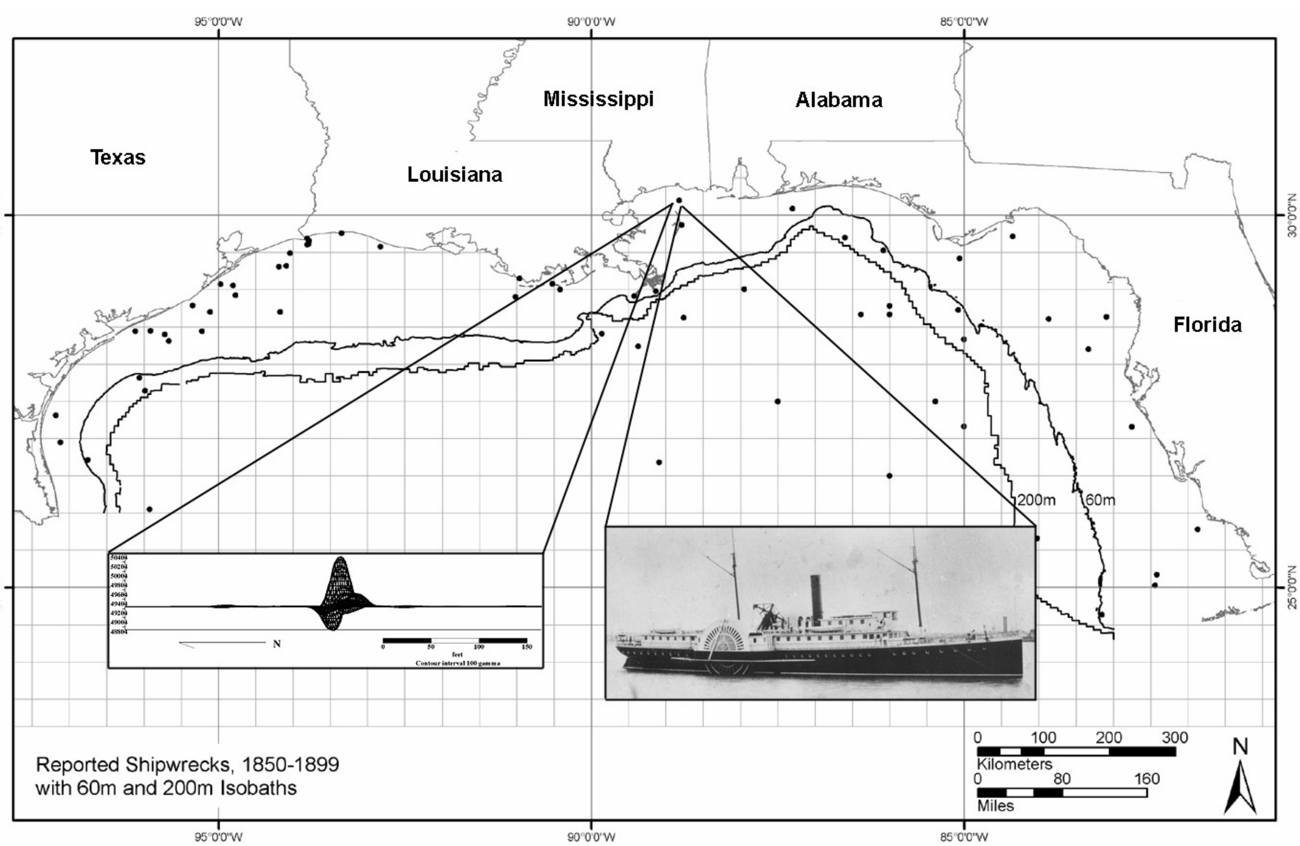
OCS Study
MMS 2003-061

Refining and Revising the Gulf of Mexico Outer Continental Shelf Region High-Probability Model for Historic Shipwrecks

Final Report

Volume II: Technical Narrative



MMS U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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Refining and Revising the Gulf of Mexico Outer Continental Shelf Region High-Probability Model for Historic Shipwrecks

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Volume II: Technical Narrative

Authors

Charles E. Pearson
Stephen R. James, Jr.
Michael C. Krivor
S. Dean El Darragi
Lori Cunningham

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1.0: INTRODUCTION

In 1973, the Federal government initiated a program to protect cultural resources existing on the submerged lands of the Outer Continental Shelf (OCS) of the United States from the effects of Federally funded and permitted activities. This program arose out of a variety of legislation enacted to ensure the proper management and protection of the nation's cultural heritage. The most pertinent of these laws were the National Historic Preservation Act of 1966, as amended, the National Environmental Policy Act (1969), and the OCS Lands Act Amendments of 1978. The program was initially placed under the authority of the Bureau of Land Management (BLM) and the United States Geological Survey (USGS), and of particular concern was the impact that Federally permitted mineral exploitation—principally oil and gas exploration and production—and Federally funded projects might have on cultural properties on the OCS. Section 206(g)(3) of the OCS Lands Act Amendments of 1978 states specifically that "such exploration (oil and gas) will not. . .disturb any site, structure, or object of historical or archaeological significance." In 1982 the Minerals Management Service (MMS), United States Department of the Interior, gained the cultural resources management responsibilities of OCS lands formerly held by the BLM and USGS and has administered the program since that time.

When the Federal government initiated its management of cultural resources on the OCS, it was recognized that a variety of types of cultural properties might exist there. However, little was known about the nature, distribution or condition of these properties that would be useful in developing strategies for their identification, assessment and management. As a result, several regional baseline studies were initiated to collect the information needed to develop and implement a reasonable cultural resources protection plan for the OCS. The purpose of these studies has been to collect information on archaeological resources on the OCS that can then be used to establish guidelines for the proper identification and protection of these resources. The first of these baseline studies was conducted for the Gulf of Mexico in 1977. Entitled *Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf* (Coastal Environments, Inc. 1977), this study considered historic resources, principally shipwrecks, as well as prehistoric resources in the development of generalized statements about the nature, distribution and preservation potential of these types of sites across the Gulf of Mexico OCS. Subsequently similar baseline studies have been conducted for the remainder of the OCS area of the United States. These have included the Atlantic coast from the Bay of Fundy to Cape Hatteras by Harvard University (Bourque 1979); the Atlantic coast from Cape Hatteras to Key West, Florida by Science Applications, Inc. (1981); the Alaskan area by the University of Alaska, Fairbanks (Dixon et al. 1986); the Pacific coast south of Morro Bay, California, by Science Applications, Inc. (1977) and PS Associates (Pierson et al. 1987); and the Pacific coast from Morro Bay north to the Canadian border (Espey, Huston & Associates, Inc. 1990).

These studies have been used by MMS to develop strategies and guidelines for addressing cultural resources relative to various types of permitted and funded activities undertaken on the OCS. The Gulf of Mexico Region (GOMR) has certainly been most critical in the entire management program, simply because of the nature of mineral exploitation there. Thousands of oil and gas wells have been drilled, thousands of miles of pipelines have been laid and other facilities and features comprising the infrastructure of the mineral extraction industry have been developed. All of these activities are ongoing and have a potential for impacting cultural remains that might exist on the vast area of submerged lands of the Gulf of Mexico. As a result, MMS established requirements for pre-development survey of specific "lease blocks" and pipeline rights-of-way in the Gulf of Mexico using remote-sensing technologies. These "lease blocks" represent the 3-mile-square units into which the entire GOMR has been divided for leasing purposes. The requirements for lease block and pipeline surveys and the resulting reports have been codified and updated in a series of Notices to Lessees (NTL) that have been issued since the mid-1970s. In addition, MMS has sponsored two studies in the Gulf of Mexico region designed to enhance and update the information and recommendations developed in the 1977 Coastal Environments, Inc. baseline study. One of these studies was concerned specifically with prehistoric cultural resources on the Gulf of Mexico OCS (Pearson et al. 1986). Using previously published geological information, much of it derived from remote-sensing surveys conducted relative to the MMS lease block survey requirements, as well as collected seismic and vibracore data, this study developed a model of prehistoric site occurrence and preservation in the area of the offshore Sabine River valley at the border of Texas and Louisiana. The other study, conducted by the Texas A&M Research Foundation, was concerned with historic shipwreck sites on the Gulf of Mexico OCS (Garrison et al. 1989). This study involved two principal tasks: 1) the reevaluation of the high-probability zone for shipwreck occurrences that had been identified as Cultural Resource Management Zone 1 in the 1977 Coastal Environments, Inc. baseline study, and 2) assess the use of the remote-sensing equipment (magnetometer and sidescan sonar) in terms of the survey strategy employed and the data interpretation then being used in MMS-mandated lease block surveys. This study collected historical information on shipwrecks from numerous sources, characterized the nature of this sample of shipwrecks, correlated the distribution of shipwrecks against a variety of variables (e.g., historic shipping routes, current and wind patterns, reef locations, etc.), and explored the preservation potential of wrecks in various natural settings in the Gulf of Mexico. These data were used to develop statements about shipwreck occurrences by identifying areas in the GOMR that had high, moderate and low probabilities for the presence of historic shipwrecks. The second task of the Garrison et al. (1989) study involved an in-field remote-sensing survey of areas within three lease blocks offshore of Texas utilizing different line spacings. The objective was to "establish an interpretive framework to characterize unidentified magnetic anomalies and sidescan sonar contacts" (Garrison et al. 1989:1-4). Of specific interest was the use of the magnetometer in detecting objects at various line spacings and in trying to "characterize and differentiate, with a high degree of confidence," differences between metallic debris and potential shipwrecks (Garrison et al. 1989:II-226).

The MMS has used the results of the Coastal Environments, Inc. 1977 study and, more specifically, the Garrison et al. 1989 effort to determine where remote-sensing surveys for historic shipwrecks will be required in the Gulf of Mexico. Specifically, this information has been used to identify individual 3-mile-square lease blocks and groups of lease blocks that have a high-probability of containing historic shipwrecks and, further, to develop remote-sensing survey strategies for these lease blocks. As of the summer of 2000, 2835 archaeological reports had been received by MMS of remote-sensing surveys conducted within lease blocks and along pipeline rights-of-way in the GOMR. These surveys had resulted in the discovery of a number of shipwrecks. However, over the years deficiencies in the model of wreck distributions and occurrences have been noted, plus new remote-sensing technologies have been developed that have application to the MMS program of offshore surveys. In June of 2000, the Gulf of Mexico OCS Region of MMS in New Orleans awarded a contract to Panamerican Consultants, of Memphis, Tennessee to reevaluate and refine the work of the previous studies on historic shipwrecks in the Gulf of Mexico, particularly the Garrison et al. (1989) study. The results of this study are presented here and they represent an effort to enhance the management of historic shipwrecks on the OCS in the Gulf of Mexico through a revision of the model of shipwreck occurrences and a refinement of the survey strategies and instrumentation used in their discovery.

1.1. Study Objectives

The objectives of this study were defined in the Request for Proposal issued by MMS in April 2000. These objectives are:

1. To update and expand the existing MMS GOMR shipwreck database by examining primary and secondary sources for shipwreck information. The existing shipwreck database will be expanded to include specific identifying characteristics of vessels potentially located on the OCS.

2. To determine the spatial correlation between: 1) shipwreck locations in the updated shipwreck database; 2) recorded seafloor hang sites listed on the MMS GOMR/NOAA sponsored “Fisherman’s Contingency Fund” or other published or private fisherman hang books; and 3) sidescan sonar targets and anomalies representing potential shipwrecks identified during previous OCS lease block surveys. Then, to ground-truth selected locations where hang sites and reported shipwreck locations appear to correlate to determine if hang sites are shipwrecks.

3. To conduct a marine magnetometer survey over several verified shipwreck sites using both the “industry-standard” proton precession magnetometer and the new cesium magnetometer instrumentation to determine whether there is a significant difference in their performance in detecting shipwrecks.

4. Based on the results from objectives (1), (2), and (3) prepare a revised predictive model for shipwrecks in the GOMR, and recommend survey instrumentation and strategies that would be the most effective in locating these shipwrecks.

In order to achieve the established objectives of this study, the work effort was divided into four principal tasks as noted in the MMS Request for Proposal. These were:

Task 1. Archival Data Collection
Task 2. Correlation of Seafloor Hang Sites, Lease Block Survey Data, and Shipwreck Archival Data
Task 3. Comparison of Marine Magnetometer Technologies and Survey Line Spacing
Task 4. Data Synthesis, Development of a Shipwreck Predictive Model, Analysis of Magnetometer Technology, and Final Report of Findings

Details on the conduct of these tasks are presented in the following chapters.

1.2. Study Area

The geographic area considered in this study consists of those lands in the Gulf of Mexico that fall under the authority of the MMS, generally referred to as the Gulf of Mexico Region or GOMR. As shown in Figure 1-1, the study area coincides with the extent of the United States Exclusive Economic Zone (EEZ). The EEZ consists of those lands now incorporated into the "lease block" system used by MMS in its management of mineral exploitation in the Gulf and incorporates most of the Gulf of Mexico north of approximately 24º north latitude. For the purposes of historical and archival research, data was collected on shipwrecks in the Gulf north of 24º and roughly between 81º and 98º west longitudes.

Analysis of shipwreck data and the data from MMS offshore surveys was confined to the area of Federal lease blocks shown in Figure 1-1. The study area includes only Federal waters and does not encompass the waters belonging to the five bordering Gulf states. The position of these state boundaries varies. In Texas, the state boundary is located three "leagues" from shore, equivalent to nine nautical miles or 10.36 statute miles (16.67 km).[1] For the states of Louisiana, Mississippi and Alabama, the boundary is three statute miles (4.8 km) from shore, while the Florida state boundary in the Gulf of Mexico is nine nautical miles or 10.36 statute miles (16.67 km) from shore. The exclusion of state waters from consideration does have significant consequences when dealing with historic shipwrecks in the region. It is generally recognized that wrecks tend to concentrate along shorelines for very logical reasons. These are related to the obvious hazards found in shallow, nearshore waters, the fact that vessels are often driven ashore by weather conditions, plus the fact that the activities of vessels tend to be spatially concentrated in nearshore areas around harbors and ports. The two previous studies of historic shipwrecks in the Gulf of Mexico by Coastal Environments, Inc. (1977) and Garrison et al. (1989) both demonstrated that the majority of recorded historic wrecks in

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[1] . English measurements are commonly used in this report because almost all activities conducted in the GOMR rely on this system. This includes the basic leasing unit, the 3-mile-square lease block, around which most remote sensing surveys are designed and the coordinate system (state plane or UTM in feet) used in survey control and in reports of findings. Metric equivalents are provided where appropriate.

the Gulf of Mexico occurred in state waters. Thus, the elimination of state waters removes a significant percentage of reported Gulf wrecks from the sample used in this analysis.

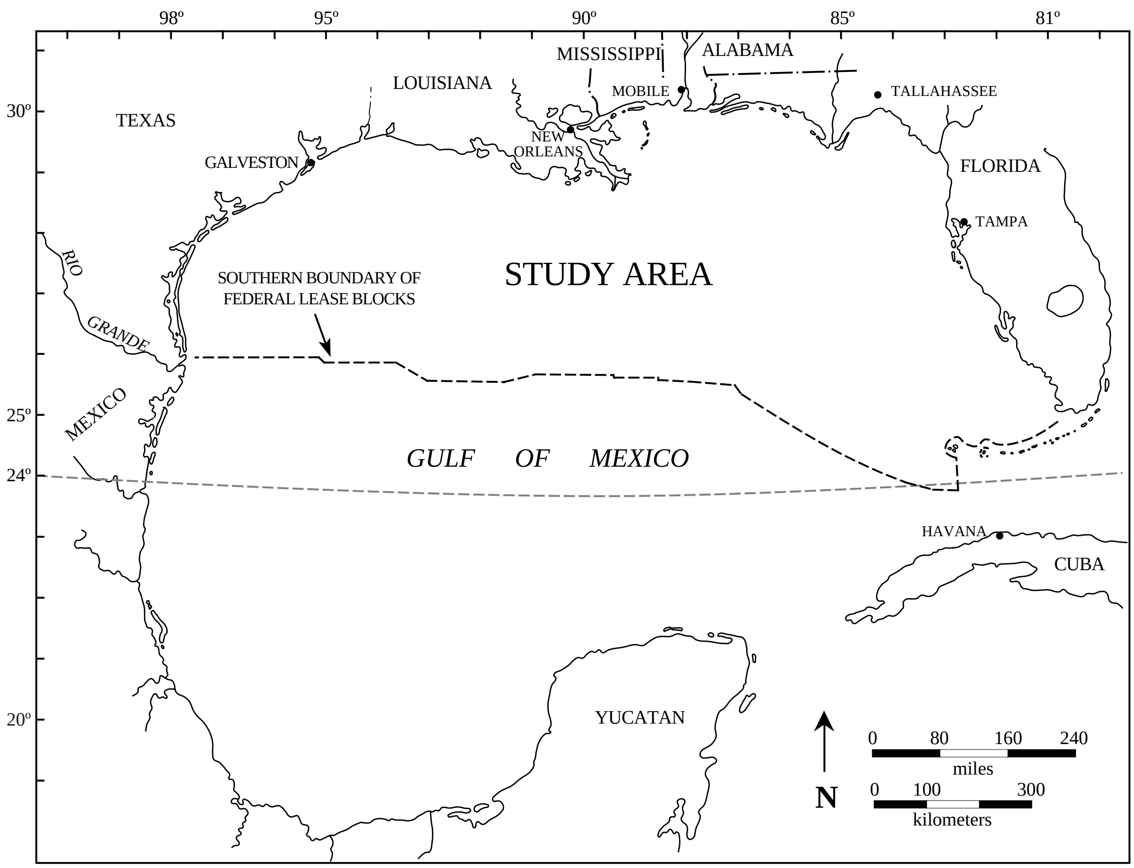


Figure 1-1. Study area.

1.3. Report Organization and Presentation of Data

This report consists of two main sections. The first section deals principally with the historical record of shipwrecks in the GOMR and the refinement and revision of the list of shipwrecks currently being used by MMS. This section includes background discussions on the present model of shipwreck occurrences in the GOMR and how that model guides MMS offshore surveys. Also presented are discussions on the list of wrecks developed in the present study. These discussions consider the rationale and methods used for developing this list and present information on the characteristics of this sample of known shipwrecks, including patterns of spatial distribution. This section also provides discussions on the association of unidentified items and objects, such as unidentified snags, objects, etc., with reported wrecks under the assumption that some of these currently unidentified objects might, in fact, be historic wrecks.

A considerable amount of the information developed in this study is presented in digital format, as stipulated in the MMS Scope of Work (SOW). Specifically, all of the data on wrecks, unidentified objects, snags, and the like have been compiled into a database using the program Microsoft Access and is presented in a Geographic Information System (GIS) format using the program ArcView. These digitized data constitute a significant segment of this report, and much of the data on wreck distributions, occurrences and correlations are presented as maps, overlays, etc. only in a digital format in ArcView. The objective is to provide MMS management personal with data in an immediately useful GIS format to aid them in decision making. Textual discussions do include maps, tables, etc., as needed to support discussions; however, in some cases these consist only of portions of complete visuals presented in GIS format.

The second main section of this report deals with the field investigations conducted in this study. This includes discussions on remote-sensing survey and diving investigations undertaken to determine the identity of a series of hang sites selected as potential wreck locations. These dive targets were selected from clusters of hangs that could represent unreported vessel remains. In some cases these targets roughly corresponded with reported vessel losses.

The majority of the second section presents the results of field trials in which old and new magnetometer models were run on three survey grids of varying intervals and speed over two shipwrecks in order to assess how each instrument recorded the same wreck site, and if differences were present, determine if these findings predicated changes to the current MMS GOMR survey methodology.

2.0: RESEARCH APPROACH – TASK 1

2.1. Background Research

The initial task of this study was to "update and expand the existing MMS GOMR shipwreck database" through the examination of pertinent sources on shipwrecks. This chapter provides information on the approach used to accomplish this task, principally, by providing information on the various sources utilized, the rationale for selecting these sources, and various shortcomings and biases that might exist in these sources.

The present "shipwreck database" used by MMS is the one developed by the Garrison et al. (1989) study and it represented our point of departure. The objective was not to go back and duplicate the work conducted by Garrison et al., but to expand upon their findings where considered appropriate and productive. The Garrison et al. study involved a fairly comprehensive examination of archival sources, publications and other resources dealing with the history of navigation and with shipwrecks in the Gulf of Mexico. Initially, no effort was made to reexamine all of the sources they used, particularly the archival sources dealing with the early historic period. Rather, the first effort of the background research was to examine pertinent publications, databases, etc., that have been produced since the 1989 study and to examine resources that they had not utilized. For example, one resource that the Garrison et al. study did not examine in detail is the large body of information found in the reports resulting from cultural resources management (CRM) studies undertaken in the coastal regions of the various states surrounding the Gulf. Examination of these reports involved visiting the state offices holding these studies in the five states that border the Gulf of Mexico.

Some amount of archaeological research on historic shipwrecks in the Gulf of Mexico has been conducted since 1989, although most of this is related to wrecks lying in state waters. These studies were examined for the information they provided on historical background and, particularly, on aspects of shipwreck preservation potentials and processes of wreck site formation in various marine settings.

The Garrison et al. study relied on several computerized databases of shipwrecks that were extant at the time. The present study has placed an even greater reliance on these types of databases because they are becoming the principal medium for documenting and archiving information on vessel losses in the Gulf of Mexico and elsewhere. Some of the advantages, and perils, in this trend to collect and consolidate shipwreck information into an increasingly smaller number of databases are discussed below.

Since the Garrison et al. study, resources on shipwrecks and historic vessels have proliferated on the Internet. A large number of Internet sites containing shipwreck as well as general maritime history information were examined during this study. Most duplicated information found elsewhere, but some proved to be useful.

Another valuable source of information used in this study, but not used by Garrison et al., are the results of MMS-mandated remote-sensing surveys conducted in the GOMR. As noted, over 2,800 survey reports have been received by the MMS since the start of the archaeological survey program. From these reports MMS personnel selected those that identified known or suspected wrecks or unidentified objects and provided this information to the authors. This information expands considerably the number of verified wrecks in the study area, although most are unidentified at present. Also, the content of these reports sometimes includes valuable background historic information. As is discussed more fully below, the data from these remote-sensing surveys constitute the principal means by which the present model of shipwreck distributions in the GOMR can be tested.

The information collected from these various sources was used to expand the present MMS shipwreck database, plus their examination helped identify areas where information in that database needed to be reassessed. This reassessment did involve going back to some of the original sources used by Garrison et al. to clarify and/or to collect additional information to incorporate in an expanded shipwreck database that included information on vessel characteristics.

2.2. Sources of Data

Garrison et al. (1989 II-11) identified five major sources of shipwreck information in their study. These were: 1) databanks; 2) documents; 3) directories; 4) descriptions; and 5) secondary literary sources. Some of these same general categories of data sources were examined in the present study, although the intensity and scope with which they were used differed from the effort expended by Garrison et al. because of the factors mentioned above. The following discussions consider the principal sources used in the present study if they differed from those listed by Garrison et al. (1989) or, as in the case of computerized databases, they contained significantly greater information than they did in 1989.

2.2.1. Computerized Databases

Garrison et al. (1989:II-12) examined several computer-based data files or databases in their study, which they identified as “data banks.” That study did note that the availability of these computer databases was a great advantage over the earlier Coastal Environments, Inc. 1977 study. Since 1989, most of the shipwreck databases used by Garrison et al. have been expanded, plus several new databases with shipwreck information have been developed. These databases represent efforts to systematically arrange shipwreck information and offer significant advantages in information storage as well as in its manipulation. However, these databases do have their shortcomings as is pointed out in the following discussions. One advantage of some of these databases (particularly those maintained by the U.S. Coast Guard and the National Oceanic and Atmospheric Administration [NOAA]), at least for the present study area, is that they include almost all vessels lost in the past couple of decades, somewhat lessening the need to search widely for wreck information in other sources.

Minerals Management Service (MMS) Databases. The Minerals Management Service office in New Orleans provided two electronic databases that were used in this study. Of central importance is the list of wrecks in the GOMR developed during the Garrison et al. (1989) study. This list, provided in Microsoft Excel format and containing 1,469 entries, represents the baseline of shipwreck information upon which the present study built. This database includes the names of vessels (as well as several “obstructions,” “fish havens,” etc.), their location in geographic coordinates, the offshore lease block within which they fall, and the principal source from which the wreck information was obtained. Miscellaneous information in the database includes a unique identification number and an identification number assigned by the original source, if applicable.

Another electronic database obtained from the MMS was the listing of snags and hangs maintained as part of the Fisherman’s Gear Compensation Fund. These represent hangs in the Gulf of Mexico identified by fishermen, principally shrimpers, as locations where their nets were caught and damaged or lost. Although this list is not specifically related to shipwrecks, it is known that wrecks, as well as other objects, exposed on the seafloor in the Gulf of Mexico are often draped with shrimp nets that have been snagged and lost on the wreck (James et al. 1991a; 1991b). Thus, snags and hangs might very well mark the location of historic vessel remains. Addressing this question was one of the objectives of this study and is discussed in more detail in later sections.

National Imagery and Mapping Agency (NIMA). NIMA is an agency of the Department of Defense that maintains a variety of databases relating to mapped resources, including shipwrecks, hangs, obstructions, well heads, platforms, etc. They now serve as the central government agency for gathering these resources and providing them to the public. NIMA collects information from a wide variety of public and private sources, including the U.S. Coast Guard (USCG) and the Naval Oceanographic (formerly Hydrographic) Office. Their principal database on shipwrecks is known as the Non-Submarine Contact (NSC) Database and it includes information provided to them from various agencies and individuals. They do not collect field data or evaluate it. NIMA now maintains the old Hangs and Obstructions file formerly kept by the Naval Hydrographic Office (HO) and they receive all wreck and hang and obstruction data from the USCG and the NOAA, although these last two agencies also maintain and provide to the public their own databases. The NIMA database also includes incomplete information from the old Merchant Vessels of the United States lists formerly maintained by various government agencies, including the USCG. The NIMA Non-Submarine Contact Database used in this study was obtained in October 2000 in Microsoft Excel format and contained 1,234 entries for the Gulf of Mexico area. These included named vessels as well as unknown vessels and objects, such as debris, wellheads and the like. Variables for each entry are: classification (unclassified, confidential and secret), a unique identification number, name, nationality, contact type (i.e., type of vessel or object), flag of sinking agent, type of sinking agent, position evaluation, source of information, location (latitude/longitude), source of depth information, depth in meters, date of sinking, date of information and gross tonnage.

The NIMA database was not available when the Garrison et al. study was conducted, but that study did utilize the Hangs and Obstructions (HO) file and the NOAA databases that have been incorporated into the NIMA records.

United States Coast Guard (USCG). The United States Coast Guard maintains a large database of shipwrecks, hangs, obstructions, etc., located in American waters principally related to navigation procedures, hazards etc. The database used in this study was obtained from the U.S. Coast Guard, Eighth Coast Guard District, New Orleans, Chief of Aids to Navigation and consisted of all entries falling within the Gulf of Mexico region. The database is in Microsoft Access (Access) format and contained 6,491 entries as of the end of 2000. The USCG collects data itself as well as from a variety of other sources. The USCG also does evaluation of some reported targets, particularly as they might be related to navigation hazards that require removal or marking. The database is of particular value because it includes information received from private sources relating to lost vessels, discovered sunken or wrecked vessels, obstructions, etc. A very large number of the losses contained in the USCG database fall within state waters and, thus, were eliminated from the final list of wrecks and objects compiled for the study area. Variables included for each entry in the USCG database are: a unique identification number, a file number, name of vessel or object, length in feet, geographic position (latitude/longitude), "status" (e.g., whether or not the entry was sunk, removed, salvaged, a hazard, etc.), waterway where located (e.g., Gulf, GOM, Mississippi River, etc.), depth in feet, remarks, state located in or near, and date of loss or report. This last entry on date is of particular concern because while it may be the actual sinking date of a vessel, it also might be the date the report of the loss was received by the USCG or the date the sunken vessel or object was found and reported. In this last instance, the date given in the USCG entry might be many years after the loss actually occurred. There is no way to distinguish among these various dates in the USCG records, and clarification usually requires comparisons with other sources of information.

The Coast Guard database does not include a variable indicating the known or presumed "reliability" or accuracy of the positions provided. Thus, unless the entry can be correlated with another source or database, it is often impossible to know how reliable the locations of loss given in the USCG database are. As is discussed in more detail later, the question of "reliability" of location is one of the most critical factors to be considered when developing statements about a sample of wrecks within a given area, whether this entails predictive statements about the spatial patterning of wrecks or the correlation of reported wreck locations with spatially defined factors (e.g., hurricane tracks, natural obstructions and hazards, etc.). Most researchers recognize that errors certainly exist in the reliability of historically reported wreck locations, but the tendency has been to ignore this problem when making final statements about wreck distributions or to rely on assumptions about reliability that have very little basis in fact.

National Oceanic and Atmospheric Administration (NOAA). NOAA maintains a database of wrecks and obstructions known as the Wrecks and Obstructions File and in electronic form as the Automated Wrecks and Obstructions Information System (AWOIS). The database consists principally of items that the National Ocean

Survey, a branch of NOAA, considers hazards to navigation. The full database is available in digital form on CD and in a searchable form on the Internet. The online version does not include all of the variables maintained by NOAA, but these are included in the electronic version available on CD in Access format. The Access version of the AWOIS database used in this study was obtained in July 2000 and contained 3,515 entries falling within the Gulf of Mexico area. This is probably the most widely used of the computerized databases by the public and by the offshore oil and gas industry in identifying targets or in assessing the probability of historic wreck occurrence in specific areas. Individual files for each vessel include several categories of information, each encompassing several variables. These include a category of general record information that contains a unique record number, “vessel terms” (i.e., the name of the vessel or identity of the object), the identity of the NOAA chart on which the object is plotted, and the water depth at the object. A second category of data includes position information, including the geographic coordinates, the datum used, and a three-level assessment of the quality (i.e., reliability) of the position information (poor, low, and high). The third category of data consists of “Project” information and includes a section on “History” and one on “Field Notes.” This section provides available descriptive information on the vessel or object and information on examinations undertaken by NOAA or other agencies. For example, the “History” section might include the dimensions and cause of loss of a vessel, or might provide information on an examination of the reported loss site. A typical example of such an entry might read “Side Scan Sonar Negative. Evaluator Recommends Deleting From Charts” and provide the date of the examination. Additional entries on the AWOIS database include reference (i.e., the source of the information used), year sunk, and a unique system number. This is one of the computer-based databases used by Garrison et al., but at the time it was provided only in an ASCII format.

Texas Antiquities Shipwreck File (TAC). The Texas Antiquities Committee in Austin, Texas, maintains this database. Presently this shipwreck file consists of a listing of approximately 2,400 entries in Access format. However, this computerized database includes only partial information on most entries. Complete entries are found only in the paper version of the shipwreck file. Categories included in this file are: name of vessel, year lost, position, Texas state lease block number and vessel type. The TAC also maintains a series of maps on which all wrecks in the file are plotted. Many of the entries in the database are derived from secondary sources and the vast majority of vessels in the database fall in state waters.

The Florida Shipwreck File, Bureau of Archaeological Research (BAR). This is the computerized shipwreck file maintained by the Bureau of Archaeological Research, Florida Division of Historic Resources, Tallahassee. When this database was examined in August 2000 it contained 282 entries of wrecks reported in the Gulf waters of the state. The number encompasses only recorded wreck sites; historic accounts of vessel losses maintained by BAR were not reviewed because these had already been examined by Garrison et al. (1989:II-12). Information provided for each wreck entry includes site number and name, location, age of vessel, and nationality when known. The vast majority of the wreck sites in the BAR database fall in state waters, but the position information on many is questionable. This is because some of the wreck sites represent unverified reports, plus, in the past some wreck positions were purposefully made overly vague in an effort to deter looting.

Texas A&M University Hang File. The Texas A&M University Hang File consists of a very large database of hang locations that have been collected by personnel with the Texas A&M Sea Grant Program over many years. Most of the information has been collected from shrimpers and consists of their reports on the location and, sometimes, identity of hangs they have encountered. The listing includes approximately 13,000 records in state and Federal waters from about the mouth of the Mississippi River westward to the Rio Grande. The Hang File is most commonly provided in a book form, but in August 2000 a computerized version of the file was obtained for this study. The database has not been updated in several years, plus almost all of the position information was obtained with LORAN systems, which can incorporate inaccuracies on the order of a quarter of a mile or more. Despite these problems, this database forms the largest collection of hang information in the Gulf of Mexico, making it extremely useful for correlating hang locations with shipwrecks. The hang database was compiled in a Microsoft Word format, but a version converted to Excel was obtained for this study.

Artificial Reef Data File (Gulf States Artificial Reef Committee). A computerized database containing information on artificial reefs in the Gulf of Mexico was obtained in WordPerfect format from the Gulf States Artificial Reef Committee, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi. When obtained in November 2000 the database contained 143 entries but was still in the process of being compiled and contains inaccuracies, duplications, and omissions (Ron Lukens, personal communication 2000). Variables for each entry include the state and county in which the artificial reef is permitted, the state permit number, the permit holder's name and address, whether the permit is active, the name of the reef, the offshore lease block in which the reef is located, geographic coordinates of the reef, size of the reef in acres, minimum depth, maximum depth, maximum relief of the reef, jurisdiction (state or Federal), the date the reef was established and the material that forms the reef. Categories of material include automobiles, boats, steel-hulled vessels, tires, oil and gas platforms, military tanks, rock, concrete, etc. Those reefs reported to contain vessels of various types were of interest to the present study.

Florida Division of Marine Fisheries Artificial Reef Database (FDMF). A computerized database of artificial reefs off the Florida coast was obtained from the Artificial Reef Program, Division of Marine Fisheries, Florida Fish and Wildlife Conservation Commission (Florida Division of Marine Fisheries [FDMF] 2003). This database has been recently made available in electronic format and was obtained in February 2003. The database contains several thousand entries and includes artificial reefs that fall in Florida state waters as well as those that fall in Federal waters. Variables for each entry include the county in which the artificial reef is permitted, the name of the reef, the date the reef was established, the material that forms the reef, the geographic coordinates of the reef, and the water depth and relief of the reef. Categories of reef materials include vessels of many types, automobiles, tires, oil and gas platforms, military tanks, bridge components, rock, concrete, etc. All vessels identified as components of artificial reefs in Federal waters in this database were incorporated into the shipwreck database developed in this study.

Miscellaneous Computer Databases. Several other computer-based databases were examined for this study, but provided relatively little useful information. Among these is a listing of shipwrecks occurring within the boundaries of the New Orleans District, U.S. Army Corps of Engineers originally compiled in 1989 (Pearson et al. 1989). Originally compiled in Dbase III format, this database contains approximately 1,800 reported and known vessel losses within the New Orleans District, which encompasses most of southern Louisiana, including the inshore areas along the Gulf of Mexico. Most of this file has been incorporated into the computerized state site file system at the Division of Archaeology, Louisiana Department of Culture, Recreation and Tourism in Baton Rouge. With only a few questionable exceptions, all of the vessels listed in this database fall in state waters. The Galveston District, U.S. Army Corps of Engineers maintains a listing of "Wrecks and Obstructions" containing over 600 entries. This list has been developed mainly for navigation and dredging purposes and all of the vessels and objects included appear to fall in state waters. The Mobile District and the Jacksonville District, whose boundaries include Gulf of Mexico waters, were contacted, but neither organization maintains any organized database of reported wrecks.

2.2.2. Internet Resources

Today there is a huge body of information on shipwrecks and maritime archaeology and history available at sites on the world wide web, none of which was available in 1989. For this study, searches were made on the Internet (normally using the search engine Google) using a variety of keywords and keyword combinations, such as shipwrecks, wrecks, Gulf of Mexico, marine disasters, underwater archaeology, maritime history, etc. Many dozens of sites of interest were discovered, although the quality and reliability of the information provided varied considerably. These include privately maintained sites as well as sites for almost all of the public agencies and public and private organizations, museums and educational institutions that collect or hold information on shipwrecks. Many of these organizations have searchable databases linked to their records or libraries. The Mariners Museum Research Library in Newport News, Virginia, for example, enables online searches of its library and photograph collections. Other agencies provide numerous links to other sites with pertinent information. Florida State University, for example, provides links to a variety of sites relating to underwater archaeology and shipwrecks. The number of shipwreck-related Internet sites and the amount of information provided on Internet sites continues to grow. While these Internet sources are extremely useful, it was found that most sites duplicated information found elsewhere and many contain erroneous or non-verified information. All must be used with caution. It is impossible to list all of the Internet sites that relate to shipwrecks, but some of the non-agency and non-organization sites examined are mentioned here.

Several Internet sites strictly provide lists of wrecks and/or information on wreck sites. These include sites such as "Lloyd's Merchant Shipping Losses and Shipwrecks" (www.lr.org/information/maritime/m-merchant.html) and "Wrecks.Net" (www.wrecks.net), although the latter lists principally vessels lost in the Great Lakes. Commonly these types of sites use secondary sources and databases, such as the AWOIS records, for their information. There are also fee-based websites that sell information on sunken vessels, such as "International Registry of Sunken Ships" (http://users.accesscomm.ca/shipwreck/) and sites that provide more general information on vessels, such as "Merchant Vessel Database" (www.boatman.com/mv) which, for a fee, provides information on merchant and recreational vessels documented by the United States Coast Guard. There are also a number of websites intended mainly for sport divers and/or treasure hunters that provide information on wrecks considered to be interesting dive sites. Most of these deal with Florida wrecks (e.g., MBT Divers webpage: www.mbtdivers.com/NUMBERSH.htm); Association of Underwater Explorers webpage: www.mikey.net/aue), but some, such as Texas Diver (www.texasdiver.com), provide information for other areas. There are a few web pages that provide links to other sites containing wreck information, such as "Shipwreck & Marine Disaster Links" (www.home.gci.net/~alaskapi/success/shipwreck).

A large number of websites are designed principally to provide historical and descriptive information on vessels, but commonly include information on losses. These are among the most useful of the Internet sources because they often incorporate descriptive information on vessels that is not included in the commonly available wreck lists. Sites in this category include "Palmer List of Merchant Vessels" (www.geocities.com/mppraetorius/intro-com) that contains an extensive listing of sail and steam merchant vessels; "Haze Gray & Underway" (www.hazegray.org), a site related to naval history and photography that includes fleet lists, vessel descriptions, photographs, and the *Dictionary of American Naval Fighting Ships* containing the histories of U.S. Navy vessels; "Schoonerman: Schooner and Tall Sailing Ships" (www.schoonerman.com) that contains a large listing of sailing vessels with basic descriptive information; "U.S. Merchant Marine" webpage (www.usmm.org) which presents information on the U.S. merchant vessels and includes a listing of U.S. merchant vessels lost in World War II; "Uboat.net" (www.uboat.net), a site that contains comprehensive information on German submarines for the period 1938 to 1945 including descriptions and specifications, crew lists, patrol summaries, etc.; and "Liberty Ships" (www.andrew.cmu.edu/~pt/liberty/liberty1.html), which provides a complete listing of liberty ships with descriptions and specifications and some photographs.

2.2.3. Published Secondary Literature

The Garrison et al. (1989:II-18) study formally addressed secondary literature, but only in general statements about the availability of secondary sources for the Spanish and French colonial period (Archives des Colonies n.d.; Chanu and Chanu 1955; Surrey 1916) and various sources on British and American wrecks such as Admiralty and Foreign Office reports, *Reports of the Steamboat Inspection Service*, *Reports of the U.S. Life-Saving Service* and the *Official Records of the Union and Confederate Navies in the*

War of the Rebellion (ORN). However, some of these sources seem more appropriately considered primary documents. Garrison et al. (1989:II-8) utilized several published historical and archaeological studies available at the time, but note that the number related specifically to wrecks in the Gulf of Mexico was relatively small. Several publications have been produced since 1989 that provide useful information on maritime history, archaeology and vessel losses in the Gulf of Mexico. Among the most valuable of these historical syntheses are *From Sail to Steam*, a comprehensive study of the maritime history of Texas by Richard Francaviglia (1998), and *The French Thorn*, an examination of French activity in the Gulf region by Robert Weddle (1991) that represents a sequel to his earlier work *The Spanish Sea* (Weddle 1985). Also useful are the several volumes on the history of French Louisiana by Marcel Giraud (1974, 1987, 1993) published by Louisiana State University Press.

The results of a number of archaeological studies of shipwrecks in or near the Gulf of Mexico have been published since 1989 that provide useful information on broader questions of maritime history as well as more specific questions on vessel types, cargoes, wreck condition and preservation in various settings, etc. All of the published accounts discovered deal with wrecks lying in state waters, but they do have applicability to the study area considered here. Among those not mentioned by Garrison et al. are studies of the 1766 wreck of *El Nuevo Constante* of the Louisiana coast (Pearson and Hoffman 1995); and the sixteenth century Emmanuel Point shipwreck in Pensacola Bay, Florida (Smith et al. 1995; 1998). Although no full publication has appeared, numerous papers have been presented on the history and archaeology of the seventeenth century French vessel *La Belle*, whose remains have been excavated and recovered from Matagorda Bay, Texas (see Weddle 2001 for a discussion of this vessel).

Another important category of secondary literature examined in this study that was little used in the 1989 study was “diving guides,” which are publications produced principally for the sport diving community. Three of these guides proved to be of great value. These are *Shipwrecks of Florida* by Steven Singer (1992); *Florida Shipwrecks* by Berg and Berg (1991); and *The Captain’s Guide to Wrecks and Reefs* by Laney Rinehart (1998). The first two publications draw heavily from the secondary literature, although Singer also used information from a variety of public documents such as Customs Service, Coast Guard, and Life-Saving Station records, essentially many of the same documents used by the Garrison et al. (1989) study. Rinehart’s publication relies heavily on information derived from his own as well as other sport divers’ activities. As a result, many of the wrecks recorded by Rinehart are unidentified, but many are found in no other source. In addition, his listings include many types of objects in addition to vessels, including such things as tires, miscellaneous metal scrap, pipes, army tanks, etc. Most of Rinehart’s information is related to the Florida Gulf coast, but he does include a number of vessels and objects off the coast of Alabama and Mississippi. Diving conditions offshore of Louisiana and Texas are less desirable for sport diving than off of Florida, such that there are many fewer recreational divers there. No comprehensive guides exist for wrecks off of these two states, although Internet sites exist listing diving opportunities for wrecks off of Texas.

2.2.3.1. Cultural Resources Management Reports

A critically important body of historical and archaeological data is contained in the large number of reports resulting from cultural resources management (CRM) studies of various sorts undertaken in the Gulf of Mexico region. Garrison et al. (1989) did not specifically consider these sources, but they now probably represent our most extensive source of information on the application of remote-sensing techniques in the search for shipwrecks, on the archaeology of wrecks, and on the condition and preservation potential of wrecks in various settings. Many of these studies have been conducted over the past 30 years, particularly within the last 15 years, but they constitute a "gray literature" that is either unknown or ignored by many researchers. Except for the surveys in Federal waters mandated by MMS, almost all of these CRM studies have been conducted in state waters and the reports are maintained by state offices, usually the office of the State Archaeologist or a similar entity. Although mainly dealing with state waters, many of these reports contain historical, archaeological and remote-sensing information that has direct bearing on assessing shipwrecks in the study area. Because of the importance of this class of sources the pertinent state offices in each of the five states bordering the Gulf of Mexico (Florida, Mississippi, Alabama, Louisiana and Texas) were visited to examine the cultural resources reports they hold.

In addition to literature related specifically to CRM projects, shipwreck-related publications sponsored or produced by various state and Federal agencies and colleges and universities were examined during the visits to state offices. Although not specifically CRM in nature, several of these publications provided useful comparative information and are noted in the following discussions.

A review of CRM and state- and university-sponsored reports reveals the extensive amount of research on shipwrecks conducted along the coast in the past two decades. Among these are numerous remote-sensing surveys, historical overviews and archaeological projects conducted in many bays and waterways along the Gulf. A large number of these studies were conducted for the U.S. Army Corps of Engineers, but some were undertaken for other government entities, as well as private concerns. Examples in Florida include several studies in the waters off Lee County (Hall 1998, 1999); investigations in and near Pensacola Bay (Baumer 1990; Bense 1988; Franklin et al. 1991; James 1989; Hunter et al. 2000; Morris and Franklin 1995; Spirek et al. n.d.; Tidewater Atlantic Research 1987); St. Andrew's Bay (Pelletier et al. 2000); near Longboat Key at Sarasota Bay (Sea Systems Corporation 1992); and an inventory of wrecks at Dog Island in Franklin County (White et al. 1995). A number of studies have been undertaken by the National Park Service on Park Service lands along the Florida Gulf coast. These include a survey and assessment of underwater archaeological sites in Biscayne National Park (Skowronek 1984; Wild and Brewer 1985); shipwreck studies of the Dry Tortugas and the Fort Jefferson National Monument (Bearss 1971; Johnson 1982; Murphy and Jonsson 1993); and the Florida portion of Gulf Islands National Seashore (Tesar 1973). The study edited by Murphy and Jonsson (1993) proved to be of particular use in providing a great deal of information on the reported and known wrecks in the Dry

Tortugas National Park. This included information on causes of loss, dates of loss, etc., which formed a valuable body of comparative data for the present study.

A fairly large number of CRM studies have been undertaken along the central Gulf coast, off the states of Alabama, Mississippi, and Louisiana. Mobile Bay, in particular, has been subject to a considerable amount of study, principally in relation to Corps of Engineers projects. Mistovich and Knight (1983) produced an overview of the cultural resources of Mobile Bay that included a listing and discussion of 282 vessels believed to have been lost in the area. Additionally, a series of remote-sensing surveys and diving projects have been conducted in the bay (Irion 1983, 1985, 1986; Irion and Bond 1984). Other CRM studies conducted along the Alabama and Mississippi coasts include an historical overview of submerged cultural resources near Bayou La Batre, Alabama (Mistovich 1987) and cultural resources studies of submerged resources of Pascagoula Harbor (Mistovich et al. 1983), the waters around Biloxi (Mistovich et al. 1993) and the offshore barrier islands (Irion 1989).

A series of cultural resources studies has been undertaken in the coastal waters of the state of Louisiana. These consist mainly of remote-sensing surveys and include work in Breton Sound (Irion and Heinrich 1993; Irion et al. 1993; Pearson 2000), the Terrebonne Bay area (Birchett and Pearson 1998; Pearson 2001) and Atchafalaya Bay (Seidel et al. 1998). Some of these projects involved diving operations, although none discovered any historic shipwrecks.

A small number of historic shipwrecks have been discovered along the Louisiana coast, but relatively few have been studied to any extent. The only wreck to receive extensive archaeological and historical study has been the Spanish merchantman *El Nuevo Constante*, lost off the central Louisiana coast in a hurricane in 1766 (Pearson and Hoffman 1995). This vessel lies in state waters at a depth of about seven-m (21 ft.) and archaeological research indicated that the very lower portion of the approximately 38-m-long (125 ft.) hull, as well as numerous items of cargo, was well preserved and only minimally scattered from the original position at the time of sinking. Although in state waters, this wreck lies in an environmental setting that is commonly found in Federal waters and, thus, provides a model of what might be expected at other wrecks in the GOMR. A large pile of rock identified as ship's ballast and some artifacts, including six iron cannons, was found in shallow water off the Chandeleur Islands in southeastern Louisiana (Garrison et al. 1989b). Founders marks on three of the iron cannons suggests the guns were cast no earlier than 1771 and might have been made as late as 1784. The authors speculate that the ballast and other materials were deposited during the third quarter of the eighteenth century. No evidence of vessel remains was found and it is speculated that the material was either dumped over the side to lighten a grounded vessel or was lost when a vessel "turned turtle" prior to the vessel drifting off, possibly sinking nearby (Garrison et al. 1989b:7–26—7–27).

The wreck of another eighteenth century Spanish vessel, *El Cazador*, was found in approximately 100-m (300 ft) of water about 50 miles south of Grand Isle, Louisiana. Lost in 1784, the wreck of *El Cazador* was discovered accidentally by a fishing boat in

1984. Subsequently a group of salvers dove on the wreck and recovered a large number of silver coins, a bronze cannon, cannon balls, an anchor, a bronze bell, fire brick, pottery, and some other miscellaneous items (*New York Times* 1993; Summers 1996). Unfortunately, little is known about the condition of the wreck, although reports indicate that wood was present and that portions of the wreck were exposed above the bottom. There is every reason to believe that other early wrecks will be exposed and similarly well preserved throughout much of the lands of the GOMR. It is possible that deepwater conditions, and/or possibly partial burial, have aided in the preservation of wood on *El Cazador*. The recent discovery of what appears to be the well preserved, partial hull of a wooden sailing vessel in over 2,000 feet of water off the mouth of the Mississippi River provides additional support for the type of preservation, and exposure, that can be expected for deepwater wrecks in the GOMR (Irion 2002).

A very large number of CRM studies has been conducted along the Texas coast, many for the Corps of Engineers. Several of these have included archaeological examinations of sunken wrecks in Gulf and near-Gulf waters that have particular relevance to wrecks in the study area. Additionally, state agencies, particularly the Texas Historical Commission, have undertaken a number of shipwreck-related studies along the Texas coast. Among the more relevant studies are remote-sensing surveys in the lower Sabine River area (Hoyt et al. 1994), in the Galveston Bay area (Arnold 1987; Arnold and Oertling 1995; Espy, Huston & Associates, Inc. 1992, 1998; Hoyt 1993), in Matagorda Bay (Arnold 1982; Pearson and Hudson 1990), in the Aransas Pass-Aransas Bay-Corpus Christi Bay area (James and Pearson 1991; Pearson and Simmons 1994; Pearson and Wells 1995) and along the lower Texas coast in the vicinity of Brownsville and Padre Island (Espey, Huston & Associates 1981; 1990a; 1990b; Glander et al. 1990; Hoyt 1991; Lenihan 1974; Nichols et al. 1981).

Although not a remote-sensing or shipwreck study per se, the work of Arnold et al. (1998) on "Liberty Ships" of the Texas coast is a particularly useful source of information. Brief examinations have been conducted of two shipwrecks off the Texas coast, the *Hatteras* and the *New York*, both of which lie in Federal waters. The *Hatteras* was an iron-hulled sidewheel steamer sunk in 1863 while employed as a U.S. Navy blockading vessel. Examinations by Texas Historical Commission and MMS personnel have provided basic information on the wreck site and a magnetic contour map (Anuskiewicz and Arnold 1992; Arnold and Anuskiewicz 1995). The *New York* was a sidewheel steamer lost in a storm in 1846. The wreck was found by a group of amateur divers after a five-year search and was briefly examined by MMS personnel in 1997. The MMS examination involved diver assessment and a remote-sensing survey of the wreck site (Irion and Anuskiewicz 1999:20-23). Neither the *Hatteras* nor the *New York* have been studied in any detail, but the small amount of information collected does expand on our understanding of wreck conditions and preservation potential on the GOMR.

Most of the marine-related CRM work along the Gulf coast has involved remote-sensing survey and some reconnaissance diving. However, as noted above, several studies have resulted in the discovery and examination of shipwrecks, many of which have been found and examined since the Garrison et al. study. Although the level of examination of these wrecks varies considerably, they do contribute to our understanding of shipwrecks in the study area. Additionally, while most of these wrecks are located in shallow inshore waters, some of these shallow-water environmental settings are comparable to ones found in the offshore waters of the study area. Thus, these wrecks can provide information on factors of critical importance in understanding wrecks in the GOMR, such as site formation processes and preservation potentials in different settings, and are used later to expand the discussions of shipwreck preservation presented in Garrison et al. (1989:II-77–II-84).

2.2.4. MMS-Mandated Archaeological Survey Reports

One source of data not used in the Garrison et al. study is the results of some of the 2,800 MMS mandated cultural resources studies that have been conducted in the Gulf of Mexico since the 1970s. MMS personnel in New Orleans provided pertinent information from survey reports where sunken vessels had been positively identified or where objects that might be vessels had been identified. In the vast majority of cases, the identification relied on sidescan sonar information; only a few instances relied on the results of magnetometer data. The information provided by the MMS consisted of xerox copies of selected portions of reports. This usually included a copy of the title page and those pages describing the vessel or object discovered, a copy of the record of the vessel or object, and, often, a portion of a map showing the identified vessel or object in relation to survey track lines or other features. As is discussed in more detail later, these archaeological survey reports and the surveys on which they are based are produced by offshore survey or energy-related companies. In a few instances, MMS provided data from the results of their own in-house remote-sensing surveys or diving operations. Information from over 130 archaeological survey reports and MMS surveys or diver inspections was received and reviewed. From these records, 90 sunken vessels have been identified in addition to 43 targets classified as "objects" that may or may not represent vessel remains. As is discussed in more detail later, this relatively small sample of wrecks represents our best and most reliable set of data for testing the model of wreck distributions in the GOMR developed by Garrison et al. (1989) and for assessing the cultural resources remote-sensing survey program currently mandated by MMS.

2.2.5. Primary Documents

Garrison et al. (1989:II-13) included "Documents" as a principal category of source materials, noting that these consisted of "unpublished materials that provide substantive data about shipwrecks." Here, these are identified as "primary documents." Garrison et al. examined the most critical of these primary sources for their study, such that the present effort mainly involved identifying and examining sources they had not used and, when necessary, going back to some of the primary sources they used to collect additional information. For example, U.S. Custom Service records for the Port of New Orleans that were not examined by Garrison et al. were reviewed in this study. Among the most pertinent of these records was the seven-volume set of ship enrollments and registrations for New Orleans for the period 1804 to 1870 (Works Progress Administration [hereinafter cited as WPA] 1942) and the records of casualties and wrecks occurring within the Port of New Orleans Custom District for the period 1873-1924 (WPA 1938). Both of these sets of records are considered primary documents, although they constitute data abstracted from the original records.

Primary accounts of shipwrecks, particularly eyewitness accounts of participants, while possibly the most reliable source of information, can require a considerable amount of effort to find, particularly in an overview study of the kind undertaken here. Numerous secondary sources, however, do contain first-hand accounts. For example, contemporary accounts of the 1554 Spanish wrecks on Padre Island are provided in Arnold and Weddle (1978), and eyewitness accounts of the 1766 sinking of *El Nuevo Constante* as well as several other vessels involved in her salvage are recounted in Pearson and Hoffman (1995). Similarly, many of the CRM studies examined include first-hand accounts or extracts from contemporary newspapers of vessel sinkings. Likewise, a few primary reports of Civil War vessel losses in the Gulf of Mexico were gleaned from the *Official Records of the Union and Confederate Navies in the War of the Rebellion* (ORN).

2.2.6. Directories

Garrison et al. (1989) included a category of research sources named "Directories," identified as "lists of the names of vessels [that] usually include dates and locations of casualties." Among the Directories examined in the 1989 study were the *Annual List of Merchant Vessels of the United States*, which covers the years since 1867; the American Bureau of Shipping Records; the various ship and shipping lists produced by the Lloyds Company of London; and the Lytle-Holdcamper List (Mitchell 1975), which is a directory of steam vessels constructed and lost in the United States for the period 1790-1868. All of these directories were reexamined in the present study, primarily to collect additional descriptive information on vessels and to clarify the information provided on location of loss in order to develop assessments of reliability (see below). In some instances, our review of these directories was undertaken to clarify data presented in the list of wrecks developed in 1989. For example, a review was undertaken of every issue of the *Annual List of Merchant Vessels of the United States* to extract descriptive information on vessels lost in the Gulf of Mexico.

Several other listings of vessels and/or wrecks that may be classified as "Directories" were examined in this study. Some of these are published, others are not. Among these are the computerized listing of over 1,800 vessels lost within the boundary of the New Orleans District of the U.S. Army Corps of Engineers mentioned earlier (Pearson et al. 1989), and a listing of 213 abandoned and derelict vessels recorded along the coast of Mississippi by the Mississippi Department of Marine Resources (Mississippi Department of Marine Resources n.d.). The Louisiana Division of Archaeology has developed a listing of shipwrecks from its site files, but like the two studies just noted, almost all of the entries fall in state waters (Clune and Wheeler 1991). Similar agencies in most other Gulf states have the capability of producing similar lists from the site file records, if they are not already maintained or produced separately. The Office of Conservation of the Louisiana Department of Natural Resources publishes a list of obstructions falling in state waters as part of their Underwater Obstruction Removal Program (Louisiana Office of Conservation 2001). The information published in this volume also is included online at the Department of Natural Resources website. This list consists of obstructions identified in relation to the Fisherman's Gear Compensation Fund. Most of these obstructions are non-vessel objects such as pilings, dredge pipe, etc., but a few are vessels. Also, only a small number of these obstructions fall in Federal waters and it appears that most of these are duplicated in the MMS database of offshore snags and hangs mentioned earlier.

In addition, several of the CRM reports mentioned above contain lists of known or reported vessel losses for specific areas. Again, most of these lists contain vessels lost in state waters, but a few include losses within the present study area.

2.3. Compilation of Revised and Expanded Shipwreck Database

The principal objective of Task 1 of this study was to add to and expand the shipwreck database developed out of the Garrison et al. (1989) study and currently used by MMS in guiding cultural resources surveys on the GOMR. The development of this database relied on the information collected from the various sources as discussed above. The Garrison et al. shipwreck database included only a few categories of information. The computerized version (Microsoft Excel format) of the database provided by the MMS contains the following variables: "Number," which is an arbitrary number assigned to each entry; "Vessel Name;" "Date of Loss," "Reference Number," which is a number assigned to or derived from the principal source of information on the vessel; "Information Source," which references the principal source from which information on the loss was obtained; "Latitude;" "Longitude;" "MMS Lease Area;" and "MMS Lease Block No."

The full database of shipwrecks developed in the Garrison et al. study (1989:II-10) included over 4,000 entries. However, the majority of these were in state waters. The 1989 computerized database of wrecks received from the MMS in June 2000 lists 1,469 "shipwrecks" in Federal waters (see Volume III, Appendix A). However, this list includes a number of duplicates, mostly consisting of the same vessels under slightly different spellings, 244 items identified as "unknown" which are unidentified wrecks derived from various sources, 23 "objects" and "obstructions" that may or may not be shipwrecks, plus several "fish havens" which represent vessels scuttled as artificial reefs. In addition, 240 of the wrecks included in the list are identified as falling within state waters. These vessels are, apparently, included in the list because of questions about the reliability of their reported location of loss and the presumption that they could, actually, fall in Federal waters. Five of these wrecks are in Louisiana state waters; all of the rest are in Texas waters. Two items in the Garrison et al. list are identified as "helicopters," but both have the same coordinates and may be the same object. The initial task of the present study was to carefully reexamine this list to try to identify and rectify duplications or errors, collect additional information on the listed vessels and to refine the locations of loss, if possible. As is discussed below, this reexamination did result in the elimination of a number of these vessels from the final shipwreck database.

Finally, it should be noted that information was collected on a variety of objects other than identified shipwrecks. Many of the sources of data examined included items identified only as “objects” or “obstructions” or items more specifically identified, such as anchor, wire cable, pipe, rig, etc. Information on most of these items was collected and is included in a master Access database, and was used in some of the analyses conducted. In this master database, however, these types of items are classified as “Objects” if there is no reason to believe they might represent shipwrecks, as opposed to items classified as “Vessels” that are identified as shipwrecks on the basis of the best available information. A few items identified as “objects” in other sets of data have been reclassified as “vessels” for the purpose of this study. This principally includes objects that might have been lost from vessels, such as anchors. Additionally included in the category of “vessels” are a few objects that are not shipwrecks but that do represent cultural items of interest to MMS in its management of cultural resources. Specifically, these include airplanes and helicopters.

2.3.1. Shipwreck Information Form

In the present study, a particular effort was made to collect and add to the database information about each reported loss that might aid in its identification should it eventually be found. In consultation with MMS personnel, the authors developed a list of variables to be recorded for each reported shipwreck that included information on location of loss, physical characteristics, construction and ownership, and aspects of the vessel’s function and use, particularly at the time of loss. In addition, notations on the source(s) of information were recorded. Ultimately, all of these data were input into the program Microsoft Access and, as noted, utilized in the GIS application ArcView. In order to expedite the collection and incorporation of this information into the Access database, a recording form was developed and used by the various researchers collecting shipwreck information. An example of this form is provided as Figure 2-1. Many of the entries in the form and in the Access database used codes, and Appendix B (in Volume III) includes a complete key to those used for the various data fields used in the Access database that was developed from this recording form.

As can be seen in the form, data on shipwrecks was collected on five principal categories of information: General Information, Location, Vessel Description, Wreck Site Information, and Documentation. As to be expected, the amount of information collected on individual wrecks varied considerably. In most instances, information on a relatively small number of variables, such as the name, type of vessel and date and location of loss, could be found. In those situations where the wreck was identified only on the basis of a remote-sensing survey even less information was available, possibly consisting only of the location and general dimensions of the wreck. In the relatively small number of cases where historical information on a particular vessel is abundant and detailed, such as those lost during World War II, many variables could be entered.

MMS SHIPWRECK INFORMATION FORM

GENERAL INFORMATION

1. VESSEL NAME (55 characters)

____

2. ALTERNATE NAME (55 characters)

____

3. 1989 MMS NUMBER (5) ____________ 4. OFFICIAL NUMBER (10) ____________________

5. STATE SITE NUMBER (8) ____________________

6. DATE OF LOSS (mo-day-year) (8) ________________ 7. CAUSE OF LOSS (2) _____

LOCATION

8. MMS AREA (3) ______ 9. MMS LEASE BLOCK (3) _______

10. LATITUDE (8) ____________________ 11. LONGITUDE (8) ___________________________

12. LORAN COR. 1 (12) ______________________ 13. LORAN COR. 2 (12) ______________________

14. NEAREST LANDMARK (port, community, landform, etc.) (50)

____

____

15. NEAREST STATE (2) _____ 16. RELIABILITY OF LOCATION (2) _____

VESSEL DESCRIPTION

17. VESSEL TYPE (3) _____ 18. PROPULSION (2) _____ 19. DATE BUILT (year) (4) ___________

20. WHERE BUILT (3) ________ 21. MATERIAL (2) _____ 22. LENGTH (5) __________

23. BEAM (width) (4) _________ 24. DEPTH HOLD (4) _____________ 25. DRAFT (4) ___________

26. TONNAGE (gross) (4) ________ 27. TONNAGE (net) (4) _______ 28. NO. OF MASTS (1) _____

29. NO. OF DECKS (1) _____ 30. BOW SHAPE (3) __________ 31. STERN SHAPE (3) __________

32. BUILDER (35)

____

33. OWNER (35)

____

34. MAIN ENGINE TYPE (3) _________ 35. HORSEPOWER (4) ________

36. NO. OF CYLINDERS (4) __________ 37. CYLINDER SIZE (inches) (3) __________

38. STROKE (feet) (2) _____ 39. DATE ENGINE BUILT (year) (4) _________

40. ENGINE BUILDER (35)

____

41. NO. OF BOILERS (2) _____ 42. BOILER TYPE (3) __________

43. VESSEL USE (2) ________ 44. HOME PORT (3) __________

45. NATIONALITY (4) ________ 46. DESTINATION AT LOSS (3) ________

47. CARGO AT LOSS (25) ____

48. ARMAMENT AT LOSS (no of guns) (3) ________ 49. VALUE AT LOSS (dollars) (8) ________

WRECK SITE INFORMATION

50. WATER DEPTH (feet) (4) _______ 51. SITE SIZE (square feet) (4) _______

52. BOTTOM TYPE (2) _______ 53. WRECK CONDITION (2) _______

54. WRECK EXPOSURE (2) ____ 55. MATERIAL COLLECTED (8) 1. ___ 2. ___ 3. ___ 4. ____

DOCUMENTATION

56. DATA DEPOSITORY (254)

____

____

____

____

____

57. REFERENCES (254)

____

____

____

____

58. LEASE BLOCK OR PIPELINE SURVEY OCS NO. (6) __________

59. VESSEL PHOTOGRAPHS (reference or attach) (35)

____

60. MAGNETOMETER DATA (reference or attach) (35)

____

61. SIDE SCAN SONAR RECORDS (reference or attach) (35)

____

62. COMMENTS (254)

____

____

____

____

63. RECORDER (12) ____________________________ 64. DATE RECORDED (8) ____________

65. SOURCE _________________

Figure 2-1. Shipwreck Information Form used in data compilation.

Most of the entries in the Shipwreck Information Form are self explanatory, but some do require explanation. The General Information category includes variables for vessel name, alternative name, 1989 MMS number, official number, state site number, date of loss and cause of loss. An alternative name was entered if the vessel was known by more than one name or if it appeared in different sources under different spellings. The “1989 MMS number” entry simply records the arbitrary number assigned to this vessel in the 1989 MMS shipwreck database, if it appeared in that list. Because all of the vessels fall in Federal waters, only a very few had state site numbers assigned. The cause of loss entry is that given in the source considered most reliable, although in many instances, cause of loss is not given or it is only noted that the vessel was “sunk.” The codes used and the corresponding causes of loss are listed below in Table 2-1.

Table 2-1. Codes Denoting Cause of Loss Categories in the Shipwreck Information Form

CODE	CAUSE
AB	abandoned
BE	beached
BU	burned
CA	capsized
CO	collided
EX	explosion
FO	foundered
GF	gunfire-battle
SC	scuttled
ST	stranded & swamped
SU	sunk
UN	unknown

The second category of information is related to the location of the wreck. "MMS Area" refers to one of the 70 lease areas that the MMS presently identifies in the GOMR and "MMS Lease Block" refers to the numbered lease block within that area. The 3-mile-square lease block and the larger lease areas are used as principal units in some of the analyses conducted in this study and are discussed more fully in the following chapter. A map and list of the MMS Lease Areas are provided as Figure 2-2 (see Table 2-2 for key to abbreviations). "Latitude" and "Longitude" represent the coordinates of the location of loss. For use in the Access database and in ArcView, this was converted to decimal degrees.

Location, of course, is probably the most critical attribute assigned to any wreck in this study because it is the basis upon which patterns of spatial distributions are determined, high-probability areas are identified, and future decisions concerning remote-sensing surveys in the GOMR will be made. Location information for the wrecks identified in this study came from a wide variety of sources, in a variety of forms and with varying degrees of reliability. Therefore, a full discussion on how wreck locations were determined, the accuracy and precision of assigned locations and the problems associated with such determinations is presented. Only converted Loran coordinates were provided for a fairly large number of wrecks, such as those described in some of the sport divers publications, so these coordinates were included in the form for the convenience of those collecting the information. As has been mentioned, Loran coordinates can be quite imprecise. Discussions with individuals who have attempted to relocate objects using Loran coordinates indicate that relocation is easiest if the same Loran system is used with the original Loran coordinates.

However, if, the Loran coordinates are converted into another coordinate system (e.g., Latitude/Longitude) and/or different positioning equipment is used, relocation can become difficult. It is apparent that converting Loran coordinates to other systems can introduce imprecision; however, no studies seem to have been conducted to assess the exact nature and extent of the error.

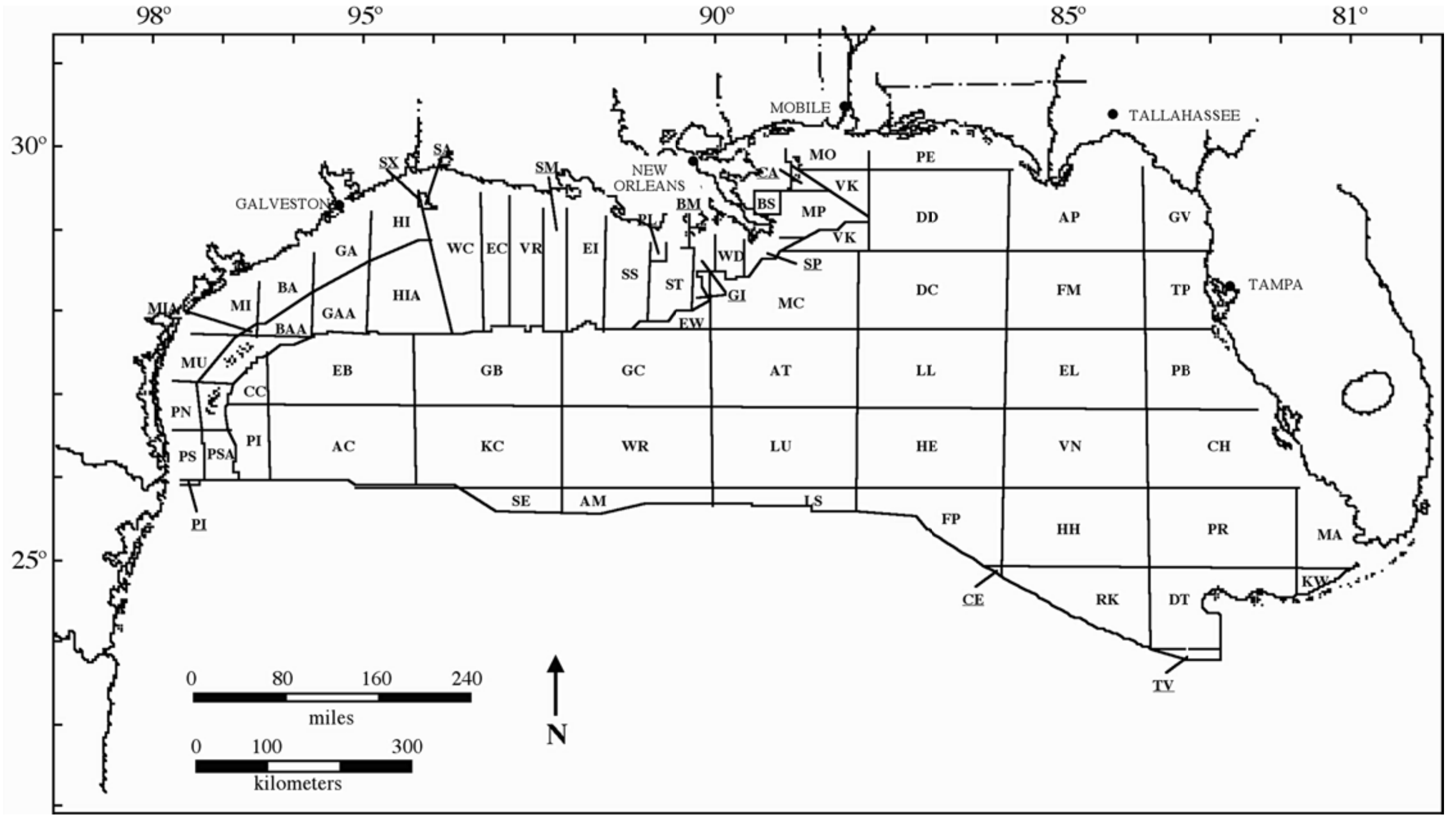


Figure 2-2. MMS lease areas in the Gulf of Mexico Region.

Table 2-2. MMS Lease Areas in the Gulf of Mexico Region

LEASE AREAS	CODE	AREA IN ACRES	AREA IN SQUARE MILES	% OF TOTAL GOMR AREA
ALAMINOS CANYON	AC	5,315,143.222	8,304.91	3.22
AMERY TERRACE	AM	1,540,459.045	2,406.97	0.93
APALACHICOLA	AP	3,529,460.676	5,514.78	2.14
ATWATER VALLEY	AT	5,439,949.728	8,499.92	3.30
BRAZOS	BA	973,068.225	1,520.42	0.59
BRAZOS A	BAA	766,080.000	1,197.00	0.46
BAY MARCHAND	BM	25,056.824	39.15	0.02
BRETON SOUND	BS	280,154.703	437.74	0.17
CHANDELEUR	CA	220,378.762	344.34	0.13
CORPUS CHRISTI	CC	676,432.513	1,056.93	0.41
CAMPECHE ESCARPMENT	CE	52,013.289	81.27	0.03
CHARLOTTE HARBOR	CH	4,807,083.957	7,511.07	2.91
DESOTO CANYON	DC	5,445,328.109	8,508.33	3.30
DESTIN DOME	DD	5,045,878.773	7,884.19	3.06
DRY TORTUGAS	DT	3,441,249.051	5,376.95	2.09
EAST BREAKS	EB	4,677,830.500	7,309.11	2.83
EAST CAMERON	EC	1,762,887.996	2,754.51	1.07
EUGENE ISLAND	EI	1,996,141.212	3,118.97	1.21
THE ELBOW	EL	5,156,726.396	8,057.38	3.13
EWING BANK	EW	610,013.380	953.15	0.37
FLORIDA MIDDLE GROUND	FM	5,006,232.622	7,822.24	3.03
FLORIDA PLAIN	FP	3,380,023.567	5,281.29	2.05
GALVESTON	GA	1,130,582.904	1,766.54	0.69
GALVESTON A	GAA	1,457,280.000	2,277.00	0.88
GARDEN BANKS	GB	5,001,323.317	7,814.57	3.03
GRAND ISLE	GI	573,215.110	895.65	0.35
GREEN CANYON	GC	5,393,813.446	8,427.83	3.27
GAINESVILLE	GV	1,488,765.944	2,326.20	0.90
HENDERSON	HE	5,446,970.742	8,510.89	3.30
HOWELL HOOK	HH	5,444,400.620	8,506.88	3.30
HIGH ISLAND	HI	845,749.744	1,321.48	0.51
HIGH ISLAND A	HIA	3,432,960.000	5,364.00	2.08
KEATHLEY CANYON	KC	5,448,699.086	8,513.59	3.30
KEY WEST	KW	162,149.206	253.36	0.10
LLOYD	LL	5,445,884.499	8,509.19	3.30
LUND SOUTH	LS	1,437,055.635	2,245.40	0.87
LUND	LU	5,441,032.921	8,501.61	3.30
MIAMI	MA	1,187,064.377	1,854.79	0.72
MISSISSIPPI CANYON	MC	4,748,859.409	7,420.09	2.88
MATAGORDA ISLAND	MI	930,692.366	1,454.21	0.56
MATAGORDA ISLAND A	MIA	51,840.000	81.00	0.03
MOBILE	MO	650,576.541	1,016.53	0.39
MAIN PASS	MP	1,547,390.992	2,417.80	0.94
MUSTANG ISLAND	MU	910,277.487	1,422.31	0.55
MUSTANG ISLAND A	MUA	1,008,000.000	1,575.00	0.61
ST. PETERSBURG	PB	3,262,314.554	5,097.37	1.98
PENSACOLA	PE	1,178,061.915	1,840.72	0.71
PORT ISABEL	PI	1,372,583.425	2,144.66	0.83
SOUTH PELTO	PL	125,176.539	195.59	0.08
NORTH PADRE ISLAND	PN	829,812.601	1,296.58	0.50
NORTH PADRE ISLAND A	PNA	599,040.000	936.00	0.36
PULLEY RIDGE	PR	5,717,157.222	8,933.06	3.46
SOUTH PADRE ISLAND	PS	829,382.009	1,295.91	0.50

Table 2-2 (continued). MMS Lease Areas in the Gulf of Mexico Region

LEASE AREAS	CODE	AREA IN ACRES	AREA IN SQUARE MILES	% OF TOTAL GOMR AREA
SOUTH PADRE ISLAND A	PSA	518,400.000	810.00	0.31
RANKIN	RK	3,437,509.027	5,371.11	2.08
SABINE PASS (LA)	SA	60,265.459	94.16	0.04
SIGSBEE ESCARPMENT	SE	1,173,025.015	1,832.85	0.71
SABINE PASS (TX)	SX	24,060.688	37.59	0.01
SOUTH MARSH ISLAND	SM	1,299,146.071	2,029.92	0.79
SOUTH PASS	SP	435,274.387	680.12	0.26
SHIP SHOAL	SS	1,816,440.123	2,838.19	1.10
SOUTH TIMBALIER	ST	1,463,997.464	2,287.50	0.89
TARPON SPRINGS	TP	3,036,509.304	4,744.55	1.84
TORTUGAS VALLEY	TV	263,120.436	411.13	0.16
VIOSCA KNOLL	VK	1,520,503.989	2,375.79	0.92
VERNON	VN	5,302,784.044	8,285.60	3.21
VERMILION	VR	1,982,747.472	3,098.04	1.20
WALKER RIDGE	WR	5,564,793.647	8,694.99	3.37
WEST CAMERON	WC	3,130,010.557	4,890.64	1.90
WEST DELTA	WD	728,847.645	1,138.82	0.44
TOTALS		**165,003,140.489**	**257,817.41**	**100.00**

Individuals with practical experience in this matter indicate that errors of up to one-quarter mile are not uncommonly encountered when using GPS and converted coordinates in trying to locate objects originally discovered by Loran (Avery Munson, personal communication 2001; Rob Floyd, personal communication 2001). In spite of these known problems, it was necessary to convert all of those Loran coordinates provided for losses into geographic coordinates (latitude and longitude) as required by the MMS and as needed to input data into a GIS application.

When diving was conducted to relocate and evaluate targets as part of Task 2, some of the targets selected (specifically, the reported hangs) to examine had originally been positioned by Loran. As is noted in later discussions on Task 2, most of the targets originally positioned by Loran were difficult or impossible to find.

Nearest landmark was included if provided in the original source of information because it sometimes played a role in determining the location of the wreck. A typical entry might be “Wine Island Pass, Louisiana,” “Cape St. George Lighthouse,” or “Port Mansfield Jetties.”

The final variable in the Location category is “Reliability of Location.” This reflects an assessment of how reliable the location of loss provided in the form actually is using a numerical scale ranging from 1, very high reliability, to 4, very low reliability. The use of this reliability factor represents an attempt to quantify how useful assigned wreck positions might be in various types of analyses. However, the assignment of a reliability value in most instances is in itself necessarily partially subjective because of the nature of the original data on the shipwreck.

A specific effort was made to define the four reliability categories in terms of the anticipated degree of difficulty there would be in relocating the wreck using the technology presently used in MMS mandated surveys. It was felt that this approach would be most useful to MMS in its cultural resources responsibilities as well as in trying to relate specific wrecks or groups of wrecks to the concept of "high-probability" locations. In essence, using wrecks assigned very low reliability factors (i.e., 3 or 4) in the identification of tightly drawn "high-probability" areas is considered questionable. The four reliability factors used are:

1. Wreck location is confirmed through physical verification and has been accurately positioned (e.g., with GPS or on an accurate, modern map) or is identified on the basis of accurately positioned remote-sensing survey. The location is considered to be very reliable such that a wreck would be easy to relocate using standard DGPS equipment.

2. A specific location is provided for a wreck or a vessel loss by an informant, reported in the literature, or on a map. Included in this category are wrecks or losses whose position is given to at least the nearest actual minute of latitude and longitude, to a specific offshore lease block, and those that have been discovered and positioned using Loran equipment. The location reliability of these wrecks or losses is considered to be moderate to good. It is anticipated that these wrecks could be discovered, but discovery would require a moderate amount of field survey with remote-sensing equipment, plus it may require additional historical research.

3. A general location for a wreck or a vessel loss is provided by an informant or in the literature. Included in this category are vessels whose locations of loss are given only in degrees of latitude and longitude. Also included in this category are vessels whose general position of loss is provided in relation to a known landmark, such as "10 miles south, southeast of Ship Island." The location reliability of these wrecks or losses is considered to be fair to poor. Discovery of wrecks included in this category could be very difficult and commonly would require a considerable amount of historical research and/or remote-sensing survey.

4. Unreliable or vague location information is provided on a wreck or place of loss of a vessel. Examples would include many early accounts of vessel losses such as reports of vessels lost in hurricanes "near latitude such and such" or other general indications of loss, such as "30 miles off Padre Island," "off the coast of Louisiana," "south of Galveston," or "between Galveston and New Orleans." Directed searches for these vessels are nearly impossible and their discovery will mainly be by chance. Also included in this reliability category are items that were reported to be "adrift," when there is no evidence to indicate where, or if, they sank as well as those cases where information is unavailable to make any assessment of the reliability of the position given.

The third category of information included on the recording form is Vessel Description. This category includes variables such as vessel type, length, width, beam, draft, where built, year built, tonnage, material (material of the hull such as wood, iron, steel, etc.) builder, propulsion, flag(s) sailed under, vessel destination when sunk, etc. The variables and the codes used are given in the Key provided as Appendix B in Volume III.

The descriptor used in the principal source of information on the loss was used when available to describe the vessel. The rationale for using "historic" descriptors is of concern for many of the variables, with Vessel Type probably being the most important. Terms for vessel types are not always specific and individuals may use different terms when referring to the same vessel or type of vessel. In some instances a ship or boat may be designated by its rig, in others by its hull form, and in others by its use or function. A single term might refer to a general class of vessels that could include various rigs, hull forms and sizes. An example commonly encountered in the present study is the use of the terms "Fishing Vessel" or "Motorized Vessel" that are used as vessel descriptors in several of the larger computerized shipwreck databases, such as those maintained by the U.S. Coast Guard and NIMA. In the Gulf of Mexico one can assume that "Fishing Vessels" are most commonly shrimp trawlers simply because this is the most common type of fishing vessel operating there. But, other types of vessels that can be generally categorized as "Fishing Vessels" (e.g., snapper or menhaden boats) have been lost in the Gulf. As a result, it is generally impossible to accurately ascertain when the U.S. Coast Guard, for example, is referring to a shrimp trawler when it uses the term "Fishing Vessel." Cross-checking sources or going back to primary sources when possible has allowed a refinement of some of these "Fishing Vessel" entries, but these are few in number.

An added difficulty is that vessel terminology changes over time. For example, in the seventeenth and into the eighteenth century the term "bilander" was applied to a two-masted vessel with square sails on the fore mast and square and lateen sails on the mizzen or rear mast. Later the term "brig," shortened from "brigantine," came to be commonly applied to this and similar types of rigs (MacGregor 1980:76-77). During part of the eighteenth century both terms were in use. Adding to the confusion of vessel type terminology is that it is often difficult to establish specific equivalencies among vessel terms used in different languages.

There are no all-purpose classification schemes applicable to every situation in anthropological or historical research. Classification has to be formulated with a specific purpose in mind (Thomas 1974). Out of necessity, this study has had to rely mainly on contemporary vessel terminology and descriptions in trying to establish a typology of vessels lost in the study area. In effect, this is an "historical" typology forced upon us by the nature of the data. This is not seen as a serious problem in the type of overview study conducted here. In general, it is safe to state that the typology used is primarily "morphological" in nature in that the types used "attempt to define broad generalities (rather than focusing upon specific traits) simultaneously considering as many traits as possible" (Thomas 1974:7). Because they are general in nature, morphological types are primarily descriptive. As with any other morphological typology, vessel types are abstract in that a type is “the composite description of many artifacts, each of which is quite similar” (Thomas 1974:22) and every type encompasses some range of variability.

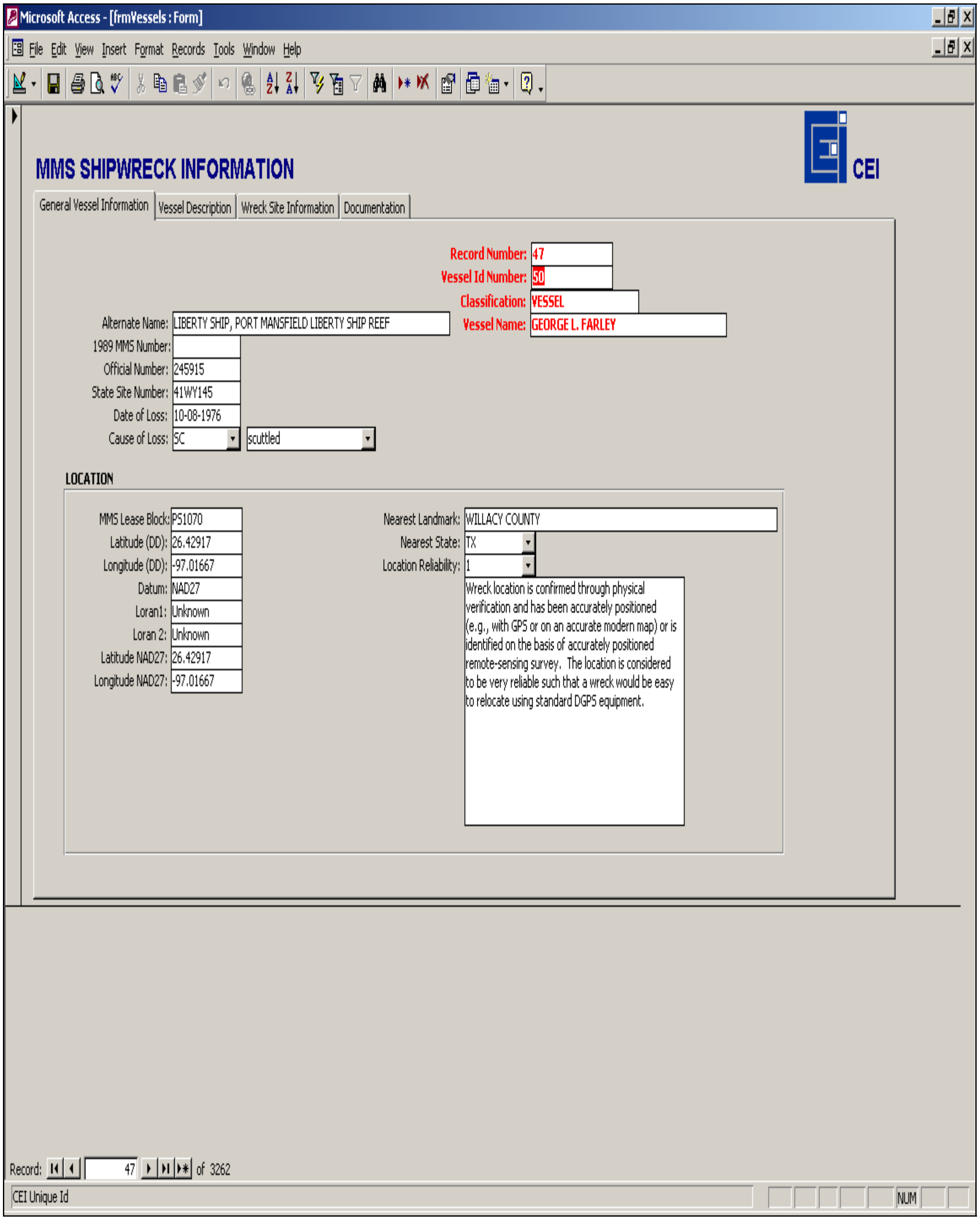
As noted, one reason for including this descriptive information in the database is to enable identification of the vessel should it ever be found, particularly during the course of a mandated MMS lease block survey. For example, information on bow and stern shape might help identify a vessel on the basis of sonar images alone.

Information on only a few of these descriptive variables is available in the sources examined for most of the vessels lost in the study area. For early vessels, this might include only the historic term describing the type of vessel, such as frigate or brig. On the other hand, for more recent vessels such as tankers sunk in World War II, or Liberty Ships scuttled as artificial reefs, descriptive information is comprehensive.

The fourth category of information on the recording form is Wreck Site Information. Data are included for the variables in this category only if the wreck has been examined by divers or the wreck has been recorded on remote-sensing records. Thus, a relatively small number of entries include information in this category.

The final category of information on the recording form is Documentation and includes entries on the sources used for data as well as where data are located or housed. For data derived from MMS archaeological survey reports, all of the information is housed at their offices in New Orleans. Also, for MMS survey reports, the official number assigned to the lease block or pipeline survey for which the report was produced is provided when that information was available. In addition, a “Comment” section is provided where miscellaneous information on the wreck or reported loss can be included. A typical entry here might include the original statement about the location of the loss as presented in the source of information for the entry (e.g., “lost about 25 miles southeast of Galveston”) or statements about the various positions provided for a loss when it appears in more than one source. Finally, the entry form includes spaces for the initials of the researcher compiling the record, the date the record was compiled, and an additional note on the principal source of the information.

As noted, this recording form was used by researchers when collecting information from various sources. Ultimately, all of this information was entered into the Access database developed for this study. The format of the Access database was altered slightly from the recording form to make data entry more efficient. All of the categories in the recording form were maintained, but a few were added, primarily to include variables for manipulating the data. For example, the general categories of “Vessel” or “Object” were assigned to each of the records, as was a variable for “Assigned Lease Block.” This latter variable was used in the program ArcView to automatically assign items to an MMS lease block on the basis of their geographic coordinates. This assignment relied on lease block coordinate data provided by MMS. An example of the four-page Access entry form is shown in Figure 2-3. Appendix B provides explanations and keys to the data fields used in the Access database.



Microsoft Access - [frmVessels : Form]

File Edit View Insert Format Records Tools Window Help

MMS SHIPWRECK INFORMATION

CEI

General Vessel Information | Vessel Description | Wreck Site Information | Documentation

Record Number: 47
Vessel Id Number: 50
Classification: VESSEL
Vessel Name: GEORGE L. FARLEY

Alternate Name: LIBERTY SHIP, PORT MANSFIELD LIBERTY SHIP REEF
1989 MMS Number:
Official Number: 245915
State Site Number: 41WY145
Date of Loss: 10-08-1976
Cause of Loss: SC scuttled

LOCATION

MMS Lease Block: PS1070
Latitude (DD): 26.42917
Longitude (DD): -97.01667
Datum: NAD27
Loran1: Unknown
Loran 2: Unknown
Latitude NAD27: 26.42917
Longitude NAD27: -97.01667

Nearest Landmark: WILLACY COUNTY
Nearest State: TX
Location Reliability: 1

Wreck location is confirmed through physical verification and has been accurately positioned (e.g., with GPS or on an accurate modern map) or is identified on the basis of accurately positioned remote-sensing survey. The location is considered to be very reliable such that a wreck would be easy to relocate using standard DGPS equipment.

Record: 47 of 3262

CEI Unique Id

NUM

Figure 2-3. Microsoft Access entry form, page 1.

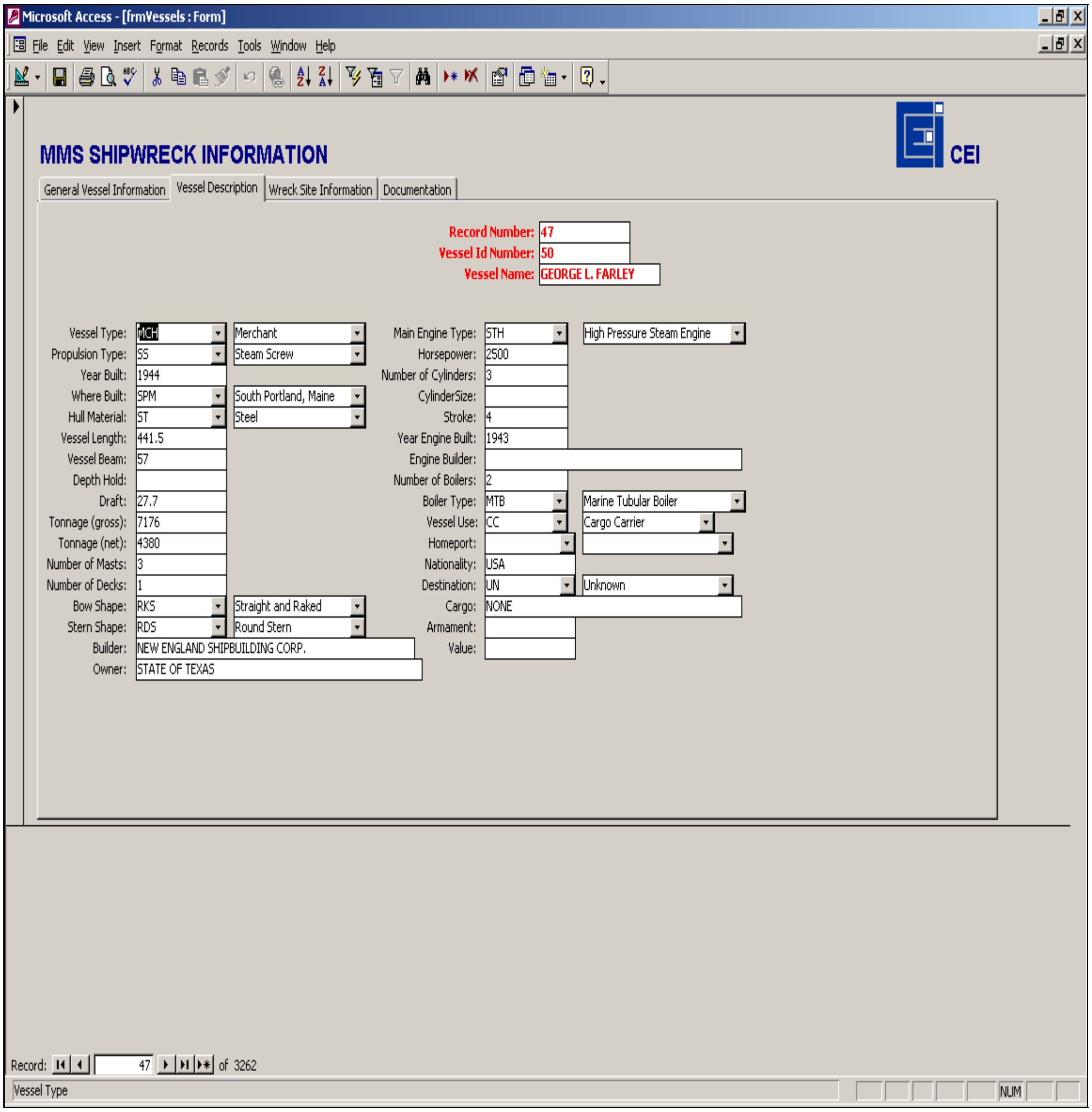


Figure 2-3. Microsoft Access entry form, page 2.

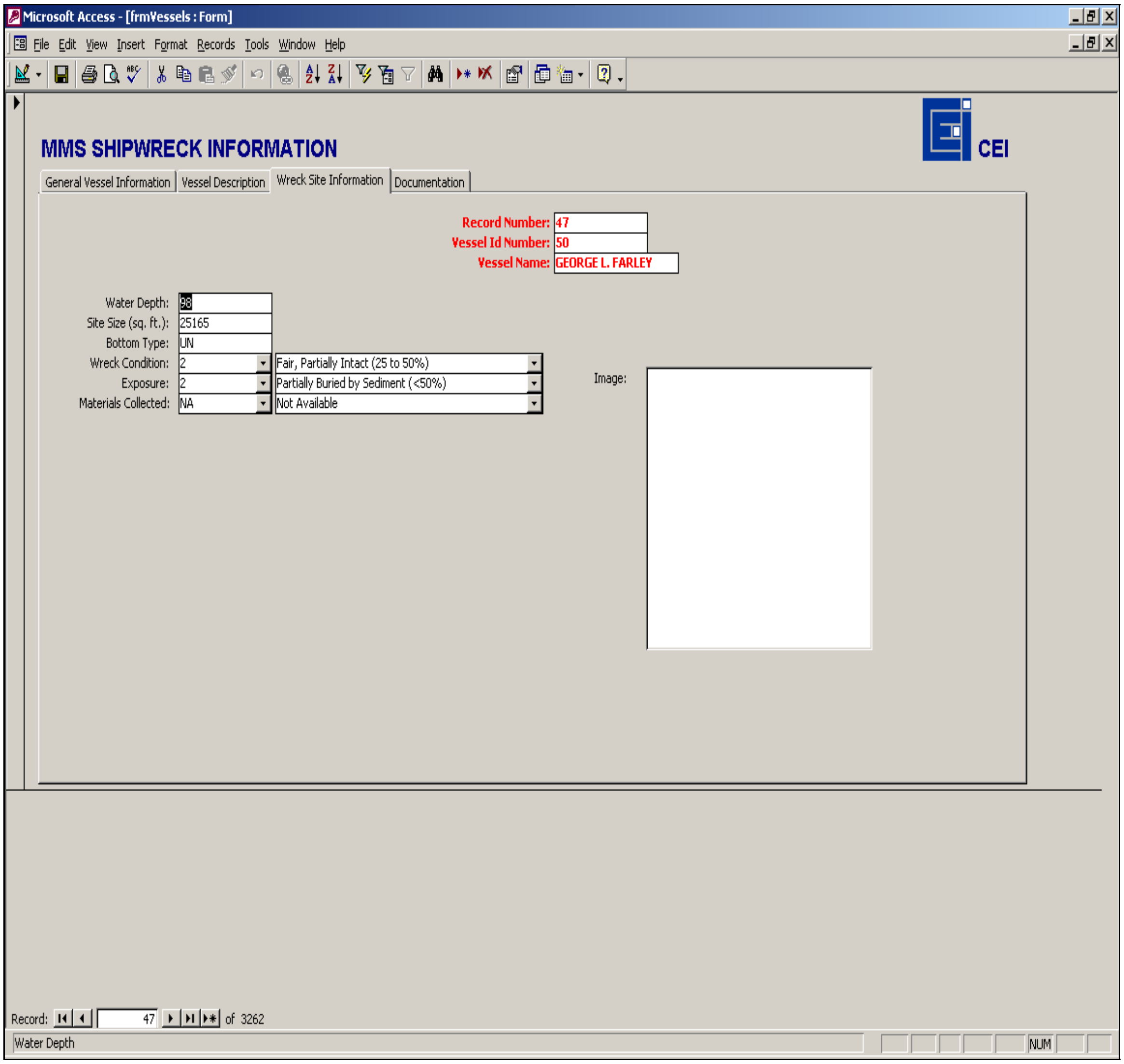


Figure 2-3. Microsoft Access entry form, page 3.

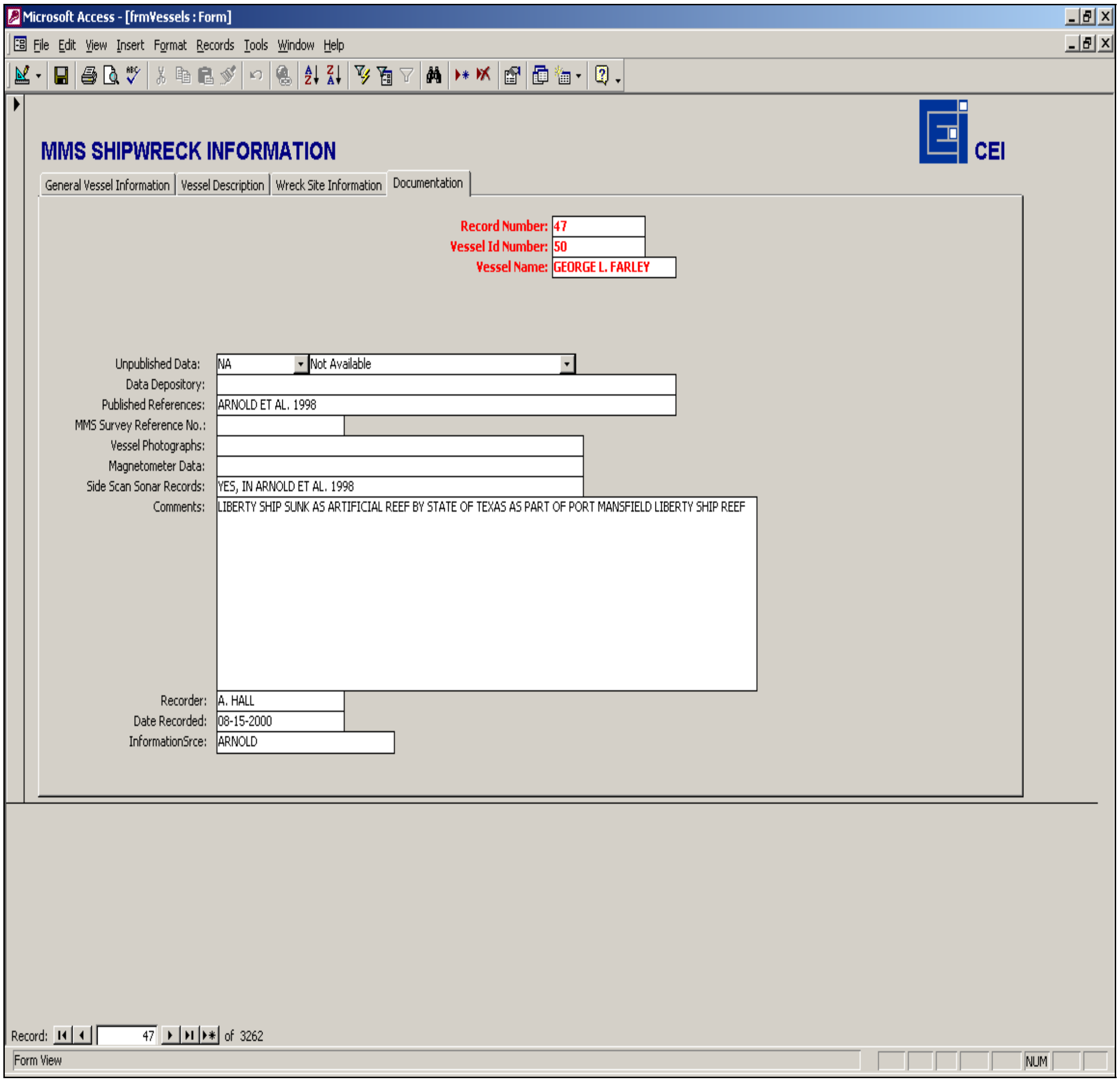


Figure 2-3. Microsoft Access entry form, page 4.

Ultimately, a list of 3,261 shipwrecks and objects was developed from the various sources used. From this a list of 2,106 items classified as shipwrecks has been developed. This list includes named vessels, unknown vessels, fish havens and artificial reefs containing vessels, objects that might be associated with vessels (such as anchors or anchor and cable), as well as helicopters and airplanes. Every effort has been made to remove duplications from this list, but some might remain. This is particularly true in the case of named vessels versus unknown vessels that have very similar or identical locations of loss. Complete discussions on the final shipwreck database are presented in Chapter 4.

3.0: SHIPWRECKS IN THE GULF OF MEXICO AND THE MMS ARCHAEOLOGICAL PROGRAM: THE 1989 MODEL

3.1. Present Model of Shipwreck Occurrence in the Gulf of Mexico

The MMS program for identifying and protecting cultural resources on Federal lands in the Gulf of Mexico began in 1973. As noted, implementation of the program was related to a variety of Federal laws and regulations promulgated prior to that date. Guidance of the program is provided in a series of Notices to Lessees and Letters to Lessees that have been issued since the initiation of the program. These documents have established the requirements and parameters for conducting surveys relative to mineral leasing and operation in the Gulf. Additionally, MMS has funded the several studies mentioned earlier on historic and prehistoric site potentials in the Gulf to aid them in designing and implementing their cultural resources management program. The MMS program of offshore archaeological surveys is the cornerstone of their overall management of the cultural resources in the GOMR. The results of the MMS offshore survey program, in terms of wreck discovery (or non-discovery), provide the principal test of the existing model of shipwreck occurrences in the offshore area. Additionally, the offshore surveys presently provide our best source of information for developing future refinements to this model. Other sources of data, such as new or expanded historical information, as well as specific archaeological programs as is represented by one aspect of the present study, may certainly enhance our understanding of shipwreck resources in the GOMR. But, it is unlikely that any other effort can be undertaken on the scale and magnitude as the present offshore MMS survey program. Thus, an understanding of the current status of that program, its design and implementation, and its relative success in locating shipwreck properties in the Gulf is a critical component of the present study.

The present MMS program of archaeological resources surveys for historic shipwrecks relies largely on the findings and recommendations presented in the Coastal Environments, Inc. (1977) study and, more specifically, in the Garrison et al. (1989) study. Although commonly referred to as a “predictive model” of wreck occurrence in the Gulf, Garrison et al. (1989) do not use this term and present their findings in the form of general statements (Garrison et al. [1989:II-122] use the term extended hypotheses to characterize some of their findings) concerning characteristics of the historic wrecks they found information on and the spatial patterns of these wrecks relative to a variety of historical/cultural and natural factors. In this chapter, a review of the Garrison et al. findings is presented that includes evaluations and assessments of those findings that, in part, have arisen from data collected in this study. Discussions on how the results of the 1989 study have been incorporated into the MMS offshore survey program are presented, followed by an evaluation of the present MMS model of shipwreck occurrences, using primarily data accumulated in MMS mandated cultural resources surveys. In the following discussions the findings of the Garrison et al. study are considered equivalent to the present MMS model of shipwreck occurrences and both are commonly referred to as the "1989 model" or, when referring specifically to the list of shipwrecks developed in the Garrison et al. study, as the "1989 database" or "1989 wreck list."

3.1.1. 1989 MMS Gulf of Mexico Shipwreck Database

As has been discussed earlier, an initial task of the Garrison et al. 1989 study was to develop a listing of shipwrecks that had occurred in the Gulf of Mexico. In developing this list they relied on a variety of sources of information, most of which have been mentioned in previous chapters and many of which, also, were used in the present study. The list of shipwrecks developed in 1989 contained "over 4,000" entries; however, this included many losses in state waters (Garrison et al. 1989:Appendices G and H). That study, as well as others (e.g., Bascom 1971; CEI 1977; Gearhart et al. 1990; Muckelroy 1977), clearly demonstrates that the majority of shipwrecks occur in "nearshore" waters rather than in the open sea. For example, Marx (1971) estimated that almost 98 percent of all vessel losses in the western hemisphere prior to 1825 occurred in less than 10-m of water and within 1.5-km of a coast; others suggest only slightly lower percentages. The data collected by Garrison et al. (1989:I-3) for the Gulf of Mexico indicated that "75 percent of shipwrecks occur in nearshore waters and the remainder in the open sea." What this means is that of the over 4,000 wrecks recorded in the Gulf by Garrison et al. only a small percentage fall in Federal waters. In fact, the final list of "shipwrecks" actually in the GOMR deriving from the 1989 study included a total of 1,469 entries. A discussion of this list is important because it served as a basis for the identification of high-probability areas in the GOMR and served as the starting point for developing a revised listing of wrecks for the present study.

The list of shipwrecks identified in the GOMR in the 1989 study was provided by MMS as a computerized database in Microsoft Excel format. For convenience and to avoid confusion, this list is referred to as the "1989 shipwreck database" in the following discussions. Nine variables are included in this database. These are: 1) Number-an arbitrary number assigned to each entry; 2) Name-the name of the vessel or object (e.g., obstruction or unknown); 3) Date of Loss-year of loss of the vessel if known; 4) Reference Number-a number assigned to or derived from the source of information for the wreck; 5) Source-a code identifying the principal source of information for the wreck; 6) Ship Location-the reported location of the wreck in decimal latitude and longitude; 7) Lease Area-the GOMR lease area in which the wreck falls; 8) Lease Block-the numbered lease block in which the wreck falls; and 9) Centroid Location-the calculated center of the lease block in which the wreck is located in decimal latitude and longitude. This "centroid" concept was used in delineating some high-probability areas as is discussed later.

The 1,469 entries in the 1989 shipwreck database include a number of items in addition to named vessels. These include "obstructions," "fish havens," "liberty ships," and "unknown" vessels. The five "fish havens" in the database represent vessels sunk as artificial reefs and are all derived from the AWOIS listings provided by NOAA, as are the six "liberty ships" in the list. The 23 "obstructions" in the 1989 database represent unidentified sunken objects that apparently have been identified as obstructions to navigation. One of these obstructions is identified as a helicopter, and the source of information on all but one obstruction was the Naval Hydrographic Office (HO). The single exception came from the AWOIS records of NOAA. The 244 items identified as "unknown" represent unknown vessels. Information on these unknowns came from several sources, but mainly AWOIS and HO.

A careful review of the 1989 shipwreck database reveals the presence of a number of duplicate entries for the same vessel. It is apparent that in compiling this listing Garrison et al. (1989) included duplicate information on the same vessel if it appeared in different sources under different spellings or if the same vessel appeared at different locations in these sources. For example, the vessel *Breton Island* appears three times in the 1989 list at slightly different geographic coordinates falling in two different lease blocks. Information on the *Breton Island* was obtained from three different sources. Similarly, the vessel *Capt. Carl* appears twice in the list at slightly different coordinates, although both place the vessel in the same lease block in the West Cameron area. Examples of the same vessel appearing multiple times under slightly different spellings include the *Nona Gail* and *Nona Gale*; the *Cuahuhtemuc* and *Cuahutemac* and the *City S Toledo* and *City of Toledo.* Generally, information on the vessels listed more than once under different spellings was derived from different sources, plus the locations of loss are often slightly different. However, this is not always the case. The vessel listed as the *City S Toledo* and *City of Toledo* is provided at the same position of loss, although the information came from two sources, AWOIS and HO. It should be noted that this vessel was actually named *Cities Services Toledo*, a tanker sunk by a German submarine in World War II (Moore 1990).

The Garrison et al. (1989) inclusion of the same vessel several times because of name or position differences represents a cautionary approach due to the inability in many instances to determine which source of information was correct. In light of the often poor quality and contradictory nature of these sources of information, this approach is not seen as unreasonable if the objective is to be as inclusive as possible when identifying high-probability locations and areas for wreck occurrences. However, these multiple inclusions will skew to varying degrees most attempts to quantitatively characterize the sample of wrecks in the database.

The 1989 shipwreck database also includes 240 vessels that fall in lease blocks within state waters. Three of these vessels are in Louisiana waters; the remaining 237 are in the state waters of Texas. Several of the Texas state lease blocks contain large numbers of shipwrecks. For example, the 1989 database assigned 58 shipwrecks to the same lease block in the South Padre Island Area and all, in fact, have been assigned the same geographic coordinates. Information on almost all of these wrecks comes from TAC files and they have been assigned the same coordinates because the historical information on their place of loss is so vague. For example, many of these vessels are simply reported as lost near or off Brazos Santiago Pass, the entrance into Brownsville at the lower end of Padre Island.

When identifiable duplicates are removed from the 1989 shipwreck database, there appear to be 1,222 unique entries, although even here some duplications might still exist. Of these entries, 986 are vessels falling in Federal waters, 214 are vessels falling in state waters, and 22 items are “obstructions.”

The complete 1989 shipwreck database of 1,469 entries is important because it was used as a principal source for identifying high-probability areas for shipwreck occurrences in the GOMR. Ultimately, the 936 lease blocks in which these 1,469 wrecks fall, plus adjacent blocks, were identified by MMS as high-probability locations and any development of these blocks would require a survey strategy designed specifically to locate historic shipwrecks. More complete discussions on these survey requirements are presented below.

3.1.2. Characteristics of the 1989 Model of Shipwrecks in the GOMR

3.1.2.1. Historical Setting

The development of a listing of shipwrecks was only one aspect of the Garrison et al. (1989) study. That study also presented a synthesis of the maritime history of the Gulf of Mexico, extending from 1508 when Sebastian de Ocampo became the first European to sail on Gulf waters (Weddle 1985), to the 1980s. This synthesis looked at the positions of shipping routes and the development of ports in the Gulf of Mexico area over time as precursors for understanding the distribution of shipwrecks in the region. The findings of the present study did not indicate significant differences in the historical overview presented in Garrison et al. Where divergences do exist, they are mainly differences in emphasis on specific historic topics or trends. These differences are more fully considered in the following chapter in discussions concerning the newly developed shipwreck database. The historical overview developed by Garrison et al. (1989) is briefly reviewed here.

The historical assessment by Garrison et al. (1989) showed that prior to 1700, the trade routes in the Gulf were largely keyed to Spanish trade out of various ports along the eastern coast of Mexico, of which Veracruz was the most important, and Central America. Out of these ports the wealth of “New Spain” was carried back to Spain. Ports in the Caribbean, such as Havana on Cuba and others on the island of Santa Domingo, became important as stopping points for vessels traveling into and out of the Gulf (Garrison et al. 1989:II-31–11-33). Havana, in particular, became significant as the assembly point for the two principal Spanish convoys sailing annually between Spain and the New World from the sixteenth to the end of the eighteenth century. These were the New Spain *flota*, which sailed from Spain to Veracruz, and the Terra Firma *flota* that sailed from Spain for Cartagena on the coast of Colombia. Both of these fleets were to gather in Havana on their return to Spain (Pearson and Hoffman 1995:10).

The arrival of the French in the Gulf region in the late 1600s lead to the development of several ports along the northern Gulf coast, such as Biloxi, Mobile, and New Orleans. The growth of these and other ports and their increasing participation in maritime trade lead to a shift in Gulf trade routes in the eighteenth century. Shipping activity was now concentrated along the central and eastern Gulf coast from about the mouth of the Mississippi River eastward. The French also maintained trade connections with their colonies in the Caribbean and, to a lesser extent, carried on trade with Spanish ports in New Spain and Cuba.

The second half of the eighteenth century saw an increase in coastal trade along the northern Gulf coast. In 1763, the French lost their holdings in Louisiana to Spain and Britain but several of the old colonial ports remained important, particularly New Orleans, Mobile and Pensacola. Trade continued to increase, particularly after the United States' acquisition of Louisiana in 1803 and Florida in 1819. The expansion of cotton agriculture into the states of Alabama, Mississippi, and Louisiana in the 1820s and 1830s had a great stimulus on maritime trade in the Gulf. Cotton became the principal cargo shipped out of ports such as New Orleans and Mobile and was carried by sailing vessel, and later steamship, to ports on the East coast, particularly New York, and Europe. At about this same time, as Garrison et al. (1989:II-23) point out, there was an expansion in the coastal trade west of the Mississippi River with the establishment of the Texas Republic in 1836. Large numbers of sailing vessels of all sizes as well as steamers were operating in the Gulf of Mexico during the period from 1830 to 1860. Numerous small sloops and schooners as well as paddlewheel steamers were involved in the local "coasting" trade carrying produce between coastal towns and communities from Florida to Texas. Larger sailing vessels and steamships were carrying cotton in huge quantities from New Orleans and Mobile out of the Gulf to distant American ports such as New York or to Europe.

The advent of the Civil War, however, stopped all normal maritime commercial activity in the Gulf. The establishment of the Federal blockade along the coast stopped most vessels from entering and leaving ports after 1861; only a few blockade runners remained active during the war.

Maritime commerce in the Gulf began to revive after the Civil War. Southern ports soon established or reestablished direct trade connections with ports in South America, Europe, the eastern United States and the Caribbean. Over time, fewer and fewer United States vessels were used in this and other maritime trades, as a wide variety of foreign vessels began to call at the old Gulf coast ports, as well as new ones, like Tampa and Port Arthur. New commodities, such as oil, joined and began to replace some of the traditional exports of the region. Garrison et al. (1989:II-23) note that the Gulf trading patterns and routes established in the latter part of the nineteenth century continued with relatively little change up to World War II. Established trading routes were disrupted during the war, in part because of the operation of 24 German submarines in the Gulf of Mexico that were successful in sinking over 50 vessels (Wiggins 1995:238). With the revival of commercial traffic after World War II, there was an increase in traffic to secondary ports along the Gulf coast. The commodities carried by vessels did change over time, with oil, grain and manufactured goods becoming increasingly important exports. By the 1980s, the port of Galveston-Houston had become the largest in the Gulf in terms of vessel traffic, followed by New Orleans-Mississippi

River. The twentieth century did see a shift in the position of Gulf trade routes, as the "principal axis of traffic shifted westward from the east-central Gulf to the west-central," a reversal of the trend seen in the late nineteenth century (Garrison et al. 1989:II-23). A principal factor in this shift was the opening of the Panama Canal in 1914.

As noted, Garrison et al. (1989) provided this brief overview of the history of maritime traffic in the Gulf of Mexico to set the stage for various analyses of the shipwreck database they developed. Particularly important was the establishment and locations of trade routes and ports over time, two variables that they used in analyses of shipwreck distributions in the Gulf.

3.1.2.2. Natural Setting

Garrison et al. (1989) present discussions on the natural setting in the Gulf of Mexico specifically as it related to its impact on the occurrence and distribution of shipwrecks. They examined the occurrence of prominent natural hazards, such as reefs, barrier islands, shoals and bars, and the impacts they have had on navigation and on vessel loss. Garrison et al. (1989) also examined winds, currents and waves in the Gulf as causal factors of vessel loss in the Gulf. Natural wind and current patterns were particularly critical during the age of sail when vessels attempted to take advantage of these natural forces whenever possible (Hoffman 1980). Thus, the positions of early sailing routes were, to varying degrees, influenced by natural forces, particularly the patterns of winds and currents.

