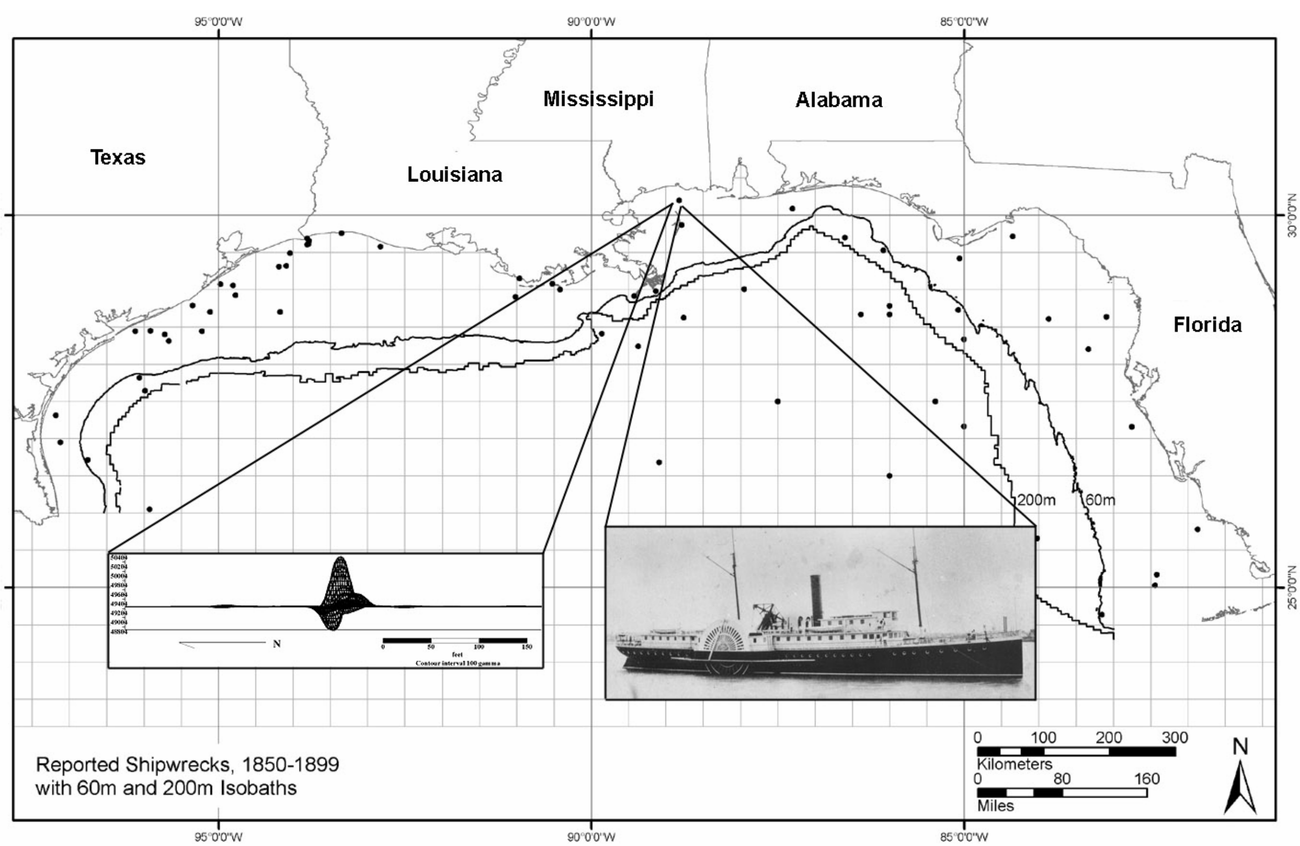
OCS Study
MMS 2003-060

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

## Final Report

## Volume I: Executive Summary




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

OCS Study
MMS 2003-060

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## Volume I: Executive Summary

