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A Diachronic Study of Some Historical and Natural Factors Linked to Shipwreck Patterns in the Northern Gulf of Mexico

Introduction

The observed distribution or pattern for historic shipwrecks is a product of a complex of historical and natural factors. These factors include imperialism, commerce, warfare and technological change, as well as natural phenomena such as equinoctial storms, currents, winds, shoals and reefs. It is the purpose of this study to evaluate some of these factors over the chronological period ranging from the 16th to 20th centuries relative to their causal linkage to shipwreck patterns. It is expected that these factors will differentially influence the location and density of shipwrecks in the northern Gulf of Mexico.

Beginning with the Coastal Environments, Inc. (CEI) (1977) study, we examined that compendium of shipwrecks. This led to the same conclusion reached by those authors—data for historic shipwrecks developed principally from secondary sources has several defects. The principal flaw is validity. The most valid reports on shipwrecks are primary sources—news accounts, official reports, logs or other direct observations of the specific shipwreck. The problem with primary sources is their lack of consolidation. To adequately research all primary source data for historic shipwrecks was beyond the resources of this study, as it was for the CEI study. We attempted to examine a collection of primary sources or facsimiles of these materials in a limited number of archives and libraries. At the outset, we further restricted the study to only those archives in the United States, with the exception of the National Archives of Mexico (AGN).

The location of earlier studies of the materials in these foreign archives was successfully sought out in several instances. For Spanish shipwrecks, excellent sources were found in studies by researchers of the National Library of France (Bibliotheque Nationale, Paris) (Chaunu and Chaunu 1955), the P.K. Younge Library of Florida History, Gainesville, Florida, and newly-printed catalogs of the holdings of AGN. For French shipwrecks of the colonial period, facsimile microfilm of the correspondence was found in Archives Nationale, Colonies, Series 13, located at the Howard-Tilton Library, Tulane University, and Paris. British losses were sought in similar facsimile data of the London Board of Trade, Lloyds, Admiralty and Foreign Office reports located principally at the research library of the Mariners Museum, Newport News, Virginia. American shipwreck data appeared in a variety of sources found at the US National Archives and its branches; further copies were located at Mariner.

Also used was a source unavailable to earlier researchers—computer-based data files. Such files have contributed to the creation of the *Hangs and Obstructions File* by the Hydrographic Office (HO), the *Automated Wreck Obstruction Information Service* file (AWOIS) of the National Ocean Survey, the *Historic Shipwreck File of the Texas Antiquities Committee* (TAC), and the *Florida Shipwreck File of the Division of Archives and History, State of Florida*.

The data in the computer files were merged with that of the primary and secondary materials collected at the various archives, and a master file of historic shipwrecks of the northern Gulf of Mexico was created. This file has over 4,000 entries (Figure 1).

Specific Factors and Shipwreck Patterns

This study examines five principal factors affecting shipwreck locations and subsequent patterning in their distribution. These are:

1. Historic Shipping Routes
2. Port Location
3. Shoal, Reef, Sand Bar and Barrier Island Locations
4. Ocean Currents and Winds
5. Historic Hurricane Paths

These factors do not account for all the shipwreck locations in the northern Gulf, but clearly they are important to understanding the distribution of shipwrecks and to developing explanatory models for shipwreck distribution.

Sailing Routes: Open Sea, Channels, and Coastal

In a perfect scheme, all losses would be along sailing routes and at nodes of a network. The actual correlation of shipwreck

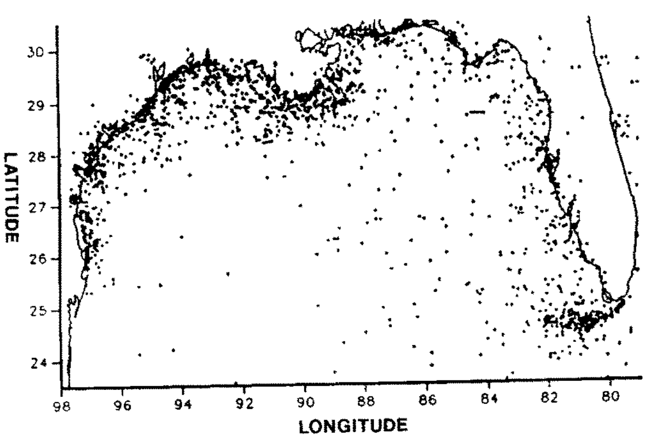

FIGURE 1. All shipwreck positions.

