WORLD WAR II MERCHANT MARINE BATTLEFIELDS IN THE GULF OF MEXICO: ANALYSIS OF THE SS *R.W. GALLAGHER* AND SS *CITIES SERVICE TOLEDO* USING 3D MODELING, PHYSICS, AND BATTLEFIELD ARCHAEOLOGY

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"The preoccupation of minds on drawing dividing lines makes it *impossible* for them to build bridges." – Dr. Rob Floyd

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ABSTRACT

WORLD WAR II MERCHANT MARINE BATTLEFIELDS IN THE GULF OF MEXICO: ANALYSIS OF THE S.S. *R.W. GALLAGHER* AND S.S. *CITIES SERVICE TOLEDO* USING 3D MODELING, PHYSICS, AND BATTLEFIELD ARCHAEOLOGY

Eric Alexander Swanson

S.S. *R.W. Gallagher* and S.S. *Cities Service Toledo* were sunk by German U-boats in the Gulf of Mexico in 1942. They were investigated for their historical significance under a project led by the Bureau of Ocean Energy Management (BOEM)/Bureau of Safety and Environmental Enforcement (BSEE) archaeologists in 2010. These two shipwreck sites provide an opportunity to analyze maritime casualties within the broader theoretical framework of battlefield archaeology. Furthermore, they provide examples of site formation processes that help explain why ships end up inverted on the sea floor during sinking events. Through the dynamic research associated with identifying these ships, their history, and their context, 3D modeling is utilized in an attempt to exhibit the current state of remote-sensing and 3D modeling software. These capabilities allow archaeologists to take a static archaeological site and present it in a way that will reveal more to the public through the growing lens of graphical interpretation and interest in World War II archaeology. This thesis builds upon a foundation of current technology and theoretical principals for future research to broaden knowledge and practice of marine archaeology in the Gulf of Mexico, and beyond.

CHAPTER I: INTRODUCTION

Research Problem

In this thesis, an archaeological perspective will encompass two shipwrecks, S.S. *R. W. Gallagher* and S.S. *Cities Service Toledo.* These oil tankers sank in the summer of 1942 from attacks by the Deutsche Kriegsmarine (German Navy, or DKM) in a series of German attacks known as “Operation Drumbeat.” Stealthy attacks in the dark of night came from the most deadly marine force known in North American waters as a response to the United States’ shipment of oil products that aided the Allies to the east. This deadly force was the German U-boat. These vessels sank within one month of each other, and their complement of armament indicates the U.S. was well aware of the risk of navigating both the Gulf of Mexico and the Atlantic Ocean at this time. Analysis of the armament offers insight into the response of the U.S. military to German U-boat activity in the Gulf of Mexico. Additionally, it offers an opportunity to understand the difference between U.S. military efforts on the threats present in the Gulf of Mexico to the efforts made to protect the Pacific or North Atlantic waters. German war diaries, U.S. Coast Guard, U.S. Navy, and U.S. Merchant Marine records give an account of each sinking and help to identify these battlefield wrecks in their current condition and allow for a detailed narrative of the events that befell the ships during the attacks. This narrative is integrated with archaeological data to provide an in-depth look into battlefield conflict theory for these types of engagements. These wrecks serve as a modern addition to the cultural, as well as environmental landscape, and add to the history of the United States' merchant marine.

There are several research questions associated with this project. What is the current condition of these vessels? What is the cultural, biological, and environmental significance of these vessels? Can the data found in studies like this provide enough evidence for inclusion on the National Register of Historic Places? How did these shipwrecks arrive in their current location, and why are they upside down? How does remote sensing data compare to physical ground-truthing by scuba divers? Is remote sensing effective in eliminating physical ground-truthing on these types of archaeological resources? What information is available to provide a dynamic battlefield theoretical explanation of events? What will this archaeological study add to the history of battlefield studies in the Gulf of Mexico?

These questions relate to the very human aspect of the two wrecks that, for their crews, company owners, and destinations, prove the idea that these catastrophic attacks' histories and meanings change throughout time. The key answer being addressed in this thesis is how the ships' importance has changed, dependent on the reader and writer, and how they continue to evolve to this day. These ships are still important to people today as memorial sites, recreational dive sites, fishing spots, shrimping grounds, navigational hazards, and avoidance areas for oil industry work. They will also prove to be important in understanding World War II (WWII) battlefield sites in the Gulf of Mexico and aid researchers in developing models and techniques used to investigate other WWII shipwreck sites by specifically addressing issues related to battlefield site preservation and formation processes. Ultimately, these casualty cases, the archaeological sites, their role in maritime history, and the methods utilized to study them will comprise the main focus of this thesis.

History and Background Information

This study incorporates a rich era of history that spans United States' culture during the advent of modern warfare. From the individual actions of those directly involved with battlefield tactics in the field to the broad patterns that were exhibited throughout the war, the year 1942 continues to be a dynamic part of WWII history. As some of the best representative archaeological samples of this time, the battlefields that are spread across the Gulf of Mexico represent this period well. These battlefields are expressed via the remains of merchant vessels sunk by deadly U-boat predators throughout the war. Two particular wrecks, discussed and examined in this study, serve to establish a solid understanding of the events that occurred in the Gulf of Mexico in the summer of 1942 during the German U-boat offensive known as "Operation Drumbeat." The wrecks, *Cities Service Toledo* and *R.W. Gallagher*, are a part of a larger group of vessels that were all attacked and sunk in the Gulf of Mexico that same year. By analyzing the historical evidence available for these vessels, the link between their archaeological remains and their available historical documentation is made clear. Cross-referencing these data helps establish a comparison between both sides of the battle, from the side of the ships' captains and surviving crew to the record of the attack formed by the captains and crews of the U-boats that sank them. While comparing the methods used in this study to similar studies across the southeast United States, a consistent model of archaeological method and theory is used on the subject of WWII archaeology.

To illustrate the impact of U-boat attacks in the Gulf of Mexico, the southeast Atlantic region saw 117 U-boat attacks reported by either Allied or German sources (Rohwer 1983). Of these attacks, 92 vessels were confirmed sunk. Over half of these attacks were in the Gulf of Mexico. A total of 64 attacks were reported in the Gulf of Mexico alone, 28 of which belonged to U.S. interests, exhibiting the danger of U-boat attacks on Allied shipping. While 49 attacks occurred in May alone, this marks the high point of success by the Germans in the region in 1942. Among the 24 vessels sunk while serving the U.S. War Shipping Administration in 1942 that were torpedoed by German U-boats in the Gulf of Mexico, two oil tankers, *Cities Service Toledo* and *R.W. Gallagher*, provide insight into the adversity faced by the Merchant Marine every day, regardless of a sinking attack or not (Rohwer 1983) (Table 1 & Figure 1).

TABLE 1
ATTACKS BY MONTH AND TOTAL U-BOAT ATTACKS IN 1942

Attacks by Month		**Totals**	
February	5	Total Reported Attacks	117
March	3	Total Vessels Sunk	92
April	8	Total Attacks on U.S. Vessels	59
May	49	Attacks Reported by Germans in GOM	64
June	21	Attacks Reported by Allies in GOM	62
July	20	Attacks on Known U.S. Vessels in GOM (Allied Reported)	28
August	10	Total Known U.S. Vessel Sinkings in the GOM (Allied Reported)	24
September	1	Total Known Vessel Sinkings in Area Around Louisiana Coastline	18

Figure 1: The 117 Allied reported WWII U-Boat attack locations in the Southeast Atlantic Region in 1942 (Drawn from Rohwer 1983 and placed by Author in 2013). Attacks considered within the Gulf of Mexico (GOM) are white, while each attack outside the GOM is red with the numbered month within the marker.

These two vessels sank within a month of each other while carrying an armament adapted to defend the oil filled transports from U-boat attacks. These vessels also represent an implementation of armament on merchant ships illustrating the United States' push to mobilize for the war effort, as well as showing the attempt of the United States to defend its assets against a growing German threat in the Gulf of Mexico.

In addition to the investigation of the armament of these two vessels, inquiry into the crew of the vessels served to be an essential part of the context of what happened to the vessels on their final days of service. Individuals that served aboard these vessels can be identified more thoroughly via examination of their associated records available within the U.S. census. These crew members also served to be a critical part of the final documentation in the form of survivor accounts submitted by the U.S. Navy. As each individual's story is recounted, it becomes clear that each vessel served to be more than just a tool used by the War Shipping Administration and oil industry companies, but as a home and source of employment for dozens of men of all ages.