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## ABSTRACT

For 20 years, the Minerals Management Service (MMS) has required cultural resources assessments for oil and gas leases in the northern Gulf of Mexico. These assessments reflect the obligations of the MMS relative to the identification, protection and management of prehistoric and historic properties that may exist on Federal lands in this area. In 1989, the Texas A&M Research Foundation conducted a study for MMS (Garrison et al. 1989) to identify high-probability areas and establish remote-sensing survey guidelines and equipment requirements most appropriate for locating historic shipwrecks on the Outer Continental Shelf (OCS) in the Gulf of Mexico Region (GOMR). Over the years, deficiencies in the 1989 model of historic shipwreck distributions and occurrences have been noted, plus new remote-sensing technologies have been developed that have application to the MMS program of offshore surveys. The present study was undertaken to refine the model of shipwreck distributions presented in the 1989 study and reevaluate the survey strategies and instrumentation recommended. This study involved four principal tasks. Task 1 involved archival data collection to update, expand and evaluate the shipwreck database produced in the 1989 study and the development of a new database. Task 2 involved the correlation of shipwreck data with other sorts of submerged object data from the GOMR, such as reported snag and hang data and objects and vessels identified during offshore remote-sensing surveys. This task included diving on selected offshore targets to determine their identity. Task 3 involved conducting magnetometer surveys at two selected shipwreck locations using differing equipment and survey strategies to compare and evaluate the instruments, refine the survey strategies currently used and determine the minimally acceptable survey line spacing for detecting historic shipwrecks. Task 4 involved the synthesis of collected data, the preparation of a revised predictive model for shipwrecks in the GOMR (Figure 1) relying on the findings of Tasks 1 and 2, making recommendations on survey instrumentation and strategies that would be the most effective in locating these shipwrecks relying on the findings of Task 3, and preparing a technical report of findings.

During Task 1, information on reported and known shipwrecks in the GOMR was collected from a variety of sources to expand the information presented in the 1989 study. The 1989 shipwreck database was revised and expanded to include a number of variables on vessel characteristics and circumstances of loss that might aid in wreck identification if discovered. All of the information on shipwrecks collected during Task 1 was incorporated into a relational database (Microsoft Access) and into a GIS program (ArcView) that can serve as a tool by MMS personnel for the continued assessment and monitoring of shipwreck data in the GOMR. Data on a variety of variables relating to the characteristics of vessels and objects were collected for the over two thousand entries ultimately included in the shipwreck database. The sample of reported shipwrecks was examined in terms of a variety of factors such as year of loss, season of loss, types of vessels, causes of loss, etc., in an effort to characterize the population of wrecks that exists in the GOMR.

