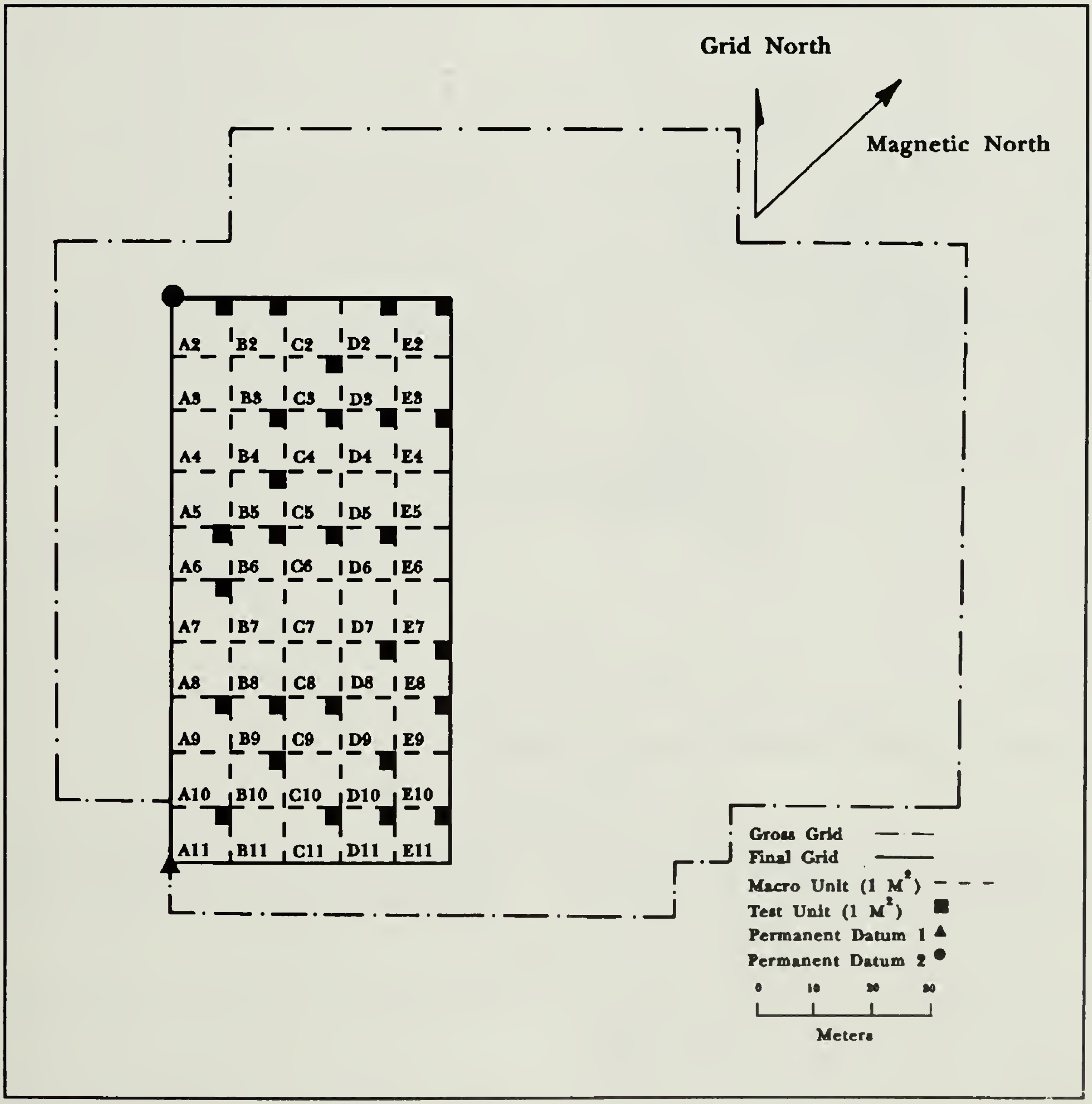


Figure 10.6. Intensive investigation focus area with subsurface test location, FOJE 009 (from Johnson 1982).

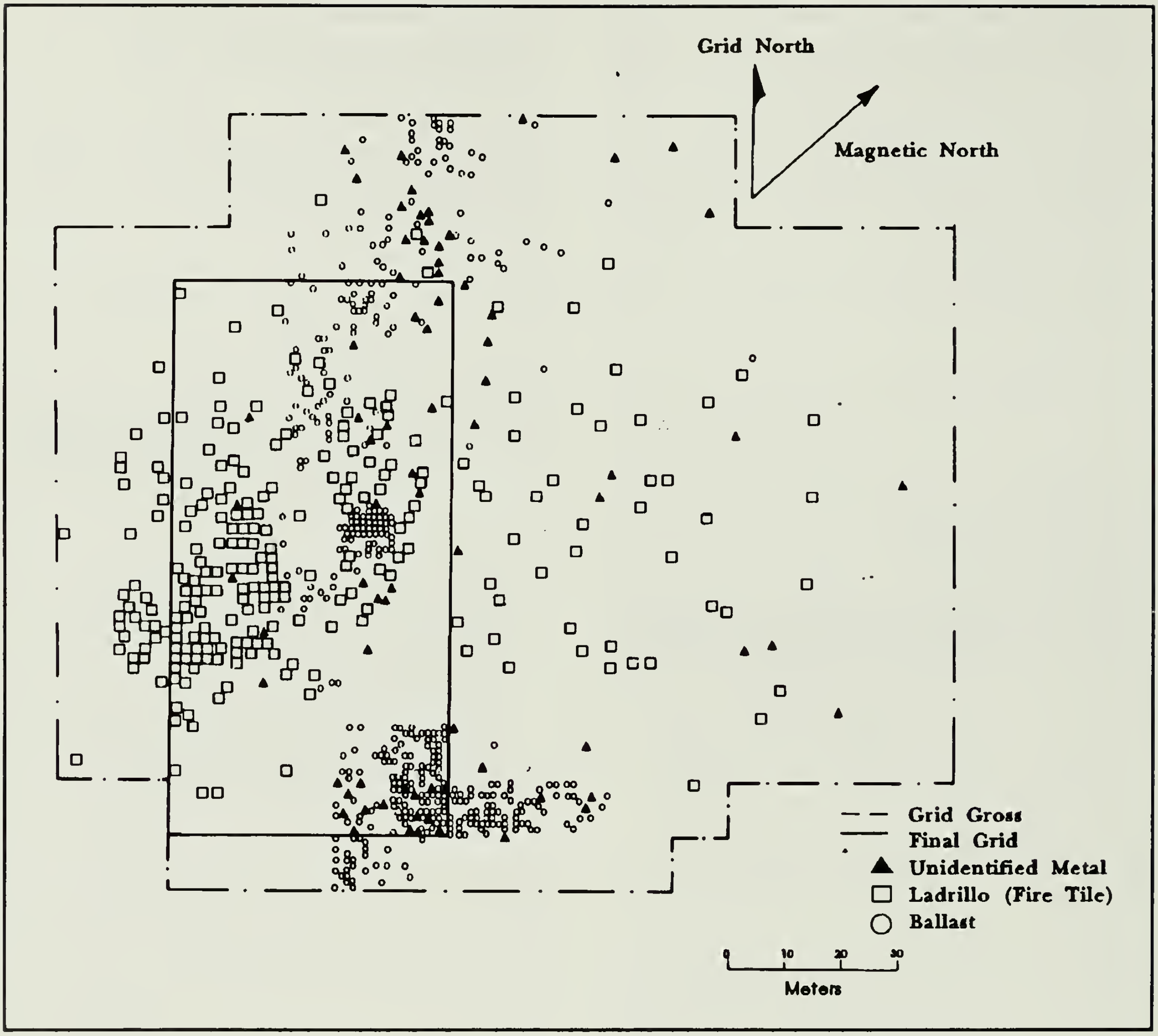


Figure 10.7. FOJE 009 artifact distribution (from Johnson 1982).

Despite analysis of recovered material, no specific temporal or cultural affiliation could be assigned to FOJE 009 (Johnson 1982b:28). The site map, although it appears to exhibit a certain amount of artifact patterning (Figure 10.7), especially for ladrillos and ballast, yielded no culturally or temporally diagnostic surface artifacts. Subsequent research showed that fire tiles were used to line ship galleys of different nationalities over a considerable time period (AD 1500-1800), so they are not diagnostic of date or cultural affiliation. Further analysis of all recovered items should be considered, however, prior to any future investigation at the site.

Relationship of FOJE 017 to FOJE 009

An attempt was made to determine the spatial relationship of FOJE 009, the alleged Spanish Wreck, and FOJE 017, the Ludert-Cooper swivel-gun "nest," by establishing datum points at each site, and recording distance and azimuth.

Two separate transects were run from FOJE-UW-17 to FOJE-UW-9. The first originated from the swivel gun nest at FOJE-UW-17 and extended to the northwest corner of the original "gross grid," marked by grid unit BB-1 [Figure 10.8]. Two teams wearing SCUBA gear surveyed the transect, keeping notes regarding visible surface material, provenienced according to 25 meter sectors. The survey covered a 10 meter swath, five meters on either side of the established transect line.

A second transect was run from a large coral head (the Datum for

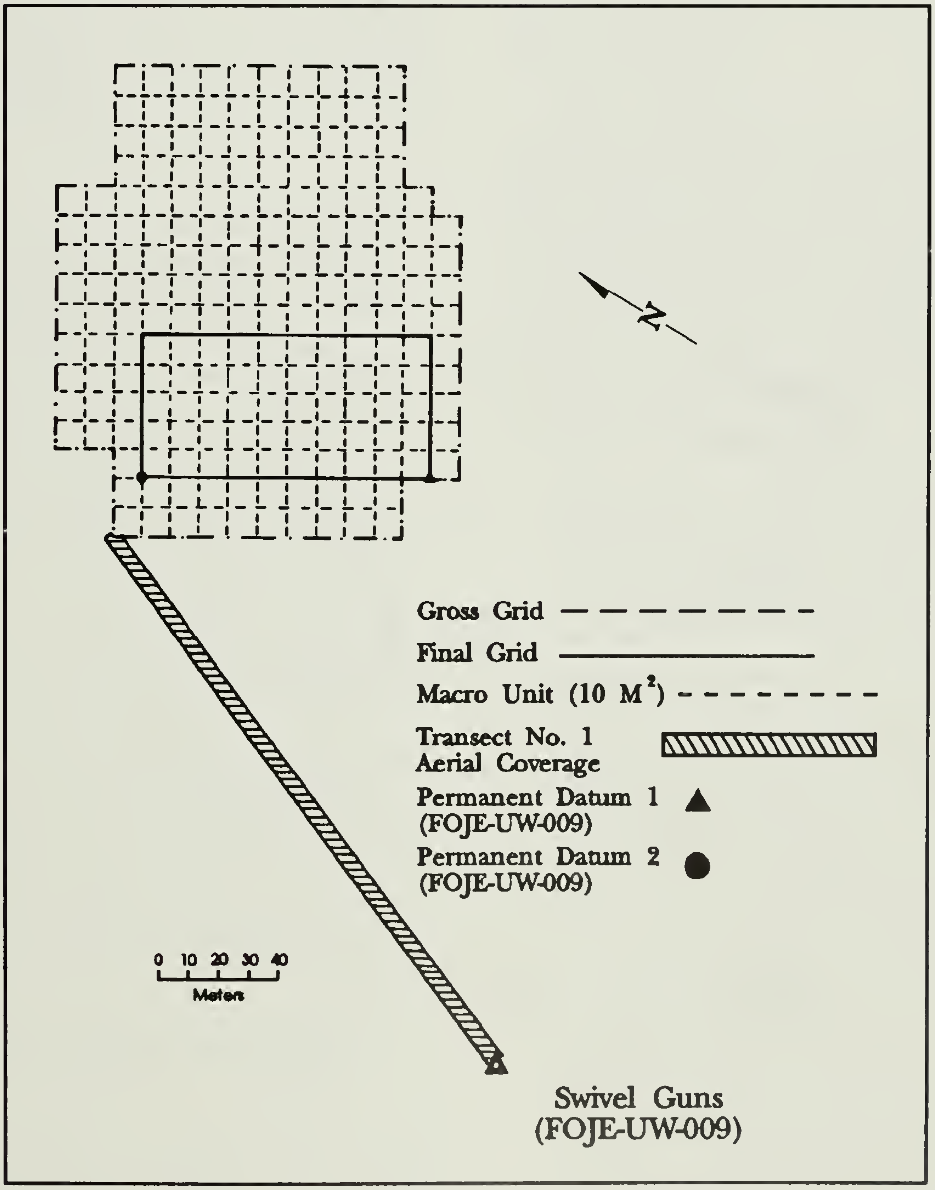


Figure 10.8. Transect number 1 (from Johnson 1982).

FOJE-UW-17) to the southwest corner of the final grid, marked by grid unit A-11 of FOJE-UW-9. Two researchers on SCUBA and three on snorkel covered a 20 meter swath (10 meters on each side of the transect line) between the two sites. Provenience was again kept by 25 meter sector, including measurements from the transect line to the objects noted (Figure 10.9) [Johnson 1982b:9].

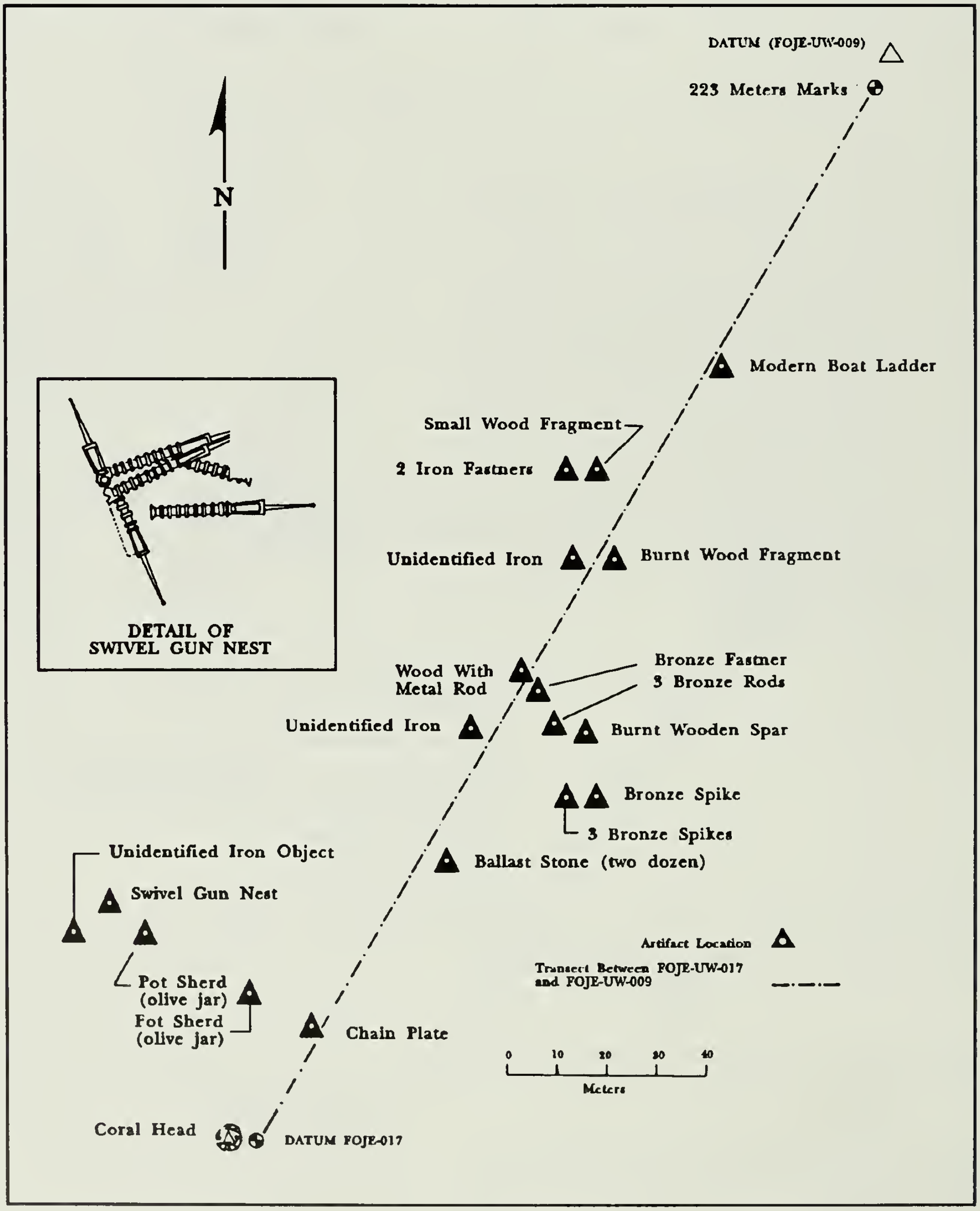


Figure 10.9. Transect number 2 (from Johnson 1982).

The first transect was approximately 220.7 m at an azimuth of 22° magnetic. "Little material was observed other than some modern rubbish. Nothing was noted that might relate to drawing a relationship between the sites in this transect" (Johnson 1982b:12). The second transect ran for a distance of approximately 230 m at an azimuth of 35° magnetic. Ballast stones similar to those recovered at FOJE 009 were noted in the immediate area of the datum at FOJE 017. "The single most interesting artifact noted during the transect survey was a brass chainplate, located within the first 25-m sector adjacent to the FOJE-UW-17 datum" (Johnson 1982b:12). This item was not recovered.

> Related test implications state that cultural material observed along a transect linking FOJE-UW-9's datum with that of FOJE-UW-17 will evidence continuous presence of related artifactual materials and that no significant zone displaying an absence of cultural material between the sites would be evident. In fact, there was at least a 100 m stretch on the FOJE-UW-9 side of the transect clear of any historic material with the exception of a stray ladrillo adjacent to the meridian forming the western portion of FOJE-UW-9... Indications are strong that the sites are definitely not continuous and it is probable that FOJE-UW-17 is a discrete site in its own right and not directly related to FOJE-UW-9 [Johnson 1982b:28].

Preservation of FOJE 017 and Reef Resources Monitoring Plan

In a related project during August, NPS Marine Research Biologist Jim Tilmant assisted the SEAC-FSU team in preservation of the swivel gun "nest" at FOJE 017 by supervising emplacement of large coral heads over the guns, which had become exposed since the previous year (Johnson 1982b:35; Tilmant 1982:2). The coral heads were lifted by sling from nearby reef areas and placed gently atop the guns. This alternative to either no action, increased surveillance, or removal of the guns was chosen as a protective measure that would leave the site intact without incurring a fairly extensive conservation commitment (Johnson 1982b:35). A trip report and photographs of the site before and after coral placement were sent to SEAC (Tilmant 1982).

An interesting side note to the above trip report is the result of coral reef studies as part of an initial reef resources monitoring plan. Though not exactly a "cultural resource study" the direct application to archeological site monitoring makes the study of more than passing interest. The reef studies reported by Tilmant (1982:2) included a survey of debris accumulation:

> Surveys were conducted to evaluate the accumulation of anchors, ground tackle and other debris at two major anchorage areas used by commercial fishing boats. These surveys consisted of counts within several 5 x 50 m quadrats at various depths. At Pulaski Light, most litter was found near the reef edge at depths of 55-60 ft. A total of 41 discarded objects were observed on five quadrats sampled (avg. = 8.2/quad.) at the 60 ft. depth. Large anchors, wire cable and nylon line were the most common objects. In the shallower depths at Pulaski, an average of 4.0 objects/quadrat at 45 ft and 6.2 objects/quadrat at 25 ft were observed. In all, 14 anchors were sighted in 14 quadrats sampled at Pulaski. The bottom was much cleaner west of Loggerhead Key where only 7

discarded objects were observed in 6 quadrats sampled (avg. 1.2 objects/ quadrat).

1985

Electrochemical Measurements at Fort Jefferson

In October 1985, Herbert Bump, Florida Bureau of Archeological Research Conservator and assistant David Muncher, along with two corrosion engineers, visited Fort Jefferson to measure submerged artifact corrosion rates. Due to high seas, the submerged artifact corrosion measurements were not taken. However, while on Garden Key, Bump and the engineers took corrosion measurements of the fort's cannon, as well as the iron Totten-embrasure frames. Preliminary measures indicated active corrosion. Bump reported that if 17-pound magnesium sacrificial anodes were attached to exposed cannon and/or window frames, corrosion rates could be significantly arrested (Bump 1985). As a deterrent to corrosive effects under seawater, sacrificial anodes could also be placed on submerged artifacts and structures after analysis by corrosion engineers and conservators. A planned follow-up trip was not undertaken, partially due to lack of interest by the NPS (Bump, personal communication).

1988

Proposed Rubble Pile Burial (No SEAC Accession #)

In May 1988, a memorandum for Section 106 Clearance was sent to the Superintendent of Fort Jefferson allowing him to proceed with a proposal to bury the rubble pile outside Front No. 6. This rubble pile was created when the ruins of the enlisted men's barracks and officers' quarters, which stood in the parade ground, were razed (dynamited and bulldozed) in the mid-1960s. They were destroyed at that time because during periods of abandonment the quarters had been salvaged and vandalized, and NPS Director Wirth determined that the three-story buildings posed a safety hazard to the visiting public. The brick, granite and slate material was deposited outside the fort on the eastern side, creating a "rubble pile" approximately 100 yd x 15 yd x 8 ft high.

In the proposal to remove the visual intrusion created by the rubble pile, park staff proposed digging a trench on the south side of the north coaling dock. The proposal stated:

> The trench will be 8 feet wide and to the depth of the water table. The rubble will be moved into the trench until filled. A second trench will be excavated adjacent to the first and filled with rubble. The process will be repeated until complete. Approximately 3300 cubic yards of material must be moved and buried. The ground level will be raised no more than 2 feet over a maximum area of one acre (i.e. 2 acre feet [Liggett 1987:2]).

Since "the intended burial site is the approximate location of the water distillation plant (1870)" (Liggett 1987:3), an archeological survey and testing of the area has been recommended prior to any digging. This work, although approved, has not been programmed for implementation as of 1991. It is considered here in order to establish the on-going necessity for terrestrial archeology in and around the fort. In this case, the historic distillation plant location is an important interpretive aspect of the fort that has yet to be revealed.

It is also noted that another additional requirement of the proposed action (other than archeological survey, testing, and possible monitoring) is that all usable brick from the rubble pile be salvaged for use in fort rehabilitation.

1989

Utility Line Installation and Removal (No SEAC Accession #)

The park has proposed digging a trenchline in the Fort Jefferson parade ground for the installation of a 3-in PVC conduit for utility lines and to remove existing unsightly and intrusive old wire. The conduits are to be buried 6-8 in deep in a 12-in-wide trench for a distance of approximately 900 ft. Recommendations were made in response to the Section 106 requirements to have a qualified archeologist conduct testing and monitoring of the proposed trenchline, as well as to leave the already-buried older, and possibly historic, lines in place (Tesar 1989).

> [Because] the history of activities and construction of and on the parade does not appear to have been well documented... archeological monitoring of the excavations for the new conduit may add useful positive and negative information about the parade area at a minimum of cost [Faust 1989].

Although approved, this work has not been carried out as of 1991 due to fiscal and scheduling considerations.

1990

Carnegie Institution of Washington Dry Tortugas Laboratory (No SEAC Accession #)

A letter sent to the of Everglades National Park superintendent by Dr. Erich Mueller of the Coastal Research and Development Institute, University of South Alabama (4/19/90) generated new interest in the Carnegie Institution's Dry Tortugas Laboratory site. In his letter Dr. Mueller provides a succinct discussion of the laboratory's significance:

> To my knowledge, this was the first tropical marine field station in the world, and the 33 volumes of research that came from here stand as classic scientific contributions. The information from these papers also provides some of the oldest baseline information about any reef system.

In the General Management Plan for the park (1983:36), further information concerning the laboratory and its site is given:

> ...the first underwater photographs, both black-and-white and color, were taken by technicians working on the reefs adjacent to the Dry Tortugas laboratory. The laboratory was abandoned in 1942, but its ruins, marked by a monument to its director, Alfred G. Mayer, are on the north end of the key. The site may well be eligible for the National Register for its historic values.

There has been no archeological evaluation of the site by the National Park Service to date. As it is, the best description of current site conditions comes from Dr. Mueller (1990:1-2), who last visited there in 1989:

> There are several structural remains: foundations, a cistern (?) and a wooden structure on the beach. The latter will be claimed by the sea soon and may or may not be worth preserving. There appears to be erosion on the NE tip of the island as a small beach escarpment

> reveals numerous artifacts from the laboratory, mostly glass... the area of obvious debris may have been a dumping site. There are remains of lab benches, glass carboys and small reagent bottles, aquaria and a pile of coral pieces... These items are being eroded and, no doubt, removed by visitors.

In his letter, Dr. Mueller suggests a project to map the site and recover exposed artifacts. In a responding letter, Everglades Superintendent Chandler agrees, adding, "it will be desirable to establish one or more public informational displays to fully interpret the historic Carnegie Laboratory site and significance it played in early tropical marine research" (Chandler 1990). Mueller states that, because of his expressed personal interest, he has been invited to examine the Tortugas Laboratory records on file at the Carnegie Institution in Washington D.C., and he would be willing to help obtain facsimiles of scientific drawings, maps, and photographs for the NPS to assist in any preproject planning or interpretive displays.

CONCLUSION

What is evident from the above overview of archeological work is the first inkling of the potential already revealed at Fort Jefferson National Monument, on land as well as beneath the water. It would be fair to state that the fort itself has not yet begun to be seriously investigated archeologically; the moat excavations of 1971 were just a brief test. In the waters surrounding Fort Jefferson are not only the remains of those vessels that carried the construction materials and men (slaves, soldiers, workers and prisoners), but also the ill-fated Spanish galleons of 1622 and later. Pirates, Indians and "turtlers" undoubtedly left their mark as well. On Loggerhead Key, the physical evidence among the ruins of the Carnegie Tortugas Laboratory reflect a scientific significance unmatched in the country. If any criticism can be made about the archeological work carried out at Fort Jefferson to date, it is insufficient publication.

The objective here has been to show inherent archeological value, as well as some of the anthropological aspects, of humans meeting the requirements of survival in such an unforgiving, yet beautiful environment as the Dry Tortugas. The dreadful logistics involved with research in this remote place demand efficient use of time and talent. By carefully reviewing the work that has gone before, and even more carefully recording (and reporting) the work to be done, we can produce synthetic and synergistic data collections that will offer the archeologists and other research investigators of the next century an integrated view of the cultural resources of Fort Jefferson National Monument.

Then, by judicious review of these resources and how best to protect and preserve them, we can give them back to the people through interpretive and educational programs. Imagine a shipwreck excavation under a transparent shell with audio headphones, closed-circuit television, and dry submersibles, with handicapped access.

CHAPTER XI

Past Archeological Work: 1985-1990

Larry E. Murphy

All documentation projects, reconnaissances and archeological investigations conducted in Fort Jefferson National Monument (NM) between 1985 and 1990 by the Submerged Cultural Resources Unit (SCRU) are presented in this chapter. Project objectives, structure, field operations and personnel are briefly described. Detailed project results and recommendations for future work are presented elsewhere in this report.

1985

Natural and Cultural Resources Video Documentation Project

At the request of Everglades National Park Superintendent Jack Morehead, SCRU photographed and video documented selected Fort Jefferson NM natural areas and cultural resources. Southeast Regional Director Bob Baker requested SCRU's participation, which would assist the park in assessing application of video technology to natural reef and shipwreck site interpretation (B. Baker to J. Cook memo 7/85).

Project objectives were to "obtain video and 35 mm color transparencies of representative cultural and natural resource features at the fort for interpretation and protection uses." Everglades Superintendent Jack Morehead also wanted SCRU personnel to become more familiar with the park to help make recommendations for future action in context of the overall submerged cultural resources management program in the National Park System (Lenihan 1985:1). Superintendent Morehead led the project and was a project photographer. Dan Lenihan, Chief, SCRU, was project director accompanied by Larry Murphy, SCRU archeologist, and Research Diving Technician/Law Enforcement Specialist Ken Vrana. Richard Curry, Resource Specialist, Biscayne National Park, also participated in this project. All diving took place from ACTIVA with Capt Cliff Green assisting diving operations.

Six days, September 8-13, were spent conducting documentation fieldwork. The following sites were documented: FOJE 008, 017, 009, 50-ft-deep patch reef about 2 miles on a 210° bearing from Loggerhead Light, FOJE 003, "Anchors and Cave Area," a lobster boat sunk in 1982 (now FOJE 030), nurse shark breeding area offshore Long Key and FOJE 029.

A site outside National Park Service (NPS) jurisdiction was visited en route from Key West to Fort Jefferson. Superintendent Morehead had earlier been asked to support a Minerals Management Service investigation of 8Mo130, an early eighteenth-century vessel on New Ground Reef. Morehead wished to compare the site's present condition with his earlier visit to determine recent sport diving and commercial salvage impact. After three documentation dives, the trip to the monument resumed.

Documentation project results included: A brief analysis of cultural sites visited during project (transmitted in Lenihan's trip report 1985), which included LORAN readings for three sites in an appendix. Nineteen videotapes and numerous photographs were taken, and two edited videotapes containing excerpts were transmitted to the park and Southeast Archeological Center (SEAC). (See Appendix 1 for a comprehensive catalog of monument videotapes.) Fifty transparencies were also transmitted to the park for interpretive use. Original video tapes were supplied to Finley Holiday Film Corporation in August 1988 for use in an interpretive film produced for the park (M. Finley letter to D. Lenihan 8/16/1988).

In addition, Lenihan submitted six recommendations in his trip report: 1) FOJE 003 (Windjammer Site) was suggested as a first-contact point for visiting divers. The site should be interpreted with an underwater map that presents a conservation message and warning about artifact removal within the park; 2) Underwater surveillance equipment should be tested for monument applications; 3) FOJE 008 (Nine-Cannon Site) should be completely mapped; 4) A submerged cultural resources assessment of the monument should be prepared; 5) An inventory of all known shipwrecks should be completed as a part of 4; 6) A survey of submerged lands within the monument should be conducted. The trip report was transmitted to the NPS Chief Historian and Chief Anthropologist who concurred: "because of the importance of inventorying and evaluating these resources, [a project to do so] should command high priority. If recommendation 4 is programmed and funded, an interdisciplinary approach is mandated" (Chief Historian and Chief Anthropologist to NPS Associate Director, Cultural Resources memo 1/3/86).

So far, recommendations 1, 3, 4 and 5 (no underwater surveillance equipment has been available) have been completed with funding supplied solely from Everglades National Park, Fort Jefferson National Monument and SCRU.

1988

The March 12-29, 1988, fieldwork under the direction of Southwest Region archeologist Larry Nordby was devoted to producing detailed documentation of FOJE 003, now known as the Windjammer Site, as follow-up to Lenihan's recommendation 1 above. A secondary objective, and back-up for 003, was documentation of FOJE 029, the Bird Key Harbor Brick Wreck, which might be accessible when foul weather denied access to 003. Objectives and historical background for this project were presented in an Operation Plan (Nordby 1988a).

This project was conducted in conjunction with the US Navy (USN) Mobile Diving and Salvage Unit 2, Detachment 506. SCRU has had a long-term working relationship with the US Navy known as "Project SeaMark," which began with documentation of USS ARIZONA in 1984. Numerous projects have been conducted under auspices of Project SeaMark, all of which involved NPS/USN cooperation documenting submerged cultural resources (Conners 1988).

Besides supplying diving and support vessel assistance, the Navy provided a helicopter for aerial reconnaissance and photography. William Krumpelman II, a USN combat team photographer, also participated and produced aerial and underwater photographs.

Strong north and northeast winds precluded work on the two target sites the project's first week. Rough weather from these directions makes both 003 and 029 difficult to work. During this time, two areas of Southwest Channel were searched for reported wrecks with negative results. Fieldwork centered on documenting three anchors and one gun tube on Garden Key (see Chapter XII). The 003 site and some hull structure on 008 were dived when conditions improved (Nordby 1988b; Ice 1988).

The project completed all objectives including a detailed site map of 003. Ten video tapes were shot and cataloged (see Appendix 1) and photographs of features and field activities were taken, including aerials of the fort and vicinity. NPS Maritime Historian Jim Delgado identified specific site features. Some small artifacts, including a wooden bucket bottom, were recorded. Lenihan's and Murphy's analysis (Lenihan 1985) of 003 was confirmed, but no additional information regarding the vessel's identification was added (Nordby 1988b:3).

Biscayne National Park Resource Specialist Richard Curry conducted a major coral colony inventory of 003. Principal coral colonies were plotted on scaled mylar drawings of main structural components. These mylars will serve as baseline data for long-term biological monitoring and other research (e.g., Mazel 1990). In addition, US Senator Bill Bradley (D-NJ), a primary sponsor of the 1987 Abandoned Shipwreck Act, and legislative aide Gene Peters visited the project. Senator Bradley and Peters visited 003, 008 and toured Fort Jefferson with Fort Jefferson NM Superintendent Bruce Rodgers.

The project investigators completed a sketch map of 029 and made the following observations: 1) Vessel is probably associated with Fort Jefferson construction and appears to be a Civil War-vintage iron steam-tug or coasting vessel. Speculative dates based on the screw and rudder-skeg assembly are 1850-1870 (Delgado 1988:2); 2) It was probably blown up after sinking, and not enough hull remains to make closer observations about construction details; 3) It was about 100 ft long, the bow present but detached; 4) A hand-blown, green glass bottle bottom with a kick-up base and pontil mark was collected. This fragment is identical to wine demijohn bottles from BERTRAND sunk in 1865 (Nordby 1988b; Switzer 1974).

In addition to documenting anchors and a gun tube on Garden Key during the project, Delgado located the 1825 brick lighthouse foundations and documented the 1875 iron lighthouse for the Maritime Initiative inventory (Delgado 1988:2). Delgado also located the lightkeeper's quarters foundations and a slate slab believed to cover a lightkeeper's wife's grave.

Plate 11.1. USN Mobile Diving and Salvage Unit 2 diver during mapping operations. USN photo by William Krumpelman II.

Plate 11.2. USN Mobile Diving Salvage Unit 2 divers aboard Navy vessel during FOJE 003 diving operations. USN photo by William Krumpelman II.

1989

Reconnaissance Project

Principal investigator was SCRU archeologist Larry Murphy assisted by Volunteer-in-Parks (VIP) participants Dr. Richard Gould, Brown University, Linda Stoll, Superintendent, Pecos National Monument and John Jolly, John B. Jolly, Inc., Seattle.

Project objectives specified in the 1989 Task Directive (Fort Jefferson 1989) included as the primary objective "conduct preparatory field operations and background research for a comprehensive research project on the submerged cultural resources of Fort Jefferson National Monument." Information was to be directed toward developing a survey design, instrument package and "reconnaissance dives will be made in all parts of the monument to evaluate bottom conditions and special survey considerations." Field objectives were to dive known sites to develop a documentation methodology, visit various park reefs, conduct a brief walking island survey and reconnaissance-level surveys of island perimeters. No survey for new sites was planned; no magnetometer survey was conducted.

Eight fieldwork days between June 27 and July 5, 1988, were utilized in this reconnaissance. Diving was done from ACTIVA, with Capt Cliff Green providing support and site locations. The following sites and areas were investigated and tasks accomplished: A sketch map of FOJE 011; located two ballast piles (now FOJE 031) of rounded cobbles on Pulaski Shoals; conducted perimeter search of 029 and Bird Key; examined construction details of 029; checked 1988 draft map of 003 onsite; located and sketched a large rigging pile near 008, which was then considered a separate site, but now included in 008; investigated a structure area in the vicinity (which was sketched by Nordby in 1988 and also considered a separate site, but now included as part of 008); located a pile of railroad iron on Pulaski Shoal (now FOJE 032); examined the Sack Wreck (FOJE 013); conducted perimeter surveys of Middle Key, East Key and Hospital Key, where we located a site (now FOJE 034) and portions of Long and Garden Keys; and located the wreck of a diesel-powered vessel (FOJE 033) on Southwest Reef. Brief walking surveys were conducted upon each island except Bush and Long Keys, which were closed because of tern nesting. Five field samples were recovered for analysis. No artifactual material other than expendable samples was collected (Stoll 1989; Murphy 1989b).

Project results including Murphy and Gould's observations, and results of field sample analyses can be found as a part of appropriate site and island discussions in the archeological record chapter and site reports below.

Plate 11.3. USN helicopter used for aerial reconnaissance and photography. USN photo by William Krumpelman II.

1990

Known Site Documentation Project

Principal investigator was Larry Murphy and field director was James Bradford, archeologist with NPS Southwest Region Division of Anthropology and veteran of numerous SCRU projects. Following a 1985 recommendation (Chief Historian and Chief Anthropologist to NPS Associate Director, Cultural Resources memo 1/3/86), this project's approach was interdisciplinary and included marine biological investigations as part of site documentation.

This project's primary objective was to document known sites for inclusion in the Fort Jefferson NM cultural resources assessment. An assessment is designed to incorporate all available site and background information for current management requirements and to serve as a basis for planning future inventory and evaluation. Primary 1990 fieldwork tasks were "to relocate known sites, position them accurately, map and evaluate them" (Lenihan 1990). In 1990, only two underwater sites had been satisfactorily mapped, 009 in 1982 (Johnson 1982b) and 003 in 1988. Most other monument sites have not been documented or even revisited by archeologists since discovery. Additional investigations were directed toward augmenting what had been done prior to 1989; no survey for new, unrecorded sites was suggested or conducted.

Final products for this fieldwork were an underwater trail guide for the Windjammer Site (003) and a cultural resources assessment combining prior fieldwork and background information. The plastic-laminated trail guide was to be provided to the park so it could be made available on loan to visiting divers as an interpretive device that would encourage diver-ranger contact and archeological site preservation. Murphy designed a version of the Windjammer Site map and wrote a text for the trail guide; both were reviewed by Everglades National Park and Fort Jefferson NM prior to printing (Figure 11.1). More than 100 trail guides were printed and supplied to Fort Jefferson NM in July 1990. The Windjammer trail guide was featured in an article on NPS trails in *National Parks* magazine (Bartfeld 1990:37-39).

Funding, as it has been for all Fort Jefferson NM research, was limited. In order to maximize returns, fieldwork was planned to incorporate volunteer divers over the course of a nine-week season, July to September 1990. Lessons from past fieldwork indicated this amount of project time would be minimally necessary for site documentation. Because of prior commitments and understaffing, SCRU archeologists could not be present for all fieldwork necessary to document the known sites. Three separate field sessions were set up: July 17-29; July 31-August 30 and September 3-19.

The first and third sessions incorporated members of the Maritime Archaeological and Historical Society (MAHS) of Arlington, Virginia. MAHS is a nonprofit, strongly preservation-oriented organization established to "increase historic knowledge associated with America's maritime heritage ... research, education, study and documentation of historic maritime activity ... and the preservation of related sites, artifacts, documents and cultures and traditions" (MAHS 1990:5). The group has documented sites in other areas, including Biscayne National Park, and was under contract to SCRU for National Archives research on Dry Tortugas vessel casualties and historical maps.

Certification and dive-evaluation protocol were discussed with Southeast Regional Dive Officer Richard Curry and procedures followed his guidelines. All non-NPS participants presented national diver certifications and medical clearances and were signed up as Volunteers-in-Parks. A swim evaluation and check-out dive was conducted by Murphy for Session 1 and 2 divers and Larry Nordby, past southwest regional dive officer, evaluated Session 3 divers.

Session 1

Larry Murphy, James Bradford and Randolph Jonsson, SCRU technician, were NPS personnel present during the session. Bradford directly supervised MAHS personnel, who were led by president William Eddy and John Seidel, anthropology professor, University of Maryland. Participants included: Stuart Ellsberg, Kevin Fuschus, Craig Heier, Richard Knudson, Pam Krim, Mel Larson, Steve Skolochenko, Jim Smailes, Arun Vohra and Mike Wagner. Some were there for half the session; all were trained in data collection techniques by MAHS and had prior field experience.

Fieldwork accomplished during the first session included beginning the Nine-Cannon (008) Site map, where 2,000 ft of base line were utilized; documentation of Windjammer construction and rigging details; Bird Key Harbor Wreck (029) sketch map and initiating the Garden Key perimeter survey. MAHS volunteers, including some whose research identified the vessel, were the first group of divers to use and evaluate the Windjammer Site underwater trail guide.

Murphy spent three days using a magnetometer, LORAN and Ilon Position Finder attempting to locate sites recorded in 1971, with negative results. Southeast Archeological Center (SEAC) site form positions were used in combination with horizontal angles recorded by the 1971 survey team to position the search area. SEAC generated latitude/longitude (lat/long) positions by charting 1971 locations with original survey data, which consisted of a series of compass bearings and Ilon horizontal angles taken between such landmarks as Loggerhead Light, Fort Jefferson Light, various landmarks and navigation buoys, which are occasionally moved during Coast Guard maintenance.

A combination of relocation techniques was utilized during this brief search. Latitude/longitude positions were loaded into the LORAN receiver as waypoints with final positioning done by Ilon and sextant. LORAN receivers give range and bearing to waypoints that can be used for navigation to a specific area. LORAN time-delays (TDs), which have a faster update rate and are generally more accurate, were computed from the lat/long data and also used as waypoints. LORAN TDs were used for navigation to the computed site position.

An effort was made to find four sites on Loggerhead Reef. In each case, there was no congruence of LORAN position and horizontal angles. In most cases, neither horizontal angles nor LORAN position coincided with 1971 site depth or bottom descriptions. Buoys were dropped on horizontal angle positions and LORAN positions and the vicinity surveyed with magnetometer, with no success. The survey was terminated. LORAN positions for known sites and computations generated for this survey have been submitted to the park and SEAC under separate cover.

Session 2

Brown University anthropology professor Richard Gould, who has a special interest in anthropological approaches to maritime archeology, organized a team made up of Brown seniors and graduate students and past volunteers who worked for him during one of his seven Earthwatch (Center for Field Research) projects documenting shipwrecks and fortifications in Bermuda (Gould 1983; 1989; 1990:194-239). Gould directed two projects, documentation of 029 and 011. He took the lead for 029 and supervised Donna Souza, a Brown master's student, during 011

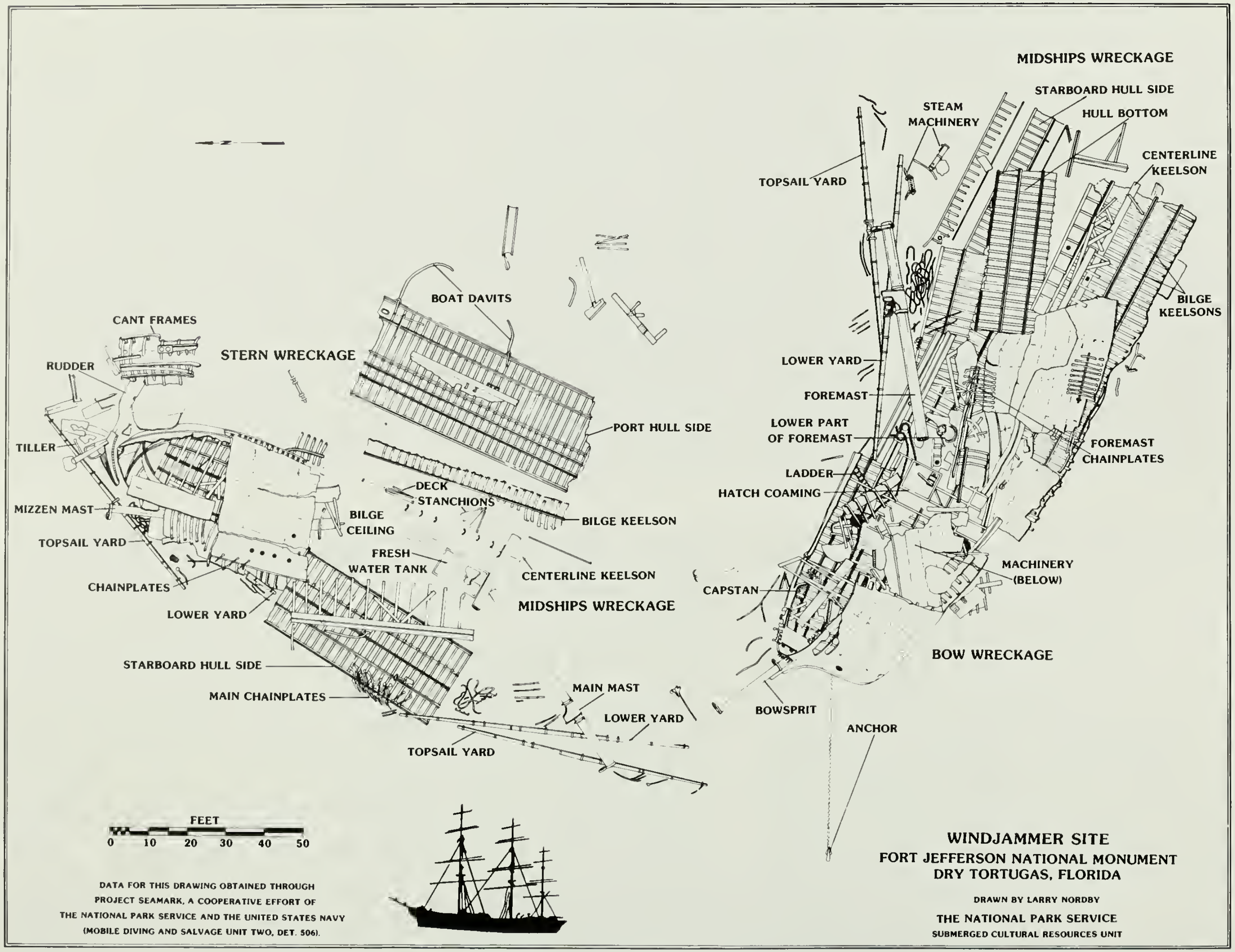


Figure 11.1. Windjammer Site trail guide.

WELCOME TO THE WINDJAMMER SITE, FORT JEFFERSON NATIONAL MONUMENT

The Windjammer Site has long been thought by some to be a steamer and called the "Steel Wreck," "French Wreck" and "Dutch Wreck," but actually it is an iron-hulled, ship-rigged sailing vessel. Originally named KILLEAN, it was built in Port Glasgow, Scotland by John Reid & Co. in 1875 for Mackinnon, Frew & Co. of Liverpool, England. KILLEAN was sold to A.D. Bordes of Dunkirk, France and renamed ANTONIN in 1893. The Norwegian company C. Zernichow & O. Gotaas bought the vessel and renamed it AVANTI in 1901.

AVANTI, like many turn-of-the-century windjammers, competed with steam ships and carried mostly bulk cargos. AVANTI sank on Loggerhead Reef, Dry Tortugas January 21, 1907 while enroute from Pensacola to Montevideo, Uruguay with a lumber cargo.

At the time of building, KILLEAN received the highest rating of 100A1 by Lloyd's of London, indicating it was a first-class vessel. The original registered dimensions were: length 261.4 feet; beam 39.3 feet and depth 23.8 feet giving 1862 gross tons. The ship had 3 masts, 2 decks and cement ballast. (Historical research was provided by members of the Maritime Archaeological and Historical Society of Washington, D.C.)

Archeological and historical research is ongoing, and much remains to be done. Can you determine how the ship broke up? Do you think it sank in a storm? Can you recognize pieces of the wreck that are not labelled?

The site map on the reverse side was done for historical and scientific documentation. It has been labelled and provided for snorkeling and diving visitors to Fort Jefferson National Monument who are interested in the rich maritime heritage found in the park's waters. AVANTI is one of numerous wrecks that occurred in the Dry Tortugas since its discovery and naming by Ponce de Leon in 1513. The proximity of these islands and reefs to the principal gulf navigation routes has made them a natural "ship trap."
You are reminded that this wreck -- like all park shipwrecks, shells, lobsters, coral and fish -- is protected by law. Nothing can be removed from underwater within the boundaries of Fort Jefferson National Monument. Please do not touch or bump the coral. Enjoy yourself; take nothing but pictures and memories.

Currently, there is no historical information about the wreck event. NPS maritime archeologists speculate the vessel was lost in a storm. Why? The port holes are sealed; only the starboard anchor on a short length of chain was located; the port anchor is missing. The anchor chain has been brought up through the hatch and wrapped around the starboard bitts, material evidence that the windlass was inoperative and the crew aboard were probably involved in an unsuccessful last-ditch effort to save their ship. What do you think?

Plate 11.4. Maritime Archaeological and Historical Society volunteers aboard ACTIVA transfer data during mapping operations. Pictured are William Eddy, Pam Krim and Craig Heier. NPS photo by Larry Murphy.

fieldwork, which became her master's research paper (Souza 1990b). Gould and Souza each contributed a chapter on their respective sites to this volume. Souza also reported her investigations to the Conference on Historical Archaeology and Underwater Archaeology in Richmond, Virginia (Souza 1990a).

Participants for the second session, from July 31 to August 30 included: William Griffin, Susan Hurley-Glowa, Joseph Los, William May, Eugene Rowe, Adam Smith, Charlotte Taylor and Steven Walker. Larry Murphy was present for the first two weeks of this session.

Fieldwork accomplished included mapping and documentation of Bird Key Harbor Brick Wreck (029) and East Key Construction Wreck (011).

Two marine biologists were invited to conduct fieldwork during this session. Gary Davis, Channel Islands National Park research marine biologist (NPS Cooperative Studies Unit, University of California, Davis), conducted comparative research on lobster populations and inventoried fish and coral on four sites (003, 008, 011 and 029). His chapter, including observations and inventory results, is in this volume (Chapter XX).

During Davis' biological inventory, Scuba-Phones were used (Plate 11.8). Scuba-Phones are wireless communication equipment with an effective 200-yard range that allow diver-to-diver and diver-to-surface

Plate 11.5. NPS archeologist Larry Murphy during magnetometer operations. Photo by John Brooks.

communication. Orcatron, manufacturer of Scuba-Phones, donated equipment use and specially adapted listen-only units for project use. Scientific and interpretive applications of this equipment were tested during the field session. Ability to communicate, allowing efficient inventory methods and surface recording of divers' observations, may prove the most effective data-retrieval means available. Everglades Assistant Superintendent Rob Arnberger participated in an interpretation application test of the device, which would allow rangers and interpreters to narrate a swim-over to diving visitors. Both tests were successful.

Charles Mazel, doctoral student at the Boston University Marine Program, investigated coral fluorescence on the counterscarp and Windjammer Wreck (003). Mazel's work

Plate 11.6. Volunteers during the August session prepare for a dive. Left to right are Charlotte Taylor, Stephen Walker, William May, Adam Smith and Richard Gould.

Plate 11.7. Volunteer Joseph Los holds a plumb-bob over a point during mapping operations. Mapping methodology utilized in all projects is base-line trilateration developed by NPS SCRU. Photo by John Brooks

is in the experimental stage, and he explored the potential of fluorescence as a technique for monitoring visitor impact. Mazel's investigation was based on the 1988 Richard Curry coral inventory mylars. His manuscript has been sent to the park and SEAC.

John Brooks, photographer and writer on assignment for *Sea Frontiers* magazine, also visited the project. Brooks' story on SCRU operations included this project, and he provided photographs to NPS. In addition, the project was a cover story for *Underwater USA*, a popular sport-diving publication (J.W. Murphy 1990).

Session 3

Jim Bradford, who had been field director for Session 1, directed this fieldwork conducted by a NPS archeology team supported by MAHS volunteers. NPS personnel from the Southwest Cultural Resources Center were archeologists Todd Metzger, Larry Nordby, Scott Travis and volunteer Jacquelyn Koenig. MAHS volunteers were Thomas Berkey, Kazuko Cook, Pam Krim, Virginia Liberman, Edward Madden, Ray Merkin, William Robey and David Shaw, each of whom participated for one week.

Plate 11.8. Gary Davis conducting biological inventory on 003 assisted by Park Diving Officer Monica Eng and Volunteer-in-Parks Joy Waldron. Divers are wearing Orcatron Scuba-Phone communication equipment. NPS photo by Larry Murphy.

This session's objectives were to complete mapping of 008, continue detailed documentation of 003 features and continue the Garden Key perimeter survey. Fieldwork included completion of the Nine-Cannon Site, augmentation of 003 construction details and perimeter survey through the north coal docks.

In all, volunteers contributed more than 5,000 hours of on-site field time to documenting Fort Jefferson's cultural resources. This fieldwork was completed cost-effectively and without a diving accident. Fort Jefferson fieldwork is logistically difficult, especially for complex diving operations. A lot of work is necessary for all field support from actual diving and data collection and reduction, to tank filling and daily housekeeping. Much of this load was borne by volunteers, freeing archeologists to concentrate on data analysis and reduction. In some ways, the 1990 fieldwork was an ambitious experiment and its success is attributable to the caliber of participants and support of the overextended staff of Fort Jefferson National Monument. This field season strongly supports a volunteer involvement approach, which should be considered for future projects.

CHAPTER XII

Fort Jefferson National Monument Archeological Record

Larry E. Murphy

INTRODUCTION

This chapter includes a comprehensive list and discussions of all sites examined in Fort Jefferson National Monument. Information from major surveys in 1971 and 1974, and results of all Submerged Cultural Resources Unit (SCRU) fieldwork between 1983 and 1990, are incorporated in the following site discussions and separate site report chapters. Results of Southeast Archeological Center (SEAC) submerged projects between 1969 and 1983 and terrestrial projects to 1990 are presented in Chapter X. Chapter XI discusses SCRU projects during 1985-1990.

Some shipwreck sites investigated in greater detail are presented as separate chapters: the Windjammer Site (FOJE 003), Chapter XIII; the Nine-Cannon Site (FOJE 008), Chapter XIV; the East Key Construction Site (FOJE 011), Chapters XV and XVI; and the Bird Key Harbor Brick Wreck (FOJE 029), Chapters XVII and XVIII. The last two sites were investigated under Richard Gould's direction in 1990.

Primary sources of 1971 information are the Florida Bureau of Historic Sites and Properties Underwater Archeological Research Section site card (UWARS site card) and SEAC site reports, both on file at SEAC, Tallahassee, Florida. Source of 1974 survey information is the W.A. Cockrell et al. report submitted to SEAC July 3, 1974. In 1981, SEAC printed site cards similar to the UWARS cards and information from these is included for pertinent sites. This chapter's site discussions along with those of Brewer and the separate site reports represent what is currently known and accessible about archeological sites within Fort Jefferson National Monument.

COMPREHENSIVE LIST OF FORT JEFFERSON NATIONAL MONUMENT SITES

Thirty-five separate sites are recorded within the park boundaries. The 1971 survey recorded 21 sites; the 1974 survey added five more; two were apparently recorded in 1981; one modern lobster boat (ca. 1981-1982) wreck was recorded in 1985, one site added after 1987 and four recorded in 1989.

FOJE 001 - Iron Ballast Wreck, SEAC Acc. No. 0185

This site was located in 12 ft of water on Loggerhead Key's north end June 23, 1971 during magnetometer survey and originally designated "Anomaly #2." The site, identified as a late nineteenth or early twentieth century sailing ship, was thought to be a schooner. Site materials observed included an iron anchor, windlass chain, dark and red rock ballast and three sizes of iron ballast. The notation "wooden timbers" probably indicates structure. The site appeared to have been dived by others, and vandalism is reported on the SEAC site report. A bronze pin was collected.

In the Fort Jefferson National Monument Shipwreck Database (shipwreck database hereafter), which currently contains 241 marine casualties for the area (see Chapter IX), there are only two Loggerhead Key reef schooner casualties. Both are strandings and neither total losses.

FOJE 002 - Swivel Gun Site, SEAC Acc. No. 0185

Three iron swivel-guns were observed and removed from the site soon after discovery on May 21, 1971 on the northwest end of Loggerhead Key. One gun may have had a muzzle tampion. No other remains were visible. Heavy staghorn coral growth made visual survey difficult. Surveyors guessed the guns were jettisoned or parts of a widely scattered wreck.

In 1977, an extreme cold-water event at Fort Jefferson killed more than 90 percent of the staghorn coral. Only small stands of live staghorn coral were observed in 1990. This site would be much easier to survey at present.

The Fort Jefferson Museum displays a swivel gun, labeled English 1780s, from this site (Plate 12.1). Five vessels are recorded in the shipwreck database lost in the Dry Tortugas between 1806-1831 (the next oldest vessel is 1775); no locations are more specific. The most likely recorded vessel possibility is SIR JOHN SHERBROKE, a ship carrying general merchandise and $60,000 in specie (Bearss 1971:44). The vessel name appears to be British and a vessel carrying specie was likely armed.

Another possibility is ACASTA, a British merchantman bound for Liverpool from Jamaica wrecked in 1818 (Bearss 1971:44). Swivel guns may have been transferred between vessels and used for signalling long after Caribbean vessels were typically armed. Consequently, there is insufficient evidence to correlate this site with historical records.

Plate 12.1. Cannon on display, Fort Jefferson, reportedly from 002. NPS photo by Larry Murphy.

Plate 12.2. Remains of Windjammer visible at low tide, 1989. NPS photo by Richard Gould.

FOJE 003 - Steel Wreck, Dutch Wreck, French Wreck, SEAC Acc. No. 0185

Hull portions were visible above the water during the 1971 survey, and some are still awash at low tide.

FOJE 003, now known as the Windjammer Site, is discussed in Chapter XIII. No material was collected during the 1971 survey. In 1989, research by the Maritime Archaeological and Historical Society under contract to the SCRU located this vessel's name and loss date. AVANTI was lost January 21, 1907. This is currently the only identified historical shipwreck in Fort Jefferson National Monument.

FOJE 004 - Schooner Wreck, SEAC Acc. No. 0185

The Schooner Wreck, Anomaly #5, was located May 23, 1971 on the south end of Loggerhead Reef. This site has not been relocated. Two "patches" of wreckage were recorded, one at least 175 ft long. Presumably, this means a 175-ft hull portion was seen. In addition, the following material was noted: "angle iron, iron ship's gear, iron knees, cable, deadeye and chain, iron davit, six-inch link chain, mast bands, possibly large anchor, bricks and railroad iron." The archeologists thought the late nineteenth or early twentieth century vessel went onto South Loggerhead Shoal from the east or southeast.

The shipwreck database lists five schooner casualties on Loggerhead Reef and Southwest Reef that were total losses. These two locations are considered together because both names were apparently applied to south Loggerhead Key reefs. Shipwreck database schooner losses are 1877, 1895, 1905, 1913 and 1922.

Cargo is known for all five documented schooner losses: one was fishing, three carried lumber and one carried sugar and molasses. If the bricks and railroad iron were cargo, then the site is probably not one of the documented sites, unless, of course, one was carrying an undocumented mixed cargo.

Another possibility is that this site is not a schooner. There is nothing listed in the observed material on site in 1971 that would definitely indicate a schooner, and the researchers do not state the evidence upon which they identified the rig. There are 23 total losses recorded in the database for Loggerhead Key reef and Southwest Reef. Cargo is known for all but two. Most were in the lumber and cotton trade, but there are two possibilities for this site: AMERICA, a three-masted ship of 613 tons wrecked in 1836, which carried passengers, white lead, tobacco and iron ware; and NANCY W. STEVENS, a three-masted bark of 346 tons wrecked in 1846, which carried a mixed cargo including general merchandise. Neither is a strong possibility based on the 1971 analysis that identified a schooner rig of the late nineteenth-early twentieth century.

FOJE 005 - Sounding Lead Wreck, SEAC Acc. No. 0185

The SEAC site report has a "project date" of 1975, indicating this site may have been visited then. The site, attributed to the twentieth century, is in about 10 ft of water almost in the breaker line of the southeast side of Long Key Reef. One of the survey team, whose father was once superintendent of the monument, suggested this site might be a Cuban ship blown out of the harbor during a hurricane.

Iron ballast bars, link chain and four sounding leads of two sizes were observed. Two sounding leads, pliers, ice tongs, sheathing tacks and a spoon were reported recovered.

The shipwreck database includes two total losses on Long Key Shoal including JONCULNITO, a Cuban fishing smack sunk November 1937 (*Key West Citizen* 12/03/1937). This ship was lost on the "west side of Long Key Shoal on the east side of the channel to Garden Key in about six feet of water," which means this smack was probably lost on the edge of Southwest Channel, while FOJE 005 plots out on the west side of Southeast Channel. The locations do not correlate but this identification is the best documented possibility at present.

FOJE 006 - Cable Site, SEAC Acc. No. 0185

This site was Anomaly #10, and located in 22 ft of water on the southwest end of Long Key. No material was collected. Material observed was chain with 6-in-long links, scattered pins and twisted steel cable. The site was thought to be partially buried and possibly associated with 007. The site may be in an area of shifting sediment; when revisited during the original survey, only cable was found.

Presence of "steel cable" would indicate a post-Civil War site. Wire-rope rigging was introduced in the late 1830s to early 1840s and in common British usage from the 1850s (MacGregor 1984:170) with extensive US manufacture and use beginning after the Civil War.

FOJE 007 - Pin Site, SEAC Acc. No. 0185

This site is located in 15 ft of water about 150 yds from 006, and may be associated with it. No material was collected. Scattered iron pins 1 1/2 in x 3 ft to 6 ft long were recorded, along with pump parts, bronze fastenings and miscellaneous fastenings.

Because 006 and 007 are possibly the same site, they will be discussed together. The 1971 researchers attributed this site to "middle to late nineteenth century." IRENE ALBURY, 14 gross tons built 1888, which foundered on Long Key, Florida, January 22, 1914 (*List of Merchant Vessel Losses* 1914:424) may be this site. This is the only historical reference to this loss at present, and there are other "Long Keys" in Florida. This is only a possible correlation until further research is conducted.

FOJE 008 - Nine-Cannon Wreck, SEAC Acc. No. 01850580

This site was discovered June 14, 1971 in 10 ft of water. Eight "mixed-period" artillery tubes, identified as "probably mostly eighteenth century in origin," were observed. A 3 lb maul head, marked "solid steel" and some heavy brass hardware were recovered. This site is reported in Chapter XIV.

FOJE 009 - Iron Ring Wreck, SEAC Acc. No. 01850580

This site was originally designated Anomaly #14 and found in 9 ft of water. The site was estimated to cover an area 400 ft east-west by 150 ft north-south. Material noted on site was: Spanish-type bricks, two iron rings 18 in x 3 ft (possibly not wreck related), forged-iron fastenings and a considerable quantity of "shore rock ballast."

Photographs of this site were generated by Earth Satellite Corporation (Marmelstein 1972). In October 1981, the site was relocated by SEAC. An extensive site investigation was conducted in summer 1982 (Johnson 1982b).

In 1985, as part of video documentation requested by Everglades National Park Superintendent Jack Morehead, SCRU visited features that could be related to this site and FOJE 017. At the time the area was referred to as the "Keel Pins" site. Twelve pins 19 in long and 1 1/2 in in diameter were located. No other artifacts were visible above the bottom sediment. The pins were videotaped and included in the Fort Jefferson Video Catalog 1985-1990 (Appendix I).

This site may be associated with a small patache sunk in 1621, or the DEL ROSARIO sunk in 1622, although correlation is not conclusive (Bearss 1971:43; see Chapter X).

FOJE 010 - Buried Wreck Site, SEAC Acc. No. 0185

This site, recorded June 16, 1971 in 10-ft depths on south Loggerhead Reef, produced a 200-gamma magnetometer reading and was originally designated "Anomaly #15." Diver investigation revealed the site was probably buried. No material was collected, and only a capstan and several pins were observed. There is insufficient information to attempt correlation with the shipwreck database.