Current circulation in the Gulf of Mexico is fairly complex and involves the interaction of the dominant current, known as the Loop Current, and associated eddies. The deeper waters of the Gulf are dominated by the Loop Current, which roughly occupies the central Gulf. This current that enters the Gulf from the south makes a large sweeping clockwise arc around the Gulf and exits to the east through the Straights of Florida, to become the Gulf Stream in the Atlantic (Sturges 1993) (Figure 3-1). The path of the Loop Current varies over time; portions might be only 10 to 20-km wide and represent near-surface phenomena, while the full current might be 100-km wide and penetrate to depths of 1,000 meters (Sturges 1993:28). The Loop Current often doubles back on itself and strong "ring" currents often break off and continue to flow in a large circle in the western Gulf.

The shallow waters of the Gulf of Mexico, as they exist on the Outer Continental Shelf, are influenced by eddies produced by the Loop Current as well as by winds, tides and freshwater inflow (Garrison et al. 1989:II-51). In the central and western Gulf, the inshore flow is normally westward except during the summer months of June, July and August, when it reverses and flows to the east. The westward flow is driven by the prevailing winds, the easterly trades that blow generally in a westward direction for much of the year. The inshore current flows in the eastern Gulf, along the coast of Florida, are somewhat more variable because the prevailing easterlies blow across the shelf, limiting the ability of longshore wind-driven currents to develop (Sturges 1993:38-39). During the summer months, the inshore current in the western Gulf reverses direction and flows to the east (Garrison 1989:II-51).

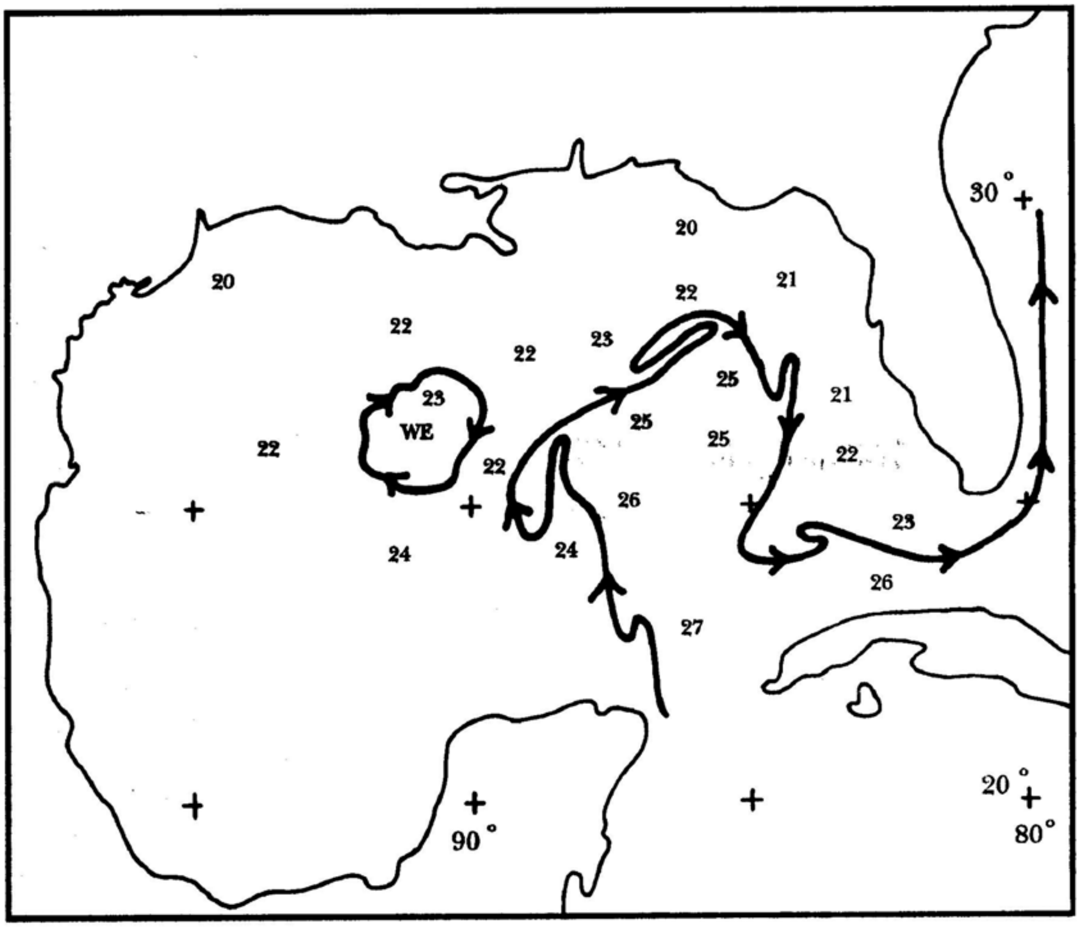


Figure 3-1. Position of the Loop Current on January 2, 1982. The values represent sea surface temperatures. The circular feature marked "WE" is a small anticyclonic, eddy or detached ring (Sturges 1993:Figure 3.3).

The wind regime in the Gulf of Mexico is dominated by the prevailing trade winds that blow generally from the east. In the western Gulf, wind direction varies from a generally southwesterly flow in the summer to a northeasterly direction in the winter. The wind direction in the eastern Gulf is less variable and most typically blows in a generally westward direction (Garrison et al. 1989:II-51; Sturges 1993:42-44). This prevailing wind regime is periodically interrupted by two other wind systems, "northers" and hurricanes. During winter months, transient frontal systems, known as northers, periodically move south from the continental United States into the Gulf of Mexico. These frontal systems are often accompanied by strong winds that can create waves up to seven meters high. These frontal systems often had deleterious impacts on vessels traveling in the upper latitudes of the Gulf.

Hurricanes represent the strongest wind systems in the Gulf of Mexico and have the greatest potential for damaging and sinking vessels. However, hurricanes are rare events, with historical data indicating an average of only one hurricane a year entering the Gulf of Mexico (Hayes 1967; Henry et al. 1975; Tannehill 1956). Garrison et al. (1989:II-53-54) looked at hurricane paths and frequencies in the Gulf and their impacts on vessel losses for the period from the earliest accounts of hurricane losses in the mid-1500s up to the 1980s. They note that the paths of historic hurricanes in the Gulf are difficult to plot accurately because they are so variable. As a result, it is difficult to accurately correlate hurricanes with vessel losses unless there is a specific historical account relating the loss to a specific hurricane. In their analysis of hurricane and vessel loss data, Garrison et al. (1989:II-54) did not see a "strong correlation between hurricanes and shipwrecks" and suggested that storms acted "only in concert with other variables such as port location and shipping routes" in creating vessel losses.

3.1.2.3. Factors of Shipwreck Preservation in the Gulf of Mexico

The 1989 study also examined factors that might lead to the preservation of historic shipwrecks in the GOMR by looking at pertinent environmental factors and their known or presumed impacts on wrecks. In terms of wooden shipwrecks, Garrison et al. (1989:II-69) note that the principal element in estimating preservation is "the identification of the burial sediment, its depth, and the inherent biological communities associated with such conditions." Using a series of examples of historic wrecks from various settings in the Gulf and elsewhere, they looked at the impacts of various natural factors on wreck preservation. These factors included sediment characteristics, energy zones, and biological and chemical factors. Comparing these factors against conditions found at several specific shipwrecks, they drew several conclusions about the relationship of preservation to site-specific environment. In general, the study concluded that "preservation is enhanced in fine-grained sediment and low energy environments and reduced in coarse grained sediment and dynamic environments" although rapid burial of remains, even in coarser-grained sediments, can reduce deterioration. They also note that preservation can be enhanced in oxygen-deprived deepwater settings, such as found in parts of the northwestern Gulf of Mexico (Garrison et al. 1989:II-83; Rezak et al. 1985).

From this assessment of these various environmental factors on known shipwrecks, the Garrison et al. study projected expected preservation potentials for various areas of the Gulf of Mexico in terms of High, Moderate, or Low potential (Garrison et al. 1989:Figure II-24).

3.1.2.4. Analysis of the Spatial Distributions of Shipwrecks in the 1989 Study

The 1989 study relied on a variety of statistical analyses to examine the shipwreck database developed. Most of these analyses were directed at trying to assess the causal factors behind observed spatial patterns seen in vessel losses. In addition, the study looked at chronological trends in vessel losses and related these to several factors, such as the development and distribution of ports around the Gulf and the shifting positions of principal trade routes. Because that study collected only minimal information on vessel characteristics, specifically the year of loss, characterization of the population of wrecks in the database was limited to assessing the interrelationships of chronological factors and spatial patterning.

In addition to looking at the simple spatial distribution of wrecks in the Gulf of Mexico on the basis of reported position of loss, Garrison et al. (1989:II-86-II-114) looked at vessel losses within quadrants of 0.5- and 1.0-degrees of latitude and longitude in size and within the 3-mile-square standard MMS lease block. The 0.5-degree quadrant analysis did show spatially discrete concentrations of wrecks that tended to be associated with port locations and, to a lesser extent, with areas of marine hazards. Cluster analysis was used to examine the association of 3-mile-square lease blocks on the basis of the number of vessels they contained and the dates of losses of these vessels. Finally, factor analysis was conducted on the wrecks in the database in an effort to discriminate some of the causal factors behind the distribution of shipwrecks seen across the Gulf. One analysis was concerned with chronological factors, and looked at the relationships between the location of wrecks against seven variables: four time periods (seventeenth, eighteenth, nineteenth, and twentieth centuries), age of ports, ports, and storms. The location of wrecks was based on the recorded position of the loss in one of 26 areas that consist of 1-degree-wide areas along the Gulf coastline from Brownsville to the Dry Tortugas. Garrison et al. (1989:II-109) note that this analysis relates only to vessels lost along "the Gulf coastline," but it is impossible to tell from the discussions how far out in the Gulf the 26 areas, and thus shipwrecks, used in the analysis extended. Interpretation of the results of this factor analysis showed several things: 1) a spatial association of sixteenth, seventeenth and eighteenth century wrecks versus eighteenth and nineteenth century wrecks; 2) a moderate association of nineteenth century shipwrecks and port development; and 3) the presence of a port seemed to be more strongly associated with wreck frequency than with the number of years the port was in existence (Garrison et al. 1989:II-110).

The second factor analysis was concerned with areal factors and used six variables (hurricanes, ports, routes, hazards, energy, and wrecks) and 10 cases (time periods) per variable. Ten large areas encompassing the GOMR were compared using these variables in relation to shipwreck frequencies in the areas. Although Garrison et al. (1989:II-110) state that each of the six variables was considered within 10 time periods, these periods are not defined and it is unknown if these represent even historical time intervals since circa 1600 or are the uneven intervals used in the cluster analysis noted above (i.e., 1600 to 1699, 1700 to 1749, 1750 to 1799, 1800 to 1849, 1850 to 1899, 1900 to 1919, 1920 to 1939, 1940 to 1959, 1960 to 1979, and 1980 to 1988 [see Garrison et al. 1989:Figure II-42]). The 10 areas were: 1. Rio Grande, 2. Western Area, 3. Central Area, 4. Central Louisiana, 5. Miss./Alabama, 6. West Florida, 7. Big Bend, 8. Middle Ground, 9. Southwest Florida, and 10. Dry Tortugas (Garrison et al. 1989:III–J-23).

3.1.2.5. Summary of Findings of the 1989 Study

Garrison et al. (1989) note that the observed spatial distributions of shipwrecks in the Gulf of Mexico do not always explain the causal factors behind these distributions. That study's efforts at factor and cluster analyses showed some relationships between positions of vessel loss and a variety of variables, but the causal link between the two is not always evident. Among the general findings of the study was the fact that vessel losses in the Gulf increased over time, which they attribute in part to improved technology that leads modern mariners to expose their vessels to greater risks than earlier navigators would have. The study also found a general association between hurricane frequency and the occurrence of wrecks, but the "highest hurricane frequency areas" did not always exhibit the highest occurrence of losses (Garrison et al. 1989:II-115). Garrison et al. did note that it was very difficult to correlate individual vessel losses with specific hurricanes or hurricane paths because of the often minimal information in the historic records.

Another finding of the 1989 study was that wrecks did tend to concentrate at natural hazards, as was expected. This was particularly evident in the over 300-km-long complex of reefs and shoals forming the Florida Keys, the Marquesas and the Dry Tortugas. Here, the "convergence of winds, current, reefs, and storms" all contributed to making this probably the most dangerous portion of the Gulf, particularly for sailing vessels (Garrison et al. 1989:II-115). Even after the advent of steam, this area remained dangerous for shipping.

Garrison et al. (1989:II-116) observed several broad-scale patterns in the distribution of shipwrecks in the Gulf. For one, there was an increase in losses in the open waters of the eastern Gulf in the late nineteenth and twentieth century, related to changes in shipping routes. For this same period, losses in the western Gulf tended to occur in nearshore areas such that open water losses in the western Gulf were less than half of those seen in the open waters of the eastern Gulf. The factors behind these differences were not readily apparent, but they were thought to be linked to traffic patterns (Garrison et al. 1989:II-116).

Garrison et al. (1989), in particular, show that shipwrecks in the Gulf are concentrated in the nearshore areas, a point mentioned earlier and one observed by most researchers. Further, the 1989 study showed a strong correlation between the locations of wrecks and ports, a trend that is most evident beginning in the nineteenth century. It was also found that the number of shipwrecks in the Gulf closely followed the number of ports established (Garrison et al. 1989:II-120).

Relying on their findings concerning shipwreck distributions and preservation potential, Garrison et al. (1989:II-122) assigned values of high, moderate or low to the 66 MMS-identified areas and subareas in the GOMR for the categories of "shipwreck potential" and "preservation potential." Shipwreck potential was based on density of wrecks occurring in the area or subarea and were: low ≤ 175 wrecks per area; moderate = 175 to 500 wrecks per area; and high ≥ 500 wrecks per area. Values for preservation potential were derived from assumptions about the natural conditions found in the areas relative to vessel preservation. These two values, shipwreck potential and preservation potential, were merged to obtain an "overall potential" for each of the 66 areas.

From this assignation of potentials to areas, Garrison et al. (1989:II-122) noted several trends in the shipwreck data. These were: 1) an increased distribution of wrecks in the eastern Gulf area away from the nearshore zone, but a lower preservation potential relative to the central and western Gulf; 2) more early wrecks in the central and Eastern Gulf than had been previously thought; and 3) an increased potential for unreported wrecks in high density areas because of higher preservation potential.

Out of these findings, the 1989 study recommended several changes in Cultural Resources Management Zone 1 (CRMZ1) (also called Archaeological Resource Management Zone 1 [ARMZ1]), the identified shipwreck high-probability area then used by MMS to guide offshore lease block surveys. Garrison et al. (1989:II-123) recommended the following: 1) the CRMZ1 should be moved to within 10-km of the coast; 2) delineation of several specific high-probability zones in the vicinity of several ports and navigation hazards where high densities of wrecks were identified; and 3) delineation of individual high-probability lease blocks outside of CRMZ1 and the high-probability zones related to the occurrence of specific historic shipwrecks. Because of the often unreliability of the reported positions of vessel losses, the eight contiguous lease blocks surrounding these individual blocks should, also, be considered high-probability areas. Subsequently, this latter factor came to be called the “centroid concept.”

3.2. Application of the 1989 Model of Shipwrecks in the Gulf of Mexico to Cultural Resources Management by MMS

Because of the findings in the Garrison et al. study, the MMS redefined the area that had been designated as “high probability” in terms of historic shipwreck occurrence and the remote-sensing survey techniques and strategies to be used. Prior to 1989 and based on the 1977 Coastal Environments, Inc. study, all of the area shoreward of a line roughly between the 40 and 60-m bathymetric contour line had been identified as Cultural Resources Management Zone 1 (CRMZ1) or Archaeological Resource Management Zone 1 (ARMZ1). This zone had been considered the high-probability area in terms of historic shipwreck occurrence and was the area requiring the most stringent remote-sensing survey strategies. As a result of the 1989 study, which showed that approximately 80 percent of historic vessels were lost within 10 km of the shoreline, MMS shifted the outer boundary of ARMZ1 to a point 10-km from the Gulf shoreline. This placed most of the newly defined high-probability area in state waters and whereas ARMZ1 originally contained an estimated 3,410 lease blocks, the redefinition of the boundary reduced this number considerably (MMS 1990). MMS also accepted the findings of the 0.5-degree quadrant analysis presented by Garrison et al. that identified twenty-one 0.5-degree quadrants displaying reported shipwreck densities sufficient to identify them as high-probability areas. These 21 quadrants were closely associated with port locations or specific natural hazards; most of the lease blocks they contained fell in state waters, outside of the boundaries of the GOMR. Finally, MMS adopted the centroid concept proposed by Garrison et al. (1989) wherein a number of high-probability areas consisting of units of nine contiguous lease blocks were identified (MMS 1990). These units were defined because of the recognition that location data on so many shipwrecks was so poor that it was deemed reasonable to encompass a larger area than the individual lease block in which the vessel was reported to have been lost. These units consisted of that lease block, plus the eight contiguous blocks. These nine-block units fell outside of the other identified high-probability areas and tend to be scattered widely across the GOMR.

As a result of the 1989 study, in 1990 MMS estimated that it reduced the number of high-probability lease blocks from approximately 3,410 to 710 (MMS 1990:3). Included in these 710 lease blocks were those that contained wrecks previously discovered by MMS-mandated surveys, a factor not considered in the Garrison et al. recommendations. Essentially, these blocks were those that would be subjected to survey strategies designed specifically to locate historic shipwrecks.

The Garrison et al. study also conducted a reevaluation of the remote-sensing survey strategies then being employed in the GOMR, and the recommendations from these findings were incorporated by MMS into their survey requirements. Complete discussions on this aspect of the Garrison et al. study are provided in the second section of this report, but they are briefly mentioned here to provide a background for the following discussions on the results of offshore surveys as tests of the 1989 model. Garrison et al. (1989) recommended, and MMS accepted, that the survey line spacing in the newly identified high-probability lease blocks would be reduced from 150-m to 50-m if the water depth in that lease block was less than 60-m. The other survey requirements then in place, particularly the use of magnetometer and sidescan sonar, would be maintained. Those high-probability lease blocks with water depths greater than 60-m would require surveys with line spacing of 300-m, and no magnetometer would be required because of the recognized difficulty of maintaining the position of a magnetometer sensor at great depths (MMS 1990:2-3).

The redefinition of high-probability areas and change in survey strategies by MMS established the parameters for offshore surveys as they have been conducted for the past 12 years. Ultimately, the findings of these surveys provide the basis for testing the model of shipwreck occurrence as developed by Garrison et al. (1989). Discussions on the conduct of lease block surveys and their findings relative to the present MMS shipwreck model are presented below.

3.2.1. MMS Archaeological Survey Requirements

The conduct of cultural resources remote-sensing surveys in the Gulf of Mexico and the requirements for reporting on these surveys have been established in a series of Notices to Lessees (NTLs) issued since 1974. These NTLs provide specific information and guidelines for conducting cultural resources surveys on the OCS in the GOMR to all lessees and operators of Federal oil, gas, sulfur and salt leases and pipeline rights-of-way in the area. The NTLs provide information on required survey parameters and instrumentation for use in designated lease blocks and establish the standards for the archaeological resource reports required of every survey. In addition to the NTLs, MMS has released a series of Letters to Lessees (LTLs) that mainly convey clarifications or provide timely pertinent information.

Since 1975, changes in survey and report requirements have been incorporated into these NTLs as knowledge of the potential cultural resources of the GOMR has been refined, as technological advancements have occurred in the survey and geophysical equipment used, and as pertinent regulatory authorities have changed. Presently (2002), archaeological survey requirements in the GOMR are guided by Notice to Lessee No. 2002-G01, effective March 15, 2002. This new NTL (NTL No. 2002-G01) replaces NTL No. 98-06, issued August 10, 1998. The Notices to Lessees provide guidelines relative to drowned terrestrial prehistoric sites on the OCS as well as to historic period shipwrecks and lighthouses. Only the historic period sites are of concern here. As noted, the present requirements for survey for historic shipwreck sites are largely derived from the findings of the Garrison et al. (1989) study.

To guide its mineral leasing activities, the Federal government has divided the lands of the GOMR into 3-mile-square (23.3 km^2) lease blocks. Groups of numbered lease blocks are incorporated into larger areas. Presently there are 70 lease areas designated in the GOMR (see Figure 2-2). The number of lease blocks within each lease area varies considerably. For example, the South Pass Area, just off the mouth of the Mississippi River, contains fewer than 100 lease blocks, while several of the larger areas in the central Gulf (e.g., Atwater Valley Area, Lloyd Ridge Area, Henderson Area) contain over 1,000 lease blocks. In those areas adjacent to the coast, many numbered lease blocks fall completely or partially within state waters and thus outside of the boundaries of the project area of the present study. Although the 3-mile-square is the standard lease block size, numerous smaller blocks occur, specifically where boundaries have been established between lease areas. The 3-mile-square lease block is extremely important because it is the principal spatial unit that is used to incorporate the model of shipwreck occurrences in the Gulf and it is the principal unit around which decisions are made relative to the need for archaeological surveys. Additionally, other than pipeline routes or specific well sites, the lease block represents the standard physical unit within which most MMS-mandated archaeological surveys are conducted. Thus, it represents a standard unit for making various sorts of quantitative comparisons across the vast area of the GOMR.

MMS does not require cultural resources surveys in all offshore lease blocks, only those known or considered highly likely to contain significant cultural resources, based on the best available data. The survey requirements vary dependent upon whether the lease block has been identified as having a high potential for containing shipwrecks or a high potential for containing prehistoric sites. In regard to historic shipwrecks, MMS requires two levels of archaeological resources surveys. In accordance with the guidelines established by the latest NTL, effective March 15, 2002, for those lease blocks identified as having a high probability of containing historic resources (i.e., principally shipwrecks) and which exhibit water depths of 200-m (656 ft.) or less, the survey lines must be no more than 50-m (164 ft.) apart. In those lease blocks with a high probability of containing shipwrecks that fall in areas with water depths greater than 200-m, survey line spacing must be no more than 300-m (984 ft.) apart. This latter spacing also is the requirement for all lease blocks deemed to have a high probability of containing prehistoric archaeological sites, regardless of water depth (MMS 2002). These same standards are applied to pipeline rights-of-way and drilling platform sites.

The water depth parameters embodied in the new NTL represent a significant difference over earlier requirements. The requirements in place between 1990 and 2002 used a water depth of 60-m as the separation between the 50-m survey line spacing and the 300-m spacing relative to historic shipwrecks (MMS 1998). These were the requirements in place over most of the period of the present study such that various figures and analyses typically reference the 60-m contour as well as the 200-m contour. Prior to 1990, the MMS mandated a survey line spacing of 150 m in all of the lease blocks then assigned to the high-probability zone known as Archaeological Resources Management Zone 1. It should be noted that all of the MMS survey data utilized in this study was collected using the pre-2002 line spacing and water depth requirements. Additionally, all of the lease blocks presently identified as high-probability locales relative to prehistoric sites fall in water depths of less than 60-m and all of these require the 300-m spacing survey. This is important to recognize because, as is noted below, many of the shipwrecks identified by MMS-mandated surveys resulting from the 1989 study have been found in those lease blocks where survey was conducted because the block was deemed to have a high potential for containing prehistoric sites, not historic shipwrecks.

In those surveys requiring 50-m survey line spacing, the required remote-sensing instruments are a proton precession or cesium total field magnetometer; a dual-channel, dual-frequency sidescan sonar system; a high frequency sub-bottom acoustic profiler; and a high frequency, narrow beam hydrographic echo sounder. The MMS also requires specific operating parameters for these instruments. For instance, the magnetometer sensor must be fitted with a depth sensor and it must be towed no more than 6-m (20 ft.) above the seafloor, and the sidescan sonar system must be operated in the 300 to 500 kHz range in water depths less than 200-m (MMS 2002). Navigation for surveys must utilize "a state-of-the-art continuous positioning system correlated to annotated geophysical records" (MMS 2002). In recent years, essentially all surveys have been conducted using differentially corrected geographic positioning systems (DGPS).

The principal equipment difference between surveys requiring 50-m line spacing and those requiring 300-m spacing is that the magnetometer is not required in the latter when water depths are greater than 200 m. This is in part because of the difficulty in controlling the position of the sensor at great depths, but also because the survey line spacing is so great that even large ferrous objects, like a shipwreck, could easily go undetected if they fell between two survey lines. The sidescan sonar is required in those 300-m blocks identified as having a high potential for containing prehistoric sites and, as noted, its use in these circumstances has been instrumental in identifying the majority of shipwrecks in the GOMR to date.

For historic shipwrecks, the two most critical instruments are the magnetometer and sidescan sonar and, as is discussed below, the sidescan sonar has been most heavily relied on in the identification of shipwrecks. The other instruments in the equipment array, the subbottom profiler and depth sounder, are less commonly relied on in the identification of wrecks, but sometimes they will provide information on the elevation of a particular wreck, if the instrument passes directly over the target.

In addition to these equipment requirements, the NTLs also provide information on the requirements of the archaeological survey report that is to be submitted to the MMS upon completion of the remote-sensing survey.

3.2.2. Results of MMS-Mandated Archaeological Surveys: Testing the 1989 Model of Shipwreck Occurrences

3.2.2.1. Identification of High-Probability Lease Blocks

The results of the Garrison et al. (1989) study have guided the implementation of the MMS archaeological survey program for the past 12 years. The results of that survey program provide our best measure of the utility and reliability of the model of wreck distributions derived from the 1989 study. Evaluation of the model requires information on a variety of parameters. For example, it is important to know which high-probability lease blocks were originally designated from the 1989 study, which of these high-probability lease blocks have been surveyed, and what are the results of those surveys. Additionally, in order to obtain some quantitative measure of the reliability or "predictability" of the 1989 model of shipwreck distributions, it is important to have the same categories of information for those lease blocks identified as unlikely to contain shipwrecks.

Exactly how many and which lease blocks have been identified as high-probability blocks for shipwrecks is of critical importance. The Garrison et al. (1989) study does not provide a specific list of the high-probability lease blocks ultimately identified, but their list of shipwrecks and their recommendations concerning the identification of groups of lease blocks with high probabilities for containing wrecks were used to develop the list. In their final shipwreck database Garrison et al. identified 1,469 "shipwrecks." These shipwrecks fall into 851 offshore lease blocks. Seventy-two of these lease blocks fall in state waters; the remaining 779 lease blocks fall in the GOMR and are of principal interest here. As noted, however, this total number of wrecks included many duplicates as well as some items classified as "obstructions" that may or may not be actual vessels. Regardless, these 1,469 entries have served the MMS as one basis for identifying high-probability areas in the GOMR. Working from this list of wrecks, the MMS followed the recommendations of the 1989 study and designated groups of high-probability lease blocks consisting of those falling within 10-km of the coast line; those falling within the 0.5 degree quadrants which contain high densities of reported wrecks; and the numerous nine-lease block units selected because of questions about the reliability of a specific record of loss.

A comparison of the shipwreck database developed by Garrison et al. against the lease blocks ultimately selected shows that the MMS utilized only reported vessel losses greater than 50 years old to assign as center points for the nine-lease block units.

Younger wrecks and those for which no date of loss was known were not used in the identification of the nine-lease block units. For example, Garrison et al. (1989) had originally identified five vessel losses in the southern third of the Vermilion Area off the western Louisiana coast. These losses all occur outside of the 60-meter depth zone. These vessels were the *Alaria*, a vessel that sank in 1975; the *Barger*, date of loss unknown; the *Swiftfish*, date of loss unknown, the *Righard P*., date of loss unknown; and an unknown vessel, also with an unknown date of loss. Because the *Alaria's* loss had occurred less than 50 years earlier and because no information was available indicating any of the other vessels were over 50 years old, the MMS has designated no high-probability areas in association with these reported wrecks.

Since 1989, additions and subtractions have been made to the original list of lease blocks identified as high-probability locales for historic shipwrecks, and no compilation of the originally identified blocks seems to exist (Rik Anuskiewicz, personal communication 2002). Therefore, it has been necessary to reconstruct that original list from data currently at hand. The MMS office in New Orleans provides specific information to offshore lessees as to the survey requirements in the GOMR, including a list of which offshore blocks require 50-m survey spacing (designated "50-m blocks" in the following discussions) and which ones require 300-m spacing (designated "300-m blocks"). This list is currently available online at the MMS, Gulf of Mexico Region, New Orleans office webpage (www.gomr.mms.gov), and it was accessed in November 2001 to obtain a listing of high-probability lease blocks. This list includes 1,830 lease blocks requiring 50-m survey line spacing, all of which are designated high-probability lease blocks for historic shipwrecks. The list also includes over 6,000 lease blocks that require surveys at 300-m line spacing. The vast majority of these 300-m blocks fall in water less than 60-m deep and are identified as high-probability locales for prehistoric site occurrence, not for historic shipwrecks. The selection of those 300-m blocks identified as high-probability blocks for shipwrecks has relied on digital files of lease blocks and their survey requirements developed by MMS and incorporated as a visual entitled "Archaeological Resources in the Gulf of Mexico" (MMS 2000) depicting all lease blocks in the GOMR. From these files and visual, 581 lease blocks requiring 300-m survey spacing have been identified as high-probability blocks relative to historic shipwrecks. This selection has relied primarily on identifying those lease blocks forming the nine contiguous lease block units derived from the Garrison et al. (1989) list of shipwrecks.

These 2,411 lease blocks comprise those that are now (November 2001) identified by the MMS as high-probability blocks relative to historic shipwreck occurrence. However, these blocks do not exactly represent those that were originally identified in the Garrison et al. 1989 model of shipwreck occurrences in the GOMR. As noted, over time, some deletions and additions to the originally compiled list have been made (Rik Anuskiewicz, personal communication 2002). Most importantly has been the addition of a number of lease blocks to the "high-probability" category when offshore surveys identified shipwrecks or objects believed to be shipwrecks in them. Most of these lease blocks containing identified shipwrecks, or possible shipwrecks, appear to have been added in 1990 when the results of previously conducted MMS-mandated surveys were incorporated into the results of the Garrison et al. study (MMS 1990). However, because the lease blocks containing identified wrecks were not elements of the 1989 model of shipwreck distributions as developed by Garrison et al., they must be removed from consideration when testing that model. Apparently, no separate list of these additions has been compiled by the MMS, but a careful review of the MMS digital files and visuals noted earlier, plus the results of offshore remote-sensing surveys provided by the MMS, indicates that 35 lease blocks containing identified wrecks are included as 50-m, high-probability blocks. Originally, these 35 lease blocks (all of which fall in water depths less than 60 m) would have been designated 300-m high-probability blocks on the basis of their prehistoric site potential; none were identified in the 1989 model as high-probability locales for historic shipwrecks. Additionally, 26 lease blocks (all in water depths greater than 60-m) that were not identified as high-probability blocks in the 1989 model and, therefore, would have required no archaeological survey, were redesignated 300-m blocks because the remains of shipwrecks had or have been found in them. A review of the present (November 2001) list of 2,411 blocks requiring survey for historic shipwrecks provided on the MMS webpage reveals that these 61 lease blocks are now included in that list. One lease block appears differently in this list of blocks requiring survey and those provided in the digital files and visual supplied by the MMS. The webpage list includes block Garden Banks 255, one of those changed from a no-survey status to a 300-m survey requirement, but this block is not shown as a 300-m block on the MMS visual (MMS 2000). However, the adjacent block, Garden Banks 254, is. A review of extracts from archaeological survey reports obtained from the MMS reveals that a pipeline survey passed through the area of Garden Banks 254 and 255 that identified an “object” on the bottom. The MMS records for the survey place the object in Garden Banks 254, but the coordinates from the survey place the object in Garden Banks 255. Regardless, the important point is that these 61 lease blocks have to be removed from the present list of high-probability blocks in order to conduct any accurate assessments of the shipwreck model as it was formulated in 1989.

Additionally, some other changes have been made to the original 1989 list of high-probability blocks. A list provided by MMS in March 2002 indicates that 32 lease blocks have had survey requirements changed from 50-m to 300-m and 27 blocks have been released from all archaeological survey requirements (Rik Anuskiewicz, personal communication 2002). A review of the recent list of blocks requiring survey on the MMS webpage, however, reveals that a few of these changes have not been incorporated into this list of blocks. For example, 18 lease blocks in the Mississippi Canyon Area were reportedly released from any survey requirements in 1999, but one of these blocks is still contained in the list of blocks requiring 300-m survey. This block has been maintained as a high-probability area because the wreck of the freighter *Alcoa Puritan,* sunk by a German submarine in 1942, is located on its boundary. Additionally, five lease blocks in the South Timbalier Area and the two in the Galveston Area that are reported to have been changed from 50-m to 300-m requirements in 1997 are still contained in the MMS list of blocks requiring 50-m survey.

As a result of these various additions and subtractions, it is estimated that a total of 2,384 high-probability lease blocks in Federal waters were identified in the original

1989 model of shipwreck occurrences (see Volume III, Appendix C). Of these, 1,804 lease blocks fall in water depths of less than 60-m and, prior to the new regulations issued in March 2002, required 50-m survey, and 580 lie in deeper water and required 300-m survey. These 2,384 lease blocks serve as the units for testing the 1989 model of shipwreck occurrences in the GOMR. This testing requires knowledge of the results of the MMS-mandated survey program.

3.2.2.2. Findings of the MMS Archaeological Survey GOMR Program

Information provided by MMS/GOMR reveals that the first report of an offshore archaeological resources survey was received by them on June 24, 1974. That study reported on a remote-sensing survey conducted in block West Cameron 437 in offshore Louisiana, an area where mineral activity has been intensive and where many additional archaeological surveys subsequently have been conducted. In the intervening 27 years, to September 2001, MMS/GOMR received 2,835 archaeological resources reports of offshore surveys (Dave Ball, personal communication 2001). Most of these studies are related to remote-sensing surveys conducted of entire 3-by-3-mile lease blocks. Some, however, represent reports for remote-sensing surveys of portions of lease blocks or of pipelines or well sites. Survey data received from MMS reveals that 2,220 offshore lease blocks in Federal waters have been subjected to archaeological resources survey. These include blocks where survey requirements were for the older 150-m as well as the 50-m and 300-m survey line spacings required after 1990. Most of these lease blocks were subjected to complete survey coverage. A number, however, appear to have been only partially surveyed, or the portion surveyed consisted of a pipeline right-of-way passing through the block. With the data supplied, it is impossible to determine how much area was covered within these partially surveyed blocks. Also, many blocks have been surveyed in part or in whole more than once. Several have been subject to survey as many as four times. Resurvey of a lease block is often requested by the MMS when there have been changes in the survey requirements for the block between the time of the initial survey and the time of whatever activity is being conducted to stimulate another survey.

If each of the 2,220 lease blocks had been covered completely by remote-sensing survey, it would represent a total of 19,980 square miles (51,748 km^2) of archaeological survey coverage in the Gulf. The total area is certainly less than this, because of the partial surveys noted. The almost twenty thousand square miles is a huge area, but it represents only about 7.7 percent of the total area encompassed in the GOMR. Although the results of these archaeological surveys do serve as our best test of the 1989 model of wreck distributions, the surveys are not randomly distributed across the entire area of the GOMR. Figure 3-2 presents information on the number of lease blocks surveyed per lease area as revealed in archaeological survey reports on file at the MMS/GOMR. Included in this figure are mainly those reports that are identified as lease block surveys per se; some surveys of pipeline rights-of-way are not included.

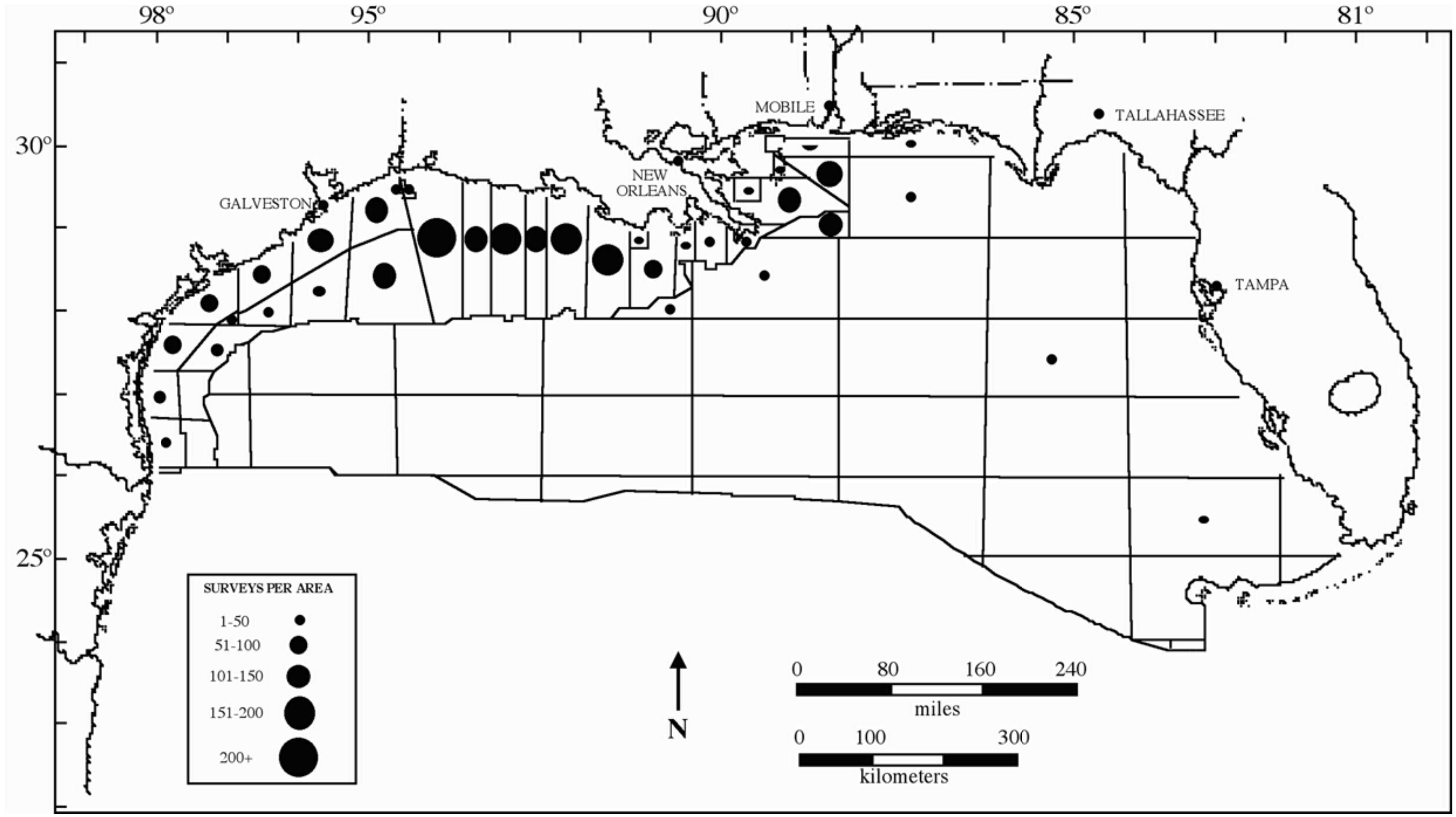


Figure 3-2. Numbers of MMS-required remote-sensing surveys conducted per lease area as indicated by archaeological reports received by MMS/GOMR, New Orleans. Data as of September 2001.

As can be seen, the vast majority of required archaeological lease block surveys have been conducted in the offshore areas of Texas, Louisiana, Alabama and Mississippi. Several have been conducted off of the coast of Florida, where mineral exploitation has been restricted, and few exist for the deeper waters of the central Gulf where archaeological surveys are not commonly required. The fact that the vast majority of archaeological surveys have been conducted in the inshore areas of the central and western Gulf is important, because it represents a “bias” in testing the 1989 model of wreck distributions. Presently, however, it is impossible to fully compensate for the spatially restricted nature of the data at hand.

3.2.3. Evaluating the 1989 GOMR Shipwreck Model

3.2.3.1. Precision and Accuracy in Shipwreck Locations in the 1989 Model

The results of the MMS archaeological survey program are used to examine the 1989 shipwreck model in two ways. One is to compare the findings of the offshore surveys against the specific location information (e.g., specific lease block) on shipwrecks provided in the 1989 shipwreck database. The other is to examine the survey findings against the less restrictive location information on wreck occurrences as reflected in the 2,384 high-probability lease blocks identified in the 1989 model.

As noted, the 1989 shipwreck database contained 1,469 entries falling into 779 different GOMR lease blocks. Some of these entries represent items such as “obstructions” that may or may not be shipwrecks, plus, as discussed previously, some duplications exist, with the same vessel listed more than once. As of September 2001, 208 of these 779 high-probability lease blocks had been subjected entirely or in part to archaeological survey. Survey reports from these lease blocks have been submitted and reviewed by MMS personnel. As noted earlier, MMS survey requirements have changed over time and it may be reasonable to presume that the identification of shipwrecks has improved with these changes. This is probably most true relative to the use of the magnetometer, where requirements for tighter line spacing and decreased sensor distance from the seafloor have certainly improved detection. However, it is unknown how many buried shipwrecks have been located during MMS-mandated surveys only with the magnetometer because the policy of avoidance means that there are no requirements to identify or verify the sources of magnetic signatures that might represent shipwrecks. Essentially, all identifications of sunken vessels have relied on sidescan sonar or a combination of sonar and magnetometer data. For the present analysis, it is assumed that the collection of sidescan sonar data in the various surveys was generally adequate to indicate whether exposed shipwrecks were present. Additionally, it has to be assumed that the interpretation of the collected data was equivalent and reliable such that if wrecks or objects were recorded on remote-sensing records, they were identified as such by the person evaluating the data. Three of these 208 lease blocks contained objects whose identity could not be confirmed; unidentified “vessels” were identified in four lease blocks; nine lease blocks contained vessels whose identity was tentatively made, and 192 of these 208 blocks produced negative results; no shipwrecks or suspected shipwrecks were found (see Volume III, Appendix D). Survey of one of the lease blocks identified in the 1989 model as having a single "unknown vessel," actually located three unidentified vessels. Thus, 13 (6.25 percent) of the 208 lease blocks identified in the 1989 shipwreck database that have been surveyed contained identified shipwrecks, while 192 (92.31 percent) of these lease blocks produced no evidence of wrecks.

As noted, this assessment considers only those lease blocks listed in the 1989 shipwreck database. These are those lease blocks within which the most reliably determined geographic coordinates for shipwrecks fall; they do not represent all of the high-probability blocks identified in the 1989 model of wreck occurrences. Therefore, this examination is not a true test of that model, but it does bear on one of the significant problems encountered in developing statements about historic vessel losses: the accuracy of the information on location of loss. Garrison et al. (1989:II-11) discuss this problem, noting that the accuracy of a shipwreck position as they used it was a function of "(1) geographic coordinates given for the shipwreck and (2) level of precision in the particular analysis." The first factor is dependent upon the character of the report of the loss. For most of the wrecks in the 1989 database, geographic coordinates have been assigned to a shipwreck based on other types of information provided about the location of loss. For many wrecks, particularly early ones, the information on loss is often simply a description of the location in reference to a shore landmark. For example, the account of loss might state that a vessel was lost "20 miles southeast of Grand Isle" or "west of Tampa Bay," or "four miles southwest of the Port Aransas jetties." Generally, only the most recent wreck reports provide geographic coordinates for the location of loss. Regardless, all of these various modes of describing a location of loss had to be used to obtain the geographic coordinates for the position of loss. As Garrison et al. (1989:II-10-11) note, the various sources of information on wrecks were examined to determine the most reliable one for developing the geographic coordinates of the location of loss.

The nature of the historical data on vessel losses means that the accuracy of geographic coordinates obtained for many wrecks will be questionable. Garrison et al. (1989) recognize this problem, but argue that the types of analyses they conducted did not require high levels of precision in wreck locations. They typically considered spatial distributions at the lease block or broader level. For example, they argue that correlating shipwreck locations with hurricane paths or with travel routes, such as the routes of the Spanish fleets in the sixteenth to eighteenth centuries, does not require a great deal of precision because the hurricane paths and shipping routes themselves varied considerably (Garrison et al. 1989:II-11).

The 1989 study did incorporate presumptions about the relative accuracy of reported wreck locations into the delineation of high-probability areas. For instance, Garrison et al. (1989:II-11) note that "the accuracy of the shipwreck positions is 0.16 for an assigned lease block whose original report gave no quantitative position." This probability is based on the assumption that a reported shipwreck location will fall within an area of six lease blocks, or 54 square miles, and is derived principally from presumptions used by the Texas Antiquities Committee in their assessment of the margin of error existing in wreck locations. This, also, is the same assumption about positioning error used by Bourque (1979) in his baseline study for the Atlantic OCS. Although no empirical evidence was provided to support this presumption about the relative accuracy of reported shipwreck positions, the 1989 Garrison et al. study generally followed it in its identification of the nine-lease-block high-probability units discussed earlier. In essence, they assume that the margin of error for a reported wreck location is on the order of 4.5 miles. Thus, the actual wreck location would most likely be contained within the area circumscribed by a 4.5-mile radius around its plotted location. In its application to the GOMR, the high-probability area so defined includes the lease block in which the wreck coordinates fall, plus the eight contiguous blocks. The use of this nine-lease-block configuration implies that a shipwreck has a 0.11 probability of occurring in its assigned lease block.

Garrison et al. (1989) had no reliable shipwreck data from the GOMR with which to test this presumption about the precision of reported and derived wreck locations. However, the results of the 208 offshore remote-sensing surveys used here permit a preliminary effort in testing this presumption. Essentially, the results indicate that a shipwreck has a 0.06 probability (i.e., 13 of 208) of falling in its specifically assigned lease block, a much lower probability than presumed by the 1989 study or suggested by other researchers (cf. Borque 1979). Even this low probability assumes that the wrecks identified in the 13 lease blocks are actually the vessels listed in the 1989 shipwreck database. The identity of one of these vessels, the *Tulsa*, has been verified by divers and two others, the *William H. Edwards* and the *Daniel Huger,* are liberty ships sunk as artificial reefs whose identity and location were well known when the 1989 database was developed. A more rigorous assessment of the question of accuracy in reported wreck locations will require verification of the identity of the other vessels and objects discovered in these 13 lease blocks.

Another way to approach the question of accuracy in reported wreck locations is to compare the actual coordinates of discovered wrecks against the coordinates derived from historical sources. In the present instance, the positions of identified shipwrecks that have been discovered by MMS-mandated archaeological surveys are compared against the positions provided in the 1989 shipwreck database developed by Garrison et al. (1989). Based on archaeological survey data supplied by MMS, ninety identified and unidentified vessels have been discovered in the GOMR as a result of MMS-mandated surveys. In addition, a number of items and objects have been found that may or may not represent vessel remains. Of these, 13 vessels have been found whose identity has been confirmed by diving or can be well established through sidescan sonar imagery and which appeared in the 1989 shipwreck database (Table 3-1). This table provides the distance in meters and miles between the location of a wreck as given in the 1989 database and the location where the vessel was actually found. The actual locations of most of these vessels were recorded by state-of-the-art positioning during the course of archaeological surveys and are believed to be extremely accurate. The location of the wreck of the sidewheel steamer *New York* was obtained by MMS personnel during the course of a remote-sensing survey and diving operations on the wreck (Irion and Anuskiewicz 1999). Information on the actual position of the *Virginia* comes from Rob Floyd (personal communication, 2001) and that of the *R.W. Gallagher* from Avery

Munson (personal communication, 2001). According to Munson, the *R.W. Gallagher* has been located by an MMS-mandated survey, but has been misidentified as the *Heredia.* The 1989 shipwreck database notes that reports of loss and the locations of loss for these vessels came from a variety of historical sources. As Garrison et al. (1989) note, they made use of what was considered the most reliable source in developing coordinates for wreck locations. Excluded from this list of discovered vessels are several ships sunk as artificial reefs since the 1970s that are included in the 1989 database, but whose exact positions were essentially known at that time. Similarly, historic wrecks whose exact locations were known in 1989, such as the Civil War steamer *Hatteras*, are excluded.

Table 3-1. Distance Between Reported Location of Loss and Actual Location of Identified Shipwrecks in the GOMR

VESSEL	YEAR OF LOSS	DISTANCE	
		METERS	MILES
ALCOA PURITAN	1942	15,025.86	9.34
BENJAMIN BREWSTER	1942	4,191.82	2.60
CITIES SERVICE TOLEDO	1942	17,057.70	10.60
GULF TIDE	1947	84.98	0.05
GUNSMOKE	1977	162.49	0.10
JOSEPHINE	1881	2,803.00	1.74
NEW YORK	1846	151,488.64	94.14
R.E. LEE	1942	19,543.62	12.14
R.W. GALLAGHER	1942	2,889.63	1.80
SHEHERAZADE	1942	1,582.00	0.98
TULSA	1943	3,083.74	1.92
U-166	1942	221,196.61	137.45
VIRGINIA	1942	10,685.67	6.64
AVERAGE		**34,599.67**	**21.50**

As can be seen, the difference in reported location of loss and actual location where the wreck was discovered ranges from 0.05 miles for the *Gulf Tide* to 137.5 miles for the German submarine *U-166*, and averages 21.5 miles. One would expect that, in general, the error in reported location of loss would be greater the farther back in time the sinking occurred. This is probably true, and the *U-166* represents a unique case. The submarine was reportedly sunk by a bomb dropped from a United States Coast Guard airplane off the central Louisiana coast in August 1942, but the pilot's account of the sinking could never be verified. The Coast Guard account placed the sinking in lease block South Timbalier 75, and subsequent searches for the submarine have generally considered this to be its general location of loss. However, in the summer of 2001, the remains of the *U-166* were discovered and positively identified in very deep water off the mouth of the Mississippi River in the Mississippi Canyon Area. Subsequent to its discovery, additional historical research of contemporary World War II records verified that the submarine was, in fact, lost off the mouth of the Mississippi River, over 135 miles east of where it was previously believed to have been lost (Church 2002).

If the *U-166* is eliminated from the list, the average error in location drops considerably, to 11.9 miles. However, as can be seen, most of the wrecks on the list are fairly modern, dating since World War II. The oldest wreck on the list, the steamer *New York*, lost in 1846, was found almost 100 miles from the location provided in the 1989 shipwreck database. The case of the *New York* is believed to be more typical and it is suspected that the geographic coordinates given for many early wrecks are in considerable error. For example, the remains of the Spanish merchant vessel *El Nuevo Constante*, sunk in 1766, were discovered in the late 1970s just off the coast of central Louisiana (Pearson and Hoffman 1995). Various wreck lists compiled from secondary historical accounts place the *El Nuevo Constante* as far west as Galveston, well over 100 miles from its actual location. The actual location of the sinking of *El Nuevo Constante* could have been determined if primary documents relating to its loss had been discovered and examined, as was the case for the *U-166*. However, overview studies, such as that of Garrison et al. (1989) as well as the present work, generally are unable to examine primary records in any detail.

Although the case of the *U-166* demonstrates that significant errors in location can exist even for relatively recent wrecks, it is obvious that the *New York* and *El Nuevo Constante* are more typical of the situation for earlier wrecks. This assessment has used a small sample of 13 positively identified wrecks and the results must be viewed with caution. Seven of the wrecks do fall within 4.5 miles of their reported location of loss, the distance that the 1989 study used as a generalized measure of potential error in reported wreck locations to identify many high-probability zones. All but one of these wrecks, however, post-date 1942, a period when reasonably accurate positions of sinkings are to be expected. It appears that the 4.5-mile radius employed to identify many high-probability areas in the GOMR underestimates the actual range of error that exists, particularly for early wrecks. The data presented here reveal, as expected, that considerable variability exists in the error associated with positions derived from historic accounts of sinkings. These are unlikely to ever be fully reconciled, but it is not believed that a single measure of this error should be assigned to all wrecks. As has been discussed in earlier sections, during the collection and compilation of the shipwreck database for this study an effort was made to quantify the “reliability” of the geographic coordinates obtained for each vessel through an evaluation of the type of information contained in the account of loss. In the following chapter, this concept of “reliability” is more fully discussed in efforts to more carefully define the error anticipated to be associated with particular wreck locations, and to more realistically define the size of high-probability zones associated with these wrecks.

3.2.3.2. Testing the Predictability of the 1989 Shipwreck Model

The 1989 shipwreck model is further examined by comparing predicted wreck locations against discovered wrecks across all of the 2,384 high-probability lease blocks identified in the 1989 model (see Volume III, Appendix C). Data obtained from MMS in

September 2001 reveal that 2,220 lease blocks in the GOMR had been subjected to archaeological survey as of that date (Dave Ball, personal communication 2001). (This number actually refers to the number of archaeological survey reports received by the MMS/GOMR. Sometimes lease blocks or pipeline rights-of-way are surveyed, but for various reasons the archaeological reports are held for a considerable amount of time before they are submitted to MMS.) Out of this number, 651 lease blocks were identified in the 1989 model as high-probability blocks relative to shipwrecks (Table 3-2). The remaining 1,569 blocks are identified as high-probability locales relative to prehistoric sites. Of the 651 shipwreck high-probability blocks surveyed, 616 are what are now (2001) identified as 50-m blocks and 35 are 300-m blocks. Some of the surveys of these blocks were conducted prior to 1990 and were undertaken on 150-m line spacing. These numbers suggest that approximately 27.3 percent of the total of 2,384 shipwreck high-probability lease blocks in the GOMR have been subjected to archaeological survey. However, while most of these surveys consisted of complete lease block surveys, some represent partial block surveys, pipeline rights-of-way, or well sites.

Table 3-2. High-Probability Lease Blocks that have been Surveyed for Historic Shipwrecks as of September 2001

LEASE BLOCKS REQUIRING 50-M SURVEY INTERVAL						
BA0342	EI0039	GA0255	GA0460	HI0106	HIA0509	MO0871
BA0364	EI0041	GA0256	GA0461	HI0107	MI0519	MO0873
BA0365	EI0042	GA0257	GA0462	HI0108	MI0528	MO0904
BA0376	EI0048	GA0268	EI0018	HI0109	MI0564	PN0948
BA0377	EI0049	GA0269	EI0019	HI0114	MI0565	PN0949
BA0378	EI0050	GA0270	EI0020	HI0135	MI0566	PN0954
BA0396	EI0056	GA0272	EI0022	HI0136	MI0567	PN0955
BA0397	EI0057	GA0273	EI0023	HI0137	MI0589	PN0957
BA0398	EI0058	GA0281	EI0024	HI0138	MI0591	PN0969
BA0399	EI0059	GA0282	EI0026	HI0140	MI0592	PN0970
BA0415	EI0060	GA0283	EI0027	HI0141	MI0599	PN0975
BA0416	EI0070	GA0286	EI0028	HI0142	MI0601	PN0976
BA0417	EI0071	GA0287	EI0029	HI0143	MI0602	PN0987
BA0430	EI0072	GA0288	EI0030	HI0154	MI0603	PN0989
BA0431	EI0079	GA0295	EI0031	HI0155	MI0622	PN0990
BA0432	EI0080	GA0296	EI0032	HI0156	MI0623	PN0993
BA0449	EI0138	GA0297	GI0017	HI0157	MI0631	PN0996
BA0477	EI0139	GA0298	GI0037	HI0160	MI0633	PN1010
BA0478	EI0140	GA0301	GI0045	HI0164	MI0635	PN1019
BA0490	EI0143	GA0302	GI0046	HI0175	MI0654	MO0908
BA0491	EI0149	GA0304	GI0054	HI0176	MI0663	MO0909
BA0509	EI0162	GA0312	GI0085	HI0177	MI0664	MO0910
BA0510	GA0104	GA0313	HI0019	HI0178	MI0666	MO0911
BA0514	GA0144	GA0315	HI0020	HI0194	MI0687	MO0912
BA0515	GA0151	GA0316	HI0021	HI0196	MI0688	MO0913
BA0516	GA0152	GA0319	HI0031	HI0197	MO0779	MO0944
BA0538	GA0181	GA0320	HI0034	HI0202	MO0819	MO0945
BS0041	GA0190	GA0324	HI0035	HI0204	MO0820	MO0946
BS0042	GA0191	GA0325	HI0036	HI0205	MO0821	MO0950
BS0053	GA0192	GA0330	HI0037	HI0206	MO0822	MO0951
BS0054	GA0209	GA0331	HI0038	HI0207	MO0823	MO0988
BS0055	GA0210	GA0332	HI0039	HI0208	MO0824	MO0989
CA0009	GA0222	GA0333	HI0047	HI0232	MO0826	MO0990

Table 3-2 (continued). High-Probability Lease Blocks that have been Surveyed for Historic Shipwrecks as of September 2001

LEASE BLOCKS REQUIRING 50-M SURVEY INTERVAL						
EC0002	GA0223	GA0334	HI0049	HI0236	MO0827	MO0992
EC0011	GA0226	GA0343	HI0051	HIA0007	MO0828	MO0993
EC0014	GA0227	GA0345	HI0053	HIA0018	MO0829	MO0997
EC0015	GA0237	GA0346	HI0054	HIA0019	MO0830	MO0998
EC0022	GA0238	GA0347	HI0065	HIA0020	MO0857	MO0999
EC0023	GA0239	GA0352	HI0066	HIA0021	MO0861	MO1002
EC0024	GA0240	GA0353	HI0067	HIA0022	MO0862	MP0007
EC0026	GA0241	GA0360	HI0089	HIA0023	MO0863	MP0018
EC0033	GA0242	GA0362	HI0090	HIA0024	MO0864	MP0019
EC0034	GA0250	GA0363	HI0092	HIA0107	MO0865	MP0020
EC0036	GA0251	GA0379	HI0093	HIA0122	MO0866	MP0029
EC0038	GA0252	GA0380	HI0095	HIA0123	MO0867	MP0043
EC0039	GA0253	GA0382	HI0098	HIA0133	MO0868	MP0057
EC0040	GA0254	GA0383	HI0105	HIA0506	MO0869	MP0061
MP0062	PE0934	SS0013	SS0144	VK0031	WC0039	WC0110
MP0063	PL0002	SS0026	SS0158	VK0033	WC0040	WC0111
MP0064	PL0004	SS0027	SS0159	VK0065	WC0041	WC0112
MP0069	PL0005	SS0028	SS0160	VK0066	WC0042	WC0113
MP0072	PL0006	SS0030	SS0167	VR0016	WC0043	WC0114
MP0090	PL0009	SS0031	SS0169	VR0017	WC0044	WC0115
MP0091	PL0010	SS0036	ST0011	VR0021	WC0045	WC0118
MP0092	PL0011	SS0037	ST0016	VR0022	WC0046	WC0134
MP0103	PL0016	SS0038	ST0024	VR0023	WC0047	WC0148
MP0114	PL0025	SS0050	ST0028	VR0025	WC0053	WC0166
MP0115	PN0894	SS0051	ST0029	VR0026	WC0054	WC0167
MP0116	PN0934	SS0062	ST0030	VR0027	WC0055	WC0186
MP0117	PN0935	SS0065	ST0031	VR0028	WC0056	WC0187
MU0745	PN0947	SS0067	ST0032	VR0034	WC0057	WC0188
MU0751	PS1073	SS0068	ST0033	VR0036	WC0059	WC0189
MU0759	PS1125	SS0069	ST0034	VR0037	WC0060	WC0291
MU0775	PS1166	SS0072	ST0035	VR0038	WC0061	WC0292
MU0776	SA0006	SS0073	ST0036	VR0039	WC0062	WD0016
MU0783	SA0007	SS0080	ST0046	VR0046	WC0063	WD0018
MU0792	SA0009	SS0085	ST0047	VR0047	WC0064	WD0020
MU0793	SA0011	SS0086	ST0048	VR0048	WC0065	WD0021
MU0811	SA0012	SS0087	ST0052	VR0054	WC0066	WD0022
MU0821	SA0014	SS0089	ST0062	VR0055	WC0067	WD0026
MU0822	SA0015	SS0090	ST0065	VR0056	WC0068	WD0027
MU0823	SA0016	SS0091	ST0066	VR0144	WC0069	WD0031
MU0827	SM0207	SS0092	ST0067	VR0145	WC0070	WD0032
MU0832	SM0208	SS0093	ST0068	VR0158	WC0071	WD0033
MU0833	SM0210	SS0094	ST0069	VR0159	WC0073	WD0034
MU0837	SM0212	SS0097	ST0070	VRO160	WC0079	WD0035
MU0842	SM0217	SS0098	ST0073	WC0018	WC0080	WD0036
MU0843	SM0218	SS0103	ST0074	WC0019	WC0090	WD0047
MU0848	SM0224	SS0104	ST0076	WC0021	WC0091	WD0048
MU0851	SM0228	SS0109	ST0080	WC0023	WC0092	WD0049
MU0853	SM0229	SS0110	ST0081	WC0024	WC0094	WD0057
MU0858	SM0237	SS0111	ST0082	WC0026	WC0095	WD0058
MU0859	SM0238	SS0113	ST0084	WC0027	WC0096	WD0059
PE0845	SM0239	SS0114	ST0102	WC0028	WC0097	WD0077

Table 3-2 (continued). High-Probability Lease Blocks that have been Surveyed for Historic Shipwrecks as of September 2001

LEASE BLOCKS REQUIRING 300-M SURVEY INTERVAL						
PE0846	SM0240	SS0127	ST0110	WC0033	WC0098	WD0078
PE0889	SM0241	SS0139	ST0111	WC0034	WC0099	WD0086
PE0890	SS0011	SS0140	SX0040	WC0035	WC0100	WD0098
PE0933	SS0012	SS0143	VK0022	WC0036	WC0109	
EL0406	MC1007	SP0072	VK0870			
EL0407	MC1008	VK0782	VK0871			
EW0305	SP0032	VK0783	VK1000			
EW0347	SP0034	VK0785	VK1001			
GI0088	SP0036	VK0786	WD0109			
MC0290	SP0037	VK0826				
MC0291	SP0038	VK0827				
MC0335	SP0044	VK0829				
MC0963	SP0045	VK0830				
MC0964	SP0060	VK0869				

Data supplied by the MMS reveals, at this writing, that a total of 135 “vessels” and “objects” have been identified in the GOMR as a result of MMS-mandated surveys. Out of this number, 90 are deemed to be actual vessels, while the remaining 45 are classified as unidentified objects. The identification of an item as a “vessel” or an “object” relied on a review of the archaeological survey reports provided by MMS. As noted, the information provided consisted of copied material extracted from the complete reports and usually contained reproductions of sidescan sonar records and segments of the text that reported on the findings and interpretations. Occasionally, portions of maps and other remote-sensing records were provided, such as data from the magnetometer or subbottom profiler. All of these data were reviewed and, in most instances, the interpretations of the reviewer matched the identification provided in the report.

However, in a very few instances, careful examination of sidescan records suggested that items identified in archaeological survey reports as “possible vessels” or “possible shipwrecks” were more appropriately classified as “unidentified objects.” Figure 3-3 provides an example of a sidescan sonar record from an MMS archaeological survey report that shows a clear image of a vessel. Many images examined were of much poorer quality than this one, making identification difficult. Information on these vessels ultimately identified in the data is contained in Table 3-3. The table includes: 1) the ID number of the vessel as contained in the database of shipwrecks developed for this study, 2) the name of the vessel if it is known or if there is some reasonable rationale for this identification, 3) the lease area in which the wreck falls, and 4) a column indicating whether or not the lease block in which it was found was identified as a high-probability block in the 1989 shipwreck model and the survey line spacing assigned to that block.

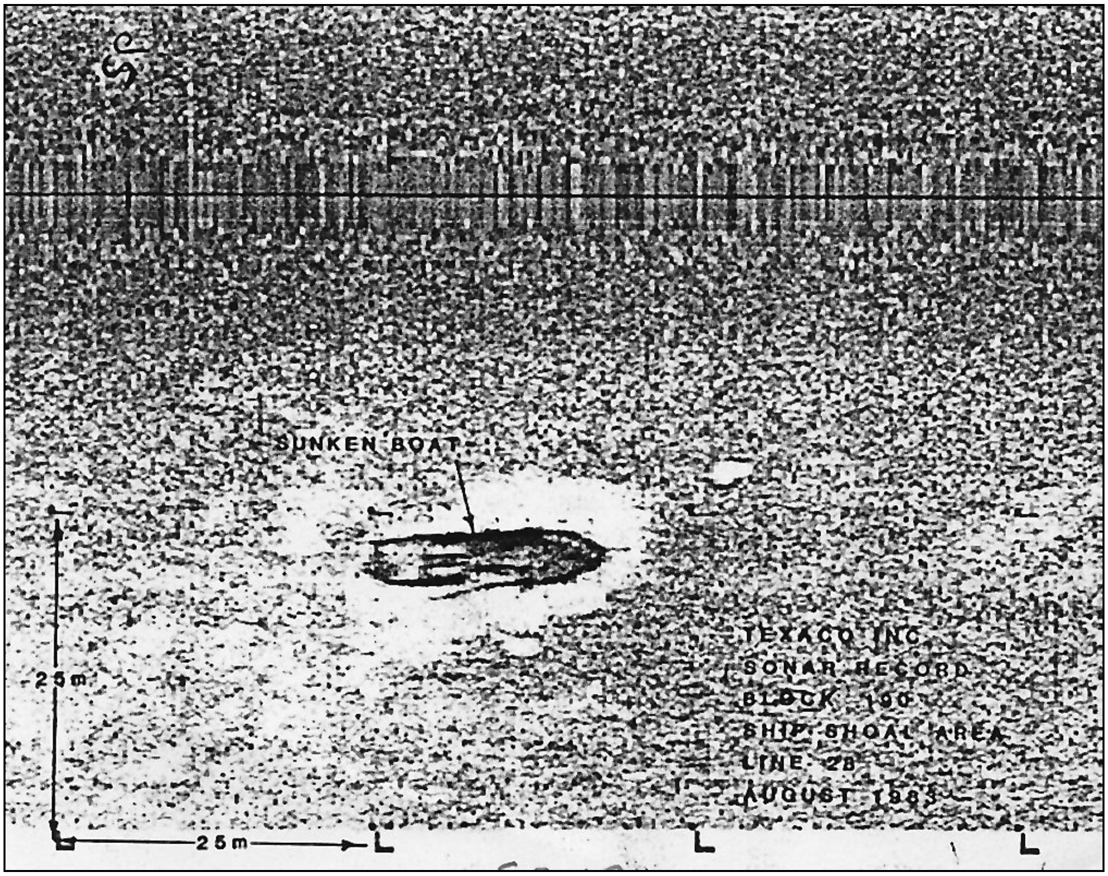


Figure 3-3. Sidescan sonar image of a shipwreck in the Ship Shoal Area.

Table 3-3. Vessels Identified by MMS Lease Area Surveys

ID	VESSEL*	LEASE AREA	HIGH-PROBABILITY STATUS**
Identified Vessels			
360	*ALCOA PURITAN*	MC	YES/300
354	*ARKANSAS (?)*	MP	NO
319	*BENJAMIN BREWSTER*	BM	YES/50
332	*CAPTAIN BRANDON JOSEPH (?)*	GA	YES/50
373	*CITIES SERVICES TOLEDO*	SM	NO
403	*DALE & DAVID (?)*	VK	NO
426	*DANIEL HUGER (?)*	PE	NO
417	*GULF TIDE*	WC	NO
362	*GULFPENN (?)*	SP	YES/300
372	*GUNSMOKE (?)*	PB	YES/50
386	*HEREDIA (?) (R.W. GALLAGHER)*	SS	NO
389	*J.A. BISSO (?)*	ST	NO
365	*JOSEPHINE*	MO	YES/50
329	*MISS AGNES*	EI	NO
379	*MISS NATALIE (?)*	PL	YES/50
344	*NEW YORK*	HIA	NO
350	*PEGASUS (?)*	MP	NO
411	*RICHARD P. (?)*	VR	NO
361	*ROBERT E. LEE*	MC	NO

Table 3-3. (continued). Vessels Identified by MMS Lease Area Surveys

ID	VESSEL*	LEASE AREA	HIGH-PROBABILITY STATUS**
Identified Vessels			
334	*SAINT MARY (?)*	GB	NO
328	*SHEHERAZADE*	EI	NO
370	*TULSA*	MO	YES/50
751	*U-166*	MC	NO
399	*WILLIAM H. EDWARDS*	VK	YES/50
Unidentified Vessels			
366	ARTIFICIAL REEF	MO	YES/50
317	UNKNOWN VESSEL	BA	YES/50
316	UNKNOWN VESSEL	BAA	NO
318	UNKNOWN VESSEL	BAA	YES/300
321	UNKNOWN TUG	EC	NO
322	UNKNOWN VESSEL	EC	NO
323	UNKNOWN VESSEL (*LAFOURCHE*?)	EC	NO
15161	UNKNOWN VESSEL	EC	NO
15166	UNKNOWN BARGE	EI	NO
325	UNKNOWN VESSEL	EI	YES/50
326	UNKNOWN VESSEL	EI	NO
327	UNKNOWN VESSEL	EI	NO
1570	UNKNOWN WRECK (*BECT 2*?)	EI	NO
1571	UNKNOWN WRECK (*BECK II*)	EI	NO
15167	UNKNOWN VESSEL	EI	NO
330	UNKNOWN VESSEL	EI	NO
333	UNKNOWN VESSEL	GA	YES/50
335	UNKNOWN VESSEL	GB	NO
337	UNKNOWN VESSEL	GC	NO
15170	UNKNOWN VESSEL	GI	NO
339	UNKNOWN VESSEL	GI	YES/300
1616	UNKNOWN VESSEL (*HAWKEYE*?)	HI	NO
343	UNKNOWN VESSEL	HI	YES/50
15169	WOODEN WRECK	MC	NO
359	UNKNOWN VESSEL	MC	NO
15097	UNKNOWN VESSEL	MC	NO
363	UNKNOWN VESSEL	MC	NO
364	UNKNOWN VESSEL	MC	NO
369	UNKNOWN IRON VESSEL	MO	YES/50
368	UNKNOWN VESSEL	MO	YES/50
371	UNKNOWN VESSEL	MO	YES/50
346	UNKNOWN VESSEL	MP	YES/50
347	UNKNOWN VESSEL	MP	YES/50
349	UNKNOWN VESSEL	MP	NO
1615	UNKNOWN VESSEL	MP	NO
15096	UNKNOWN VESSEL	MP	NO
351	UNKNOWN VESSEL	MP	NO
352	UNKNOWN VESSEL	MP	NO
353	UNKNOWN VESSEL	MP	NO
356	UNKNOWN VESSEL	MP	NO
357	UNKNOWN VESSEL	MP	NO
378	UNKNOWN VESSEL	PL	YES/50
377	UNKNOWN VESSEL	SM	NO
391	UNKNOWN VESSEL	SS	YES/50
385	UNKNOWN VESSEL	SS	NO

Table 3-3. (continued). Vessels Identified by MMS Lease Area Surveys

ID	VESSEL*	LEASE AREA	HIGH-PROBABILITY STATUS**
Unidentified Vessels			
384	UNKNOWN VESSEL	SS	NO
15168	UNKNOWN WRECK	SS	NO
387	UNKNOWN BARGE	ST	YES/50
394	UNKNOWN VESSEL	ST	YES/50
392	UNKNOWN VESSEL	ST	YES/50
15098	UNKNOWN VESSEL	ST	NO
396	UNKNOWN VESSEL	SX	YES/50
398	UNKNOWN VESSEL	VK	YES/50
1610	UNKNOWN VESSEL	VK	NO
400	UNKNOWN WRECK	VK	NO
402	UNKNOWN BARGE	VK	NO
405	UNKNOWN VESSEL	VK	NO
15095	UNKNOWN VESSEL	VK	YES/300
406	UNKNOWN VESSEL	VK	NO
407	UNKNOWN VESSEL	VK	YES/300
412	UNKNOWN OBJECT (AIRCRAFT?)	VR	NO
415	UNKNOWN VESSEL	WC	YES/50
418	UNKNOWN VESSEL	WC	NO
421	UNKNOWN VESSEL	WC	NO
1611	UNKNOWN VESSEL	WD	YES/50
1569	UNKNOWN VESSEL	WD	YES/50

*A "?" indicates tentative identification of vessel.
** Identifies whether or not the lease block was identified as having a high probability for containing a shipwreck from data presented by Garrison et al. 1989 and the survey line spacing required for the block. Data as of September 2001.

As shown in Table 3-3, twenty-four vessels have been assigned names, but the identity of most has not been verified, so those that are tentatively identified are noted with a question mark. The remaining 66 entries in the list represent unidentified vessels of various sorts. In a few instances, the archaeological survey report provided a very tentative identification of the vessel and these are noted, although their accuracy is questionable. One of the items in the Unidentified Vessel category is identified as an "Artificial Reef," and this consisted of the remains of at least five medium-sized vessels sunk as part of an artificial reef off the Alabama coast in the Mobile Area. One item in the list is classified as an "Unidentified Object" and tentatively identified as an "aircraft." This item appeared as a rather amorphous object on sidescan records that were tentatively identified as an aircraft in the archaeological survey report. A careful review of the sidescan record did not enable an accurate identification of this object, but its identification as an airplane must be considered tenuous. However, because aircraft are included in the vessel category in the database developed in this study, this item is included in this list of discovered vessels.

Table 3-4 provides similar information for items classified as "Objects" from archaeological surveys. Most of these items appear on sidescan sonar records, but a few consist of presently unidentified magnetic anomalies.

Table 3-4. "Objects" Identified by MMS Lease Area Surveys

ID	OBJECT*	LEASE AREA	HIGH-PROBABILITY STATUS**
358	UNKNOWN OBJECT	AP	NO
320	UNKNOWN OBJECT	EB	NO
324	UNKNOWN OBJECT	EC	NO
15162	MAGNETIC ANOMALY 25	EC	YES/50
15163	MAGNETIC ANOMALY 58	EC	YES/50
15164	MAGNETIC ANOMALY 44	EC	YES/50
15165	MAGNETIC ANOMALY 70	EC	YES/50
331	UNKNOWN OBJECT	EI	NO
1614	UNKNOWN OBJECT	GA	YES/50
336	UNKNOWN OBJECT	GB	NO
338	UNKNOWN OBJECT	GI	NO
345	UNKNOWN OBJECT	HIA	NO
1573	ARMY TANKS	MO	YES/50
348	UNKNOWN OBJECT	MP	NO
355	UNKNOWN OBJECT	MP	NO
1572	UNKNOWN OBJECT	MP	NO
374	UNKNOWN OBJECT	SM	NO
375	UNKNOWN OBJECT	SM	NO
376	UNKNOWN OBJECT	SM	NO
382	UNKNOWN OBJECTS	SP	NO
1621	UNKNOWN OBJECT	SP	YES/300
1612	UNKNOWN OBJECT	SS	NO
1613	UNKNOWN OBJECT	SS	NO
1618	UNKNOWN OBJECT	SS	YES/50
388	UNKNOWN OBJECT	ST	NO
393	UNKNOWN OBJECT	ST	NO
395	UNKNOWN OBJECT	ST	NO
427	UNKNOWN OBJECT	ST	NO
397	UNKNOWN OBJECT	VK	YES/50
401	UNKNOWN OBJECT	VK	NO
408	UNKNOWN OBJECT	VR	NO
409	UNKNOWN OBJECT	VR	NO
410	UNKNOWN OBJECT	VR	NO
413	UNKNOWN OBJECT	VR	NO
1619	UNKNOWN OBJECT	VR	NO
1620	UNKNOWN OBJECT	VR	NO
404	UNKNOWN OBJECT	WC	YES/50
414	UNKNOWN OBJECT	WC	YES/50
416	UNKNOWN OBJECT	WC	NO
419	UNKNOWN OBJECT	WC	NO
420	UNKNOWN OBJECT	WC	NO
422	UNKNOWN OBJECTS	WC	NO
1622	UNKNOWN OBJECT	WC	NO
423	UNKNOWN OBJECT	WD	YES/50
425	UNKNOWN OBJECTS	WD	NO

* The identification is derived from the archaeological survey report.

** Indicates whether or not the lease block was identified as having a high probability for containing a shipwreck from data presented by Garrison et al. (1989) and the survey line spacing required for the block. Data as of September 2001.

One of the items included in this list is the several “Army Tanks” identified in the Mobile Area. These tanks are clearly distinguished on the sidescan records and represent material placed on the seafloor to create an artificial reef. These tanks are classified as “Objects” primarily because they have been purposefully placed at this location, unlike airplanes and helicopters that have been classified as “Vessels” principally because they represent cultural items accidentally lost at sea.

Specific information on the locations of all of these discovered vessels and objects are readily available in the Access format shipwreck database provided with this report and they can be viewed in the ArcView format provided. More generalized information on the spatial distribution of wrecks discovered in the GOMR is provided in Figure 3-4. This figure provides information on the numbers of vessels identified in various lease areas. As can be seen, most of the vessels have been found in the waters off the central Gulf, extending from near Mobile, Alabama, to the central Texas coast. Not surprisingly, this area corresponds closely to the region where most of the offshore survey work has been conducted, as shown in Figure 3-2 above. A very small number of vessels (N=4) appear in areas where no lease block surveys are reported to have been conducted.

These vessels have been discovered during the course of pipeline right-of-way surveys, rather than actual lease block surveys. Of some interest is a lack of discovery of vessels on the lower Texas coast, an area that has been subjected to a considerable amount of archaeological survey and an area where Garrison et al. (1989) project a fairly large number of wrecks. For comparison, Figure 3-5 presents information on the numbers of reported wrecks per lease area derived from the 1989 shipwreck database developed by Garrison et al. (1989). As can be seen, the 1989 database lists over 150 wrecks in Federal waters along the lower Texas coast; why so few have been discovered here is unknown. It is possible that wrecks in this area can be totally buried by the clay and silty clay bottom sediments that characterize the region.

Excavations at one of the 1554 Spanish fleet wrecks (site 41KN10, believed to be the vessel *San Esteban*) off Padre Island, Texas, revealed that all of the remains of the vessel were buried by 0.6 to 1.3-m of sand, silt and shell. It was believed that wreckage had migrated downward through loose sediments to an underlying dense and impenetrable Pleistocene clay surface. Marine growth on artifacts indicated that wreckage had been exposed in the water column for long periods of time prior to the initiation of excavations in 1972 (Arnold and Weddle 1978:195-198). This site lies close to shore where current and wave dynamics and sediments are somewhat different from those in offshore areas; however, it is reasonable to assume that offshore wrecks in the lower Texas area can become totally or partially buried. This is certainly true for two nineteenth century wrecks known from the offshore area of the upper Texas coast, the *Hatteras* and *New York*, both of which were partially buried when discovered (Arnold and Anuskiewicz 1995; Irion and Anuskiewicz 1999).

One question to ask is whether the discovery of wrecks in the GOMR is a factor of the number of remote-sensing surveys conducted in an area rather than the actual density of wrecks in that area. If it is the latter, then one might argue that the “predictability” of the 1989 model is supported.

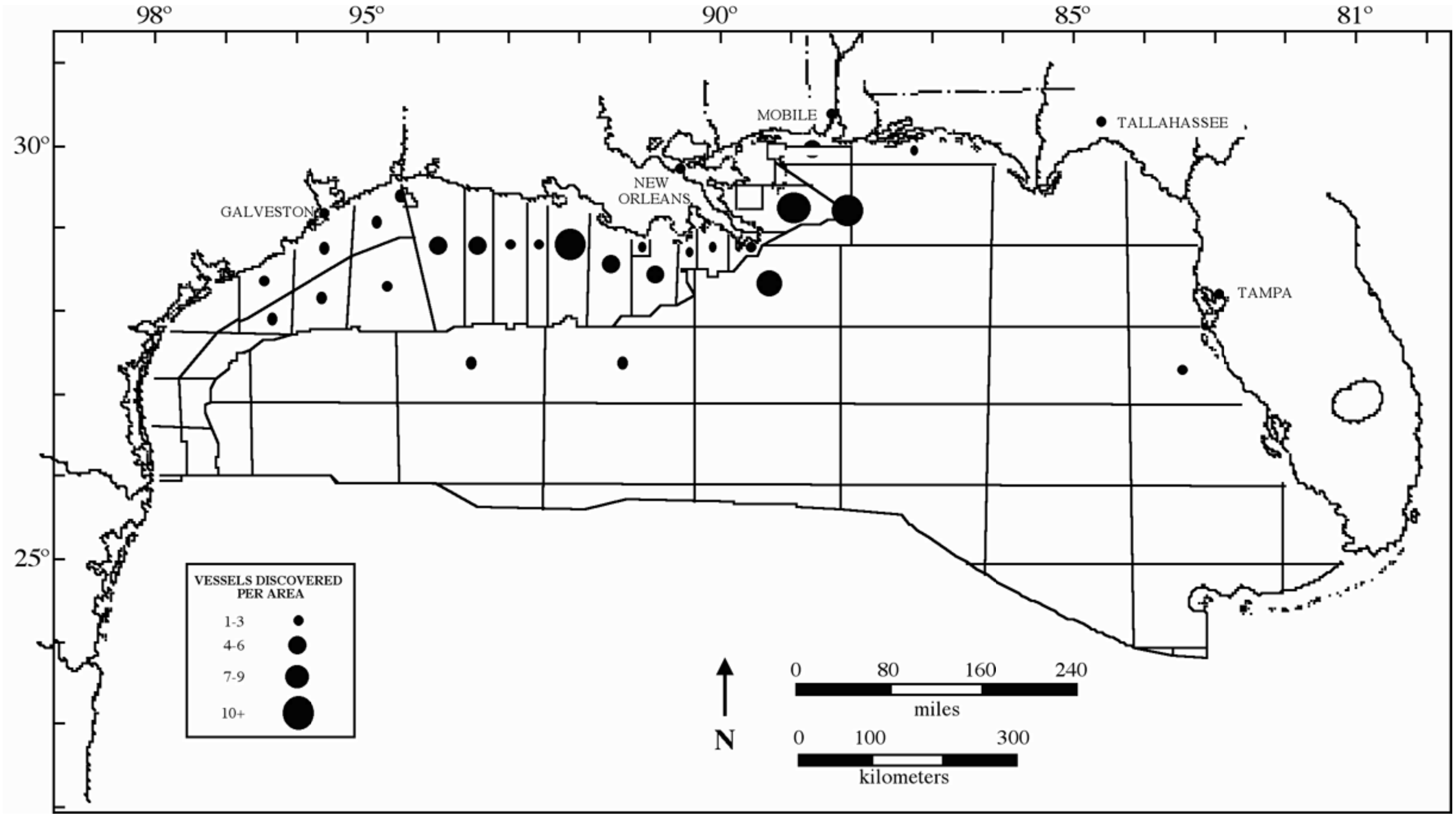


Figure 3-4. Numbers of vessels discovered by MMS-required surveys per lease area. Data as of September 2001.

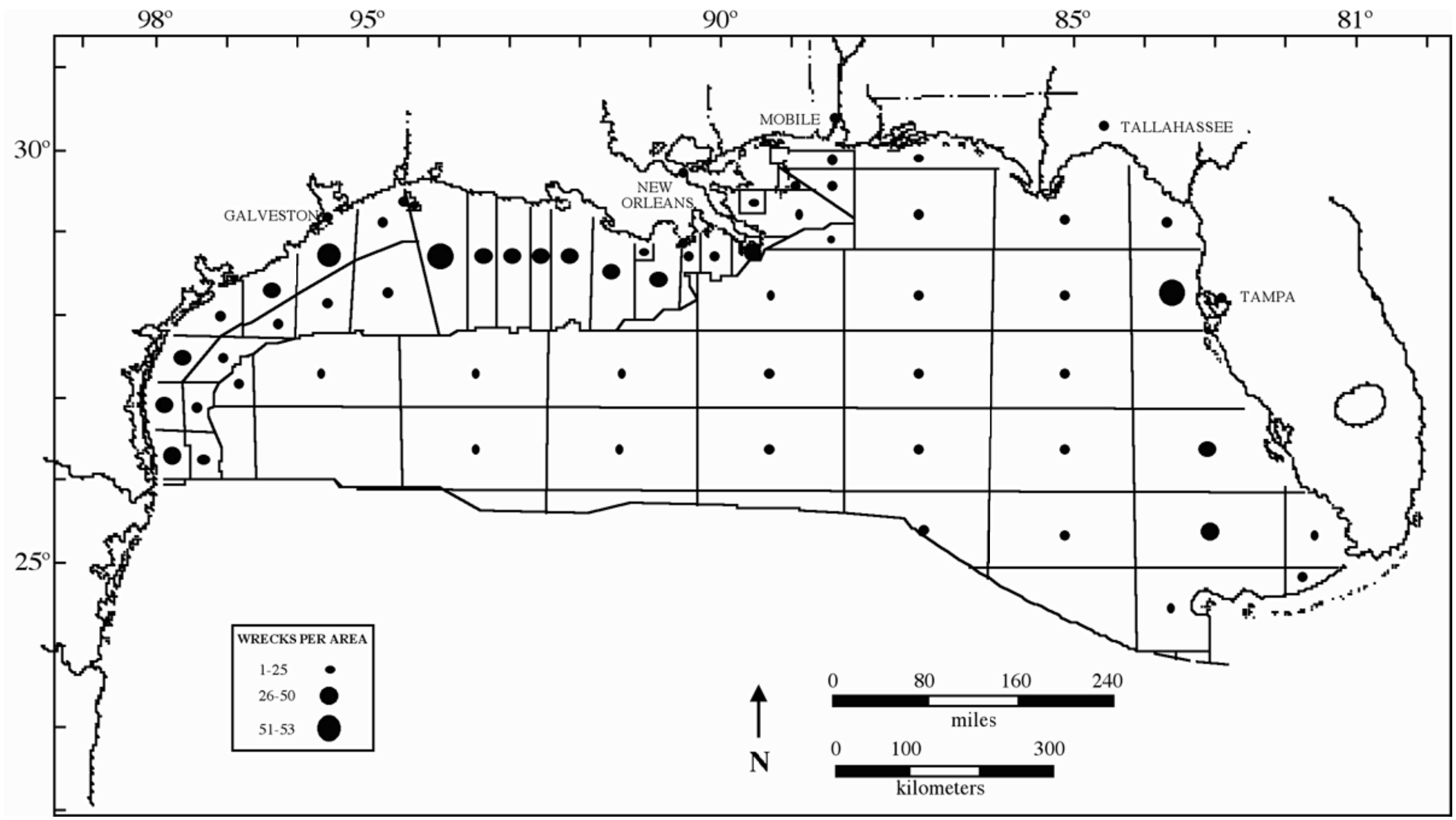


Figure 3-5. Numbers of reported shipwrecks per lease area indicated by the 1989 shipwreck database developed by Garrison et al. **(1989).**

To look at this relationship, correlation coefficients were computed on three sets of survey data, using the 70 MMS lease areas as the spatial units of analysis. The correlation analysis tool provided in the software program Microsoft Excel was used in this analysis. Essentially, this analysis measures if two ranges of data move together; that is, whether large numbers in one set are associated with large numbers in the other. The analysis returns the covariance of two data sets divided by the product of their standard deviations using the formula:

$$\mathbf{P}_{x,y} = \mathbf{\mathit{cov}\,(X,Y)/q_x \times q_y} \text{ where}$$

$$\mathbf{q_x^2 = 1/n \sum (X_i - u_x)^2} \text{ and}$$

$$\mathbf{q_y^2 = 1/n \sum (Y_i - u_y)^2}$$

The first correlation analysis looked at the relationship between the number of surveys conducted in each lease area versus the number of vessels found. This analysis indicated that there was a 0.6320 correlation between these two variables. This indicates that there is a positive relationship between these two sets of data: i.e., the more surveys conducted, the more vessels found, but that the correlation is not extremely high. The second analysis looked at the relationship between the number of surveys conducted and the number of vessels reported by lease area in the 1989 shipwreck model. This analysis revealed a roughly similar correlation coefficient of 0.6409, again showing a moderate correlation between the two variables. Finally, the relationship between the numbers of vessels found by archaeological survey and losses reported by lease area in the 1989 model was examined. This relationship shows a weak correlation, producing a correlation coefficient of 0.3786.

Another way to assess the reliability of the 1989 model of shipwrecks is to determine if there is any significant difference between the number of shipwrecks found in lease blocks designated high-probability blocks relative to the number found in designated non-high-probability lease blocks. This analysis used all 2,220 lease blocks in the GOMR for which there were archaeological survey reports, as of September 2001. As noted earlier, 651 of these have been designated as high-probability lease blocks as a result of the 1989 Garrison et al. study. Archaeological surveys have identified sunken vessels in 33 of these lease blocks. A total of 57 sunken vessels have been identified in the 1,569 non-high-probability lease blocks surveyed. Thus, the probability of finding a shipwreck in a high-probability lease block is 0.05, only slightly higher than the probability of finding a wreck in a non-high-probability block, which is 0.04.

A chi square test (x^2) was conducted to determine if there is any statistically significant difference between the results of surveys conducted in high-probability blocks and those conducted in non-high-probability blocks. The chi square test is a “goodness-of-fit” technique that can be used to determine the significance of differences between independent groups using observed and expected occurrences (Siegel 1956:43, 104). In the present case, the two independent groups are the surveys conducted in high-probability lease blocks (N=651) and those conducted in non-high-probability blocks (N=1,569). Under the 1989 shipwreck model, the expectations are that there will be a difference between the results of surveys in the two categories of lease blocks. Following statistical hypothesis testing, this expectation would constitute what is known as the "alternative hypothesis" (H_1). Statistical tests are, normally, used to test what is called the "null hypothesis" (H_o). In this instance, H_o states that there is no difference between the two categories of lease blocks relative to the occurrence of shipwrecks. The significance level selected for acceptance or rejection of the null hypothesis is .05, a standard used in most social science research.

The formula used in analysis is one that is most applicable to 2 x 2 contingency tables (Siegel 1956:107). The formula, contingency table and the computed value of x^2 are presented in Table 3-5. The degree of freedom for a 2 x 2 chi square analysis = 1. The computed value of x^2 = 2.92. This value is less than the critical value of chi square expected at a significant level of .05 (3.84) if there was a statistical difference between the two categories of lease blocks (Siegel 1956:Table C). This means that the null hypotheses cannot be rejected and we can assume that there is no statistical difference between finding wrecks in high-probability lease blocks and finding wrecks in non-high-probability lease blocks.

Table 3-5. Chi Square Analysis of GOMR Lease Block Survey Results

$$x^2 = \frac{N\,(|AD-BC| - N/2)^2}{(A=B)(C=D)(A=C)(B=D)}$$

where:

N = number of cases
A, B, C, D = the cells in the contingency table

	High-probability blocks	Non-high-probability blocks	Total
With shipwrecks	33 (A)	57 (B)	90
No shipwrecks	618 (C)	1512 (D)	2130
Total	651	1569	2220

x^2 = 2.92

This analysis, of course, uses only the sample of surveys that have been conducted and their results and the chi square analysis measures this sample. For the present, we presume that this sample is representative of the population of high-probability and non-high-probability lease blocks in the GOMR, but there is currently no way to evaluate this presumption. Additionally, we have used a level of significance of .05, meaning that the finding has a 5 percent chance of not being true. As noted, the .05 level of significance is a standard accepted in social science research, but an examination of critical values of chi square reveals that the null hypotheses could be rejected at a level of significance of .10. If this level of significance were used, it would mean that the finding has a 10 percent chance of not being true.

The various analyses presented here provide some quantitative evaluations of the 1989 model of shipwreck occurrences in the GOMR. These analyses have relied on actual results of the MMS-mandated archaeological survey program, a program that has been designed on the findings of the 1989 model. It is apparent from these analysis that the "power of prediction" of the 1989 model in regard to shipwreck locations is extremely weak. This weakness lies, principally, in the lack of precision found in the geographic coordinates assigned to reported losses. This is certainly not surprising given the nature of much of the available information on locations of loss, and is a problem that was fully recognized in the 1989 Garrison et al. study. In light of the fact that a very large number of historic accounts of vessel losses are extremely vague, rectifying this problem would not be easy. If one wished to strengthen the location of loss information on the entire population of reported shipwrecks in the GOMR, it would require an extensive amount of historical research, principally in primary documents, and how successful such an endeavor would be is unknown. Another way to strengthen the predictability of the model is to weigh the available information on location of loss in terms of its "reliability" and use this information to categorize the entire population of reported wrecks in the GOMR in terms of their likelihood of discovery. Essentially, the locations of some wrecks are predictable and the MMS archaeological survey program can be designed in such a way to account for this. On the other hand, the locations of a very large number of wrecks are not reliably predictable, a factor that, also, should be incorporated into the MMS archaeological survey program. These questions are more fully explored in the following chapter.

4.0: THE 2001 MODEL OF SHIPWRECK OCCURRENCES IN THE GULF OF MEXICO

4.1. Introduction

The previous chapter discussed the model of shipwreck occurrences in the Gulf of Mexico as derived from the 1989 study by Garrison et al. and how that model has been used by MMS in its archaeological survey program in the GOMR. Several shortcomings of the 1989 model have been pointed out. As noted, most of these shortcomings are related to the nature of historic shipwreck data used in these types of overview studies. The database of shipwrecks developed in the 1989 study represented one of its major components and one of the principal tasks of the present study was to expand upon that listing. As discussed in Chapter 1, Task 1 of the present study as described in the Request for Proposal issued by MMS in April 2000 was to:

> ". . . update and expand the existing MMS GOMR shipwreck database by examining primary and secondary sources for shipwreck information. The existing shipwreck database will be expanded to include specific identifying characteristics of vessels potentially located on the OCS" (MMS 2000).

The results of Task 1 are presented in this chapter. Included are discussions on the procedures and rationale involved in acquiring data for the new shipwreck database and some of the problems encountered in developing this listing. Characteristics of the newly developed database are presented in terms of a variety of factors that relate to the population of shipwrecks in the GOMR. These include a variety of quantitative and qualitative measures of factors such as the types of vessels lost, period of loss, cause of loss, etc. Discussions also include assessments of the preservation potential of shipwrecks in the GOMR, drawing upon characteristics of the natural setting of the region and the findings of recent archaeological research on shipwrecks in the area. Finally, the spatial distributions of shipwrecks, as revealed in information contained in the database, are discussed. The findings from these analyses and discussions constitute a "model" of shipwreck occurrences in the GOMR. It is a model in that it represents a simplified theoretical construct that depicts a set of complex phenomena. The variables and attributes selected for consideration are those that are considered most meaningful to the purposes of the model. The selection of some characteristics and the elimination of others in analyses means that the model presented here, as with most other models, is only a partial representation of reality (Clarke 1972:12). The effort has been made to incorporate into the model those characteristics that will be most meaningful to the MMS in its effort to protect historic shipwrecks in the GOMR and, specifically, to direct its offshore archaeological resources remote-sensing survey program.

All of the following discussions build and draw upon the information presented in Garrison et al. (1989) and numerous comparisons are made between the data obtained in that study and this one. No extensive discussions on the maritime history of the Gulf of

Mexico are presented here. That history is amply discussed in the Garrison et al. (1989) study and the earlier work by Coastal Environments, Inc. (1977). Additionally, a number of published works provide excellent accounts on various aspects of the maritime history of the Gulf of Mexico region (cf., Arnold and Weddle 1978; Francaviglia 1998; Pearson and Hoffman 1995; Weddle 1985, 1991, 1995), plus the numerous cultural resources management reports discussed earlier add to this. However, specific aspects of the maritime history of the GOMR are briefly discussed when this is indicated by findings made during the collection of information for this study and when that information might not have been fully presented elsewhere.

Also discussed in this chapter are findings related to Task 2 of this study. As described in the Request for Proposal, Task 2 was to:

> ". . . determine the spatial correlation between: 1) shipwreck locations in the updated shipwreck database; 2) recorded seafloor hang sites listed on the MMS GOMR/NOAA sponsored "Fisherman's Contingency Fund" or other published or private fisherman hang books; and 3) sonar targets and anomalies representing potential shipwrecks identified during previous OCS lease block surveys. Then, to ground-truth selected locations where hang sites and reported shipwreck locations appear to correlate to determine if hang sites are shipwrecks" (MMS 2000).

The specific aspects of Task 2 included in this chapter are those related to the spatial correlations seen between shipwreck locations and recorded seafloor hang sites and previously located targets identified during previous MMS-mandated surveys. The findings from this analysis were used to direct the ground-truthing of selected targets by divers. The results of the diving operations are presented in the following chapter.

4.2. Compiling the 2001 Shipwreck Database

4.2.1. Nature of the Historic Record of Shipwrecks in the GOMR

The shipwreck database developed for this study ultimately contained 2,106 entries of items classified as "Vessels." In addition, information on a total of 1,155 items classified as "Objects" was collected. The 2,106 entries classified as "Vessels" comprise the "2001 shipwreck database" as it is discussed here and it represents the list of critical concern. The items identified as "Objects" are, however, utilized in some of the analyses presented. The variables recorded for each entry have been noted in Chapter 1 and the complete database with all "Vessels" and "Objects" is provided in Microsoft Access format as a separate element of this technical report. Appendix E (see Volume III) presents the 2001 shipwreck database containing what are considered the most critical categories of information for the following discussions. These are: 1) Vessel ID Number; 2) Vessel Name; 3) Vessel Type; 4) Cause of Loss; 5) Year Built; 6) Year of Loss; 7 and 8) Latitude and Longitude determined for the position of loss in NAD27 decimal degrees; 9) MMS Lease Block in which the position of loss falls; 10) Location Reliability; and 11) Source of information. Appendix E also includes an explanation of each of these entries.

All of the various sources discussed in Chapter 2 were used in the compilation of the shipwreck database presented as Appendix E. These sources varied considerably in terms of the type and value of the information they provided. Some consideration of the general nature of this information is in order. Everyone who works with the historical record of shipwrecks recognizes the limitations inherent in much of this record. These limitations are related to many factors, some of which can be overcome or partially controlled, others which cannot. At the outset, it must be recognized that not all shipwrecks have been incorporated into the historic record or the record of losses is so vague as to be almost useless in a study of their distribution, as is attempted here. This is particularly true during the earliest period of vessel activity in the Gulf of Mexico. The first recorded shipwreck in the Gulf of Mexico seems to have occurred in early 1520, when several ships of an expedition led by Panfiló de Narváez were sunk by a storm off Tabasco on the eastern coast of present-day Mexico (Weddle 1985:117-118). However, by this time, the Spanish had been sailing in or on the peripheries of the Gulf of Mexico for almost two decades and it can be assumed that other ships were lost at earlier dates and not recorded. Additionally, there are numerous early accounts of vessels lost that are so vague as to have minimal value in distributional studies. Vessels were scattered by storms and never seen again and ships sailed from ports, never to be heard from again. Accounts of vessels lost out of sight of land may never appear, or will be vague and of little use in trying to plot positions of loss.

While these problems in the data are more commonly found in the records of the early historic period, they do continue into the present. Accounts and official records of vessel losses in the Gulf of Mexico during the eighteenth and nineteenth century tend to be associated with larger commercial or military ships. Losses of private vessels, or small commercial vessels, are often never officially recorded or the record of loss is extremely vague. Coastal Environments, Inc. (1977:16), for example, point out the omission of small, coasting vessels in listings of wrecks in the Gulf of Mexico, despite the fact that large numbers of small sloops and schooners were involved in this trade during the nineteenth century and many were certainly lost. This continues into the present, and an examination of the record of sinkings of craft such as those associated with the offshore fishing and oil industry reveals that many have gone unreported or under-reported or that information on their losses is vague.

The two previous studies of historic shipwrecks conducted by the MMS in the Gulf of Mexico both recognized and commented on these inherent difficulties in historic records of shipwrecks. Both of these studies drew heavily on secondary resources and both noted the fragmentary and often contradictory nature of those resources. The Coastal Environments, Inc. (1977:8-16) study discusses some of the significant problems with using secondary resources. Many of the sources used in that study derived information from “popular compendiums” that, in turn, drew from previous secondary sources. Thus, “any errors or prejudices of earlier writers” become perpetuated in subsequent publications (Coastal Environments, Inc. 1977:12). Additionally, secondary sources commonly do not provide the criteria used to originally include or exclude shipwrecks in their listings.

Changes in place names over time, or similarities in names, also can create problems when dealing with secondary as well as primary sources. Coastal Environments, Inc. (1977:13) commented on the Spanish use of the term *La Florida* to refer to a huge area, encompassing parts of the Gulf of Mexico, Caribbean and Atlantic Ocean. Some authors have placed sinkings in the Gulf of Mexico, when the only reference to the loss was "in *La Florida*." Numerous examples exist of changes in place names or of confusion as to where an early place name actually meant. For example, the Spanish originally used the name "Espîritu Santo" to refer to the Mississippi River; later the French and the Spanish used the name to refer to present-day Matagorda Bay on the central Texas coast, plus both also used the name "San Bernardo" to refer to Matagorda Bay, while the French at times used the name "Saint Louis" (Weddle 1985:369; 1991:77). Additionally, over time Spanish and French accounts named a variety of locations on the Gulf coast "Espiritu Santo" in part because of serious misunderstandings of what was referred to in earlier accounts or errors in its true location (Weddle 1991:105).

Inevitably, these types of errors can find their way into even recent works. For example, in the shipwreck database in the Gulf of Mexico developed in the Garrison et al. (1989) study, two steamboats are recorded lost off the Chandeleur Islands (in lease block Chandeleur Island 51) on the coast of southeastern Louisiana. These were the steamboats *Leopard* and *Rufus Putnam*, both reportedly lost in 1825, making them among the earliest steamboats lost in the Gulf of Mexico and thus of some historical interest. One facet of the present study was to reevaluate, where possible, the wreck database created by Garrison et al. in order to correct errors. In this particular instance, it was discovered that Garrison et al. relied on information for these two vessels provided in the Coastal Environments, Inc. (1977) study. Examination of the "Shipwreck Data Sheets" produced by CEI indicated that they had obtained their information on the two wrecks from Bruce Berman's (1972) *Encyclopedia of American Shipwrecks*, one of the commonly used popular compendiums of American shipwrecks. Berman and CEI each report that both of these steamers were "snagged" and lost off "Pt. Chicot, LA" in 1825. CEI provides no other specific locational information for the two vessels. Garrison et al., however, seem to have identified Point Chicot as a place name associated with the Louisiana coast in or near the Chandeleur Islands. An examination of maps of the region shows no landform named Point Chicot, although there is a Chicot Island in Breton Sound inside of the Chandeleurs.

It was apparent that there was a problem with the inclusion of these two vessels in the 1989 MMS wreck list. Both vessels were unusually early for steamboats in the Gulf, plus both had been reported "snagged," which normally refers to a vessel running into a log, a rather unlikely event off the Chandeleur Islands. Additionally, it was known that Point Chicot was a place name found along the Mississippi River in northern Louisiana, a location where snaggings of steamers was relatively common. This led to a review of information on steamboat losses on the Mississippi River presented in what is known as the Lytle-Holdcamper List, published as *Merchant Steam Vessels of the United States, 1790-1868* (Mitchell 1975) and a recent cultural resources management study of the navigation history and shipwrecks along this section of the Mississippi River (Wells et al.

1999). Both vessels are included in the Lytle-Holdcamper List, and both are reported to have been snagged and lost at Point Chicot, Louisiana. Further, both of these steamboats appear to have been typical western river steamers: the *Leopard* was a 73-ton sidewheeler built at Silver Creek, Indiana, in 1822 while the *Rufus Putnam* was a 68-ton sidewheeler constructed at Marietta, Ohio in 1822 (Mitchell 1975:126, 189). These two steamboats were typical river steamers and it is unlikely that either would have ever ventured into the Gulf of Mexico. Additionally, the reference to Point Chicot in the Lytle-Holdcamper List seems clearly to refer to the location along the Mississippi River. It is apparent that Berman (1972) indicated these vessels were lost in the Gulf of Mexico, a fact perpetuated by the CEI and Garrison et al. studies, with Garrison et al. going on to identify Point Chicot as a location near the Chandeleur Islands, possibly a confusion with Chicot Island.

The vessel *Theresa F.* is another example of the types of problems that are all too often encountered when using various sources of data on even relatively recent shipwrecks and the impact these problems can have on the MMS archaeological survey program. In the list of wrecks derived from the Garrison et al. (1989) study two vessels named *Theresa F*. are listed (see Appendix A). The coordinates given for both vessels are the same and they fall within the West Delta Area, just off the mouth of the Mississippi River. It appears that Garrison et al. listed this vessel twice because data were derived from two different sources: the Hydrographic Office (HO) and the list of losses provided in *Merchant Vessels of the United States* (MVUS). The information derived from the MVUS records indicates the vessel was lost in 1960, while no date of loss was provided in the HO records. A reexamination of the original MVUS records (MVUS 1961) reveals that the vessel *Theresa F*. foundered in July 1960 “about 40 miles ESE of Freeport, Texas.” The MVUS provides no additional information on the location of the sinking of this *Theresa F.*, but it is apparent that it did not sink anywhere near the mouth of the Mississippi River. The coordinates used in the MMS wreck list by Garrison et al. came from the records of the Hydrographic Office, but where that office got them is unknown. The successor to the Hydrographic Office, the National Imagery and Mapping Agency (NIMA), continued to use the coordinates, placing a vessel named *Theresa F.* in the West Delta Area, off the mouth of the Mississippi (NIMA 2000).

In 1968, a vessel named *Theresa F*. did sink near the entrance to the Mississippi River. The MVUS notes that the towboat *Theresa F*. “capsized and sank near SW Pass Sea Buoy” while towing the barge *Freeport 1* from Tampa, Florida to the Mississippi River (MVUS 1969). No coordinates for the position of sinking are provided. It would appear that this is the *Theresa F*. listed by Garrison et al. and that the Hydrographic Office derived the coordinates for the location of loss from the verbal description given in the MVUS (1969). However, Garrison et al. seem to have assigned the date of loss for the *Theresa F*. sunk off Freeport, Texas, to the towboat sunk off Southwest Pass.

To add to the confusion, NIMA does report the loss of a vessel named *Tricia F*. off the upper Texas coast in 1960 (NIMA 2000). The coordinates given by NIMA place the sinking in the Galveston Area, about 40 miles south, southeast of Freeport, Texas. This is almost certainly the vessel identified as the *Theresa F*. in MVUS records. It is apparent that there has been considerable confusion about the vessels named *Theresa F.*

and *Tricia F*. The *Theresa F*. listed in the West Delta Area in the 1989 shipwreck database, presumably, refers to the towboat that sank near the Southwest Pass Buoy in 1969, but the date of loss given is for the vessel of the same or similar name that sank nine years earlier off Freeport, Texas.

As noted, the location of the *Theresa F*. off the mouth of the Mississippi River was apparently derived from the original verbal description of its location of sinking near the Sea Buoy. However, a more complete review of records relating to the loss of this vessel has revealed that the coordinates provided by the HO and given in Garrison et al. are incorrect. When the *Theresa F*. capsized, three of the men aboard were killed, an event that resulted in an official inquiry and production of a Marine Casualty Report by the United States Coast Guard (USCG 1971). The records of this inquiry provide very specific coordinates for the position of loss, a position that is different from the one given by the HO and used in the 1989 MMS wreck list. These USCG coordinates place the location of the sinking of the *Theresa F.* in the South Pass Area, a short distance east of the location given in the MMS wreck list. In light of the official nature of the Coast Guard inquiry, it is believed that the coordinates they provide are the most accurate location of the sinking of the *Theresa F*.

This kind of confusion is inevitably going to arise in certain cases because of the nature of the available data on vessel losses. In this case, the confusion was greater than normal because it seems to have been confounded by two vessels with the same or similar names. Critically important is that the presumed location of the *Theresa F.* in the West Delta Area is presented in all of the readily available and commonly used shipwreck databases, including the list now used by the MMS, and remote-sensing surveys in the area have relied on this presumption in the interpretation of their data.

The cases of the *Theresa F.,* the *Leopard* and the *Rufus Putnam* serve to highlight the kinds of errors likely to be incorporated in almost any listing of historic shipwrecks, including the one presently used by the MMS to direct its offshore survey efforts. Although the requirement of the present study was principally to build on and expand upon the wreck list developed by Garrison et al., it became apparent with these vessels, and other examples, that a reassessment of every one of the over 1,400 wrecks in the 1989 list would be necessary in order to clarify any errors that might exist. This reassessment involved, where possible, a reexamination of the sources of data listed by Garrison et al. (1989) for every entry in the 1989 shipwreck database. Some errors were identified, resulting in some vessels being eliminated from the list while others were assigned different locations of sinking. A particularly valuable aspect of this reevaluation was that it collected information that could be used in assessing the “reliability” of the location of loss for many individual vessels. As is discussed in more detail later, this “reliability” assessment is considered an important element in modeling shipwreck distributions within the study area. Some errors and contradictions in the data, however, could not be resolved, a problem faced and recognized by the two earlier studies.

4.2.2. Determining Geographic Coordinates for Shipwrecks in the Database

The procedures described by Garrison et al. (1989:II-10-11) in assigning geographic coordinates to reported shipwreck losses are essentially the same as those used in this study. In the final database of shipwrecks developed, coordinates are provided as decimal latitude and longitude, a format that allows the mapping of wreck distributions in GIS formats. The 1989 shipwreck database represented the point of departure for developing the present database and the geographic coordinates provided in that study have been used except where additional data on wrecks suggested that that information might be incorrect.

Most of the sources examined did not provide exact latitudes and longitudes for losses; generally, the location of loss was provided in descriptive terms. These descriptions have been included in the "Comment" section of the Access format shipwreck database accompanying this report. The purpose of including these descriptions is to provide researchers easy and direct access to the data from which the coordinates were developed. Additionally, as has been discussed in an earlier chapter and is more fully explained below, these descriptive statements often were the basis upon which an assessment of a position's "reliability" was obtained. When only descriptive statements were available, these were followed to obtain the geographic coordinates by plotting the position of the wreck in ArcView. For example, if the description of loss stated that the vessel sank "about 12 miles southeast of Galveston" this position was determined by scaling it off in ArcView. In those instances where the description stated that a loss occurred "10 miles off Grand Isle" and no direction was provided, the position was presumed to be perpendicular to that coastline, as did Garrison et al. (1989:II-11). In the case of a large shore feature, such as Grand Isle, the center of the feature was used as the reference point. A variety of maps and navigation charts were used to identify various landforms and locations encountered in these descriptive statements.

It is apparent that some undetermined amount of error can be incorporated in the coordinates obtained from these types of descriptions. Commonly, the distances and the directions given are obviously "best guesses;" few contain language that would indicate any great degree of precision in the estimate. Additionally, when no direction is given, it is impossible to accurately assess the error incorporated in selecting a point perpendicular to the named shore feature. This error is likely to be compounded when the onshore position referenced is a large landform, such as "Grand Isle."

If the source used provided geographic coordinates, these were used, even if they were very general; for example, consisting of a position only to the nearest degree. A large number of the wrecks included in the database had their positions originally recorded in Loran coordinates that had been subsequently converted to geographic coordinates. These geographic coordinates were used. Where multiple sources existed, the source considered most reliable was used to determine the position of loss. Generally, the most reliable source was a primary account of the loss, if one was found. In those few instances where recent archaeological or remote-sensing survey work had located historic vessels, the position of loss was obtained from this recent work.

4.3. Characteristics of the 2001 Shipwreck Database

The 2,106 entries in the shipwreck database compiled for this study represent some presently unknown proportion of the total population of shipwrecks existing in the GOMR. However, this listing is believed to incorporate much of the variability found in that population of wrecks in terms of factors such as vessel types, causes of loss, periods of loss, etc. In light of this presumption, the shipwreck database does provide a point of departure for developing generalized statements about the population of wrecks in the study area. As is discussed in more detail below, there are recognizable gaps in the available shipwreck data that make it difficult to assess the reliability of some of the generalizations presented. For example, there is an obvious underreporting of wrecks in the study area for earlier historic periods. Because of this, it remains unknown as to how accurately the shipwrecks that are known from early periods actually characterize the population of wrecks from those periods. Similarly, there is a gap in our knowledge of small pleasure and fishing craft that have been lost in the region in the twentieth century. Many of these types of vessels operated outside of the purview of various government agencies and thus their existence, as well as their loss, may have never been recorded. In recent years, at least for the past 25 or so, the losses of many of these types of vessels have been recorded (for example, in USCG records), but for much of the first half of the twentieth century they may not have been. These types of vessels might be of lesser concern in this study than in other similar ones because the study area includes only Federal waters and excludes the nearshore, state waters where many of these types of craft would have confined their activities.

Information in the shipwreck database is examined in a variety of ways. In most of these efforts, comparisons are made with the 1989 shipwreck database developed by Garrison et al. and, where appropriate, with other similar sets of data.

The 2001 shipwreck database represents an increase of 638 entries over the 1989 shipwreck database. However, as noted earlier, the 1989 database included a number of obvious duplicate entries, some of which could be identified. If these duplicates were removed, the increase in the number of entries in the new database would represent about 800 entries. Table 4-1 compares the number of wrecks reported in the 1989 database against the numbers developed in this study by MMS lease area. The table also shows the difference between the two data sets. As can be seen, in a few lease areas there are fewer wrecks listed in the new database than had been included in the 1989 list. In most instances, this was because it was determined that some vessels shown falling in Federal waters in the 1989 list are now believed to be most reliably located in state waters.

Table 4-1. Differences Between Number of Shipwrecks Reported in 1989 Study and This Study by Lease Area

LEASE AREA		NUMBER OF LOSSES-THIS STUDY	NUMBER OF LOSSES-1989 STUDY*	DIFFERENCE
ALAMINOS CANYON	AC	1	1	0
AMERY TERRACE	AM	0	0	0

Table 4-1. (continued). Differences Between Number of Shipwrecks Reported in 1989 Study and This Study by Lease Area

LEASE AREA		NUMBER OF LOSSES-THIS STUDY	NUMBER OF LOSSES-1989 STUDY*	DIFFERENCE
APALACHICOLA	AP	57	27	30
ATWATER VALLEY	AT	5	0	5
BRAZOS	BA	42	43	-1
BRAZOS A	BAA	19	6	13
BAY MARCHAND	BM	1	3	-2
BRETON SOUND	BS	14	13	1
CHANDELEUR	CA	8	1	7
CORPUS CHRISTI	CC	3	1	2
CAMPECHE ESCARPMENT	CE	0	0	0
CHARLOTTE HARBOR	CH	45	21	24
DESOTO CANYON	DC	10	11	-1
DESTIN DOME	DD	37	17	20
DRY TORTUGAS	DT	28	18	10
EAST BREAKS	EB	7	5	2
EAST CAMERON	EC	43	35	8
FLORIDA PLAIN	FP	3	0	3
EUGENE ISLAND	EI	97	51	46
THE ELBOW	EL	6	7	-1
EWING BANK	EW	2	1	1
FLORIDA MIDDLE GROUND	FM	19	17	2
GALVESTON	GA	93	73	20
GALVESTON A	GAA	26	19	7
GARDEN BANKS	GB	3	1	2
GRAND ISLE	GI	29	18	11
GREEN CANYON	GC	14	3	11
GAINESVILLE	GV	8	8	0
HENDERSON	HE	8	9	-1
HOWELL HOOK	HH	10	10	0
HIGH ISLAND	HI	50	33	17
HIGH ISLAND A	HIA	60	24	36
KEATHLEY CANYON	KC	1	3	-2
KEY WEST	KW	5	1	4
LLOYD	LL	10	6	4
LUND SOUTH	LS	0	0	0
LUND	LU	11	13	-2
MIAMI	MA	10	6	4
MISSISSIPPI CANYON	MC	36	20	16
MATAGORDA ISLAND	MI	45	25	20
MATAGORDA ISLAND A	MIA	0	1	-1
MOBILE	MO	71	27	44
MAIN PASS	MP	60	35	25
MUSTANG ISLAND	MU	57	49	8
MUSTANG ISLAND A	MUA	13	10	3
ST. PETERSBURG	PB	57	24	33
PENSACOLA	PE	93	21	72
PORT ISABEL	PI	2	0	2
SOUTH PELTO	PL	17	5	12
NORTH PADRE ISLAND	PN	30	33	-3
NORTH PADRE ISLAND A	PNA	8	5	3
PULLEY RIDGE	PR	38	29	9
SOUTH PADRE ISLAND	PS	44	38	6
SOUTH PADRE ISLAND A	PSA	8	4	4
RANKIN	RK	0	0	0
SABINE PASS (LA)	SA	17	22	-5

Table 4-1. (continued). Differences Between Number of Shipwrecks Reported in 1989 Study and This Study by Lease Area

LEASE AREA		NUMBER OF LOSSES-THIS STUDY	NUMBER OF LOSSES-1989 STUDY*	DIFFERENCE
SIGSBEE ESCARPMENT	SE	0	0	0
SABINE PASS (TX)	SX	2	6	-4
SOUTH MARSH ISLAND	SM	32	19	13
SOUTH PASS	SP	33	39	-6
SHIP SHOAL	SS	95	51	44
SOUTH TIMBALIER	ST	88	46	42
TARPON SPRINGS	TP	55	57	-2
TORTUGAS VALLEY	TV	0	0	0
VIOSCA KNOLL	VK	21	10	11
VERNON	VN	8	4	4
VERMILION	VR	62	39	23
WALKER RIDGE	WR	2	2	0
WEST CAMERON	WC	124	72	52
WEST DELTA	WD	55	30	25
OUTSIDE OF LEASE AREAS		148**	240	-92
TOTALS		**2106**	**1468**	**638**

*The 1989 shipwreck database does not include a lease area for one vessel, thus the total number shown here is one less than the 1,469 entries in that database.
**Does not include vessels falling in numbered MMS lease blocks extending into or lying entirely in state waters.