Cities Service Toledo was 8,192 gross tons, active in the trading of oil-related commodities for nearly 25 years (U. S. Department of Commerce (USDC) 1942:19) (Figure 2).

Figure 2: S.S. *Cities Service Toledo* at sea 13 February 1942 (unsourced USCG 1942).

The owner of this vessel, Cities Service Oil Company, was an active oil company that lost ships in the Gulf of Mexico at the time, while other oil companies such as Standard Oil Company faced similar marine losses. The Standard Oil Company owned the other vessel focused on in this thesis, *R.W. Gallagher*. This vessel was another large oil-carrying ship that weighed 7,989 gross tons (USDC 1942:52) (Figure 3).

The benefit of utilizing *R.W. Gallagher* as a representative of the Standard Oil Company relates to the amount of documentation that this company kept in recording the vessels in its ownership that were attacked during WWII (Standard Oil Company 1946). These documents helped in identifying a comparative model in which both sinking events could later be mathematically broken down for their initial site formation process.

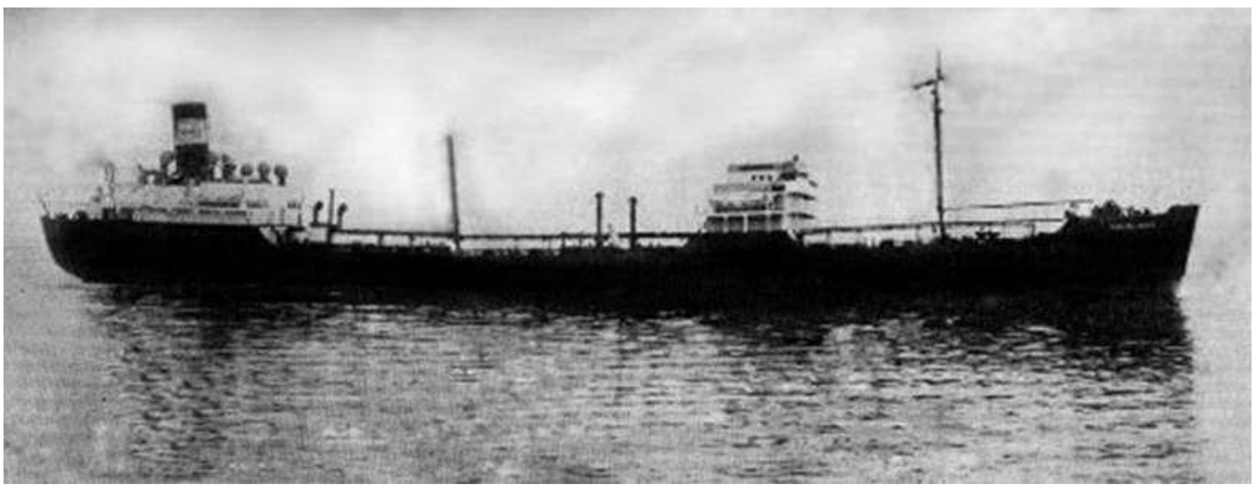


Figure 3: S.S. *R.W. Gallagher* at sea in 1938 (Standard Oil Company 1946:357).

Both *Cities Service Toledo* and *R.W. Gallagher* were armed at the time they were attacked. This armament is indicative of an approach that the United States' government implemented to defend merchant vessels from attack with what means were available at the time. By investigating the types of gun complements aboard the ships, this thesis will defend the claim that these vessels were not adequately protected from attacks by U-boats in the Gulf of Mexico.

The armament on these ships also included armed merchant marine guards who added significant historical documentation, but were unable to defend the vessels from sinking without separate escort craft. Had the oil tankers been escorted by vessels equipped to counterattack U-boat attacks, the battles may not have been as successful for the German DKM.

DKM *U-158* and DKM *U-67* were U-boats directed by German Admiral Karl Dönitz as a part of the greater Operation *Paukenschlag* (Operation Drumbeat). The campaign laid claim to 64 merchant vessel attacks in the year of 1942 by a fleet of 24 U-boats in the region (Blair 1996:475; Rohwer 1983). The availability of German documents provided each U-boat's log to create a dynamic relationship between U.S. documents and archaeological evidence. This method of comparison allows for a theoretical expansion of battlefield theory and model building later discussed in this thesis. Documentation from both sides of these battles allows for archaeological research to bridge the gap in historical documentation and create a new understanding of the human past.

Data and Methods

In the case of the WWII shipwrecks located in the Gulf of Mexico, as well as their particular histories and the analytical process involved with archaeological investigation, several sets of data were compiled that will form the core of the research for this thesis. Altogether, it is the combination of several disciplines that help to document the life-span of two individual ships sunk by German U-boats in 1942, representing only two of approximately 64 Allied vessels attacked in the same 12 month span along the eastern United States (Rohwer 1983:73-144).

The location of these two wrecks and their current condition ties the research population to their sinking events and their location in the Gulf of Mexico. The fact that these vessels lie within the Gulf shows that an under-represented facet of United States' WWII history is not as far away as people make it seem. It is important to exhibit the effect that U-boat attacks had on U.S. shipping lanes throughout the war. By exploring this effect, the literature and knowledge of these events can be dynamically expanded from their current state. The context in which they lie today is much different from when they were in working order as oil-tankers, and is better understood with the archaeological investigation that took place in August 2010. Through identification of *Cities Service Toledo* and *R. W. Gallagher* using remote sensing technology and diver ground-truthing, their historical documents may be compared to diagnostic findings to create a dynamic comparison of their past and present using the battlefield archaeological method, as discussed below.

The process of data collection for submerged sites has evolved significantly over the years. The key to understanding this evolution can be observed in the investigation of these two WWII shipwrecks in the Gulf of Mexico conducted in August of 2010. Utilizing some of the most technologically advanced techniques and methods available, the approach to this topic yields a solid cohesive foundation for analysis. A key factor in the methodology used to investigate and identify these two particular WWII shipwrecks involved non-invasive techniques. Remote sensing data were collected by Tesla Offshore, LLC aboard M/V *Nikola* and subsequently M/V *Spree* during field investigations in 2010 (Evans et al. 2013:10-14) (Figure 4).

Figure 4: Field archaeological crew and M/V *Spree* crew on deck in 2010.

These data were streamed digitally into computer storage where they were additionally constructed into graphics by specialized software. This information allows researchers to identify the shape, size, depth, location, and appearance of the vessels as they appear today. When the visual representations from remote sensing are compared to historical accounts and images, stronger inferences can be made regarding their identities. Once preliminary vessel histories have been compiled the physical investigations of the sites can begin.

In this particular study, physical investigations involved several remote sensing techniques in conjunction with scientific diver ground-truthing on the sites themselves. Divers were physically able to locate and record diagnostic details of the two vessels to enhance the data compilations that had been made earlier in the process. Examples of these physical data are photographs of diagnostic features such as propeller and rudder sizes, bilge keel measurements, hull plating measurements, and propeller shaft measurements that match historical blueprints and reports given in the sinking accounts. Additionally, assessment over the current physical state and integrity of the vessels in terms of cultural resource value was recorded and established through diver visual inspection and photographic observations.

With respect to analysis and interpretation, several tools have become available to the researcher as the field of shipwreck archaeology has grown significantly over the years. Increased availability of computer graphics software, the ease of sharing information over the internet, and analysis of the data collected is relatively simple. Due to the documentation of the shipwrecks in government records, these accounts and locations are known and need only be sought in their appropriate catalogs across major archives located in the eastern United States. Additionally, knowledge of the damage that was inflicted upon the wrecks may be compared with remote sensing data, diver drawings, as well as photography taken on location. Accounts and cultural association to the sites will be made in conjunction with the goal of providing the significance of these vessels to living history and their ultimate identity within families and communities in the United States. The objective to create these ships' identities is not limited to its physical appearance or those who lived directly in and around them, but how they relate to WWII in the Gulf of Mexico and how these merchant vessels changed with time. Ultimately, these vessels are the remaining cultural material evidence of attempts made to safeguard U.S. war efforts. This expression can be seen in the ways in which people utilized and manipulated these vessels, which will be illustrated within this thesis. From observing their original histories, to mapping their archaeological context in relation to these histories in three dimensions, to physical observation and comparison to the industrial landscape across the Gulf of Mexico, the analysis of these wrecks will function to show the dynamic nature of maritime culture in a very comprehensive manner.