FOJE 011 - Construction Wreck, SEAC Acc. No. 0185

This site is directly associated with Fort Jefferson construction and is reported in detail in Chapters XV and XVI.

FOJE 012 - Metal Wreck, SEAC Acc. No. 0185

This site was located in 10-12 ft of water east of East Key and recorded June 15, 1971. No material was collected, and only a short length of 3/4-in or 1 in or larger cable and a late anchor were noted by divers. Consequently, the site was not considered a shipwreck by investigators, although it was recorded as one.

FOJE 013 - Sack Wreck, SEAC Acc. No. 0185

This site near Pulaski Light in 18 ft of water contained scattered remains, including "ballast bars" and hundreds of cement sacks. The site was recorded in 1971 and relocated in 1989. This site is not documented in the shipwreck database.

The site was originally located June 15, 1971 on shoals south of Pulaski Light during the SEAC survey, and designated Anomaly #19 indicating it was found during magnetometer survey.

The 1971 UWARS site card states the site is the scattered remains of a vessel, which gave a broad 200-gamma reading. Site size was estimated to be 300 ft x 75-100 ft.

Site features listed in 1971 were 18 in x 4 ft iron "ballast bars," hundreds of cement sacks and miscellaneous rigging. The main wreck portion was apparently located 200 yds from the sack concentration in the direction of Pulaski Light. A buried 125-gamma anomaly was noted 200 yds to the south. A wreck symbol is located in the general vicinity of this site on the 1986 NOAA Chart 11438. On C&GS Chart 585, which was used by the 1971 group, there is no wreck symbol in this area.

This site was visually relocated during the 1989 SCRU reconnaissance by Capt Cliff Green aboard ACTIVA on July 1, while maneuvering in a systematic pattern in the reported site vicinity. A single dive was made by Captain Green, R. Gould and L. Murphy, and a visual area survey was conducted with diver propulsion vehicles by Gould and Murphy.

The site consists of approximately 250 2 ft 6 in x 1 ft 6 in sack-shaped forms that appear to be hardened cement sacks (Plate 12.3). The pile covers a 400 sq ft area, with sacks about five feet high in the pile's center. The pile lies on a low reef at the edge of a sandy area. Two ferrous metal pieces roughly the dimensions given in the 1971 report were found, and some hemp-core wire rope was located. No other wreck related material was found. There was no hull structure, fittings, fasteners or much else that would indicate a shipwreck. The visual search, which proceeded in overlapping transects along a north-south course through the site in both directions more than 300 yds, proved negative. An expanding circle-search originating at the sacks and spiralling out an estimated 250-300 yds was also negative. No remote sensing was conducted; the structure reported in 1971 was not relocated and may have been buried.

The site clearly does not represent a shipwreck, and does not immediately appear to be a wreck scatter. The site, if ship-related, probably represents a stranding. Because of the water depth and site compactness, a fair-weather stranding is indicated rather than one resulting from storm conditions. Principal evidence supporting a stranding is the site's proximity to the deep-water Pulaski Shoals drop-off. The site is about 220 yds from 60-ft depths and about 200 yds from the 30-ft contour. The 1971 investigators reported 18 ft of water at the site; the ACTIVA fathometer indicated 16 ft.

The total sacks represent about 25 cu yds of cement. A cubic foot of cement weighs about 100 lbs dry. An estimate of cement weight represented on site is about 30 tons. If it is assumed that this weight was thrown overboard to lighten a stranded vessel, it is informative to translate this weight into how much it might decrease a vessel's draft. It is, of course, impossible to estimate the vessel

Plate 12.3. Sack-shaped forms, probably cement near Pulaski Light, FOJE 013. NPS photo by Larry Murphy.

size that discharged the cement bags, but an example may aid site interpretation.

The relationship of a certain vessel size to its displacement is virtually unique, and few vessel displacement curves are easily accessible. However, one early twentieth century example is supplied by Desmond (1919: 28-29). A displacement curve is depicted for a vessel 230 x 32 x 20 ft with a 1,050 gross tonnage. This is a reasonable example because presence of cement in sacks rather than barrels represents a vessel from the last quarter of the nineteenth century at the earliest. The size is reasonable for a vessel in the coastal trades that might be carrying such a cargo.

United States displacement is calculated with 2,240-lb tons. Thirty tons of cement represent about 26.7 displacement tons. The example vessel deadweight on a 12-ft draft is 750 tons and 960 tons on a 13-ft draft. A reduction of 17.5 tons reduces draft about 1 in. Consequently, a discharge of 30 tons from the example vessel when loaded on a 13-ft draft would raise it about 1 1/2 in. This might be enough to release a stranded vessel, particularly if very little of the vessel was grounded, and additional cargo was shifted or a tow vessel employed. Presence of metal and cable indicate more than a simple cargo lightening.

However, there are some problems with this speculation. The site is in about 16 ft of water, which would mean a larger vessel than the example. Removal of 30 tons from a larger vessel, especially fully loaded, would diminish the draft less than the 1 1/2 in of the above example. In addition, the site is a bit over 200 yds from Pulaski Light. The site does not reflect a vessel hard aground, as would be expected if the casualty occurred in foul weather and rough seas. It is difficult to imagine a scenario where in calm weather a vessel would lightly ground 200 yds from a principal lighted navigation warning, unless it was servicing the light. More curious things have certainly happened at sea, but this does raise a necessity to consider alternatives.

If the site is a grounding, there may be indications remaining in the substrate. Grooves and gouges often remain visible long after a stranding. The site could be part of a wreck scatter after all, with this feature being a "bounce spot" that happened in heavy seas with hull remains further inshore. However, it would be expected that such a bounce site would be more scattered than this one. The site could be a dump, but there is little evidence or rationale for disposal in this area. Or, the cement could have been lost or disposed of during construction of Pulaski Light.

A final possibility is that the site may have been a well site. In 1979, an exploratory well site near the Marquesas Islands was examined by scientists interested in assessing oil-well impact on coral reefs (Smith and Hunt 1979). Although the researchers concentrated on the 1958-1963 time period, they found at least 14 offshore wells drilled in this area between 1947 and 1973 (Smith and Hunt 1979:23). All but the two wells drilled in 1947 had precise locations--most were near the Marquesas. The closest drill site to the Tortugas was Rebecca Shoal.

Smith and Hunt examined a circa 1960 test-well site that "contained a cluster of hardened sacks; 106 sacks were counted ... The coverings were gone ... their hardness and color led us to assume that they were concrete" (1979:6). They also located metal debris including cable, pipes and drill casing (p. 13). The sacks apparently were used as foundation levelling for drillship spud-support pads.

Test drilling may have never been allowed within the monument. Location of 013 is just outside the 1936 Administrative Boundary, but within the Legal Boundary, which is one of few places where shallow water can be found in the Dry Tortugas outside the Administrative Boundary. Early ship- or barge-mounted drill rigs could only operate in water shallow enough to allow securing with spuds. It may be unlikely that the site represents a test well, but it cannot be discounted by what is currently known, either from the archeological or historical records. But then, neither can the other possibilities be supported.

Little can be said confidently about this site at present. It has received only two cursory reconnaissance-level examinations nearly 20 years apart. Future research should be directed toward a more intensive and systematic site survey (particularly for additional artifacts and hull scars), sampling the sack material, high-resolution remote sensing and additional historical research.

FOJE 014 - Fischer, Robinson, Clausen Wreck, SEAC Acc. No. 0185

This site is not named on the SEAC site report form. The site was located June 9, 1971 on the south end of Loggerhead Key, by those named while fishing. The site contains scattered late nineteenth to early twentieth century shipwreck remains. Structure was observed, along with iron knees, tubing, bronze and iron fasteners, pulleys and hooks. The site was scattered over the reef in 15-35 ft depth. No material was removed. Insufficient data exist to correlate this site with any of the 23 documented total losses for this area in the shipwreck database.

FOJE 015 - Deadeye Wreck, SEAC Acc. No. 0185

This site on southeast Loggerhead Key Reef produced a broad 600-gamma magnetic anomaly. The scattered 18-ft deep site was attributed to the mid to late nineteenth century. Material observed was iron rigging, 6-in [long] link chain, steel cable concentrated in one area, wooden deadeye with a 4-ft long strap and drift pins. There was additional wreckage, possibly associated, of iron pipe and another deadeye located 125 to 140 yds to the southeast.

Presence of "steel cable" indicates a site probably no earlier than 1860. There are 17 post-1860 vessels recorded as total losses on Loggerhead and Southwest Reefs in the shipwreck database, any could be this site.

FOJE 016 - Shrimp Boat, SEAC Acc. No. 0185

A modern, recently wrecked shrimp trawler was located in 1971 in North Key Harbor by diving a buoy, probably placed by the wreck owners to mark the site. No material was collected from the 6-ft deep site on the shoal southeast of North Key Harbor. The wreck, estimated to be 6-10 months old, was scattered and deteriorating, but recognizable.-

FOJE 017 - Ludert-Cooper Site (8Mo836) SEAC Acc. No. 850580

The SEAC site report indicates discovery during the 1971 survey, but the site card records a date of October 1981. The site record card is different than the previous ones (which are Florida UWARS) and is labelled Underwater Archeological Site Record, Southeast Archeological Center. The rest of the record card is identical to the UWARS card. Apparently, SEAC made a copy of the Florida UWARS form and began using their own, indicating that this site was not recorded in 1971 as indicated on the computerized SEAC site report. Johnson (1982b:iv) states the site was located in October 1981 during SEAC investigations of 009, 200 m away.

The SEAC card states that 7 wrought-iron swivel guns were located, along with a "bronze or brass chainplate" and ceramic fragments identified as Iberian olive jars. A swivel gun was collected in 1981. Thirty artifacts were collected from 009 and 017 (Johnson 1982b:2).

A joint National Park Service (SEAC) and Florida State University team investigated 009 and 017 extensively during the 1982 summer (Johnson 1982b). "Samples of ballast, brass material and one ceramic sherd were recovered" (Johnson 1982b:i). Investigation results are in Chapter X.

In 1985, SCRU visited the swivel-gun area at the request of Superintendent Jack Morehead. Four guns were observed, videotaped and photographed. The general area was surveyed, using diver propulsion vehicles, by Morehead and Richard Curry, resource management specialist from Biscayne National Park. About 100 yds from the guns, some 3 ft 3-in-long iron pins and a piece of iron 4 in x 1/2 in x 2 ft were located (Plate 12.4). Five 2 ft 8-in fasteners laying in a parallel line 8-12 in apart were located and recorded (Lenihan 1985:6-7). This feature was identified as an apparently undisturbed keel location, where a section of keel deteriorated and left the pins in their proper location and orientation without any trace of wood. These features appeared to continue under an old staghorn reef.

This area lies near the transect discussed in the Johnson report (1982b; see Chapter X). Features observed in 1985 are believed close to the area where bronze fasteners, rods, burnt wood and ballast were reported in 1982. None of the latter features was observed in 1985.

This is an important site, and the oldest investigated in the monument. Speculation centers on the site being a 1622 vessel; results so far are promising, but inconclusive. The brief investigation in 1985 and some of the 1982 observations indicate the site may be in a naturally active area with current and wave action uncovering and burying material. The general area has been known to commercial treasure hunters since at least 1972 and called the "DEL ROSARIO Site." This area should be considered a top priority for ranger patrol and systematic investigation in future archeological fieldwork.

FOJE 018 - Two-Cannon Site, SEAC Acc. No. 0185

This site is located offshore on the west side of Loggerhead Key near the lighthouse. Discovery is attributed to the 1971 survey, but it was apparently discovered in October 1981 (SEAC site card). Investigators reported only two gun tubes observed. Lack of material indicates a probable dump site rather than a shipwreck.

FOJE 019 - Brick Wreck, SEAC Acc. No. 0185

This site is recorded on a UWARS site card and apparently was discovered in 1971 as Anomaly #8 offshore Loggerhead Key just south of the light. The 10-ft-deep site has bricks, iron strakes 15 ft x 1 ft, prybars and a windlass. No material was collected.

No correlation can be made with any historically documented site lost on Loggerhead Key or Reef.

FOJE 020 - No Site Name, SEAC Acc. No. 0185

Site apparently was discovered during 1971 survey and attributed to late nineteenth or early twentieth century. A 16 ft x 30 ft "steel structure of beams and plate" was noted laying flat on the bottom in 14 ft of water. The site was originally Anomaly #20. It was speculated this might be part of the steel wreck (old site 75, now FOJE 003). No material was collected.

FOJE 021 - No Site Name, SEAC Acc. No. 0185

Apparently this site was discovered during the 1971 survey and named Anomaly #22, which produced a 60-gamma reading. A small quantity of rigging and pins, and several dozen straight-sided barrels, thought to contain iron nails, were noted. No material was collected. The site cannot be correlated with any documented in the shipwreck database.

FOJE 022 - No Site Name, SEAC Acc. No 0185

Site originally gave a 100-gamma anomaly (Anomaly #22). The site was partially buried, with iron rods and cable visible on the bottom in 20 ft of water. No material was collected. Site not designated a shipwreck.

There are a total of 37 casualties that were not total losses recorded in the shipwreck database for Loggerhead and Southwest Reefs. Of these, four occurred on Southwest Reef (none list Loggerhead Reef) after 1860, and were only partially salvaged.

FOJE 023 - Iron Ballast Wreck 2, SEAC Acc. No. 0185

Site was discovered in 1971 on Loggerhead Key Reef's southern end through examining an 800-gamma anomaly (Anomaly #6). Chain, iron wreckage and several 1 ft 6 in x 1 in x 3 ft "ballast bars" were recorded on this 10-ft deep site. No material was removed.

Plate 12.4. Larry Murphy examines hull fasteners in the 009, 017 vicinity, 1985. NPS photo by Jack Morehead.

If the "iron wreckage" is structure, then no recorded vessel correlates with this site. AVANTI (003) is the only iron-hulled vessel recorded lost on Loggerhead or Southwest Reefs.

FOJE 024 - No Site Name (8Mo248), SEAC Acc. No. 01850433

This site was recorded as Site #1 during the 1974 survey. Site depth was 25-30 ft. No material was collected. The following were recorded onsite: trailer hitch, 6-ft drive chain, two 3-ft steel cable loops, one "Civil War" brick, steel drum and "shrimper bucket." The site was designated a modern shipwreck. No site in the database corresponds to it.

FOJE 025 - No Site Name (8Mo249), SEAC Acc. No. 01850433

This 1974 shipwreck site, originally "Site #3," was 20 ft deep. Site features reported were: steel cable, concrete, U-bolt in wood, 5 ft x 4 ft piece of iron. No material was collected. "Steel cable" places it probably after 1860. None of the total losses in the database correlates with this site.

FOJE 026 - No Site Name (8Mo250), SEAC Acc. No. 01850433

This site (Site #4) was classed as a modern shipwreck by the 1974 survey team, but the SEAC site report designates it "isolated artifacts." The site was in 20 ft of water. Fifty feet of 1/4-in cable, a brass wood-tub handle, and a modern shrimp boat anchor and chain were recorded.

FOJE 027 - No Site Name (8Mo251), SEAC Acc. No. 01850433

This 30-ft deep site on Loggerhead Reef, like 8Mo250, is listed on the UWARS site card as a shipwreck site, while the SEAC site Report form classifies it as isolated artifacts. Material reported includes: iron strap, wood fragments, cut stone, barrel hoop, modern wire-nails. A brass pin was recovered. The site depth indicates a probable foundering. No ressels in the shipwreck database foundered on Loggerhead Key or Reef.

FOJE 028 - No Site Name (8Mo252), SEAC Acc. No. 01850433

This 10-ft deep site was originally designated "Site 5." It is a definite shipwreck site with wooden beam, gears, anchor, ballast, fittings and animal vertebrae recorded on the seabed. The following material was collected: bronze rudder gudgeon, square nails, iron shot and an oriental brass coin.

There are 23 total losses documented for Loggerhead Key and Southwest Reef. None can be definitely correlated with this site.

FOJE 029 - Bird Key Harbor Brick Wreck, No SEAC Accession Number

This site has long been known by the NPS, but apparently designated FOJE 029 only sometime after 1987. A site report that

Plate 12.5. Cannon from Two-Cannon Site, FOJE 018. Jack Morehead is the video diver in the background. NPS photo by Larry Murphy.

Plate 12.6. FOJE 030, 1985. Diver is Jack Morehead. NPS photo by Larry Murphy.

includes 1989 and 1990 field operations appears in Chapters XVII and XVIII. This site is not documented in the shipwreck database.

FOJE 030 - No Site Name

Sites beginning with 030 have not yet been entered into SEAC site files, and consequently, as yet have no state numbers or SEAC accession numbers. These numbers were assigned by Murphy in 1989. FOJE 030 is a lobster boat sunk in 1981 or 1982. This site, known as "V-J" lobster boat, was dived and videotaped by SCRU in 1985 and reported in the trip report of that field operation (Lenihan 1985:7; Appendix I).

The vessel, about 50 ft in length, is laying on its starboard side. There is a large channel iron projecting from the bow (Plate 12.6). The hull is virtually intact; electronic gear including fathometer and radio were located in the cabin; the only thing missing was the prop. The 1985 trip report (Lenihan 1985) suggested the wreck should be monitored to note position shifts and the processes affecting it as it is transformed into an archeological site.

FOJE 031 - No Site Name

This site, near Pulaski Shoal drop-off north of the light, was reported to ACTIVA Capt Cliff Green. The site was located by using provided LORAN coordinates and conducting a visual area search. The site was finally spotted during survey with diver propulsion vehicles (DPVs).

The site is in 10 ft of water and consists of two round-rock ballast piles about 4 1/2 ft high and 10 ft in diameter (Plate 12.7). No other materials were located. Centers of the flattened conical piles are 48 ft apart. Rounded rock, often associated with early Spanish wreck sites, is sometimes called "egg-rock ballast." Water-worn rocks or cobbles were used for centuries by many European vessels and are not in themselves diagnostic. Each pile is about 6 tons of rock, assuming 100 lbs per cu ft and 2,000-lb tons.

These twin piles undoubtedly represent a stranding site where a vessel dumped ballast sufficient to raise the hull enough to float free. The two ballast piles were formed by throwing rocks off both vessel sides. The rock pile centers represent the ship's beam plus the toss distance. Ballast stones were likely thrown away from the vessel side to ensure they did not fall against the hull side and restrict its release. It is probable that stern-deployed kedge anchors were used, implying the use of a ship's boat and the ability to sound the area for the shortest escape route.

The site location supports a stranding. The 30-ft contour is about 400 yds to the east. About 500 ft away to the north is the closest deep water, 12-14 ft, which might indicate the direction the vessel departed. Apparently, the ship entered the shoal from the east in fair weather and probably left to the north taking the shortest route to deep water.

This is an important site archeologically because it provides a clear signature for one kind of marine disaster: a fair-weather

Plate 12.7. Twin ballast piles comprising FOJE 031, Pulaski Shoals, 1989. Second pile is dimly visible upper right. NPS photo by Larry Murphy.

stranding. Signature development for other marine disasters and activities should be an important part of the long-term research at Fort Jefferson National Monument.

There are 13 strandings documented for Pulaski Shoal where neither vessel nor cargo was lost. Cargo is documented for all 13. Three were carrying phosphate rock and can be eliminated as possibilities; the rock on this site was rounded, unlike mined phosphate rock, which would be irregular. Of the remaining 10, 3 occurred before 1850 and are particularly likely possibilities: ALLBREE, a Boston ship with 12.8-ft draft carrying cotton from St. Joseph, Florida to Boston, that stranded in 1839; brig HORACE, going from New York to New Orleans with a cargo of paving stone and miscellaneous cargo stranded in 1842 with the cargo partially salvaged; and SOUTHPORT, carrying rice, hay and ballast from Charleston to Apalachicola that stranded in 1846 (Bearss 1971:58,62,68).

Strandings of HORACE and SOUTHPORT are both likely prospects for this site. The *Key West Admiralty Record* (Vol. 3:9 pages, numbers illegible) indicates HORACE's crew and assisting wreckers jettisoned paving stones and ballast. It is assumed that paving stones meant street paving stones, thus were probably cobbles. Apparently, three jettisoning incidents occurred. The wreckers stated the brig's crew was throwing over ballast when they arrived onsite. "They [wreckers] then lightened the brig by throwing overboard paving stones for two hours," and later, after the brig grounded again, "all hands were employed in discharging paving stones."

HORACE's stranding site is given as "inner reef of the northeast flat of the Tortugas being north, northeast from the lighthouse and distant about 7 miles" (Admiralty Record Vol. 3). The location of 033 is 6 3/4 mi from Garden Key Light. It is likely the lighthouse referred to is Garden Key because wreckers typically used the Garden Key anchorage and would have more likely indicated the distance from their location, rather than the more distant Loggerhead Light.

SOUTHPORT is also a good possibility for this site. We do not have the Key West Admiralty Record for this incident; the following information is from Bearss (1971: 68).

SOUTHPORT stranded on Pulaski Shoals the night of March 4, 1846 bound for Apalachicola, Florida with 20 tierces (a measure larger than a barrel and smaller than a hogshead) of rice, hay and ballast. The ship lay broadside to the reef, and the crew had thrown 13 tons of ballast overboard by the time wreckers arrived. Wreckers threw over additional ballast and used kedge anchors to free the hull. Because the amount of ballast located on site corresponds with the recorded amount, SOUTHPORT is the best prospect for this site. An area survey for additional materials should be done. Lack of additional ballast deposits could eliminate HORACE, which jettisoned multiple ballast piles during its stranding.

FOJE 032 - Railroad-Iron Site

This site was spotted during visual surveys aboard ACTIVA July 1, 1989. A scattered pile of railroad rails was seen in 9 1/2 ft of water depth on Pulaski Shoal. LORAN position numbers were recorded. The Railroad-Iron Site has not been dived as of the 1990 fieldwork. Although this is an archeological site, it is at present indeterminate whether it represents a shipwreck or disposal, either of refuse or as a result of stranding.

A possible casualty for this site is LAKE WINONA, a steamer that ran aground during the September 1919 hurricane. The crew abandoned ship for a day. LAKE WINONA's hull was badly damaged, and 600 tons of damaged cargo were jettisoned. The Puerto Rico bound cargo was not specified (Bearss

Plate 12.8. FOJE 033, Diesel Wreck, 1989. The diesel engine, covered with coral, is visible at the top of photo. Ship's wheel is at lower left (arrow). NPS photo by Richard Gould.

1971:125; *Coast Guard Casualty Reports* 1913-39, entry 483).

FOJE 033 - Diesel Wreck

This shipwreck was located by accident while giving Fort Jefferson divers requalification dives just off Southwest Reef. Richard Gould, Lucy Doyle and Linda Stoll were surveying south of Long Key Reef for cultural materials when they found this site.

The site contained a brass ship's wheel near a diesel engine (Plate 12.8), hull structure including sternpost (Plate 12.9) with two brass gudgeon plates with 3-in pintle holes attached, sounding lead, 4-in OD pipe with right angle fittings (cooling or exhaust?), two 8 in x 4 in x 8-ft iron bars, 2-in thick iron fastenings and structural support elements (Plate 12.10), remnants of a lead-acid battery and 1/2-in diameter brass or copper tubes with regularly spaced holes drilled completely through. Multiple sections of drilled tubing were fashioned into a square. The drilled tubing could have been used for hold aeration; possibly this vessel was involved in marine specimen collection.

The ship's wheel (Plate 12.11) was 2 ft in diameter. The diesel engine block (Plate12.12) was 3 ft 10 in long by about 2 ft wide. The shaft was 2 in in diameter, and there was a flywheel 1 ft 6 in in diameter attached to the main shaft in the front and a shaft coupling on the rear of the block. The fuel pump was present atop the block.

FOJE 033 is the remains of a small twentieth century vessel made of wood, with rather heavy iron hull support features. The site dates to the late 1920s at the earliest. Rudolph Diesel introduced diesel engines in 1893; with the first marine engine produced in 1902. The first ocean-going, diesel-powered ship was the 1910 Dutch oil tanker VULCANUS (Spratt 1953:55-56).

The site, which was only dived once, was located in 10-ft depths on the reef just shoreward of a steep deep-water drop-off. Sitescatter suggests a storm-driven wreck. Measured sketches were made of some features. The site should be mapped and historical research conducted to determine vessel identity. No documented wreck currently in the shipwreck database corresponds to this site. One possibility is that the site was associated with the Carnegie Institution marine research facility on Loggerhead Key.

FOJE 034 - Hospital Key Site

This site was located July 2, 1989 during reconnaissance perimeter surveys of the smaller Tortugas islands. The island was circled counter-clockwise beginning at the west side by three snorkel divers (Gould, Stoll, Murphy) using diver propulsion vehicles. Offshore the key's east south side a pile of concreted ferrous material, including

Plate 12.9. Sternpost of Diesel Wreck 033. Gudgeon strap is visible by knife blade. NPS photo by Richard Gould.

Plate 12.10. Diesel Wreck 033, 1989. Hull fasteners and iron structural support members. NPS photo by Richard Gould.

Plate 12.11. Ship's wheel 003, 1989. NPS photo by Richard Gould.

Plate 12.12. Diesel block 033, 1989, diver Larry Murphy. NPS photo by Richard Gould.

railroad iron, was located in less than 10 ft of water (Plate 12.13). Some of the scattered material may be fasteners. Two features indicate this material may be a wreck: a square, ferrous machinery-mount and a warping head. This site was photographed, but not mapped. A detailed map is needed along with systematic metal-detector survey of the area. Like all the other sites in Fort Jefferson National Monument, more historical documentation is needed. There are no documented marine casualties for Hospital Key.

FOJE 035 - Coast Guard Dock Ballast Pile

This wreck south of the Coast Guard docks on the east side of Loggerhead Key is in shallow water (6-7 ft), perpendicular to shore and easily located from the surface. The wreck can be seen from atop the lighthouse. The wreck was spotted from the surface in 1989, and dived August 11, 1990. One dive was made; the site was measured and sketched.

The oval-shaped ballast pile is 47 ft x 16 ft (Plate 12.14). Ballast is about two feet high over intact, unburied wooden hull structure (Plate 12.15). Ballast rock is mostly irregular blocky shaped, with some cobbles and smaller stones present. About twenty rocks were scraped, and all appeared similar--dark mottled, possibly granite or basalt. Chemical and optical analysis of a single sample classified the rock as an alkalic basalt (Husler 1991).

A structural feature (Feature 2) on the eastern extremity of the pile was hand fanned and examined. A transverse plank 3 in thick was close to hull planks 6 in wide and 2 1/2 in thick. Wood portions were charred. A soft, red ceramic fragment, possibly brick, was observed in the sediment between the hull planks, which were about 2 ft apart. This feature was not diagnostic as to stern or bow, although certainly from near one of the hull ends, probably stern, assuming the vessel went in bow first. No sign of sternpost, knee or deadwood was visible, but hull dimensions at this point indicate it was close to the sternpost, possibly just forward the sternpost knee. Neither keel nor keelson was observable.

Feature 3 was located on the ballast pile's south side 18 to 25 ft from the eastern end (Plate 12.16). This feature consists of intact hull structure including hull planks, floors, filling frames and ballast. Hull structure is iron fastened with no sign of sheathing. Hull frames are 6 in x 4 in, hull planks are 2 1/2 in thick. No ceiling was visible. The hull broke along the hull bottom inside the bilge turn. Consequently, the ship's beam was wider than the 16 ft of ballast on site, at least 20 ft. No frames or hull-side structure were found along or near the ballast pile.

Sample Analysis - No artifacts were removed. Four samples for identification and analysis were collected:

Plate 12.13. Pecos NHP Superintendent Linda Stoll examining FOJE 034 offshore Hospital Key, 1989. Principal feature is this large concreted pile of ferrous material. Site was discovered during DPV perimeter surveys. NPS photo by Larry Murphy.

Plate 12.14. Coast Guard dock ballast pile 035, 1990. NPS photo by Larry Murphy.

FS 4 - Small rock from top of ballast pile.
FS 5 - Wood sample from exposed plank Feature 3.
FS 6 - Caulk sample from between exposed planks Feature 3.
FS 7 - Wood sample from exposed frame Feature 3.

FS 4, a ballast rock was classed as an alkalic basalt containing 52.94 percent SiO_2, 2.95 percent Na_20 and 1.49 percent K_2O (Husler 1991).

The hull-bottom plank (FS 5) was maple. The frame was unidentifiable because of the sample's proximity to a knot and rotted condition. The wood (FS 7) was from a ring-porus conifer with heavy ring boundaries, no rays and with large pores, possibly it was chestnut, but identification was uncertain (Dean 1991).

The wood is likely chestnut. In 1879, the American Shipmasters' Association, which produced specifications for the *Standard American Classification of Vessels* for use by insurance underwriters, gave an eight-year assignment to both maple hull-bottom planks and chestnut floors (American Shipmasters' Assoc. 1879:xxvii). It would be unlikely that woods with different year assignments would be used in constructing a hull, because the overall insurance assignment would be for the lowest year. Maple and chestnut indicate a northern-US built vessel.

FS 6 was removed from between planks and thought to be caulk. However, it was mostly iron, (54% Fe_2O_3) and calcium oxide

Plate 12.15. Coast Guard dock ballast pile, 1990. Stadia rod is resting on interior of outer hull planks, south side. NPS photo by Larry Murphy.

(CaO 3.30%) and the remainder traces of various compounds (Husler 1991), indicating that the sample was mostly deteriorated iron products, likely from a nearby fastener. The lack of cuprous compounds indicates an unsheathed iron-fastened vessel.

This is a small unsheathed, iron-fastened, rock-ballasted sailing vessel, probably mid-nineteenth century or earlier, based on size and construction details. The rocks' irregularity in shape and size suggest ballast, rather than raw material for construction. The rock and hull-construction wood suggest a northern, possibly New England vessel, or perhaps Canadian. New England, especially New York, dominated Gulf shipping in the first half of the nineteenth century.

The ballast pile represents about 50 cu yds of rock (considering pile taper on the ends). Loose stone has a weight of about a ton per sq yd (75 lbs/cu ft) and solid limestone around 2 1/4 tons per sq yd (170 lbs/cu/ft). Assuming 1 3/4 tons per sq yd for the ballast on 035, the site contains about 87 tons of ballast.

Middendorf (1903:58) developed a ballast factor for vessels by dividing tons of vessel ballast by registered gross tons. This ballast factor, which was for fixed ballast, generally ranged from .4 to .55 tons/ship's registered tons. A test of Middendorf's ballast factor was conducted with American vessels by the San Francisco Maritime Museum (Anon. nd.). In all cases, vessels with known ballast weights met or exceeded Middendorf's recommendation. (This factor is but a general guide; vessels have a wide range of variability, including no ballast at all.)

Using Middendorf's factors, the 87 tons of ballast on this site would be sufficient for a vessel of 150 to 200 gross tons. This ship was probably not carrying a load of lumber. An analysis of 17 nineteenth century vessels, most of which were large, square-rigged vessels, gave an average ballast factor of .256 while carrying lumber. If this factor is used for the ballast on site, an estimated tonnage of 339 tons results, which is inconsistently high based on scantling size.

Hull plank thickness of 2 1/2 inches, assuming little abrasion, indicates a vessel of about 100+ tons (e.g., American Shipmasters' Assoc. 1891: 56; *Lloyd's Register* 1851:13. *Lloyd's Rules* of 1869:Table B, required 2 3/4 in hull plank for vessels of 100 tons). [Hull plank thickness is not always reliable for hull size determination.] Use of filling frames between floors and first futtocks (Plate 12.16) make a solid structure and indicates at least nineteenth century, possibly early local

Plate 12.16. Coast Guard dock ballast pile 035, Feature 3, where samples were collected. NPS photo by Larry Murphy.

twentieth century practice. Filling pieces were often omitted on smaller vessels.

No indication of rig was present. The site is in shallow, protected water. The upper works and rigging would have been easily salvaged soon after the wreck; lack of rigging materials indicates that was the case.

The ship could have been schooner or square rigged. The number of masts is unknown, but was more likely two rather than three. Schooners were common in the coasting trade in the nineteenth century. For longer voyages, barks, brigs and ships were often used, particularly in the first half of the nineteenth century. Some schooners, particularly those with centerboards, could run light. Presence of ballast may indicate a square-rigged vessel involved in long distance rather than coastal trade.

The rigging was probably salvaged. If the masts were not, the evidence necessary for rig determination may be on site. If the vessel carried only a lower and top mast, which can be determined through location of mast caps, it is definitely a schooner. If the foremast consisted of lower, upper and top-gallant masts, then it was square-rigged, likely a brig or brigantine. A high-resolution metal detector survey and limited test excavation of the site's perimeter could provide the mast caps.

Plate 12.17. An aerial depicting relationship of islands east of Garden Key. Bush (center) and Long (right) Keys are visible to the right, Hospital, Middle Key and East Key (left to right, arrows) are visible at the top. Channels and Garden Key anchorage can also be discerned. USN photo by William Krumpleman II.

This vessel, possibly a square-rigger, was probably travelling in ballast, or perhaps carrying passengers or very light cargo. The vessel may have been bound for one of the major north-Gulf ports in ballast to pick up a one-way cargo. This was not uncommon in the nineteenth century. The database contains information on 10 vessel casualties in the Dry Tortugas that were travelling in ballast--all were ships or barks except for three schooners, all were bound for Gulf lumber ports, most for Apalachicola, Florida.

Historical Correlation

The site's location would likely be documented as Loggerhead Key, rather than Loggerhead Reef or Southwest reef. The shipwreck database contains four vessels that are total losses on Loggerhead Key, two are reasonable possibilities. One of these is a Cuban fishing smack lost in 1923, which can be discounted. The other is FRANCIS ASHBY, a brig carrying coffee, honey and tobacco, lost in 1843 en route from Cuba to

New York (Hambright nd:13). Original documents have not been located for this vessel. One inconsistency is that the location is listed as "Loggerhead Key (American Shoals)." American Shoals is further east than Loggerhead Key. More historical research is necessary to determine the identity of 035. The best possibility would be the Loggerhead Lighthouse logs, which have yet to be located.

Future Work

This site should be thoroughly documented, and a detailed metal detector perimeter survey should be done. High resolution magnetometry should locate other ferrous components indicating additional wreckage scatter and hull components. Trenching through the ballast pile would allow structure documentation and location of features, such as centerboard case or mast steps, that would allow a more complete site description.

OTHER SITES AND FEATURES ON AND NEAR THE ISLANDS AND REEFS OF FORT JEFFERSON NATIONAL MONUMENT

Anchorages

The Dry Tortugas contain many good anchorages; none have been surveyed, even at the reconnaissance level. All anchorages are potential archeological sites as a result of refuse disposal from moored vessels. Some of the primary anchorages are: north of Fort Jefferson between White Shoal and Middle Ground; southwest of the fort; northeast of East Key; Pulaski Shoal; west of Loggerhead Key; Bird Key Harbor and perhaps North Key Harbor.

Presence of historically interesting site scatter would be a function of water depth and protection offered at each site. Some anchorages were used by everyone, such as those south and north of the fort. Modern shrimpers and commercial fishermen often anchor at Pulaski, East Key and the west side of Loggerhead, and that has probably been the case for a very long time. Anchorages close to the fort, particularly on the north, were used by military vessels. Detailed examination and comparison of these principal anchorages should reflect long-term patterns of maritime behavior in the Dry Tortugas.

Ship Repair Sites

The Tortugas have very likely been used for ship repair since earliest times. Repair sites, careenages and ballast dumps are undoubtedly to be located within the monument's waters. For example, Captain Leonard Tawes (1967) writing about early coasting in the Gulf of Mexico mentions taking a load of powder to Fort Jefferson and throwing ballast overboard (Tawes 1967:100). Captain Tawes also noted that: "This little island, called Gorden [Garden] Key, afforded a splendid little harbor where our ships could put in and repair after a battle ... they could put in there and heave out, caulk the bottoms, and copper them without leaving their posts (Tawes 1967:101).

Garden Key

Various features have been documented on Garden Key. Two prominent features inside the parade ground were noted by NPS Maritime Historian Jim Delgado in 1988.

Delgado found and sketched the 1825 Garden Key Lighthouse brick foundations (Figure 12.1). He also located the lightkeeper's quarters foundations, and a slate slab believed to cover the grave of a lightkeeper's wife (Delgado 1988:2).

An anchor and gun tube have been placed on each side of the wooden bridge leading to the sally port. There is no known provenience for these two unconserved artifacts, and it is not recorded when they were first displayed. Larry Nordby and Dan Lenihan documented and drew these features in 1988 (Figures 12.2 and 12.3).

It is strongly recommended that these unconserved, deteriorating artifacts be removed from their prominent position at the entrance to Fort Jefferson and placed underwater, perhaps at the swimming beach where they may become snorkeling attractions. Placement underwater would not conserve them, but would remove them from view as poor examples of an earlier, uninformed NPS approach to submerged artifacts. Presently, there is nothing to distinguish these artifacts at Fort Jefferson from the many deteriorating anchors and gun tubes looted from historic shipwrecks that are on display up and down the Florida Keys.

This gun tube (Figure 12.2), which may have come from 008 (Capt Cliff Green, personal communication) is nearly featureless and in bad shape. Severe corrosion and spalling have obliterated details and even traces of some features. There are no markings on the tube or trunnions. Saying

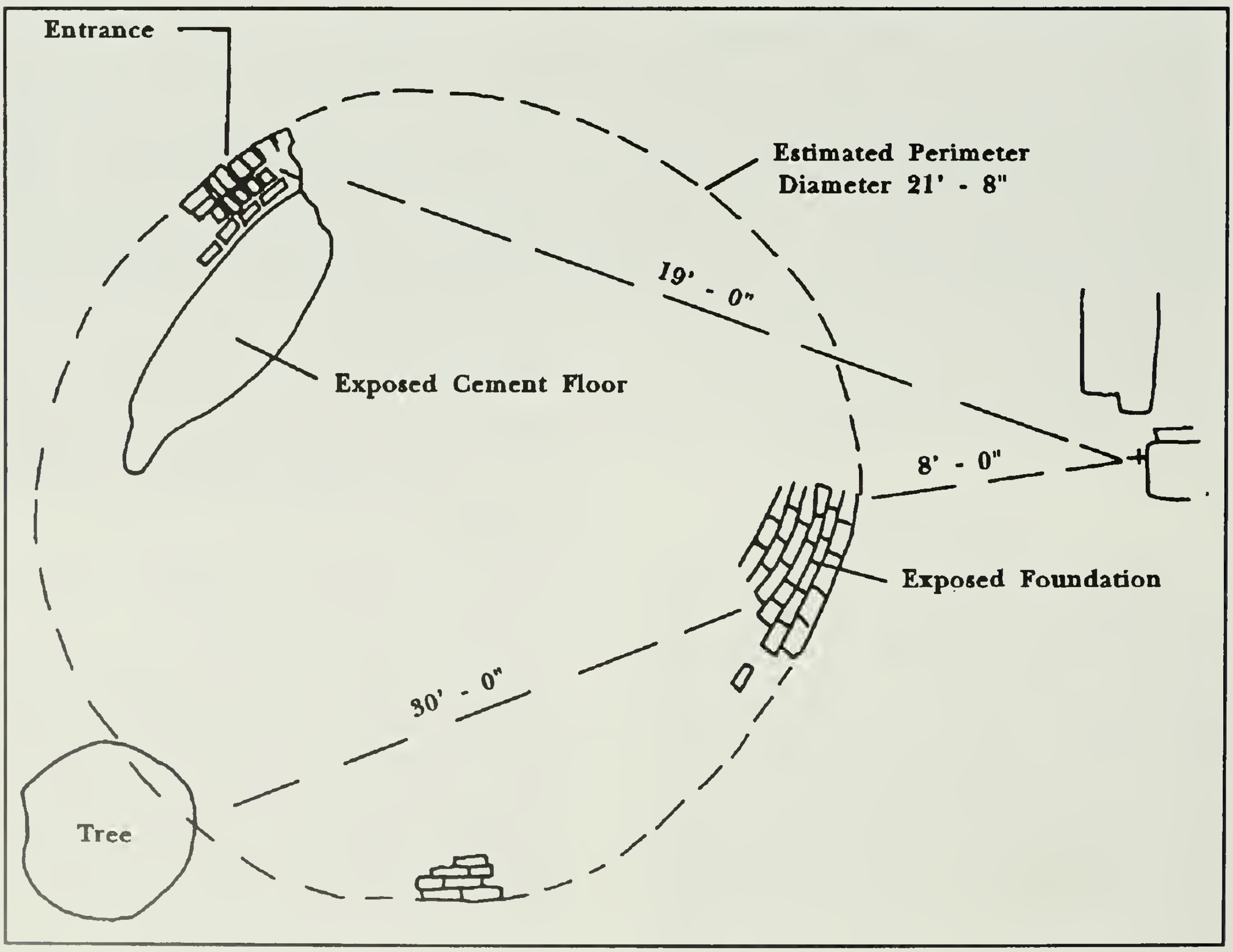


Figure 12.1. Drawing of 1825 Garden Key Lighthouse foundations in Fort Jefferson parade grounds. Drawing by James Delgado.

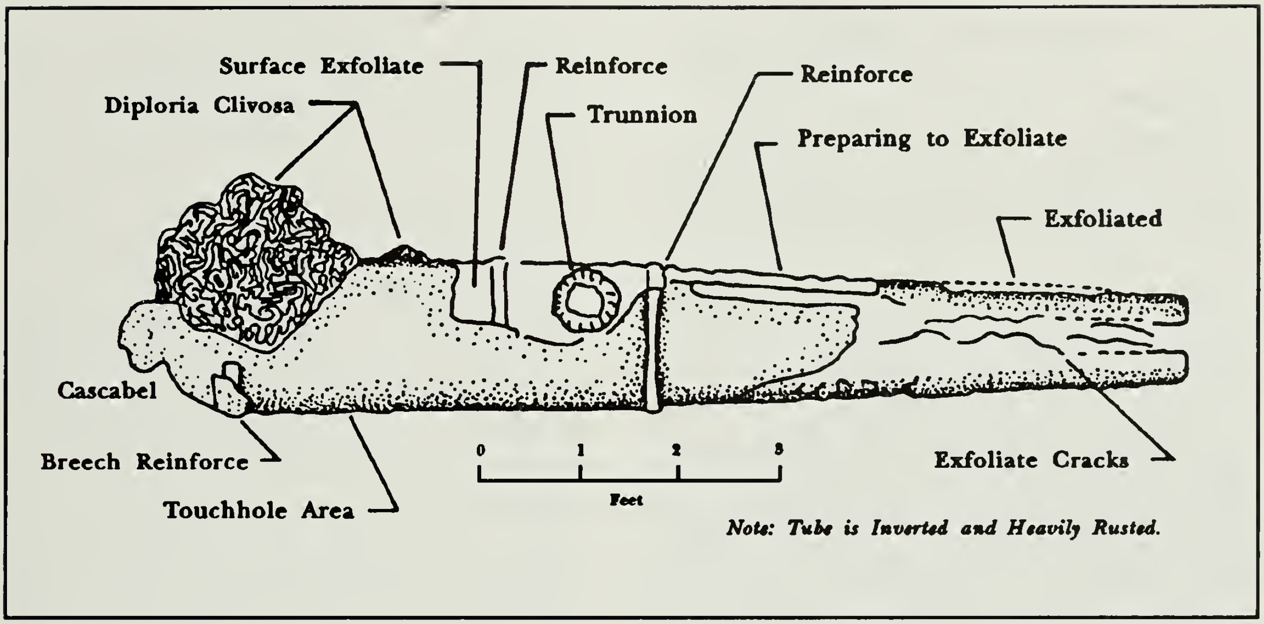


Figure 12.2. Gun tube at sally-port bridge. Drawing by Larry Nordby.

much about a cast-iron gun tube, particularly one in poor shape, is a speculative, often subjective proposition. There are no clear diagnostic features and formulas for unmarked iron gun tubes for age and nationality. However, some observations and inferences will be offered, because of possible relevance to site 008.

The first and second reinforces are discernible, the chase heavily damaged with cracks and exfoliation. The chase is tapered, and there is no sign of muzzle flare or reinforcing ring. Lack of muzzle flare is problematic, and it may indicate a damaged barrel, one that has seen serious erosion, or possibly a gun that was cut. Guns with damage or casting faults were shortened and put in service as "cutts" (Hohimer 1983:1). It may be that the muzzle flare and astragal were removed along with the encrustation after the cannon was recovered, or they may have been blown off in service.

The trunnions are low and 6 in in diameter, largely the result of cracking and swelling of the iron. Trunnion diameter measurement on the sally-port gun is unreliable, although if the gun were in good shape, it would have been diagnostic. From about 1740 on, trunnions were about one caliber (bore diameter) long and about one caliber in diameter and tapered until 1760, when they became straight (H. Peterson 1969:41).

Overall length (gun length plus breech) is 8 ft; gun length is 7 ft 6 in. Gun-tube length is normally taken from back of the rear reinforce to the muzzle. Distance from the reinforce rear to the cascabel end, is the breech; the two are added for overall length (Roth 1989:193,196). Measured bore diameter is 2.5 in, which indicates a two- or three-pounder (shoots a 2-3-lb ball). However, like the trunnions, the bore diameter measurement is unreliable because of deterioration. "Caliber" has a dual meaning. Currently it means bore diameter in inches; historically a second meaning indicated ratio of bore diameters to bore length. Thus a 4-in bore diameter gun with a bore length of 40 in would be a 10 caliber gun. If the sally-port gun has an assumed bore length of 6.8 ft

(81"), its caliber is 32 for a diameter of 2.5, which is unlikely. The bore length was not measured.

Hogg (1970:266) gives a formula for calculating iron gun weight. Using Hogg's formula, which often gives a heavier than actual weight (Hoyt 1986:36), and assuming a bore length of 6.8 ft for the sally-port gun, a weight of 2,694 pounds results. Guns were measured in long hundredweight (cwt) of 110 pounds. Thus, the sally-port gun is 24 cwt.

Trunnions are positioned low, at the barrel bottom below the bore of the sally-port gun. There is a common notion that low trunnions indicate an old gun. One commonly held sequence is that from 1476-1520 trunnions were centered, then lowered to the barrel bottom in the early sixteenth century, where they remained until 1760 (actually 1756, Hogg 1970:59) when Muller raised them back to center.

Trunnion placement is often considered diagnostic, but it is not reliable. Hoyt (1986:5-7; 57-59), in one of the few gun studies that include trunnion location, asserts empirical data is currently insufficient to confirm this (or any other) trunnion-location pattern, especially for other nationalities. One of Hoyt's points is that Muller's treatise was theoretical, and there was a delay in adopting changes he advocated. The time of adoption of Muller's changes have not been tied to the material record. In fact, it is not clear if Muller's dictums were universally adopted at all. Harold Peterson (1969:41), states that British guns kept their trunnions low until the nineteenth century (Hohimer 1983:17; Tucker 1989:27). Hoyt notes that both high and low trunnions are documented for reliably dated English cannon between 1776 and 1800 (Hoyt 1986:58).

The bore diameter measurement is clearly not what it was originally. Gun length and caliber are not consistent with a two- or three-pounder. It is more likely that the bore has been diminished by expansion and corrosion products and was originally larger. The 7 ft 6-in length is indicative of at least a six-pounder, which would have had a bore diameter of about 3.6 in, and produces a more reasonable caliber of 22 for the sally-port gun. Nine-pounders were also built with this length, and would have had a bore diameter of 4.2 in, giving a caliber of 19-20.

Some alternative sally-port gun weights were calculated for bore diameters appropriate for a six- or nine-pounder, which are more likely sizes for the sally-port gun. For a 3.6-in (a 6-pounder) diameter bore the weight is 2,598 lbs (23-24 cwt); for a 4.2-in bore, which would indicate a nine-pounder, the weight is 2,531 lbs (23 cwt). The computed weight for a nine-pounder of 9 ft in length is 2,843 (25-26 cwt).

About the only way to proceed is to examine available naval ordnance establishments. The most easily accessible of these is British, although there is nothing identifying this as a British gun. Assuming the gun is British, a reasonable procedure is to determine to which set of ordnance establishments the gun conforms, with the set of variables of bore diameter and weights. This may give some idea of manufacture date. Hohimer (1983) has compiled British naval ordnance establishments, and this work was principally used for the following discussion.

The 1660-1685 ordnances indicate a 2-3-in-bore gun would weigh less than 800 lbs. A 3.5-in bore and 2,590-pound tube weight is characteristic of a culverin, which have lengths between 9-9 1/2 ft (Hohimer 1983:6). This establishment is likely too early for the sally-port gun.

In 1703, establishments indicate an 8-ft cannon was a six-pounder and they varied from 6 ft 7 inches to 8 ft 7 in (Hohimer 1983:7-8). In 1716, they were similar. In 1736, John Armstrong, Surveyor of Ordnance tried to standardize guns by defining certain lengths for the manufacturers. Generally, these were lengths of twenty times bore diameter, although Peterson states Armstrong suggested a length of 23-27 calibers, which was criticized as too long (Peterson 1969: 38,41).

British gun tubes of 1740s were the general proportions for the century. A 7 ft 6-in or 8-ft tube could be a six-pounder (20-21 cwt), or a nine-pounder of 24-26 cwt and 4.2-inch bore (Hohimer 1983:12). In 1753, guns were lighter and shorter: a six-pounder was 7 ft long and 17 cwt and a nine-pounder was 8 ft 5 in of 23 cwt. In 1756, the Muller system proposed shorter guns, about 15 calibers for naval service, but it is not clear when or if this was ever adopted (Hohimer 1983:17). This system would have made both six- and nine-pounders 7 ft long. The 1764 ordnances noted a 7 ft 6 in and an 8-ft six-pounder of 19-22 cwt. By 1780, six and nine-pounders were 6 ft 6 in to 7 ft long (Hohimer 1983:38), although longer barrels for these sizes were being produced until 1800.

The following table (from Hohimer 1983:45-49) gives introduction dates for possible cannon of the sally-port gun dimensions between 1677-1800, anything less than a six-pounder would be shorter than the sally-port gun:

Size	Length	Date	Weight (cwt)	Date	Weight	Date	Weight
9	8'0"	1743	27	1761	26.2	-	-
9	7'6"	1753	24.2	1761	24.2	1800	26.2
6	8'0"	1743	22	1761	22	1800	21.2
6	7'6"	-	-	1761	20.2	1800	20.1

Hogg (1970:276) gives a table for English ordnance for 1828. In the table, he gives specifications for a six-pounder having an overall length of 96.5 in (8 feet) and a weight of 23 cwt, which closely matches the sally-port gun.

Based on the rounded breech of the sally-port gun, it may be early. Early breeches, prior to 1750, were domed (Peterson 1969: 41). It is unknown how reliable this attribute is.

In summary, the current literature is not sufficiently reliable regarding specific attributes to definitively date the sally-port gun. The gun's deteriorated condition has made bore diameter measurements inaccurate and speculative, with even the length questionable, all of which exacerbate the problem of identification. However, one thing can be noted: this tube is similar to ones on the Nine-Cannon Site (FOJE 008, see Chapter XIV).

An iron-stocked anchor (Figures 12.3 and 12.4), now on the right side of the sally-port bridge, is more recognizable and in somewhat better shape than the gun tube. This anchor is also reported to be from FOJE 008, recovered by shrimpers in 1964 or 1965. The anchor is partially encrusted with marine growth, rusty and exfoliating. There is stud-link chain attached to the anchor ring, which is a shackle, with a second shackle.

The stock length is 8 ft; shank length 8 ft 6 in. The rounded arms are 3 ft long, and 5 ft 9 in between palm tips. Palms are 1 3/4 in thick and 1 ft 5 in x 1 ft 3 in.

Based on the following attributes, the anchor is nineteenth century, likely mid-century or later. Iron replaced wood stocks for anchors less than 1,500 lbs. in weight (British

Navy) early in the nineteenth century. Presence of a shackle instead of a circular ring indicates a date after the first quarter nineteenth century. Stud-link chain appeared after 1816 (Harland 1988:198). The rounded arms also indicate a nineteenth century anchor; this one is of the Rodger's or Admiralty pattern, most probably the latter based on palm shape (Cotsell 1856:15-20).

A midnineteenth century formula for estimating anchor weight gives a weight of about 7 cwt (770 lbs) (*Cyclopaedia of Useful Arts* 1854:np.). This formula gives an approximation that is increasingly light for large anchors, but it should be quite accurate for anchors of this size. The same source gives a rule-of-thumb for merchant ships that indicates naval vessels would carry a bower anchor equivalent to about 1 cwt per gun.

The *American Lloyd's Registry* of 1862 requires a best-bower anchor of 900 pounds for a vessel of 100 tons (American Lloyd's 1862:xviii). Vessels over 300 tons were required to carry both stream and kedge anchors. If this anchor is a stream anchor, it could be from a vessel of 300 tons; if a kedge, it could be for a vessel of 1,500-2,000 tons, if the vessel that lost it was following Lloyd's specifications, which set standard practice. This anchor is probably from a vessel of either 300 tons or 1,500-2,000 tons.

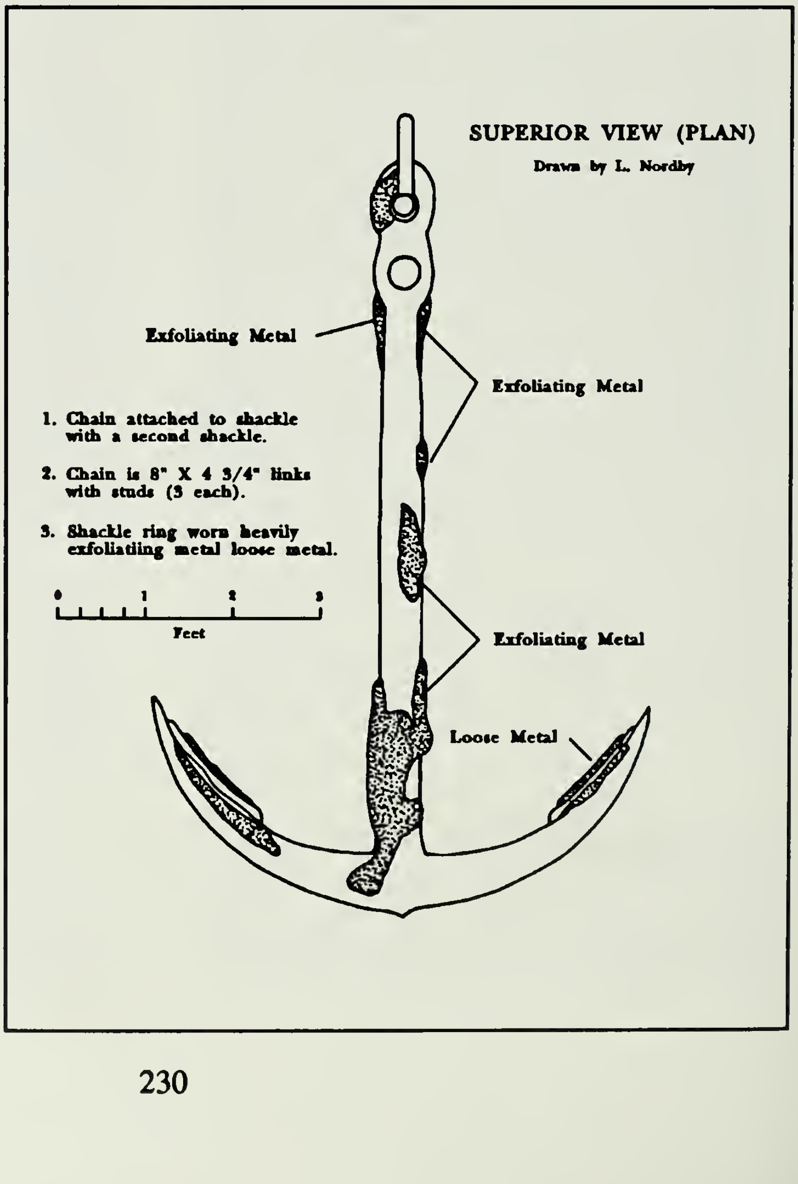


Figure 12.3. Iron-stocked anchor at sally port. Drawing by Larry Nordby and Daniel Lenihan.

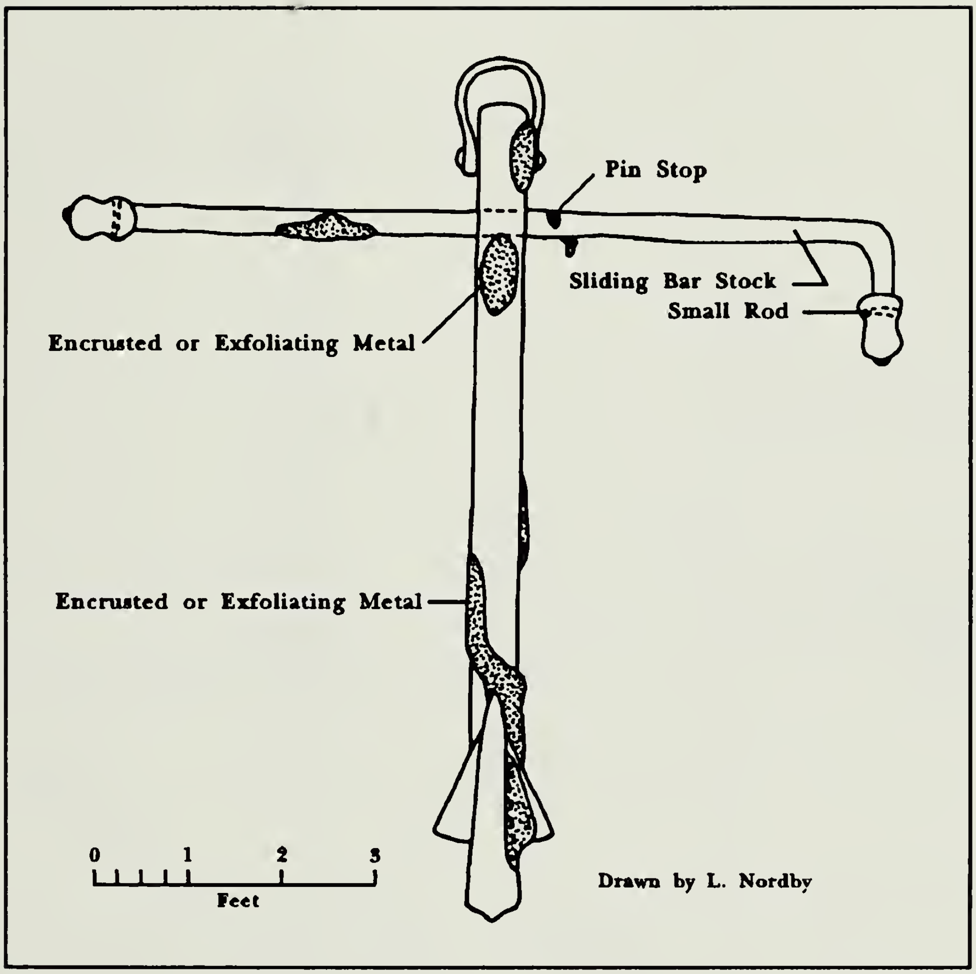


Figure 12.4. Iron-stocked anchor at sally port, side view. Drawing by Larry Nordby and Daniel Lenihan.

There are two other anchors of interest on the north coal docks. Anchor 1 (Figure 12.5 and 12.6) is another iron-stock anchor. This anchor has a 5 ft 7-in shank, with an iron ring instead of shackle. Arms are 2 ft in length, 3 ft 5 in tip-to-tip. Palms are 9 in x 11 in. The estimated weight is 2.5 cwt (275 lbs.). According to the 1862 Lloyd's Registry, an anchor this size is only appropriate as a kedge for a vessel of 200-300 tons.

Coal dock anchor number 2 is similar, but smaller than anchor 1. The shank is 4 ft 6 in; there is no stock. The palms are 7 in x 9 in; 3 ft 7 in tip-to-tip. Estimated weight is about 1 cwt (110 pounds), which would be about the correct size for a kedge anchor for a 100-ton vessel (American Lloyd's 1862:xviii).

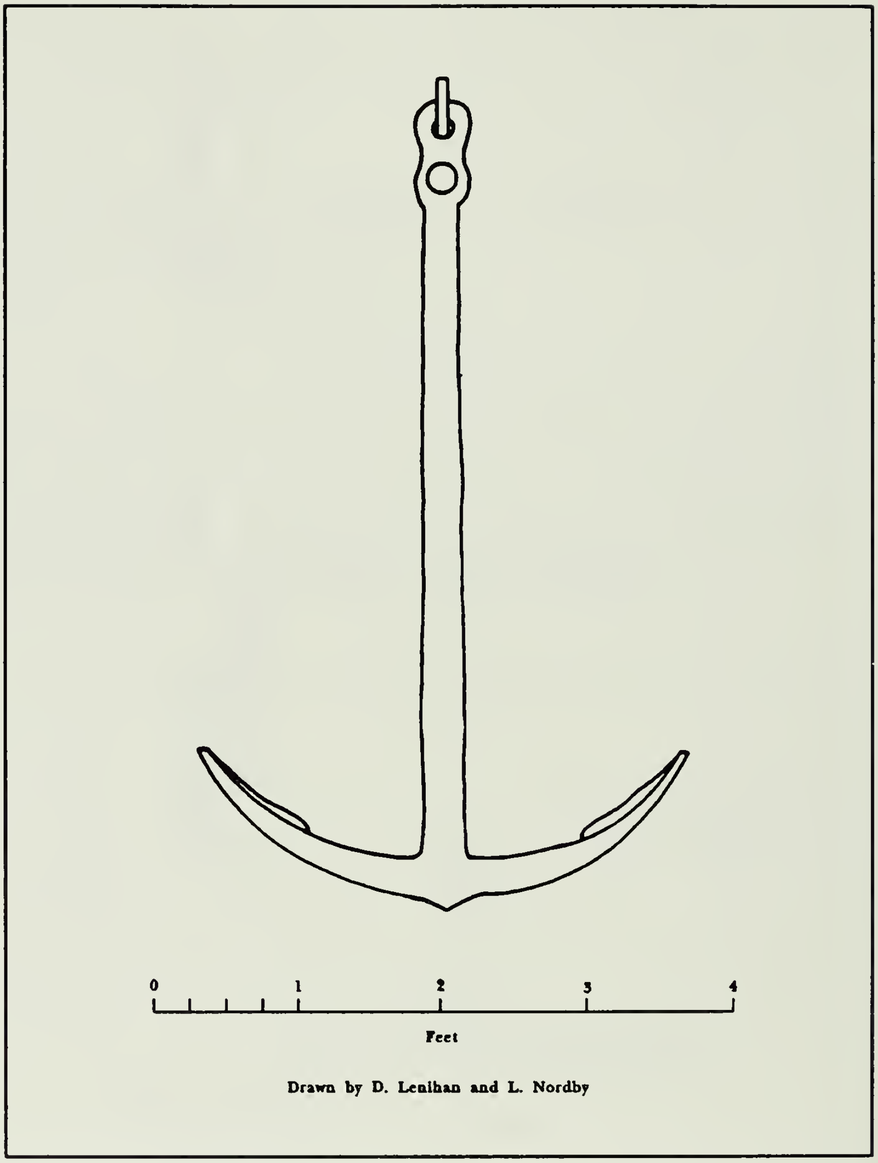


Figure 12.5. Anchor 1, north coaling docks. Drawing by Larry Nordby and Daniel Lenihan.