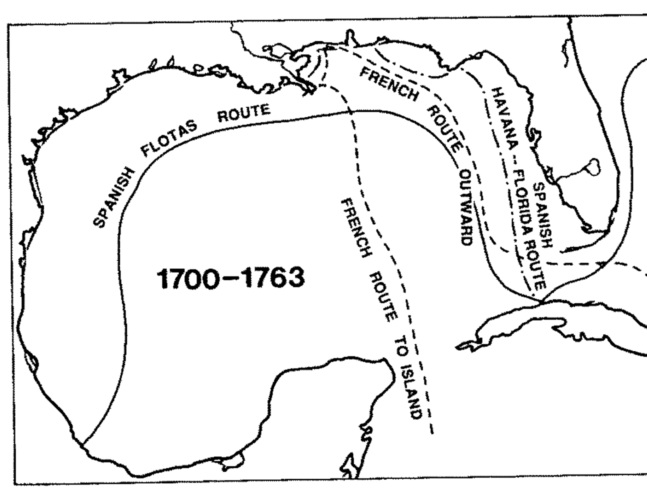

FIGURE 2. Shipping routes 1700 - 1763.

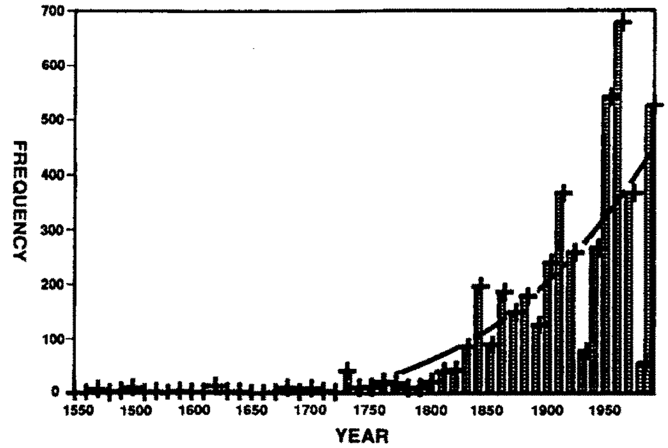

FIGURE 3. Shipwreck frequency by decade.

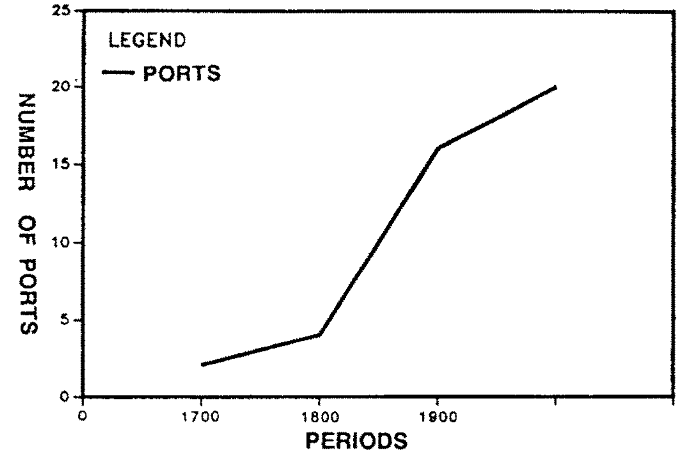

FIGURE 4. Port development - northern Gulf.

sites to sailing routes is difficult. The distribution of shipwrecks and the location of sailing routes for a given period are linked variables in that they can predict the behavior of either to a finite and measurable degree. What this level of predictability is remains to be assessed. Sailing routes were of particular importance, both in a navigational and a strategic sense. During the Spanish era of exploration, these routes were defined by trial and error. This information was gained through the loss of ships. Even so gained, the early navigator of the Spanish Gulf was restricted to a few principal routes determined by the Westerlies outbound to the New World and the tack against them in return, using the Gulf Loop Current (Rezak, Bright, and McGrail 1985:24-26) to reach the Gulf Stream (Hoffman 1980:5-7). In the Gulf, Spanish period and later ships braved the Yucatan Channel and thence the Straits of Florida, i.e., a great arc from New Spain, to near the mouth of the Mississippi River and southeast to the Straits. It is this route that has greatest significance for all periods during the age of sail in the Gulf (Figure 2).

Inspection of Figure 1 reveals a moderate-to-low frequency of shipwrecks in the deep open Gulf for all periods of interest. Why? The open sea is the ship's element. There it can maneuver with the winds, turn to the sea and, in short, be less endangered other than in exceptional cases such as rogue waves or freak storms such as the Solano Hurricane of 1780 (Millas 1968).