Remote sensing data helps complete an understanding of a vessel by identifying its location, magnetic, and acoustic appearance underwater. By incorporating aspects of site formation processes in this study, an understanding of the environment around the wrecks will conclude that these sites maintain purpose and support life around them in their current state. By understanding the processes that form the sites, and the biological environments around them, their importance and use by human maritime culture will be better understood. Above all, the identification of a unified and comprehensive use of several cross-disciplinary tools is the central method that will come through the process of this research.

Theory

Through the shifting tides of archaeological theory, one finds many written examples of how people have changed the materials in their culture to cope, defend, and aid the overall political and economic endeavors of their time. By utilizing the battlefield archaeological theory principles as presented by Douglas Scott, David Conlin, and Matthew Russell, the battle site formation and relationships shared by both sides of each conflict represented by these two sites can be established. Scott et al. published their premiere theory on battlefield archaeology in *Archaeological Perspectives on The Battle of Little Bighorn* in 1989. The primary focus of the book was to identify several components of terrestrial battlefield sites in context and relate them to available historical documentation (Scott et al. 1989). The comparison of these data allowed Scott et al. to develop a comparative model that both identified general patterns present on battlefields (gross patterns) and specific individual troop movement patterns by identifying artifacts that related directly to documentary evidence of their use and distribution (dynamic patterns). This theoretical model was utilized in a terrestrial archaeological method, but Conlin and Russell utilized battlefield theory to investigate the battlefield between C.S.S. *H.L. Hunley* and U.S.S. *Housatonic* in a maritime setting (Conlin and Russell 2006). Some significant differences exist between the two studies, but they were both used as reference to uniquely study and interpret the two oil tanker wreck sites in this project.

Within several documentary resources, the written record of the way these vessels were identified will aid in illustrating the archaeological remains present on the seafloor. This will also explain specific wartime behavior made by the United States in the Gulf of Mexico during this period in history through an examination of the archaeological record. By combining the gross and dynamic patterning of battlefield archaeology established by Douglas Scott et al. in 1989 and Conlin and Russell in 2006 with the modular comparisons of historical resources with archaeological remains established by Tiago Fraga in his 2004 thesis project, the battlefield approach of archaeology on these vessels will introduce a foundation for future projects regarding WWII in the Gulf of Mexico (Conlin and Russell 2006; Fraga 2004; Scott et al. 1989).

Significance

The significance of the research conducted on *Cities Service Toledo* and *R.W. Gallagher* is part of a growing momentum within the field of shipwreck archaeology on WWII shipwrecks (Church et al. 2007a; Church et al. 2007b; Church et al. 2009; Enright et al. 2006; Evans et al. 2013; Gearhart et al. 2011; McKay and Nides 1998; Wagner 2010; Warren et al. 2010). As war vessels and casualties of war from this era now qualify for inclusion on the National Register of Historic Places under the National Historic Preservation Act as nationally significant cultural resources, projects like this will need to be conducted to provide insights into their integrity and importance to history and culture. This particular study addresses many of the preliminary research conditions that will benefit similar projects in the field, and is aimed to aid in the advancement of techniques and methodologies for the future benefit of these types of wrecks. In addition, this thesis will provide a basis for projects utilizing the numerous technologies that exist in marine archaeology. Many of these projects are currently being conducted in the Gulf of Mexico and elsewhere in an attempt to identify and catalog wrecks along the outer continental shelf (Evans et al. 2013:1-20). Through additional analyses of the current conditions of these wreck sites the processes that affect their integrity and condition as battlefields, cultural dive locations, and biological habitats will be noted and supply further information that can furnish a base model that may be comparatively applied to other wrecks in similar conditions (Figure 5).

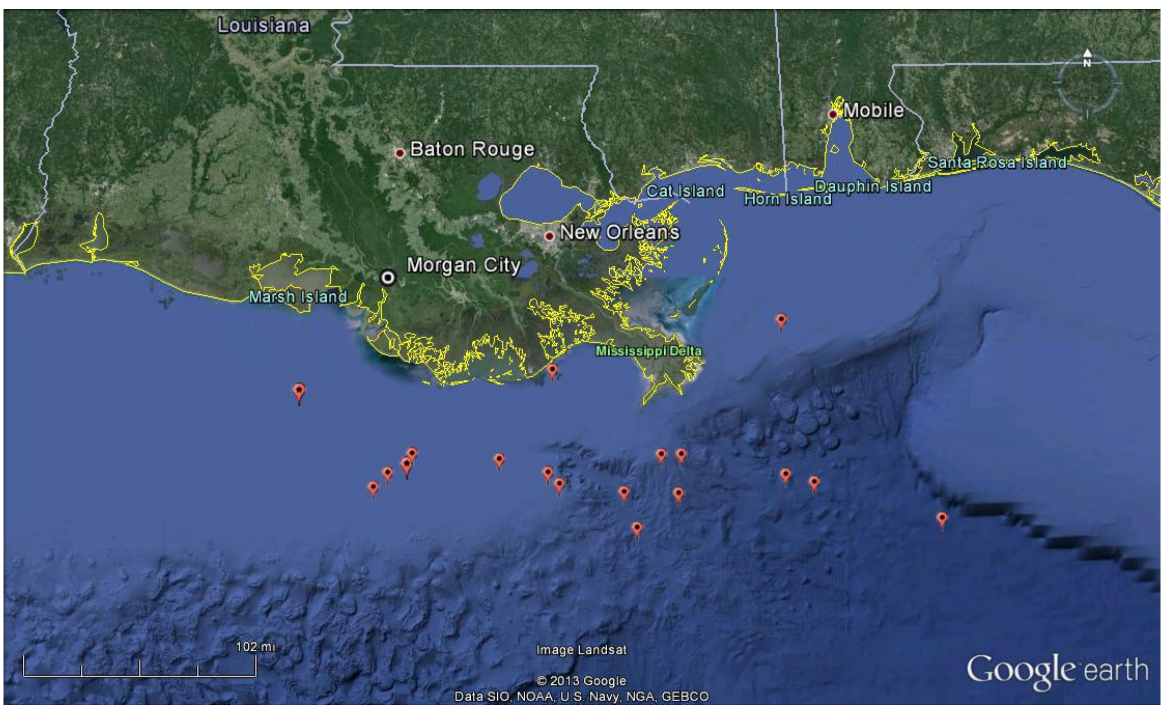


Figure 5: The 18 recorded WWII U-boat sinking attack locations surrounding the area where S.S. *Cities Service Toledo* and S.S. *R.W. Gallagher* currently lie (Rohwer 1983; Wiggins 1995:114-115). S.S. *Cities Service Toledo* and S.S. *R.W. Gallagher* are demarcated with a starred pin.

Ultimately, the significance of this thesis will be to provide innovative techniques to a growing study of merchant vessels sunk during WWII in the Gulf of Mexico. Many of these ships lack sufficient documentation of their current condition or a thorough compilation of their historical record. This research will demonstrate the pivotal role of the United States' Merchant Marine in the Gulf of Mexico during WWII, expound upon new theoretical principles in underwater war sites, expand upon the understanding of catastrophic battle events on the water in an archaeological sense, and expand upon techniques that may further reach out to public understanding of United States' cultural heritage in a time of war.