Perimeter Surveys - 1989

A brief Garden Key perimeter survey was conducted by Gould, Stoll and Murphy on July 2. The objective was to note density and type of visible material, and determine its relation to Fort Jefferson, if possible. The intent was to develop a methodology for systematic survey of Tortugas island perimeters.

Reconnaissance survey was conducted with DPVs and scuba to a depth of 25 ft along the west channel edge from the main dock past the north coal docks (Stoll 1989). This area was chosen because historical documentation (Bearss 1983; Chapter VIII) indicated use of this area with some historical structures in the vicinity, particularly privies, that might produce heavy trash disposal. Few artifacts were observed; the bottom is

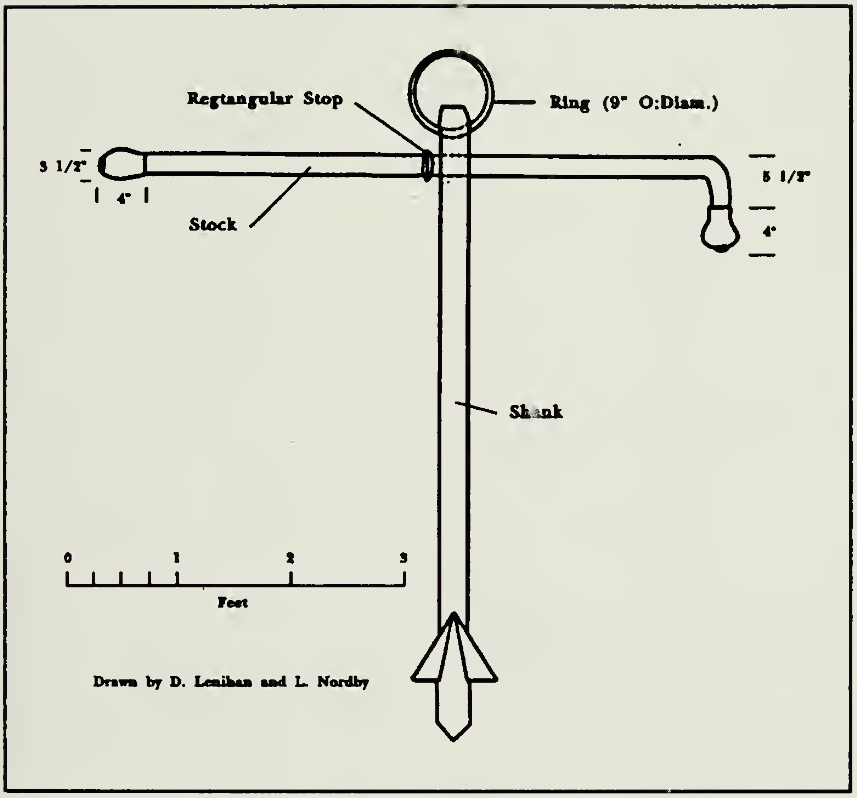


Figure 12.6. Anchor 1, north coaling docks, side view. Drawing by Larry Nordby and Daniel Lenihan.

composed of fine calcitic mud that would bury most material. Still, systematic visual survey might prove productive, and this was included in planning for the 1990 field operations.

1990 Perimeter Survey

The amount of activity that has taken place since the 1840s gives the area surrounding Garden Key a very high potential for historical material associated with fort construction and later activities. One objective for the 1990 fieldwork was to begin a systematic visual survey of Garden Key's perimeter. Two results were expected: an assessment of archeological potential and development of a reasonable methodology for conducting a systematic perimeter surveys of all the islands. In addition, the ongoing Garden Key perimeter survey provided a back-up site for divers when offshore sites could not be dived because of poor conditions.

Methodology. A three-sided rectangular border made of parachute cord formed the survey block. The block was placed so the two sides were perpendicular to shore with each end placed at the water's edge. The connecting line offshore was kept parallel to the shoreline. The ends and corners of the block were weighted. The block was 28 m square, with lanes marked every 4 m on the offshore line. Onshore, a tape measure was laid between block ends.

The procedure was to place the weighted end of a second tape measure on the first mark on the offshore line from the left (facing shore), perpendicular to the block boundary line. A diver swam down each side surveying one side of the line starting from shore. Upon reaching the tape end, a pull signal was given to the shore-based recorder

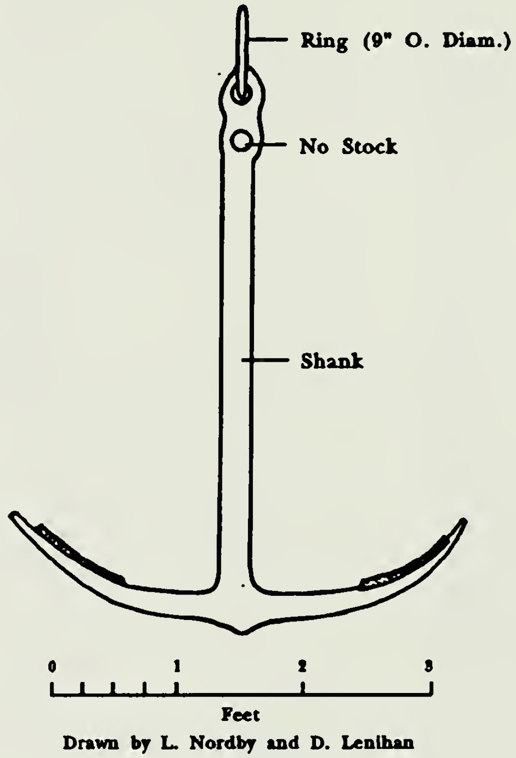


Figure 12.7. Anchor 2, north coaling docks. The anchor is an iron-stocked type, but the stock is missing. Drawing by Larry Nordby and Daniel Lenihan.

to move the tape to the 8 m mark while the diver moved the tape end to the next mark on the offshore block line. When the block coverage was complete, the block lines were flipped, left to right, the right end of the block becoming the left end of the adjoining block.

Divers within the survey block kept notes on mylars that were marked with the block number and transect lane numbers. Any materials were positioned by lane number, distance from offshore grid line and estimated distance (maximum of 2 m) left or right of the transect lane. Visibility was sufficient to ensure complete coverage and accurate line placement. The first three blocks produced little associated with Fort Jefferson. Some pieces of an airplane were located, the remaining material was recent except for some bricks. Results of the perimeter survey blocks to the north coal docks is below. Metal detector survey is recommended for future surveys.

Loggerhead Key

A brief walking survey was conducted by Ranger Joe Hayes, R.A. Gould, L. Stoll and L. Murphy July 3, 1989.

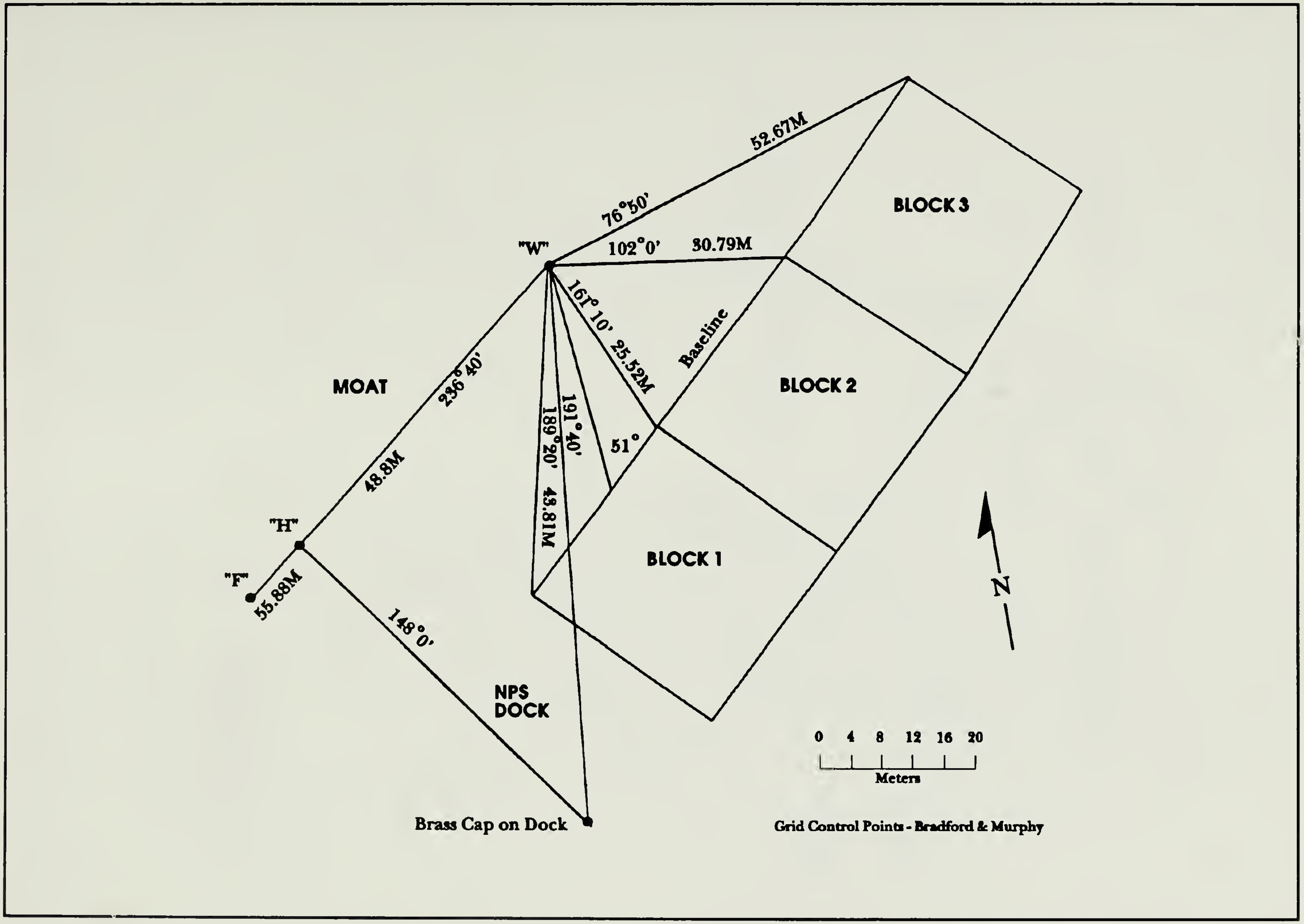


Figure 12.8. Grid control points. Drawing by Jim Bradford.

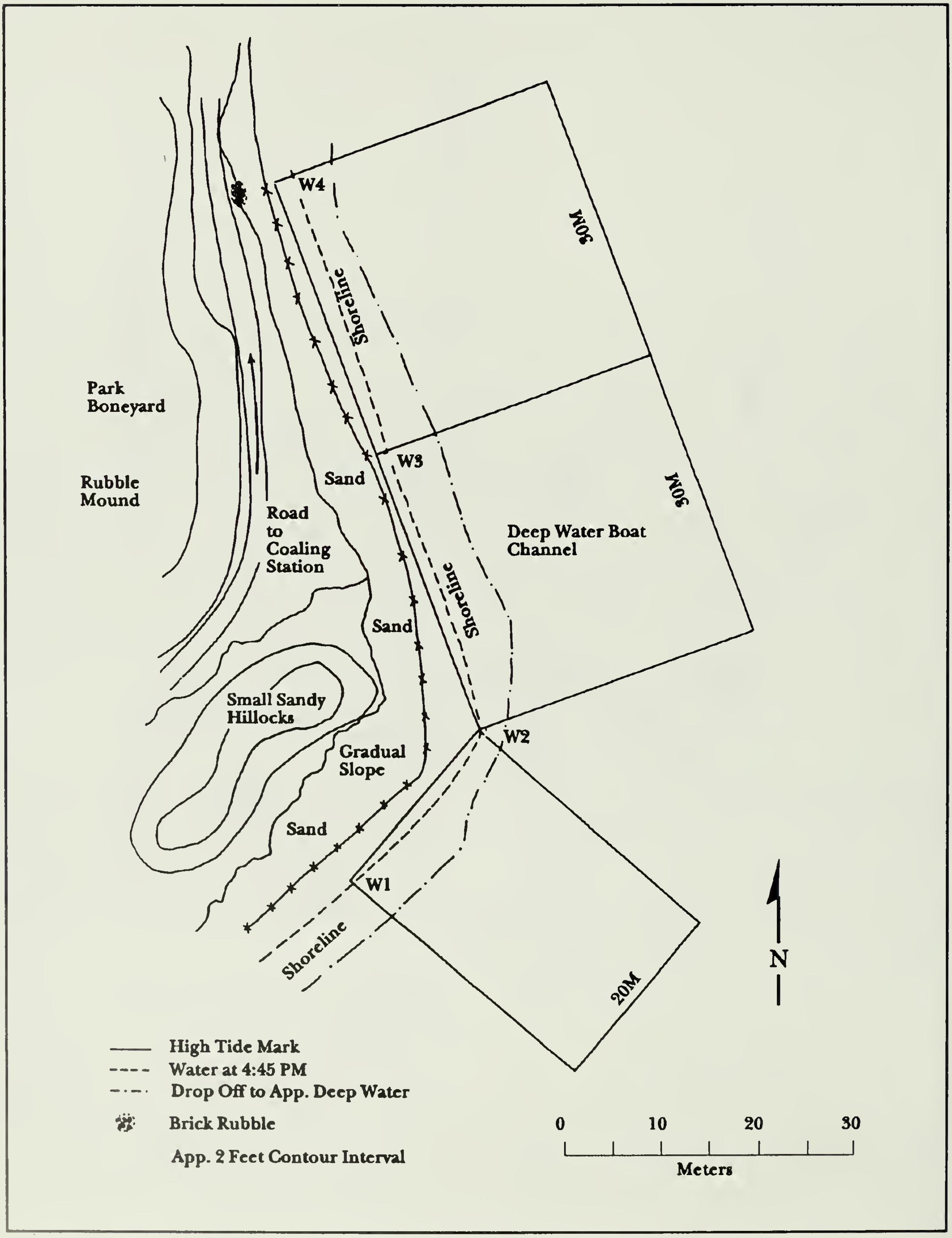


Figure 12.9. Perimeter survey area blocks. Drawing by Scott Travis.

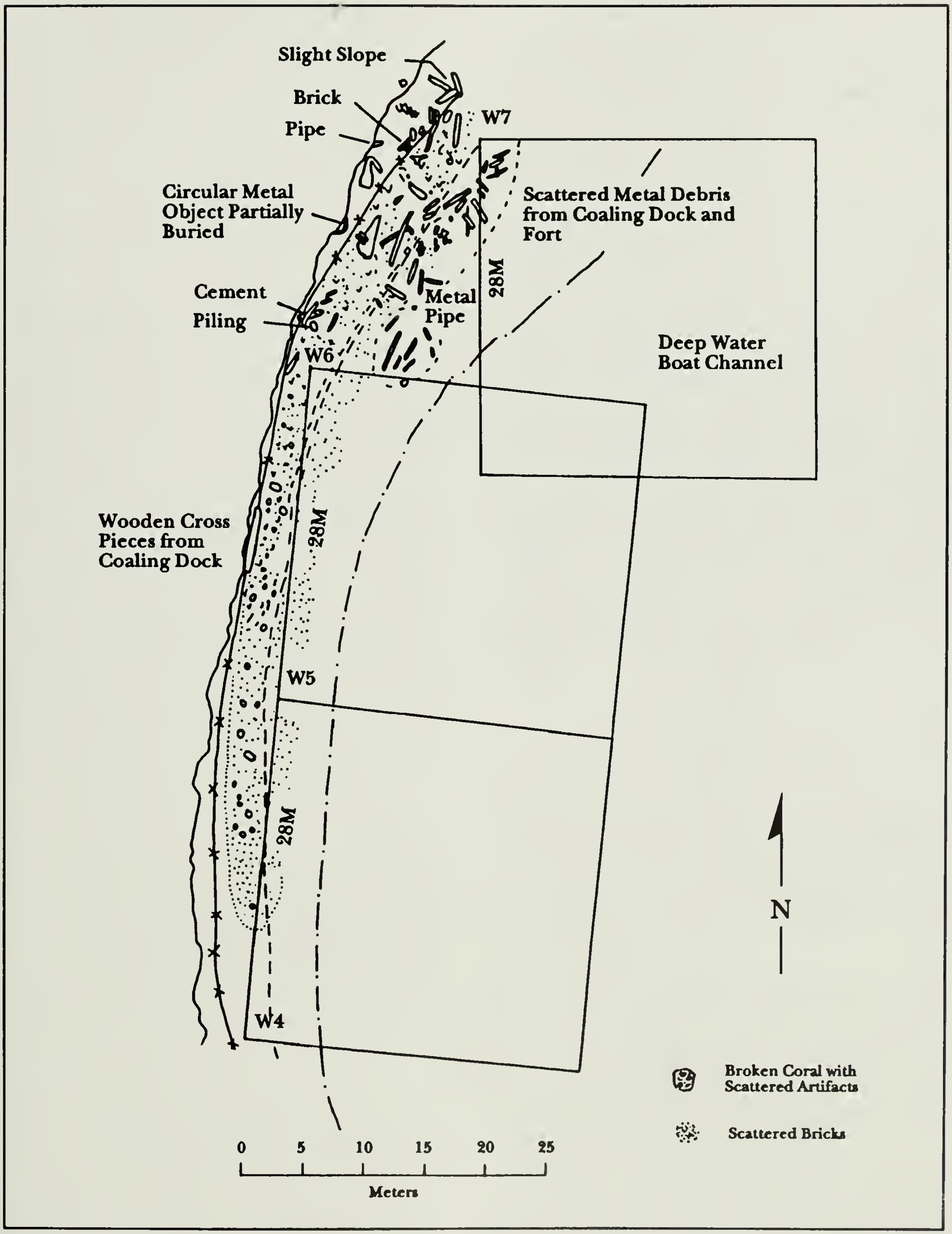


Figure 12.10. Grid area blocks, two north coaling docks. Drawing by Scott Travis.

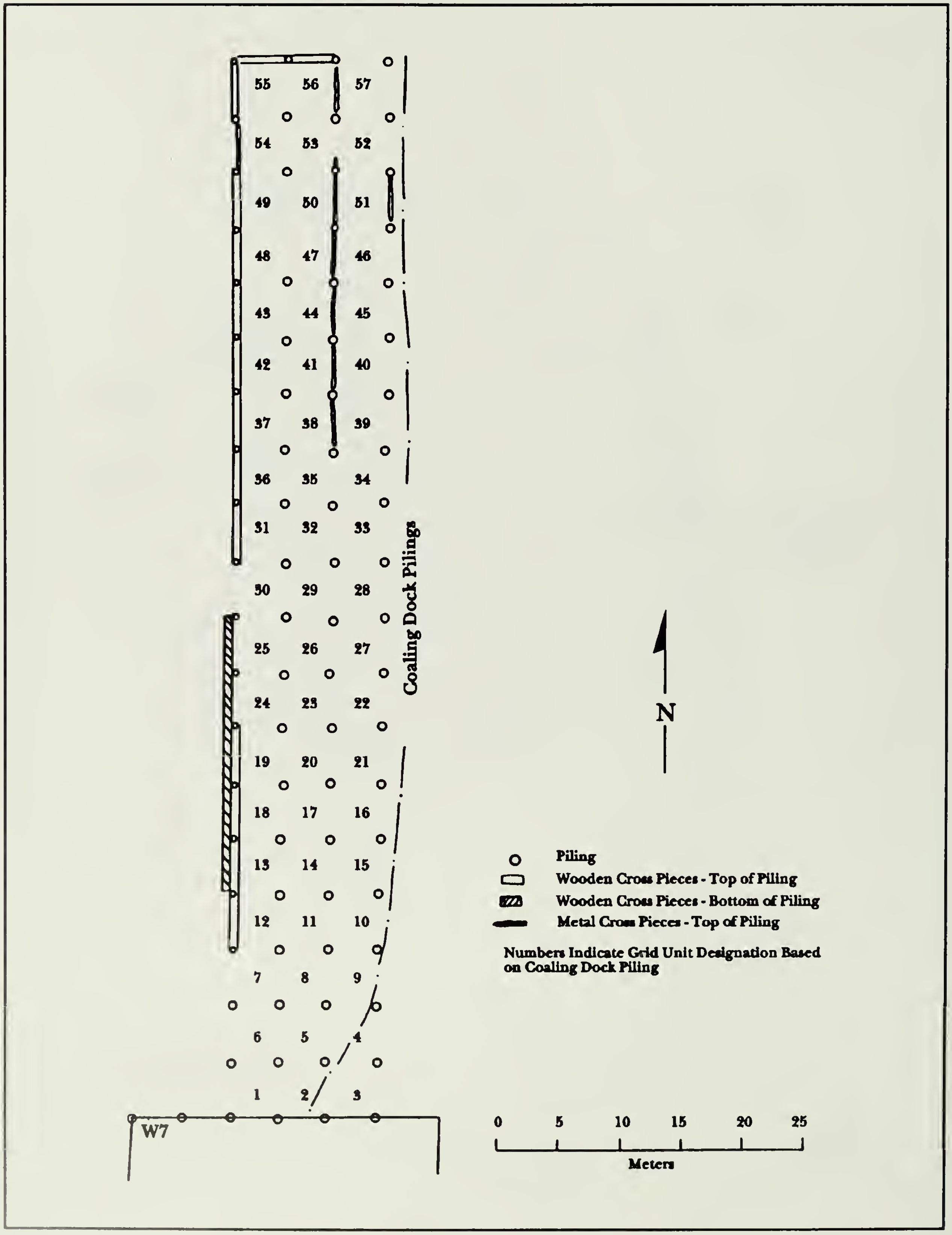


Figure 12.11. North coaling docks survey area. Drawing by Scott Travis.

Principal sites on Loggerhead Key are the Coast Guard lighthouse, outbuildings and related features and remains of the Carnegie Institution research station. In addition, there is an antenna on the island's south end that apparently is a government listening post.

The dominant features on the island's north end are related to the Carnegie Institution, which had a marine research station on the island from 1904 to about 1944. This station was one of the premier marine research facilities in the US in the first half of this century. Numerous buildings and other features were built during the station's operation (Mayer 1910; see Chapter IV). The institution had a small fleet (Mayer 1910:401), including an engine-powered craft. The institution made many notable contributions to marine biology, oceanography and geology, including producing the world's first underwater color photographs (Langley 1927:56). Building foundations, probable cistern or holding tanks and scattered debris, including remnants of laboratory materials and glass were observed in 1989. This area should be surveyed and recorded in detail. Sites associated with the Carnegie Institution are likely National Register eligible.

North of the Coast Guard station are some other features apparently not related to the Carnegie station, including a mound, dry-laid stone wall and grave. The single, isolated grave says: "Thomas Lehay Mass, Ord. Seaman US Navy, March 5, 1898" Bearss (1983:389) reports a seaman died of yellow fever while occupying the Bird Key hospital in 1898. Presence of the Spanish-American War period grave is of interest because normal military practice would probably have been to return the body to Key West for burial. This seaman may have been buried on Loggerhead and not transported to the military cemetery because he was a yellow-fever victim, and there was widespread fear of an epidemic.

The island should be completely surveyed. Terrestrial magnetometry would be appropriate for location of historical features; however, concentration of thick vegetation, especially sisal and prickly pear, would make it difficult (Murphy 1989a).

There is a natural geological feature on Loggerhead Key that might be important for interpretive purposes. The most extensive beachrock in south Florida is found on Loggerhead Key, particularly the intertidal region on the northwest side, where it exceeds eight feet in thickness (Ginsburg 1953:85-91). Beachrock thickness is result of long-term eustatic sea level changes. The principal mineral in this beachrock, which can be exposed for twenty feet offshore at low tide, is aragonite (Multer 1971:25). Interpretation of this feature would give visitors an understanding of Dry Tortugas island and reef formation and change relative to ongoing climatic variables, which include global warming and sea level rise.

Hospital Key

A terrestrial survey was done July 2, 1989. Nothing notable was observed. A perimeter survey was also conducted by Gould, Stoll and Murphy. Survey objectives were to conduct a general reconnaissance to note relevant site formation processes and locate cultural features on land and in the water.

Hospital Key, previously known as Sand Key, was the principal sand source for fort construction (Bearss 1983:42). The island had a ten-patient hospital from 1862-67 (Manucy 1938; 1943b:99; Bearss 1983:291). Graves of yellow fever victims may also have been on Sand Key (Manucy 1943:325).

Another survey objective was to resolve a historical question, if possible. Bearss (1983:224) states that in mid-April 1861 the fort engineer was directed to build sea-coast

Plates 12.18 and 12.19. Two masonary block types located offshore Hospital Key, 1989. Top--Linda Stoll examines an L-shaped block. Bottom--Richard Gould examines more numerous rectangular masonary blocks. NPS photos by Larry Murphy.

Plate 12.20. A large iron box located in 1989, about a meter below the seabed in a gully on the northeast corner of Hospital Key. NPS photo by Larry Murphy.

including Sand Key and Bird Key. Bearss states: "a drawing of the sand battery being built ... on Bird Key [was sent]. A lunette-shaped work, its principal face was nearly parallel to the northeast front of Fort Jefferson" (Bearss 1983:224 from May 25, 1861 letter Morton to Totten). Bird Key was the principal earthen fortification; the problem is that it faces the southwest or west face. The northeast face of the fort looks directly at Hospital Key. The question is whether any temporary fortifications were built on Sand (Hospital) Key. Resolution of this question depends on future survey on and around Hospital Key.

The Hospital Key perimeter survey was productive. This key, which can serve as a representative model of Dry Tortugas mobile keys, has a zone lacking coral growth immediately offshore the island's perimeter. There were some algae and other soft growth in the clear zone, but not corals. At the clear zone's edge, normal reef growth occurred. Interpretation of this observation is that the clear zone represents the area within which the island sand moves. The seasonal island movement has been discussed in Chapter II. Apparently, seasonal (and long-term) sand movement is sufficient to maintain an area free of coral bordering the key. Periodic burial kills coral growth in the clear zone. This clear zone is a biological signature of sand-key dynamics and reflects a formation process that would affect any cultural materials on the island.

The survey team circled the key west to south using DPVs. Principal features were photographed. Off the east end of the island a concentration of ferrous material, including railroad iron was located and designated a site (FOJE 034) discussed above. North of 034, five blocks of mortared brick were found (Plate 12.18 and 12.19). Two types were noted, an "L" shaped block and rectangular blocks. These may be foundation blocks from the structure that gave the key its name. These blocks are the appropriate size for a small frame structure and were probably foundations for the 1862-1867 hospital building. No features attributable to other structures, such as fortifications, were located.

The last feature of interest was located on the northeast corner of the key, where a gully had formed. The island was actively moving and covering up a large iron box, which was just visible about a meter below the sea bottom in the gully side (Plate 12.20). Identity and function of the box are unknown. There were also masonry blocks located in this gully.

OTHER SITES

In July 1989, Lucy Doyle and Pat Givens located a large, set anchor that had been seen by Givens nearly ten years earlier. When Givens first discovered it, the anchor had a large chain attached that was laid out straight along the bottom. If this is the same anchor that was seen by Givens earlier, the chain is now buried.

This anchor is in 15 ft of water, embedded in sand and turtle grass, with one fluke pointing straight up and the shank buried. It is a large anchor; the accessible arm is 52 in from the shank center to the palm end. The fluke is 32 in long by 20 in across the base. Doyle and Givens describe it as "very close [in appearance] to the anchor that sits at the entry way to the fort" (L. Doyle 1989). The anchor location is vague: "it is amazing to us that a ship this size was in the area (obviously accidentally), because it is very shallow (4-8 ft) around it ... It is in the reef area north of Hospital Key near the boundary of the Park."

East Key

A ground survey July 3, 1989 produced no cultural material other than modern trash, which was collected for disposal. A perimeter survey with snorkel and DPVs was conducted. The key's perimeter contained much sand and eel grass, little cultural material was observed. A rudder with zincs attached, probably from a modern shrimp trawler, was located, and an isolated pipe and a few pieces of coal were noted. Biological observations: 110 turtle nests were counted on the island and six lobster carapaces were found in a pile offshore during the snorkel survey. The lobsters had been illegally taken.

Middle Key

This key was awash during survey operations July 3, 1989. A perimeter snorkel survey was conducted with negative results. There is much sand cover and eel grass in the vicinity offshore, with reefs to the southwest.

Bird Key

The key was awash in 1989, and no walking survey was done. A brief perimeter survey was conducted by Gould and Stoll July 4, 1989. Most cultural material found seemed associated with the Bird Key Harbor Brick Wreck (029). Wreck scatter was observed more than 200 ft north of the main site.

Bird Key, like Hospital Key, had structures built during Fort Jefferson's occupation. A frame hospital was built in 1861 (Bearss 1983:225). Apparently an earthwork was built (Bearss 1983:224) and soldiers buried on this key in the 1860s (Bearss 1983:258; O'D 1869:284). A 30 ft x 34 ft hospital, an 8 ft x 16 ft kitchen and a 6 ft x 10 ft outhouse were begun in 1896, and completed in 1897 with the construction of a boardwalk and landing. Nine wounded seamen who survived MAINE's destruction in Havana harbor were treated on Bird Key (Bearss 1983:387-389). No trace of features related to these structures or graves was located. An indication of what might be a foundation and landing structure was observed from a Navy helicopter used for aerials during the Project SeaMark documentation of 003 in 1988 (Plate 12.21). Additional survey is needed, with the addition of high-resolution remote sensing on land and underwater.

Long Key

No surface survey was conducted; the island was closed because of nesting terns. A brief offshore survey of the southeast side was conducted July 4, 1989, with DPVs. The reef appeared healthy and vigorous. The area was very rocky with a long, shallow reef that drops to the 80-ft channel. The area would be a good possibility for wrecks of vessels entering the channel from the southwest. No cultural materials were observed. Biological observation: Some twisted lobster carapaces were noted from illegal lobstering activity.

Bush Key

No survey was conducted of Bush Key because of nesting terns. No offshore survey, other than along the channel, was conducted. Nothing was located.

Plate 12.21. Aerial taken during reconnaissance of Bird Key aboard a USN helicopter, 1988. The dark form to the left is the Bird Key Harbor Brick Wreck 029. Three other features are visible in very shallow water. The uppermost is a small linear feature (arrow), another feature is visible below it to the right. In the upper right corner is a larger square feature, perhaps a foundation. [The width of the main 029 scatter is about 16 feet.] USN photo by William Krumpleman II.

CHAPTER XIII

Windjammer Site (FOJE 003)

Larry E. Murphy

LOCATION

The Windjammer Site (FOJE 003) is located on Loggerhead Reef, south of Loggerhead Key, about 1,100 yd southwest of the island's southern end. The wreck's position is marked by an exposed-wreck symbol on 1986 NOAA Chart 11438.

Past Work

The site was recorded May 23, 1971, during survey fieldwork (see Chapter X). The original recorder indicated it was a "wreck of [an] old iron steamer, reportedly Dutch." Wreckage was exposed above the water in about 15-20 ft depth, and was reported breaking up (Florida Underwater Archeological Research Section Site Record Card 1971). This site has been known by various names, including "Steel Wreck," "Dutch Wreck" and "French Wreck." It is currently listed on the Southeast Archeological Center Site Report form as "Steel Wreck." No further fieldwork by archeologists is recorded for this site until 1985.

However, the site was used for biological research because of its dense fish population. In 1975 and 1976, ichthyological research compared "species/time random count technique" fish observations on 003 for two years as part of the Tortugas Reef Atoll Continuing Transect Studies (TRACTS), which was a joint program between National Park Service (NPS) and Harbor Branch Foundation, Inc. (Thompson and Schmidt 1977). This site was described then as:

> a steamer which grounded in the 1920s. Wreckage is spread over several hundred square meters. Depth at French Wreck is a uniform 6.7 meters ... the wreck lies in a broad, flat, in-shore area of uniform depth, with no areas of high profile coral growth near by. Its fish fauna is highly visible and concentrated in a relatively small area [Thompson and Schmidt 1977:284, 287].

These researchers recorded 134 different species on 003 in 1975 and 137 in 1976.

Fish observation research was also reported in an article comparing reef fish populations between four Tortugas sites, including 003, and four John Pennekamp State Park populations. Tortugas sites showed less diversity than the Pennekamp sites, with the 003 population similar to that of surrounding reefs (Jones and Thompson 1978).

1985 Fieldwork

This site was dived during a natural and cultural resources video documentation project by NPS Submerged Cultural Resources Unit (SCRU) members (see Chapter XI). The resulting project trip report included Lenihan and Murphy's site observations:

> The remains are of a metal-hulled sailing vessel with an estimated length of around 275-300 feet and an estimated beam of 35 feet. Indications such as the depth of floor frames,

Plate 13.1. Example of fish populations on FOJE 003, 1990. NPS photo by Larry Murphy.

thickness of metal and construction techniques point to an iron rather than a steel hull ... All observed rigging was for square sails, which may indicate the vessel was ship rigged instead of bark (definitely not barkentine) rigged ... The vessel is an iron-hulled, ship-rigged cargo vessel, perhaps British built. A guess on the date of construction would be the period 1880-1884 ... around 1800 or 1900 tons ... If it [the wreck] occurred before 1915, it was probably in the Caribbean trade rather than the California trade [Lenihan 1985:3-5].

Lenihan's trip report also recommended that 003 be utilized as a "first contact point for visiting sport divers:"

The idea would be to provide a positive, educational visitor experience on a site that had a reasonably high carrying capacity. In the context of this open-handed approach, a conservation message and a firm warning about removing artifacts from any historic site in a national park could be easily inserted. The site designated by Fischer as FOJE UW 003 ... would be ideal for these purposes ... It is close to the fort, easy to find ... and relatively safe to dive ... The site is an attractive one, located in a beautiful environmental context, and is also a fascinating study in marine architecture and wreck-formation processes. The configuration of the wreck would lend itself to a low-key interpretive trail that could be oriented to a plasticized underwater map ... Installation of a mooring buoy ... would minimize anchor damage to the wreck structure or associated coral... The information gleaned from a state-of-the-art mapping operation on the site could be adapted to such interpretive purposes with very little additional effort [Lenihan 1985: 8-9].

1988 Fieldwork

This project, basically a follow-up to Lenihan's 1985 recommendation, took place between March 12 and 29. This was a Project SeaMark cooperative venture with US Navy Mobile Diving and Salvage Unit (MDSU) 2, Detachment 506; NPS archeologist Larry Nordby was field director. NPS Maritime Historian James Delgado also participated and made notes on wreck features (Delgado 1988).

One important accomplishment of the 1988 fieldwork was an inventory of principal coral colonies growing on the wreck. The inventory was conducted by Richard Curry, resource specialist, Biscayne National Park. This inventory provides a base line for future work and was utilized by a coral researcher in 1990 (Mazel 1990).

1989 Fieldwork

This project was a short reconnaissance survey conducted by Larry Murphy and Richard Gould of Brown University. Dives were conducted to check particular features recorded in 1988.

Plate 13.2. Aerial view during joint US Navy MDSU and NPS SCRU operations on 003. NPS vessel ACTIVA is to the right, USN vessel left. View is to the west. USN photo by William Krumpelman II.

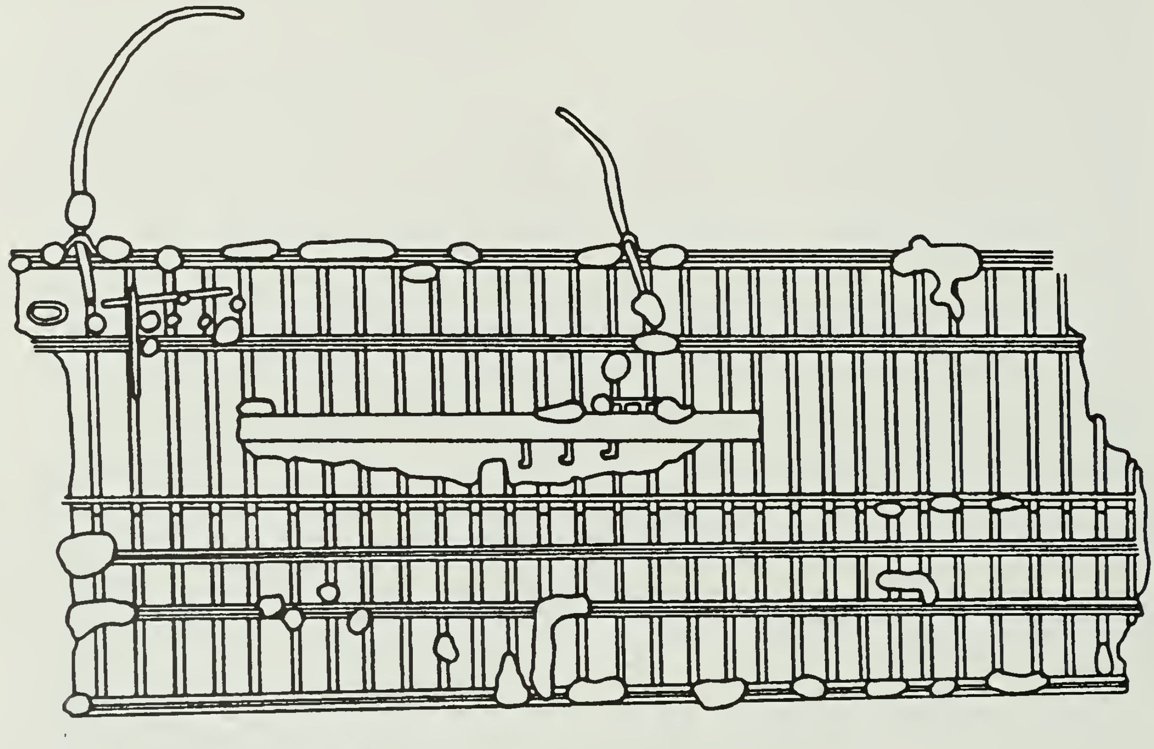


Figure 13.1. Coral colonies growing on 003. Example from Richard Curry biological inventory. Structure is Feature 3 area. Drawing by Richard Curry and Larry Nordby.

1990 Fieldwork

The visitor interpretation map suggested by Lenihan in 1985 was produced and provided to visitors in May 1990 (see Chapter XI). Detailed information on midships hull, bow and stern structure and rigging details was collected by NPS personnel and Maritime Archaeological and Historical Society (MAHS) volunteers. Drawings of specific features, including a hull cross-section, were produced and are presented below.

Vessel History

The vessel's identity was unknown to the NPS until January 1990 when the MAHS, under contract to SCRU for historical research, identified this site. Steve Skolochenko, MAHS member working on Fort Jefferson NM historical research, located information indicating 003 was the Norwegian ship AVANTI, sunk January 22, 1907, on Loggerhead Reef en route to Montevideo from Pensacola with a lumber cargo. AVANTI was built as KILLEAN in 1875, then sold to the French in 1893 who renamed it ANTONIN. The ship was later sold to a Norwegian firm and renamed AVANTI in 1901.

Steve Haller, Curator of Historic Documents, San Francisco Maritime National Historical Park, researched Lloyd's Register of British and Foreign Shipping. The following details are from three Lloyd's lists (1876-77; 1894-95; 1902-03).

AVANTI was built as KILLEAN by John Reid and Company, Port Glasgow, for Mackinnon, Frew and Co. of Liverpool in 1875. The iron-hulled, ship-rigged vessel's first survey in Clyde, Scotland February 2, 1875 gave the following registered dimensions: length 261.4 ft, beam 39.3 ft, depth 23.8 ft, for a net tonnage of 1768, gross tonnage of 1862 and under-deck tonnage of 1676. The two-decked ship had a forecastle deck 42 ft 9 in long and a poop deck 43 ft long. The hull contained one bulkhead and 75 tons of permanent cement ballast. The ship was rated 100A1, with the broad A indicating iron construction.

The Lloyd's rating indicates a first-rate ship. Early in the eighteenth century, Lloyd's of London established classification standards to evaluate vessels for insurance purposes. Lloyd's classified its first iron vessel in 1838; in 1844, iron vessels were given letter designations. In 1854, a table of rules and scantlings was generated that specified grades of 6, 9 and 12 years. Later, the ratings 80A, 90A and 100A were used corresponding to the grades.

Hull dimensions of KILLEAN give a length-to-beam ratio of 1:6.65; a length-to-depth ratio of 1:11 and a beam-to-depth ratio of 1:1.65. The 1875 American Lloyd's (p. xxxi) for iron vessels gives a suggested line of immersion or load draft for a hull of KILLEAN's dimensions of 6 ft 11 1/2 in of freeboard, which would give a hull draft of about 17 1/2 ft (5.3 m).

No plans exist for this vessel. An inquiry about hull plans for KILLEAN was made to a maritime researcher in Glasgow, Scotland by Richard Gould (Thomas 1990). Apparently, most Reid ship drawings vanished many years ago. Inquiries to the National Maritime Museum, Greenwich, England were also negative.

KILLEAN was sold to the French company A.D. Bordes & Fils, renamed ANTONIN and resurveyed at Dunkirk, France in 1894. Dimensions were the same, with 1,761 gross tonnage. The vessel was again top-rated at 100A1, with the addition of the cross indicating it was built under supervision of a Surveyor to the Association.

The final vessel survey was conducted in Christiania in 1902 when ANTONIN was bought by the Norwegian firm Acties Avanti (C. Zernichow & O. Gotaas) and renamed AVANTI. The dimensions were the same, but with gross tonnage of 1,818 tons. AVANTI again was rated 100A1.

The firm Antoine-Dominique Bordes et Fils, who owned this ship for about seven years, was one of the largest and best known companies employing sailing vessels world wide. Between 1890 and 1914, when ANTONIN was owned by Bordes, the nitrate trade was one of the most profitable in the world (Allen 1978:71), and Bordes was one of the principal companies that supplied more than 500,000 tons of nitrate fertilizer annually to European farmers. In 1900 this company owned about 40 large vessels, mostly employed in the Chilean nitrate trade. Although no supporting documentation exists at present, ANTONIN was probably employed in the nitrate trade when owned by the A.D. Bordes company.

A.D. Bordes' ships were well known and respected as fast ships, well-fitted and beautiful. Each carried the distinctive Bordes color scheme of light gray hulls, white masts and black-and-white trompe l'oeil gunports, which made them look like men-of-war (Allen 1978:82). In 1882, Antonin, Antoine's son, joined the firm. In 1893, KILLEAN was purchased and named for him. ANTONIN sailed for Bordes until 1902 when it was replaced by a larger, more economical vessel, also named ANTONIN. The new ANTONIN, more than 1,000 tons larger than the older vessel, was a steel four-masted bark of 3,071 gross tons, built by the French builder Chantiers de France of Dunkirk. The first ANTONIN was a victim of the rapid growth in sailing vessels. At 1,800 gross tons, KILLEAN was a very large ship in the middle 1870s, but by 1900, few vessels of this type were built smaller than 2,000 tons (Lubbock 1929:VI:119), many like the new ANTONIN were 3,000 tons. The larger vessels took advantages of economies of scale in a stiffly competitive bulk-trade transportation business.

Currently, little is known of Acties. Avanti, the Norwegian company that last owned this vessel as AVANTI. This may have been a small company owned by the partners Zernichow and Gotaas. Apparently the aging vessel was used as a tramp carrier seeking cargoes wherever available, and Pensacola was a good place for lumber cargo at this time.

The Florida lumber industry had great demand for transport vessels. In the last quarter of the nineteenth century, Florida lumber exports increased five-fold. Key attributes of this expansion included an influx of foreign, especially British, investment and redirection of lumber exports to Europe and Latin America. Lumber accounted for 85 percent of total shipments from Pensacola in the 1880s (Thurston 1972:212-214). Harbor improvements, especially the dredging of a 30-ft deep channel, led to continued growth of Pensacola and a quadrupling of exports between 1895 and 1900, which made Pensacola the leading Florida port and the third largest Gulf port behind New Orleans and Mobile (Thurston 1972:216).

AVANTI was damaged and stranded east of the P.A.&T Railroad Wharf in Pensacola during the October 28, 1906, hurricane (Pensacola Journal 10/28/1906). The vessel casualty list from this hurricane indicates Pensacola's trade at the time. Of at least a dozen vessels damaged in this hurricane, only one was US registered. The others reflect a trade dominated by European companies: five Norwegian vessels, one each British, Portuguese, Swedish and German and two Italian vessels were damaged (Tesar 1973:162-168). It is unknown whether damage from this storm contributed to AVANTI's loss three months later in the Dry Tortugas.

Nothing is known about the Dry Tortugas wreck event. The Loggerhead Lighthouse logs, which would be an important primary source, have not been located.

Historical Context

The iron-hulled KILLEAN/ANTONIN/AVANTI represents an important step in sailing ship evolution. During the nineteenth century, three-masted sailing ships of wood, hemp and manila, around 100 ft long, evolved into steel vessels more than 300 ft long with four and five steel masts with wire rigging. Few clippers of 1849 were larger than 500 tons, but rapid expansion of international competition, pressed by repeal of the British Navigation Acts and the discovery of California gold, created demand for larger, faster ships. Ship size soon doubled and trebled.

Experiments with iron construction began early. GOLAITH, an 1836 77-ton ketch, was the first iron vessel registered by *Lloyd's Register*. The first iron-hulled, full-rigged ship was IRONSIDES, built 1838 in Liverpool (MacGregor 1984:148).

Early vessels demonstrated iron hull viability. Iron turned out to be a desirable hull construction material for commercial vessels, and it was rapidly employed, particularly in Great Britain; advantages of iron hulls were being touted by the 1850s.

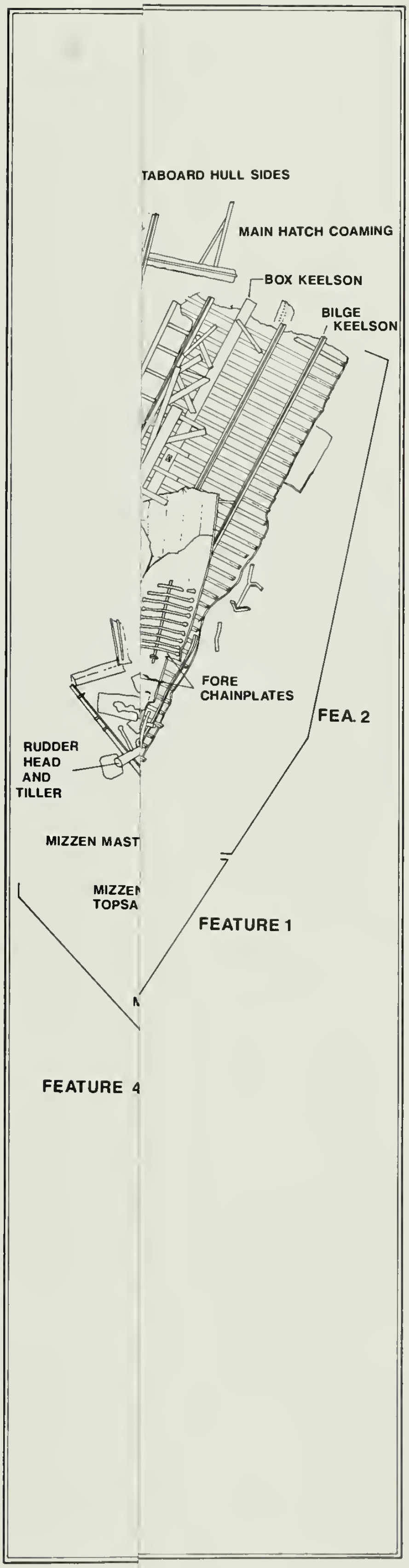

TABOARD HULL SIDES
MAIN HATCH COAMING
BOX KEELSON
BILGE KEELSON
FORE CHAINPLATES
FEA. 2
RUDDER HEAD AND TILLER
MIZZEN MAST
FEATURE 1
FEATURE 4

Figure 13.

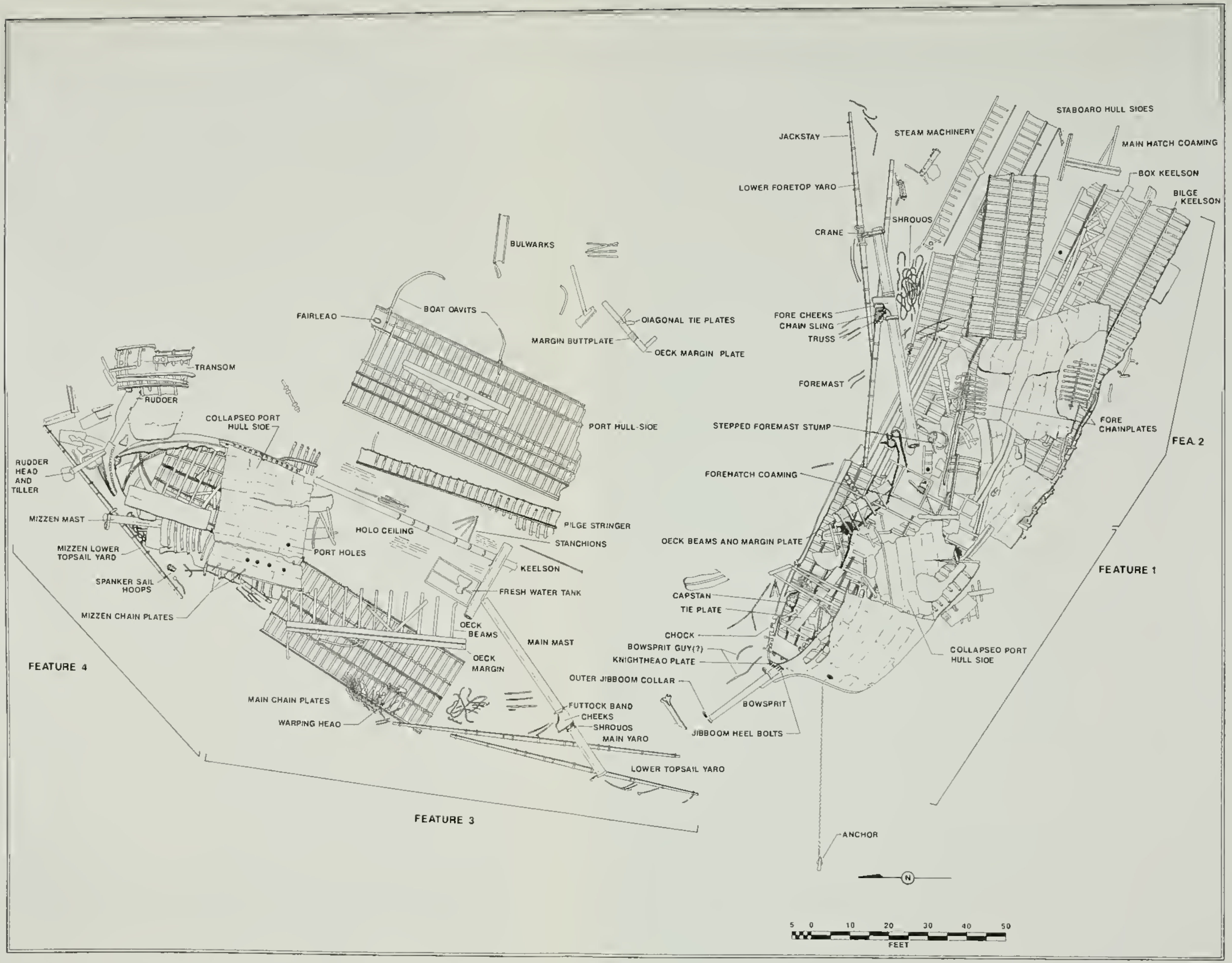


Figure 13.2. FOJE 003 site map. Drawn by Larry Nordby.

Iron hulls could be built cheaper, had greater capacity than a wooden vessel of the same dimensions, were more durable and had less upkeep (MacGregor 1988:130-131). Early experiments showed riveted iron-hull construction stronger than the best oak hulls (e.g., Fairbain 1865:91). For a ship of 1,000 tons, an iron ship, because of its thinner frames and sides, carried 7.5 percent more cargo than an oak hull and 21.46 percent more than a fir hull of the same registered dimensions. Each of these attributes contributed to higher profits and increased merchant interests in iron hulls.

It was not until 1855 that Lloyd's developed a set of rules for iron construction. In total output, the boom years for British iron construction were 1864, 1869 and 1875 (MacGregor 1988:131-135). Steel use was growing and became widespread in the late 1870s after development of the Siemens-Martin steel production process. British wooden vessel construction all but ended in the 1870s.

KILLEAN was built at the pinnacle of the British iron three-master; more of these vessels were built in 1873 and 1874 than any other period. The iron four-master appeared in 1875, and shortly came to dominate newly constructed vessels. These later vessels developed the very full lines of the large carrier, little of the fine clipper lines, retained in some measure on earlier vessels, was in evidence (Lubbock 1929:VI:151-152). The builder, John Reid and Company, built their first large iron vessel, a 1,000 tonner, in 1854, which was the only one they built that decade (MacGregor 1988:134).

The year KILLEAN was built was a pivotal one for large sailing vessels. Steam was on the ascendancy, and vessels built after this time had more emphasis on capacity than speed. Ships after 1875 tended to be larger and lines more full than those before (MacGregor 1988:258).

Site Description

The wreck is in two main wreckage fields. The bow portion, about 110 ft long excluding bowsprit, lays east-west and consists of bow, midships and foremast. The second field, about the same length and laying north-south, is composed of midships, stern, mizzen and main-mast structures (Figure 13.2).

This site description is in five parts: Feature 1 is the bow section to aft the foremast; Feature 2 is the midships area associated with the bow section and is the largest hull portion; Feature 3 is the midships section forward of the stern, which is Feature 4 (Figure 13.2). The fifth part discusses the rigging except for the bowsprit and headgear, which is discussed as part of Feature 1.

Feature 1 Area

The main structural feature is the bow itself, which lies on the starboard side, port side up, with the port gunnel awash.

Sufficient bow structure remains to give an impression of the ship's hull form. The fine clipper-like bow indicates a vessel built with speed considered over carrying capacity, like many 1870s vessels. By the 1880s, carrying capacity took precedence and dominated large sailing ship design as steamers cut into the fast trades (Lubbock 1929:VI:245). AVANTI clearly retains some of the fine clipper lines of earlier vessels.

The awash bow portion has diminished since the early 1970s, when the exposed portion was visible from a long way from the wreck at any tide level. The current portion exposed, only visible at low tide, is close to the bow, forward of the full-beam hull. The starboard gunwale is collapsed inward beginning about 55 ft from the bow. The port bow, the bulwark of which is awash at low tide, is intact for about 30 ft. The bulwarks of

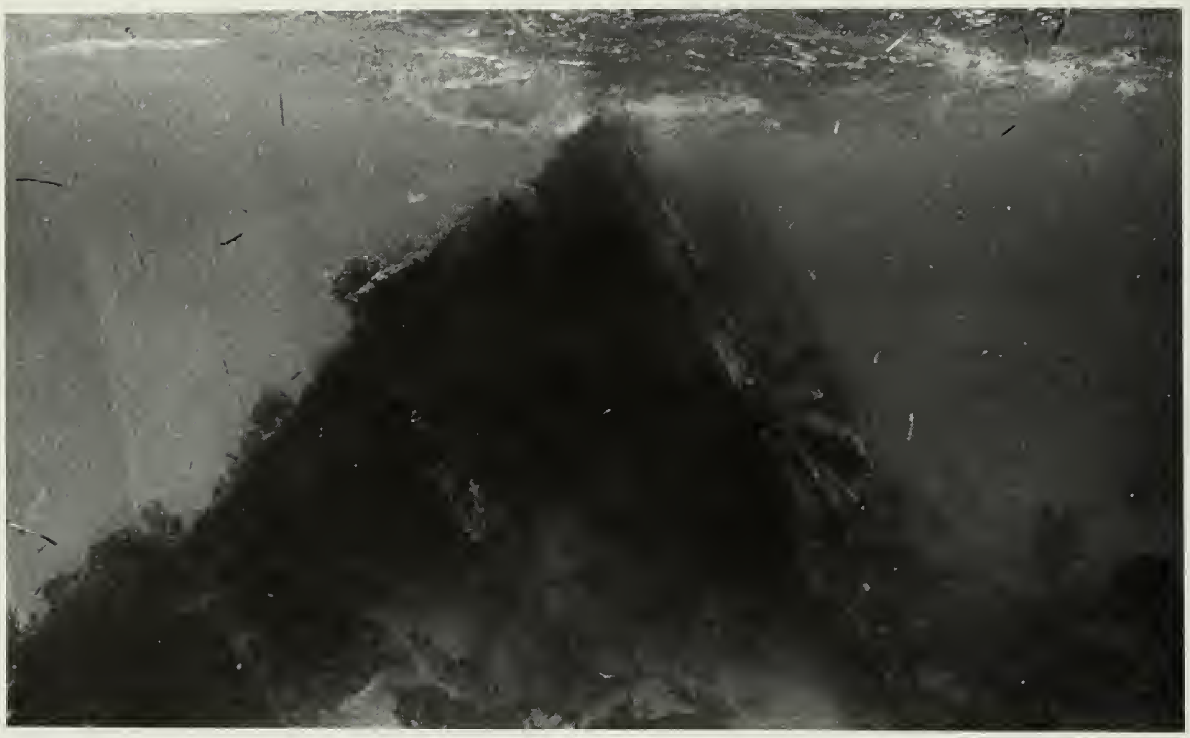


Plate 13.3. AVANTI bow section looking forward, 1988. Main deck is to the right with bowsprit heel visible. USN photo by William Krumpelman II.

the collapsed piece were exposed prior to its collapse.

The undamaged stem lies above the sand; the bottom scours out around the forefoot. The bow area is intact in the deep floor area where the ship's beam narrows to meet the stempost. The deep floors, which are equivalent to the deadwood area of a wooden ship, are very strong, forming a triangular structure reinforced by iron breast and deck-hook plates, shell plates and deck beams. In an iron or steel vessel, bow and stern portions are the strongest features and tend to stay intact, unlike wooden hulls wherein bow and stern construction is usually very weak and rarely survives a shipwreck.

The stem is a solid iron forging. American Lloyd's rules for 1875 required a 10 1/2 in-wide x 3 in-thick stem and stern post. This probably varied little from specifications of Lloyd's of London under which this ship was built. Breast hooks are 2 1/2 ft wide on the aft end.

The bowsprit is in place, though the timber jib-boom, like the wooden topmasts, is gone. Outboard length of the bowsprit is 23 ft 2 in to the end of the cap; its diameter is 2 ft. Jib-boom length for Clyde-built iron ships of the period was commonly 2:1 (Underhill 1946:31), indicating AVANTI's jib-boom may originally have been about 45 ft long, for a total length of about 68 ft. It was not

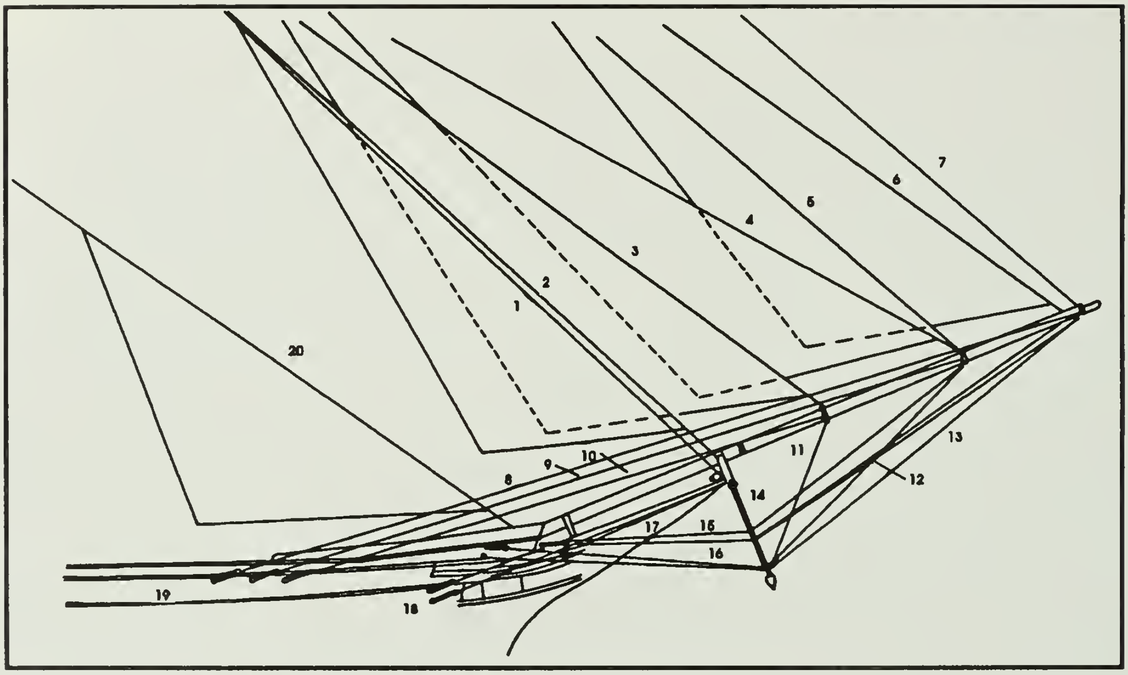
Plate 13.4. Bow of AVANTI, 1990. Diver is Randy Jonsson. NPS photo by Larry Murphy.

uncommon for older jib-booms to be cut down in later use; it is unknown if this was done to AVANTI. The composite bowsprit/jib-boom was replaced by an iron or steel spike boom on most vessels built during the 1880s.

Bolts for the jib-boom heel chock are visible; inner and outer jib-boom bands are in place. The inner jib stay attachment on the outer band collar is not discernible because of coral growth. Internal diameter of the outer band collar is 1 ft 7 in, which indicates the jib-boom diameter. The steeve, or angle between bowsprit and waterline, is about 20°.

Few headgear features are observable because of coral growth. There is a double link on the port side, behind the knighthead, probably for a forestay. Another feature, an eyebolt on the port side, may be for an upper forestay. There are some stay mounts in place just aft the jib-boom heel bolts. Bobstays, bowsprit shrouds and martingale stays are missing. Most of these were chain or solid bar and would be expected to survive, even if encrusted. Their complete absence indicates postdepositional removal. A labelled drawing of a contemporary vessel's headgear is presented for comparison in Figure 13.3.

Many bowsprit internal spar bedding features remain intact. The bowsprit projects through the forward bulkhead of the forecastle (housing length 18 ft) and is riveted directly to 6-in-wide main deck beams on 4-ft centers. Atop the deck beams is a flat web plate 4-ft 10-in athwartship and 4 ft 6 in long to which a 1-in-thick, 8-in-wide cap 3 ft from the aft end of the bowsprit is riveted. The bowsprit



From Plate X Lloyd's Report 1874:141 (Mac Gregor 1984:186)

1. Fore topmast stay
2. Fore topmast stay sail stay
3. Inner jib stay
4. Out jib stay
5. Fore top-gallant stay
6. Flying jib stay
7. Fore royal stay (probable)
8. Flying-jib guy

9,10. Jib guys
11,12,13. Martingale stay chains
14. Martingale
15. Bobstay
16,17. Martingale backstays
18. Bowsprit shroud chains
19. Jib guy chainplates
20. Fore stay and fore stay sail

Figure 13.3. Headgear for a vessel comparable to KILLEAN.

aft end is split and flattened, "U-shaped" rather than tubular. The edges are flanged and riveted to the web plate. The bowsprit steeve raises the bowsprit 1 ft 8 in above the forward end of the attachment plate, compensated by two iron wedges placed beneath the bowsprit.