The 1989 shipwreck database, as noted earlier, did include 240 entries identified as falling in state waters. The present database also includes a number of shipwrecks whose reported positions fall in state waters, despite the fact that only shipwrecks within MMS lease areas are of principal concern in this study. These particular vessels are included in the database because of uncertainties about their location of loss. As shown in Table 4-1, these include 148 entries with no lease block designations. These vessels fall outside of numbered MMS lease blocks. A few of these vessels fall south of the MMS lease areas, but most fall within the waters of the states bordering the Gulf. In addition, there are 219 entries that fall in numbered MMS lease blocks that extend into or lie entirely in state waters. Most of these entries lie in Louisiana and Texas state waters and are identified in Appendix E. These vessels have been included in the shipwreck database dependent upon the reliability value assigned to their reported position of loss. Those vessels in state waters assigned a location reliability of 2 whose plotted position falls closer to Federal waters than to the state shorelines have been included in the database. Thus, if the vessel lies in Louisiana state waters, its reported position of loss has been determined to be more than 1.5 miles from the shoreline. All of those vessels with positions of loss in state waters or near the southern edge of the GOMR that are assigned poor location reliabilities of 3 or 4 have been included in the database. In light of the uncertainties about the reliability of the plotted position of these vessels, they may actually lie within the MMS lease areas.

The 2,106 entries in the shipwreck database encompass a variety of items in addition to historically reported shipwrecks. The entries include nine aircraft, nine helicopters, 14 objects identified as anchors or anchors and chain, and structural remains associated with an historic lighthouse, the Ship Shoal Lighthouse, an iron screw pile structure erected off the Louisiana coast in 1859 (Cipra 1997:156-160). These items are included because they represent, or have the potential for representing, historically significant cultural remains. Within the list are an estimated 1,290 named shipwrecks, that is, vessels whose official name has been determined. This number is an estimate, because some shipwrecks are identified in various sources by descriptive statements or nicknames that may or may not be the vessel's official name. This is particularly true of wreck names derived from sport diver accounts and records, such as "Lipscombe Tug," "O-Tower Barge," or "Redfish Barge." Sources were compared to try to sort out these naming problems and identify the vessel's actual name, but this was not always successful.

The database also includes over 470 "Unknown Vessels" in addition to several entries identified as "Unknown Wreck," "Unknown Tug," "Unknown Fishing Vessel" and the like. Additional entries include 64 "Pleasure Craft" and other wrecks identified only by their length, plus wrecks identified only as "Shrimp Boats," "Wrecks," "Sailing Vessels," and a number of "Barges" named in various ways. Sources were compared to see if these unnamed entries could be associated with a named shipwreck and, where possible, this was done. Otherwise, the nomenclature used in the original source was maintained.

4.3.1. Chronological Trends

4.3.1.1. Year of Loss

Year of loss information was obtained for 1,419 vessels, or 67.4 percent of the total items included in the 2001 shipwreck database. The earliest shipwreck included in the database is the *San Jorge*, lost in 1625, and the latest losses are two vessels that were sunk as elements of artificial reefs in the year 2001. Much of the information on recent losses was obtained from computerized databases maintained by various government agencies (e.g., NOAA, NIMA, and USCG) that are updated only periodically. Most of these databases were obtained in the fall of 2000 and, therefore, they will contain only some of the Gulf of Mexico losses for that year and it is possible that not all of the losses for 1999 have been incorporated in all of these lists.

In the present study, data on recent losses have been collected even though historical significance as stipulated by the National Register of Historic Places normally applies to resources over 50 years old. This follows the approach used by Garrison et al. (1989), even though the ultimate selection of some high-probability lease blocks by the MMS did eliminate vessels that have been lost in the past 50 years. Other studies (e.g., the Pacific coast MMS study by Gearhart et al. [1990]) have used a 50-year-ago date of sinking as an end date for data collection. One of the hazards in using the 50-year-ago loss date is that many vessels that have sunk within the past 50 years are greater than 50 years old and, thus, might represent significant historic resources under National Register criteria. In this study, for example, year of build and year of loss were obtained for 689 vessels. Of these, 490 losses have occurred in the past 50 years (i.e., since 1950). Out of this number, 242 vessels were 50 years old or greater in the year 2000, when the present study was initiated. If the year of loss were the only criterion used for establishing potential historical significance, these vessels, constituting 49.4 percent of the total in this group, would be eliminated from consideration. It is impossible to know if this proportion can be extended to those vessels of unknown date of build that have been lost in the past 50 years, but it is presumed that a fairly large percentage of them are greater than 50 years old.

Figure 4-1 provides data on vessel losses by 25-year intervals using the 1,419 entries in the database for which year of loss is known. These data show a pattern of an overall increase in the frequency of vessel losses over time, with a very dramatic increase in number of reported wrecks occurring after 1950. As seen in Figure 4-1, the 1951-1975 twenty-five-year interval has almost five times as many reported wrecks as the previous interval. In fact, more losses are reported in the GOMR for the period 1951 to 1975 than for the entire historic period before that date.

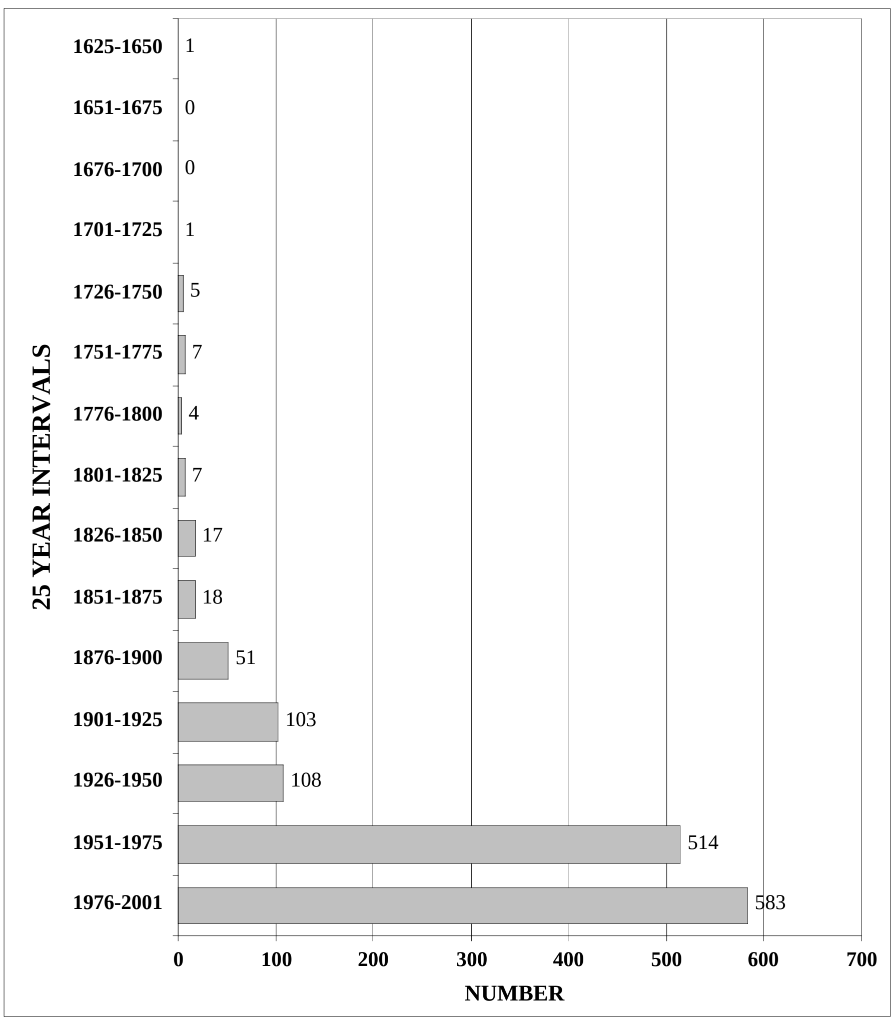


Figure 4-1. Shipwreck frequencies in the GOMR by 25-year intervals, 1625-2001. Data from 2001 shipwreck database.

This significant increase in the number of reported losses after 1950 is partially a reflection of an actual increase in losses because of a significant increase in the number of vessels operating on the Gulf of Mexico, but it is also a reflection of recent trends in reporting losses. As has been noted, there is an obvious bias for underreporting losses during earlier historic periods. Additionally, in the past several decades, reports of losses have become more inclusive in terms of the types of vessels considered. For example, the USCG and other agencies now record losses of pleasure craft and small fishing vessels, classes of vessels that were typically ignored in earlier years as can be seen in sources such as the *Merchant Vessels of the United States*.

One factor that has contributed to some of the increase in reported losses in the past 25 years or so is the inclusion of a number of artificial reefs in the 2001 shipwreck database. These represent vessels of various types deliberately scuttled in the past 25 years or so to form artificial reefs and fish havens. A number of these vessels are World War II-era ships (particularly "Liberty Ships") and their inclusion in the database tends to disproportionately increase the representation of this class and age of vessels relative to other types that have been lost to natural causes.

The pattern of losses by 25-year-intervals seen in the 2001 shipwreck database is very similar to that seen in the 1989 shipwreck database, as shown in Figure 4-2. The two databases show a very similar pattern through the 1951-1975 interval. The divergence after that date is because the 1989 database includes data only through 1987 and, as noted above, the present study has incorporated only a portion of the losses occurring after the year 2000. It is not surprising that these two sets of data resemble one another since they are dealing with the same subset of reported shipwrecks, e.g., those occurring in Federal waters in the Gulf of Mexico, plus the present study drew extensively on data contained in the 1989 database.

Garrison et al. (1989:Table II-15) also provide year of loss data in 10-year intervals for the period 1500 to 1986, including 4,154 entries, and incorporate data on all vessel losses in the Gulf of Mexico, including those occurring in state waters. In essence, this dataset represents a regional compendium for frequency of losses over time. Murphy and Jonsson (1993) have synthesized information on the vessel losses that occurred in the Dry Tortugas and the immediate vicinity, southwest of the Florida Keys. In their data, they include reports of actual losses as well as "casualties" which may or may not actually result in a sinking. They have included casualties because they might produce archaeological materials even if no sinking occurred, the same reason that these reports are included in the present study. The Dry Tortugas data include information on the year of loss or casualty for 215 vessels. These data can be viewed as a "local" set of shipwreck information from the Gulf of Mexico, although the Dry Tortugas must be considered somewhat atypical features relative to regional shipwreck occurrences.

Historically, the Dry Tortugas and the adjacent Marquesas Islands represented one of the most dangerous hazards to shipping in the Gulf. These islands consist of a series of low reefs and carbonate sandbanks extending westward from Key West and lying at the edge of the main shipping channel between the Gulf of Mexico, the Western

Caribbean and the Atlantic Ocean. Over the years, these islands have been the site of numerous shipwrecks; Bearss (1971) reported that they have been the site of the largest number of wrecks in the Gulf of Mexico.

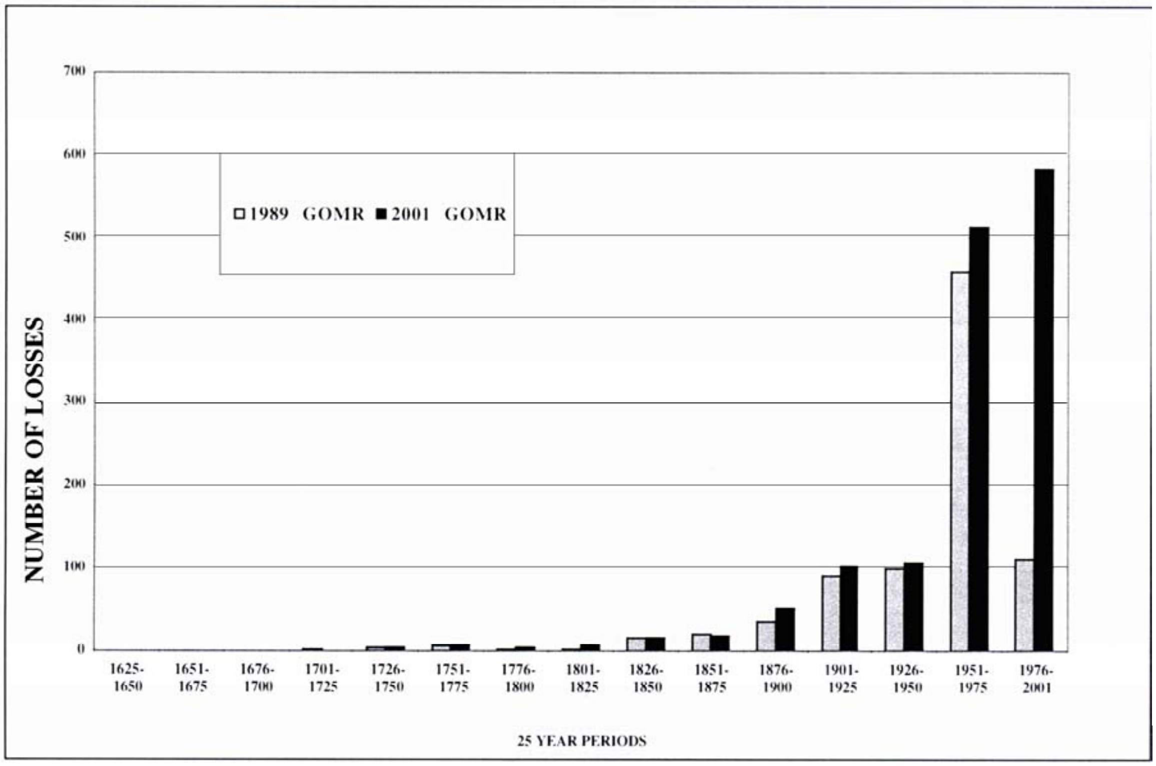


Figure 4-2. Comparison of shipwreck frequencies in the GOMR by 25-year intervals provided in the 1989 shipwreck database and the 2001 shipwreck database.

The data on losses by decade provided by Murphy and Jonsson (1993) for the Dry Tortugas and by Garrison et al. (1989) for the entire Gulf region are presented with the data obtained in the present study in Figure 4-3. In this figure, the data have been converted to percentages to permit valid comparisons and have been truncated at 1969, the last year for which the Dry Tortugas data are available. The Garrison et al. "regional" data generally follow the trend seen in the present shipwreck database up to the 1930-1939 decade. After that, the present database exhibits proportionally more losses for the next three decades. The Dry Tortugas loss data show considerable divergence from the other two datasets.

All three sets of data show a peak of losses in the 1840-1849 decade, but the Dry Tortugas data show a considerable increase in the proportional number of wrecks for the three decades from 1830 to 1859. The Dry Tortugas data also show a peak in losses during the two decades from 1880 to 1899 that is only slightly expressed in the other two datasets. Interestingly, all three sets of data show a similar increase in losses for the period 1900 to 1929. In general, as noted earlier, the trend seen in the 2001 shipwreck database as well as the Garrison et al. "regional" 1989 database is an increase in reported losses over time. Interestingly, this has not been the trend observed elsewhere.

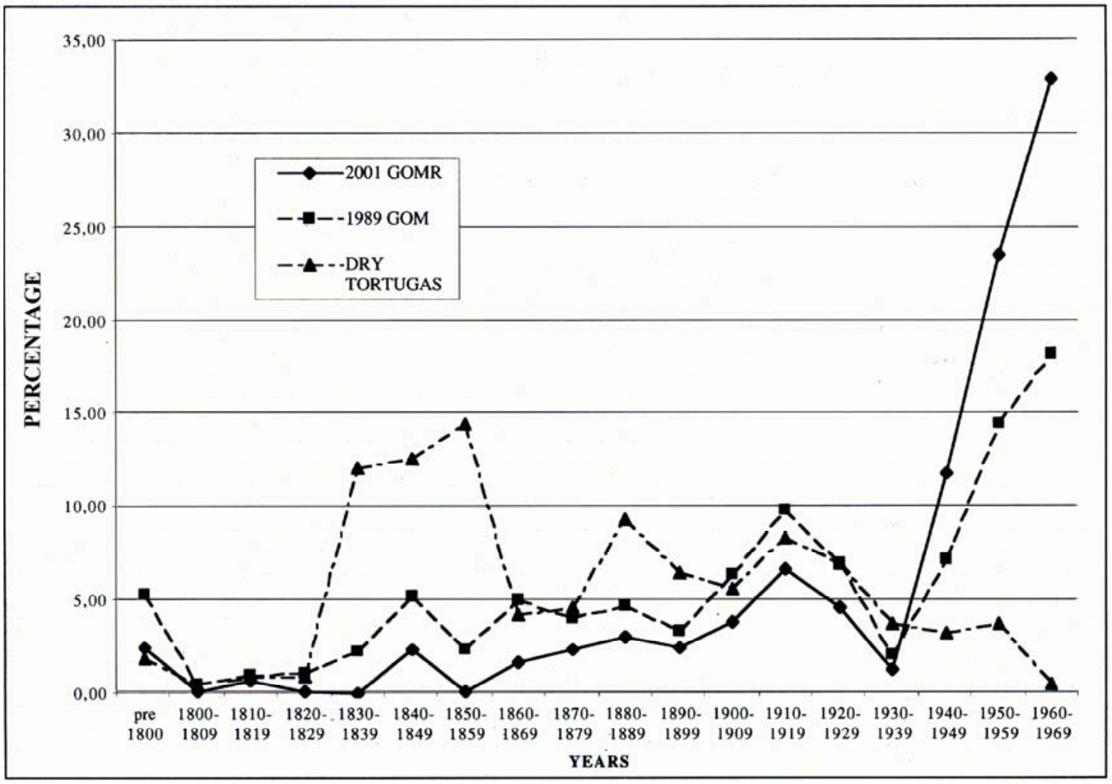


Figure 4-3. Proportional frequencies of shipwrecks by 10-year intervals for three sets of data: the 1989 data for the entire Gulf of Mexico region, data from the Dry Tortugas and vicinity and the 2001 shipwreck data from Federal waters of the Gulf of Mexico developed in this study. Data prior to 1800 is consolidated. Gulf of Mexico regional data from Garrison et al. (1989) and Dry Tortugas data from Murphy and Jonsson (1993).

The Dry Tortugas data shown in Figure 4-3 indicate a peak of losses in the 1850s, two slight peaks in the 1880s and around 1910, and then a fairly rapid decline in losses since then. Similarly, information on "casualties" and "strandings" for all of the United States for the period 1906 to 1936 reported in the "Loss List" of the *Merchant Vessels of the United States* shows a general decline in losses since the 1920s (Murphy and Jonsson 1993:150). Bourque (1979), in the study of shipwrecks on the Atlantic OCS, showed a decline in losses after 1880 and the 1977 CEI study of shipwrecks in the Gulf of Mexico reported a decline in losses after 1910. In contrast, the data in Figure 4-3 show a significant increase in the number of losses in the GOMR beginning in the 1940s, particularly after World War II. An examination of the types of vessels lost during this period reveals that a significant number are identified as "Fishing Vessels" or more specifically as "Shrimp Trawlers," or as "Pleasure Vessels" or, on the basis of their names or types, can be identified as vessels associated with the offshore oil and gas industry.

This reflects the great expansion of the fishing, particularly shrimping, industry across the entire Gulf of Mexico since the 1940s, and the development and expansion of the offshore oil and gas industry in the central and western Gulf during the same period. In addition, it reflects the rise of recreational boat use in the waters of the Gulf of Mexico. For the past several decades the largest number of vessels operating in the Gulf of Mexico have been associated with these three activities. Consequently, these types of craft constitute the greatest number of losses.

These types of modern vessels appear to be underrepresented in the Dry Tortugas shipwreck data presented by Murphy and Jonsson (1993). That study used 1969 as a cutoff date, meaning that very recent losses are excluded. Additionally, it appears that the historical sources used in the Dry Tortugas study were not those that typically include information on recent losses, such as the U.S. Coast Guard records. Thus, some of the divergence between the Dry Tortugas and the two Gulf of Mexico datasets for losses occurring after the 1930-1939 decade is believed to be a factor of the sources of information used, not a reflection of the actual losses that occurred.

Garrison et al. (1989) argue that the increase in losses during recent periods might reflect the fact that modern sailors take greater risks because of their increased confidence in and reliance on modern ship and navigation technology. This could be true, but, as noted earlier, it is more likely that the increased number of losses in recent years is principally a reflection of the tremendous increase in the number of vessels operating on Gulf waters, particularly those associated with recreational boating, fishing, and the oil and gas industry. Typically, these types of vessels are ignored in overview studies of “historic shipwrecks” under a general presumption that they are of minimal historical value. Some certainly are too young to meet the 50-year-old age criterion for National Register significance, but many are over 50 years old and these and others can provide valuable information on a variety of characteristics of these relatively recent craft. The general neglect of these more recent classes of vessels by historians as well as archaeologists means that, for some, we know less about their origins, construction and technological development than we do about seventeenth century ships.

Less obvious temporal trends can be seen in the 2001 shipwreck database year-of-loss data. Only after 1725 do more than five wrecks per 25-year interval occur (see Figure 4-1). This coincides with the establishment and expansion of settlements on the northern Gulf of Mexico and an increase in cross-Gulf travel. Garrison et al. (1989:II-99) show more wrecks for the whole Gulf of Mexico region prior to 1725, but the majority of these represent vessels lost on shore or close to shore and not in offshore waters. Additionally, there is no doubt a bias for underreporting wrecks during these very early periods (Garrison et al. 1989:II-86). Only after 1875 do more than 50 losses occur for a 25-year interval (see Figure 4-1). This reflects the increase and expansion of maritime trade in the Gulf during the last quarter of the nineteenth century with the establishment of new Gulf ports such as Port Arthur and the growth of others, such as Tampa (Garrison et al. 1989:II-23). Additionally, this increase reflects an expansion in reporting of wrecks by various agencies and organizations. For example, in 1876 the United States Life Saving Service began to publish its *Annual Reports* that included ship casualty data.

4.3.1.2. Age of Vessel at Loss

The 2001 shipwreck database contains 689 vessels for which date of build and year of loss are reported. These constitute only 33 percent of the total entries in the database, so the age at loss on this sample can only be extended to the entire database with some caution. The average age for all of these vessels was 16.5 years at the time of their reported loss or casualty. It was anticipated that the age of vessels lost would vary over time, with earlier vessels tending to be older at the time of loss. Albion (1938:98), for example, reports that the normal use-life of a nineteenth century merchant ship was about 20 years while others suggest that the average age of vessels in 1900 was about 10 years (Murphy and Jonsson 1993). For the 38 vessels in the 2001 database lost before 1900, the average age was 11.6 years at the time of loss, while the average age of 654 vessels lost after 1900 was 16.7 years. This did not support the initial assumption that earlier vessels would be older at the time of their loss and it is considerably at odds with Albion's (1938) estimate of the use-life of the typical nineteenth century merchant vessel. To further examine the relationship of year of build and age at time of loss, correlation coefficients were computed on two sets of age-related variables. One analysis compared the year of build with the age of the vessel at the time of loss, while the other looked at the correlation between the year of loss and the age of the vessel at loss. The correlation analysis used in this analysis is provided in the software program Microsoft Excel and has been described in Chapter 3. This analysis measures if two ranges of data move together; that is, whether large numbers in one set are associated with large numbers in the other. In the first analysis, which examined the relationship between the year of build and the age at loss, the value of the correlation coefficient was a negative number, -0.37244. This means that the farther back in time a vessel was constructed, the younger it was at the time of its reported loss, although the correlation is weak. The correlation coefficient obtained when comparing the year of loss with the age of the vessel at the time of loss was a positive value, 0.07263, but is also indicative of a very weak correlation. It is apparent that there is no strong correlation between period of loss and the age of loss of vessels in the sample of 6989 vessels used here. As noted, it is unknown how reflective this is of the entire population of vessels lost in the GOMR.

Vessel age at time of loss was also examined across vessel type. For the nineteenth century it is generally assumed that sailing vessels had much longer life spans than did steam vessels. This is certainly true when comparing sailing vessels, which had life spans of 20 to 25 years, against western river steamers, which had notoriously short life spans on the order of only five years (Hunter 1949; Pearson and Wells 1999). However, relatively little information has been synthesized on the life span of steamers operating in marine settings.

The 2001 shipwreck database contains 303 vessels with information on type, year of build and year of loss. There are a total of 90 that can be identified as sailing vessels in this number, most (N=82) of which are classified as "Schooners" in historical accounts, while the remainder consist of vessels identified variously as "Ships," "Sloops," "Brigs," "Sailing Vessel," etc. The average age at loss for these sailing vessels was 21.9 years and 48 percent (N=43) of the vessels were over 20 years old at the time of their loss. Many, but not all, of these vessels did operate during the nineteenth century, so the data may not be directly comparable with other data sets dealing with nineteenth century ships. The oldest vessel in the database is a sailing vessel, the schooner *Henry Mearn*, which Singer (1992) reports was built in 1866 and sank in 1978 when 112 years old. Murphy and Jonsson (1993:155) report that the average age for sailing ship "casualties" in the Dry Tortugas was 13.5 years, while the average age for sailing ships "lost" in the Dry Tortugas was 15.8 years. These figures are somewhat lower than seen in the 2001 GOMR data, plus in the Dry Tortugas data, only 38 percent of the vessels lost were older than 20 years. The lower average age of sailing vessels lost in the Dry Tortugas relative to the open waters of the Gulf of Mexico as a whole cannot be fully explained. However, it is likely that the increased hazard to shipping presented by the Dry Tortugas played a part.

Only nine vessels classified as "steamers" are included in the 303 vessels with information on type, year of build and year of loss (see Volume III, Appendix E). These included vessels classified as "Sidewheelers," "Sternwheelers," and simply "Steamers." Seven of these vessels were constructed and operated in the nineteenth century, and two were built and operated in the twentieth century. The average age for these vessels at the time of loss was 8.7 years, considerably lower than that found for sailing vessels, as was anticipated.

Further comparisons in differences in age of loss across types of vessels were made by looking at other classes of vessels. For example, 54 vessels are identified broadly as non-sailing merchant vessels. These include "Freighters" (n=18), "Merchantman" (n=19) and "Tankers" (n=17). The average age for these vessels at time of loss was 25.0 years. Sixty-five vessels can be classified generally as "fishing" craft. These include 16 vessels identified as "Shrimp Trawlers" and 49 as "Fishing Vessels." The average age for these vessels at the time of loss was 14.6 years. Finally, the average age at the time of loss of the 27 vessels classified as "Barges" was 13.2 years.

It is apparent from these numbers that vessels of various types have quite different average life spans. This was generally expected and is related to factors such as size, manner of construction, and function of the vessel. Those vessels classified as general non-sailing "merchant vessels" had the longest average life spans of all types in the sample, averaging 25.0 years old at the time of their loss. These tend to be large, expensive vessels that are typically designed, constructed, and operated for long working lives. Fishing vessels, on the other hand, tend to be smaller craft that are more susceptible to natural and man-made hazards and thus tend to have shorter life spans. Interestingly, the data suggest that there is no significant correlation between the age of a vessel at the time of loss and the period of time when that vessel was built or operated.

4.3.1.3. Season of Loss

Information on the month of loss was obtained for 968 vessels and is presented as a bar graph in Figure 4-4. The numbers of losses for each month are provided in the graph. January and November have the highest recorded number of losses and March the lowest, but overall there is a roughly equal distribution of losses across all months. Seasonality of losses should provide some clues as to the impact that weather-related events have had on shipwreck losses in the GOMR. As noted in the previous chapter, the periods of poorest weather in the Gulf of Mexico tend to be during the winter months when “northers” frequently cross the area, and the late summer and fall when hurricanes can occur, mostly between August and October. A total of 354 vessels are reported to have been lost during the four winter months of November, December, January and February. This represents 36.6 percent of the total losses with a known month of loss, again only slightly above the number that would be expected by chance. It appears that poor winter weather (e.g., northers) has not had a significant impact on the overall number of losses occurring over the course of the year in the GOMR.

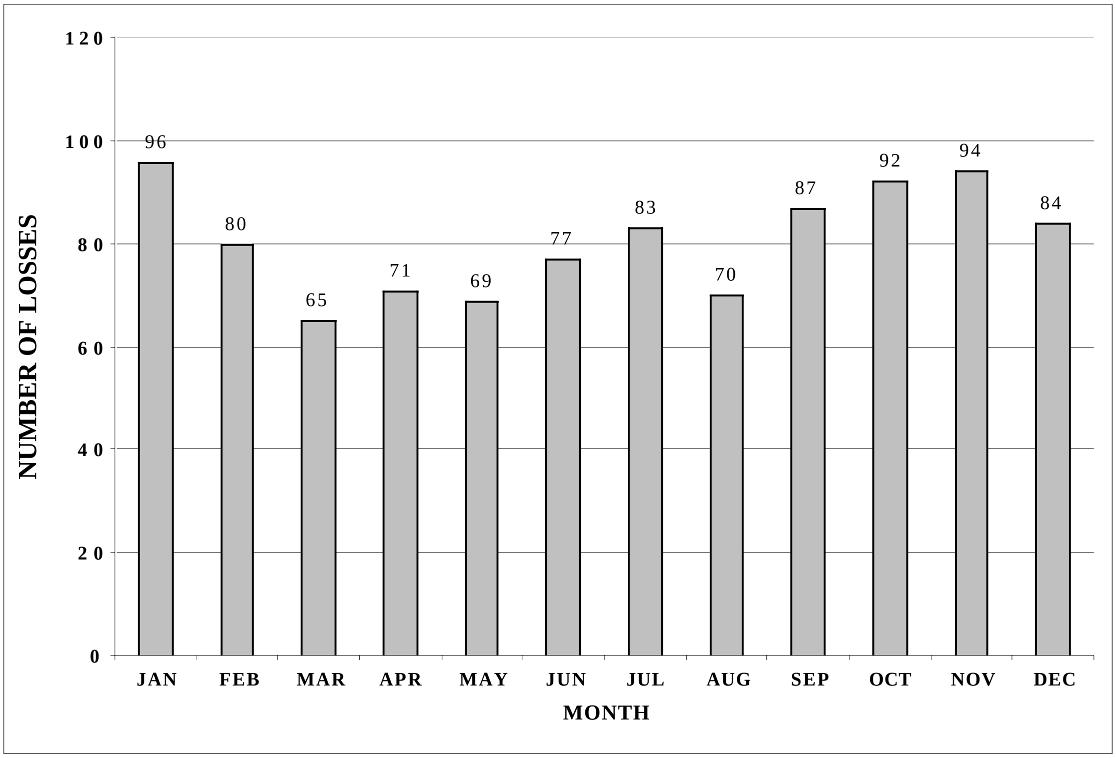


Figure 4-4. Reported losses per month for vessels in the study area. Data from 2001 shipwreck database.

Garrison et al. (1989:II-53 – II-68) present an extensive discussion on the impact of hurricanes on shipwrecks in the Gulf of Mexico. In particular, they looked at the spatial distributions of shipwrecks as they might relate to hurricane paths through time. Their data did not show a strong correlation between hurricanes and shipwrecks over time, either in frequency or spatial distribution (Garrison et al. 1989:II-54). They did note that there was a correlation between numbers of losses and large hurricanes for specific years, but in the majority of cases, the wrecks of interest occurred in state waters, outside of the present study area. Relatively few hurricane-related vessel losses have occurred in the study area since the 1989 study and these data would not substantially alter the findings reported by Garrison et al. (1989). The shipwreck data collected in this study do allow some generalizations about the relationships of hurricanes and vessel losses in the Gulf that supplement the findings reported in the 1989 study.

Despite their danger, the frequency of hurricanes in the Gulf of Mexico is low. Data for the late nineteenth and twentieth centuries indicate an average occurrence of only one hurricane per year in the Gulf of Mexico (Henry et al. 1975). In terms of the present data shown in Figure 4-4, 25.7 percent of all reported losses occurred during the principal hurricane season, August through October, essentially the number that would be expected by chance. This suggests that, overall, hurricanes do not have a significant impact on the numbers of vessels lost over the course of the year. While the data presented here do not show a strong correlation between the hurricane season and numbers of vessels lost, hurricanes and other weather-related phenomena did influence shipping activity in the Gulf and had an impact on losses. The Spanish very quickly learned of the dangers of hurricanes and scheduled their fleet sailings around the peak hurricane season. Despite all efforts, however, they experienced severe losses because of delays in fleet sailings or because of out-of-season hurricanes. Large numbers of Spanish ships were lost in the Florida Keys and the Bahama Channels during hurricanes in 1633, 1715, and 1722. In 1766, delays in getting the annual fleet off from Veracruz until September resulted in the loss of two ships run aground on the northern Gulf coast (Pearson and Hoffman 1995).

In a study of historical hurricanes that considered their impact on shipwrecks, Millas (1968) noted that the most important elements in the association of shipwrecks, natural or historical factors and hurricanes are: 1) reported shipwreck frequency; 2) seasonality; 3) historic period; and 4) development of ports and trade routes. As ports increased, and shipping expanded along more diverse routes, the “interplay of a normal storm frequency guaranteed a higher incidence of vessel losses” (Garrison et al. (1989:II-53). If this is true, it is expected that the loss of vessels during the hurricane season would show an increase in the GOMR over time corresponding to the known expansion of shipping activity and sailing routes. By about 1875, the major ports on the northern Gulf of Mexico had been established and shipping routes were fully expanded. Presumably, then, vessel losses due to hurricanes would be proportionally greater after 1875 than before, meaning that losses during the peak hurricane season should also be proportionally greater, unless non-weather factors are overriding the effects. The 2001 shipwreck database contains only 48 vessels with a known month of loss and a sinking date prior to 1875. This sample is probably too small to be statistically meaningful, but 21, or 43.4 percent, of the losses occurred during the three-month peak hurricane season. This number is somewhat greater than that obtained for the entire sample of 968 wrecks and may suggest that hurricanes had a greater impact on vessel losses prior to 1875. This finding seems to be at odds with the Garrison et al. presumption that losses to hurricanes would increase after about 1875. However, it is possible that the high incidence of hurricane-season losses during earlier years is mainly a factor of reporting, in that losses due to hurricanes were more likely to elicit interest than were losses due to less dramatic weather phenomena.

Patterns in seasonality of vessel activity in the Gulf also will influence the number of vessels lost during each month. For example, during the period from about 1830 to the Civil War, large numbers of vessels traveling in the Gulf of Mexico were involved in the cotton trade. Shipments of cotton peaked during the period from November to May and it is possible that the increased numbers of vessels working in the region during this period led to increased losses, which have contributed to the pattern of losses shown in

Figure 4-4. Also, since the late 1930s offshore shrimping has been important in the Gulf of Mexico with very large numbers of vessels involved in it. Although Gulf shrimpers often operate year-round, the peak seasons for nearshore shrimping have traditionally been in the spring between May and July and in the fall and early winter from mid-August to mid-December. In light of the fact that a large number of the vessels included in the 2001 shipwreck database are believed to be shrimp trawlers, it can be expected that the seasonal activity of these vessels has influenced the monthly losses. This would be particularly true when high numbers of these vessels coincided with adverse weather conditions, such as during the winter months.

Figure 4-5 provides information on the relative frequency of losses by month for all vessels with that information and for all "Shrimping Vessels" with month of loss information. This category of Shrimping Vessels (N=131) includes those identified as "Shrimp Trawlers," "Trawlers," and simply as "Fishing Vessels" in Appendix E. The data indicate some significant divergences in the months of loss for Shrimping Vessels relative to All Vessels, particularly for the months of June and July when proportionally more Shrimping Vessels have been lost. These are the months when shrimping is at its peak and when the largest number of trawlers are active. Shrimping Vessel losses also occur in somewhat higher frequencies during November and January and February, but they are lower during May and during the late summer and early fall. These data seem to suggest that the shrimping season has a greater influence on the numbers of Shrimping Vessels lost than does the weather. In essence, when more boats are operating in the Gulf, more will be lost, regardless of seasonal weather patterns.

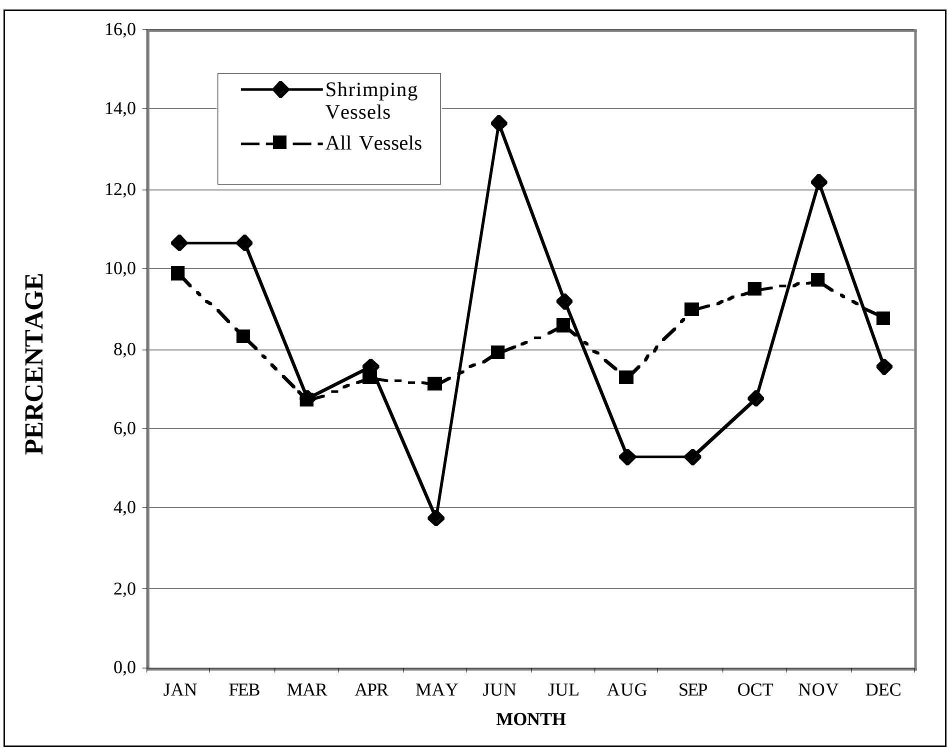


Figure 4-5. Reported losses per month for All Vessels and those identified as Shrimping Vessels (Fishing Vessels, Trawlers, and Shrimp Trawlers). Data from 2001 shipwreck database.

Murphy and Jonsson (1993) examined the month and season of loss for vessel casualties and losses in the Dry Tortugas. Their data showed no strong association of season with reported casualties or losses. For example, for both casualties and losses, they found that between 51 and 53 percent occurred during the winter months of September through January. In the GOMR sample, 453 wrecks are reported for this five-month period, representing 46.8 percent of the total for the year.

As Murphy and Jonsson (1993:148) found for the Dry Tortugas, it would appear that weather, as a seasonal phenomena, has not been a strong primary determinant of vessel losses in the GOMR. Many ships, of course, have been lost to bad weather in the Gulf of Mexico, but factors other than the season of the year seem to be at play. For example, Murphy and Jonsson (1993:148) suggest that “product seasonality and concomitant shipping demands” have had an impact on the wreck population in the Dry Tortugas. They note, for example, that vessels carrying cotton constituted a significant number of those operating in the Gulf during much of the nineteenth century. The transportation of cotton by ship peaked during November to May and in the Dry Tortugas, the seasonal losses of vessels known to have carried cotton cargoes correlates with this trend.

4.3.2. Types of Vessels

A large variety of vessel types have been used and lost in the waters of the Gulf of Mexico. In the 2001 shipwreck database, “Vessel Type” was determined for 929 entries, resulting in the identification of a total of 53 different types of vessels (Table 4-2).

Table 4-2. Types of Vessels in the 2001 Shipwreck Database

VESSEL TYPE	CODE	NUMBER
Barque	BAR	2
Barge	BGE	109
Barkentine	BNK	1
Brig	BRG	5
Brigantine	BRI	2
Buoy Tender	BYT	1
Cabin Cruiser	CCR	2
Clipper	CLP	1
Crane Barge	CRB	2
Crewboat	CRW	8
Cutter	CUT	1
Destroyer Escort	DES	2
Dive Tender	DVT	2
Drilling Rig	DIR	19
Dredge	DRE	8
Exploration Vessel	EXP	1
Fishing Vessel	F/V	252
Ferryboat	FER	3
Freighter	FRT	25

Table 4-2. (continued). Types of Vessels in the 2001 Shipwreck Database

VESSEL TYPE	CODE	NUMBER
Gunboat	GBT	1
Galleon	GLN	2
Hopper Barge	H/B	4
Jack-up Barge	JUB	22
Landing Craft	LDC	7
Landing Ship	LNS	2
Landing Ship, Tanks	LST	2
Lugger	LUG	1
Motor Vessel	M/V	65
Merchant	MCH	36
Mine Sweeper	MSW	1
Pleasure Craft	P/C	64
Paddlewheel Boat	PDL	1
Passenger Steamer	PAS	3
Patrol Boat	PAT	3
Sailboat	SAI	11
Schooner/barge	SB	1
Schooner	SCH	104
Sidewheeler	SDW	5
Shrimp Trawler	SHM	36
Ship	SHP	7
Skiff	SKI	1
Sloop	SLP	3
Steamer	ST	4
Sternwheeler	STW	1
Submarine	SUB	6
Supply Vessel	SPV	1
Tug or Tow boat	T/B	3
Tanker	TNK	23
Tow Boat	TOW	3
Torpedo Boat	TPB	1
Trawler	TRA	5
Tugboat	TUG	47
Yacht	YCT	8
Total Known Vessel Types		930
Other		
Aircraft	ACFT	9
Anchor/Chain	ANCH	14
Helicopter	HELO	9
Unknown/Unclassified		1145
TOTAL		**2107**

Figure 4-6 provides information on the numbers of vessels in each type for those having five or more entries. As discussed in Chapter 2, the designation of a “Vessel Type” was principally drawn from the historic sources used. In most instances this resulted in a functional descriptor (e.g., Tanker, Fishing Vessel, Jack-up Barge), but often in a more general statement about the rig or form of propulsion of the vessel (e.g., Schooner, Steamer, etc.). As noted earlier, there is no “correct” way to develop a typology system. The one used here results in a large number of types, most but not all of which are somewhat functional in nature. Like all typologies, it does have problems. For example, “Schooners” comprise the second largest number of vessel types in the database (N=104), but this is a category determined by type of rig and it might include a variety of functional types of vessels, such as merchant vessels, fishing vessels, etc. The historic sources examined do not permit an accurate functional classification of most of the vessels included in the Schooner category.

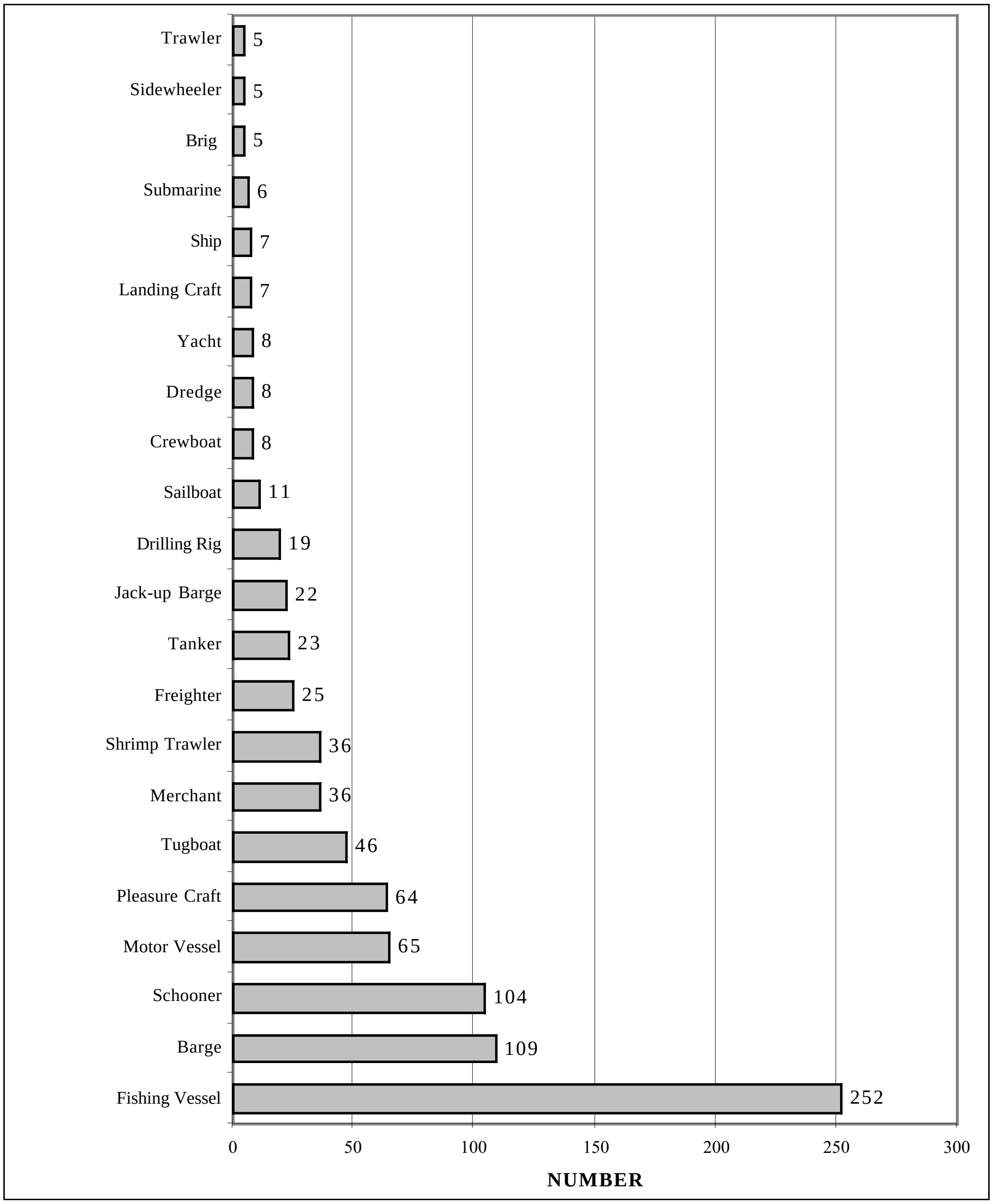


Figure 4-6. Vessel types in the 2001 shipwreck database containing five or more entries.

Other shipwreck studies have faced the same problem in developing vessel typologies and have opted for differing strategies of classification. For example, Gearhart et al. (1990), in their regional overview of shipwrecks along the Pacific coast, used an approach similar to the one used in the present study, resulting in a fairly large number of vessel types. They arrived at 38 types of vessels (plus an unknown category) in their inventory of reported wrecks. Some categories are functional (e.g., Fishing, Tug) while others are related to rig or propulsion (e.g., Schooner, Gas-powered, Oil-powered).

On the other hand, Murphy and Jonsson (1993) arrived at only nine vessel types, plus an unknown category, in their typology of vessels lost or reported as casualties in the Dry Tortugas. They used a few functional categories (e.g., Tanker, Barge), but most of the 311 vessels in their sample were subsumed under rig or propulsion categories (e.g., Schooner, Brig, Engine Powered), resulting in a much smaller number of types of vessels. Because of the various typologies used in different studies, quantitative comparisons do become difficult, or must be made only across specific categories.

Figure 4-7 provides information on the mode of propulsion recorded for 683 vessels in the shipwreck database. Excluded are two entries identified as “towed” vessels and one propelled by “oar.” Sailing craft as a whole comprise just over 22 percent of the vessels of known type in the GOMR database. The vast majority of these are identified as “Schooners” (N=104) and the others include miscellaneous craft such as “Brigs,” “Sloops,” or just “Sailboats” (see Table 4-2, Figure 4-6). One vessel in the list is identified as a sailing “lugger.” This was the small, seven-ton lugger *Meteor*, built in 1903 and lost in 1916 (Appendix E). The large number of schooners in the database is not surprising, considering how important these sailing vessels became during the nineteenth century. Schooners, with their fore-and-aft rigs, were first constructed in the first quarter of the eighteenth century and began to gain popularity late in the century.

By the 1830s, the schooner and the single-masted sloop were the most common vessels involved in maritime commercial activities along the coasts of the United States. Schooners gained popularity because they were fast sailers and, with their fore-and-aft rigs, they required fewer hands to man than did square rigged (“ship rigged”) vessels of similar size. The two-masted schooner was the typical form into the 1830s, when three-masted versions began to be constructed. Later in the nineteenth and into the twentieth century, schooners with four and more masts were built. These large schooners were typically used in long-distance ocean trades. The smaller, two-masted schooner and the sloop became the mainstay of the “coasting” or coastwise trade in the United States, traveling between coastal ports carrying all manner of cargoes.

In the Gulf of Mexico, large numbers of schooners were used in the coasting trade in the nineteenth century (Francaviglia 1998). An example of the numbers involved in the trade can be seen by those enrolled and registered at the Port of New Orleans, the largest port on the Gulf coast during this period. Between 1804 and 1820, 281 schooners were enrolled at New Orleans; they represented the most popular “rig” of vessel enrolled in the city. Of this number, only two had been constructed prior to 1790; the rest had been constructed between 1791 and 1820, a period when the schooner was rapidly growing in popularity and American coastwise trade was expanding (WPA 1942:1:x).

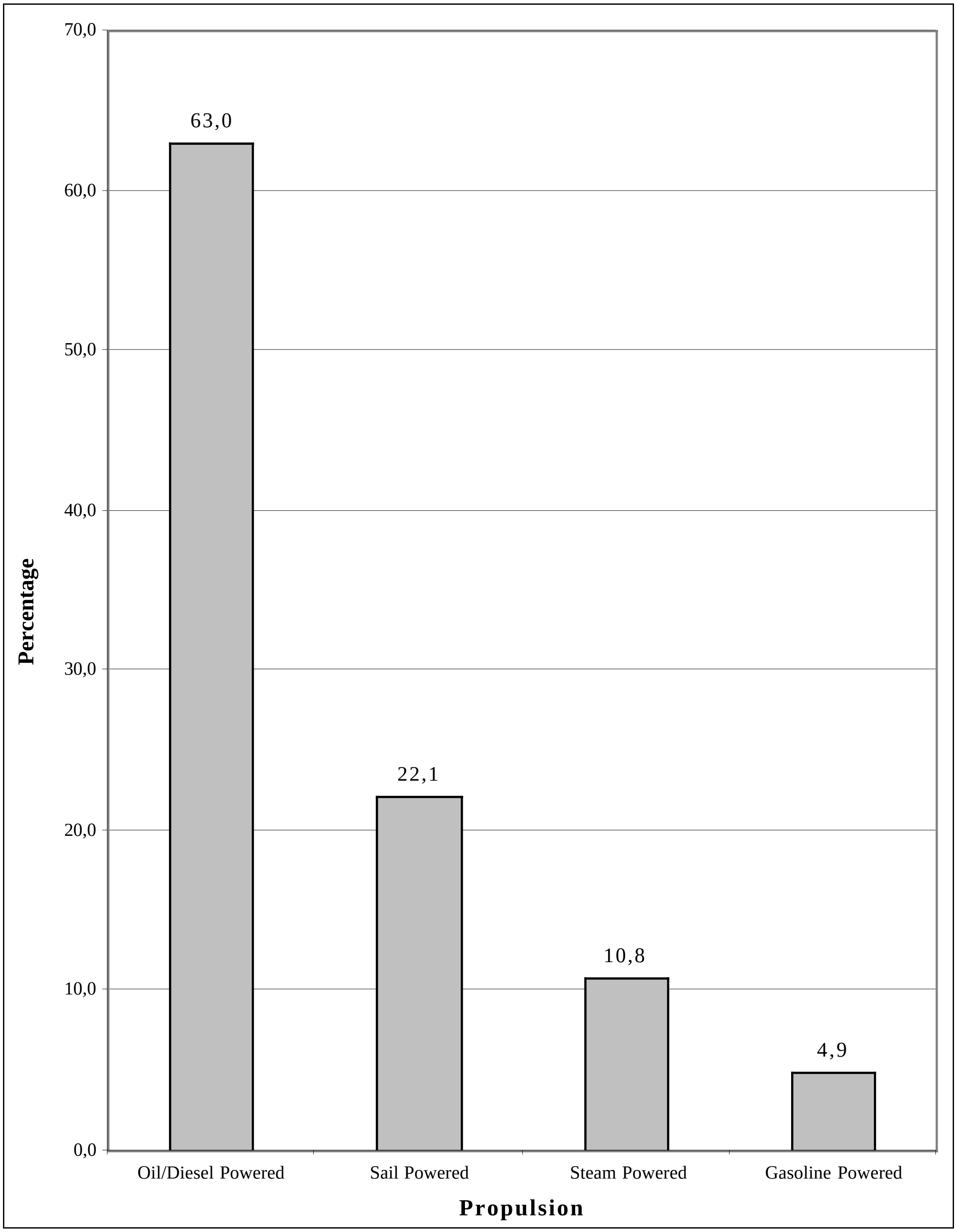


Figure 4-7. Relative frequencies of modes of propulsion recorded for vessels in the 2001 shipwreck database

Most of these schooners were involved in some aspect of the coasting trade. Many were small, less than 50 or 60 feet long and under 100 tons of burden, and were used to carry goods between small communities on the central Gulf coast and the larger ports such as New Orleans, Mobile and Pensacola. By the period 1830 to 1840, a total of 498 schooners were enrolled in New Orleans and they still represent the most common type of vessel enrolled in the city, followed by steamboats (N=334) (WPA 1942:3:xii). As in earlier years, many of these vessels worked in the coasting trade; now, however, some extended their trading activities westward to Texas, as well as eastward to ports along the west Florida coast and panhandle. By this time cotton had become the South's principal export and New Orleans was a major cotton port. By 1840 many larger schooners were sailing out of the Gulf to ports in the northeastern United States or Europe with cotton and returning with a wide range of manufactured goods and merchandise. Lumber also became an important commodity carried by schooners in the coasting trade, as well as in long distance trade out of the Gulf region (Murphy and Jonsson 1993). Schooners continued in use through the nineteenth century, but were increasingly displaced by steam vessels after the 1840s.

Dates of build are known for 82 of the 104 schooners identified in the shipwreck database. These range from 1831 to 1919, with about 70 percent (N=57) constructed prior to 1900. The lengths of all but one of the schooners in the database range from 43 to 162 feet. The one exception was the 215-foot-long *State*, built in 1901. The burden for 95 schooners is known and this ranged from just 11 tons to 2,052 tons. Most of the 39 schooners of less than 150 tons burden in the database are likely to have been involved in the coastal trades. Many of those larger than 150 tons may have been principally sailing in long-distance trades across the Gulf of Mexico, or to ports outside of the Gulf.

Other sailing vessels are only poorly represented in the shipwreck database. These include 12 entries identified only as "Sailboats," five as "Brigs," three as "Sloops," two as "Brigantines," three as "Barques" (Barks), seven as "Ships," two as "Galleons," and one as a "Schooner Barge" (see Appendix E). Many of these represent early types of vessels operating prior to the mid-nineteenth century; one of the reasons for their small numbers might be due to the underreporting of losses during early periods, as has been noted. This phenomenon also might be exaggerated when vessels lost onshore or in nearshore waters have been eliminated from consideration, as in the present study.

In their Dry Tortugas data, Murphy and Jonsson (1993) found that sailing vessels comprised the majority of vessel losses and vessel casualties. They represented 79.9 percent (N=201) of the 311 losses and casualties for which information on rig was available. This is almost four times the representation of sailing vessels seen in the 2001 shipwreck database. It is believed that the principal reason for this lies in the sources used for obtaining shipwreck information, as has been noted earlier, in that the Dry Tortugas data do not incorporate shipwreck data from many of those sources that include recent or non-commercial losses. The Dry Tortugas data do indicate that schooners were the most common type of vessel lost there, comprising 36.7 percent of the losses. However, many brigs (N=52), barks (N=52), and ships (N=43) are also included in the loss and casualty data presented by Murphy and Jonsson (1993), classes of vessels poorly represented in the 2001 GOMR database.

Vessels classed as "Fishing Vessels" comprise the largest category in the shipwreck database. A total of 252 fishing vessels are identified in the database, forming 27.1 percent of the vessels assigned to type. A review of the available data on the age of these vessels indicates that most, if not all, are twentieth century in date. Of the 49 Fishing Vessels for which date of build is known, the earliest is the *Ida Q.*, built in 1924; most of the others were constructed after 1950. The majority of these boats are believed to be shrimp trawlers, although the sources providing data on their losses rarely identify them as such. A small number might have been involved in other Gulf fisheries, such as red snapper or menhaden. If the 41 vessels identified in the sources examined as “Shrimp Trawlers” or “Trawlers” are added to the Fishing Vessel category, then it forms almost one third (31.5 percent) of the total number of shipwrecks of known type in the database. This large representation is seen primarily as a reflection of the importance of the Gulf shrimping industry and a statement on the large number of shrimping vessels operating in the region. The importance of the Gulf shrimping industry can be seen in the fact that in the year 2000, Gulf of Mexico landings of the three principal shrimp species fished (brown, white and pink shrimp) consisted of just over 125 metric tons valued at roughly 640 million dollars. Surprisingly, however, the importance of the types of vessels involved in the industry and their potential large number as shipwrecks in the Gulf are largely overlooked. Murphy and Jonsson (1993) make no mention of shrimp trawlers in their study of wrecks in the Dry Tortugas, although shrimp boat wrecks are known to exist there (Murphy 1993b:209). Garrison et al. did not include vessel type in their 1989 shipwreck database, but they do briefly describe the “Shrimper” in their Appendix E listing vessel types used in the Gulf of Mexico (Garrison et al. 1989:Appendix E).

The shrimp trawler, and the offshore shrimping industry as it is known today, developed as a result of the perfection of the otter trawl early in the twentieth century (Robinson and Seidel 1995:22). Some have suggested that the Gulf of Mexico shrimp trawler developed out of the sailing lugger with the replacement of the sail by gasoline engines which had been perfected for use in boats during the latter years of the nineteenth century (Custer 1994; Robinson and Seidel 1995). The sailing lugger was in common use along the Louisiana, Mississippi, and Alabama coasts, particularly in the oyster industry. There is debate as to how much the hull form changed with the adaptation of the gasoline engine to the old sailing lugger form. Alterations known to have occurred included the elimination of the centerboard trunk that was found on some sailing luggers and the addition of an aft cabin to house the engine and controls. The earliest motorized luggers were small, 20 to 30 feet long, but larger vessels were soon developed, apparently originating in the Biloxi, Mississippi, area. These large vessels were more seaworthy and most were adapted for use in oystering (Robinson and Seidel 1995:19). Wilson (1983) suggests that the earliest vessel that can be defined as a shrimp trawler was the *Eagle*, built in Bayou La Batre, Alabama in 1925. The early, lugger-form shrimper largely confined its operation to inshore waters. Guevin (1991) reports that Florida fishermen introduced the offshore shrimp trawler into the Gulf during the 1930s when the potential for offshore shrimping in the Gulf was discovered. The vessel used came to be called the “South Atlantic Trawler” and was a design derived from the Greek sponge boats used on the west coast of Florida. If the *Ida Q.*, built in 1924 and the earliest identified Fishing Vessel in the 2001 shipwreck database, was in fact a shrimp trawler, it would represent one of the earliest examples known and a vessel of obvious historic importance.

The shrimp trawler reached its present form and style in the very short period between the end of World War II and about 1950. Possibly because of the need for maximum rear deck working space, it was among the first powered fishing craft to have a forward-located pilothouse. The hull, however, retained characteristics of the old Greek sponge boats with its full body, sweeping sheer line and fine entrance. Originally built of wood, most trawlers now have steel hulls (Guevin 1991).

Today, shrimp trawlers are typically powered by diesel engines, but some early examples used gasoline engines. In fact, the *Ida Q.* mentioned above is reported to have been powered by a gasoline engine (MVUS 1936). As shown in Figure 4-7, “Oil/Diesel Powered” vessels constitute over 60 percent of those for which mode of propulsion was recorded. Their high representation is largely because the publication *Merchant Vessels of the United States,* which was one of the most important sources used in this study, consistently provides this type of information on lost vessels. Many of the “Oil/Diesel Powered” vessels are also identified as “Fishing Vessels.”

Another general class of vessels that is modestly represented in the 2001 database incorporates those that are involved in the offshore oil and gas industry. These include vessels identified as “Crewboats,” “Drilling Rigs,” “Supply Vessels,” and “Jack-up Barges” (Table 4-2). Like the shrimp trawler discussed earlier, this class of vessels tends to be ignored in historical shipwreck studies. In fact, some of the items, such as “Drilling Rigs,” are generally not classified as vessels. As noted earlier, these are included because they do represent cultural objects that might be discovered during the course of MMS-mandated lease block surveys. Also, most of these types of vessels will be less than 50 years old, having been put into use after the late 1940s with the development of the offshore oil industry. When considered as a whole, those vessels that can be identified as related to the offshore oil and gas industry include 50 entries, representing only 5.4 percent of the vessels identified as to type. This is considered an under-representation of the actual number of vessels in the database that were associated with the offshore mineral industry. For example, some of the vessels identified only as “Barges” may have been involved in some aspect of this industry, but the sources do not provide sufficient information to determine this. Additionally, some of the vessels identified only as “Motor Vessels” actually might be crewboats or offshore supply boats.

The first true offshore oil well was drilled off of Morgan City, Louisiana, in the Ship Shoal Area in November 1947. Since that time a variety of watercraft have evolved to supply the offshore oil industry. During the early years of the industry wooden shrimp trawlers, luggers and the like were used and modified as necessary. By the mid-1950s, however, vessels were being constructed specifically for offshore oil work. In 1955, the Tidewater Marine Service Company of Louisiana launched the *Ebb Tide*, reportedly the first vessel built expressly for service of the offshore oil industry (Tidewater Marine Service Company 2002). Since then, huge numbers of vessels have been constructed specifically for work in the offshore oil industry. These vessels are used to ferry workers back and forth to offshore platforms and drilling rigs (crewboats), or carry cargo (supply boats) or serve in specialized activities as anchor boats, dive boats, mud boats (to transport drilling mud) or seismic survey boats. Typically these vessels are steel-hulled and range from about 30 feet to as much as 400 feet long; many have a low, open deck aft of a raised pilot house/crew's quarter section. The low, open deck area serves as a work or storage area and is typically over twice the length of the cabin/pilot house section (Garrison et al. 1989:E-9). On some of the passenger carriers (crewboats), this aft work area is decreased or eliminated and replaced by cabin space.

Early offshore drilling was conducted from barges modified for that purpose. The first "submersible" drilling rig constructed specifically for offshore work was the *Mr. Charlie*, built in 1953. This drilling rig consisted of a large barge measuring 220 feet long, 75 feet wide and 14 feet deep with the drilling platform and machinery constructed on it. During drilling, the barge was flooded to sink to the bottom where it provided a stable platform for the work (The Rig Museum [www.rigmuseum.com]). The *Mr. Charlie* was first used in East Bay, Louisiana, in 1954, but could operate only in water less than 40 feet deep. Since that time large numbers of submersible and semi-submersible drilling rigs have been constructed and used in the Gulf of Mexico.

Twenty-two "Jack-up Barges" are included in the 2001 shipwreck database. These also are a craft designed primarily for the offshore oil industry. They consist of a barge on which tall legs ("spuds") are mounted. Hydraulic engines are used to extend the legs (usually three in number) to the bottom and, ultimately, to lift the barge above the water. This turns the barge into a stable working platform; these vessels are used for all kinds of construction and maintenance activities in the offshore oil industry.

4.3.3. Cause of Loss

One of the categories of information collected in this study was Cause of Loss. Entries used in casualty tables provided in *Merchant Vessels of the United States* provided a principal basis for developing the Cause of Loss categories. This publication classifies vessel losses according to six principal types of casualty. These are:

1. Foundered - casualties due to leaking or capsizing of vessels, including vessels lost at sea not due to collision or burning, and vessels not reported after sailing.
2. Stranded - casualties due to vessels running aground, striking, rocks, reefs, bars, etc.
3. Collided - collision between vessels only.
4. Burned - casualties due to fire.
5. Abandoned - casualties resulting from abandonment at sea not related to age.
6. Any other type of casualty.

Some modifications were made to these listings because of cause of loss entries provided in other sources. The categories "Beached," "Capsized," "Explosion," "Gunfire-Battle," "Scuttled," and "Sunk" were added to the categories listed above on the basis of specific information provided in other sources. The fact that various sources categorize and report losses in different ways can create problems in analyses and comparisons, but, as has been done for other categories of information, the effort here has been fairly expansive in an effort to capture the variability expressed in the historical records used. Among the problems that can be readily seen are that categories such as "Capsized" given in one source might be classified as "Foundered" by the *Merchant Vessels of the United States*. One of the most common listings for cause of loss in United States Coast Guard records is simply "Sunk." This category has been used in the database, but it is often a statement of condition, not cause, because so many USCG listings involve the remains of sunken vessels that have been discovered, not reports of casualty events themselves.

In general, marine casualties can be classified as weather-related, equipment-related, or due to human error. In some but not all instances, the specific cause of loss given for a vessel can be tied to one of these general causes. For example, many vessels are reported to have "Foundered," but only rarely are the events leading to the foundering identified. It is generally believed to be weather-related, but this may not always be the case (Gearhart et al. 1990:IV-68).

Not all of the marine casualties identified in the various sources and included as losses in the 2001 shipwreck database actually represent sinkings. It is apparent from some sources that vessels included in the database did not actually sink, but were involved in marine accidents that did not result in the loss of a vessel, or that others were salvaged after their sinking. In other instances cargo or ballast might have been purposefully jettisoned and the event became reported as a casualty. It is not always possible to identify these types of non-sinking accidents in the sources used. Despite this, however, all events identified as marine casualties or accidents are included as losses under the assumption that the accident or the subsequent salvage activity might have left archaeological remains as evidence of the event. This follows the approach used in other, similar studies (e.g., Gearhart et al. 1990; Murphy and Jonsson 1993; Pearson et al. 1989). When information is provided in the sources that might modify the cause of loss entry, such as reports of salvage, these have been included in the Comments section in the Access database.

Information on a cause of loss was collected for 1,300 entries in the database, representing 61.7 percent of the total. This information is displayed in Table 4-3. However, as can be seen, 486 of these fall under the category "Sunk." An examination of the database reveals that information on most of those vessels in this Sunk category comes from USCG or from NIMA records. In most instances, the NIMA records themselves were derived from USCG data. Additionally, 67 of the vessels in the Sunk category are listed as Unknown Vessels, normally meaning that they represent unidentified vessels that have been reported or discovered after their sinking. Thus, at least for these 67 entries, the term Sunk is a statement on condition, not cause, and it is likely that this observation can be extended to many of the named vessels for which sunk is provided as a cause of loss. If the Sunk category is removed as a known cause of loss, then 814 entries have what can be considered a known cause of loss. The relative frequency of occurrences of these known causes of loss is provided in Figure 4-8.

Table 4-3. Reported Causes of Loss

CAUSE		NUMBER OF VESSELS	%
Abandoned	AB	8	0.4
Beached	BE	2	0.1
Burned	BU	153	7.3
Capsized	CA	14	0.7
Collided	CO	82	3.9
Explosion	EX	7	0.3
Foundered	FO	374	17.8
Gunfire-Battle	GF	44	2.1
Scuttled	SC	101	4.8
Stranded/Swamped	ST	29	1.4
Sunk	SU	486	23.1
Unreported	UN	806	38.3
TOTAL		**2,106**	

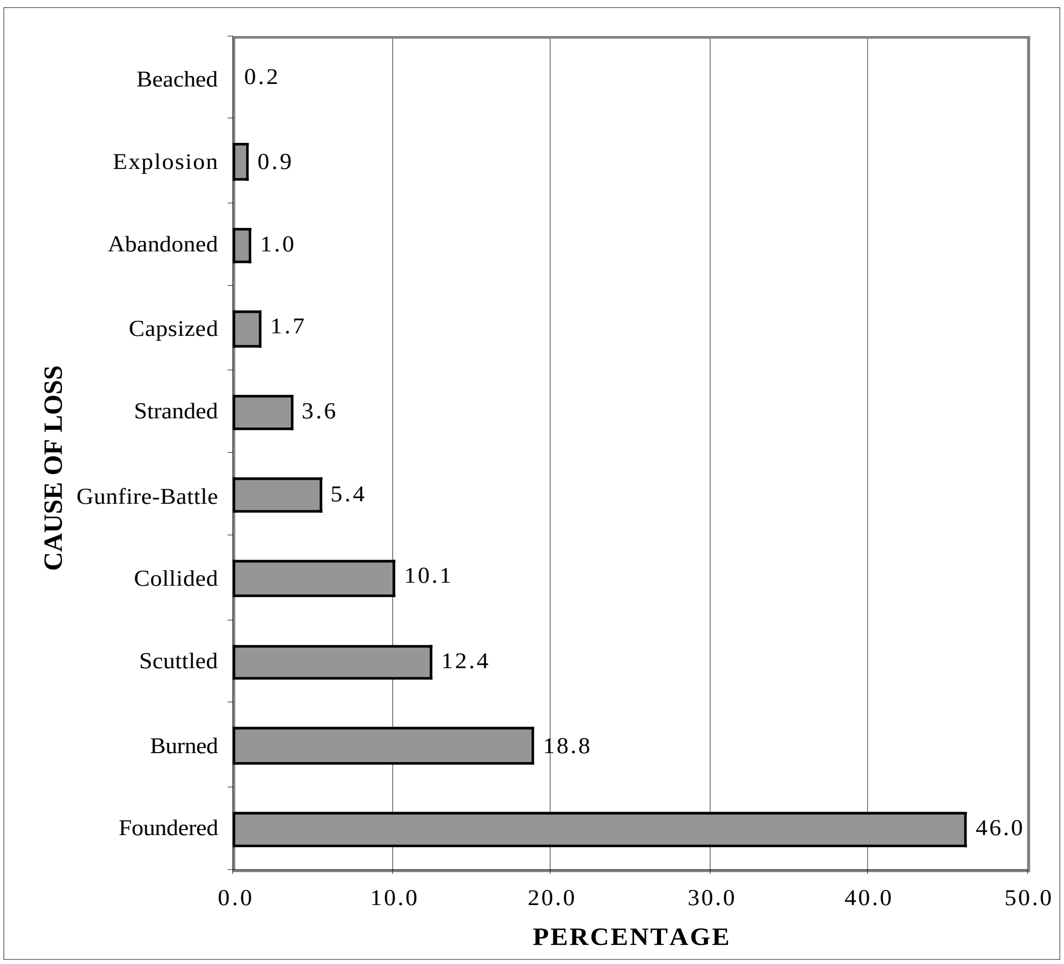


Figure 4-8. Relative frequencies of known causes of loss for vessels in the 2001 shipwreck database.

Vessels that "Foundered" constitute the majority of those with a known cause of loss, representing almost one-half of the total. Other studies have shown that foundering is generally a principal cause of reported losses, but this is in part because this category is commonly used to encompass a variety of sinking events. For example, in *Merchant Vessels of the United States* listings, foundering essentially encompasses any casualty that cannot be explained in any other way. It is impossible to tell how many of the founderings included in the database are weather-related, equipment-related or due to human error. Summary statistics on vessel casualties for various portions of the United States are available in the Annual Reports of the U.S. Life-Saving Service. These statistics include information on whether losses are weather-related, related to navigation or seamanship, related to equipment, or are due to other causes.

However, these data do not extend after 1914 and have minimal comparative value in the present instance, because 311 (83 percent) of the founderings in the database occurred after 1915. Garrison et al. (1989) do not provide cause of loss data in the 1989 shipwreck database, although they do discuss factors of loss in general terms, particularly as related to hurricanes and natural features, such as shoals, bars and reefs.

If founderings are largely weather-related, one might expect more foundering losses to occur during the late summer and winter months when Gulf weather conditions tend to be at their worst, primarily because of hurricanes and northers. Figure 4-9 provides information on the frequency of occurrence of reported founderings by month and the data do, in fact, show high occurrences during the worst weather months of October through January. This seems to suggest that weather played some role in founderings, but additional information would be needed to verify this assumption.

A substantial number (N=153) of vessels are reported to have burned. This constitutes almost 20 percent of the total number of reported causes of losses. Vessels of all types are included in this category so there does not appear to be any strong correlation between vessel type and burning. However, the majority (N=126; 81.8 percent) of the burning cases occurred since 1950. Again, this high number is likely to be a reflection of the underreporting of most specifics of vessel losses during early periods.

Forty-four vessels are reported to have been lost to "Gunfire-Battle" (Table 4-3). The vast majority of these consist of vessels lost in the Gulf of Mexico during World War II, mostly from actions by German U-boats (Appendix E). Twenty-nine vessels are reported to have been lost due to "Stranding" or "Swamping" and two are reported to have been "Beached." Because the present study is considering only those vessels falling in Federal waters, an initial assumption would be that few vessels would be lost in the study area due to these causes. Relatively few hazards that could result in these causes of loss exist in the study area. A review of the vessels included in these categories of losses reveals that most have been assigned very low reliabilities for their positions of loss and a few do fall in state waters. Thus, the possibility exists that some unknown number of these losses resulting from stranding and beaching actually occurred in state waters.

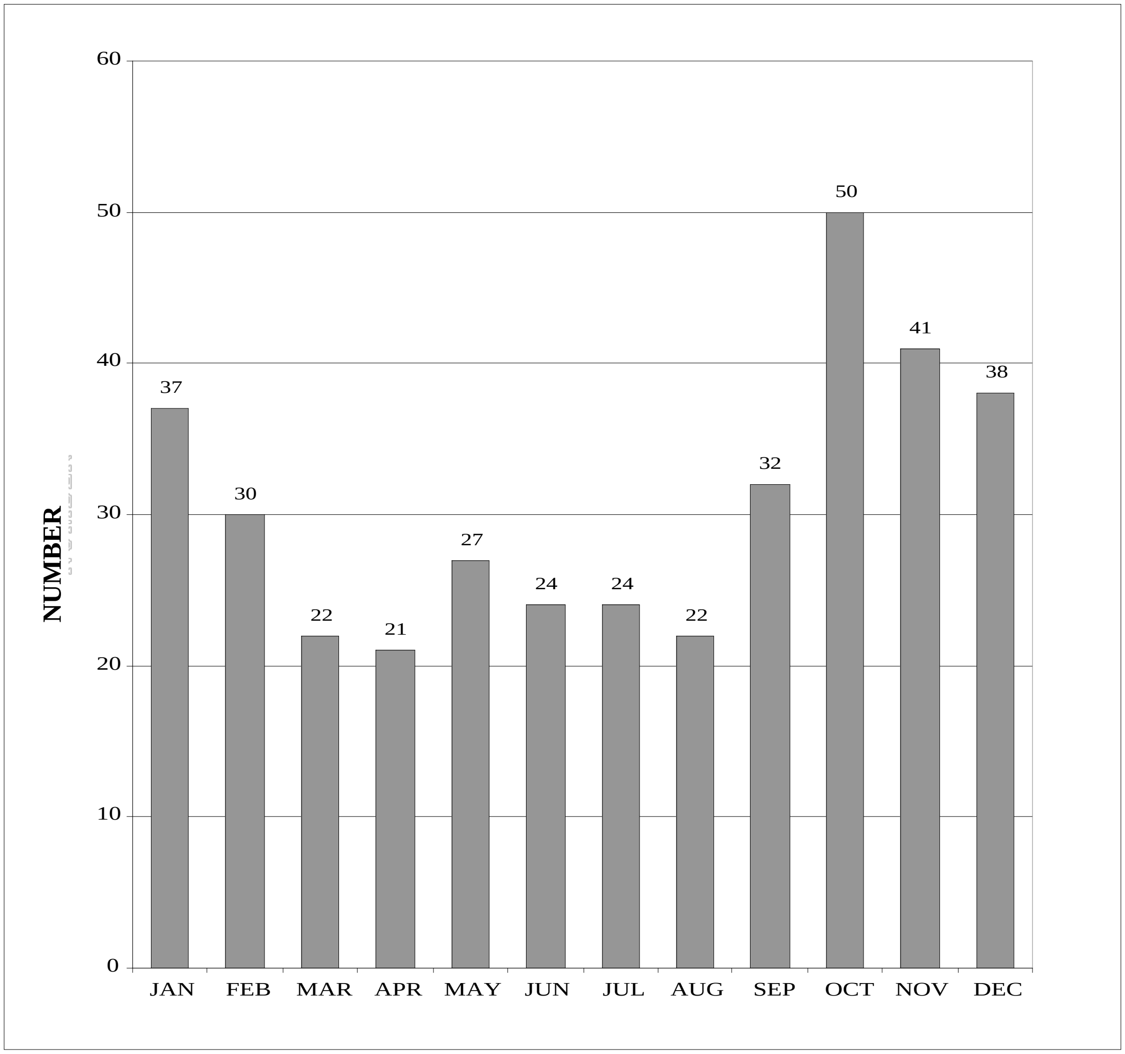


Figure 4-9. Numbers of "Founderings" per month for vessels in the 2001 shipwreck database.

Scuttlings account for 101 of the known reported causes of loss (Table 4-3). As noted previously, this number is relatively high because of the inclusion in the database of a number of vessels purposefully scuttled to create artificial fishing reefs.

4.4. Shipwreck Preservation Potentials in the Study Area

The 1989 study by Garrison et al. presents a detailed discussion on those factors that affect the preservation of shipwrecks in the GOMR. Among the factors they considered were energy zones, biological and chemical factors, water depth, and sediment characteristics. In that discussion, they drew on previous archaeological work that provided information on the survival of shipwreck material in various settings (e.g. Clausen 1965; Mathewson 1975, 1977; Muckelroy 1978; Watts 1985; Keith et al. 1985; Keith and Simmons 1986). They noted that the "key element in estimating preservation of wooden shipwreck material is the identification of the burial sediment, its depth, and the inherent biological communities associated with such conditions" (Garrison et al. 1989:II-69).

In high-energy zones, such as those found in shallow water in the wave zone, destruction of vessel fabric tends to be high, particularly in the case of wooden vessels. A number of examples from the Gulf region have demonstrated the level of destruction of wooden vessels grounded in shallow water where materials are either removed or scattered around the wreck site. The general assumption is that waves and currents are more damaging to a shipwreck than are biological or chemical factors (Muckelroy 1978). However, even in high-energy settings such as in a wave zone, segments of vessels, in particular the lower hull, as well as individual elements can be reasonably well preserved. This is especially true if they become covered with sediment that can provide some protection from the physical impacts of waves and currents as well as providing a low-oxygen environment that inhibits the activity of biological organisms. Garrison et al. (1989) provide several examples from the Gulf region where the processes of sediment transport lead to the rapid burial and ultimate preservation of ship remains in moderate to high-energy environments. More recent studies from the region, such as those of the wrecks of the *Gen. C.B. Comstock* in Texas (James et al. 1991a) and the *Emanuel Point Ship* in Pensacola Bay (Smith et al. 1998), further substantiate these conclusions. Except in a few locales, these high-energy zones do not occur in the study area, so these impacts are of less concern than they are for shoreline settings.

The rapidity of burial and the nature of the sediments themselves are critical factors in the degree of preservation of a shipwreck. Overall, the more rapidly elements of a wreck are covered and the finer grained the sediments are, the greater the degree of preservation. In general, fine-grained sediments, such as clays and silts, are more conducive to preservation than are coarse-grained sediments, such as sand. Fine-grained sediments tend to produce environments lower in oxygen content than do coarse sediments, thus tending to restrict biological and chemical activity. The activities of many organisms, such as the wood-damaging shipworm *Teredo* common to warm marine waters, are eliminated or restricted by burial. However, some organisms, such as sulfide-reducing bacteria, typically thrive in low dissolved oxygen environments, like those found in muds (Richards 1957). These organisms tend to be destructive to metals, particularly ferrous metals (Hamilton 1976). Thus, some settings that might be conducive to the preservation of wood and other organics may be detrimental to certain classes of metals.

In the Gulf of Mexico, the process of burial of shipwrecks is typically going to occur more rapidly in shallow, nearshore waters where sediments are more mobile due to currents and wave action. However, these nearshore sediments tend to be coarse grained materials, thus the potential for preservation by rapidity of burial is, to some extent, offset by the characteristics of the sediments. Additionally, it has been shown that wrecks in nearshore settings do not necessarily remain buried after they are initially covered by sediments. For example, examination of the 1913 wreck of the Army Engineers hopper dredge *Gen. C.B. Comstock*, located at the outer edge of the wave zone off Freeport, Texas, revealed that the burial and exposure of portions of the wreck varied over time (James et al. 1991a). The degree of burial or exposure appeared to be seasonal, presumably related to yearly current and wave patterns. Despite its location in a high-energy environment, excavation of the wreck revealed that the entire lower hull of the vessel was intact and wreckage was not scattered over a wide area. Additionally, the wooden hull of the vessel was well preserved, as were numerous organic and some types of metallic artifacts; although many of the ferrous items from the wreck did display significant deterioration (James et al. 1991a). The rapid burial of the *Comstock*, even though by coarse grained sands, contributed to its excellent preservation. Although, in general, Garrison et al. argue that high energy environments are not conducive to shipwreck preservation, they do note that in high energy settings with coarse grained sediments, preservation can be enhanced if rapid burial of the remains occurs (Garrison et al. 1989:II-83). This is exactly the situation found at the *Comstock* site.

The offshore sediments in the Gulf of Mexico tend to be fine-grained muds (clays and silts) and their degrees of movement and rates of deposition are lower than is found nearshore (McGowen et al. 1976). Overall, sediment rates in the open sea are only on the order of 0.012 meters per year, but localized areas with more rapid rates do exist; for example, just off the mouth of the Mississippi River and, to a lesser extent, in the offshore areas of central and western Louisiana.

In recent years, particularly since the discovery of the RMS *Titani*c in 1985, our knowledge of the preservation potential of shipwrecks in deep water has expanded (Ballard 1989). Earlier assumptions were that vessels in deep water would, in general, be well preserved because of the low energy settings found there and the low levels of biological activity anticipated in deep, cold marine waters (Garrison et al. 1989:II-69). However, it has been found that certain marine boring organisms can survive in very deep water, as do marine bacteria that can result in the destruction of organic and metal materials (Ryan 1987). The recent discovery of several wrecks in deep water in the Gulf of Mexico adds to our information on deepwater wrecks, but does not clarify all of the factors affecting preservation of wrecks in these settings. Information contained in archaeological survey reports provided by the MMS indicate that as of September 2001, 16 vessels had been identified during offshore archaeological surveys in the GOMR in water depths greater than 500 feet. Seven of these vessels were located in more than 3,000 feet of water. Sidescan sonar records represent the only information we have on the conditions of most of these vessels. In general, these records depict complete or largely complete hulls or major segments of vessels exposed above the seafloor. The exposure indicates that these vessels have not been completely buried by sediments; however, vessels that have been completely buried would not be detected by sidescan sonar. The sidescan sonar records seem to indicate minimal dispersal of material around these wrecks, but again, it is possible that the available records would not show small, scattered objects. Also, other deepwater wrecks, particularly the *Titanic*, do show large and obvious “debris trails” consisting of materials lost from the vessels as they sank (Ballard 1989). It is likely that some deepwater wrecks in the Gulf, particularly some of the large tankers and freighters sunk during World War II, will exhibit extensive and obvious debris trails such as those seen with the *Titanic*.

Two of the deepwater wrecks found in the Gulf of Mexico have been more carefully examined by ROV submersibles and video images provide additional insight into their conditions. One of these vessels is the World War II German submarine *U-166*, discovered in approximately 5,000 feet of water off the mouth of the Mississippi River. Images of the vessel indicate that the principal metallic structural elements are in relatively good condition; however, the wooden grating that once covered the submarine decks appears to have deteriorated completely (Church 2002). The hull segments of the submarine are partially buried, but it is not known how much of this burial is due to sedimentation since sinking or how much might be due to the impact of the vessel into the soft bottom sediments at the actual sinking itself.

The remains of a wooden vessel have been recently discovered in 2,650 feet of water in the same general vicinity as the *U-166*. These remains consist of an approximately 60-foot-long segment of wooden hull resting upright on the bottom. It appears as if all or most of the length of the hull is extant, and an estimated nine to 13 feet of its height. Metal sheathing was observed on the exterior of the hull and interior features such as frames and the keelson could be seen. The exposure of these elements suggests that there is very little sediment filling the interior of the hull. Overall, the wood on the wreck appears to be in good condition and current presumptions are that it represents a small sailing vessel (schooner?) lost during the first half of the nineteenth century (Irion 2002). Like the *U-166*, this wooden wreck is only minimally covered by sediment, supporting presumptions about the low rates of sedimentation in much of the deep Gulf. However, the fact that the wood on this fairly early wreck appears to be well preserved, while it is believed to be entirely gone on the recent submarine wreck, suggests that the preservation of organics in deepwater settings in the GOMR are variable and the result of complex phenomena that are not yet fully understood.

Another wreck discovered in relatively deep water in the Gulf of Mexico is that of the eighteenth century Spanish vessel *El Cazador*. This wreck is located in approximately 300 feet of water about 50 miles south of Grand Isle, Louisiana. Although the wreck of *El Cazador* is in much shallower water than the two wrecks noted above, it does provide some information on what to expect at wreck sites in the deeper waters of the GOMR. *El Cazador* was lost in 1784 and discovered accidentally by a fishing boat in 1984. Subsequently a group of salvers dove on the wreck and recovered a large number of silver coins, a bronze cannon, cannon balls, an anchor, a bronze bell, fire brick, pottery, and some other miscellaneous items (*New York Times* 1993; Summers 1996). Little is known about the condition of the wreck at the time of discovery, although reports of the finders reveal that wood was present and that portions of the wreck were exposed above the bottom. The minimal amount of information available on this eighteenth century wreck does indicate that very little sediment covered it, reflective of the small amount of sedimentation occurring in the deeper areas of the Gulf. A wide range of metallic and other non-organic artifacts was preserved on the wreck site and it appears that some wood was preserved, although the information on this is sketchy. The condition of *El Cazador* seems to argue for reasonably good preservation of wrecks, even wooden ones, in moderately deep waters of the study area.

4.4.1. Sediment Characteristics and Preservation Potentials in the Study Area

Garrison et al. (1989:II-77) note that, generally, the environments within which shipwrecks can be found in the Gulf of Mexico can be classified as: 1) static and hypoxic (e.g., low oxygen); and 2) dynamic and aerobic. The static and hypoxic environment is considered most conducive to preservation, but as noted, variability in preservation potentials does exist between these two very generalized settings.

Garrison et al. (1989) looked at 17 wreck sites from various shelf settings and compared various physical characteristics of the wreck, such as distribution of wreckage and the condition of organic and non organic remains, against environmental factors, such as current velocity, biological activity, etc. Several conclusions were drawn from these data (Garrison et al. 1989:II-78):

1. Structural remains tended to be poorly preserved where vessels were sunk in dynamic, coarse sediment environments.
2. Organic remains tended to be poorly preserved in dynamic, coarse sediment environments.
3. The preservation of other classes of artifacts varied widely with little observed correlation with the specific environmental variables used in the analysis.
4. Discontinuous wreck sites occur only in dynamic, coarse sediment environments.
5. Nineteenth century wrecks are better preserved than earlier wrecks.

Since the 1989 study, several historic wreck sites have been discovered in the Gulf of Mexico. Those that are most relevant to the present study are those found in the "open waters" of the Gulf; these are relatively few in number and most have been discussed earlier. Among these are several off the Texas coast, including the "*303 Hang Wreck*" consisting of the remains of a well-preserved, wooden two-masted schooner approximately one mile off the upper Texas coast (James et al. 1991b); the late-nineteenth century Army Engineers dredge *Gen. C.B. Comstock,* located just 600 meters offshore of Surfside, Texas (James et al. 1991a); the wreck of the Civil War blockade runner *Denbigh*, just offshore of Bolivar Peninsula near the entrance to Galveston Bay (Arnold et al. 2002); and the wreck of the sidewheel steamer *New York,* lost in 1846 off the upper Texas coast (Irion and Anuskiewicz 1999; Irion and Ball 2001).

Wrecks that have been discovered off the central Gulf coast include the Spanish vessel *El Cazador,* lost in 1794 and discovered in about 300 feet of water off the central Louisiana coast; the recently discovered remains of the World War II German submarine *U-166* in about 5,000 feet of water off the mouth of the Mississippi River; the well-preserved wooden hull of a circa 60-foot long vessel in roughly 2,600 feet of water off the mouth of the Mississippi River; and the well-preserved remains of the iron hulled sidewheel steamer *Josephine* that sank in 1881 south of Ship Island, Mississippi (Irion and Anuskiewicz 1999). The available information on these wrecks is variable, because few have been carefully studied. Where published information is available (e.g., the *Gen.*

C.B. Comstock and the *303 Hang Wreck*), that information typically supports the general propositions about shipwreck preservation in the Gulf of Mexico presented by Garrison et al. (1989). However, some slight alterations in Garrison's expectations are suggested.

The most important of these seems to be that a greater chance of preservation occurs in dynamic, high-energy environments than had been anticipated. It appears that the processes that lead to burial and ultimately the protection of wrecks are not as uncommon in these settings as had been thought as evidenced by numerous historic wrecks discovered in moderate and high energy settings. In a number of cases, the integrity of large portions of hull structure is maintained and often wood and other organics are reasonably well preserved. It is possible that the conditions conducive to wreck preservation in these high-energy environments are very localized. Examples of these localized settings would be where topographic depressions exist into which wreckage can settle and be covered by sediments or where sediment transport is sufficiently rapid to quickly bury wreckage, creating a protective cover. It is likely that the weight of wreckage combined with the scouring effects of currents can facilitate rapid settling and burial in coarse-grained sediments. This may have been among the burial processes occurring at one of the 1554 Padre Island wreck sites (41KN10) and at the 1913 wreck of the *Gen. C.B. Comstock* near the mouth of the Brazos River (Arnold and Weddle 1978:198; James et al. 1991a). However, at both of these sites the presence of marine growth and borer damage on buried remains indicated that they had been uncovered and exposed for one or several periods of time in the past. In general, however, these high-energy conditions are of only minimal concern in this study because these settings are rare in the study area.

In some instances, the wreckage itself contributes to creating an environment conducive to preservation. Structural pieces can serve as sediment traps, speeding up the process of sediment accumulation. Ballast can cover structural elements and protect them while in other settings, wreck structure attracts and encourages the growth of marine organisms, such as oysters and barnacles, that can provide protection to wreck elements. Both of these factors seem to have occurred at the sixteenth century *Emanuel Point Ship* site. Located on a sand bar in Pensacola Bay, the wreck is capped by a large pile of stone ballast plus a dense stratum of shell that has developed on the "artificial reef" created by the ship remains (Smith et al. 1995:19). These have contributed to the protection of the underlying vessel remains and to the preservation of a wide range of organic and non-organic materials.

Despite the variability seen in shipwreck preservation, some generalizations about the spatial distribution of environmental settings, and thus potentials for shipwreck preservation, can be made. Ultimately, Garrison et al. (1989:II-77) determined that, in general, the "main determining factor in the survival of archaeological remains is sediment type and distribution." Relying on the distribution of sediment types across the outer continental shelf area of the Gulf of Mexico, that study identified regions of Low, Moderate, and High shipwreck preservation potential (Garrison et al. 1989:Figure II-50).

Figure 4-10 presents information on general sediment distributions in the continental shelf region of the Gulf derived from Rezak et al. (1985), overlain with MMS lease areas. The expected preservation potentials of major sediment areas are classified using the three categories of Low, Moderate, and High used in Garrison et al. Information from recently discovered or examined shipwrecks, plus general information on wreck conditions obtained during the development of the 2001 shipwreck database, has suggested some changes in the preservation potentials of sediment areas originally assigned by Garrison et al. (1989). Garrison had assigned a Low preservation potential for almost all of the shelf area off the western coast of Florida. This is generally a karstic shelf region overlain in areas by a veneer of sands that thickens shoreward (Berg 1986). Archaeological wreck site descriptions from this region are available almost exclusively for vessels lying in shallow, inshore waters and outside of the study area, such as around the Dry Tortugas (e.g., Murphy 1993b).

However, the large number of sport diver accounts from this region indicate that many of those wrecks lying in the shoreward portions of the GOMR along the Florida coast are reasonably well preserved. Because of this, the inshore area characterized by "quartz sand and shell" has been changed from the Low preservation potential assigned by Garrison et al. to a Moderate preservation potential (Figure 4-10).

Garrison et al. assigned a Low preservation potential to all of the mostly karstic shelf region off of Florida characterized by "Shell sand with quartz" sediments in Figure 4-10. This was because this is typically a sediment-starved area where the chances for rapid burial of wreckage that might enhance preservation are relatively low (Garrison et al. 1989:II-120). An overall lack of data on wrecks from this region makes it difficult to confidently assign a preservation potential to this broad area. However, bottom sediments do thicken shoreward in this area, plus, as noted above, numerous well-preserved wrecks are known from the immediately adjacent "quartz sand and shell" region (Figure 4-10). The availability of sufficient sediment for burial in parts of this area, plus an overall low energy environment, suggests that the preservation potential of portions of this broad region may be higher than estimated by Garrison et al. (1989). In light of these factors, the entire region is assigned a Low to Moderate preservation potential, recognizing that this assignment must remain tentative until such time as additional wreck data are available.

The broad area of sand, silt and clay lying off the western Louisiana and upper Texas coasts had been identified by Garrison et al. as having a Low-Moderate preservation potential. The identification of several vessels in this area on MMS records, plus the condition of the *303 Hang Wreck* (James et al. 1991b) discovered in this sedimentary setting, have been used to assign an overall Moderate preservation potential to this region. The sand, silt and clay area off the extreme lower Texas coast is assigned a Moderate preservation potential because its sedimentary character is similar to the region of the upper Texas coast and Louisiana.

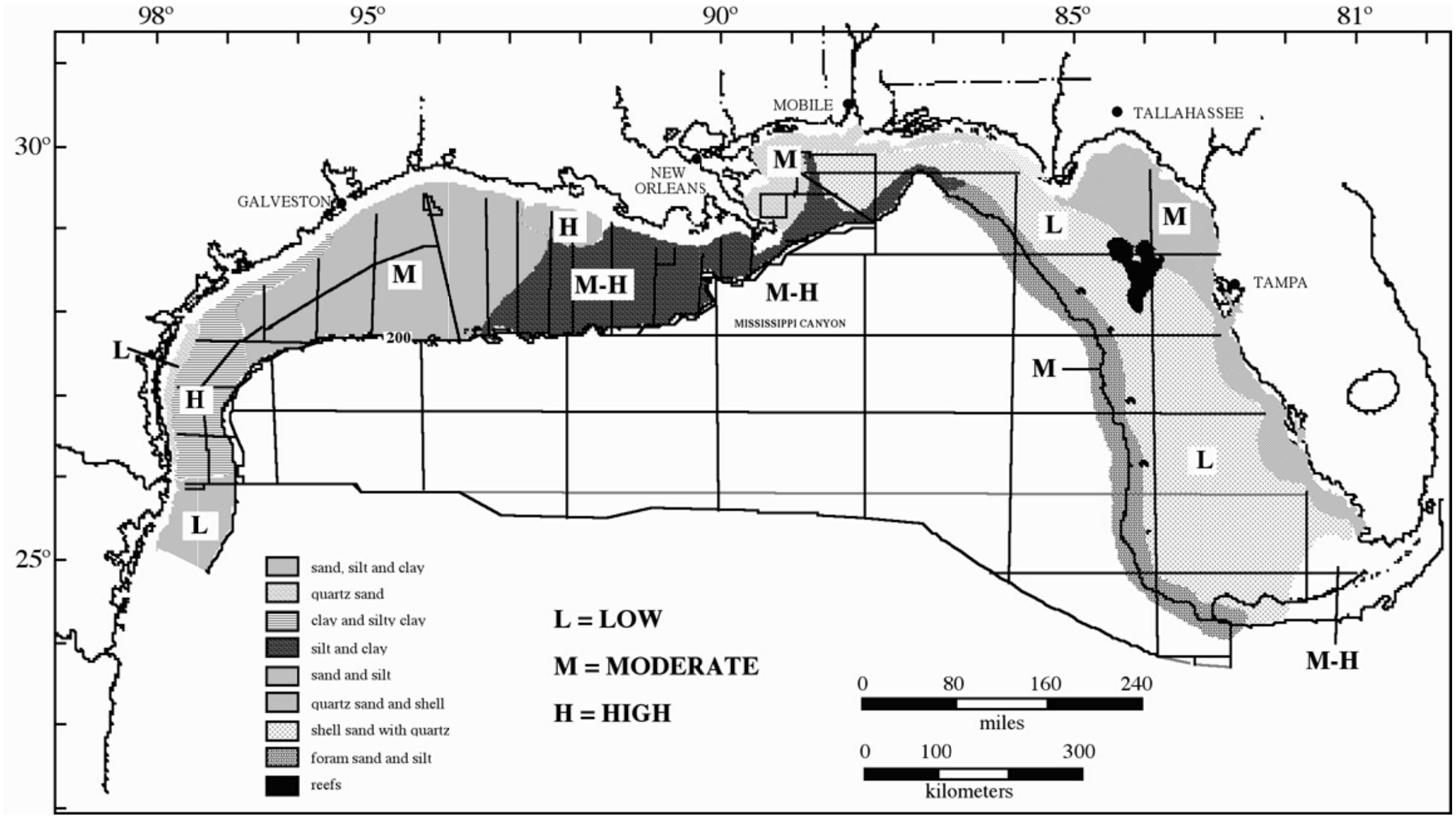


Figure 4-10. Sediment zones and preservation potential in the study area (adapted from Rezak et al. 1985).

Garrison et al. (1989) classified the inshore region of “quartz sand” that borders the shore of the Florida panhandle and extends westward to the Mississippi River delta as having a Low-Moderate preservation potential. This sedimentary zone barely extends into the study area, but several wrecks have been found in this zone and in the “shell sand with quartz” zone lying farther offshore. Among these are the steamer *Josephine* and the sailing vessel *Tulsa*, as well as several unidentified vessels discovered during the course of MMS-mandated remote-sensing surveys. It is presumed that the preservation potential of this zone will be variable, with inshore areas, where high energy conditions are more likely to exist, having a lower potential than the deeper water sections. However, these deeper water segments are those falling within the study area such that they have been designated as Moderate in terms of preservation potential.

Assignment of preservation potentials to the entire deepwater section of the GOMR is difficult because of a lack of wreck data. However, in the deep water area off the mouth of the Mississippi River several wrecks have been discovered that show a remarkable degree of preservation. Most of these have been identified only with sidescan sonar but two, the World War II submarine *U-166* and the unidentified wooden sailing vessel believed to date to the nineteenth century, have been visually examined with video cameras. Both are very well preserved and show minimal dispersion or burial by sediment. We feel confident in assigning a Moderate-High preservation potential to this area of the open Gulf (i.e., the Mississippi Canyon Area) and, based on findings from deepwater areas around the world, it is likely that a similarly high potential can be extended to almost all of the deepwater areas in the GOMR.

4.5. Patterns of Shipwreck Distributions

4.5.1. Introduction

The spatial distributions of historic shipwrecks in the GOMR is of ultimate concern in this study. The foregoing discussions have considered a variety of characteristics of the sample of shipwrecks included in the 2001 shipwreck database and these characteristics constitute elements on the “model” of shipwreck occurrences in the GOMR developed in this study. This section of the report presents discussions on the spatial patterning observed in these shipwrecks, and examines this patterning relative to chronological trends, vessel type, etc. Some data on distributions are presented as illustrations in this section. However, the various files developed in ArcView from the digital database in Microsoft Access that accompany this report represent the principal visual expression of shipwreck data developed in this study. Additionally, the ArcView files provide a GIS format that permits ease in manipulation of all of the shipwreck data collected.

The present examination of shipwreck distributions builds upon that originally presented in Garrison et al. (1989) and follows some approaches used in other similar studies. The original Coastal Environments, Inc. (1977) study of shipwrecks in the Gulf of Mexico compiled a list of shipwrecks and developed several generalizations about the temporal and spatial distributions of wrecks across the Gulf. Other studies have emphasized the relationship of various factors such as shipping routes, port locations, natural hazards and the like with shipwreck locations and have argued that these factors are "causal" in the observed distributions of shipwrecks (Pierson et al. 1987; Science Applications, Inc. 1981).

Garrison et al. (1989) examined spatial distributions in a number of ways, some of which are continued in the present study. As has been discussed in Chapter 3, they looked at general trends in distributions over time, and examined the spatial patterning of wrecks in light of a variety of spatial and temporal factors. One analysis looked at the occurrence of shipwrecks across 1.0-degree and 0.5-degree quadrants of latitude/longitude. Agglomerative cluster analysis was used to examine relationships among shipwreck variables across 1.0-degree quadrants in the Gulf of Mexico. The principal objective was to see if there were any spatial patterns observed in clusters of quadrants produced across the number of shipwrecks within each quadrant and dates of loss. Nine clusters were produced in the analysis, but the conclusions drawn about the meaning of the clusters were very general (Garrison et al. 1989:II-101–109).

The 1989 study also used factor analysis to examine several variables affecting shipwreck locations and patterns (Garrison et al. 1989:II-109). These factors were: 1), historic shipping routes; 2) port location; 3) shoals, reefs, sandbars, and barrier islands; 4) ocean currents and winds; and 5) historic hurricane routes. Their analysis used the principal component factor analysis in the program STATVIEW. Two analyses were undertaken. One factor analysis looked at chronological factors and examined seven variables (four time periods, age of ports, ports, and storms) across 26 "observations." These observations were areal sectors developed by dividing the Gulf coastline into 26 units. Three factors resulted from this analysis. Factor 1 was "characterized as an association of 16th, 17th, and 18th versus 19th and 20th century wreck locations" interpreted as a demographic factor. An association of variables representing nineteenth century shipwrecks and port development characterized factor 2. Factor 3 associated ports and storms with wrecks, but the association was extremely weak. Generally, wreck frequency seemed to be more closely associated with the number of years a port was in existence, rather than the simple existence of the port.

The second factor analysis looked at areal phenomena. As noted previously, this analysis used six variables (hurricanes, ports, routes, hazards, energy, and wrecks) and 10 cases (time periods) per variable, although the time periods are not defined. These variables were examined across ten areas in the Gulf of Mexico. As described by Garrison et al. (1989:II-110), the value of the variable "hurricane" was frequency per time period as derived from Tannehill (1956); "ports" was number of ports; "routes" was the number of periods with major inter- or intra-Gulf routes present; and "hazards" represents major reef, shoal, or other hazards. "Energy" apparently represents major energy zones in the Gulf, but this variable is not defined.

Two factors were identified in this analysis. Factor 1 was interpreted as depicting a strong association of shipwrecks to routes and hazards and Factor 2 associated shipwrecks with port locations.

The present study places less reliance on statistical treatment of the shipwreck data than did the Garrison et al. (1989) study. This has been done for a number of reasons. For one, the greater amount of information collected on individual shipwrecks has permitted a much more comprehensive discussion of the characteristics of the sample of shipwrecks in the database than was possible for Garrison et al. (1989). These characteristics have been presented in the earlier discussions and, in general, are believed to be applicable to the population of shipwrecks in the GOMR as a whole. Additionally, some of the analytical techniques undertaken by Garrison et al. (1989) directed at characterizing the spatial distributions and associations of shipwrecks across the Gulf may have less utility than thought. This is particularly evident in light of the demonstrated unreliability of the position information available for a large number of wrecks. If, as has been shown in the previous chapter, there is no statistically significant difference between finding shipwrecks in identified high-probability areas and finding them in designated non-high-probability areas, then using these same wreck positions in statistical analyses that examine spatial parameters is certainly going to be questionable. This does not mean, for example, that the associations of various factors (e.g., hurricane occurrence, navigation routes, etc.) with shipwreck locations projected by Garrison et al. (1989) may not have validity, but it does suggest that the strength of many of these associations is likely to be weak. Until an increased degree of reliability can be obtained for the positions of a very large number of reported shipwrecks, these factors will have utility only in the very broadest sense. Principally because of this factor, no effort has been made to expand upon the cluster and factor analyses approaches in Garrison et al. (1989).

4.5.2. Broad Spatial Patterns

Figure 4-11 presents information on the locations of all reported wrecks in the 2001 shipwreck database. Overall, the spatial distribution of wrecks generally mirrors that found by Garrison et al. (1989) and by CEI (1977). The majority of vessel losses are in near coastal waters, even though wrecks known to fall in state waters have been eliminated from the database. As seen in the figure, the majority (N=1,738 or 82.5 percent) of reported wrecks fall inshore of the 60-meter contour line, the line that has until recently been used by MMS in the design of its historic shipwreck survey program. Overall, this distribution tends to support the validity of the 60-meter contour as meaningful in survey design. One area where a concentration of losses occurs outside of the 60-meter contour is off the mouth of the Mississippi River. Here, deep water extends close to shore and this fact, coupled with the importance and longevity of the Mississippi River as an entrepot in maritime trade, has contributed to a concentration of losses. Other areas of wreck concentrations are apparent. One is in the Dry Tortugas, Marquesas Islands, and Florida Keys area off southwest Florida. As has been noted, this is an area where the combined association of a major shipping route with the natural hazards of an extensive reef and shoal complex has resulted in an increased potential for vessel losses. It is also apparent that reported losses are more concentrated off the coast in the central and western Gulf coast than in the eastern Gulf as a whole (Figure 4-11).

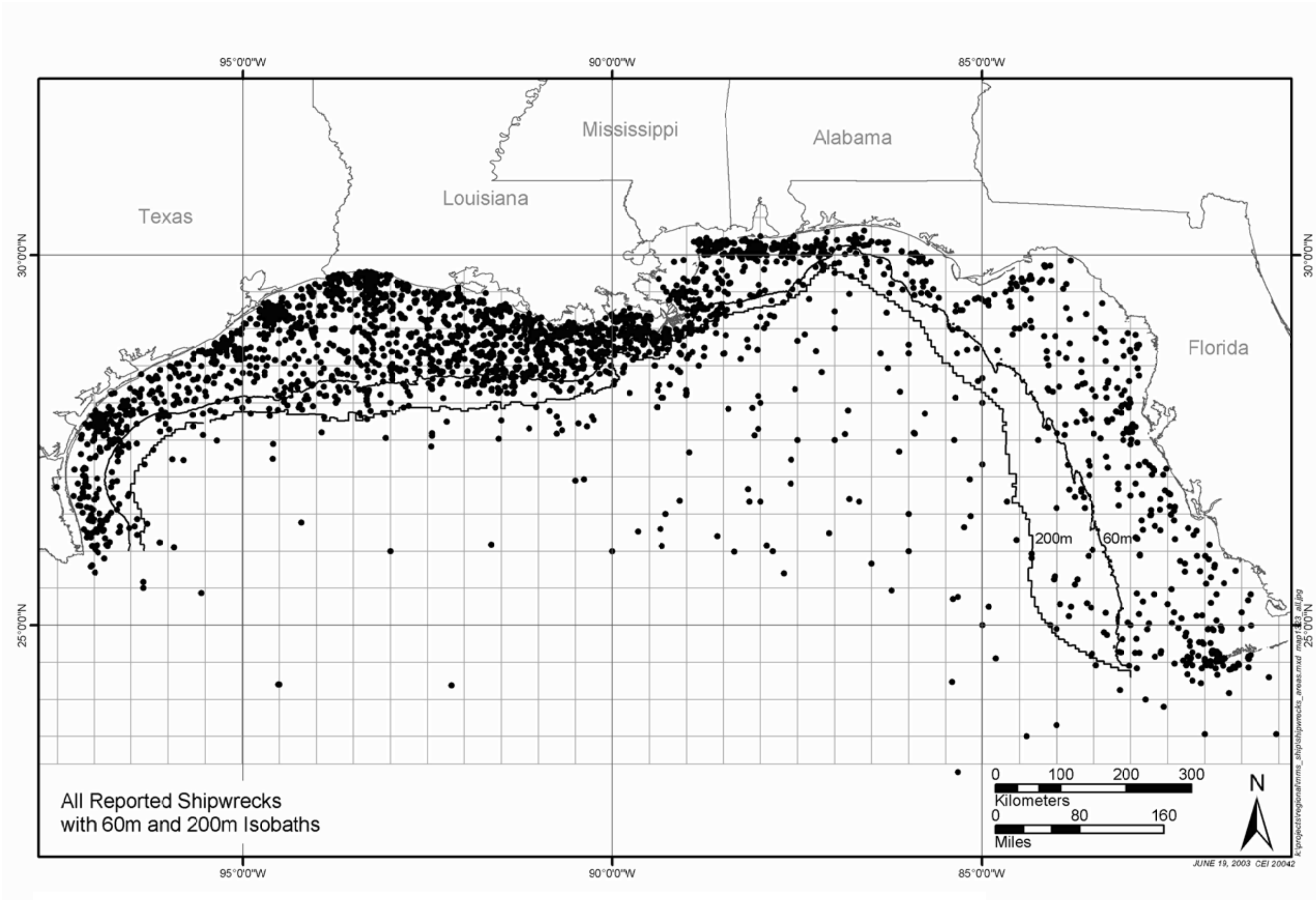


Figure 4-11. Positions of all entries classified as "Vessels" in the 2001 shipwreck database.

Within this general concentration, densities are higher near the mouth of the Mississippi River and along the central Louisiana coast, in the area off of Galveston and in the area off of Corpus Christi. Some of these concentrations are obviously reflective of the locations of ports, as was noted by Garrison et al. (1989). A few vessel locations fall south of 24º latitude and, thus, outside of the GOMR (Figure 4-11). These vessels have been maintained in the 2001 database because of the unreliability of their reported position of loss.

The density of wrecks in the open Gulf beyond the 60-meter contour line is overall, relatively low, but more reported wrecks do occur in the eastern half of this area than the western. Garrison et al. (1989:II-116) noted the same phenomena in their data and it appears to be principally related to vessel traffic patterns. Historically, a principal entrance and egress into the Gulf of Mexico has been through the Straits of Florida. As seen in Figure 4-12, prior to the mid-nineteenth century the primary offshore routes of vessels traveling into and out of the Gulf were concentrated in the area east of the Mississippi River. Since the latter quarter of the nineteenth century, there has been an expansion of routes into the western Gulf, as demonstrated by Figure 4-13 that shows modern shipping routes in the Gulf of Mexico. Even in modern times, however, much of the vessel traffic going to points outside of the Gulf passes through the Straits of Florida, continuing to produce a concentration of traffic in the eastern Gulf. The 70 lease areas designated in the GOMR by the MMS provide a convenient unit for examining broad patterns of shipwreck distributions and complement the specific loss information presented in Figure 4-11. Occurrences of reported shipwrecks across MMS-designated lease areas are provided in Figure 4-14.

Although at a broader scale, Figure 4-14 also clearly portrays the pattern of shipwrecks concentrated around the periphery of the Gulf, within the 60-meter contour, with many fewer reported losses in the central Gulf area. In particular, reported losses are concentrated in the lease areas along the Louisiana and upper Texas coast, and off the western Florida panhandle. Also, there is a slight increase in losses in the nearshore lease areas off of the central Florida Gulf coast, generally around Tampa.

This information is particularly useful when compared against the shipwreck information in the 1989 shipwreck database presented earlier as Figure 3-5. The categories of “Wrecks per Area” are equivalent in both figures. These figures demonstrate increases in reported wrecks in the new database for all of the lease areas along the central Gulf coast and much of the western coastal area. Particular increases are indicated in lease areas off of Mobile and Pensacola and slight increases off the central Florida coast in the vicinity of Tampa. Few obvious changes are seen in the numbers of wrecks reported in lease areas in the open Gulf.

Several factors tend to account for the more obvious differences seen in the occurrences of wrecks by lease area in the 1989 and the 2001 databases. Part of this is simply the incorporation of an additional 12 years of wreck data. However, the nature of the sources used and the types of entries accepted into the 2001 database are equally important factors.

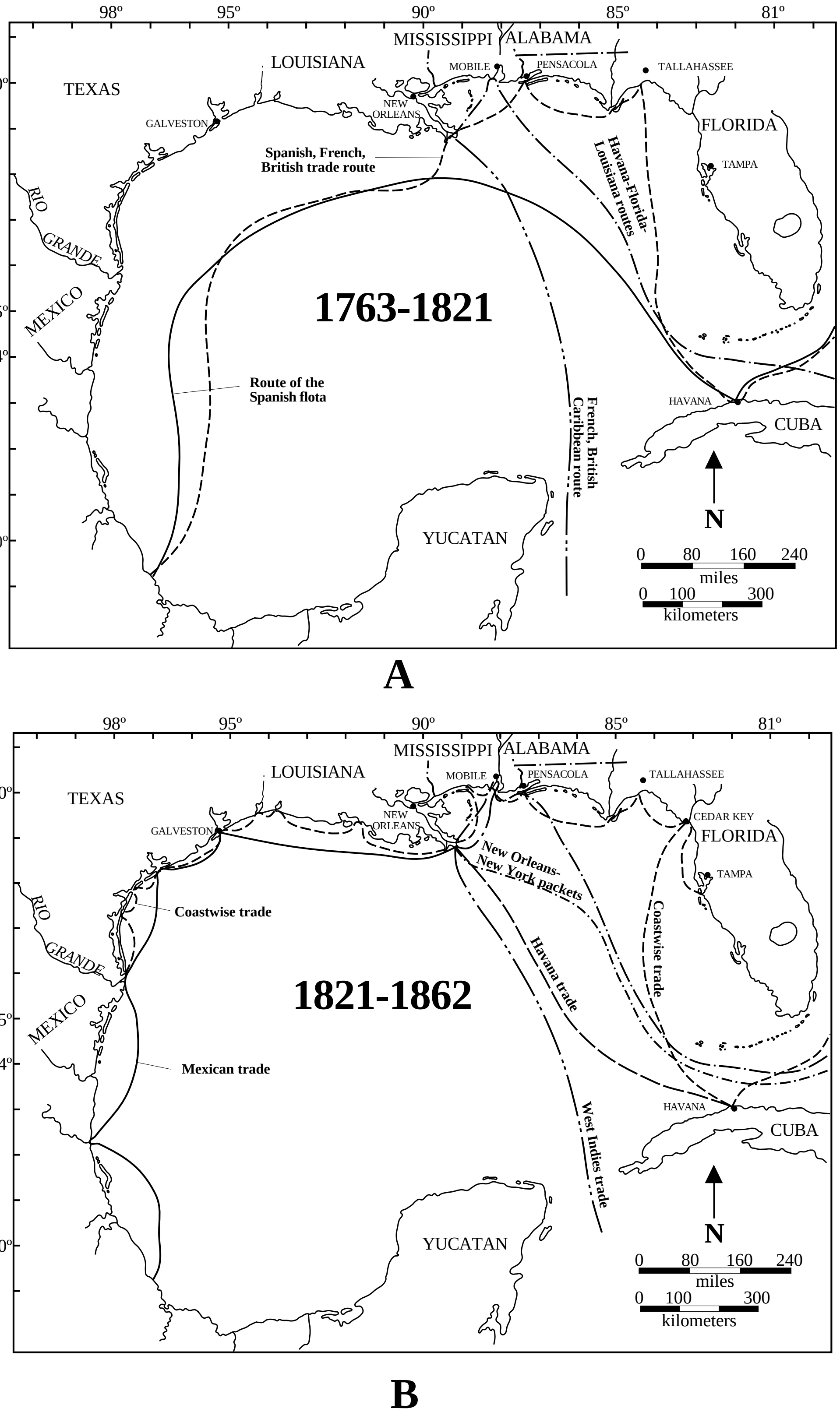


Figure 4-12. Historic shipping routes in the Gulf of Mexico. A. 1763-1821; B. 1821-1862 (adapted from Garrison et al. 1989:Figure II-4).