Research Presentation

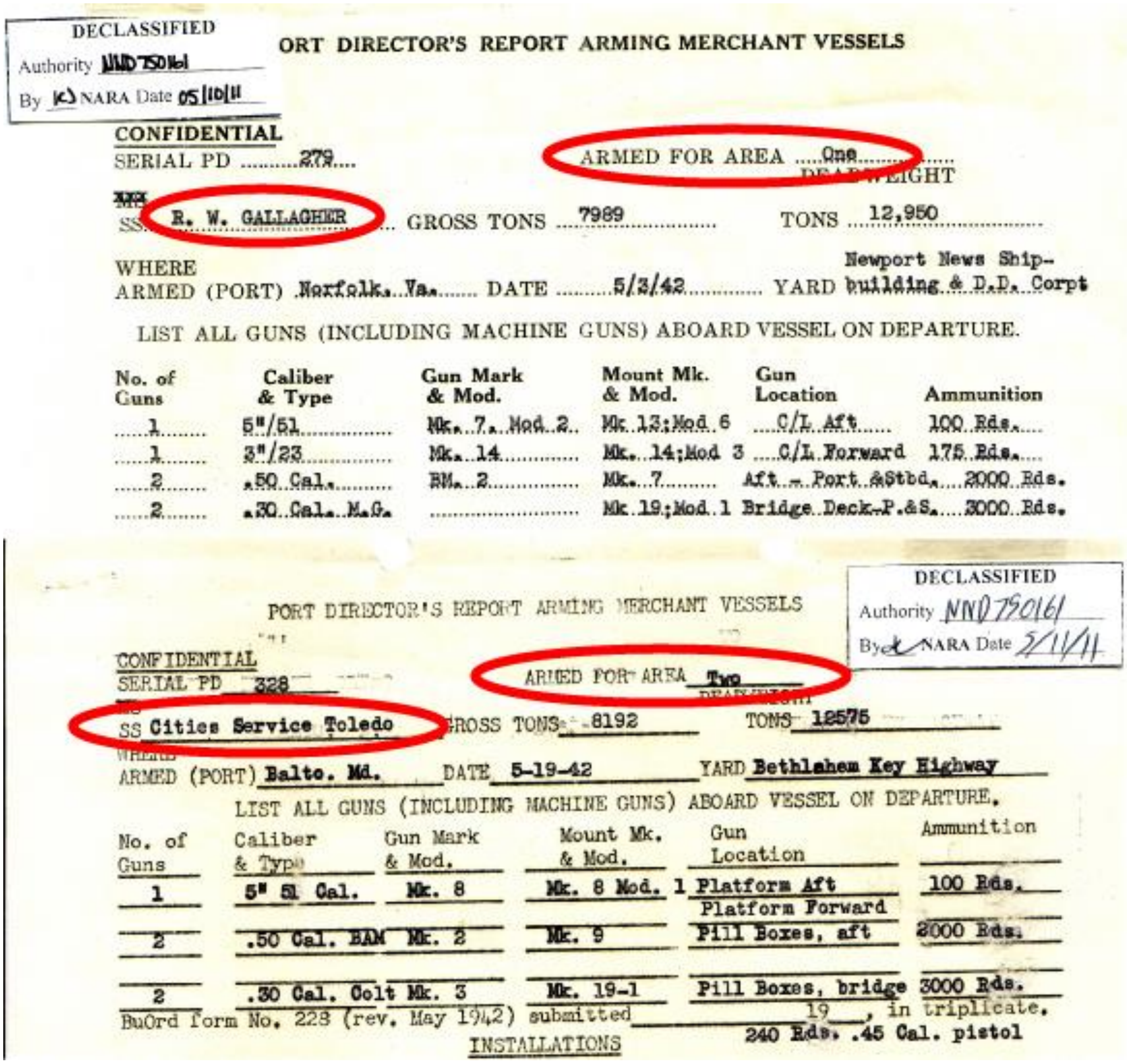
As a subject that requires several modes of interpretation and analysis, the discussion of two oil tankers in this study will be divided into seven chapters. The next chapter will address the particular research context in regards to the geographical and historical background. Chapter III will address previous investigations involving both *R.W. Gallagher* and *Cities Service Toledo* directly and indirectly through similar research projects and similar wreck studies that share similar research interests involving WWII in the region. Following that chapter will be the methodological chapter that discusses the historical archaeological processes involved with studying these two WWII wrecks. Chapter V presents the results that the methodological processes revealed during the research process and presents a lead-in to the particular arguments that will be made in the next chapter. The discussion chapter, Chapter VI, provides the complex relational evaluation of how the research questions have been answered throughout the project, bringing together the fundamental principles discussed in the preceding chapters and connecting them. In the final chapter, the study's final conclusions will be summarized.

CHAPTER II: RESEARCH CONTEXT

Introduction

Every shipwreck holds its own individual history. The core to researching these wrecks involves analytical processes associated with archaeological investigation using several sets of compiled data. Information utilized for this study is acquired using tools from the disciplines of anthropology, archaeology, geology, biology, oceanography, chemistry, hydrography, engineering, and history. The unification of these disciplines to answer research-based questions is not only beneficial, but increasingly common among research projects in the 21st century. In addition, the technology developed from the fields of geology, oceanography, engineering, and marine architecture plays an essential role in the success of this study. Altogether, the combination of these tools helps to provide this study with clarity and relevance in researching two individual oil tankers sunk by *Deutsche Kriegsmarine Unterseeboots* (German U-boats) during World War II. These two vessels were among 64 Allied vessels sunk or damaged in the Gulf of Mexico in 1942 (Rohwer 1983; Wiggins 1995:238) (Table 1).

These two oil tankers, *R.W. Gallagher* and *Cities Service Toledo*, provide insight to the adversity faced by merchant mariners every day, regardless of an attack or not. These oil-filled transports sank within a month of each other despite carrying armament adapted to defend against U-boat attacks. Historical investigation reveals that the armament comparison between the vessels differed by one three-inch gun added to *R. W. Gallagher*. The difference was determined by their area of operation (Office of the Chief of Naval Operations (OCNO) 1942a; OCNO 1942b) (Figure 6).[1]


DECLASSIFIED
Authority NND 750161
By KJ NARA Date 05/10/11

PORT DIRECTOR'S REPORT ARMING MERCHANT VESSELS

CONFIDENTIAL
SERIAL PD 279
ARMED FOR AREA One
SS R. W. GALLAGHER GROSS TONS 7989 DEADWEIGHT TONS 12,950
WHERE ARMED (PORT) Norfolk, Va. DATE 5/3/42 YARD Newport News Shipbuilding & D.D. Corp.

LIST ALL GUNS (INCLUDING MACHINE GUNS) ABOARD VESSEL ON DEPARTURE.

No. of Guns	Caliber & Type	Gun Mark & Mod.	Mount Mk. & Mod.	Gun Location	Ammunition
1	5"/51	Mk. 7, Mod. 2.	Mk. 13; Mod. 6	C/L Aft	100 Rds.
1	3"/23	Mk. 14	Mk. 14; Mod 3	C/L Forward	175 Rds.
2	.50 Cal.	BM. 2	Mk. 7	Aft - Port &Stbd.	2000 Rds.
2	.30 Cal. M.G.		Mk 19; Mod. 1	Bridge Deck-P.&S.	3000 Rds.

PORT DIRECTOR'S REPORT ARMING MERCHANT VESSELS

DECLASSIFIED
Authority NND 750161
By NARA Date 5/11/11

CONFIDENTIAL
SERIAL PD 328
ARMED FOR AREA Two
SS Cities Service Toledo GROSS TONS 8192 DEADWEIGHT TONS 12575
WHERE ARMED (PORT) Balto. Md. DATE 5-19-42 YARD Bethlehem Key Highway

LIST ALL GUNS (INCLUDING MACHINE GUNS) ABOARD VESSEL ON DEPARTURE.

No. of Guns	Caliber & Type	Gun Mark & Mod.	Mount Mk. & Mod.	Gun Location	Ammunition
1	5" 51 Cal.	Mk. 8	Mk. 8 Mod. 1	Platform Aft	100 Rds.
				Platform Forward	
2	.50 Cal. BAM	Mk. 2	Mk. 9	Pill Boxes, aft	2000 Rds.
2	.30 Cal. Colt	Mk. 3	Mk. 19-1	Pill Boxes, bridge	3000 Rds.

BuOrd Form No. 228 (rev. May 1942) submitted 19 , in triplicate.
240 Rds. .45 Cal. pistol
INSTALLATIONS

Figure 6: Comparison of the armed guard reports regarding the arming areas and specific armaments of S.S. *R.W. Gallagher* and S.S. *Cities Service Toledo*. Both were armed in May 1942, when the reports were produced (OCNO 1942a; OCNO 1942b).

1 This reference is in regards to the "Port Director's Report Arming Merchant Vessels" for S.S. *Cities Service Toledo* and S.S. *R.W. Gallagher*. The enumeration indicates the reference's archived box number, respectively.

The areas demarcated at the top of their armament reports, Area One for *R.W. Gallagher* and Area Two for *Cities Service Toledo*, seem to be the only clue to account for the difference in the complements. No additional information identifying these areas was found. The presence of armament on merchant ships illustrates the United States' push to mobilize for the war effort, as well as showing the attempt of the United States to defend its assets against a growing German threat in the Gulf of Mexico. The tankers' crews also provide an essential element of the documentation of what happened during their battlefield engagements.

This study's research population, the *R.W. Gallagher* and *Cities Service Toledo*, are put into relevant historical context by integrating the location of these wrecks and the examination of the events that sank them. The fact that these vessels lie within the Gulf of Mexico shows an important facet of United States' involvement during WWII that has been previously marginalized. It is important to address the impact that U-boat attacks had on U.S. shipping lanes throughout the war in order to expand the literature and knowledge of these events for future study. The context in which they lie today is better understood after in-depth archaeological analysis. Through the identification of *Cities Service Toledo* and *R. W. Gallagher* using remote sensing technology and diver ground-truthing, their historical documents may be compared to diagnostic findings to create a dynamic expression of their past and present conditions. More WWII battlefield sites in the Gulf of Mexico may be examined and interpreted with increased efficiency in the future by utilizing the methods and practices used to examine and interpret the shipwreck sites explored in this study.