Bow structure consists of 1 1/2-in-thick, 12-in-wide longitudinal tie plates. Two of these plates run along each side of the bowsprit. Along the hull side is the deck stringer to which main deck beams are attached. The deck hook for the main deck is in place. Atop and along the outer hull edge is the waterway and margin planks. Deck beams are on 4-ft centers.

There is a 2 1/2-in-diameter pipe on the inner hull plates on the port side of the bow, which could be the crew's head soil-pipe.

The chain locker would have been in this area. A chain pile was observed leading to the starboard bitts and likely indicates the chain locker location. Chain pipes were not located.

These would have fed anchor chain through the 'tween deck area from the main deck, where the windlass was mounted, down to the chain locker. Chain locker bulkheads are missing, and chain has spilled into the forepeak. Indications of a collision bulkhead were expected in this area, but none was located. A single bulkhead is indicated on the ship's registry; its location is unknown, but most likely was in the bow forward of the windlass.

A 42-ft 9-in-long forecastle is specified in the original registry. The forecastle would have contained crew's accommodations and below-deck storage. This deck would have extended from the bow to forward of the fore hatch, which is still attached to main deck beams.

Few fore-deck gear features are visible. Nothing related to the catheads and anchor stowage was observed. This may be the result of salvage activities. Both bow chocks are present and in place. Some vertical bolts forward of the chocks were probably to anchor wooden deck and bow rails.

The top of a windlass pawl rim can be observed below the mangled hull plates forward of the foremast and fore-hatch coaming. The windlass appears to have been forced sternward. Normally, windlass and capstan, which were connected by the capstan drive shaft, would have been further forward, likely within 25-30 ft of the stem. It could not be determined if the windlass was properly rigged or not.

The anchor and cable are some of the most interesting site features, and they provide stark evidence of wreck events. The starboard anchor is set, and about 55 ft of stud-link anchor chain are laid out straight to the

Plate 13.5. Bowsprit internal bedding, view looking upward, 1988. Unidentified US Navy diver in foreground. NPS photo by Larry Nordby.

starboard hawse pipe. The anchor cable has been brought out of the forecastle area, wrapped around a circular fitting and then around the starboard bitts, which are still mounted on a 40-ft section of margin plate separated from the hull. It appears that the vessel was in dire straits when wrecked, indicated by the missing port anchor. The only reason for bringing the anchor chain out of the forecastle and wrapping around the bitts is as a last ditch effort to secure the vessel. Apparently, there was no confidence the windlass would hold the ship, or there simply was not time to run the cable slack from the anchor with the windlass.

The 3-ft 2-in-long, 2 ft 2 1/2-in-diameter forward capstan has broken from the forecastle deck and is lying on the inside starboard hull. The capstan is a double-purchase type (there are two rows of capstan-bar holes) in bands 6 in wide; the mounting casting is 6 in thick. No pawls were observed. The capstan plate, typically of brass and engraved with ship's particulars, has been removed. Capstan mounting bolts are of various lengths, indicating it was probably torn out during the wreck event. The capstan was connected to the windlass by a shaft leading up from the windlass and turned with a worm gear. The capstan drive shaft, or spindle, is broken. Capstan and windlass were operable by hand, lack of steam pipes indicates they were not steam driven.

The coaming for the maindeck fore hatch, still square and connected to main deck beams and half beams, is about 10 ft forward of the foremast. A small ferrous drum lies inside the coaming. No deck planking remains, although iron deck beams and margin plates are present. It is unknown whether the lower deck ('tween deck) had planking.

Midships Wreckage Field

Feature 2 Area

A cross section, Figure 13.4, developed from various wreck portions was compiled from data gathered by Jim Delgado and Larry Nordby in 1988 and MAHS personnel Richard Knudson and Arun Vohra in 1990. The hull had a box keelson, side keelson with intercostal plates, bilge keelson, two stringers below the lower deck and one in the 'tween decks area. The side and bilge keelsons and stringers are composed of two angles, and all but the upper hold stringer have a vertical plate between them. The frames are z-bar construction and on 2-ft centers. The cross section is not complete; some additional construction details, primarily on the floors and beams, are needed.

The box keelson was common during the period, but later replaced by other forms more resembling vertical girders. Box-keel construction was with four separate flat plates, the two larger horizontal. Two vertical plates were riveted to 3 1/2-in angle irons in each corner, which were attached to the upper and lower plates. The problem with box keelsons was that although strong, it was impossible to determine interior corrosion and deterioration.

No sign of a bilge pump was observed. The pump would have been located just aft the main mast, in the area of most severe hull damage. Pump parts may have been collected by recent divers.

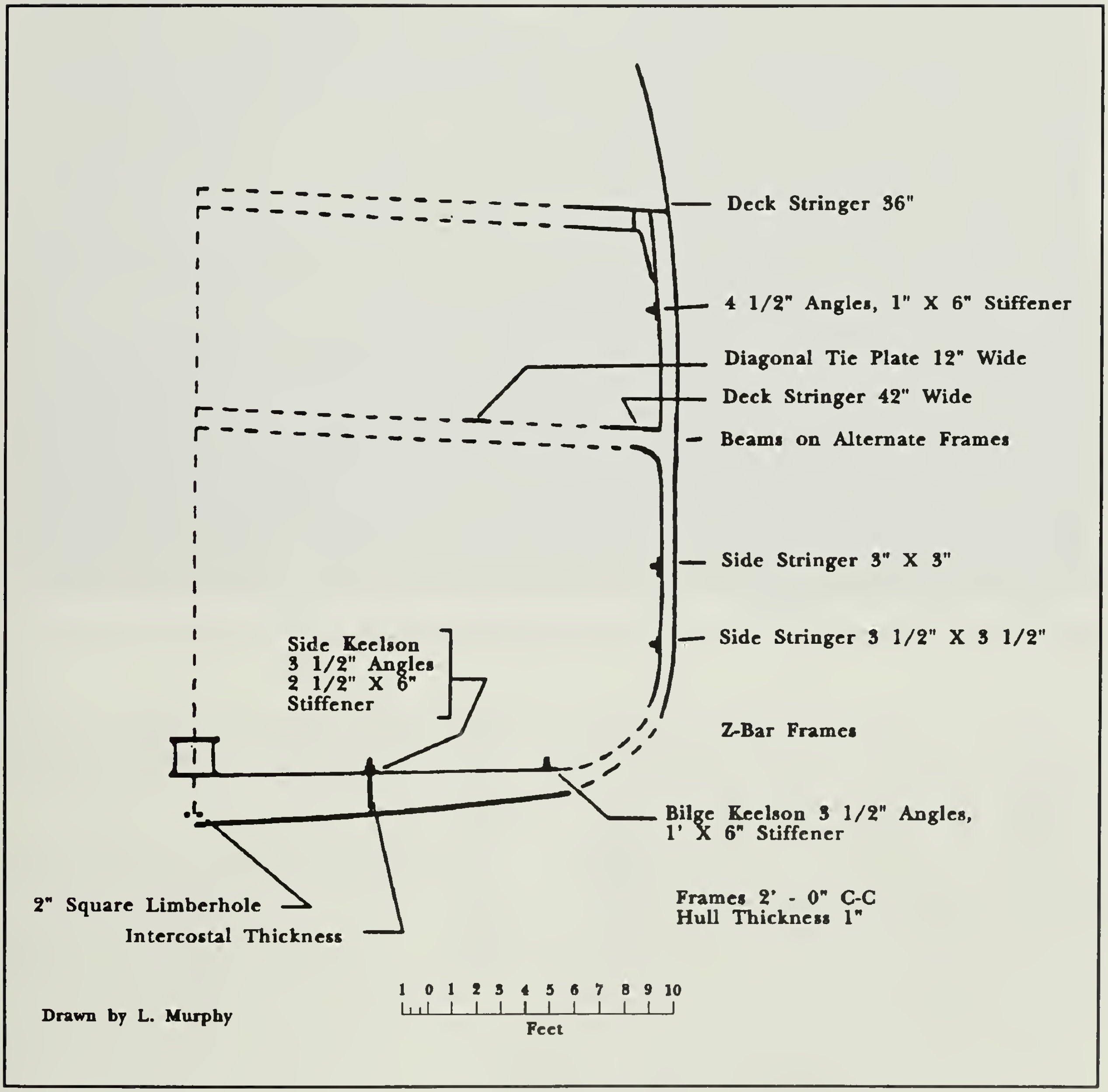


Figure 13.4. Compiled midships hull cross section.

Plate 13.6. Box keelson (left) and frames, 1989. NPS photo by Richard Gould.

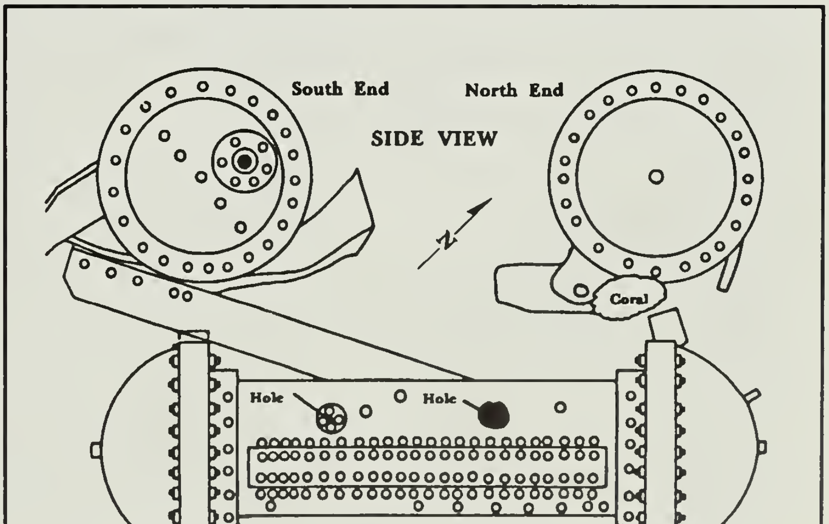
There are hull-side portions containing foremast chainplates. The chainplates were attached inside the bulwarks to shell plates extended up the bulwarks for that purpose. The chainplates were flat on the lower end, to allow riveting to the bulwarks. The chainplate body is round, and the upper portion corresponding to wooden deadeyes, is a flat shackle that was attached to the shrouds and backstays.

The hull portion containing chainplates has been broken from the hull and is laying on a piece of outer hull. Starboard hull portions are beneath the mast, which indicate they must have collapsed inward before the mast fell. Some intact portholes, dogged shut, lie beneath the foremast. The closed deadlights indicate the ship had been secured for heavy weather prior to wrecking.

Parts of steam-driven machinery pieces are on site. A double-riveted pressure vessel 4 ft 5 in long and 1 ft 6 in diameter is located in the area. The domed ends are bolted together. A second piece lying to the southeast has a 7-in hole and portions of what appear to be a handle on it. A machinery plan view is Figure 13.5. This machinery is the engine from a steam-powered cargo winch apparently housed in the midships deck house.

Plate 13.7. Frames and stringer, 1988. Note heavy coral growth. NPS photo by Larry Nordby.

Figure 13.5. AVANTI steam machinery. Likely from a cargo winch located in the midships deck cabin. Drawing by Jackie Koenig and Pam Krim.



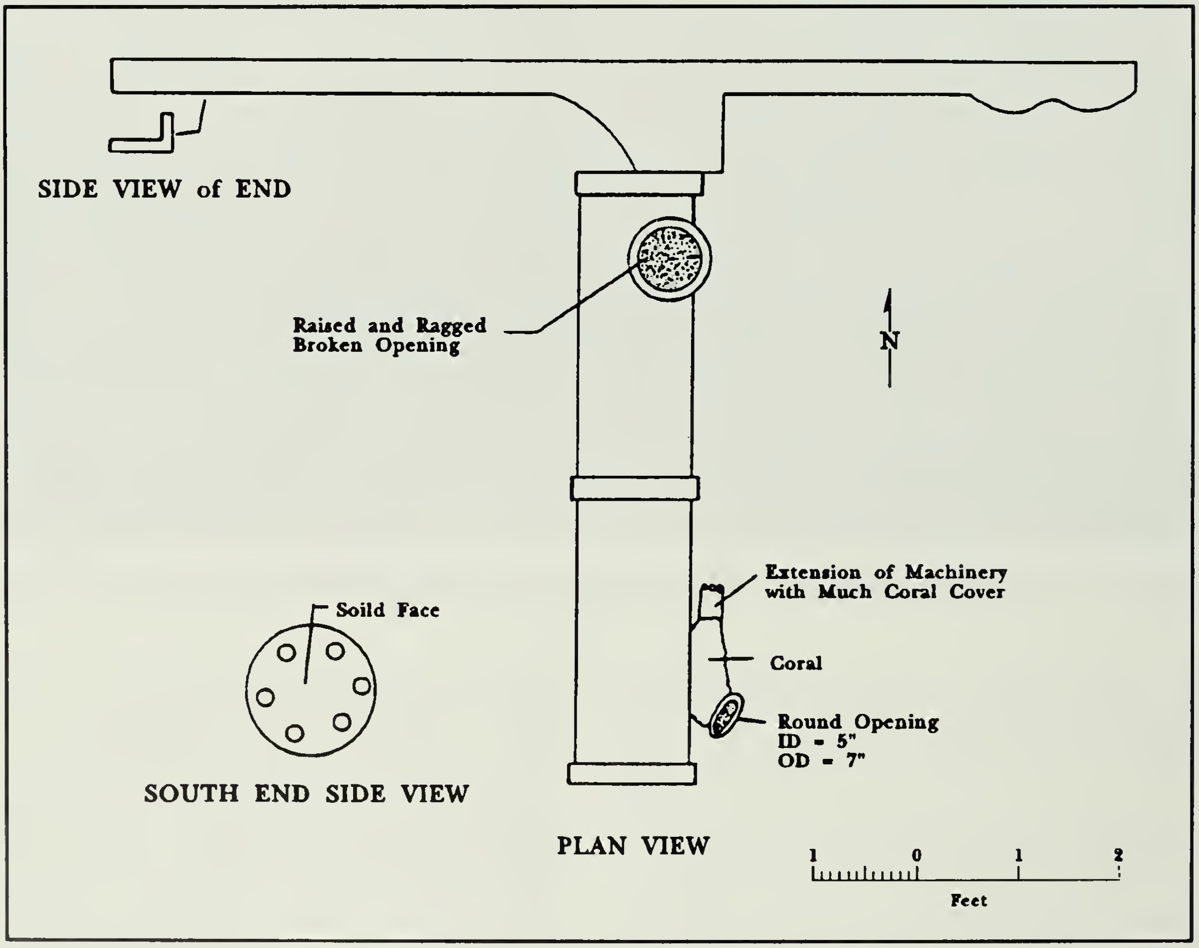


Figure 13.6. AVANTI steam machinery. Probably from a cargo winch. Drawing by Jackie Koening and Pam Krim.

Feature 3 Area

This is the midships hull aft of Feature 2. Most of the port hull side from bilge to bulwark is present. This hull portion, which contains the boat davits, would have been just forward of the poop deck. Just aft the intact boat davit is a mooring fairlead through the bulwarks, which was just above the main deck level.

A portion of the box keelson is visible above the sand. This area is usually buried, which has preserved the pine or fir wooden hold ceiling. In some areas the keelson has vertical flanges, which were probably for securing hold stanchions. Some hold stanchions lie off the keelson's port side.

Just west of the centerline keelson in this area is the riveted iron fresh-water tank. The tank was single riveted every two inches and contained internal cross bracing. The fresh-water tank would have been in the hold and accessible through a hand-operated pump on the main deck. This tank, 7 ft x 12 ft x 5 ft, would hold about 3,000 gallons.

A section of deck margin plates, beams and diagonals lies on starboard hull side to the west and toward the main mast. Main mast chainplates are visible. A cargo-winch warping-hub associated with the steam machinery in Feature 2 was also located in this area (Plate 13.8).

Plate 13.8. Warping hub laying on hull side. Chainplates can be seen to the left. NPS photo by Larry Nordby.

Feature 4 Area

The forward-most feature is a 24-ft portion of port hull that has fallen inward. This hull side extends from the rail to the bilge and is 35 ft wide and contains ten hullstrakes. Two 4-in-wide rubrails are at the gunwale and above the upper port holes. This line of port holes would have been in the poop, the lower (to the east on the drawing) would have been the 'tween decks area. All portholes and deadlights (port lids) have been removed. This hull section is just forward of the deep-floors section of the stern.

The deep-floor stern section is intact laying on its starboard side with the port hull side above the bottom. The stern has separated below the counter. The transom and poop deck have been torn off. An iron-hull stern, unlike a wooden hull, is very strong because of the triangular support members, in this case 2-ft x 1-ft crutches. Iron and steel hull sterns and bows tend to remain intact and offer good opportunity for examination of hull construction technique details.

The stern post is intact. Gudgeon straps are present, but the gudgeons are sheared off, likely during the wreck when the rudder was unshipped.

The unbalanced rudder is present with the bottom of the rudder lying to port, indicating the stern moved to starboard during or sometime after the wreck. The rudder post is 12 ft long. Rudder pintles are visible; the

Plate 13.9. Jim Bradford documenting stern section, 1990. The rudder post and tiller can be seen above him to the right. NPS photo by Michael Eng.

trunk, stuffing box and tiller are in place. No other remains of the steering gear could be located, another indication of salvage.

Stern bulwarks in the area of the poop were very rounded and turned inward in a "half-round" shape. The mizzenmast chainplates, unlike those of the other masts, were outside the hull to separate the shrouds from the mast as widely as possible, for maximum strength in an area of diminished hull width.

Masts and Rigging

AVANTI was ship-rigged with three masts, and all three lower masts are on site. In 1873 and 1874, eleven large vessels were dismasted in a twelve-month period and an investigation was conducted by the British government. Results of this investigation, which found one of the problems to be overmasting, included reductions of yard length and mast height, eventually led to the development of the four-masted ship in 1875 (MacGregor 1984:188). Dimensions of yards and masts of AVANTI reflect these changes.

Standing rigging was wire-rope. Wire-rope rigging was an important advancement in maritime technology appearing in the 1830s and 1840s, first appearing on British vessels. Wire-rope rigging added great strength to standing rigging for its size--comparable tensile strength wire rope was one quarter of the diameter of hemp rope of the same strength (Wallace 1856:192; Macgregor 1984:150-1). Wire rope reduced top-hamper weight, which lowered hull center-of-gravity and allowed taller masts capable of carrying enormous expanses of sail. Smaller diameter wire rope reduced wind resistance, and its durability reduced costs.

Standing rigging utilized wire rope and turnbuckles, called rigging screws, which were inside the bulwarks. Rigging screws first appeared in 1836, but were little used until the large iron sailing vessels of the 1870s (MacGregor 1984:189). Foremast and main mast chainplates were in the bulwark interior, while those for the mizzenmast were outside.

Cheek plates are on each mast. Cheeks are triangular iron plates at the mast top that support the trestletrees. Upper and lower futtock bands are in place. Topmast shrouds were attached to these bands. There is little else left of the lower mast tops, which must have been of wood. Topmasts and topgallant masts, which the ship undoubtedly had, were timber, and no remnants have been located on site. The ship carried single main courses with double topsails. Topsails were split into upper and lower sails beginning in the 1850s (Greenhill 1980:28) and soon became standard rig on larger vessels. The division of topsails made sails easier to handle, which allowed smaller crews and lower costs. One drawback to the split topsail was the addition of another yard's weight to the tophamper.

Currently, it is unknown if AVANTI carried double top-gallant sails. This may be determined from vessel photographs or from detailed site examination and test excavation that could locate buried rigging elements.

The masts appear to be of iron, rather than steel, based on shell-plate thickness. Consequently, probably they are original. Steel spars were in use at least since 1863 (Anderson and Anderson 1947:194) and preferable to iron for masts and yards because of lighter weight. It is interesting that if the masts and yards are indeed iron, they were not replaced sometime during the ship's life with steel.

Masts are strengthened by three internal angle-iron bracings with three 4 1/2-in x 1-in arms protruding into the mast's interior. The bracing indicates construction from three plates, each bent to about 120°, although this has not been verified. Overlapping plates are joined by double-row rivets along vertical joints that also secure internal angle-iron stiffeners. Rivets are 4 in apart, rows 2 in apart. Masts have 1-ft-wide bands about every

10 ft, which cover horizontal-butt locations. Spider bands, which provide lashing points for running rigging and normally are about 4 ft above the weather and main deck, were not observed.

The yards appear to be constructed without internal bracing. Typically, there are 3-, 4- and 6-in-wide bands shrunk around the yard. Four-inch yard bands attach the yard to the lower truss and upper crane. Three-inch irons are spaced variably along the yards. Yards ends were probably plugged with wood, which is now gone.

The foremast is 60 ft long and 22 in in diameter. The upper topmast hoop is 18 in in diameter. Cheeks are attached. The trestle-tree is of 5 1/2-in-thick stock and 2 ft 2 in and 1 ft 9 in in internal dimension, which would be the dimensions of the topmast heel. The foremast stump appears to be stepped, the upper portion apparently breaking below deck after the hull reached its present location.

Both the lower and lower topsail yards are attached and rigged. These yards are heavily encrusted, and it is difficult to discern most construction details. The 69 1/2-ft-lower fore topsail yard is 18 in in diameter in the center and tapers to 8-in-diameter ends. The 84-foot lower yard is 20 in in diameter and tapers to 10 in in diameter. Both yards are attached and rigged, including the chain sling on the lower yard. Both yards have intact jackstays, which

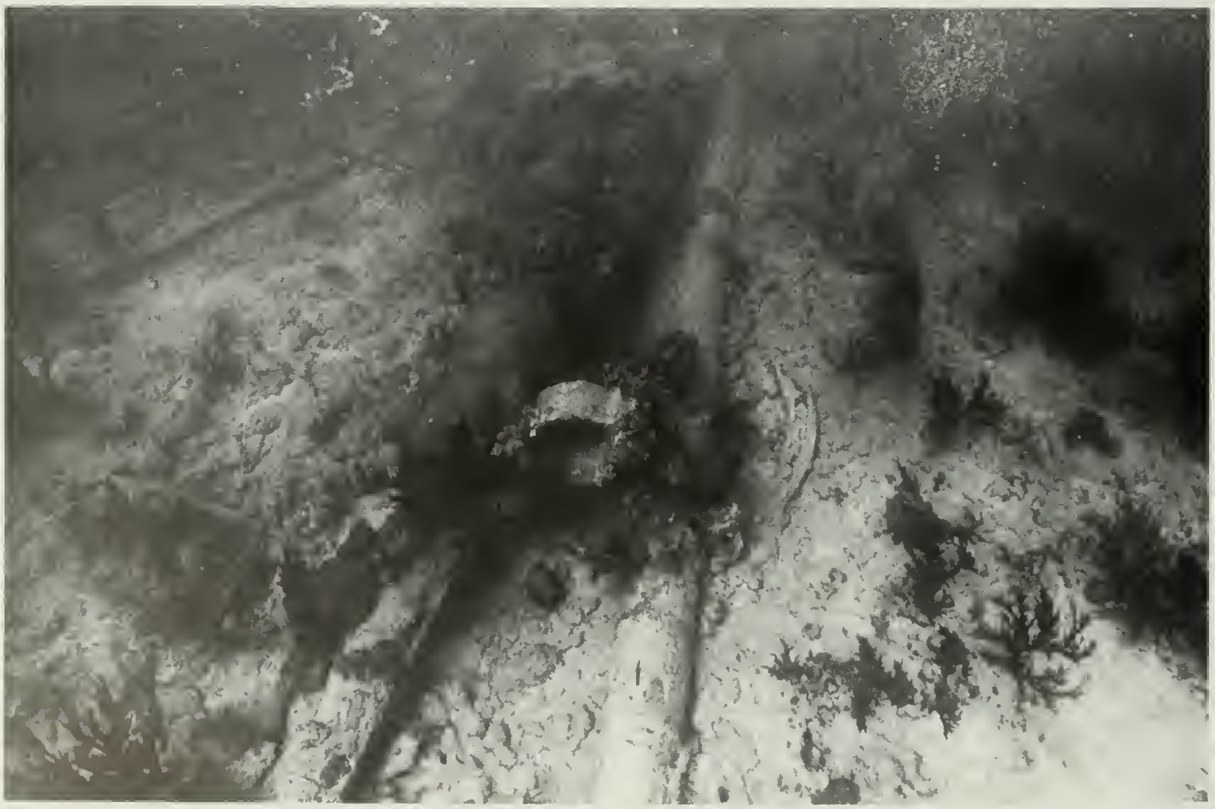


Plate 13.10. Top of foremast looking west. The circular band is the mast top that supported the wooden topmast. The mast is laying on the lower yard, the lower topsail yard is to the right. USN photo by William Krumpelman II.

Plate 13.11. Pile of wire-rope shrouds near foremast, 1988. NPS photo by Larry Nordby.

held the sails. Jackstays are set up on small iron stanchions atop the yard, unlike earlier practice when sails were bent to the lower yard edge.

A pile of hemp-core wire rope shrouds lies south of the mast near the foremast cheeks (Plate 13.11). The rope is heavily encrusted.

The total main mast length is 76 ft. Shroud loops still remain on the mast above the cheeks. Main lower yard is 79 ft 6 in. Internal diameters were not measurable because of coral growth. Like the foremast, the truss and chain sling are present. Sheet blocks are present. Sheet blocks, which are in pairs (port and starboard), are attached to the crane band in the yard's center. The chain sling is attached to the upper chain band.

The main lower topsail yard is 70 ft in length and 7 in diameter at the end. The yard has 40 bands observable, most 3 in wide.

The mizzenmast is present near its appropriate position in the stern. The mast is partially buried within the stern structure and an accurate length was not obtained. The mast has partially broken open.

No indication of boom and gaff, apparently wood, were located. A pile of hoops was located, and these are most likely spanker sail hoops.

The crossjack yard, which is the lowest on the mizzenmast, is under the stern. The mizzen lower topsail yard is laying off the starboard stern.

Construction Summary

The vessel is an iron-hulled sailing ship dramatically representative of the height of British iron-hulled ship building in the last quarter of the nineteenth century. Hull construction is on the longitudinal framing system. Inner-outer hull strakes, 36 in wide, are butt-plated and chain riveted. Butt plates are 1 in x 3 ft 4 in and have four rivets per row, typically 13 rows. Chain riveting, where rivets are in a line perpendicular to the joint, was recognized as the strongest method available to connect hull plates and proximates the strength of the hull plates themselves (Fairbain 1865:45). Rivet holes were punched by flat steel punches. Hull rivets are 1 1/2 in diameter and placed every 4-6 in. Location of collision bulkhead has not been established.

AVANTI had a raised forecastle and poop. The main deck was complete. The crew's head may have been on the port side forward, as presence of a pipe indicates. There was a lower or 'tween deck that may have been decked, although this has not been confirmed archeologically. The hold floor had at least partial ceiling, probably of fir or pine.

More detailed site documentation needs to be done to establish main and 'tween deck layout in the absence of construction plans. There was likely a chart house on the poop, along with steering gear and binnacle, but no trace of these has been located. A midships deckhouse is indicated by steam machinery, which would have been used for cargo handling and therefore logically located amidships. Rails, pumps, deck fittings, cabin bulkheads, running rigging, sails, boats, hatches, ladders, skylights and other fixtures are absent. Most portholes have been removed.

Because of iron's resistance to corrosion, much greater than steel's, the vessel remains in remarkably good shape. The high level of preservation of this site should allow it to remain an excellent example of the pinnacle of British iron shipbuilding traditions for future students of marine architecture for a very long time.

Site Formation

There is sufficient material evidence present to develop a probable wreck event sequence in absence of historical documentation.

It is known that AVANTI was outbound for Montevideo, and consequently headed south when stranded on Loggerhead Key Reef, on a portion of the reef that juts to the southeast. The wreck lies more than 1,000 yd within the 30-ft contour and 100 yd within the 18-ft contour of NOAA Chart 11438. AVANTI likely came in from the north-northeast driven by a strong northwest wind. High winds, particularly from the north, frequently occur in January and February.

The site is in 18-21 ft of water; the ship carrying a full cargo had up to a 17 1/2-ft draft, based on recommended immersion level in the 1875 American Lloyd's rules. The vessel was carrying lumber, so it is unlikely that it was at its deepest load line, even with a deck load. This indicates the vessel was probably in distress before stranding and may have been taking on water that increased its draft.

Indications are that the ship wrecked in a storm. Absence of the port anchor may mean the vessel dropped it farther offshore in an effort to stop its progress toward the reef. This demonstrates that the crew aboard knew where they were and were attempting to avoid the Tortugas reefs. That the anchor is missing supports the assumption that the ship was in distress, probably taking on water, and was for that reason unable to rely on sailing away from the islands.

AVANTI struck the reef broadside to the waves. When grounded or shortly before, the starboard anchor was dropped, which is a common practice to secure the ship in the shallows and prevent it from slipping off into deep water and sinking.

The ship began to break up, apparently somewhere along the main hatch area, which would have been just forward of the main mast. The hull, buffeted from the north-northwest by waves strengthened after maximum fetch of the width of the Gulf of Mexico, began to split apart. The vessel moved easterly enough to set the anchor, which began to tilt the hull to starboard, deck to the waves. The mizzen mast fell, then the stern post came to rest nearly atop it. The forward 125 ft of hull, buoyed somewhat by its lumber cargo, pivoted on the starboard anchor, which is pulled straight, until the hull was perpendicular to the waves, which were from the north-northwest as indicated by the forward hull position (Feature 1 and 2).

Proximity of foremast to mast stump is evidence the foremast remained upright until sometime after the hull came to rest in its present location. Presence of shrouds supports this sequence. The hull-side section arrangement in this area is complex--there are five layers of hull structure in some places. Both hull portions containing chainplates in Feature 2 are separated and inboard up, lying atop hull sections that are outboard side up. These pieces would have had to fall inward alternately. The mast lies atop what is likely starboard hull, evidence that the hull collapsed prior to the mast falling. This appears to have been the result of the initial wreck event and subsequent storms, some with heavy waves from the west. The mast stood for some time as the hull sides caved inward.

The stern appears to have been forced at some time in an opposite direction (westerly) about 15 ft after being separated from the hull bottom. The hull side containing the boat davits and lying inboard side up would have been lined up with the forward edge of the hull side lying outboard side up atop the stern, which seems to be about 15 ft east of the intact stern section. The centerline keelson does not line up with the stern centerline, again offset about 15 ft. The westward shift of the stern may have been during the wreck event, but sometime after the crossjack yard separated from the mizzenmast. The rudder heel position probably indicates the original place the stern came to rest during the initial wreck event. The rudder heel is typically the deepest hull portion. The rudder stock seems to have been bent to port from a westerly (starboard) shift of the intact stern section. It is this shift that broke the counter and transom.

Postdepositional Effects

Later storm effects are evidenced in the wreck. The large port hull portion near the bow in Feature 1 that was once awash, definitely collapsed since 1971. The port hull side near the stern lying outboard side up with portholes shown in the site map, appears to have been postdepositional, and would have had to have fallen after the hull side containing the boat davits collapsed outward.

Cultural effects are also notable. Most portable artifacts are missing from the site. Extent of immediate salvage operations are unknown, but may have been extensive. Wreckers were still operating in the area in 1907, and AVANTI would have been easily accessible as soon as the storm that wrecked the ship subsided. The steam machinery may represent some salvage activities. Machinery pieces from the same winch are more than 200 ft apart. The warping head in Feature 3 and machinery of Feature 2 are certainly associated. The winch could have been broken up and separated during the wreck event, or these pieces may have been discarded in these locations by salvors. The only thing supporting salvage is that the rest of the machinery is missing from the site.

Site Significance

The Windjammer Site is significant and certainly eligible for the National Register of Historic Places at a national level of significance. The wreck has high site integrity and is a rare representative of the class of British-built iron-hulled three-masted ships built at the pinnacle of this type vessel production by a major iron shipbuilder, John Reid; designer is unknown.

The historic function was water-related general cargo transportation. When lost, the vessel was employed in the Florida-Caribbean lumber industry at the turn of the twentieth century. The period of significance is 1875-1907; significant dates are 1875 and 1901-1907 when it was apparently involved in transporting Florida lumber in the Caribbean trade. Areas of significance are Archeology/Historic non-Aboriginal; Commerce; Maritime History; Transportation. National Historic Landmark thematic associations are: XIIA4 Timber and Lumber; XIID1 Export and Import; XVIII Transportation.

Major vessel significance derives from potential to yield information on late nineteenth century iron-ship construction techniques and practices during the peak of the transition from wood to modern steel ship construction. Iron construction was a short-lived answer to problems of increasing sailing vessel size and efficiency during the beginning of intense competition with steam for foreign market transportation domination. Few iron vessels of this once typical, now rare, type remain, and few complete plans are available for comparative study. Archeological questions regarding variances between plans and as-built practice, and revisions made during the course of a vessel's life, must rely on examination of remaining examples of this technology. Restored museum vessels are often good for comparative study, but some have been altered considerably from as-built configuration. Few vessels remain due to the salvage value of iron hulls. Only two known shipwrecks of this type are currently available in the United States for comparative study, both within National Park Service waters: AVANTI and GOLDENHORN in Channel Islands National Seashore.

Norman Brouwer (1985) has compiled a list of historic ships world-wide, useful for determining possible comparisons and for study of specific vessel types. Following is a list of iron-hull British-built vessels comparable to FOJE 003.

Table 13.1. Known large British iron-hull sailing vessels world-wide (Brouwer 1985)

Name	Year Built	Gross Tons	Location	Rig	Current Use
FALSTAFF	1875	1465	Chile	ship	Aground
CO. OF PEEBLES	1875	1691	Chile	4m ship	Aground
LADY ELIZABETH	1879	1208	Falklands	bark	Aground
BAYARD	1864	1319	So. Georgia	bark	Abandoned
CO. of ROXBURGH	1886	2209	Tuamoto Is	4m ship	Abandoned
FALLS OF CLYDE	1878	1809	Hawaii	4m ship	Restored
WAVERTREE	1885	2170	New York	ship	Restored

Suggestions for Future Work on this Site

Much detailed documentation is needed for this site. Metal detecting and test excavation are desirable for more complete determination of remaining site features. The fieldwork reported in this chapter should be considered only as an initial site documentation effort. Few construction details have been adequately documented.

A glaring need is for more historical documentation on the ship's life and the wreck event. Lack of historical documentation may hinder National Register nomination. A register nomination, however, should be completed soon.

The site is beautiful, and an ideal location for snorkelers and divers interested in shipwrecks or marine life. The interpretive map should be continued. However, if diving pressures increase, a mooring, or perhaps a couple of moorings, will be necessary. Often boats visiting the site will anchor into the wreck structures, which damages coral and the wreck.

CHAPTER XIV

Nine-Cannon Site (FOJE 008)

Larry E. Murphy

LOCATION

The Nine-Cannon Site lies about 200 yds inside the 18-ft contour on Loggerhead Reef's southwest side. Site depth ranges from 15 ft in the north area to about 11 ft at the scattered cannon feature, for which the site is named, to 10 ft deep at the southern end. Six-foot depths and patch reefs are found to the southwest. Farther south, the area deepens to about 16 ft. Small patch reefs and sand pockets characterize the area (Figure 14.1).

PAST WORK

The site was discovered and recorded June 6, 1971 during the 1971 NPS survey (see Chapter X). The survey team noted nine cannons:

> ... one 65 in long, muzzle blown off, others 69 in long, all short ones appear to be very poor grade of iron. Some several 9 ft slender guns preliminary visual seems to indicate they may be "long 6's" (6 pounders), possibly English (could not tell exactly under conditions, but cascabels appeared slightly bun shaped.)...There is large broken anchor, 1 wood stock anchor over all. Large amount of 8-in-link stud chain, chain plate and wooden deadeye reported, quantity of steel cable.
>
> The above material would seem to indicate a group of mixed period artillery tubes, probably mostly eighteenth century in origin. The total assemblage strongly suggests these tubes may simply have been carried as permanent ballast aboard a later period vessel - circa midnineteenth century [Florida Underwater Archeological Research Section Site Card 6-14-71].

This site was recorded as a "middle to late nineteenth century" site.

Members of a Southeast Archeological Center (SEAC) and Florida State University Academic Diving Program field team visited the site in October 1981 (Johnson 1982b: Appendix D; see Chapter X), mapped a portion of 008 (see Figure 10.5), made a photomosaic and assessed the cannons "through physical measurements:"

> ...Preliminary indications are that the nine cannons appear to be of consistent vintage, probably eighteenth century although cultural affiliation seems indeterminable at this stage of the investigation.
>
> The cannon range from approximately 17 calibers to 27 calibers with an average caliber of 24 indicating possibly mideighteenth century. It was after midcentury that British guns began averaging 19 calibers and below (Manucy 1949:31-49).
>
> There appear to be six 9-pounders, two 6-pounders and one 4-pounder [Johnson 1982b:Appendix D].

1985 Fieldwork

Submerged Cultural Resources Unit personnel visited the Nine-Cannon Site during the Natural and Cultural Resources Video Documentation Project September 1985 (see Chapter XI). The site was video documented because Superintendent Jack Morehead considered this site subject to heavy sport diving visitation and potential looting (see Appendix). Observations were compiled in a trip report (Lenihan 1985):

> ... At the northern extreme of the area there are two features: a whole anchor and a set of large gears, probably from a winch. The appearance of these features suggest that a portion of ship structure, probably the bow, disintegrated in this area.
>
> Near the gear wheels, a section of stud-link chain is concreted in a formation above the sea floor. The configuration is unlikely to have formed unless the links of the anchor [cable] were supported while they concreted together. The probable explanation of this peculiar formation is that the chain concreted while being supported on wood structure that has since deteriorated. In the immediate vicinity is a cylindrical piece of lead. This is a hawse pipe; there is stud-link chain in the center of the tube.

1988 Fieldwork

The site was visited by members of the site 003 documentation team under direction of Larry Nordby (see Chapter XI). Nordby and others located wooden structure and ballast and made a sketch. This site was relocated in 1989.

1989 Fieldwork

Larry Murphy and Richard Gould visited 008 briefly during the June-July reconnaissance (see Chapter XI) with the intention to relocate features observed in 1985 (gears and anchor) and determine association with the nine cannons. During this search on June 30, a 22-ft diameter pile of hemp-core, wire-rope rigging was located (Feature 4, Figure 14.1). Within the pile were mast caps, 5- and 6-in wooden deadeyes, forelock (keyed) iron fasteners and bits of Muntz metal. An anchor with a 10-ft shank was also located nearby along with associated stud-link chain. A lower top with a 2-ft diameter round portion and a 1 ft 9-in square portion was located, and an upper mast cap with round and square portions 1 ft 2 in inside measurements was also found (Murphy 1989a). The site was given a provisional field site-number until the proximity and association with the Nine-Cannon Site could be established. The gears and anchor observed in 1985 were not relocated.

This team dove another area in the Nine-Cannon vicinity during 1989 where they photographed the ballast pile atop wooden hull structure located by Nordby (Feature 2, Figure 14.1). This site, like the rigging pile above, was given a provisional field site-number until the relationship with FOJE 008 could be established. Both the rigging pile and ballast pile are now (1990) included under "Nine-Cannon Site (FOJE 008)," which was determined to be a complex, multicomponent site covering a wide area.

1990 Fieldwork

Fieldwork on the Nine-Cannon Site was conducted during two two-week sessions, one each in July and September. During the July session, a Maritime Archaeological and Historical Society (MAHS) team spent six days mapping on-site, and during the September session, nine days were spent by a joint NPS-MAHS team completing mapping operations (see Chapter XI). During these sessions, more than 2,000 ft of base line were laid with proximal artifacts and general environmental context mapped (Figure 14.1). Towed-diver visual searches were done in the general area for additional large features. Artifacts are widely scattered throughout this area; not all were mapped.

The base line tied together major features in the vicinity of the nine cannons and established provenience for areas observed in 1981 and 1989. The windlass gears and anchor observed in 1985 were relocated in 1991 during an instructor dive-training workshop with representatives from major dive-certification agencies. These features were tied into a point on the original 1990 base line. As a result, the windlass, anchor and chain features observed in 1985, the ballast and structural features and the rigging pile observed in 1989 were relocated and included as features of FOJE 008, rather than separate sites.

Site Description

Figure 14.1 depicts base lines and large feature relationships along with general environmental context (sand and coral areas). The dashed lines generally represent the area mapped.

Feature 1 includes the nine iron cannons, which are concentrated in two groups: a group of six to the north and three cannon about 120 ft to the south. The northern group of six covers an area about 60 ft x 25 ft aligned north-south, with two groups of three about 25 ft apart lying to the south. The remaining three cannons, about 120 ft south, are spread in a 130-ft line north-south, with each cannon about 60 ft apart. It is assumed that all these gun tubes are somehow related, and they represent a contemporary deposit. There is nothing that convincingly eliminates a multiple-event deposition sequence for these cannon except proximity, alignment and apparently contemporaneous guns.

The cannons will be discussed in north to south order. Cannon numbers are the order they were relocated in 1990. The northern group of three include cannons 3, 4 and 2. The next group of three include 6, 5 and 7, with 9, 1 and 8 making up the southern group. Table 14.1 presents basic gun-tube dimensions. These tubes were differentially encrusted with varying coral growth, and measurements are consequently incomplete and of variable accuracy (Plate 14.1). In some cases, tubes were measured by different teams, and the measurements varied somewhat. Encrustation obscured measurements and only partial measurements could be obtained on some guns. No diagnostic markings could be distinguished. Gun measurements are in Table 14.1.

The formula used to determine gun weights was $2.5(D^2L-5/6d^2l)$ as developed by O.F.G. Hogg (1970:266), where D = mean tube diameter, L = length overall, d = bore diameter and l = bore length. Some measurements, particularly bore length, were estimated for this analysis. Hoyt (1986:36) has observed the Hogg formula typically gives an estimate in excess of actual weight, consequently, for the table a length between the overall length and muzzle to base ring length was used for weight calculations. Table 14.1 weight estimates are therefore quite rough, as would be any estimates derived from encrusted gun-tube measurements. These measurements may be high because of inclusion of encrustation thickness. These measurements do, however, provide some data for basing a guess of gun characteristics for analytical purposes. All guns have low trunnions; i.e., mounted below the bore centerline.

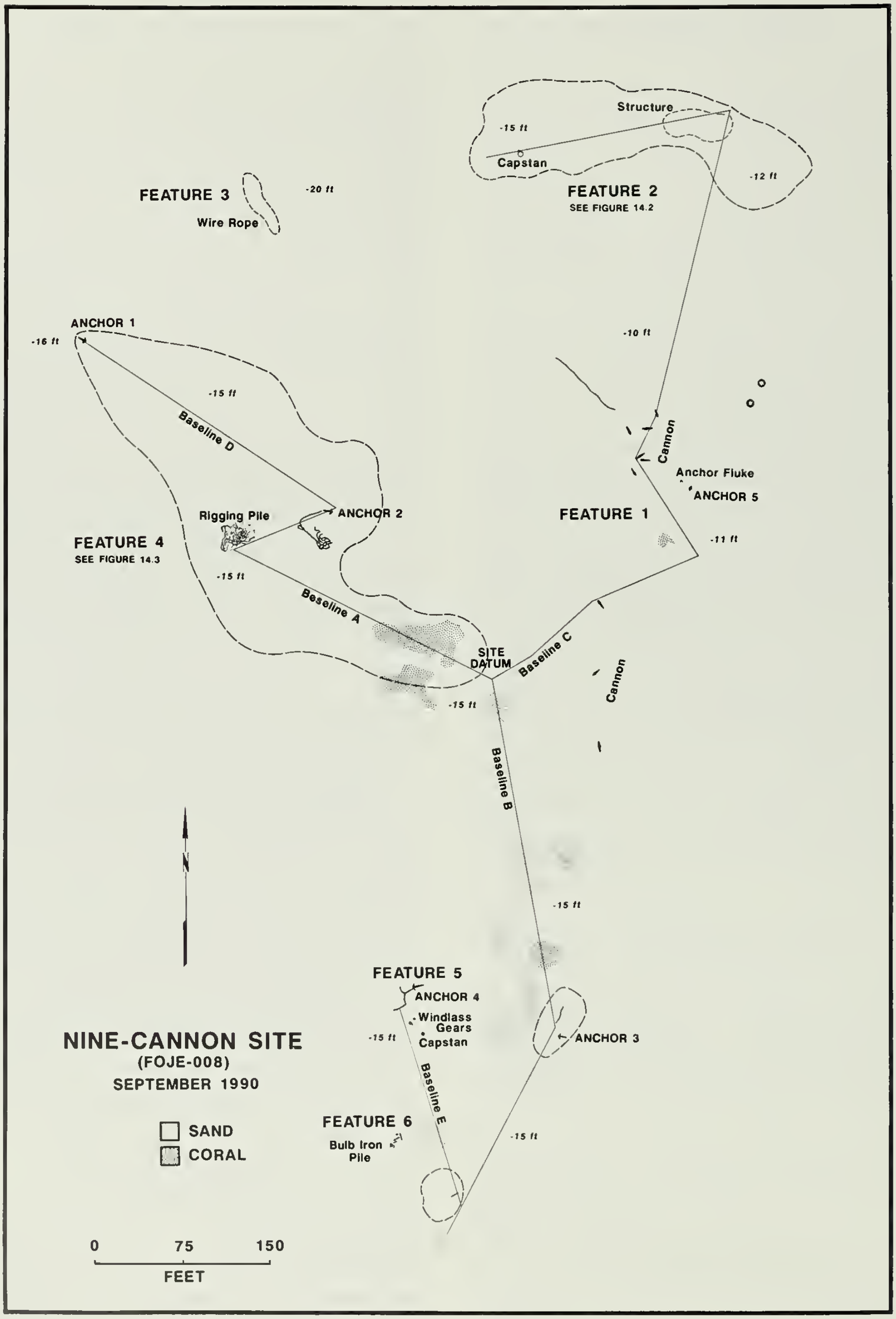


Figure 14.1. Principal features and base lines of the Nine-Cannon Site (FOJE 008) (1985, 1990 and 1991). A copper-clad site-datum rod was placed at the junction of the three base lines. Drawing by Jim Bradford.

Plate 14.1. One of the FOJE 008 cannons. NPS photo by Larry Murphy.

Hohimer (1983) has compiled a useful listing of various British Naval Gun Establishments that specify required gun characteristics from 1700 to 1815 augmenting Hogg's Appendix II that gives ordnance particulars (Hogg 1970:268). The most compelling measurement of the site's guns is overall length, bore diameters can generally be discounted except to note that the trunnion diameters for the 8-ft tubes are about 4 in. As early as the 1736 Establishments, trunnions typically equalled the bore diameter (e.g., Hohimer 1983:10). Examination of the British Establishments using tube overall length and weight estimates gives the following guess as to gun types. This analysis does not assume that the tubes are British, but does assume these Establishments generally reflect contemporary European practice and therefore useful in determining likely type and date.

These guns appear to be eighteenth or very early nineteenth century based on Hogg's general Establishment synthesis (1970:267, Appendix II). According to the synthesis, guns 3, 2, 9, 1 and 8 are 12-pounders, 4 is likely a 9 pounder, and 5 and 7 are most likely 4-pounders, but could possibly be 6-pounders. (During this period, guns were named for projectile weight.) However, examination beyond utilization of Hogg's general synthesis is useful to refine this analysis.

Given the gross Nine-Cannon Site gun-tube measurements and estimated weights, a more detailed examination can be conducted to see whether their characteristics fit any Establishment particularly well. These data are presented below. Utility of this exercise lies in determining date ranges and possible types for these guns. Establishment data from Hogg (1970:Appendix II) and Hohimer (1983) are in Table 14.2.

Table 14.1. Nine-Cannon Gun Tube Measurements

Cannon Number	Length Overall Inches	Muzzle to Base Ring	Trunnion Center to Muzzle	Trunnion Diameter	Base Ring Diameter	Muzzle Diameter	Bore Diameter	Estimated Weight CWT
3	103"	7'-10"	4'-5.5"	4"+	1'-4"	11"	6"(?)	26
4	84"	6'-2"	3'-4"			8"	3"(?)	17
2	101"	7'-8"	4-'8"	4"	1'-5"	10"	3.5"	29
6								
5	68"	5'-2"						
7	66"		3'-2"		11"	5"		8
9	105"	8-'2"	4'-7"	6"	1'-4"	9"	6"	21
1	98"	7'-9"	4'-5"	4"	1'-2"	9"	5.5"(?)	23
8	96"	7'-6"	4'-4"	4"	1'-5	8"		23

Table 14.2. British Naval gun establishments and the Nine-Cannon guns.

FOJE 003 Gun #	Hogg (1970:267) Synthesis	Naval Ordnance 1660-1685 (Hohimer 1983:6)	1743 Establishment (Hohimer 1983:12)	1753 Establishment (Hogg 1970:274)	1760 Establishment (Hogg 1970:275)	1764 Establishment (Hohimer 1983:25)	1776 Establishment (No 4 pounders)	1828 (Hogg 1970:276)
3	12 pounder	Larger Saker	9 pounder	9 pounder	9 pounder	9-12 pounder	12 pounder	9 pounder
4	9 pounder	Ordinary Saker	6-9 pounder	6 pounder	6 pounder	6 pounder	9 pounder	6 pounder
2	12 pounder	Large Saker	12 pounder	9 pounder	12 pounder	12 pounder	12 pounder	9 pounder
6								
5	4 pounder	Light Saker	4 pounder	4 pounder	4 pounder	4 pounder		
7	4 pounder	Light Saker	4 pounder	4 pounder	4 pounder	4 pounder		
9	12 pounder	Large Saker	9 pounder	9 pounder	9 pounder	9-12 pounder	12 pounder	6 pounder
1	12 pounder	Large Saker	9 pounder	9 pounder	9 pounder	9-12 pounder	12 pounder	6 pounder
8	12 pounder	Large Saker	9 pounder	9 pounder	9 pounder	9-12 pounder	12 pounder	6 pounder

Site FOJE 008 Gun-Tube Analysis

The Nine-Cannon tubes represent a group of probably contemporary tubes including 4-pounders, 6-pounders, and either 9- or 12-pounders, depending on which Establishment is applied. A review of particular gun types is helpful in narrowing down the time period and gun sizes.

Guns 5 and 7 are most likely 4-pounders. However, a 5 ft 6 in 3-pounder was in use between 1703-1716. The 5 ft 6 in 4-pounder weighing about 11 cwt was introduced in 1761 and used through the century (Hohimer 1983:4). These guns are more likely 4-pounders, rather than the earlier 3-pounder because characteristics of other guns suggest a post 1761 date.

Guns 1 and 8 appear to be very similar with lengths of 8 ft and 8 ft 2 in. The 8-ft 9-pounder was introduced in 1703, replaced by an 8 ft 6-in gun in 1716, reintroduced in 1743 and obsolete by 1770. However, an 8-ft 6-pounder was introduced in 1703 and weighed around 21 cwt in 1800 (Hohimer 1983:47). Guns 1 and 8 are most likely 6-pounders. Gun number 9 is most likely a 9-pounder. This size gun was introduced in 1716 and used throughout the century.

Gun 4, a 7-ft tube, could be either a 6-pounder or a 9-pounder. A 6-pounder was used until 1716, and the size was reintroduced in 1743 and in use in 1800. A 7-ft 9-pounder was also introduced in 1743 (Hohimer 1983:47-48). This 008 gun weight estimate is somewhat light for a 9-pounder. Insufficient data exist to make a firm distinction, but gun 4 is probably a 6-pounder.

Guns 3 and 2 are most likely 9-, possibly 12-pounders. Eight-foot 6 in 9-pounders of 26-29 cwt were introduced in 1716 and used through the century (Hohimer 1983:47). The 12-pounders of this length were introduced in 1743 and weighed about 31 cwt (Hohimer 1983:46).

The site's gun tubes were probably deposited in the last half of the eighteenth century because they best represent a post-1743 date. If the smaller guns are 4-pounders, then the cannon feature dates after 1761 and likely before 1770 when the 8-ft 9-pounders became obsolete. Cannons could, of course, be carried on vessels beyond date of obsolescence. If the cannons are from the latter half of the eighteenth century, then the eight measured guns on site most likely represent: 2 9- or 12-pounders (#3 and #2), 1 9- or 6-pounder (#9), 3 6-pounders (#4, 1 and 8) and 2 4-pounders (#5 and #7). These cannons should be measured again by one archeologist to ensure data consistency to verify this analysis.

The Establishments also specify number and size of cannons to be placed on particular British naval vessel classes. It should be a straightforward matter to determine which classes of vessels require 12-pounders, 9-pounders, 6-pounders and 4-pounders, and it may help determine whether the larger guns are 12- or 9-pounders, assuming of course, that vessels only carried prescribed guns. This determination aids site interpretation through suggesting which vessels may have carried the site's guns. Hypothetical explanations to account for the cannons and their distribution can be generated that can ultimately be tested against the archeological and documentary record.

Hohimer published required gun Establishments for 1757, 1761, 1762, 1780, 1792 and 1793. No vessel specified 12s and 9s together until 1780 for a 64-gun ship, which carried no 6-pounders, and in 1792, the 12s were replaced by 18-pounders (Hohimer 1983: 20, 21, 23, 37, 39). Assuming all the larger cannon are 9-pounders except for gun number 4, which appears to certainly be a 6-pounder, 9s and 6s were not specified together for smaller vessels until 1792 and 1793 when they were required for vessels of 24 and 28 guns.

Although the discussion includes post-1780 Establishments, the 008 guns were most likely made before this date if they are indeed British. Soon after 1780, a ring was added atop the cascabel button to hold the breech rope in place (Lavery 1987:94). None of the 008 cannon had a cascabel ring.

Presence of the 4-pounders supports a small vessel of the latter half of the eighteenth century. Four-pounders were used aboard quarterdecks of 30-gun vessels between 1716 and 1743, and aboard 24-gun vessels. The 4-pounder appears on gun lists until 1800, although it apparently was little used in the later period (Lavery 1987:103). Four-pounders were carried aboard ship-rigged sloops, which carried three masts. Those carrying 10 or 12 guns carried 4-pounders (Lavery 1987:123). Because of the larger tubes on site, the vessel was probably larger than a sloop.

The most probable small vessel that would carry the 008 tubes as primary battery is a 24- or 28-gun frigate. The peak of the 28-gun frigate was the 1780s when it carried 24 9s, with the earlier vessels carrying 4 3-pounders, and the later ones replacing them with 6-pounders (Lavery 1987:122). The 24-gun frigates carried 22 9s and 2 6s after 1760. There were also 20- and 22-gun frigates that are possibilities. These vessels carried 9-pounders and 3-pounders, although few were built, but 14 of these vessels were added to the fleet in the 1790s (Lavery 1987:123).

The assumption above is that the vessel that lost the 008 cannons was a smaller wrecked vessel. A problem with this hypothesis is that no iron ballast, structure or other artifacts have been located associated with the guns. The British navy adopted kentledge (iron ballast) for permanent ballast, and it was in common use by the 1750s (Lavery 1987:186). Typically both kentledge and shingle ballast were carried, with shingle ballast averaging four times the iron ballast (Lavery 1987:187). Neither iron ballast nor shingle was located anywhere on site, and it is unlikely to have been salvaged. If these cannon are from a small vessel of the latter half of the eighteenth century as the cannons indicate, the hull should be nearby. Possibly the loss of these cannons lightened the hull sufficiently to pass into very shallow water to the south where it broke up or escaped the shallows. Additional site survey is needed in the area.

Another hypothesis is that the Nine-Cannon Site gun tubes are from the upper decks of a larger vessel, and the scatter represents a north-south wreckage trail of a vessel in serious storm distress. The site depths run from 15 ft in the north to about 11 ft depth at the cannons increasing to about 15 ft at the southern site area, which may indicate a probable north to south vessel path because the open sea lies to the northeast of the site. Examination of British Establishment upper-deck armament provides the following possibilities for larger vessels carrying the 008 9- and 6-pounder guns: in 1757, 9s and 6s are found on vessels of 60, 50 and 44 guns; 1761 9s are prescribed for vessels of 80 and 44 guns (none require a 6-pounder); 1762 no 9s and 6s required together; 1780 80- and 44-gun vessels have both; and 1792 50-, 28- and 24-gun vessels have both 9 and 6-pounders. Of course, all the larger vessels (except the 1792 28- and 24-gun warships) would have larger cannons associated on lower decks. The larger cannon could be 32-, 42-, 24- or 18-pounders. The obvious test of the hypothesis that the 008 cannons represent upper deck armament of a large vessel is to magnetically survey the area to determine whether any of the larger guns are in the area. Most likely, they would be inshore (probably south) of the site cannon scatter.

It is also a possibility that the cannon scatter represents the only evidence of a grounding. Deeper water is located both north and south of the site (more than 16-ft depths about 300 ft north, and about the same depth around 350 ft south). Possibly, a vessel entered from north to south, hit the shallower water, dumped the guns, which lightened the vessel sufficiently to cross the 11-ft shallows to deeper water. Without location of additional structure, this may be the most likely explanation of the nine cannons of Feature 1.

Another hypothesis, suggested by the 1971 site recorders, is that the cannon represent permanent ballast of one of the two later vessels whose remains comprise other 008 site features. This possibility is unlikely. Ballast cannons aboard merchant vessels has been a much discussed subject, however, documentation of the practice is rare. This possibility would be more supportable if other ballast and hull-bottom features were located in the immediate cannon-scatter vicinity. The nearest ballast and hull bottom features are Feature 2 (discussed below), which is 280 ft north of the northern-most cannon, in deeper water (Figure 14.1). It is very unlikely the cannons are associated with this hull bottom because of proximity and age disparity.

In summary, the 008 gun tubes of Feature 1 represent a contemporary deposition of 9-, 6- and 4-pounders probably from the last quarter of the eighteenth century, likely dropped from a small vessel that passed across the shallows. The available data point to a grounding event, rather than a shipwreck.

Feature 2

This feature is composed of a wooden hull-bottom portion, ballast, steam fittings, ground tackle, iron rigging, structural elements and deck furniture representing a shipwreck that broke up in a relatively discrete area. Figure 14.2 represents about 4,300 sq yds of mapped seabed containing the majority of this wreck site.

Hull Structure. The 55 ft x 25 ft section of hull bottom is from amidships; there are no clear bow or stern indications; no cant frames are visible. It may be assumed that the western end is the bow section because it faces the ground-tackle features. No excavation was done.

The structure is fastened with 1 1/4 in diameter copper-alloy pins with 2-in diameter clinch 1 1/2 in diameter trunnels. The frames are 12 in sided. molded dimensions were not obtainable. According to *Rules of the Classification of Wooden Vessels* (nd: 50 Table No. 2 Dimensions of Timber) a vessel of 1,200 tons requires 12-in sided floor timbers of white oak. Softer woods require a 15-20 percent increase. Assuming a 15 percent increase, a 500-700-ton vessel would require 12 in sided floor timbers of wood softer than oak (equivalent to 10 1/2 in of white oak).

Wood Analysis. Structural wood samples were collected in June 1989 and September 1990 and submitted for analysis (Dean 1990, 1991). Samples collected in June 1989 were: FS 689-7- trunnel, identified as maple (*Acer*); FS 689-8-frame, was poplar (*Populus*); and FS 689-9-hull-plank, identified as pine (*Pinus*, 12 rings) (Dean 1990). Additional samples were collected by the team documenting the site in September 1990: FS 10-hull plank, *Acer*; FS 11-frame, *Acer*; FS-12 trunnel, a diffuse porous nonconifer with prominent ring boundaries and rays (unable to be more specific); FS 13-ceiling, Douglas fir (*Pseudotsuga menziesii*) or some species of true fir (*Abies*) or spruce (*Picea*); FS 15-keelson, large species of pine (*Pinus*). [It is unknown why the frame samples do not agree, one identified as poplar, the other maple. Because no classification rules examined mention poplar, the frames are assumed to be maple for this analysis.]

Maple, which does not corrode iron fasteners as does oak, was used for floors in the American northeast (Hall 1880:102). Pine, especially southern pitch pine was frequently used for keelsons beginning in the last half of the nineteenth century. Fir has been commonly used on the west coast for shipbuilding (Hall

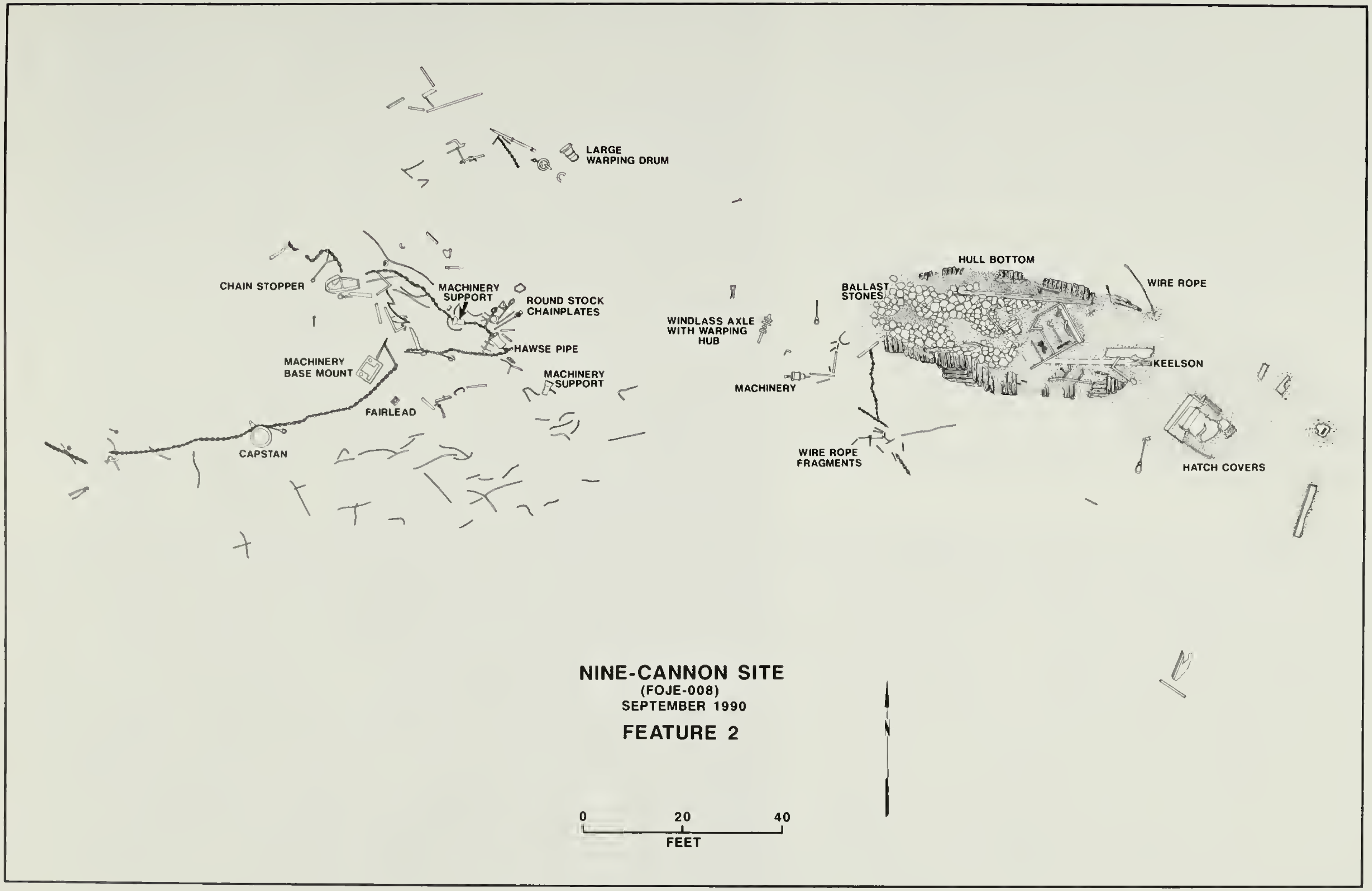


Figure 14.2. Feature 2 area of Nine-Cannon Site. Drawing by Larry Nordby and Jim Bradford.