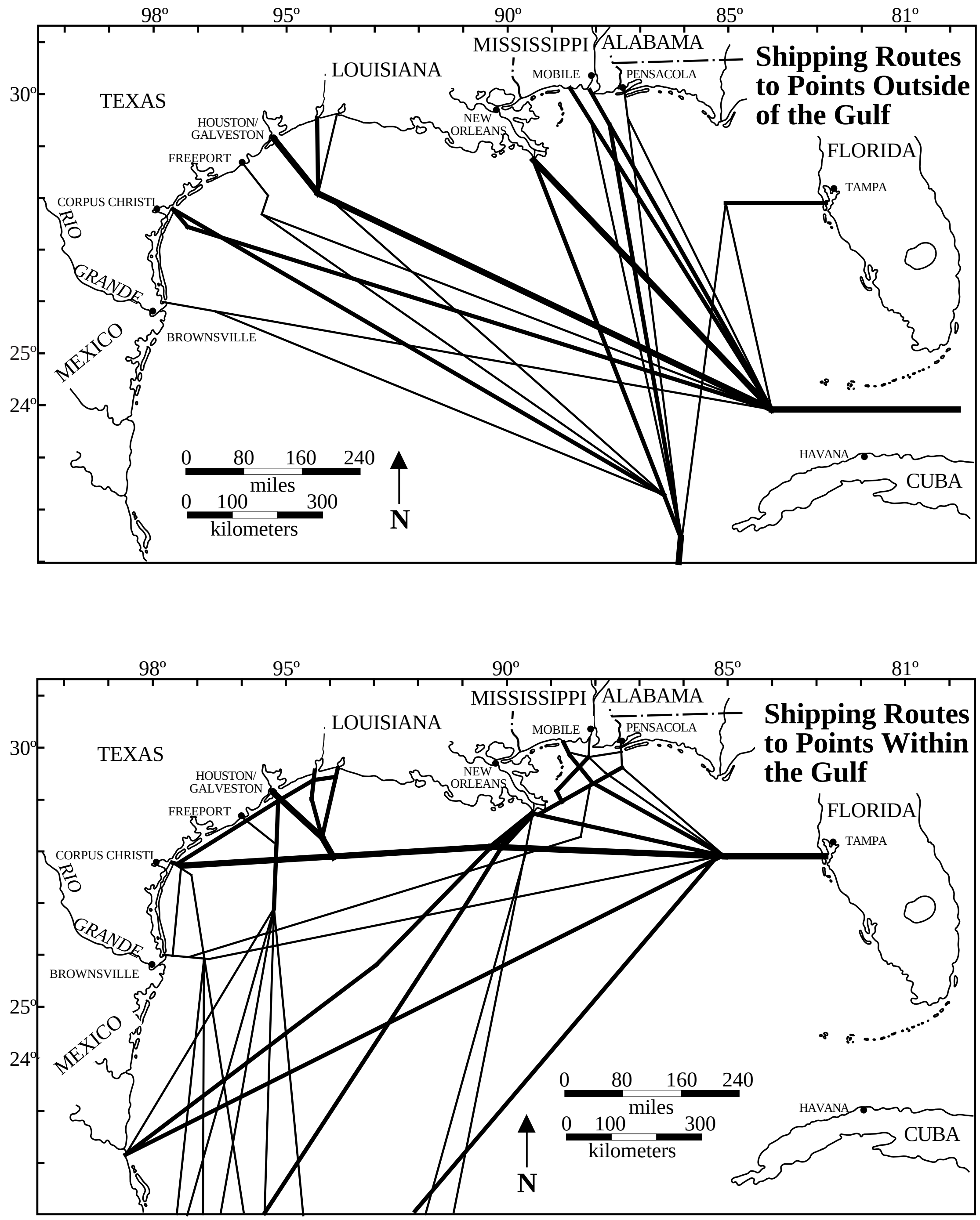


Figure 4-13. Modern shipping routes in the Gulf of Mexico (adapted from Garrison et al. 1989:Figure II-5).

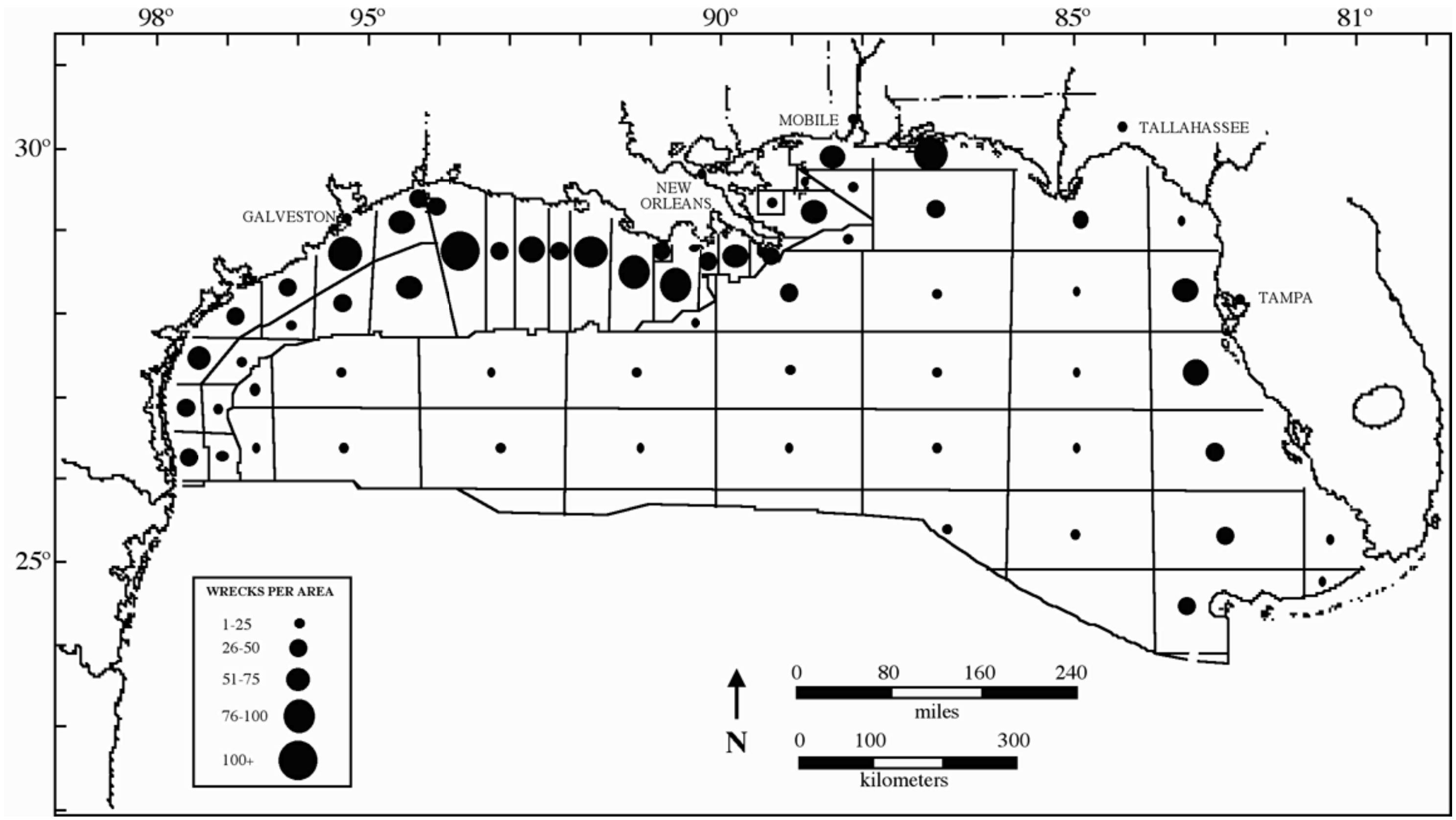


Figure 4-14. Number of reported shipwrecks per MMS lease area. Data from 2001 shipwreck database.

For example, the increase in numbers of wrecks along the Florida coast, and to a lesser extent along the Alabama and Mississippi coasts, is partially related to the inclusion of a considerable amount of wreck information derived from popular sport diver publications and accounts. These sources were not utilized in the 1989 study, or were only used sparingly. Two of these popular works, Rinehart (1998) and Singer (1992), plus several sport diver webpages (e.g., MBT Divers), have been the principal source for over 130 entries in the new database. Another factor contributing to the increase in included wrecks has been a heavy reliance by the present study on several electronic databases maintained by various government agencies on vessel casualties. Some of these were used in the 1989 study, but not all. These databases contain large numbers of unnamed and unidentified vessels, identified by entries such as “Unknown Vessel,” “Obstruction,” “18-Foot-Pleasure Craft” and the like. These entries were included in the present database when they could not be positively correlated with named vessels or with other unknown vessels and objects. As noted earlier, there are close to 800 of these unnamed vessel entries in the database, representing about 38 percent of the total. By contrast, in the 1989 database unnamed vessels and obstructions represent only about 19 percent of the total entries.

Because the MMS GOMR lease areas are of varying sizes, the information on frequency of reported wrecks shown in Figure 4-14 is somewhat misleading as an expression of relative densities of vessels. Figure 4-15 presents the same data on vessel losses by frequencies of reported wrecks per 1,000 square miles of lease area. The data from four very small lease areas (Sabine [LA], Sabine [TX], South Pelto, and Bay Marchand) have been combined with their immediately adjacent lease area so they will not seriously skew the results. As can be seen, this considerably moderates some of the large differences seen in the figure displaying simply the number of vessels per lease area. Particularly evident is a reduction in the densities of wrecks off the central and western Louisiana coast and a generally homogeneous distribution of wrecks along almost the entire Florida coast.

4.5.3. Spatial Distributions in Shipwrecks Through Time

Chronological trends in GOMR vessel losses as they relate to frequency over time, by season, and by other factors have been discussed previously. Figures 4-16 through 4-23 present information on the spatial distribution of vessels losses through time in the study area. The information is provided in 50-year increments and serves to portray broad trends in settlement and commerce around the northern Gulf of Mexico.

1600-1649. Only a single vessel dating earlier than 1700 is included in the database. This is the galleon *San Jorge*, reportedly lost off the Texas coast in 1625 (Figure 4-16). However, the historical information on the loss of this vessel is very vague and its true position is unknown (Berman 1972). As seen in Appendix E, the geographic coordinates provided for this vessel have been assigned a Reliability Factor of 4, meaning that its reported position is very unreliable.

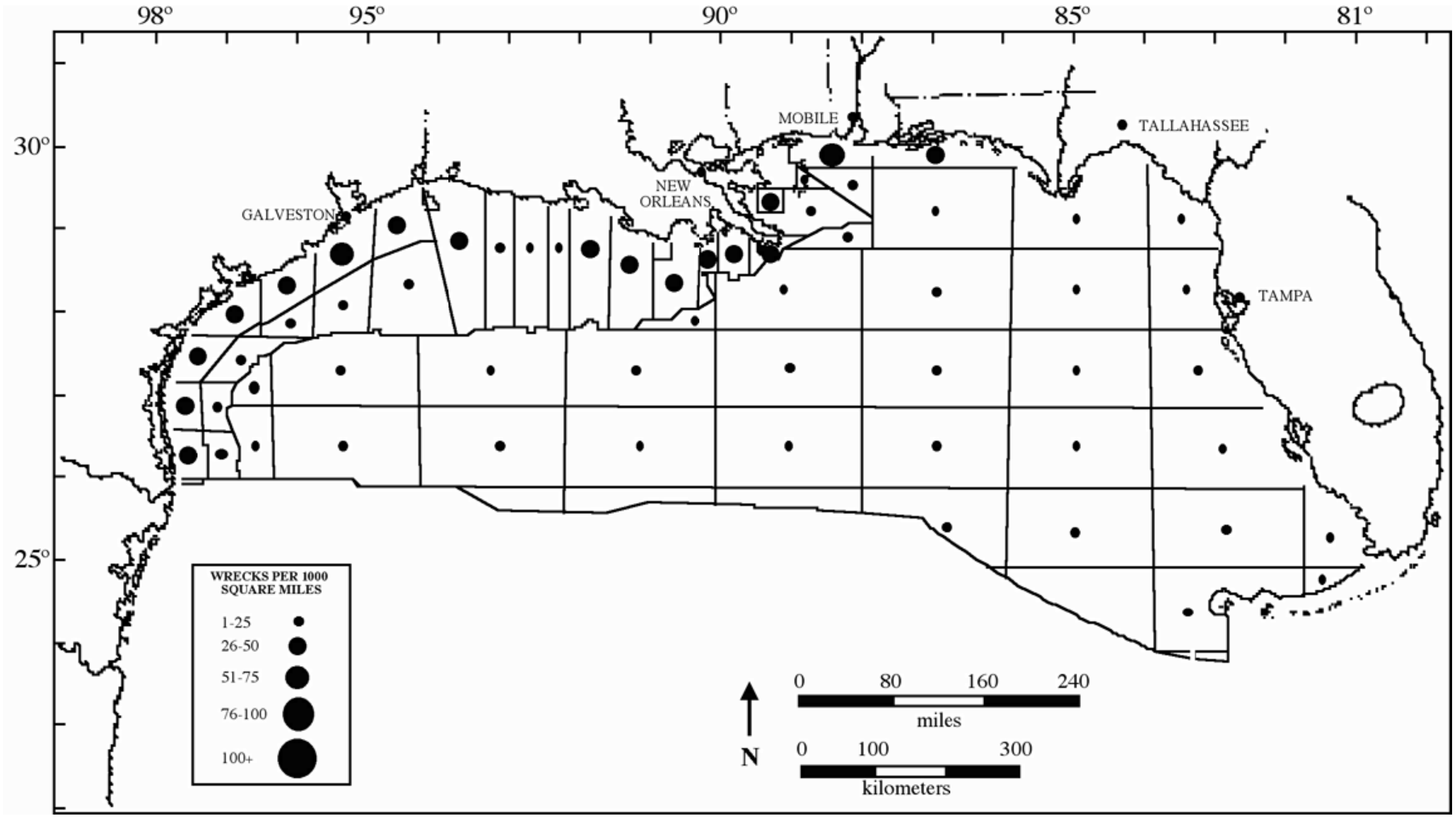


Figure 4-15. Number of reported shipwrecks per 1,000 square miles per MMS lease area. Data from 2001 shipwreck database.

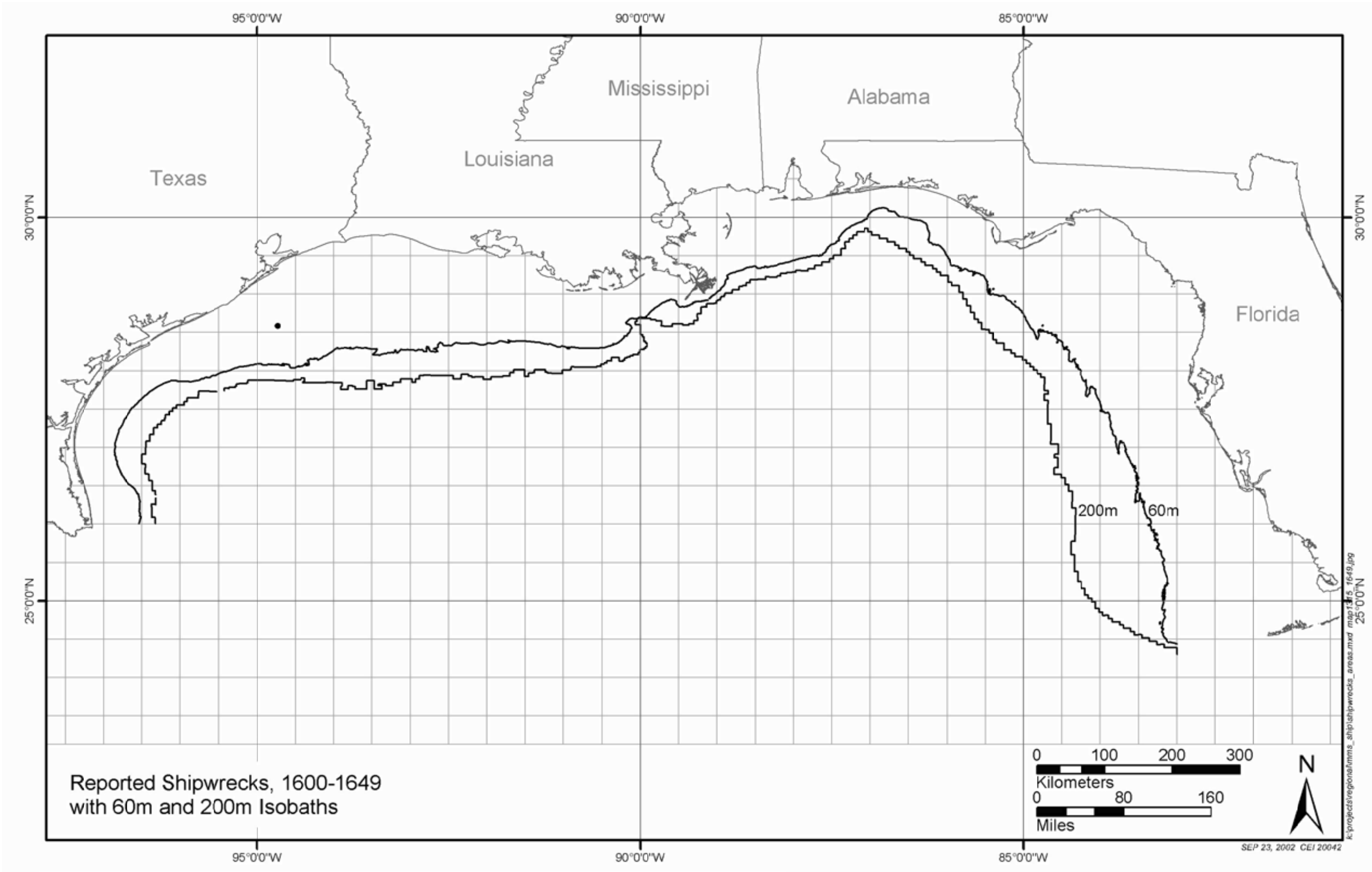


Figure 4-16. Position of reported shipwreck, 1600-1649.

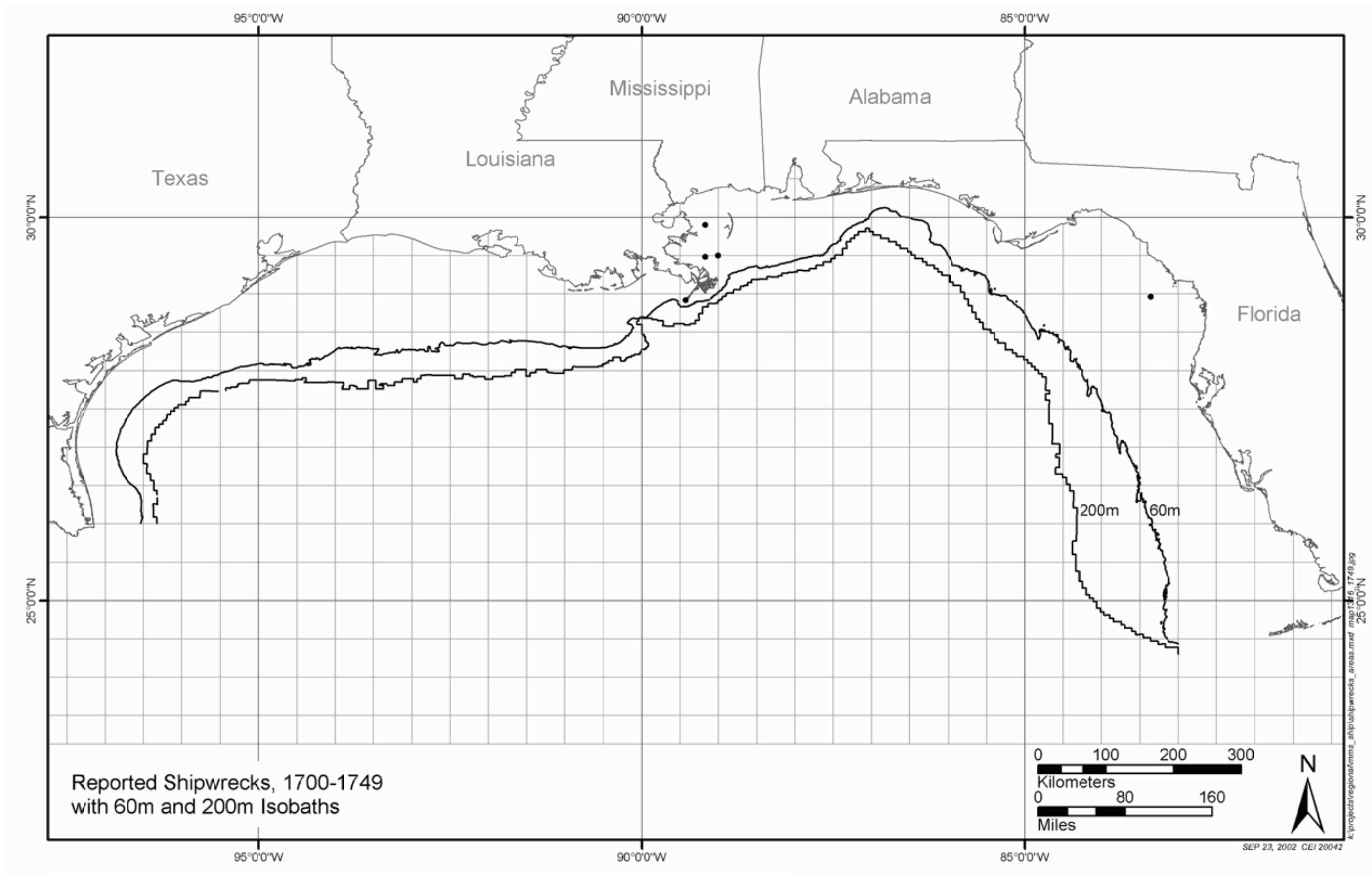


Figure 4-17. Positions of reported shipwrecks, 1700-1749.

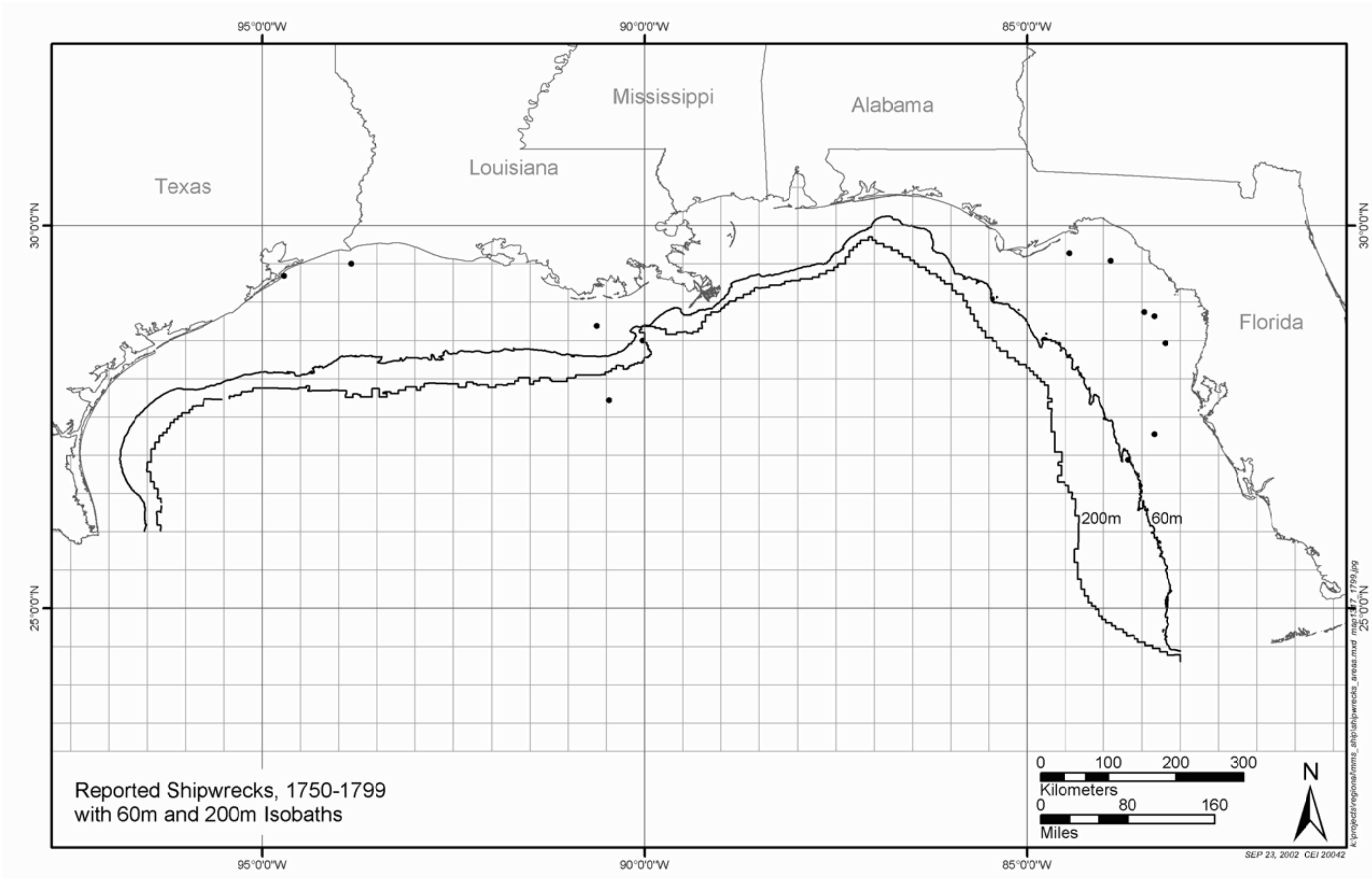


Figure 4-18. Positions of reported shipwrecks, 1750-1799.

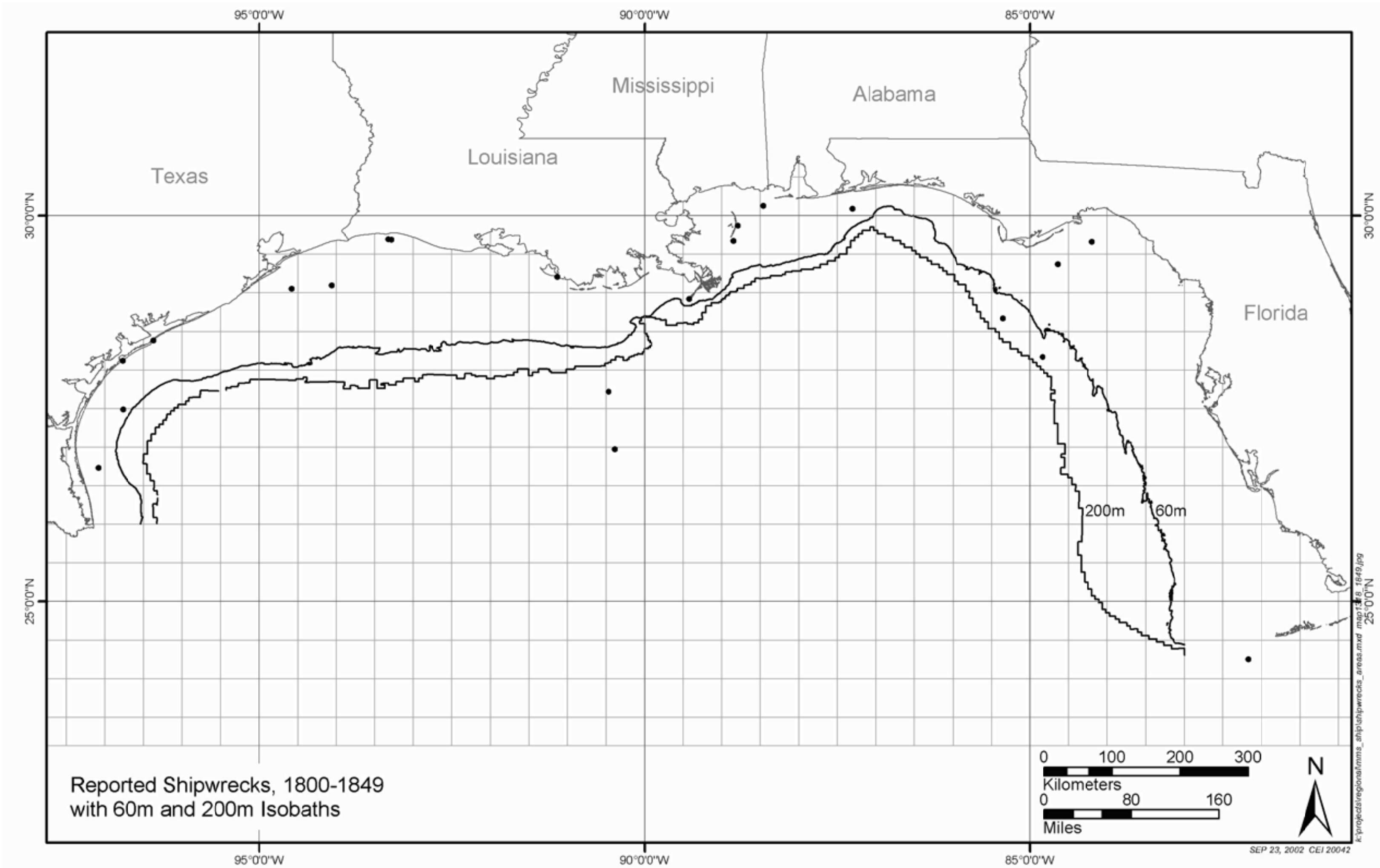


Figure 4-19. Positions of reported shipwrecks, 1800-1849.

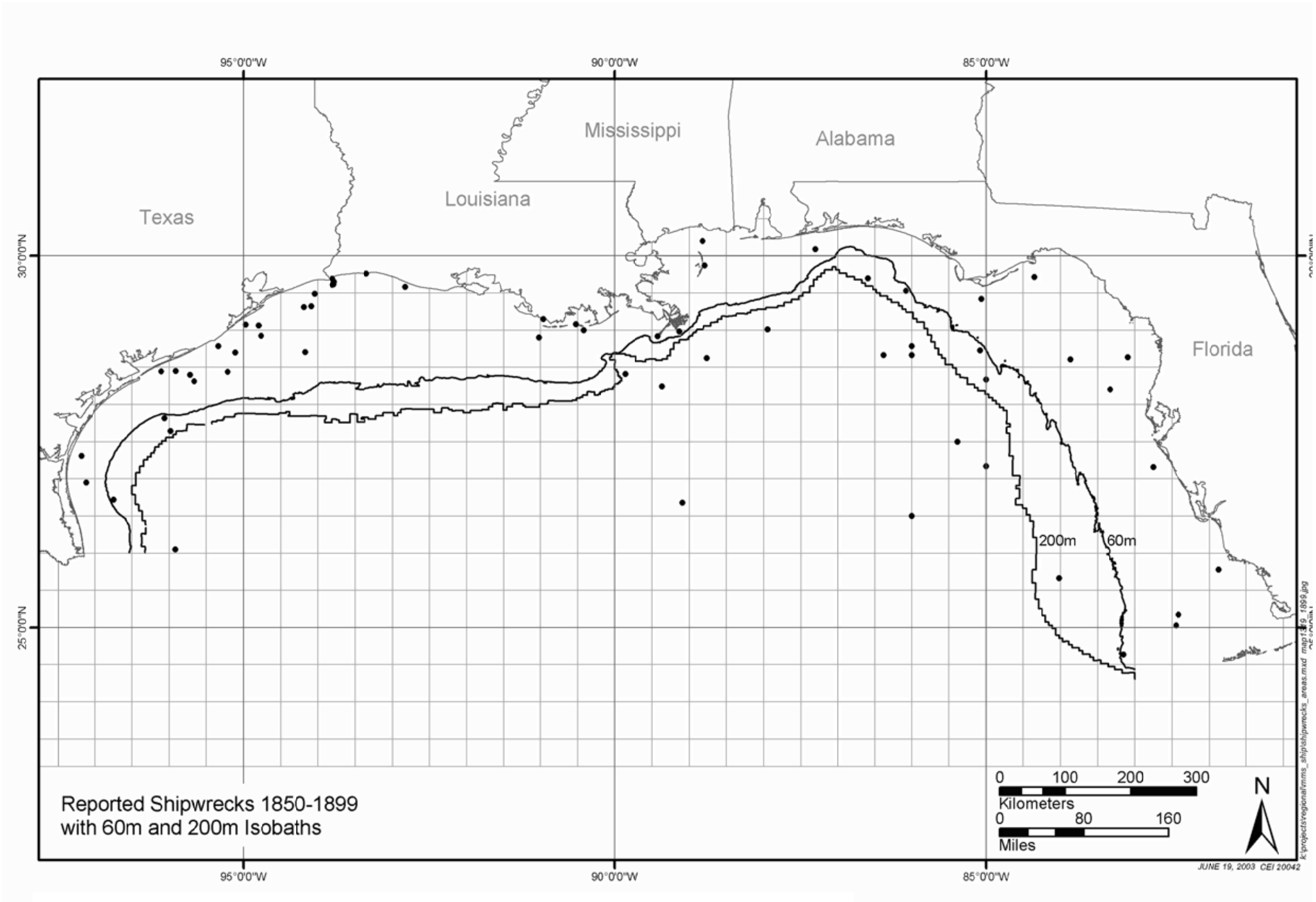


Figure 4-20. Positions of reported shipwrecks, 1850-1899.

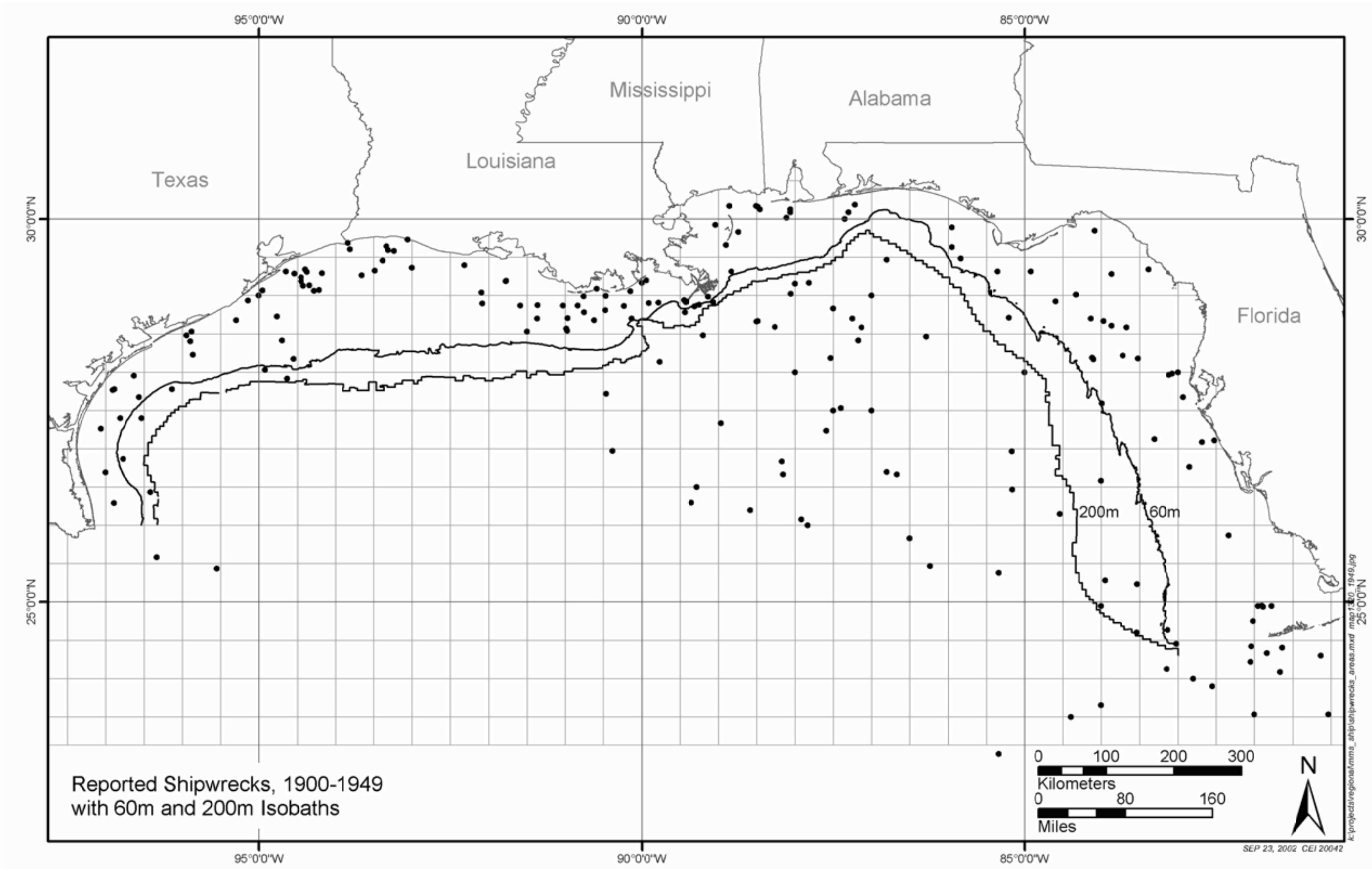


Figure 4-21. Positions of reported shipwrecks, 1900-1949.

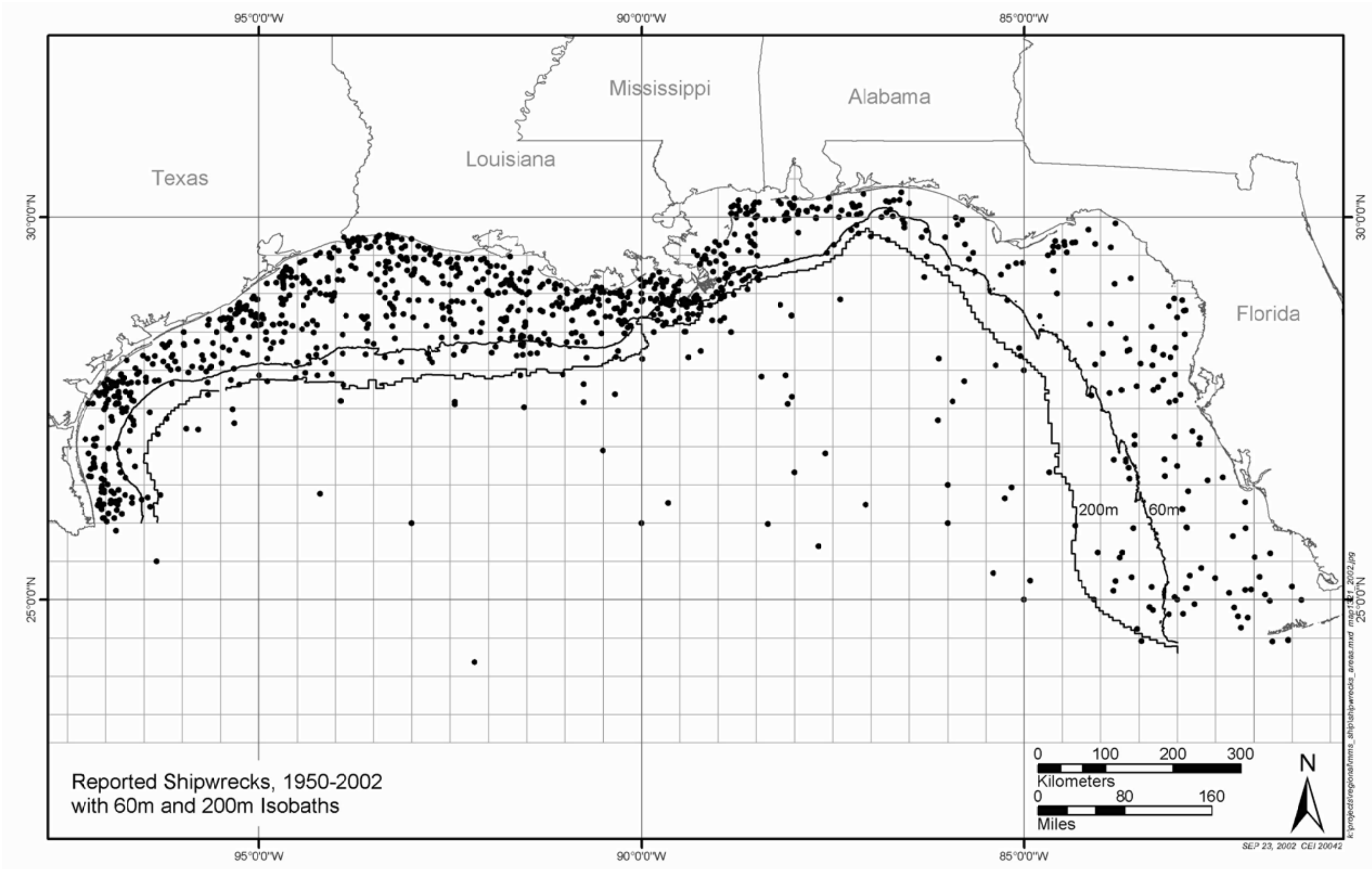


Figure 4-22. Positions of reported shipwrecks, 1950-2002.

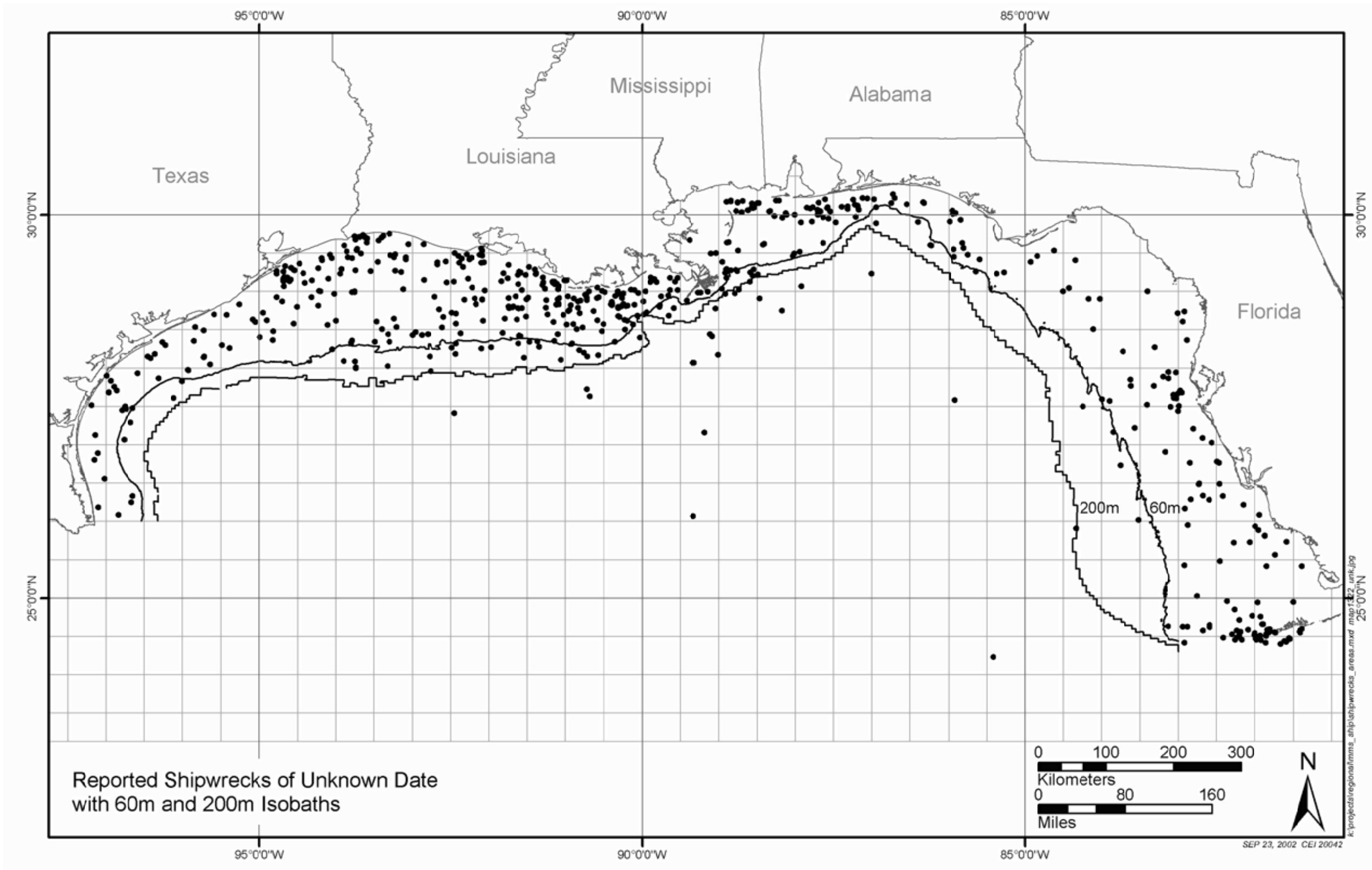


Figure 4-23. Positions of reported shipwrecks of unknown date.

The fact that there is only this single reported loss in the study area prior to 1700 is partially an expression of the small numbers of vessels actually sailing on the open waters of the Gulf at that time. Those losses that are reported prior to 1700 tend to lie close inshore, outside of the boundaries of the study area. As Garrison et al. (1989) note, these earlier losses reflect the early period of Spanish exploration of the northern Gulf and the establishment of the annual flota routes. The established route of the flota out of Veracruz was north along the Mexican coast to about 25 degrees north and then northeast until the Louisiana coast was sighted, and then south or southeast past the Florida Keys and to Havana (Figure 4-12A).

If a hurricane struck the fleet while it was following this route, the general tendency would be for ships to be driven in a roughly northerly or northeasterly direction toward the shore. Most of the early known and reported flota losses consist of vessels that were driven ashore under these circumstances, such as in 1554 and 1622. Little is known about vessels that might have been lost far offshore in the open Gulf or, if known, information on where they might have gone down is so inaccurate as to be of little use in looking at spatial patterns of loss.

1650-1699. No vessels are reported lost in the study area for the period 1650 to 1699. Again, this is a reflection of both relatively light vessel traffic and the bias of underreporting during these early periods, particularly of vessels lost far from land. A number of losses are known to have occurred along the margins of the Gulf during this period, but they lie outside of the study area (Garrison et al. 1989). Those that are known or reported are mostly Spanish, but the recent discovery of the 1686 wreck of the French vessel *La Belle* in Matagorda Bay, Texas, is reflective of the beginning of French activity in the northern Gulf.

1700-1749. A small number of losses are reported in the study area during this period. Most are located in the vicinity of the mouth of the Mississippi River and are related to the establishment of French settlements in the Biloxi-New Orleans area early in this period and, ultimately the establishment of the colony of Louisiana and the development of New Orleans as a port (Figure 4-17). The lack of reported losses in the western Gulf is seemingly due to the lack of cross-Gulf routes of trade and to the few settlements then in that area.

1750-1799. There is both an increase in number and an expansion in the distribution of losses reported in the study area during this period (Figure 4-18). This reflects the expansion of settlements along the Gulf coast, plus an increase in maritime commercial activity to serve the growing population. This expansion in commerce was partially expressed in the establishment of additional trade routes across the open waters of the Gulf (see Figure 4-12A). Several losses are reported west of the Mississippi River and, for the first time, losses are reported in the deep waters of the Gulf, beyond the 60-meter contour line.

1800-1849. During this period reported shipwrecks are thinly scattered across the inshore waters of the entire study area (Figure 4-19). The first half of the nineteenth century was a period of great expansion of shipping activity in the Gulf region. The United States acquired the Louisiana Territory and New Orleans grew into an important seaport, funneling goods into and out of the heartland of America via the Mississippi River. Cotton agriculture expanded west from the eastern seaboard and the crop became the most important export of the South. There was a tremendous expansion of the coastwise trade as numerous small sailing vessels were used to transport cotton and other products from small towns and landings into the major ports, such as New Orleans, Mobile, and Pensacola. Larger sailing vessels were used to carry these products out of the Gulf to northeastern centers, such as New York, or to European and Caribbean destinations. The development of the steam engine represented a major technological change that had great impact on water travel. The steam engine was quickly adapted to use in ships and during this period steamers became involved in coastwise passenger and cargo trade, as well as in the long distance trade to eastern and European ports. Maritime trade to Texas became important during this period after its independence from Mexico and particularly after it joined the Union (Francaviglia 1998; Pearson and Simmons 1995). In light of the large numbers of vessels known to have been sailing in Gulf waters during the first half of the nineteenth century, it is believed that the small number of losses reported for this period is a serious under-representation of actual losses.

1850-1899. Two obvious changes appear in the pattern of distribution of shipwrecks in the study area during the latter half of the nineteenth century (Figure 4-20). These are an increase in wrecks in the inshore waters of the western Gulf and an increase in wrecks in the open waters of the eastern Gulf. This latter pattern reflects increasing commercial vessel traffic along cross-Gulf routes, principally from New Orleans to the Straits of Florida. The inshore, western Gulf losses express the establishment or expansion of several important Texas ports, such as Galveston/Houston and Corpus Christi. After the Civil War the expanding cattle industry in Texas came to prominence in the state's maritime commerce. Packeries, plants where cattle were butchered and processed into meat, hides and tallow, sprang up along the Texas coast and these products, as well as live cattle, became important exports. A large percentage of these cargoes was carried aboard steamers that had been first put into service in the 1830s (Guthrie 1988:80-93). The most important of the steamer lines operating along the Texas coast was the Morgan Line, owned by transportation magnate Charles Morgan, who had been attracted specifically to these Texas ports by the opportunities provided in shipping cattle and cattle products (Baughman 1968).

Garrison et al. (1989:Table II-16) note that the "westward distribution [of wrecks] is offset by the principal ports of New Orleans and Mobile in the North-central Gulf area." No similar concentration of wrecks is seen off either New Orleans or Mobile in the present data and it is apparent that the pattern observed by Garrison et al. is because of their inclusion of nearshore and onshore losses.

1900-1950. The pattern of wrecks in the study area for the first half of the twentieth century reflects the full maturation of settlement and commercial patterns in the Gulf that began in the late nineteenth century (Figure 4-21). Particularly important were the continued growth of New Orleans and the rising importance of Tampa and several

Texas ports, such as Houston, Galveston, Freeport, Corpus Christi and Brownsville. This period saw the birth and growth of the oil industry and the use of many vessels in the transport of oil products. A number of wrecks occur in the open Gulf, but they are concentrated in the eastern half of this area, reflecting a pattern that began prior to 1850. This is believed to be indicative of the continued importance of traffic routes from New Orleans and other central Gulf ports to the Straits of Florida, despite the expansion of shipping routes into the western Gulf during this period.

Some of the increase in reported losses during this period is due to the expansion of fisheries in the Gulf, as has been discussed earlier. The concentration of losses off of the central Louisiana coast is partially related to the growth of the shrimping industry. Garrison et al. (1989:Table II-100) report an increase in losses off the southwestern Florida coast for 1940-1959, and suggest it is related to the expansion of fisheries and the growth of the Tampa trade. The small cluster of wrecks shown in the vicinity of the Florida Keys in Figure 4-21 appear to be an early expression of these phenomena.

1950-2002. As discussed earlier, there has been a tremendous increase in the number of reported wrecks in the study area since 1950; this phenomenon is fully expressed in Figure 4-22. There is a general concentration of losses off the coast from the area of Pensacola west to southern Texas, with obvious clusters of wrecks off the mouth of the Mississippi River and off Galveston, Freeport, and Corpus Christi. These are in part reflective of the increasing growth of commerce into and out of these ports. However, many of the losses during this period are of fishing vessels of various sorts, as well as pleasure craft, and the concentrations seen are heavily influenced by the losses of these types of vessels. Also, the expansion and growth of the offshore oil industry during this period and the concomitant loss of vessels associated with it also contribute to the concentration of vessels in the inshore areas of the central and western Gulf.

Overall, there are still a relatively small number of vessels lost in deeper waters of the open Gulf, but the old pattern of a concentration in the eastern Gulf is no longer obvious. The full maturation of the inter-Gulf shipping routes shown in Figure 4-13 is expressed in the distribution of losses across the entire area of the central Gulf.

Shipwrecks of Unknown Date. Figure 4-23 presents the locations of all of the vessels in the shipwreck database that have no date of loss. The concentration off the Florida Keys is partially related to accounts from sport diver publications that report on wrecks of unknown identity and age. Many of the other entries consist of items recorded as Unknown Vessels, Obstructions, and the like. Some of the concentration seen off the coast between Mobile and Galveston is due to Unknown Vessels identified during the course of MMS-mandated surveys.

4.5.4. Distribution of Reported Shipwrecks by Reliability Categories

As has been discussed previously, it is believed that the principal reason for the lack of predictability in the 1989 model of shipwreck distributions is the lack of precision in the reported positions of a very large number of vessels. In an effort to gain a handle on this rather significant problem, we attempted to quantify how reliable a position of loss was by assigning a numerical value to reported positions of loss. These numerical values (identified as Reliability Factors) ranged from 1, very high reliability, to 4, very low reliability, and are defined in Chapter 2. The use of this reliability factor represents an attempt to strengthen the reliability and predictability of the model of shipwreck distributions developed. It was felt that this approach would be most useful to the MMS in its management responsibilities as well as in trying to relate specific wrecks or groups of wrecks to the concept of "high-probability" areas and locations. In essence, using wrecks assigned very low reliability factors (i.e., 3 or 4) in the identification of tightly drawn "high-probability" locales is considered questionable.

The assignment of a reliability factor relied on the available information in the various sources used. As noted, the quality of this information varied widely. In some instances, such as with data from MMS-mandated offshore surveys that used state-of-the-art-positioning systems, we are confident of the recorded positions. In other instances, we have relied on the information provided in the source as to the reliability of the position of loss. For example, NOAA (AWOIS) provides a three-level assessment of the "quality" of the coordinates on many losses, with specific definitions as to what each level means in terms of the likely error in the position. These levels of quality were generally used in assigning reliability to entries in the database. However, in numerous instances, a cross check of the original source of data for the AWOIS entry indicated that the information on the location of loss was not always as precise as suggested by the level of quality assigned. Where these discrepancies were found, the presumed reliability of the original source was used. Other sources used for shipwreck data provide no assessment on the potential error that might be contained in a given position, and reliability had to be determined on the basis of a reading of the available records of loss. Specifics on how this selection was made have been presented in Chapter 2.

Ultimately, a Reliability Factor of 1 was assigned to 214 entries in the shipwreck database, a Factor of 2 was assigned to 807 entries, a Factor of 3 to 566 entries, and a Factor of 4 to 519 entries (Figure 4-24). Figures 4-25 through 4-28 provide information on the spatial distributions of losses by Reliability Factor. The losses assigned a Factor of 1 tend to be concentrated off the central and western Gulf coast, with another concentration in the Florida Keys. The vessels in the Florida Keys tend to represent losses reported as shipwreck sites to the state of Florida while those along the central and western Gulf coast are mainly discoveries from offshore remote-sensing surveys. Losses assigned a Factor of 2 are widely spread around the perimeter of the Gulf, with concentrations extending from near Pensacola westward.

Vessels assigned Reliability Factors of 1 and 2 represent 48.5 percent (N=1021) of the total entries in the 2001 shipwreck database. These losses are those with the most accurately reported positions and are those that are considered most useful in accurately modeling spatial distributions of shipwrecks in the GOMR and in the delineation of specific, spatially defined high-probability locales.

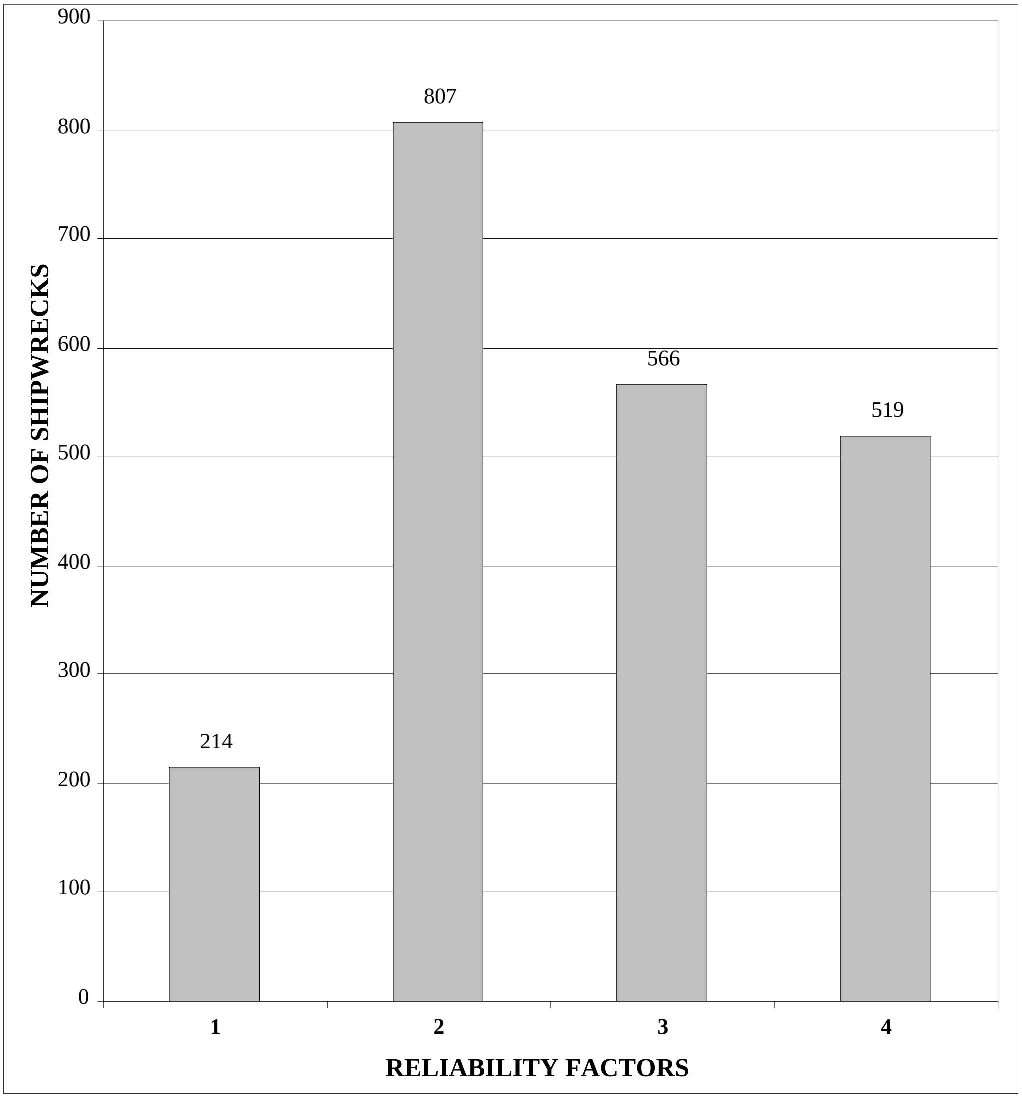


Figure 4-24. Frequency of reported shipwrecks by reliability categories.

Figure 4-27 provides information on entries assigned a Reliability Factor of 3. The accuracy of the recorded positions of these vessels is considered poor to moderate. These 566 losses, comprising 26.9 percent of the entries in the database, are widely scattered around the periphery of the study area. However, several noticeable concentrations are seen off the Texas coast. Information on the vessels in this category is derived from a variety of sources, but large numbers were originally recorded in the lists of losses published in *Merchant Vessels of the United States*. A typical position of loss provided for these vessels would be "about 25 miles NE of Port Isabel." The imprecision in these types of descriptions of loss is the reason that these have been assigned Reliability Factors of 3. Vessels placed in this category have only questionable utility in accurately modeling wreck distributions in the study area.

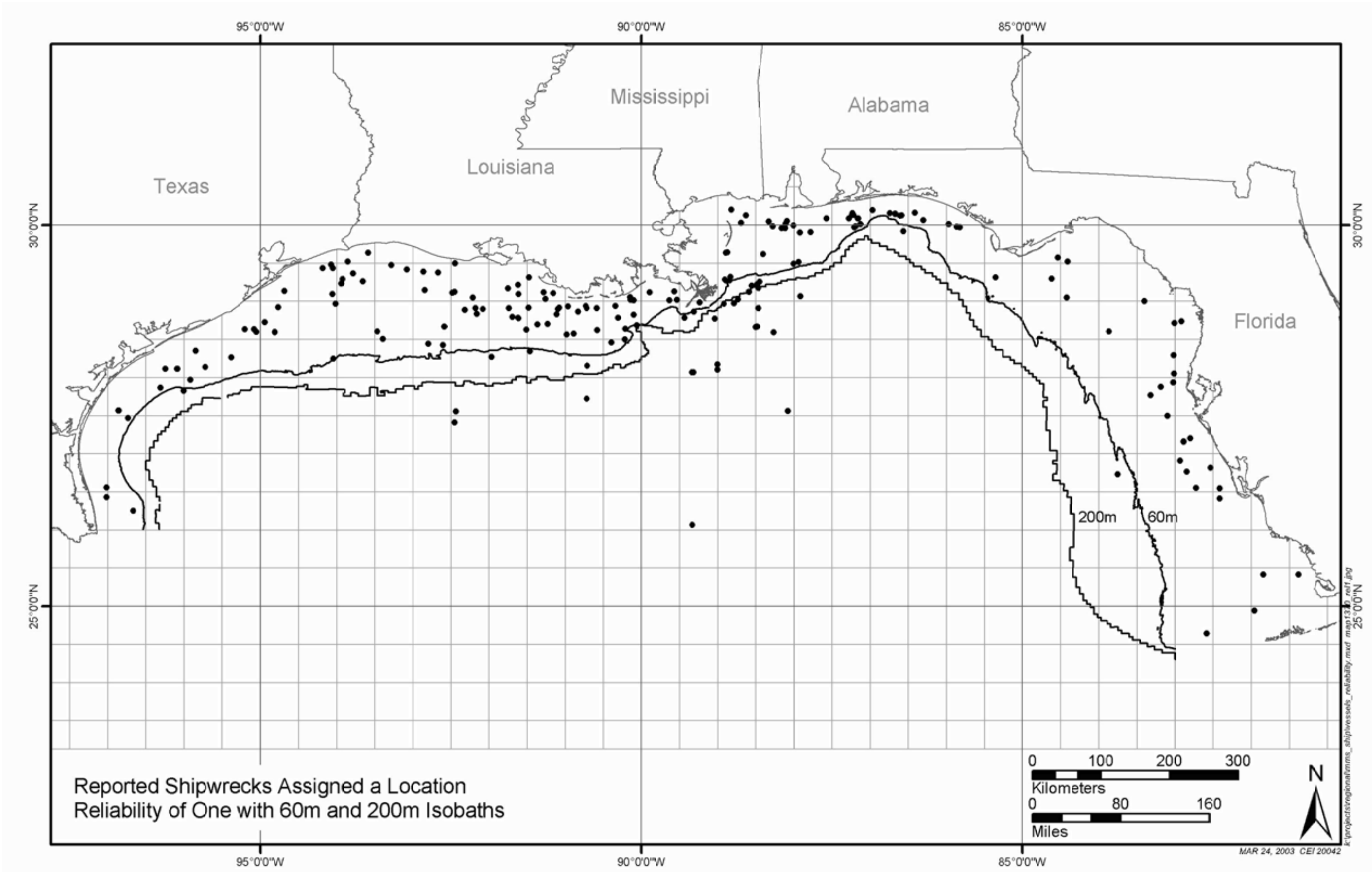


Figure 4-25. Positions of reported shipwrecks assigned Reliability Factor 1.

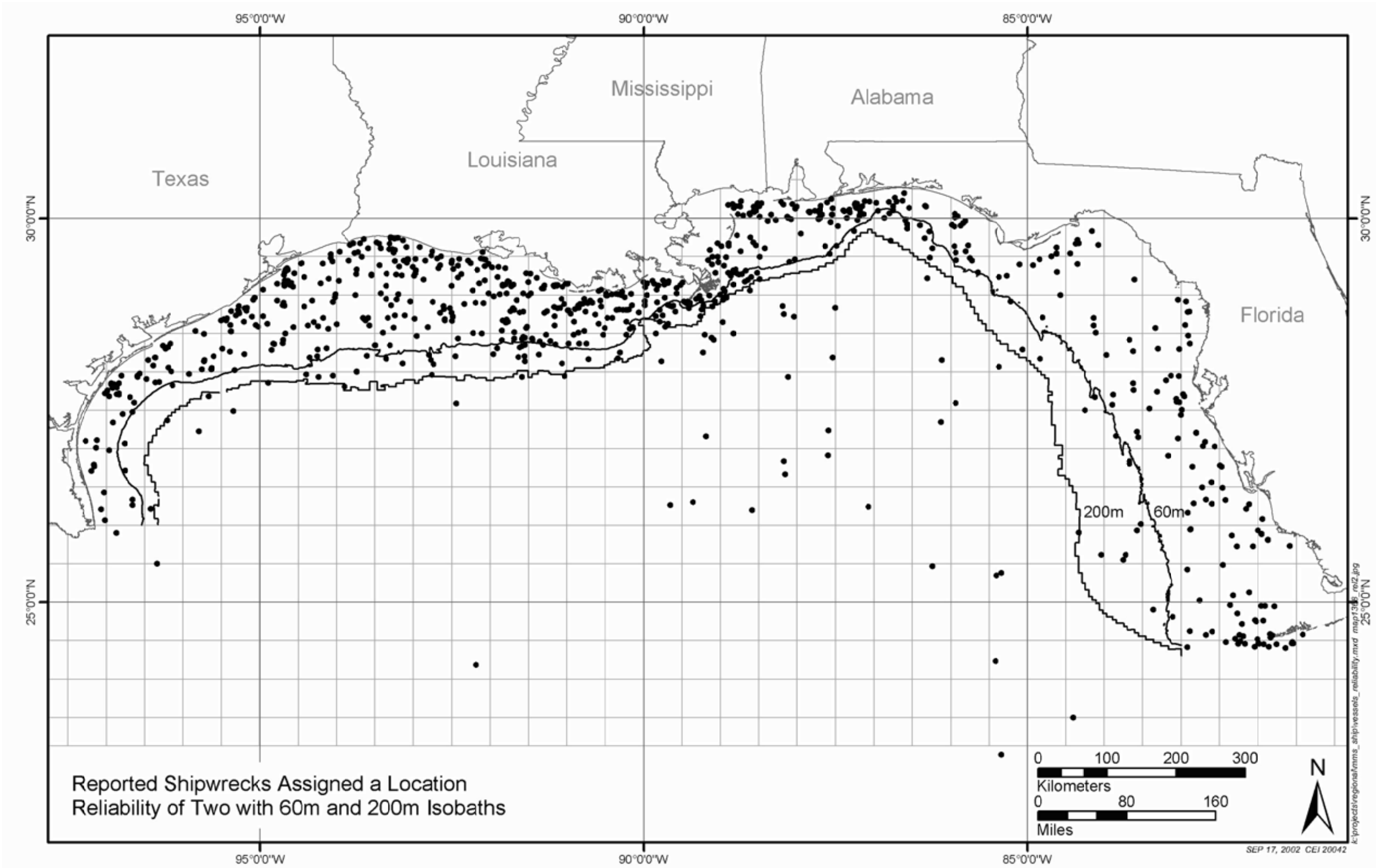


Figure 4-26. Positions of reported shipwrecks assigned Reliability Factor 2.

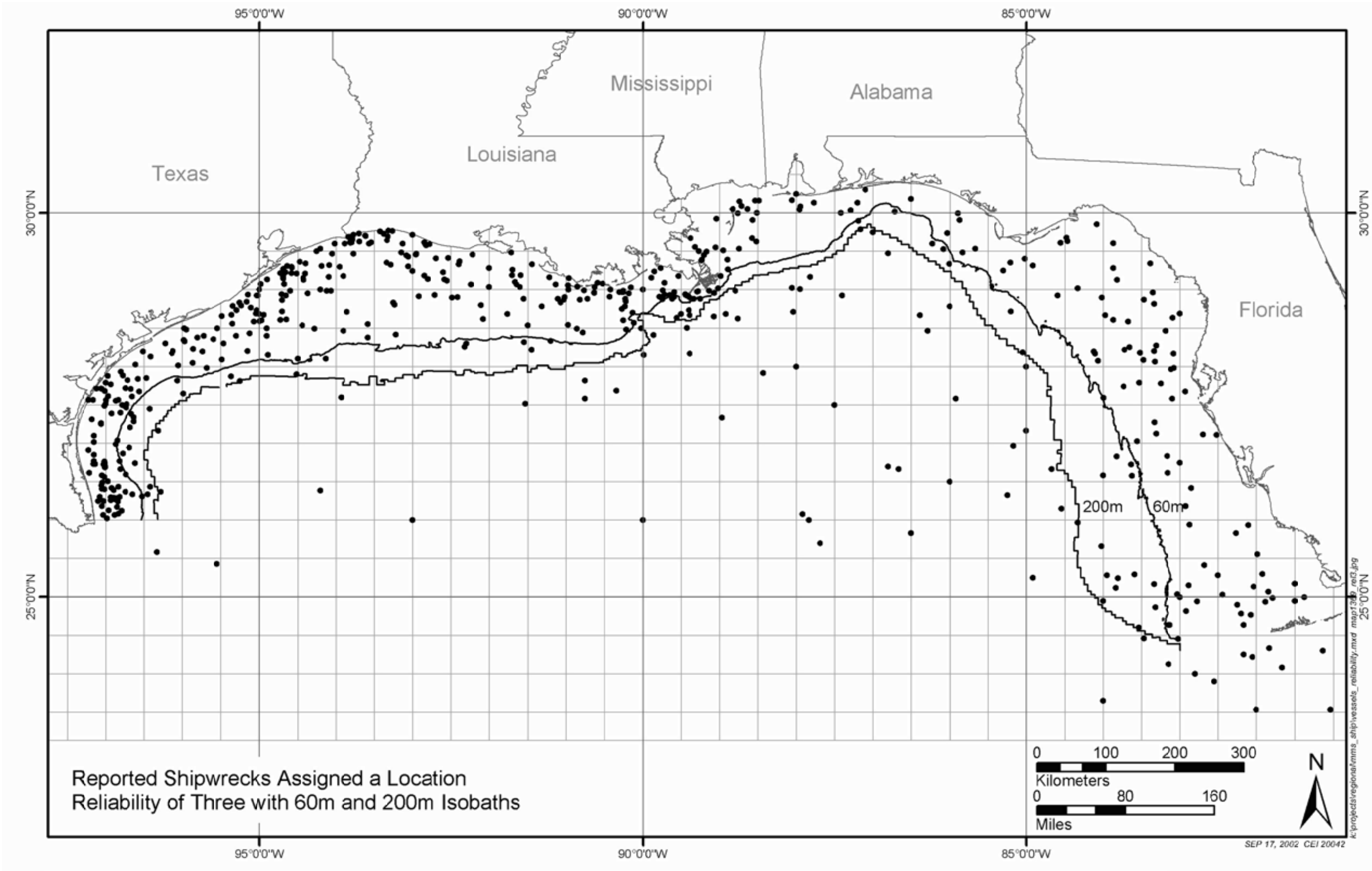


Figure 4-27. Positions of reported shipwrecks assigned Reliability Factor 3.

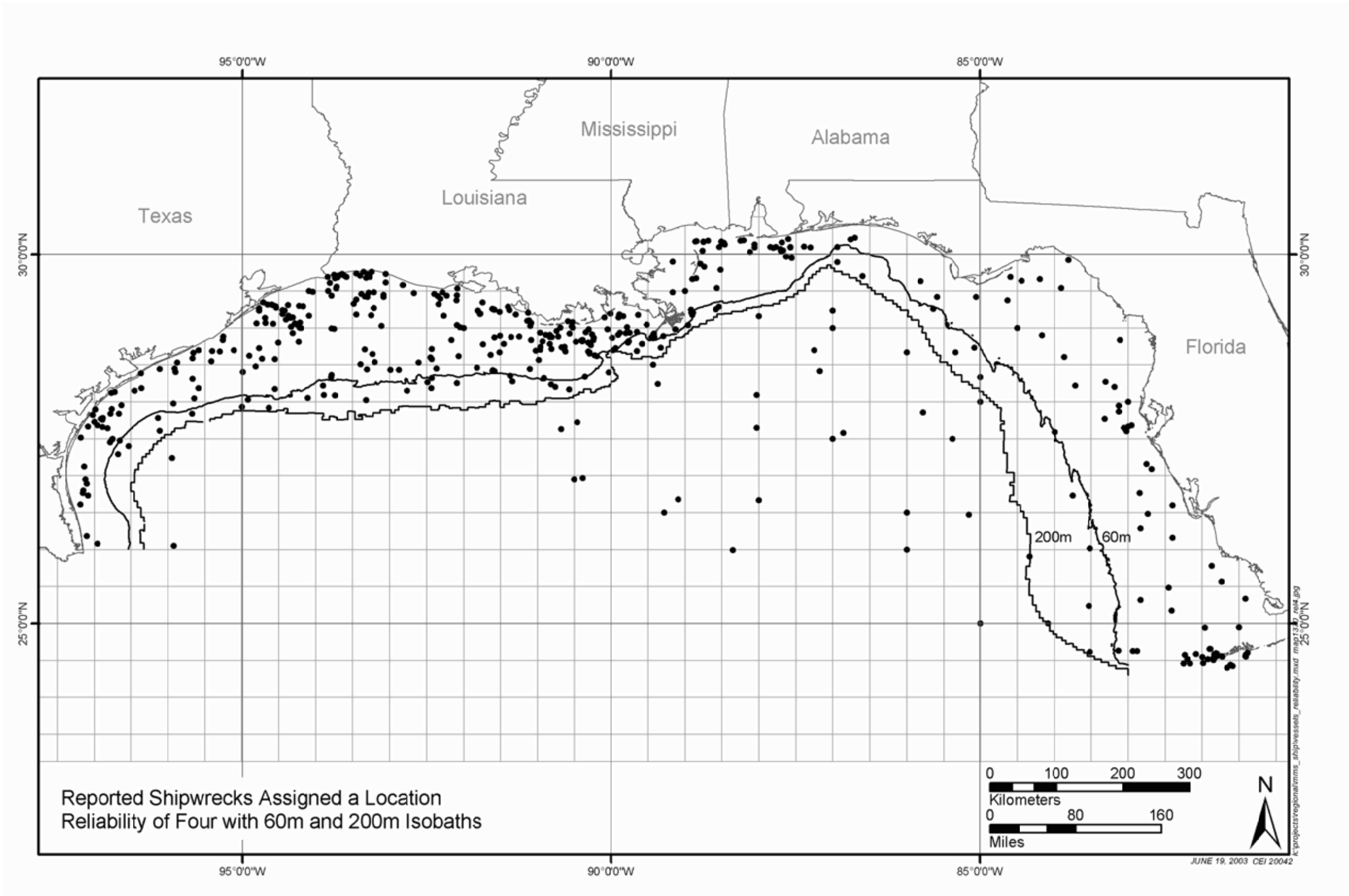


Figure 4-28. Positions of reported shipwrecks assigned Reliability Factor 4, poor or unknown reliability data.

Because of this, it is not believed that they can be realistically used to identify specific high-probability locations, such as an individual offshore lease block or a small cluster of lease blocks. It seems most reasonable to use vessels assigned a Reliability Factor of 3 only in the identification of spatially large high-probability zones. The reported positions of loss for vessels assigned a Reliability Factor of 4 are shown in Figure 4-28. The poor precision of reported locations or the lack of information on the potential error in the positions of these vessels means that they have little utility in realistically modeling shipwreck distribution in the study area.

4.5.5. Spatial Analysis: 1.0- and 0.5-Degree Units of Latitude and Longitude

In their treatment of the 1989 shipwreck data, Garrison et al. (1989) examined the distribution of wrecks across the Gulf in 1.0- and 0.5-degree quadrants of latitude and longitude. In that analysis, they established the arithmetic mean centers of aggregations of shipwrecks in quadrants of this size, primarily to examine concentrations of wrecks at a scale fine enough to be useful in identifying potential high-probability areas. Ultimately, the results of the 1.0-degree quadrant analysis were found not to be useful in revealing patterns in the distribution of wrecks. The large size of the area prohibited the expression of meaningful distributions. However, the 0.5-degree analysis did show meaningful patterns in wreck distributions and the results became one basis for identifying lease blocks with high probabilities of containing shipwrecks.

A similar approach was used to examine wreck distributions in the present study. The purpose was to portray wreck distributions in an objective manner and, if concentrations were seen in these distributions that appeared to be meaningful, use them, as did Garrison et al. in the identification of high-probability areas. As was done in the 1989 study, the distributions of wrecks were examined by looking at their concentration or aggregation within 1.0- and 0.5-degree units of area. The result of the analysis is essentially a reflection of wreck densities across the study area. The analysis was conducted using the analytical tools available in ArcView. This was considered important because one objective of this study was to incorporate all of the collected data into a GIS format that could be used by MMS personnel in the management of offshore cultural resources. ArcView is extremely flexible and it is anticipated that the MMS will use the data submitted in a variety of analytical procedures beyond those considered or undertaken in this study.

The procedures in this analysis involved first establishing 1.0- and 0.5-degree-diameter circles (e.g., 0.5-degree [49.568 km/30.8 miles] and 0.25-degree [24.784 km/15.40 miles] radii or "buffers") around every vessel entry in the 2001 shipwreck database that had been assigned a Reliability Factor of 1, 2, or 3. It was felt that those vessels with very poor reliability (Reliability Factor 4) or an unknown reliability should be eliminated from the analysis because of the serious questions about their actual location. The elimination of these very poorly positioned losses should strengthen any arguments developed from the distribution patterns seen, including the identification of high-probability areas. The inclusion of these poorly positioned entries would only serve to reduce the reliability in predicting which wrecks would actually fall in these areas.

Once the 0.5- and 0.25-degree buffers were established around every entry, ArcView was queried to display all of the buffered zones that contained 50 or more and 25 or more reported wrecks. These numbers were selected as a reasonable starting point in the analysis after viewing overall numbers and densities of wrecks in the study area and after viewing several different densities per buffered area. This procedure resulted in the identification of clusters of wrecks with densities of 25 or more and 50 or more per 1.0- and 0.5-degree-diameter areas. The results indicated that the use of 50 or more wrecks per unit was not useful in assessing wreck distributions; very few 1.0-degree units and no 0.5-degree units were identified containing this number of vessels.

Figures 4-29 and 4-30 show the locations of those 1.0-degree and 0.5-degree units containing 25 or more reported shipwrecks. In presenting this information, these 1.0- and 0.5-degree diameter areas have been converted into the standard 3-by-3-mile lease block units used by MMS by showing every offshore lease block that is contained within or that intersects the 1.0- and 0.5-degree circles. As seen in Figure 4-29, the use of the larger 1.0-degree units is not particularly useful in discerning interpretable patterns; it simply shows the distribution of wrecks at a very gross level along almost the entire Gulf coast.

The pattern of wreck distribution shown in the 0.5-degree analysis, however, does show some meaningful distributions. As shown in Figure 4-30, concentrations of reported losses occur in the central and western Gulf, principally within the 60-m contour. To some extent, these concentrations correlate with the locations of principal ports, a phenomenon also seen by Garrison et al. in their use of 0.5-degree quadrants. What is reflected is not so much the use of (and ultimate loss near) these ports by large, commercial vessels such as tankers or other merchant vessels, but the use of these major ports, as well as adjacent smaller docking facilities, by large numbers of fishing vessels, particularly shrimpers, as well as pleasure craft and offshore oil service vessels. This increased usage has resulted in increased losses.

In particular, the extension of areas of high reported wreck densities west of the Mississippi River along the central Louisiana coast is an indication of the high number of fishing and oil industry-related vessels that have been lost there. This part of the coast of Louisiana contains numerous small ports (e.g., Cocodrie, Morgan City, Houma) out of which these types of craft have operated in the past, and continue to operate today. Only off the mouth of the Mississippi River do concentrations of losses extend much beyond the 60-m contour line. This is accounted for by a combination of high vessel traffic associated with the Mississippi River and by the extension of deep water close to shore.

In contrast to the western and central nearshore Gulf region, the eastern Gulf off the coast of Florida shows no concentrations of reported losses in the analysis using 0.5-degree-diameter units (Figure 4-30). However, when the size of the unit of analysis is increased to 1.0 degree, as shown in Figure 4-29, an extensive area off the central Florida coast and in the area just north of the Florida Keys is displayed. These generalized clusters appear to be reflective of shipping activity associated with the Tampa region and with the increase in numbers of vessels reported lost in and near the region of the Keys.

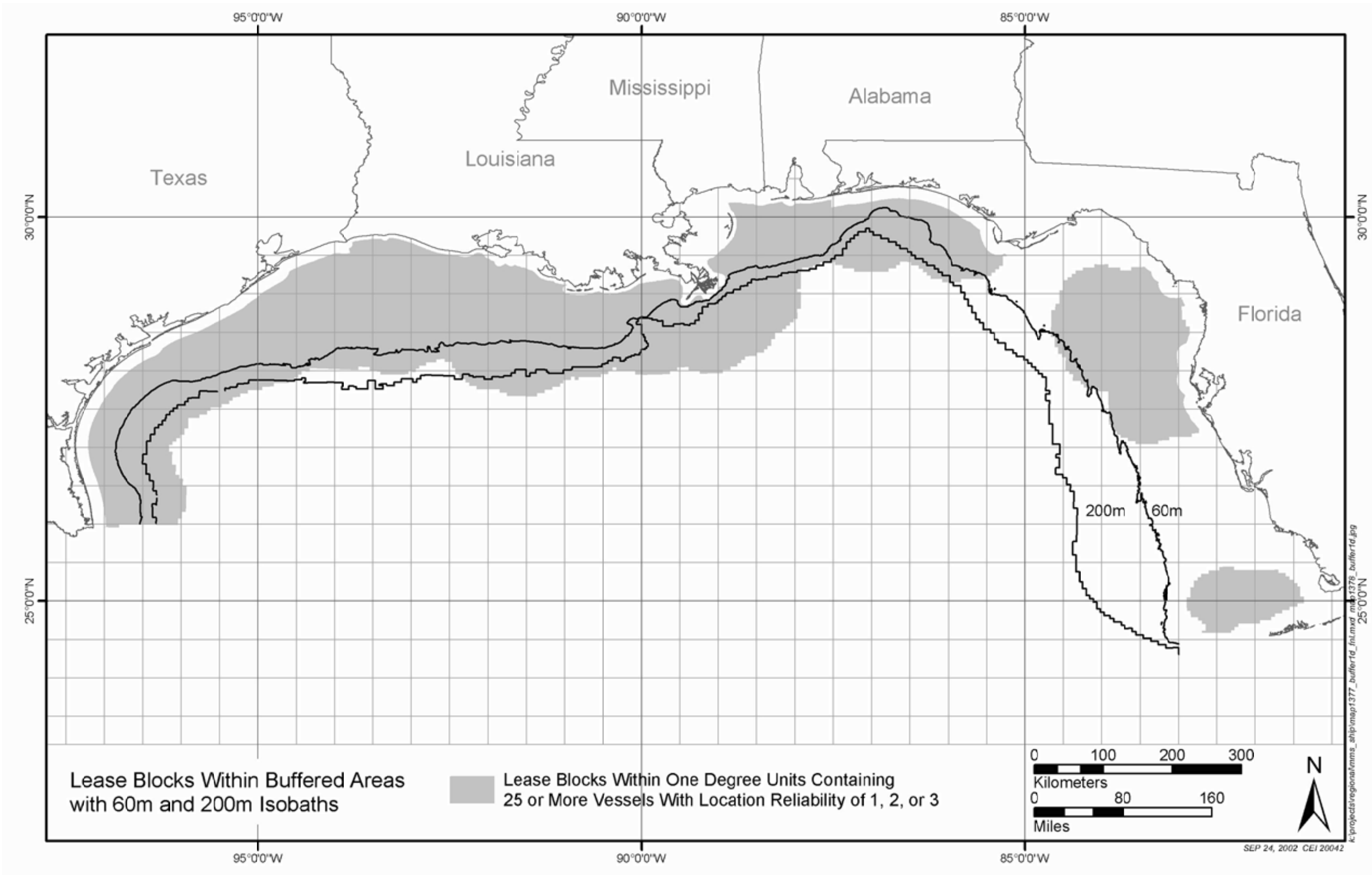


Figure 4-29. One-degree units containing 25 or more vessels with Location Reliability of 1, 2, or 3.

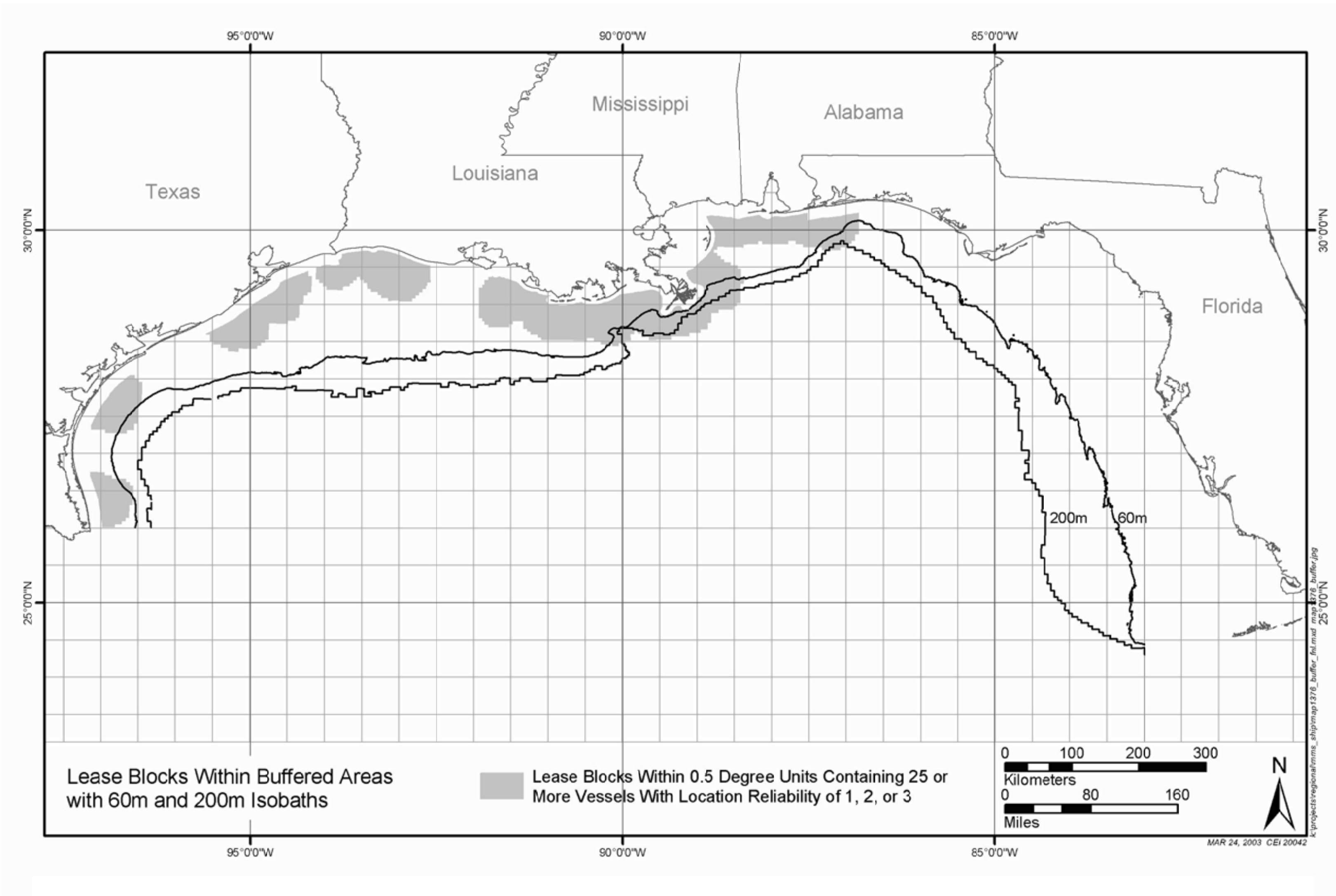


Figure 4-30. One-half degree units containing 25 or more vessels with Location Reliability of 1, 2, or 3.

The results of these analyses are similar in many ways to those arrived at by Garrison et al. (1989). They also found that the use of areas 1.0-degree in size was too gross to see meaningful patterns. Their analysis using 0.5-degree quadrants with 50 or more vessels was quite similar to the results presented here (Garrison et al. 1989:Figure II-40). That analysis relied on losses in state waters as well as in Federal waters, and used the number of 50 or more vessels rather than 25, but it did show concentrations of losses near port areas along the central and western Gulf coast. The only high concentration quadrants shown east of Pensacola by Garrison et al. were in the Florida Keys themselves.

4.5.6. Correlation of Reported Shipwrecks with Other Seafloor Objects

Task 2 of this study involved the correlation of reported shipwreck locations in the updated database with seafloor hang sites and with targets identified during MMS-mandated remote-sensing surveys and to ground truth approximately 20 selected locations where hang sites or objects and reported shipwreck locations were spatially correlated. The reason for looking at the spatial relationship between reported hangs and reported shipwrecks is because of the common observation that shrimp nets are often caught on exposed portions of wrecks in the Gulf of Mexico. Particularly expressive of this phenomenon is the *303 Hang Wreck*, a wooden, two-master schooner located approximately one mile off the upper Texas coast (James et al. 1991b). This wreck had originally been identified as a shrimp net hang, designated “Hang 303.” Numerous other similar examples are known. The proposition was that clusters of reported shrimp net hangs would correlate with reported shipwreck locations. The relationship between reported shipwrecks and other seafloor objects was examined in several ways. Shipwreck locations were compared against items classified as “Objects” in the database, the positions of named shipwrecks were compared against the positions of “Unknown Shipwrecks” and, finally, reported shipwreck locations were compared against reported net hang locations.

4.5.6.1. Spatial Association of “Unknown Wrecks” to Named Shipwrecks

It is suspected that some number of the entries in the 2001 shipwreck database classified as unknown vessels or wrecks are, in fact, the same as some of the named vessels in the database. During the compilation of the database, if the information examined permitted a clear indication that a named vessel in one source was, in fact, equivalent to an unnamed vessel in another source, only the named vessel was maintained. However, in many instances these associations were unclear or not possible and both entries were kept. To more fully examine the possibility that unknown wrecks in the database might be the same entities as some identified or named vessels, the spatial relationship between the two categories was looked at. Initially, ArcView was queried to identify all vessels in the database identified as “Unknown” in any form that lay within 2.4 km, or 1.5 miles, of any named or identified vessel. This distance was used because it represents one-half the distance across the standard 3-x-3-mile offshore lease block, meaning that the analysis looked at roughly lease block-sized units. This resulted in the selection of 219 unknown vessel entries, many of which are multiple, in that the same unknown vessel might fall within 2.4 km of more than one named vessel. The large number of multiple entries suggested that meaningful spatial relationships were not going to be seen in such a large area. Therefore, this list was shortened to encompass only those unknown vessel entries lying within 500 m (1,640 feet) of named or identified vessels. These data are shown in Table 4-4.

Seventy-one entries are included in Table 4-4. Confining the area of the search eliminated most duplicates, but a few remain. For example, the Unknown Vessel ID No. 12456 lies almost exactly at the same location given for the vessel *Antonio Ensen* (or *Antonio Ensenat*) and about 186 m from a vessel identified only as a "Wreck" in the sport diver publication by Rinehart (1998). Both Unknown Vessel listings are derived from AWOIS, as is the entry for the *Antonio Ensen*, a merchant vessel lost in 1943. There seems to be no doubt that one of the Unknown Vessel entries is equivalent to the listing for the *Antonio Ensen*, even though both are derived from AWOIS. This simply shows the types of duplications that commonly can be found in the same source.

It is also possible that the Wreck identified by Rinehart is also the *Antonio Ensen*, and that the 186-m difference between the two locations is simply related to errors in the positioning systems used in the two sources.

It is apparent from the entries in Table 4-4 that some unknown vessels can be reasonably associated with named vessels whose identity and position are known or considered very reliable. An example would be the case of the Unknown Vessel assigned Vessel ID Number 12423 that lies about 9-m from the wreck of the *Breton Island*. Presumably, these entries refer to the same vessel. In other instances, the close spatial association of entries might serve to strengthen the reliability of the positions provided for named vessels. For example, the Unknown Vessel identified by Vessel ID Number 11691 has been assigned a location reliability of 1 on the basis of information provided in the NIMA records, and it lies only 25 meters from the reported location of the barge identified as *R.O. 6*, that has been assigned a location reliability of 2. If these represent the same vessel, then it would be possible to assign the *R.O. 2* a Reliability Factor of 1 for its position.

For the present, it is impossible to positively equate most of the unknown vessels with the named vessels in Table 4-4, although it does appear that many exist. Physical identification/diver verification is likely to be the only way to make positive associations.

4.5.6.2. Spatial Association of Shipwrecks with "Objects"

As noted earlier 1,155 entries in the database were classified as "Objects." Some of these have been identified on the basis of information provided in the sources used, and include items such as Obstructions, Well Heads, Cylinder Tanks, Pipes, etc. However, how reliable these identifications are is unknown. In addition, a number of entries consist of items that are unidentified and are classified only as Objects

Table 4-4. Unnamed Vessels that Lie within 500 m (1,640 feet) of Named Vessels

UNNAMED VESSEL ID NUMBER	NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	INFORMATION SOURCE FOR UNNAMED VESSEL	DISTANCE TO NAMED VESSEL (meters)	NAMED VESSEL ID NUMBER	VESSEL NAME	LOCATIONAL RELIABILITY OF NAMED VESSEL	MMS LEASE AREA	INFORMATION SOURCE FOR NAMED VESSEL
237	UNKNOWN VESSEL	2	GA	TAC	18.9	236	HATTERAS	1	GA	CEI; TAC
239	UNKNOWN VESSEL	2	GA	TAC	32.9	238	CLEO SUE	3	GA	AWOIS; TAC
244	UNKNOWN VESSEL	3	GA	NIMA	8.3	1468	TX-2981-ZV	3	GA	USCG
316	UNKNOWN VESSEL	1	BAA	MMS	382.8	1463	MY LADY	2	BAA	USCG
325	UNKNOWN VESSEL	1	EI	MMS	379.1	1283	WAGON TRAIN	2	EI	USCG
385	UNKNOWN VESSEL	1	SS	MMS	451.0	1117	RIG	2	SS	USCG
1533	UNKNOWN WRECK	2	PE	AWOIS	62.5	1838	LIPSCOMB TUG	1	PE	RINEHART
1534	UNKNOWN WRECK	2	PE	USCG	123.1	452	OFFSHORE 1/2 BARGE	2	PE	RINEHART
1538	UNKNOWN MOTOR VESSEL	2	PE	USCG	169.1	447	TUG NORTH OF SPARKMAN	2	PE	RINEHART
1543	UNKNOWN WRECK	2	MO	USCG	454.8	921	LIBERTY SHIP	2	MO	AWOIS
7539	UNKNOWN VESSEL	4	SA	USCG	1.1	918	QUE 5	2	SA	MVUS
7557	UNKNOWN VESSEL	4	MO	USCG	53.6	596	VACA DEL MAR	2	MO	AWOIS; MVUS
7558	UNKNOWN VESSEL	4	PE	USCG	104.0	1673	CANDY SHIP	2	PE	RINEHART
11691	UNKNOWN VESSEL	1	MC	NIMA	25.1	1205	R.O. 6	2	MC	MVUS
11697	UNKNOWN VESSEL	2	PB	NIMA	1.2	1278	THAT’S-A-MY-BOAT	2	PB	NIMA
11733	UNKNOWN VESSEL	1	CH	NIMA	176.4	1658	HMS BAY RONTO	2	CH	BERG
11777	UNKNOWN VESSEL	2	PR	NIMA	75.1	1831	SHERRI F	2	PR	RINEHART
12080	UNKNOWN VESSEL	4	GA	NIMA	20.9	207	ATHENA 2	3	GA	AWOIS; TAC
12088	UNKNOWN VESSEL	4	MI	NIMA	14.7	142	LYCO I	2	MI	AWOIS; TAC
12122	UNKNOWN VESSEL	4	EC	NIMA	1.0	926	SP 2	2	EC	MVUS
12138	UNKNOWN VESSEL	1	MI	NIMA	120.0	130	OCEAN EXPRESS	2	MI	AWOIS
12139	UNKNOWN VESSEL	1	EI	NIMA	0.0	1312	PHILADELPHIA	2	EI	USCG
12143	UNKNOWN VESSEL	1	SM	NIMA	60.1	373	CITIES SERVICES TOLEDO	1	SM	MMS
12148	UNKNOWN VESSEL	1	MU	NIMA	43.2	101	MADALINE GOFORTH	3	MU	MVUS; AWOIS
12155	UNKNOWN VESSEL	2	GA	NIMA	32.4	243	CAPT. DOC	3	GA	AWOIS; TAC
12157	UNKNOWN VESSEL	1	PS	NIMA	45.3	53	BEULAH	3	PS	AWOIS
12253	UNKNOWN VESSEL	2	MI	NIMA	41.0	1295	AIRCRAFT/CESSNA 210	2	MI	USCG
12268	UNKNOWN VESSEL	2	PSA	NIMA	0.0	1451	MEXICAN BOAT	3	PSA	USCG
12272	UNKNOWN VESSEL	2	MI	NIMA	40.9	1484	RIO NUECES	3	MI	USCG
12282	UNKNOWN VESSEL	2	ST	NIMA	67.6	1952	25 FT DERELICT F/V	2	ST	USCG
12284	UNKNOWN VESSEL	2	EI	NIMA	102.6	1395	JESSIE CURRIEL	2	EI	USCG
12316	UNKNOWN VESSEL	1	BAA	NIMA	41.1	1958	26 FT FIBERGLASS P/C	2	BAA	USCG
12320	UNKNOWN VESSEL	1	WC	NIMA	101.6	1555	WRECKS AND OBSTRUCTIONS	2	WC	USCG

Table 4-4. (continued). Unnamed Vessels that Lie within 500 m (1,640 feet) of Named Vessels

UNNAMED VESSEL ID NUMBER	NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	INFORMATION SOURCE FOR UNNAMED VESSEL	DISTANCE TO NAMED VESSEL (meters)	NAMED VESSEL ID NUMBER	VESSEL NAME	LOCATIONAL RELIABILITY OF NAMED VESSEL	MMS LEASE AREA	INFORMATION SOURCE FOR NAMED VESSEL
12323	UNKNOWN VESSEL	1	HI	NIMA	41.3	1029	VICTORY	2	HI	AWOIS
12340	UNKNOWN VESSEL	1	HIA	NIMA	41.3	1275	SEA PILOT	2	HIA	USCG
12341	UNKNOWN VESSEL	1	BAA	NIMA	0.4	1274	SEA LIONESS	2	BAA	USCG
12343	UNKNOWN VESSEL	1	ST	NIMA	31.4	1238	GEMINI	2	ST	USCG
12348	UNKNOWN VESSEL	2	EI	NIMA	0.8	1100	BELL 206 HELICOPTER	2	EI	USCG
12423	UNKNOWN VESSEL	2	SS	NIMA	9.2	882	BRETON ISLAND	1	SS	AWOIS
12438	UNKNOWN VESSEL	4	DT	AWOIS	52.7	1754	LANDING CRAFT	3	DT	SINGER
12451	UNKNOWN VESSEL	4	CH	AWOIS	215.8	1658	HMS BAY RONTO	2	CH	BERG
12452	UNKNOWN VESSEL	4	CH	AWOIS	223.6	1658	HMS BAY RONTO	2	CH	BERG
12456	UNKNOWN VESSEL	4	PB	AWOIS	1.1	993	ANTONIO ENSEN	2	PB	AWOIS
12456	UNKNOWN VESSEL	4	PB	AWOIS	186.3	1784	WRECK	2	PB	RINEHART
12461	UNKNOWN VESSEL	4	MU	AWOIS	53.9	94	HELICOPTER	2	MU	AWOIS
12468	UNKNOWN VESSEL	4	PB	AWOIS	38.1	1983	41 FOOT P/C	2	PB	USCG
12495	UNKNOWN VESSEL	4	TP	AWOIS	34.5	1788	YSD-71	3	TP	LEGACY
12513	UNKNOWN VESSEL	4	HIA	AWOIS	32.5	1436	SAN ANTONIO	3	HIA	USCG
12526	UNKNOWN VESSEL	4	HI	AWOIS	41.6	298	MR. B.	3	HI	AWOIS, TAC
12571	UNKNOWN VESSEL	4	PE	AWOIS	147.2	1673	CANDY SHIP	2	PE	RINEHART
12572	UNKNOWN VESSEL	4	PE	AWOIS	101.7	1673	CANDY SHIP	2	PE	RINEHART
12578	UNKNOWN VESSEL	4	PE	AWOIS	22.9	1968	WOODEN HULL BOATS	2	PE	USCG
12656	UNKNOWN VESSEL	4	WD	AWOIS	27.3	1314	DRILLING RIG	2	WD	USCG
12662	UNKNOWN VESSEL	4	PB	AWOIS	38.5	1960	26FT P/C	2	PB	USCG
12666	UNKNOWN VESSEL	4	SS	AWOIS	72.8	386	HEREDIA	1	SS	MMS
13005	UNKNOWN VESSEL	4	PE	AWOIS	178.2	449	BARGE NORTH OF SPARKMAN	2	PE	RINEHART
13005	UNKNOWN VESSEL	4	PE	AWOIS	263.5	450	SHRIMP BOAT OFF MOBILE BAY	2	PE	RINEHART
13098	UNKNOWN VESSEL	4	MO	AWOIS	271.7	442	DRYDOCK	2	MO	RINEHART
13129	UNKNOWN VESSEL	4	KW	AWOIS	49.4	1823	SAILING VESSEL	3	KW	SINGER
14003	UNKNOWN VESSEL	4	WC	AWOIS	29.5	608	CAPT. JACK	3	WC	GARRISON
14016	UNKNOWN VESSEL	4	PE	AWOIS	56.8	451	WALLACE	1	PE	RINEHART
14083	UNKNOWN VESSEL	4	PB	AWOIS	407.4	1626	10 FATHOM WRECK	2	PB	RINEHART
14096	UNKNOWN VESSEL	4	PE	AWOIS	48.8	1510	STEEL TUG BOAT	2	PE	USCG
14168	UNKNOWN VESSEL	4	DD	AWOIS	24.5	1400	LARGE BARGE	2	DD	USCG
14169	UNKNOWN VESSEL	4	PE	AWOIS	91.1	1838	LIPSCOMB TUG	1	PE	RINEHART

Table 4-4. (continued). Unnamed Vessels that Lie within 500 m (1,640 feet) of Named Vessels

UNNAMED VESSEL ID NUMBER	NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	INFORMATION SOURCE FOR UNNAMED VESSEL	DISTANCE TO NAMED VESSEL (meters)	NAMED VESSEL ID NUMBER	VESSEL NAME	LOCATIONAL RELIABILITY OF NAMED VESSEL	MMS LEASE AREA	INFORMATION SOURCE FOR NAMED VESSEL
14235	UNKNOWN VESSEL	4	PL	AWOIS	27.4	1393	JACK-UP RIG	2	PL	USCG
14236	UNKNOWN VESSEL	4	PL	AWOIS	28.0	530	CRANE	3	PL	HO
14378	UNKNOWN VESSEL	4	WC	AWOIS	19.0	1555	WRECKS AND OBSTRUCTIONS	2	WC	USCG
14392	UNKNOWN VESSEL	4	MU	AWOIS	96.9	1464	NOAA WRECK	2	MU	USCG
14688	UNKNOWN VESSEL	4	HI	AWOIS	19.2	1945	22 FT BAYLINER	2	HI	USCG
15075	UNKNOWN VESSEL	4	HIA	AWOIS	23.1	1551	WRECK	2	HIA	USCG

To see if named vessels could be associated with these objects, the spatial relationship of all items classified as Vessels in the database was compared against all items as Objects. As with the assessment of unknown vessels to named vessels, ArcView was queried to identify all Vessels that lay within 500-m (1,640 feet) of an entry identified as an Object. The results are shown in Table 4-5.

As can be seen, a number of vessels lie close to items classified as objects. For example, the vessel *Allen* is reported to be less than one meter away from an unidentified "obstruction." Both entries come from AWOIS data, but could very well represent the same item in light of the numerous duplications contained in the AWOIS records. In other instances, Vessels with known and very reliable locations, such as the liberty ships *Edward W. Scripps* and *George L. Farley,* sunk as artificial reefs, are closely associated with unidentified objects whose positions are not reliably known. In instances where items classified as Unknown Vessels are spatially close to identified Objects, this could mean that the vessels have been misidentified and mis-classified. For example, the Unknown Vessel assigned Vessel ID Number 12659 is less than 30 m from an object identified as a "collapsed oil well structure" by the USCG. It is possible that the AWOIS records identifying this entry as a Vessel are incorrect. The lack of information provided in many of the sources prohibits positive associations between the two classes of entries, and in most instances diving to verify these associations will be necessary.

4.5.6.3. Spatial Association of Shipwrecks to "Objects" Identified During Offshore MMS-Mandated Remote-Sensing Surveys

One of the specific requirements of Task 2 was to correlate reported shipwreck locations with objects identified during MMS lease block surveys. Table 4-6 presents information on all entries classified as Vessels in the 2001 database that fall within 2.4-km (1.5 miles) of items identified as unknown objects during offshore remote-sensing surveys as listed in Table 3-5. This distance was selected to provide some relationship to the standard 3-x-3-mile lease block within which most surveys are undertaken. Only 17 associations are shown and in only four of these are the distances between the vessel and the unidentified object less than 500-m. In two instances entries classified as "Unknown Vessel" are within 60 meters of "Unknown Objects" identified during MMS surveys. It is believed that these unknown objects are very accurately positioned and could very well represent the nearby vessels. In fact, one of the Unknown Vessels was also identified during an MMS survey.

The great distances between the other Unknown Vessels and the Objects from MMS surveys make it difficult to ascertain if, in fact, the two are the same object. The named vessels in Table 4-6 all have been assigned Reliability Factors of 2, 3 or 4, meaning that there are varying amounts of error in their plotted position. Thus, any one of these vessels could be the object identified during the remote-sensing survey, but the only way to verify this would be through physical examination of the Unknown Object.