Physical Environment

The Gulf of Mexico is a marine region heavily impacted by natural forces. It is a region where weather and several sedimentary deposition factors play a significant role in the environment. The Gulf Stream Loop current provides the North American coastline with equatorial water temperatures and high pressure circulatory systems often causing destructive forces to act upon cultural and environmental features of the ecosystem (Keim 2009:57). Tidal pressures and seasonal discharge flows also play a significant role in the deposition of sediments coming from the coastline (Steward 1981:21). A major contributing factor to the site formation processes for the shipwrecks in this study is the alluvial sediments being discharged from the Mississippi River. Additionally, hurricanes that frequent the Gulf of Mexico in this area have had significant impacts on similar shipwreck sites in the past and will be considered in this study (Church et al. 2007a:28).

The shape of the North American coastline around the Gulf of Mexico has changed dramatically over time. Sediment types have varied due to significant events involving sea-level rises and falls during different glacial cycles. During the period in which these shipwrecks arrived on the seafloor, the sediments present along the Outer Continental Shelf (OCS) were primarily quartz sand, clays, and silts (Francisca et al. 2005:929). The final deposition of these sediments depended heavily on the environment for locomotion. The site formation processes are established around each wreck site by identifying the environmental factors involved and continuous depositional accumulation.

The Gulf Stream provides the North American coastline with varying high-pressure systems that interact with low-pressure systems coming from the high-altitude regions to the north. Storm systems often develop as these two systems interact along the edge of the continent. Seasonal flooding and discharge events also vary in intensity and heavily influence erosion of sediments from land, causing major river systems to transport the granules into the ocean. These grains travel at varying distances primarily determined by particle size and by fluid movement around them (United States Army (USA) 2002:5-1). The Mississippi River is the largest river that empties into the Gulf of Mexico adjacent to these two sites. The Mississippi River's sediment types, consisting primarily of quartz sands, clays, and silts, also resemble that of the region of study in the Gulf of Mexico (Dwyer 1997:1.8-1.9).

The tidal effects on these granules pull the finer sediment further out to sea. As heavy tides pull on the particles, the wind and tidal currents agitate their movement, and carry them in the general direction of the forces in motion. Though these general actions follow seasonal and annual trends, significant events that affect the movement of particles in the water occur intermittently throughout their movement along the seabed. One example of significance is the effect of powerful hurricanes that impact the region for a significant portion of every year in various, infrequent, patterns (USA 2002:5-3).

The impact of hurricanes on archaeological sites in the past has varied from very little to very significant. Hurricanes of category 1-3 (on the Saffir-Simpson scale) may only cover or uncover a site slightly with increased wave heights. Category 4-5 hurricanes may dramatically alter an archaeological site, damage the structure of the site, or completely destroy the integrity of a cultural resource (Church et al. 2007a:28; Gearhart et al. 2011). By systematically monitoring sites around the Gulf of Mexico, hurricanes and tidal factors can be taken into consideration in identifying their effect on site formation processes when attributing depositional and degradational factors that may change the integrity of an archaeological site.

By analyzing the sediments around each shipwreck, the deposition date range of the shipwreck can be deduced by examining the age and oxygen saturation of the granules (Evans et al. 2013). Also, examining the extent of scour and mounding of sediments around each wreck reveal several factors in site formation. These variables can determine the intensity of change in a long-term look at the environmental effects on shipwrecks. The salinity of the water in the surrounding area additionally contributes to the destruction of the steel-hulled vessels through natural electrolysis. Salinity sampling also aids in looking at how biological life may be affected in the area. By examining these factors, date ranges and general environmental statistics can be used to evaluate the cultural and environmental importance of these areas (Church et al. 2007a).

The biological life surrounding these shipwrecks consists of several fish, plant, and invertebrate species. They subsist on the nutrients and materials deposited into the area via alluvium ejection by the Mississippi river. The shipwrecks in this study have become a form of artificial reef. These reefs currently serve a purpose other than for cultural heritage, as a home to the diverse flora and fauna present in the Gulf. Because these wrecks also present navigational and fishing obstructions at 24.38 to 30.48 meters (80 to 100 feet) of saltwater (msw/fsw) depth, they prevent heavy shrimping and oil drilling, thus biological life around these wrecks thrives in an isolated ecosystem. These wrecks should be preserved in their current state not only for cultural heritage, but for environmental protection as well.

Several thousand acres of leased oil industry property surround these wrecks (Minerals Management Service (MMS) 2003). Oil production from natural reservoirs thousands of meters below the seafloor has increased in this region since 1980 (Iledare and Keiser 2007) (Figure 7). This industry flourishes due to the increased focus on energy independence in the United States, and two divisions of United States Department of the Interior monitor and regulate the use of these submerged lands and resources. The Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) strive to implement strict rules and guidelines for the oil industry to follow during their expeditions for natural resources, but can only regulate U.S. Government-owned submerged resources regarding minimum survey

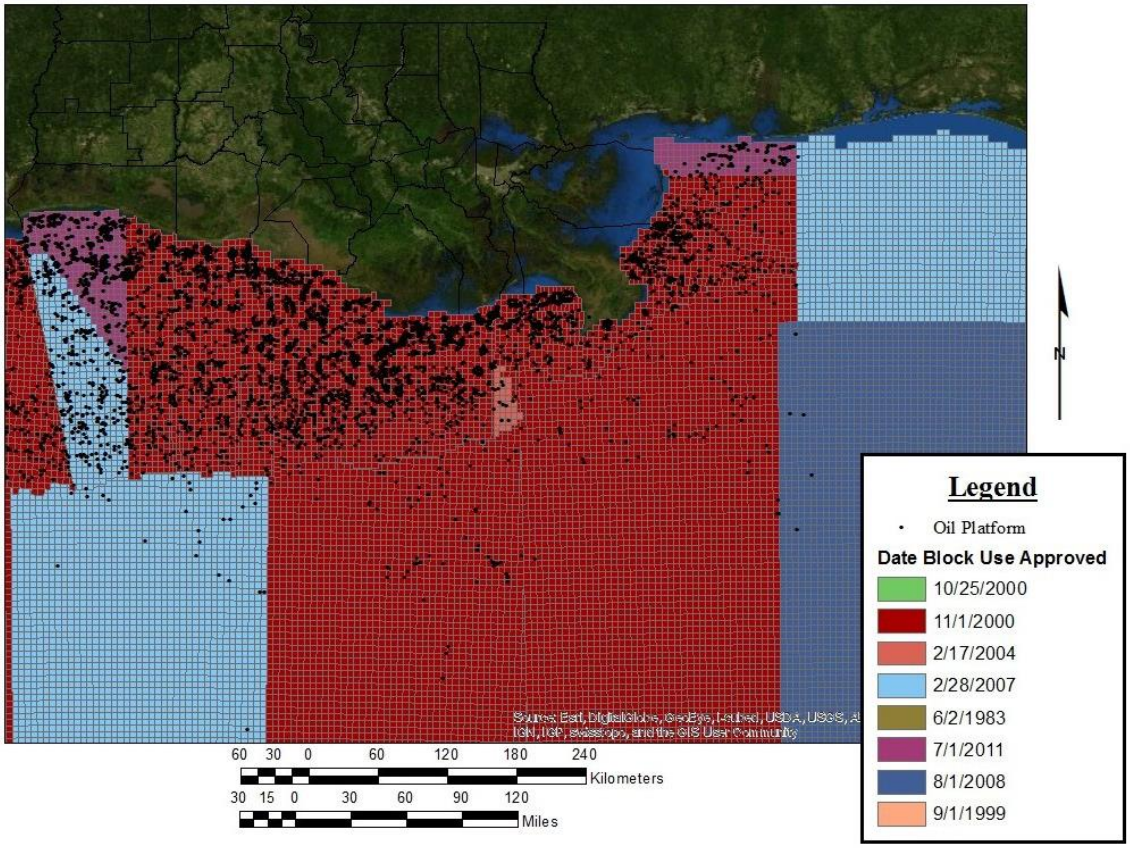


Figure 7: Map of the federally controlled three nautical mile lease blocks used in oil and resource exploration. All blocks and platforms are current to 08 July 2013.

areas and techniques and in avoiding cultural and environmentally protected resources (Irion 2002). Legislation makes up the basis of the industry's leading compliance issues regarding resource protection. Though laws have made enforcement of resource protection possible, consequences are usually only able to be enforced after a violation occurs. As an example, the impact on the *Mardi Gras* wreck off the coast of Louisiana by an oil pipeline project could only be mitigated after the damage had been done, though a compliant survey had been conducted in the area beforehand (United Nations Educational, Scientific, and Cultural Organization (UNESCO) 2010). Only when more legislative action is enacted to protect these types of resources will they receive adequate protection. Until then, documentation of the possible significance of any known cultural resources in the Gulf of Mexico is necessary for their preservation. This documentation will ensure that, in cases like that of the *Mardi Gras* site's damage, the resource can be preserved within the public record with archaeological research project reports.