In the case of channels and coastal waters, the hazards are self-evident. The ship must again approach land. The shipwreck patterns reflect this for all periods. In the Spanish period, however, there was no need to come to land in the northern Gulf, as there were no ports; hence, few losses are seen. Channels are the most dangerous even today. Improvements in navigation, ship design and sea-keeping still do not prevent losses in these areas. Likewise, high-loss probabilities exist for coastal routes where the mariner may be gulled by the apparent safety of the shore only to fall prey to shoals, shifting shallows and hazards such as debris from streams entering the Gulf at many points.

Ports

Ships must come to land at ports. The land is the first enemy of a ship built to exist in equilibrium with a fluid environment. Ships must enter port for obvious reasons—trade, supplies, refit, etc. They must do so carefully, as the distribution of wreck sites at these points indicates.

Losses were high for the 16th/17th centuries, and for good reason, given the lack of navigational aids, vulnerability to storms, known piracy and warfare. Losses increased during the 18th century for most of the same reasons, as well as the increase in the number of ports. In the 19th and 20th centuries, even with improvements in navigational aids and ship design, losses at ports continue to be higher than in other areas except the Straits of Florida. A peak value occurs for shipwrecks in ports in the 19th century. The increase in number of ships lost increases with the same basic curve, although not at the same rate, as that seen for the increase in number of ports (c.f. Figures 3 and 4).

Shoals, Reefs, Sand Bars, and Barrier Islands

There are several obvious natural factors which may be used to predict the locations of historic shipwrecks. These include the locations of shoals, reefs, sand bars and barrier islands. However, the locations of shipping obstacles like sand bars and barrier islands can change dramatically over time.

Bars such as longshore spits off headlands are factors in explaining the occurrence of wrecks in shallow waters. Ships, particularly those of larger tonnage, encountering these hazards are stranded. The nearshore bar, entrance bar and the shoal are generally one and the same. Examples of treacherous shoal areas are those off Cape San Blas (Florida) and the Mississippi Delta. These shoal areas have claimed a larger proportion of shipwrecks over that seen for the Gulf as a whole.

The distribution of known shipwrecks points to another key factor in Gulf shipwrecks—the 192-mile reef and shoal complex of the Florida Keys, Marquesas, and the Dry Tortugas. Throughout all the time periods of the Gulf navigation, these hazards destroyed more ships than any other natural obstruction.

Other obstructions came into play as vessels encroached into shoal waters in their efforts to raise the ports along the Gulf shore. Still, the combination of factors of wind, current, reef and storm made the Straits of Florida the most hazardous area for ships attempting this exit from the Gulf. Charlevoix (1763) recognized this, as did those who preceded and followed him. When using the great Loop Current flowing eastward (Figure 5), any deviation of a half of a degree north or

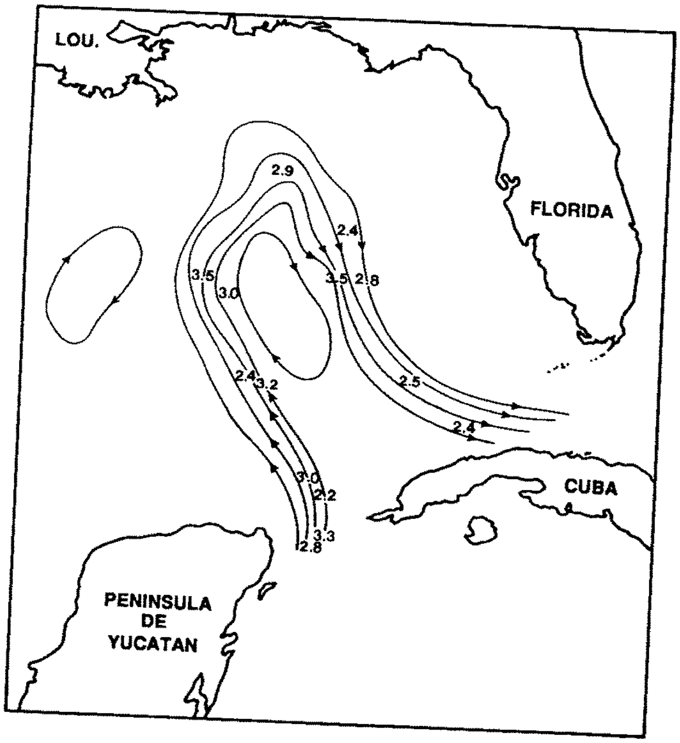

FIGURE 5. The loop current.

south placed a ship at the mercy of counter-currents and the west-blowing Trades. The powerful Gulf stream generally availed them nothing if a powerful storm passed over the Straits at the same time. To the mariner of the 16th century, all the Straits lacked were dragons. He and others who followed later may not have feared the unknown, but they learned all too well the real perils of this passage.