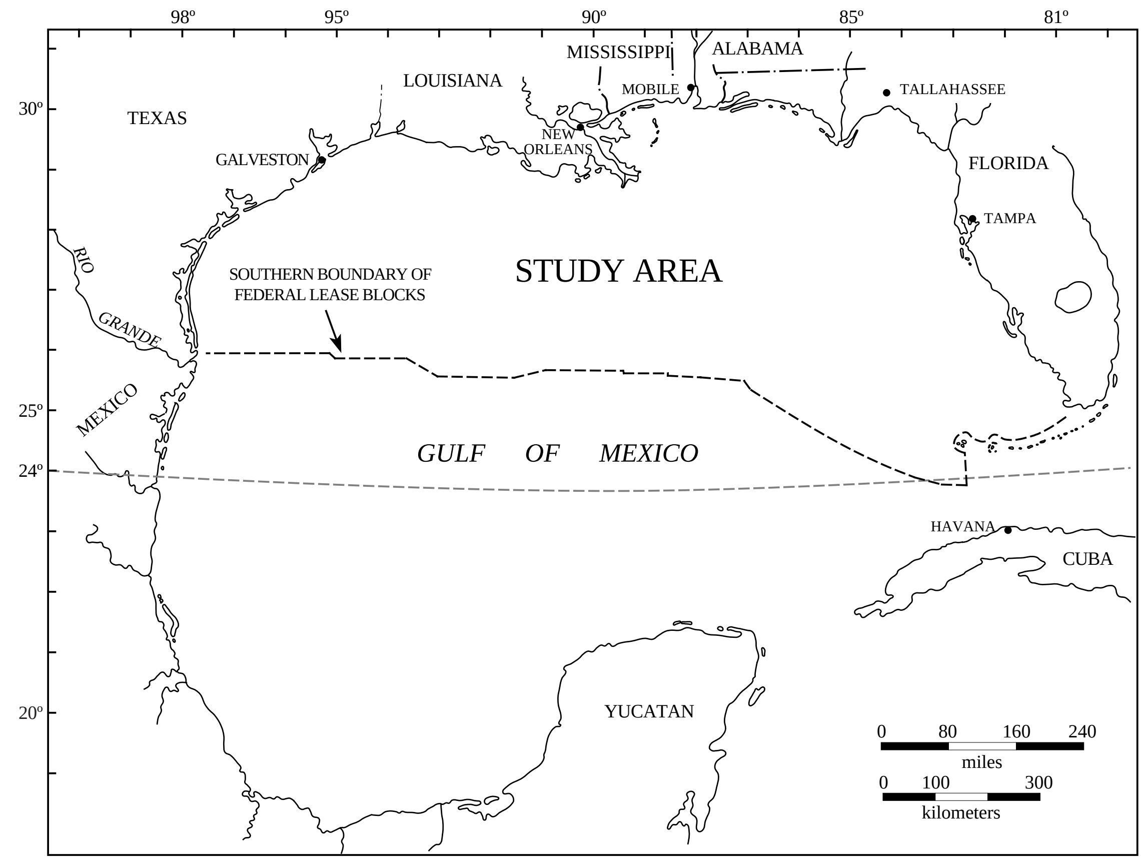


**Figure 1. Study area.**

In Task 2, the collected shipwreck data were compared against other classes of submerged objects, such as reported snags and hangs, to determine if spatial correlations existed. In an effort to determine if reported hangs and unidentified objects equated with shipwrecks**,** remote-sensing survey and diving were conducted at selected hang sites, unknown objects, unknown vessels and reported shipwreck locations. Twenty target areas, which actually represented 52 recorded target locations (i.e., hangs, unknown vessels, obstructions, etc.), 31 of which were reported hang locations, were selected for both survey and subsequent diver investigation. Of the targets investigated, only three could have been or caused a hang site: a modern shipwreck and two areas of modern debris associated with the oil industry. These results raise numerous questions, the least of which is coordinate accuracy of hangs, especially in light of the fact that of the 31 hang locations only 10 percent were found to actually contain objects that could result in a hang.

To accomplish Task 3, a survey was conducted over two known shipwrecks at varying transect intervals with a Geometrics 866, a Geometrics 881 cesium magnetometer, a Geometrics 877 proton precession magnetometer, and a SeaSPY Marine Magnetics Overhauser-type magnetometer. A submersible base station was also employed to determine its applicability to offshore surveys as it might apply to post-mission processing of magnetic data. All four magnetometers were run on three grids of varying intervals and speeds over the 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.

As part of Task 4, a revised model for shipwreck occurrences in the GOMR was developed. The development of a new model required an evaluation of the 1989 model of shipwreck distributions now used to direct offshore surveys. This evaluation found that there is considerable unreliability in the 1989 model's identification of high-probability areas. Data from offshore remote-sensing surveys reveal that there is no statistically significant difference between finding a shipwreck in a designated high-probability area and finding one in any other area. In the development of a new model an effort is made to increase the predictability of historic shipwreck locations, and the resulting identifications of high-probability areas, by incorporating quantitative measures of "reliability" into the positions of loss recorded for reported shipwrecks. This information, in conjunction with patterns of shipwreck density distributions, is used to identify high-probability zones and individual clusters of high-probability lease blocks in the GOMR. The new model identifies considerably more high-probability lease blocks in the GOMR than did the 1989 study. Task 4 also included recommendations for survey instrumentation and strategies based on the findings of Task 3. It was found that all magnetometers used performed well in the field trials, but it is recommended that a closer transect interval than the 50-m now used should be considered for use in high-probability areas. Additionally, the functionality of submersible base stations is discussed, as are the relationships of magnetic duration and amplitude relative to vessel speed, and comments are provided on several factors that influence the conduct of MMS GOMR surveys and the subsequent analysis of data.