Historic Context

The effect of WWII in the Gulf of Mexico is an important part of United States' history. Contributions made by the United States War Department, the United States Merchant Marine, the United States Navy, the merchant vessel's owners, and the crews that traveled throughout the Atlantic Ocean in 1942 exhibit this point with several historic documentary sources. The coastal communities that provided and cared for the men who worked on these ships still carry the memories of this era. Other portions of the documentary evidence of the events that surrounded the Gulf of Mexico's battlefield environment are also contained in several archival locations across the country. Though German U-boats presented a significant threat to shipping lanes at this time, several efforts were made to protect Allied petroleum products. Shipping vessels' crews and owners were well aware of U-boat activity in the Gulf of Mexico, and remained in close proximity to the shoreline during travel (Wiggins 1995:142-143). These ships often engaged in zig-zag patterns and were often armed (though poorly), as can be seen in the case of *R. W. Gallagher* and *Cities Service Toledo.* It is through the record of these two merchant vessels that the effect of WWII in 1942 can be seen from several points of view: their catastrophic sinking, the identities of those that perished in the attacks, how survival is related via official accounts, and how strategic decisions were made as a result of U-boat attacks in the Gulf of Mexico. By utilizing previous research and databases, archival collections, census data, written accounts, autobiographies, official reports, and oral accounts, the histories of these events make up a significant portion of cultural heritage. In addition, archaeological data, vessel documentation, and vessel modification show the human effect on these vessels through time. The changes to these ships are directly attributable to people ranging from the individual crewmen to administrative and executive officers.

The history of each vessel and its crew comes from their relationships throughout time and how their identities changed. By identifying the individuals that lost their lives on *R.W. Gallagher* and *Cities Service Toledo*, the simple acknowledgment of their efforts can be awarded with documentation. On board *Cities Service Toledo*, 45 crew members served in hostile waters. In the example of *R. W. Gallagher*, a 52-man crew set out to deliver the essential Esso "C" bunker fuel to Port Everglades, Florida, to assist the Allied war effort. A torpedo strike left nine crewmembers dead, most of whose stories remain filed away in historic documentation (Moore 1983:505). Transcription and cross-referencing these records allows for the identification of the men who served aboard these vessels can be identified over 70 years later. A record of the individuals who served aboard these ships can be established by utilizing the available data on the group of men who perished during the conflicts.

In the early years of the Atlantic and Gulf of Mexico theater of WWII, German strategy was extremely effective in disrupting United States shipping lanes. In early 1942 the *Kriegsmarine*, comprised of 24 U-boats in the Gulf of Mexico, violently dominated the waters around the coast of the United States (Rohwer 1983). They marked and attacked vessels aiding Allied war efforts. Twenty-five attacks were recorded in May alone, with no confirmed U-boat fatalities (Rohwer 1983; Wiggins 1995). German strategy during the war along the United States coastline certainly dictated the direction in which American military and merchant strategists took to secure their ships and cargoes. The skill and aptitude of the *Kriegsmarine* at this time was hardly matched by U.S. response on the Atlantic coast, as indicated by the level of Allied casualties stemming from attacks by U-boats. The German strategy of attacking the western Atlantic front began in November of 1941 during negotiations with the Japanese, whom had decided to prepare to wage war in the Pacific (Blair 1996:431). The pace of war had already escalated when the U.S. began to lend-lease war supplies to Europe via the North Atlantic, and the tipping point for Germany to join the war against these efforts was evident by November 1941. The Lend-Lease Act effectively ended the neutrality of the United States in defense of Britain, and subsequently the Allies, by shipping supplies and offering economic aid during the war (Staley 1943). The ultimate reality of this decision by the U.S. government led to the Germans targeting part of this economic weapon (merchant shipping). After the Japanese effectively overpowered Allied forces throughout East Asia and the Western Pacific in December of 1942, it was clear that the United States would need to dedicate the majority of its Navy to the Pacific front (Blair 1996:434). This gave the Germans an opportunity to deploy dozens of U-boats to control the lightly-defended Atlantic coastline.

The German fleet was ill-prepared for a high-seas conflict with their navy; the total number of U-boats available for operations was initially six. This deficiency required expediency in building a strategic U-boat fleet (Blair 1996:438; Felknor 1998:192). Under the command of Admiral Karl Dönitz, the *Kriegsmarine* began Operation *Paukenschlag* or "Drumbeat" on 19 December 1941 (Gannon 1990:xvi, 1). The plan was fairly simple in that the entire eastern coastline of the United States saw hundreds of merchant interactions every day, leaving these ships open to attack (Gannon 1990:xvii). The available Type IX U-boats were the only submersibles capable of making the 3,000 mile one-way trip and returning to Lorient, France, after a patrol (Blair 1996:438) (Figure 8).

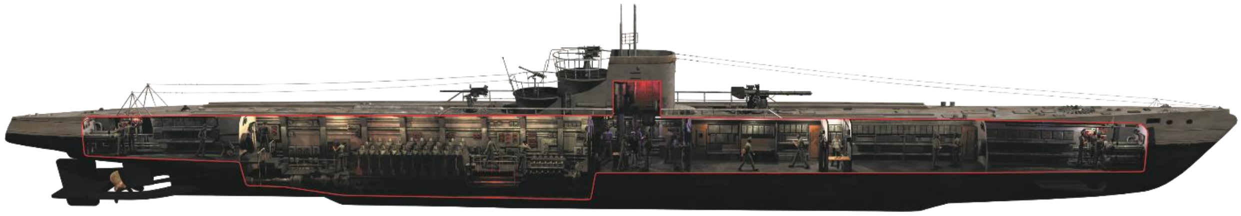


Figure 8: DKM Type IX U-boat. Illustrated by Ian Palmer (Williamson 2002:Plate D)

Dönitz initially intended for the fleet to attack the mid-to north Atlantic waters because the phosphorescent waters surrounding the 10 mile continental shelf around Florida would illuminate U-boat movements at night (Blair 1996:439). The instinct to attack U.S. shipping by surprise was not seen as a worthwhile goal at first because of the relatively indirect role U.S. shipping played in the war in 1941, but Dönitz proved this method would be deadly in the following months (Blair 1996:440-441). Though he was able to muster up an additional force of nine Type VII U-boats for his campaign in the Atlantic, Dönitz was thwarted in his attempts to build an ancillary force of U-boats to be used in the West by Adolf Hitler, who believed that an Allied invasion of Norway was imminent (Blair 1996:443) (Figure 9).

Figure 9: DKM Type VII U-boat. Illustrated by Ian Palmer (Williamson 2002:Plate D)

This belief led Hitler to curtail a strike against the United States' coastline, nearly unprotected, as the country amassed its Navy in the Pacific (Blair 1996:448-450). As the situation progressed, reports of the presence of the U-boat fleet buzzed throughout the U.S. Naval command. The report that attacks were coming by mid-January were met by Fleet Admiral Ernest King with urgency, but he could organize sufficient convoys and protective escorts with the limited resources available to him (Blair 1996:454-455; Gannon 1990:338-339).