1880:134; Davis 1918:57), however, this ceiling sample may be spruce. Douglas fir was one of the most important American shipbuilding woods at the turn of the nineteenth century (Estep 1918:7-8). All woods used had a rating of 11 or 12 years, except for maple frames, which were rated for seven years. Poplar was not listed (Table No. 1: Showing the Number of Years Assigned to Different Kinds of Timber, *Rules for the Classification of Wooden Vessels* nd:49). Indications are that this vessel is a high quality, perhaps northeastern American-built hull.

Ballast. There are about 40 tons of irregular rock ballast on Feature 2. On-site ballast can be used to generate a rough estimate of ship size by comparing with ballast amounts of known vessels sizes. This is a small amount of ballast on this structure based on Middendorf's (1903) ballast factor (obtained by dividing ballast tons by vessel's gross tons). Assuming a ballast factor of .256 (obtained as an average of documented west-coast lumber vessels (Anon. nd)) would give only an estimated 150 gross tons for the vessel (obtained by dividing the ballast by the ballast factor). Halving the ballast factor gives an estimate of about 300 gross tons--both much too small for other vessel attributes. Additional hypotheses are: 1) the vessel was of a design that required little permanent ballast; 2) ballast was lost elsewhere or has been removed; or, most likely, 3) this vessel was heavily laden and its cargo has been removed or has deteriorated.

Rigging. There is much 1 1/2-in diameter hemp-core wire rope in the area. This measurement, like the others, includes encrustation, which was thin on the wire rope. This wire rope was part of the standing rigging. Chainplates, constructed of iron round-bar stock, indicate deadeyes and lanyards were used for rigging.

Wire rope was developed in Great Britain perhaps as early as the 1830s (Macgregor 1984:150-151) and in naval use in the 1840s (Wallace 1856:194), but did not come into common use in America until after the Civil War (wire rope is not mentioned in an American book on spars and rigging practice, Murphy and Jeffers 1849, and its large-scale US manufacture began only after the Civil War). In the 1850s, most large British ships had wire standing rigging with deadeyes and lanyards (Macgregor 1984:151). Rigging screws (turnbuckles) first appeared in general use on larger vessels in the mid-1870s (Murray 1961:145), although they were described as early 1856 (Wallace 1856:193). Wire rope apparently was accepted by the International Board of [Great] Lake Underwriters by 1876 (Dorr 1876:76-77), and wire rope was used for standing rigging on the majority of Great Lakes vessels by 1880 (Hall 1880:139). It is assumed that Great Lakes practice reflected general US practices, although size requirements for these vessels were less than for ocean carriers. Consequently, the hemp-core wire rope on site indicates a date likely no earlier than the 1850s if a British vessel, more likely the mid-1870s or later, because the vessel appears US built because of the woods employed (especially Douglas fir and maple). It is uncertain how long deadeye-and-lanyard use persisted in general practice after the 1870s, but they appear on smaller, wooden US vessels built after 1900.

Wire-rope diameter is useful for estimating vessel size. Wire rope, unlike chain, is measured and specified in shipbuilding classification rules by circumference. The 1 1/2-in wire rope found in the area gives about a 4 1/2 in circumference. Great Lakes vessels required 4 in circumference wire rope for use as lower rigging and stays aboard a 600-ton vessel, and 4 1/2 in wire rope aboard an 800-ton vessel. This provides a vessel size range. However, it is high because, typically, requirements were a bit less for lakes vessels than ocean carriers, and the field measurement included encrustation.

Iron-rod, or bar-stock, chainplates are clearly associated with Feature 2 (Plate 14.2, Figure 14.3). These 5 ft long chainplates are made of 1 1/2 in-bar stock. There are 1 ft 2 in long x 1 1/2 in chainplate preventer bolts and half-inch-thick backer plates present. The backer plates are 1 ft 7 in long and contain two bolts, which generally indicates hardwood attachment. The chainplates accommodated a 1 ft 1 in deadeye. Chainplate length and deadeye size clearly indicate lower, rather than upper shrouds. Round, iron bar-stock chainplates appeared earlier than the flat-bar chainplates that appeared in the latter part of the nineteenth century. For example, as found aboard C.A. THAYER, a National Maritime Museum, San Francisco, schooner built in 1895 that is rigged with flat-bar chainplates. In addition, short sections of open-link chain of 1-in diameter were located. This chain was probably part of headgear rigging such as bobstay or martingale chains.

Ground Tackle. Some of the most prominent site features are the chain cable and 4-ft diameter capstan (Figure 14.4). There are about 140 ft of stud-link chain cable in the immediate area (Figure 14.2). The chain is not wrapped around the capstan. Probably a windlass was employed for cable operations, and portions of a steam windlass are on site. Additional features are the 2 ft 9 in long, 11 in internal diameter hawse pipe, cable stopper and iron structural support features that indicate the vessel's bow deteriorated in the

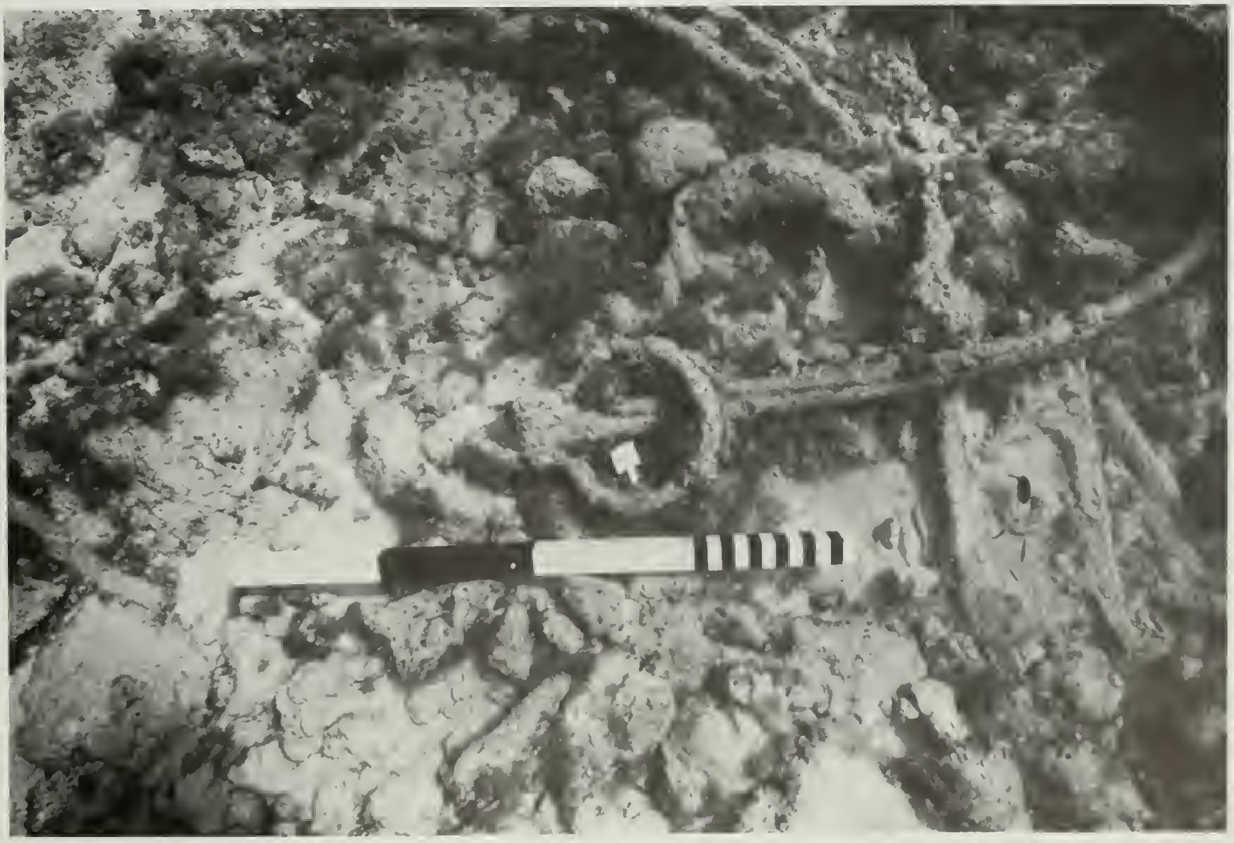


Plate 14.2. Round-bar chainplates associated with Feature 1. NPS photo by Jim Bradford.

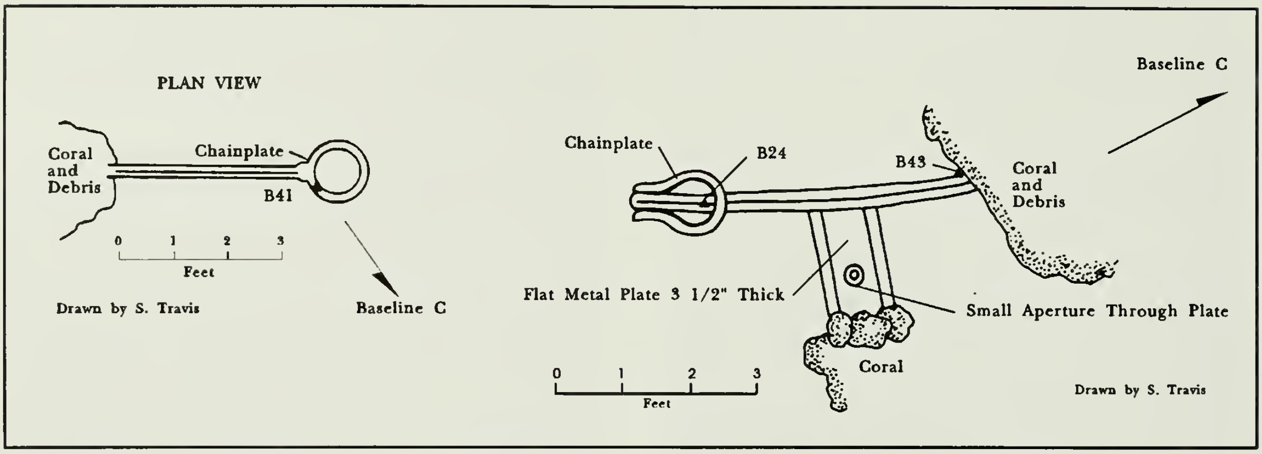


Figure 14.3. Two examples of 008 round-bar chainplates. Drawings by Scott Travis.

western area of Figure 14.2. No anchors were located clearly associated with this site. However, some were located in the area (Figure 14.1) and are discussed below.

The stud-link chain is 1 1/2 in in diameter; chain cable is measured in diameter. Encrustation probably makes the measurement somewhat in excess of original diameter. Examination of vessel classification rules provides an estimate of the original vessel size based on chain cable size requirements. The *Rules for the Classification of Wooden Vessels* (nd:Table No. 4 Chains and Anchors for Sailing Vessels) requires 1 1/2-in chain cable for a vessel of 600 tons, and 1 1/4 chain for a 300-ton vessel (Campbell 1974:49). Lakes vessels required less chain thickness. For example, 1 1/4-in chain was required for a 400-ton vessel, and a 800-ton vessel required 1 1/2-in diameter chain (Dorr 1876:77).

Machinery. Numerous machinery parts and sections of 6-in diameter pipe were located including a steam engine used to power deck machinery, machinery mount base-plate, wheels, shafts and other items indicating this vessel carried steam-operated deck machinery, which dates the site to at least the last half, more probably last quarter, of the nineteenth century.

Additional diagnostic features are two 8 ft 6 in+ wide iron or steel hatch covers, one atop the ballast pile and one to the west of the structure. Little information could be located about dating these features. Because of American iron production dates, assuming this is an American vessel as the wood species indicate, these hatch covers would place the vessel loss likely no earlier than 1880s.

Feature 2 Conclusions

Indications are that this site is an American -built merchant vessel dating to the last half, more probably last quarter, of the nineteenth century. Principal diagnostics are shipbuilding wood, wire-rope rigging, chain-cable size, iron or steel hatch covers, and steam machinery. The vessel was about 600 tons in size, iron reinforced, and, because of the small amount of ballast, carrying a full cargo of heavy materials, which was likely salvaged or has perhaps deteriorated. Lack of associated

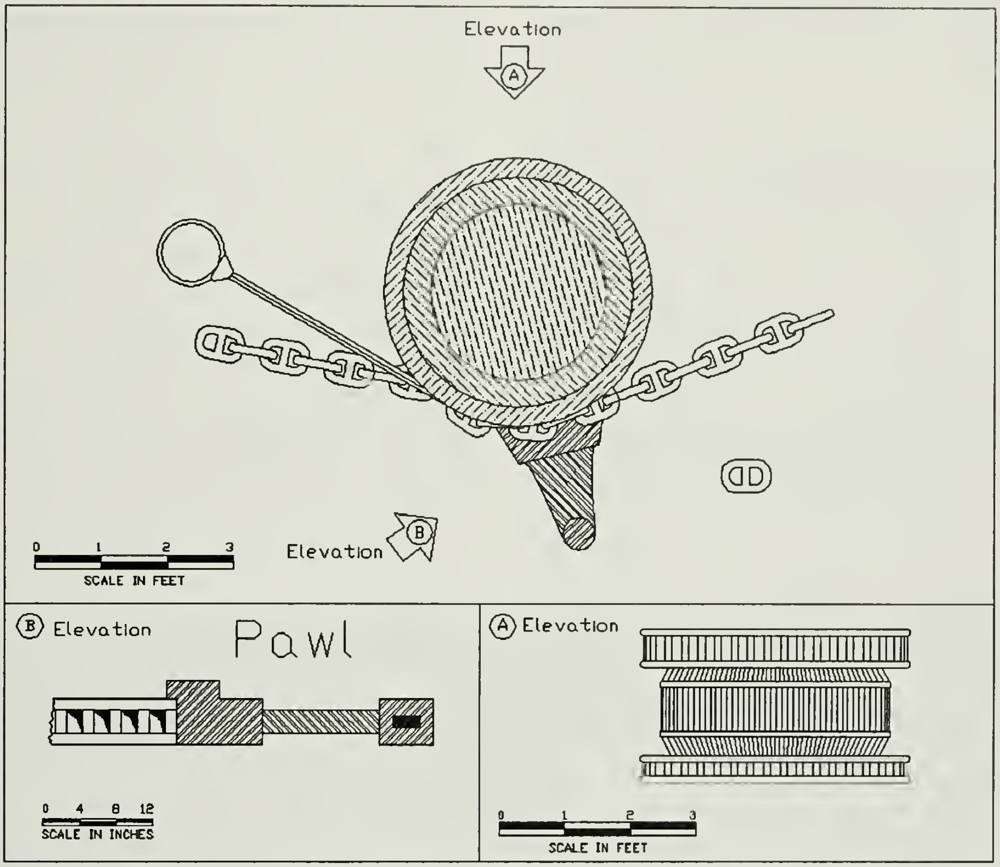


Figure 14.4. Capstan and stud-link chain associated with hull structure of Feature 2. Original field drawing by John Seidel; Autocad drawing by Tim Smith.

rigging indicates salvage activity. Because of limited time on site for feature examination, further work is needed to substantiate and augment this analysis.

Feature 3

This feature is primarily a concentration of wire rope fragments. These fragments are similar to those found on Features 2 and 4, and consequently, could be associated with either feature. Detailed measurements and further examination of this feature are needed to determine association.

Feature 4

Feature 4 consists of material associated with a 22 ft diameter wire-rope rigging pile recorded by Murphy and Gould in 1989. At first inspection, we thought the rigging pile may have been collected and jettisoned during a salvage operation. However, location of chain, iron bars, numerous hull fasteners, mast caps and other material indicates the area is more representative of a primary wreck site, rather than a secondary deposition (Murphy 1989a).

The rigging pile contains at least six 8-in diameter shroud deadeyes; iron, fore-locked hull-fasteners 32 in x 1 3/4 in; iron bars 3 in x 1 in x 6 ft; a mast ring 7 in wide and 15 in in diameter; and two mast caps, one with 2 ft diameter inside measurements (Plate 14.2), the other, 1 ft 2 in inside measurements. The larger is probably a lower top, the smaller an upper. There is a piece of steam-driven machinery with a spoked wheel 3 ft across and 5 in thick attached to a 3 1/2 in geared shaft to the south of the pile.

One of the most diagnostic elements associated with this feature is flat iron-strap (or flat-bar) chainplates (Plate 14.3, Figure 14.5) located within 100 ft of the rigging pile. These chainplates contain deadeyes similar in size to those attached to the shrouds within the pile, indicating likely association. Presence of these chainplates, which are smaller and of a different style than the bar-stock chainplates of Feature 2, provide clear evidence that these two features unquestionably represent two different vessels. A single vessel would not be carrying both types and sizes of chainplates. The vessels are roughly contemporary, with the vessel carrying the shrouds of Feature 4 a possibly smaller, probably later, vessel.

Associated with the rigging pile and contained in the Feature 4 designation are two undeployed anchors. The anchors lay flat on their arms, with anchor 1's shank elevated about 40° above the bottom (Plate 14.4). Multiple anchors are expected on wreck sites. Ships normally carried many anchors, for example midnineteenth century vessels were required by classification rules to carry at least two bower anchors, a stream anchor and a smaller kedge anchor. The bowers were normally carried on deck for ready deployment in coastal waters. The stream and kedge anchors would likely be below decks. Classification rules specified necessary sizes for each anchor relative to vessel tonnage, although in practice anchor sizes varied somewhat being more commonly larger than specified. If the ship were in distress, the bower and other anchors might be deployed and perhaps lost; smaller anchors would, consequently, be more likely to be found near the structure of a shipwreck.

The anchor at the end of base line B, designated anchor 1 (Figure 14.1, Plate 14.4) is 9 ft 5 in in length with arms 7 ft 4 in wide. The anchor has a collapsible iron stock, a feature that appeared in 1860 (Campbell 1974:49). No chain cable was attached to this anchor.

Anchors were normally specified by weight. Estimated anchor weight in hundred-weights (cwt=110 pounds) is generated by a midnineteenth century formula: Anchor weight in CWT = Overall length^3 x .0114 (*Cyclopaedia of Useful Arts* 1854:np). Anchor 1 weighs about 9.7 cwt or 1,075 lbs. The *Rules for the Classification of Wooden Vessels* (nd:53, "Table No. 4 Chains and Anchors for Sailing Vessels") requires a bower anchor of this weight for a vessel of 200 tons. A stream anchor of this size aboard a vessel of 700 tons, which is more likely the size vessel carrying the rigging found on site. This anchor was unrigged, and likely stowed below decks, which supports its use as a stream anchor.

Anchor 2 lies directly northeast of the ballast pile. Detailed measurements were impossible because of heavy coral growth. Overall length was 10 ft 2 in, giving an estimated weight of 12 cwt or 1,320 lbs. This anchor is associated with 1 1/2 in diameter chain cable. Campbell estimates an anchor of this length would be for a vessel of 500 tons (Campbell 1974:49). By weight, this size bower is required for a vessel of 250 tons; a stream anchor aboard a vessel of 1000 tons (*Rules for the Classification of Wooden Vessels* nd:53). However, a 1,000-ton vessel requires a 1 3/4-in diameter chain, much in excess of anything found on site.

Feature 5

This feature was originally located in 1985, and not relocated until 1991 during a one-week training workshop in underwater archeology for sport diving certification agency representatives. Feature 5 is in the southern part of the site area (Figure 14.1). The feature consists of stud-link chain, an anchor, a hawse pipe with stud-link chain inside, wooden structure beneath a small anchor whose shank is raised about 30° to 40° above the seabed, a set of iron gears and a small capstan.

This anchor was rigged for use; there is open-link chain shackled to the upper end of the shank. It appears to be fouled in stud-link chain (Plate 14.5). The shank is 5 in square, and it is 8 ft 6 in-long over all. The length of the arms is 5 ft 5 in. The anchor weight is 7 cwt, or 770 lbs. A 100-ton vessel required a bower this size; a 700-pound stream anchor was required aboard a 500-ton vessel, a kedge anchor of this size aboard a 1,200-ton vessel (*Rules for the Classification of Wooden Vessels* nd:53).

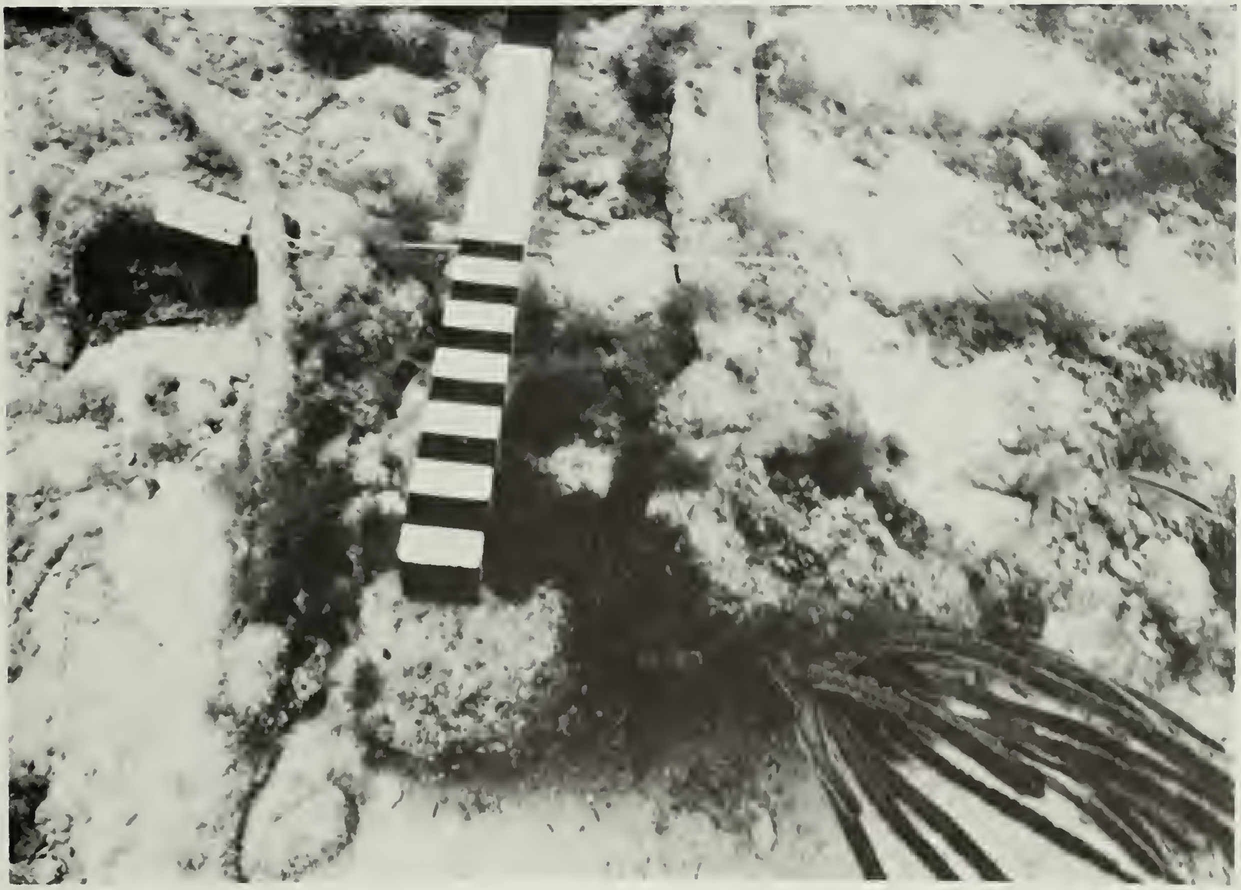


Plate 14.3. Flat-bar chainplate associated with the rigging pile of Feature 4. NPS photo by Larry Murphy.

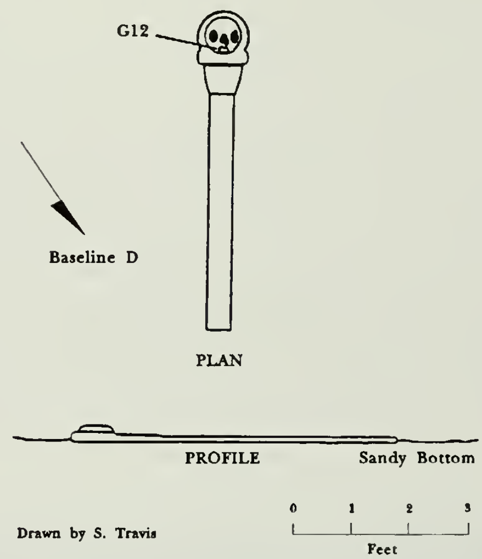


Figure 14.5. Example of flat-bar chainplate associated with the rigging pile of Feature 4. Drawing by Scott Travis.

The following description was done by the 1985 investigators:

> ...The anchor was rigged, but not deployed, which points to it being a stream or kedge [anchor]. The flukes came to rest on the bottom with the shank supported by the wooden stock while it concreted in place. The stock has decayed and left the anchor shank sticking up in the water column....
>
> Hand fanning directly under the crown of the anchor revealed wood and ... Muntz-metal sheathing....

The 1985 investigators' speculation was that this anchor was a kedge anchor. However, location of a capstan, which is 2 ft 7 in high with a base diameter 2 ft 6 in, supports this anchor being a stream anchor. This capstan is of a size appropriate for a vessel much smaller than 1,200-tons. There were few other artifacts diagnostic for size located.

Stud-link anchor chain has also concreted above the seabed, most likely, as was surmised in 1985, while supported by wooden structure, which has since disintegrated. Presence of stud-link chain does indicate a wreck date later than 1819, however, the Muntz-metal hull-sheathing beneath the anchor dates this feature more likely after 1850. Muntz metal (also called composition metal and yellow metal) was patented in the 1830s, but apparently did not come into common use until midcentury (Ronnberg 1980:141).

Research on the gear wheels (Plate 14.6 and 14.7) since 1985 confirms these gears are part of a wooden windlass. A similar windlass from the latter half of the nineteenth century is in Figure 14.6. The gears are the windlass pawl rims and purchase rims, the wooden portions have deteriorated. No other iron portions of the windlass were observed on site in 1985.

The pawl rim is 2 ft in diameter with 1 ft 8 in inside diameter and 4 in wide pawl. The

Figure 14.4. Anchor 1 near Feature 4. Anchor is unrigged and not deployed. NPS photo by Larry Murphy.

purchase rims are 2 ft 3 in in diameter, and 1 ft 6 in inside diameter.

Additional bow features in the area included hawse pipes, one with chain cable inside. South of the gear wheels was a bobstay, part of the ship's headgear. The bobstay had an internal diameter of 5 in. Southwest of the gears some iron breast hooks were observed, but not measures.

Anchor 3 is located directly east of Feature 5. This anchor has a length of 8 ft 10 in, giving an estimated weight of 7.8 cwt or 858 lbs. This anchor is similar in size and weight to the one of Feature 5. Stud-link chain cable of similar dimension to that of Feature 5 was located in proximity. Anchor 3 is considered part of Feature 5 because of similarity of anchors and chain.

Feature 6 (Figure 14.7) is bulb iron most likely associated with the vessel represented by Feature 5.

CONCLUSIONS

The Nine-Cannon Site is a complex, multicomponent site consisting of at least

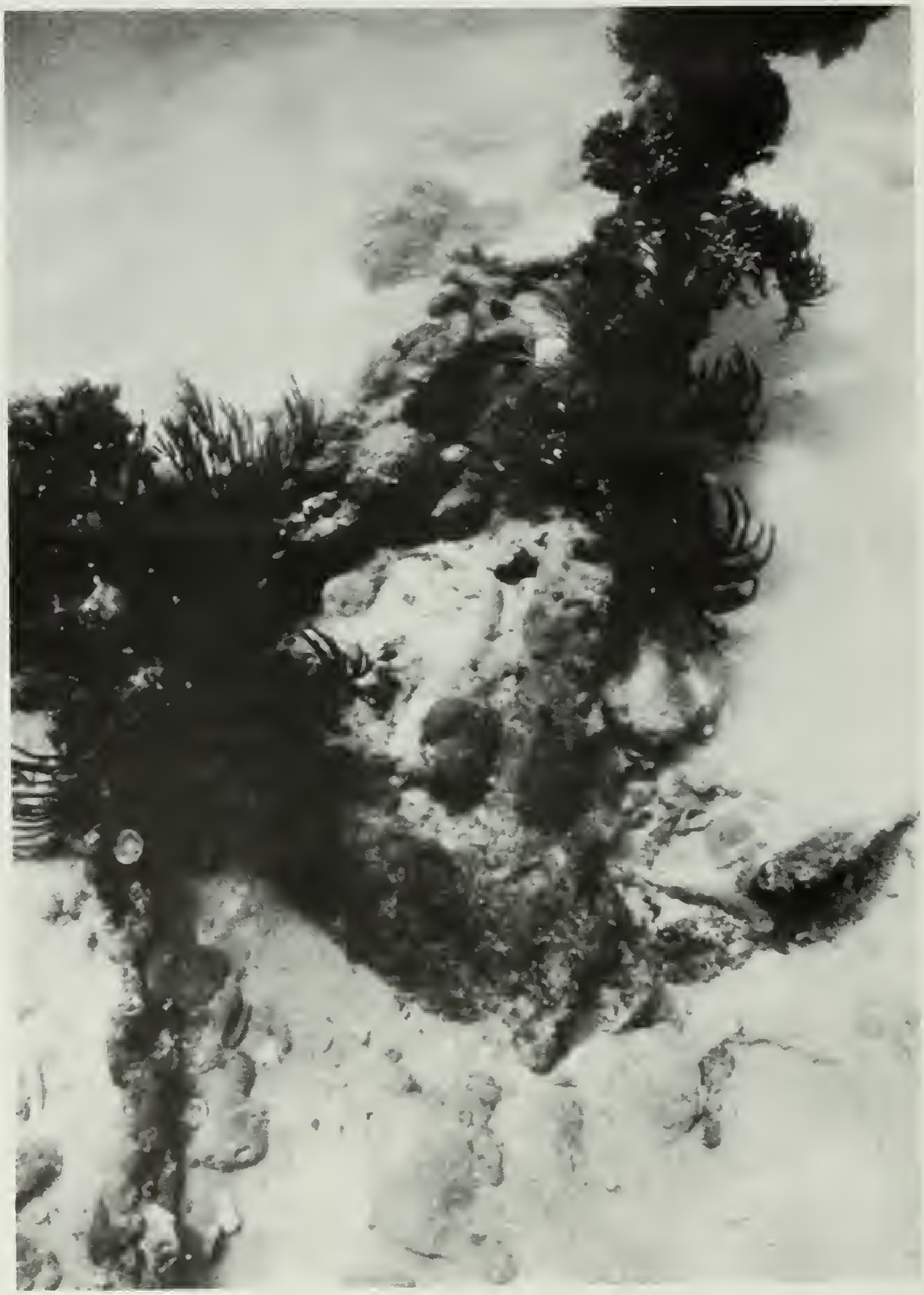


Plate 14.5. Anchor flukes with open-link chain visible. NPS photo by Larry Murphy.

three, possibly four, casualty sites spread out over a wide area. Feature 1 is likely the only evidence of a grounding; Feature 2 is about a 600-ton vessel and different from Feature 4, which is a perhaps a smaller, later wreck. Feature 5 may represent another wreck entirely, or, less likely, could be related to Feature 4. Indications are, however, Feature 5 is a discrete site. Because FOJE 008 lies closer to the northern edge of Loggerhead Reef, the probably path for a vessel striking this reef portion is from north to south. It is

Plate 14.6. Wooden windlass pawl rims and purchase rims. NPS photo by Larry Murphy.

less likely, though not impossible, that a vessel could have made it to this area coming from the south. Interpretation has assumed north to south track. Feature 5 definitely represents deposition of a ship's bow in this area (iron breast hooks were also found in the area). Feature 4 reflects generally amidships rigging, with no bow representation, except for anchor 2, which is associated with chain cable.

HYPOTHESES DISCUSSIONS

Primary hypotheses represent the most likely interpretation based on current evidence. Secondary hypotheses are residuals, possibilities, but not likely. Further testing and documentation are necessary to augment present interpretation and test these hypotheses.

Primary Hypotheses

1. Feature 1 is a discrete grounding event. Most likely hypothesis based on evidence.

2. Features 2 and 4 represent separate events. Evidence strongly supports this hypothesis, especially different size and style of chainplates associated with each feature. Indications are that Feature 2 was salvaged.

Plate 14.7. Close-up of wooden windlass pawl rims. NPS photo by Larry Murphy.

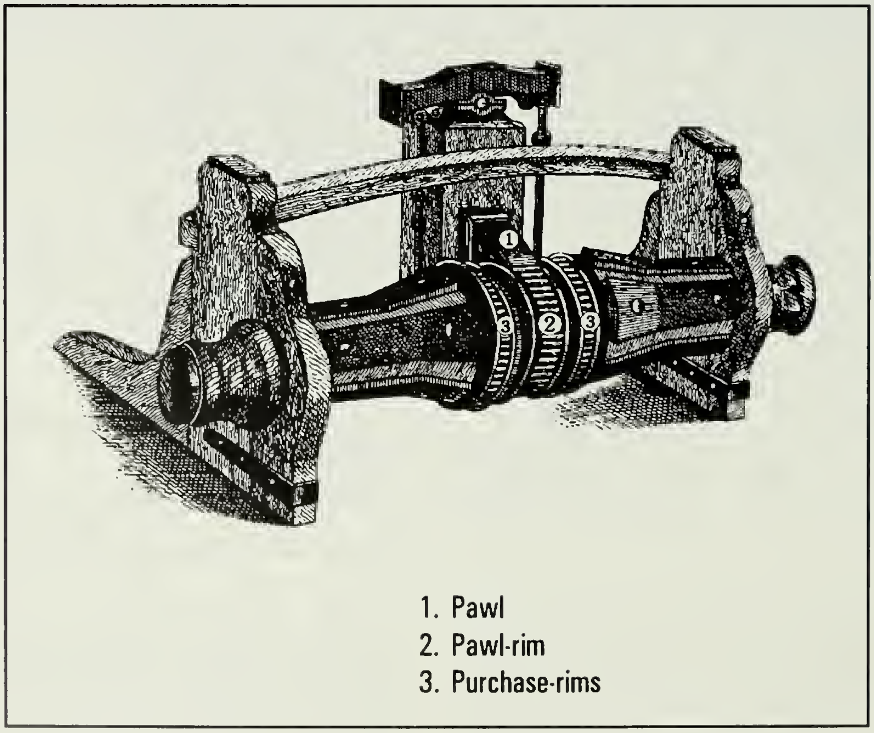


Figure 14.6. Drawing of wooden windlass from the midnineteenth century (after Paasch 1890:Plate 70).

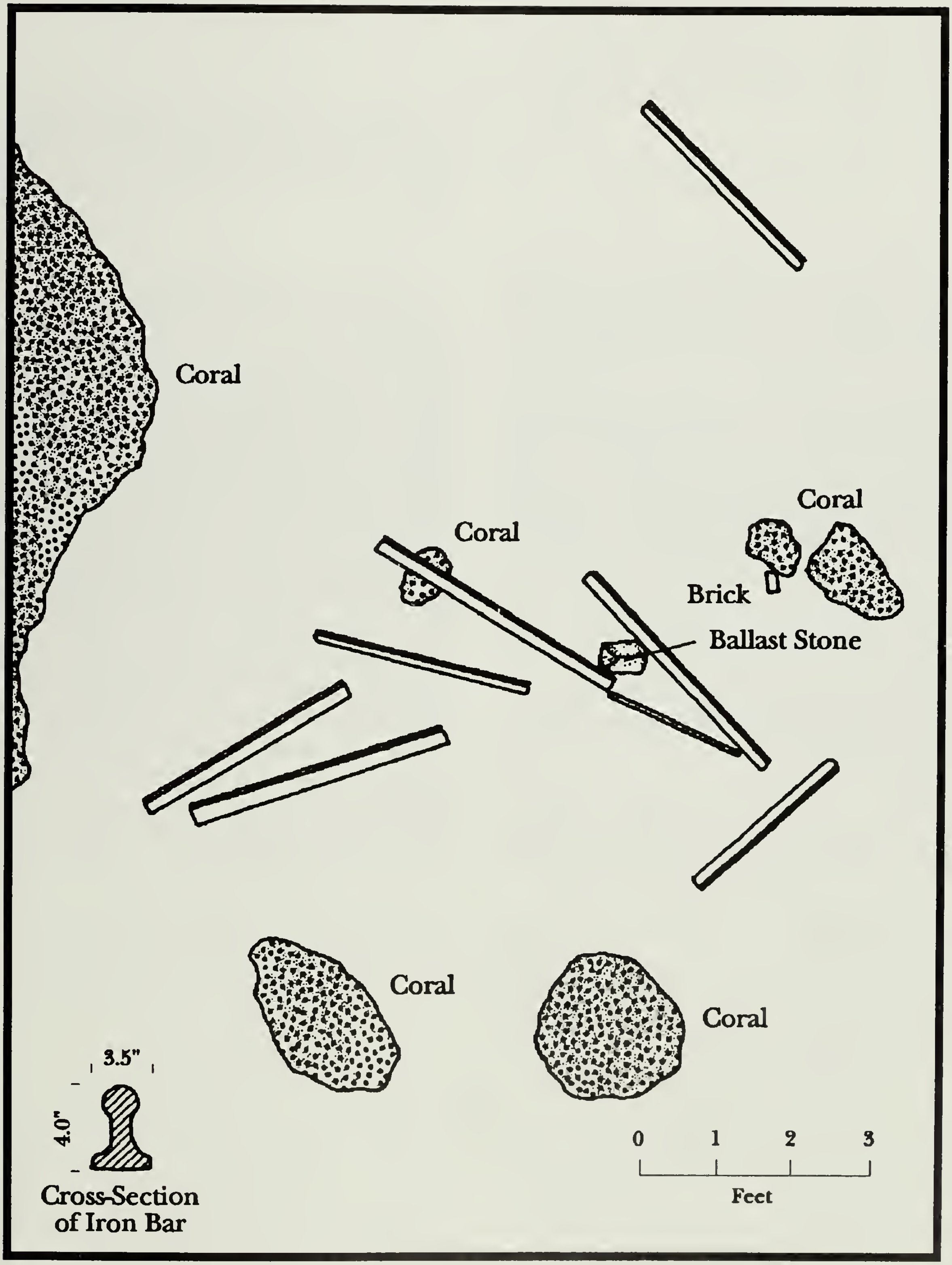


Figure 14.7. Feature 6, bulb iron scatter. Drawing by Scott Travis.

3. Feature 5 is a separate event. This is most likely. There is little evidence to connect this feature with other features, however, extensive survey and continued mapping may provide more evidence.

Secondary Hypotheses

1. Feature 1 is associated with Feature 2. Must somehow account for age disparity between cannon and structure and explain south to north distribution from shallow to deeper water.

2. Features 2 and 4 are a single wreck. Must explain difference of chainplate types. Supporting evidence for hypothesis is that wreck features are contemporary, and vessel sizes represented by both features are similar.

3. Features 5, 1 and 2 represent a single wreck scatter. This can be discounted because of duplication of bow features (hawse pipes, windlasses, capstans) in Features 5 and 2. Deck machinery of Feature 5 was manual; Feature 2, steam driven.

4. Features 5 and 1 are associated, This is a logical possibility. However, indications are that Feature 5 is much later (50-100 years) than Feature 1, and this hypothesis relies on south to north vessel track.

5. Feature 5 is associated with Feature 4. Assumes south to north vessel track. There is little evidence upon which to connect these features.

This site is methodologically one of the most challenging so far investigated at Fort Jefferson NM. The site clearly needs much more work, being the least documented of the 1990 fieldwork sites. An important aspect of this site documentation is a high-resolution remote sensing survey to magnetically determine site extent. Bathymetry of the area is also important for site interpretation, especially to determine likelihood of vessel tracks across the area. More on-site documentation is necessary to trace separate wreck events and produce a comprehensive site report. Further field documentation should not be attempted, except for specific features such as the ballast area, without remote sensing and electronic positioning. The fieldwork and analysis presented here should be seen only as a first cut at interpreting this complex area.

CHAPTER XV

Archeological Record: East Key Construction Wreck (FOJE 011) Fieldwork Prior to 1990

Larry E. Murphy

PAST WORK

The 1971 SEAC survey first recorded the East Key Construction Wreck June 15. The site was discovered by magnetometer, which recorded a 2,960-gamma reading (probably the "iron pile," see Chapter XVI). The Florida Underwater Archaeological Research Section (UWARS) site card notes that three types of "iron ballast blocks," some wood, bronze fasteners, scattered bricks and iron fastenings were located. Also noted were "slate" flagstones similar to those at the fort, granite, cement barrels and metal ingots. Some flat rock fragments were taken for comparison to the fort's flagstone; results were not reported.

The Construction Wreck is currently marked with a wreck symbol on NOAA Chart 11438 in its correct location. There is no wreck symbol on the earlier C&GS Chart 585, which was used by the 1971 survey team. The 10-ft deep site lies 400 yd inside the 30-ft contour marking the shoal edge east-southeast of the site (see Figure 16.2).

1989 FIELDWORK

This site was visited June 28 and 29, 1989. Participants were Fort Jefferson National Monument (FOJE) employees L. Doyle, P. Given, and A. Brown along with archeologists R. Gould and L. Murphy, who sketched the site to determine the nature of features, site extent and use for planning future work. Investigation technique was for two divers to lay out a 300-ft long tape along the site's center from a structure feature that appeared to be near the northwest site extremity. Divers recorded compass directions and swam perpendicular transects to ascertain scatter extent. Pat Given, on snorkel, drew a quick site sketch using the tape as control. Gould sketched features and Murphy wrote descriptions and photographed. Six field samples were collected for analysis.

Site Description

A brief site description will be presented based on the 1989 reconnaissance; subsequently, the site was investigated more completely in 1990 by Donna Souza (see Chapter XVI). This site is a shipwrecked sailing vessel apparently carrying building materials for Fort Jefferson (Plate 15.1).

Numerous quarried rectangular stone blocks are present, some with very flat sides, while some appearing rougher. Ten blocks were measured; the range was 4 1/2 ft to nearly 8 ft long, by 1-3 ft wide and 3, 4, 5 or 6 in thick. These were identified as likely flagstone blanks for Fort Jefferson.

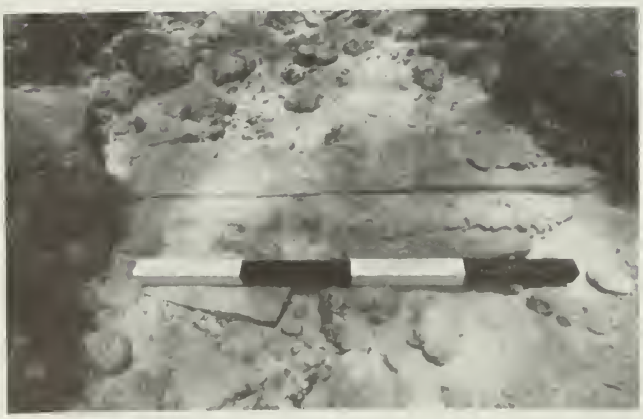
The ship carried numerous barrels of material that hardened in barrel-shaped casts. No barrel staves or iron hoops were observed. Many barrels lay in orderly lines end to end as they would have been stowed aboard ship, indicating some well-preserved portions of the site. A pile of roughly 4-in x 4-in ferrous, rectangular blocks of various lengths was

Plate 15.1. East Key Construction Wreck cargo. NPS photo by Eugene T. Rowe.

Plate 15.2. Capt Cliff Green removing a sample in 1989 from a stone block on FOJE 011 for analysis and comparison with Fort Jefferson flagstone. Sample was graywacke, the same material as the fort's flagstones. NPS photo by Larry Murphy.

Plate 15.3. Large wood fragments and iron pins. This feature is hull deadwood. NPS photo by Larry Murphy.

Plate 15.4. Hull planks where wood samples were removed in 1989. The upper plank is pine, the lower oak. Muntz-metal hull sheathing remnants were also recovered and sampled. NPS photo by Eugene T. Rowe.



noted. Ship fasteners, some connected by wood fragments, iron drifts, bronze drifts and square bronze spikes were observed on the site.

Some hull fragments more than 10 ft long containing iron pins were found near the "iron pile" (Plate 15.3). These most likely represent bow or stern deadwood.

The structure area, which was the datum for the sketch map and is Feature 1 on Souza's map (see Figure 16.1), contained exposed hull planks beneath rows of barrel casts. Two contiguous hull planks, each 12 in wide and an estimated 2 in thickness, were observed beneath the casts. The planks were eroded on the sides, so a reliable thickness was not obtained.

Hull planks were fastened with trunnels and bronze fasteners about 1 1/2 in diameter on 1-ft centers, indicating frames of about 6-in sided dimension. No frame fragments were observed.

The two hull planks appeared to be different species (Plate 15.4). The darker had oak grain, the other appeared to be pine. A sample of each and a piece of trunnel were taken for positive identification: sample analysis verified the field observation.

Hand-fanning at the plank edge revealed brass-colored hull sheathing indicating Muntz metal, which dates the site to the 1850s or later. Some scattered sheathing bits of were embedded in the coral bottom.

Sample Analysis

Samples were labelled FOJE 6-89-1-5 and 10. John Husler, University of New Mexico Geology Department (Husler 1989), analyzed hull sheathing constituents, the barrel cast material and identified the flagstones, and University of Arizona Laboratory of Tree-Ring Research identified the wood (Dean 1990).

Sample 1 - Hull sheathing. Sample was badly oxidized brass. After cleaning with dilute acid and rinsing with acetone, it was analyzed, revealing these principal constituents: 65-66 percent copper, 33-35 percent zinc, 0.5 percent lead and 0.9 percent tin. Detailed analysis was:

Element	Weight Percent
Cu	65.7
ZN	34.3
Pb	0.50
Ni	0.27
Co	<0.001
Ag	0.038
Fe	0.38
Sn	0.87
	101.5

This alloy is consistent with Muntz metal located on other sites.

Sample 2 - Trunnel in exposed plank, possibly pine. Results: Pinus sp. (knot?).

Sample 3 - Possible pine hull plank pine. Results: Pinus sp. (16 rings). The pine of samples 2 and 3 appear to be United States in origin.

Sample 4 - Abutting hull plank, possibly oak. Results: Quercus sp.

Sample 5 - Barrel cast. Results: Contained 21.7 percent SiO_2 and 25.9 percent MgO. The magnesium and calcium are combined as carbonates based on the high loss on ignitions (21.2% at 1000°C) and rapid gas evolution upon treatment with 1N hydrochloric acid (Husler 1989). Constituent analysis and comparison with Portland and natural cement are given in Chapter XVI (Table 16.2).

Sample 10 - Portion of flat rock. Results: Geological identification is graywacke, a type of sandstone. This material appears identical with first-tier flagstone in the fort.

Plate 15.5. Iron block feature, 1989. NPS photo by Larry Murphy.

Site Analysis

The site represents a wrecked sailing vessel dating perhaps to the 1860s. The ship is most likely northern built and possibly southern patched, indicated by the pine hull-plank and trunnel. The pine hull-patch indicates the vessel was either an older vessel not warranting a first-class repair with an oak plank replacement, or perhaps a northern-built vessel owned by a southern company. The vessel did not receive a first-class repair for some reason, and this would have altered its insurance classification rating.

The vessel was carrying mixed construction materials for Fort Jefferson and the voyage likely originated in New York. Construction supplies were primarily procured and shipped from the Corps of Engineers' offices there known as the New York Agency (Bearss 1983:226-228).

This site is about 3 nautical miles northeast of Southeast Channel. If the vessel was making for Fort Jefferson and sunk in a storm, the storm was most likely a tropical cyclone, which would produce strong southeast winds. The wreck may have occurred in the fall. Fort construction work was minimal during the summer "sickly" season, and cyclones are most likely in the fall. Of course, the vessel might have been sunk any time as a result of pilot error.

Hull deadwood features were located on the site extremity nearest East Key. Although this represents bow or stern, it is unknown at this time. If the ship was underway when it struck, it is likely bow. It could be stern structure if the vessel was in distress before wrecking and had an anchor deployed, which would have made the vessel enter the shallows stern first. No sign of the rudder or other stern features was located.

The vessel was partially salvaged indicated by the total absence of standing or running rigging elements. Wreckers were active in the area during the nineteenth century, and there was a ready market for salvaged rigging (e.g., Dodd 1944:197 and Key West Admiralty Wreck Reports, which frequently report rigging salvage). Damaged vessels were repaired and refitted in Key West creating an on-going demand for recycled rigging materials.

The site's 10 ft depth would allow virtually complete recovery of rigging elements, including chainplates and deck fittings, none of which were located in the immediate site area. However, if the vessel sank in a severe storm that broke up the hull, the upperworks could have been swept away. Site compactness and undisturbed rows of barrels lying atop hull structure argue against this possibility.

Fort floor flagstone measurements conducted during this field session indicate the cargo stones may have been destined for the large parade-ground magazine. This unfinished magazine lacks inner floors, but contains the thickest flagstones located in the fort in its foundation. (This speculation was supported by Souza's 1990 research.)

It is curious that no construction materials seem to have been salvaged. The cargo was certainly accessible. Although the cement would have been useless, the other materials would have ready use a few miles away at the fort. The large parade-ground magazine was never completed. For some reason the materials were not valuable enough to retrieve, although the means to do so were available.

The Fort Jefferson Shipwreck Database currently lists five nineteenth century sailing vessels as total losses near East Key. Four carrying general merchandise were lost before 1865. One lost in 1893 was in ballast. No known wreck is a reasonable possibility for this site.

Additional historical research is needed. A likely source would be shipping documents of contract suppliers and those of the New York Agency. The vessel was probably insured, and contemporary insurance records should be consulted. Fort Jefferson and Loggerhead Light logs and local newspapers are other possibilities.

This site was considered a top priority for documentation in 1990 because of its association with Fort Jefferson, ease of access and visitor interpretation potential. This reconnaissance provided information for planning the documentation fieldwork and laying out principal research questions.

CHAPTER XVI

East Key Construction Wreck (FOJE 011) 1990 Investigations

Donna J. Souza

INTRODUCTION

This study was undertaken as part of a survey conducted by the National Park Service to assess submerged cultural resources within Fort Jefferson National Monument (NM). During summers of 1989 and 1990, archeologists participated in fieldwork under the overall direction of Larry Murphy, of the National Park Service (NPS) Submerged Cultural Resources Unit (SCRU). Richard Gould supervised the 1990 fieldwork on this site.

Dry Tortugas Geography

Dry Tortugas reefs form an elliptical atoll-like structure about 27 km along the major, or southwest-northeast, axis and 12 km on the minor axis. Three major banks, or keys, Pulaski (NE), Loggerhead (W), and Long Key (S) are separated by 10-20 m deep channels on the northwest, southwest, and southeast (Davis 1982) (see Figure 1.1). The banks surround a 12-23 m deep lagoon, a natural harbor where ships passing through the straits of Florida have taken refuge for more than three centuries (Bearss 1971).

The form and structure of the Dry Tortugas reefs has been determined by the prevailing physical environmental conditions. Shape of major banks is determined by prevailing westerly currents. Southeastern, or windward, bank reefs reflect moderate wave energy generated by mild summer "trade winds," while the massive coral buttresses and hard bottom areas along the northern rim appear to result from regular high-energy winter storms (Davis 1982). However, short-term extreme climatic events, such as hurricanes or thermal shocks, may significantly alter large scale features of the reefs (Davis 1982).

In 1990, there were seven keys at the Dry Tortugas. From west to east, they were Loggerhead, Garden, Bush, Long, Hospital, Middle, and East Keys. Middle Key is frequently awash and Hospital Key is occasionally submerged during spring tides, but the remainder are continually above sea level. Names of the keys have changed several times since the eighteenth century, sometimes swapping the names of Bush and Long Keys. Bird Key was completely lost following the hurricane of 1919.

STUDY CONTEXT

Archeology pertaining to preparations for war from the midnineteenth century onward can be used to identify and test certain cultural uniformities. For instance, in the evolution of the modern arms race there are repeated examples of the revival of archaic technologies and their continued use well beyond their practical usefulness (Gould 1990:162). Use and development of these technologies include the concept of "deterrence"; that is, the development of a technology or defense system in order to deter an enemy, either real or imagined, from attacking. Development of defense systems is often accompanied by continued investment in them even when it has become obvious they are obsolete (Gould 1990:195). Fort Jefferson, built as part of the "third system" of United States coastal fortifications, is a prime example.

Though commercially uninteresting, the strategic location and natural harbor of the Dry Tortugas was recognized as a potential base of operations to control Florida Straits navigation. In July 1829, Commodore John Rodgers reported to the Secretary of the Navy that if occupied and fortified, the Dry Tortugas would constitute the "advance post" for gulf coast defense. These islands were "directly in the track of all vessels passing to and fro, not only between them and the Mississippi, but between every part of west Florida and our eastern states." At the same time, no other site presented the "same facilities in communicating" with ports in Cuba and on the Mexican Gulf Coast. If the Dry Tortugas were fortified, the commerce of La Habána and "even the homeward bound trade of Jamaica, would be subjected to its grasp" (Bearss 1971). In 1847, the US Corps of Engineers began construction of Fort Jefferson on Garden Key. Because there were few island resources, all construction materials (except fill and coral aggregate), supplies, and labor force were transported to the Dry Tortugas via ship. Work continued for almost thirty years, but the fort was never completed.

A majority of Dry Tortugas shipwrecks are merchant cargo ships en route to United States, South American, European and Caribbean destinations. During thirty years of construction, however, some ships carrying construction materials to Fort Jefferson also wrecked. Study of this particular wreck group, which we can refer to as "construction" wrecks, could help provide answers as to why cost of building and maintaining the fort was so high, and why the fort and some of its major detached structures were never completed.

METHODOLOGY

Objectives

There are no known records documenting events that led up to the wrecking of the ship at East Key. All information presented here regarding the ship and the observed seabed distribution was gathered through underwater survey, so the results should be considered preliminary. It should be stressed, however, that this study focuses on more than just a shipwreck; it examines the relationship between this shipwreck and Fort Jefferson construction history. The primary source of historical information is Bearss 1983.

A major consideration of this study, and a fundamental philosophy of the SCRU, is conservation of shipwreck and underwater archeological sites. Increased awareness of the need for conservation in all archeological site investigation has forced researchers to develop methods for selective, and even nondestructive, archeology (Gould 1983:21). Except for removal of small samples for identification and analysis, all work performed on the East Key Wreck was completely nondestructive and concentrated on mapping site details. The entire site was measured and mapped using a combination of direct measurement and base line trilateration, a thoroughly tested and proven mapping technique developed by the SCRU and used with excellent results on the USS ARIZONA (Lenihan et al. 1989; Slackman 1984:101) and at Isle Royale National Park (Lenihan 1987).

In addition to surveying the immediate wreck concentration, a wide area survey, covering more than 500,000 sq ft, was conducted to determine if the site represented a single event, or if there were materials

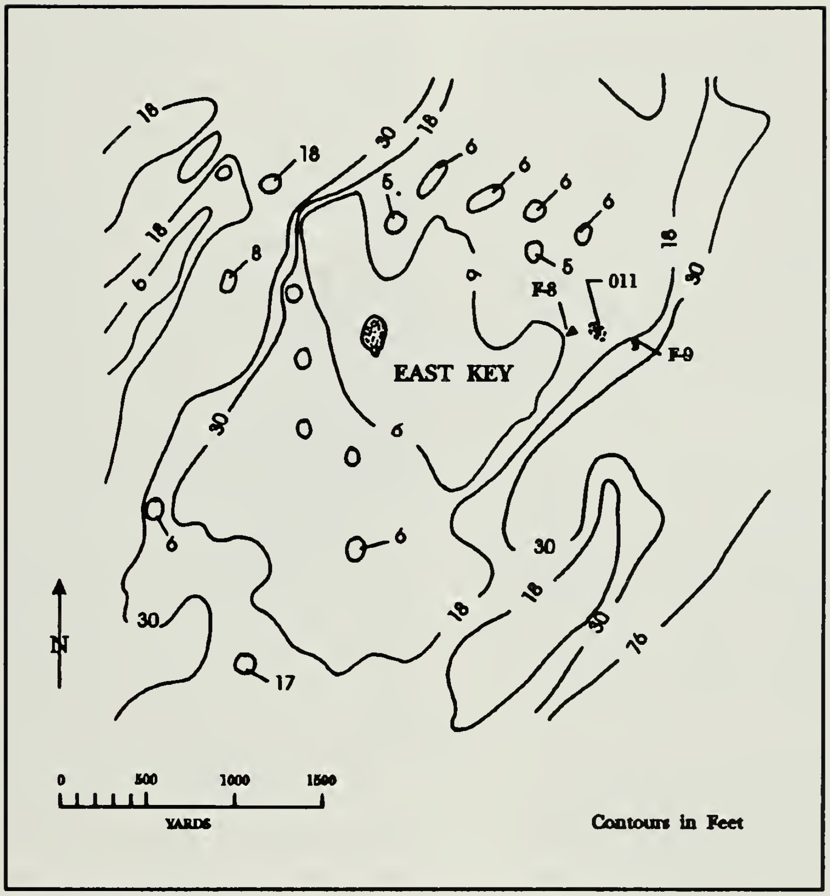


Figure 16.1. East Key Construction Wreck Site, contours and positions of Features 8 and 9.

superimposed from multiple wrecks and strandings. This area survey located additional materials probably associated with the East Key Wreck laying outside the major debris field. Two additional features were recorded: an anchor and a transom with detached beam.

Base Line Measurements

A preliminary site "swim-over" was done to determine base line positioning to ensure it passed through the densest area of the debris field. Two base lines were used. Base line 1 was 163.8 ft long and at an angle 10° relative to north. Base line 2 continued from base line 1 for a distance of 94.5 ft with a turned angle of 185°. The datum point was placed at the 0-ft marker on base line 1.

All site measurements were recorded in feet and tenths of feet rather than in metric measures because American and many European shipbuilders traditionally use units of feet. Using feet and tenths facilitated plotting measurements onto a field map using a ten-to-the-inch scale. It also facilitates the use of an electronic calculator when measurements are compared and analyzed statistically.

Measuring teams usually consisted of three divers: two divers worked the tape measure and one diver recorded the data. Other dive teams drew details and photographed features.

Each trilaterated point was plotted onto a field map. Then, each plotted point was used as a subdatum for a series of direct measurements. In this way, each group of barrels, graywacke slabs, and all features were drawn onto the map in relation to the plotted trilaterated points. As a cross-check, a semicontrolled photomosaic of the site was completed. The photomosaic was assembled and compared to the field map and minor modifications and corrections were made. In addition, specific features were photographed and drawn.

CONTROLS--FORMATION PROCESSES

In order to make reasonable inferences from the archeological record, investigators must take into account a variety of processes that have had an impact on the evidence.

> Because formation processes operate in biased ways, the historic and archeological records cannot be taken at face value. Instead of 'reading' those records in a direct and superficial way, the archeologist is forced to investigate formation processes themselves, assessing and correcting for their many effects [Schiffer 1987:7].

Historical and archeological record formation processes are of two basic kinds: cultural and noncultural. Cultural formation processes result from human behavior that affect or transform artifacts after their initial period of use in a given activity. Noncultural formation processes include natural environmental impact upon artifacts and archeological deposits (Schiffer 1987:7).

In order to interpret data leave in the remains of seafaring activities, it is important to understand what happens to a ship and its contents during the wrecking processing and after it has settled onto the seabed. Muckelroy defines a shipwreck as "the event by which a highly organized and dynamic assemblage of artifacts are transformed into a static and disorganized state with long-term stability" (1978:157). Validity of conclusions reached in maritime archeology depends on the understanding of these processes, so their study must occupy a central place in the subdiscipline (Muckelroy 1978:157).

Environmental or noncultural factors affecting a submerged site are different from those found on land. However, operating factors have an effect on every site in varying degrees, making archeological evidence more homogeneous than on most terrestrial sites.

As Muckelroy notes (1978:163), the main determining factor in survival of archeological remains underwater is attributes of the seabed deposit. This includes underwater topography, nature of the coarsest material within the deposits, and nature of the finest material in them. The East Key Wreck Site seabed deposit is what Muckelroy classifies as a Class Two-type site (1978:164). The topography is more than 70 percent bottom sedimentary deposit and includes deposits of everything from boulders to silt. While there are no actual boulders at the East Key Wreck Site, the barrel-shaped cement forms act as "artificial boulders" and may have the same effect as natural boulders on the topography and seabed movement. For this reason, the ship's cargo, flagging stones and cement barrels, has actually helped to preserve the site. In this type of environment one expects to find elements of structural remains, many objects in scattered distribution, and, perhaps, some organic remains. While no organic remains were located other than hull structure at the East Key Wreck Site, the observed seabed distribution and amount of structural remains are consistent with a Muckelroy's Class Two site.

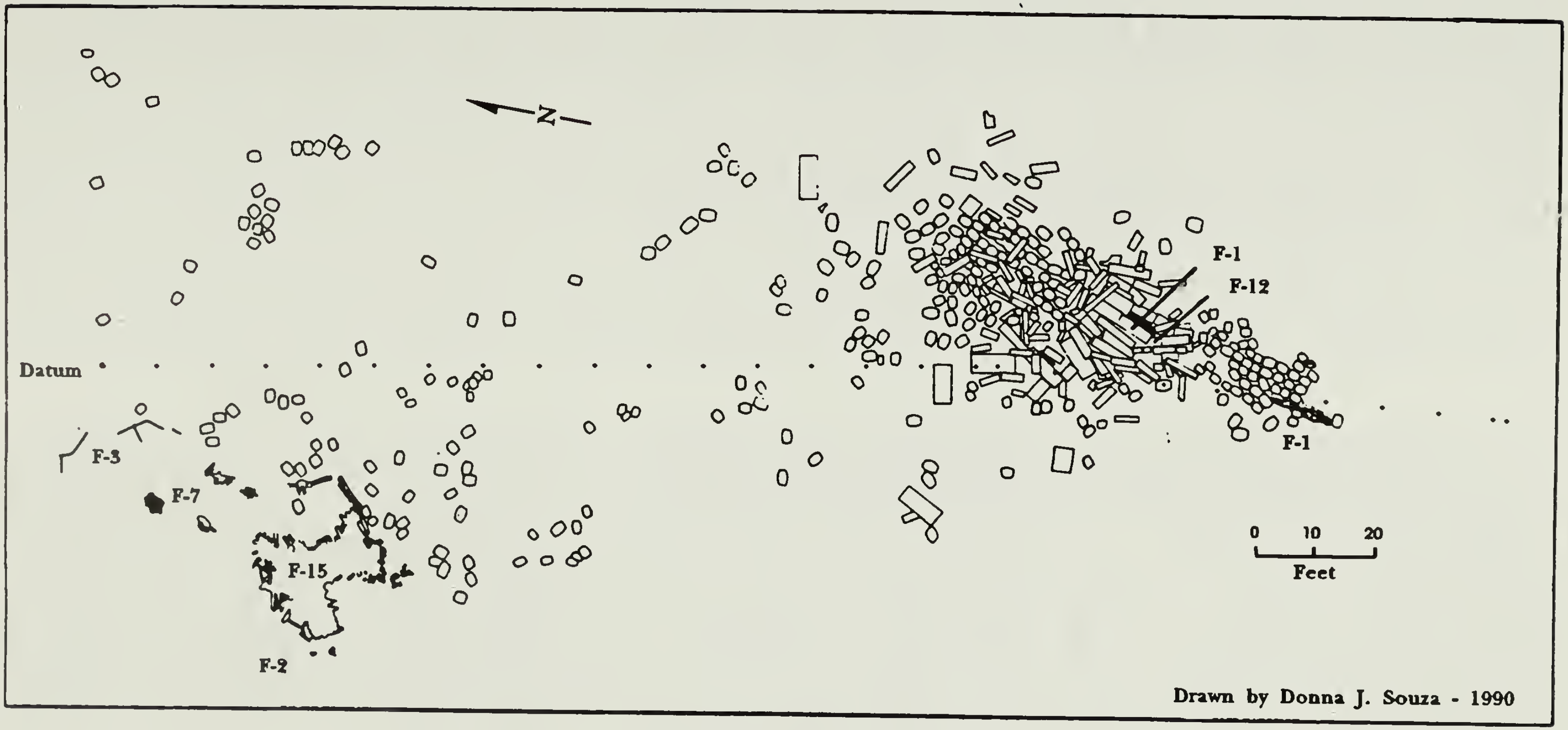


Figure 16.2. Site map of East Key Construction Wreck Site. Drawn by Donna J. Souza.