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## ACKNOWLEDGMENTS

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Lori Cunningham of Coastal Environments, Inc., was responsible for all aspects of the study involved with placing collected data into Microsoft Access and ArcView. This included design of the database, manipulation of the collected data, and development and design of all of the maps included with the ArcView database. Her efforts were key to the success of this project. Dion O'Rielly, also of Coastal Environments, Inc., aided Ms. Cunningham, and was responsible for finalizing the Access database and converting much of the collected data into formats compatible for use in Access and ArcView.

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# EXECUTIVE SUMMARY

For 20 years, the Minerals Management Service (MMS) has required cultural resources assessments for oil and gas leases in the northern Gulf of Mexico. These assessments reflect the obligations of the MMS relative to the identification, protection and management of prehistoric and historic properties that may exist on the Outer Continental Shelf (OCS) in this area, known as the Gulf of Mexico Region (GOMR). 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 in this region. All of these activities are ongoing and have a potential for impacting cultural remains, including historic shipwrecks, that might exist on the vast area of submerged lands in the Gulf of Mexico.

The MMS has sponsored several studies to collect information on cultural resources in the GOMR. These studies have been used to help design and guide a remote-sensing survey program intended to identify cultural resources on the GOMR OCS. Studies conducted in 1977 (Coastal Environments, Inc. 1977) and 1989 (Garrison et al. 1989) were directed specifically at collecting information on historic shipwreck resources in the region. The MMS has used the results of the 1977 Coastal Environments, Inc. study and, more specifically, the 1989 Garrison et al. 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, approximately 2,800 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 have 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. The present study was initiated in the summer of 2000 specifically to reevaluate and refine the model of shipwreck occurrences and distributions presently in use.

The objectives of this study 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 these objectives, this study was divided into four principal tasks. Task 1 involved archival data collection to update, expand and evaluate the shipwreck database developed in the 1989 study and the development of a new database. Task 2 involved the correlation of shipwreck data with other sorts of submerged object data from the GOMR, such as reported snag and hang data and objects and vessels identified during offshore remote-sensing surveys. This task included diving on selected offshore targets to determine their identity. Task 3 involved conducting magnetometer surveys at two selected shipwreck locations using differing equipment and survey strategies to help refine the offshore survey approaches currently used. Task 4 involved the synthesis of collected data, the preparation of a revised predictive model for shipwrecks in the GOMR relying on the findings of Tasks 1 and 2, making recommendations on survey instrumentation and strategies that would be the most effective in locating these shipwrecks relying on the findings of Task 3, and preparing a technical report of findings.

All of the information on shipwrecks collected during Task 1 was incorporated into a relational database (Microsoft Access) and incorporated into a GIS application (ArcView) that can serve as a tool for MMS personnel for the continued assessment and monitoring of shipwreck data in the GOMR. The present study considered only those shipwrecks lying in OCS waters. The very large number of shipwrecks known to lie in state waters in the Gulf of Mexico (Garrison et al. 1989) is not included in the shipwreck database developed. Data on a variety of variables relating to the characteristics of vessels were collected for the 2,106 entries ultimately included in the database. These variables included categories such as vessel type, mode of propulsion, dimensions, date of build, builder, date of loss, cause of loss, etc. Information on non-shipwreck “objects,” hang sites, etc., identified in the GOMR was also included in the database.

The data on shipwrecks, objects and hangs come from a variety of sources. These include wreck information from the two earlier MMS studies and data from offshore lease block surveys. Several computerized databases containing information on vessel losses and other objects in the GOMR were utilized. These included records from the U.S. Coast Guard, NOAA, the National Imagery and Mapping Agency, the U.S Fish and Wildlife Service, and similar agencies from each of the Gulf states. In addition, the records at all of the state archaeologist's offices of the Gulf states were examined to collect information on offshore remote-sensing surveys or shipwreck work that has been done. Also examined were pertinent publications dealing with shipwrecks, including historical and archaeological works as well as sport divers publications. Net hang data from the government's fisherman compensation fund as well as hang and obstruction data from Texas A&M University and the Louisiana Department of Natural Resources were also collected.