The limited organization of a convoy system, headed by the Canadian navy, was met on a multinational level by the Allies on 22 January 1941, but was staged to engage merchant movements in the North Atlantic (Blair 1996:457). A small fleet of 10 destroyers was dispatched immediately for use on the Atlantic coastline in what was a botched series of communication errors between King and others, and the increased defense of North Atlantic interests was initiated (Blair 1996:458). By the end of January 1942, King emphasized that coastal communities begin to defend their coastlines, placing the importance of command on leaders of the "Coastal Frontiers" (Blair 1996:461). Political efforts to "blackout" the coastlines often met deaf ears; failure to decrease the illumination of the coastlines allowed for steady U-boat success along the Gulf Coast. One such effort, Operation Dimout, was enacted on 1 June 1942 by Major General Richard Donovan to cut city lighting from Texas to Louisiana. Though the efforts were clear for the purposes of protecting Allied shipping, highway lights still illuminated the coastline (Wiggins 1995: 88-89, 98). Merchant vessels were encouraged to navigate in a "zig-zag" pattern to avoid easy targeting by torpedoes that followed a straight trajectory. The Eastern Sea Frontier was the region commanded by Admiral Adolphus Andrews. Though the effort to organize counter-measures to the U-boat threat along the coast was in motion, Dönitz's U-boats succeeded in sinking 41 ships, or nearly 236,000 tons, in the first month of Operation Drumbeat (Blair 1996:475).

With the growth of tactical responses to U-boat attacks ranging from radar, Huff Duff (HF/DF or High Frequency direction finding utilizing radio triangulation), depth charges, sonobuoys, bombs, LORAN (Long Range Navigation, utilizing triangulation techniques with low frequency radio transmissions), MAD (Magnetic Anomaly Detector), and sonar plotting near the eastern Atlantic, the German successes in the west Atlantic provoked Hitler to follow Dönitz's directives in growing the U-boat fleet and attacking the U.S. coastline and Allied shipping (Blair 1996:492). The development of the Four Rota Enigma coding machine allowed the German fleet to continue to encrypt their transmissions and move undetected by Allied forces.

The importance of silence was crucial during this period, and U-boats would travel alone to ensure greater success and stealth (Blair 1996:495). By March 1942, the number of U-boats active on the southeast coast of the U.S. by this time had risen to 26, and successes began to increase as patrols were crediting higher kill counts to individual U-boat captains (Blair 1996:497). The Caribbean and southeastern U.S. was left without escorts or convoys though the importance of protecting the merchant ships influenced them to join convoys to the North (Felknor 1998:210). The United States armed these merchant ships with munitions, merchant marines, and armed guards, as the lack of convoy organization and military support in these regions was reduced because of their distance from German deployment zones (Felknor 1998:214-215). Dönitz saw opportunity in the warmer waters to the south as defensive mechanisms began to adequately protect Allied shipping along the United States' eastern coastline (Gannon 1990:268). As months progressed, German "Wolfpacks," or groups of strategically linked U-boats, began to sink larger numbers of merchant ships in the North Atlantic, and smaller numbers of U-boats were sent south where convoys were not utilized to protect Allied shipping. Among the 24 U-boats present in the Gulf of Mexico from March 1942 to August 1942 were *U-158* and *U-67* (Rohwer 1983) (Figures 10 and 11).

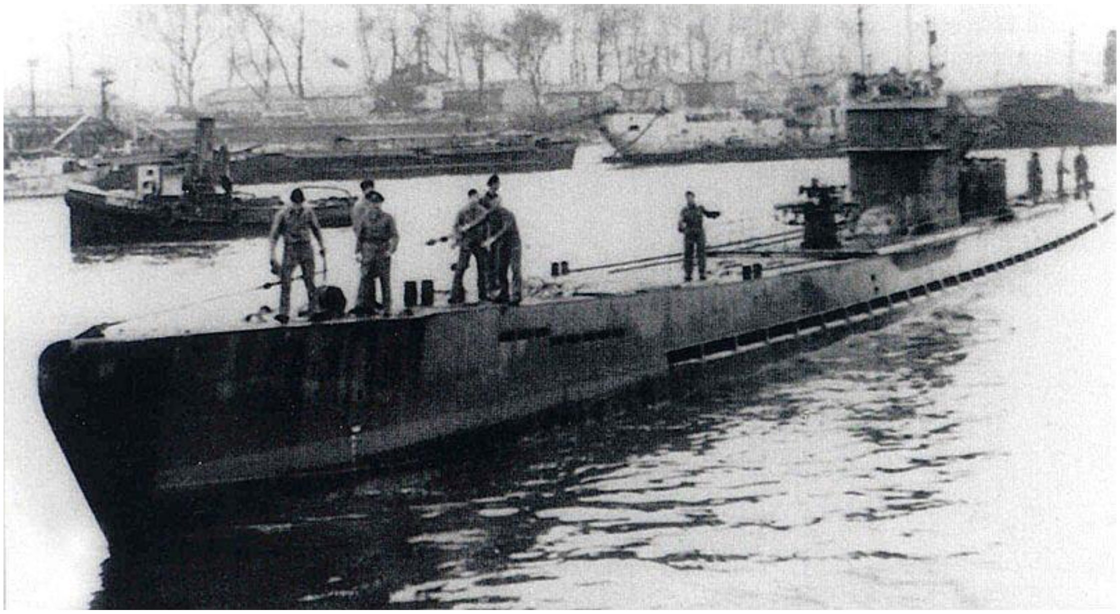


Figure 10: DKM *U-158* in port (Lettens 2009).

Figure 11: DKM *U-67* in Lorient, France, 8 August 1942, after its tour in the Gulf of Mexico (Wiggins 1995:105).

Figure 12: Kapitänleutnant Erwin Rostin of DKM *U-158* (Bredow 2012).

U-158 was under the leadership of Kapitänleutnant Erwin Rostin, a U-boat ace who had earned the *Ritterkreuz* (Knight's Cross) (Kurowski 1995) (Figure 12). *U-158*'s career ended with its final attack on the S.S. *Henry Gibbons* on 24 June 1942 when the submarine was attacked and lost in the Caribbean on 30 June 1942 (Blair 1996:612-613; Rohwer 1983:105; Rostin 1942; Wiggins 1995:91-93). *U-67* was led by Korvettenkapitän Günther Müller-Stöckheim who also earned the Knight's Cross after sinking over 100,000 tons of Allied shipping (Kurowski 1995) (Figure 13). Both captains' diaries were transcribed, translated, and studied for dates associated with the appropriate sinking event for each ship. The results of these translations will be discussed in later chapters.

Figure 13: Korvettenkapitän Günther Müller-Stöckheim on board his DKM *U-67* (Bredow 2012).

The unfortunate loss of many crew members serving on vessels contracted by the War Shipping Administration has been under-represented in historical reviews. Ample documentation exists on these men beyond ship manifests and casualty reports, though they have not been significantly cross-examined with many reports. Many family blood lines ended with a number of these individuals. The purpose of identifying the crew members who were killed or injured during the attacks is to exhibit the significance of these vessels as war graves on a national battlefield. The documents reveal a common lifestyle shared by men aboard these types of merchant ships. They were living in a way that kept them tied to the maritime industry for many years, continuing a trade that many individuals had developed over a lifetime. Many of those who were lost had also worked aboard the same vessels or with the same company on several previous voyages.

The Attacks

Cities Service Toledo was built as S.S. *J.A. Bostwick* in 1918 by Bethlehem Shipbuilding Company through its Harlan & Hollingsworth Corporations subsidiary in Wilmington, Delaware (USDC 1942:19, 544) (Figure 14).

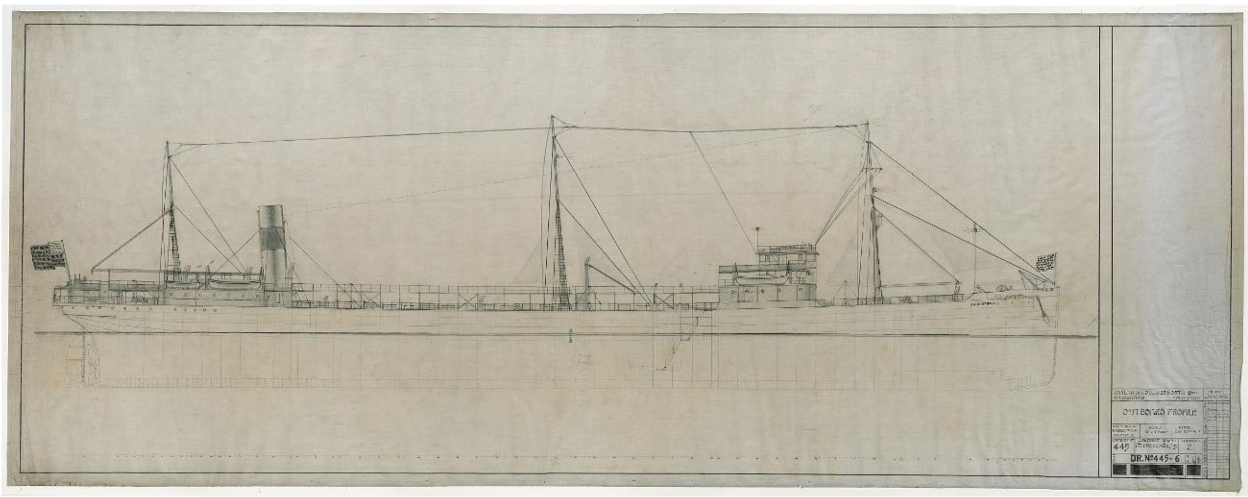


Figure 14: S.S. *Cities Service Toledo* (S.S. *J.A. Bostwick*) original ship's profile plan (Harlan and Hollingsworth Corporation (HHC) 1916). Image courtesy of the Hagley Museum.