Table 4-5. Vessels that Lie within 500 m (1,640 feet) of Items Classified as "Objects"

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFO. SOURCE	DISTANCE TO OBJECT (meters)	OBJECT ID NUMBER	OBJECT NAME	LOCATIONAL RELIABILITY OF OBJECT	OBJECT INFO. SOURCE
1958	26 FT Fiberglass P/C	2	BAA	USCG	279.6	7299	BLOWN OUT PIPELINE	4	USCG
1960	26FT P/C	2	PB	USCG	319.2	14084	OBSTRUCTION	4	AWOIS
1995	60 FT F/V	2	SS	USCG	305.4	7219	DESTROYED OIL PLATFORM	4	USCG
453	*ALLEN*	2	PE	AWOIS	0.7	13127	OBSTRUCTION	4	AWOIS
1088	*ANNIE P.*	2	WC	USCG	361.6	7027	SUBMERGED OBSTRUCTION	4	USCG
1088	*ANNIE P.*	2	WC	USCG	416.5	14459	OBSTRUCTION	4	AWOIS
855	*BAR PILOT*	3	MP	MVUS	498.4	1572	UNKNOWN OBJECT	1	MMS
995	*BARGE*	2	WC	AWOIS	28.1	7060	SUB OBSTN	4	USCG
1110	*BOOM*	2	MO	USCG	9.6	14087	OBSTRUCTION	4	AWOIS
456	*BUS BARGE*	2	MO	RINEHART	310.6	12603	OBSTRUCTION	4	AWOIS
86	*CONRAD WEISER*	1	MU	TAC	43.3	13150	OBSTRUCTION	4	AWOIS
530	CRANE	3	PL	HO	0.8	11978	OBJECT	1	NIMA
530	CRANE	3	PL	HO	343.4	14717	OBSTRUCTION	4	AWOIS
530	CRANE	3	PL	HO	346.7	1890	CYLINDER TANK	2	USCG
530	CRANE	3	PL	HO	346.7	7141	CYLINDER TANK	3	USCG
884	CU 708	2	WD	MVUS	485.6	11645	OBJECT	1	NIMA
48	*EDWARD W. SCRIPPS*	1	PS	TAC	10.1	46	OBSTRUCTION	2	HO
48	*EDWARD W. SCRIPPS*	1	PS	TAC	92.9	12120	OBJECT	2	NIMA
48	*EDWARD W. SCRIPPS*	1	PS	TAC	96.8	47	OBSTRUCTION	2	HO
1714	Exxon Rig	1	AP	RINEHART	207.7	12717	OBSTRUCTION	4	AWOIS
50	*GEORGE L. FARLEY*	1	PS	TAC	10.1	46	OBSTRUCTION	2	HO
50	*GEORGE L. FARLEY*	1	PS	TAC	92.9	12120	OBJECT	2	NIMA
50	*GEORGE L. FARLEY*	1	PS	TAC	96.8	47	OBSTRUCTION	2	HO
1260	*GULF ISLAND VI*	2	MI	USCG	41.6	14183	OBSTRUCTION	4	AWOIS
236	*HATTERAS*	1	GA	CEI; TAC	13.2	12649	OBSTRUCTION	4	AWOIS
236	*HATTERAS*	1	GA	CEI; TAC	20.4	7577	OIL WELL CHRISTMAS TREE	4	USCG
94	HELICOPTER	2	MU	AWOIS	11.7	12109	OBJECT	4	NIMA
905	*J. STORM II*	2	SP	MVUS	368.6	12943	OBSTRUCTION	4	AWOIS
905	*J. STORM II*	2	SP	MVUS	373.4	11671	OBJECT	1	NIMA
905	*J. STORM II*	2	SP	MVUS	373.4	7450	WELL HEAD	4	USCG
629	*JELYGE*	2	WC	AWOIS	92.4	14938	OBSTRUCTION	4	AWOIS
629	*JELYGE*	2	WC	AWOIS	434.0	14940	OBSTRUCTION	4	AWOIS
49	*JOSHUA THOMAS*	1	PS	TAC	10.1	46	OBSTRUCTION	2	HO
49	*JOSHUA THOMAS*	1	PS	TAC	92.9	12120	OBJECT	2	NIMA
49	*JOSHUA THOMAS*	1	PS	TAC	96.8	47	OBSTRUCTION	2	HO
1402	*LEWIS BROTHERS*	3	MO	USCG	304.8	12574	OBSTRUCTION	4	AWOIS

Table 4-5. (continued). Vessels that Lie within 500 m (1,640 feet) of Items Classified as "Objects"

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFO. SOURCE	DISTANCE TO OBJECT (meters)	OBJECT ID NUMBER	OBJECT NAME	LOCATIONAL RELIABILITY OF OBJECT	OBJECT INFO. SOURCE
921	LIBERTY SHIP	2	MO	AWOIS	0.7	13101	OBSTRUCTION	4	AWOIS
1456	*MISS SOPHIE*	3	MO	USCG	78.9	7102	BUOY HI	4	USCG
7449	OBSTRUCTION	4	SS	USCG	0.2	652	OBSTRUCTION	2	HO
124	*PENROD*	3	MI	HO	50.9	13179	OBSTRUCTION	4	AWOIS
658	*PENROD 52*	2	EI	USCG	28.9	12685	OBSTRUCTION	4	AWOIS
87	*RACHEL JACKSON*	1	MU	TAC	43.3	13150	OBSTRUCTION	4	AWOIS
1435	*RELIANT SEAHORSE*	2	SP	USCG	328.5	6874	PILING	4	USCG
458	RUBBLE BARGE "E"	2	MO	RINEHART	97.4	12603	OBSTRUCTION	4	AWOIS
1804	*S TOWER*	2	AP	RINEHART	203.1	12717	OBSTRUCTION	4	AWOIS
367	*SHERWOOD ANDERSON*	2	MO	RINEHART	56.2	14139	OBSTRUCTION	4	AWOIS
6857	SUNKEN DRILLING RIG	4	ST	USCG	0.8	653	OBSTRUCTION	2	HO
6857	SUNKEN DRILLING RIG	4	ST	USCG	241.7	14190	OBSTRUCTION	4	AWOIS
370	*TULSA*	1	MO	MMS	24.5	13097	OBSTRUCTION	4	AWOIS
370	*TULSA*	1	MO	MMS	32.8	14112	OBSTRUCTION	4	AWOIS
369	UNKNOWN IRON VESSEL	1	MO	MMS	18.4	14120	OBSTRUCTION	4	AWOIS
398	UNKNOWN VESSEL	1	VK	MMS	26.4	14125	OBSTRUCTION	4	AWOIS
237	UNKNOWN VESSEL	2	GA	TAC	27.5	7577	OIL WELL CHRISTMAS TREE	4	USCG
12659	UNKNOWN VESSEL	4	WD	AWOIS	27.6	7572	COLLAPSED OIL WELL STRUCTURE	4	USCG
14236	UNKNOWN VESSEL	4	PL	AWOIS	27.8	11978	OBJECT	1	NIMA
14236	UNKNOWN VESSEL	4	PL	AWOIS	27.8	7461	CRANE	4	USCG
237	UNKNOWN VESSEL	2	GA	TAC	30.6	12649	OBSTRUCTION	4	AWOIS
248	UNKNOWN VESSEL	2	GA	TAC	32.1	12524	OBSTRUCTION	4	AWOIS
247	UNKNOWN VESSEL	2	GA	TAC	32.7	12519	OBSTRUCTION	4	AWOIS
12150	UNKNOWN VESSEL	1	HIA	NIMA	33.4	12489	OBSTRUCTION	4	AWOIS
15096	UNKNOWN VESSEL	1	MP	MMS	35.9	1572	UNKNOWN OBJECT	1	MMS
12269	UNKNOWN VESSEL	2	ST	NIMA	41.0	11680	OBJECT	1	NIMA
12461	UNKNOWN VESSEL	4	MU	AWOIS	42.7	12109	OBJECT	4	NIMA
246	UNKNOWN VESSEL	2	GA	TAC	44.4	12522	OBSTRUCTION	4	AWOIS
246	UNKNOWN VESSEL	2	GA	TAC	54.1	7585	CONCRETE BLOCK	4	USCG
12073	UNKNOWN VESSEL	2	WC	NIMA	56.0	416	UNKNOWN OBJECT	1	MMS

Table 4-5. (continued). Vessels that Lie within 500 m (1,640 feet) of Items Classified as "Objects"

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFO. SOURCE	DISTANCE TO OBJECT (meters)	OBJECT ID NUMBER	OBJECT NAME	LOCATIONAL RELIABILITY OF OBJECT	OBJECT INFO. SOURCE
14016	UNKNOWN VESSEL	4	PE	AWOIS	57.3	13107	OBSTRUCTION	4	AWOIS
11802	UNKNOWN VESSEL	2	MP	NIMA	61.7	7227	TELEDYNE 16	4	USCG
11803	UNKNOWN VESSEL	2	MP	NIMA	62.3	7227	TELEDYNE 16	4	USCG
15098	UNKNOWN VESSEL	1	ST	MMS	64.8	395	UNKNOWN OBJECT	1	MMS
13996	UNKNOWN VESSEL	4	SA	AWOIS	65.0	7537	OBSTRUCTION	4	USCG
13996	UNKNOWN VESSEL	4	SA	AWOIS	65.7	650	OBSTRUCTION	2	HO
12637	UNKNOWN VESSEL	4		AWOIS	84.0	12638	OBSTRUCTION	4	AWOIS
15036	UNKNOWN VESSEL	4		AWOIS	96.9	15037	OBSTRUCTION	4	AWOIS
275	UNKNOWN VESSEL	2	GA	TAC	101.7	7592	STEEL SKELETON TOWER	4	USCG
275	UNKNOWN VESSEL	2	GA	TAC	107.9	12539	OBSTRUCTION	4	AWOIS
15019	UNKNOWN VESSEL	4		AWOIS	111.7	15037	OBSTRUCTION	4	AWOIS
12733	UNKNOWN VESSEL	4		AWOIS	140.9	12729	OBSTRUCTION	4	AWOIS
15021	UNKNOWN VESSEL	4		AWOIS	151.4	15037	OBSTRUCTION	4	AWOIS
15020	UNKNOWN VESSEL	4		AWOIS	158.5	15037	OBSTRUCTION	4	AWOIS
15038	UNKNOWN VESSEL	4		AWOIS	162.9	12731	OBSTRUCTION	4	AWOIS
15042	UNKNOWN VESSEL	4		AWOIS	176.0	15037	OBSTRUCTION	4	AWOIS
11769	UNKNOWN VESSEL	1		NIMA	185.8	15031	OBSTRUCTION	4	AWOIS
12432	UNKNOWN VESSEL	4		AWOIS	187.9	12431	OBSTRUCTION	4	AWOIS
12634	UNKNOWN VESSEL	4		AWOIS	199.9	15031	OBSTRUCTION	4	AWOIS
12940	UNKNOWN VESSEL	4	SS	AWOIS	203.9	12941	OBSTRUCTION	4	AWOIS
13232	UNKNOWN VESSEL	4		AWOIS	235.4	12731	OBSTRUCTION	4	AWOIS
12639	UNKNOWN VESSEL	4		AWOIS	243.7	15017	OBSTRUCTION	4	AWOIS
12635	UNKNOWN VESSEL	4		AWOIS	245.6	15034	OBSTRUCTION	4	AWOIS
12628	UNKNOWN VESSEL	4		AWOIS	255.2	12971	OBSTRUCTION	4	AWOIS
352	UNKNOWN VESSEL	1	MP	MMS	255.4	12664	OBSTRUCTION	4	AWOIS
12637	UNKNOWN VESSEL	4		AWOIS	255.8	15017	OBSTRUCTION	4	AWOIS
12316	UNKNOWN VESSEL	1	BAA	NIMA	262.7	7299	BLOWN OUT PIPELINE	4	USCG
352	UNKNOWN VESSEL	1	MP	MMS	262.8	7597	OBSTRUCTION	4	USCG
15022	UNKNOWN VESSEL	4		AWOIS	270.6	15039	OBSTRUCTION	4	AWOIS
15038	UNKNOWN VESSEL	4		AWOIS	272.1	15040	OBSTRUCTION	4	AWOIS
15016	UNKNOWN VESSEL	4		AWOIS	295.6	15040	OBSTRUCTION	4	AWOIS
15025	UNKNOWN VESSEL	4		AWOIS	298.1	15037	OBSTRUCTION	4	AWOIS
15018	UNKNOWN VESSEL	4		AWOIS	299.8	15037	OBSTRUCTION	4	AWOIS
12639	UNKNOWN VESSEL	4		AWOIS	308.5	12638	OBSTRUCTION	4	AWOIS
12662	UNKNOWN VESSEL	4	PB	AWOIS	315.0	14084	OBSTRUCTION	4	AWOIS

Table 4-5. (continued). Vessels that Lie within 500 m (1,640 feet) of Items Classified as "Objects"

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFO. SOURCE	DISTANCE TO OBJECT (meters)	OBJECT ID NUMBER	OBJECT NAME	LOCATIONAL RELIABILITY OF OBJECT	OBJECT INFO. SOURCE
13231	UNKNOWN VESSEL	4		AWOIS	328.0	15037	OBSTRUCTION	4	AWOIS
12636	UNKNOWN VESSEL	4		AWOIS	334.2	12633	OBSTRUCTION	4	AWOIS
14236	UNKNOWN VESSEL	4	PL	AWOIS	342.4	14717	OBSTRUCTION	4	AWOIS
14236	UNKNOWN VESSEL	4	PL	AWOIS	347.5	1890	Cylinder Tank	2	USCG
14236	UNKNOWN VESSEL	4	PL	AWOIS	347.5	7141	CYLINDER TANK	3	USCG
12634	UNKNOWN VESSEL	4		AWOIS	373.3	15015	OBSTRUCTION	4	AWOIS
11832	UNKNOWN VESSEL	4	ST	NIMA	373.9	11828	OBJECT	4	NIMA
11769	UNKNOWN VESSEL	1		NIMA	377.0	15015	OBSTRUCTION	4	AWOIS
15016	UNKNOWN VESSEL	4		AWOIS	380.3	12731	OBSTRUCTION	4	AWOIS
11842	UNKNOWN VESSEL	4	ST	NIMA	384.0	11828	OBJECT	4	NIMA
12635	UNKNOWN VESSEL	4		AWOIS	385.6	12642	OBSTRUCTION	4	AWOIS
12636	UNKNOWN VESSEL	4		AWOIS	387.1	12632	OBSTRUCTION	4	AWOIS
7444	UNKNOWN VESSEL	4	EI	USCG	398.2	12033	OBJECT	1	NIMA
12635	UNKNOWN VESSEL	4		AWOIS	403.9	12641	OBSTRUCTION	4	AWOIS
12150	UNKNOWN VESSEL	1	HIA	NIMA	405.6	7567	OBSTRUCTION	4	USCG
12636	UNKNOWN VESSEL	4		AWOIS	406.4	15034	OBSTRUCTION	4	AWOIS
12635	UNKNOWN VESSEL	4		AWOIS	413.9	12643	OBSTRUCTION	4	AWOIS
12360	UNKNOWN VESSEL	4	HIA	NIMA	414.9	15140	HIGH ISLAND A-281 REEF	2	GSMFC
12150	UNKNOWN VESSEL	1	HIA	NIMA	426.4	12490	OBSTRUCTION	4	AWOIS
12738	UNKNOWN VESSEL	4		AWOIS	441.1	12734	OBSTRUCTION	4	AWOIS
13230	UNKNOWN VESSEL	4		AWOIS	445.5	12731	OBSTRUCTION	4	AWOIS
385	UNKNOWN VESSEL	1	SS	MMS	451.0	7110	CAPSIZED RIG	4	USCG
13103	UNKNOWN VESSEL	4	MO	AWOIS	453.1	13116	OBSTRUCTION	4	AWOIS
12637	UNKNOWN VESSEL	4		AWOIS	458.7	12632	OBSTRUCTION	4	AWOIS
15043	UNKNOWN VESSEL	4		AWOIS	461.1	15037	OBSTRUCTION	4	AWOIS
13230	UNKNOWN VESSEL	4		AWOIS	461.8	15037	OBSTRUCTION	4	AWOIS
11845	UNKNOWN VESSEL	4	ST	NIMA	470.0	11828	OBJECT	4	NIMA
12635	UNKNOWN VESSEL	4		AWOIS	479.8	12633	OBSTRUCTION	4	AWOIS
12634	UNKNOWN VESSEL	4		AWOIS	492.5	11742	OBJECT	1	NIMA
11683	UNKNOWN VESSEL	1		NIMA	494.8	12731	OBSTRUCTION	4	AWOIS
12634	UNKNOWN VESSEL	4		AWOIS	495.7	12434	OBSTRUCTION	4	AWOIS
12636	UNKNOWN VESSEL	4		AWOIS	496.8	12642	OBSTRUCTION	4	AWOIS
1543	UNKNOWN WRECK	2	MO	USCG	454.8	13101	OBSTRUCTION	4	AWOIS
451	*WALLACE*	1	PE	RINEHART	0.7	13107	OBSTRUCTION	4	AWOIS
399	*WILLIAM H. EDWARDS*	1	VK	RINEHART 1998	22.5	13109	OBSTRUCTION	4	AWOIS

Table 4-6. Vessels that Lie within 2.4 km (1.5 miles) of "Objects" Identified in MMS-Mandated Surveys

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFORMATION SOURCE	DISTANCE TO OBJECT (meters)	OBJECT ID NUMBER	OBJECT NAME	LOCATIONAL RELIABILITY OF OBJECT	OBJECT INFORMATION SOURCE
911	*ATLAS*	3	SS	LLOYDS	1685.9	1618	UNKNOWN OBJECT	1	MMS
855	*BAR PILOT*	3	MP	MVUS	498.4	1572	UNKNOWN OBJECT	1	MMS
604	*BLUE WAVE*	3	SS	AWOIS	1685.9	1618	UNKNOWN OBJECT	1	MMS
1410	*BUCANEER*	2	ST	USCG	2002.3	393	UNKNOWN OBJECT	1	MMS
1325	*CASTAWAY*	2	VR	USCG	1843.8	408	UNKNOWN OBJECT	1	MMS
1056	*FULL COUNT*	2	SP	USCG	2236.4	382	UNKNOWN OBJECTS	1	MMS
1512	JACK UP RIG	2	MP	USCG	1959.3	1572	UNKNOWN OBJECT	1	MMS
1421	*JAMIE E*	2	ST	USCG	1038.4	395	UNKNOWN OBJECT	1	MMS
1265	*ORION*	2	WC	USCG	798.2	414	UNKNOWN OBJECT	1	MMS
763	*RECESS II*	4	WC	MVUS	1722.8	1622	UNKNOWN OBJECT	1	MMS
910	*SHIP ISLAND*	2	VR	MVUS	1126.9	410	UNKNOWN OBJECT	1	MMS
15096	UNKNOWN VESSEL	1	MP	MMS	35.9	1572	UNKNOWN OBJECT	1	MMS
12073	UNKNOWN VESSEL	2	WC	NIMA	56.0	416	UNKNOWN OBJECT	1	MMS
12166	UNKNOWN VESSEL	2	SS	NIMA	661.7	1618	UNKNOWN OBJECT	1	MMS
12502	UNKNOWN VESSEL	4	SS	AWOIS	675.3	1618	UNKNOWN OBJECT	1	MMS
11788	UNKNOWN VESSEL	2	ST	NIMA	2167.5	388	UNKNOWN OBJECT	1	MMS
11830	UNKNOWN VESSEL	4	GI	NIMA	2178.8	338	UNKNOWN OBJECT	1	MMS

4.5.6.4. Spatial Association of Shipwrecks to Reported Hang Sites

For many years, shrimpers in the Gulf of Mexico have collected information on the positions of "hang" sites, locations where their nets have been caught or damaged by objects on the bottom. The principal reason for doing this has been to permit avoidance of these objects because the damage or loss of fishing gear can represent a considerable expense to the fisherman. The identities of the objects producing the hangs are rarely known, but range from pilings to pipe to historic shipwrecks. Net hangs and snags are particularly common in areas where the offshore oil industry has been active and where, over time, numerous large objects have been lost or abandoned on the seafloor. Over the years a number of private listings of hangs have been compiled by individual shrimpers or shrimper organizations, plus several official listings of hangs have been developed. In the present analysis, two sets of hang data were used: one maintained by Texas A&M University and one maintained by the MMS.

The largest of the official listings of offshore hangs is the Texas A&M Hang File, developed by the Texas A&M University Sea Grant Program. This file contains over 13,000 entries covering an area generally west of the mouth of the Mississippi River. The information included in the Texas A&M Hang File has been collected from many shrimpers over many years and the positions of hangs have been recorded using a variety of techniques. The vast majority of the positions were obtained with Loran systems that can, as noted earlier, incorporate inaccuracies of up to a quarter mile. Despite the potential for positioning error, the Texas A&M Hang File represents the largest compiled source of hang data and is invaluable in the type of analysis undertaken here. The Hang File data used were a computerized version of the file obtained from the Texas Sea Grant Program in which all hang positions had been converted to latitudes/longitudes.

The listings of hangs and snags obtained from the MMS represents data maintained as part of the Fisherman's Gear Compensation Fund. These represent hangs in the Gulf of Mexico identified by fishermen, principally shrimpers, as locations where their nets were caught and damaged or lost. Many of the hangs in the Gulf are objects derived from the offshore oil industry and include items such as pipes, abandoned well sites, discarded equipment, etc. The Fisherman's Gear Compensation Fund draws on monies pooled by the oil industry to compensate fishermen for damaged or lost gear.

One way to assess the association of shipwrecks and hang sites is to examine the spatial relationships of the two. Presumably, some shipwrecks that have been snagged by nets over the years will be represented by reported hangs. Table 4-7 presents a listing of all "Vessels" in the 2001 shipwreck database that lie within 200-m (650 feet) of a reported hang included in the MMS or Texas A&M hang listings. A fairly small number of vessels are represented in this sample, although increasing the distance in the analysis significantly expands the number of vessels included. However, one aspect of this analysis was to help direct a field program that involved diving on hangs that might be associated with wrecks, and it was felt that a 200-m search radius encompassed the largest area that reasonably could be examined.

Table 4-7. Vessels that Lie within 200 m (650 feet) of Reported Hangs

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFORMATION SOURCE	DISTANCE TO HANG (meters)	INFORMATION SOURCE FOR HANG	MMS FISH FUND NO. OR TEXAS A&M ID NUMBER	REMARKS OR DATE OF HANG
1944	22 FT P/C	4		USCG	48.3	A&M	314	
1082	*AFRICAN QUEEN*	2	PS	USCG	93.3	A&M	8502	
872	*BECT NO. 2*	2	EI	MVUS	122.8	MMS	19910001	1/1/90
1528	*BLUE HULL VESSEL*	3	EI	USCG	163.5	MMS	1988008	DESTROYED A NET AND 2 DOORS
1116	CAL DIVE INTERNATIONAL JACK UP LEGS	2	SS	USCG	155.4	MMS	1993150	8/20/93
1116	CAL DIVE INTERNATIONAL JACK UP LEGS	2	SS	USCG	168.5	MMS	1994131	9/7/94
243	*CAPT. DOC*	3	GA	AWOIS; TAC	180.1	A&M	1231	
86	*CONRAD WEISER*	1	MU	TAC	0.6	MMS	19913954	
1306	CRANE BARGE	2	MU	USCG	184.7	A&M	7463	
624	IMCO DRILLER	2	ST	NIMA	146.8	A&M	5187	
624	IMCO DRILLER	2	ST	NIMA	146.8	A&M	3889	
389	*J.A. BISSO (?)*	1	ST	MMS	33.5	A&M	5535	
389	*J.A. BISSO (?)*	1	ST	MMS	33.5	A&M	3648	
1512	JACK UP RIG	2	MP	USCG	93.8	MMS	1991140	8/29/91
1395	*JESSIE CURRIEL*	2	EI	USCG	175.0	MMS	1990138	LOST TWO 50' NETS
1246	*KELLY CHOUEST*	2	VR	NIMA	196.8	A&M	3136	
876	*LOUISE*	3	EC	MVUS	107.0	A&M	1957	
2	*MARANTHA*	3	PS	AWOIS	101.5	A&M	4770	
2	*MARANTHA*	3	PS	AWOIS	101.0	A&M	8350	
821	*MARY JOHN*	4	ST	MVUS	141.1	A&M	4192	
821	*MARY JOHN*	4	ST	MVUS	141.1	A&M	5381	
1022	*MARY M.*	3	WC	AWOIS	100.0	A&M	2050	
641	*MAVERICK*	2	MP	NIMA	86.7	MMS	1994127	8/30/94
641	*MAVERICK*	2	MP	NIMA	128.7	MMS	1991016	10/22/90
329	*MISS AGNES*	1	EI	MMS	73.5	MMS	1989073	LOST 2-54' NETS, 1 LAZY LINE

Table 4-7. (continued). Vessels that Lie within 200 m (650 feet) of Reported Hangs

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFORMATION SOURCE	DISTANCE TO HANG (meters)	INFORMATION SOURCE FOR HANG	MMS FISH FUND NO. OR TEXAS A&M ID NUMBER	REMARKS OR DATE OF HANG
7413	OBSTRUCTION/VESSEL	4	VR	USCG	172.3	A&M	10439	
202	*PEARL LOUISE*	3	GA	MVUS	45.0	A&M	1038	
202	*PEARL LOUISE*	3	GA	MVUS	45.0	A&M	5970	
87	*RACHEL JACKSON*	1	MU	TAC	0.6	MMS	19913954	
11	*RITA*	3	PN	MVUS	143.2	A&M	8644	
1437	*SARGENT*	3	PL	USCG	28.0	A&M	5081	
1437	*SARGENT*	3	PL	USCG	28.0	A&M	3805	
107	*SCORPION*	2	MU	AWOIS	137.1	A&M	6590	
107	*SCORPION*	2	MU	AWOIS	137.1	A&M	214	
328	*SHEHERAZADE (?)*	1	EI	MMS	165.9	A&M	10891	
1276	*SOLIDEZ*	3	PS	USCG	190.5	A&M	8496	
1514	SUNKEN SHIP	2	WC	USCG	189.2	MMS	1984182	LOST ENTIRE SIDE RIG
103	*TARAMBANA*	2	MU	TAC, AWOIS	65.4	A&M	6962	
1368	*TIGER SHARK*	2	WC	USCG	0.0	MMS	1996003	10/16/95
927	*TOMMY BRAD*	2	EI	MVUS	85.3	A&M	9881	
671	*TRADEWIND*	3	EC	HO	178.8	A&M	2607	
14242	UNKNOWN	4	SS	AWOIS	47.6	A&M	3511	
321	UNKNOWN TUG	1	EC	MMS	190.8	A&M	2305	
339	UNKNOWN VESSEL	1	GI	MMS	110.1	A&M	4227	
339	UNKNOWN VESSEL	1	GI	MMS	110.1	A&M	5414	
339	UNKNOWN VESSEL	1	GI	MMS	144.8	MMS	1990233	9/10/90; LOST 3 BRIDLES CABLES, 2 DUMMY DOORS, 2 NETS
339	UNKNOWN VESSEL	1	GI	MMS	112.4	MMS	1991126	8/8/91
384	UNKNOWN VESSEL	1	SS	MMS	150.7	MMS	1997046	LOST A 90 FISH TRAWL COMPLETE EXCEPT THE FLOAT LINE

Table 4-7. (continued). Vessels that Lie within 200 m (650 feet) of Reported Hangs

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFORMATION SOURCE	DISTANCE TO HANG (meters)	INFORMATION SOURCE FOR HANG	MMS FISH FUND NO. OR TEXAS A&M ID NUMBER	REMARKS OR DATE OF HANG
421	UNKNOWN VESSEL	1	WC	MMS	43.4	MMS	1984182	LOST ENTIRE SIDE RIG
11788	UNKNOWN VESSEL	2	ST	NIMA	134.6	MMS	1988098	
11832	UNKNOWN VESSEL	4	ST	NIMA	164.7	MMS	1993069B	1/7/93
11834	UNKNOWN VESSEL	4	WD	NIMA	158.7	MMS	1993075	1/19/93
11836	UNKNOWN VESSEL	4	ST	NIMA	193.1	MMS	1990149	5/7/90
11837	UNKNOWN VESSEL	4	GI	NIMA	139.2	A&M	4627	5/7/90
11837	UNKNOWN VESSEL	4	GI	NIMA	139.2	A&M	5119	
11838	UNKNOWN VESSEL	4	ST	NIMA	147.0	MMS	1993039	11/20/92
11841	UNKNOWN VESSEL	4	ST	NIMA	195.0	MMS	1993069	1/7/93
11842	UNKNOWN VESSEL	4	ST	NIMA	195.9	MMS	1993069B	1/7/93
11844	UNKNOWN VESSEL	4	ST	NIMA	153.9	MMS	1993077B	1/21/93
11845	UNKNOWN VESSEL	4	ST	NIMA	13.7	MMS	1993069B	1/7/93
11847	UNKNOWN VESSEL	4	SP	NIMA	109.5	MMS	1993094	3/3/93
11848	UNKNOWN VESSEL	4	GI	NIMA	96.9	MMS	1993099	3/17/93
11851	UNKNOWN VESSEL	2	ST	NIMA	54.6	MMS	1993121	6/4/93
11853	UNKNOWN VESSEL	2	GI	NIMA	194.2	MMS	1993124	6/15/93
11854	UNKNOWN VESSEL	2	ST	NIMA	61.2	A&M	3824	
11854	UNKNOWN VESSEL	2	ST	NIMA	61.2	A&M	5108	
11896	UNKNOWN VESSEL	1	EI	NIMA	149.2	MMS	1990066B	DAMAGE NOT LISTED.
12076	UNKNOWN VESSEL	2	SM	NIMA	49.8	A&M	11326	
12140	UNKNOWN VESSEL	1	VR	NIMA	125.3	A&M	3060	
12146	UNKNOWN VESSEL	1	VR	NIMA	109.9	A&M	10807	
12388	UNKNOWN VESSEL	4	SM	NIMA	56.2	MMS	992011	92/11/16; LOST 2 45' NETS W/TEDS,10X40 DOORS, CABLE
12388	UNKNOWN VESSEL	4	SM	NIMA	56.2	MMS	1993033	92/11/16 LOST 2 45' NETS W/TEDS, 10 X40 DOORS, CAB

Table 4-7. (continued). Vessels That Lie within 200 m (650 feet) of Reported Hangs.

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFORMATION SOURCE	DISTANCE TO HANG (meters)	INFORMATION SOURCE FOR HANG	MMS FISH FUND NO. OR TEXAS A&M ID NUMBER	REMARKS OR DATE OF HANG
12391	UNKNOWN VESSEL	4	MU	NIMA	0.0	MMS	1993036	92-11-18 LOST 2 58'NETS, CHAIN, AND ROPE
12396	UNKNOWN VESSEL	4	EI	NIMA	113.7	MMS	1993078	1/22/93
12401	UNKNOWN VESSEL	4	SS	NIMA	117.7	A&M	9459	
12405	UNKNOWN VESSEL	4	EI	NIMA	117.6	MMS	1994014	1/11/93
12409	UNKNOWN VESSEL	4	VR	NIMA	140.8	MMS	1986001	BROKE 2 NETS
12412	UNKNOWN VESSEL	4	EI	NIMA	61.0	MMS	1993097	3/16/1993; DAMAGED 2-40' NETS, 2 TEDS
12415	UNKNOWN VESSEL	4	PL	NIMA	195.6	MMS	1993101	3/25/93
12419	UNKNOWN VESSEL	4	SS	NIMA	107.1	MMS	1993104	4/8/93
12420	UNKNOWN VESSEL	4	SS	NIMA	159.0	MMS	1993105	4/13/93
15170	UNKNOWN VESSEL	1	GI	MMS	120.3	A&M	4443	
15170	UNKNOWN VESSEL	1	GI	MMS	110.1	MMS	1985128	DAMAGED NET, BOARD, CHAIN
11846	UNKNOWN VESSEL	4	ST	NIMA	196.9	MMS	1993090	2/24/93
11852	UNKNOWN VESSEL	2	ST	NIMA	165.6	MMS	1993123	6/15/93
11856	UNKNOWN VESSEL	2	MP	NIMA	95.0	MMS	1993130B	6/29/93
12140	UNKNOWN VESSEL	1	VR	NIMA	125.3	A&M	11578	
12155	UNKNOWN VESSEL	2	GA	NIMA	182.2	A&M	1231	
12188	UNKNOWN VESSEL	2	SS	NIMA	96.9	A&M	10566	
12388	UNKNOWN VESSEL	4	SM	NIMA	56.2	MMS	1992011	92/11/16; LOST 2 45' NETS W/TEDS,10X40 DOORS, CABLE
12401	UNKNOWN VESSEL	4	SS	NIMA	158.6	MMS	1993083	1/29/93
12420	UNKNOWN VESSEL	4	SS	NIMA	144.8	MMS	1993083	1/29/93
15170	UNKNOWN VESSEL	1	GI	MMS	120.3	A&M	5644	
11830	UNKNOWN VESSEL	4	GI	NIMA	165.1	MMS	1993065	12/29/93

Table 4-7. (continued). Vessels That Lie within 200 m (650 feet) of Reported Hangs.

VESSEL ID NUMBER	VESSEL NAME	LOCATION RELIA-BILITY	MMS LEASE AREA	VESSEL INFORMATION SOURCE	DISTANCE TO HANG (meters)	INFORMATION SOURCE FOR HANG	MMS FISH FUND NO. OR TEXAS A&M ID NUMBER	REMARKS OR DATE OF HANG
11843	UNKNOWN VESSEL	4	ST	NIMA	165.3	MMS	1993077	1/21/93
11966	UNKNOWN VESSEL	1	SS	NIMA	55.7	A&M	3511	
12373	UNKNOWN VESSEL	4	SM	NIMA	98.3	A&M	3201	
12408	UNKNOWN VESSEL	4	VR	NIMA	197.0	A&M	3225	
323	UNKNOWN VESSEL (*LAFOURCHE*?)	1	EC	MMS	197.1	A&M	2194	
323	UNKNOWN VESSEL (*LAFOURCHE*?)	1	EC	MMS	197.1	A&M	11594	
1570	UNKNOWN WRECK (*BECT 2*?)	1	EI	MMS	114.3	A&M	11144	
1283	*WAGON TRAIN*	2	EI	USCG	54.1	MMS	1985152	LOST 1 NET, DAMAGED 1 NET
733	*YUMA*	3	WD	AWOIS	172.9	A&M	3777	
733	*YUMA*	3	WD	AWOIS	172.9	A&M	5041	

Most of the vessels in Table 4-7 are spatially associated only with a single reported hang. A few, however, are within 200 meters of multiple hangs. For example, the vessel identified as "Cal Dive International Jack Up Legs" and presumably representing the legs from a jack-up barge, is within 200 meters of two hangs included in the MMS data. The two hangs are both approximately 160 meters away from the named vessel. There is no way of knowing if these hangs are associated with the reported jack-up legs, but if they are, it would seem to suggest that the recorded position of the vessel is 160 meters or so off.

Several vessels are associated with multiple Texas A&M hangs, but the data on most of these are somewhat confusing. For example, the vessel *Pearl Louise* is near two Texas A&M hang locations recorded by different ID numbers, but the distance to both is exactly the same. This appears to be related to the conversion of hang positions from Loran to geographic coordinates that resulted in a rounding off of the latter.

Despite the large number of hangs reported in the GOMR, only a few can be spatially correlated with reported shipwreck locations. This finding was not particularly surprising and at the beginning of this study it was proposed that relatively few spatial associations between these two categories would be found (Panamerican Consultants, Inc. 2000). This was because of the known lack of precision in most of the coordinates available for hang sites, plus the unreliability anticipated in the position information for a great many shipwrecks in the GOMR.

In addition to this assessment of the spatial relationships of vessels and reported hangs, ArcView was used to identify individual clusters or groups of hangs that existed by themselves. The assumption was that clusters of hangs derived from multiple reports would correlate with some relatively substantial object on the bottom, possibly an unreported historic object. A large number of clusters of two or more hangs falling within a 200-m circle were identified across the nearshore waters of the central and western Gulf. Of ultimate concern, however, were clusters that were located in a spatially confined area and in less than 100 feet of water, because this information was going to be used to direct diving operations that were restricted to this water depth.

5.0: CORRELATION OF SEAFLOOR HANG SITES, LEASE BLOCK SURVEY DATA, AND SHIPWRECK ARCHIVAL DATA: FIELD INVESTIGATIONS - TASK 2

5.1. Ground-truthing of Selected Targets

As discussed in Chapter 4, a component of Task 2 of this study involved an assessment of the relationship between reported shipwreck locations and reported hang and snag sites under the presumption that some reported hang sites represent shipwrecks. The rationale for conducting this assessment is the demonstrated fact that shipwrecks in the Gulf of Mexico are often festooned with nets, ropes, cables, etc., that have been caught on exposed elements. The first phase of this task involved correlating the positions of reported shipwrecks, unknown shipwrecks, objects and hang sites as has been discussed in Chapter 4. The second phase of Task 2 involved ground-truthing a sample of selected hang sites and reported shipwreck and object locations in an effort to determine if hang sites represented actual shipwrecks. As specified in the Scope of Work, approximately 20 targets were to be selected and then subjected to remote-sensing survey to determine if obvious seafloor features existed. If any targets represented seafloor features of interest, then diving would be conducted to determine their identity and, if any were vessels, to make assessments of significance to the extent possible.

The selection of the 20 targets relied on vessel and object data in the 2001 shipwreck database and reported hang data from the Texas A&M and MMS hang files discussed previously. Target selection drew on the information on the spatial correlation of reported shipwrecks, unknown shipwrecks, objects and hangs as presented in Tables 4-4, 4-5 and 4-6 and on visual examination of these data presented in ArcView format. Target selection was based on a variety of factors, the most critical relating to a target's ability to address questions concerning hang/shipwreck correlations. Targets chosen for examination had the following characteristics:

- Groups of hangs that correlate spatially (cluster around or near) with unidentified objects that had been discovered during remote-sensing surveys.

- Groups of hangs that correlate spatially (cluster around or near) with a reported wreck location.

- Groups of hangs that correlate spatially (cluster around or near) with only themselves, the cluster suggesting the presence of an object exposed above the seafloor.

- Precisely located unidentified objects discovered during remote-sensing surveys, regardless of association with hangs under the presumption that these might represent unidentified shipwrecks.

Additional factors involved in the target selection process related to practical considerations of conducting the field investigations, and included the depth of water at targets, as well as their location relative to access. The SOW provided by MMS stipulated that all targets to be investigated had to be situated in less than 100 feet of water, thus allowing for relatively safe diving conditions. Furthermore, during the selection process consideration was given to how far potential targets were from a port, as well as the distances between targets, distance being a critical element relative to budget constraints and how much time was available for target examination. While the entire GOMR area inshore of the 100-foot depth line was reviewed during target selection, the area that had the highest concentration of targets meeting the above-stated characteristics and which, also, complied with the concerns about water depth and distance, was located offshore of central Louisiana. After consultation with MMS GOMR personnel on the selection process, 20 targets in this area were chosen and approved for investigation (Table 5-1). Figure 5-1 illustrates the location of these targets in the area offshore of Louisiana.

Table 5-1. Task 2 Targets Selected for Investigation

Target No	Lease Block	Target Type	Survey Area (feet)	Comments
1	SM 17	1 unknown object (374)*	600 x 600	Amorphous sidescan target, LR 1**
2	SM 19	1 unknown object (375)	600 x 600	Rectangular sidescan target, LR 1
3	SM 211	4 hangs, 1 unknown vessel (12424)	1600 x 1650	LR 2 for unknown vessel
4	SM 231	1 hang, 1 unknown vessel (12373)	1000 x 1000	LR 4 for unknown vessel
5a 5b	ST 20 ST 20	4 hangs, 1 unknown object (11840), 1 unknown vessel (11836)	900 x 1500 600 x 600	LR 4 for object and vessel
6	ST 77	1 hang, 1 unknown vessel (389)	1100 x 1700	Sidescan target, possible *J.A. Bisso*?, LR 1 for unknown vessel
7	SS 71	2 hangs	1350 x 700	Possible association with # 8
8	SS 71	1 hang, 1 unknown object (12379)	650 x 1450	Possible association with # 7, LR 4 for object
9	SS 73	2 hangs, 2 unknown objects (12376 and 12380)	1000 x 1700	LR 4 for objects
10	SS 109	1 hang, 2 unknown vessels (12502 and 12166)	1300 x 1000	LR 2 for unknown vessel 12166, LR 4 for unknown vessel 12502
11	PL 2	1 hang, 1 unknown object (12382)	800 x 1800	LR 4 for unknown object
12	PL 5	1 hang, 1 unknown vessel (12415)	750 x 1400	LR 4 for unknown vessel
13	PL 14	3 hangs	1400 x 2600	Possible association with # 15
14	VR 35	1 hang, 1 unknown vessel (12409)	1000 x 1000	LR 4 for unknown vessel
15	VR 118	1 unknown object (408)	600 x 600	Amorphous sidescan target, LR 1
16	EI 23	3 hangs, 1 unknow vessel (12405)	1600 x 2000	LR 4 for unknown vessel
17	EI 42	2 hangs, 1 unknown vessel (12363)	1700 x 1500	Possible association with # 18, LR 4 for unknown vessel
18	EI 53	1 hang, 2 unknown vessels (12402 and 12359)	1500 x 1400	Possible association with # 17, LR 4 for unknown vessels
19	EI 68	3 hangs	1300 x 1300	Possible association with # 20
20	EI 68	1 unknown object (obstruction, 7076)	600 x 600	Possible association with # 19, LR 4 for unknown object

* Numbers refer to CEI ID Number of vessel and object entries in 2001 Shipwreck Database; **LR = Location Reliability

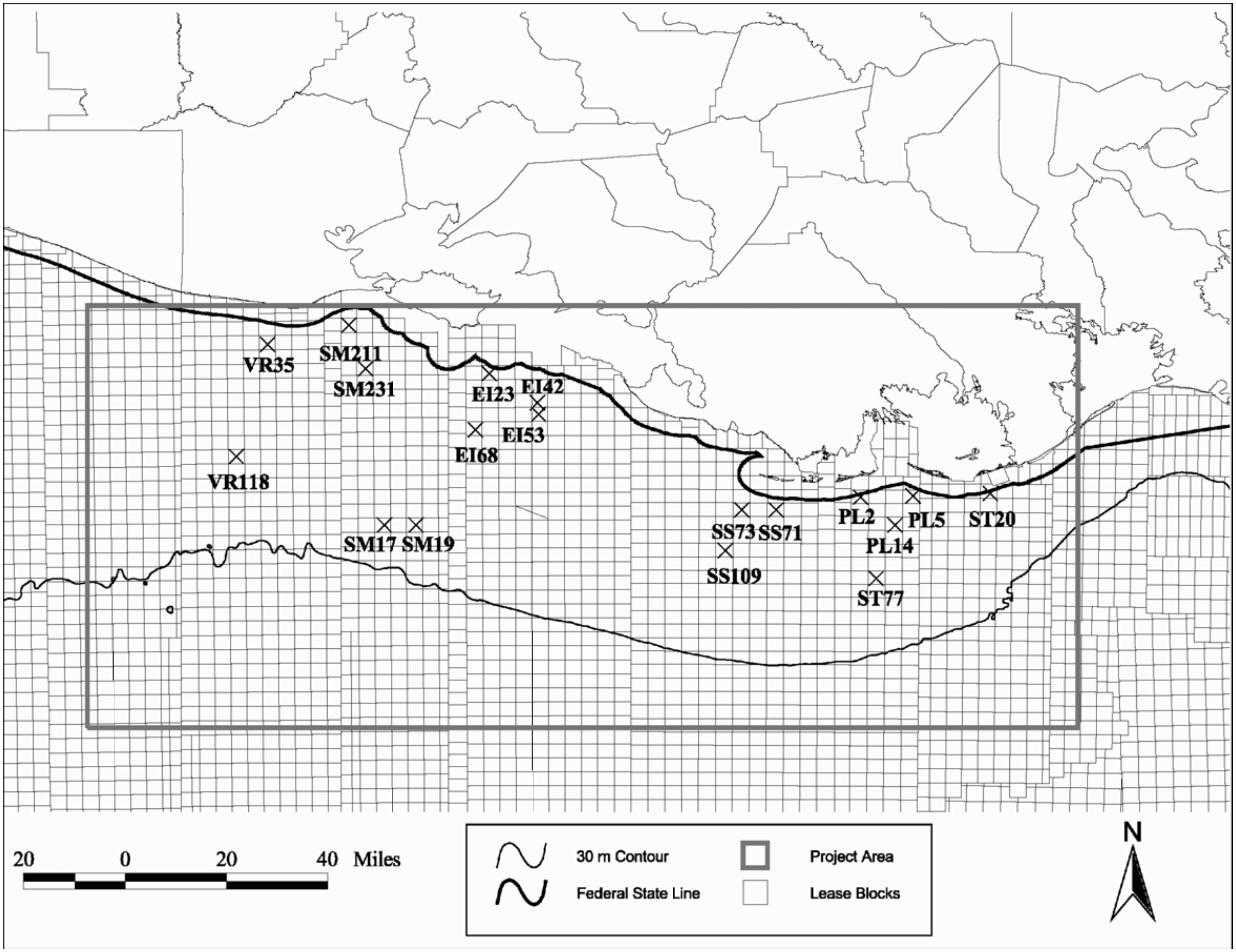


Figure 5-1. Lease block map illustrating lease blocks containing targets selected for investigation

These “targets” do not represent single point locations, but consist of areas surrounding an individual item or a cluster of items, as indicated in Table 5-1 and illustrated in Figure 5-2. With the exception of those targets deemed to be very precisely located (e.g., Targets from Table 5-1 with a Location Reliability of 1), we elected to examine a fairly large block around multiple hangs, objects, or unknown vessels. Each block was designated a single “target,” rather than each item within the block. This was implemented on the belief that closely clustered items could represent the same object that had been given slightly different coordinates in various sources. This was believed to be particularly pertinent for the hangs, because their coordinates typically represented converted Loran positions, positions known to often contain some amount of error. Furthermore, designating each item in a cluster as a separate target would have minimized the ability to correlate discrete, but spatially clustered objects.

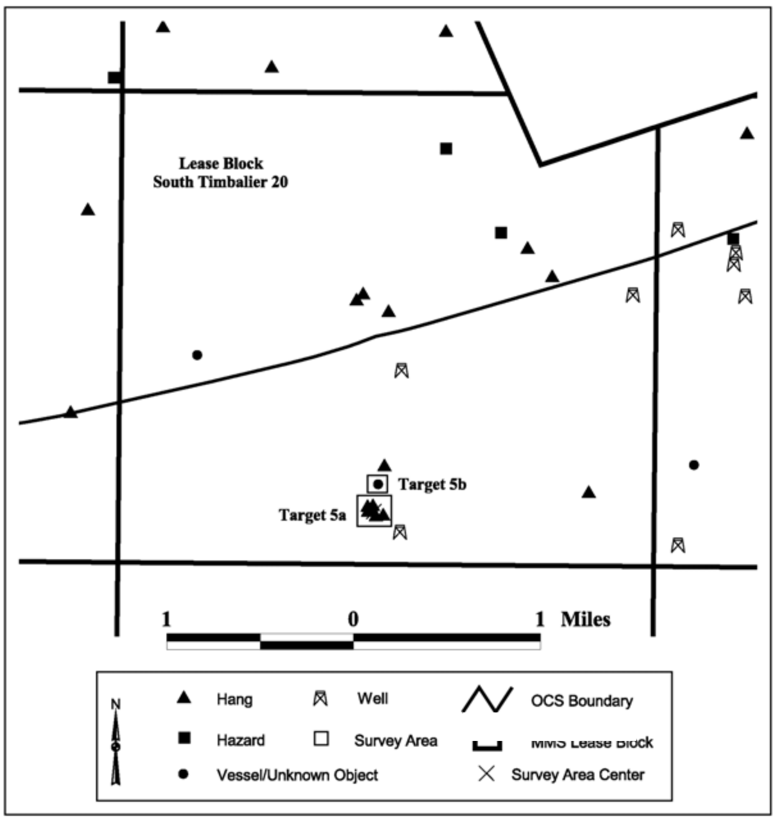


Figure 5-2. Lease block map with Target 5 survey area. Located in South Timbalier 20, the survey area encompassed the recorded locations of one unknown object, one unknown vessel and four hangs.

This is particularly relevant in light of the above-stated presumption that closely clustered hangs or obstructions could represent the same object with slightly different coordinates. As opposed to 20 separate, individual targets, the use of these survey areas as “targets” offered a much larger sample of 52 recorded “items” to investigate that included 31 hangs, 12 unknown vessels, and nine unknown objects. Even this number of 52 items, however, represents an extremely small sample of the total number of vessels, objects and hangs known to exist in the Gulf of Mexico. The results of these target investigations must be viewed in this light and any effort to extrapolate these results to the GOMR as a whole has to be considered tentative at best.

Table 5-1 presents the number (Target No.) assigned to the target, the MMS lease block within which the target is located, the Target Types as identified in the sources of information used, the size of the survey area examined by remote-sensing survey at the target location, and Comments that provide basic information on the targets. Under Target Type, the CEI ID Number from the 2001 shipwreck database is provided for vessels and objects. Included in the Comments are the location reliability factors for objects and vessels derived from the 2001 shipwreck database. During target selection, an effort was made to incorporate the concept of location reliability into the process. For example, as shown in Table 5-1, three of the targets with location reliability factors of 1 (i.e., with what are believed to be very precise positions) are associated with unknown objects, while one (Target 6) is associated with an unknown vessel tentatively identified as the *J.A. Bisso*. Thus, these targets offered the opportunity to determine if these precisely located "objects" might, in fact, represent the remains of vessels, while in the case of Target 6, it would provide a verification of a tentative identification, as well as determine if the reported hang at Target 6 was associated with the vessel.

Target 3 consists of a cluster of four reported hangs, plus an unknown vessel assigned a location reliability of 2, indicating a moderately high reliability in its reported position. In this instance, investigation would enable an assessment of this reliability assignment, plus it would examine the relationship of hang sites with wreck sites, should the unknown vessel be located here. The same reasoning was used in the selection of other targets containing reported hangs and unknown vessels. As seen in Table 5-1, most of the "unknown vessels" at these targets have reliability factors of 4, indicating a low reliability for the reported location, or that no information was available to make such an assessment. It would have been desirable to examine targets that expressed a range of location reliabilities, but relatively few unknown vessels with nearby hangs were identified within the offshore area selected for diving and most of these had location reliabilities of 4.

Target 5 consists of a cluster of four hangs, plus an unknown object and an unknown vessel, both of which have a location reliability of 4. Additionally, these latter two items have the same coordinates and both are derived from the same source, the electronic database produced by the National Imagery and Mapping Agency (NIMA). It is likely that these represent the same item that has been entered twice in the NIMA database. However, one is clearly identified as a vessel, while the other isn't. As seen in Table 5-1, Target 5 has been separated into 5a and 5b because the area of the hangs (Target 5a) was examined separately from the area of the unknown vessel and object (Target 5b). The rationale for this division is presented in the discussion of Target 5.

There are several other instances of "unknown vessels" and "unknown objects" with the same coordinates in the 2001 shipwreck database. Sometimes these are derived from the same source of information, and sometimes they are from different sources. In the cases where both items were identified as the same thing, either a vessel or an object, only one was retained in the database. However, in instances where one is identified as a vessel and one as an object, both have been retained unless other information was found to substantiate the presumption that they represented the same item. This was done because it is presently impossible to accurately classify either entry as a vessel or an object.

In the case of Target 10, in lease block Ship Shoal 109, one hang and two unknown vessels are identified in proximity to one another. One of these vessels has been assigned a location reliability of 2 and the other a reliability of 4. The reported locations of the two vessels are very close to one another, and it is possible that the two actually represent the same vessel that has been provided slightly different coordinates in different sources. Target 20 is an unidentified object, identified as an "obstruction" in USCG records. In fact, the USCG record for this entry notes that there was a report of a cable snagging on the obstruction (see 2001 shipwreck database).

5.1.1. Investigative Methods

The investigation of the 20 selected targets was conducted in two phases, a survey phase that served to locate the target (if present), and a diving phase to verify, identify and, to the extent possible, assess the historical significance of objects or vessels found. As stated above, 20 previously selected targets were to be surveyed using a magnetometer, sidescan sonar and DGPS positioning; the area of survey coverage at each target is provided above in Table 5-1. For targets precisely located during previous remote-sensing surveys and those consisting of single items, a close-interval remote-sensing survey was conducted of only a small block (600 feet x 600 feet) with the target coordinates at the center of the block (e.g., see Targets 1, 2, 15 and 20 in Table 5-1). The areas surveyed at other targets were sufficiently large to encompass the items of interest. If an above-seafloor feature was identified during remote-sensing survey, its position would be refined with a close-interval sidescan sonar and magnetometer survey to obtain sufficiently precise information to direct subsequent diver investigation. A five-person archaeological dive team would then examine targets that represented above-seafloor features in order to determine their identity and, to the extent possible, assess their historical significance. The instruments and methods used in target survey and examination are discussed below, along with their respective findings.

5.1.2. Remote-Sensing Survey: Methods and Equipment

Positioning for all of the survey work utilized a Motorola LGT-1000 Global Positioning System (GPS) linked to a Starlink MRB-2A MSK Radiobeacon receiver for differential (DGPS) capabilities. The remote-sensing instruments used were a Marine Sonic sidescan sonar and an EG&G Model 866 marine magnetometer. The vessel *Sea Ox*, out of the ASCO fuel dock in Intracoastal City, Louisiana, was used for the initial remote-sensing survey phase of the 20 targets. The *Sea Ox* is a 110-foot utility boat provided by Sea Boat Rentals, Inc. of Galliano, Louisiana (Figure 5-3).

Figure 5-3. The 110-foot *Sea Ox* used for remote-sensing refinement of 20 hang sites within the GOMR.

Differential Global Positioning System. Accurate positioning was essential to permit returns to locations for supplemental remote-sensing operations and diver investigation of targets. These positioning functions were accomplished using a Motorola LGT-1000 GPS (Figure 5-4). The Motorola LGT-1000 is a global positioning system that, when linked to the Starlink MRB-2A, MSK Radiobeacon receiver, attains differential capabilities. These electronic devices interpret transmissions from satellites in the Earth's orbit and from a shore-based station to provide accurate coordinate positioning data for offshore surveys.

Figure 5-4. Differential global positioning system (DGPS) used for the project.

The Motorola system processes both satellite data and differential data transmitted from a shore-based GPS station utilizing RTCM 104 corrections. The shore-based differential station monitors the difference between the position that the shore-based receiver derives from satellite transmissions and that station's known position. Transmitting the differential that corrected the difference between received and known positions, the DGPS constantly monitored the navigation beacon radio transmissions in order to provide a real-time correction to any variation between the satellite-derived and actual position.

Both the satellite transmissions and the differential transmissions received from the shore-based navigation beacon were displayed directly onto the screen of the LGT-1000 and were updated continuously every second. The level of accuracy for the system was considered at ±1 meter throughout the survey. For this survey, Louisiana South State Plane Coordinates, based on the 1927 North American Datum (NAD 27), were used.

Sidescan Sonar. The sidescan sonar system used was a Marine Sonic Technology Sea Scan (Figure 5-5). The software included with the Sea Scan Personal Computer (PC) system controls the collection of sonar imagery as well as navigational input and displays the data to the operator utilizing a 13-inch color monitor. The Sea Scan PC allows the operator to view wide tracts of the seafloor by isonifying along a predetermined swath width and recording the strength of the echoes from the seafloor. This is performed by a towfish towed just above the seafloor. The towfish emits a continuous, narrowly focused beam of sound perpendicular to the path of forward motion. The sound pulses pass through the water and are reflected by the seafloor and from various objects resting on it, such as shipwrecks, debris, and topographic features (sand ripples, rocks, etc.). The strength of the signal returned to the towfish is recorded and the entire sonar record line is drawn onto the screen for viewing. An image of the seafloor is constructed line by line as the sonar record line from each pulse of the sonar is returned to the PC and then displayed onto the color monitor.

Figure 5-5. Marine Sonic Technology sidescan sonar system.

The Sea Scan PC utilizes an Intel-based computer with the Windows v3.1 operating system for system control and data display. The Sea Scan program allows the operator to control the sonar data collection process, zoom in on various sonar images for increased axial resolution, and to save sonar images with the related navigational data.

The Sea Scan PC can read navigational information from external navigational devices such as GPS and Loran C units. External navigational units must support the NMEA 0183 Standard for Interfacing Marine Electronics Navigational Devices 1.5, which was adopted in December 1987 by the National Marine Electronics Association (NMEA). The NMEA proprieties allow marine instruments to send and receive information based on a block serial transmission. NMEA sentences (each uniquely identified by a header that identifies the transmitter) are transmitted over a serial cable. Any external navigational system that supports these sentences then sends the information to a serial port on the Sea Scan PC. When an incoming sentence arrives, the Sea Scan PC accounts for the current latitude and longitude, course-over-ground, and speed-over-ground.

The function of the Sea Scan PC software is to display the relevant sonar image on the screen. Every time the sonar towfish emits an acoustic pulse, the reflection data is recorded and displayed along a horizontal line on the display screen. As the towfish passes over the seafloor, it continually emits an acoustic pulse. The image of the seafloor is then drawn by the reflection data, line by line. The reflection data is recorded in a 1,000-line image file. Therefore, only the latest 1,000 lines of the sonar record are stored in the computer's memory. Unless every 1,000-line file is saved automatically, when a new sonar line is recorded it writes over the old sonar line.

For every acoustic return from the seafloor, an intensity value (from zero to 255) is recorded. A value of zero indicates that no return was detected in that particular sample and an intensity level of 255 indicates that the maximum intensity was detected. It is these 256 levels of acoustic intensity that are drawn onto the color monitor utilizing a 64-element color scale. Therefore, the intensity values between zero and 255 are converted to an intensity value of zero to 63, which are then drawn on the screen by the color scale elements of zero to 63, respectively.

The Sea Scan PC also features an integrated plotter with a current and survey mode plot display function. The plotter allows the operator to set search patterns and monitor swath coverage while collecting sonar records (Figure 5-6). Once a feature (such as a shipwreck) is located, it may be marked on the Sea Scan plotter for future reference.

Magnetometer. The magnetometer used was a Geometrics 866 marine magnetometer (Figure 5-7). The G-866 is comprised of a hydrocarbon-filled sensor, a tow cable, and a topside console where signal processing and amplification is achieved. An external printer is utilized to print the collected data. The G-866 is probably the most well known and was once the most widely used magnetometer. The "industry-standard" for many years, while not completely obsolete, it is no longer being produced and is being replaced with newer models by many companies.

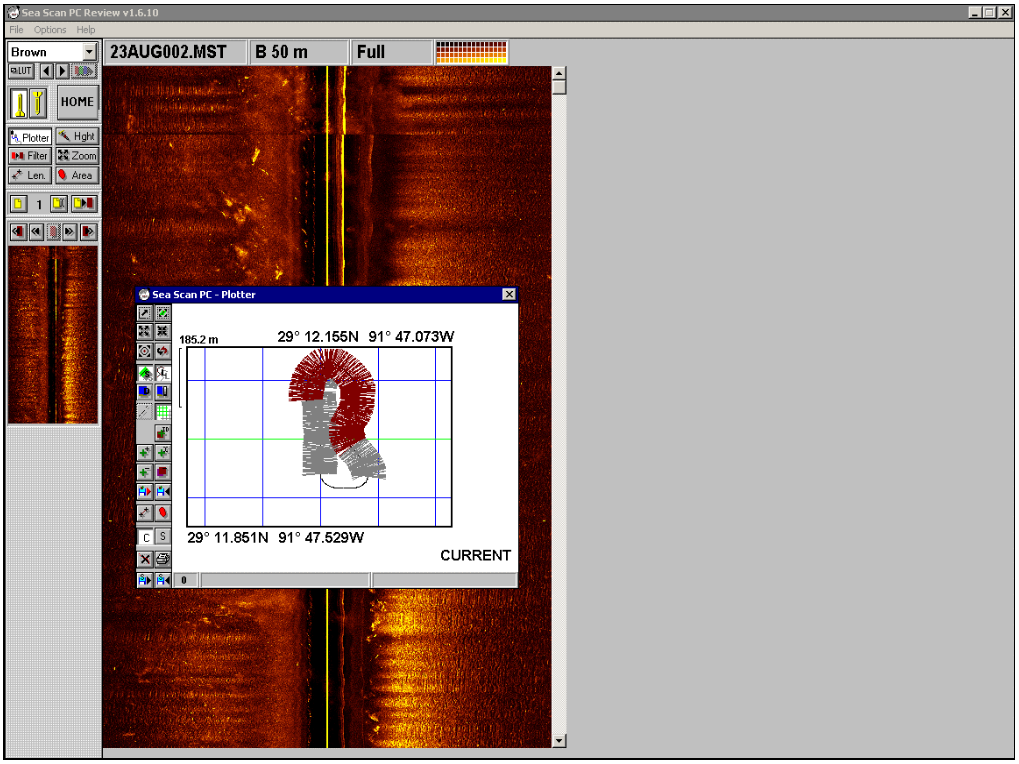


Figure 5-6. Sea Scan PC plotter window showing overlapping coverage between survey lines.

Figure 5-7. Geometrics Model G-866 marine magnetometer console and towfish.

5.1.3. Sidescan Sonar Survey: Results

The initial plan for the first phase of target evaluations was to undertake a remote-sensing survey of each target location using both the sidescan sonar and the magnetometer. However, during the mobilization of the survey vessel *Sea Ox*, it was determined that the magnetometer cable brought for the survey was not long enough to distance itself from the magnetic interference of the vessel. Rather than expend time waiting for a new cable, it was decided to proceed with the survey of targets using the sidescan sonar alone. This did not seriously affect the overall results of Task 2, because the intent was to dive only at targets where obvious bottom features (potential hangs) were seen, information that would come only from the results of the sidescan sonar survey. Essentially, this first survey effort with the sidescan sonar resulted in the elimination of several targets from further evaluation. Subsequently, prior to diving, magnetometer surveys were conducted at those targets that did exhibit identifiable bottom features. The sidescan sonar survey of targets was conducted between August 21 and 24, 2001. The results of the sidescan sonar survey of all 20 targets are presented below. This is followed by discussions of the magnetometer surveys and diver investigations at those targets where they were warranted.

Each of the targets was subjected to a sidescan sonar survey of various grid sizes (see various plot maps). To establish the number of survey lines (or "track lines") needed to achieve adequate coverage, the location of the target item, or the center of the group of target items, was entered into a computer and the appropriate number of offsets calculated along the shortest side of the pre-determined grid square. The space between track lines depended upon the size of the grid. While only seven track lines were necessary to adequately survey any grid, every track line had overlapping swath coverage providing complete coverage of each area.

Target 1, SM 17. The sidescan sonar survey of Target 1, located in lease block South Marsh 17, was conducted on August 22, 2001. Target 1 consisted of a single unknown object identified during an MMS-mandated remote-sensing survey (Lease block survey G12886, see Table 5-1 and 2001 shipwreck database). The reported position for the target was at Louisiana South State Plane Coordinates (NAD 27) N = 91370, E = 1769105. A survey block measuring 600 feet square and centered on this position was fully covered with seven parallel track lines (Figure 5-8). Survey lines were spaced 100 feet apart and oriented in a north-south direction. Water depth at the target was approximately 80 feet.

A review of the sidescan sonar records in the field identified an object on the sea bottom near the center of the surveyed area, very close to the position identified in the original survey records (Figure 5-9). This object was observed on at least three survey lines and consisted of several thin, linear elements lying parallel to one another combined with at least three shorter, crossing diagonal members. The maximum length of the target was approximately 47 feet. The regular geometry of this object suggested that it was manmade, thus Target 1 was slated for additional magnetometer and diver investigations.

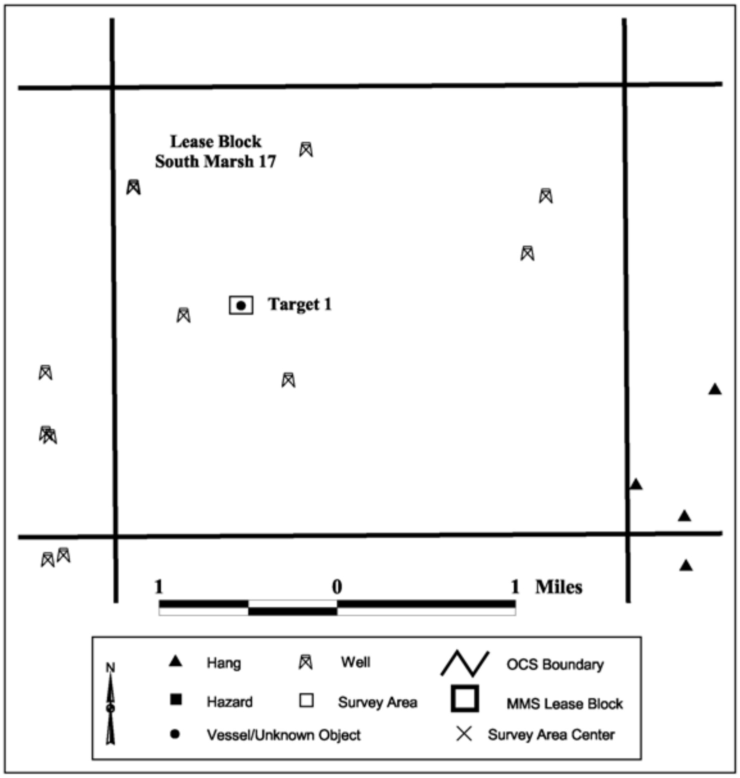


Figure 5-8. Target 1, SM 17 survey area.

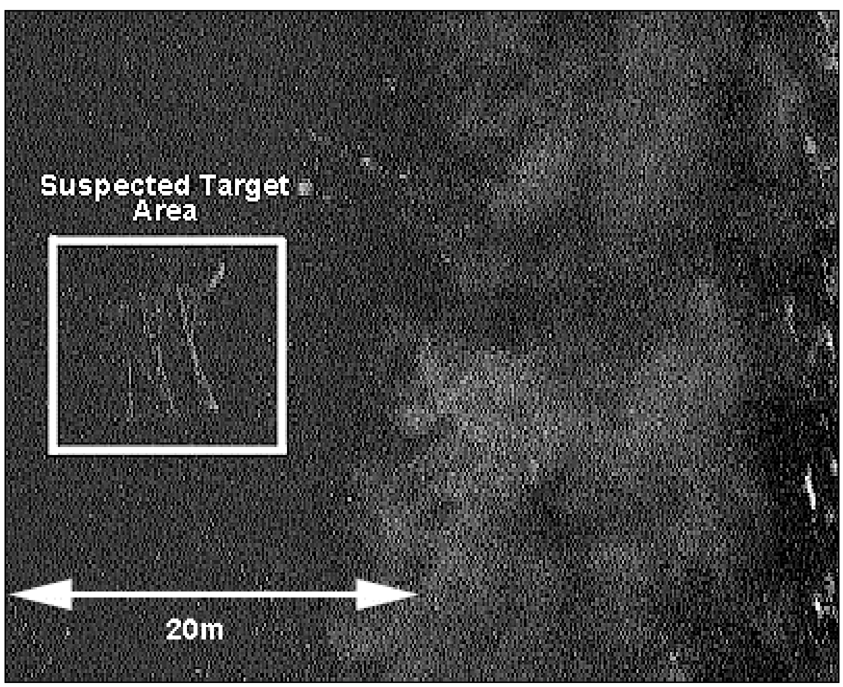


Figure 5-9. Sidescan sonar image of Target 1, SM 17; note the diagonal cross features of the target.

Target 2, SM 19. Target 2, located in the southwestern quarter of lease block South Marsh 19, like Target 1, consisted of a single unknown object identified during a previous MMS-mandated sidescan sonar survey (Lease block survey G16319, see Table 5-1 and 2001 shipwreck database). The sidescan sonar records of the previous survey indicated that the object was rectangular and measured about 13 by 26 feet in size. An object tentatively identified as a piece of shrimp net was trailing from one side of the object. The sidescan sonar survey of Target 2 was undertaken on August 22, 2001 (Figure 5-10). A survey block measuring 600 feet square was centered over the object's location (Louisiana South State Plane Coordinates [NAD 27] N = 85755 E = 1797839) and this area was fully covered with seven parallel track lines. Survey lines were spaced 100 feet apart, oriented in a north-south direction. Water depth at the target was 80 feet.

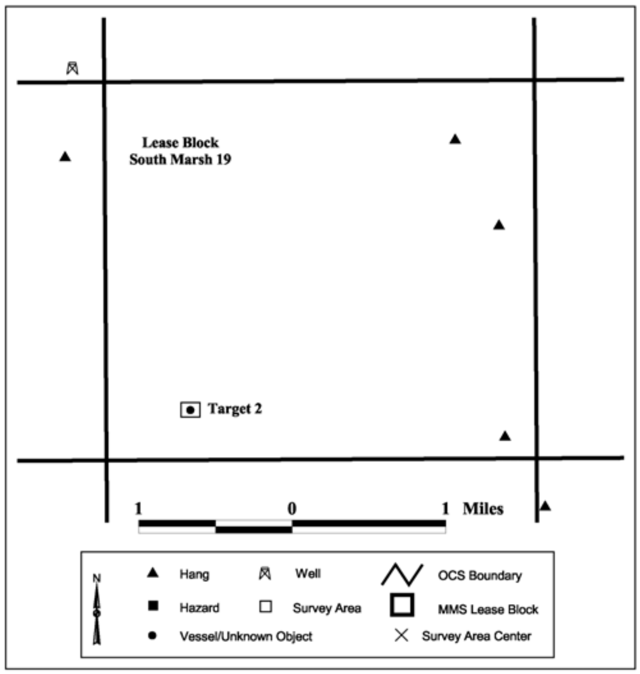


Figure 5-10. Target 2, SM 19 survey area.

The review of the collected sidescan sonar data indicated no above-seafloor objects. Despite these findings, however, a magnetometer survey was subsequently conducted over this target location because of the precise nature of the information on its existence presented in the MMS-mandated survey. The results of the magnetometer survey are discussed later, but it is noted that they, also, were negative.

Target 3, SM 211. Target 3 is located near the western boundary of lease block South Marsh Island 211 (Figure 5-11). As listed in Table 5-1, this target contained four hang sites and one unknown vessel assigned a position reliability of 2 (CEI ID Number 12424 in the 2001 shipwreck database). This target was selected, principally, to see if the cluster of snags might represent the unknown vessel. An initial effort to conduct a sidescan sonar survey of this target was undertaken on August 21, 2001, but water depths at the target were on the order of only 10 feet, too shallow to collect useable data because of the deep draft of the *Sea Ox*. The sidescan sonar survey was subsequently conducted with another vessel on September 13, 2001. The water depth was approximately 10 feet at the time of the sidescan sonar refinement.

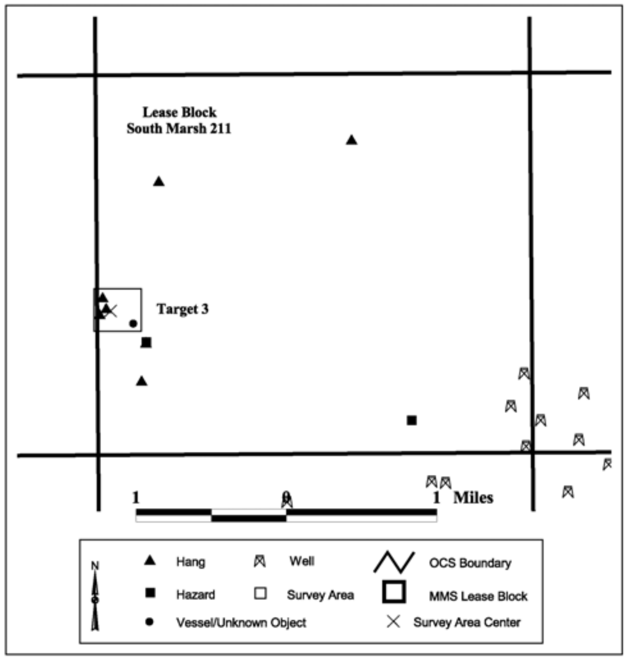


Figure 5-11. Target 3, SM 211 survey area.

The survey area at Target 3 measured 1650 feet by 1600 feet in size, with the long axis of the survey block oriented in a north-south direction. The survey block was centered on the five items reportedly located here (at Louisiana South State Plane Coordinates (NAD27) N = 29599; E = 1751134). Survey coverage of the area was accomplished with seven survey lines consisting of a centerline and three offsets to the east and west. The line spacing was 233 feet between survey track lines. The sidescan sonar was set to 50-meters-per-channel, thus giving a 100-meter-per-transect swath (328 feet). This allowed for an approximately 30 percent overlap on adjacent transects, giving full coverage of the target area. Analysis of the sidescan sonar data in the field and more detailed examination in the lab identified no obvious seafloor features of interest. Natural features in the record indicated only the presence of dolphins and a school of fish or shrimp during the running of the survey lines.

Several reasons may lie behind the fact that no seafloor objects were identified at Target 3. First, the positions of all of the items identified at this target must be considered somewhat imprecise. The unknown vessel has been assigned a location reliability of 2, suggesting the potential for some error in its reported position, and all of the hangs apparently were originally reported in Loran coordinates. Secondly, evidence of recent shrimp trawling activity through the target area was obvious in net drag scars on sonar records, suggesting that the reported hangs might have been displaced or completely removed through this activity at some time in the past. Thirdly, it is possible that the hangs reported at this location were buried at the time of the sidescan sonar survey. The shallow water at Target 3, plus its inshore position, places it at a location where bottom sediments can be moved around by wave action as well as by nearshore currents. As discussed previously, marine growth and wood damage to the remains of vessels such as *El Nuevo Constante*, which is located off the western Louisiana coast in about 20 feet of water, suggest periodic burial and exposure of remains. Similarly, the hangs at Target 3 might be periodically exposed or buried, dependent upon wave, storm and current conditions and their impacts on sediment transport. Because there were no indications of any above-seabed features in the target area, no further work was recommended for this location.

Target 4, SM 231. Target 4, located in lease block South Marsh Island 231, consisted of one reported hang and one unknown vessel (Figure 5-12). The unknown vessel (CEI ID Number 12373 in the 2001 shipwreck database) was assigned a very low location reliability of 4, indicating a vague and possibly unreliable position. Target 4 was surveyed by sidescan sonar on August 23, 2001, when water depths over the area ranged from 9 to 12 feet. The survey area measured 1,000 feet by 1,000 feet and was centered on a point midway between the reported positions of the two items at the target (Louisiana South State Plane Coordinates [NAD 27] N = 258031; E = 1756892).

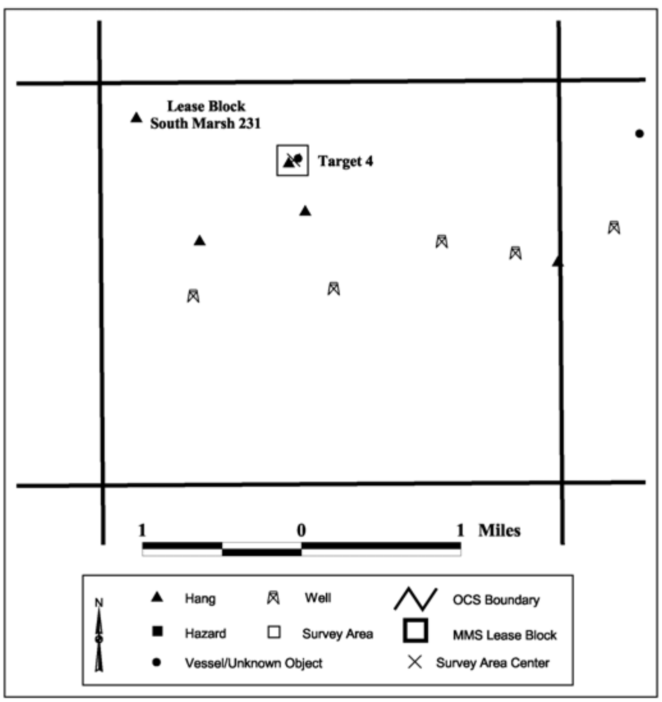


Figure 5-12. Target 4, SM 231 survey area.

Seven track lines were run over the target area in an alternating north-south direction. Line spacing was 150 feet with the sidescan sonar swath coverage set at 50-meters per channel. During the survey, numerous drag scars from trawling activities were visible on the sonar records (Figure 5-13). No other cultural objects or features were noted and, therefore, Target 4 was eliminated from additional examination.

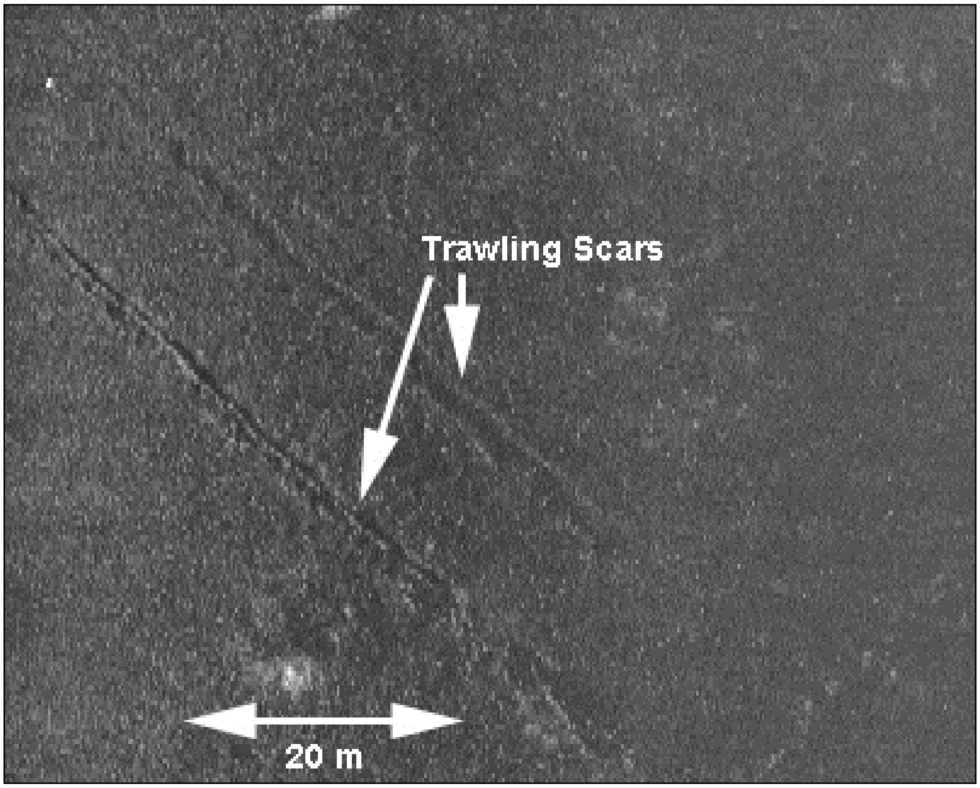


Figure 5-13. Sidescan sonar image of drag scars from trawling activity near Target 4, SM 231.

Target 5, ST 20. Target 5, located in the southern portion of lease block South Timbalier 20, encompassed a cluster of four hangs, one unknown object and one unknown vessel (see Table 5-1). The water depth at Target 5 was 38 to 42 feet. As noted earlier, the unknown object and vessel both had been assigned very poor location reliability (reliability of 4), but both had the same reported position and might represent the same item identified in two different ways. Because of the great distance between the cluster of hangs and the unknown vessel and object, the entire target area was surveyed in two parts. In subsequent discussions, the cluster of hangs is identified as Target 5a, while the unknown vessel and object are identified as Target 5b.

The sidescan sonar survey of Target 5a, the cluster of hangs located in the southern part of the target area, was conducted on August 22, 2001. The survey area over the hangs measured 900 feet by 1,500 feet and was centered at Louisiana South State Plane Coordinates (NAD 27) N = 121405; E = 2326904. Complete coverage of this area was obtained with seven survey track lines spaced 140 feet apart. Swath coverage was set at 50-meters per channel during the survey of this area.

Review of the sidescan sonar data during the survey identified a slight rise on the seafloor in the area of the reported hang sites (Figures 5-14 and 5-15). The anomalous rise covers an area approximately 34.5 feet square. Because of the presence of this object, this area of Target 5 was slated for subsequent magnetometer survey and diver examination.

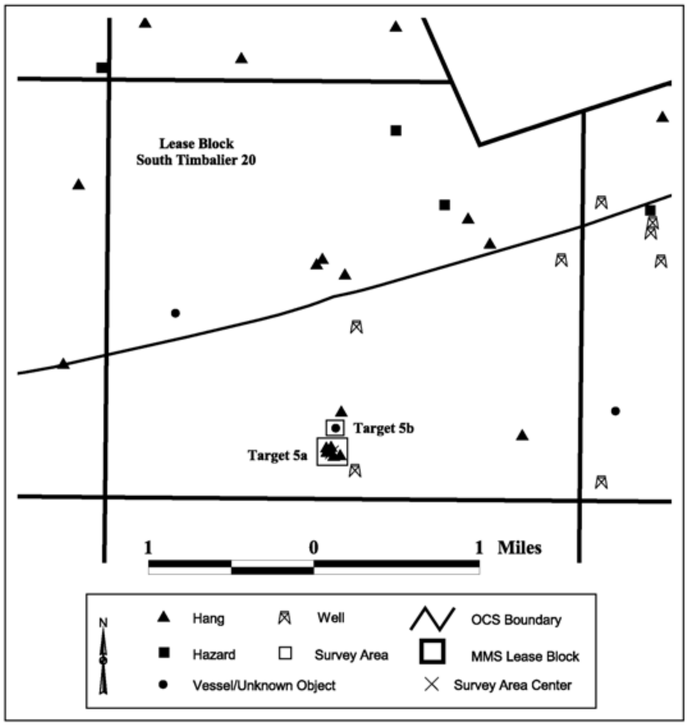


Figure 5-14. Target 5, ST 20 survey area.

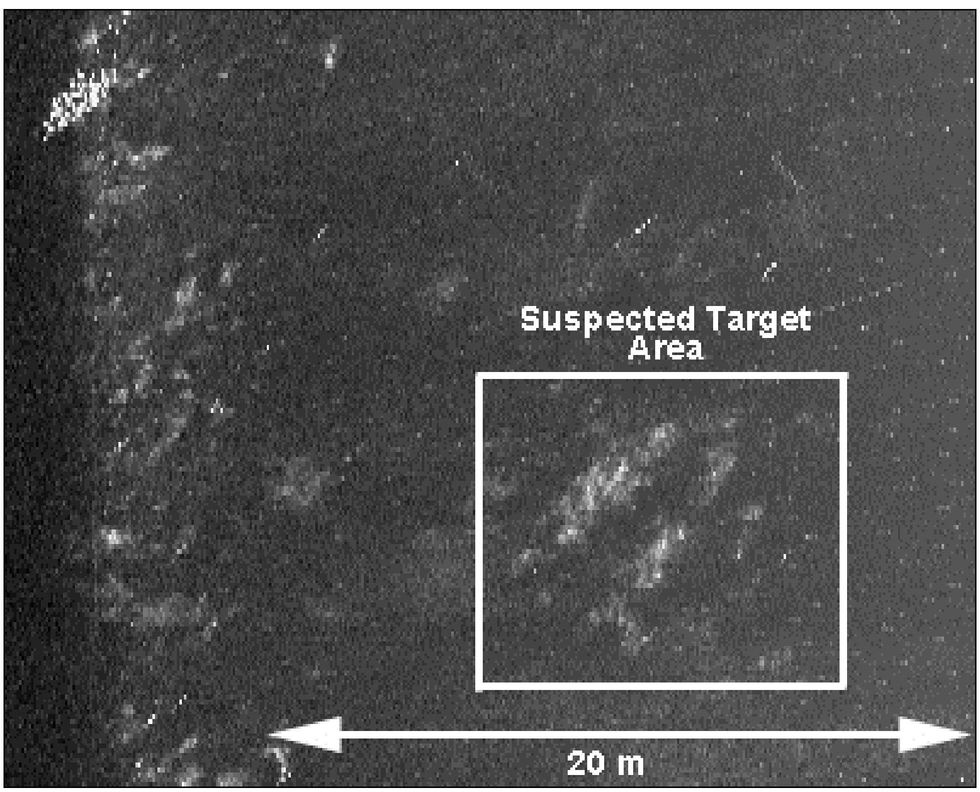


Figure 5-15. Sidescan sonar image of Target 5a, ST 20.

The second part of the survey of Target 5 considered the reported unknown vessel and unknown object in the northern portion of the target area. Survey coverage of these items, designated Target 5b, was accomplished with seven survey lines spaced 100 feet apart with swath coverage set at 50-meters per channel. The survey block over these items measured 600 feet by 600 feet and was centered at their reported location (Louisiana South State Plane Coordinates [NAD27]).

Sidescan sonar records at the Target 5b location revealed the presence of a large number of linear objects covering a substantial area. The total area of the target could not be determined due to the large amount of sea life (i.e., fish, shrimp) over the target obscuring the sonar return. The linear objects appear to be strewn across the seafloor in roughly a northwest to southeast orientation (Figure 5-16). Because of the presence of these objects, this portion of the Target 5 area was also selected for later magnetometer survey and diver examination.

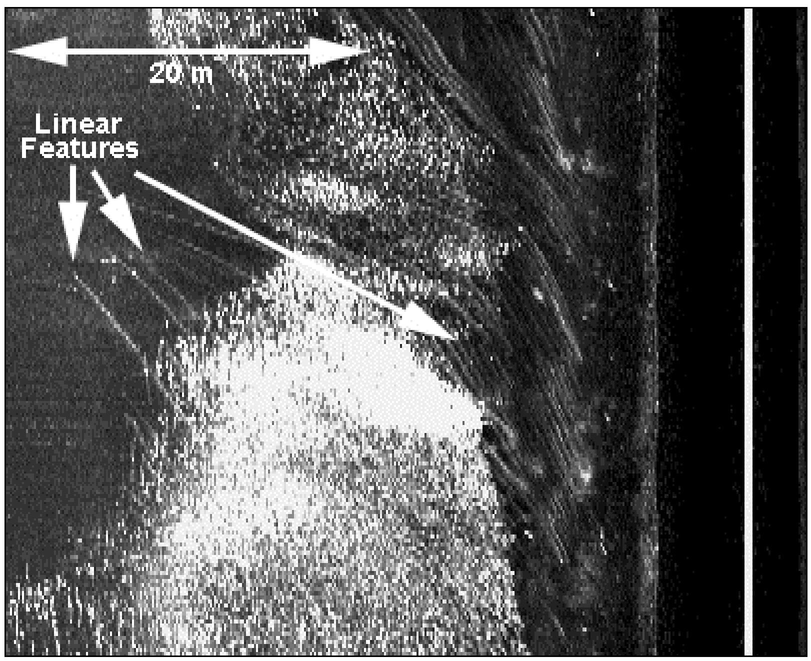


Figure 5-16. Sidescan sonar image of Target 5b, ST 20; note the large number of linear features on the seafloor. A school of fish or shrimp swimming over the target account for the heavy masking effect.

Target 6, ST 77. Target 6, located in lease block South Timbalier 77, consisted of a reported hang site and an unknown vessel (see Table 5-1; Figure 5-17). The unknown vessel had been located during a previous MMS-mandated remote-sensing survey and had been tentatively identified as a vessel named *J.A. Bisso* in a cultural resources survey report by Northland Research, Inc., in the year 2000 (see CEI ID Number 389 in the 2001 shipwreck database).

The sidescan sonar survey of Target 6 was conducted on August 22, 2001. The area surveyed measured 1,000 feet by 1,700 feet and was centered on Louisiana South

State Plane Coordinates (NAD 27) N = 33503; E = 2219914. Seven track lines (oriented north/south) were run over the area, completely covering the selected target area. Track lines were spaced 150 feet apart, covering an area 1,050 feet total. Water depth on site was approximately 56 feet. No obvious seafloor features were observed on the collected sidescan records. Due to these negative findings, no additional investigations were slated for this area.

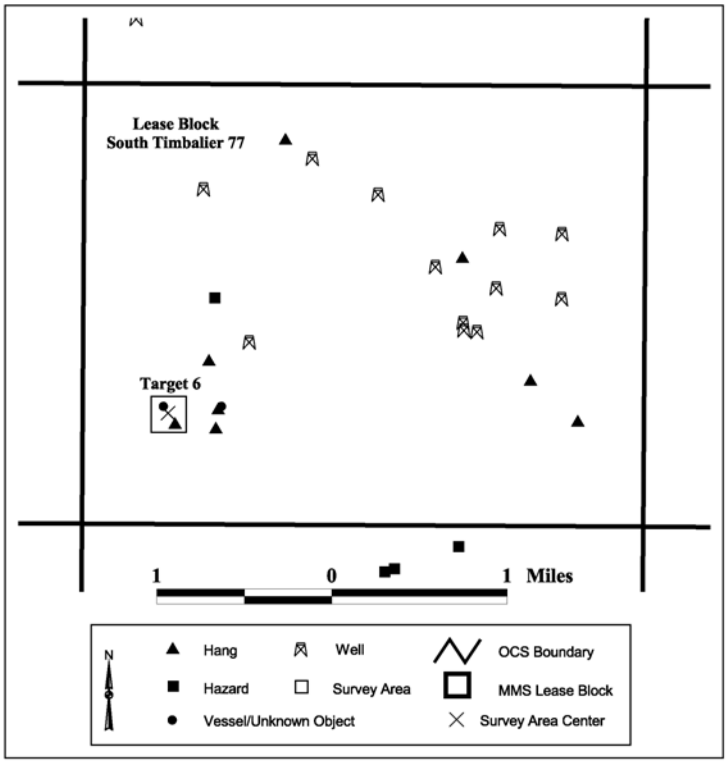


Figure 5-17. Target 6, ST 77 survey area.

Target 7, SS 71. Target 7, located in lease block Ship Shoal 71, consisted of two reported hang locations positioned approximately 700 feet apart (see Table 5-1; Figure 5-18). One hang location came from Texas A&M records and was a converted Loran position. The other hang location came from MMS Fisherman Contingency Fund records and may be a converted Loran coordinate, although this is not specified in the available records. The fact that the hang was reported in 1986, before GPS was in common use, suggests it was originally recorded in Loran.

The survey area at Target 7 consisted of a 1,350-foot-by-700-foot block centered at Louisiana South State Plane Coordinates (NAD 27) N = 103952; E = 2133989, a point midway between the two hang locations. Sidescan sonar coverage of this block was achieved with seven survey lines spaced 110 feet apart and run in a north-south direction. Sidescan sonar swath coverage was set at 50 meters per channel. No seafloor features were observed on the sonar records and no additional work was undertaken at Target 7.

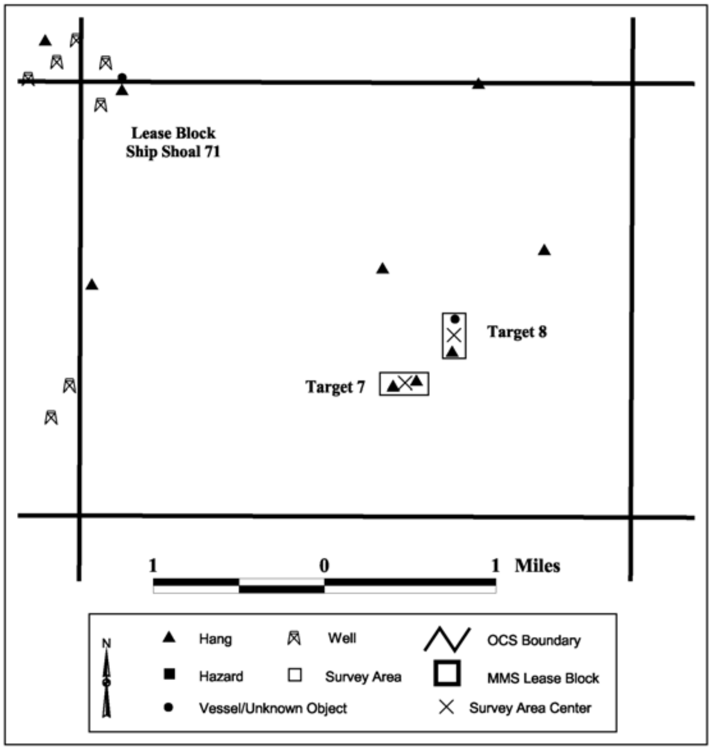


Figure 5-18. Target 7, SS 71 and Target 8, SS 71 survey area.

Target 8, SS 71. Target 8 is located in lease block Ship Shoal 71, a short distance northeast of Target 7. The items in Target 8 consisted of one reported hang and one unknown object (CEI ID Number 12379 in the 2001 shipwreck database) (Figure 5-18). The unknown object had been assigned a poor location reliability factor of 4. A 650-foot-by-1450-foot survey block was established over the target area, centered at Louisiana South State Plane Coordinates (NAD27) N = 105495; E = 2135365, a point midway between the hang and object locations. Sidescan sonar coverage of this block was achieved with seven survey lines spaced 110 feet apart and run in a east-west direction. The sidescan sonar swath coverage was set at 50 meters per channel. A careful review of the collected sonar records revealed no objects of interest on the bottom and Target 8 was eliminated from additional consideration.

Target 9, SS 73. Target 9, located in lease block Ship Shoal 73, consisted of two reported hang locations and two unknown objects (see Table 5-1; Figure 5-19). Both objects are assigned a poor location reliability of 4. A survey grid measuring 1,700 feet by 1,000 feet was centered over a point representing the midpoint of this cluster of objects (at Louisiana South State Plane Coordinates [NAD27] N = 108065; E = 2097455). This target was surveyed on August 23, 2001, and coverage was achieved with seven track lines run in a east-west orientation. Survey lines were spaced at 150 feet with swath coverage set at 50 meters per channel.

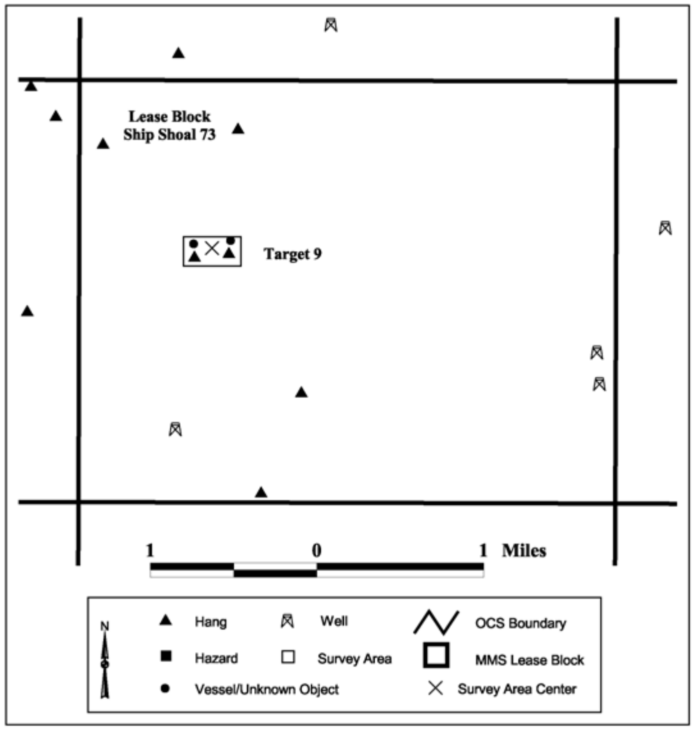


Figure 5-19. Target 9, SS 73 survey area.

The sidescan sonar records revealed the presence of one feature of interest in the target area. This was an elongated object, narrower at one end than the other, that somewhat resembled a stretched-out trawl net (Figure 5-20). The anomaly covers an area approximately 66.42 feet square. The existence of this object resulted in the selection of Target 9 for later magnetometer survey and diver investigation.

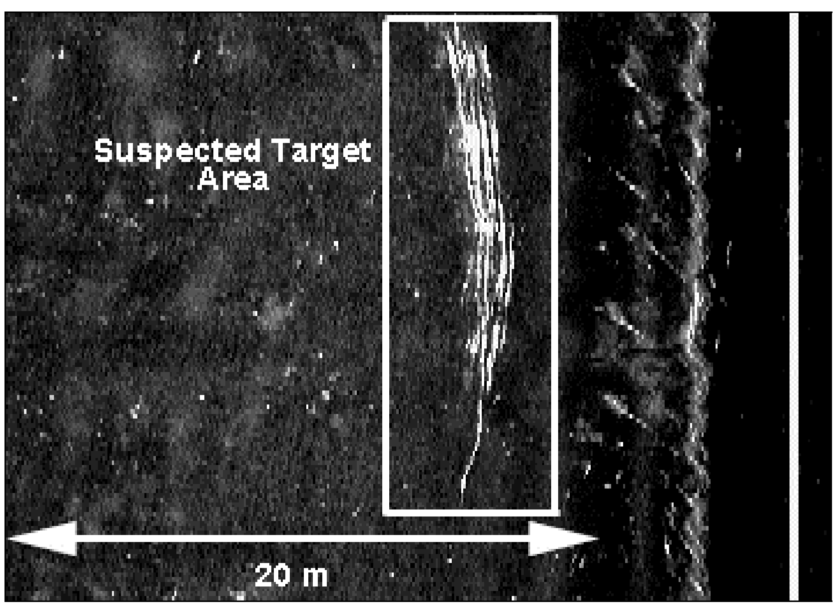


Figure 5-20. Sidescan sonar image of Target 9, SS 73, tentatively identified as a trawl net.

Target 10, SS 109. Target 10 is located in lease block Ship Shoal 109 in approximately 40 feet of water. The target contained a single reported hang and two unknown vessels (see Table 5-1). One vessel had been assigned a moderate location reliability of 2 and the other a poor location reliability of 4. A survey block measuring 1,300 feet by 1,000 feet that encompassed these objects was surveyed with the sidescan sonar on August 22, 2001 (Figure 5-21). This block was centered at Louisiana South State Plane Coordinates (NAD27) N = 60816; E = 2080221. Complete coverage of this block was attained with seven survey track lines oriented in an east-west direction and spaced 170 feet apart. Sidescan sonar swath coverage was set at 50 meters per channel. No objects of interest were identified on the sonar records and no additional investigations were conducted at Target 10.

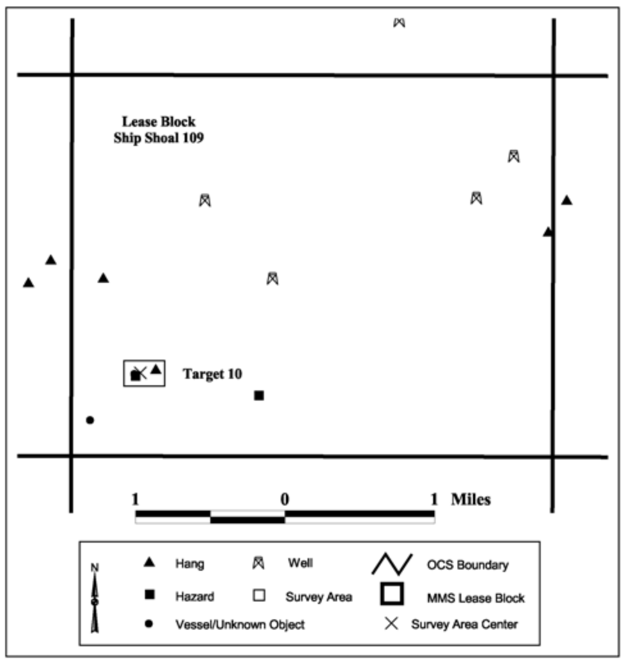


Figure 5-21. Target 10, SS 109 survey area.

Target 11, PL 2. Target 11 is located in lease block South Pelto 2 in approximately 30 to 35 feet of water. The items identified at this target were a single reported hang and single unknown object that had been assigned a poor location reliability of 4 (see Table 5-1). The survey grid at Target 11 measured 800 feet by 1,800 feet in size and was centered at Louisiana South State Plane Coordinates (NAD27) N = 122525; E = 2210109, a point midway between the reported positions of the two items of interest (Figure 5-22). Full survey coverage of the Target 11 area was obtained with seven survey track lines oriented in a north-south direction and spaced 100 feet apart. Sidescan sonar swath coverage was set at 50 meters per channel. A review of sonar records during and after the survey revealed no objects of interest within the area and it was eliminated from additional investigations.

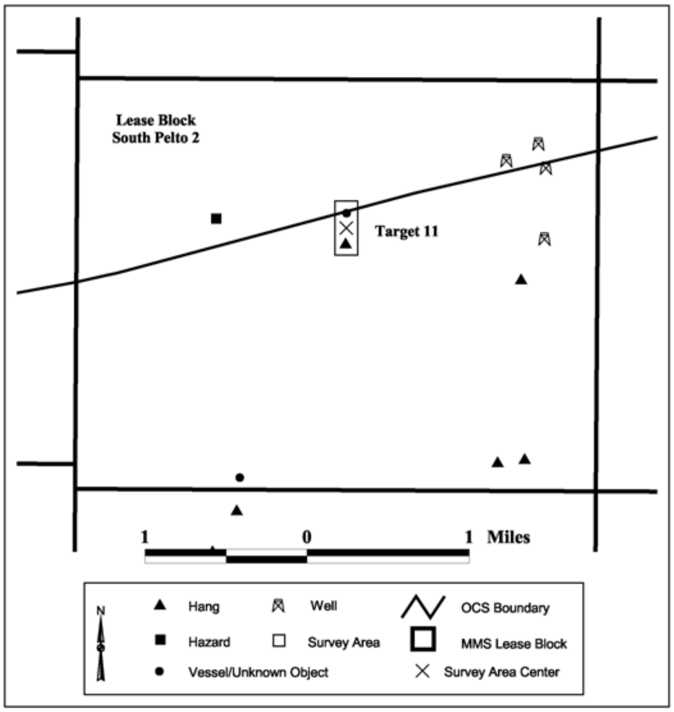


Figure 5-22. Target 11, PL 2 survey area.

Target 12, PL 5. Target 12, located in lease block South Pelto 5, consisted of one reported hang and one unknown vessel that had been assigned a poor location reliability of 4 (see Table 5-1). Water depths over the target area ranged from 30 to 35 feet. The sidescan sonar survey of Target 12 was conducted on August 22, 2001 (Figure 5-23) and involved examination of an area measuring 1,000 feet by 1,600 feet. This survey block was centered at a point midway between the reported positions of the hang and the unknown vessel (at Louisiana South State Plane Coordinates [NAD27] N = 123641; E = 2260010), and complete coverage was achieved with seven survey lines run in a north-south direction and spaced 100 feet apart. Swath coverage was set at 50 meters per channel. A review of all sidescan sonar records failed to identify any seafloor objects of interest within the survey area. Therefore, Target 12 was eliminated from further investigation.

Target 13, PL 14. Target 13, located in lease block South Pelto 14, consisted of three reported hang locations, all derived from Texas A&M records. The water depth at Target 13 is approximately 42 feet. A survey grid measuring 1,400 feet by 2,600 feet was positioned over a spot representing the center point of this group of hangs (Louisiana South State Plane Coordinates [NAD27] N = 98381; E = 2236364) (Figure 5-24). Full sidescan sonar coverage was achieved with seven survey lines spaced 220 feet apart and run in a north-south direction. Careful review of the sidescan sonar records identified no objects of interest within the area and Target 13 was eliminated from further investigations.

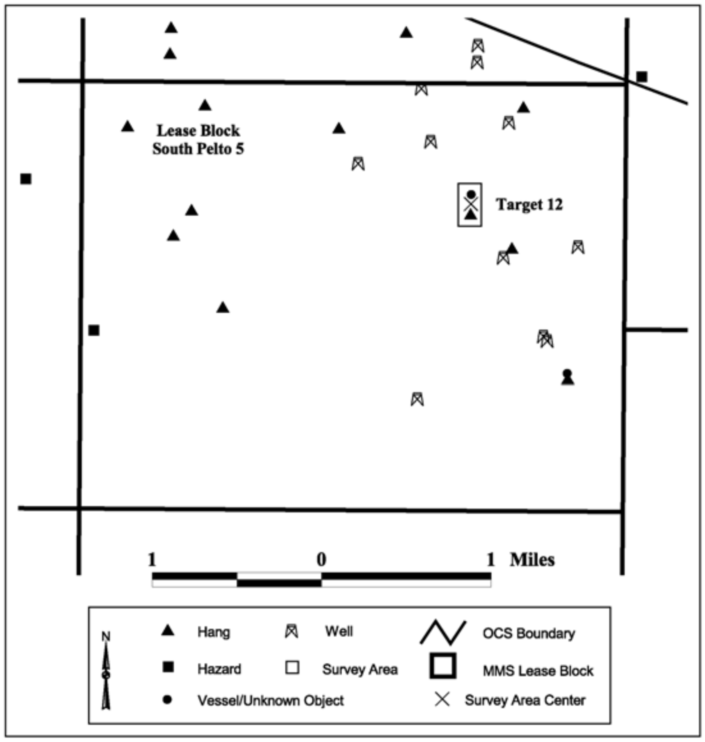


Figure 5-23. Target 12, PL 5 survey area.

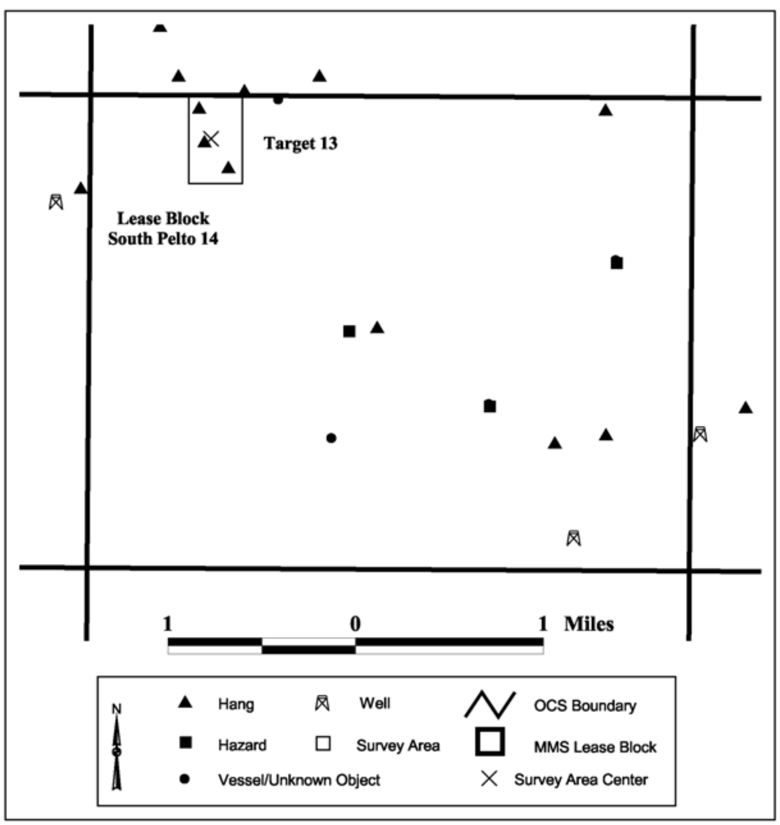


Figure 5-24. Target 13, PL 14 survey area.

Target 14, VR 35. Target 14 was located in lease block Vermilion 35 and consisted of one reported hang and one unknown vessel that was assigned a poor position reliability of 4 (see Table 5-1). The hang position is derived from MMS Fisherman Contingency Fund data and the record notes that the hang "broke 2 nets," seemingly indicating a substantial object on the bottom. A 1,000-by-1,000-foot survey block was established over a point midway between the two objects (at Louisiana South State Plane Coordinates [NAD27] N = 279330; E = 1676149), and sidescan sonar coverage was obtained with seven survey lines run in a north-south direction (Figure 5-25). Swath coverage was set at 50 meters per channel. Water depth on site was about 30 feet.

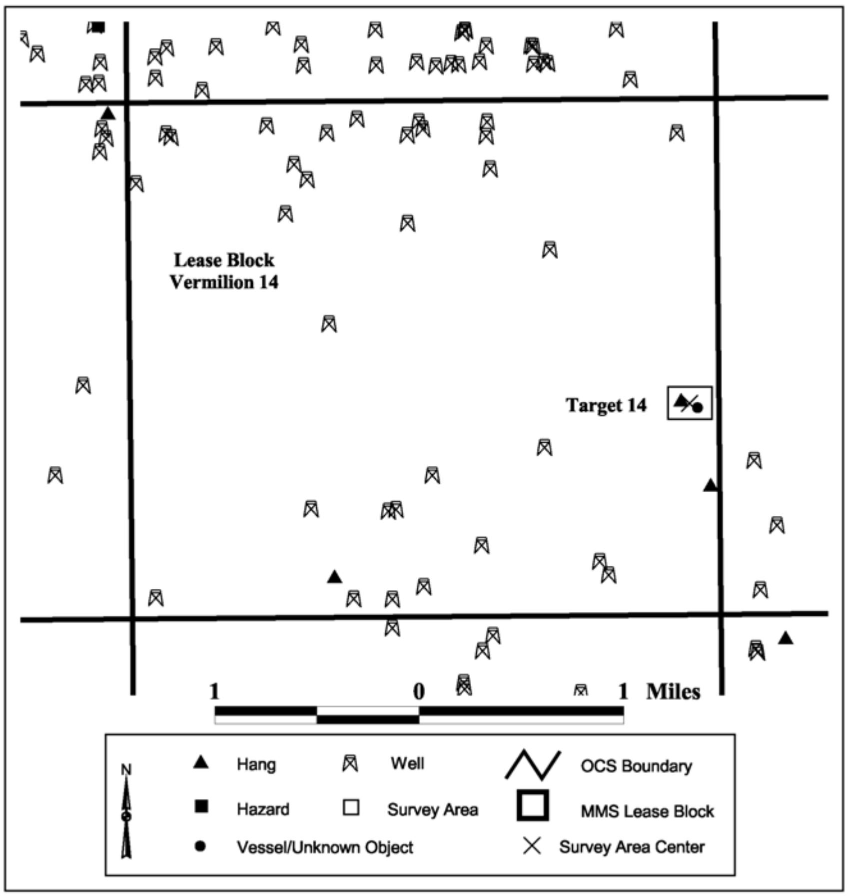


Figure 5-25. Target 14, VR 35 survey area.

The sidescan sonar records revealed a group of three low rises or humps on the seafloor in the target area (Figure 5-26). These rises cover a small area measuring 29.3 feet square. Because of the presence of these objects, Target 14 was slated for additional investigation in the form of a magnetometer survey and diver examination.

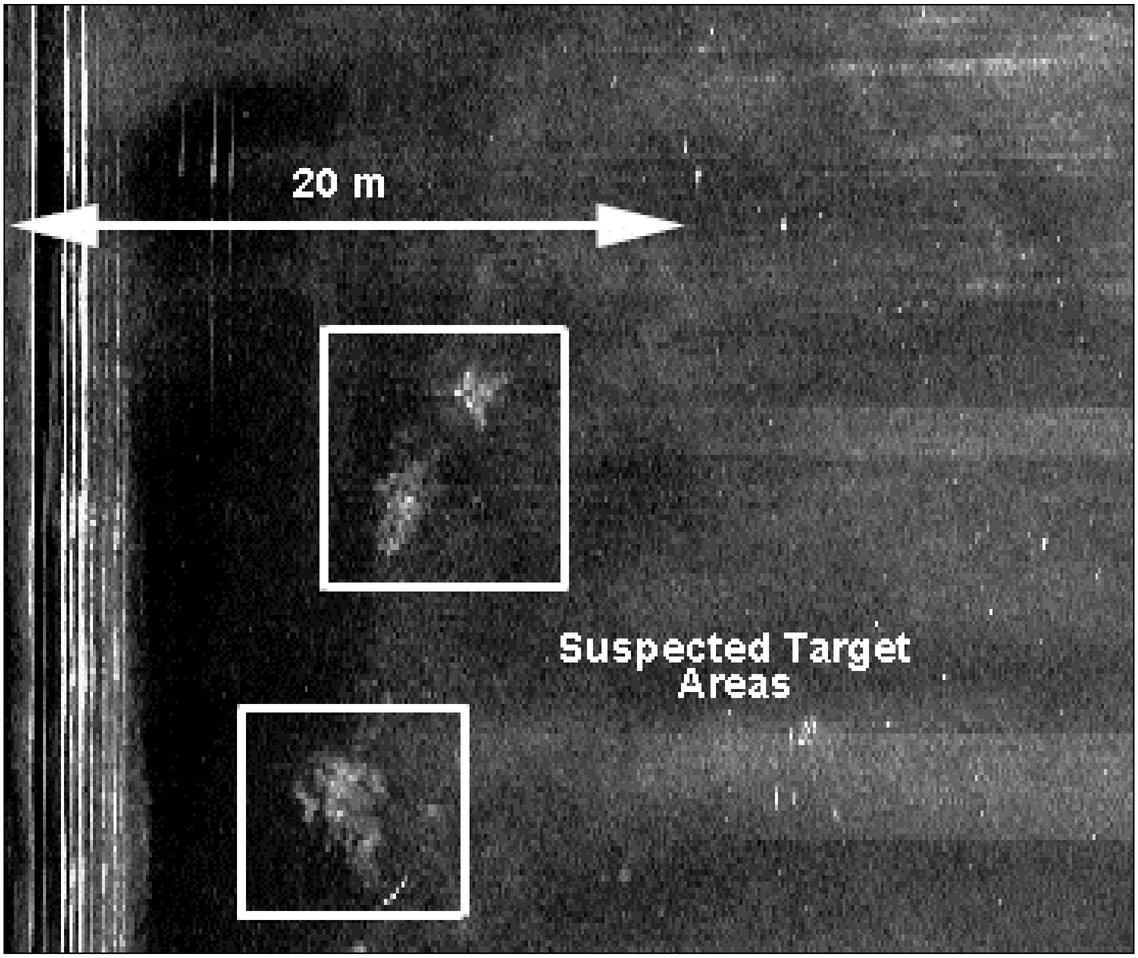


Figure 5-26. Sidescan sonar image of Target 14, VR 35, identified as three small rises off the seafloor.

Target 15, VR 118. Target 15, located in lease block Vermilion 118, contained a single unidentified object recorded during an MMS-mandated survey and assigned a position reliability of 1 (see Table 5-1). A survey grid measuring 600-feet-square was positioned over the object location (at Louisiana South State Plane Coordinates [NAD27] N =164262; E= 1633365), and the sidescan sonar survey of the target was conducted on August 21, 2001 (Figure 5-27). Coverage of the area was achieved with seven survey lines spaced 100 feet apart, oriented in a north-south direction. Sidescan sonar swath coverage was set at 50 meters per channel and water depth on site was 65 feet.

Sonar records revealed the presence of an object on the seafloor near the center of the surveyed area. The object was recorded on three alternate track lines and appeared to consist of a linear feature measuring approximately 45 feet long, off of which extended a number of shorter, diagonal and intersecting pieces (Figure 5-28). The identity of this somewhat amorphous-shaped object could not be determined, but its regular and geometric form suggested it was a cultural item and, thus, it was slated for additional magnetometer survey and diver investigation.

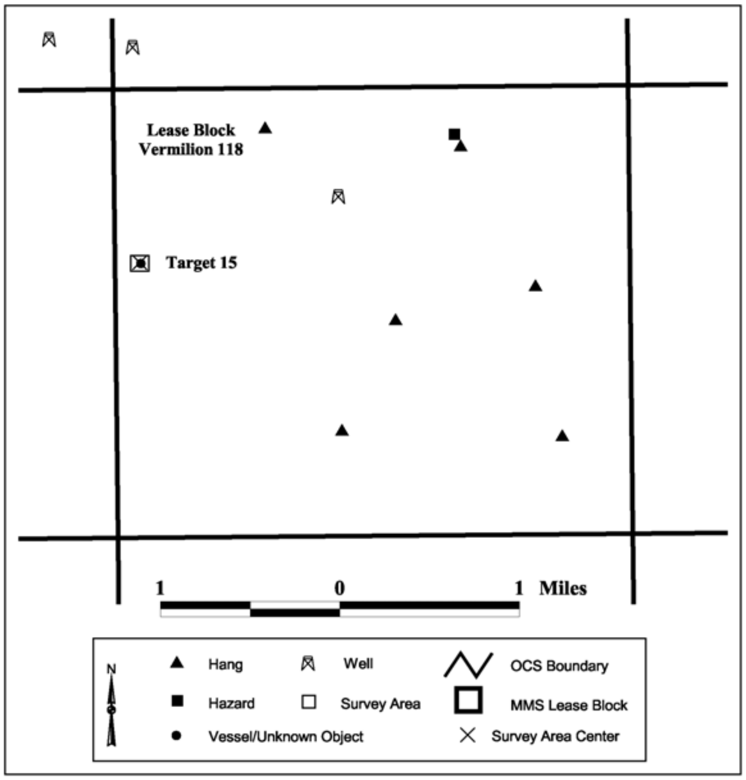


Figure 5-27. Target 15, VR 118 survey area.

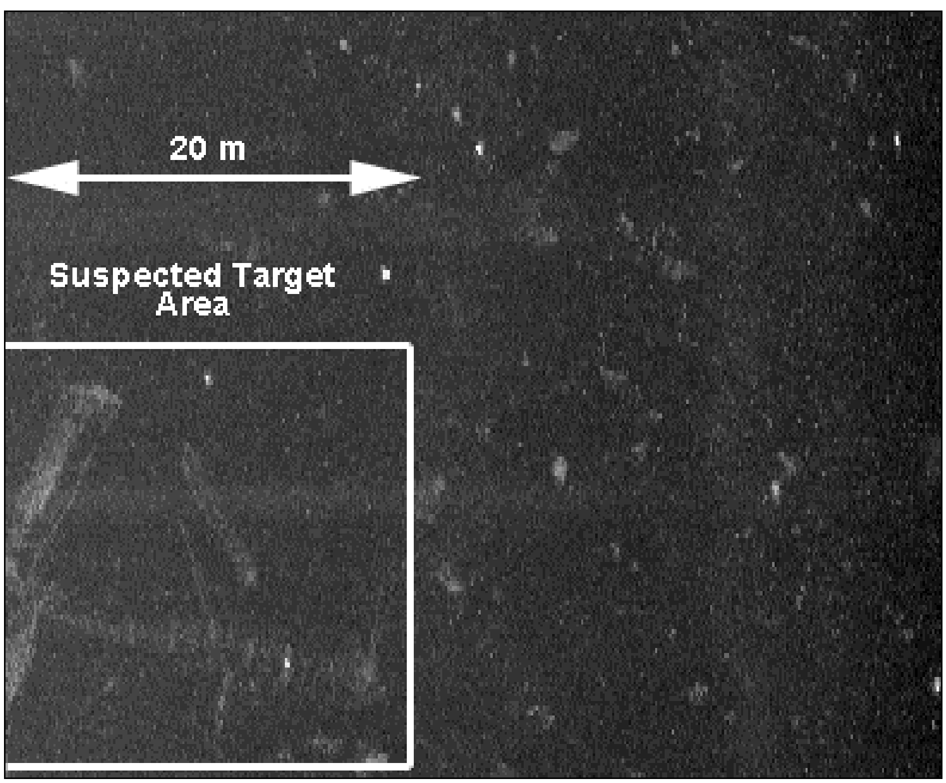


Figure 5-28. Sidescan sonar image of Target 15, VR 118. Note the interesting linear features of the target.

Target 16, EI 23. Target 16, located in lease block Eugene Island 23, consisted of three reported hangs and one unknown vessel. All of the hangs were derived from MMS Fisherman Contingency Fund records and the unknown vessel had been assigned a location reliability of 4, indicating poor reliability (see Table 5-1). A 1,600-foot-by-2,000-foot survey grid, centered on the midpoint of the cluster of items (at Louisiana South State Plane Coordinates [NAD27] N = 246163; E = 1870024), was established and the sidescan sonar survey was conducted on August 23, 2001 (Figure 5-29). Coverage was achieved with seven survey lines oriented in an east-west direction and spaced 195 feet apart. Sidescan sonar swath coverage was set at 50 meters per channel. Water depth at Target 16 ranged from 15 to 18 feet.

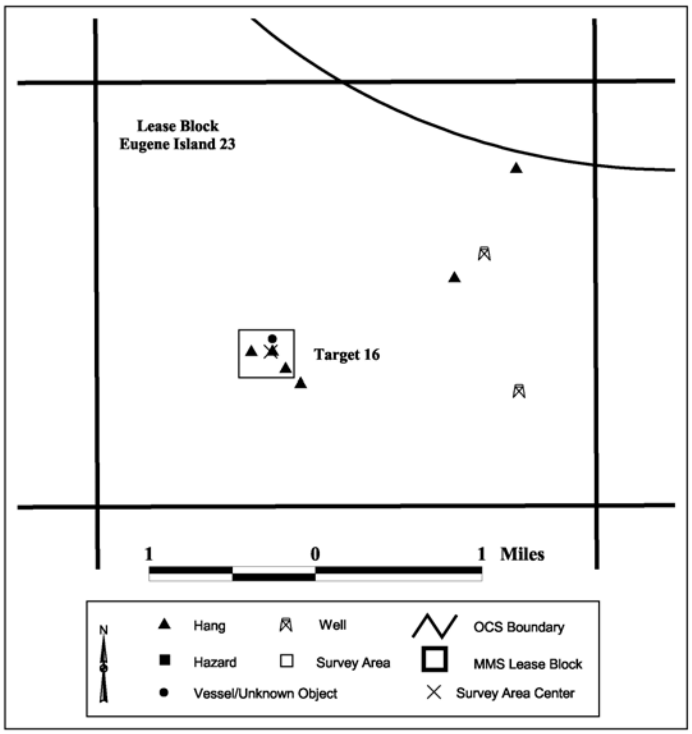


Figure 5-29. Target 16, EI 23 survey area.

A careful review of sonar records identified no objects of interest and no additional work was slated for Target 16.

Target 17, EI 42. Target 17, located in lease block Eugene Island 42, consisted of two reported hangs and one unknown vessel (see Table 5-1; Figure 5-30). The vessel had been assigned a poor location reliability of 4. A 1,700-foot-by-1,500-foot survey grid was established over the center point of the three items (at Louisiana South State Plane Coordinates [NAD27] N = 212656; E = 1919534); the sidescan sonar survey was conducted along seven track lines spaced 235 feet apart and oriented in an east-west direction. Sidescan sonar coverage was set at 50 meters per channel. Water depths over the survey area ranged from 20 to 25 feet. A review of the sidescan sonar records identified a large area of unidentified objects consisting of parallel, linear and somewhat sinuous features (Figure 5-31).

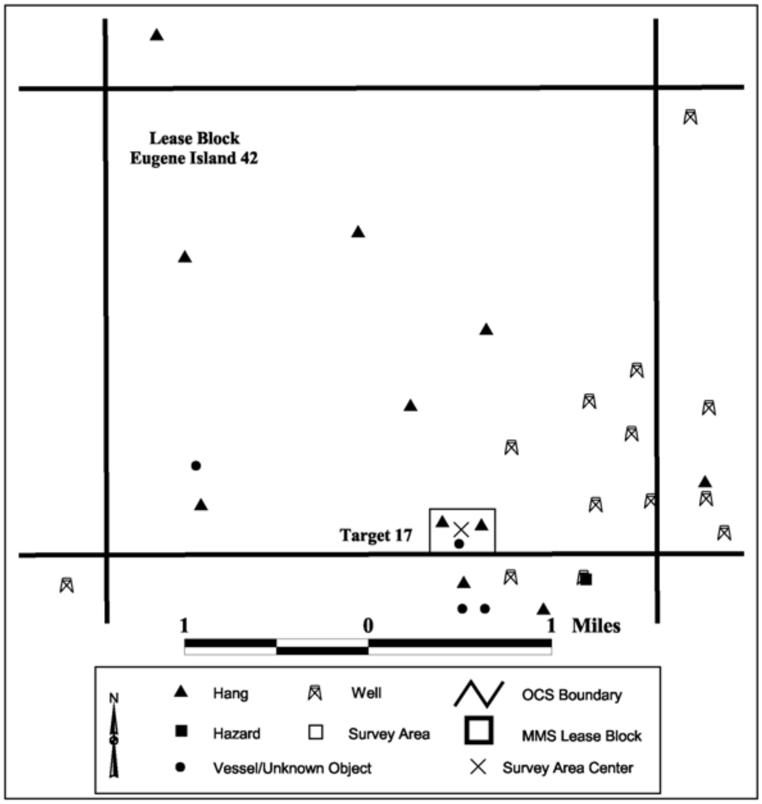


Figure 5-30. Target 17, EI 42 survey area.