One aspect of this study was to "test" the 1989 model in terms of its reliability in the identification of high-probability offshore lease blocks. This was done, principally, through using the results of remote-sensing surveys provided by MMS. These surveys have identified a large number of sunken vessels, possible vessels, and unidentified objects in the GOMR. The locations of the approximately 90 items believed to represent shipwreck remains were compared against the high-probability areas identified in the 1989 study. It was found that many of the wrecks identified in offshore surveys are not located in designated high-probability blocks. Statistical analyses revealed that there is no significant difference in finding a shipwreck in a designated high-probability lease block and finding one in a lease block not so designated. These findings bring into question the reliability of the 1989 data in the identification of high-probability lease blocks and its overall utility as a "predictive model." It was found that the principal reason for lack of predictability in the 1989 model rests in an overall lack of precision in reported shipwreck positions. An effort was made to quantify the precision existing in reported positions of loss by assigning measures of reliability to the positions obtained for each entry in the database. These "Reliability Factors" (numbered from 1-high reliability, to 4-low reliability) were one of the elements used in the delineation of high-probability areas in the GOMR. Essentially, vessels assigned a very low reliability of position of loss have little utility in modeling spatial distributions, except in the very broadest sense, or in developing reliable predictive statements about these distributions. Thus, these vessels have not been used in defining tightly drawn high-probability areas.

The sample of reported shipwrecks in the database was examined relative to a variety of factors, such as year of loss, season of loss, types of vessels, causes of loss, etc., in an effort to characterize the population of wrecks that exists in the GOMR. Findings indicate that the frequency of losses increases over time, mirroring the findings of the Garrison et al. (1989) study. In fact, approximately 41 percent of all shipwreck losses in the database with known dates of loss have occurred in the past 25 years and slightly over 77 percent have occurred in the past 50 years. This pattern is in large part a reflection of the great increase in the number of vessels operating in the Gulf of Mexico in the past 50 years, particularly fishing (shrimping) vessels, recreational craft, and vessels associated with the offshore oil and gas industry. Additionally, this pattern is a reflection of the underreporting of losses during earlier historic periods.

Interestingly, other studies, including the Coastal Environments, Inc. (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 an historic shipwreck might be. 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 at time of loss was examined and the results indicate no strong correlation between the age of a vessel and the historical period when it was lost. However, there is a correlation between the age of vessel at loss and its type. Large, twentieth-century merchant ships lost in the GOMR are the oldest vessels as a class, with an average 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.

Additionally, assessments of the known age of vessels at the time of loss reveals some important information concerning the use of year of loss as a measure in assessing historical significance. Generally, for cultural properties to be considered significant and eligible for inclusion in the National Register of Historic Places they have to be at least 50 years old. Because of the 1989 study, vessels lost in the previous 50 years were excluded from consideration in some delineations of high-probability areas. Shipwreck data in this study indicates that approximately 49 percent of all vessels reported lost in the past 50 years for which the date of build is known are actually greater than 50 years old. If the year of loss were the only criterion used for establishing potential historical significance, these vessels would be eliminated from consideration and their locations of loss would not be used in the delineation of high-probability areas as, in fact, has been done in the 1989 model. 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. It is obvious that date of build, if known, must be used rather than the sinking date in making assessments of historical significance and, by extension, delineating high-probability areas.

Information on month of loss was used to examine seasonal patterns in sinkings. It was anticipated that some increases would occur during the hurricane season and during the winter months when weather conditions in the Gulf of Mexico are at their worst. However, the available data show no significant differences in the frequencies of losses by month of the year when the entire shipwreck database is considered. It is apparent that, overall, seasonal weather conditions have not been primary determinants of vessel losses. These findings, coupled with the unreliability of so many positions of loss, mean that efforts to correlate spatial distributions of shipwrecks with specific hurricane tracks are likely to be unproductive. This is particularly true in the open waters of the Gulf, as is the area considered here, where many reported positions of loss are very unreliable, particularly for earlier time periods. These types of correlations can best be undertaken with known vessels at known positions and, by and large, these wrecks will be found onshore or in inshore state waters, outside of the present study area.