Unlike those on land, cultural processes affecting submerged sites are limited to a relatively few identifiable activities (Muckelroy 1978:158). These include salvage operations, looting and activities of archeologists. A cultural transform that Muckelroy does not address, however, is the possible effects of other ships, either through wrecking, stranding, or while at anchor. These complicate site interpretation by introducing postdepositional alterations or adding later nonrelated material.

Wrecking Process

Three principal processes that lead to material loss from a shipwreck site are wrecking, salvage operations, and disintegration of perishables (Muckelroy 1978:166). The wrecking process is both an extracting filter and a scrambling device. An extracting filter acts to remove objects from the observed seabed distribution. A scrambling device is any force that tends to scatter objects during the wrecking process or after the materials have come to rest on the seabed. These processes include not only the breakdown of organization at the moment of impact, but also the continued break-up of wreckage on the seabed. Extractive and scrambling processes include the stages by which the vessel wrecks up until the time it becomes part of the seascape; anything that happens after stabilization can be described as seabed movement (Muckelroy 1978:169).

Wood and other materials float, at least until they become waterlogged. In the case of the East Key Wreck, it is impossible to estimate which items may have simply floated away. There is no doubt, however, that the ship was dragged down by a combination of its contents, flagging stones and barrels filled with cement, and inflowing water. Weight of these materials on board helped keep the wreck in place until much of it became embedded in the seabed. This set of circumstances is very similar to many classical ships, such as the YASSI ADA wreck, which was pinned down by its amphora cargo (Bass 1982:32), and the wreck of DARTMOUTH, whose hull had been pinned down by iron and flint ballast (Martin in Muckelroy 1978:166).

Cement barrels, being saturated with water and much too heavy to float away, spilled around the site as the ship began to break apart. Because of their cylindrical shape, they tended to be more susceptible to the effects of changing currents. Some eventually rolled a considerable distance from the ship structure.

Seabed Movement

Seabed movement is primarily the result of water movement, by either tidal currents or wave action. The East Key Wreck Site lies at a shallow depth and is in a high-energy environment. Wave-induced water and sediment motion depend on varying weather conditions. There is a slight but constant current moving north to south at this site, and it is more than enough to move coarse coralline sediment. During the fieldwork, each day upon reaching the site it was necessary to fan away redeposited sediment that covered previously exposed planks. Sediment helped to preserve planks that had become firmly embedded. However, the coarse sediment texture also has had a scouring effect on the remaining wood components.

Several hurricanes (Table 16.1) have hit the Dry Tortugas since Fort Jefferson construction began. These storms may have had a dramatic impact on the East Key Wreck Site and have contributed to the further break-up and redistribution of cultural material. The haphazard scattering of many 400-pound cement barrels, the transom located 557 ft away from the wreck site, and the many scattered deadwood pieces all are testimony to devastating storm effects.

Table 16.1. Hurricanes and Tropical Storms Since 1855

Month	Year	Wind Speed (mph)	Name
Aug	1856	N/A	---
Oct	1865	N/A	---
Oct	1870	N/A	---
Oct	1873	N/A	---
Sep	1875	N/A	---
N/A	1906	N/A	---
N/A	1910	N/A	---
Sep	1919	84	---
N/A	1921	N/A	---
Sep	1926	138	---
Sep	1928	75	---
Sep	1935	86	---
Oct	1944	120	---
Sep	1947	155	---
Sep	1960	92	Donna
Aug	1964	110	Cleo
Sep	1965	136	Betsy
Jun	1972	43	Agnes (T.S)
Sep	1975	104	Eloise
Aug	1979	95	Frederic
Aug	1985	96	Gloria

The graywacke flagstone (Figure 16.1) area, however, has not been as seriously affected by seabed movement. The flat, rectangular shape of the flagging stone make them naturally resistant to seabed movement. Because prevailing current is north to south, the pile of graywacke flagging stones has actually acted as a buffer against the current and protected the area immediately to the south. In this area are several rows of barrels, still end to end in neat rows as they would have been stowed within the ship's hull. It is here, also, that hull planks are found. These planks run under the graywacke pile and cement barrels for a distance of at least 50 ft. The flagging-stone pile has also acted as a barrier that prevented, to a great extent, movement of several barrels immediately to the north. The barrels became wedged against the pile and settled into the seabed.

Other Noncultural Transformation Processes

The common shipworm (*Teredo navalis*) can have a devastating impact on a shipwreck site. This worm has been the bane of navies and merchant fleets from ancient times until the advent of metal-hulled vessels. In more recent times, it has become the bane of underwater archeologists. Any submerged, exposed wood becomes a feast for the shipworm, and there is little chance of any wood remaining after prolonged exposure.

The East Key Wreck Site is a high-energy area. The water temperature is warm, and there are the voracious shipworms. Under these conditions, one would not expect to find a great deal of ship structure on any wreck site, and this is the case with the East Key Wreck Site. Fortunately, however, the particular configuration of cement barrels and flagging stones has acted to protect some of the hull planks that became buried under these materials and are therefore protected from shipworms and other marine organisms. The currents and many storms that have wracked the area have also aided in the preservation of some of the wooden ship components by burying them in the seabed, and protecting them from marine organisms and the continued scouring effect of seabed movement.

Multiple Events

An area that is as hazardous to ships as the Dry Tortugas is likely to have many wrecks and strandings occur over time within a relatively small area. There are areas within the Dry Tortugas that are especially dangerous and are veritable ship-traps. One such place is immediately to the south of Loggerhead Key. The Nine-Cannon Site (FOJE 008) appears to have at least three shipwrecks superimposed on one another (L. Murphy 1990).

There have been numerous accounts of ships in the Dry Tortugas becoming stranded and subsequently refloated. In many instances, successful release of these ships was due to the off-loading of cargo and/or ballast in order to lighten the ship. It is reasonable to assume that an area where a ship has wrecked is also a likely place for a ship to become stranded (and vice versa). Whether or not the stranding becomes a wreck depends on the tides, winds, the crew's ingenuity and luck. Off-loaded materials from these strandings could easily be superimposed upon a wreck site or debris from a previous stranding. The cannons at the Nine-Cannon Site, for instance, could be material that was off-loaded in a successful attempt to refloat a stranded ship.

Ships at anchor can also have an impact on underwater sites. This is most likely to occur through anchor positioning and dragging or trash disposal while on site.

As discussed earlier, a wide area survey was conducted to determine if the materials located at the East Key Wreck Site represent a single or multiple event. The only materials located during this survey were an anchor and a transom. While it cannot be stated with absolute certainty that these artifacts are, indeed, associated with the East Key Wreck, their location relative to the wreck and their size and type make it highly probable. It can therefore be concluded that the East Key Wreck Site is a single, discrete event.

Salvage

In the absence of historical documentation regarding salvage operations on the East Key Wreck, it is difficult to speculate about what materials were salvaged. The cement, once saturated with seawater, was no longer usable, so its salvage would not have been attempted. The flagging stones, however, were (and still are) perfectly suitable for construction purposes. Yet there is no evidence that any attempt was made to recover them. The depth of the wreck is only 12 ft at high tide, and the technology for salvage of the materials certainly existed in the nineteenth century and in this area. In fact, salvage in the Dry Tortugas has been a lucrative business for more than two hundred years (Bearss 1971). The fact that the flagging stones were not recovered is even more interesting considering there is evidence that some salvage of this vessel did take place.

Taking into account the probability that some of the rigging would have floated away during the wrecking process or decomposed after being deposited on the seabed, one would still expect to find some artifacts such as iron hardware, chain plates, mast hoops, and block and tackle fittings. However, except for a single mast hoop, no rigging was found. While lack of rigging at the wreck site may be considered as negative evidence, it is highly probable that the wreck was stripped shortly after having run aground. In addition, the small quantity of yellow bricks observed at the site could indicate that there was, at that time, a pressing need for bricks and, therefore, the cargo of yellow brick was recovered. But, while we can be reasonably certain that there was more rigging and hardware present initially, we do not know how many bricks there were at the wreck site to start with. On the other hand, these yellow bricks could have been firebricks and not cargo at all. If there had been any steam-operated deck machinery, as Feature 10 suggests there may have been, these bricks could have lined its firebox. In any case, it is clear that certain materials at the East Key Wreck Site had a higher priority for salvage. This process of "selective salvage" needs to be examined more closely in order to determine why rigging was salvaged and construction materials were not.

Other Cultural Transformation Processes

There is no doubt that salvage is the primary cultural transformation process affecting the East Key Wreck Site. However, there is another that needs to be considered, namely, looters and relic collectors. The Southeast Archeological Center's Site Inventory Record, apparently completed in 1987, indicates primary site disturbance as vandalism. It is impossible to determine how much material has been removed from the site by divers collecting relics, but there is no question that their presence has had an impact. Feature 13 (Plate 16.1) consists of seven copper fasteners that were found under one of the smaller flagging stones with two more found under a nearby coral head.

Plate 16.1. Feature 13, cache of copper fittings is evidence of diving activity. NPS photo by Donna Souza.

This assemblage could not have occurred as a result of environmental processes, nor is it a likely association from the ship itself. A diver most likely gathered the fasteners from around the site and stored them under the flagging stone and coral head, perhaps to be collected at a later time, or at the dive's end. This feature is similar to what Schiffer refers to as a cache--a specialized type of de facto refuse produced under conditions of abandonment where return is anticipated (Schiffer 1987: 92). As Feature 13 demonstrates, return may be anticipated but does not always take place.

Over time, a shipwreck becomes an artificial reef, a complete ecosystem with all manner of corals and fish; and, where there are fish, there are usually fisherman. Both commercial and sport fisherman can contribute to the transformation of a shipwreck site. Since Fort Jefferson NM is a protected area, commercial fishing is prohibited and sport fishing is kept to a minimum. However, the possibility of poachers is very real and their effects should be considered. In unprotected areas, it is common to find remnants of snagged fishing nets around a wreck site. While working on the HMS VIXEN project (a protected wreck where fishing is not allowed) in Bermuda, it was necessary to remove yards of monofilament from the wreck during the course of the field study. Fishing activity, particularly repeated anchoring and trash disposal, can alter shipwreck sites.

Cultural formation processes also include archeological activities. As noted earlier, except for removal of small amounts of material for identification and analysis, all the work accomplished on the East Key Wreck by this research project was completely nondestructive, and no excavation or removal of artifacts took place. Sediment was fanned away from some sections of wooden structure for the purpose of measuring, mapping and photographing. After the work on a particular section had been completed, it was recovered with sand. A few items such as the mast hoop and deadwood pieces were lifted from the seabed for measuring or photographing, but were replaced in their original position. No encrusting marine species were removed from any artifacts or ship structure.

SITE DESCRIPTION AND HYPOTHESIS

The Site

The East Key Wreck Site is located approximately 1,500 yd east of East Key in the Dry Tortugas at a depth of two fathoms at high tide (Figure 16.1). The area is a typical shallow reef environment, generally flat with coarse coralline sediment. There is a slight but almost constant north to south current. Encrusting marine species include brain corals (*Diploria*), sea fans (*Gorgonia*) and fire coral (*Millepora*) (see Chapter XX). The amount of encrustation ranged from moderate, on objects such as the cement barrel forms and gray-wacke flag Plate 16.3). Visibility during the project ranged from 20 ft to 50 ft, depending on tides and weather conditions. Water temperature remained a constant 88°F.

Materials observed on the seabed included barrel-shaped cement forms, slabs of flagging stones in various sizes, timbers, iron ingots, and scattered bricks. The observed seabed distribution covers an area of approximately 50,000 sq ft (Figure 16.2).

Features

The most prominent feature of the East Key Wreck is the "cement barrels." Barrel-shaped hardened cement formed when dry cement packed inside wooden barrels became saturated with seawater (Plate 16.2).

The wooden barrels themselves have long since decomposed due to seawater exposure

Plate 16.2. Barrel-shaped cement forms. NPS photo by Donna Souza.

and wood-boring worms (*Teredo navalis*). These "barrels" are distributed haphazardly throughout the wreck site but with a higher concentration around the end of base line 2. In this area, the "barrels" are lying end-to-end, in neat rows, as they would have been packed as cargo.

More than one hundred slabs of material identified as graywacke (Husler 1989) were observed at the East Key site (Plate 16.3).

Plate 16.3. Stacks of graywacke flagstones. NPS photo by Eugene T. Rowe.

Graywacke is a "kind of sandstone composed of grains of sand, which are of various sizes connected together by a base of clay-slate, and hence this rock derives its gray color and solidity" (Pettijohn 1987:197). The term "graywacke" comes from an old German mining term, "waken" for waste or barren (Dott 1971:167) and the natural gray color of the material. This material was used in quantity as flagging stones for the casemate floors at Fort Jefferson (Bearss 1983:134).

A 15-ft x 20-ft iron pile composed of small beams and rods (Feature 15) is located approximately 15 ft from base line 1 (Figure 16.2). No construction materials could be seen under the iron pile. This pile is enclosed by strands of rotten cord that were originally impregnated with tar or pitch. These ropes were probably tied around the iron pieces to keep them from shifting while the ship was underway.

It has not yet been determined if this iron was part of the ship's cargo or if it was used as ballast. There are several cement barrel forms scattered around the pile, suggesting that it is associated with the East Key Wreck rather than material off-loaded from another ship that was stranded in the same area. No similar types of iron hardware were located at Fort Jefferson, although this does not rule out the possibility that the iron was raw material to be worked at the fort. Because ships transporting materials and supplies to Fort Jefferson would have no return cargo, the most parsimonious explanation is that the ship was carrying its own ballast for the return trip. More information is needed, however, before any conclusions can be made.

A few hull planks, designated as Feature 1 (initially M2) (Plate 16.5), were observed along base line 2. These planks run under several rows of cement barrel forms. The materials of these planks have been identified as pine (*Pinus*) and oak (*Quercus*) (Dean 1990). The planks are 1-ft wide with trunnels spaced 1-ft apart along the length. Two pine planks are edge-to-edge and have two 1/2-inch bronze fasteners, indicating that the ship was patched. Since the pine sample is a species indigenous to the South and the oak sample is

Plate 16.4. Feature 15, "iron pile." NPS photo by Eugene T. Rowe.

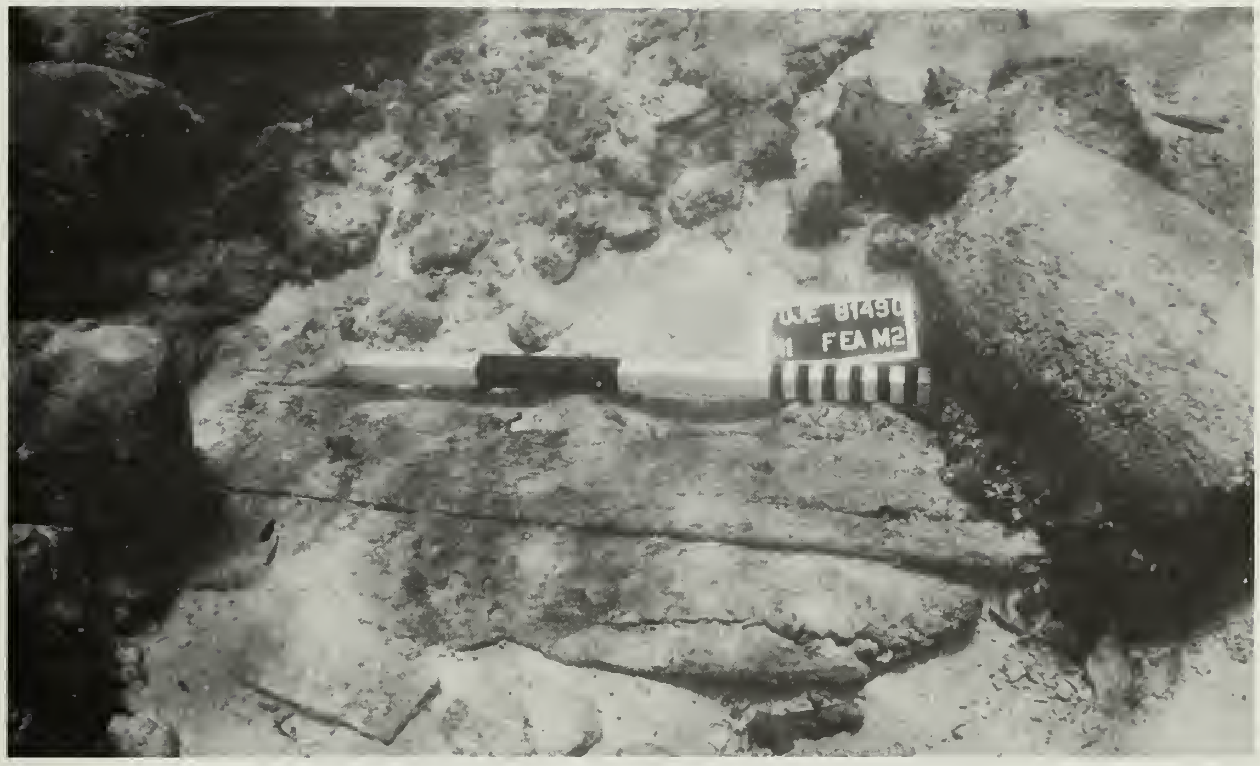


Plate 16.5. Feature 1, outer hull planks. NPS photo by Larry Murphy.

indigenous to the North, it could indicate that the ship was built in the North and repaired in the South. The dimensions of these planks and fastenings are consistent with a ship of 350 tons (Desmond 1919:21).

Hull sheathing fragments were observed on many of the planks, particularly around the area at the end of base line 2. The metal was identified as Muntz metal, a copper-zinc alloy that came into common use in the midnineteenth century (Ronnberg 1980). Several detached pieces, some up to 2-in across, were also found throughout the wreck site.

Several sections of deadwood (Feature 7), solid pieces of timber scarfed together lengthwise on the keel, were located along base line 1 near the iron pile. The sections ranged in size from 11.7 ft x 3.2 ft to 4.3 ft x 1.0 ft. Each contain iron fasteners. Three sections of iron railing (Feature 3) were located along base line 1 near the datum point. The rail has a diameter of 1 2/3 in and lengths of 6.7 ft, 6 ft, and 1.9 ft.

A single mast-hoop (Feature 12, Plate 16.6) was located west of the iron pile. The hoop has a slightly oval shape with inside dimensions of 1.9 in x 1.7 in. The oval shape is possibly due to damage sustained during seabed movement. The hoop is 3.5 in wide and 1.5 in thick. There is a hinge directly opposite a flanged ring of 1 in diameter. No other rigging was recognized on the site.

Two features were located during the wide area survey. The first, a transom that probably

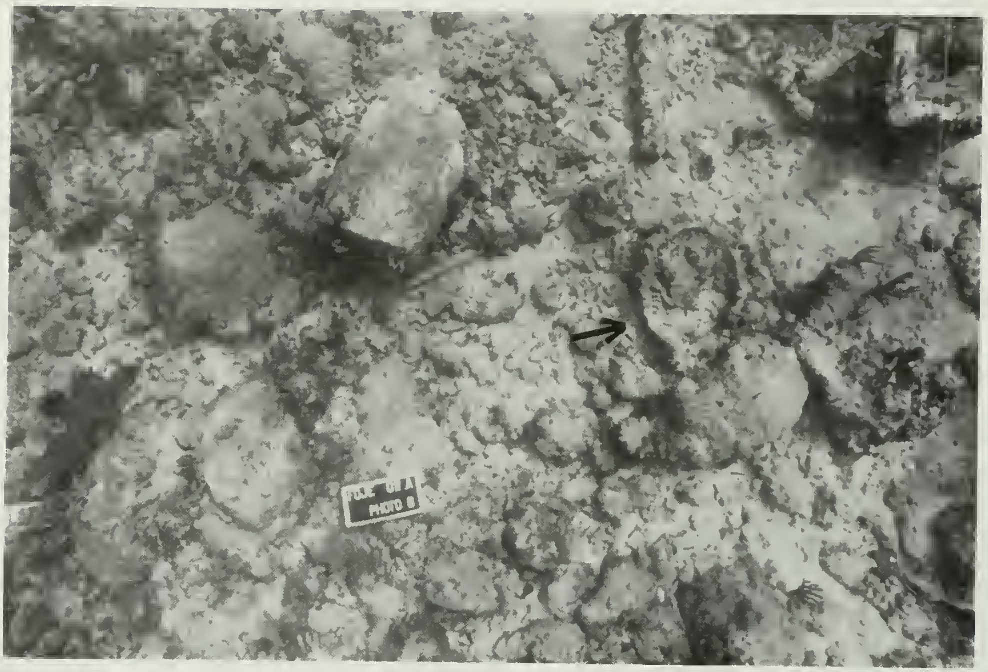


Plate 16.6. Feature 12 (arrow), mast hoop. NPS photo by Eugene T. Rowe.

supported a lower deck, was located 557 ft from the datum at a bearing of 290°. This transom, designated as Feature 8 (Plate 16.7), is a symmetrical triangular shape. It is 18.1 ft wide at the top, and its sides, slightly curved inward, have a length of 10.6 ft. There are eight vertical iron fasteners, .7 to .10 in high, arranged 1 ft apart in staggered rows. Along one side is an attached wood beam 2 in wide and 9.1 ft long. This section has small vertical iron fittings spaced 1 ft apart.

An isolated wood plank 18.8 ft x. 95 ft was located approximately 18 ft from the transom. Vertical iron fasteners arranged in staggered rows along the top are spaced .7 ft apart. There are several large iron fittings at each end. Along one side there are seven horizontal fittings spaced .5 ft apart. Each end of the plank is notched in a dove-tail type of fitting. Due to its proximity, size, and fastener arrangement, it is probable that this plank is associated with the transom. The plank appears to have been attached to the top of the transom and was the piece that held it in place.

The second wide-area survey feature located is an anchor, Feature 9 (Plate 16.8). Its elliptical arms identifies it as a Rodger's Patent anchor, a type in common use since 1824. It may also be associated with this ship. The anchor was found 527 ft from the datum point at a bearing of 140° at a depth of 28 ft. It has a 5-ft shank and an iron stock of 7.6 ft. The distance between flukes is 3.8 ft; the ring diameter is .7 ft. There is a shackle on the ring attached to a link chain, now heavily encrusted. The anchor is made completely of iron with no evidence of wood. There are no markings to indicate the manufacturer.

Two other anchors were located approximately 100 ft from Feature 9. Both were made of galvanized iron, indicating that they were of recent manufacture and, therefore, not associated with the East Key Wreck Site.

Plate 16.7. Feature 8, transom. NPS photo by Eugene T. Rowe.

Plate 16.8. Feature 9, anchor located at Reef's Edge. NPS photo by Eugene T. Rowe.

These two anchors, however, do provide evidence that other ships have become stranded near East Key and that the Dry Tortugas continues to be dangerous to navigation.

Seven copper fasteners were found together under one of the flagging stones 30 ft from base line 2. Two additional copper fasteners were located under a nearby coral head. Designated as Feature 13 (Plate 16.1), these nine fasteners ranged in size from .75 ft to 1.3 ft in length. All had a diameter of .5 in. Two Feature 13 fasteners still had wood attached.

The only other detached copper fasteners were located separately along base line 2. The first, approximately 6 ft from base line 2, is 1.2 ft long with wood fragments and encrustation. The second, located 8 ft from base line 2, is .8 ft long and also has some wood fragments attached.

Feature 10 consists of the detached component of an iron mechanism. It was located 146 ft from the datum point at a bearing of 330°. This piece is 6 ft in length with a square flanged opening at one end. The opening is .75 ft square with an inside opening of .5 ft. An iron strap 1.4 ft long runs along one side. A detached iron fragment with a round bolt .75 ft long was found next to the structure. A few inches away is a long bolt .91 ft long with the nut still attached. An iron comb-shaped object lies .5 ft away from the long piece. This object is .75 ft square with 4 indentations 3 in deep and .5 in wide. This piece is somewhat similar to a Worthington pump steam valve seat (King 1849:38). The Worthington pump was used as an auxiliary pump for cleaning ships' bilges and other tasks requiring pumped water. A simple slide version of this component was patented in 1849 (King 1879). Another iron object lies 7.25 ft from the long piece and is 1.91 ft long, 3 in wide, with attached bolt.

It has not yet been determined if Feature 10 is associated with the East Key Wreck. More information is required before a final determination can be made. No other mechanical components were located at the site.

Several scattered bricks were observed around the wreck site. These bricks are the yellow Pensacola-type bricks used in Fort Jefferson construction. The number of bricks observed at the site was too small to determine if they are associated with the wreck or whether they are simply scattered debris from the fort's construction period. It is possible that the ship was carrying a shipment of bricks in addition to its cargo of cement and flagging stones, and that most of the bricks were salvaged shortly after the ship ran aground. Several very small fragments of window glass were observed in the sediment around the site. It is not known if this glass was part of the ship structure, or if there was a shipment of glass on its way to the Fort.

Hypothesis

It is my hypothesis that the loss of construction materials on wrecked ships en route to Fort Jefferson significantly contributed to the almost continuous delays in the construction schedule and the high cost of building and maintaining the fort. The shipwreck referred to as the East Key Wreck, sometimes called the "cement barrel wreck," was a wooden-hulled ship of the late nineteenth century. The ship was carrying a cargo of mixed construction materials intended for the completion of the detached structure known as the "big magazine" at Fort Jefferson. Salvage or replacement of materials for the unfinished, yet obsolete, fort was too costly and any further plans for its construction were abandoned.

It is further hypothesized that the materials located at the wreck site are a potential "archeological signature" of the construction of defense systems located on island groups. Materials such as those damaged due to exposure to seawater, those of no intrinsic value, and those available in abundance (and therefore easily replaced), such as flagging stones and bricks, are not likely to be salvaged, even when conditions favor salvage.

Test Implications

As a test of the stated hypothesis, measurements were taken of flagging stones from the wreck site and compared with measurements of flagging stones taken from a random sample of casemate floors at Fort Jefferson and from the partially completed floor of the detached parade-ground magazine. A series of statistical analyses was conducted to determine any significant variation in size between the three groups of flagging stones. If the flagging stones from the wreck site do not vary significantly from those of the casemate floors, the hypothesis will be disproved as it could indicate that the materials located at the wreck site were possibly intended for the further construction of the third tier of casemates or repair of the lower casemates.

If any further substantial construction of the fort took place after the loss of the ship at East Key, the hypothesis will be disproved as it would be possible that the construction materials on board were intended for some structure other than the detached parade ground magazine.

If it can be demonstrated that the materials found on the East Key Wreck are construction materials intended for the big magazine located on the parade grounds of Fort Jefferson, it would be possible to explain, in part, the continued cost overruns and delays that were experienced during the construction period of the Fort. By locating and examining other construction wrecks within the boundaries of Fort Jefferson NM to determine which materials had been salvaged, it would be possible to identify an "archeological signature" of the construction of defense systems by industrialized nations on island groups such as the Dry Tortugas and Bermuda.

ANALYSIS

Data Analysis

Table 16.2 gives a comparison of the chemical composition of dry natural cement, a sample of material from the East Key Wreck, and material identified as Portland cement (Construction Technology Laboratories 1987:10) found on the Ledbury Reef Wreck at Biscayne National Park, Florida. While there are only minor differences in most of the compounds, there is a much higher content of Magnesia (MgO) in the natural cement. Natural cement compositions vary, depending on the region of its origin, but according to Eckel, "the natural cements usually carry 20 to 25 percent magnesia" (Eckel 1922:248). Cement aboard the East Key Shipwreck Site is natural cement.

Natural cement was generally used in the American construction industry until roughly 1865, when the advantages of Portland cement became known (Construction Technology Laboratories 1987:3). The first works for manufacturing Portland cement in England were established in 1825. The first plants to be established outside of England were in Belgium and Germany about 1855. Importation to the United States began about 1865 and the first Portland cement made in the United States was produced by David O. Saylor in 1871 (Blanks and Kennedy 1955:5).

Table 16.2. Comparison of Cement Materials (Percentages)

	Dry Natural Cement	East Key	Ledbury Reef
SiO_2	20.20	21.70	21.08
TiO_2	-	.27	.10
AL_2O_3	4.40	4.15	4.29
Fe_2O_3	2.80	2.40	2.39
MnO	-	.27	.04
MgO	22.24	25.90	1.72
CaO	41.60	4.40	67.19
Na_2O		1.44	.08
K_2O	1.62	.18	.13
SO_3	2.06	.84	3.26
H_2O+CO_2	6.90	21.20	N/A
HO_2	-	16.84	N/A

A random sample of six barrels was measured to determine any size variance. The data collected are displayed in Table 16.3. Any difference in size can be attributed to expansion of the cement due to exposure to seawater and varying strengths of wooden barrels that contained it. There are indications in some of the barrel forms that many of the wooden barrels cracked due to the expansion of cement during setting, damage that occurred during the wrecking process or later when the barrels were moved about the seabed by currents or storms.

A barrel having dimensions of 2.13 ft in height between heads and a diameter of 1.3 ft would have a total capacity of 3.186 cu ft. Using available figures for Portland cement as a guide, one barrel would contain a net weight of 378.0 pounds (Eckel 1922:491-492). Allowing for the weight of the wooden barrel at 22 pounds, the total weight of one packed barrel of dry cement would be 400 pounds (Eckel 1922:491-492). A total of 361 cement barrel forms were observed on the East Key Wreck Site, yielding a minimum cargo weight of 72.2 tons.

Table 16.3. Dimensions of "Cement Barrels" in Feet

Sample	Height Between Heads	Diameter
1	2.1	1.2
2	2.2	1.2
3	2.2	1.2
4	2.1	1.3
5	2.2	1.3
6	2.2	1.3

At the East Key Wreck Site base line 2 was laid through the area where the graywacke flagging stones were most concentrated. It is apparent from their observed position that the stones had been stacked, one upon the other, in rows during transport. Some slipping and scattering of the stones took place during the process of wrecking or during one of the many hurricanes that hit the Dry Tortugas since the wreck. In some areas along base line 2, it was observed that cement barrels had been stacked on top of flagging stones for shipping. Due to the scattering and stacking of the stones, not all the material could be reached for measuring. A total of 101 stones were measured, approximately 85 percent of the graywacke material located at the site.

The graywacke slabs varied in size, with the mean length being 3.8 ft, mean width 1.4 ft, and mean thickness 3.5 in. Total volume of the graywacke material was calculated to be 179.28 cu ft. At 2.3 grams/per/cu/cm 1 cu ft of graywacke weighs 143.58 pounds. Adding in the estimated 15 percent of unmeasured material yields a flagstone cargo weight of 14.8 tons.

Total area of graywacke material was calculated to be 553.97 sq ft; taking into consideration 15 percent unmeasured material, the estimated area of the materials is 637.07 sq ft. The detached parade-ground magazine, as it now stands, has eight alcoves, each covering an area of 75.5 sq ft for a total area of 604 sq ft. Allowing for the partially constructed floor already in place, and calculating some waste as material is trimmed to fit in place, the graywacke flagging stones located at the East Key Wreck Site are of sufficient quantity to complete the floor of the "big magazine."

A random sample of 101 flagging stones in the casemate floors of Fort Jefferson was measured to compare with those found on the East Key Wreck Site. A t-test was done to establish whether or not any difference between the two groups was statistically significant and not due to natural variability in the samples. Group 1 consisted of the random sample of measurements from casemate floors, and Group 2 consisted of 101 flagging stones measured from the East Key Wreck Site.

Plate 16.9. Detached parade-ground magazine. NPS photo by Donna Souza.

A comparison of length between the two groups yielded a mean of 3.55 ft for Group 1 and 3.83 ft for Group 2. The calculated t-value between these two groups is -1.44 with 171.17° of freedom. This statistic indicates that there is no statistically significant difference between the length of the materials located at the East Key Wreck Site and those in place in the casemate floors of Fort Jefferson. A t-test was also done to compare the width between the two groups, and this produced dramatically different results. The mean width of Group 1 was 2.59 ft and that of Group 2 was 1.41 ft. This yielded a t-value of 19.94 with 163.29° of freedom. This indicates a highly statistically significant difference in width.

Standard deviation for width was .305 for Group 1 and .511 for Group 2, indicating that stone widths at the wreck site varied slightly more than those in the casemate floors. A comparison of lengths provided a similar result. Standard deviation for length was 1.051 for Group 1 and 1.626 for Group 2. This indicates that while there is still some variance in the lengths between the two groups, differences are not as significant as for width.

This discussion leads to the conclusion that difference in length between the two samples of flagging stones can be attributed to natural variation, while the difference in width, being statistically significant, cannot. The stones measured from the East Key Wreck Site, with a mean width of 1.41 ft, are significantly more narrow than those of the casemate floors. Since it is possible to make the stones shorter but not wider, the flagging stones located at the East Key Wreck Site could not have been intended for the further construction of casemate floors. The pattern for casemate flooring is 6 rows of 2.5 ft in width to cover the 15-ft-wide casemates.

The flagging stones in the center of the grillage of the detached parade-ground magazine were measured to compare to those of Group 1 and Group 2. Since the sample is quite small (19), no statistical comparison can be attempted. However, all of the stones in this sample had a uniform width of 1 ft; length varied slightly from 2.6 ft to 2.8 ft. This would indicate that the stones were ordered pre-cut and upon arrival at Fort Jefferson were trimmed further by stone cutters to fit into place. The presence of stone cutters is confirmed in a monthly report of operations at Fort Jefferson for May-August 1862: "The blacksmiths had made general repairs to tools and machinery; sharpened masons' and stone cutters' tools; ... and fitted lead to roof surfaces" (Bearss 1983:250).

The fragments of hull sheathing observed throughout the East Key Wreck Site are of the alloy "Muntz metal," which came into common use after 1855. The cement at the wreck site has been identified as raw natural cement, a material in common use in the United States until 1871, when the first Portland cement was produced. This places the date of the wreck to be sometime after 1855 and before 1871. Considering the pine patch found in the hull planks, which is unmistakably a repair, it is probable that the ship had been in service for several years before being wrecked at East Key. Taking this into account, it would place the wreck at the later end of the time frame, which coincides with the late period in the construction history of Fort Jefferson.

Late in 1861, Chief Engineer Joseph G. Totten sent notice that some of the most important structures at Fort Jefferson remaining to be built were the large parade-ground magazines and that work should be commenced immediately (Bearss 1983:205). In February 1862, Totten sent a set of detailed drawings entitled "Plans, Sections and Elevations of a Detached Magazine," along with instructions for the foundations and grillages (Bearss 1983:206). It was not until 1864, however, that construction of one of the magazines was actually begun. Due to delays, lack of materials, and shortage of labor force, work proceeded slowly. In a report of work accomplished during the 12 months ending June 30, 1866, Superintending Engineer Walter McFarland reported the status of the detached parade-ground magazine as having been "raised from its foundation to reference (13'6") and the principal arch turned" (Bearss 1983:262).

No further work on the magazine took place in the years that followed, and the partially completed structure soon began to fall into disrepair. In 1876 Colonels Horatio G. Wright and Zealous B. Tower of the Board of Engineers for Fortifications submitted a comprehensive report on the status of the construction and condition of Fort Jefferson and its detached structures. In that report they called attention to the condition of the detached magazine. The structure, as it then stood, had its walls laid up to the spring line of the principal arch and the arch turned. Since the walls were only 6 ft thick, the report questioned whether the arches detailed in the plans were bombproof. They suggested that an additional course of concrete on top might correct the deficiency (Bearss 1983:346). Despite their recommendations, no further modification or construction of the parade-ground magazine took place.

In the years that followed the partial completion of the detached parade-ground magazine, construction at Fort Jefferson focused on the repair and maintenance of the Officers' Quarters, the barracks, and on increasing the fort's armament (Bearss 1983:303-309). During the years 1871-1874, no funds were appropriated for construction at Fort Jefferson. The balance of funds was used for repair of the barracks and the seawall. In 1874, a modest amount of funds was made available to the Corps at Fort Jefferson. Five barbette platforms were modified, but no construction took place (Bearss 1983:330). In 1875 and 1877, no construction funds were available and no construction was attempted. All available funds were used for the maintenance and protection of "public properties" at Fort Jefferson from 1878 to 1889. The Army pulled out of Fort Jefferson in 1889 and it was then turned over to the Marine-Hospital Service (Bearss 1983:357-379).

CONCLUSIONS

As stated in my hypothesis, I believe that the ship wrecked at East Key was carrying a cargo of mixed construction materials intended for the completion of the "big-magazine" at Fort Jefferson. As this study has shown, the graywacke material located at the East Key Wreck Site is identical to material used as flagging stones for the floors of the casemates and the detached parade-ground magazine. The flagging stones at the wreck site are significantly more narrow than stones currently in place in the casemate floors and, therefore, cannot have been intended for those floors. The widths of the flagging stones are comparable to stones already in place in the "big magazine" and they are of sufficient quantity to complete the unfinished floor.

The ship located at the East Key Wreck Site was a wooden-hulled vessel, possibly a schooner, of approximately 350 tons. The ship was carrying construction materials intended for the completion of the detached parade-ground magazine located at Fort Jefferson and was wrecked during the year 1866 or 1867. The rigging and some construction materials such as bricks were salvaged for repair or maintenance of other structures at Fort Jefferson. Cost of replacement of cement and cost of salvaging flagging stones for the already obsolete detached parade-ground magazine was too much for the limited construction funds for Fort Jefferson, and any further plans for its completion were abandoned.

Loss of materials at the East Key Wreck Site contributed to the delays and added to the expense of construction at Fort Jefferson. It will be necessary to study other construction wrecks in the Dry Tortugas in order to understand the full scope of the effect that shipwrecks and the materials lost on them had on the construction history of Fort Jefferson.

CHAPTER XVII

Bird Key Harbor Brick Wreck (FOJE 029) Fieldwork Prior to 1990

Larry E. Murphy

The Bird Key Harbor Brick Wreck has long been known by National Park Service (NPS) personnel. A memo by Southeast Archeological Center (SEAC) archeologist George Fischer (Fischer to Nordby 3/8/88) stated he had visited the site in 1969. A site visit was not recorded during the 1971 survey, and this shipwreck was not listed among known sites then. Florida State University students photographed and mapped the wreck in 1976 (Logan 1976; see Chapter X). Members of the NPS Submerged Cultural Resources Unit (SCRU) briefly snorkled the site in 1985 (Lenihan 1985:7). The Bird Key Harbor Brick Wreck was recorded as site number FOJE UW 029 by SEAC sometime after 1987.

The Bird Key Harbor Brick Wreck is located on the Bird Key Bank's east side in about 6 ft of water, lying bow to shore, listing to starboard. Principal site features are hull bottom, iron frames and stern deadwood, drive shaft and 5 1/2-ft, four-blade screw. The dark, oblong shape of the site against the surrounding white sand is easily visible from the air (see Plate 12.21).

1988 FIELDWORK

A survey team under Larry Nordby's direction visited the site the afternoon of March 21 and the morning of March 22 when conditions were rough at UW 003 (see Chapter XI). Larry Nordby, Ron Ice, Jim Delgado and Rich Curry made a sketch map. Afternoon dives on March 22 were terminated because of strong current.

A single glass bottle bottom was recovered (Acc. FOJE #11, Acc. No. 129) from the starboard side about 1 m from the hull and 10 m from the propeller. The thick, green-glass bottom is asymmetrical and contains a kickup and pontil scar with no mold marks, indicating it is hand-blown (Plate 17.1). Most characteristics are consistent with demijohns similar to

Plate 17.1. Green, glass bottle bottom recovered from 029 in 1988 (FOJE Accession Number 11). Bottle identified as a midnineteenth century demijohn. NPS photo by Jerry Livingston.

those recovered from the stern-wheel steamer BERTRAND, lost April 1865. This bottle type was commonly used for intoxicants (Class III, Type 1, Switzer 1974:22-24; see also Petsche 1974).

1989 FIELDWORK

Objectives were to examine the site for diagnostic features, hull structural elements and engineering features so a reasonable priority could be set and methodology developed for future site documentation. A secondary objective was to determine site scatter and assess other factors for planning the 1990 fieldwork.

The site was visited June 29 and July 4, 1989, by Richard Gould, Linda Stoll and Larry Murphy. On June 29, they snorkeled the wreck and general site; scuba was used on July 4. Diving tasks included structural feature examination and a general perimeter survey to determine site scatter extent and direction. One wood sample, FOJE-689-6, was removed. This was from an outside hull plank and identified as oak (*Quercus* sp., Dean 1990).

Site Description

This brief description is based on the 1989 reconnaissance. A more detailed presentation is in Chapter XVIII. This shipwreck is a screw-driven, narrow-beamed, steam vessel likely involved in some way with Fort Jefferson construction activities. The hull had a hard-chined flat bottom with longitudinal sponsons that increased deck-load space without altering length-to-beam ratio, which is important for vessel speed. The hull length-to-beam ratio is estimated to be about 1:6-7, indicating a vessel built for speed.

The wreck lies with a starboard list, bow to Bird Key Bank. Stern deadwood has separated from the hull and is lying on its starboard side with the four-blade propeller and 6-in-diameter shaft still attached. Iron straps heavily reinforce the deadwood.

The encrusted screw blades are 3 ft long, 1 ft 6 in at the base and 2 ft 10 in wide on the outboard end. The detached, unbalanced, bottom-supported rudder, with rudder head features missing, lies a few feet to starboard stern. The rudder, blades and hub are wrought iron. The 1-ft square hub-nut assembly appears asymmetrical on the stern face indicating it is keyed; the key is about 10 in long. The stern deadwood iron reinforcing supported the combined weight of the shaft, screw and rudder.

Interior hull features are boiler features, floor plates and iron floor-frames. Frames are on 2-ft centers, 4 ft wide at the floor and 1 ft high (moulded). There are remnants of a moulded centerline longitudinal feature composed of two 2-in x 2-in angle-irons 4 in apart with angles facing the hull side. Additional construction features, particularly longitudinal support mechanisms were sought, but none observed. It was expected that some additional longitudinal hull support would have been necessary for this hull design, but none was found. Detailed investigation of hull fasteners, strapping and reinforcement features, especially in the stern, was planned for future fieldwork.

No evidence of engine, condenser, pumps or other steam machinery was located. The engine was likely a direct-acting, horizontal high-pressure type. During the 1850s, direct-acting engines superseded geared engines in Great Britain (Smith 1937:146), although direct-acting engines had been common for decades on US western rivers. Some mid-1840s screw steamers carried 45-80 psi engine pressure turning about 45 revolutions per minute (Fraser 1845:5; Walker 1861:25). No stern tube or shaft log evidence remained on site. Lignum vitae was introduced as bearing material in 1856 (Graham 1958:46), replacing brass (Smith 1937:79). Determination of bearing material will require encrustation removal in some areas along the shaft.

Bricks amidships represent the boiler bed position. The boiler was likely a square or rectangular fire-tube type. It was undoubtedly made of iron, as steel was rarely used for boiler construction until availability of open-hearth steel around 1874 (Smith 1937:197). It possibly could have been an early water-tube type, probably vertical. This type was available in the early 1860s (Walker 1861:25).

The port hull-side, which is accessible along the bilge, was examined for construction details. Hull construction is composite--iron frames and wood hull-planks, with iron shell-plates on the hull bottom. Iron shell--plates attached to the frames are covered with 2-in-thick oak hull-planks. Muntz-metal hull sheathing was noted on the planks. Sheathing iron hulls with planks and cuprous sheets was common in midcentury to diminish rapid biological fouling common to iron hulls. Because of rapid galvanic iron corrosion when in the presence of copper, all iron had to be thoroughly insulated from the copper components. A necessary question arises regarding the exposed iron stern-components on this vessel. The prop, shaft, rudder and rudder skeg do not appear to have been sheathed and would have been exposed to galvanic reduction. What methods, if any, were employed to protect the iron components?

Composite hulls were an early variation for screw-powered vessels. By the mid-1860s, composite construction was recognized as being much too weak for the strain and vibration of screws (Graham 1958:46). Composite construction for ocean vessels in general was passing out of favor by the mid-1860s, and "could not be recommended on the score of economy or safety" (Fairbain 1865:71). Hull construction on this site supports an early construction date, or possibly indicates a local (southern) builder.

Gould and Stoll's 1989 site perimeter investigation indicated artifact scatter extends at least 50 m to starboard. No material was observed on the seabed off the port side. Two unmarked yellow bricks and a red brick were located close to the wreck.

Site Analysis and Engineering Context

The vessel is an early narrow-beam, shoal-draft screw steamer and appears to be the oldest screw-powered vessel in NPS waters. Screw propellers are generally considered to have been introduced in the 1840s. However, British screw propeller patents appeared in 1832 by B. Woodcraft and F.P. Smith in 1836 (Murray 1863:136), six weeks before John Ericsson (Smith 1937:67), who is sometimes credited with inventing the screw propeller. Ericsson demonstrated a functioning screw-driven vessel to the British Admiralty in 1837 (Graham 1958:39-40), but no interest was shown, and Ericsson moved to the US in 1839. Hull vibration was a serious problem with early propellers and, coupled with inherent weakness of wooden-hull sterns, limited screw acceptance until the advent of iron hull construction, which was primarily the result of merchant development (Smith 1937:95).

The first iron steamer, the side-wheeler AARON MANBY, was built in England in 1822. The vessel was similar in dimension to the Bird Key Harbor site: 106.8 ft between perpendiculars and 17.2 ft beam, draft of 3.5 ft (Brady 1954:2). The first iron screw-steamer built in this country was VANDALIA, 1839, designed by Ericsson and built by the Phoenix Foundry for lake use, closely followed by CLARION for ocean use between New York and Havana. There were about fifty propellers operating in the US by 1840 (Porter 1918:3), and about the same number in the

British Navy ten years later (Smith 1937:75). Soon steamers appeared in the Gulf and Caribbean; in 1855 the Ericsson Company built the iron steamer MATANZAS for the West Indies trade (Porter 1918:7). A pair of screws were fitted to J.S. MCKIM, a vessel in the Gulf trade in the early 1840s (Cramp 1909:149). This vessel was later used as a transport in the Mexican War. Some early iron steamers were constructed specifically for the Gulf trade (Cramp 1909:156-157).

The most diagnostic site attributes are hull features, primarily composite construction, and the low-pitch, four-blade prop that appears large for this size ship. These features are consistent with construction and machinery practices prior to the Civil War. In the early 1860s, three and four-blade props were considered superior to two-blade props because of greater speed and less vibration (Murray 1863:138). The design may be a local Loper propeller modification (Ridgely-Nevitt 1981:191), which was in use in the early 1850s. Loper and Ericsson propeller designs were the two principal competitors in the mid to late 1840s (Fraser 1845). The Ericsson version, less successful than the Loper style, was similar to the original John Stevens screw design.

The Bird Key Harbor vessel may have been carrying bricks to Fort Jefferson and for this reason has long been known as "the Brick Wreck." Brick construction on the fort began in 1848 (Bearss 1983:46), and southern bricks were used in the 1850s. Captain Scarrit, who procured Fort Jefferson construction materials in 1853, noted: "Pensacola bricks averaged about 90 cubic inches, whereas northeastern bricks measured less than 60 cubic inches" (Bearss 1983:73). A contract let at the same time for Pensacola bricks specified they be at least 90 cu in volume for use at Fort Jefferson and Fort Taylor (Bearss 1983:74). Yellow bricks located on 029 were more than 90 cu in.

In 1985, SCRU speculated the vessel may have been an old, local vessel salvaging bricks from the fort (Lenihan 1985). It seemed unlikely a screw would have been employed in carrying materials to the fort as early as the ante-bellum yellow-brick construction period, which was a very early period for US screw-driven vessels. Gould's research reported below indicates the vessel probably was carrying materials to the fort.

It is curious that bricks would have been carried on the most expensive, fastest vessel type available in the 1850s and early 1860s. Period steamers were much more likely to carry high yield passengers or expensive merchandise. The numerous Gulf schooners would more likely be carrying bricks, considered bulk cargo. Pensacola brick manufacturers agreed to transport bricks to Fort Jefferson aboard a "vessel drawing 14 feet of water" in the 1850s (Bearss 1983:72), indicating use and availability of large sailing vessels at this time.

The Bird Key Harbor Brick Wreck, because of its small size, narrow beam and shallow draft, would be an impractical brick transportation vessel. Assuming it was doing so, why would it be carrying bricks? Perhaps there was a shortage of more practical vessels, or it was important to get a small cargo of bricks to the fort in a short time. There were contract and transportation difficulties with southern brick manufacturers beginning in the 1850s (Bearss 1983:76). Possibly this was an attempt by a supplier to get a cargo to the fort quickly in a difficult time. Or, the vessel may have been carrying samples for shipment acceptance, with the bulk of the shipment to be sent upon sample acceptance by fort engineers. Clearly, more historical research is needed for this site.

1990 BRICK NOTES

Since this site's discovery and naming, it has been assumed the vessel carried Fort

Jefferson construction bricks, either to or from the fort. However, little solid evidence associating bricks found on this site with Fort Jefferson has ever been offered beyond presence of yellow bricks on the wreck, and pre-Civil War Pensacola yellow bricks were used in fort construction. Gould's 1990 site documentation produced some good evidence, although not elaborated in his report (Chapter XVIII).

In 1964 Stanley South suggested an index for brick comparisons based on the sum of three measurements in 1/8-in increments (e.g., an 8 1/8-in dimension equals 65 eighths). Lazarus (1965) conducted a brief study of Pensacola bricks evaluating South's index. Within Lazarus' research population was a single positively identified Fort Jefferson-type brick made by Abercrombie in the period 1857-1860. Abercrombie was the principal Fort Jefferson brick contractor before the Civil War. This brick measured 9 in x 4 1/4 in x 2 1/2 in (Lazarus 1965:75,79) giving a South's brick index of 126.

Gould measured 25 yellow bricks directly associated with 029, two partial-brick measurements were eliminated. The average South index was 125.7, with a range of 121-134, which supports direct association of 029 bricks with Fort Jefferson and perhaps from Abercrombie yards. Fourteen red bricks, probably New England origin, from 029 were also measured, one measurement was rejected as in error or from a partial brick. The South's brick index for red brick was 110, range of 97-130.

The 1989 reconnaissance recorded some specific observations, including its probable early date and Fort Jefferson association. The site's normally protected location would make it a possible backup location for diving on days other sites are weathered out, except in periods of strong northerly winds (Nordby 1988a). Strong current could affect work on the site, which is about 6 ft deep. Local knowledge was insufficient to determine under what conditions this site would prove an acceptable backup.

Lenihan's observation, that if this vessel was involved in the fort construction, "it would be an early propeller and therefore of considerable significance to marine history and architecture" (Lenihan 1985:7), contributed to making detailed documentation of this site a top priority for the 1990 fieldwork, which is reported in Chapter XVIII.

CHAPTER XVIII

Bird Key Harbor Brick Wreck (FOJE 029) 1990 Fieldwork

Richard A. Gould

After a preliminary examination during the summer of 1989, we decided to conduct a base line survey of this small shipwreck the following summer. The wreck is located in shallow water ranging from 4-9 ft deep at mean tide on Bird Key Bank inside the west end of Bird Key Harbor approximately 1,700 yd southwest of the Fort Jefferson lighthouse. Our initial interest focused on remains of the ship's cargo of bricks found scattered within the hull area and over a broad area to the north on Bird Key Bank. These bricks indicated the ship's destination was Fort Jefferson and suggested that more could be learned about the historical relationship of the wreck to the fort's construction history by mapping the wreck site in detail.

Plate 18.1. Side view of propeller. NPS photo by Larry Murphy.

Plate 18.2. Port hull-bottom view showing iron frames, wooden hull planks over iron shell plates. Fragments of Muntz-metal sheathing were observed. NPS photo by Richard A. Gould.

Prominently visible wreck features also indicated the ship itself might be of historical interest, especially for what it could tell us about early Gulf of Mexico steamboat construction and design. Our initial examination showed that the ship had a large, four-bladed screw propeller with flared tips to the blades, which preceded screws with narrow blade tips. This differs from the Griffith's screw in which the outer part of the blade narrows and comes to a more pointed tip. The Griffith's screw was introduced, primarily in England, from around 1855 (Yeo 1894:182), so, even allowing for delays in the dissemination of this technology, the propeller on the Bird Key Harbor Brick Wreck must date from prior to or around that period.

Examination of hull remains revealed the ship was of composite construction, with wrought-iron frames, iron hull plates along the bottom and partway up the sides, and an exterior covering of wood. A hull plank sample (FS 689-6) was identified at the University of Arizona Laboratory of Tree-Ring Research as oak, but no species identification was possible. Composite hull construction was fairly common on commercial ships during the midnineteenth century (Thearle 1910; Paasch 1890; Doyere 1895), and this feature provided another indicator of the ship's general antiquity. Finally, presence of outer hull sheathing of Muntz metal, a copper-zinc alloy introduced during the 1850s as an alternative to higher-priced sheathing of pure copper, pointed to a midnineteenth century date.

1990 FIELD SEASON

In July, a volunteer group from Maritime Archaeological and Historical Society (MAHS) conducted preliminary site measurements.

Detailed site mapping and recording was carried out over a four-week period in August 1990 by a team of volunteers recruited under the National Park Service Volunteers in Parks (VIP) program. All volunteers were checked out by Park Service staff members in diving and boat-handling skills and were trained at the start of the project in site-recording techniques, including base line trilateration. Volunteers were rotated regularly between the Bird Key Harbor Brick Wreck Site and the East Key Wreck (UW 011), so it was unusual to have more than five volunteers on site at any one time. All archeological recording activities at this site were supervised directly by Richard Gould, although several site visits by Larry Murphy provided timely and useful advice. From time to time, staff members and VIPs from Fort Jefferson National Monument (NM) assisted in the fieldwork, and their help, too, was welcome.

Diving conditions were generally benign, although strong tidal currents sometimes swept across Bird Key Bank. Although not a serious safety hazard, these currents made accurate site recording difficult and led to several instances where planned dives were cancelled. The shallow depth of the site and its generally exposed condition meant no decompression or penetration diving was required. But the site was uncomfortable as a place to work owing to the combined effects of currents and surge in the shallow water on the divers, who often collided with marine growth covering the wreck. Visibility was variable, ranging from 12-30 ft, according to the strength of tidal currents and surge.

The site recording program was planned in three stages. First, a trilateration survey and direct measurements (based on trilaterated points) were carried out on parts of the ship's structure that remained relatively intact or articulated with other structural elements. Second, further trilateration and direct measurements were done to measure and map detached structural elements. And, third, limited measurement and recording were done for portable artifacts larger than brick size. No attempt was made in the 1990 field season to record location and characteristics of smaller items, because such an effort would require different techniques, and an evaluation of Park Service policies and procedures for conducting archeological excavations on submerged sites.

The approach used in 1990 was entirely nondestructive archeologically. Some portable artifacts, such as marked bricks and pieces of ship's machinery, were brought ashore for superficial cleaning and were drawn and photographed in detail. These items were then returned to the locations from which they were recovered, where they presently rest.

SITE CONDITION

The shallow and exposed location of Bird Key Bank represents a high-energy environment that is subject to intense scouring and silt movement, especially during storms. Plate 12.21 shows an aerial view of the site and two other features (which were not investigated). The shipwreck has acted as an artificial reef, providing a firm, hard substrate for marine growth and associated animal life. The area surrounding the wreck is characterized by loose silt and coral rubble, with patches of turtle grass and some small coral heads in some of the shallow areas. There is a shallow scour in the seabed along the port side of the wreck with a corresponding low rise about 20 ft out from and parallel to the ship's

Plate 18.3. Richard Gould during mapping operations in 1990. NPS photo by Larry Murphy.

hull. This is the result of strong tidal current action, which we observed several times.

The wreck itself is thickly covered in marine growth, with fire coral especially well represented. The site abounds in fish and lobsters. A few selected parts of the shipwreck were subjected to superficial cleaning and removal of marine growth to facilitate accurate measurement and photography. These areas included the propeller, the deadwood structure (including the propeller shaft), frames and features along the port side, and some detached hull structure near the bow. In each case, a serious effort was made to avoid exposing bare metal. Sometimes, too, hand fanning was used to remove surficial silt when tracing key portions of the ship's structure, such as the bow frames and propeller shaft. Such fanning rarely penetrated more than 6 in below the seabed, but even such limited efforts revealed many small artifacts such as copper or bronze fasteners, screws, fittings, broken bottles and bricks resting loose in the silt near the ship's hull.

The ship's hull structure remains reveal a sequence of destruction that included both human and natural factors. The ship was driven onto Bird Key Bank with the engine running, although it is not known whether this was done by accident (an error in navigation?) or on purpose (was the ship already in danger of sinking?). A look at the site map (Figure 18.1) shows that the bow struck the sandbank and "accordioned," breaking into two separate pieces. The intact hull area closest to the bow was also deformed by the shock of the initial collision with Bird Key Bank. The ship's bow struck at almost a right angle to Bird Key Bank, pointing west in a direction slightly south of Loggerhead Key.

Meanwhile, at the stern, the propeller struck the seabed, tearing the deadwood away from the main part of the lower hull. The ship was being driven forward while the propeller had been reversed and was turning in a counterclockwise direction. The deadwood was twisted over onto its starboard side at an angle of 32°, where it presently rests with the propeller shaft running through it, still intact and attached to the propeller. Forward of the thrust bearing there is a gap of about eight feet where the separation from the hull occurred, and the ship's structure in and around this gap is especially broken up and deformed. The ship's rudder was torn off at this time and came to rest flat on the seabed a short distance to starboard of the propeller.

The main part of the lower hull survived the shock of striking the bank relatively intact and came to rest leaning to starboard at an angle of 12° (20° less than the ship's deadwood) and more or less level fore-and-aft. A total of 33 ship's frames were found still relatively intact and attached to some degree to other elements of the lower hull, although many of these frames were broken and bent. The port side of the lower hull has survived better than the starboard side, with more frames, stringers, and sections of hull plating attached and visible.

Plate 18.4. View of hull interior showing frame, brick and typical coral growth. NPS photo by Richard A. Gould.

Given the shallow depths in this area, it is reasonable to assume the deck and superstructure above the lower hull were exposed above water after the grounding occurred, making access for salvage easy. After settling on Bird Key Bank, the ship was subjected to salvage operations, perhaps more than once, that led to the removal of the engine and most of the ship's machinery. Shattered iron firebox and boiler components as well as thick frames and other elements show jagged breaks indicative of blast damage. Blasting no doubt accounts for the initial breakage of the ship's structure, especially when dealing with heavy structural elements. For example, parts of the ship's firebox, including 1.5-in-thick iron plates and layered brickwork, were found in at least seven, widely scattered parts of the site. These included one large piece thrown more than 60 ft from its original location amidships and one of the ship's cast-iron firebox doors. Many other large structural elements were detached due to salvage operations, and these now either rest inside the hull or form a kind of "halo" on the seabed around the lower hull.

Further scattering of detached structural elements and portable artifacts resulted from storms that swept across Bird Key Bank after the sinking and salvage of the wreck. Such detached items tend mainly to occur across a debris field that extends north of the wreck. Two clusters of iron wreckage from the ship's structure were recorded along with nearby bricks and other, smaller objects. One of these clusters occurred 422 ft north of the ship's starboard side, while the other was 840 ft north of the same point. Such a wide distribution of ship's structure and/or machinery was most likely the result of a two-part sequence involving initial detachment due to blasting during salvage, followed by further dispersal from powerful storms.

CHRONOLOGY AND CHARACTER OF THE SHIP

So far the historical analysis of the ship and the circumstances of its loss is based almost entirely upon archeological evidence and must be regarded as preliminary. Archival research is planned, especially in the Pensacola area, where this ship is believed to have collected its cargo of bricks. No identification has been made yet of this ship, but enough is known about it from our archeological findings to make positive identification likely once the relevant archives have been studied. Many provisional conclusions presented here should be regarded as low-level hypotheses to be tested in relation to whatever documentary sources become available.

Our survey revealed that there are three types of brick present on this site. One type consists of unmarked yellow bricks identical in size, shape and texture to those used in construction of curtains, bastions, and other major parts of Fort Jefferson (and at Fort Taylor in Key West). These bricks were the ship's primary cargo, and there is a strong possibility that many others were present on board at the time of the sinking. Some may have been recovered during postwreck salvage operations. Both other brick types were used in the ship's firebox. Portions of the firebox were found intact, with bricks laid in courses and mortared in place. The firebox was made of 1.5-in-thick iron plates, lined on the inside with a course of yellow firebricks facing the fire, and a course of red bricks serving as insulation between the layer of yellow firebricks and the iron plates enclosing the firebox. A total of 18 yellow firebricks with the marking, "EVENS & HOWARD, ST. LOUIS," were found at the site, including two cemented directly into the firebox structure.

Figure 18.1. Bird Key Harbor Brick Wreck Site (FOJE 029). Drawing by Richard A. Gould.

These were manufactured by the Evens and Howard Firebrick Company from 1857 to 1930 (Gurcke 1987:232). Two other yellow firebricks were found at the wreck site with different markings that could not be fully deciphered or dated. The red insulating bricks were probably of northern origin and were similar to red bricks used in parts of Fort Jefferson. Had some of these red brick not been cemented directly into the firebox structure, we might have assumed the loose red bricks in the vicinity to be part of the ship's cargo.