Ocean Currents and Winds

The influence of winds and currents during the ages of sail, the 16th to 19th centuries, was significant. The wind fields created by the patterns of the Trades made for easy westward journeys, but necessitated tacking or sailing off the wind in eastward crossings of the Gulf. The pattern for the winds varies from easterly in winter to south-southeast in summer. To take advantage of the summer wind regime meant the sailing vessels from New Spain, Tierra Firme or the Caribbean sailed northeasterly courses for much of their journeys before turning southeastward to the Florida Straits.

In particular, vessels from Veracruz followed routes which allowed them to take advantage of easterly flowing currents, most notably the Loop Current. Precursor to the Gulf Stream, this deepwater movement aided mariners in their battles to sail into the winds that impeded them from direct crossings of the Gulf latitudes. Only with the coming of steam-powered vessels and colonization of the northern shore was this pattern significantly modified.

During the 16th to 18th centuries, traffic from the Caribbean crossed the Gulf as shown in route maps (Figure 2). As ports developed on the north shore, commerce grew up between the Gulf and Atlantic coasts (Figures 6 and 7). More vessels beat against the Gulf Stream in rounding Florida. Always dangerous, the reef passage on westward journeys required vessels to sail north of the Gulf Stream and take advantage of the counter-current in this area. The margin for error was reduced and many vessels learned this only after wrecking on the reefs and shoals of the Straits area. This continued to be the case into the early 20th century, taking its toll of the coastal schooners and other sailing vessels involved in this trade.

This discussion reiterates earlier observations of the overall importance of the Gulf wind and current regimes in the determination of shipwreck locations. Still, the patterns observed for Gulf shipwrecks are first the result of economic decisions involving maritime commerce. The mariners took what they could from the winds and currents that prevail in the Gulf to chart the sailing routes we observe in the historic records. The winds and currents are thus boundary conditions within which vessels operated to accomplish their primary tasks. This is clearly seen in the change from the shipwreck pattern of earlier periods when compared to later periods. The Spanish lost ships principally at the Straits, not because of a poor reading of currents or winds. This ignores the skill of those navigators. Instead, many vessels fell prey to anomalies of weather, e.g., northers or hurricanes. Less frequently, they made costly errors in navigation that resulted in their wrecking. As a determining cause in shipwreck patterns, winds and currents must be viewed as important, but secondary, factors.

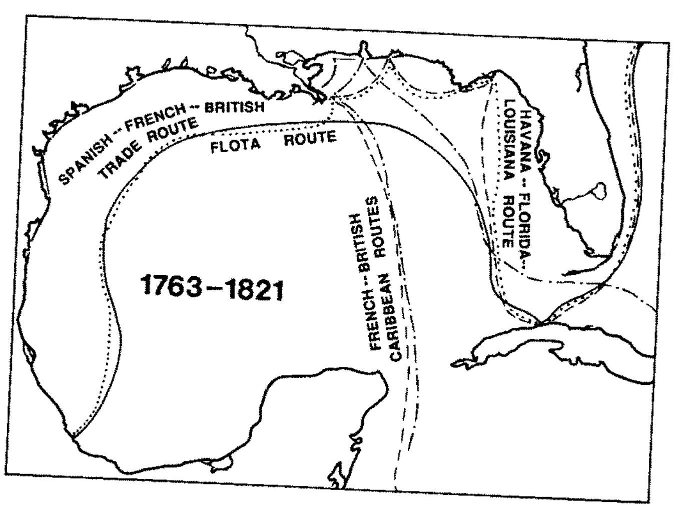

FIGURE 6. Shipping routes 1763 - 1821.

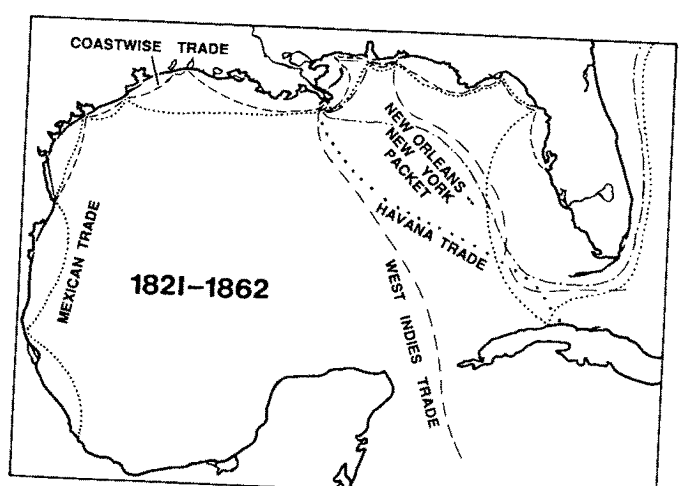

FIGURE 7. Shipping routes 1821 - 1862.