Information on month of loss does show that certain types of vessels exhibit distinct seasonal patterns of loss. Specifically, the losses of craft identified broadly as "shrimping vessels" show peaks during June and July and during November. These months correspond with the two principal peaks of the shrimping seasons. These data suggest that the number of vessels operating in the Gulf at any one time is a greater predictor of frequency of loss than are seasonal weather phenomena. Similar findings have been made for shipwrecks in the area of the Dry Tortugas, where it was argued that for some classes of vessels seasonal shipping activities had a greater influence on loss frequencies than did weather (Murphy and Jonsson 1993).

Information collected on vessel types lost in the GOMR shows that fishing vessels of various sorts 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 shrimp trawlers, 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.

The overall patterns of wreck distributions seen in the 2001 database are in many ways similar to those shown in the 1989 study, even though most of the discussions in that earlier study did consider nearshore and onshore wrecks not utilized in this study. The concentration of reported losses in waters closer to shore shown by most researchers is reflected in the 2001 GOMR shipwreck data. However, because losses occurring inshore of OCS 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. Just over 82 percent of all reported losses in the present database fall inside of the 60-m contour line.

The overall distribution of wrecks in the study area reflects broad settlement and economic trends. These show very few losses in the study area prior to 1750, and significant increases in numbers do not appear until after 1850. Few early vessel losses are seen in the western Gulf, and the early losses after 1700 are generally indicative of settlement band trading activities along the central and eastern Gulf relating to the expansion of French settlement and control along the northern Gulf coast. The patterns of wreck distributions over time clearly show that, at a broad level, the locations of loss correlate with the development of historic shipping routes.

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 fishing (principally shrimping) industry as well as recreational boating and the offshore oil and gas industry. Beginning in the nineteenth century, concentrations of vessels occur off of major ports of the central and western Gulf, but these are not so apparent along the Florida coast.

The potentials for shipwreck preservation in the GOMR are 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 low over much of the study area. 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 are, commonly, only partially buried by sediment. These conditions appear to exist throughout the GOMR where water depths are over 10 m or so. However, many of the vessels seen in these sidescan records appear to be relatively modern and might represent steel-hulled ships whose preservation will differ from wooden-hulled examples. Few of these vessels, however, 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.

In Task 2, shipwreck data were correlated with other sorts of submerged object data from the GOMR, such as reported snag and hang locations and objects and vessels identified during offshore remote-sensing surveys. This task also included remote-sensing survey and diving on selected offshore targets to determine their identity. The initial remote-sensing survey of each of the 20 target areas ultimately selected revealed that only ten contained bottom features indicative of submerged cultural resources. Target inspection by divers indicated that of the ten potential targets, only one represented a shipwreck. Designated Target 15, this wreck was a modern, steel-hulled shrimp trawler unassociated with any reported hangs, and historically nonsignificant based on National Register of Historic Places (NRHP) eligibility criteria. Of the remaining nine targets, two represented modern debris such as pipe or platform debris associated with the oil industry, and seven represented natural bottom features or had negative findings.

The 20 target areas investigated actually contained 51 recorded target locations (i.e., hangs, unknown vessel, obstruction, etc.), 29 of which were reported hang locations. Of the targets investigated, only three could have been or caused a hang site: a shipwreck and two areas of modern debris associated with the oil industry. These results raise numerous questions, the least of which is coordinate accuracy of hangs, especially in light of the fact that of the 29 hang locations only 10 percent was found to actually contain objects that could result in a hang.

With regard to hangs representing shipwreck sites, only one target (Target 15) was identified as a wreck, albeit a modern trawler. However, while Target 15 was covered by shrimp net, it was never recorded as a hang location, making correlation of our findings further problematic. Our findings aside, we know that net hangs can and do represent historic shipwrecks. Two examples include the 303 Hang site, off the Texas coast, and the *El Nuevo Constante* site, off the Louisiana coast, both of which are discussed in the technical narrative.