The firebricks marked "EVENS & HOWARD, ST. LOUIS" are securely dated and indicate the ship could not have sunk before 1857. The yellow bricks used in the construction of Fort Jefferson and present in firm of Raiford and Abercrombie in Pensacola, based on a contract with the Army dated August 24, 1854 (Ellsworth 1974:251). Difficulties with production and quality control delayed the delivery of Pensacola bricks to the fort in significant quantities until 1858. But, from then until the start of the Civil War, the firm (reorganized and renamed Bacon and Abercrombie) produced more than 16 million bricks for the federal government, most of which were used in the construction of Fort Jefferson and Fort Taylor. Under secessionist pressure, the firm stopped producing bricks for the Federal government after February 26, 1861. The brickyard was finally burned by Confederate forces in March 1862. So, the latest possible date for the cargo of Pensacola yellow bricks found associated with the Bird

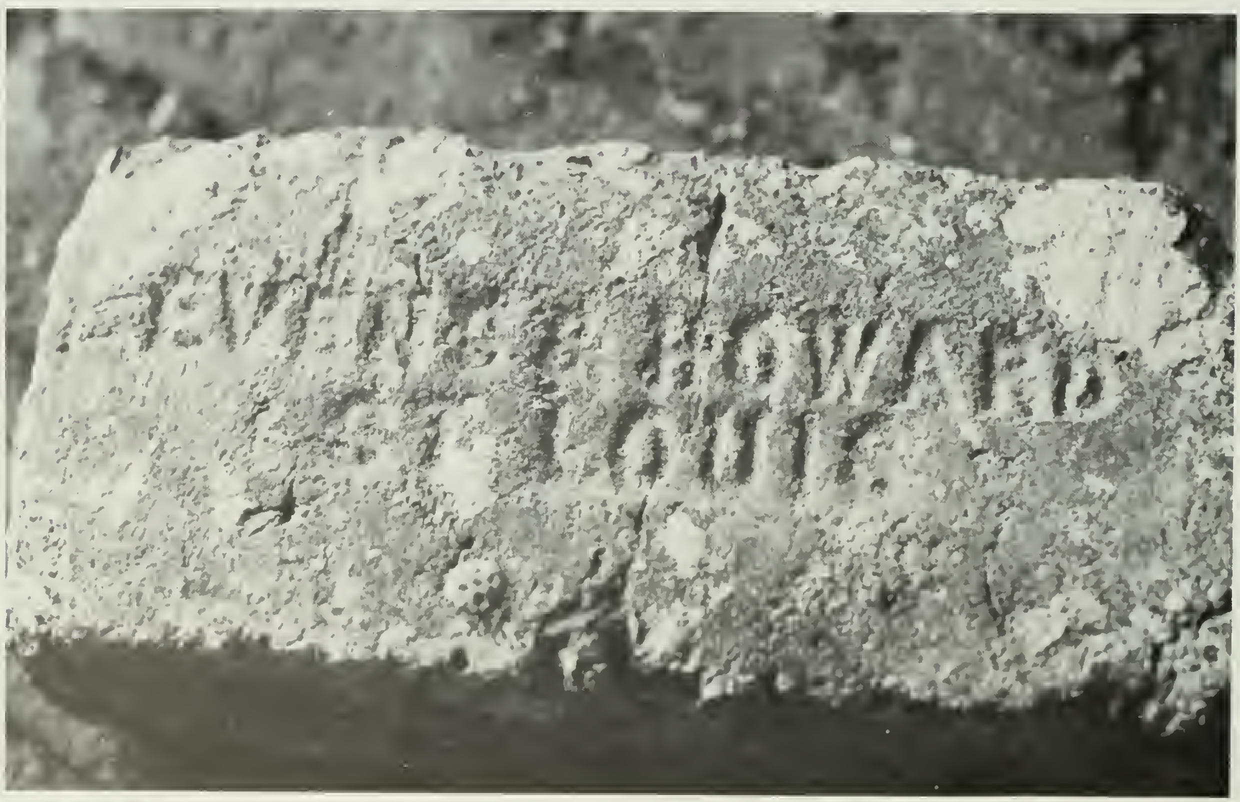


Plate 18.5. Marked brick from 029. NPS photo by Richard A. Gould.

Key Harbor Brick Wreck is 1861, and the loss of the ship must have occurred sometime between 1857 and 1861.

The ship was a shallow-draft, flat-bottom steamboat with a narrow lower hull of composite construction and with frames that flared outward on each side near their tops to support a broad main deck. The trilateration plot reveals a minimum length for the lower hull from the bow to the propeller of 108 ft (103 ft between perpendiculars). Measured across at the top of the iron sheathing 1 ft above the hull bottom, the maximum lower hull beam is 12 ft, while the maximum beam at the point below where the sponsons flare outward was 14 ft. These measurements indicate the lower hull was narrow in relation to its length, with a fineness ratio of 1 to 8.6. The lower hull was hard-chined as well as flat-bottomed and narrow, all of which suggests that the ship was intended for use in shallow and relatively sheltered waters as opposed to operating in the open sea. No evidence was found for combined sail-and-steam propulsion, such as was common for seagoing steamships of the midnineteenth century. Absence of rigging and mast hardware on the wreck site, or especially mast steps within the hull area can be accepted as reasonable, albeit negative, evidence for exclusive steam propulsion. This interpretation is strengthened by the fact that the lower hull had neither a keel nor true keelsons.

Although the ship's engine and much auxiliary machinery was removed during salvage operations, other elements were left in remarkably good condition. The propeller and propeller shaft assembly are of special interest. These were made of massive, solid wrought iron, which accounts for surviving the grounding impact with little visible damage. By comparison, the lower hull and deadwood structures were lightly built. The propeller measured 6 ft in diameter from tip to tip (Plate 18.6) and had four blades, each expanding in width from the hub to a maximum of 2 ft 10 in (Plate 18.7). The propeller geometry is simple, as the measured distances between blade tips and from tip to hub for each blade are also 2 ft 10 in. Viewed from astern, only the lower portside blade shows any damage due to grounding, and this is confined to a small part of the blade tip in contact with the seabed. This damage, slight though it is, shows that the propeller was turning counter-clockwise at the moment it struck the seabed--that is, it was being run in reverse as the ship backed down immediately prior to grounding. This evidence supports the idea that the ship grounded accidentally, although the possibility still exists that the ship was being slowed down just before impact, even if the grounding was intentional. This was not a true screw propeller but more closely resembled a set of four flat paddles, each set into the hub at an angle of 65°. There was no curvature to any of the blades except at the base where each blade merges with the hub. The hub was square in cross section, but, even after light cleaning, it was difficult to see the locking pin assembly in detail.

From an engineering standpoint, this propeller represents a combination of good workmanship in wrought iron and poor ship design. The propeller's heavy weight and flat blades probably produced intense vibration and torque, which called for a propeller shaft of equally heavy construction. The propeller and shaft assembly can be viewed as overbuilt in relation to the rest of the structure, and the vibration transmitted to the ship, especially around the stern, must have been alarming while under power. There is clear evidence for this in the deadwood assembly surrounding the propeller shaft in the form of heavy iron strapping wrapped around the outer composite covering of the deadwood. Remnants of three of these straps are still resting in place partially covering the deadwood, while openings in the deadwood covering indicate where two additional straps were attached and later torn away. There are five straps on each side, supported by a composite iron-wood-iron sleeve with a V-shaped cross section fitted over the deadwood keel. Such heavy strapping near the stern is best explained as something that was added on after the ship was completed and the propeller's vibration and torque effects had been experienced while under way.

Jammed into the seabed underneath the lower portside propeller blade is a portion of the skeg, and about four feet to starboard of the lower starboard propeller blade the ship'srudder lies flat on the seabed. The rudder was fashioned from a solid wrought-iron slab 3-in thick and is intact and virtually complete. Like the propeller and propeller shaft assembly, the rudder was massively overbuilt, perhaps to withstand the turbulence generated by the propeller. The pintle and bushing are still attached to the rudder.

Forward of the thrust bearing, a single frame aligned with the deadwood structure projects from the seabed, marking the forward end of the deadwood where it became detached from the rest of the lower hull. Additional frame structure associated with the deadwood may be present below the seabed surface, but we did not excavate to explore this possibility. The 8-ft gap forward of this frame represents a break in the hull structure where the deadwood tore away from the rest of the lower hull when the ship struck Bird Key Bank. The surface of the seabed here is covered with twisted frames and stringers, many of them detached and resting loose. At the point where the first of the lower hull frames appears, there is twisted lower-hull

Plate 18.6. Bird Key Harbor Brick Wreck propeller. NPS photo by Larry Murphy.

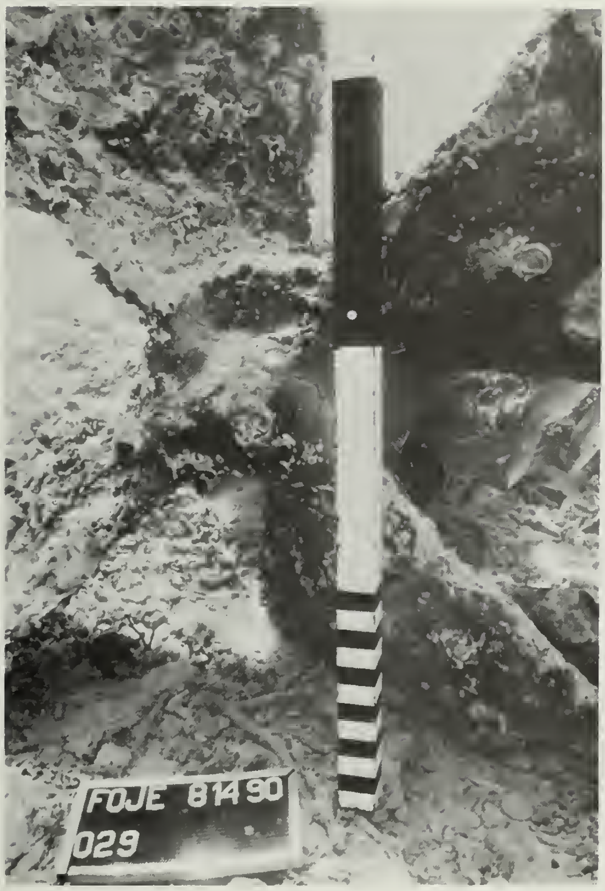


Plate 18.7. Close-up of propeller hub and key. NPS photo by Larry Murphy.

plating along the port side that also reflects effects of the collision with Bird Key Bank. For purposes of orientation, this frame was designated as Frame 1, with each frame encountered forward of Frame 1 being numbered consecutively and identified on the plan of the wreck site, for a total of 33 visible frames. Any frame attached in some way to the lower hull structure was included in this total. In addition, at least nine detached frame elements were found near the bow and along the seabed on the ship's starboard side.

It was possible to trace the iron plating of the lowermost part of the ship's hull along the port side continuously from Frame 1 to Frame 31. The twist in the outer hull plating referred to earlier extended forward only as far as Frame 3. From that point forward the hull plating accurately reflects the curvature of the lower hull along a line parallel to, and 1-ft above, the flat hull bottom. Spacing from midpoint to midpoint of each frame is 1.5 ft throughout the ship. It was not always possible to trace each frame continuously across the lower hull, owing to debris and marine growth, which was especially thick along the ship's centerline. The plan drawing assumes continuity with frames that were measured and found to be aligned from the port to the starboard sides of the lower hull. Excavation under the debris within the lower hull would be required to establish whether or not some of these frame ends are actually connected. The lower hull plating on the starboard side was less well preserved and could be traced only from Frame 11 to Frame 17. Hull curvature here matched that on the portside hull and allowed us to measure across the ship at a point at or close to its maximum beam (at Frame 17). Estimates of the ship's beam are based on these measurements.

Our best look at the ship's frames came from a section on the port side from Frame 6 to Frame 9 (Figure 18.2). This section was cleared of surficial marine growth and recorded in detail to provide a picture of the attachment of longitudinal stringers to the frames, and of the relationship of the frames there to the ship's firebox. While many of the ship's frames consisted of simple angle irons of L-shaped cross section, the frames here were more complex in shape and served also to support the firebox assembly in the midships area. The outward flare at each frame top that forms an overhang or sponson along the port side was clearly visible and is assumed to have been matched symmetrically by the starboard frames. Unfortunately, ends of these curved frame elements are all truncated, so we cannot accurately estimate the sponson overhang. One clue to this could

Plate 18.8. Balanced rudder of 029. NPS photo by Larry Murphy.

come from a scatter of eight curved iron frame elements resting on the seabed close along the lower port hull side. These may have been supporting elements attached in some way to the hull frames to reinforce the main (cargo) deck at the point of overhang. Of course, this interpretation is only provisional and must await further documentation.

The 1.5-in thick rectangular iron plate resting upon and attached to Frames 9, 10 and 11 on the port side is almost certainly a baseplate for the ship's firebox. There is a round hole 1 ft in diameter near one corner of the plate along with a red insulating brick still cemented to this same corner (Plate 18.10). Further forward, resting on Frames 13, 14 and 15 but not attached to these frames, is another iron-plate fragment of similar size and thickness, with layers of both yellow firebrick and red insulating brick still cemented in place (Figure 18.3).

Additional fragments of thick iron plate with firebricks and/or red insulating bricks still attached occur nearby, but the exact number and shape of these pieces will be hard to determine without extensive removal of marine growth and overlying debris. These shattered plates with their associated layers of brick represent the heavily blasted components of the original firebox, and, as indicated earlier, additional brickwork elements and a cast-iron firebox door occur widely scattered over the site. The iron slabs associated with

Plate 18.9. Jack shaft (left) and thrust bearing (right). NPS photo by Larry Murphy.

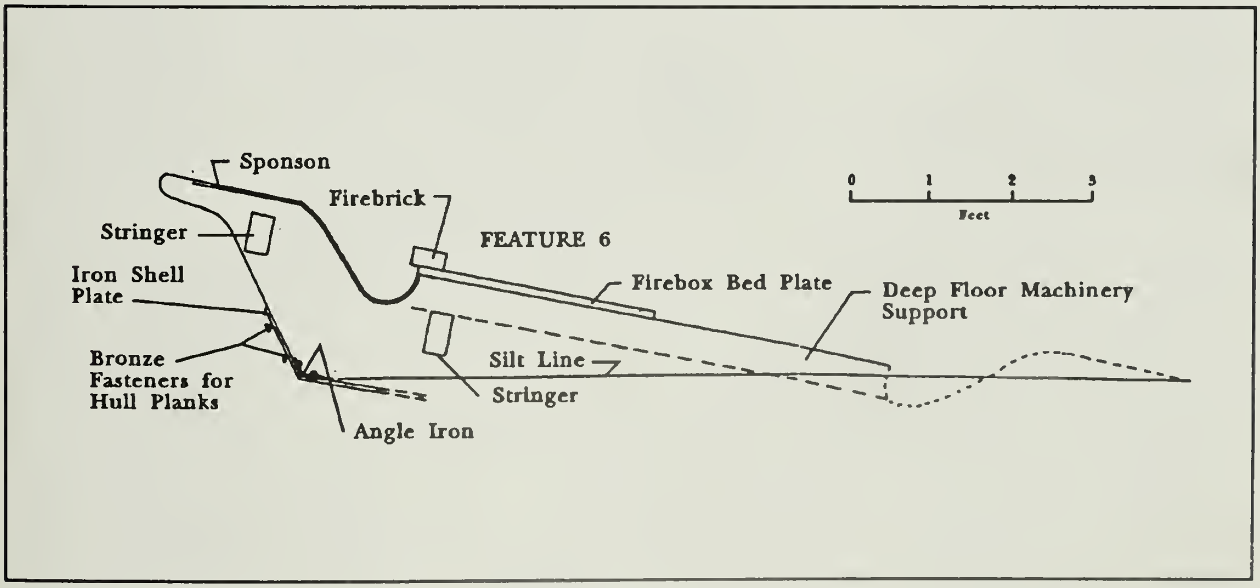


Figure 18.2. Hull cross section. Drawing by Richard A. Gould.

the firebox are the thickest metal on the ship, with the rim surrounding the baseplate hole achieving a thickness of 2.5 in. Substantial amounts of coal were found resting on the bottom plates of the lower hull near the firebox, especially along the port side. It is unlikely that coal was actually bunkered in such an inaccessible location. Instead, the bunkers were probably destroyed during salvage, and the residual coal within these bunkers came to rest below them inside the lower hull.

Resting nearby and partly overlaying the firebox assembly are two rectangular iron pieces and, a few feet astern of these, two more fragments of similar thickness and shape. These pieces are 1 in thick except at the edges and corners, which are rounded and up to 1.5 in thick. These appear to be pieces of an "...ordinary low pressure American angular flue boiler," (Ward 1860:39 and Figure 1) and also resemble the boiler shell for low-pressure boilers of rectangular or box-shaped section described by Yeo (1894: 13). The dimensions of these pieces suggest a rectangular iron shell 8 ft long, 3 ft wide and 2 ft high, although it is possible that more than one of these may have been present. Such a rectangular firebox-boiler assembly would be consistent with the pre-1857 construction date inferred for this ship. More exact identification of the firebox-boiler assembly may be possible once plans and documents on early Gulf Coast steamboats have been studied.

Plate 18.10. Machinery spaces bed plate with 1-ft diameter hole. NPS photo by Eugene T. Rowe.

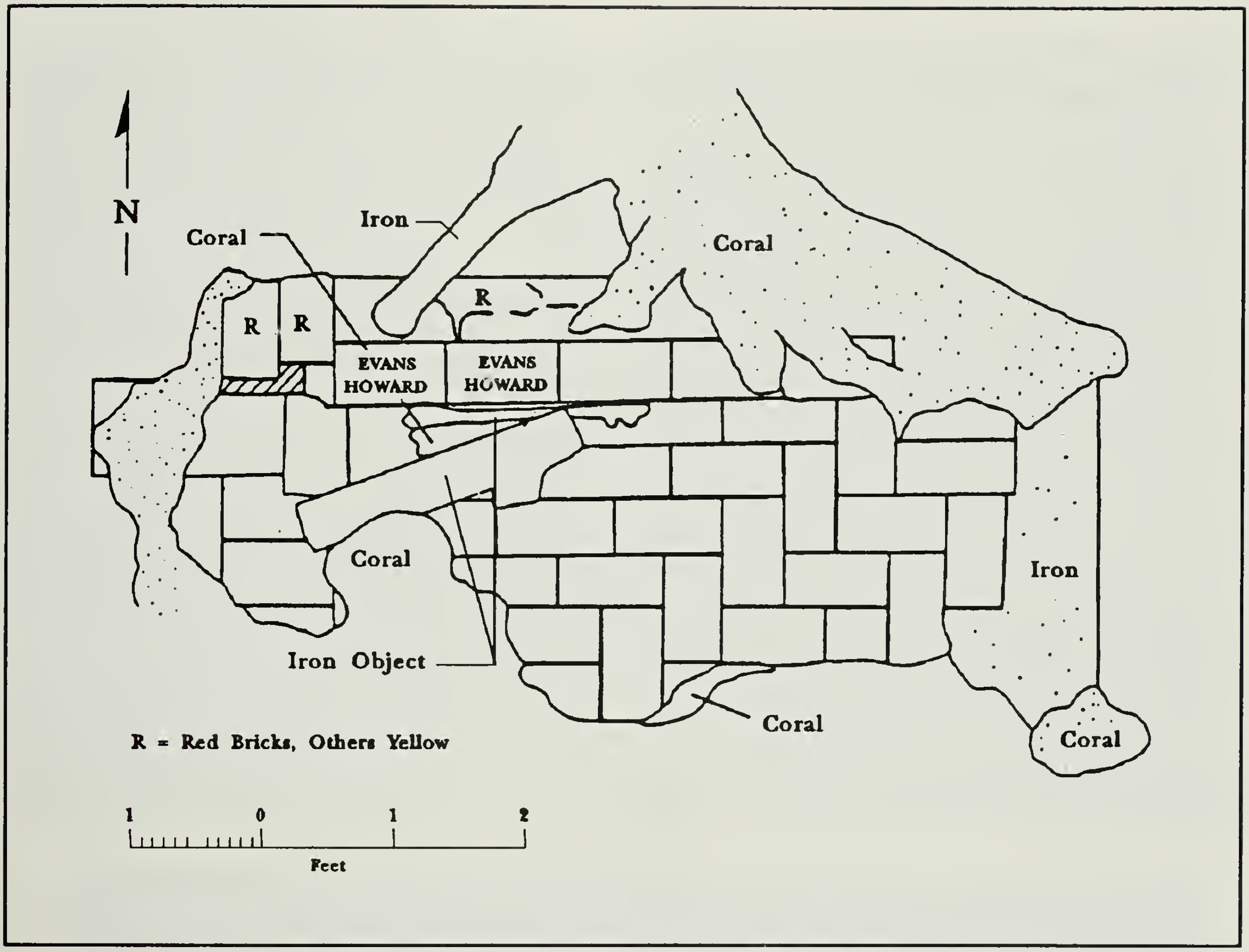


Figure 18.3. Brick arrangement in boiler firebox. Drawing by Richard A. Gould and Charlotte Taylor.

Extending forward from Frame 16 to Frame 31 along the port side is a longitudinal member attached to the hull interior at each frame. It is continuous except for three breaks that occurred during the ship's destruction, either at the time it sank, or, more likely, during salvage operations. This is the heaviest structural element found on the wreck, and we assume that it was matched by an identical element along the starboard side since torn away by blasting during salvage. A similar item 18 ft long was found resting on the seabed along the starboard hull side, and this could be a segment of the missing starboard longitudinal frame, now detached from its original position. On the port side, the longitudinal frame terminates in an area of bent and twisted metal between Frames 31 and 32. It is unclear whether the longitudinal extended beyond Frame 32. If so, it would have intersected the curving outer hull line within a few feet, and the bow would have been unsupported much beyond Frame 33, which might help to account for the extreme damage to the bow during the ship's grounding on Bird Key Bank.

Forward from Frame 31 we encountered a jumble of twisted metal and bent frames, with at least two fully detached elements. By tracing these elements by means of fanning the seabed and surficial removal of marine growth, we determined that the bow was a lightly constructed combination of iron plates meeting along the bottom and lower hull sides, joined at the seams by angle iron strips with a single line of rivets along each side of the seam (Plate 18.11).

No keel or keelson elements were present, but a large fragment of wood, presumably from the outer hull, was found articulated with a detached element of the bow structure (Plate 18.12). At the seabed along the port side near Frame 32, was a well-preserved segment of the ship's composite hull structure. This was a layered sandwich of Muntz metal outer sheathing, wood, and inner iron plating, still held in place by the original bronze fasteners. These small, nail-like fasteners were seen at various places on the outer plating of the lower hull and deadwood.

PORTABLE ARTIFACTS AND DETACHED ELEMENTS

Items larger than a brick were recorded and mapped. These appear on the site map or in the notes describing the concentrations farther north on Bird Key Bank. The two concentrations of what appear to be elements of ship's machinery have been drawn and photographed, but no identification has yet been possible. It would be worthwhile to remove these iron objects temporarily for light cleaning and detailed recording because they appear to be distinctive and potentially identifiable. Another slab-like piece of detached iron wreckage resting 180 ft north of the wreck might also merit closer examination, although it may be harder to identify.

Although the ship was stripped of engine and machinery during salvage, a

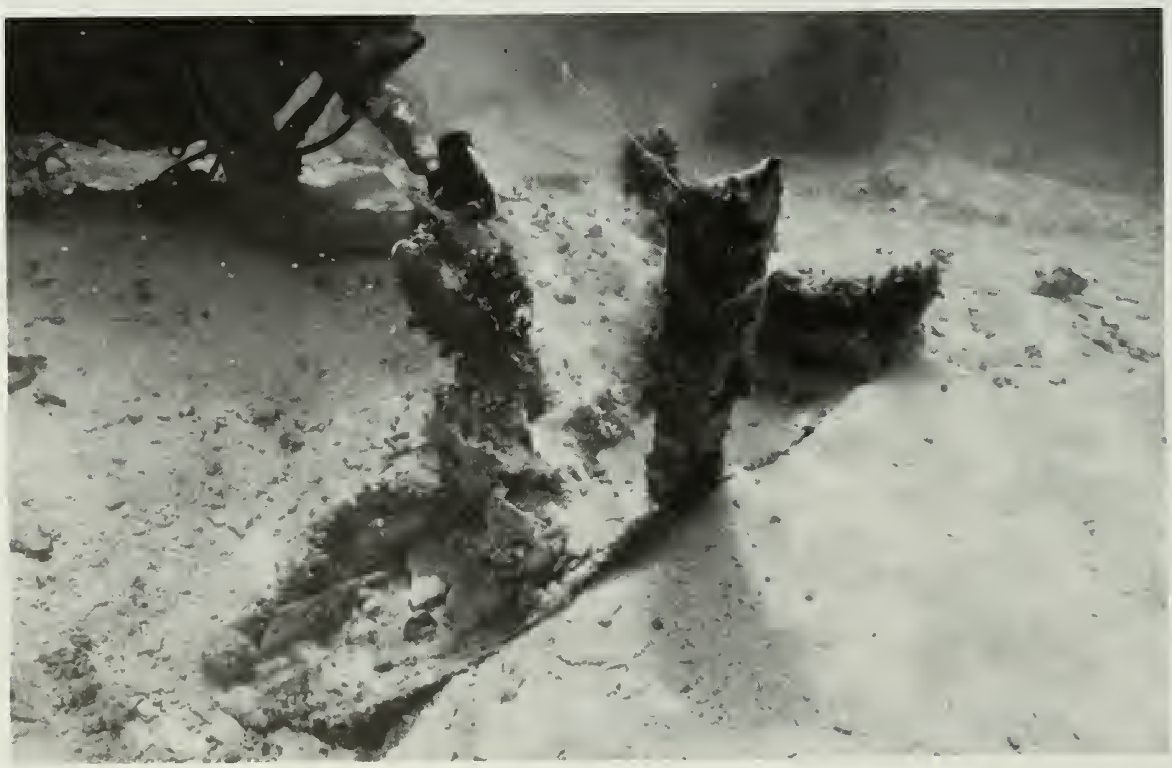


Plate 18.11. Iron bow structural elements. NPS photo by Eugene T. Rowe.

Plate 18.12. Wood fragments attached to bow structure. NPS photo by Richard A. Gould.

well-preserved globe-valve assembly (Figure 18.4) was found resting loose on the seabed immediately next to the lower port hull side between Frames 20 and 21. This item may be worth recovering and subjecting to a complete cleaning and conservation treatment, as it appears to be fairly characteristic of midnineteenth century steam engineering. It would be easy for some relic collector to "poach" this item. The same can be said for two unusual, curved, yellow specialty bricks presently resting on top of the debris along the centerline of the lower hull near Frames 19 and 20. These were clearly part of the ship's cargo, as was another large, flat yellow specialty brick lying in the debris field about 5 ft north of the lower hull.

The cast-iron object lying farther out in the debris field is interpreted as a firebox door, and it, too, should be considered for recovery and conservation. It appears to be complete and could be a diagnostic element of the ship's steam engineering. These items would be excellent material for an interpretive exhibit at Fort Jefferson and would be protected better in such a context than in their present location. Along with this, I recommend that a few marked firebricks and some construction bricks be recovered (after in situ recording) for similar treatment, for a possible interpretative display on brickmaking and transport in relation to Fort Jefferson construction history.

Similar steps should be considered for smaller portable artifacts resting in and around

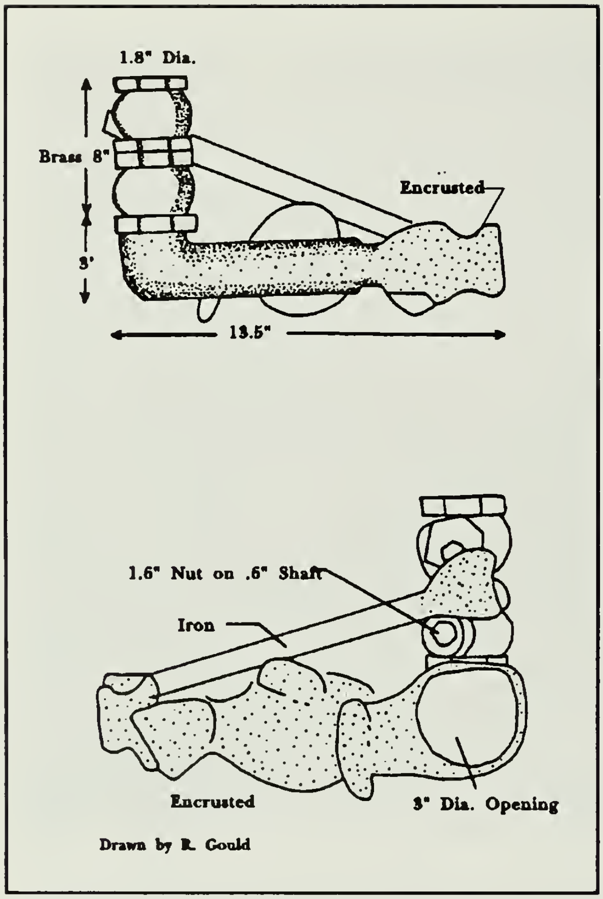


Figure 18.4. Valve assembly. Drawing by Richard A. Gould.

the shipwreck and across the debris field. These include at least four probable midnineteenth century bottle bottoms, which can be compared with contemporary collections from well-documented wrecks such as that of the steamboat BERTRAND (Petsche 1974; Switzer 1974). Several small copper and bronze fittings of unknown function were found in and around the lower hull, especially in the bow area. It may be advisable to recover and conserve these, too, as they are potentially diagnostic elements of nautical hardware and would be extremely easy for someone to "poach." Because of their small size, a storm sweeping across Bird Key Bank could be expected to dislodge or bury such items before long. I realize that such action would represent a departure from the more usual nondestructive approaches favored by the Submerged Cultural Resources Unit.

The discovery of numerous small portable artifacts at the Bird Key Harbor Brick Wreck Site was unexpected. It will be important for the NPS to decide on its priorities in this case. Is it more important to maintain the integrity of the shipwreck site and its physical associations strictly as found and recorded during our survey? Or would it be better to modify this strict nondestructive approach to allow for limited removal of objects, once their associations are recorded, for purposes of research and for potential interpretive display?

Another factor in the choice of artifacts for recovery is the relative difficulty involved in their conservation. Some materials, such as brick, copper, bronze, and glass, are relatively easy to treat and conserve, while others, such as wood and cast and wrought iron, pose real difficulties and require extensive treatment. So another recommendation is that recovery of the full range of materials be deferred until the Fort Jefferson-Dry Tortugas Project is operating on a scale sufficient to provide the necessary conservation facilities on shore. Limited recovery involving only materials that are easy to conserve would be feasible for next season, but a more comprehensive, long-term approach would be better from both a research-oriented and a preservation-oriented point of view.

CONCLUSIONS AND RECOMMENDATIONS

From archeological evidence obtained in 1989 and 1990, we know that the Bird Key Harbor Brick Wreck (FOJE 029) was a small steamboat slightly over 100 ft long that was wrecked as a result of grounding on Bird Key Bank sometime between 1857 and 1861 while transporting a cargo of Pensacola-made yellow construction bricks to Fort Jefferson. Details

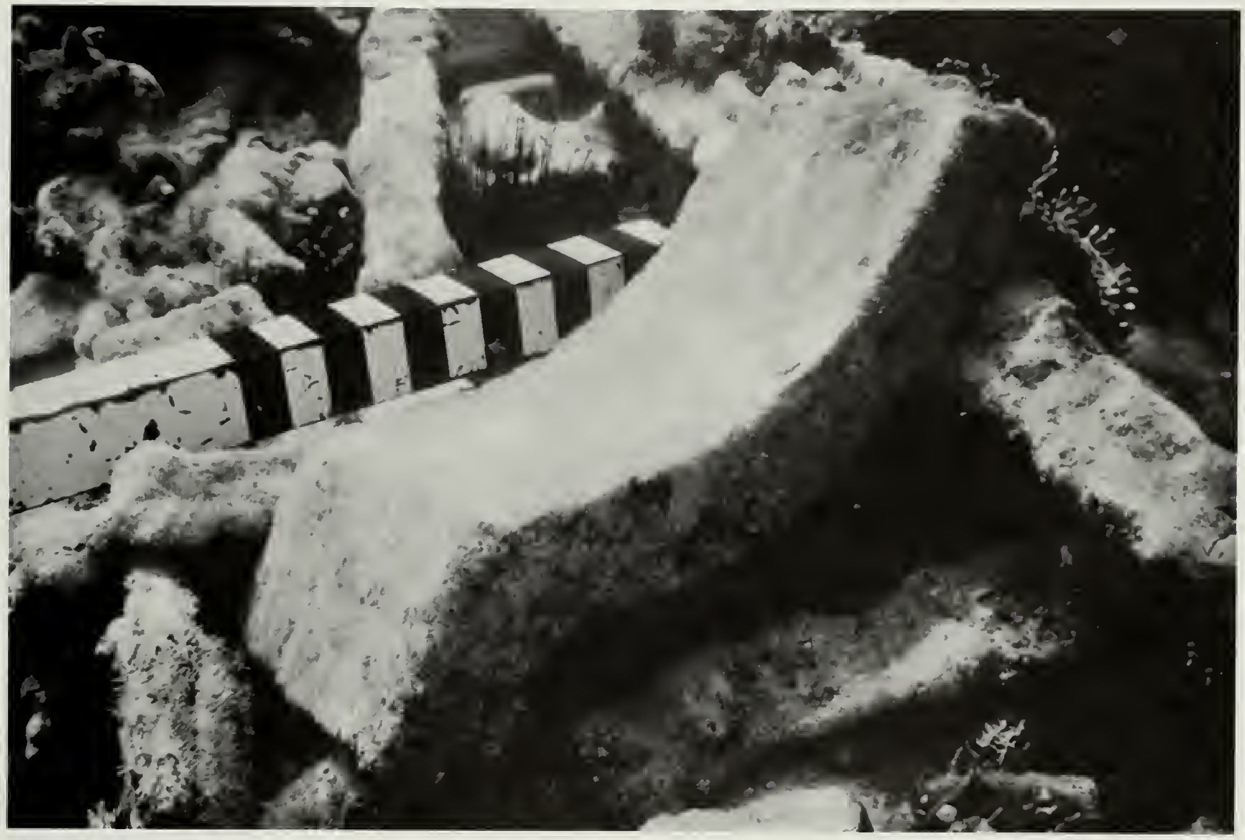


Plate 18.13. Yellow specialty brick. NPS photo by Richard A. Gould.

of the ship's construction indicate it was intended to operate in sheltered coastal waters. Its flat-bottomed lower hull and presumed shallow draft made it suitable for operating in the shoal waters around Fort Jefferson. It seems likely, from specific features of the ship's structure such as the propeller, the hull sheathing, and the composite construction of the lower hull, that the ship was built sometime during the late 1840s or in the 1850s, probably in a gulf port yard, and spent its short career operating along the shores and islands of the Gulf of Mexico.

A closer look at the archeological evidence of the ship's structure revealed that this vessel was most likely the product of a "vernacular" shipbuilding tradition along the Gulf Coast that was the direct antecedent for steamboats (including ironclads) used by the Confederate States during the American Civil War. Further study of the wreck will proceed according to the hypothesis that ship construction in this region then was not a specialized industry, with shipyards set aside for such work, but was an activity embedded within a more broadly-based ironworking industry that addressed a wide range of tasks. The firm that built this steamboat probably manufactured bridge and architectural iron, farm equipment, and possibly even railroad rails and machinery as well. This hypothesis is based on the unspecialized nature of most of the ship's identifiable elements. The lower hull was formed primarily from L-shaped angle irons and iron plates, with specially designed frames only in the midships area where support for the firebox-boiler assembly was needed. The propeller was especially revealing, as it showed none of the refinements of contemporary screw propeller design already underway in other parts of the world where shipbuilding and design were more advanced.

The quality of construction appears to have been good, with carefully joined and finished frames and plates. The rudder, propeller, and propeller shaft would have represented a major effort at wrought-iron technology for that time and place. But, as suggested earlier, the skill and craftsmanship in wrought iron was not matched by the ship's design, which shows clear signs of unseaworthiness and hydrodynamic inefficiency. The paddle-like propeller configuration and the need for heavy external strapping over the ship's deadwood reveal flaws in the ship's design and point to a mismatch between the heavily built propeller and propeller shaft and the lightly constructed lower hull. The lower hull was flat-bottomed and hard-chined, avoiding curves commonly found in the lines of better designed ships' hulls, probably for manufacturing ease. Reliance upon longitudinal frames and stringers for hull stiffening, instead of a keel and/or curved keelsons, left the lower hull vulnerable along the bottom and bow to scraping and crushing in the event of grounding. The ship's almost eggshell-like construction was evident in the bow area, where the force of grounding bent and broke the bow into twisted fragments. It will be useful to see to what extent later Gulf-built steamboats encountered similar problems, especially during the Civil War.

The most important priority for further research is archival. One likely source is newspaper accounts from the Pensacola area for the period of 1857 to 1861 pertaining to the brick shipment the firm of Raiford and Abercrombie, and any ship losses in connection with those shipments. Entries for this period in the *West Florida Times* and *Pensacola Gazette* will need to be searched. In 1858, the Key West firm of Tift and Company took over shipping arrangements of bricks manufactured by Raiford and Abercrombie for Fort Jefferson and Fort Taylor (Ellsworth 1974:253), so it will be useful to investigate archives at the Monroe County Public Library, Key West, as well. This documentary research should also include a broader-based investigation of steamboat construction along the Gulf Coast, as it will be important to determine how typical this ship was of regional state-of-the-art shipbuilding practices during the midnineteenth century.

Further archeological work at the Bird Key Harbor Brick Wreck Site will depend upon a NPS decision regarding controlled excavation and limited recovery of portable artifacts and materials in and around the wreck. This decision can be deferred until the scope of the NPS' commitment to a larger, long-term research program at Fort Jefferson NM is known. As I indicated earlier, the longer the delay in implementing such a decision, the greater will be the risk of loss of portable artifacts will be due to storms and relic collectors. I strongly support the policy of encouraging sport divers and snorkelers to visit the wreck, and I hope to see such access facilitated by a reduced-size version of the site map on a plastic card that visitors could use to guide them around the wreck site. But such a policy must also involve consideration of site risk from unauthorized artifact collection, which is difficult to control even in a setting as well maintained and supervised as Fort Jefferson NM. My recommendation, therefore, is that limited archeological excavation and removal of specified artifact materials be undertaken at the Bird Key Harbor Brick Wreck site at the earliest opportunity with the aim of obtaining a representative collection of items for interpretive purposes at the park before these items are lost. I would be willing to carry out both the archival research on this wreck and to design and supervise the excavation research later along whatever lines the Submerged Cultural Resources Unit and National Park Service authorities decide are appropriate.

CHAPTER XIX

Fort Jefferson Artifact Inventory

Frances E. Day

This inventory is compiled from material provided by Richard Faust, Chief, Southeast Archeological Center (SEAC), April 8, 1991.

Accession 185 - This list includes material collected from the 1969 through 1971 projects carried out by George Fischer. All materials are located at SEAC, Tallahassee.

Number	Description	Provenience
2581	Two champagne bottles. Late nineteenth century, dark green. Height 11 3/4", base diameter 3 5/8", neck diameter 1 1/2", base indent 2 1/4".	Swimming beach
2582	Ale bottle. White stoneware used to 1920s, ca. 1860.	Moat
2583	Champagne bottle. Late nineteenth century, dark green, height 10", base diameter 2 3/4", neck diameter 1", base indent 2".	Moat
2584	Two lead sounding weight type sinkers. Length 9 3/16", width (base) 1", concave base, tapers to eye at top.	Southwest side of Long Key
2585	Lead weight. Rectangular base 2 1/2" x 2 1/4", length 7 5/16", tapers to top, eye at top, hole measures 3/4", weight 10 pounds.	Southwest side of Long Key
2586	Pipe-like item. Iron, length 13 1/2", diameter of barrel or shaft (hollow) 5/8".	Square "L"
2587	Whiskey bottle. Quart size, mold blown, dark brown, embossed on side: Isaac Mansbach & Co., Fine Whiskies, Philadelphia. Height 9 3/4", base diameter 4", base concave.	Moat square
2588	Pin. Iron with eye in end. Length 26", eye 1 3/4".	Nineteenth century cannon wreck on Southwest Reef at Loggerhead Key
2589	Bowl fragment. Ironstone, white, embossed with flower design on lip of bowl. Crest and manufacturers stamp in black on back: Stone China ANTHONY SH... BURSLEN...	Moat, bastian 4

Number	Description	Provenience
2590	Hammer head. Marked "cast steel" in block letters, octagonal shape, oval eye, large end diameter 1 3/4", small end diameter 3/4", piece of handle still in head, fan handle 3/4" diameter.	Nine-Cannon Wreck
2591	Brass strap and spike. Strap: length 19", width 3 1/8", thickness 3/4". Spike: length 14", diameter 1". Strap and spike bent. One end of strap broken off at a spike hole. Originally three spikes 6" apart.	Nine-Cannon Wreck
2592	Brass strap. 14 1/2" long brass strap, 3/8" wide, 3/4" thick.	Nine-Cannon Wreck
2593	Brass spike. 13" long, 3/4" diameter brass spike, bent but complete.	Nine-Cannon Wreck
2594	Oval hoop. Iron, long diameter 18 1/2", short diameter 15 1/2", height 3 1/2", thickness of metal 1/4". Possible mast band recovered from Brick Wreck by Curt Johnson. Midnineteenth century ??	Brick Wreck southeast end of Loggerhead Key
2595	Bowl fragment. Ironstone, length 9", height 3", sides are white, fluted and undersigned. Approximately 1/2 a bowl.	Moat, bastion 4
2596	Wine bottle with cork in. Light green, sheared and applied lip. Height 12", base diameter 2 3/4".	Moat, bastion 4
2597	Perfume bottle. Clear glass, rectangular, marked in embossed black letters.	Moat, bastion 4
2598	Bottle. Clear, glass, height 7 3/8", mouth diameter 2", base diameter 3".	Moat, bastion 4
2599	Clear, thin glass bottle fragment. Base is concave and 2" in diameter.	Moat, bastion 4
2600	Bone button. White, 1 1/4" diameter wide, 1/4" diameter length.	Moat, bastion 4
2601	Two bottles. Clear, glass pharmaceutical, 1 quart size, 9 1/2" height, 3 1/8" base diameter.	Moat, bastion 4
2602	Bottle. Clear, glass, beverage. Height 10 1/8", base diameter 2 1/2".	Moat, bastion 4
2603	Nut. Iron, hexagonal, 2 3/4" across, 1" hole for bolt.	Moat, bastion 4
2604	Bottle. Clear, glass, mold-blown, medicinal. Square 1 5/8", height 4 3/4".	Moat, bastion 4

Number	Description	Provenience
2605	Bottle. Clear, glass, mold-blown. Ink stains still visible, one side rounded, other side faceted. Height 2 5/8", base diameter 1 3/8".	Moat, bastion 4
2606	Bottle. Clear, glass, small flask type. Height 3 7/8", width 2".	Moat, bastion 4
2607	Bottle. Bottom fragment of a clear, glass, olive oil bottle. Height 3 1/2", base diameter 2".	Moat, bastion 4
2608	Bottle. Clear, glass, twelve-sided, height 2 5/8", base diameter 1 5/8".	Moat, bastion 4
2609	Bottle fragments. Three fragments of a dark green, half gallon, midnineteenth century jug. Base fragment height 5 5/8", diameter 5 1/4".	Moat, bastion 4
2610	Ink bottle. Clear, glass, octagonal, height 2 1/2", base diameter 1 3/4".	Moat, bastion 4
2611	Medical bottle embossed: H.T. AND CO. at shoulder of neck. Height 6 3/4", diameter 3".	Moat, bastion 4
2612	Whiskey bottle. Brown, glass, three-piece mold base embossed with concentric rings. Height 11 1/4", base diameter 2 3/4".	Moat, bastion 4
2613	Bottle. Black, glass, three-piece mold, height 8 3/8", base diameter 2 3/4".	Moat, bastion 4
2614	Whiskey bottle. Black, three-piece, mold blown. Embossed on base: ELLENVILLE GLASS WORKS. Height 11", base diameter 3 1/8".	Moat, bastion 4
2615	Wine Bottle. Green, glass, with cork piece remaining within. Height 9 1/4", base diameter 2 1/4".	Moat, bastion 4
2616	Medical bottle. Light green, glass, embossed on shoulder: ER SQUIBB. Height 6", base diameter 2 1/2".	Moat, bastion 4
2617	Wine bottle. Large, black, glass, magnum, height 9 3/4", base diameter 2 3/4".	Moat, bastion 4
2618	Whiskey bottle. Black, glass, two-piece, mold blown, height 8 1/2", base diameter 2 3/4".	Moat, bastion 4
2619	Two bottles. Black, glass, three-piece, mold-blown. 1) height 8 3/8", base diameter 2 3/4". 2) Height 9", base diameter 2 1/2".	Moat, bastion 4
2620	Pipe. Broken, clay, length 3 1/8", height 1 3/4".	Moat, bastion 4

Number	Description	Provenience
2621	Bottle. Clear, medical, base diameter 1 1/2", height 3 7/8".	Moat, bastion 4
2622	Bottle. Clear, glass, medical, height 4 3/4", base diameter 1 3/4".	Main sewer drain in moat near sally port
2623	Bottle. Clear, glass, medical, rectangular and broken. Height 6 3/4", width 2", thickness 1 1/2".	Main sewer drain in moat near sally port
2624	Whiskey bottle. Brown, glass, embossed INO. WYETH & BRO - PHILADELPHIA - LIQ. EXT. MALT. Height 9 1/8", base diameter 2 7/8".	Main sewer drain in moat near sally port
2625	Brandy bottle. Green, glass, half gallon size, two mold, hand finished. Height 10 3/4", widest width 7".	Main sewer drain in moat near sally port
2627	Coffee cup. White, stoneware, with missing handle. Height 3 1/8", base diameter 3 1/4".	Main sewer drain in moat near sally port
2628	Dish fragment. White, stoneware, stamped on bottom 1 3/4" high: Sharpes Warrented Fireproof. Length 6 3/8", width at widest point 4".	Main sewer drain in moat near sally port
2629	Soda bottle. Round bottomed, green tint, glass, ca. 1860s. Height 9", diameter 2 1/2".	Main sewer drain in moat near sally port
2630	Bottle fragments. Bottom and several side pieces with two sides embossed. 1) LD LONDON DOCK, 2) ER & CO AD SI NY, 3) has "GI" on broken edge. Base 3" x 3".	Fort Jefferson NM
2631	Bottle fragment. Embossed: ORNIA FIG SYRUP CO. RANCISCO, CAL. Length 4", width 1 7/8".	Swimming beach
2632	Six assorted bottle necks.	Swimming beach
2633	Broken mug. White-gray, base imprint: WIN BROS. Height 3 1/4", diameter 3".	Swimming beach
2667	Brass fitting. Large with two brass spikes. Originally four spikes, possibly pivet from ship's rudder. Length 10", thickness: small end 2", large end 4 3/8".	Nine-Cannon Wreck
2668	Two fire tiles. Length 11 1/2", width 5 1/2", height 1".	Spanish Wreck Southwest Reef
2669	Fire tile. Length 11 1/2", width 5 1/2", height 1".	Spanish Wreck Southwest Reef
2670	Brick. Dark red, cap for fort construction. Length 7 3/4", width 3 1/2", height 2 1/4".	Brick Wreck southeast of Loggerhead
2671	Two bricks. Length 8 3/4", height 4", width 2 1/2".	Southeast end of Loggerhead
2672	Brick fragment. Maker's mark - C. WILLIS. Length 6 1/4", height 2 3/8", width 4 1/4".	Moat near sally port

Number	Description	Provenience
2673	Ballast stone. Irregularly shaped piece of soft, light colored granite.	Nine-Cannon Wreck
2674	Brick. Dark red, cap for fort. Length 7 1/2", height 3 3/8", width 2 1/4".	Southeast of Loggerhead
2675	Flagstone fragment. Triangular, base 12 1/2", altitude 7 3/8".	Construction off East Key
2676	River cobbles. Six 2" to 6" in largest measurement.	Spanish Wreck
2677	River cobble. Black, possible ballast. Diameter 5".	Nine-Cannon Wreck
2678	Two ballast rocks. Length 6", width 5", height 1 1/4".	Spanish Wreck ?
2679	Bottle. Clear, glass, rectangular, medicinal type. Height 5", width 1 3/4", thickness 1/2".	Fort Jefferson NM
2680	Rock fragment. Gray, layered, irregular shaped triangle, 2" x 1 1/4".	Moat, front 5
2681	Bottleneck. Light-green, fluted.	Moat, front 5
2682	Four pieces of copper sheeting, eight metal pin fragments 1" diameter.	Fort Jefferson NM
2683	Miscellaneous glass bottle fragments. Dark green, kick up bottoms. 3 necks, 2 bases, 3 mid sec frags, 3 shoulder frags.	Fort Jefferson NM

Accession 206 - This list includes miscellaneous materials turned in by park personnel and visitors

2634	Bottle. Lime green tint, culinary, simplified gothic. Height 9 12/32", base diameter 2 29/32" x 2 8/32", neck diameter inside 1 8/32", neck diameter outside 1 18/32". Bertrand class 5.	Fort Jefferson NM
2635	Bottle. Aqua green, medicinal, ER Squibb. Height 7", neck diameter inside 22/32", neck diameter outside 1", base diameter 2 24/32". Bertrand class 7.	Fort Jefferson NM
2636	Bottle. Clear, glass, perfume. Height 3 8/32", base diameter 1 7/32", neck diameter inside 22/32", neck diameter outside 1". Bertrand class 4.	Fort Jefferson NM
2637	Bottle. Amber green, ale, three-piece, mold blown, basal up kick pontil mark, basal rim beveled. Height 8 24/32", base diameter 2 26/32", neck diameter inside 22/32", neck diameter outside 31/32". Bertrand class 1.	Fort Jefferson NM

Number	Description	Provenience
2638	Bottle. Aqua, ale, embossed: A.B.G.M. Co. Height 9 16/32", base diameter 2 18/32", neck diameter inside 21/32", neck diameter outside 1". Bertrand class 1 or 2.	Fort Jefferson NM
2639	Bottle. Amber green, ale or brandy, dark black in direct light, three-piece blown mold, basal up kick, pontil mark, flat basal rim, conical neck embossed drawing, Height shoulder 5 16/32", base diameter 2 29/32", neck diameter inside 24/32", neck diameter outside 1". Bertrand class 1 or 3.	Fort Jefferson NM
2640	Bottle. Medium green, ale, two-piece blown and turned mold, medium basal up kick, beveled base. Height 9 28/32", base diameter 2 26/32", neck diameter inside 22/32", neck diameter outside 1". Bertrand class 1.	Fort Jefferson NM
2641	Bottle. Clear, glass, booze (?), muzzle loading cannon shaped. Height 6 1/2", base diameter 2". Bertrand class 3.	Fort Jefferson NM
2642	Bottle. Olive green, wine, three-piece blown mold, basal up kick, concave shoulders. Height 9 24/32", base diameter 2 23/32", neck diameter inside 23/32", neck diameter outside 1". Bertrand class 3.	Fort Jefferson NM
2643	Bottle. Ale, salt glaze stoneware, wheel thrown, two-tone buff and honey. Letter "D" at base. Height 8 8/32", base diameter 2 29/32", neck diameter inside 23/32", neck diameter outside 1". Bertrand class 1.	Fort Jefferson NM
2644	Bottle. Octagonal, aqua, ink. Height 1 24/32", base diameter 2 10/32" per side, neck diameter inside 19/32", neck diameter outside 1 2/32". Bertrand class 6.	Fort Jefferson NM
2645	Bottle. Clear, glass, booze (?), ring neck bulb, embossed: Malaga Joaquin Bueno Y Ca, Height 12 4/32", base diameter 2 28/32", neck diameter inside 22/32", neck diameter outside 1 4/32". Bertrand class 3.	Fort Jefferson NM
2646	Chalice (?), oil lamp (?), vase (?). Clear, blown, ornate, resembles cut glass. Height 7 24/32".	Fort Jefferson NM
2647	Bottle. Aqua, round bottom, soda, embossed: CASWELL HAZARDS AND COMPANY NEW YORK GINGER ALE. Height 9", base diameter 2 12/32", neck diameter inside 22/32", neck diameter outside 1". Bertrand class 2.	Fort Jefferson NM

Number	Description	Provenience
2648	Bottle. Green tint, round bottom, soda, embossed: CANTRELL & COCHRANE DUBLIN AND BELFAST. Height 9", base diameter 2 10/32", neck diameter inside 25/32", neck diameter outside 1 2/32". Bertrand class 2.	Fort Jefferson NM
2649	Bottle. Clear, glass, medicinal, three-piece mold blown, embossed: USA HOSP DEPT. Height 6 24/32", base diameter 2 23/32", neck diameter inside 20/32", neck diameter outside 30/32". Bertrand class 7.	Fort Jefferson NM
2650	Bottle. Brown, medicinal, embossed on bottom. Height 3 28/32", base diameter 2 4/32", neck diameter inside 25/32", neck diameter outside 1 6/32". Bertrand class 7.	Fort Jefferson NM
2651	Bottle. Olive green, wine, slight dish base, blown and turned in three-piece mold, concave shoulder. Height 9 16/32", base diameter 2 16/32", neck diameter inside 22/32", neck diameter outside 1". Bertrand class 3.	Fort Jefferson NM
2652	Bottle. Smokey green, wine, base only.	Fort Jefferson NM
2653	Bottle. Clear, purple tint, glass, medicinal (?), inscribed Greever-Lotspeich Mfg. Co. Knoxville, Tenn. U.S.A. Height 6 8/32", base diameter 2" x 28/32", neck diameter inside 12/32", neck diameter outside 24/32". Bertrand class 7.	Fort Jefferson NM
2654	Bottle. Clear, glass, two-piece blown mold, culinary. Height 7 28/32", base diameter 2 10/32", neck diameter inside 17/32", neck diameter outside 28/32". Bertrand class 5.	Fort Jefferson NM
2655	Bottle. Clear, aqua tint, medicinal, embossed Vegetable Pain Killer Davis. Height 4 16/32", base diameter 1 13/32" x 24/32", neck diameter inside 10/32", neck diameter outside 20/32". Bertrand class 7.	Fort Jefferson NM
2656	Bottle. Clear, glass, medicinal. Height 3 24/32", base diameter 1 16/32" x 28/32", neck diameter inside 12/32", neck diameter outside 20/32". Bertrand class 7.	Fort Jefferson NM
2657	Bottle. Aqua tint, ale, bottom embossed A.B.G.M. CO. in center B 9. Height 9 16/32", base diameter 2 20/32", neck diameter inside 22/32", neck diameter outside 1". Bertrand class 1.	Fort Jefferson NM

Number	Description	Provenience
2658	Bottle. Clear, glass, booze, two-piece blown and mold, very slight dished bottom, ring neck. Height 11 16/32", base diameter 3 16/32", neck diameter inside 24/32", neck diameter outside 1 6/32". Bertrand class 3.	Fort Jefferson NM
2659	Bottle. Champagne, green, high basal up kick, free blown, ring neck. Height 11 28/32", base diameter 3 24/32", neck diameter inside 22/32", neck diameter outside 1 5/32". Bertrand class 3.	Fort Jefferson NM
2660	Bottle. Aqua, ale, embossed A.B.G.M. Co., center C 2. Height 9 16/32", base diameter 2 19/32", neck diameter inside 22/32", neck diameter outside 1". Bertrand class 1 or 2.	Fort Jefferson NM
2661	Bottle. Aqua, toiletries, broken stopper, embossed AQUA DE FLORIDA MURRAY Y LANMAN DROGUISTAS NEW YORK. Height 5 8/32", base diameter 2 7/32". Bertrand class 4.	Fort Jefferson NM
2662	Bottle. Brown, ale or beer, two-piece mold blown, slight dished base, bulbous neck, convex shoulders, turned collar, brandy. Height 9 12/32", base diameter 2 16/32", neck diameter inside 22/32", neck diameter outside 1". Bertrand class 2.	Fort Jefferson NM
2663	Bottle. Brown, ale or beer, two-piece mold blown, slight dished base, bulbous neck, convex shoulders, modern collar lip. Height 9 12/32", base diameter 2 18/32", neck diameter inside 20/32", neck diameter outside 1". Bertrand class 1.	Fort Jefferson NM
2664	Bottle. Brown, ale or beer, two-piece mold blown, slight basal dish, mark on bottom possibly letter B or 9, brandy collar. Height 9 8/32", base diameter 2 19/32", neck diameter inside 22/32", neck diameter outside 1". Bertrand class 1.	Fort Jefferson NM
2665	Bottle. Green, booze, three-piece blown mold, ring neck, conical neck, basal up kick, on bottom round base H. HEYE BREMEN. Height 11", base diameter 3", neck diameter inside 24/32", neck diameter outside 1 4/32". Bertrand class 3.	Fort Jefferson NM
2666	Bottle. Champagne, body only, dark green, free blown, high base up kick.	Fort Jefferson NM
2684	Two glass doorknobs;, glass stopper LEA & PERRINS; sherd, violet-colored bottle mouth; sherd, clear, molded glass, chicken wire imbedded.	Fort Jefferson NM

Number	Description	Provenience
2685	Pipes. Historic, clay, nineteenth century. 1) Grape molded ; 2) T.D.mark; 3) two column and leaf molded.	Fort Jefferson NM
2686	Cement. Three molded pieces with rough incised number: 370.	Fort Jefferson NM
2687	Three forks, four tined silver plated; three spoons, silver plated; spoon, handle and upper half of bowl; three fragments of three keys, one each; large decorative hinge; latch, turn-bolt; two brass, US military buttons; brass padlock fragment; fragment copper broch flight of seven birds; oil lamp hardware, metal wick holder; oil lamp hardware, metal wick shield; steel star fasteners; doorknob, brass; doorknob shaft with ornate shield; latch, swivel brass; latch, lifter type, brass; latch, bar; door jam faceplate for bolt slot; two cannon primer fuses, unfired; two cannon primer fuses, fired; two fragmentary cannon primer fuses; unidentified object shaped like tiny doorknob; two miniballs, one large and one small; brass cartridge.	Fort Jefferson NM
2688	Ceramic, black doorknob; ceramic, brown doorknob; gray stoneware jug; impressed O.TINKHAM.1847; jar lid decal design and label CREME D AMANDES AMERES; ceramic keyhole faceplate; earthernware plate yellow glazed, potters mark ADAMS ROYAL IVORY TITIAN WARE LAKEWOOD.	Fort Jefferson NM
2689	Wood. Three pieces, ornate hand carved, painted white.	Fort Jefferson NM
2690	Light bulb. Very early, long double looped filament.	Fort Jefferson NM
2729	Bottle. Ink, stoneware, brown salt glaze, wheel-thrown. Height 8 20/32", base diameter 3 14/32", neck diameter inside 24/32", neck diameter outside 1/5/32".	Fort Jefferson NM

Accession 580 - The materials listed were recovered by George Fisher and Richard Johnson October 10, 1981 from FOJE 009.

14601	Olive jar rim fragment	Fort Jefferson NM
14602	Olive jar rim fragment	Fort Jefferson NM
14603	Spanish fire tile	Fort Jefferson NM
14604	Olive jar rim fragment	Fort Jefferson NM
14605	Brass rod with brass ring	Fort Jefferson NM
14606	Spanish fire tile	Fort Jefferson NM

Number	Description	Provenience
14607	Unidentified small iron concretion	Fort Jefferson NM
14608	Olive jar rim and body fragment	Fort Jefferson NM
14609	Copper/brass pin	Fort Jefferson NM
14610	Olive jar rim fragment (middle period)	Fort Jefferson NM
14611	Olive jar rim fragment (middle period)	Fort Jefferson NM
14613	Olive jar sherd	Fort Jefferson NM
14614	Coarse earthernware sherd	Fort Jefferson NM
14615	Olive jar sherd	Fort Jefferson NM
14616	Olive jar sherd	Fort Jefferson NM
14617	Olive jar sherd	Fort Jefferson NM
14618	Olive jar sherd	Fort Jefferson NM
14619	Giant olive jar sherd	Fort Jefferson NM
14620	Fragment brass sheeting (poor condition)	Fort Jefferson NM
14621	Copper/brass pot rim	Fort Jefferson NM
14622	Ballast stone	Fort Jefferson NM
14623	Ballast stone	Fort Jefferson NM
14624	Brick/ballast stone	Fort Jefferson NM
14625	Swivel gun (wrought iron)	Fort Jefferson NM
14626	Unidentified coral fragment	Fort Jefferson NM
14627	Large ballast stone	Fort Jefferson NM
14628	Ladrillo with brain coral	Fort Jefferson NM
14633	14 assorted ballast stones	Fort Jefferson NM
14634	Ballast stone	Fort Jefferson NM

Accession 594 - FOJE 009 list of recovered material.

594 FS #1	Unidentified wood, brass fastener fragment	E-2
594 FS #2	Ladrillo fragment, two glass fragments, unidentified iron fragment	B-10
594 FS #3	Ballast stone, buckle, brass fragments	E-11
594 FS #4	Seven ballast stones	D-4

Number	Description	Provenience
594 FS #5	Ceramic fragment (whiteware ?)	D-6
594 FS #6	Iron fastener	G-00

The materials listed were recovered by Ron Gibbs in 1971.