Historic Hurricane Paths

The location of sailing routes and ports may determine the principal locations of shipwrecks, but these historical factors do not, in themselves, cause shipwrecks. The interaction of these factors with the third category of the natural factors, hurricanes, is responsible for numerous maritime losses. These storms of the Gulf of Mexico's summer and fall months have historically been a menace to mariners of all periods. This is true even today, when satellites track and computers predict locations of these great storms. Vessels that fall afoul of the course of a hurricane do so at great risk.

The early navigators learned the hard way. Columbus experienced a hurricane as early as his second voyage on June 16, 1494 (Henry et al. 1975:11). The Spanish quickly learned to schedule fleet sailings to accommodate the peak season for these storms. Understanding the seasonal nature of the hurricane did not guarantee that such recognition would translate into adherence to rational sailing practices. Captains of flotas challenged the odds and ofttimes lost. Early examples are the 17th and 18th century fleets lost in the Florida Keys and Bahama Channel.

The French and British were aware of the force of hurricanes, with the reports of the storms and their destruction along the northern Gulf beginning almost as soon as observers were in residence (Gauld 1796). As shown by the Chaunus (1955), the percentage of vessels involved in the "carrera" system that suffered loss due to storms was 16.7%. This landmark study evaluated over 11,000 sailings (over a 2% sample). This percentage for the first one and one-half centuries in the Gulf's maritime history should be reliable. The intercorrelation of historic hurricane data and suites of well-documented shipwreck data (MVUS; Florida) show percentages of storm-related loss, primarily from hurricanes, to be 16% and 9.1%, respectively.

Chronological Trends: 16th-20th Centuries Summary

To summarize chronological trends in the shipwreck patterns related to general historic factors such as flota cycles, colonization, commerce and shipping routes, the data is organized in 50-year periods from 1500-1899 and 20-year increments thereafter.

TABLE 1

CHRONOLOGICAL TRENDS IN GULF SHIPWRECK DISTRIBUTIONS BY 50-YEAR PERIODS

1500-1549	Losses reflect period of Spanish exploration of the northern Gulf of Mexico.
1550-1599	Distribution begins to show pattern of losses determined by flota routes. Losses off Texas are flota vessels wrecked by storm while on this route. Losses off Florida are likewise. The Straits area beginning to take its toll.
1600-1649	The principal losses are still Spanish flota vessels. The 1622 hurricane losses in the Keys are a significant portion of the shipwreck pattern for this period.
1650-1699	The pattern reflects the first French losses in the Gulf at Matagorda Bay in 1685. The remainder are Spanish losses.
1700-1749	The distribution shows the first major change in the northern Gulf's shipwreck pattern. This is due to the French colonization of Louisiana and the increase in a similar interest by the Spanish in Pensacola to balance the French presence.
1750-1799	The pattern of shipwrecks in the northeastern Gulf is the result of two basic processes: colonization and commerce. The French and Spanish have reached the height of their maritime activities in the northern Gulf of Mexico. The flotas end in the last quarter of this century.
1800-1849	The shipwreck distribution shows the extension of the colonization process to the northwestern Gulf of Mexico area. Texas and Louisiana, west of the Delta, have port development at a significant level after the 1830's, with Galveston, Brownsville and Freeport rising in importance.
1850-1899	The continued shift westward in the shipwreck distribution is offset by the principal ports of New Orleans and Mobile in the north-central Gulf area. The observed pattern is shown by the extent of the Texas data for the period. Losses in the Straits continue, as it is the major egress channel for inter-Gulf commerce. Eastern Gulf losses in the Civil War are under-represented in the Panhandle region, e.g., Apalachicola and Cedar Key.
1900-1919	The pattern is fully modern with intra- and inter-Gulf commerce developed between all major ports. The eastern area has Tampa growing as a port, and major fisheries off the Panhandle and Florida Keys. The distribution of open-Gulf shipwrecks reflects the major commercial sea route to the Mississippi River and New Orleans.
1920-1939	The pattern for the modern era is the result of 20th century Gulf commerce in commodity goods, e.g., oil and agricultural exports.
1940-1959	Two principal factors increase the number of shipwrecks off southwest Florida: fisheries and Tampa trade. For the northwestern Gulf, it is singularly petroleum production offshore. Intra-Gulf routes shift westward toward Galveston and Houston.
1960-1979	The major intra-Gulf, inter-Gulf route axes are still east-west, reflecting bulk cargo movement from central to northwest Gulf ports. Losses increase in the northwestern area and are related to oil exploration and production on the outer shelf.