To accomplish Task 3, a survey was to be conducted with both the “industry-standard” proton precession magnetometer and the new cesium 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 877 proton precession magnetometer. The Geometrics 877 is the replacement for the proton precession industry standards currently employed in the Gulf, i.e., the Geometrics 801 and the Geometrics 866 proton precession 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 a Geometrics 866 (G-866), a Geometrics 877 (G-877), a Geometrics 881 (G-881), and a Marine Magnetics SeaSPY (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 50m. Mirroring the Notice to Lessees (NTL) 98-06, the new NTL 2002-01 (MMS 1998; 2002) 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 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 oftentimes 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 which 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 of varying intervals and speed 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.

Task 4 involved the synthesis of collected data, the preparation of a revised predictive model for shipwreck distribution in the GOMR, and making recommendations on survey instrumentation and strategies that would be most effective in locating these shipwrecks. A general assessment of the probability of occurrence of shipwrecks in the study area was achieved by comparing reported shipwreck densities with preservation potentials across the GOMR, generally following the approach used by Garrison et al. (1989). This analysis demonstrated that shipwreck potentials were moderate to high along the western and central Gulf in nearshore lease areas, decreasing to a low and 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 is particularly true for some of the lease areas off the central and western Louisiana coast and just to the east of the mouth of the Mississippi River.

An effort was made to objectively identify high-probability zones and areas in the GOMR using the analytical tools in the GIS program ArcView. ArcView was used to identify areas of varying size that showed clustering of reported losses of various densities. Ultimately, it was determined 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. To strengthen the reliability of the true shipwreck potential of these selected areas, all vessels with a low (i.e., Reliability Factor 4) or unknown reliability in their reported position of loss were eliminated in the analysis.

These high-probability 0.5-degree units exist as overlapping and adjacent entities extending along the central and western Gulf coast. None occur in the eastern Gulf off the coast of Florida. Although Garrison et al. (1989) used losses from inshore state waters, the distribution of the 0.5-degree high-probability units in that study resembled, to some extent, the ones obtained here.

These 0.5-degree units encompass only a segment of the reported shipwreck population in the GOMR, and we have identified high-probability areas outside of these high-density zones to account for other reported wrecks. The identification of these other areas relied heavily on the Reliability Factors discussed above. First, all lease blocks containing reported or discovered shipwrecks assigned a Reliability Factor of 1 are classified as high-probability lease blocks. Secondly, all lease blocks containing the positions of reported shipwrecks assigned a Reliability Factor 2 are considered as high-probability lease blocks. Further, following the lead of Garrison et al. (1989), because of the potential for error assigned to Reliability Factor 2 the eight contiguous lease blocks around the one containing the vessel position are included as high-probability blocks. No effort is 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 management. However, age is a “moving target” and it seems more appropriate for the MMS to use ArcView to identify those vessels (and associated individual lease blocks or 9-lease block clusters) that 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 and in the identification of high-probability lease blocks.

Vessels assigned Reliability Factor 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.

The distributions of all of these various classes of high-probability areas are shown in Figure 2. High-probability zones are concentrated off the central and western Gulf coasts, principally within the 60-m contour line. The most significant concentration of high-probability areas beyond the 60-m contour is in the area off the mouth of the Mississippi River.

These high-probability areas 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 reported 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.