9700	Cannon. Iron, possibly seventeenth century Swedish, recovered prior to April 1969 by NPS Fort Jefferson employee--probably recovered from Loggerhead iron ballast wreck in 1968. Muzzle face to breech 53", flat breech approximately 10" in diameter, 4" cascabel knob. Muzzle diameter 4.5", bore impossible to tell due to coral covering. Chase length, muzzle face to trunnions approximately 30". The cannon was exposed to the air for about one year before resubmerging in moat.	Fort Jefferson NM
9714	Gun. Swivel with yoke, possibly mideighteenth century and English, sacket at cascabel for tiller. Recovered 5/31/71.	Northwest side of Loggerhead
9715	Cannon. Iron, mideighteenth century, possibly English. Appears to be a two-pounder deck gun. It and number 15 were lying on top of each other--they may have been chained together and used as a kedge anchor to pull stranded vessel off the shoals. Recovered 5/31/71.	Northwest side of Loggerhead
9717	Fragment of a light-green, hand-blown glass demijohn. Possibly Portuguese nineteenth or twentieth century. Fragment is curved, 6" wide at its widest point and 15" long around the widest point of its curve.	Moat square "N"
9718	Knife. "Tree" brand jack knife, midtwentieth century 4" long.	Square "M"
9721	Two brass fragments. Gilded, approximately 1/2" square.	Moat square "M"
9722	Cartridge box plate. Civil War, lead filled, stamped brass, "US." Badly corroded. Makers name stamped on back. 3 3/8" long, 2 1/4" wide. Recovered 6/3/71.	Swimming beach
9736	Button. Brass, with eye, badly corroded, no insignia legible, same size as a Union C.W. eagle button, 3/4". Recovered 6/6/71	Moat, basion 4

Number	Description	Provenience
9737	Gun. Iron, swivel, breech is rounded and seems to have a cascabel knob instead of a sacket. The muzzle swell is quite pronounced. Overall length 36", 18" trunnions to muzzle face, yoke 13" long. Approximately 6" diameter of muzzle, approximately 8" at breech. Recovered 6/7/71.	Northwest side of Loggerhead
9738	Brass fixture from midnineteenth century. Possibly a bearing. Top of race has three 1/4" holes for screws around its perimeter. The bearing itself has a 3/4" home for a shaft in its center. The whole object is 1 1/8" long. Recovered 6/2/71.	Southeast end of Hospital Key
9744	Knife. Heavily encrusted, rigging, ca. 1860s, 4" long, 1" wide. Recovered 6/8/71.	Moat, bastion 4
9754	Blade. Iron, encrusted, broken shoual, 12 1/2" long x 10" wide. Recovered 6/10/71.	Moat, bastion 4
9755	Fragment. Heavily encrusted, iron, possibly a fragment of a nineteenth century stone plate, 30" long, 8" wide. Recovered 6/8/71.	Moat, bastion 4
9756	Fragment. Heavily encrusted, iron, possibly a fragment of a nineteenth century stone plate, "L" shape 16" on one leg and 15" on the other. Recovered 6/8/71.	Moat, bastion 4
9760	Spike. Brass, blunt point, headed, rectangular, 6 1/4" long, 3/4" x 1/2" square. Recovered 6/10/71.	Tip of Southwestern Reef
9767	Bottle. Olive green, glass, flash type-medical, hear top, ca. 1860s, 4 1/2" high, 2 1/2" wide. Recovered 6/10/71.	Moat, bastion 4
9772	Bottle. Clear, glass, soda, with stopper, ca. 1880s-1890s. Embossed on side: LATROPICAL FABRICA DE SODA THOMAS MENDOZA. 7" high, 2 3/8" high. Recovered 6/12/71.	Moat between drainbridge and bastion 6
9773	Half wooden tool handle, 4 1/2" long, 1 1/8" wide. Recovered 6/11/71.	Moat, bastion 4
9775	Bottle. Clear, glass, medical, ca. 1860s, 6 3/4" high, 2 5/8" base diameter. Recovered 6/17/71.	Main sewer drain moat near sally port.
9776	Medical bottle, three-piece mold, ca. 1860s, 7" high, 2 1/2" diameter. Recovered 6/17/71.	Main sewer drain moat near sally port
9782	Metal object. Encrusted, shaped like a spatula, 13" long, 3" wide. Recovered 6/17/71.	Main sewer drain moat near sally port
9786	Wood piece with iron fastening, 16"long, 13 1/2" wide at widest point. Recovered 6/17/71.	Spanish Wreck Southwest Reef

Number	Description	Provenience
9787	Iron fastening, encrusted, 16" long. Recovered 6/17/71.	Spanish Wreck Southwest Reef
9788	Iron fastening, 28" long. Recovered 6/17/71.	Spanish Wreck Southwest Reef
9794	Metate. three legged (tripod), Mexican, slightly concave, black vesicular basalt. 3" wide pockmark 2" to left (left edge of pick) of left side of metate and on center from front to back about 1" deep. 22 1/2" long x 13" wide, standing 10 1/2" high at back, 5" high at front, thickness 2 1/2", legs triangular. Front pair 3" at base, 3" high. Back leg 7" high, 4" wide at base (back), 6" wide on base sides. Recovered 6/23/71.	Main sewer drain near sally port
9826	One briar bavarian-style pipe bowl badly decomposed on side, 2 1/8" long, 2" wide. Recovered 6/11/71.	Tip of Southwest Reef

Fort Jefferson ordnance inventory by Edwin Olmstead, March 15, 1985.

Six 15-in Rodman smoothbore guns, perhaps with consecutive army Registry Nos. 145 through 150 from Cyrus Alger & Co. in South Boston, MA. Registry Nos. 145 through 148 which are identifiable and No. 150 presumed so, are documented in the *Register of Inspections of Cannon* (henceforth *Register*, National Archives Record Group 156 entry 214) p. 143. They were inspected, proofed, accepted and assigned army Registry numbers on August 21, 1871 by Lt Col Theodore Thadeus Sobieski Laidley.

1. <u>15-in Rodman</u>	Eighth piece counterclockwise starting at casemate quarters.	
Upper muzzle face:	Registry No.	145
	Gunfounder	C.A. & Co.
	Weight in Pounds	49,510
Lower muzzle face:	Ordnance Officer Inspecting	T.T.S.L.
	Year of Manufacture	1871
Right rimbase face:	Gunfounder's Number	2316
Tube top:	Acceptance for & Ownership by US Army	US

2. <u>15-in Rodman</u>	First place counterclockwise from casemate quarters.	
Upper muzzle face:	Registry No.	146
	Gunfounder	C.A. & Co.
	Weight in Pounds	49,546
Lower muzzle face:	Ordnance Officer Inspecting	T.T.S.L.

Right trunnion and rimbase buried.
Tube top buried.
Per *Register* p. 143, Alger's right rimbase (gunfounder's) number for this piece should be 2320.

3. <u>15-in Rodman</u>	Ninth piece counterclockwise from casemate quarters.	
Upper muzzle face:	Registry No.	147
	Gunfounder	C.A. & Co.
	Weight in Pounds	49,644

Lower muzzle face:	Ordnance Officer Inspecting	T.T.S.L.
	Year of Manufacture	1871

Right trunnion & rimbase buried.

Tube top:	Acceptance for & Ownership by US Army	US

Per *Register* p. 143, Alger's right rimbase (gunfounder's) number for this piece should be 2321.

4. 15-in Rodman	Tenth piece counterclockwise from casemate quarters.	
Upper muzzle face:	Weight in Pounds	49,606
Right rimbase:	Indistinct 2324 presumably Alger gunfounder's number.	

In combination, these point toward Alger Registry No. 148, per *Register* p. 143.

5. 15-in Rodman — Lighthouse; fourth piece counterclockwise from casemate quarters.

Because of inverted mounting and tar-like surface protection, no marks found other than date 1871. Per *Register* p. 143, discovery of one or more of the following could support the others: Alger Registry No. 149, Alger gunfounder's (right rimbase) No. 2326, or weight 49,680 lbs.

6. 15-in Rodman	Sixth piece counterclockwise from casemate quarters.	
Upper muzzle face:	Weight in Pounds	49,454

Weight agrees with that of Alger Registry No. 150 and right rimbase (gunfounder's) No. 2328, per *Register* p. 143.

Four 10-in Parrott Rifles, also known to the army as "300-pounder" but to the navy as "250-pounder." All produced by West Point Foundry, Robert Parker Parrott proprietor Cold Spring, New York. All documented in *Register* p. 280.

1. 10-in Parrott Rifle	Second piece counterclockwise from casemate quarters.	
Upper muzzle face:	Weight in Pounds	26,860
	Army Registry No.	13
	Year of Manufacture	1864
	Gunfoundry	W.P.F.
Lower muzzle face:	Ordnance Officer Inspecting	Capt Stephen Carr Lyford (S.C.L.)
	Land Diameter of Rifled Bore	10 in
Left trunnion face:	Anticiptation of Possible Navy Proof	P
Right rimbase:	Gunfounder's identification number	96

Per *Register* p. 280, inspected, proofed and acepted by Captain Lyford January 13, 1865 despite muzzle stamping for the previous year.

2. 10-in Parrott Rifle	Fifth piece counterclockwise from casemate quarters.	
Upper muzzle face:	Army Registry No.	--23
	Year of Manufacture	1865
	Gunfoundry	W.P.F.
Lower muzzle face:	Ordnance Officer Inspecting	Capt Richard Mason Hill (R.M.H.)
	Land Diameter of Rifled Bore	10 in
Top of tube:	Acceptance for & Ownership by US Army	US
Left trunnion:	Anticipation of possible navy proofing	P

Right trunnion & rimbase buried.
Per *Register* p. 280, the weight should be 26,860 pounds and the right rimbase number 606. Inspected, proofed and accepted by Captain Hill June 16, 1865.

4. <u>10-in Parrott Rifle</u>	Third piece counterclockwise from casemate quarters.	
Upper muzzle face:	Weight in pounds	26,920
	Army Registry No.	25
	Year of Manufacture	1865
	Gunfoundry	W.P.F.
Lower muzzle face:	Ordnance Officer Inspecting	Capt Richard Mason Hill (R.M.H.)
	Land Diameter of Rifled Bore	10 in
	Acceptance for & Ownership by US Army	US
Left trunnion buried.		
Right trunnion:	Robert Parker Parrott	R.P.P.

Per *Register* p. 280, the right rimbase number should be 620. Inspected, proofed and accepted by Captain Hill July 26, 1865.

<u>24-Pounder Iron Flank Howitzer, Model of 1844, in bastion</u>.
No marks found other than stamping "US" for army acceptance. US iron flank howitzers are known to have been produced by Cyrus Alger & Co., South Boston, Massachusetts; Bellona Foundry, Midlothian, Virginia; Fort Pitt Foundry (also known by many other names), Pittsburgh, Pennsylvania; Mount Vernon Iron Works, Mount Vernon, Ohio; Seyfert, McManus & Co., (also known in part as "Scott Foundry"), Reading, Pennsylvania; Tredegar Foundry, Richmond, Virginia and West Point Foundry, Cold Spring, New York.

<u>24-Pounder Bronze Coehorn Mortar, in museum.</u>

Upper muzzle face:	Army Registry No.	134
	Year of Manufacture	1861
	Gunfoundry	Ames Manufacturing Co., Chicopee, MA (A.M. Co.)
Lower muzzle face:	Weight in Pounds	164
	Ordnance Officer Inspecting	Capt Richard Mason Hill (R.M.H.)
Right rimbase:	Gunfounder's Identification Number	196

Per *Register* p. 21, inspected, proofed and accepted by Captain Hill October 10, 1864.

CHAPTER XX

Ecological Assessment of Selected Shipwreck Sites at Fort Jefferson National Monument, Florida, August 8-11, 1990

Gary E. Davis

Editor's Note. Dr. Davis, who has conducted long-term biological research at Fort Jefferson National Monument and Biscayne National Park, was asked to participate in the 1990 project to provide a marine biological perspective on potential impact of archeological research in a protected coral reef environment. His perspective is important to planning and executing future archeological investigations in national parks containing coral reef systems.

INTRODUCTION

The National Park Service (NPS) protects the nation's natural and cultural heritages. Occasionally, management actions required to protect natural and cultural values conflict, and managers appear to be forced into choosing either natural or cultural resources at the expense of the other. Historic shipwrecks set in coral reef or other shallow marine ecosystems can present such a dilemma.

Shipwreck structures provide stable, hard substratum upon which a variety of organisms settle and thrive. Frequently these organisms obscure and threaten the shipwreck integrity, and may accelerate wreck decomposition. Wreck excavation to elucidate its cultural values, after 50-300 years of ecological succession, threatens the structure and function of the wreck's biological community. The purpose of this chapter is to explore potential guidelines for balancing archeological investigative needs and ecological impacts, without compromising the values of either natural or cultural resources.

METHODS AND SITE DESCRIPTION

Case studies of four shipwrecks were conducted to compare site-specific criteria for evaluating and mitigating ecological impact and to develop general guidelines for future archeological investigations. The four selected wrecks represent a variety of ecological settings and ship construction types at the Dry Tortugas.

Fort Jefferson National Monument encompasses about 19,000 ha of the 23,000 ha coral reef and sea-grass ecosystem at Dry Tortugas, Florida. The reefs form an elliptical, atoll-like, structure roughly 27 km by 12 km 217 years (Davis 1982). Water depths immediately outside the reef system range from 11-29 m, rise to 2-3 m on top of the banks, and dip to 12-23 m in the central lagoon.

Prevailing physical environmental conditions shape the basic form and structure of Dry Tortugas reefs. The major reef building corals that provide basic Dry Tortugas reef structure are the star corals, *Montastrera annularis*, M. *cavernosa*, and brain corals in the genus *Diploria*. The fragile branching staghorn coral, *Acropora cervicornis*, also forms extensive, nearly monotypic, reefs of several hundred hectares, but they are remarkable dynamic. They apparently develop over about 100 years, only to die back and start over following extreme storms or other natural disturbance (Davis 1982).

Infrequent extreme events, such as hurricanes and thermal shocks, dramatically alter basic reef structure and composition. The classic Caribbean spur and groove reef along the southeastern rim of the "atoll" reflects the gentle summer trade winds and prevailing easterly currents. Massive buttress reefs and rocky, octocoral-dominated reefs on the northern and western exposures reveal the power of winter storm fronts sweeping across the Gulf of Mexico from North America.

Extensive sea-grass meadows cover shallow, less stable substrata, protected from storm waves and strong currents in the lagoon and on the tops of the interior banks. On coral rubble and thin sand, at high wave energy sites, rapidly growing algae dominate the benthic community, especially along the northwestern side of the atoll.

The combination of substrata and prevailing environmental conditions dictates what biological community can survive. The introduction of new, stable, hard substrata (i.e., shipwrecks) into different environmental settings permits an evaluation of the relative roles of environment and substratum in determining community structure. Shipwrecks also significantly alter local biological community dynamics far beyond the physical perimeter of the wreckage itself. For example, lobsters and fish that hide in wrecks during the day forage in surrounding regions at night, thus modifying community structure through predation and competition in over 200 ha surrounding the wreck itself.

FOJE 003 - Windjammer Site AVANTI

This large, recent, iron-hulled wreck provides exceptional vertical relief of nearly 7 m in an otherwise low-profile hard bottom dominated by 30 species of octocorals (sea whips and fans) and a few low-growing scleractinian corals. It is located in a high wave-energy zone during winter storms, and provides abundant shelter for fishes and mobile invertebrates, such as spiny lobsters and urchins. The high-profile wreck structure affords ample attachment surfaces for hermatypic corals well above the scouring bottom sand and provides corals access to stable, well-lighted surfaces in strong currents.

In short, the wreck provides an ideal site for coral reef development in an area that would not naturally support reef corals. Fish abundance and diversity on this wreck is as high or higher than nearby naturally occurring reefs, but much higher than in the surrounding octocoral community (Jones and Thompson 1978). At least 14 of the 50 *Scleractinia* and *Millepora* corals found at Dry Tortugas occur on the wreck, but the major Dry Tortugas reef building corals, *Montastrea* sp., provide only incidental benthic cover and do not contribute significantly to reef structure at the wreck site.

FOJE 029-Bird Key Harbor Brick Wreck

This low-profile wreck is located in a sea-grass bed, surrounded by a sparse octocoral community, on top of a shallow bank at a depth of less than 3 m. It is an exposed site, with little solid substrata for reef development. The wreck provides hard surfaces for coral attachment, but sand scouring and high suspended sediments from the surrounding sand and rubble largely limit the successful corals to those adapted to highly disturbed sites, such as *Millepora* sp. and *Siderastrea radians*. A diverse assemblage of reef fishes congregate at the wreck, with more than 30 species present, but this assemblage is considerably less diverse than nearby natural reefs, which usually support 60-100 species.

FOJE 011 - East Key Construction Wreck

Wreck material at this site is scattered through an octocoral community at a depth of 4-5 m, just behind the algal-dominated community at the eastern bank crest edge. Rather than adding a single structure with unusual vertical relief, this wreck provides additional scattered hard substrata on a coral rubble bottom. Consequently, the fish and invertebrate assemblages in this area are not specific to the wreck structure, but rather are characteristic of the entire community.

FOJE 008 - Nine-Cannon Site

Similar to the East Key Construction Wreck, this wreck is scattered across a sand and coral-rubble bottom without adding significantly to the region's vertical relief. It is in the same high-energy setting and octocoral community as the Windjammer Site, but shows less diverse coral and fish assemblages, virtually identical to those found in the natural octocoral and algae dominated communities found at this site. Unlike the Windjammer Wreck, there is little evidence that the wreck materials have significantly altered the biological assemblages, other than minor changes in local distributions of corals attached to wreck debris.

DISCUSSION

Living coral reefs occupied 866 ha (3.8%) of the seafloor at the Dry Tortugas in 1976 (Davis 1982). In spite of occupying such a small proportion of the bottom, these biological communities were largely responsible for building the entire 23,000 ha submarine structure, and their protection is an important concern of park managers. Rarity of living coral reefs also adds to concern for their survival. Guidelines for any activity that threatens coral reefs need to provide a means to weigh the potential value of information, or other benefits, derived from the activity and the long-term reef impact.

National Park Service policies and regulations regarding protection of natural resources leave no doubt that even minor intrusive archeological shipwreck investigations would be in violation, regardless of the potential cultural values at stake. The key to resolving this apparent conflict is in the definition and identification of "natural" resources. If the resources at risk are truly natural biological communities and not artifacts of human intervention, then they should receive all of the protection afforded under policy and regulation. If, however, the resources in question are individual organisms or assemblages that exist only because of human intervention, then they should not be considered natural resources for the purposes of NPS policy and regulation.

The four shipwreck cases studied at Dry Tortugas indicated that nearby natural ecological systems appeared either unaffected or negatively impacted by the human intervention of creating the wreck. At the Windjammer and the Bird Key Harbor sites, wreck structure provided shelter for abnormal concentrations of predators and grazers that probably have altered the surrounding community structure and maintain it in the altered state. At the other two sites, wreck material is scattered among natural hard rubble and contributes nothing new or unique to the natural structure or substrata. In all four cases, encrusting organisms simply form a coral reef facade. It is not a functional coral reef ecosystem. It exists only because of the artificial structure provided by modern human activity. In these cases, archeological investigative activities would have no long-term or significant ecological impact, other than on individual organisms.

General guidelines for future investigations should include an ecological clearance that determines if the affected natural resources are in a normal or artificial setting. If the shipwreck material forms an integral part of the natural system, e.g., it is overgrown by major structural elements of a bank or buttress reef in a system that was in place prior to the wreck, then disturbance should be considered only if the cultural values are extremely high. If the biological encrustations on the wreck are only reef facades, then intrusive investigations should be able to proceed, with due consideration to disturbance to the adjacent natural systems.

CHAPTER XXI

Recommendations for Fort Jefferson National Monument Future Research and Resources Management

Larry E. Murphy

Over the last fifteen years, National Park Service (NPS) managers have become increasingly aware that resource management responsibilities do not cease at water's edge. The first issue facing managers who have direct responsibility for submerged cultural resources is knowing what they are responsible for--what sites exist within their underwater jurisdiction. Often sport divers and commercial treasure hunters know more about what is underwater in national parks than the managers directly responsible for site preservation and interpretation. The National Park System contains 356 areas of which at least 60 have significant submerged cultural resources. Most of these are in the nascent stage of investigation. Fort Jefferson National Monument (NM) is no exception.

Fort Jefferson NM contains an impressive array of cultural resources on land and underwater. Primary NPS management objectives are inventorying, evaluating, registering, interpreting and protecting the full range of cultural resources. Fort Jefferson NM is not an easy place to separate land and underwater cultural resources, nor would it be appropriate to do so. Consequently, suggestions here are made for both underwater and land areas within the monument, and the monument is treated as a unit. A long-term plan for park archeological research is necessary to make research cost-effective and enable managers to take advantage of appropriate research opportunities presented by outside sources.

GENERAL RESEARCH FRAMEWORK

The following are some fundamental issues that should be considered at the inception of archeological research within the monument. Fieldwork should produce a database for long-range management decisions; should not be limited to site-specific concerns; should be cumulative to be cost effective; should involve questions and scientists of numerous disciplines; and finally, research should be done with as little negative site and environmental impact as possible. Each issue will be discussed separately. These few issues do not exhaust the possibilities, but they offer a basic framework to guide managers in making decisions about appropriateness of research and what to expect from it.

1. The first issue for future research is that fieldwork effectively produce data necessary for long-term management requirements of evaluation, protection, preservation and interpretation. Principal objectives for future work should be to answer the seemingly simple questions: What sites are present?, What is happening to them?, How did this collection of sites come to be? and What is their significance?

Data should be collected so they will be cumulative, comprehensive, integrated, comparative and readily accessible. Only computer technology provides necessary infrastructure for data collection, storage, manipulation and presentation sufficient for management and research needs. Data compatibility with

Everglades National Park's geographical information system (GIS) and NPS GIS standards should be a high priority. All fieldwork products from the initial planning stages should be designed to be compatible with GIS products and augment a comprehensive digital database directly accessible by managers, future researchers and planners. Computer software interface is essential to allow managers and others to effectively and efficiently conduct inquiries at various levels and scales, including park, area, sites (both cultural and natural aspects), artifacts and available aerial imagery. All materials should be integrated and based on geographical coordinates and accessible either through database attribute or locational queries.

2. Research should emphasize a regional perspective, rather than just analyzing archeological sites as separate, isolated elements, which has been the approach taken by most prior shipwreck investigations. Defensible significance evaluation must include the widest possible site context. The regional approach should be followed and refined during future surveys and evaluations.

In the Dry Tortugas case, "regional" has a very wide meaning. Seafaring is wide-ranging, with shipwreck sites scattered everywhere that maritime cultures have been active. Individual maritime societies are not tightly bounded, closed entities amenable to independent analysis. A regional approach to maritime sites, then, must encompass all the maritime cultures active in the vicinity, including vernacular craft use in local activities.

Implicit in the meaning of "region" is the assumption that a shipwreck concentration is not just an accidental, haphazard conglomeration of unlucky vessels. It is rather, to some degree, a representative sample of all maritime activity in a specific area over time that is structured by a complex interaction of natural and cultural factors. Vessels wrecked in the Dry Tortugas represent the activities, interactions and conflicts of all maritime cultures that have ever been active in the area. The general geographic area is the Gulf of Mexico, the western Caribbean and the eastern seaboard, however, study must also be directed to maritime European and American cultures themselves.

Also inherent in a regional approach is the assumption that a group of shipwrecks and related sites can be productively interpreted by an archeological-anthropological perspective. Recovery of specific details is important, but relevant research perspectives should go further to examine the relationships between patterning and variability in the archeological record and the past behavior they represent. Principal research topics should emphasize cultural processes such as intersocietal contact and acculturation, and competition and conflict among social groups and over time. Interpretation of the park's archeological record should include examination of social variables such as ethnic and cultural associations, and economic and political relationships.

The research approach should be regional, historical and social-scientific. Archeological interpretation should go beyond augmenting historical documentation, particularly by focusing on processes that are variable between cultural groups. The time depth of the Dry Tortugas wreck collection allows investigation and interpretation of change in the material record over a long period of time, while controlling for environmental and geographical variables. Ships, whether commercial or military, are parts of cultural systems, and it is those larger cultural systems that should be the object of investigation through their representation in the study area's material and documentary record. In short, Fort Jefferson NM maritime sites can best be accounted for (understood, explained and interpreted) by developing and using broad principles of maritime human behavior in interpreting material remains, in addition to the historical documentary record of more traditional approaches. The NPS National Historic Landmark Themes (see Chapter VII) provides a reasonable framework for this research.

3. Field research should be comprehensive, integrated and cumulative. There is no justification for separating terrestrial from underwater research in the Dry Tortugas, or for solely focusing on shipwrecks.

Prehistoric Research. Prehistoric archeological research, although not a primary survey focus, should be incorporated into research projects. Inundated Paleoindian and Archaic sites are discussed in Chapter V, and possibility of their presence, although slim, cannot reasonably be dismissed. It is not considered cost-effective at present to specifically survey for early inundated sites, but their possibility is sufficient in the study area to consider collection of samples appropriate to paleoenvironmental analysis during test excavations on historical remains.

Paleoenvironmental Research. Chapter II indicates the knowledge limits about Dry Tortugas island formation, alterations and environmental sequences. Local sea-level curves have not been firmly established. Collection of sediment samples contributing to regional geomorphological development, paleoenvironmental sequence and sea-level curve formulation should be conducted during any test excavations. Numerous analytically important sediments will be encountered in Fort Jefferson NM excavations. Peat and subaerially formed soilstone crust, useful for exposed surface dating, have been collected in the Quicksands area close to the park (Robbin 1984). This environmental information is important. Appropriate core and sample collection and analysis will add little to overall project costs.

Euroamerican and Fort Jefferson Research. Terrestrial historical archeology is an important part of a comprehensive Fort Jefferson NM survey. The fort and its construction have left rich material remains that have received only cursory research consideration. Consequently, historical archeological research should include both terrestrial and underwater sites. Full terrestrial survey, including magnetometry and testing, could be done with a small crew and nominal expenditure.

Fort Jefferson research orientation should be, like the underwater sites, from a wide context and comparative perspective focusing on questions of process as well as history. Emphasis should be on investigating and interpreting the fort as a cultural system that was part of a much larger cultural system, particularly in relation to international interactions.

For example, a research question might investigate commonly held beliefs about third-system forts. The well-known historical argument that masonry fort construction was halted and revised after demonstration of the rifled exploding shot effectiveness against masonry walls, particularly during bombardment of Fort Pulaski, does not seem to apply to Fort Jefferson, where construction was not halted and few revisions were made. Much of Fort Jefferson's history reflects technological developments, strategic planning and its unique position as a maritime, rather than a harbor, fort, the principal difference being its isolation from land-based support.

Processual aspects of Fort Jefferson interpretation as a cultural system should consider questions of support and change. The support system was entirely maritime. Fort construction, materials procurement, transportation, provisioning and labor force have not been documented archeologically. Archeological documentation will provide a Fort Jefferson material chronology that may vary considerably from one relying solely on documents. Some fort construction aspects have scant documentation. For example, the various labor groups that built the fort--slaves, freemen, soldiers, Irish and prisoners--have little documentation, but each group surely left a distinctive archeological record. Processual questions about the fort should focus on construction, support, ethnic and social group variability, recycling, refitting, refuse deposition, abandonment and finally reuse in many forms, including memorialization as part of the National Park System.

4. Future research should continue to be multidisciplinary. The earliest underwater surveys incorporated researchers from disciplines other than archeology (see Chapter X), and contributors to this report represent many disciplines. Environmental context is very important, and the research opportunity offered by comprehensive Fort Jefferson NM survey is most effective and efficient if multidisciplinary. For example, as Chapter III indicates, there is very little Dry Tortugas physical oceanographic information, although principal Gulf of Mexico currents have been widely studied.

Wreck-formation processes should be comparatively studied in order to develop predictive models, both park specific and general. To be an effective model, geologists, oceanographers, coastal geomorphologists and marine biologists need to be directly involved. NPS has staff scientists that should be used as a first-source for development of ancillary research designs that complement overall project goals. Full integration of cultural resource investigations with NPS coral-reef studies should be a priority to maximize fieldwork returns. For example, development of side-scan sonar signatures for coral species and substrate recognition will provide a comprehensive coral-density base line that would augment Davis' prior work (1982) analyzing a century of Dry Tortugas coral change. If magnetic survey costs, which are mostly positioning and boat time, are funded for cultural resources, it would add relatively little cost to support side-scan sonar and subbottom instrumentation that has specific natural-resource returns and directly contribute to the GIS database. One GIS product should be an accurate digital depiction of the entire reef system.

Cost-efficiency and cost-effectiveness increase markedly with data generation applicable to many disciplines and research interests, including shipwrecks and environmental monitoring. Much interest has recently developed in environmental issues, from coral bleaching to global warming. A comprehensive Fort Jefferson NM remote-sensing survey could produce data applicable to current and long-term environmental research, and thus be a significant model for many disciplines on present and future issues.

5. The last basic element of the research approach should be to develop and refine the conservation ethic by emphasizing maximum data return with minimum disturbance of archeological remains. Any site disturbance must be minimal for the specific questions, scientific and fully justified. The issues discussed in Chapter XX dealing with the balance between natural and cultural resource investigation will have to be addressed in determining appropriate field research methodology.

SOME GENERAL RESEARCH DOMAINS

1. The principal hypothesis regarding the Fort Jefferson NM maritime site population is that the maritime casualty archeological record is structured by behavioral and cultural processes, and not solely the product of natural forces. Natural forces are viewed here as contributing factors or perhaps constraints, but not as deterministic--all marine sites in Fort Jefferson cannot be explained merely by environmental factors and technology alone. In order to account for a particular wreck pattern at a given location, the cultural context that produced them must be rigorously investigated. Research questions oriented to systemic explanations of change and variability are

important. The general archeological problem is specific pattern recognition and then accounting for the pattern in the widest possible context. Emphasis is on human behavior that has a high degree of patterned repetition.

Shipping routes are examples of patterned repetition. They are part of trade networks structured by cultural, behavioral and economic processes. Study of vessels wrecked by natural and cultural events will reflect the structuring processes of a changing and developing trade and transportation network, and allow examination of the network that is distinctly archeological. Cycles of trade and markets driven by regional patterns, which are in turn driven by larger patterns, alter risk acceptance, use of force, resistance and ultimately what appears in the archeological record. The larger trade network in which most of the park's marine sites took part is the modern world-system as described by Wallerstein (1974, 1980, 1989), Braudel (1972, 1982, 1984) and others. Questions involving operation of large-scale spatial systems, and the local, regional and interregional responses, are fundamental to explaining and interpreting Fort Jefferson NM maritime sites.

2. The natural forces that create wreck concentrations must be understood, which involves defining "ship traps," or high-density shipwreck locations. Certainly, more wrecks occur where there are more ships, but a comprehensive examination of natural factors will extend understanding beyond this low-level empirical generalization. Examination of Dry Tortugas as a "ship trap" will likely clarify general wreck formation principles, both natural and cultural, that will be applicable to other locations. Validity of patterns recognized, and the variables isolated to account for them, will come from tests done on other ship concentrations.

3. Site-level questions are primarily historical. Basic questions at the site level are age, function and cultural affiliation. A basic research problem on a site-specific level is methodological. How does one generate data necessary to determine the nature of shipwreck concentrations within the stringent conservation parameters of "maximum returns from minimum impact" as generally established in NPS 28 (USDOI 1985)? The problem forces continual refinement of techniques in all investigative stages from historical research to remote-sensing deployment, to field and laboratory data analysis. Refinement of what is meant by minimum impact as only that necessary to answer specific justifiable questions needs to be accomplished as an ongoing aspect of fieldwork in NPS areas.

4. The principal research question regarding Fort Jefferson as a strategic entity should examine the complex and varying social system that constructed a large outpost in an isolated, high-stress environment taxing the limits of contemporary technology, engineering and logistics. How does the material record reflect the construction, revision, use and abandonment of the fort and surrounding islands, and provide information on past activities beyond that available in documents?

5. A general research domain involves investigation of archeological site formation processes, both on land and underwater. The theoretical and methodological framework of Schiffer (1987), Butzer (1982) and others should inform such inquiry. Cultural and natural processes both require investigation to account for site variability and to ascertain general regularities that obtain for sites in similar environments. Interfaces between natural and cultural processes should be specifically examined. Little is known about environmental processes affecting underwater sites. Some are obvious, some are not. Currently there is uneven information about natural environmental process and how they affect submerged cultural materials.

GENERAL REMOTE-SENSING SURVEY METHODOLOGY

The Submerged Cultural Resources Unit (SCRU) has developed a general approach to remote-sensing survey for marine sites. Primary source for additional information and examples is the *Point Reyes National Seashore Submerged Cultural Resources Survey* report (Murphy 1984:85-140). Additional information is contained in Murphy and Saltus (1991).

Remote sensing, inherently nondestructive, uses electronic instruments or aerial photography to systematically collect information used to locate, evaluate and monitor cultural and natural resources. For submerged sites, three electronic instruments are particularly important: the magnetometer, side-scan sonar and subbottom profiler. These instruments are deployed aboard a boat with sensors overboard.

The magnetometer is the most important instrument for locating historical sites by detecting ferrous material concentrations. Side-scan sonar uses sound to graphically portray the seabed and any material protruding above it. The subbottom profiler, which also uses sound, can determine the depth below the seabed and nature of consolidated and unconsolidated sediments, and sometimes, presence of buried cultural materials.

The magnetometer, because of its primary importance, is the instrument used to determine lane spacing during site survey. This instrument detects the earth's magnetic field and measures it in units of nanoteslas or gammas. Ferrous masses causes an exaggerated or anomalous reading from the earth's ambient magnetic field. Anomaly strength and duration is related to ferrous mass proximity to the sensor and its size. Minimally, the magnetometer is run with a digital fathometer that provides water depth.

Registering anomalies is only one aspect of magnetometer or other remote-sensing surveys. Recording the anomaly location is equally important; the boat location has to be accurately determined. Electronic positioning is critical to underwater archeological survey to ensure full coverage at the desired sample interval, to relocate areas of interest and record site positions. Information collected by remote-sensing instruments is usually of little use if data locations are unknown. There has been no electronically positioned survey in Fort Jefferson NM, and consequently, all areas surveyed so far will have to be redone. Cumulative remote-sensing data collection depends on accurate electronic positioning, and remote-sensing survey should not be done without it.

There are many electronic positioning methods, but two are most important for archeological purposes: shore-based microwave transmitters and the global positioning system (GPS). LORAN is simply too inaccurate for comprehensive archeological survey. Microwave station positions must be accurately surveyed to produce geographical coordinates, but when surveyed properly, their absolute accuracy is within 3-5 m compared to the LORAN's 100 m. Global positioning systems utilize signals received from orbiting satellites for positioning information. A GPS variation called real-time differential positioning (DGPS), which coordinates mobile positions with a stationary receiver on a known point through radio communication, represents the current state-of-the-art. This system is capable of a few meters accuracy with one-second updates during survey. Subcentimeter accuracy of specific points is possible through post-processing calculations and increased occupation times. Global positioning is the system of choice because it is more efficient than shore-based systems for multiple vessels working concurrently in different park areas, for example a dive boat investigating potential sites while the survey boat continues collecting data. All that is required for DGPS is the appropriate receivers, communication equipment and computer, which dispenses with daily shore-based microwave station maintenance. GPS coverage is complete throughout the monument area; to have complete coverage with microwave stations, they would have to be moved around the park, which diminishes survey execution flexibility and severely limits concurrent operations and increases costs and necessary logistic support.

During an underwater cultural resource survey, the first step is to determine a preplotted survey block and desired survey lane spacing. Lane spacing is normally specified and justified in the project survey design. A computer screen or plotter that accurately indicates real-time vessel position guides the boat pilot as the vessel moves along the survey lane. A computer collects and stores the boat's position and survey instrument readouts for postplotting analysis. Postplot data reduction and analysis typically occurs daily so voids in the survey block can be quickly corrected.

Ideally, all three remote-sensing instruments would be run concurrently: the magnetometer detects ferrous mass locations; the side-scan sonar topographically depicts the seabed, coral reefs and cultural materials; and the subbottom profiler graphs the substrate structure and overburden that would have to be removed during test excavations. Thus comprehensive natural and cultural information would be ideally collected with a single boat pass. When done correctly, a magnetometer survey need only be done once. The other data gathering could be repeated for comparative purposes to detect changes in natural features.

Remote-Sensing Survey Parameters

Minimum-transect lane spacing for general exploratory magnetometer survey should be 30 m or less, and in low-probability areas, perhaps up to 40 m. These lane parameters provide acceptable coverage at efficient cost. The 30 m lane spacing recommendation is based on analysis of the few colonial-period vessels that have been magnetically surveyed. A reasonable target mass is 450 kg (about 1,000 lbs), which is based on anchors and cannon of the latter half of the sixteenth century. Cannons from the 1554 Spanish Plate Fleet ranged from 100 to 140 kg and anchors varied from 104 to 425 kg. The 450 kg target mass should give an anomaly reading of at least 10 gammas, considering a linear object exactly between 30 m lanes. (It should be noted, however, that magnetic intensity can vary as a factor of 2-5 under certain conditions (Breiner 1973:48)). The reasoning is that under some circumstances an isolated early colonial period artifact could theoretically be missed, but a shipwreck size scatter containing multiple large masses would likely not be. Anomaly selection for investigation is a complex issue, and a methodology and rationale for investigation must be included in the survey design.

Magnetic evaluation of riverine vessels support 30 m lane spacing for magnetic survey. Although 50 m lane spacing has become standard for some investigations, our conclusion is that it is too coarse a pattern. Of a selection of twelve riverine vessels magnetically surveyed, all would have been represented by a 15-m-long, 10-gamma segment of a 30 m transect. At least four of these would have been undetected if centered between two 50 m lanes. These four vessels likely to be missed on a 50 m lane spacing include an 1840 65-ft towboat, a 55-ft schooner, a 27-ft hull segment of a modern shrimp boat and a 44-ft coastal sailing vessel (Murphy and Saltus 1990:94).

Data should be reduced to allow clear depiction of intensity and duration on an appropriately scaled chart (for an example, see Murphy 1984). Minimally, all anomalies of 10 gammas for a length (duration) of 10-15 m should be considered to represent possible watercraft remains and should be investigated further. Anomalies of smaller size and duration should be examined during survey of activity areas, such as anchorages, and sampled during in-water block investigations. Completion of this phase allows selection of areas likely to be significant maritime casualty or activity sites, and allows priority development for onsite examinations or "ground-truthing."

A second data-generation phase is important for delineating the extent and relationships of anomalies likely to represent a casualty site. Transects no wider than 10 m should be run well beyond the anomaly concentration area and postplotted as contours. Magnetic contouring on 10 m or less transects is the most reliable way of determining intrasite magnetic feature association and predicting target-mass location for test excavation. In our experience, contouring magnetic data collected on 30 m lanes has limited utility.

Side-scan sonar survey ideally should be run concurrently during magnetic survey. A 500-600+ kHz sensor currently produces the highest resolution bottom depiction. Digital sonar with slant-range correction is preferable because it provides a permanent record that is analytically versatile and can be utilized by GIS programs. Sonograph signatures for various coral species should be developed, which would provide a 100 percent coverage of surveyed areas useful for long-term coral monitoring and a means for rapid resurvey and comparison. A permanent digital record is important in assessing alterations of coral density over time, or damage from stranding casualties like the MAVRO VETRANIC, which damaged a park reef in 1989.

Subbottom or seismic profiler technology has recently progressed to developing high-resolution rendition of shallow seabed layers. The new "chirp" subbottom profiler particularly meets archeological requirements. Archeologists are usually only interested in the top few meters of bottom sediment, an area that is typically compromised by the common single-frequency profilers. Chirp profilers use a multiple-frequency signal producing essentially noise-free images from the seabed top to about 100 m depth. The chirp system transmits a computer-generated digital, wideband FM pulse that allows quantitative evaluation and classification of bottom sediments useful to geological and archeological purposes.

Another important remote-sensing tool is aerial photography, which has been used for terrestrial archeological purposes since 1921 (Solecki 1960; Duel 1969), and since the mid-1970s by the National Park Service (Lyons 1976). Benefits of an aerial perspective for underwater survey have long been known, with inundated Mediterranean port photointerpretation preceding World War II (Throckmorton 1972) and an early application of balloon shipwreck search in 1961 (Peterson 1973). A successful, pioneering application of aerial submerged-site photography was conducted at Fort Jefferson NM in 1971 and 1974 when shallow-water shipwrecks were recognized on aerial photographs taken especially for submerged site survey purposes (Lenihan 1974; Marmelstein 1972a,1975,1977; see Chapter X).

Complete aerial photographic coverage of the reef system should be considered a priority for determining reef morphology, cultural site locations and serving as a comparative baseline for future investigations. Efficient film and filter combinations coupled with interpretive signatures for wrecks and bottom topography can provide much information in a cost-effective, GIS accessible format. For integration of aerial photographic techniques into archeological and biological research and monitoring programs to occur, an assessment of the efficiency of water penetration and accurate bottom portrayal capabilities of various film and filter combinations must be researched, and specific biological and cultural feature signatures must be developed and ground-truthed. Multispectral imagery has the highest potential for contributions to NPS needs. Rendition should be in both large and small scale to provide a synoptic overview and sufficient resolution to determine small features, such as wreck scatters and reef scars.

RANGE OF LIKELY FORT JEFFERSON NATIONAL MONUMENT HISTORICAL SITES

Generally when underwater sites are mentioned, only shipwrecks come to mind. However, a wide range of historical sites are likely to be found beneath Fort Jefferson NM waters. The term "marine casualty site" used in this report includes the following sites: shipwrecks, site scatters, small boat sites, stranding sites, ship repair locations, discard and refuse areas.

Shipwrecks can range from sites like the Windjammer (003), where large intact hull fragments remain, to a completely buried scattered site with little structure present. They can be consolidated or scattered. Muckelroy termed concentrated wrecks "continuous sites," and those more scattered "discontinuous sites" characterized by sterile areas within the site boundary and no clear site locus (Muckelroy 1978:182-200). While this typology is descriptive and methodologically useful, it does not encompass all cases. For example, a site may be a bit of both, such as a vessel that strikes bottom in a wave trough spilling material only to be lifted by the next crest and finally deposited behind the outer reef to form a "continuous site." Complexity arises quickly when multiple events overlay, such as the case of Nine-Cannon Site (008), where there is clearly more than one marine casualty.

Associated with shipwrecks are site scatters. Site scatters can be primary or secondary. Primary scatter occurs during the wreck event and is part of the initial deposition. Secondary site scatter results from later site-formation processes such as waves or current impact prior to burial and stabilization. An example again is the Windjammer Site, where the vessel broke in two during the initial deposition. Later forces shifted the stern and collapsed some hull portions. Primary and secondary scatters may be in opposite directions, or a site may be nothing more than a hull fragment from a vessel broken up offshore floating in and being deposited in the area. Cultural activities can also impact sites, such as anchors dragging through a site, later ship groundings or dredging activities.

Small boat sites will probably be located in anchorages or around islands. For example, some sand and coral barges were lost during fort construction.

Stranding sites will also be located. Numerous strandings occurred in the Dry Tortugas, and ships that were not removed are shipwrecks. Others may have been removed cleanly, leaving little or no trace except reef scars. Some may have jettisoned materials, such as site 031, the twin ballast piles on Pulaski Shoals. Still others may have left anchors or other gear lost from the stranded or assisting vessels during the salvage effort.

It may also be the case that a vessel grounds, only to later float free leaving no material evidence of the event except a reef scar. For recording purposes, the scar can be considered as a site where no artifactual evidence exists. The site would be recorded and documented because it is part of the material record of the park's maritime activity.

Activity sites can be distinguished from casualty sites and include the following types. Ship repair sites could be located anywhere that ships were repaired or serviced. It was a common practice to take refloated vessels into the Dry Tortugas harbor for temporary repair prior to towing to Key West for admiralty litigation. Other vessels may have been repaired during the course of a voyage, temporarily sheltering in Dry Tortugas anchorages. There are historical indications that careening may have taken place in the Dry Tortugas (Burgess 1967:100-101). Careening is bringing a ship over on its side so the hull bottom can be inspected or repaired. Any of these sites may have left residues linked to their activities.

Discard sites offer numerous and variable possibilities. Schiffer (1987:58-79) discusses refuse sites and distinguishes between primary and secondary discard. Primary refuse is discard at the location of use. Trash discarded elsewhere comprises secondary refuse. Worn-out tools discarded at a ship-repair location would certainly be primary refuse; waste materials from the bilge thrown overboard may be considered secondary refuse. While Schiffer's model may need some revision for maritime application, these kinds of distinctions are important because they focus attention on the variable activities that lead to material becoming part of the archeological record, which is analytically important to understanding how the archeological record is formed and what type of behavior it represents. The point here is that discard sites are considered archeologically important and behaviorally complex, and they must be addressed in park survey designs.

Refuse can also be displaced. Refuse displacement underwater occurs by the same natural processes that move any material: waves and current. Cultural displacement also occurs from dredging or slumping of shores or channels.

Discard areas include anchorages, areas around docks and landings and trash disposal areas. These sites vary in terms of formation and structure. For example, anchorages represent many short duration discard events from various sources. A landing or dock area would be more continuous discard over the life of the site by people engaged in similar activities. Trash deposition may be a single large event or many smaller events accumulating over a long time period. Little is known about Fort Jefferson trash disposal practices. Likely some, if not most, trash discarded from the fort is underwater. Fort Jefferson privy areas, often rich in artifactual material in other historical sites, were over the water. Island perimeter areas should receive close-grained examination during any comprehensive park survey.

This list is not exhaustive, but is intended to indicate complexity of the park's archeological record. One important point is that survey methodology must be variable and justified in terms of sites likely to be located within the targeted survey block. No particular survey methodology will be appropriate for all areas within Fort Jefferson NM.

GENERAL SITE INVESTIGATION METHODOLOGY

Field methodology and analysis should be standardized for Fort Jefferson NM underwater site investigation. There are no adequate precedents we can use as models for investigation of a large number of buried or partially buried marine sites. It will be necessary for the NPS to develop research designs, preservation and protection plans, methods and techniques appropriate to management requirements and goals for submerged, buried marine archeological sites. Work conducted by SCRU at Isle Royale National Park (Lenihan 1987) produced a model for investigation of exposed, nearly intact shipwreck remains; the work at Fort Jefferson is intended to be the model for investigation of a large collection of buried marine sites.

There should be clear levels of investigations with each level providing the foundation of the next. For example, all surface site manifestations should be documented and analyzed prior to test excavation or any other site disturbance. Included in this level may be the collection and documentation of materials for dating or cultural association. Information provided by surface manifestation analysis is necessary to guide the next investigative level, which involves limited and precise test excavations to acquire data not available from exposed materials. Principal questions are temporal determination, function, cultural affiliation and site formation processes; secondary questions involve physical aspects of the site, such as nature of contents, integrity, scatter extent, and possible threats. Determination of threats is dependent on a comprehensive assessment of environmental context.

Following is a set of suggested investigation levels of sites located during systematic remote-sensing survey. These are offered as a starting point for developing standardized multilevel methodology. For full utilization of investigative levels, a database allowing cumulative data storage and access and refinement of level standards is necessary.

Level 1: Remote-Sensing Site Reconnaissance

After site location has been determined through analysis of general block survey results, an electronically positioned high-resolution magnetic survey should be completed. This intensive magnetic survey should be conducted on 10-m or less lane-spacing and extend well beyond recognizable site limits. Data reduction minimally includes magnetic and bathymetric contours, and ideally examination of high resolution side-scan sonar imagery. High-resolution aerial imagery should be used along with the side-scan imagery to determine natural site context. To maximize information, contour depths of unconsolidated sediments should be generated at this stage, which would require a subbottom profiler capable of high-resolution display of the top 10-20 m of sediment (such as the chirp system).

Level 2: Diving Reconnaissance

Includes nondisturbance, nonimpact determination of visible materials and proximal environmental context. Initial task would be placement of site datum with accurate geographic coordinates. Products would be a measured sketch map and written observations from diving investigations, positioned photographs and video with accurate feature provenience. Metal detector transects for the extent and direction of site scatter may be included. Brief biological and geological context descriptions would be completed.

Level 3: Site Documentation

This intensive level requires site-specific planning that utilizes remote-sensing data, aerials and results of Level 2 diving reconnaissance. Products would be detailed site map, systematic metal-detector survey, artifact documentation and analysis, sample collection and analysis and increased video and photographic recording, including controlled or semicontrolled mosaics and digitization. Basically, a site investigation exhausts what can be learned from noninvasive investigation and includes biological and geological descriptions. Exposed diagnostic artifacts may be collected for either detailed documentation or, more rarely, for conservation.

Level 4: Site Test-Excavation

This is an intensive investigation and includes test excavation based on the assimilation and analysis of all prior levels. Test excavation will be planned, appropriate and cumulative to ascertain subsurface site scatter and features.

Level 5: Complete Documentation

This is the highest level of intensive investigation and the most comprehensive. Major features would be thoroughly documented, which may require more excavation than Level 4. Documentation would be consistent with Historic American Building Survey-Historic American Engineering Record (HABS-HAER) guidelines modified for underwater application. An appropriate candidate for this level among the known sites is the Windjammer Site (003). Although extensive excavation would not be necessary, some would be required. The objective would be to bring documentation of 003 exposed and buried remains to HABS-HAER standards or equivalent.

Collections Considerations

Not only plans, but necessary funding must be secured for field and laboratory conservation prior to test excavations or artifact recovery. Test excavations, necessary for most site evaluation, incurs conservation expense. There are at least three levels of artifact conservation: 1) field laboratory stabilization and documentation, 2) complete laboratory conservation and 3) permanent curation.

A project-specific conservation program will be necessary. The only NPS precedent for such a program was developed by Western Archeological Center's curator Brigid Sullivan for the 1982 Point Reyes survey (Sullivan 1982). Although artifact recovery was anticipated, none occurred. Most underwater archeological projects conducted by SCRU have recovered few artifacts and have not required a field laboratory, and artifact conservation has been done on contract. Future Fort Jefferson NM test excavations for site evaluation will require a field curator and on-site field conservation and documentation facilities.

A conservation program is fundamental, and its development must precede any site investigation levels that include test excavation or surface artifact collection. Such a program should be developed in consultation with Southeast Archeological Center, knowledgeable NPS curators service-wide, and principals from academic, federal and state institutions directly involved with submerged artifact conservation. If possible, international institutions should be consulted, particularly in Canada, Great Britain, Sweden and Australia.

SPECIFIC OBJECTIVES AND RECOMMENDATIONS FOR FORT JEFFERSON NM

Objective 1

Conduct comprehensive systematic remote-sensing survey of waters within the park's jurisdiction.

Discussion

This assessment has demonstrated that there have been twenty years of piecemeal, inadequately funded short-term underwater archeological projects at Fort Jefferson NM. It is counterproductive to continue this sort of noncumulative effort. Results of all projects to date have not provided managers with adequate knowledge of the cultural resources within a single acre of submerged park lands. If money sufficient for conducting an adequate survey is unavailable, lesser projects should not be done because they give the illusion that progress toward inventorying and evaluation of park resources is being made, when in fact little useful information is being produced.

Parameters

Systematic survey must include accurate (+- 3-4 m) electronic positioning that produces geographic coordinates, ground truthing of anomalies and documentation minimally equivalent to diving reconnaissance level (level 2 above). Magnetometer lane spacing within the park's 30-ft depth contour should be 30 m or less. Some other areas may be as much as 40 m. Data reduction should be in symbols that indicate magnetic anomaly position, intensity and duration (Murphy 1984).

Any research should identify specific questions pertinent to generation of a cumulative database of maritime anthropological, archeological and historical information on the park's sites and produce reports and other timely products useful to understanding and interpreting park resources. A general research design for the park should be a priority. This design should be periodically reviewed and revised. Each research project, including surveys, should have its own specific research design and should include, but certainly not be limited to, addressing some of the research problem sets and issues mentioned above. No surveys that fail to meet these minimal requirements should be supported.

Objective 2

Documentation of sites as found by systematic survey or chance finds including additional documentation of mapped sites in this volume.

Discussion

No site within the park has complete documentation of visible remains. Sites reported in this volume that have seen fieldwork in the 1980s and 1990 are adequately documented for most management purposes, although additional documentation may be desirable in most cases. Chance finds of additional sites are possible, and these should be documented at least to the level of those reported in this report. There is also the possibility that some researcher might have specific research questions that could be answered best at Fort Jefferson NM in a nondestructive, nonimpact investigation, which is an appropriate research use of resources.

Parameters

Chance finds of new wrecks should be documented at least to the level of those in this report that have been investigated in the 1980s and 1990. Future documentation projects must be nondestructive or minimally destructive, with all disturbance fully justified and cleared with SEAC, which is responsible for archeological compliance in Southeast Region. Minimally, research should address issues and themes relevant to park interpretation. All projects should be supervised by a competent professional archeologist who dives and has experience in underwater archeology and is responsible for documentation, final report and other products.

Objective 3

Establish baseline interpretive information on sites including present appearance, marine organisms and state of preservation and stabilization.

Discussion

A brief video and photographic inventory of known sites should be assembled. Information should be gathered in a manner that would permit use for law enforcement and monitoring purposes, as well as interpretation. Identify specific objects on site in sufficient detail that their identity would be unassailable in a courtroom.

RECOMMENDATIONS

1. A systematic, comprehensive, cumulative cultural resource survey be conducted along parameters discussed above. This assessment has demonstrated that there is a remarkable potential for archeological remains on land and underwater in the Dry Tortugas. A comprehensive submerged resource survey has been seen as a priority by marine archeologists associated with the fort for more than twenty years. Several superintendents have strongly supported such a survey. The project could be completed in phases if sufficient money is not available to do it at once. However, large blocks of time must be available in order for a survey

to be cost-effective. Short-term positioned surveys are not cost-efficient because of mobilization costs and weather constraints.

2. Computer GIS infrastructure be developed for integrating park natural and cultural site information.

3. Continue documentary research. Comprehensive cultural resources research in the Dry Tortugas is dependent on historical documentation, and systematic historical research should continue. Much more historical research is needed on all aspects of marine casualties and marine and land-based activities. Much of this research can be conducted under contract on specific topics, such as Loggerhead light construction; dredging operations; Carnegie Institution activities, and Coast Guard operation history, among others. Historical research on Fort Jefferson is not exhausted, much can be added to the excellent foundation laid by Edwin Bearss (1983).

4. All subsurface impact on the islands be monitored by an on-site archeologist. Additional documentation of terrestrial features and Fort Jefferson should be an on-going concern.

5. Future fieldwork have research designs and specific report and other product obligations. Research designs employed by in-house or contracting archeologists should minimally include research orientation and domains discussed above. Historical research should augment National Historic Landmark themes appropriate to the park.

6. National Register nominations be prepared for park sites. Thematic and district nominations should be developed. Nomination of Fort Jefferson NM as a World Heritage Site should be pursued.

7. Greater presence of NPS staff on shipwreck sites is important. Fort Jefferson has rarely had sufficient ranger personnel to conduct regular patrols throughout the year. Diver monitoring for natural and cultural resource violations should be regularly conducted throughout the monument's jurisdiction.

8. Every effort be made to interface natural and cultural resource protection and drug interdiction in the area to achieve multiple benefits from funds and technology to maintain strict management control.

9. Mooring buoys be considered at specific natural and cultural sites, particularly the Windjammer Site (003), which should be developed as a contact site.

10. Serious consideration be given to establishing a long-term field research station at Loggerhead Key. Besides the historic antecedent of the Carnegie Laboratory, there are successful precedents for long-term research accommodation at Biscayne, Channel Islands and Everglades National Parks. Fort Jefferson NM is an ideal laboratory for multidisciplinary research programs that would directly benefit the NPS.

11. The NPS explore federal agency and academic partnerships for cooperative investigations of Fort Jefferson resources. Project SeaMark has been an exemplary model of what can be accomplished with a cooperative program between Navy and NPS. Increased NOAA involvement in the area may also present opportunities for mutually beneficial cooperative research. Multidisciplinary academic cooperative research programs at the graduate level should be encouraged.

APPENDIX

Fort Jefferson National Monument Video Catalog

Randolph W. Jonsson

This is a catalog of Fort Jefferson National Monument video footage shot during 1985, 1988 and 1990. An X prior to the tape code denotes copies rather than original footage. FOJE denotes Fort Jefferson, followed by tape number, year shot and tape size (i.e., .75 = 3/4 inch, .5 = VHS and .5c = VHS compact).

All originals are filed at the Submerged Cultural Resources Unit, Santa Fe, New Mexico. Copies are available upon request.

TAPE		DURATION
X-FOJE-1A-85.5		2:24:33
0-15:56	Site 8Mo130 Newground Reef Wreck	
15:56-20:10	Site UW-018: Two-Cannon Site	
20:10-40:31	Site UW-008: Nine-Cannon Site	
40:31-49:04	UW-008 Nine-Cannon Site with emphasis on anchor chain area	
49:04-55:48	Search for a shrimp boat 2 miles SW of Loggerhead Key lighthouse	
55:48-1:02:39	Bird Key Wreck	
1:02:39-1:14:42	UW-017 and 009: Keel pins area	
1:14:42-1:19:46	Keel pins area	
1:19:46-1:31:15	Lobster boat	
1:31:15-1:41:46	Lobster boat	
1:41:46-1:51:12	Anchor caves near Loggerhead Key	
1:51:12-1:57:13	Anchor caves area	
1:57:13-2:02:57	Nurse sharks near Long and Bush Key, plus surface footage of ACTIVA, Fort Jefferson and Coast Guard shuttle boat	
2:02:57-2:06:12	Nurse sharks and surface, Long and Bush Keys	
2:06:12-2:11:38	Surface, Fort Jefferson	
2:11:38-2:20:33	UW-003 wreck of iron sailing vessel (bow)	
2:20:33-2:24:33	Wreck of iron sailing vessel stern	
X-FOJE-1B-85.5		27:49
0-15:04	UW-003 wreck of iron hull sailing vessel	
15:04-20:45	Close-ups of marine life	
20:45-27:49	Additional footage from UW-003	

TAPE		DURATION
FOJE-1-85.5c	9/8/85--Site 8Mo130: Newground Reef. Divers examine artifacts around site	15:08
FOJE-2-85.5c	9/9/85--Site UW-008. Various cannon, fluke broken from anchor, piece of lead, anchor chain	20:18
FOJE-3-85.5c	9/9/85--Site UW-008: Nine-Cannon. Broken anchor fluke, various cannon, other artifacts anchor chain, large partially buried anchor, hawse pipe.	20:44
FOJE-4-85.5c	9/9/85--Sites UW-017 + UW-009. Swivel guns and keel pins, divers examining other artifacts.	11:20
FOJE-5-85.5c	9/10/85--Site UW-018: Two-Cannon Site. Includes footage of pins found by J. Morehead near UW-009 - UW-017.	9:07
FOJE-6-85.5c	9/10/85--Site UW-003. UW-003 and search for shrimp boat.	21:52
FOJE-7-85.5c	9/20/85--Site UW-003. Stern area of iron sailing vessel (UW-003).	21:54
FOJE-8-85.5c	9/10/95--Site UW-003. Survey.	21:00
FOJE-9-85.5c	9/10/85--Site UW-003. Good overview of iron sailing vessel wreck from stern to bow.	21:00
FOJE-10-85.5c	9/1/85--Footage of nurse sharks in shallow water near Long Key.	11:33
FOJE-11-85.5c	9/11/85--Footage of interior and exterior of sunken lobster boat.	21:18

TAPE		DURATION
FOJE-12-85.5c	9/11/85--Additional footage of sunken lobster boat interior and exterior.	21:56
FOJE-13-85.5c	9/11/85--Surface footage of Fort Jefferson and harbor shot from deck of ACTIVA. Activity on aft deck of ACTIVA.	16:52
FOJE-14-85.5c	9/12/85--Footage from anchor/cave area including lobsters under rocks (poor visibility).	12:42
FOJE-15-85.5c	9/12/85--Additional footage from anchor/cave area--too dark to discern detail. Footage of divers boarding ACTIVA.	19:24
FOJE-16-85.5c	9/13/85--Surface footage of Fort Jefferson detailing construction and structures in courtyard.	19:31
FOJE-17-85.5c	9/13/85--Site UW-003. Survey of iron sailing vessel wreckage, also showing divers drawing and measuring structures.	21:54
FOJE-18-85.5c	9/13/85--Site UW-003. Close-up footage of marine organisms around wreck site (fish, coral, etc.).	17:42
FOJE-19-85.5c	9/13/85--Site UW-029. Bird Key Brick Wreck footage of coral encrusted wreckage including large, intact propeller.	6:45
FOJE-1-88.5	3/88--Site UW-009. Overview of wreck site.	31:21
	3/88--Site UW-003. Overview of wreck site.	8:36
FOJE-2-88.5	3/88--Site UW-003. Divers mapping wreck site, tracking along base line, survey of wreckage.	1:09:11

TAPE		DURATION
FOJE-3-88.5	3/88--Surface footage including: Fort Jefferson seawall, north coaling docks, activities on ACTIVA, Senator Bradley's arrival, meeting with Jim Delgado, snorkeling trip.	1:50:06
FOJE-4-88.5	3/88--Site UW-003. Footage of Senator Bradley and aide at wreck site.	21:16
FOJE-5-88.5	3/88--Site UW-003. Close-up footage wreckage and encrusting growth.	2:02:17
FOJE-6-88.5	3/88--Surface footage of Fort Jefferson architecture, interpretive signs, moat and seawall; helicopter aerial footage.	
FOJE-7-88.5c	3/88--Site UW-003. Divers mapping and photographing wreck site.	19:47
FOJE-8-88.5c	3/88--Site UW-003. Divers mapping and measuring wreck site.	22:07
FOJE-9-88.5c	3/88--Site UW-003. Swim along base lines over wreck site; divers measuring artifacts.	22:06
FOJE-10-88.5c	3/88--Site UW-003. Divers measuring and photographing wreck site.	13:44
FOJE-1-90.5c	7/90--UW-008. Work shots of diver photographing artifacts with measuring rod for scale.	13:14
FOJE-2-90.5c	7/90--UW-008. Diver fans sand away from timbers, photographs artifacts; anchor chain and capstan.	8:44
FOJE-3-90.5c	7/90--UW-008. Divers taking measurements from base line, photographing artifacts; anchor chain, anchor.	8:44

TAPE		DURATION
FOJE-4-90.5c		20:16

7/90--UW-008. Divers setting base line, measuring structures and recording data on underwater slates; school of squid; several cannon; barracuda; diver taking measurements on capstan; remnants of pump and crank.

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SUBMERGED CULTURAL RESOURCES UNIT REPORT AND PUBLICATION SERIES

The Submerged Cultural Resources Unit was established in 1980 to conduct research on submerged cultural resources throughout the National Park System with an emphasis on historic shipwrecks. One of the unit's primary responsibilities is to disseminate the results of research to National Park Service managers, as well as the academic community. A report series has been initiated in order to fulfill this responsibility. It has been incorporated into an umbrella series entitled Southwest Cultural Resources Center Professional Papers. The following are the categories:

Submerged Cultural Resources Assessment

First line document that consists of a brief literature search, an overview of the maritime history and the known or potential underwater sites in a park, and preliminary recommendations for long-term management. It is designed to have immediate application to protection and interpretation needs and to become a source document for a park's Submerged Cultural Resources Management Plan.

Submerged Cultural Resources Survey

Comprehensive examination of blocks of park lands for the purpose of locating and identifying as much of the submerged cultural resources base as possible. A comprehensive literature search would most likely be a part of the Phase I report but, in some cases, may be postponed until Phase II.

Phase I--Reconnaissance of target areas with remote sensing and visual survey techniques to establish location of any archeological sites or anomalous features that may suggest the presence of archeological sites.

Phase I--Evaluation of archeological sites or anomalous features derived from remote-sensing instruments to confirm their nature and, if possible, their significance. This may involve exploratory removal of overburden.

Submerged Cultural Resources Study

A document that discusses, in detail, all known underwater archeological sites in a given park. This may involve test excavations. The intended audience is managerial and professional, not the general public.

Submerged Cultural Resources Site Report

Exhaustive documentation of one archeological site which may involve a partial or complete site excavation. The intended audience is primarily professional and incidentally managerial. Although the document may be useful to a park's interpretive specialists because of its information content, it would probably not be suitable for general distribution to park visitors.

Submerged Cultural Resources Special Report Series

These may be in published or photocopy format. Included are special commentaries, papers on methodological or technical issues pertinent to underwater archeology, or any miscellaneous report that does not appropriately fit into one of the other categories.

Published Reports of the Southwest Cultural Resources Center

1. Larry Murphy, James Baker, David Buller, James Delgado, Roger Kelly, Daniel Lenihan, David McCulloch, David Pugh, Diana Skiles, Brigid Sullivan. *Submerged Cultural Resources Survey: Portions of Point Reyes National Seashore and Point Reyes-Farallon Islands National Marine Sanctuary*. Submerged Cultural Resources Unit, 1984.

2. Toni Carrell. *Submerged Cultural Resources Inventory: Portions of Point Reyes National Seashore and Point Reyes-Farallon Islands National Marine Sanctuary*. Submerged Cultural Resources Unit, 1984.

3. Edwin C. Bearss. *Resource Study: Lyndon B. Johnson and the Hill Country, 1937-1963*. Division of Conservation, 1984.

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7. Toni Carrell. *Submerged Cultural Resources Site Report: NOQUEBAY, Apostle Islands National Lakeshore*. Submerged Cultural Resources Unit, 1985.

8. Daniel J. Lenihan, Toni Carrell, Thom Holden, C. Patrick Labadie, Larry Murphy, Ken Vrana. *Submerged Cultural Resources Study: Isle Royale National Park*. Submerged Cultural Resources Unit, 1987.

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