Spatial Analysis: Arithmetic Mean Centers (AMC)

A clear trend in the scatter plots of the shipwreck location plots is the aggregation of the distributions over the northern Gulf with time. In order to examine this distribution, the arithmetic mean center (AMC) has been calculated for the shipwrecks within quadrats of 0.5 and 1 degree. No attempt has been made to look at the variation in the aggregation of AMCs over time. This has been done with other techniques such as factor analysis. The objective is to examine the presence or absence of aggregation at the most general level. This technique merely takes the average of the cell (quadrat) frequency and plots this average as a coordinate value. The results are summarized in the following charts (Figures 8-11).

TABLE 2

AMC ANALYSIS: ONE DEGREE QUADRATS

AMC Analysis: One degree quadrats

a. K = 1 The plot simply shows quadrats with reported shipwrecks. Little in the way of locational or spatial trends can be seen. (Not shown.)

b. K ≥ 10 Here the criterium for assigning an AMC is that the quadrat must have ≥ 10 shipwrecks. What is interesting is a two-level spatial distribution of AMC's. The inner row of points correspond to nearshore shipwrecks, while the second, more seaward distribution, indicates deeper water shipwrecks. This distribution collapses with the increase of (n) as seen in the next step (Figure 8).

c. K ≥ 50 The distribution of AMC's follows that of the nearshore shipwrecks with little representation of the less-numerous offshore losses (Figure 9).

TABLE 3

AMC ANALYSIS: 0.5 DEGREE QUADRATS

K ≥ 10 The distribution differs significantly from the 1-degree quadrat results. This reflects the effect of quadrat size on the analysis; larger size reflects broad-scale patterning, while small quadrats are sensitive to finer-scale patterning (c.f. Hodder and Okell 1978). Note the way the pattern more nearly approximates 1-degree quadrat results of n ≥ 50. The trend is toward the nearshore at Texas, but more seaward in western Louisiana and western Florida (Figure 10).

K ≥ 50 Here the distribution collapses onto all the major port locations of the northern Gulf, with the exception of Tampa. This may be an artifact of an under-representation of data for the western Florida ports. Given that the Texas and Florida data bases are the most complete of those of the Gulf area, this may not be the case (Figure 11).

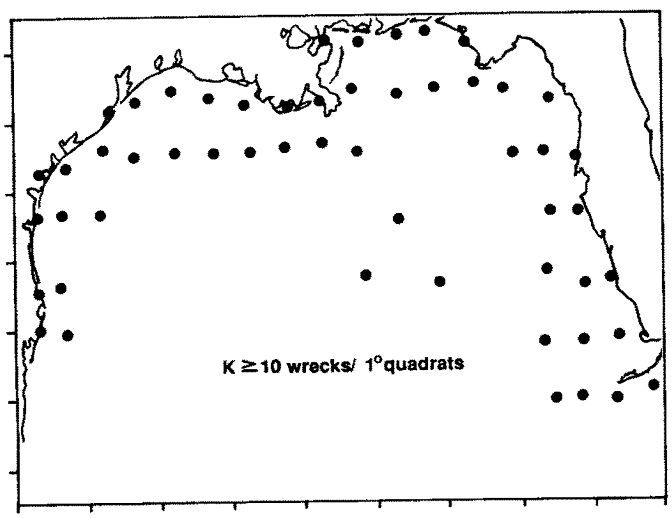

FIGURE 8.

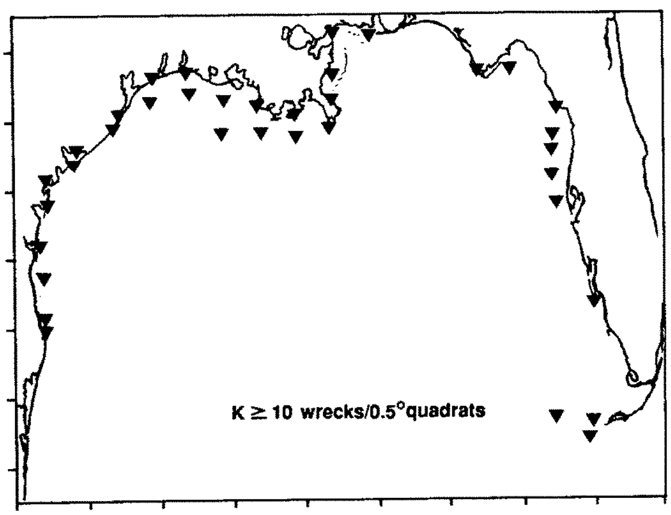

FIGURE 10.