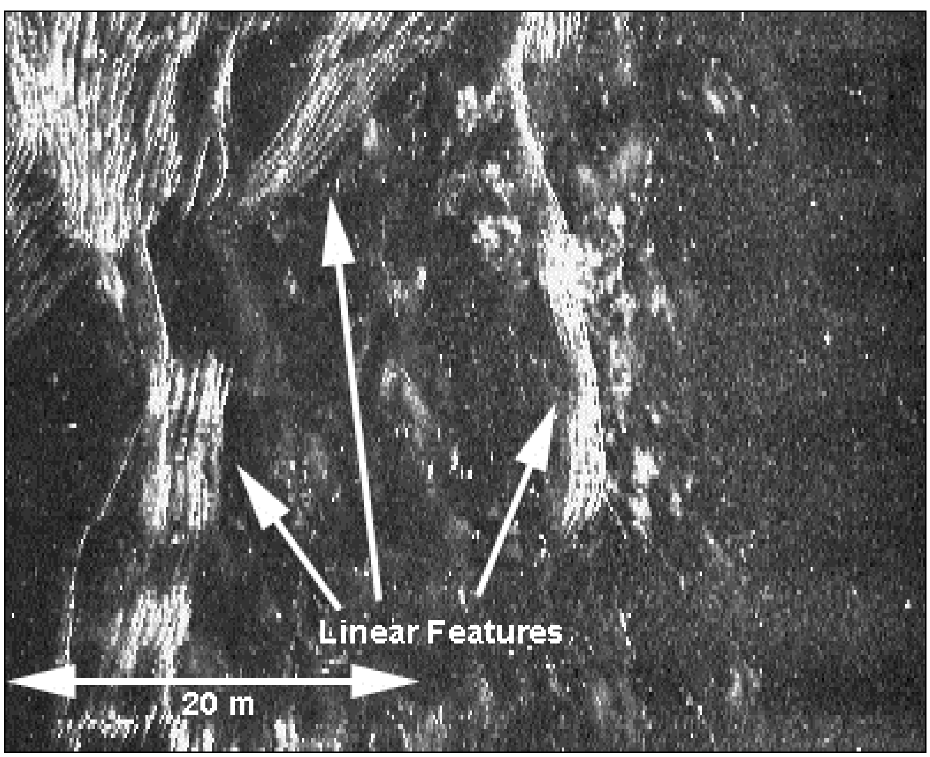


Figure 5-31. Sidescan sonar image from Target 17, EI 42 showing numerous linear features.

These features resembled the drag scars from trawling activity that were commonly observed in this and other areas surveyed, but these were more obvious and much more clearly delineated than any others observed. Although these features might simply reflect very recent trawling activity at this location, it was decided to conduct a magnetometer survey and diver investigations at Target 17 to try to verify their identity.

Target 18, EI 53. Target 18, located in the northeastern corner of lease block Eugene Island 53, consisted of one reported hang site and two unknown vessels, both of which had been assigned a poor location reliability of 4 (see Table 5-1). A survey block measuring 1,500 feet by 1,400 feet was established over the midpoint of this cluster of items (at Louisiana South State Plane Coordinates [NAD27] N = 210472; E =1919780), and the sidescan sonar survey was conducted on August 23, 2001 (Figure 5-32). Full coverage of the target area was achieved with seven survey track lines spaced 220 feet apart. The water depth at the target was 21 feet.

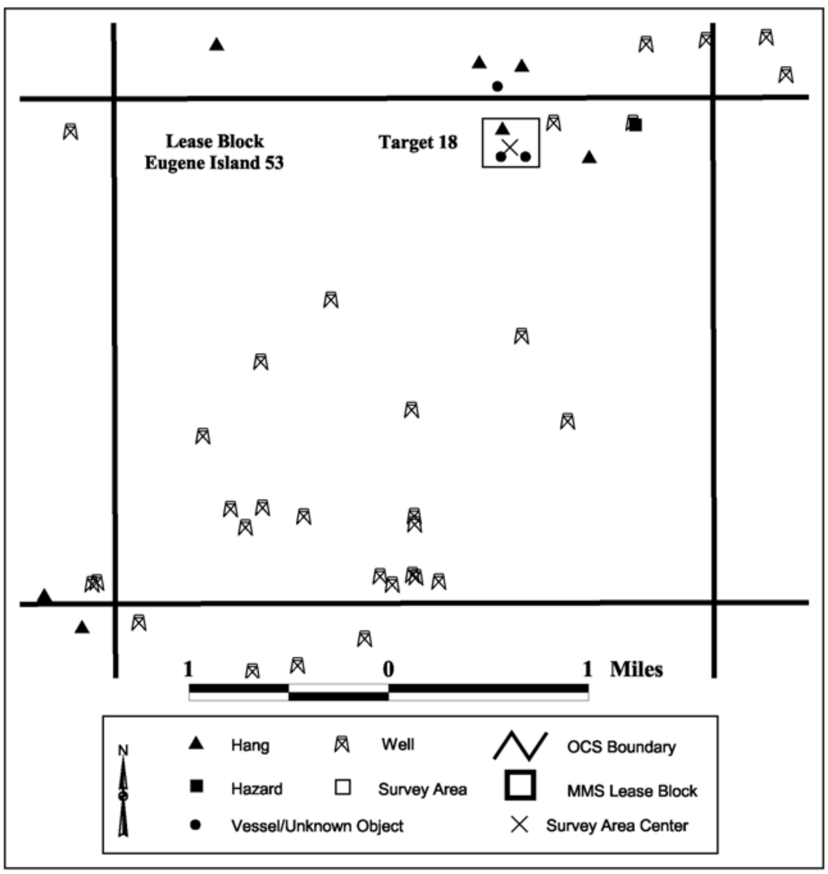


Figure 5-32. Target 18, EI 53 survey area.

As was typical of many of the areas surveyed, a number of drag marks from shrimp trawling activity were observed in the Target 18 area. No other obvious cultural features were observed on sonar records; however, what appeared to be a depression in the seafloor was noted (Figure 5-33). The depression appears to be associated with a shrimp trawler scar extending across the seafloor. Because this target represented an anomalous feature on the seafloor, it was slated for additional investigations by magnetometer and divers.

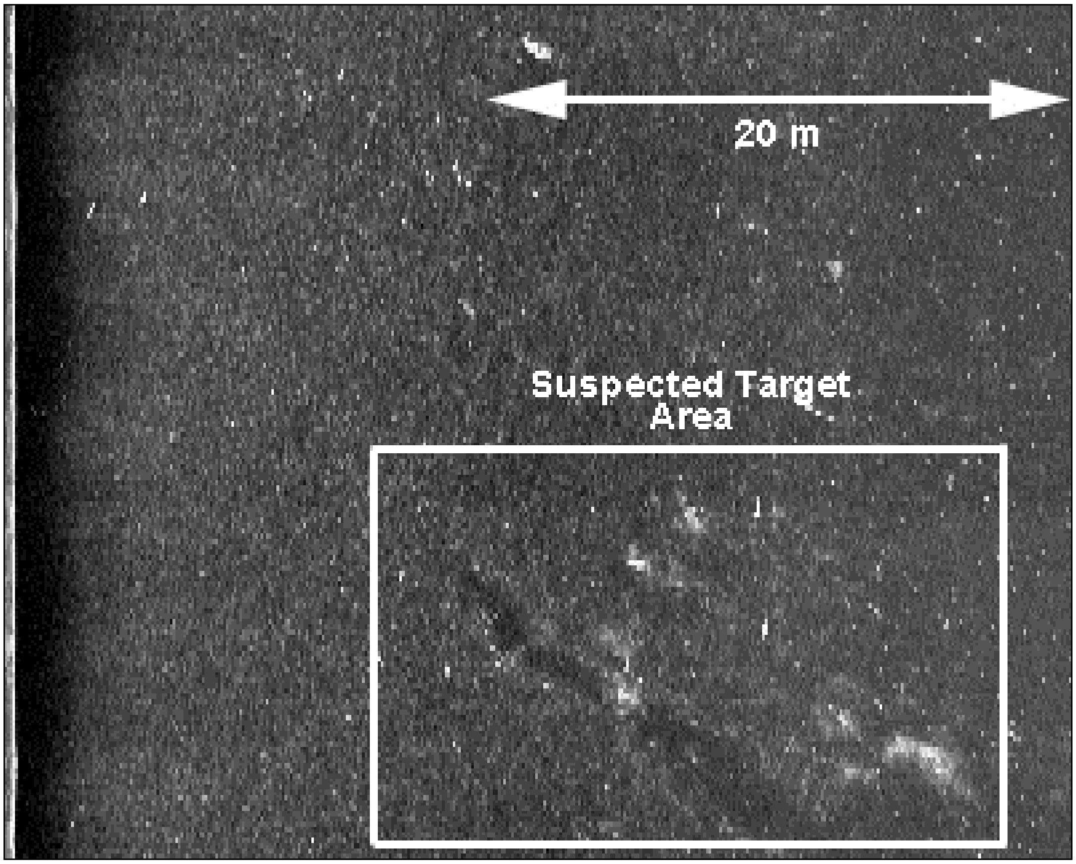


Figure 5-33. Sidescan sonar image from Target 18, EI 53 showing what appears to be a depression in the seafloor.

Target 19, EI 68. Target 19, located near the northern boundary of lease block Eugene Island 68, consisted of three reported hang locations (see Table 5-1). Two of these hangs come from Texas A&M records and one comes from MMS Fisherman Contingency Fund records. A survey block measuring 1,300 feet by 1,300 feet was established over the midpoint of the cluster of hangs (at Louisiana South State Plane Coordinates [NAD27] N = 196479 E = 1854345), and it was surveyed along a series of seven track lines spaced 200 feet apart and oriented in a north-south direction (Figure 5-34). The water depth at Target 19 was 30 to 35 feet.

Monitoring of the sonar records during the survey, as well as a complete review of all records at a later date, identified no seafloor features of interest in the Target 19 area. Therefore, no additional work was slated for this target.

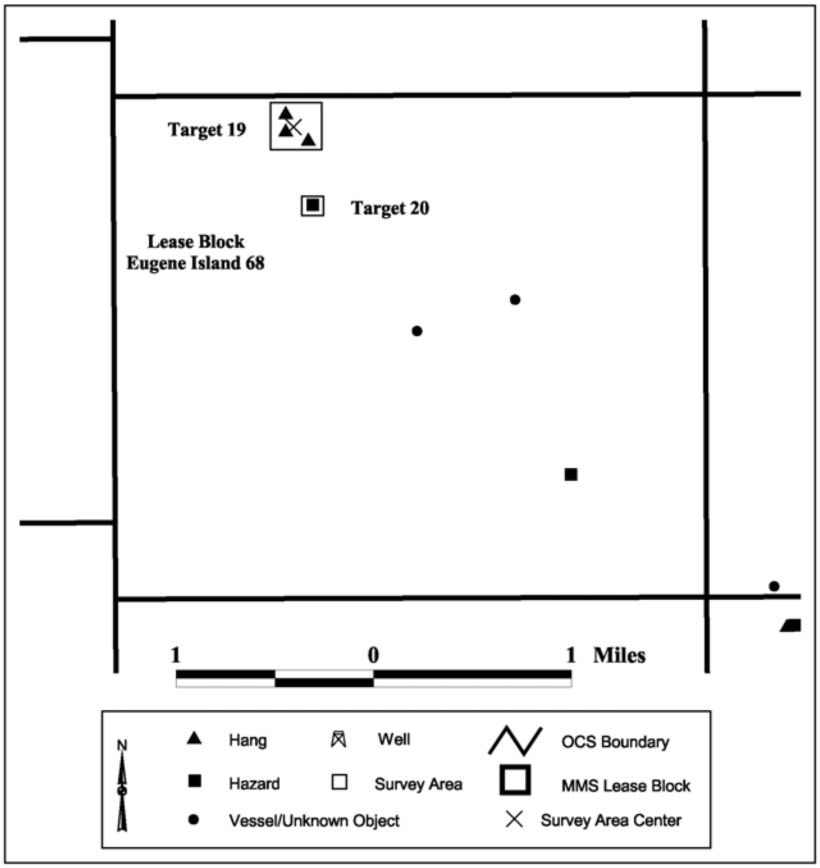


Figure 5-34. Target 19, EI 68 and Target 20, EI 68 survey areas.

Target 20, EI 68. Target 20 consisted of a single unknown object located in the northwestern quarter of lease block Eugene Island 68 that was assigned a poor location reliability of 4 (see Table 5-1). This object is derived from USCG records that identify it as an “obstruction” and note that there was a report of a cable snagging on it (see CEI ID Number 7076 in the 2001 shipwreck database). A 600-foot-by-600-foot survey grid was centered over the reported position of the object (Louisiana South State Plane Coordinates [NAD27] N = 194237; E = 1854821) (Figure 5-34). Full coverage of the target area was achieved along a series of seven track lines, spaced at 100-foot intervals.

The sidescan sonar records revealed no features of interest and Target 20 was eliminated from additional examination.

5.1.4. Diver Investigations: Methods

The sidescan sonar surveys identified objects of interest at nine of the 20 targets examined. Information on those targets containing objects of interest is listed in Table 5-2. Each of these targets was subjected to a systematic magnetometer survey and then diving was conducted.

Table 5-2. Targets Slated for Diver Investigation

Target Number	MMS Lease Block	Northing	Easting	Area	Length	Comments
1	SM17	91412.389	1769078.602	na	6.16m	Linear features, likely manmade.
5a	ST20	120988.557	2326372.413	77.6 m. sq.	9.28m	Sizeable rise off seafloor.
5b	ST20	121970.913	2327104.371	na	na	Unidentified linear feature(s) with lg. amounts of sea life.
9	SS73	107659.226	2097948.188	na	20.13m	Linear feature, possibly trawling net.
14	VR35	279351.382	1675945.699	10 m. sq.	4.45m	Three small rises off seafloor.
15	VR118	164324.464	1633326.653	na	14.21m	Criss-crossed linear features, likely manmade.
17	EI42	212565.767	1918883.951	na	na	Unidentified linear feature(s) with lg. amounts of sea life.
18	EI53	210344.367	1920340.807	na	26.05m	Sizeable depression in the seafloor.

(Note: All coordinates are presented in Louisiana South State Plane, NAD 27).

The magnetometer survey utilized a Geometrics G-866 magnetometer and similar survey procedures were conducted at each of the nine targets. Initially, a survey block measuring 600 feet by 600 feet was established over each target location using the coordinates obtained from the sidescan sonar survey as the center point of the block. The survey of each target was conducted along a series of parallel track lines spaced at 100-foot intervals. The magnetometer sensor was towed behind and beyond the magnetic influence of the vessel and at a depth of not more than 20 feet above the bottom. All magnetometer data were integrated concurrently with the DGPS and onboard navigation system. A review of the collected magnetic data was undertaken in the field to determine the absence/presence of ferrous metal within the survey area. If magnetic anomalies were recorded within the area, their location was noted and procedures to refine their positions were conducted. This refinement involved conducting additional passes over the anomaly with the magnetometer and dropping buoys at the point of maximum magnetic change, the presumed center of the magnetic anomaly. Buoys were continually dropped and recovered until this point was precisely located (Figure 5-35). Once the magnetic target was relocated and buoyed, remote-sensing operations ceased and diving began.

Initial diver investigation of targets took place between September 12 and 15, 2001. Vessels employed included the 53-foot M/V *Mañana* and the M/V *Carrier*, a 100-foot utility boat out of Morgan City, Louisiana (leased from Seaboat Rentals, Inc.). Both vessels were mobilized out of Intracoastal City, Louisiana. The *Mañana* was to serve as the dive and survey boat and the *Carrier* as crew accommodations. This was necessary due to the distance offshore of some targets and scarcity of shore facilities along the Louisiana coastline.

Figure 5-35. Buoy deployment during target refinement.

Vessel problems forced an end to the diving activity after just two targets were examined. Target examination was recommenced on October 5, with the vessels M/V *Enterprise* and the M/V *Offshore Retriever*. The M/V *Enterprise*, a 60-foot long-range cruiser/trawler, served as a support vessel and living quarters for the crew (Figure 5-36). The 44-foot M/V *Offshore Retriever* served as the primary survey vessel and dive platform (Figure 5-37). Dive operations were completed on October 18, 2001.

A standard set of procedures was used during the diver investigation of each target. Once the target was relocated and buoyed, the dive vessel was securely anchored over the target location. A diver was then placed in the water at the buoy location to begin a bottom search.

The first objective was to obtain an accurate depth reading using a pneumo gauge, then relay the environmental conditions on the seafloor (i.e., current, bottom type, visibility). Currents tended to be minimal during the investigation and bottom types tended to be soft sediments. Visibility, affected by depth and excessive swell, typically ranged from zero to five feet.

Figure 5-36. Support vessel M/V *Enterprise*.

Figure 5-37. Survey and dive platform vessel M/V *Offshore Retriever*.

If the source of the anomaly was not discovered near the buoyed location, the diver was then guided (by means of surface communications) to a pre-determined distance from the buoy. The diver's location, in relationship to the buoy, was then recorded by the surface crew and further examination involved the diver searching the bottom while swinging in arcs across the target area, controlled by the dive hose. At the end of each arc, the dive hose was let out 10 feet and the diver swung another arc in the opposite direction. While moving along the bottom the diver would extend his body and feel for objects. Diver arcs continued around the buoyed location until the area was systematically and completely covered or until the target was located. Arcs around the target area extended the full length of the diver's rig, typically 200 feet in all directions from the target location. Divers relayed information on bottom conditions (e.g., sediment characteristics, topography) and discoveries to the surface where notes were made.

Surface Supplied Air (SSA) was used during all diving operations. Divers employed a Superlight 17-B helmet connected to a surface-supplied air source, radio communications cable, safety tether, and pneumo hose (Figure 5-38). On the surface various individuals and pieces of equipment ensured safe dive operations. A dive tender was required to aid the diver in donning and doffing equipment and to tend the diver while submerged and moving about the seabed. The radio operator kept in constant contact with the diver and relayed messages between the diver and the surface support team. A standby diver was on site during all diving in case of an emergency. A dive supervisor was present to coordinate the activity of the diver and surface support team.

Figure 5-38. Diver, employing Surface Supplied Air, returning from a dive.

5.1.5. Diver Investigations: Results

Target 1, SM 17. The magnetometer survey of Target 1 was conducted on September 15, 2001. The findings of the sidescan sonar (discussed above) had indicated the presence of several thin, linear elements lying parallel to one another combined with at least three shorter, crossing diagonal members. The maximum length of the object was approximately 47 feet and its position was recorded at state plane coordinates N = 91328; E = 1769119. This position was buoyed and served as the center point for the magnetometer survey. A magnetic contour map showing the results of the survey is presented as Figure 5-39. As can be seen, a relatively complex set of magnetic signatures was recorded, principally in the southeastern quarter of the survey grid. The complex magnetic anomaly located closest to the target observed on sidescan sonar records, at state plane coordinates N = 91330 E = 1769290, had a total magnetic deviation of 114 gammas and covered an area approximately 192 feet across. The intent was to immediately dive on Target 1, but high seas (five to eight feet) and 20-knot winds delayed diving operations until conditions were more favorable.

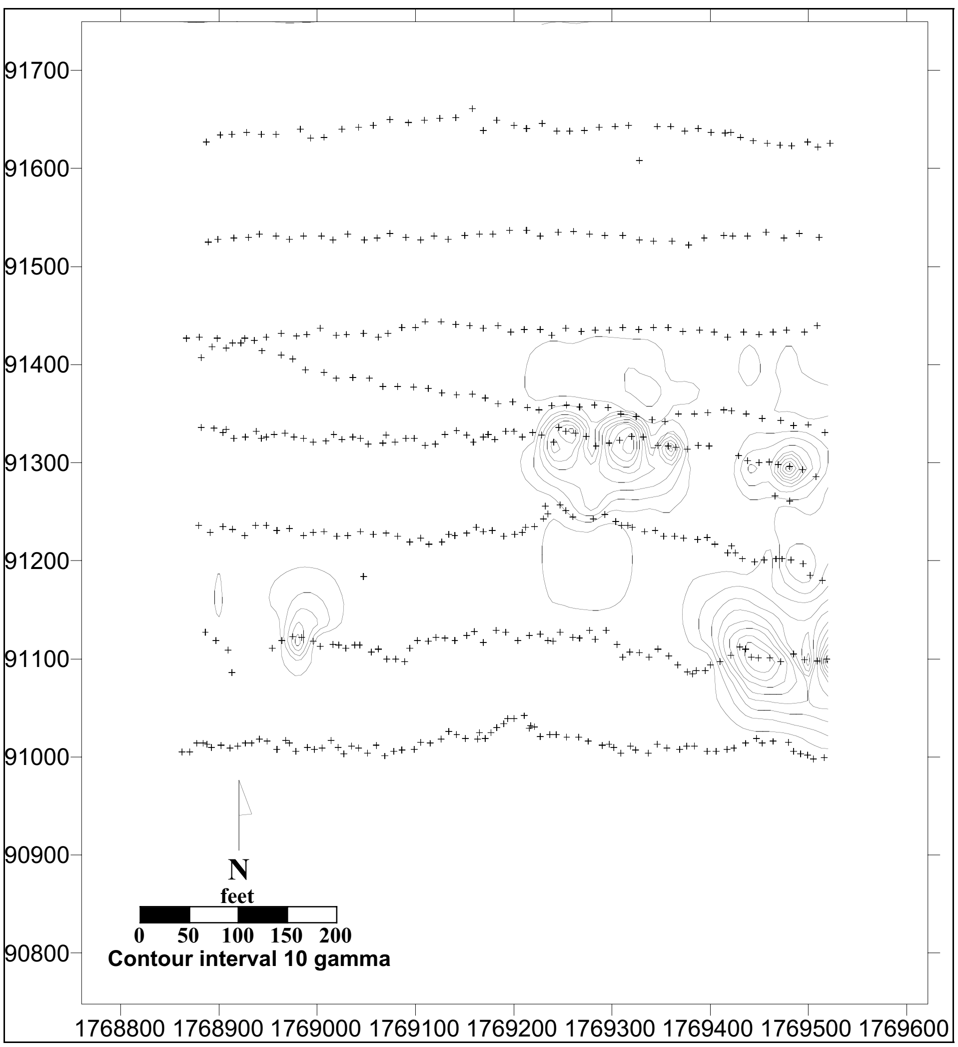


Figure 5-39. Magnetic contour map of Target 1, SM 17.

Diving was conducted at Target 1 on October 18, 2001. Water depth at the target was 81 feet and visibility on the bottom ranged from zero to one foot with no current. Within 11 minutes of searching the target area, the diver located the target, which appeared to be the base of an offshore oil or gas platform. The exposed remains consist of a 12-inch-diameter vertical post; one large iron diagonal reinforcement (extending into the sediment); two smaller diagonal reinforcements (also extending into the sediment); one broken horizontal iron beam (extending off the vertical piling); and two disarticulated iron supports (Figure 5-40). Similarities in this structure can be seen in existing offshore oil and gas platforms that employ larger cylindrical pilings as well as diagonal cross braces (Figure 5-41). A depth reading with a pneumo-gauge taken at the top of the large, vertical post registered 72 feet, meaning that this element rises approximately nine feet above the bottom. The magnetic signatures to the east and southeast of these materials suggest that other remains of the structure exist in that direction.

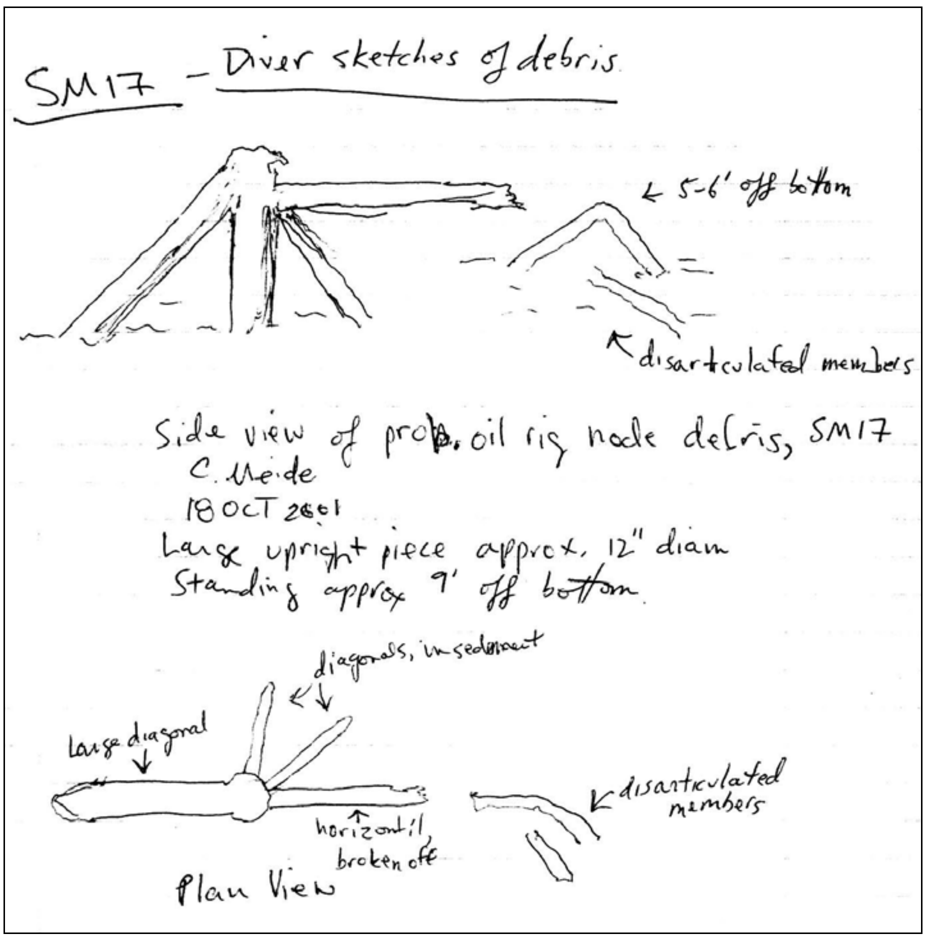


Figure 5-40. Diver sketch of the remains of Target 1, SM 17, identified as the base to an offshore rig (Note: Figure not to scale).

The relief and substantial construction of these objects suggest that they would represent a dangerous hang to shrimp nets. However, neither the Texas A&M nor the MMS data list any hangs in close proximity to Target 1. The diver reported no shrimp trawling nets hung on the obstruction during the investigation.

Figure 5-41. Example of an offshore rig.

Target 2, SM 19. As noted in the previous discussions, the sidescan sonar survey of Target 2 revealed no features of interest. However, the failure to find anything at this location was somewhat unexpected, because the object reported to be here had been discovered during an MMS-mandated remote-sensing survey and, thus, is presumed to have been precisely located. Therefore, despite the negative findings of the sidescan sonar survey, it was decided to undertake a magnetometer survey at Target 2 as an additional check of this area. This survey was conducted on October 18, 2001. The area surveyed consisted of a 600-foot-square block centered on the reported state plane coordinates of the object (N= 85755; E = 1797839). The survey was conducted along nine survey track lines, spaced at 100-foot intervals and oriented in a north-south direction (Figure 5-42). Weather conditions during the survey were relatively calm with two-foot seas and east winds blowing five to 10 knots.

As shown in Figure 5-42, no magnetic anomalies were recorded over the reported target location. There are several possibilities as to why Target 2 was not discovered. It is conceivable that the target location was incorrectly reported in the original survey report. While this is possible, it is unlikely considering the typical accuracy involved in offshore cultural resources and hazard remote-sensing surveys. Another, and probably more reasonable explanation, is that the object has been displaced from its original position by trawling activity. As noted earlier, the original survey report did note that a piece of shrimp net appeared to be attached to the object, suggesting that it was acting as a hang. The size of the object, about 13 by 26 feet, indicates that it might have been a large box or tank of some sort. Although such an object might be heavy, it appears to be of a size that could be dragged at least short distances when caught by a shrimp net.

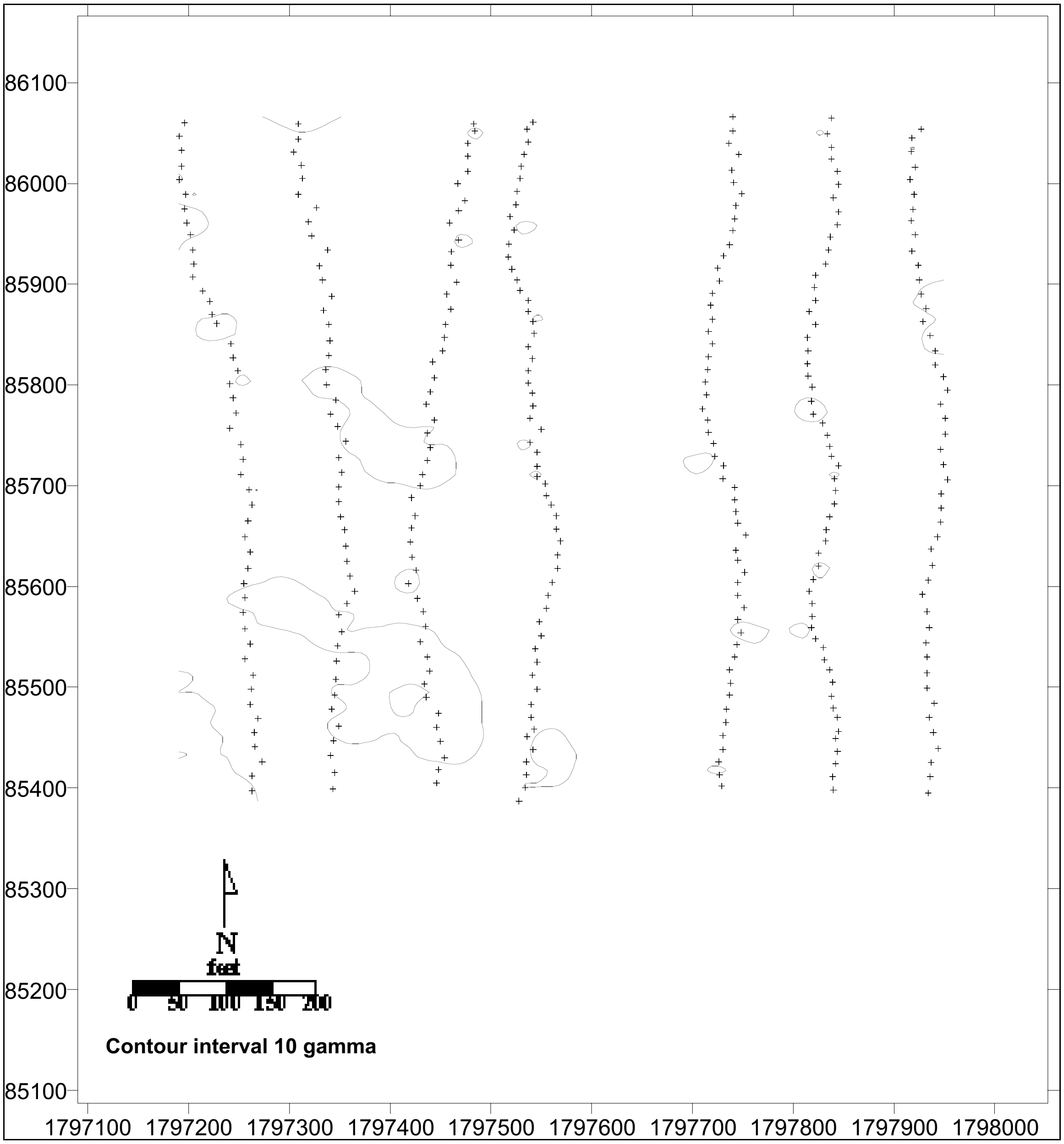


Figure 5-42. Magnetic contour map of Target 2, SM 19.

Target 5a, ST 20. The sidescan sonar survey of the target designated Target 5a identified a hump or rise off the seafloor. It was impossible to determine if this was a natural or a manmade feature. A magnetometer survey of this target location was undertaken on October 8, 2001. The survey was conducted along seven track lines run in a north-south direction over an area measuring 600-feet square (Figure 5-43). This survey block was centered over the position of the identified seafloor feature and the survey lines were spaced 100 feet apart.

The contour map of the recorded magnetics, shown as Figure 5-43, revealed only a small, localized magnetic anomaly in the southeastern portion of the survey block. The magnetic deflection of this anomaly was only 49 gammas and the fact that it was recorded only on a single track line is suggestive of a small, isolated ferrous object. Despite its small size, a diver examined this anomaly. Examination involved the diver searching the bottom while swinging in arcs across the target area, controlled by the dive hose. The water depth at this target was 42 feet. Ultimately, a systematic search of an area measuring 200 feet by 200 feet was covered around the small magnetic anomaly. No objects were discovered.

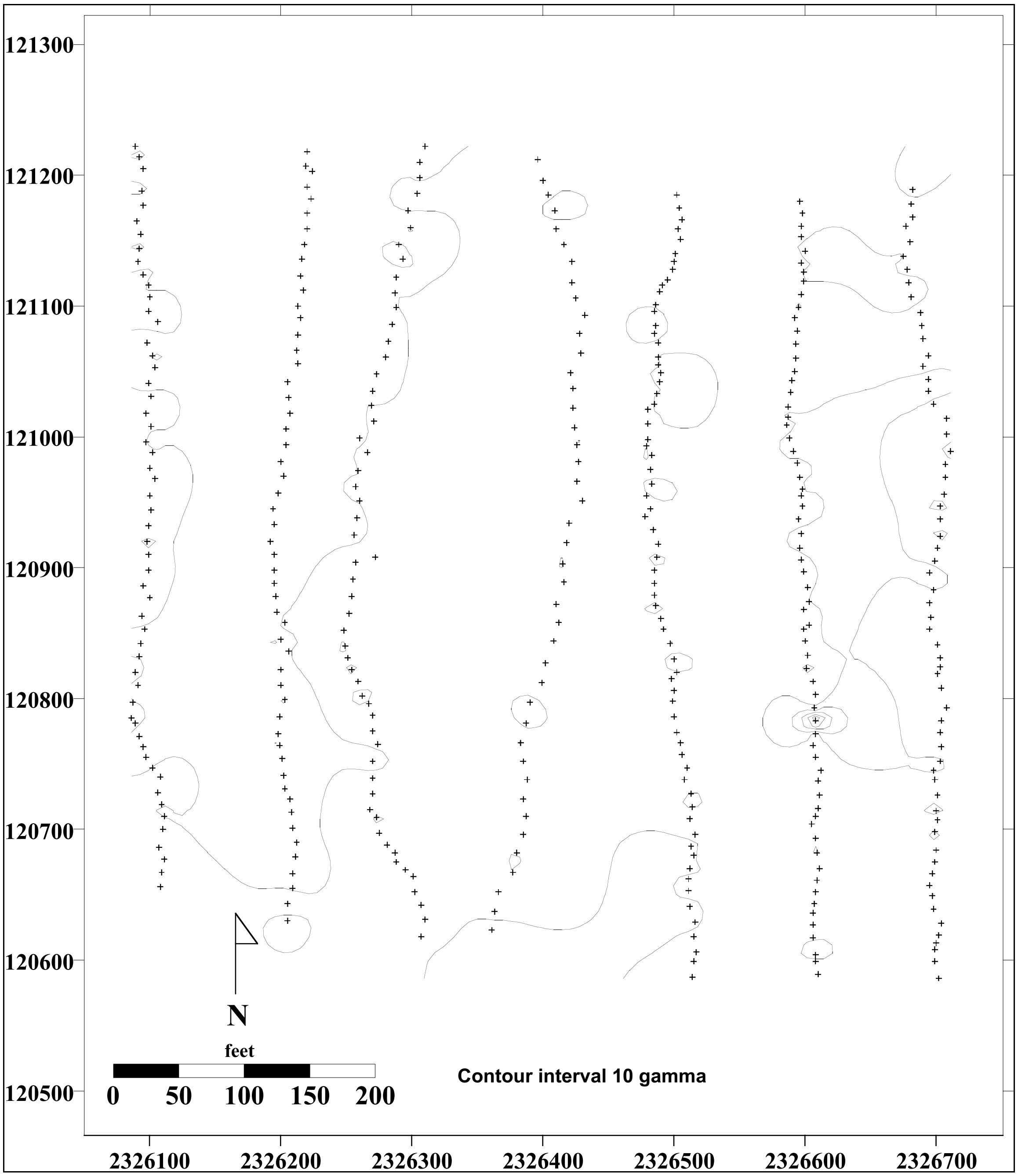


Figure 5-43. Magnetic contour map of Target 5a, ST 20 showing an absence of magnetic material within the survey area.

Target 5b, ST 20. The magnetometer survey of Target 5b, the reported unknown vessel and unknown object located in the northern portion of the Target 5 area, was conducted on October 8, 2001. The sidescan sonar survey of this target revealed the presence of a large number of linear objects on the seafloor. The position of these objects was buoyed and a 600-foot-by-600-foot survey block was established around this point. This block was surveyed with the magnetometer along seven track lines oriented in a north-south direction and spaced 100 feet apart. The survey recorded a large magnetic anomaly very close to the buoyed position at the center of the survey block (Figure 5-44). The total magnetic deviation of this signature was 4,079 gammas and it covered an area approximately 380 feet across. After completion of the basic magnetic survey, the target area was refined with additional survey and a buoy was placed at the identified center of the magnetic signature. During the refinement survey, fathometer records revealed an object rising five or six feet above the seafloor at the magnetic anomaly. The water depth at the target was 38 feet.

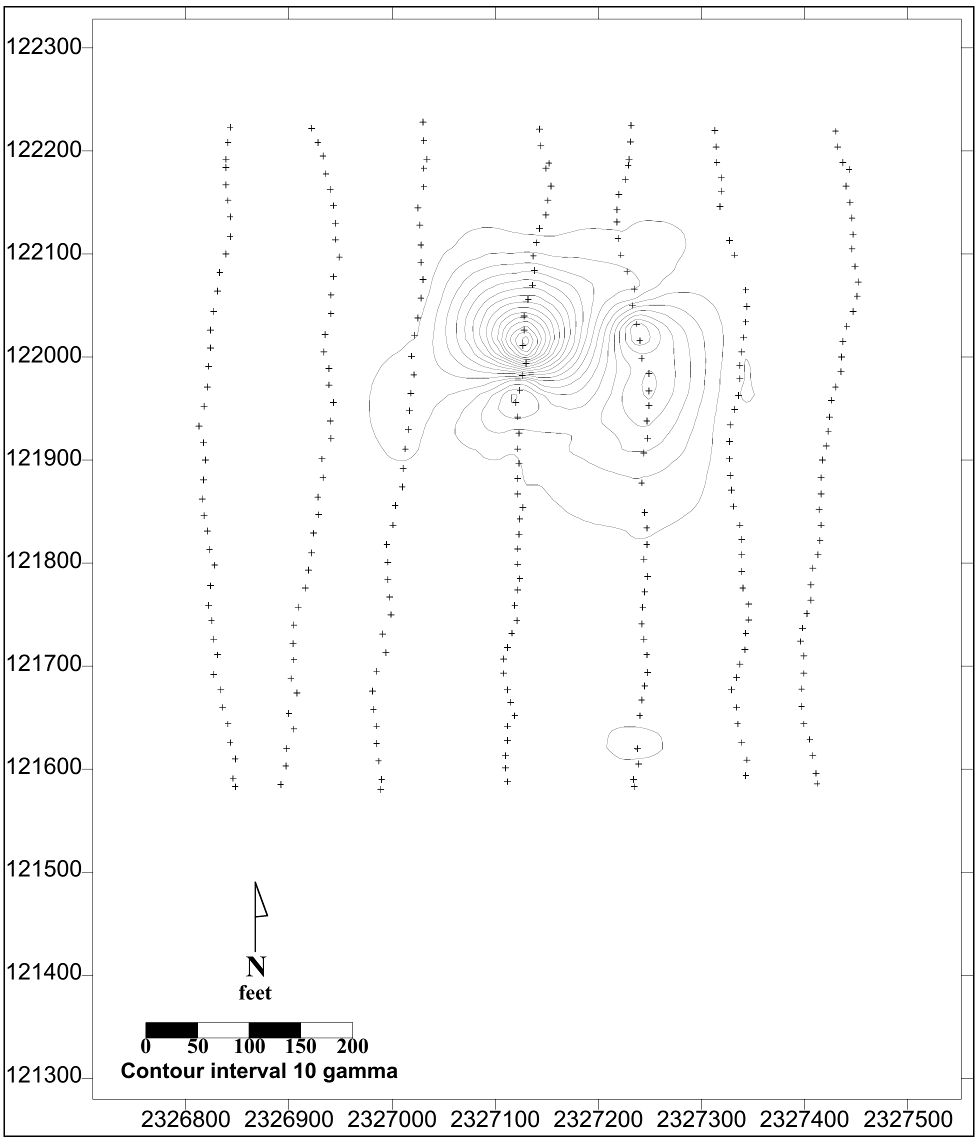


Figure 5-44. Magnetic contour map of Target 5b, ST 20.

Once the target was buoyed, diving operations commenced. Within a few minutes of reaching the bottom, the diver located a large number of iron or steel pipes stacked on the seafloor. The pipes appeared to have diameters ranging from 10 to 12 inches. It was determined that the pipes were oriented in a north-south direction, but their overall length was not ascertained. In some areas the pipes rose five to six feet into the water column. A few pieces of one-inch-diameter rope, apparently entangled in the pipes, were noted. The center of the pile of pipes was determined to be at state plane coordinates N = 121990; E = 2327100.

All of the pipes had a layer of marine growth on their surface and it is presumed that they represent pipeline or platform construction material or dredge pipe. How these pipes got to this location is unknown. It is possible that they accidentally fell off an offshore supply vessel or they may have been purposefully dumped to avoid appropriate disposal procedures. Of some interest is the location of these pipes relative to the various objects identified in the Target 5 area. The pipes are located at almost the exact position of the reported unknown vessel and unknown object designated Target 5b. As noted earlier, both of these items had been assigned a poor location reliability of 4 and it was believed that both likely represented the same item, even though they appear as separate entries in the computerized database of Non-Submarine Contacts maintained by the National Imagery and Mapping Agency (see Table 5-1). The poor location reliability was assigned to these items because the NIMA records provide no information regarding the reliability of the coordinates for them. It is believed, however, that the "unknown vessel" and the "unknown object" in NIMA records both refer to this pile of pipes and that the coordinates given by NIMA are accurate. Exactly why the NIMA database lists two different items at this location is unknown, but it is presumably because they had two sources of information for the same position, one source calling it an unknown object and the other an unknown vessel.

Also of interest relative to this pile of pipes are the several hang locations designated as Target 5a. These hangs are clustered approximately 1300 feet south, southwest of the pile of pipes, yet neither the sidescan sonar, magnetometer survey nor the diving operations discovered anything at the Target 5a location. Hang records for the Fisherman Contingency Fund obtained from MMS reveal that these hangs date from as early as 1992, and it appears that all of the hang locations were originally recorded as Loran coordinates. It is further believed that the slight variations in the reported positions of the hangs is related both to the inherent inaccuracies in Loran and to how close to the actual hang location the original Loran readings were obtained. Thus, it is believed that the cluster of hangs identified as Target 5a likely represents a single object. Finally, it is also believed that this single object producing the hangs is actually the pile of pipes identified as Target 5b. The approximately 1300-foot difference between the positions of the cluster of hangs and the pile of pipes is probably principally related to error in the algorithm used to convert the Loran coordinates to latitude/longitude coordinates.

Target 9, SS 73. The magnetometer survey of Target 9, located in lease block Ship Shoal 73, was conducted on October 7, 2001. The sidescan sonar survey of this target had revealed the presence of a linear object tentatively identified as a trawl net (see

Table 5-2). As at the other target locations, a 600-foot-square survey block was established over the identified target position and the magnetometer survey was conducted along seven track lines spaced 100 feet apart and oriented in a north-south direction. No discernable magnetic anomalies were recorded during the survey (Figure 5-45); however, it was decided to have a diver examine the target area to try to locate and ascertain the identity of the feature identified by sidescan sonar. The water depth at the target was 30 feet and the search procedures used were the same as described above. The diver reported several apparent trawl net scars crossing the ocean floor, but no evidence of the feature identified during the earlier sidescan sonar survey. If this object was, in fact, a trawl net, it is likely to have drifted away from its original position or been dragged away by shrimping activity.

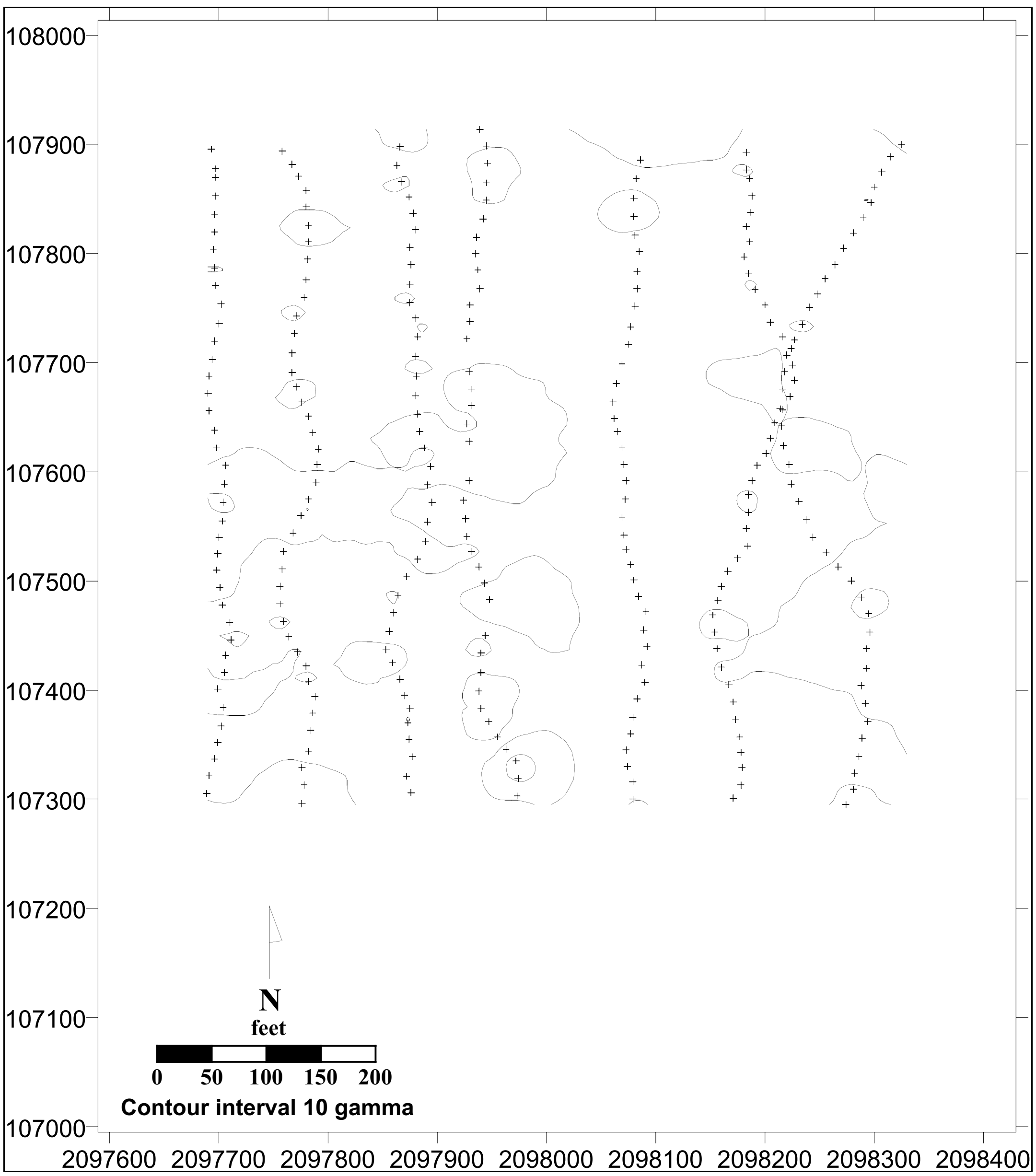


Figure 5-45. Magnetic contour map of Target 9, SS 73.

Target 14, VR 35. The magnetometer survey of Target 14, in lease block Vermilion 35, was attempted on September 14, 2001, but equipment malfunctions delayed the survey until October 12, 2001 (Figure 5-46). One reported hang and one unknown vessel had been identified at this location and the sidescan sonar survey had recorded three small rises on the seafloor whose identity could not be determined (see Tables 5-1 and 5-2). A 600-foot-by-600-foot block was established around the center point of the identified sidescan sonar target (state plane coordinates N = 279,269 E = 1,675,988) and the magnetometer survey was conducted along seven track lines spaced 100 feet apart and oriented in an east-west direction. Water depth at the target site was approximately 30 feet.

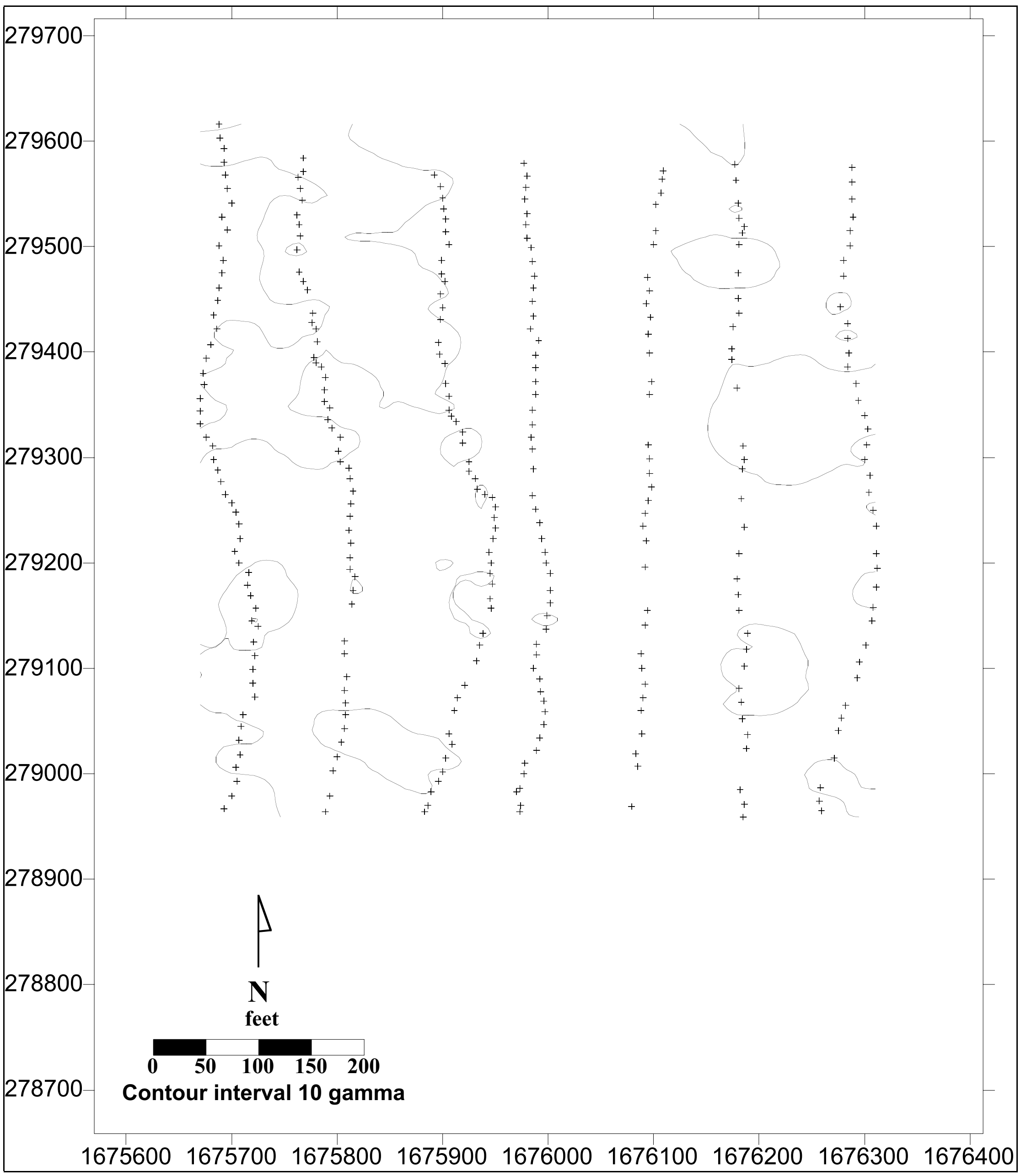


Figure 5-46. Magnetic contour map of Target 14, VR 35.

No magnetic anomalies of interest were recorded at this target; however, diver examination of the bottom was undertaken in order to try to locate and identify the three low mounds identified during the sidescan sonar survey. The previously described bottom search techniques were employed that encompassed an area extending approximately 100 feet on all sides of the identified target position. The diver reported a smooth and flat bottom consisting of soft mud in the entire area searched. Neither the three low rises nor any other cultural features or objects were discovered. It is suspected that the three slight rises observed on the sidescan sonar are natural features that were too low and indistinct for the diver to identify.

Target 15, VR 118. The magnetometer survey of Target 15, located in the northwestern quarter of lease block Vermilion 118, was conducted on October 12, 2001. The sidescan sonar survey of this target had identified a series of linear features at this location, consisting of an approximately 45-foot long piece with several shorter linear pieces crossing or extending off of it at various angles. The object could not be identified, but its regular and geometric form suggested it was manmade. A 600-foot-square survey block was established over the target location and the magnetometer survey was conducted along seven track lines spaced at 100-foot intervals and oriented in a north-south direction. A single, large magnetic anomaly was recorded near the middle of the survey block, centered very close to the position recorded for the target (Figure 5-47). The magnetic signature consisted of a dipole measuring approximately 300 feet across with a total magnetic deviation of 1,755 gammas.

Upon completion of the magnetometer survey the center of the magnetic anomaly was determined through additional refinement survey and buoyed. The water depth at the buoyed location was 65 feet. Diving operations were undertaken using the standard procedures described earlier. On the bottom, very close to the buoy location, the diver discovered a large amount of metal (steel?) cable, much of which was heavily encrusted with marine growth. Just south of the cable, the diver identified a long piece of partially buried pipe lying on the seafloor with an identifiable lip on the exposed end as well as a three-inch-diameter eyelet and associated bolt. The pipe was tentatively identified as an "outrigger" from a shrimp boat. Additional investigation of the possible outrigger identified a substantial amount of shrimp net snagged along the object. The diver proceeded down the presumed outrigger and discovered the side of a metal boat hull located at state plane coordinates N = 164350 E = 1633370. The vessel appeared to be lying on its side and it is believed to be the wreck of a modern shrimp trawler, probably with a steel hull. A depth reading taken on the side of the hull revealed a depth of 57 feet, meaning that the hull rises about eight feet above the bottom.

Only a limited amount of time was available for diver examination of this target, and dimensional information on the wreck was not obtained. However, there is no doubt that it represents the remains of a shrimp trawler, probably a modern one. Target 15 had originally been identified as an "unknown object" with a location reliability of 1, on the basis of a previously conducted remote-sensing survey (see Table 5-1 and CEI ID Number 408 in the 2001 shipwreck database). The identity of this vessel at Target 15 is unknown; however, as shown above in Table 4-6, only one vessel in the 2001 shipwreck database is reported to have been lost within 1.5 miles of its location. This is the fishing vessel *Castaway*, which, according to USCG records, was lost in lease block Vermilion 119 about 6,050 feet (1844 m) away. The *Castaway* has been assigned a location reliability of 2, meaning that its reported position is only moderately reliable (see CEI ID Number 1325 in the 2001 shipwreck database). Little is known about the *Castaway*, but its identification as a "fishing vessel" almost certainly means that it was a shrimp trawler, like the vessel found at Target 15. The fact that the *Castaway* was likely a shrimp trawler and that its reported position of loss is not precisely known means that it might be the vessel at Target 15, but this cannot be confirmed with the data presently at hand.

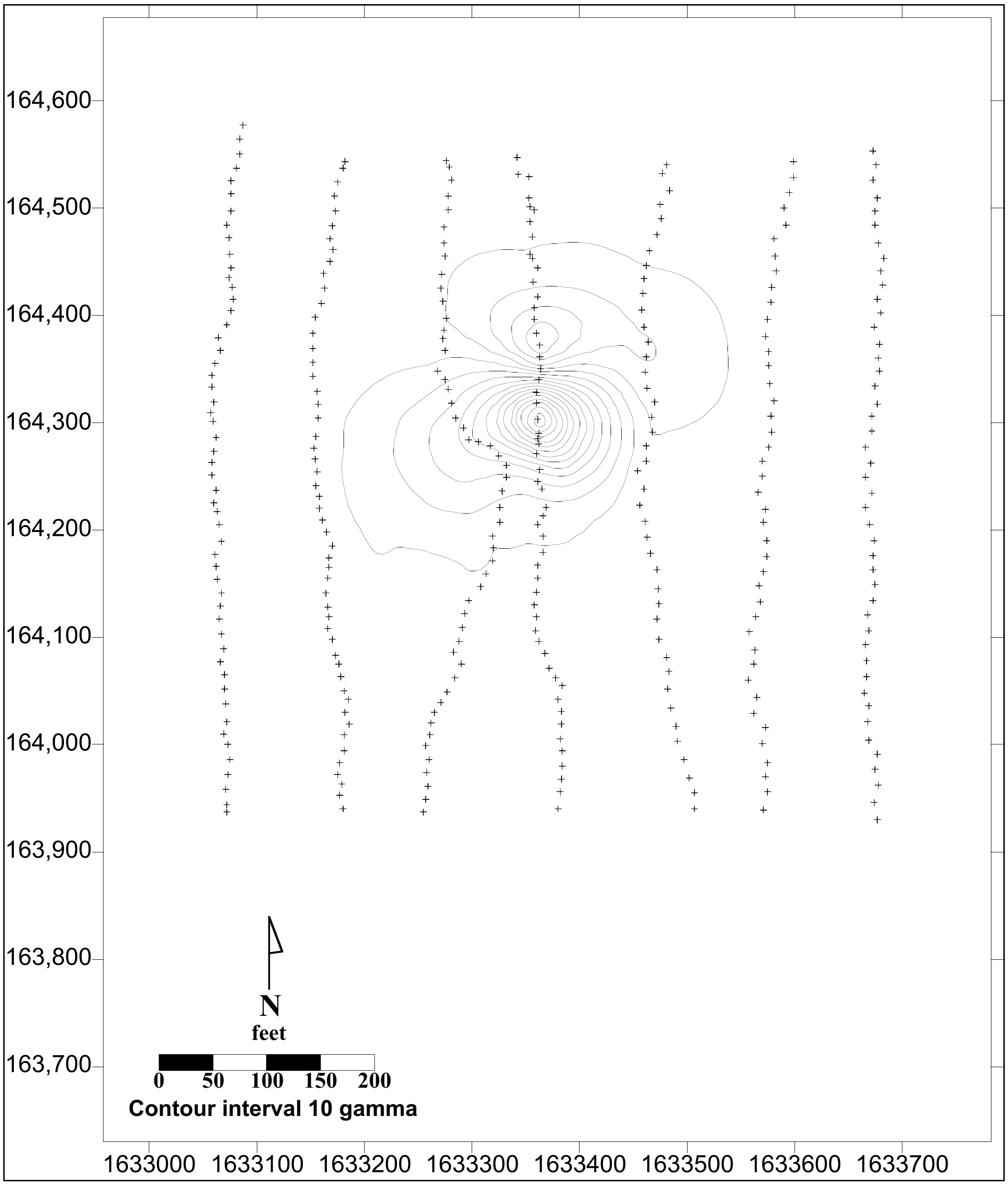


Figure 5-47. Magnetic contour map of Target 15, VR 118.

Target 17, EI 42. The magnetometer survey and diver investigation of Target 17 was conducted on October 14, 2001. This target originally had been identified as the location of two hangs and one unknown vessel, the latter assigned a poor location reliability of 4. The sidescan sonar survey of this target had revealed the presence of numerous linear and sinuous parallel features that could not be identified. A buoy was placed at the target coordinates and a 600-foot-square survey block was centered on this location. The magnetometer survey of this block was accomplished along seven survey lines spaced 100 feet apart and oriented in a north-south direction. As shown in the magnetic contour map presented as Figure 5-48, a linear magnetic anomaly with a magnetic deviation of 55 gammas was recorded near the survey block's northwest corner. The center of this magnetic signature was determined through additional survey and was buoyed, and diving operations were conducted.

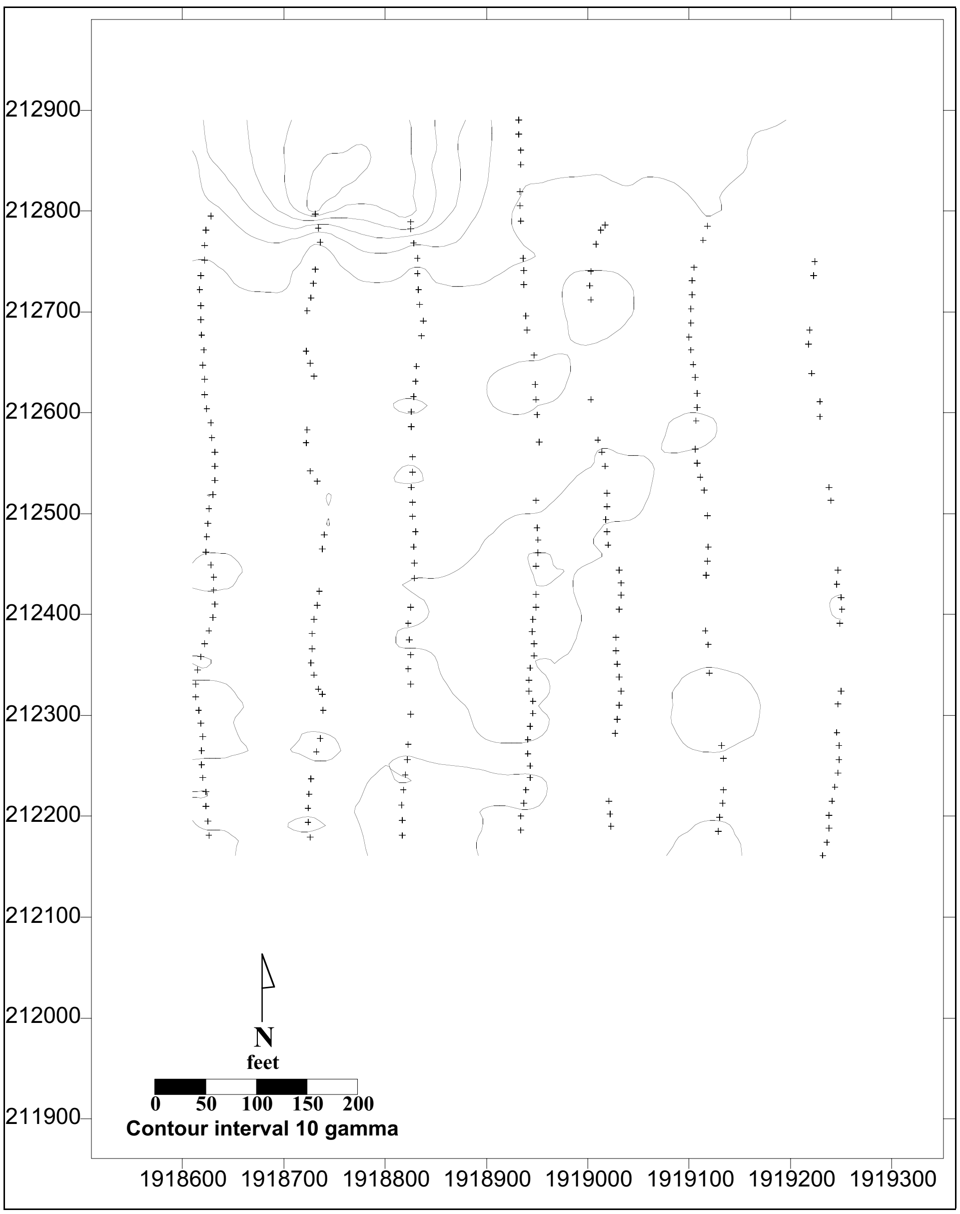


Figure 5-48. Magnetic contour map of Target 17, EI 42.

The water depth at the buoy was 14.5 feet and visibility was minimal because the water was heavily laden with silt due to high winds during the previous night. The diver search of the target area followed the standard procedures described earlier and covered an area extending just over 200 feet in all directions from the buoyed target center. No cultural objects or features of any type were found during the search. The source for the magnetic anomaly appears to be buried, but it may represent a single piece of metal pipe or some other linear debris. This assumption is based on the anomaly's linear appearance and its relatively small magnetic intensity. The feature(s) recorded during the sidescan sonar survey (see Figure 5-31) may not have been bottom features at all, but a large school of fish or shrimp.

Target 17 is located in relatively shallow water where sediment transport can be fairly high due to wave action and nearshore currents. Thus, the source of the magnetic anomaly, which was buried at the time of the present examination, may be exposed at other times. If so, it could represent the source object for the two hangs reported near its location. Further, the now-buried object might represent the source of the report for the "unknown vessel" located nearby. However, verification of either of these presumptions would require excavation and exposure of the buried object.

Target 18, EI 53. The magnetometer and diver investigation of Target 18, located in lease block Eugene Island 53, was undertaken on October 14, 2001. The objects originally identified at this location had been a single hang and two unknown vessels that had been assigned poor location reliabilities of 4 (see Table 5-1). The sidescan sonar survey of this target revealed only what appeared to be a depression in the seafloor (see Table 5-2). The position of this depression was buoyed and a 600-by-600-foot survey block was established around it. The magnetometer survey of this block was accomplished along seven track lines spaced at 100-foot intervals, oriented in a north-south direction. No significant magnetic anomalies were recorded (Figure 5-49).

Diving was undertaken to try to locate and identify the "depression" seen on sidescan records (see Figure 5-33). The water depth at the target location was 14.5 feet. Diver examination involved the standard procedures discussed previously. The area around the identified "depression" was completely examined, but no evidence of the depression was found, nor were any cultural features or objects. The diver did note that there were numerous areas of very "soft" sediment. It is possible that the depression originally seen on sidescan sonar records was one of these area of soft sediments where the sediments had been removed by current or wave action or had been dug out by the board of a shrimp net.

5.2. Discussion

This chapter has presented the results of the final portion of Task 2 of this study, the field investigation of a series of selected targets in the GOMR to determine their identity. The overall objective of Task 2 was to determine if there were correlations between a variety of objects identified in the GOMR, specifically hang sites, reported shipwreck and targets identified during previous lease block remote-sensing surveys.

Information on the spatial relationships of some of these classes of objects is presented in Chapter 4. This information, plus published hang data and data from the 2001 shipwreck database presented in ArcView format, was used in the selection of the 20 target areas examined by remote-sensing survey and diving. One particular interest of this phase of the study was the relationship between reported net hang locations and objects or shipwrecks. As noted previously, several of the historic shipwrecks discovered in the region are entangled with pieces of nets and ropes lost by fishermen, principally shrimpers. Additionally, several thousand hang locations have been reported in the GOMR. Thus, it is presumed that some unknown number of individual or, possibly more likely, clusters of reported hangs represent historic shipwreck locations.

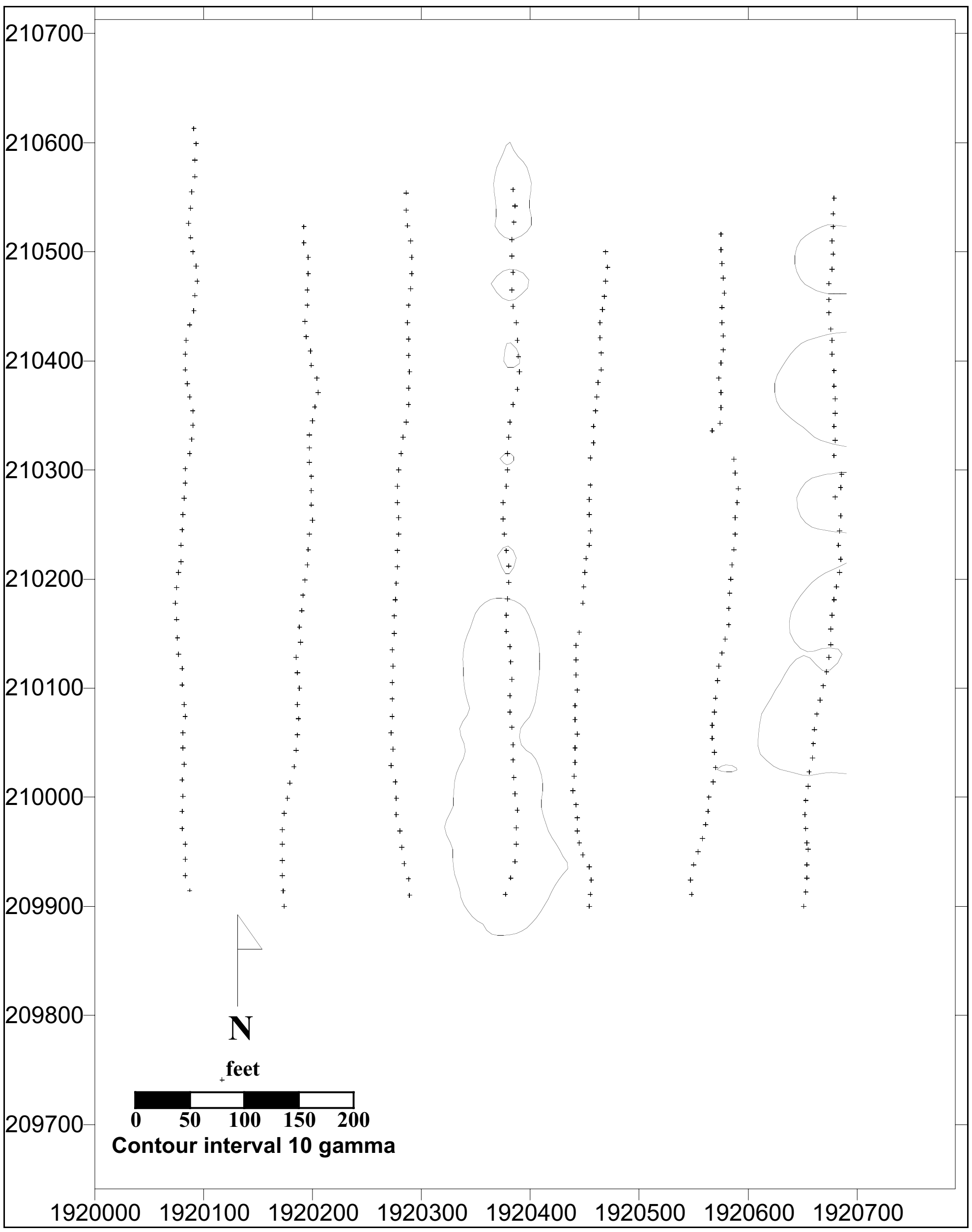


Figure 5-49. Magnetic contour map of Target 18, EI 53.

The 20 target areas selected actually contained or represented 52 recorded "items" that included 31 hangs, 12 unknown vessels, and nine unknown objects. The initial sidescan sonar survey of the selected target areas revealed that only eight target areas contained bottom features indicative of submerged cultural objects (see Table 5-2). Because one target area, Target 5, was divided into two areas, 5a and 5b, this represented nine target locations ultimately examined. Target inspection indicated that of the nine potential targets, only one, Target 15, represented a shipwreck. Located in Lease Block VR 118, Target 15 is identified as a modern, steel-hulled shrimp trawler unassociated with any hangs listed in the MMS or Texas A&M databases. The only identified vessel reported to have been lost in the near vicinity of Target 15 is the fishing vessel (presumably shrimp trawler) *Castaway*, lost in 1983 at a reported position over a mile away. However, the reported position of loss of the *Castaway* has been assigned only a moderate level of reliability, meaning that the vessel found at Target 15 could be the *Castaway*. The available information suggests that this vessel does not meet the criteria for eligibility to the National Register of Historic Places (NRHP). Interestingly, this one shipwreck was not associated with any of the hang locations maintained by MMS or Texas A&M.

Of the remaining eight targets, one represented what is believed to be the remains of a destroyed oil or gas platform, one consists of a large pile of metal pipe, while nothing was found exposed on the bottom at the remaining six. However, magnetics at one of these six targets, Target 17 in lease block Eugene Island 42, suggest the presence of a buried object, possibly a piece of pipe.

Two of the items discovered during diving, the vessel at Target 15 and the presumed platform remains at Target 1, represent objects identified during OCS lease block surveys. As anticipated, both of these objects were very accurately positioned and were discovered within a few feet of the position reported in the original survey. Additionally, both of these objects rise several feet above the seafloor and could easily hang shrimp nets; in fact, the vessel was entangled with a considerable quantity of net and rope. However, neither of these targets represents reported hang locations. In fact, nothing was found in the near vicinity of any of the reported hang locations examined. These results raise several questions about the spatial relationship of reported hang locations and objects on the bottom in the GOMR.

Probably most important is the accuracy of the reported hang locations. As has been discussed, inaccuracies in reported hang locations can arise from a variety of factors. These include the use of Loran for recording many of them and the fact that the position of the snag on the bottom may not be the exact location where the person actually recorded the position because of factors such as net length and boat movement as the hang position was recorded. Additionally, the conversion of Loran coordinates into other coordinate systems appears to embody inaccuracies. All of these factors may be in play at the Target 5 location. As noted above, a large pile of iron pipe was found about 1,300 feet from a cluster of reported hangs. Diver examination of the area of the hangs found nothing on the bottom, and it is believed that the pipes actually represent the source of all of these hangs. The relatively slight differences in the locations of the individual hangs may be due to inherent inaccuracies in the Loran system and to factors (e.g., boat movement, net and net line length, etc.) preventing the fishermen from recording coordinates directly over the hang location. This has resulted in a tightly grouped cluster of reported hangs. However, this entire cluster is about 1,300 feet from the pipes that are believed to represent the actual hang. This error appears to be related to the conversion of Loran coordinates into the geographic coordinates (i.e., latitude and longitude) in the MMS hang records and then into the state plane coordinates used during the survey and diving operations reported here. It is presumed that if a Loran system had been used to relocate Target 5, it in fact would have identified a point very close to the pile of pipes.

The error undoubtedly arises in the conversion from Loran to other coordinate systems because no error is typically found in converting back and forth between latitude/longitude and state plane systems. For example, during a recent attempt to relocate an historic wreck originally positioned by Loran, Krivor (2002) reports several hundred feet of error when converting from Loran to state plane coordinates, but very little error when converting from state plane to latitude/longitude. It would appear that the algorithms used to convert Loran coordinates need more study.

Another explanation that may account for the failure to discover some objects at their reported coordinates is because they have been moved from their original locations. This phenomena has been well documented in areas where shrimp trawling is common. In a study in Mobile Bay, Irion (1986) found that 24 percent of anomaly positions originally recorded could not be relocated. He attributed this to shrimpers catching and moving the objects from their originally surveyed positions. Garrison et al. (1989:II-222) reported a similar phenomenon in their study in the GOMR where 25 percent of anomalies selected for ground truthing could not be relocated. Similar findings are reported by Pearson and Hudson (1990:34) in Matagorda Bay, Texas; by Tuttle (1999) in the Gulf of Mexico off Quintana, Texas; by Krivor (2000) off Rockaway, New York; and by Tuttle and Krivor (2000) in Charleston Harbor, South Carolina.

In the present study, Target 2 in lease block South Marsh Island 19 might be a case where the target object has been moved from its original location. As noted, the unknown object at Target 2 consisted of a rectangular box identified during a previous lease block remote-sensing survey (see Table 5-1). It is presumed that the object was very precisely located; however, no evidence of this object was found during the sidescan sonar survey of Target 2. The most reasonable explanation for not finding the box seems to be that it has been moved from its original position. Interestingly, the original survey report notes that an object tentatively identified as a piece of shrimp net was caught on one side of the box. This suggests that the box did act as a snag for nets, although no recorded hang sites are located in the near vicinity of Target 2 (see Figure 5-10). The lack of reported hangs at this location might support the idea that the box was moveable, and that when caught it shifted and nets came loose before they or the vessel's rigging were seriously damaged.

In the case of Target 5b, the pile of large-diameter pipes, we have been able to clarify the identity and assigned position reliability factor. As noted, two items were reported at this position, an unknown vessel and an unknown object, both of which had been assigned a poor position reliability factor of 4. The unknown vessel at this location can be eliminated from the 2001 shipwreck database and the unknown object can be assigned a location reliability of 1.

As noted, the relationship of reported hangs to shipwrecks is of particular interest because it is believed that individual or clusters of reported hang sites might be useful as indicators of unreported shipwrecks. Only one target, Target 15, was identified as a wreck, albeit a modern trawler. The vessel has been very tentatively identified as the *Castaway*, reportedly lost in 1983. However, while shrimp net was entangled on Target 15, it is not recorded as a hang location in the two sources of hang data used. In spite of these findings, we know that hangs can and do represent historic shipwrecks. Two examples include the 303 Hang site off the Texas coast and the remains of the *El Nuevo Constante* off the Louisiana coast. The latter site represents the remains of an eighteenth century Spanish merchantman located by a shrimper in 1980. Pearson and Hoffman (1995:4) note that the shrimper, Curtis Blume, caught his nets on the wreck when he "was dragging in the shallow, muddy waters about a mile offshore of the Rockefeller Wildlife Refuge in southwestern Louisiana. This was only the second time Blume had fished this particular spot; the local Louisiana shrimpers avoided the area because it was known to contain a snag that damaged nets." Subsequent excavation of the wreck discovered numerous pieces of netting and rope entangled in the remains.

The second example is the 303 Hang wreck site. The site represents the intact hull of a two-masted schooner that local Texas shrimpers know as the "303 Hang" in reference to the Loran coordinates that identify the location as a net snag. Discovered when a pipeline was built atop the wreck, the 100-foot wooden-hulled vessel sits upright in 30 feet of water, but completely buried in the bottom. Designated state site 41BO173, archaeological investigations revealed that shrimp netting was entangled on both the bow stem and stern post (James et al. 1991b). One phenomenon observed at this site was that it might have acted as a hang only seasonally. During the initial inspection of the site in January, three feet of fine, silty sand covered the vessel, but when investigated in July, the sand had disappeared, leaving the top edge of the hull visible. James et al. (1991b:31) hypothesized that the sand had migrated over the wreck with the "summer being a period of little or no sand coverage [and] with winter seeing a remigration and accumulation of sands to the offshore areas. Snagged shrimp nets on both the stem and stern posts, along with other modern debris in the hull, were noted during the January investigation, suggesting that the wreck had undergone and was most likely still undergoing alternating periods of exposure and coverage." It is presumed that other wrecks and objects lying on the bottom in other areas of the GOMR act as similar, seasonally exposed hangs.

6.0: COMPARISON OF MARINE MAGNETOMETER TECHNOLOGIES AND SURVEY LINE SPACING - TASK 3

As stated in the SOW, the goals of Task 3 were: 1) a comparison of the "industry-standard" proton magnetometer (i.e., Geometrics 866) that is currently employed in marine archaeological surveys to the current state-of-the-art cesium magnetometer to determine if a change in the Minerals Management Service Gulf of Mexico Region (GOMR) survey methodology is warranted; and 2) to evaluate both magnetometers at various survey line spacings to determine the minimally acceptable survey line spacing for detecting historic shipwrecks. To accomplish this task, magnetometer surveys would be conducted over two known shipwrecks.

Ultimately, four magnetometer models were employed for this task, a Geometrics 866 (G-866), a Geometrics 877 (G-877), a Geometrics 881 (G-881), and a Marine Magnetics SeaSpy (SeaSpy). While only two magnetometers were initially identified for the study, discussions with the project geophysicist, S. Dean El Darragi, and MMS personnel indicated that it would be beneficial to the project to field-assess other magnetometer models in addition to the two currently identified in the contract for the survey trials of Task 3. Two additional magnetometer types were identified that were believed should be added to the Phase 3 survey. These included an Overhauser effect proton magnetometer and the new G-877 proton precession magnetometer. The G-877 is the replacement for the proton precession industry standards currently employed in the Gulf, i.e., the Geometrics 801 and the 866 precession proton magnetometers. These latter models, while still employed by many of the survey companies involved in the oil and gas industry, are no longer being produced (as well as their respective parts), and are being phased out by many firms. It was believed that employment of the G-877 would contribute significantly to the project in that the assessment of magnetometer types in a shipwreck survey mode would be a much more "up-to-date" study given the fact that the current G-866 slated to be assessed against the cesium model is no longer being produced. Relative to employment of the Overhauser type magnetometers, produced by Marine Magnetics and others (i.e., GEM Systems), Overhauser magnetometers offer similar sensitivity as the cesium magnetometers, particularly at moderate speeds (both the cesium and Overhauser are more sensitive to magnetic deviations than their free precession counterparts). Perhaps more germane to our study is the fact that these magnetometers are and will be employed by Gulf survey companies on projects that will have MMS purview. In conversations with FUGRO (John Chance and Associates), they have stated that they will be replacing their aging proton precession units (the G-801 and G-866) with newer Overhauser proton magnetometers. Therefore, the addition of these two models offered to keep the study "up-to-date" and more reflective of systems employed now and that will be employed in the future by oil and gas industry-related companies.

Figures 6-1 through 6-4 illustrate the four magnetometers employed in this aspect of the investigation. For a detailed discussion on magnetometer technologies and their employment in the Gulf's oil and gas industry, please refer to Appendix F.

Figure 6-1. While not completely obselete, the G-866 is no longer being produced and is being replaced with newer models by many companies.

Figure 6.2 The G-877 proton precession marine magnetometer used in Task 3.

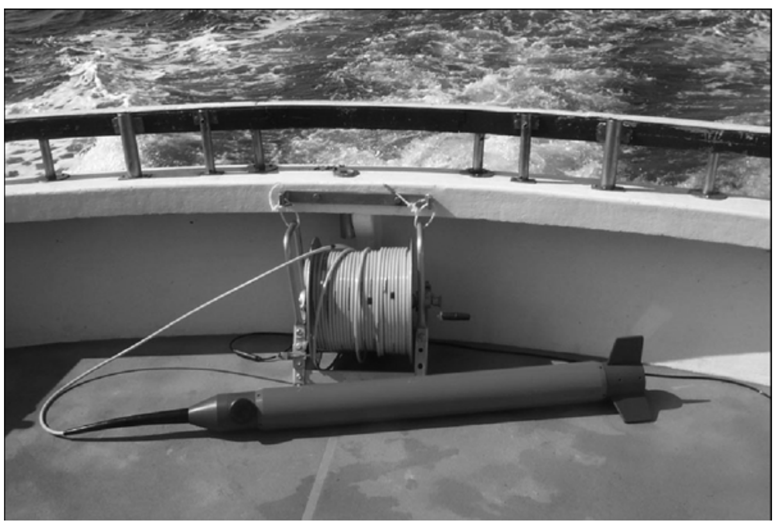


Figure 6-3. Marine Magnetics' "SeaSPY" Overhauser effect marine magnetometer used in Task 3.

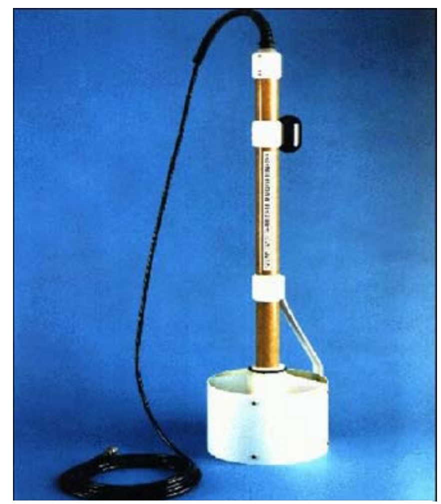


Figure 6.4 G-881 cesium marine magnetometer used in Task 3.

Besides the two additional magnetometers, it was also decided that a submersible base station be tested to determine its applicability to offshore surveys as it might apply to post-mission processing of magnetic data, especially with regard to surveys with line spacing of 50-m. Mirroring the NTL 98-06, the new NTL 2002-01 requirements do not stipulate the employment of base stations or contouring of magnetometer data. This is a reflection of the fact that, apart from oil rigs or platforms which cannot be employed as a suitable location because of their inherent magnetism, there is nowhere to place a base station in offshore Gulf waters. Currently, the locations of encountered magnetic anomalies are simply marked with a symbol (▲) and an identifying number, and presented in tabular format with anomaly information including line number, shot point, and coordinates. With regard to the latter, exact coordinates for the object creating a magnetic anomaly are next to impossible to acquire when data is not contoured. Contouring would in many cases locate the source of the anomaly exactly. Therefore, a Sentinel® submersible base station was included in this task in an effort to assess its functionality in the field, and answer questions concerning employment in offshore surveys relative to issues of diurnal variation and the functionality of contouring.

6.1. In-Field Magnetometer Comparison Survey

6.1.1. Survey Research Design

The second aspect of Task 3 was to evaluate the four magnetometers at various line spacings to determine the minimally acceptable survey line spacing for detecting historic shipwrecks, as well as to determine if there are differences between the various magnetometers in detecting a wreck site. To accomplish this task, the marine survey was to be conducted with each magnetometer over two known shipwrecks at varying transect intervals. The wrecks employed in the survey were the *Josephine*, an iron-hulled sidewheeler, and the *Rhoda*, a wooden-hulled sailing ship. Both nineteenth century wrecks, it was thought that surveying a wooden- and an iron-hulled vessel would generate more comparative data relative to the detection of different types of wrecks, than if two wrecks of the same hull composition had been selected.

6.1.1.1. Investigated Shipwrecks

The *Josephine*. The first vessel chosen for the assessment survey of magnetometers and line spacing was the *Josephine*, a metal-hulled sidewheeler (Figure 6-5). Investigated in 1997 and 1999 by divers from the MMS and designated state site 22Hr843, the shipwreck was identified as the remains of the nineteenth century merchant steamship (Ball et al. 2001).

Built in 1868 for Charles Morgan at the Harlan and Hallingsworth shipyard in Wilmington, Delaware, the *Josephine* was 235 feet long and 34 feet in breadth, with an 18.5 ft. depth of hold. Employed for over twelve years between Louisiana and Texas as a passenger, mail, and cargo carrier, the vessel was reassigned to the New Orleans to Havana route in January 1881. In February of that year, on its return to New Orleans the vessel ran into severe weather and began to take on water. It eventually foundered south of Biloxi, between Horn and Ship Islands, Mississippi. As stated by Ball et al.:

> …the wreck lies in 38 feet of water, about six miles off the Mississippi Barrier Islands. Though most of the lower hull of the wreck remains buried in sediment, the upper hull, above the waterline, is no longer present. The most prominent features of the vessel are the remains of the paddlewheels and the walking beam engine, which has collapsed to the starboard side of the wreck. The walking beam, a diamond-shaped feature mounted on an A-frame, connected the engine piston to the eccentric of the paddlewheels. Several spokes are still present on the paddlewheels, and both paddlewheel shafts are still mounted in their pillow blocks. The remains of the smokestack and the boilers also lie nearby (Ball et al. 2001:134).

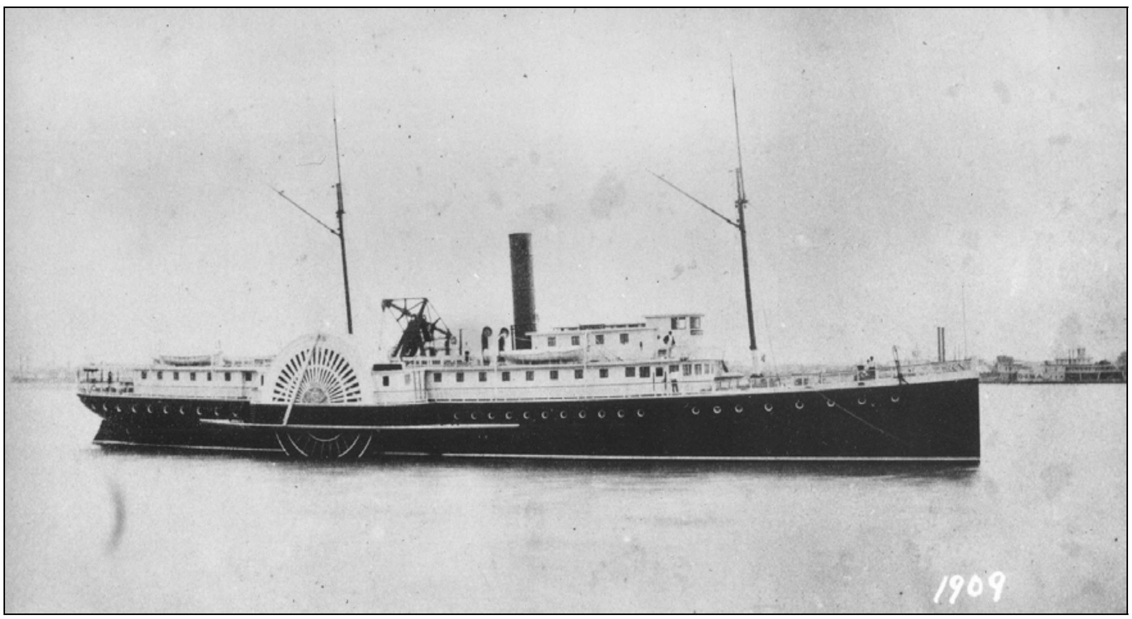


Figure 6-5. Image of the *Josephine*, a metal-hulled sidewheeler (courtesy of the Mariner's Museum, Newport News, Virginia).

As indicated by the acoustic image presented in Figure 6-6, the remains appear to represent an extremely intact wreck site. Ball et al. state that:

> …during the sinking process the *Josephine's* iron hull remained intact. Soon after the vessel sank the below-deck portion of the wreck filled with sand and mud, preserving artifacts below the mudline. This shipwreck has remained undisturbed for 120 years and represents a virtual time capsule from the year 1881. Even though most of the ship's exposed wooden features such as the wheel-house and above-deck cabins have disappeared, the passengers' and crew's personal items, the ship's cargo below the main deck, and all of the mechanical components of the ship's steam engine would be well preserved (Ball et al. 2001:136).

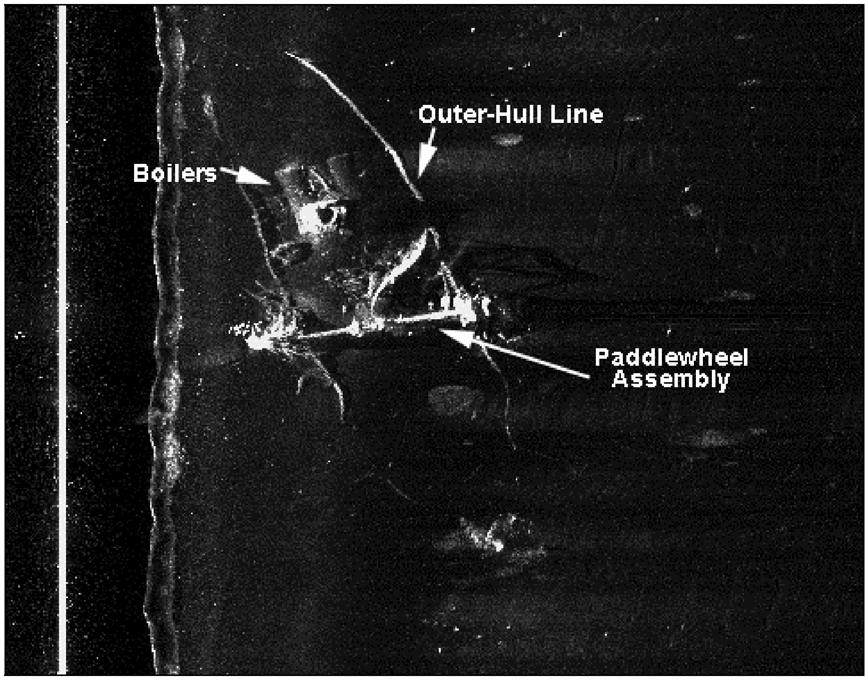


Figure 6-6. Acoustic image of the *Josephine* wreck site. Note the outline of the hull, the paddlewheels, collapsed smoke stack and boilers (as presented in Ball et al. 2001:136).

The *Rhoda*. The second vessel chosen for the assessment survey of magnetometers and line spacing was the *Rhoda*, a Canadian-built wooden-hulled bark. First recorded in 1991 by the Florida Bureau of Archaeological Research (BAR) and designated state site 8ES1899 (Franklin et al. 1991), the site underwent preliminary investigations in 2000 by the University of West Florida (UWF). Currently the Master thesis topic for university student John Rawls, the majority of information for the *Rhoda* comes from his research, including a recent paper presented at the Society for Historical Archaeology Conference in Mobile, Alabama.

Built for Edmiston and Co. timber importers by William Russell in 1864 in Quebec City, Quebec, Canada, she was 186 feet long, 33 feet in breadth, and 22 feet in depth. Copper-clad and originally ship-rigged, she was re-rigged in 1873 as a bark. She arrived in Pensacola in August of 1882, and while in port was driven across the bay during a violent storm and capsized near Santa Rosa Island. Condemned and offered for public salvage, it is uncertain to what extent if any salvage operations were conducted, and the vessel disappeared from public record after being sold for $725 (Rawls 2001). Recently investigated by UWF (Figure 6-7), as stated by Rawls:

> The site encompasses an area of ca. 1170 square meters on the seabed. Many of the ship's architectural features are exposed above the bottom surface and exhibit moderate preservation. These architectural features include timbers, two ballast piles, a row of standing iron features, many iron 'knees,' and many unidentified concretions. A possible galley stove which might be associated with the vessel is located on the north end of the site (Rawls 2001).

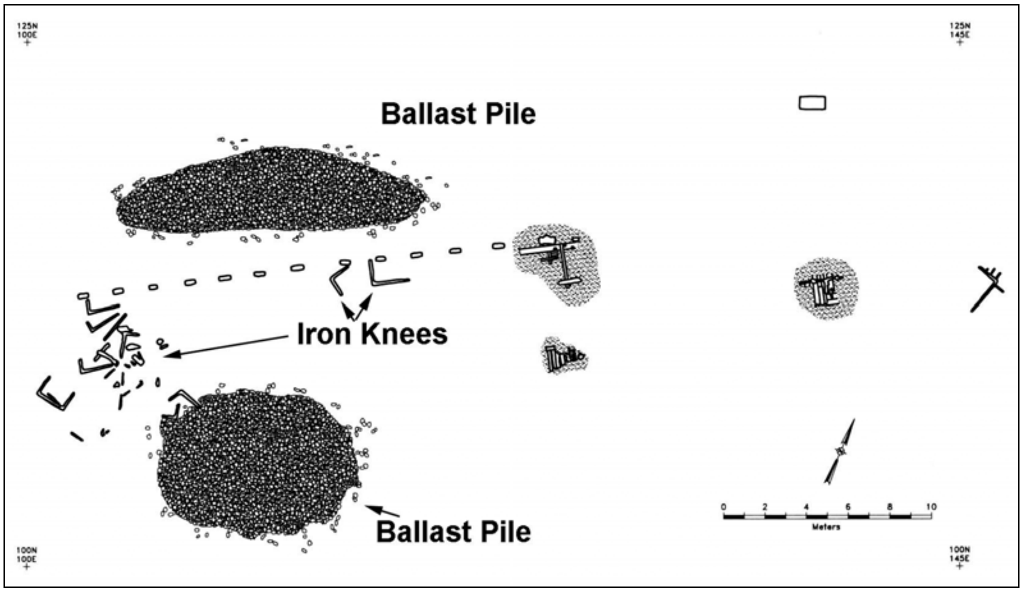


Figure 6-7. Site plan for the *Rhoda* shipwreck (courtesy of John Rawls).

With the site containing numerous in situ artifacts such as ceramics, glass, and a set of parallel rules for navigation, he goes on to state that "the site appears to be moderately disturbed from years of commercial fishing activities (i.e., dragging of shrimp nets). Also a popular fishing location, fishermen have deposited modern debris on the site in efforts to artificially enhance its reef-like environment" (Rawls 2001).

6.1.1.2. Survey Requirement Parameters

The magnetometer comparative survey adhered to methodology currently required by the MMS/GOMR Notice to Lessees (NTL) No. 98-06, Enclosure 1, Section II, Data Acquisition Instrumentation, and Section III, Survey Parameters. Data Acquisition Instrumentation and Survey Parameters employed are as follows:

- The sensor of the magnetometer must be towed as near as possible to the seafloor; a distance of six meters (20 feet) or less is required.

- A mechanical or digital depth sensor must be attached to the magnetometer sensor, and each survey line must be annotated with tow sensor depth and the start of the line (SOL) and end of the line (EOL) times.

- Magnetometer sensitivity must be one gamma or less, with the data sampling rate not to exceed one-second intervals. The use of the "zero-mode" setting is prohibited.

- Background noise level must not exceed three gammas peak to peak.

- The magnetometer sensor must be towed at a distance far enough astern that precludes magnetic influence from the survey vessel.

- Navigation for the survey must be accomplished by using a state-of-the-art continuous positioning system correlated to annotated geophysical records. The navigation system must have an accuracy of five meters or less.

6.1.1.2.1. Survey Line Spacing

As stated, the survey would be conducted with each of the four magnetometers over two known shipwrecks at varying transect intervals. Illustrated below in Figure 6-8 and Figure 6-9, two transect grids would be run with each instrument, one based on a 30-meter parallel survey interval and a larger one based on a 25-meter parallel survey interval, with the wreck coordinates at or near the center of the grid.

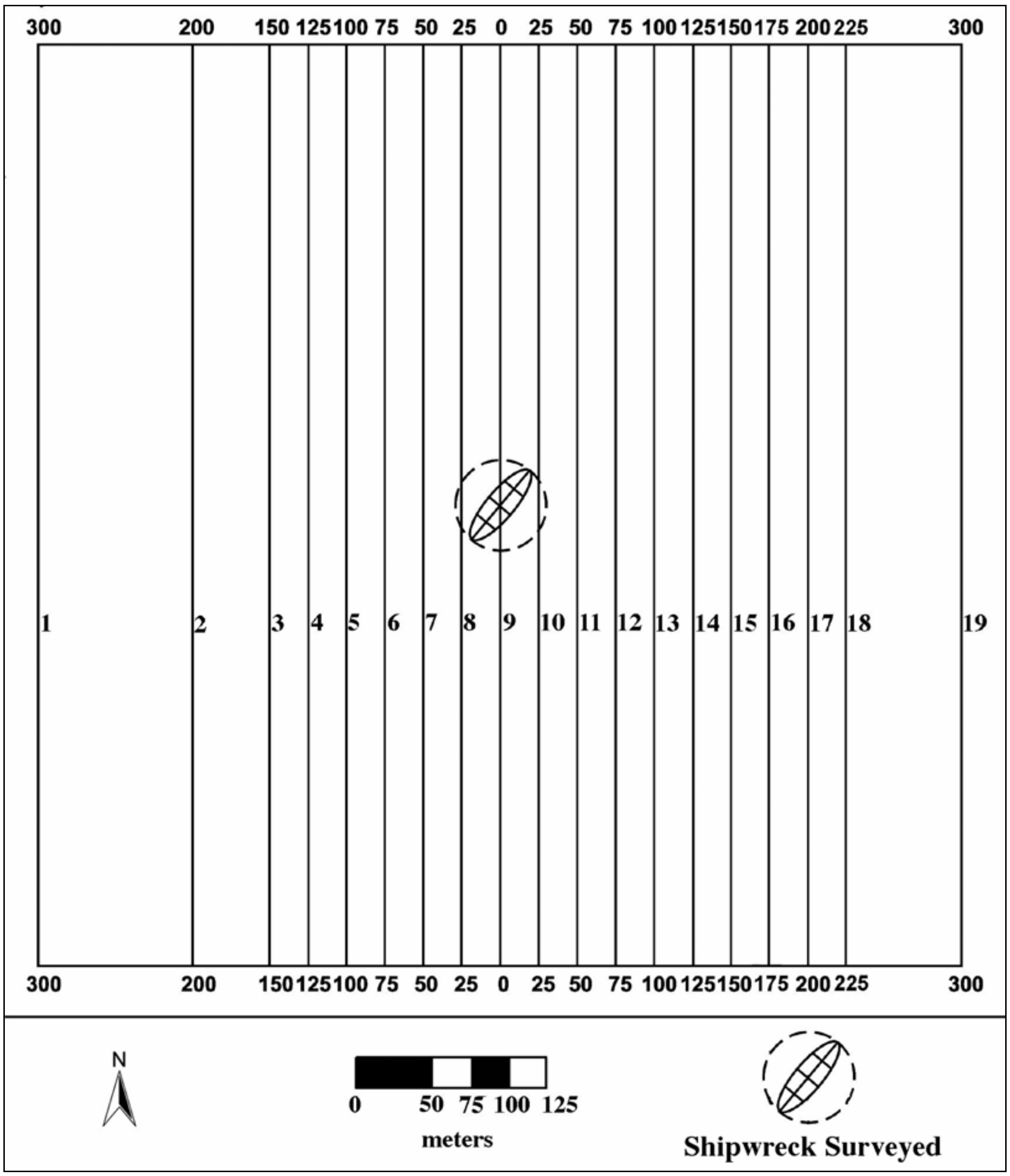


Figure 6-8. 25-meter survey interval grid with 19 tracklines to be run in a north to south direction at four knots.

Presented in Figure 6-8, the large 25-meter survey interval grid was 600 meters square and, employing the wreck coordinates as the center of the grid (Line 9), was initially composed of 17 transects or lines spaced at 25 meters out to 150 meters and then intervals were spaced at 200 and 300 meters. However, during field trials it was elected to add two additional lines spaced at 25 meters to either side of Line 17 (i.e., 16 and 18) to allow for complete coverage of a wooden barge located southeast of and in close proximity to the *Josephine*. Illustrated in Figure 6-9, the 30-meter survey interval grid was 150 meters square and was composed of transects spaced at 30 meters. Line 6 crossed the center of the wreck coordinates in this grid.

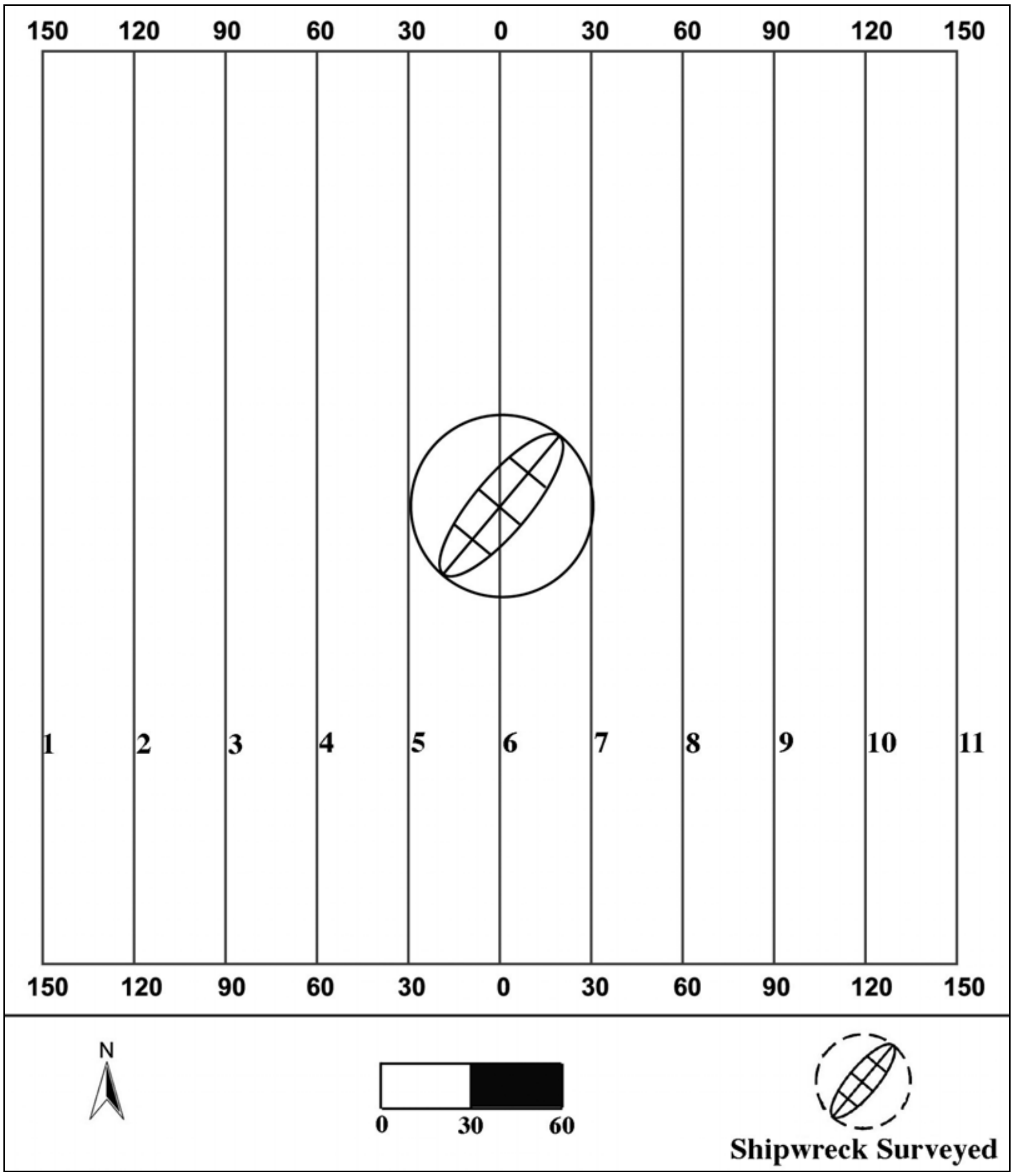


Figure 6-9. 30-meter survey interval grid with 11 tracklines to be run in a north to south direction at both four and seven knots.

All surveys were to be run in a north/south direction beginning on either the west or east side of the established grid. If a west to east direction was chosen for a starting point on the grid, then all instruments were to employ this direction of grid survey. Both grids were to be surveyed with each instrument at a constant four-knot vessel speed. However, the 30-meter survey interval grid was again to be surveyed at seven knots with all instruments. With respect to the survey, a total of three grids were to be run with each instrument, both a 25- and a 30-meter survey interval grid, each at four knots, and a 30-meter survey interval grid at seven knots.

It should be understood that the employment of a 25-meter survey interval in the 25-meter survey interval grid was not intended to address issues of a 25-meter survey interval increment (i.e., 25-meter versus 30-meter versus 50-meter). Rather, during post processing and analysis the employment of a 25-meter interval allowed the 50-meter survey interval grid to be shifted to the right or left by 25 meters in an effort to determine if the wreck site would fall outside of or go undetected by the 50-meter interval.

6.1.1.2.2. Base Stations

Mirroring both the NTL 98-06 and the new NTL 2002-G01 requirements, the SOW did not stipulate the employment of base stations or contouring of magnetometer data. As stated above, this is a reflection of the fact that, apart from oil rigs or platforms which cannot be employed as a suitable location because of their inherent magnetism, there is nowhere to place a base station in offshore Gulf waters. However, besides testing two additional magnetometers, it was also decided that a submersible base station be tested to determine its applicability to offshore surveys as it might apply to post-mission processing of magnetic data, especially with regard to surveys with line spacing of 50-m. Because a Sentinel® submersible base station was included in this task in an effort to assess its functionality in the field, and answer questions concerning employment in offshore surveys relative to issues of diurnal variation and the applicability of contouring, land base stations were also included to provide comparative base station data. Listed below, two land-based base stations and one submersible base station were to be employed. They included:

- Marine Magnetics' "Sentinel Sub-Sea" submersible base station
- Marine Magnetics' "Land Sentinel" land-based base station
- Geometrics land-based base station

Each company's land station was to be employed during the survey with their respective magnetometer. Marine Magnetics' "Sentinel Sub-Sea" submersible Base Station would be employed for the duration of the survey. For the Pensacola survey, the land base station was placed at Fort Pickens. For the Biloxi survey, the base station was placed on Ship Island. Both administered by the National Park Service, permits were acquired from the Gulf Shores National Seashore for land base station placement.

6.1.1.2.3. Navigation/Positioning

It was proposed that navigation during the grid survey would be accomplished with a Trimble AG132 DGPS linked to a navigation and data logging computer running Hypack MAX software for navigation and data archiving. An SG Brown Gyro would also be used to accurately determine sensor lay-back. State Plane coordinates, based on the 1983 North American Datum (NAD 83) coordinate system, were used for this project.

6.1.1.2.4. Post Survey Data Analysis and Presentation

The Research Design proposed that analysis and presentation of data was to initially consist of:

- Strip chart examples for each instrument on each shipwreck will be produced for each survey grid of varying line space.

- Production of tables of recorded data (gamma strength, duration, line spacing, sensor depth, vessel speed, etc.).

- Contour maps from data generated by each magnetometer for each survey grid of varying line space.

Furthermore, analysis and presentation of data would be directly related to addressing questions concerning instrumentation and survey parameters. Questions to be addressed included but were not limited to the following:

- Magnetometer Type – While we realize that certain magnetometers are more sensitive than others (i.e., cesium versus proton), we need to determine how each magnetometer type detects the same wreck site with regard to signal strength and duration. Employing strip charts and magnetic contour maps for each instrument, maximum gamma deviation and duration will be analyzed and compared with one another.

- Line Spacing – What is the maximum/minimum line spacing or interval that allows detection of the wreck by each instrument? With the two grids we will be able to assess how each instrument detects each wreck site employing a 30-meter survey interval, a 25-meter survey interval, a 50-meter survey interval, a 100-meter survey interval, a 150-meter survey interval, and a 300-meter survey interval. Employing strip charts and magnetic contour maps for each instrument, maximum gamma deviation and duration will be analyzed and compared with one another for each grid interval.

- Vessel Speed – Do increased speeds affect ability of instruments to detect a wreck, and/or how are increased speeds reflected in the recorded maximum gamma deviation and duration of a known wreck site? As stated, both grids will be surveyed with each instrument at a constant four knot vessel speed. However, the 30-meter survey interval grid will again be run at seven knots. Employing strip charts and magnetic contour maps for each instrument, signal strength and duration will be analyzed and compared with one another to address questions regarding increased survey speeds, including speed relative to increased noise.

- Diurnal Variation – Is diurnal variation sufficient to affect the interpretation of magnetic data, especially in the evaluation of a magnetic signature relative to the possibility of it representing a shipwreck? And does adjusting for diurnal variation affect, enhance, or alter magnetic signatures and their subsequent interpretation in these settings? Additionally, is there a difference between employment of data from the land-based and submersible base station readings? These questions will be addressed by comparing strip charts, magnetic contour maps, and tabular signal strength and duration data that:

  - Is in its original and unsmoothed format.
  - Has been "smoothed" with base station readings, both from the land-based and submersible stations.
  - Has been "smoothed" with an averaging program without the use of base station readings.

- Shipwreck Signatures – It is possible that the magnetic signatures of relatively intact wrecks, as might be expected in much of the GOMR, will not produce the complex signatures commonly found at dispersed wreck sites in high energy environments, like surf zone settings. Wreck sites in the offshore GOMR may more typically produce relatively simple magnetic signatures. Therefore, will recorded magnetic signatures match those previously described by Garrison et al. (1989) and derived from earlier work? Employing strip charts, tabular data, and magnetic contour maps, signatures will be analyzed and compared with earlier findings/hypotheses to address this question, as well as to more specifically characterize the magnetic signature/s of historic vessels in the GOMR.

6.1.2. Survey Methodology

The methods employed during the Task 3 survey were the same during the entire project. Regardless of the vessel utilized, all survey equipment was set up first, including the Trimble AG132 GPS unit, the SG Brown Meridian gyrocompass and all associated navigation computers. In an effort to provide accurate navigation, the current edition of Hypack MAX (Version 5b) was used to create the 25-m survey interval grids and the 30-m survey interval grids over each respective wreck site. Refer to Appendix G for a detailed discussion of the survey equipment employed during this aspect of the investigation.

Coordinates for the *Josephine* were provided by the MMS while the coordinates for the *Rhoda* were provided courtesy of the University of West Florida's Program in Underwater Archaeology. Wreck locations were forwarded onto VPSI at which time the survey grids were established.

Base Stations. Base stations, two land-based and one underwater unit, were employed for the duration of the survey to address diurnal variation. The two land-based stations were the Geometrics 856 and the Marine Magnetics Sentinel Base Station. The underwater base station was the Marine Magnetics Sentinel Sub-Sea Base Station.

Suitable locations for the land base stations were found prior to the survey. The initial location for the land base stations in Pensacola, Florida was located on the barrier islands near Fort Pickens. While this location was suitable for the base stations and was approximately one mile from the *Rhoda*, personnel from Geometrics were concerned about the location's close proximity to the seashore. It has been speculated that placement of a base station in close proximity to an active surf zone may affect localized changes in the Earth's magnetic field due to tides, the conductive property of sea water, and the possibility of electrical currents in the sea water. These factors may cause inaccurate readings that do not reflect the general time variations in the magnetic field (George Tait, personal communication September 2002). To alleviate any potential data problems, the land base station location was moved on June 23, 2001 to Perdido Key, located west of Fort Pickens. This area, situated further from the seashore, allowed for easy access for base station deployment. The following table indicates the location of both the land base stations for both Pensacola and Biloxi (Table 6-1).

Table 6-1. Land Base Station Coordinates During the Task 3 Survey

Location	Northing	Easting
Pensacola, FL. – Fort Pickens	3354141	477676
Pensacola, Fl. – Perdido Key	3350811	454637
Ocean Springs, MS. – Gulf Islands National Seashore	3363291	327954

(All coordinates provided in UTM 16, NAD27)

The land base station location for the *Josephine* was originally going to be set up on Ship Island, one of the barrier islands located offshore the Mississippi coastline. While this location would have been suitable, time constraints getting to Ship Island (via the survey vessel) and setting up the equipment were not feasible. An additional location was decided upon at the Gulf Islands National Seashore, located immediately east of Ocean Springs, Mississippi (Figure 6-10). This location was easy to reach prior to survey each morning and was relatively free of magnetic interference.

Each base station was set up prior to each day's remote-sensing survey. Technicians from Geometrics as well as Marine Magnetics were responsible for setting up each base station prior to survey work each day (Figures 6-11 and 6-12). A field technician from Panamerican watched the instruments each day to discourage any tampering with the equipment. At the end of each day each base station was shut off and the data downloaded to computer. Data collected every day was then provided to Panamerican at the end of the survey.

Figure 6-10. Gulf Islands National Seashore near Oceans Springs, Mississippi provided an excellent location for the land base stations.