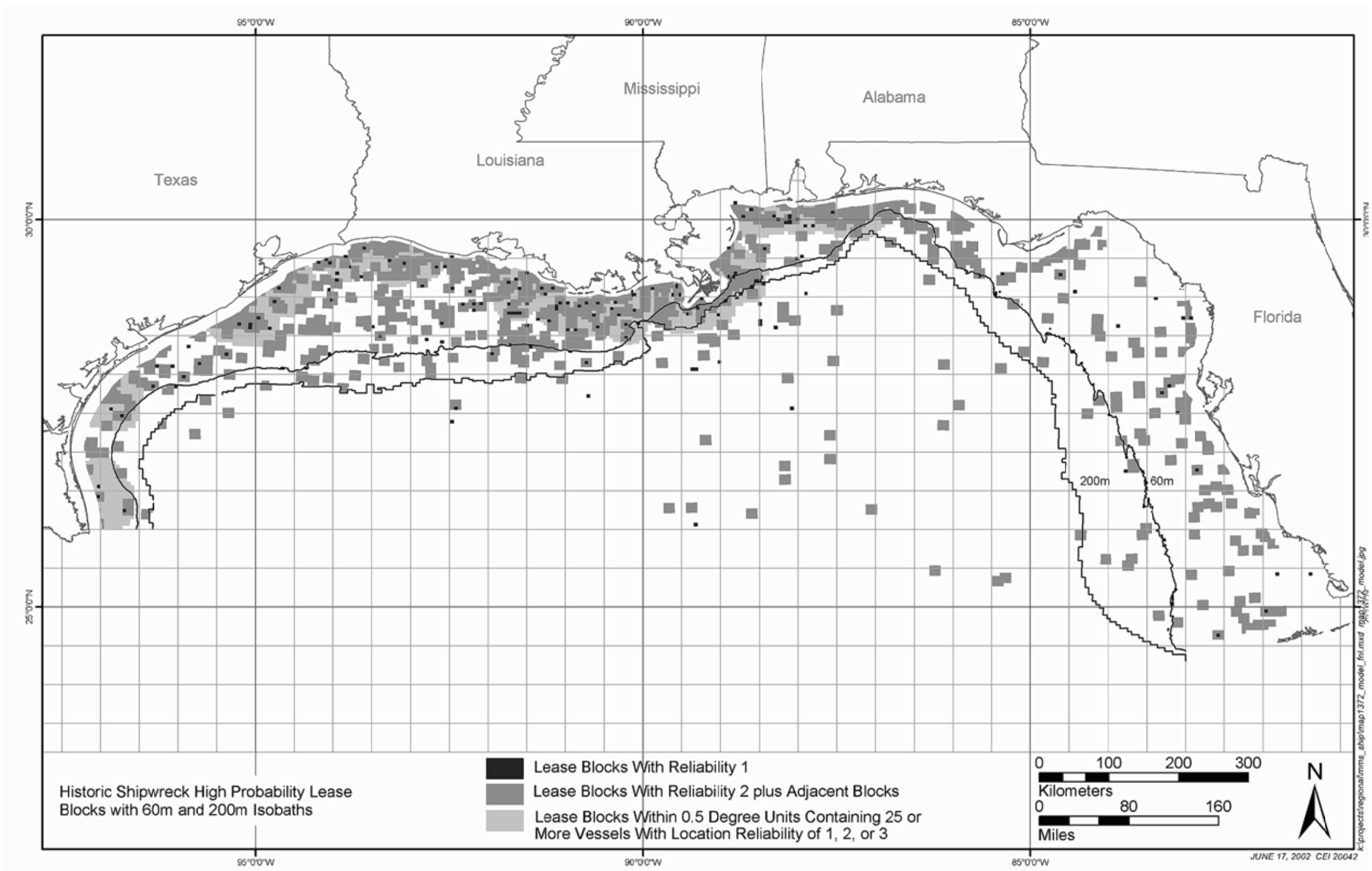


**Figure 2. High-probability lease blocks identified in the study area.**

Based on the findings of Task 3, recommendations on survey instrumentation and strategies that would be most effective in locating shipwrecks within the GOMR include the following:

- The investigation revealed that all magnetometers performed well in the field trials, including the G-866, the "industry-standard" that we feel at this time has become antiquated although is still functional in most respects.

- 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-866 system, 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 are 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 current navigation programs (i.e., 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.

- Relative to the increased depth of 200 meters or less for survey of high-probability OCS lease blocks, early magnetometer sensor types such as the G-866 have significant limitations in that they will not physically sink below 225 feet below the water surface regardless of how much tow cable is deployed. This does not allow the sensor to be within the MMS specification of being within 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 seven 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. Because of the release mechanism’s failure more in-field research is needed before any recommendations on its use can be made.

- Because contouring presents critical analytic data, it is recommended that even without the use of a base station, offshore magnetometer 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.