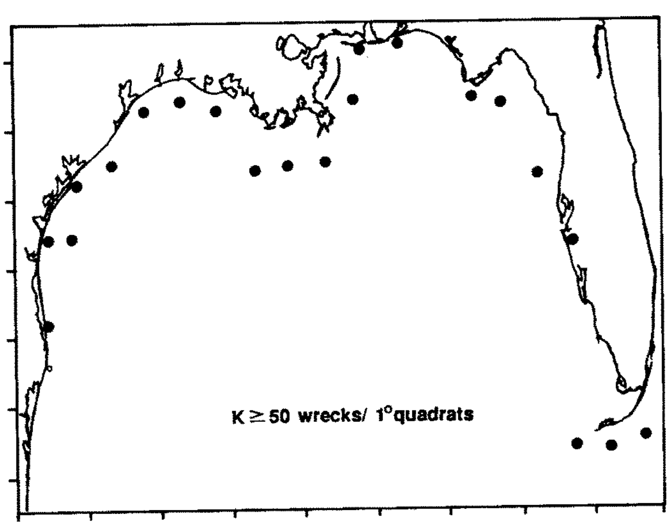

FIGURE 9.

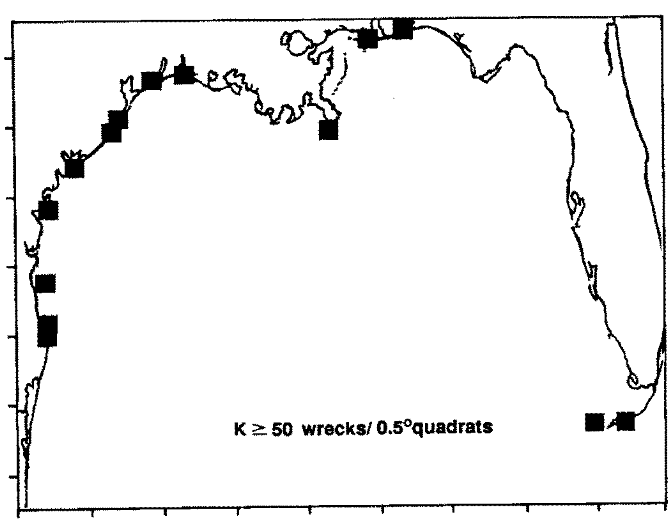

FIGURE 11.

	Wrecks 20th C.	Wrecks 19th C.	Wrecks 18th C.	Wrecks 17-18th C.	Age Oldest Port	Ports,Major	Major Storms
1	13	38	0	0	149	1	13
2	10	57	0	4	88	1	8
3	11	42	0	0	142	1	15
4	47	69	0	2	144	1	10
5	61	64	0	0	153	1	9
6	102	117	0	0	167	1	12
7	30	29	0	0	148	1	9
8	0	0	0	0	0	0	9
9	0	0	0	0	0	0	12
10	24	0	0	0	138	1	7
11	126	0	0	0	270	1	26
12	21	12	0	0	270	1	26
13	57	42	0	0	118	3	9
14	39	23	12	0	288	1	21
15	30	0	0	0	168	1	3
16	0	0	0	0	0	0	12
17	15	11	0	0	34	1	9
18	0	0	0	0	0	0	0
19	0	0	0	0	0	0	14
20	0	0	0	0	0	0	13
21	53	0	0	0	113	1	21
22	0	0	0	0	0	0	10
23	10	0	0	0	148	2	7
24	11	0	0	0	0	0	6
25	22	14	43	15	166	1	12
26	156	57	87	29	0	0	15

a.

	Factor 1	Factor 2	Factor 3
Wrecks 20th...	.716	.511	.414
Wrecks 19th...	.387	.777	-.084
Wrecks 18th...	.955	-.001	.089
Wrecks 17-...	.956	.023	.016
Age Oldest P...	-.07	.617	.71
Ports,Major	-.162	.797	.206
Major Storms	.188	-.001	.938

b.

FIGURE 12. Factor analysis, chronological factors. a. Chronological variables. b. Chronological factors, oblique solution reference structure, orthotran/varimax.