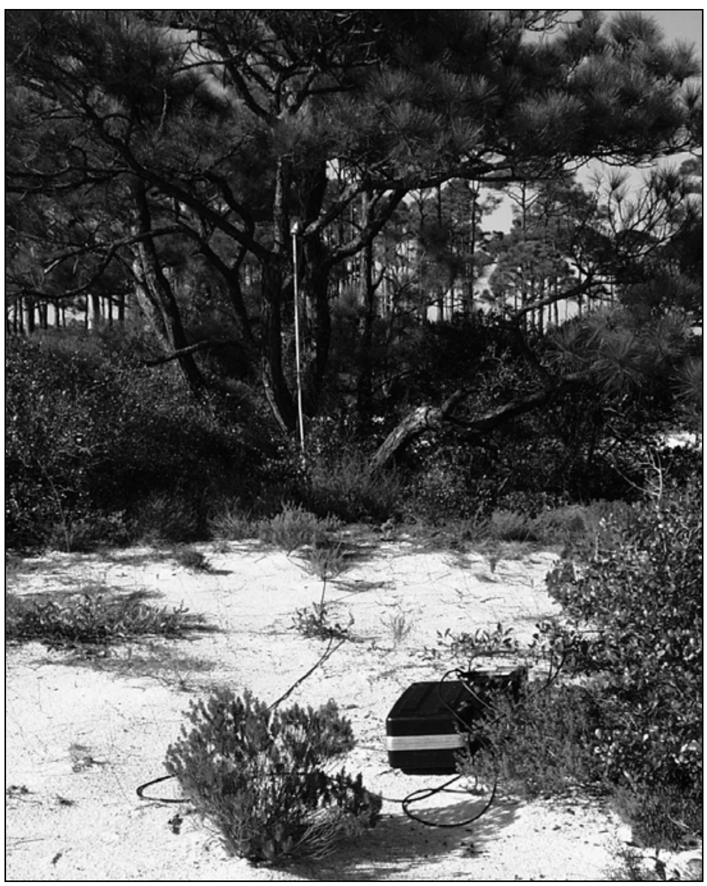


Figure 6-11. Geometrics' G-856 land base station ready to collect data at Perdido Key, Florida.

Figure 6-12. Marine Magnetics Sentinel base station being readied to collect data in Perdido Key, Florida.

Research Permits. To comply with Federal and state research requirements, non-intrusive permits were obtained from both the United States Department of the Interior (National Park Service) and the Florida Department of State (Division of Historical Resources, Bureau of Archaeological Research). A Scientific Research and Collecting Permit (Study #GUIS-00012, Permit #GUIS-2001-SCI-0011) was issued for the survey, allowing for the placement of land base stations within the Gulf Islands National Seashore.

Additionally, a non-intrusive research permit was granted for survey work over the *Rhoda* (1A-32 Archaeological Research Permit Number 0001.38 Comparison of Marine Magnetometer Technologies, 8ES2994) by the Florida Department of State, Division of Historical Resources, Bureau of Archaeological Research. Each permit was provided to the appropriate land-managing agency prior to survey and was carried at all times by Panamerican personnel during field work.

Survey Vessels. Due to vessel availability, weather conditions, and environmental constraints, it was necessary to use a number of vessels during Task 3 remote-sensing operations. Beginning in Pensacola, Florida on June 21, 2001, the first vessel used during the task was provided by AAA Fishing Charters, based out of Perdido Key, Florida. The vessel was the *Quester*, a 40-foot charter boat with a 13-foot 6-inch beam. Although the vessel was suitable for remote-sensing operations, its draught and the presence of a shoal at the south end of the *Rhoda*'s 25-meter survey interval grid prompted a change in survey vessels when operations reconvened later in the year.

Moving to the *Josephine* site on June 25, 2001, all equipment was again set up and calibrated aboard the *Miss Hospitality*, a 51-foot long, 16-foot wide charter boat equipped with twin V8 diesel engines (608 horsepower). Since the wreck of the *Josephine* was approximately 12 miles off Biloxi, Mississippi, this boat was ideally suited for offshore survey work. An air-conditioned cab helped keep all electronics dry and cool during the running of the survey.

Returning to the *Rhoda* site on October 1, 2001 to finish the Task 3 survey, a more suitable survey vessel was located, considering the presence of a notable shoal at the south end of the 25-meter survey interval grid. Provided by Undertow Marine Towing of Pensacola, the *Undertow III* was a 32-foot long crew boat with a 12-foot beam and a 4.7 foot depth of hold (Figure 6-13). The vessel, powered by an 871 Detroit diesel, had ample rear deck space and an enclosed cabin to protect all electronics. This vessel was also employed when the survey reconvened at the *Josephine* site.

Figure 6-13. 32-foot charter boat *Undertow III,* based out of Pensacola, Florida.

6.1.3. Daily Survey Procedures

After setting up the navigational equipment and land base stations, the appropriate magnetometers were brought onboard the respective survey vessel, depending on which was to be used that day (Figure 6-14). Once established which instrument(s) would be run, the survey vessel proceeded to the appropriate wreck site to begin running tracklines. The following table represents the schedule during Task 3 operations (Table 6-2).

Figure 6-14. Stern of the vessel *Quester* being readied for daily survey. All instruments were typically brought onboard each day.

Table 6-2. Schedule of Task 3 Operations

Date	Wreck Site	Instrument	Survey Interval Grid completed	Comments
6/21/01				Mobilization
6/22/01	*Rhoda*	G-881	25-m., 30-m. 4knt.	
6/23/01	*Rhoda*	G-881 SeaSPY	30-m. 7 knt. 25-m.	
6/24/01	*Rhoda*	SeaSPY G-877	30-m. 4knt., 30-m. 7 knt. 25-m.	
6/25/01	*Josephine*	G-881	25-m., 30-m. 4knt., 30-m. 7 knt.	
6/26/01	*Josephine*	G-877	25-m., 30-m. 4knt., 30-m. 7 knt.	
6/27/01	*Josephine*	SeaSPY	None	Adverse weather
6/28/01				Demobilization
9/26/01	*Josephine*			Mobilization
9/27/01	*Josephine*	SeaSPY	25-m., 30-m. 4knt., 30-m. 7 knt.	
9/28/01	*Josephine*	G-866	None	Blown G-866 bulkheads
9/29/01	*Josephine*	G-866	25-m., 30-m. 4knt., 30-m. 7 knt.	

Table 6-2. (continued). Schedule of Task 3 Operations

Date	Wreck Site	Instrument	Survey Interval Grid completed	Comments
9/30/01				Travel
10/01/01	*Rhoda*	G-866 G-877	25-m., 30-m. 4knt., 30-m. 7 knt., 30-m. 4knt., 30-m. 7 knt.	
10/02/01				Travel

Underwater Base Station. Upon reaching the survey area, the first objective was to deploy the Marine Magnetics Underwater Sentinel Base Station. Placed within a half mile of the 25-meter grid, the Sentinel base station was deployed each morning prior to running track lines and then retrieved at the end of the day before returning to the dock (Figure 6-15).

Figure 6-15. Deploying the Marine Magnetics Sentinel base station near the wreck of the *Rhoda*, Pensacola, Florida.

The Sentinel base station was rigged with a concrete block that acted as a weight, keeping the instrument on the seafloor. A buoy rigged to the top of the Sentinel base station kept the instrument vertical in the water column and provided positive flotation to the unit(s) when released to the surface (Figure 6-16).

Figure 6-16. The Marine Magnetics Sentinel underwater base station prior to daily deployment.

Attached to the concrete block was a release mechanism produced by EdgeTech Communication and Control Products Group (EdgeTech). Referred to as a Coastal Acoustic Release Transponder (CART), this mechanism allows for equipment to be placed on the seafloor and retrieved (at the surface) when an acoustic signal is sent to the unit (Figure 6-17).

Figure 6-17. The EdgeTech Coastal Acoustic Release Transponder (CART).

This unit is designed for applications from the surf zone through the continental shelf (to a depth rating of 1,000 meters) and can release up to 500 kg. EdgeTech utilizes alkaline batteries (with a long life option for extended deployments), providing 1 1/2 years of operation. To release the CART, in effect sending the Sentinel base station to the surface (where it was recovered after each day of survey), an EdgeTech AMD200 Deck Unit Command Transmitter was used (Figure 6-18). Lightweight and durable, the AMD200 is capable of transmitting all EdgeTech commands using a Binary Acoustic Coding System (BACS). Small, reliable, and self-contained, this system utilizes a Binary FSK-1 6,11 block cyclic code with 12,000 unique command codes.

Figure 6-18. EdgeTech AMD200 Deck Unit Command Transmitter used to transmit a unique code to the CART.

At the end of each day of survey, a unique code was typed into the AMD200 after placing a transponder over the side of the survey vessel into the water (Figure 6-19). The acoustic release on the CART would then be triggered, sending the CART, Sentinel Base Station and float to the surface (Figure 6-20). One exception to the Sentinel being recovered at the end of each day occurred on September 27, 2001. After using the AMD200 transmitter to recover the Sentinel base station, the unit did not return to the surface. The unit remained on the seafloor until the afternoon of September 29, 2001 when it was recovered by a Panamerican diver. After manually recovering the base station, it was observed that the release mechanism failed to disengage after the AMD200 signal was sent to the unit from the survey vessel, apparently due to a damaged internal component.

It was speculated that the unit was damaged when the elasticity in the release assembly bounced the concrete anchor up, in effect rendering the release useless. EdgeTech indicated that the unit's internal structure was not as strong as usual since the unit used during the Task 3 operations was a prototype. The current release mechanisms produced by EdgeTech are apparently much stronger than the prototype (Doug Hrvoic, personal communication May 2002).

Figure 6-19. AMD200 transponder ready to place in the water.

Figure 6-20. Recovery of the Marine Magnetics Sentinel underwater base station, EdgeTech CART, and float after finishing a day of survey.

Survey Track lines. Once the position of each wreck was determined, a series of track lines was then created with Hypack MAX. The appropriate interval offsets (25-meter interval, 30-meter interval) were applied to the respective grids, providing the necessary coverage for the survey.

The appropriate magnetometer was readied for operations after deploying the Sentinel underwater base station. Each towfish was set up prior to deployment on the stern of the survey vessel and readied for survey (Figure 6-21). After water depth over the wreck site was determined, the appropriate amount of cable was let out and the survey vessel was brought up to speed (four or seven knots). After enough cable was let out to satisfy MMS requirements, the running of survey lines began (Table 6-3), starting west of each grid and proceeding to the east over both vessels.

Figure 6-21. Geometrics 877 being prepared for survey.

Table 6-3. Instrument Layback

Instrument	***Rhoda***	***Josephine***
G-866		
25-meter SI* grid	80’ (24.4m)	132’ (40.2m)
30-meter SI grid, 4 knot	80’ (24.4m)	132’ (40.2m)
30-meter SI grid, 7 knot	110’(33.5m)	180’ (54.8m)
G-877		
25-meter SI grid	120’ (36.6m)	240’ (73m)
30-meter SI grid, 4 knot	120’ (36.6m)	240’ (73m)
30-meter SI grid, 7 knot	135’ (41m)	300’ (91.5m)

Table 6-3. (continued). Instrument Layback

Instrument	*Rhoda*	*Josephine*
G-881		
25-meter SI grid	75' (22.8m)	170' (51.8m)
30-meter SI grid, 4 knot	75' (22.8m)	170' (51.8m)
30-meter SI grid, 7 knot	100' (30.5m)	220' (67m)
SeaSPY		
25-meter SI grid	150' (46m)	125' (38m)
30-meter SI grid, 4 knot	150' (46m)	125' (38m)
30-meter SI grid, 7 knot	150' (46m)	222' (68m)

*SI = Survey Interval

All magnetometers used during the Task 3 survey were equipped with depth sensors, allowing all to be towed at the required depth of 20 feet or less (from the seafloor) as stipulated by MMS survey parameters. During the survey the depth of each towfish was constantly monitored to comply with these survey standards.

The Geometrics 881, the Geometrics 877, and Marine Magnetics SeaSPY were equipped with internal sensors, allowing the depth to be monitored digitally during each track line. The Marine Magnetics SeaSPY unit also employed an altimeter, allowing for the operator to view the distance of the towfish from the ocean floor (Figure 6-22).

Figure 6-22. The Marine Magnetics SeaSPY magnetometer being deployed. Note the cylindrical altimeter sensor near the nose of the towfish.

Combined use of the depth sensor and altimeter data can provide users with a bathymetric image of any given survey area. The depth sensor input from each of these instruments was recorded as a separate stream of data, allowing for the vertical position of the towfish within the water column to be determined at any location within a grid.

The Geometrics G-866 was not equipped with an internal depth sensor; rather, an attached unit was mounted approximately three feet up the cable from the sensor (0.5% 100 psig sensor for 150' max. water depth). This sensor is equipped with an HSP LCD digital readout (with RS-232 output and zero/span adjust) that is easily viewed during the running of track lines (Figure 6-23). Depth readings were then recorded on the G-866 stripchart for review later during data processing.

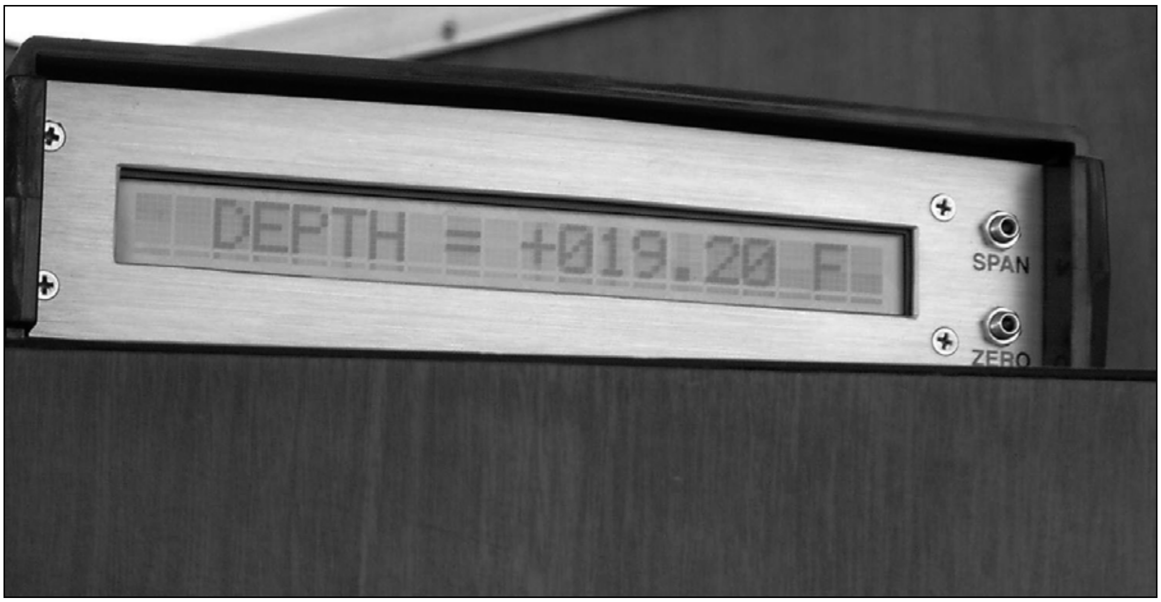


Figure 6-23. Digital readout used to monitor the G-866 sensor depth during the Task 3 survey.

Prior to any Task 3 field work the original survey research design (prepared by Panamerican) outlined the survey parameters to be followed during operations. These parameters included vessel speed, line spacing, survey grid size, and towfish depth. While this research design was strictly adhered to during the survey, one addition was made while in the field. While underway to the *Josephine*, Rik Anuskiewicz and Captain Kenny Barhanovich recalled the presence of an additional wreck within the 25-meter survey interval grid. This wreck consists of a barge identified during the preliminary remote-sensing survey conducted by the MMS of the *Josephine* (Figure 6-24).

Since the wreck represents another example of a vessel type found within the GOMR, it was decided to obtain the coordinates of the wreck from the MMS. The wreck was then plotted within the existing 25-meter survey interval grid. Plotting the coordinates of the barge placed it very near the 200-meter offset on the southeast corner of the 25-meter survey interval grid. To collect additional magnetometer data from the barge, two track lines were added to the existing 25-meter survey interval grid. These lines, spaced 175-meters and another placed at 225-meters from the zero line, in effect boxed in the extent of the barge and increased the total number of lines run over the *Josephine* from seventeen to nineteen.

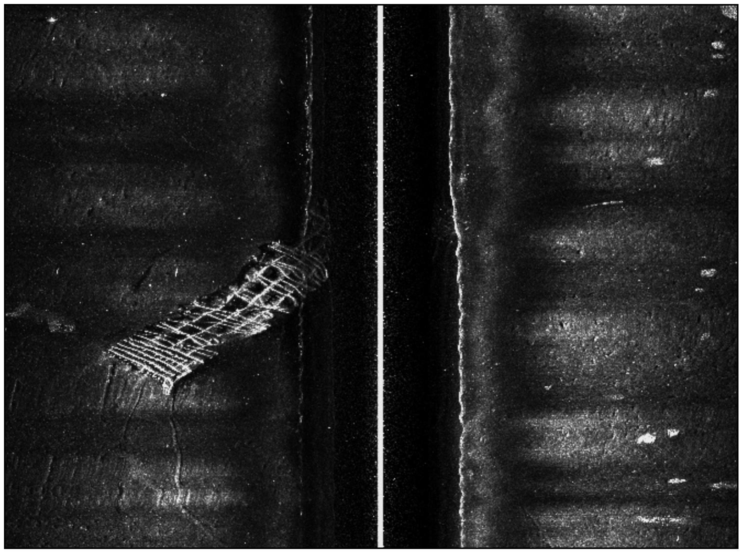


Figure 6-24. Sidescan sonar image of the barge located near the wreck of the *Josephine* (courtesy of MMS/GOMR).

6.1.4. Post-Survey Data Processing

The system for post-survey data processing for the *Rhoda* and the *Josephine* wrecks was the Coastal Oceanographics' Hypack Max Version 5b program. The data for each magnetometer was viewed in the raw format. All spikes and extra tails on the end of the grid lines were edited out and the remainder then saved into an edited format. Once in the edited format a graph was prepared, as well as a graph for the base stations (Marine Magnetics, Sentinel land base station, Marine Magnetics underwater Sentinel base station, and the Geometrics G-856 base station). All grids were then separated into separate line files in an Excel format for further line comparison and data quality. Each line file was then processed by line and graphed for a visualization of data, allowing for a complete and thorough review of each track line of data as well as the inspection of any anomaly signatures. Maximum and minimum gamma signatures were closely examined as well as magnetic signature duration, and positioning data (i.e., northings and eastings).

6.2. Survey Results

As described above, all four magnetometers were run on three grids over two shipwrecks in an effort to determine how each instrument detected that same wreck site with regard to maximum gamma deviation and duration. It should be stated that this aspect of the investigation was not a contest to determine which instrument recorded the highest gamma amplitude or deviation at the greatest spaced interval, nor was it a controlled laboratory experiment where a sensor could be pulled past a piece of iron of a known mass along an unwavering track spaced at an exactly known distance unaffected by wind or current. Rather, it was a field trial conducted to simulate an actual survey environment, with the *Josephine* situated in a high-current, open-ocean location and the *Rhoda* in a somewhat protected bay environment, and to assess how each instrument recorded the same wreck site, and if differences were present, determine if these findings predicated changes to the current MMS/GOMR survey methodology.

6.2.1. Magnetometer Amplitude Comparisons

Basic magnetometer data for each instrument is presented in a number of graphic and tabular formats that illustrate differences in gamma amplitude or deviation and duration. Figures 6-25 through 6-27 are line graphs for the 25-meter survey interval grid, the 30-meter survey interval grid, and the 30-meter survey interval 7-knot grid respectively, that represent the total gamma deviation or amplitude for each instrument over the *Josephine* wreck site by track line. Table 6-4 lists maximum, minimum, and total gamma deviation for each of the various instruments, again by numbered track line for each of the survey grids over the *Josephine*. Similarly, Figures 6-28 through 6-30 are line graphs for the 25-meter survey interval grid, the 30-meter survey interval grid, and the 30-meter survey interval 7-knot grid respectively, that represent the total gamma deviation for each instrument over the *Rhoda* wreck site by track line. Table 6-5 lists maximum, minimum and total gamma deviation for each of the various instruments, again by numbered track line, for each of the survey grids over the *Rhoda*. Accompanying comparative strip charts for each instrument by line for the various grids for each wreck are presented in Appendices I-N.

Beginning with the *Josephine* grids, two wrecks are actually represented in the Josephine 25-meter survey interval grid: the *Josephine,* which is the much larger anomaly, and a smaller anomaly produced by the wreck of a (suspected?) wooden barge located several hundred feet away to the east, southeast. Both the graph in Figure 6-25 and Table 6-4 reveal that over the center of the wreck (Line 9), the G-877 magnetometer had the largest gamma deviation (13,442), with the SeaSPY having a similar but slightly lower reading (12,371), followed by the G-881 (9,068) and then the G-866 at 6,639 gamma. The same order occurred over the barge, with the highest deviation recorded by the G-877 at 4,682 gamma, followed by the SeaSPY at 4,088 gamma, the G-881 at 3,379 gamma, and then the G-866 at 1,879 gamma.

In gross gamma deviation, all four instruments detected the wreck site with large readings beginning with Line 7 through 11, with the highest readings at Lines 9 and 10 respectively. As indicated by Line 8, the G-877 had a much larger initial gamma perturbation/detection rise. However, this reading, as well as a similar occurrence for the G-881 on Line 18 on the barge wreck, may be a result of a minor track line variation between sensors that is discussed below. While the readings from all instruments represent large magnetic anomalies for both wrecks in this grid, it is interesting to note that the G-877 appears at first glance to be the most sensitive with respect to gamma deviation, a surprising finding given that its sensitivity is theoretically below that of the Overhauser and cesium sensors (see above discussion). However, as the following illustrations and tables indicate, there is some variation in which instrument records the highest deviation.

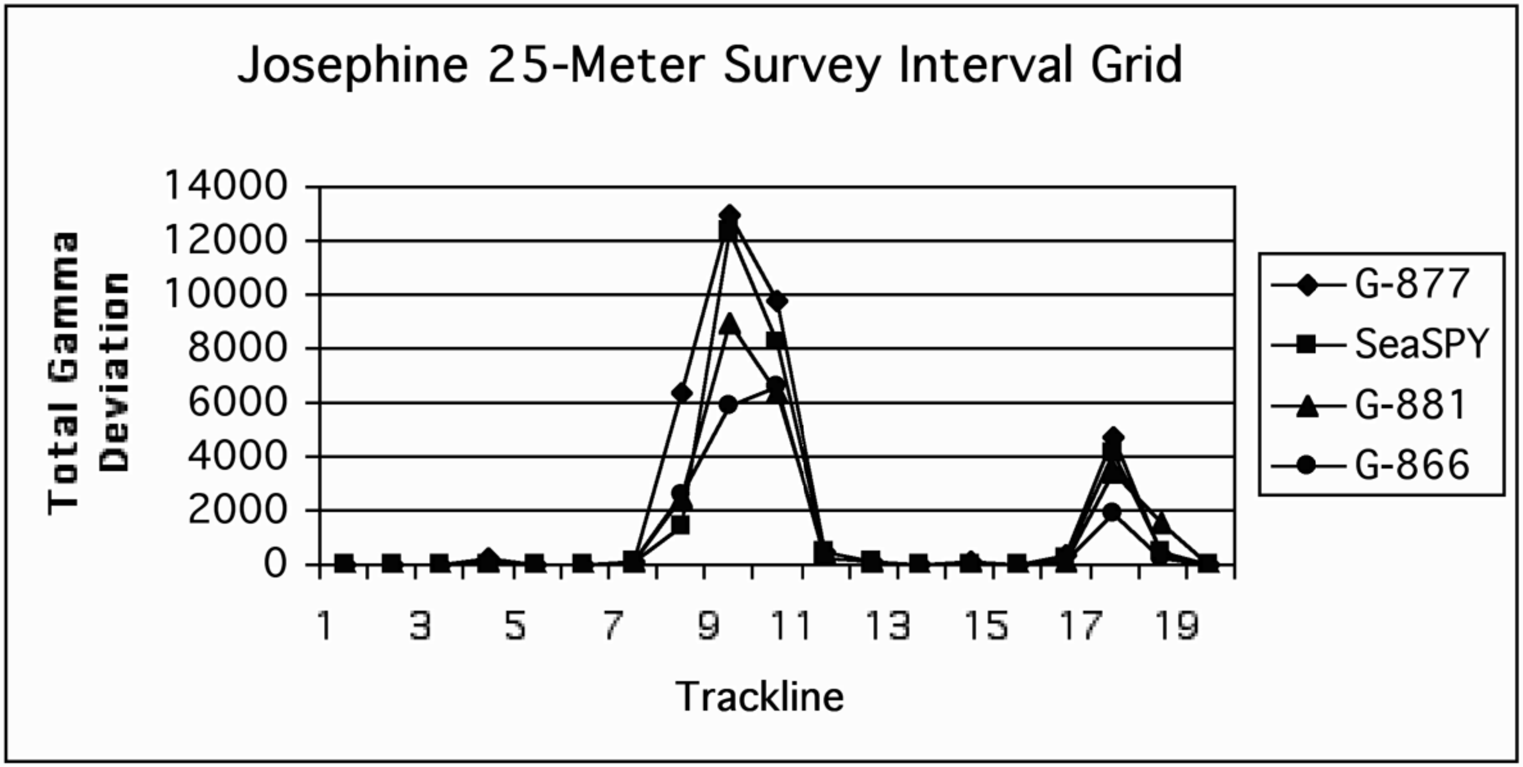


Figure 6-25. ***Josephine*** **25-meter survey interval grid total gamma deviation graph.**

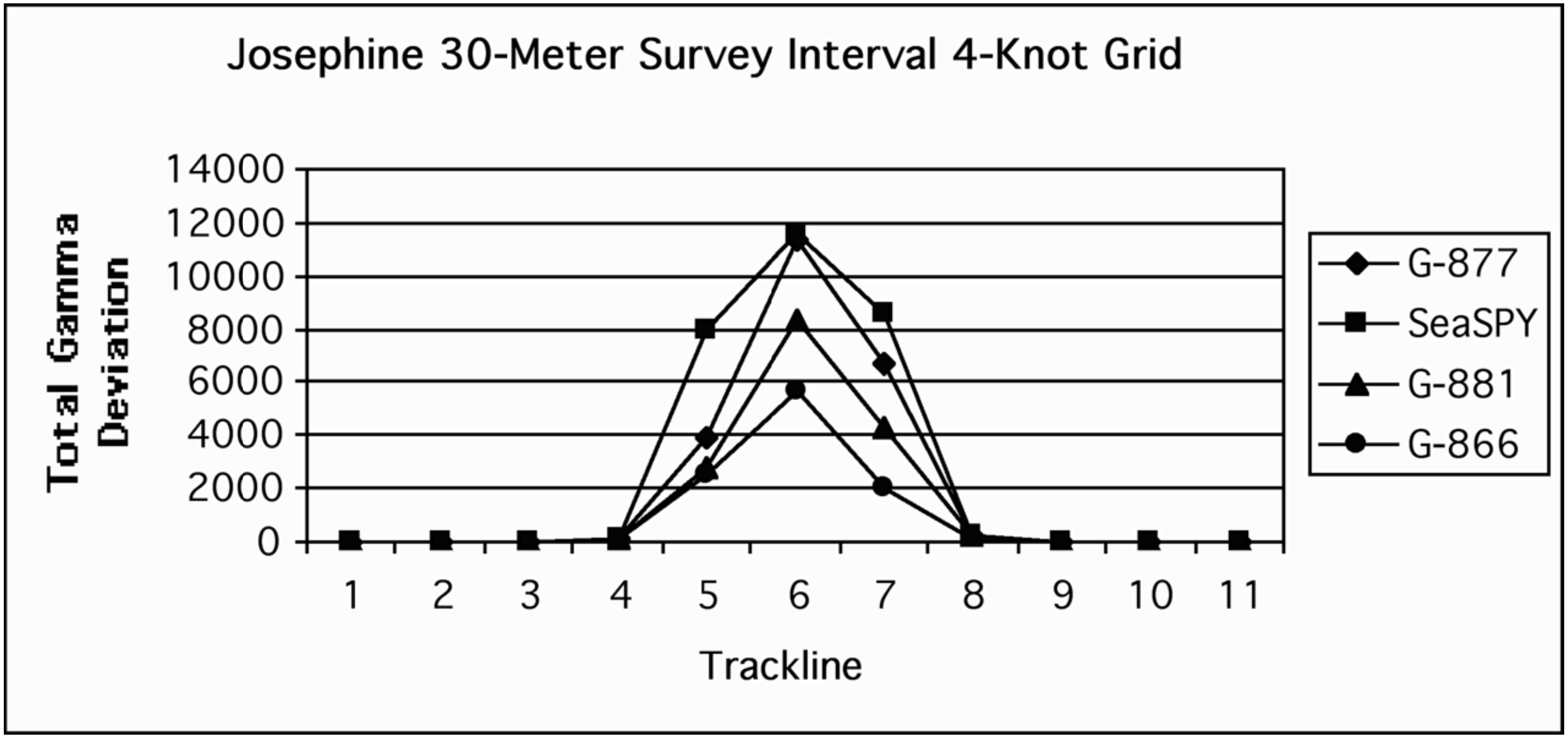


Figure 6-26. ***Josephine*** **30-meter survey interval 4-knot grid total gamma deviation graph.**

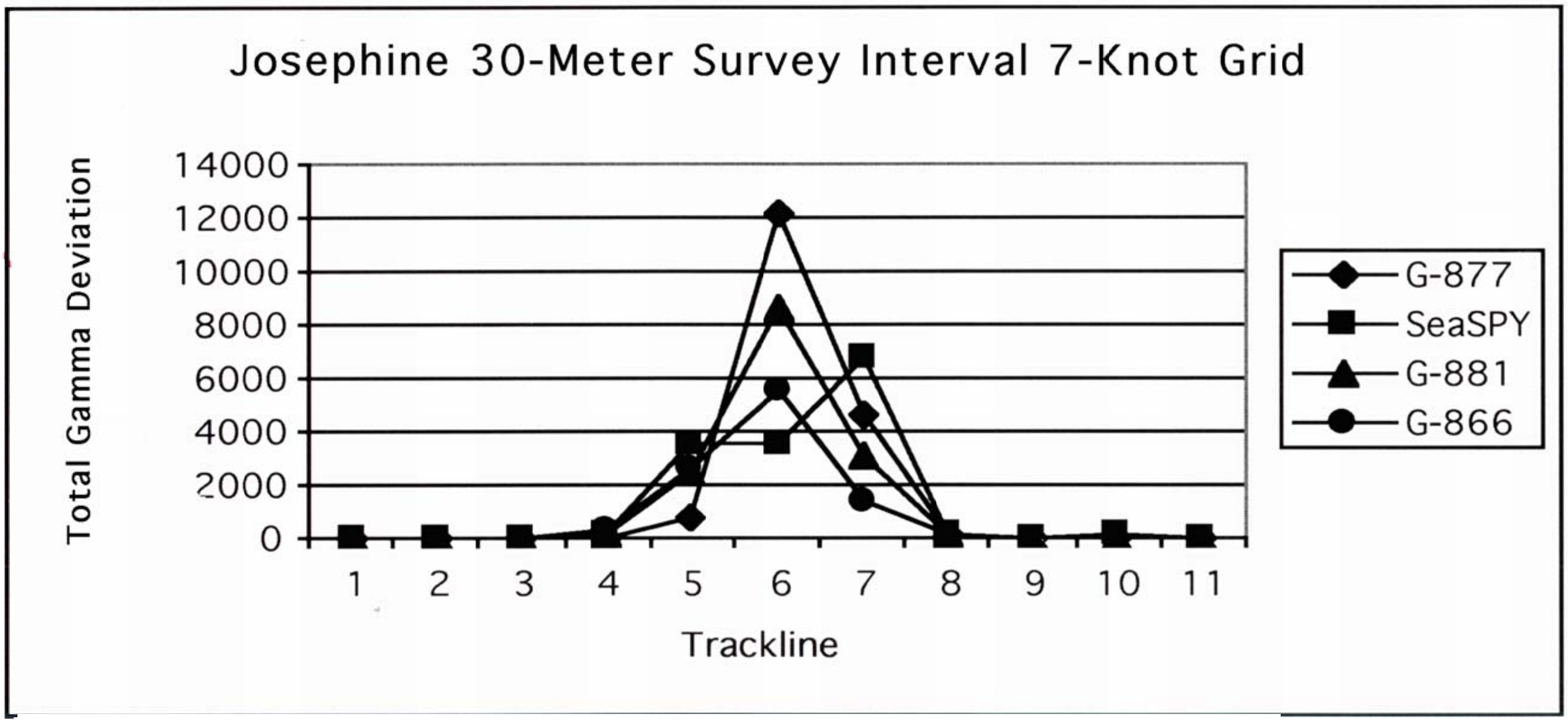


Figure 6-27. ***Josephine*** **30-meter survey interval 7-knot grid total gamma deviation graph.**

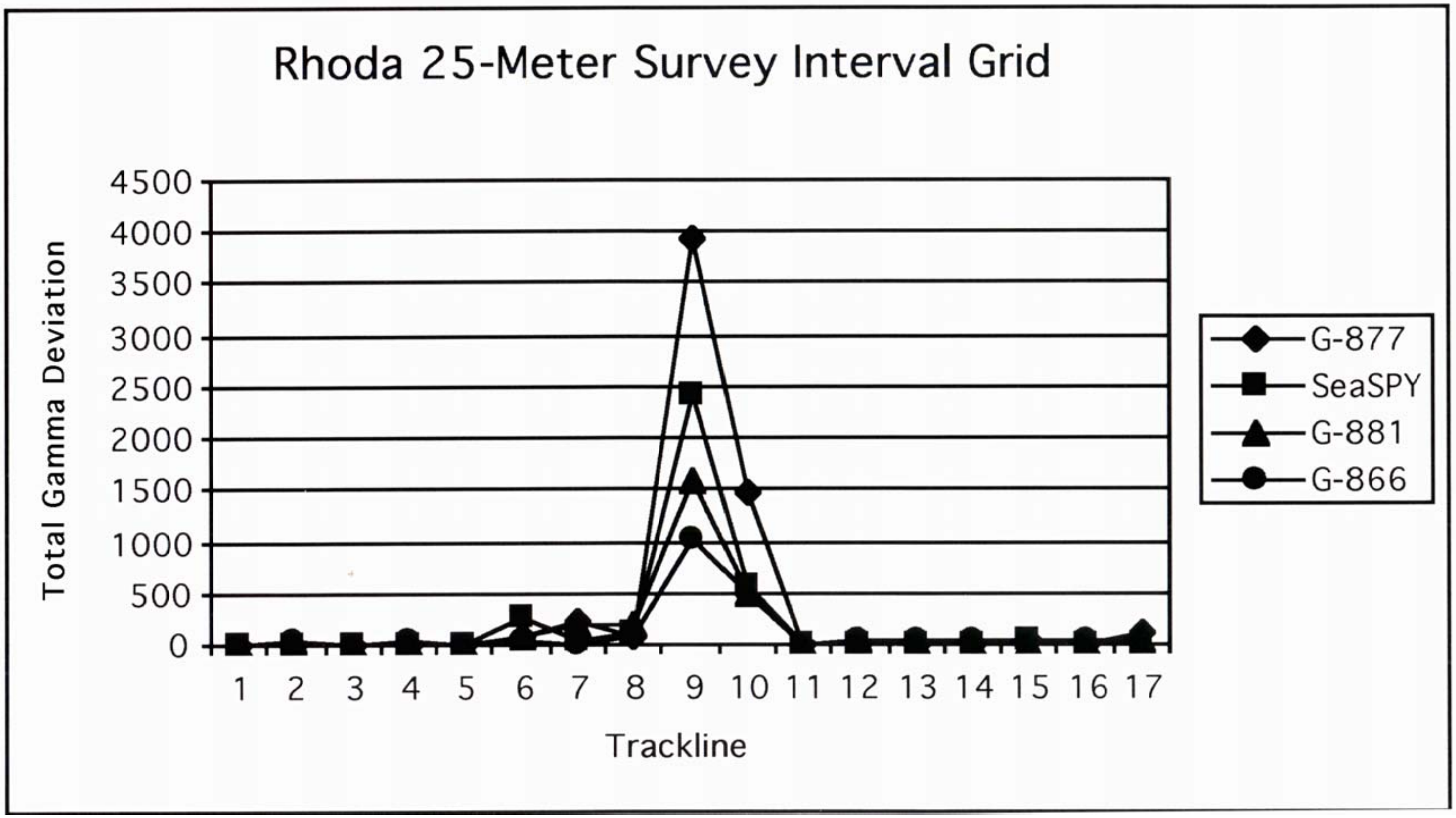


Figure 6-28. ***Rhoda*** **25-meter survey interval grid total gamma deviation graph.**

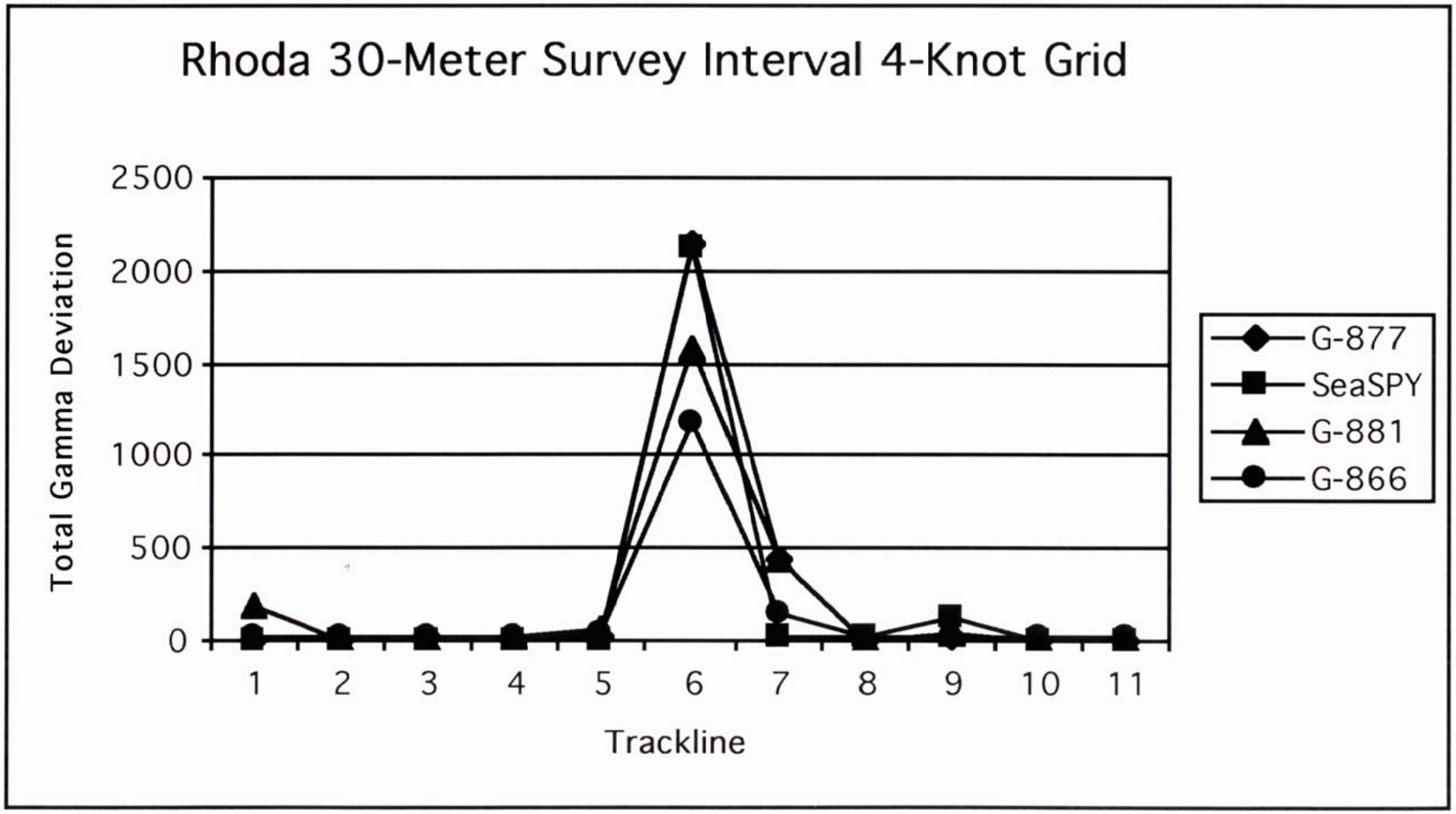


Figure 6-29. ***Rhoda*** **30-meter survey interval 4-knot grid total gamma deviation graph.**

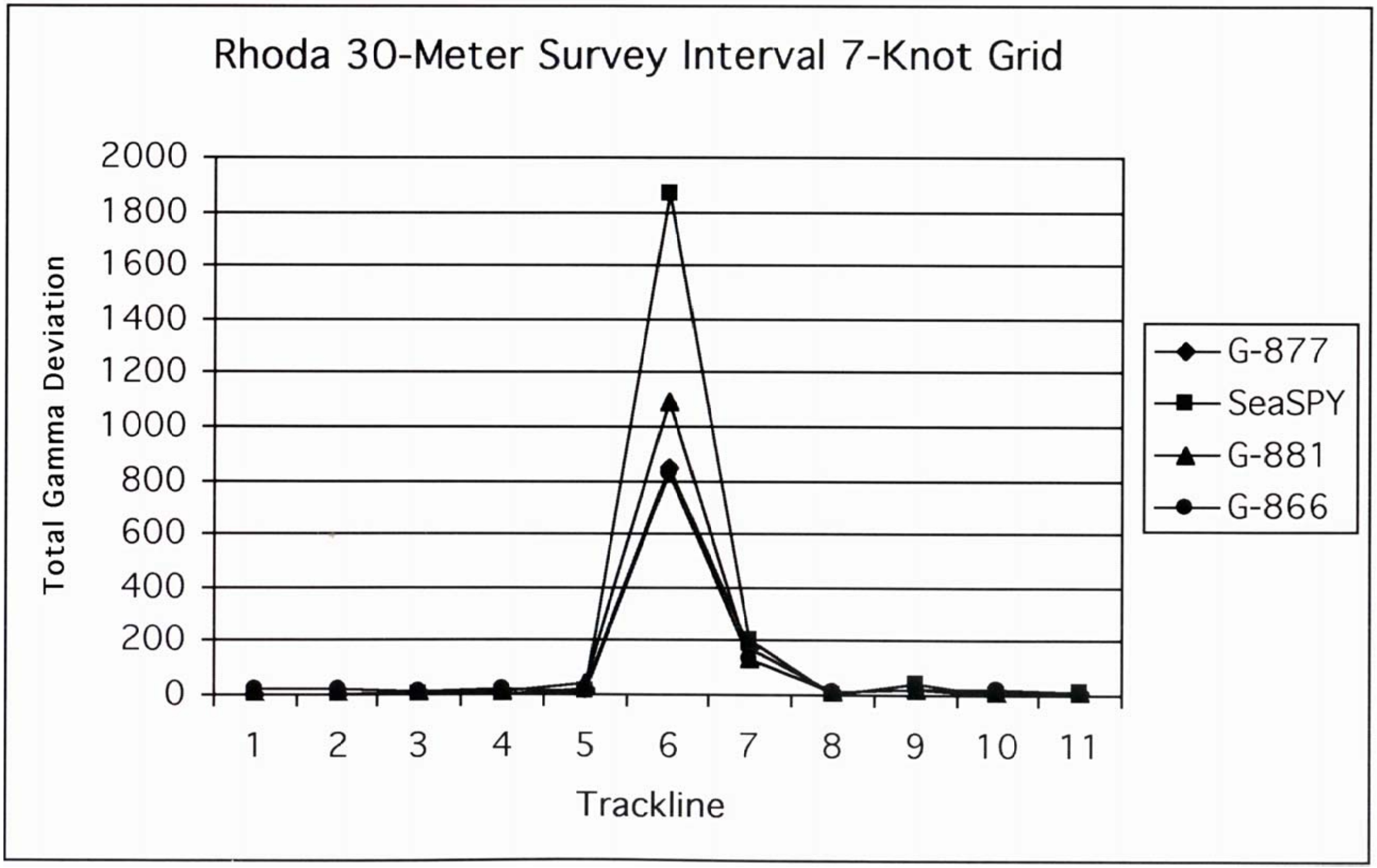


Figure 6-30. ***Rhoda*** **30-meter survey interval 7-knot grid total gamma deviation graph.**

Table 6-4. *Josephine* Line Data for All Grids and Instruments

JOSEPHINE 25-METER SURVEY INTERVAL GRID					
G-866					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)*
1	49136	49130	49150	20	N/A
2	49136	49131	49139	8	N/A
3	49134	49120	49160	40	N/A
4	49131	49110	49139	29	N/A
5	49131	49113	49138	25	347’
6	49131	49106	49142	36	387’
7	49131	48993	49142	149	364’
8	49133	48030	50641	2611	537’
9	49132	47367	53237	5870	534’
10	49135	45986	52625	6639	587’
11	49135	48925	49148	223	439’
12	49137	49056	49142	86	449’
13	49138	49116	49141	25	347’
14	49140	49124	49142	18	72’
15	49140	49099	49144	45	186’
16	49141	48991	49159	168	321’
17	49142	48356	50235	1879	511’
18	49143	48946	49197	251	288’
19	49143	49135	49161	26	N/A
G-877					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49268	49265	49270	5	N/A
2	49263	49260	49262	2	N/A
3	49263	49259	49261	2	N/A
4	49256	49209	49412	203	95’
5	49246	49200	49246	46	272’
6	49240	49198	49247	49	442’
7	49244	49121	49245	124	419’
8	49245	44039	50609	6570	537’
9	49249	37186	50628	13442	564’
10	49256	40336	50433	10097	570’
11	49264	48803	49269	466	288’
12	49248	49174	49250	76	390’
13	49250	49231	49261	30	678’
14	49241	49213	49327	114	249’
15	49242	49204	49254	50	268’
16	49246	48938	49266	328	302’
17	49247	45581	50263	4682	367’
18	49253	48967	49289	322	275’
19	49257	49256	49258	2	N/A
G-881					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49252	49251	49253	2	N/A
2	49251	49258	49260	2	N/A
3	49263	49259	49264	5	N/A
4	49267	49172	49277	105	114’
5	49269	49257	49270	13	223’
6	49271	49242	49271	29	311’

Table 6-4. (continued). *Josephine* Line Data for All Grids and Instruments

JOSEPHINE 25-METER SURVEY INTERVAL GRID					
G-881					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)*
7	49273	49163	49274	111	334’
8	49272	48199	50728	2529	577’
9	49268	47107	56137	9030	547’
10	49266	46212	52701	6489	505’
11	49262	48808	49311	503	265’
12	49257	49179	49259	80	259’
13	49267	49243	49269	26	350’
14	49270	49252	49336	84	124’
15	49273	49243	49273	30	62’
16	49276	49169	49286	117	160’
17	49271	47677	51056	3379	350’
18	49275	48623	50131	1508	318’
19	49274	49271	49277	6	N/A
SeaSPY					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49256	49255	49257	2	N/A
2	49218	49216	49219	3	N/A
3	49218	49211	49220	9	285’
4	49219	49184	49221	37	482’
5	49219	49207	49220	13	485’
6	49222	49193	49221	28	528’
7	49222	49111	49223	112	613’
8	49224	48369	49805	1436	541’
9	49220	46708	59079	12371	810’
10	49220	45680	53863	8183	695’
11	49219	48803	49251	448	557’
12	49221	49159	49222	63	721’
13	49219	49192	49221	29	695’
14	49219	49200	49252	52	780’
15	49217	49182	49218	36	649’
16	49217	49013	49259	246	373’
17	49218	47345	51433	4088	387’
18	49216	48834	49350	516	426’
19	49216	49213	49218	5	N/A
JOSEPHINE 30-METER SURVEY INTERVAL 4 KNOT GRID					
G-866					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49143	49134	49175	41	N/A
2	49143	49125	49150	25	N/A
3	49146	49126	49162	36	226’
4	49147	49066	49154	88	360’
5	49145	48375	50847	2472	413’
6	49151	47648	53276	5628	442’
7	49153	48340	50363	2023	311’
8	49155	49005	49158	153	305’
9	49156	49128	49157	29	209’
10	49156	49136	49175	39	193’
11	49154	49116	49166	50	229’

Table 6-4. (continued). *Josephine* Line Data for All Grids and Instruments

JOSEPHINE 30-METER SURVEY INTERVAL 4 KNOT GRID					
G-877					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49253	49258	49260	2	n/a
2	49261	49247	49261	14	68’
3	49264	49240	49264	24	141’
4	49265	49161	49266	105	288’
5	49266	47382	51285	3903	396’
6	49267	39352	50724	11372	472’
7	49269	43579	50304	6725	324’
8	49268	49055	49261	206	301’
9	49269	49234	49269	35	213’
10	49279	49252	49285	33	85’
11	49268	49227	49269	42	226’
G-881					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49269	49264	49270	6	N/A
2	49270	49254	49270	16	N/A
3	49272	49251	49272	21	N/A
4	49276	49188	49276	88	288’
5	49278	48043	50873	2830	350’
6	49268	47119	55993	8874	476’
7	49271	47719	52191	4472	488’
8	49274	49083	49274	191	231’
9	49277	49253	49277	24	226’
10	49279	49261	49322	61	N/A
11	49281	49247	49285	38	N/A
SeaSPY					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49193	49185	49199	14	N/A
2	49197	49185	49195	10	N/A
3	49196	49169	49194	25	396’
4	49197	49098	49199	101	367’
5	49200	46547	54475	7928	534’
6	49207	46629	58232	11603	557’
7	49212	46729	55366	8637	629’
8	49222	49024	49222	198	478’
9	49220	49180	49221	41	554’
10	49220	49197	49245	48	500’
11	49210	49210	49213	3	N/A
JOSEPHINE 30-METER SURVEY INTERVAL 7 KNOT GRID					
G-866					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49155	49157	49175	18	N/A
2	49156	49145	49163	18	229’
3	49155	49134	49159	25	164’
4	49155	48840	49162	322	301’
5	49157	48173	50768	2595	541’
6	49156	47131	52598	5467	501’
7	49158	48227	49667	1440	364’

Table 6-4. (continued). *Josephine* Line Data for All Grids and Instruments

JOSEPHINE 30-METER SURVEY INTERVAL 7 KNOT GRID					
G-866					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
8	49158	49026	49158	132	367’
9	49159	49142	49168	26	137’
10	49160	49135	49162	27	91’
11	49161	49110	49169	59	160’
G-877					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49275	49271	49276	5	N/A
2	49263	49250	49263	13	N/A
3	49267	49240	49267	27	118’
4	49274	49230	49274	44	279’
5	49275	48637	49352	715	370’
6	49276	38677	50859	12182	534’
7	49265	47325	51871	4546	380’
8	49263	49155	49265	110	357’
9	49272	49249	49272	23	219’
10	49275	49255	49322	67	52’
11	49277	49230	49285	55	N/A
G-881					
Line	Background	Minimum	Maximum	Amplitude	Duration
1	49282	49277	49282	5	N/A
2	49283	49269	49283	14	N/A
3	49283	49261	49283	22	354’
4	49282	49193	49282	89	469’
5	49282	48182	50724	2542	400’
6	49282	47146	55820	8674	544’
7	49283	48049	51108	3059	472’
8	49283	49183	49285	102	150’
9	49283	49264	49284	20	172’
10	49280	49256	49281	25	N/A
11	49281	49248	49281	33	N/A
SeaSPY					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49215	49211	49217	6	N/A
2	49216	49197	49217	20	101’
3	49216	49183	49217	34	508’
4	49219	49136	49222	86	537’
5	49219	47649	51210	3561	423’
6	49221	45692	49280	3588	639’
7	49222	46773	53486	6713	724’
8	49223	49006	49224	218	148’
9	49224	49153	49225	72	449’
10	49226	49204	49320	116	541’
11	49226	49197	49238	41	567’

*Duration of an anomaly is the distance necessary for the wavelength to reach a maximum and/or minimum and return to ambient background.

Table 6-5. *Rhoda* Line Data for All Grids and Instruments

RHODA 25-METER SURVEY INTERVAL GRID					
G-866					
Line	Background	Minimum	Maximum	Amplitude	Duration(ft.)*
1	49263	49255	49272	17	N/A
2	49264	49246	49273	27	N/A
3	49262	49253	49270	17	N/A
4	49260	49243	49274	31	N/A
5	49257	49251	49267	16	N/A
6	49254	49243	49263	20	N/A
7	49253	49248	49260	12	N/A
8	49249	49211	49268	57	65’
9	49250	48907	49941	1034	341’
10	49245	49142	49633	491	403’
11	49246	49240	49256	16	154’
12	49240	49231	49259	28	N/A
13	49246	49234	49260	26	N/A
14	49245	49227	49266	39	N/A
15	49247	49239	49259	20	N/A
16	49245	49225	49264	39	N/A
17	49245	49229	49263	34	N/A
G-877					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49358	49352	49359	7	N/A
2	49363	49361	49363	2	N/A
3	49367	49366	49367	1	N/A
4	49363	49362	49365	3	N/A
5	49366	49364	49368	4	N/A
6	49366	49345	49404	59	124’
7	49366	49314	49558	244	95’
8	49366	49323	49387	64	154’
9	49358	46737	50664	3927	298’
10	49363	48766	50256	1490	383’
11	49365	49354	49369	15	239’
12	49370	49368	49371	3	108’
13	49370	49359	49373	14	N/A
14	49370	49363	49371	8	N/A
15	49365	49355	49374	19	N/A
16	49362	49358	49364	6	N/A
17	49362	49320	49428	108	N/A
G-881					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49331	49328	49332	4	N/A
2	49330	49328	49356	28	N/A
3	49331	49328	49331	3	N/A
4	49331	49327	49331	4	N/A
5	49331	49326	49331	5	N/A
6	49330	49316	49381	65	127’
7	49329	49279	49450	171	85’
8	49330	49213	49410	197	413’

Table 6-5. (continued). *Rhoda* Line Data for All Grids and Instruments

G-881					
Line	Background	Minimum	Maximum	Amplitude	Duration(ft.)*
9	49330	48801	50336	1535	249'
10	49333	49207	49684	477	314'
11	49331	49326	49337	11	400'
12	49337	49323	49344	21	337'
13	49336	49331	49336	5	N/A
14	49341	49333	49340	7	N/A
15	49340	49337	49343	6	N/A
16	49344	49345	49347	2	N/A
17	49347	49337	49371	34	N/A
SeaSPY					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49341	49339	49341	2	N/A
2	49340	49338	49342	4	N/A
3	49343	49342	49344	2	N/A
4	49344	49342	49345	3	N/A
5	49344	49343	49345	2	N/A
6	49343	49301	49556	255	75'
7	49341	49323	49349	26	59'
8	49343	49289	49392	103	131'
9	49355	48570	50975	2405	423'
10	49345	49193	49770	577	334'
11	49345	49339	49347	8	216'
12	49345	49340	49351	11	85'
13	49347	49345	49348	3	N/A
14	49350	49348	49351	3	N/A
15	49353	49337	49370	33	N/A
16	49355	49352	49355	3	N/A
17	49358	49357	49360	3	N/A
RHODA 30-METER SURVEY INTERVAL 4 KNOT GRID					
G-866					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49243	49227	49248	21	N/A
2	49241	49234	49249	15	N/A
3	49240	49225	49254	29	N/A
4	49240	49231	49247	16	186'
5	49238	49217	49257	40	200'
6	49240	48809	49980	1171	534'
7	49240	49181	49322	141	485'
8	49244	49232	49252	20	344'
9	49244	49229	49254	25	N/A
10	49244	49237	49252	15	N/A
11	49245	49231	49257	26	N/A
G-877					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49274	49273	49275	2	N/A
2	49274	49273	49276	3	N/A
3	49275	49267	49279	12	23'

Table 6-5. (continued). *Rhoda* Line Data for All Grids and Instruments

RHODA 30-METER SURVEY INTERVAL 4 KNOT GRID					
G-877					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
4	49276	49274	49278	4	N/A
5	49280	49273	49284	11	265'
6	49277	48239	50378	2139	380'
7	49279	49165	49616	451	314'
8	49280	49275	49281	6	137'
9	49281	49275	49287	12	141'
10	49280	49278	49281	3	N/A
11	49284	49282	49286	4	N/A
G-881					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49349	49162	49353	191	N/A
2	49350	49350	49351	1	N/A
3	49351	49345	49354	9	124'
4	49352	49350	49363	13	45'
5	49355	49328	49383	55	291'
6	49356	48849	50422	1573	383'
7	49350	49208	49639	431	220'
8	49352	49350	49353	3	98'
9	49352	49327	49370	43	95'
10	49355	49353	49356	3	N/A
11	49356	49353	49358	5	N/A
SeaSPY					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49353	49351	49352	1	N/A
2	49348	49346	49348	2	N/A
3	49345	49344	49346	2	N/A
4	49340	49339	49348	9	85'
5	49337	49330	49340	10	49'
6	49335	48517	50629	2112	357'
7	49347	49348	49370	22	331'
8	49352	49335	49359	24	203'
9	49344	49277	49401	124	82'
10	49339	49338	49342	4	N/A
11	49335	49334	49336	2	N/A
RHODA 30-METER SURVEY INTERVAL 7 KNOT GRID					
G-866					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49258	49249	49266	17	N/A
2	49253	49251	49266	15	N/A
3	49259	49248	49271	23	N/A
4	49259	49253	49262	9	N/A
5	49258	49254	49262	8	N/A
6	49260	48996	49823	827	472'
7	49260	49224	49357	133	432'
8	49255	49256	49266	10	N/A
9	49262	49246	49269	23	196'
10	49262	49256	49276	20	N/A
11	49265	49261	49268	7	N/A

Table 6-5. (continued). *Rhoda* Line Data for All Grids and Instruments

RHODA 30-METER SURVEY INTERVAL 7 KNOT GRID					
G-877					
Line	Background	Minimum	Maximum	Amplitude	Duration(ft.)*
1	49286	49285	49287	2	N/A
2	49286	49285	49287	2	N/A
3	49288	49280	49291	11	52'
4	49288	49285	49289	4	N/A
5	49289	49272	49291	19	85'
6	49289	48925	49775	850	360'
7	49289	49232	49410	178	485'
8	49288	49283	49291	8	232'
9	49289	49278	49295	17	180'
10	49288	49283	49290	7	N/A
11	49288	49285	49291	6	N/A
G-881					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49342	49340	49345	5	N/A
2	49338	49337	49339	2	N/A
3	49335	49329	49338	9	124'
4	49334	49330	49336	6	180'
5	49334	49310	49350	40	423'
6	49335	48946	50034	1088	331'
7	49335	49276	49408	132	252'
8	49331	49327	49338	11	108'
9	49331	49319	49338	19	95'
10	49332	49330	49332	2	N/A
11	49332	49327	49333	6	N/A
SeaSPY					
Line	Background	Minimum	Maximum	Amplitude	Duration (ft.)
1	49334	49333	49334	1	N/A
2	49329	49329	49330	1	N/A
3	49333	49331	49336	5	N/A
4	49329	49326	49330	4	N/A
5	49327	49322	49331	9	N/A
6	49324	48529	50397	1868	338'
7	49323	49216	49419	203	337'
8	49323	49319	49323	4	147'
9	49324	49296	49340	44	98'
10	49324	49323	49325	2	N/A
11	49325	49317	49327	10	N/A

*Duration of an anomaly is the distance necessary for the wavelength to reach a maximum and/or minimum and return to ambient background.

Figure 6-28 illustrates the *Rhoda* 25-meter survey interval grid total gamma deviation graph; Table 6-5 lists maximum, minimum and total gamma deviation for each of the instruments over the wooden-hulled wreck site. Apart from minor differences due to track line variation between sensors on Lines 6 and 7, the G-877 had the largest gamma deviation over the *Rhoda* with 3,927 gamma. The SeaSPY again had a slightly lower reading of 2,405 gamma, followed by the G-881 at 1,535 gamma, and the G-866 at 1,034 gamma.

Figures 6-26 and 6-29 illustrate the *Josephine* and the *Rhoda* 30-meter survey interval grid total gamma deviation graphs, followed by Figures 6-27 and 6-30 which are the 30-meter survey interval 7-knot graphs for each wreck. Tables 6-4 and 6-5 accompany their respective graphs. Unlike both the 25-meter survey interval grids, the SeaSPY has the highest reading in the 30-m grid over the *Josephine* at 11,603 gamma on the central line, Line 6 (Figure 6-26). The G-877 has a similar but slightly lower reading with 11,372 gamma followed by the G-881 at 8,874 gamma, and the G-866 at 5,628 gamma. This order is reflected for Lines 5 and 7 but with the added characteristic that the SeaSPY has much higher amplitudes than all three other instruments. Possibly a result of minor track line offset (see easting positions), these findings appear to be reflected in the 30-meter survey interval 7-knot grid discussed below.

The *Rhoda* 30-meter survey interval grid total gamma deviation graph (Figure 6-29) reflects readings similar for both the *Josephine* and *Rhoda* 25-meter survey interval grids as well (Table 6-5), with the order of intensity being the G-877 at 2,139 gamma, the SeaSPY (2,112), the G-881 (1,573), and then the G-866 at 1,171 total gamma deviation for Line 6, the line with the highest readings. It is interesting to note that the SeaSPY falls below all the instruments on Line 7.

The *Josephine* 30-meter survey interval 7-knot grid total gamma deviation graph (Figure 6-27, Table 6-4) seemingly reflects readings similar to the 30-meter survey interval 4-knot grid but with one caveat. At face value the 30-meter survey interval 7-knot grid looks dissimilar to the other grids in that the SeaSPY has the lowest reading on the centerline, even well below both the G-881 and the G-866. However, it has the highest reading of all instruments for both Lines 5 and 7, reflective of readings for the 30-meter survey interval 4-knot grid. Unable to characterize this occurrence, a review of the raw data indicated that when the sensor started to detect the highest reading it went into an "initialized tuning" mode and unknowingly ceased recording accurate magnetic data for some 13 seconds. Discussions with the manufacturer stated that:

> …the wreck's magnetic effect was so huge that at this speed, the magnetic field at the sensor was changing faster than the maximum spec of the instrument. Looking at the data, it was changing at about 3000nT [nanoTeslas = gammas] per second. The SeaSPY firmware [that was on] monitors the quality of the data, and when it falls below a certain value it is designed to automatically reset the operating parameters to ensure that everything is set correctly. Note that in the 4 knot survey, the anomaly appears perfectly. This is because the field changes slower - around 1800nT per second….The firmware's automatic monitoring features can be switched off, and in this case, I am sure that the mag would have read the full anomaly at 7 knots as well (Doug Hrovic, personal communication 2002).

Given this information, it is suspected that if the firmware's automatic monitoring feature had been switched off, the SeaSPY would have recorded a similar reading on the 30-meter survey interval 4-knot grid, equal to or above the G-877, as well as the other two instruments.

The *Rhoda* 30-meter survey interval 7-knot grid total gamma deviation graph (Figure 6-30, Table 6-5) is somewhat similar to the *Josephine's* 30-meter survey interval 7-knot grid if we take into account the "firmware" issue discussed above in that the SeaSPY has the highest reading on Line 6, the centerline, with 1,868 gamma, followed by the G-881 with 1,088 gamma, the G-877 surprisingly lower than the G-881 with 850 gamma, and then the G-866 with 827 gamma. Possibly a reflection of increased speed, a review of positioning coordinates indicates that all sensor positions are comparable to within one or two meters of the track line center. When compared to recorded readings on Line 9 of the 25-meter survey interval grid, which has the same easting coordinates, the readings are much lower at the greater speed even though sensor positions are comparable to within one or two meters of the track line center. However, these findings are not reflected in the *Josephine* grids. When recorded readings for all instruments on Line 9 of the *Josephine* 25-meter survey interval grid are compared with Line 6 of the wreck's 30-meter survey interval 7 knot grid, the readings are only slightly lower.

While the order of which instrument records the highest deviation appears generally to remain relatively constant, with the SeaSPY and G-877 exchanging places followed by the G-881 and then the G-866, the variation in that order seems to be due to minor differences associated with track line position (i.e., the location of the sensor). Lending credence to this statement is the fact that different readings were recorded for many of the same instruments along the same line of the same grid, additional lines being run for one reason or another (i.e., aborted due to vessel traffic, offline, etc.). Furthermore, gamma deviation for the same instrument varied widely for the same line but on different grids, like that mentioned in the paragraph above. For instance, the Line 9 reading for the G-877 *Josephine* 25-meter survey interval grid is 13,442 total gamma deviation, while the total gamma deviation for Line 6 of the 30-meter survey interval grid (both lines having the exact same easting) is 11,372, over two thousand gammas different. The reading was similar in the northing but some four meters different in the easting. This variation in readings is common as indicated in Table 6-4.

If we look at the graphic presentation of the grid lines in Appendices I through N, as well as data in Tables 6-4 and 6-5, we are able to compare shape and duration of the recorded readings by line. As stated by Garrison et al., "the shape of a magnetic anomaly along a survey line is a result of the same factors that influence the amplitude," orientation of the anomaly source within the Earth's external field. He goes on to state that "most authors refer to shape as dipolar or monopolar. The fall-off of the strength of the anomaly is expressed in the slope of the profile. Typically, the steeper slope values are associated with dipolar anomalies while monopolar anomalies have broader, less steep profiles" (1989:II-173). The report lists rules (after Tite 1972) that anomalies ideally follow in the GOMR:

1. The maximum of the anomaly lies to the south of the feature, the displacement being approximately equal to one-third of the depth to the center of the feature;

2. The separation between two points, in a straight line traverse, at which the anomaly has half its maximum value is approximately equal to the depth or width of the feature, whichever is greater; and

3. A reverse anomaly (i.e., decrease in magnetic field intensity) may occur to the north of the feature at a distance equal to the depth; the reverse anomaly does not exceed 10 percent of the maximum normal value of the anomaly except in the case of metallic iron (Garrison et al. 1989:II-173).

Another quantitative descriptive parameter of magnetic data is duration. More properly defined as wavelength or the total observed magnetic perturbation, duration can be measured in temporal units as well as the spatial unit of distance along a track line. By comparing both duration and shape (see Appendices I through N and Tables 6-4 and 6-5), we are able to make several statements for each instrument.

Tables 6-4 and 6-5 present duration of the recorded amplitude by line for each wreck grid. Many lines are marked as N/A or non applicable if there was no perturbation or if it was thought that a recorded anomaly did not relate to the wreck site. This was especially true for the *Rhoda*, as anomalies that appeared on lines hundreds of meters away from the wreck site were thought to be non-related debris. Additionally, it was impossible to determine the eastern terminus of magnetic influence of the *Josephine* and the western terminus of influence for the barge, as the influence seems to run together (see Lines 11 through 15 of Appendix I), making characterizations of these lines problematic at best.

A review of the duration (Tables 6-4 and 6-5) and strip charts for the 25-meter survey interval grid track lines immediately atop and to the east of the *Josephine* shows that, beginning from the east, the wreck site's magnetism begins to first affect Line 5. We see a small amplitude anomaly but with several hundred feet duration for all instruments for this line. Generally and as expected, both the amplitude and duration steadily intensify and increase for each track line closer to the center of the wreck. For the center lines over the wreck with the highest amplitude, Lines 8, 9 and 10, the duration is highest as well. Interestingly, the SeaSPY records the highest duration for these and other lines, appreciably higher in many instances, although the G-877 had the highest amplitudes for the lines. The G-866 and G-881 had durations similar to one another, with the G-866 slightly higher. Interestingly, the G-866 had the highest duration of all instruments on Line 17, the centerline over the barge, although its amplitude was the lowest.

Similar to the 25-meter survey interval grid, the SeaSPY had the highest duration for the 30-meter survey interval grid as well, with the other instruments generally equal in duration for all lines. The 30-meter survey interval 7-knot grid again shows the SeaSPY with the highest durations. In a comparison between the 30-meter survey interval grids, the durations for the respective lines for each instrument vary to the point that no real comparisons can be made. For instance, the durations for the SeaSPY are higher for Lines 3, 4, 6, and 7 of the 30-meter survey interval 7-knot grid but higher on Lines 5, 8 and 9 of the 30-meter survey interval 4-knot grid.

With the wreck centered at Lines 8, 9 and 10, duration readings for the *Rhoda* 25-meter survey interval grid find the G-877 and the G-881 with generally the higher readings. However, similar to the above 30-meter survey interval grid comparisons, the durations for the respective lines for each instrument vary to the point that no real comparisons can be made. With respect to the *Rhoda* 30-meter survey interval 4-knot grid, the G-866 has the highest durations for any instrument, although it had the lowest amplitude readings (similar to *Josephine* Line 17). The other three instruments generally had similar durations. Reflecting findings of the 25-meter survey interval grid, the 30-meter survey interval 7-knot grid durations for the respective lines for each instrument again vary to the point that no real comparisons can be made. This holds true as well in comparison between the 30-meter survey interval 4 knot grids.

A qualitative review of the magnetic strip charts allows for a comparison of the anomalies recorded by each instrument by line and grid and raises several aspects of anomaly shape as well as characteristics of each instrument (Appendix I through N). Beginning with the *Josephine* 25-meter survey interval grid, we see the G-866 is somewhat noisy for the first four lines, which are presented in a 10 gamma scale, while the other instruments are extremely quiet. Two anomalies not associated with the main part of the wreck site (possibly an anchor?) appear on Line 4. Recorded as two small anomalies by the G-866, it is recorded as a small and relatively large anomaly respectively by the other three instruments; however, each instrument records both anomalies somewhat differently. While the G-877 and G-881 record the smaller anomaly to the north (left), it is just the opposite for the SeaSPY. Both the SeaSPY and G-881 show the southern anomaly in a broad negative field. This same broad or long duration negative is seen on all instruments for Line 5, although the SeaSPY has a brief positive at the maximum negative and the G-877 has an abrupt negative. Line 6 again sees a broad or long duration negative for all instruments but of greater amplitude. Line 7 is again a long duration negative but of increasing amplitude. Line 8 is a dipole but with varying maximum negative and positive amplitudes and illustrates the rule listed above that the maximum of the anomaly lies to the south of the feature. With the exception of the G-877, Line 9 shows similar dipoles for the other three instruments with some complexity in the negative. The G-877 signature differs because the line was inadvertently run in the opposite direction to the others. While admittedly straying from the research design, it serves to illustrate the effect that direction of survey has on shape characteristics of an anomaly, given that lease block survey lines are not all run in the same direction.

Line 10 shows similar dipoles with the exception again of the G-877, which has a much smaller positive and a much larger negative than the other three. Line 11 shows similar dipoles but with varying complexity to the signal in its initial positive amplitude. Lines 12 and 13 are generally broad negatives with lowering amplitude, suggesting that these lines are no longer over the main wreckage but to the side. However, the G-877 has a small positive, indicating some material still in the vicinity. Line 14 is a broad negative with a brief but sharp positive, with the exception of the G-866, which lacks the latter characteristic. Line 15 is a complex series of mainly negatives for all instruments, while Line 16 shows a dipole with a large negative (again, the G-877 was run in the opposite direction). Lines 17 (centered over the barge) and 18 again show similar large dipoles for the instruments while Line 19 is void of any anomaly. At this point it should be mentioned that the high amplitude of the barge suggests that it may be composed of iron and not wood as initially indicated.

With only slight differences, the 30-meter survey interval 4-knot grid varies in anomaly shape, similar to the 25-meter survey interval grid, with each instrument mostly reflecting the same shape. When compared to the 30-meter survey interval 7-knot grid, only minor variations are observed, most of which may be explained to likely differences in exact sensor position.

Findings for the *Rhoda* grid lines are similar to those seen for the *Josephine*, a much larger wreck whose magnetic effect was recorded over many more lines than the wooden bark. Examining the main lines over the wreck site—Lines 8, 9 and 10—variation is seen for the instruments in Line 8 while Lines 9 and 10 appear to be mostly mirror images. Examination of the 30-meter survey interval 4-knot grid generally shows the same minor variation. Differences in Line 5 for the G-881, however, are attributable to the instrument recording a higher amplitude, while the exact opposite occurs on Line 8 where the instrument records a low perturbation. Similar to the *Josephine*, when compared to the 30-meter survey interval 7-knot grid, only minor variations are observed, most of which may be explained to likely differences in exact sensor position.

Aside from duration or shape issues, the strip chart records presented in Appendices I through N beg mention of the NTL's instrumentation guidelines as they pertain to magnetometer strip chart recorders. Reflecting abilities of the for-years industry standard but now antiquated G-801 and G-866 systems, the NTL requires dual scale readings, strip chart speeds, and annotation of the strip charts with shot points and recorder speed. However, given the computer-driven, digital-nature of all instruments today, these requirements appear now to be outmoded and in need of revision, at least for those magnetometers that are totally digital (i.e., G-877, G-881, SeaSPY, etc.). Magnetic data from these digital models is collected simultaneously in the same file along with positioning, depth, time, layback, gyro, etc., making annotation unnecessary. Additionally, the strip chart is presented digitally on the screen in navigation programs such as HYPACK® and may be set at any gamma scale. Furthermore, when post-processing data, track lines and any attendant anomalies can also be viewed and presented in any gamma scale to allow for optimum characterization of that anomaly.

6.2.2. Line Spacing

As stated above, magnetometers were to be evaluated "at various line spacing to determine the minimally acceptable survey line spacing for detecting historic shipwrecks." The current 2002 NTL stipulates that for "OCS blocks that have a high probability for containing historic resources in water depths 200 meters or less, the survey line spacing is no more than 50 meters. For OCS blocks that have a high probability for containing prehistoric archaeological resources or historic resources in water depths greater than 200 meters (656 feet), the survey line spacing is no more than 300 meters" (MMS 2002).

Leaving aside for now discussions on the size of shipwrecks as archaeomagnetic features or previously posited shipwreck signal characteristics (see Garrison et al. 1989:II-211-226), Table 6-6 below represents detection of our three known shipwrecks at varying line spacing or transect interval.

Table 6-6. Survey Transect Interval Detection Rates by Instrument

G-866			
Transect Interval	***Josephine***	***Rhoda***	**Barge**
300-m	No	No	No
150-m	Yes	No	No
	2 lines low amplitude		
100-m	Yes	No	Yes
	1 line high, 1 line low		1 line low amplitude
50-m	Yes	Yes	Yes
	2 lines high, 2 lines low	1 line high, 1 line low	1 line high, 1 line low
30-m (4-knot)	Yes	Yes	NA
	3 lines high, 4 lines low	1 line high, 3 lines low	
G-881			
Transect Interval	***Josephine***	***Rhoda***	**Barge**
300-m	No	No	No
150-m	Yes	No	No
	2 lines low amplitude		
100-m	Yes	Yes	Yes
	1 line high, 1 line low	1 line low amplitude	1 line low amplitude
50-m	Yes	Yes	Yes
	2 lines high, 2 lines low	1 line high, 1 line low	1 line high, 1 line low
Transect Interval	***Josephine***	***Rhoda***	**Barge**
30-m (4-knot)	Yes	Yes	NA
	3 lines high, 3 lines low	2 lines high, 2 lines low	
G-877			
Transect Interval	***Josephine***	***Rhoda***	**Barge**
300-m	No	No	No
150-m	Yes	No	No
	2 lines low amplitude		
100-m	Yes	Yes	Yes
	1 line high, 1 line low	1 line low amplitude	1 line high deviation
50-m	Yes	Yes	Yes
	2 lines high, 2 lines low	1 line high, 2 lines low	2 lines high deviation
30-m (4-knot)	Yes	Yes	NA
	3 lines high, 4 lines low	3 lines high, 2 lines low	

Table 6-6. (continued). Survey Transect Interval Detection Rates by Instrument

SeaSPY			
Transect Interval	***Josephine***	***Rhoda***	**Barge**
300-m	No	No	No
150-m	Yes	No	No
	2 lines low amplitude		
100-m	Yes	Yes	Yes
	1 line high, 1 line low	1 line low amplitude	1 line high amplitude
50-m	Yes	Yes	Yes
	2 lines high, 2 lines low	1 line high, 1 line low	2 lines high deviation
30-m (4-knot)	Yes	Yes	NA
	3 lines high, 4 lines low	1 line high, 4 lines low	

Based on Table 6-4 above, each instrument's grid was reviewed as it related to the detection of each known site location at varying transect intervals. It was attempted to treat each wreck site as if it were the only wreck in that grid. Treating all three wreck sites as separate entities would allow not only an assessment of minimal acceptable transect spacing, but might indicate minimal transect spacing based on vessel type (i.e., metal-hulled, wooden-sailing, wooden barge). As discussed above, however, it was difficult if not impossible, at least with respect to a review of the strip charts, to determine the eastern terminus of magnetic influence for the *Josephine* and the western terminus of influence for the barge, the influence seeming to run together (see Lines 11 through 15 of Appendix I).

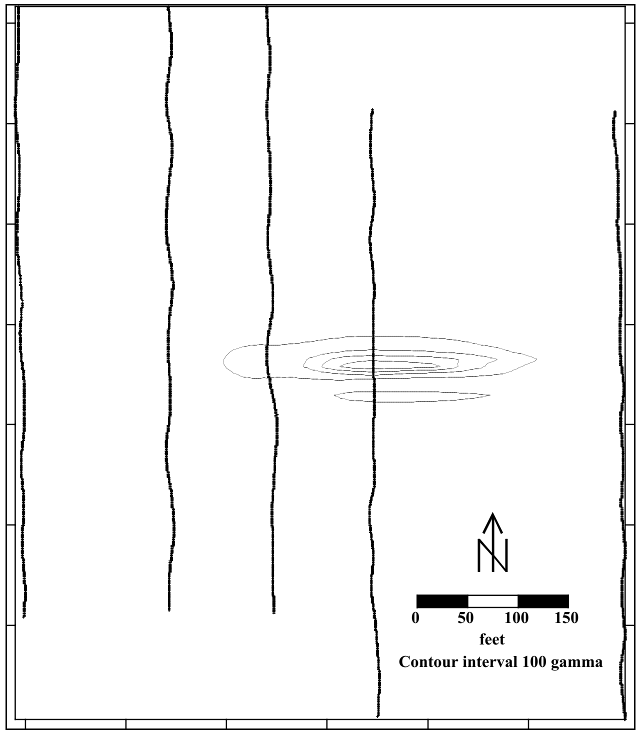
The data from the various transects in the table were projected atop the wreck site and then shifted over one or more lines in an effort to determine if the wreck site would fall outside of or go undetected by the chosen transect interval. For example, if we look at the G-881 data in Table 6-4, the *Josephine* wreck site on the 25-meter survey interval grid falls mainly between Transect Lines 7 and 12 with the highest gamma deviation on Lines 9 and 10 (the 105 gamma reading on Line 4 is not part of the main wreck site, but may be an anchor or some other related component). If we had started the survey on Line 3, the G-881 would not have detected the vessel at a 300-meter survey interval because the wreck site basically covers 175-meter or eight 25-meter survey lines, and of these eight Lines 6 and 13 are relatively minor perturbations (because the eastern terminus is somewhat problematic given the presence of the barge, Line 13 is thought to be the terminus for the *Josephine* given its similarity to Line 6). If a 150-meter transect survey interval began a line at Line 6 (minor amplitude), this line would have produced a minor negative amplitude anomaly of 29 gamma, and 150 meters away Line 12 would have produced another relatively minor amplitude anomaly of 80 gamma (200 gamma was chosen as the demarcation between High and Low amplitude in Table 6-6). If a 100-meter transect survey interval began at Line 6, the survey would have detected a high deviation of 6,488 gamma but only on one line, Line 10, and a low amplitude anomaly on Line 12 (see Table 6-6). Starting at Line 12 and going the other direction also would have detected the wreck at a very high gamma deviation but again on only one line, Line 9. Employing a 50-meter transect survey interval and beginning at Line 6, the G-881 would have detected the wreck on Line 8 at 2,490 gamma, Line 10 at 6,488 gamma, and Line 12 at 80 gamma. In Table 6-6, the *Josephine* is shown as being detected on a 50-meter transect survey interval on two lines with high gamma deviation (Lines 8 and 10) and on one line (Line 12) with a low gamma deviation. In the 30-meter survey interval four-knot transect, the *Josephine* would be detected across five survey lines, three of which have extremely high deviation (Lines 5, 6 and 7), and two with low gamma deviation (Lines 4 and 8), low deviation being under 200 gamma. Lines 3 through 9 are employed on the 30-meter survey interval grid as the extent of the wreck and reflect the same extent as the 25-meter survey interval grid.

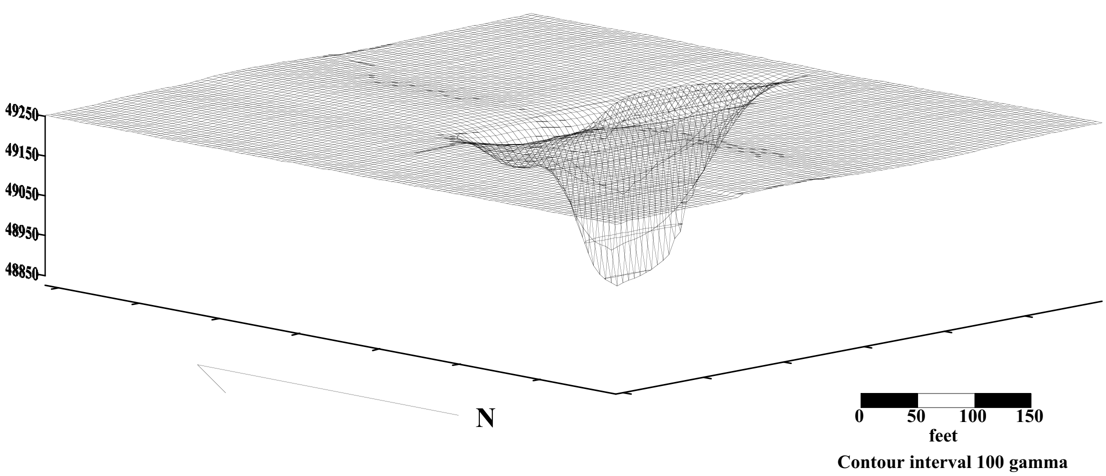
This same method was applied to the barge and all grids for the *Rhoda*. Recorded mainly on Lines 16, 17 and 18 of the 25-meter survey interval grid, the barge site was considered to cover Lines 15 through 18. Based on Table 6-5 and strip chart print-outs (Appendices I-N), the *Rhoda* on the 25-meter survey interval grid falls between Lines 6 through 10.

In an effort to help visualize and quantify the detection rates at the various transect intervals, contour maps were generated in Surfer 7.0® with G-881 data for both the *Josephine* and the *Rhoda* 25-meter survey interval and 30-meter survey interval 4-knot grids (Figures 6-31 through 6-46). In addition to precisely locating the wreck site, a contour map presents a visual signature of the site that can then be analyzed relative to its complexity and spatial attributes. For our purposes the contour maps also allow us to comparatively visualize the differences in the magnetic signatures recorded at the varying survey transect intervals.

Created by employing the Inverse Distance to Power and Spline Smoothing functions of Surfer®, the maps represent 100-meter survey interval transect data presented at both a 100 and 10 gamma contour; two 50-meter survey interval transects, one with even lines and one with odd lines, each presented at both a 100 and 10 gamma contour; and finally the 30-meter survey interval 4-knot grid, presented at both a 100 and 10 gamma contour. Each transect interval and its attendant gamma contour is presented in three contour maps of varied two and three-dimensional views for better visualization of the anomaly's signature as it relates to complexity, spatial attributes, and minimum and maximum gamma deviation.

Notice the *Josephine* is visible at the 100-meter survey interval transect even when presented at a 100 gamma two-dimensional contour, while the *Rhoda* is problematic at best when presented at a two-dimensional 10 gamma contour and basically nonexistent as a 100 gamma contour map. All three wrecks are present on the 50-meter odd-even survey interval transect 100 gamma contour maps; however, the *Rhoda* becomes a much more complex signature when presented at a 10 gamma contour interval. Note that while there are differences between the 50-meter survey interval odd and even transects, all three wreck sites were detected. Also note the increasing complexity of the wreck sites as the transect interval becomes narrower (i.e., 100-meter, 50-meter, 30-meter).





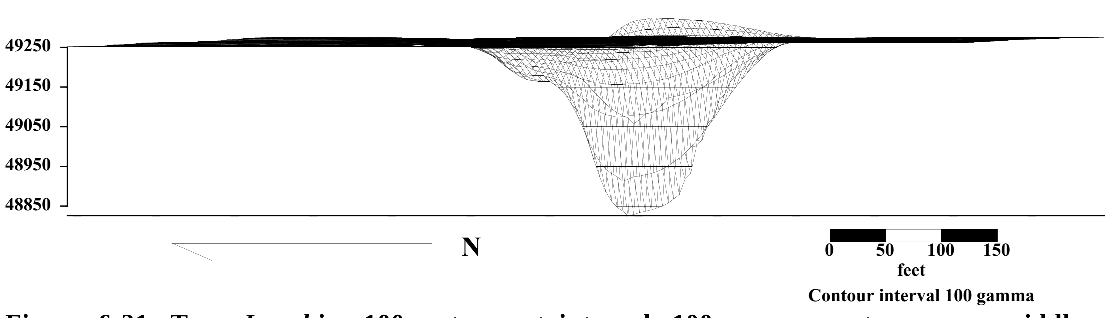


Figure 6-31. Top: *Josephine* 100-m transect interval, 100-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.

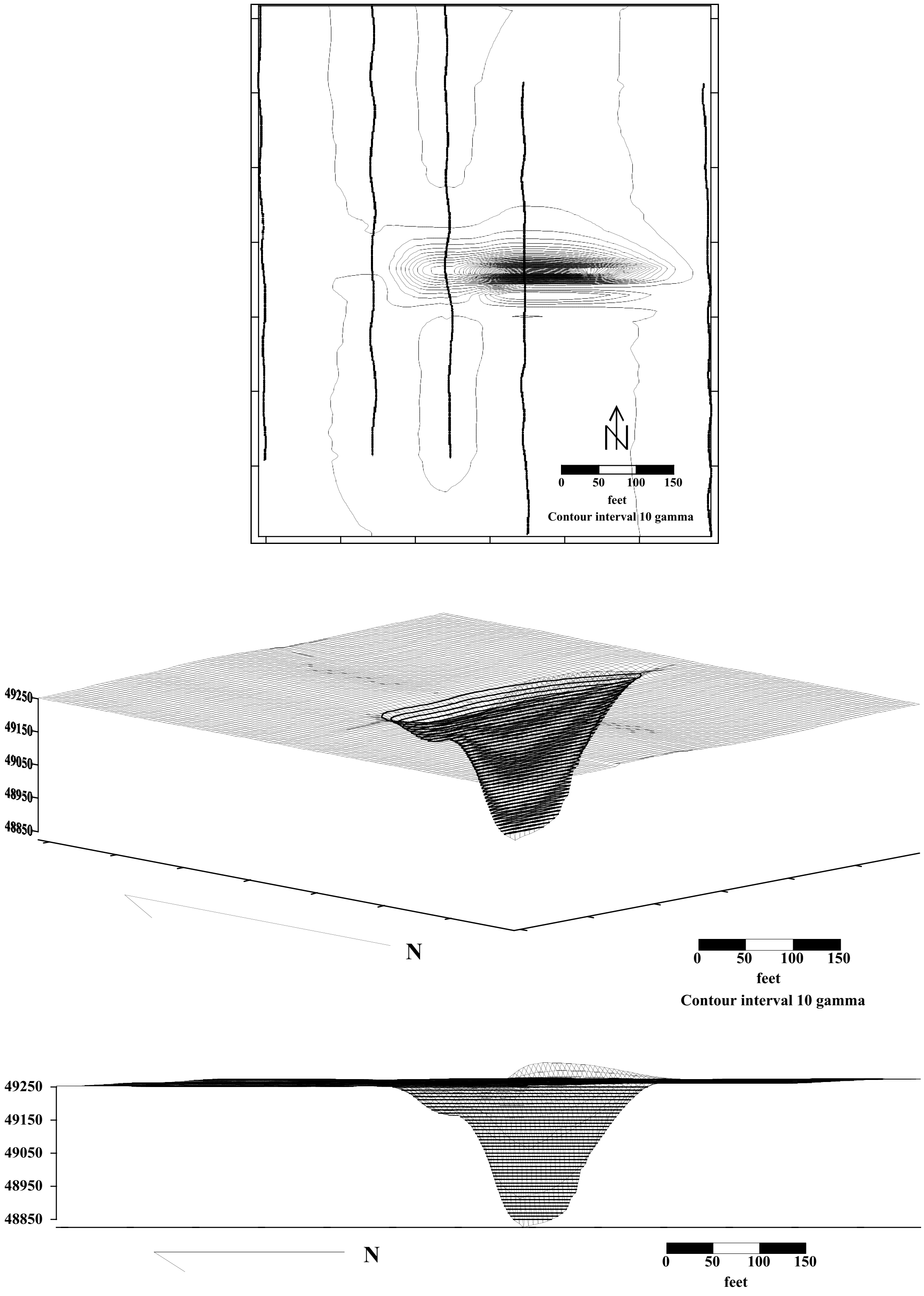
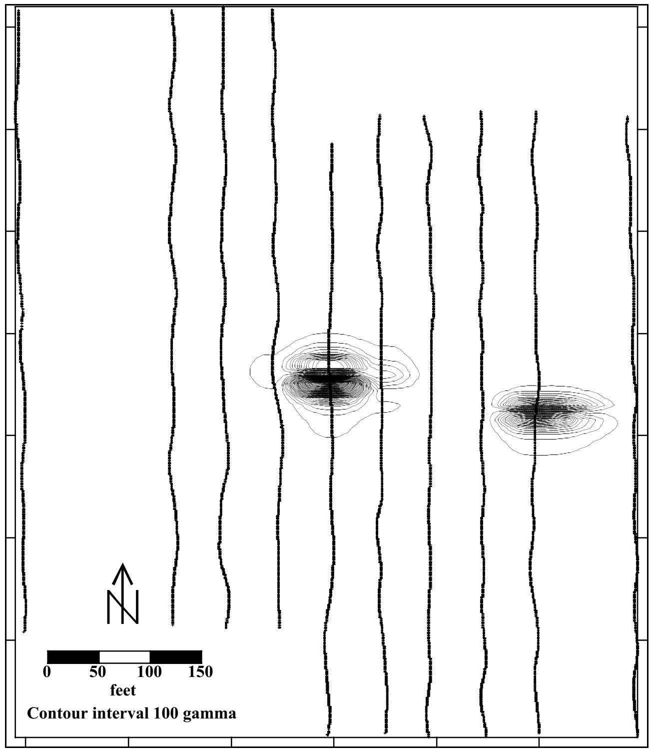
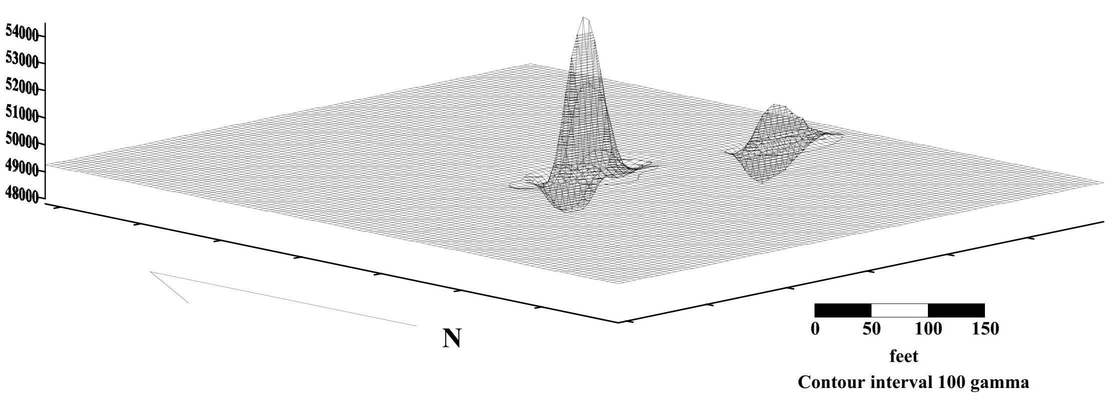


Figure 6-32. Top: *Josephine* 100-m transect interval, 10-gamma contour map; middle: two-dimensional view, bottom: three-dimensional view.





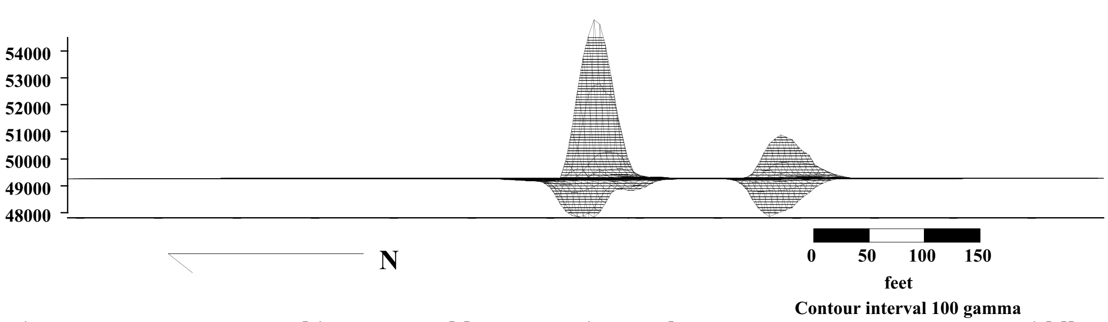
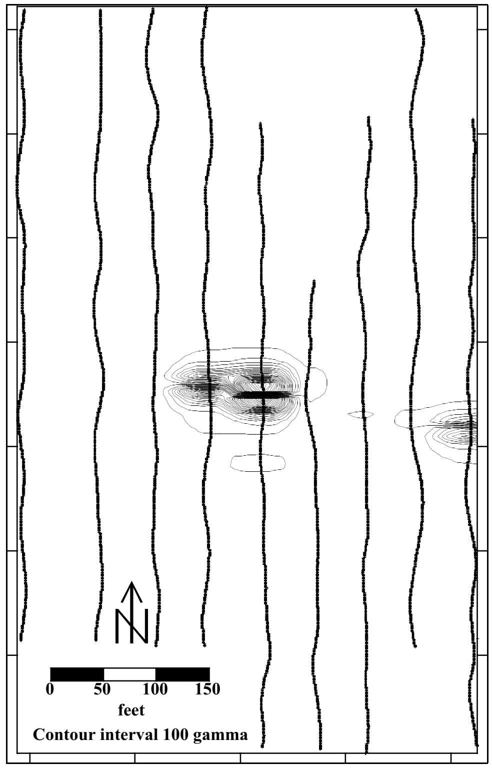
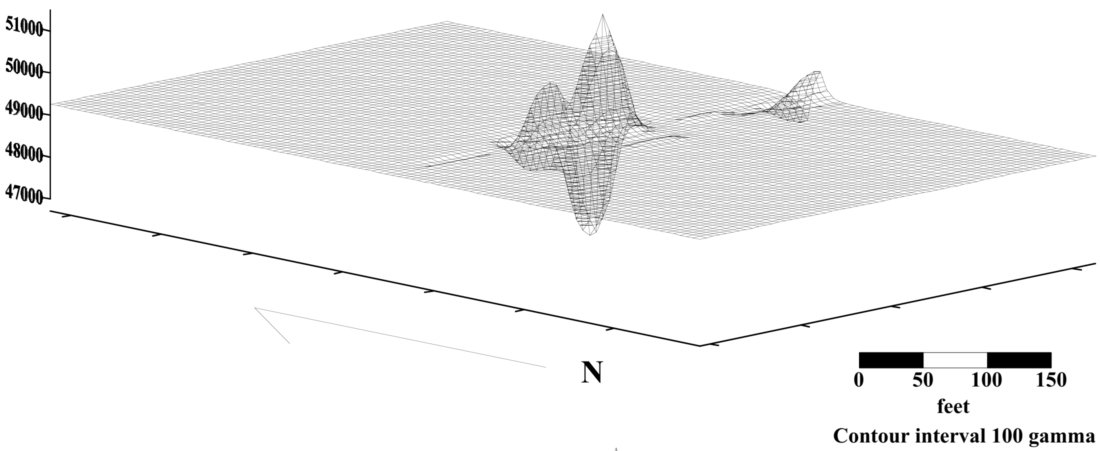


Figure 6-33. Top: *Josephine* 50-m odd transect interval, 100-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.





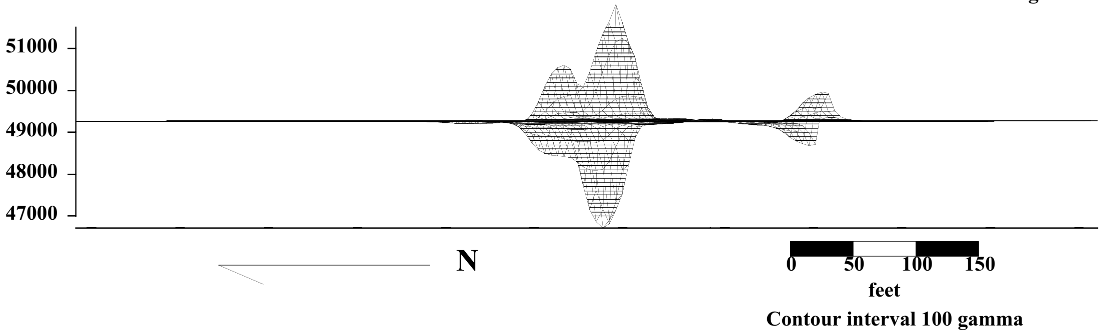


Figure 6-34. Top: *Josephine* 50-m even transect interval, 100-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.

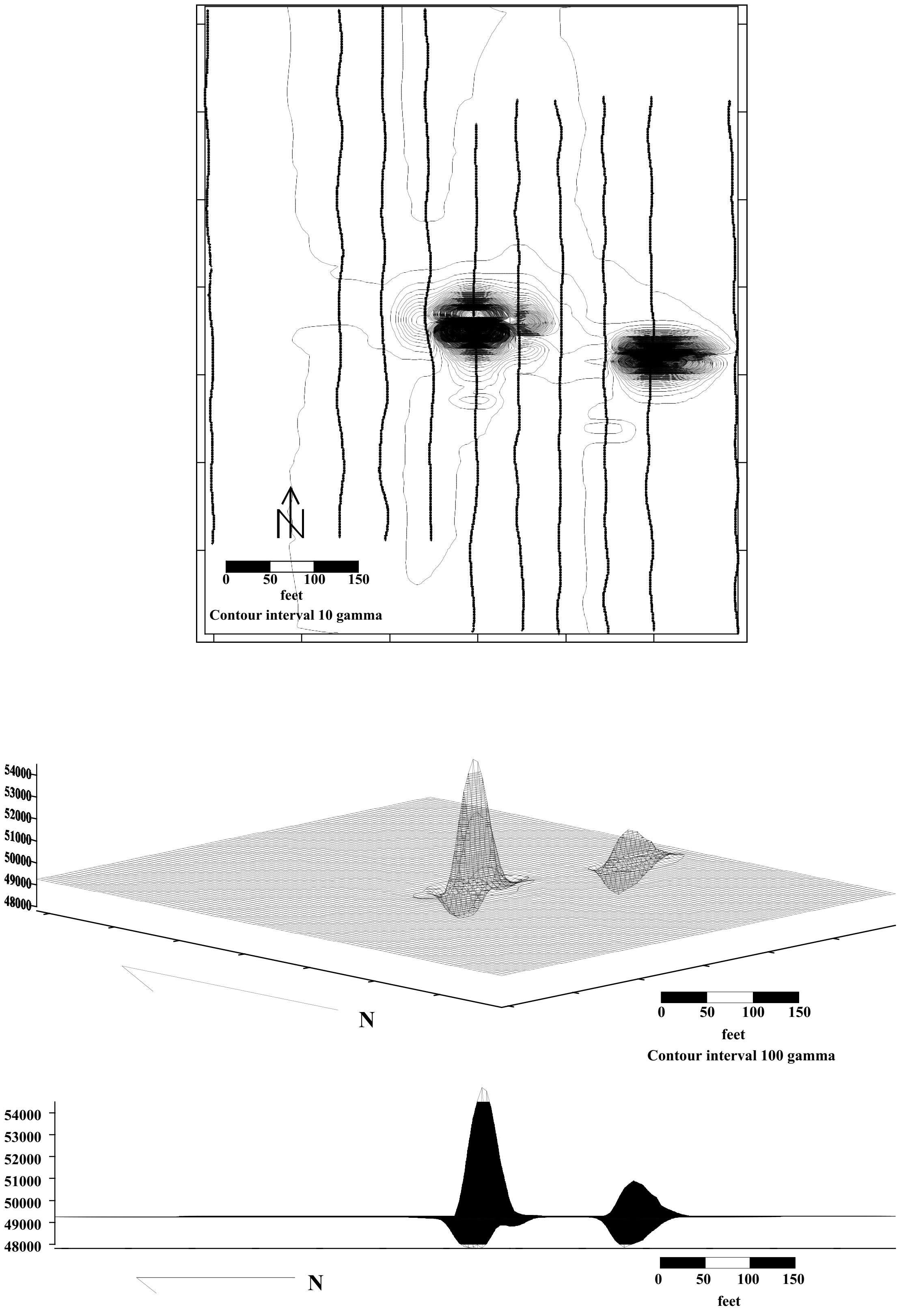
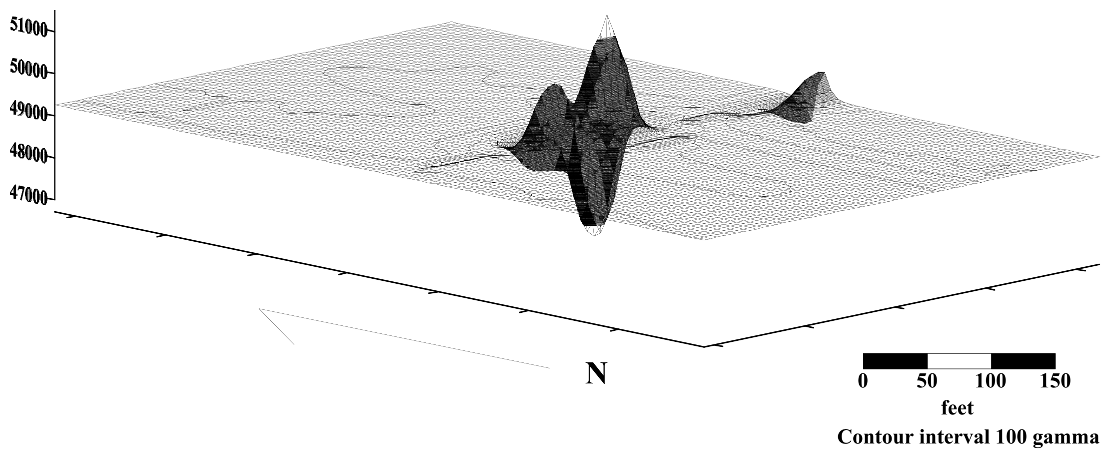


Figure 6-35. Top: *Josephine* 50-m odd transect interval, 10-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.



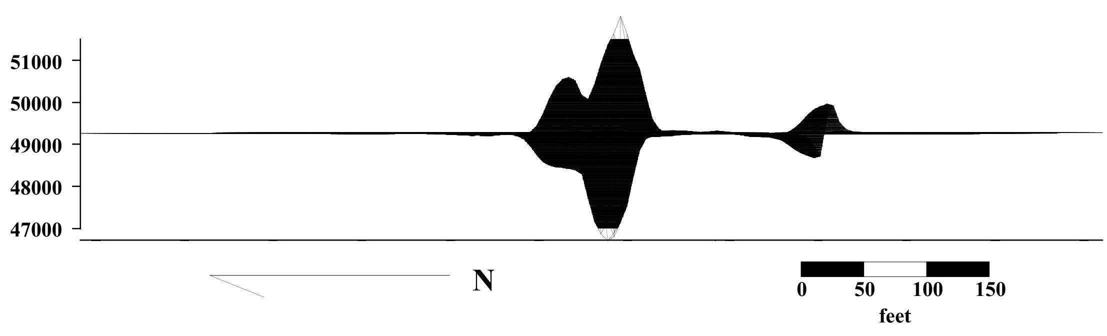


Figure 6-36. Top: *Josephine* 50-m even transect interval, 10-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.

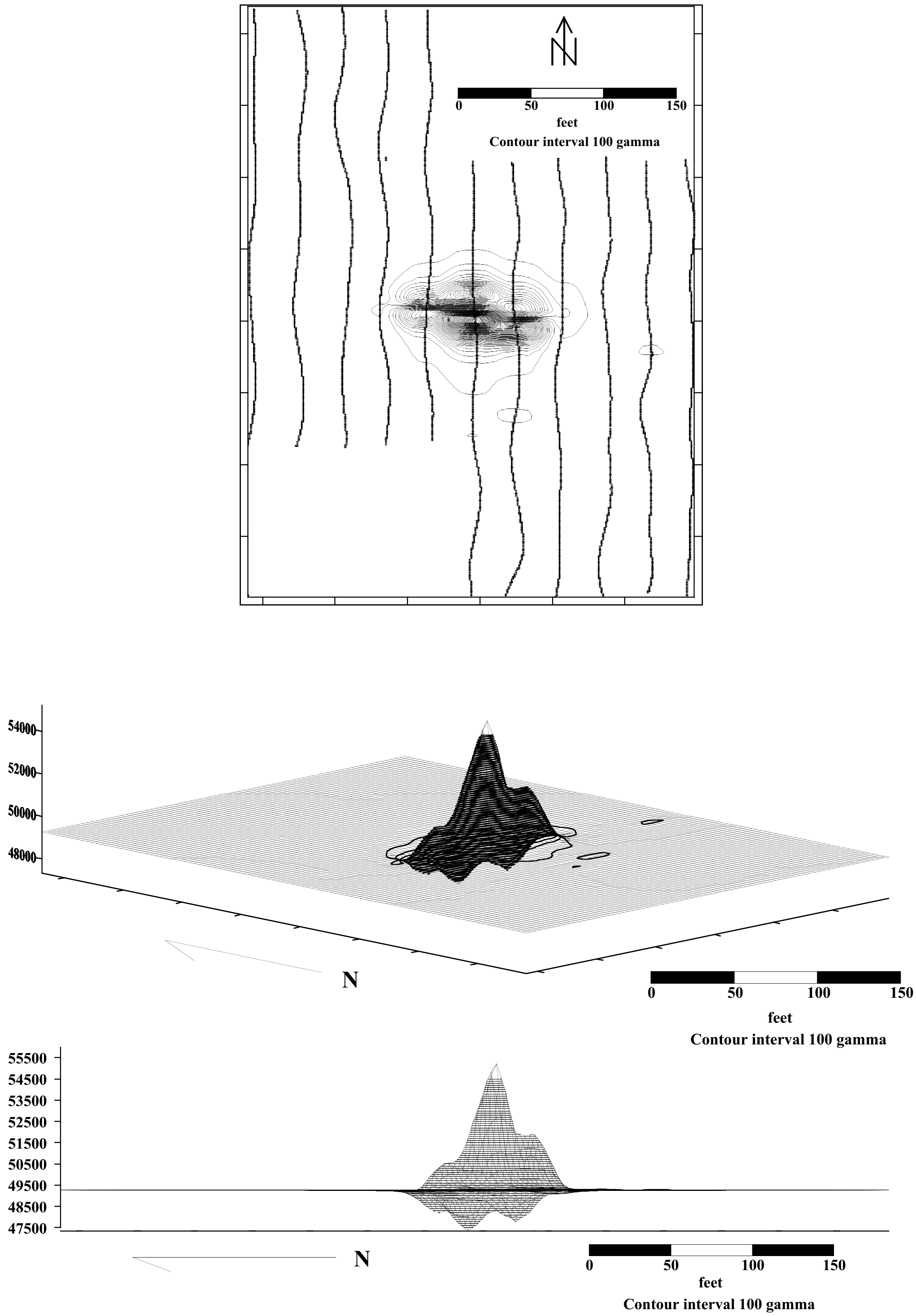
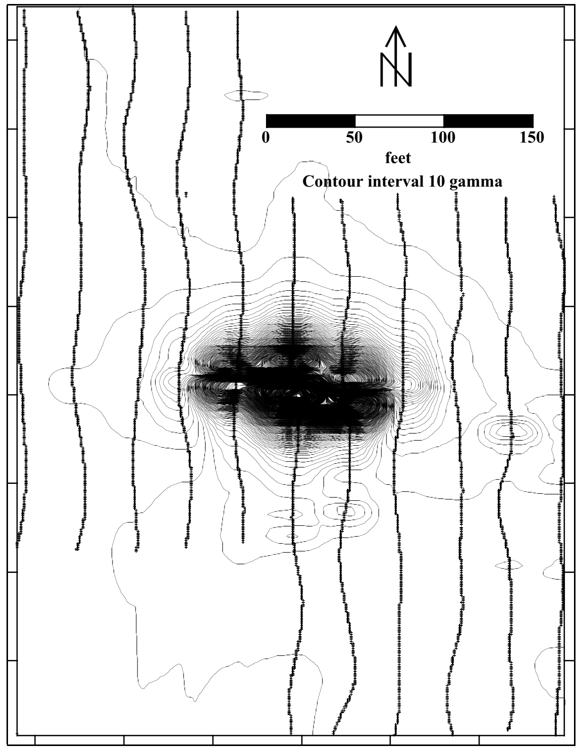
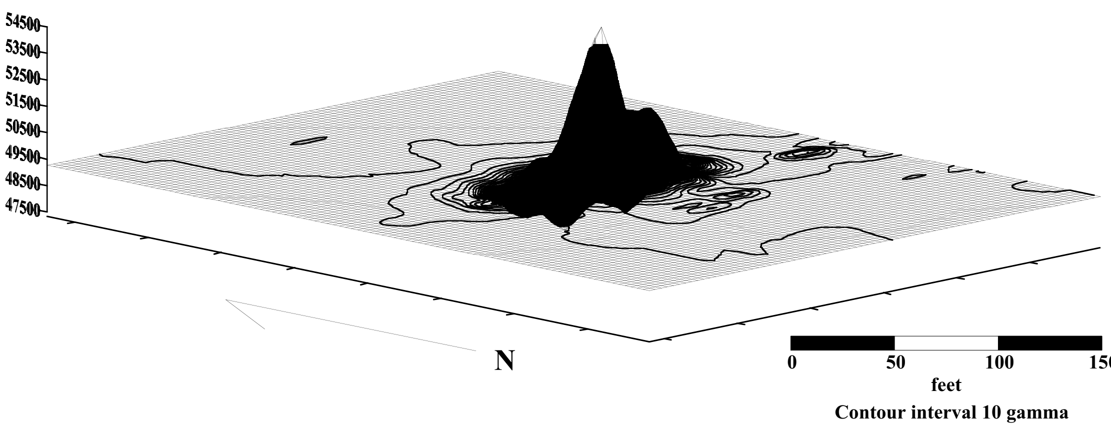


Figure 6-37. Top: *Josephine* 30-m (4-knot) transect interval, 100-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.





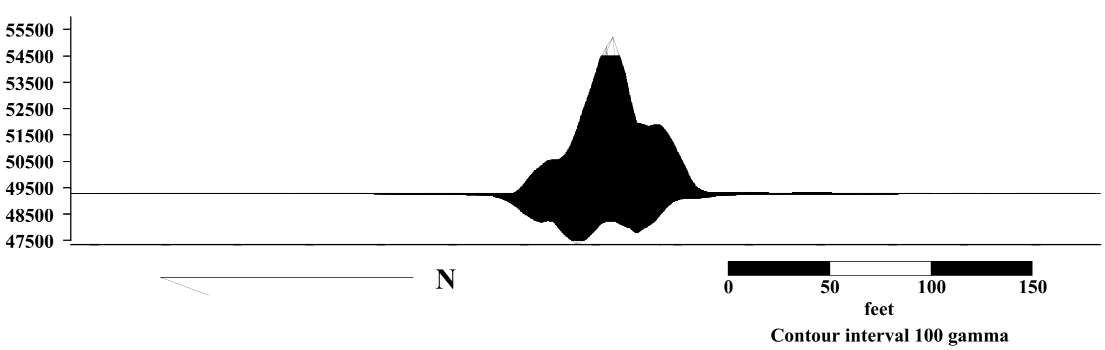
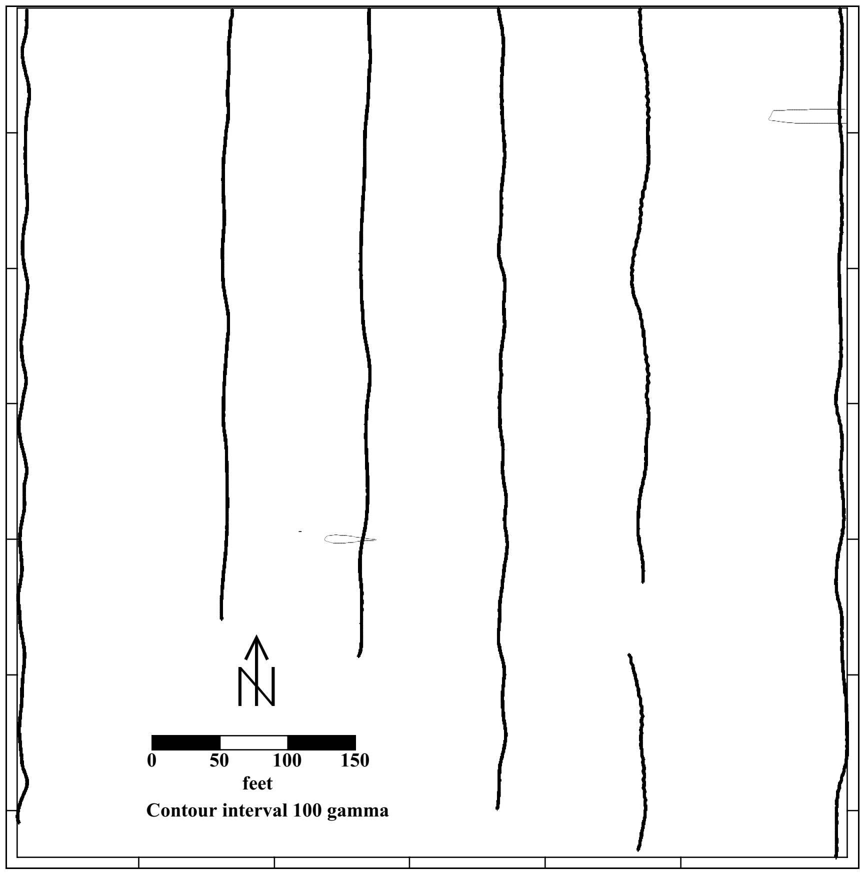
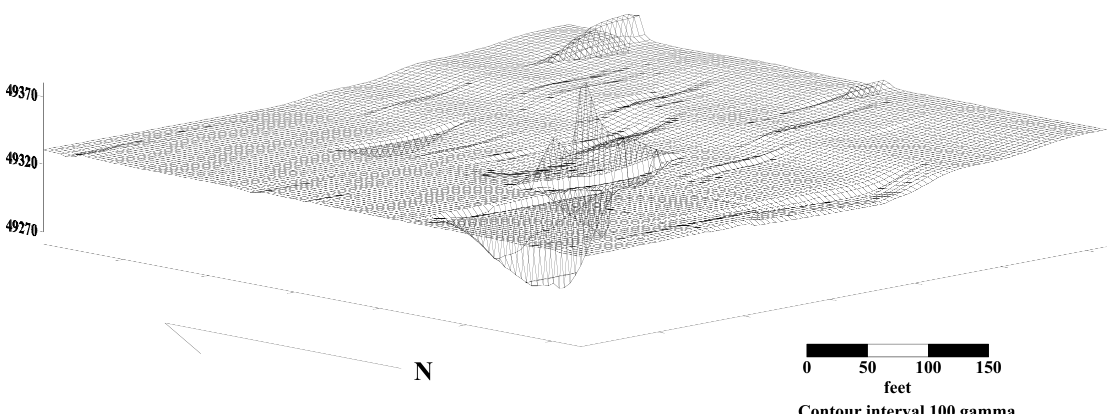


Figure 6-38. Top: *Josephine* 30-m (4-knot) transect interval, 10-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.





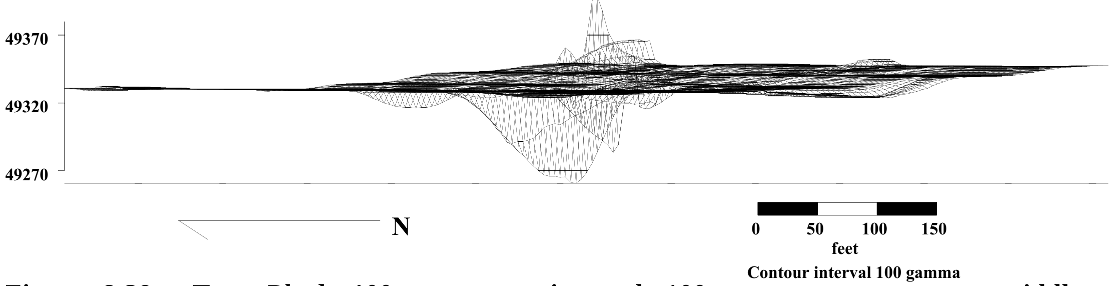


Figure 6-39. Top: *Rhoda* 100-m transect interval, 100-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.

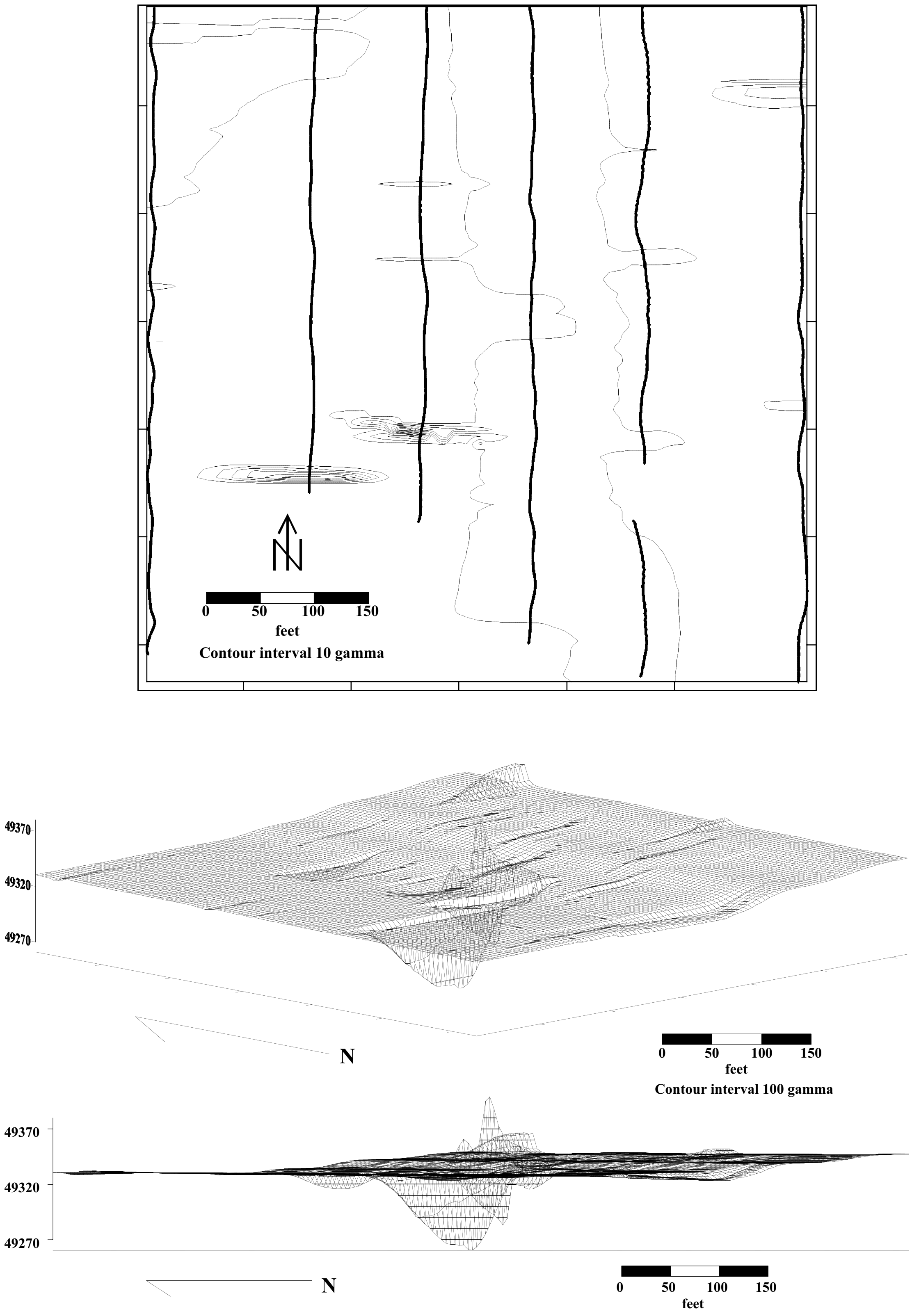
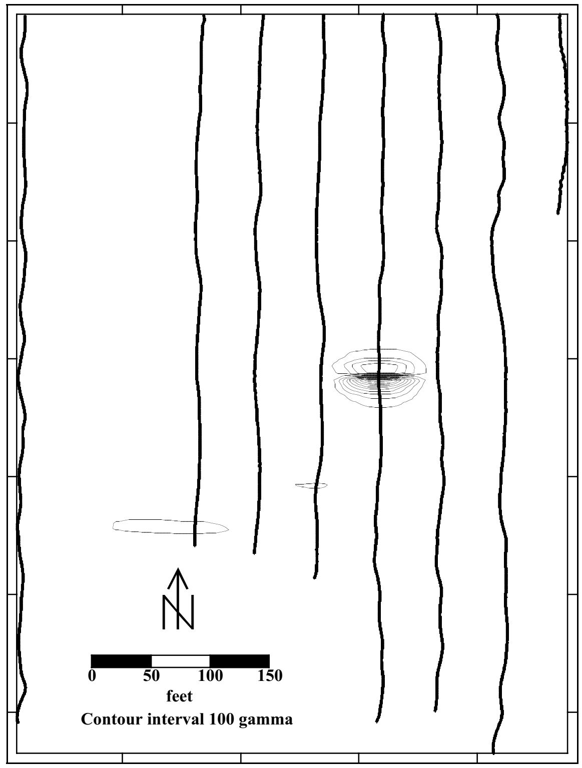
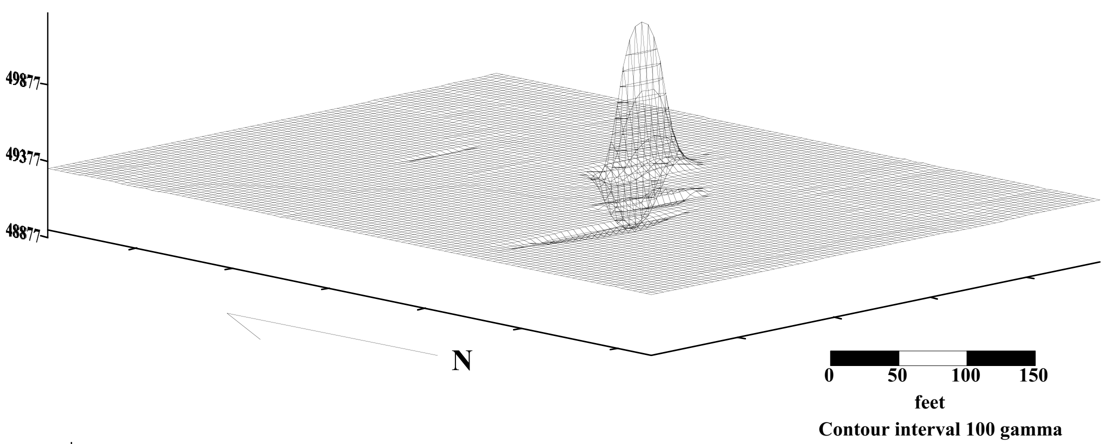


Figure 6-40. Top: *Rhoda* 100-m transect interval, 10-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.





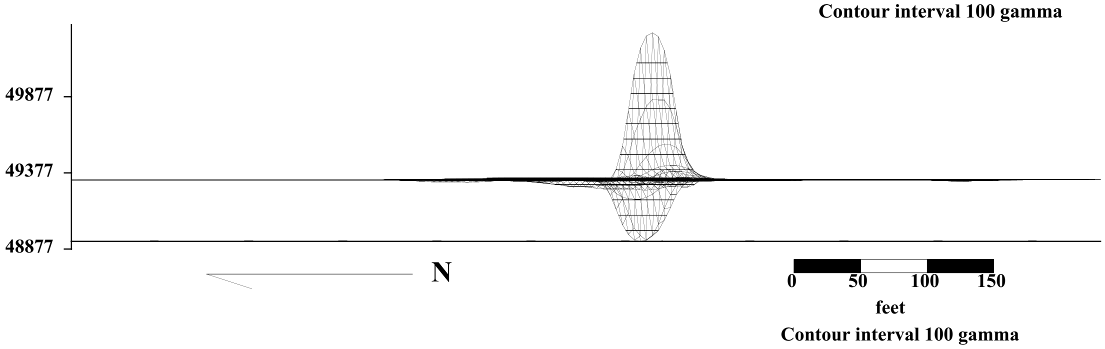
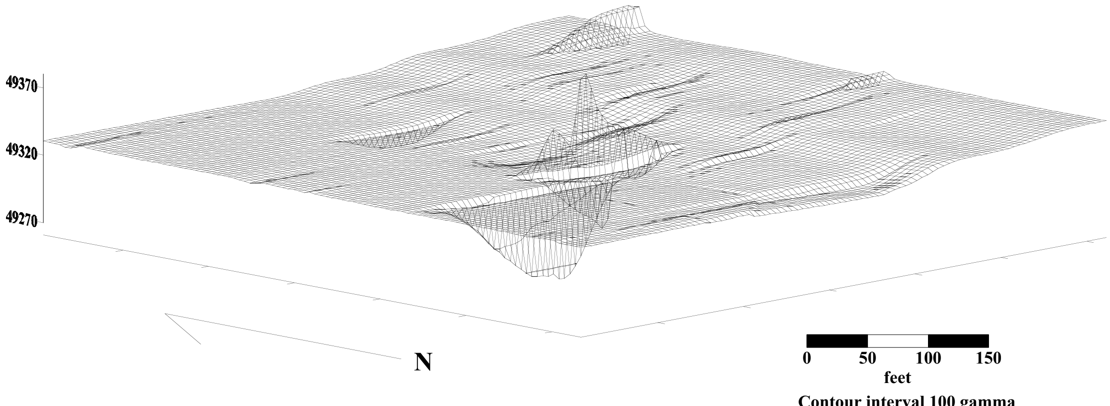


Figure 6-41. Top: *Rhoda* 50-m odd transect interval, 100-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.



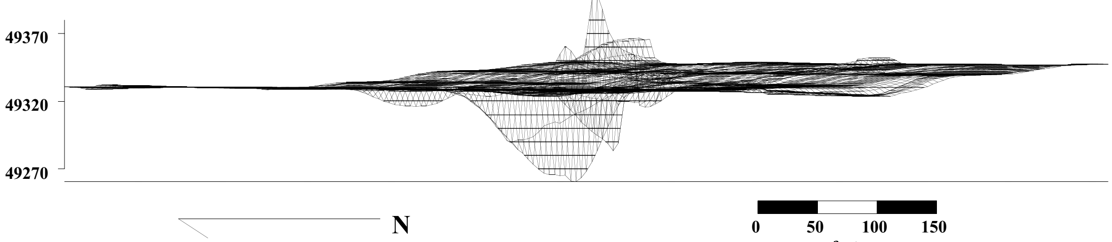
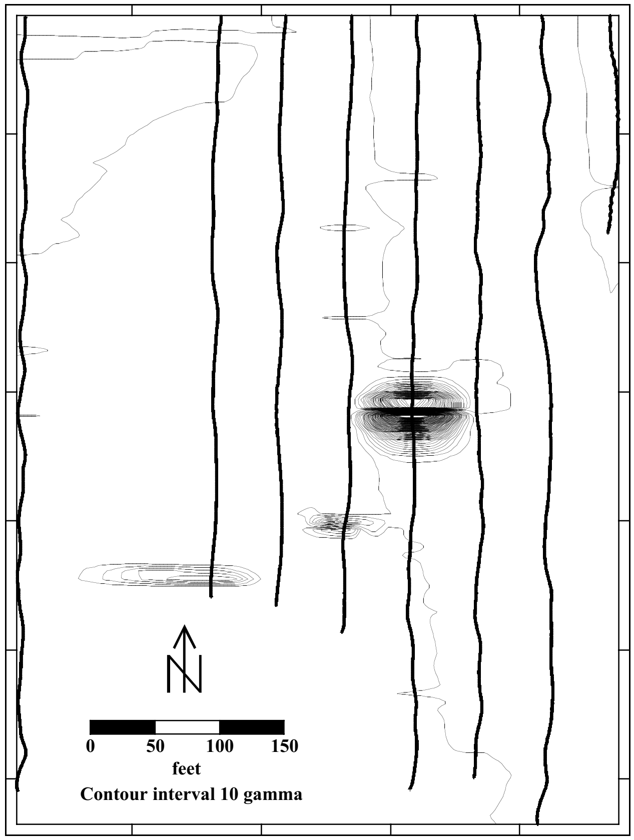
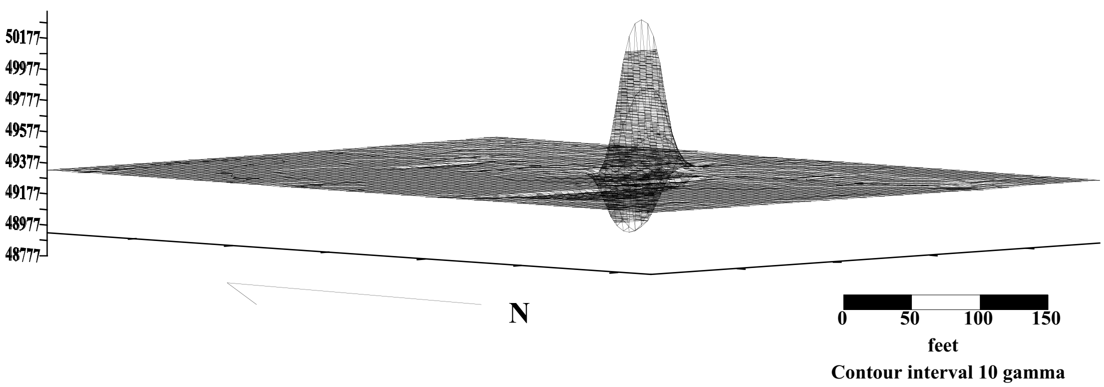


Figure 6-42. Top: *Rhoda* 50-m even transect interval, 100-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.





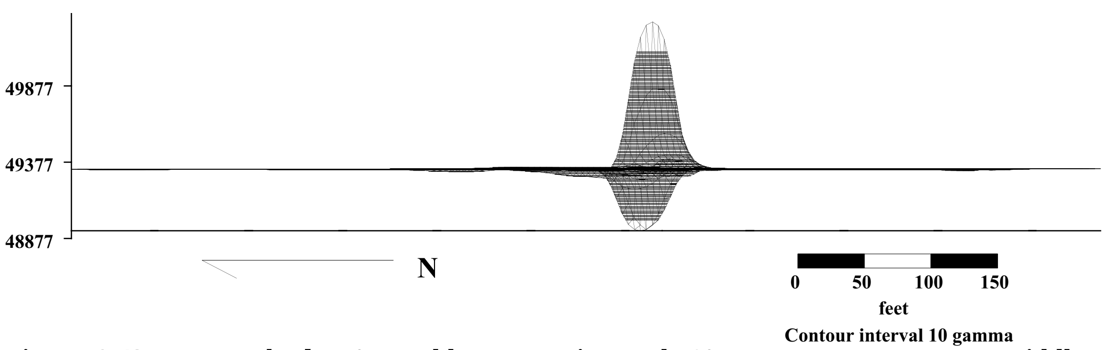


Figure 6-43. Top: *Rhoda* 50-m odd transect interval, 10-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.

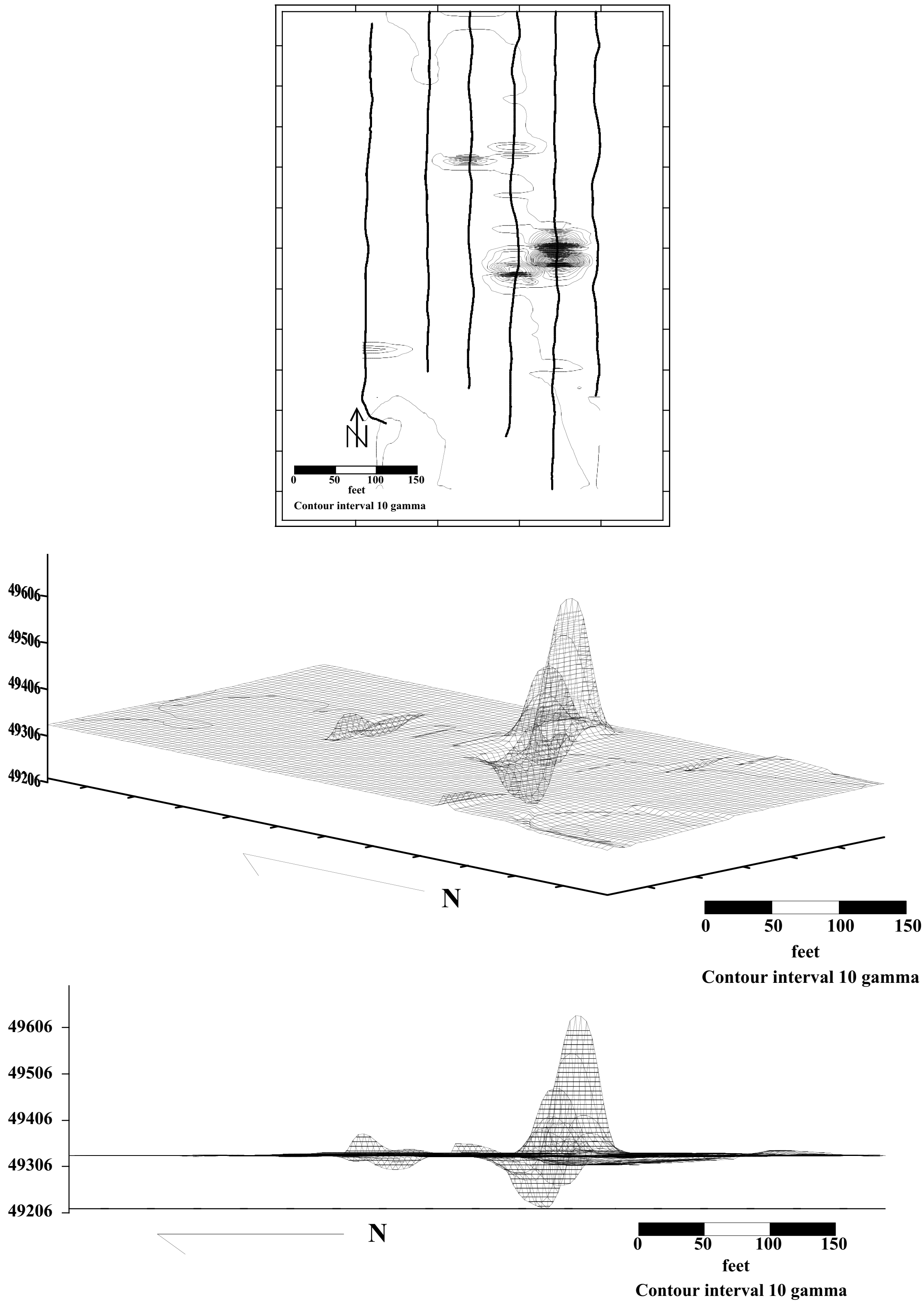
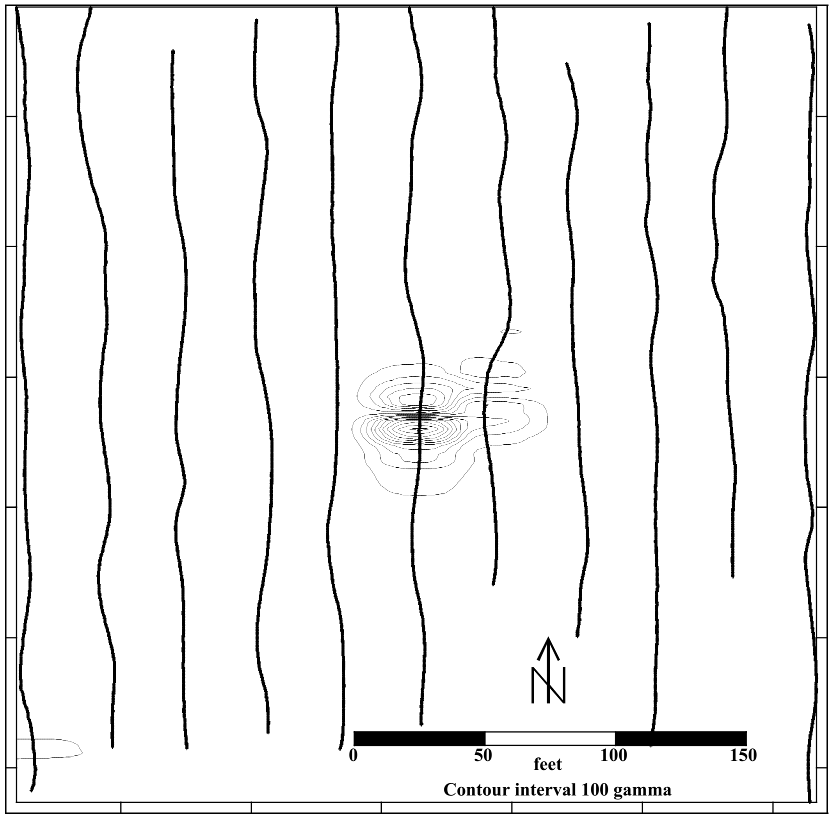
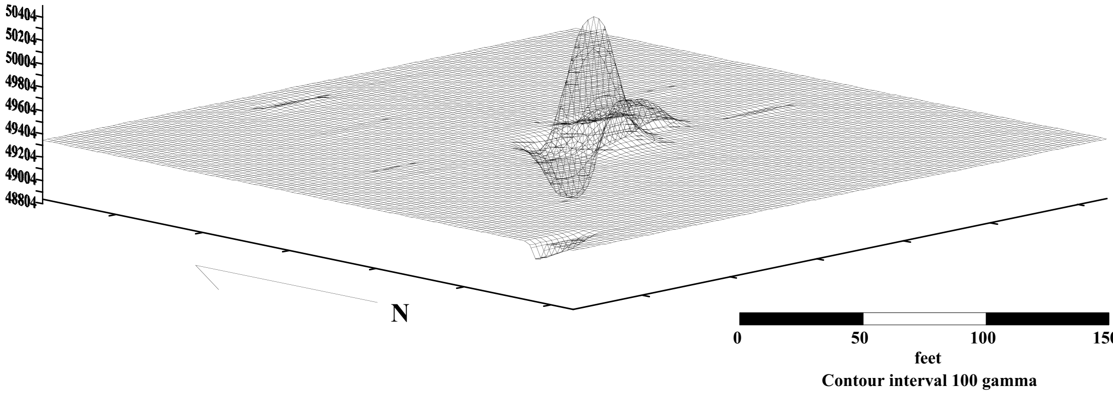


Figure 6-44. Top: *Rhoda* 50-m even transect interval, 10-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.





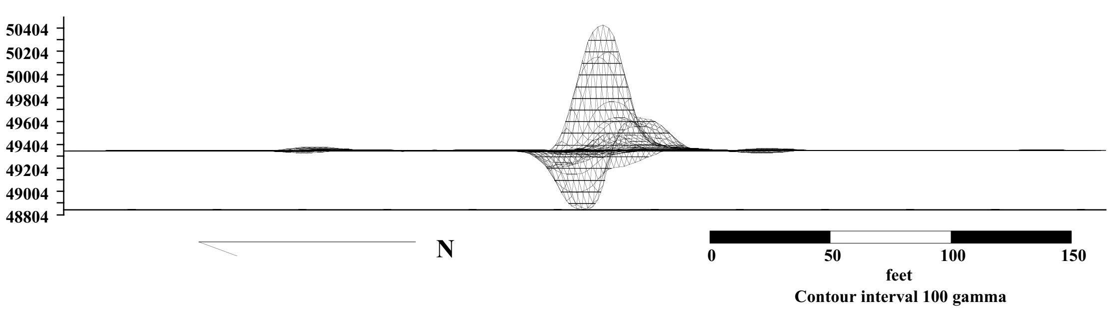


Figure 6-45. Top: *Rhoda* 30-m (4-knot) transect interval, 100-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.

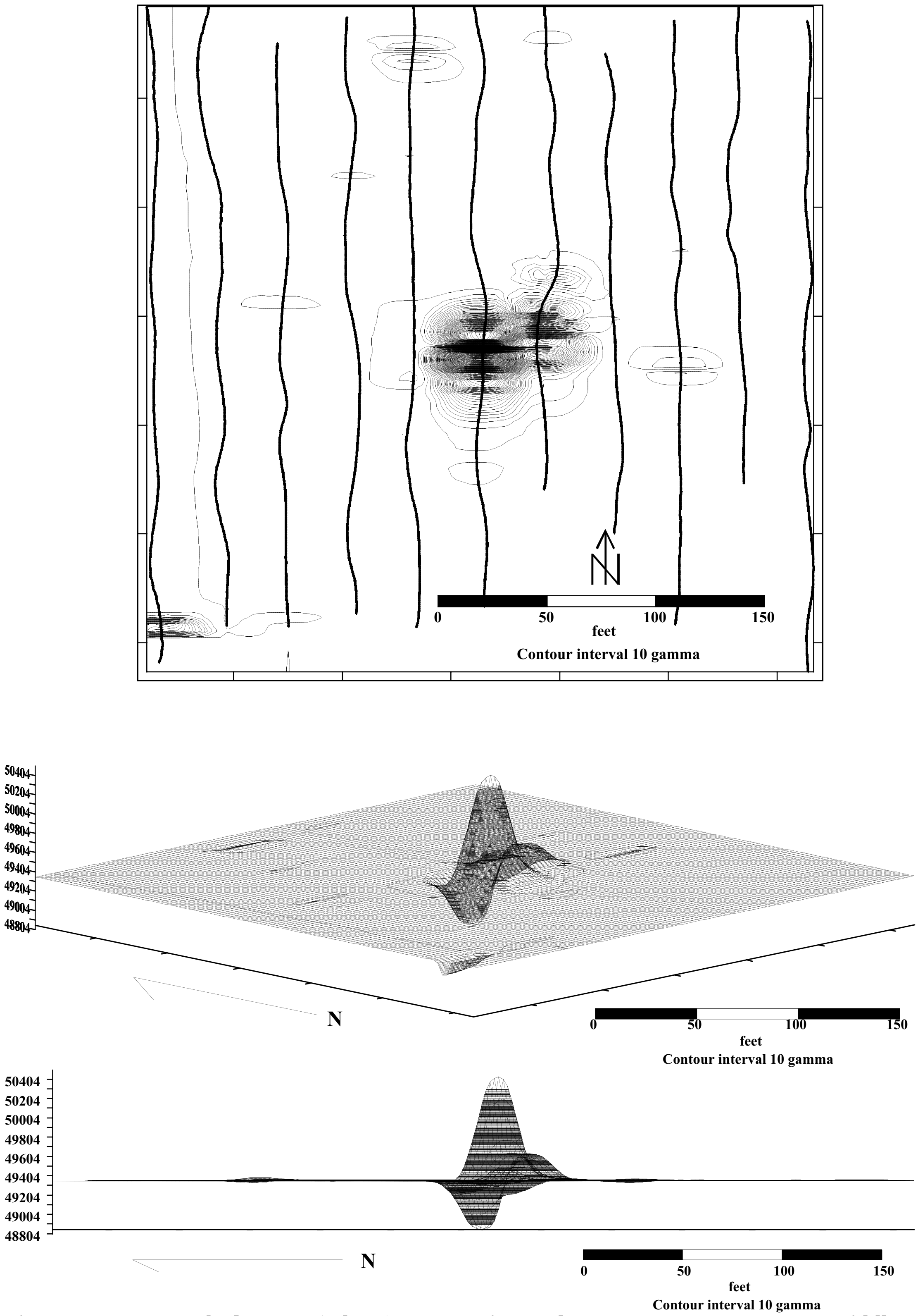


Figure 6-46. Top: *Rhoda* 30-m (4-knot) transect interval, 10-gamma contour map; middle: two-dimensional view; bottom: three-dimensional view.

Allowing a visual comparison between transect intervals specific to our study, it can be stated that contour maps employed in any survey provide critical analytic aspects of an anomaly such as location, amplitude, size and complexity. As illustrated by the 50-meter and 30-meter survey interval transect maps, even without the use of a base station, offshore survey data can be effectively contoured in situations where a survey is conducted as a single unit (i.e., not split over multiple days).

Findings in Table 6-6 indicate that none of the three vessels would be located with a 300-m survey interval transect, even with a wreck site with such high magnetic influence as the *Josephine*. While the vessel is detected as a low amplitude anomaly on two transect lines by all instruments on the 150-meter survey interval transect, however, the other two vessels go undetected. With the exception of the G-866, the *Rhoda* is detected by all instruments on the 100-meter survey interval transect as a single line of low amplitude. The *Josephine* is detected at this interval on two transect lines, one with a high and one with a low amplitude. The barge is detected by all instruments on the 100-meter survey interval transect but varies by instrument as either a single transect line of either high or low amplitude. The 50-meter survey interval transect, the interval or line spacing stipulated by the NTL for water depths of 200 meters or less, detects all wrecks by all instruments on multiple transect lines of varying amplitude. The metal-hulled *Josephine*, obviously larger in magnetic influence than the *Rhoda* or the barge, is detected on two transect lines of high and two lines of low amplitude for all instruments. Both the *Rhoda* and the barge are detected by all instruments at a minimum of one high and one low amplitude line, although the barge is detected at high amplitude on two transect lines by the G-877 and the SeaSPY. However, as illustrated in Table 6-6, the 30-meter survey interval transect, because of its narrower spacing, detects both the *Josephine* and *Rhoda* on more lines and at higher amplitude by all instruments than with the 50-meter survey interval transect. Although the 30-meter survey interval transect is not a requirement of MMS surveys, it has been adopted by several state agencies with purview over submerged cultural resources. Relative to the states that border the GOMR, Louisiana defers to the MMS NTL and typically requires a 50-meter survey interval transect, Mississippi employs a 30-meter survey interval, and both Texas and Florida require surveys to be conducted with 30-meter line spacing in areas of high probability within their state waters.

The ability of the current 50-meter survey interval transect to effectively record the wrecks examined in this study has been amply demonstrated and argues for its effectiveness in locating many of the classes of vessels known to have been lost in the GOMR. However, it should be emphasized that the vessels examined in the present study are large and contain considerable quantities of ferrous metal. The 50-meter survey interval is unlikely to be effective in identifying all wreck types in the GOMR, especially earlier wrecks containing less iron or small wooden vessels or parts of wooden vessels that produce smaller magnetic signatures.

Discussions with the Florida State Underwater Archaeologist indicated that several early and extremely significant shipwrecks, such as the Emanuel Point Wreck and the *Nuestra Señora del Rosario* (which date to 1559 and 1705 respectively), would have gone undetected with a 50-meter survey interval transect because of their lack of detectable magnetic materials (Roger Smith, personal communication 2002). In the case of the Emanuel Point Wreck, the second oldest shipwreck discovered in the United States, a single anchor was the main anomaly source. Therefore, it is recommended that in order to provide better detection capability for all types of shipwrecks, especially earlier wrecks which might be the most historically significant types within the GOMR, a closer spaced transect interval, such as the 30-meter survey interval, should be considered by the MMS for employment in high probability areas.

6.2.3. Effects of Vessel Speed on Amplitude or Durations

Two questions were identified with respect to vessel speed and its effect on magnetic data:

- Do increased speeds affect the ability of instruments to detect a wreck?

- How are increased speeds reflected in the recorded signal strength and duration of the magnetics of a known wreck site?

As stated above, the *Rhoda* 30-meter survey interval 7-knot grid total gamma deviation was different than readings from all previous graphs, with the SeaSPY having the highest reading on Line 6, the centerline, with 1,868 gamma, followed by the G-881 with 1,088 gamma, the G-877 with 850 gamma, and the G-866 with 827 gamma. Thought to possibly be a reflection of increased speed, a review of positioning coordinates indicated that all sensor positions were comparable to within one or two meters of the track line center for Line 6. When compared to recorded readings on Line 6 of the 30-meter survey interval 4-knot grid, the readings are only slightly lower. However, Line 7 has a higher reading for the 30-meter survey interval 7-knot grid. When compared to Line 9 of the 25-meter survey interval grid which has the same easting coordinates, the readings are much lower at the greater speed, even though sensor positions are comparable to within one or two meters of the track line center. A review of all instruments for the *Rhoda* grids shows that the 30-meter survey interval 7-knot grid generally has lower readings but not always. However, these findings are not reflected in the *Josephine* grids. When recorded readings for all instruments for all grids are compared, the readings are generally the same with little variation in readings. Furthermore, between the 30-meter survey interval 4-knot and the 30-meter survey interval 7-knot grids, the highest readings recorded over the wreck are from the 30-meter survey interval 7-knot grid.

With regard to the question of whether increased speeds are reflected in the duration of the magnetics of a known wreck, Garrison et al. state that “a survey of eight knots will produce a shorter duration signature than one done at four knots” (1989:II-223). A comparison of durations obtained on Line 9 of the 25-meter survey interval grid for both wrecks and those obtained on Line 6 of both the 30-meter survey interval 4-knot and the 30-meter survey interval 7-knot is presented in Table 6-7 to address this issue (these lines for each wreck have the same easting and all lines are the central line over each wreck site). The table illustrates that the high speed survey over the *Josephine* actually had higher numbers than its 30-meter survey interval counterpart, and, with the exception of the SeaSPY reading, the 30-meter survey interval 7-knot numbers are only slightly lower than the 25-meter survey interval grid. Almost converse to the *Josephine*, the *Rhoda* 25-meter survey interval grid is generally lower than the 30-meter survey interval 7-knot grid, while the 30-meter survey interval 4-knot grid has higher readings than both other grids, but again with the exception of the SeaSPY reading. These findings seem to argue against the Garrison et al. statement and indicate that durations are not affected by speed, and, based on the data presented in Table 6-7, neither is amplitude.

Table 6-7. Comparison of Duration and Amplitude

Josephine								
Survey Interval Grid	Duration (ft)				Amplitude			
	G-866	G-881	G-877	SeaSpy	G-866	G-881	G-877	SeaSpy
25-M	534'	547'	564'	810'	5,870	9,030	13,442	12,371
30-M 4-Knot	442'	476'	472'	557'	5,628	8,847	11,372	11,603
30-M 7-Knot	501'	544'	534'	639'	5,467	8,674	12,182	3,588
Rhoda								
Survey Interval Grid	Duration (ft)				Amplitude			
	G-866	G-881	G-877	SeaSpy	G-866	G-881	G-877	SeaSpy
25-M	341'	249'	298'	423'	1,034	1,535	3,927	2,405
30-M 4-Knot	534'	383'	380'	357'	1,171	1,573	2,139	2,112
30-M 7-Knot	472'	331'	360'	338'	827	1,088	850	1,868

It should be stated that different tow bodies (i.e., sensors) will behave differently with respect to speed changes. Sensor depth is affected by cable layback, weight of cable (i.e., steel, kevlar) and sensor, tow speed, cable diameter, hydrodynamics of the tow body, and the effects of cable or tow body depressors. For an interactive display of the differences produced by varying speed, and cable and sensor type, please visit <http://www.geometrics.com/TowDepth.htm>. With regard to our survey, uniform sensor depths reflecting NTL requirements were maintained at the higher speed by increasing layback and/or adding additional cable weights depending on the requirements of each instrument to maintain the proper depth.

6.2.4. Base Stations

Mirroring both the NTL 98-06 and the new NTL 2002-G01 requirements, the SOW did not stipulate the employment of base stations or contouring of magnetometer data. As stated above, this is a reflection of the fact that, apart from oil rigs or platforms which cannot be employed as a suitable location because of their inherent magnetism, there is nowhere to place a base station in offshore Gulf waters. It was recommended, however, that a submersible base station be tested to determine its applicability to offshore surveys as it might apply to post-mission processing of magnetic data, especially with regard to surveys with line spacing of 50-meters. Because a Sentinel submersible base station was included in this task in an effort to assess its functionality in the field, and answer questions concerning employment in offshore surveys relative to issues of diurnal variation and the applicability of contouring, land base stations were also included to provide comparative base station data. As indicated above, three base stations were employed during the survey of each vessel, the Sentinel submersible, a Marine Magnetics land, and a G-856 land base station. The Sentinel collected readings at one-second intervals while the other two took readings every twenty seconds. Presented in Figure 6-47 are strip charts for each of the three base station readings collected during the survey of the *Josephine* with the G-881. Representative of all other survey days, the graphs show almost identical readings for the three instruments over an eight-hour period. Both land base stations show several small perturbations that are not seen on the Sentinel, the latter's readings being exceptionally smooth, most likely a reflection of its location underwater away from land activity. These small perturbations and what appears as low-level noise are observed on some of the other land base station days as well, but the overall readings for all three instruments are similar.

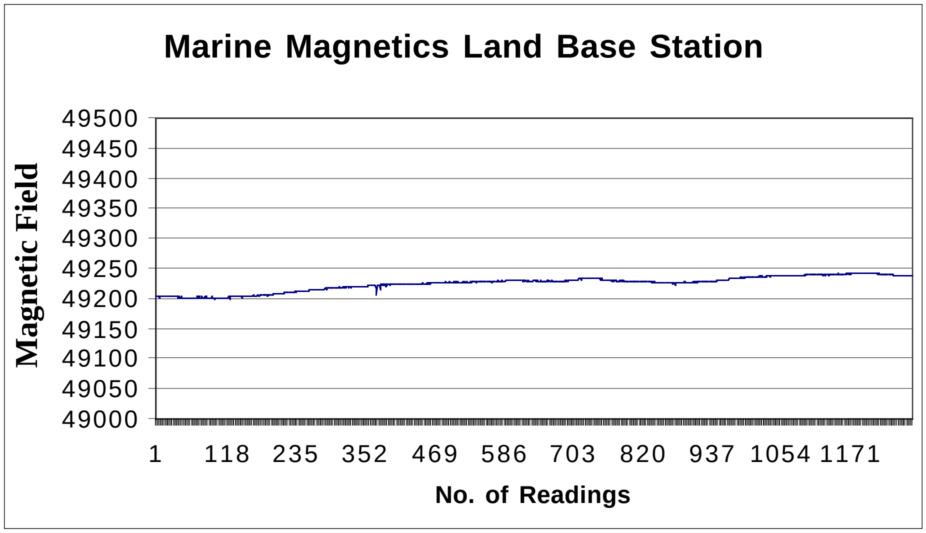
While not stipulated as a requirement by the NTL 2002-G01, employment of the Sentinel during our investigation highlighted its potential as an offshore tool in the collection of data for post-processing of magnetic survey data. As discussed above, however, the acoustic release failed on one occasion and had to be retrieved manually by divers, a scenario impossible in most GOMR survey situations. A prototype, the release is said to have undergone corrective redesign.

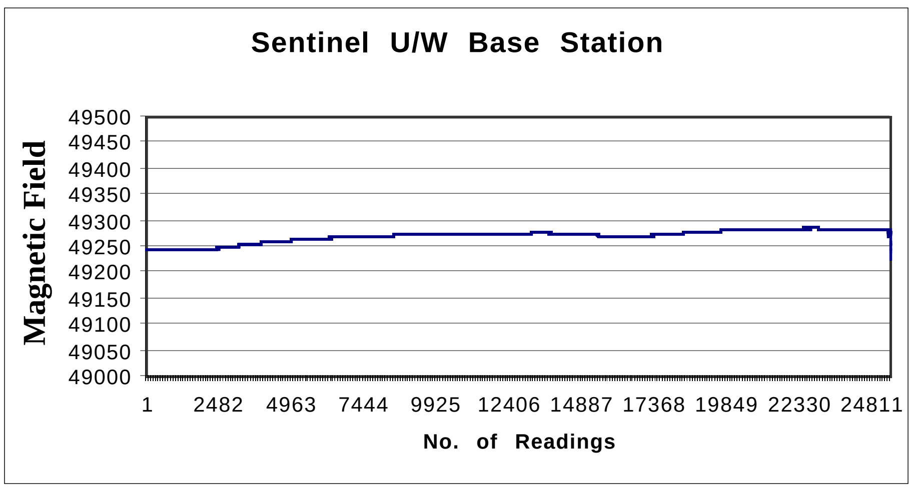
In addition to assessing differences in land versus submersible base stations, data from the base stations was employed to determine its applicability to offshore surveys as it might apply to post-mission processing of magnetic data, especially with regard to surveys with line spacing of 50-m. Additionally, data was employed to determine if correcting for diurnal variation affects, enhances, or alters magnetic signatures.

In simplified terms, because the Earth's magnetic field varies over time, these variations can cause inaccuracies in survey data, particularly if the data is collected over multiple days. The effects of this variation can be corrected by collecting parallel magnetic data at a fixed sensor location over the period of the survey. This base station data is time-correlated to the survey data, and can be employed to remove the effects the short term and diurnal variations present in the Earth's magnetic field. Corrections are achieved by subtracting corresponding time readings of the base station data from the survey data using the following formula:

Diurnal Reading(t) = Roving Mag(t) – Base Station(t), where (t) = identical time

Ideally, base station readings are taken at the same time interval as the survey data. In the event of fewer base station readings, the processing software discussed below will interpolate the missing readings.





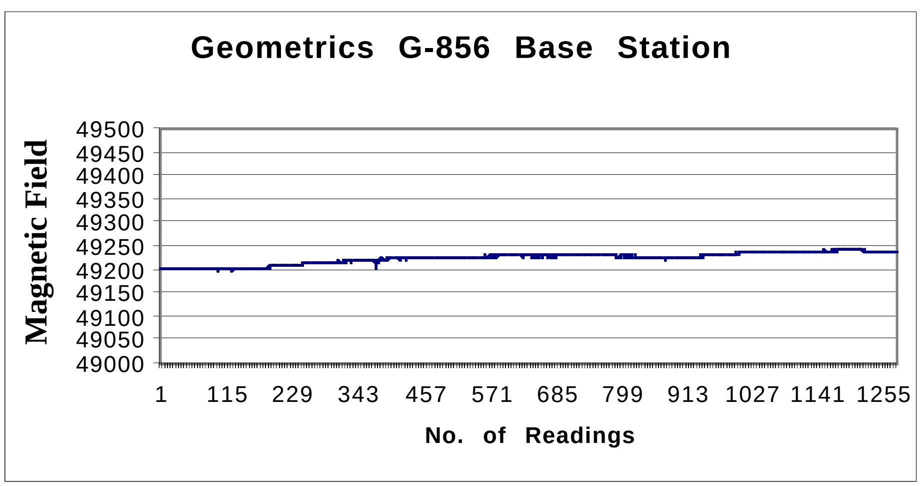


Figure 6-47. Strip charts for each of the three base station readings collected during the survey of the *Josephine* with the G-881.

Processing of magnetometer base station and survey data to remove short term and diurnal variations in magnetic data is called "correcting." Correction was achieved for our purposes using software from Geometrics called MagMap2000. This software can read and process magnetic data from a variety of sources, and functions included line by line analysis, graphical editing and processing of data, analysis of anomalies, and contouring of data. Corrections are achieved through a simple operation in MagMap2000. The result is a text file in Surfer (.DAT) format which contains, in addition to the original magnetic data, an additional column containing the corrected readings. The resulting file is then opened in Surfer 7.0, gridded using Inverse Distance to Power and Spline Smoothing, and a contour map created.

Corrections were performed on Geometrics G-881 magnetometer data collected at the *Josephine* site on June 25, 2001 over three different grids. Two different base stations were used, including a Geometrics G-856 land-based and a Sentinel sea-based. The results are displayed in Figures 6-48 through 6-50. The data was contoured in 100 gamma intervals.

As previously discussed, several hypotheses were posed regarding the evaluation of the effects of diurnal variation on magnetic data:

- Does adjusting for diurnal variation affect, enhance, or alter magnetic signatures and their subsequent interpretation?

- Is there a difference between employment of data from the land-based and submersible base stations readings?

In addressing these questions, the data compared had the following characteristics:

- Is in its original, uncorrected format.

- Has been corrected with base station readings from both land-based and submersible base stations.

Does adjusting for diurnal variation affect, enhance, or alter magnetic signatures and their subsequent interpretation? A simple comparison of the data for each correction illustrates the extent to which the corrections affect the original data (Table 6-8). When examining the Geometrics 881 data for the 30-meter survey interval 4-knot grid, one can see that the difference between the uncorrected data, data corrected with the G-856 land base, and data corrected with the Sentinel marine base is negligible. Consequently, the contour maps are very similar (Figures 6-48 through 6-50). Similar results were obtained with other combinations of grids and speeds.

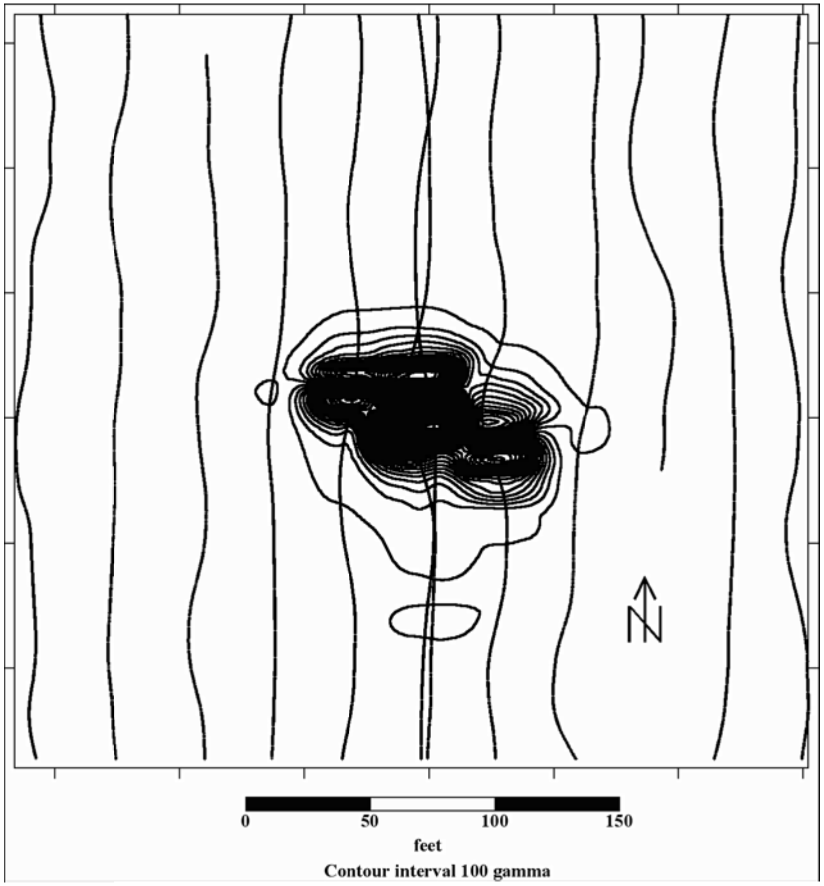


Figure 6-48. ***Josephine*** **30-meter survey interval 4-knot grid G-856 uncorrected data contoured with 100 gamma interval.**

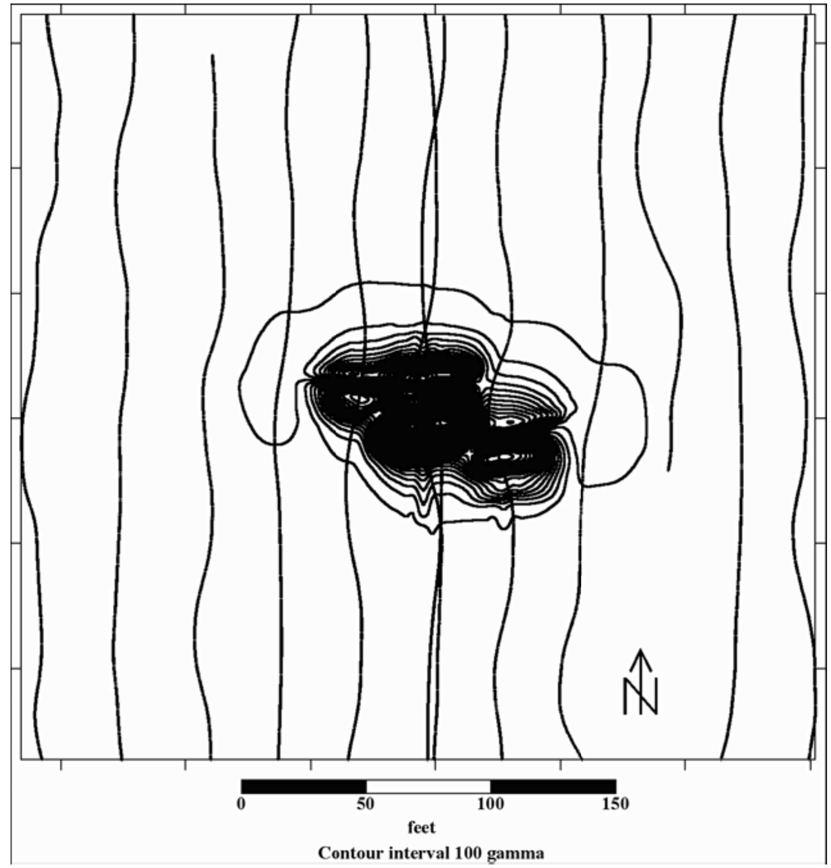


Figure 6-49. ***Josephine*** **30-meter survey interval 4-knot grid G-856 corrected data contoured with 100 gamma interval.**

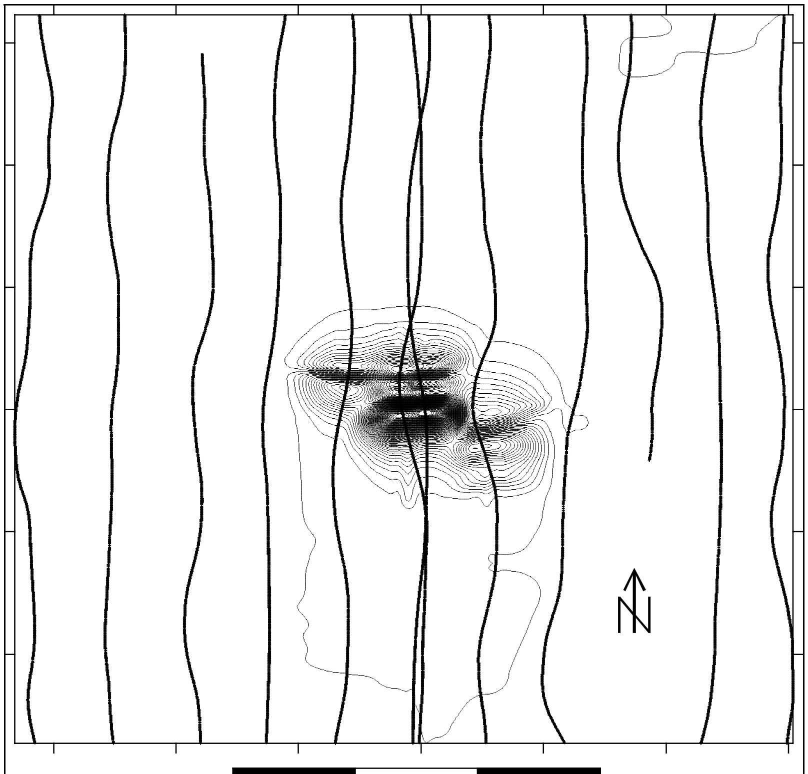


Figure 6-50. ***Josephine*** **30-meter survey interval 4-knot grid Sentinel corrected data contoured with 100 gamma interval..**

Table 6-8. Comparison of G-881 Data Values for *Josephine* 25-Meter Survey Interval Grid.

Data	Low Mag Reading	High Mag Reading	Range
uncorrected	46211.89	62526.56	16314.67
856 corrected	-3007.96	13296.1	16304.06
Sentinel corrected	-3055.98	13255.61	16311.59

As stated above, during current surveys the locations of encountered magnetic anomalies are simply marked with a symbol (▲) and an identifying number, and presented in tabular format with anomaly information including line number, shot point, and coordinates. With regard to the latter, exact coordinates for a magnetic anomaly are next to impossible to acquire when data is not contoured. While one can tell where along the survey line it was encountered, one cannot tell if the anomaly originated from a source to the right, to the left, or directly on the survey line. Contouring would in many cases precisely locate the position of the anomaly. Furthermore, and perhaps more importantly, a contour presents a visual signature of the anomaly that can then be analyzed relative to its complexity and spatial attributes, signature characteristics that help differentiate between anomalies that potentially represent an historic shipwreck and those that represent modern ferromagnetic debris.

Because the difference between corrected data and uncorrected data is negligible, and the fact that contouring presents critical analytic data, it should be concluded that, even without base station data, offshore survey data should be contoured in situations where a survey is conducted as a single unit (i.e., not split over multiple days).

6.3. Shipwreck Types and Magnetic Signatures

A number of studies have attempted to systematically classify the physical expressions of shipwrecks in terms of spatial distributions of materials and anticipations about the preservation of various structural elements. For example, Muckelroy (1978) has presented the idea of classifying wreck sites along a simple dichotomy. In his scheme, wreck sites can be classified as "discontinuous" or "continuous," which are expressions of the spatial distribution of wreck materials and are reflective of site formation processes, particularly the initial processes. The "continuous" site is one in which wreck materials are localized and elements and objects are not separated by extensive sterile areas. The "discontinuous" site is one where wreckage is widely scattered as a result of the wrecking process. Although the discontinuous wreck pattern is generally considered to occur in high energy settings, such as along beaches and shallow coastal areas (e.g., Clausen and Arnold 1975), they can exist in deepwater settings if the initial wrecking event included processes that tore apart or scattered vessel elements at and during sinking. In the GOMR, one can envision a discontinuous wreck site in the case of an explosion and fire aboard a wooden-hulled steamer. However, the general lack of high-energy settings in the GOMR indicates that the typical historic shipwreck site in the study area will display a "continuous" pattern in terms of distribution, a presumption generally supported by the available sidescan sonar imagery from the area as noted previously.

Others have attempted to correlate shipwreck patterns with particular types of magnetic signatures. For example, Delgado et al. (1984) and Gearhart (1988) have classified shipwreck patterns in terms of the spatial distribution of wreck materials and the anticipated characteristics of correlative magnetic signatures. Their work has dealt exclusively with high-energy settings, such that their findings are not totally applicable to the GOMR, but they are mentioned briefly. Reflecting mid-range theory building, they identify three types of sites based on the spatial distribution of wreckage. These are the buoyant hull pattern, buoyant hull fracture pattern, and the buoyant structure pattern.

The buoyant hull site is one which is "continuous" under Muckelroy's definition and reflects a situation where a vessel came ashore relatively intact. Gearhart (1988:40-43) argues that the magnetic signature associated with these types of wrecks will, typically, consist of a linear distribution of multiple anomaly peaks embedded in a larger, principal magnetic signature. Additionally, the long axis of the overall anomaly pattern will be oriented along the axis of the hull. Gearhart also notes that the long axis of the anomaly, and the vessel's hull, will be parallel to the water line because of the tendency of a buoyant hull to turn broadside to waves when aground. Note that the signatures for our three vessels, both in tabular and contour map format, fall within the confines of the buoyant hull site definition.

The buoyant hull fracture site is reflective of a vessel's hull that breaks up soon after coming ashore. Therefore, wave action tends to scatter vessel elements away from the main body of the wreck. If waves are sufficiently large, vessel components can be scattered high up the beach while buoyant objects might drift away. The magnetic signature associated with this type of wreck will consist of the pattern seen with the buoyant hull site, plus a pattern of lower intensity, spatially discrete (single source) anomalies radiating inland (upslope) and downcurrent from the principal signature (Gearhart 1988:41).

The buoyant structure wreck site develops when a vessel breaks up offshore and only buoyant objects float ashore. This wreck type might leave a trail of wreckage scattered for some distance along a beach. Gearhart (1988:43) suggests that the magnetic signature associated with this wreck type will consist of numerous, spatially separated anomalies of varying intensities generally scattered in uneven patterns along a beach.

While these studies are of some interest in correlating wreck characteristics and processes to magnetic signatures, they specifically relate to near-shore, high-energy settings. These settings are rare in the study area (GOMR), such that these models have only minimal direct applicability. In identifying anomaly patterns that are characteristic for shipwrecks within the GOMR, Garrison et al. summarize characteristics that differentiate between shipwrecks and modern ferromagnetic debris.

Anomaly and Sidescan Sonar Patterns Characteristic of Historic Shipwrecks

1. multiple peak anomalies or spatial frequency;
2. differential amplitude anomalies;
3. areal distribution ≥10,000 square m;
4. long gradients and duration;
5. axial or linear orientation of anomalies;
6. scour areas associated with anomalies;
7. exposed structure is geometrically complex and associated with anomalies; and
8. relative locational permanence.

Anomaly and Sidescan Sonar Patterns Characteristic of Modern Ferromagnetic Debris

6. single peak anomalies or no spatial frequency;
7. few if any differential amplitude anomalies;
8. localized areal distribution ≤10,000 square m;
9. sharp gradients and short duration;
10. random, non-axial orientation of anomalies;
11. scour areas with no associated anomalies;

12. exposed debris geometrically simple; and
13. relative locational permanence.
14. (Garrison et al. 1989:II-223)

All three wrecks investigated in our study certainly meet the majority of characteristics for historic shipwrecks listed above. And while not a part of the study, obtained sidescan images of at least the *Josephine* and the barge indicate that, at least for these two wrecks, the last three characteristics apply as well.

Related to the characteristics of amplitude and duration, in an effort to assess potential significance of anomalies, Pearson et al. developed general characteristics of magnetometer signatures most likely to represent shipwrecks. The report states that "the amplitude of magnetic anomalies associated with shipwrecks vary [*sic*] considerably, but, in general, the signature of large watercraft, or portions of watercraft, range from moderate to high intensity (>50 gammas) when the sensor is at distances of 20 ft. or so" (1991:70). Employing a table of magnetic data from various sources as baseline data, the report goes on to state that "data suggest that at a distance of 20 ft. or less watercraft of moderate size are likely to produce a magnetic anomaly (this would be a complex signature, i.e., a cluster of dipoles and/or monopoles) greater than 80 or 90 ft. across the smallest dimension…" (Pearson et al. 1991:70).

While establishing baseline amounts of amplitude and duration reflective of the magnetic characteristics for a shipwreck site, the authors recognize "that a considerable amount of variability does occur" (Pearson et al. 1991:70). Generated in an effort to test the 50-gamma/80-foot criteria and determine amount of variability, Table 6-9 lists numerous shipwrecks as well as single- and multiple-source objects located by magnetic survey and verified by divers. Although not an exhaustive compilation of known shipwreck signatures, all shipwrecks meet and surpass the 50-gamma/80-foot criteria, while all single-object readings, with the exception of the pipeline, fall below the criteria. However, the signature of the pipeline should show up as a linear feature on a magnetic contour map and not be confused with a single-source object. While the shipwrecks and single objects adhere to the 50-gamma/80-foot criteria, the multiple objects do not. If all targets listed in the table had to be prioritized as to the potential for representing a shipwreck site based on the 50-gamma/80-foot criteria, three multiple-object targets would have to be classified as potentially significant.

Appreciably lower in amplitude than the 200 gamma high/low demarcation employed in the interval detection rates above, it is interesting to note that the *Rhoda* (the wreck with the lowest recorded amplitude in our study) would not meet the 50-gamma/80-foot criteria of a potentially significant anomaly employing a 100-meter interval with the SeaSPY, the G-877, or the G-866 (see Table 6-5 above). Rather, it would only begin to meet this criteria for all four instruments once the 50-meter transect interval was employed.

Table 6-9. Compilation of Magnetic Data from Various Sources

Vessel/Object	Type & Size	Amplitude	Duration	Reference
Shipwrecks				
J.D. Hinde	129-ft sternwheeler	573	110	Gearhart and Hoyt 1990
Mary Somers	iron-hulled sidewheeler	5,000	400	Pearson et al. 1993
Gen. C.B. Comstock	177-ft. wooden hopper dredge	200	200	James et al. 1991a
Mary	234-ft. iron-hulled sidewheeler	1,180	400	Hoyt 1990
El Nuevo Constante	126-ft. wooden collier	65	250	Pearson et al. 1991
Virginius	sidewheel blockade runner	12,000	400	Tuttle 2002
Tug	wooden with machinery	30,357	176	Tuttle and Mitchell 1998
Mexico	288-ton wooden bark	1,260	454	Tuttle and Mitchell 1998
Star of the West	172-ton ocean-going wooden-	8,300	400	Krivor et al. 2002
James Stockton	55-ft. wooden schooner	80	130	Pearson et al. 1991
Homer	148-ft. wooden sidewheeler	810	200	Pearson and Saltus 1993
modern shrimp boat	segment 27 x 5 ft.	350	90	Pearson et al. 1991
Confederate	numerous vessels with	110	Long	Irion and Bond 1984
Single Objects				
pipeline	18-in. diameter	1570	200	Duff 1996
anchor	6-ft. shaft	30	270	Pearson et al. 1991
iron anvil	150 lbs.	598	26	Pearson et al. 1991
engine block	modern gasoline	357	60	Rogers et al. 1990
steel drum	55 gallon	191	35	Rogers et al. 1990
pipe	8 ft. long x 3 in. diameter	121	40	Rogers et al. 1990
railroad rail segment	4-ft. section	216	40	Rogers et al. 1990
Multiple Objects				
anchor/wire rope	8-ft. modern stockless/large	910	140	Rogers et al. 1990
Anomaly F	stiff arm crane from a dredge	986	40 secs.	Irion and Bond 1984
cable and chain	5 ft	30	50	Pearson et al. 1991
scattered ferrous	14 x 3 ft	100	110	Pearson et al. 1991

Although Garrison et al. modern debris-type anomalies “do not mimic patterns expected for historic shipwrecks” (1989:II-223), in a later study Pearson et al. state that “even though a considerable body of magnetic signature data for shipwrecks is now available, it is impossible to positively associate a specific signature with a shipwreck or any other feature” (1991:69). However, the general lack of high-energy settings in the GOMR indicates that the typical historic shipwreck site in the study area will display a “continuous” pattern in terms of distribution, a presumption generally supported by both the magnetic signatures of our three investigated sites and the available sidescan sonar imagery from the area as noted previously.

7.0: SUMMARY AND CONCLUSIONS

7.1. Introduction

The overall objective of this study has been to provide the Minerals Management Service with information that will enhance its ability to protect historic shipwreck resources in the Gulf of Mexico Region (GOMR) from the effects of its permitted actions. Data have been collected on reported shipwreck occurrences and these have been used to characterize particular aspects of the shipwreck population believed to exist in the Gulf of Mexico. Particularly important has been an assessment of the spatial distributions of reported shipwrecks and their utility in defining areas of high probability that can be used to direct future offshore remote-sensing surveys. Additionally, field work was undertaken to evaluate several offshore targets that represent reported hang sites and unidentified objects in order to clarify the relationship between these types of items and historic shipwrecks. Finally, controlled surveys were conducted over two identified wreck sites using several marine magnetometers in various survey parameters. The results were used to identify optimum survey parameters and instrumentation in offshore remote-sensing surveys. The results of all of these aspects of the study are summarized in this chapter and recommendations arising from these findings are presented.

7.2. Model of Shipwreck Occurrences in the GOMR: The 2001 Shipwreck Model

The Scope of Work for this study requested the preparation of “a revised predictive model for shipwrecks in the GOMR.” The model in question was that developed in the 1989 study by Garrison et al. That study collected and synthesized a considerable amount of information on shipwrecks in the Gulf of Mexico and developed statements about the patterns of occurrences and distributions of those wrecks. Like any model, the 1989 study attempted to synthesize complex observations and isolate the “essential factors and interrelationships” which accounted for the variability seen in the objects of interest, i.e., shipwrecks (Clarke 1972:12). That model relied principally on the spatial distribution of reported shipwreck losses to develop generalizations about those factors influencing the observed distributions. From the MMS perspective of cultural resources protection, the critical expression of the 1989 model is found in the high-probability areas (e.g., lease blocks) identified in the GOMR that are being used to direct offshore remote-sensing surveys.

Like most models, the 1989 model of shipwreck occurrences in the GOMR must be considered hypothetical in nature. It was based on particular sets of collected data and seemed reasonable in light of that data. However, as is also the case in most models, changes and alterations in the model are conceivable and, in fact, expected with the collection of greater amounts of data. The Scope of Work for the present study required that the 1989 model be revised and expanded and we considered that testing that model was prerequisite to undertaking these tasks. As has been demonstrated in previous sections, shortcomings in the 1989 model exist. These shortcomings can be related mainly to the lack of precision that exists in the positions assigned to a very large number of shipwrecks in the GOMR. An effort has been made to ameliorate this problem, principally by weighing the reliability of the coordinates provided for shipwrecks and recognizing that some will be useful in some sorts of spatial analyses, but not in others.

7.2.1. Characteristics of the Vessels in the 2001 Shipwreck Model

Data were collected that relate to various physical, chronological and spatial characteristics of the 2,106 reported shipwrecks in the compiled database. Many of the conclusions and inferences drawn from analyses of this sample of reported wrecks are very similar to those proposed by Garrison et al. (1989); others add to and expand on the information contained in that study.

Garrison et al. collected no information on vessel characteristics other than the year of loss and reported position of loss. Some of the conclusions of that study concerning the chronology of losses are mirrored in the findings presented here. Both have revealed that the frequencies of reported wrecks in the GOMR increase through time, with a quantitative increase occurring after about 1950. The present database, in fact, shows that more vessels have been reported lost in the Gulf of Mexico in the past 50 years than in the previous four hundred. This can be related to several factors, but it is not believed that the increase in losses through time is due to improved technologies that influence modern mariners to take more risks, as suggested by Garrison et al. (1989:II-115). Rather, it is expressive of the sheer number of vessels operating in the Gulf, numbers that have increased dramatically in the past several decades. These vessels are exposed to the same weather conditions and similar natural and man-induced hazards faced by earlier ships, and even modern technologies cannot overcome all of these dangers, resulting in losses. Additionally, these high numbers reflect the enhanced level of reporting of marine casualties by various agencies that has occurred in the past 50 years. Interestingly, other studies, including the CEI (1977) study of losses in the Gulf of Mexico, have not shown similar increases in casualties and losses in recent years. This discrepancy appears to lie principally in the types of sources used to collect shipwreck information and the definition of what constitutes an historic shipwreck. Other studies have tended to rely on sources that provide information only on named vessels and/or on vessels that can generally be categorized as “commercial” in nature. This has resulted in the exclusion of large numbers of unnamed and unidentified wrecks and many smaller vessels, such as those involved in fishing and recreational activities, all of which were included in the present study.

The age of vessels included in the 2001 shipwreck database at the time of loss does not show a strong correlation with the historical period of use, but appears to be most closely associated with the type of vessel and how it was used. Large, twentieth-century merchant ships lost in the GOMR are the oldest vessels as a class, with an average use life of about 25 years, while the average use life of modern fishing vessels is only about 15 years. The average age of the small sample of pre-modern steam-powered vessels lost in the study area was only about nine years.

The age of vessels at loss in the database is presumed to provide some information about the attributes of the entire population of wrecks in the study area. In addition, age at loss is an important MMS cultural resources consideration in that it relates to the identification of significant historic shipwrecks in the GOMR under the guidelines established by the National Register of Historic Places. These guidelines, generally, impart significance only on vessels that are over 50 years old. Analyses presented here have demonstrated that using the year of loss as the date from which the 50-year interval for potential significance is computed eliminates almost 50 percent of vessels that should be included because of their age when lost. Thus, when the year of build is known, it rather than the year of loss must be used in identifying potentially historic shipwrecks and, by extension, in identifying high-probability areas.

Information collected on vessel types lost in the GOMR shows that fishing vessels of various sorts, but principally shrimp trawlers, are the most numerous class of losses reported and likely represent the most numerous type of vessel in the entire population of wrecks. Most of these fishing vessels are twentieth century in date and generally have been overlooked by historians and archaeologists. Early vessels that attract the most historical and archaeological interest are relatively few in numbers and widely scattered in distribution.

Causes of loss were examined using information derived from various historical sources. Garrison et al. (1989) discussed effects of hurricanes in detail and concluded that they account for about 16 percent of losses during the period 1945-1976, while others (Chanu and Chanu 1955) have suggested that storms accounted for a similar percentage of losses in the Spanish flota vessels. Losses since the 1989 study provide little additional information on the effects of hurricanes, but seasonal patterns of loss were examined for all reported shipwrecks. Overall, there is no strong correlation with season of the year and frequency of losses, suggesting that neither hurricanes nor winter storms are overriding factors in the losses of vessels throughout the course of a year. However, an examination of the losses of vessels associated with shrimping shows a strong seasonal pattern in losses. Significantly, more shrimping vessels were lost during the peaks of the shrimping season in the spring and in the fall than during the rest of the year. In this instance, as it has been noted relative to the increased frequency of losses through time, it is argued that the number of vessels in the Gulf at any one month or season of the year is a stronger predictor of the frequency of losses that will occur than is the weather. Similar findings have been made for vessels operating in the nineteenth century cotton trade that were lost in the Dry Tortugas (Murphy and Jonsson 1993).

7.2.2. Spatial Patterning in the 2001 Shipwreck Model

Although there are questions about the reliability of the specific positions provided for many reported losses, the general distribution of known shipwrecks in the GOMR is considered meaningful. The overall patterns of wreck distributions seen in the 2001 database are in many ways similar to those shown in Garrison et al. (1989), even though many of the discussions in that study did consider nearshore and onshore wrecks not utilized in this one. The concentration of reported losses in waters closer to shore shown by most researchers is reflected in the 2001 GOMR shipwreck data. Because losses occurring inshore of Federal waters are not included in the present study, the data on reported wreck locations relative to the shoreline is not directly comparable to other studies. However, as noted earlier, over 80 percent of all reported losses in the database fall inside of the 60-m contour line (see Figure 4-11).

The elimination of inshore losses (i.e., in state waters) in this study does exclude the concentrations of wrecks at natural hazard locations such as the Dry Tortugas, Cape San Blas, and the Chandeleur Islands that were apparent in the Garrison et al. (1989) data. Natural hazards such as these are uncommon in the deeper waters of the GOMR and, thus, have had less influence on shipwrecks there. A concentration of reported losses in the shallow waters of the Ship Shoal area off of the Louisiana coast represents one of the few areas where these types of natural features seem to have influenced losses in the study area.

The overall distributions of wrecks in the study area reflect broad settlement and economic trends and their influence on maritime traffic and routes. Very few losses occurred in the study area prior to 1750, and significant increases in numbers do not appear until after 1850. In light of the known history of vessel use in the 1800 to 1840 period, and the small number of losses reported for that period, we must assume that losses for this period are seriously underreported. This is possibly true for earlier periods, but seems to be most apparent for the first half of the nineteenth century.

Few early vessel losses are seen in the western Gulf and the early losses after 1700 are generally indicative of settlement and trading activities along the central and eastern Gulf relating to the expansion of French settlement and control along the northern Gulf coast. Garrison et al. (1989) attempted to correlate trading routes with shipwreck losses, but found difficulty in quantitatively defining the spatial relationships between the two. In light of these results, this study has not attempted a similar approach. However, the patterns of wreck distributions over time presented above clearly show that, at a broad level, the locations of loss correlate with the development of historic shipping routes.

The increased numbers and concentrations of losses in nearshore areas of the central and western Gulf beginning in 1900, and particularly after 1950, appear to be closely related to the growth of the shrimping industry as well as recreational boating and the offshore oil and gas industry. Beginning in the nineteenth century, concentrations of vessels do occur off of major ports of the central and western Gulf, but these are not so apparent along the Florida coast. Garrison et al. (1989) noted a similar concentration of vessels in areas of ports beginning in the nineteenth century, although it appears that many of the losses they used to examine this association lay in state waters.

Garrison et al. (1989:II-116) also noted that the western Gulf had high concentrations of losses both along and near shore, while the eastern Gulf had an incidence of shipwrecks in the open sea that was more than double that of the west. Garrison et al. (1989) do not define the specific area meant by the “open sea,” but the present study does not show such a large difference between those vessels in nearshore areas and offshore areas in the eastern Gulf (see Figures 4-11 and 4-15). The apparent reason for this divergence from the Garrison et al. data is the use in this study of different sources for wreck information, particularly sport diving guides, that contain a great deal of information on losses off the west coast of Florida. It is still apparent, however, that the differences in overall reported wreck frequencies for inshore and offshore waters of the study area are greater for the central and western Gulf than for the eastern Gulf.

The potentials for shipwreck preservation in the study area have been reviewed, supplementing information provided in Garrison et al. (1989) with more recent information on losses from the open waters of the Gulf. The new data suggest that conditions for preservation in high-energy settings in the Gulf region appear to be somewhat better and more widespread than previously had been thought. In general, however, these types of high-energy settings are relatively rare in the GOMR such that sediment transport and deposition is moderate to low over much of the study area. Some amount of burial by sediment certainly does occur in some areas, but even at the few early vessels examined in the study area, such as the Civil War steamer *Hatteras*, lost in 1863 (Anuskiewicz and Arnold 1992), the sidewheel steamers *New York*, lost in 1846, and the *Josephine*, lost in 1881 (Irion and Ball 2001; Irion and Anuskiewicz 1999), vessel remains are still exposed above the seafloor. A review of sidescan sonar records from MMS-mandated surveys reveals that a large number of the vessels identified appear to be relatively intact, show minimal scatter of wreckage, and commonly are only partially buried by sediment. These conditions appear to exist throughout much of the GOMR where water depths are over 10-m or so. However, many of the vessels seen in these sidescan sonar records appear to be relatively modern and might represent steel-hulled ships whose preservation will differ from wooden-hulled examples. Few of these vessels have been examined by divers and specifics on their identities and conditions remain unknown.

Only in recent years has any information been collected on the condition of wrecks in deepwater portions of the GOMR. Although only a small number of deepwater wrecks have been found, the available evidence suggests that preservation is good, generally supporting findings from other parts of the world.

7.3. Identification of High-Probability Areas in the GOMR

The two previous studies of shipwrecks in the GOMR have each identified “high-probability areas” for shipwrecks in the Gulf of Mexico that have been used to direct offshore remote-sensing surveys. The CEI (1977) study noted that shipwrecks tended to be concentrated in a zone within about 10-km of the shoreline and were concentrated in areas of seaports, natural hazards and navigation routes. This zone was designated as Cultural Resource Management Zone 1 (CRMZ1), but as Garrison et al. (1989) noted, its outer boundary was often well beyond 10-km from the coast as finally drawn. The Garrison et al. (1989) study relied more heavily on finer scale assessments of the densities of reported shipwreck locations in their identification of high-probability areas in the Gulf. They suggested maintaining the high-probability zone lying within 10 km of the coast, plus they identified specific areas of high wreck densities resulting from their analysis using the quadrant approach discussed earlier. The high-probability zones they delineated generally fell in the vicinity of several ports and navigation hazards where high densities of wrecks were identified. Ultimately, the MMS used the results of the 0.5-degree quadrant analysis in the identification of high-probability zones. Additionally, Garrison et al. (1989) recognized that individual lease blocks outside of the high-probability quadrants and CRMZ1 should be considered high-probability locations because of their potential for containing shipwrecks. Because of the often unreliability of the reported positions of loss of vessels, Garrison et al. (1989) suggested that the eight contiguous lease blocks surrounding the individual block with a reported wreck location also should be considered high-probability areas. Figure 7-1 provides information on the location of historic shipwreck high-probability areas (i.e., by lease block) in the GOMR presently identified by the MMS as derived from the Garrison et al. (1989) study.

Various analyses presented in this study have demonstrated that the predictability of the 1989 model as it has been used to identify high-probability areas in the GOMR is weak. Relying on GOMR remote-sensing survey data, it has been shown that there is no statistically significant difference between discovering a shipwreck in an identified high-probability lease block or in finding one in a lease block not assigned a high probability of containing historic wrecks. The principal reason behind this is the unreliability in the reported positions of loss for so many vessels. Because of the nature of the reports of loss on these vessels, it is impossible to entirely overcome this built-in error in the data. However, an effort has been made to account for the potential error inherent in reports of loss by assigning measures of reliability to the determined geographic coordinates of loss. The assignment of geographic positions to a vessel ultimately derives from a complex set of variables related to the initial account of loss. The use of a measure of reliability, as is done here, cannot take into account all of those variables, nor in many if not most cases, can it entirely ameliorate all of the error incorporated in many wreck positions finally obtained.

However, this represents an initial step in trying to measure the utility of the principal variable used in spatial analyses, the position of loss. As long as no efforts are made to account for this error, the strength of statements about shipwreck distributions in the GOMR will remain weak and the predictability of any models of these distributions will be uncertain.

Other techniques for increasing reliability of positions are possible, but the most obvious ones are difficult to accomplish. For example, a careful search for, review and analysis of every primary account of loss for every vessel assigned a questionable position might serve to accomplish some of this. This would be a tremendous undertaking and would not clear up the questions about many losses. In a large number of cases, the original accounts of loss simply do not contain sufficient information to strengthen the accuracy of the assigned position of loss. For the present, we believe that the use of reliability assessments, as is done here, is the most expedient and efficient way of enhancing the strength and predictability of statements about the spatial distributions of shipwrecks in the study area.

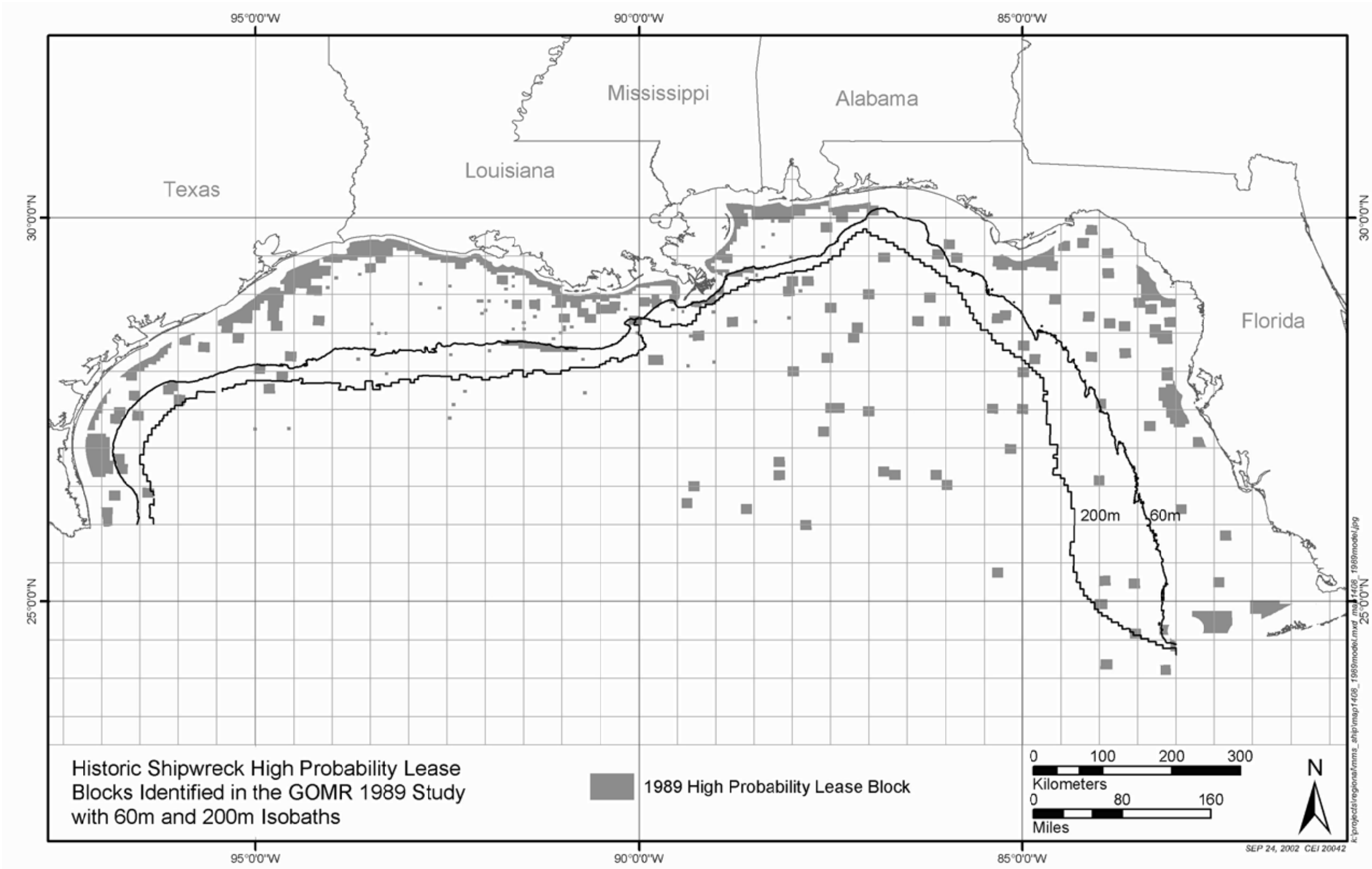


Figure 7-1. Historic shipwreck high-probability lease blocks identified in the GOMR in the 1989 study.

A general assessment of the probability of occurrence of shipwrecks in the study area can be achieved by comparing wreck densities with preservation potentials across the GOMR. This follows an approach presented in Garrison et al. (1989) for the GOMR and by Pearson et al. (1989) for historic vessel losses within the boundaries of the New Orleans District of the U.S. Army Corps of Engineers. Data on shipwreck densities, preservation potential and overall potential are provided in Table 7-1 for the 70 MMS lease areas in the GOMR. The overall potential represents the merged value of shipwreck densities and preservation potential. The preservation potentials are derived from information on sedimentary characteristics and on known shipwreck preservation for areas of the GOMR as displayed in Figure 4-10. Shipwreck densities are derived from the distributions of shipwrecks across lease areas per 1,000 square miles of area as shown in Figure 4-15. The values used in Table 7-1 are: Low ≤ 25 reported wrecks per 1,000 mi^2; Moderate = 26 to 50 reported wrecks and High ≥51 reported wrecks.

Table 7-1. Shipwreck Occurrence and Preservation Potentials for MMS Lease Areas

LEASE AREA	SHIPWRECK POTENTIAL	PRESERVATION POTENTIAL	OVERALL POTENTIAL
SOUTH TEXAS			
PORT ISABEL	LOW	HIGH-MODERATE	MODERATE
SOUTH PADRE ISLAND	MODERATE	HIGH	MODERATE TO HIGH
SOUTH PADRE ISLAND A	LOW	HIGH	MODERATE
CORPUS CHRISTI	LOW	HIGH	MODERATE
NORTH PADRE ISLAND	MODERATE	HIGH	MODERATE TO HIGH
NORTH PADRE ISLAND A	LOW	HIGH	MODERATE
MUSTANG ISLAND	MODERATE	HIGH	MODERATE TO HIGH
MUSTANG ISLAND A	LOW	HIGH	MODERATE
CENTRAL/EAST TEXAS			
MATAGORDA ISLAND	MODERATE	HIGH	MODERATE TO HIGH
MATAGORDA ISLAND A	LOW	HIGH	MODERATE
BRAZOS	MODERATE	MODERATE TO HIGH	MODERATE TO HIGH
BRAZOS A	LOW	MODERATE TO HIGH	MODERATE
GALVESTON AREA	HIGH	MODERATE TO HIGH	HIGH
GALVESTON AREA A	LOW	MODERATE	LOW TO MODERATE
HIGH ISLAND	MODERATE	MODERATE	MODERATE
HIGH ISLAND A	LOW	MODERATE	LOW TO MODERATE
SABINE PASS (TX)	HIGH	MODERATE	MODERATE TO HIGH
WESTERN LOUISIANA			
SABINE PASS (LA)	HIGH	MODERATE	MODERATE TO HIGH
WEST CAMERON	LOW	MODERATE	LOW TO MODERATE
EAST CAMERON	LOW	MODERATE TO HIGH	MODERATE
VERMILION	LOW	MODERATE TO HIGH	MODERATE
SOUTH MARSH ISLAND	LOW	MODERATE TO HIGH	MODERATE
EUGENE ISLAND	MODERATE	MODERATE TO HIGH	MODERATE TO HIGH
CENTRAL/EASTERN LOUISIANA			
SHIP SHOAL	MODERATE	MODERATE TO HIGH	MODERATE TO HIGH
SOUTH PELTO	HIGH	MODERATE TO HIGH	HIGH
SOUTH TIMBALIER	MODERATE	MODERATE TO HIGH	MODERATE TO HIGH
EWING BANK	LOW	MODERATE TO HIGH	MODERATE

Table 7-1. (continued). Shipwreck Occurrence and Preservation Potentials for MMS Lease Areas

LEASE AREA	SHIPWRECK POTENTIAL	PRESERVATION POTENTIAL	OVERALL POTENTIAL
GRAND ISLE AREA	MODERATE	MODERATE TO HIGH	MODERATE TO HIGH
BAY MARCHAND	HIGH	MODERATE TO HIGH	HIGH
WEST DELTA	MODERATE	MODERATE TO HIGH	MODERATE TO HIGH
MISSISSIPPI CANYON	LOW	MODERATE TO HIGH	MODERATE
SOUTH PASS	MODERATE	MODERATE TO HIGH	MODERATE TO HIGH
MAIN PASS	LOW	MODERATE TO HIGH	MODERATE
BRETON SOUND	MODERATE	MODERATE	MODERATE
MISSISSIPPI/ALABAMA			
CHANDELEUR	LOW	MODERATE TO HIGH	MODERATE
MOBILE	HIGH	MODERATE TO HIGH	HIGH
VIOSCA KNOLL	LOW	MODERATE TO HIGH	MODERATE
FLORIDA PANHANDLE			
PENSACOLA	MODERATE	MODERATE	MODERATE
DESTIN DOME	LOW	LOW TO MODERATE	LOW TO MODERATE
APALACHICOLA	LOW	LOW TO MODERATE	LOW TO MODERATE
CENTRAL FLORIDA			
GAINESVILLE	LOW	MODERATE	LOW TO MODERATE
TARPON SPRINGS	LOW	LOW TO MODERATE	LOW TO MODERATE
ST. PETERSBURG	LOW	LOW TO MODERATE	LOW TO MODERATE
CHARLOTTE HARBOR	LOW	LOW TO MODERATE	LOW TO MODERATE
SOUTHWEST FLORIDA			
PULLEY RIDGE	LOW	LOW TO MODERATE	LOW TO MODERATE
MIAMI	LOW	LOW TO MODERATE	LOW TO MODERATE
KEY WEST	LOW	MODERATE	LOW TO MODERATE
DRY TORTUGAS	LOW	LOW TO MODERATE	LOW TO MODERATE
WESTERN OPEN GULF	LOW	UNKNOWN	UNKNOWN
EASTERN OPEN GULF	LOW	UNKNOWN	UNKNOWN

As seen in Figure 7-2, the distribution of overall shipwreck potentials across the GOMR shows moderate to high potentials along the western and central Gulf in the nearshore lease areas, decreasing to a low to moderate potential in the nearshore areas in the eastern part of the Gulf. This is generally the trend observed by Garrison et al. (1989). However, it is suspected that the overall shipwreck potentials obtained for some lease areas are underestimates of their true potential. This seems to be particularly true for some of the lease areas off the central and western Louisiana coast, such as those from the Eugene Island to West Cameron areas, and those south of Mobile, Alabama. As shown in Figure 3-4, offshore remote-sensing surveys have located a number of sunken vessels in these areas. Sidescan sonar records suggest that many of these wrecks are well preserved and in reasonably good condition. However, few of these wrecks have been physically examined by divers and their identity, age, and true condition are not known. Additionally, these are lease areas where numerous remote-sensing surveys have been conducted and the densities of known wrecks here is certainly partially reflective of this.

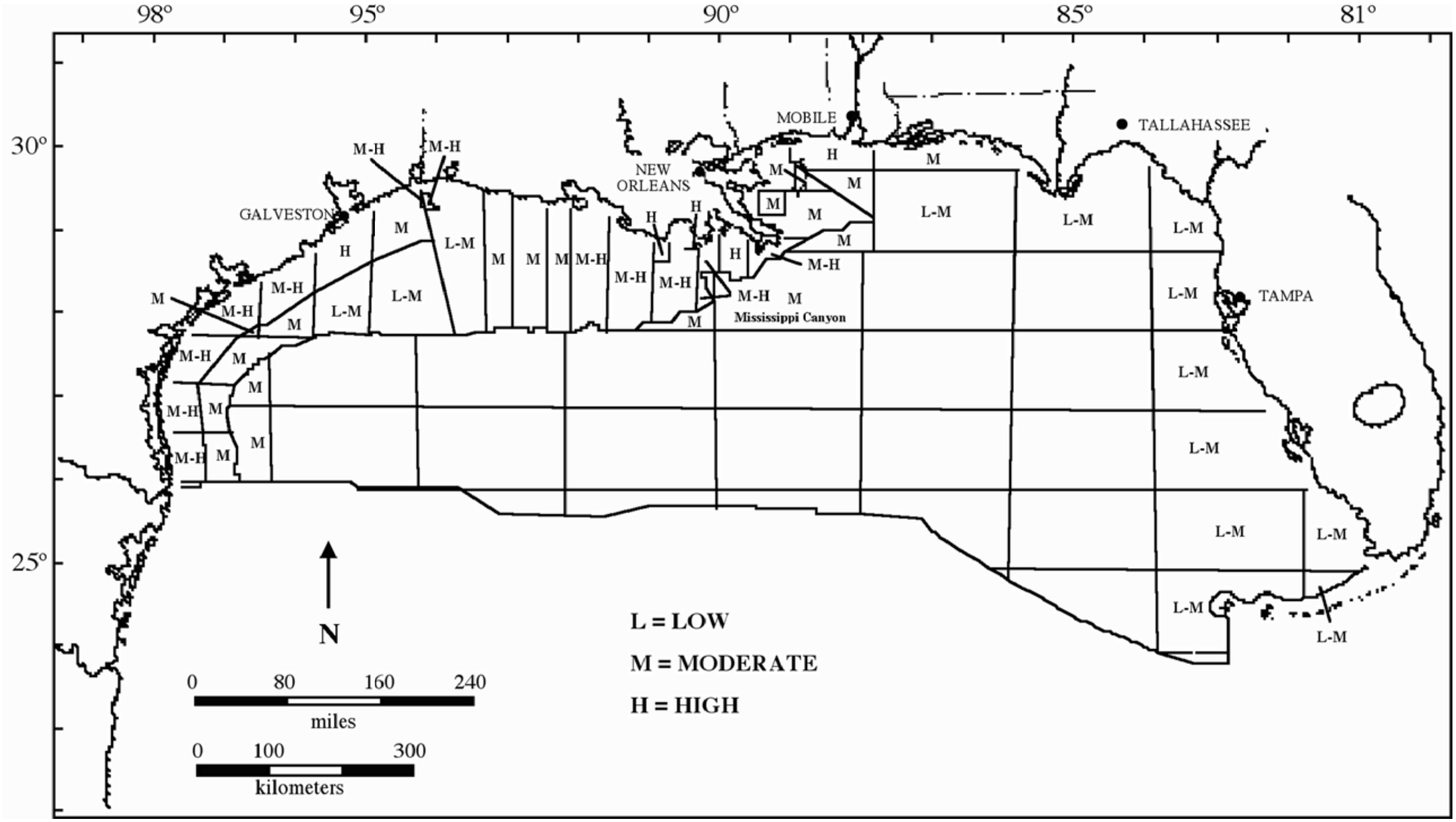


Figure 7-2. Overall shipwreck potentials by lease areas.

Table 7-1 and Figure 7-2 provide general information on shipwreck potentials across the GOMR. The identification of specific and spatially more restricted high-probability zones in this study generally follows the technique presented by Garrison et al. (1989), tempered with the concept of reliability discussed above. We have used ArcView to objectively identify areas of shipwreck densities using the data from the 2001 shipwreck database. Ultimately, we suggest that those areas containing densities of 25 or more reported shipwrecks per 0.5-degree unit of area should be classified as high-probability areas.

We have attempted to strengthen the reliability of the true shipwreck potential of these selected areas by eliminating from consideration all of those reported wrecks that have a very low reliability in their reported position of loss or for which insufficient information is available to make such an assessment (i.e., Reliability Factor 4). ArcView uses circular areas in its density analysis and these have been converted into standard MMS offshore lease blocks by including in each high-probability area all of the lease blocks within or that intersect the circular areas.

These high-probability 0.5-degree units exist as overlapping and adjacent entities extending along the central and western Gulf coast (see Figure 4-30). Although Garrison et al. (1989) used many losses from inshore state waters, and the present study uses only those in state waters assigned location Reliability Factors 2 and 3, the general distribution of the 0.5-degree high-probability units in the 1989 study resembles the ones obtained here. To an extent, these areas reflect “port’ activity, as was indicated by Garrison et al. (1989), but not necessarily losses occurring in and around port entrances, where the combination of high vessel densities and natural hazards produced increased losses. In the present instance, the concentration of losses in the general vicinity of ports is seen primarily as a reflection of higher vessel densities with only minimal influences from natural hazards like shoals, bars, etc.

These 0.5-degree units encompass only a segment of the reported shipwreck population in the GOMR and, as in the Garrison et al. (1989) study, we suggest that the identification of high-probability areas outside of these high density zones must be considered to take into account other reported wrecks. In the identification of other areas, we have relied heavily on the Reliability Factors discussed above. First, we suggest that all lease blocks containing reported or discovered shipwrecks assigned a Reliability Factor of 1 should be classified as high-probability lease blocks. Secondly, we suggest that all lease blocks containing the positions of reported shipwrecks assigned a Reliability Factor 2 be considered as high-probability lease blocks. Further, following the lead of Garrison et al. (1989), because of the potential for some error in the positions of vessels assigned a Reliability Factor 2, we suggest that the eight contiguous lease blocks around the one containing the vessel position be included as high-probability blocks.

No effort has been made to further refine the identification of these lease blocks on other vessel attributes, of which age is probably the most important. Specifically, vessels generally have to be over 50 years old to be considered historically significant and thus of greatest concern to MMS cultural resources protection endeavors. However, age is a “moving target” and it seems more appropriate for the MMS to use ArcView and the information contained in the 2001 shipwreck database to identify those vessels (and associated individual lease blocks or nine-lease block clusters) which should be maintained in this high-probability class through time. As discussed earlier, date of build is available for many vessels in the database and should be used over the date of loss in computing age for an assessment of potential significance.

Vessels assigned a Reliability Factor of 3 have been eliminated from consideration in the selection of individual high-probability lease blocks because of concerns about the potential for error in their reported position. They have, however, been used in the identification of the more general 0.5-degree areas of high probability. As noted, vessels assigned a Reliability Factor of 4, because of serious questions about their position accuracy, have not been used in identifying high-probability areas.

Garrison et al. (1989) also identified as high-probability areas all of the lease blocks in Federal waters falling within 10 km of the shoreline, essentially maintaining the principal recommendation from the earlier 1977 CEI study (see Figure 7-1). Ultimately, all of these high-probability lease blocks as identified by the MMS for its survey program fall off of the states of Louisiana, Mississippi and Alabama, where state boundaries extend only 4.8-km (three miles) offshore. The data collected in the present study do not support the specific delineation of those Federal lease blocks within 10-km of the coastline as high-probability blocks. However, as seen in Figure 4-30, most of these lease blocks are encompassed within the 0.5-degree units containing 25 or more reported losses and thus are delineated as high-probability lease blocks on this criterion.

Figure 7-3 provides information on the distribution of all of the various classes of high-probability areas identified in this study. A full listing of the lease blocks included in all of these areas is provided as an ArcView file. As can be seen, high-probability areas are concentrated off the central and western Gulf coasts, principally within the 60-m contour line. The most significant concentration of identified high-probability lease blocks beyond the 60-m contour is off the mouth of the Mississippi River. Under the most recent NTL regarding MMS archaeological survey requirements, those high-probability lease blocks falling in water depths of less than 200-m would be subjected to remote-sensing surveys using line spacing of 50-m, while those in deeper waters would utilize 300-m line spacing.

As seen in Figure 7-3, only a relatively small number of high-probability lease blocks fall in water deeper than 200-m. This means that the vast majority of the lease blocks identified as high-probability areas in this study will be subjected to remote-sensing surveys using 50-m line spacing.

The total number of lease blocks identified as high-probability locales in this study is 5,198, considerably more than the 2,469 currently identified by MMS. As can be seen in Figures 7-1 and 7-3, much of the increase is in our identification of many more high-probability lease blocks along the central and western Gulf coast. There is a slight increase in the number of high-probability lease blocks identified in the eastern Gulf off the Florida coast, while little difference is seen in the number of high-probability lease blocks identified in the deeper waters of the Gulf by the two studies.

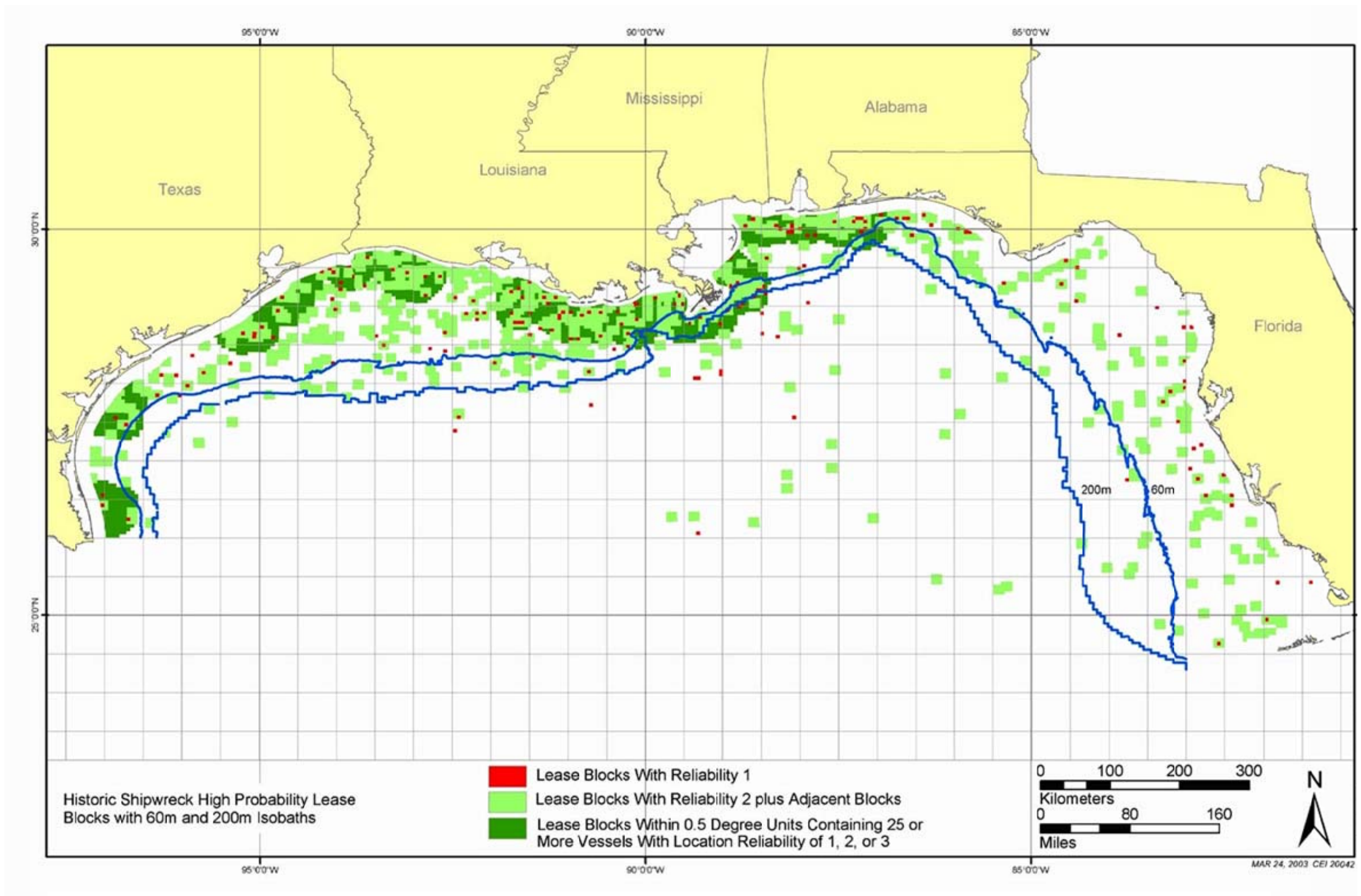


Figure 7-3. Historic shipwreck high-probability lease blocks identified in the GOMR in the present study.

The identification of a greater number of high-probability lease blocks in this study results from several factors. The demonstrated poor predictability of the 1989 model lies principally in the unreliability of reported positions of loss. In the identification of 0.5-degree high-probability units we have utilized a wreck density that results in the selection of areas that are fairly large under the presumption that this will "capture" some of the positioning errors known to exist. As a result, these 0.5-degree areas encompass more lease blocks than did those in the 1989 study.

Another reason for the increased number of high-probability lease blocks is because no effort has been made to eliminate vessels that are less than 50 years old in the identification of the high-probability lease blocks outside of the 0.5-degree units. As noted above, the age of vessels reported lost in the GOMR is a "moving target" that will require periodic assessments and updates by the MMS in its identification of potentially significant wrecks and the selection of high-probability areas. The data necessary to do this are provided in the ArcView files and shipwreck database submitted as part of this study. Although we recommend that the MMS undertake the process of eliminating vessels and their associated high-probability areas on the basis of age, the database has been examined along these lines to provide some idea of how many lease blocks might be eliminated assuming the age criterion is based on the year 2001. The findings are presented below.

In the selection of high-probability lease blocks outside of the 0.5-degree units, 502 entries in the shipwreck database were used, all of which have been assigned Reliability Factors 1 or 2 for their position reliability. Date of build information reveals that 44 of these vessels have been constructed since 1951 and, because they are less than 50 years old, they do not meet the age criterion for significance. All 44 of these vessels have been assigned a Reliability Factor of 2, therefore each has been incorporated into a nine-lease-block high-probability unit. Together, these 44 vessels incorporate 396 high-probability lease blocks that, as of the year 2001, could be subtracted from the 5,198 high-probability lease blocks identified in our model. The date of build is unknown for 396 of the 502 entries used to identify high-probability lease blocks outside of the 0.5-degree units. Two hundred four of these have been lost since 1951 and, under the parameters of the 1989 model, would be eliminated in the identification of high-probability blocks because they sank less than 50 years ago. One hundred seventy-two of these are assigned a Reliability Factor of 2 and 32 a Reliability Factor of 1, meaning that these losses together incorporate 1,580 lease blocks that could be eliminated as high-probability blocks if date of sinking is used in assessing age and potential significance. Finally, no date of loss is available for 185 of the vessels used in the selection of high-probability lease blocks outside of the 0-5-degree units. Of these, 130 are assigned a Reliability Factor of 2 and 55 a Reliability Factor of 1, and together they contribute to the identification of 1,225 high-probability lease blocks. In sum, these vessels that are either known to be less than 50 years old, or sank in the past 50 years, or whose date of sinking is unknown, contribute to the identification of a total of 3,201 high-probability lease blocks in our model. However, many of these represent overlapping lease blocks and the actual number of individual lease blocks involved is 2,155. Therefore, if these criteria are used for eliminating vessels that are or might be non-significant because they are less than 50 years old, it would reduce the total number of identified high-probability lease blocks in our model to 3,043. In essence, the 5,198 identified high-probability blocks must be considered a maximum number that will be reduced dependent upon the criteria selected by the MMS for eliminating any vessels deemed non-significant on the basis of age. As noted in Chapter 4, almost 50 percent of all vessels lost in the GOMR in the past 50 years with a known date of build are over 50 years old. Thus, the MMS must be cognizant of the fact that using the date of loss in identifying vessels that might meet the National Register age criterion for significance is going to eliminate from consideration a large number of vessels whose true age does meet that 50-year-old requirement.

The high-probability areas identified in this study constitute the most important expression of the "model" of shipwreck occurrence in the Gulf of Mexico relative to MMS management of historic shipwrecks in the GOMR. It is a model, and thus is a simplified expression of sets of complex phenomena. An effort has been made to make the shipwreck data more useful in identifying high-probability locations through the collection of more information on more attributes than had been done in the 1989 study. In addition, the concept of "Reliability" in terms of reported position of loss has been incorporated in an attempt to strengthen the identification of high-probability areas. We believe that the predictability of the 2001 shipwreck model has been enhanced by the addition of these various elements, but ultimately, the model will require testing to ascertain its viability.

7.4. Correlation of Hangs and Reported Shipwrecks

In an effort to correlate hangs with reported shipwreck positions**,** ground-truthing was conducted of selected hang sites, unknown objects, unknown vessels and reported shipwreck locations.

The initial sidescan sonar survey of each of the 20 target areas revealed that only nine target areas contained bottom features indicative of submerged cultural resources (see Table 5-1). Target inspection indicated that of the nine potential targets, only one represented a shipwreck. Located in the Vermillion Area, Target 15 was a modern steel-hulled shrimp trawler unassociated with any reported hangs. This vessel is not considered significant based on National Register of Historic Places (NRHP) eligibility criteria. Of the remaining targets, two represented modern debris such as pipe or platform debris associated with the oil industry, and six represented natural bottom features or had negative findings.

The 20 target areas investigated actually encompassed 52 reported or recorded objects, 31 of which were reported hang locations. These 31 reported hang locations fall in 16 of the targets (actually target areas) examined. These hangs represent locations where fishermen, principally shrimpers, have caught their nets on objects on the bottom. The examination of these reported hangs was of particular interest because of the demonstrated fact that historic wrecks in the GOMR are commonly entangled in shrimp netting and rope, meaning that some hang locations should represent unreported wrecks. At only one of the 16 targets containing reported hangs, Target 5, was an object found that might constitute the hang site. Even in this instance, however, the object believed to have produced the hangs (a pile of pipes designated Target 5a) was over 1,000 feet away from the reported hang locations. One other target, Target 17, is believed to contain a buried object that could constitute a hang when exposed, although this is only a tentative assumption. If we assume that both Target 5 and Target 17 do contain the objects producing the reported nearby hangs, then the correlation of reported hang locations with an object on the bottom has been verified in only 12.5 percent (2 of 16 targets) of the cases examined. If only Target 5 is considered to be reliably identified as a hang source, then in only 1 in 16 (6.3 percent) instances were reported hang locations associated with a verified object.

In no instance did reported hang locations correlate with a shipwreck. The remains of the modern trawler found at Target 15, the only vessel found during the diving, are not spatially associated with any reported hang locations provided in the Texas A&M or MMS hang records used. However, a large quantity of netting was entangled on the trawler, indicating that it has snagged nets. Why it is not listed as a hang in the sources examined is unknown. The one other object discovered that would constitute an obvious hang is Target 1, the probable remains of an oil or gas platform found in lease block South Marsh Island 17. However, like the wreck at Target 15, there is no indication that this object has been reported as a hang location.

As noted previously, the 20 targets examined represent an extremely small sample of the total population of hangs, objects and shipwrecks reported in the GOMR. At only one of 16 target locations could reported hangs be associated with an object on the bottom and in this instance, the object and the hangs are approximately 1,300 feet apart. As has been discussed, this discrepancy in positions is almost certainly due to the conversion of Loran coordinates, in which most hang positions were originally recorded, into latitude/longitude or state plane coordinates. No information was collected that could be used to evaluate how consistent this 1,300-foot difference is across the GOMR. However, it is suspected to vary dependent upon location. In the case of Target 5, it is very likely that if a Loran system had been used to relocate the cluster of hangs, the actual position obtained in the GOMR would have been very close to the pile of pipes.

Target 15, the modern shrimp trawler, is identified in the 2001 shipwreck database as an unknown object. This object had been located during a lease block remote-sensing survey and appears as an amorphous object.

7.5. Comparison of Magnetometer Technologies and Survey Line Spacing

As stated in the SOW, the goals of Task 3 were: 1) a comparison of the “industry-standard” proton magnetometer (i.e., Geometrics 866) that is currently employed in marine archaeological surveys to the current state-of-the-art cesium magnetometer to determine if a change in the MMS/GOMR survey methodology is warranted; and 2) to evaluate both magnetometers at various survey line spacings to determine the minimally acceptable survey line spacing for detecting historic shipwrecks. To accomplish this task, the marine survey was to be conducted with each magnetometer over two known shipwrecks at varying transect intervals. The wrecks employed in the survey initially included the *Josephine*, an iron-hulled sidewheeler and the *Rhoda*, a wooden-hulled sailing ship, but subsequently included a barge suspected of being iron-hulled.

While only two magnetometers were initially identified for the study, it was decided that it would be beneficial to the investigation to field-assess other magnetometer models in addition to the two currently identified in the contract for the survey trials of Task 3. These included an Overhauser effect proton magnetometer and the new Geometrics G-877 proton precession magnetometer. The G-877 is the replacement for the proton precession industry standards currently employed in the Gulf, i.e., the G-801 and the G-866 precession proton magnetometers. These latter models, while still employed by many of the survey companies involved in the oil and gas industry, are no longer being produced (as well as their respective parts), and are being phased out by many firms. Relative to employment of the Overhauser type magnetometers, produced by Marine Magnetics and others (i.e., GEM Systems), Overhauser magnetometers offer nearly the same sensitivity as the cesium magnetometers, particularly at moderate speeds. Perhaps more germane to our study is the fact that these magnetometers are and will be employed by Gulf survey companies on projects that will have MMS purview. Therefore, the addition of these two models offered to keep the study "up-to-date" and more reflective of systems employed now and that will be employed in the future by oil and gas industry-related companies. The four models employed in our survey included the Geometrics G-866, Geometrics G-877, Geometrics G-881, and Marine Magnetics' SeaSPY.

Besides the two additional magnetometers, it was also decided that a submersible base station be tested to determine its applicability to offshore surveys as it might apply to post-mission processing of magnetic data, especially with regard to surveys with line spacing of 50-m. Mirroring the NTL 98-06, the new NTL 2002-01 requirements do not stipulate the employment of base stations or contouring of magnetometer data. This is a reflection of the fact that, apart from oil rigs or platforms that cannot be employed as a suitable location because of their inherent magnetism, there is nowhere to place a base station in offshore Gulf waters. Currently, the locations of encountered magnetic anomalies are simply marked with a symbol (_) and an identifying number, and presented in tabular format with anomaly information including line number, shot point, and coordinates. With regard to the latter, exact coordinates for a magnetic anomaly are next to impossible to acquire when data is not contoured. Contouring would in many cases locate the anomaly exactly. However, surveys are often conducted over many days with interruptions by weather common. Without a base station to correct for this effect, the diurnal variation that would be recorded during surveys that extended over a long period of time makes contouring problematic at best. Therefore, a Sentinel® submersible base station was included in this task in an effort to assess its functionality in the field, and answer questions concerning employment in offshore surveys relative to issues of diurnal variation and the applicability of contouring.

During Task 3 of the investigation, all four magnetometers were run on three grids over two shipwrecks in an effort to determine how each instrument detected that same wreck site with regard to maximum amplitude and duration. It should be stated that this aspect of the investigation was not a contest to determine which instrument recorded the highest gamma amplitude or deviation at the greatest spaced interval; nor was it a controlled laboratory experiment where a sensor could be pulled past a piece of iron of a known mass along an unwavering track spaced at an exactly known distance unaffected by wind or current. Rather, it was a field trial conducted to simulate an actual survey environment, with the *Josephine* situated in a high-current, open-ocean location and the *Rhoda* in a somewhat protected bay environment, and to assess how each instrument recorded the same wreck site, and if differences were present, determine if these findings predicated changes to the current MMS GOMR survey methodology. Our investigation revealed that all magnetometers performed well in the field trials, including the G-866, a system that is antiquated although functional in most respects. Specific findings of this aspect of the investigations are as follows:

- While the order of which instrument records the highest amplitude appears generally to remain relatively constant, with the SeaSPY and G-877 exchanging places followed by the G-881 and then the G-866, the variation in that order seems to be due to minor differences associated with track line position (i.e., the location of the sensor).

- The ability of the current 50-m transect interval to effectively record the wrecks examined in this study has been amply demonstrated and argues for its effectiveness in locating many of the classes of vessels known to have been lost in the GOMR. However, it should be emphasized that the vessels examined in the present study are large and contain considerable quantities of ferrous metal. The 50-m interval is unlikely to be effective in identifying all wreck types in the GOMR, especially earlier wrecks containing less iron or small wooden vessels or parts of wooden vessels that produce smaller magnetic signatures. Therefore, it is recommended that in order to provide better detection capability for all types of shipwrecks, especially earlier wrecks which might be the most historically significant types within the GOMR, a closer spaced transect interval, such as the 30-m interval, should be considered by the MMS for employment in high-probability areas.

- Reflecting abilities of the for-years industry standard but now antiquated G-801 and G-866 systems, the NTL requires dual scale readings, strip chart speeds, and annotation of the strip charts with shot points and recorder speed. However, given the computer-driven, digital-nature of all instruments today, these requirements appear now to be outmoded and in need of revision, at least for those magnetometers that are totally digital (i.e., G-877, G-881, SeaSpy, etc.). Magnetic data from these digital models is collected simultaneously in the same file along with positioning, depth, time, layback, gyro, etc., making annotation unnecessary. Additionally, the strip chart is presented digitally on the screen in HYPACK (and other navigation programs) and may be set at any gamma scale. Furthermore, when post-processing data, track lines and any attendant anomalies can also be viewed and presented in any gamma scale to allow for optimum characterization of that anomaly.

- Relative to the increased depth of 200 meters or less for survey of high-probability OCS blocks, early magnetometer sensor types such as the G-866 have significant limitations in that they physically will not sink below 225 feet regardless of how much tow cable is deployed. This does not allow the sensor to be towed within the MMS specification of six meters of the seafloor in deeper waters. Therefore, the magnetometer chosen for survey at the deeper depths should be required to meet depth parameters.

- Durations for each instrument vary to the point that no real comparisons can be made. And, durations and amplitude do not appear to be affected by speeds up to 7 knots.

- While not stipulated as a requirement by the NTL, employment of the Sentinel during our investigation highlighted its potential as an offshore tool in the collection of data for post-processing of magnetic survey data. Although the actual magnetometer operated excellently, collecting extremely smooth data, as discussed above the acoustic release failed on one occasion and had to be retrieved manually by divers, a scenario impossible in most GOMR survey situations. A prototype, the release is said to have undergone corrective redesign. We suggest additional field trials of the release mechanism before recommending this recovery system.

- Because contouring presents critical analytic data, it is recommended that even without the use of a base station, offshore survey data should be contoured in situations where a survey is conducted as a single unit (i.e., not split over multiple days).

- For all magnetometers, the manufacturer’s firmware automatic monitoring feature should be switched off if it will impede the collection of data such as occurred with the SeaSPY.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.