Factor Analysis: Chronological and Areal Variables

Further analyses such as multivariate-factor studies have partitioned associations between shipwrecks and chronological and areal variables. The results are summarized as following analyses.

Analysis 1: Chronological Factors

The matrix to be factored is composed of seven variables and 26 observations for each variable (Figure 12a). A principal components factor extraction method was utilized. The factors were evaluated for independence and variance accountability using axis rotation techniques. The program used was STATVIEW 512+ (Abacus Concepts 1986).

The variables include five which measure shipwreck frequency in the six periods. Note that data for the 16th century was merged with that of the 17th century due to the low number of shipwrecks known for these periods. Further, it is assumed that the processes underlying the patterns were basically the same for both periods. The data for the 19th century has been partitioned for the opposite reason. Processes responsible for the observed patterns have changed and, to more adequately see this, the data has been scaled accordingly. The results of the factor analysis appear in Figure 12b. Our interpretation of these results is:

1. Three factors were defined.
2. These factors are largely independent of one another; the orthogonal solution is fundamentally that of the oblique solution (1.454 vs. 1.468).
3. The variance is equally divided between these factors (0.43, 0.31, 0.26, for factors 1-3).
4. Factor 1 is characterized as an association of 16th, 17th, 18th versus 19th, and 20th century wreck locations or, conversely, a demographic factor, e.g., colonial period locations don't predict other later period locations.
5. Factor 2 is characterized by a moderate association of variables representing 19th century shipwrecks and port development.
6. Factor 3 associates age of port and storms. The linkage is not compelling. The existence of ports seems to be more strongly associated with wreck frequency than that of the years the port (or ports) has been in existence. This association may be due to the larger number of vessels lost in ports to storms. Again, the proportion of the variance explained by this factor is low.

Analysis 2: Areal Factors

This factor study utilized a matrix composed of six variables and 10 cases per variable (Figure 13a). The methodology differs from the previous analysis in that large-scale areas of the Gulf are examined regarding the presence of hurricanes, ports, traffic routes, hazards, energy zones, as to shipwreck frequency. The hurricane frequency is taken from Tannehill (1956:119) with little alteration. The variable "routes" represents the number of periods with major inter- or intra-Gulf

	Hurricanes	Ports	Routes	Hazards	Energy	Wrecks
1	10	1	2	0	3	3
2	10	2	2	0	3	12
3	10	6	2	0	1	27
4	5	2	3	3	2	15
5	15	4	3	2	2	6
6	13	1	3	2	3	4
7	4	0	3	0	0	6
8	4	2	3	0	2	6
9	4	1	4	5	0	4
10	4	0	4	5	0	17

a.

	Factor 1	Factor 2
Hurricanes	-.675	-.067
Ports	-.097	.707
Routes	.698	-.152
Hazards	.672	.001
Energy	-.892	-.39
Wrecks	.468	.94

b.

FIGURE 13. Factor analysis, areal factors. a. Areal variables. b. Areal factors, oblique solution reference structure, orthotran/varimax.

routes present; "hazards" represents major reef, shoal or other hazards.

The results of the factor study are as follows (Figure 13b):

1. Two factors were identified. This was seen when restricting the program to this number of factors, and then allowing the program to determine the number of factors independently.

2. The factors are not strongly intercorrelated, although the same cannot be said of the variables.

3. The orthogonal solution seems a good approximation when compared to the unrotated or oblique solution. Following the oblique solution (varimax), we see a proportionate accounting of the variance 0.63 for Factor 1 and 0.37 for Factor 2.

4. Factor 1 is interpreted as depicting a strong association of shipwrecks to routes and hazards (0.698, 0.672).

5. Factor 5 associates shipwrecks and ports. Our first inclination is to call this the "ports" factor. Recalling the results of the previous factor study, the association may reflect higher losses of vessels due to storms. Ports tend to concentrate ships and great hurricanes destroyed significant numbers of vessels while in port (cf. Millas 1968).

Summary

This study has utilized manipulation of an automated data base to examine patterning in shipwrecks, over time, in the northern Gulf of Mexico. Using spatial and statistical analysis methods along dimensions such as routes, ports, hazards and storms, we have seen that patterns follow historic trends in population growth, movement and concomitant economic activities. European imperialism, colonialization and commodities determined routes and port locations and subsequent shipwrecks. Hazards and storms sank many vessels along shipping routes, with concentrations seen at major ports and hazards such as the Florida Reef Complex. Hurricanes have been determined to be less important as a factor in shipwreck patterning than originally thought. This lack of determinism reflects the random behavior observed for these storms.

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