The oil tanker was intended to carry oil and fuel along the U.S. coast and across the Atlantic. The ship was registered as an 8,192 gross ton oil tanker with the Department of Commerce, official number 216608 (USDC 1942:19, 544). The original single steam screw engine was replaced with an oil-burning 2,800 horsepower engine (USDC 1942:19). *J.A. Bostwick* was renamed *Cities Service Toledo* on 19 March 1929 and recommissioned to serve the Cities Service Oil Company[2] on 2 September 1936 (Bureau of Marine Inspection and Navigation, Bureau of Navigation (BMIN) 1929). The Cities Service Oil Company was based in New York at the time of sinking, and was carrying 83,000 barrels of crude oil from Corpus

2 The Cities Service Oil Company became CITGO in 1983, purchased by The Southland Corporation (PDVSA).

Christi, Texas to Portland, Maine during its final voyage (U.S. Coast Guard (USCG): 1942-1944a). This transport mission operated during Operation Dimout (Wiggins 1995:88-89, 98).

Cities Service Toledo was fully armed at the time of its sinking. The armament on this trade vessel is indicative of the emphasis on protecting petroleum supplies coming from the United States during WWII. These weapons were fitted under contract by the War Shipping Administration to combat the growing number of shipping casualties in 1942. This particular ship was fitted with a five-gun complement: one five-inch gun in the stern, two .50 caliber machine-guns, and two .30 caliber machine-guns (OCNO 1942a) (Figure 6).

U-158 reported the sinking of *Cities Service Toledo* on 12 June 1942. *U-158* had just recently successfully attacked S.S. *Hermis* and M/S *Sheherazade.* According to U.S. historical records, the oil tanker was hit by four torpedoes on its starboard side at approximately 02:00 on 12 June 1942. The first two struck amidships, followed five minutes later by two additional torpedoes (Powers 1942). The attack ignited oil in the holding tanks, which caused a fire that spread quickly throughout the ship (Powers 1942). Though caught off-guard, the crewmen were able to attempt a counter-attack. Three rounds from the five-inch gun were fired in retaliation, but the weapon's gears malfunctioned, forcing the gunners to abandon their counter-attack and jump overboard (Powers 1942). After burning for two hours, the vessel sank stern first (Powers 1942). All available life rafts along with two life boats were immediately destroyed in the fire, followed by a third life boat that was abandoned after igniting in the oily water (Powers 1942). Of the 46 crew members (including the navy gunners) present on the vessel at the time of the attack, 11 crew members (and four navy gunners) lost their lives (USCG 1942-1944a) (Table 6, Appendix A).

Eleven crewmen and four navy gunners were killed while serving on board *Cities Service Toledo* when it sank (Mason 1942; Moore 1983:483; Sanders 1942). Two crew members killed during the attack are additionally located in a previously documented crew list from 11 February 1942. Historic documentation reveals that 60 year old Ludwig Stockl, Boatswain, and 22 year old Harvey B. Jorgensen, Oiler, had previously served aboard *Cities Service Toledo* (U.S. Customs Service 1930). It is through examination of the documents that men such as Everett B. Hatch, who died on duty as a maintenance engineer during the attack, may be recognized for their service (USCG 1942-1944a).

Four of the lost crew members on *Cities Service Toledo* have census and other records available. Some still have living relatives, which aided in providing more detailed information for each individual. Two men that appear in the Federal Census are 20 year old Messman Thurlow J. Morkan and 36 year old Third Mate Early H. Rawls. Morkan is present in the 1930 census as the 8-year-old son of Irish parents in Manhattan, New York (United States Bureau of the Census (USBS) 1931). Rawls is identified as the 14-year-old son of a widowed mother, Frankie Rawls, in Smiths Station, Alabama, in the 1920 census (USBS 1921). One crew member, 26-year old fireman Edward Oppenheimer, appears in the Louisiana State Death Index for 1942. This is the only known public record of Oppenheimer. The record of 35-year old Everett B. Hatch, deck maintenance crewman, is present in both the 1910 and 1920 Federal Censuses (USBS 1913; USBS 1921). Hatch's engraved gravestone reveals that he is buried in a family grave plot with Lura Hatch Allen and Calvin B. Hatch (Lindsay 2010). His sisters, Frances J. Hatch and Charlotte Hatch were still living at the time this research was conducted, though they could not be reached for information regarding their relative, Everett.[3] Survivors of the attack: Charles Bobuk, Theodore Roosevelt Hall, and James Handy, appear in *Times Picayune* articles recalling the event that sank *Cities Service Toledo* on 12 June 1942.

Cities Service Toledo is now assumed to be at a depth of 29.57 meters (97 feet) of salt water (msw/fsw) in the Gulf of Mexico. Remote sensing data indicate that the vessel is approximately 120 meters (420 feet) long and 19.8 meters (65 feet) wide, with 8.5 meters (28 feet) of overall relief from the seafloor. The wreck is positioned approximately 67.6 kilometers (42 miles) south of West Cote Blanche Bay, Louisiana. A large breach around amidships is visible and the propeller and rudder is missing from the oil tanker. This damage will be shown and evaluated in later chapters. The propeller shaft projects from the hull where it meets its gear assembly within the vessel. Ship's plans and dimensions of *Cities Service Toledo*'s propeller and propeller shaft were found among historical documents held by the Hagley Museum and Library in Wilmington, Delaware (Harlan and Hollingsworth Corporation (HHC) 1916). A goal of archaeological dive teams was to establish solid diagnostics from various aspects of the hull and prop shaft dimensions. Upon comparison of diagnostics with the remote-sensing data, the application of the historical data reveals more to the ship than just what is visible underwater. The methods, results, and discussions of that goal will be discussed in the following chapters.

R.W. Gallagher was built in 1938 by Bethlehem Shipbuilding Corporation in Sparrows Point, Maryland for the Standard Oil Company (U. S. Department of Commerce 1942:52)

3 Note: The Hatch family information is available on the Hatch interactive family tree on http://www.ancestry.com, though the image of his head stone is omitted for privacy purposes.

(Figure 15).[4] As with *Cities Service Toledo*, the tanker was originally rigged with a steam screw and later fitted with an oil-burning 3,500 horsepower engine (U. S. Department of Commerce 1942:52). The ship was chartered to the U. S. War Shipping Administration in Newport News, Virginia, on 20 April 1942. The 7,989 gross ton vessel was carrying 80,855 barrels of Esso bunker fuel to Port Everglades, Florida, from Baytown, Texas, when it sank (USCG 1942-1944b; U. S. Department of Commerce 1942:52). At the time of the attack, the ship was fitted with six guns: one five-inch gun in the stern, one forward three-inch gun, two .30 caliber machine-guns on the bridge, and two .50 caliber machine-guns aft (OCNO 1942b) (Figure 5).

U-67 and survivors of the attack reported the sinking of *R.W. Gallagher* on 13 July 1942. *R. W. Gallagher* was the final kill by *U-67* before returning to Lorient, France, on 8 August 1942 (Wiggins 1995:98, 106). The tanker was struck by two torpedoes; the first hitting forward of amidships on the starboard side; the second striking forward of the engine room. A large fire erupted immediately following the first torpedo strike causing the oil within the tanker's hold to ignite and an explosion blew apart the starboard side of the vessel. It was reported that the fire was perpetuated by a degaussing equipment explosion that spread heated wires across the decks (Henderson 1942). Three life boats were destroyed, limiting the possibility of escape for the crew. Of the 53 documented crew members on board, nine men were lost, and the remaining crewmembers were rescued by the U.S. Coast Guard cutter *Boutwell* and by U.S. Navy planes (Henderson 1942).

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4 The Standard Oil Company shortened their name for their transport branding to "ESSO," and later re-branded their name to Exxon, eventually merging with Mobil to form ExxonMobil in 1999 (ExxonMobil).

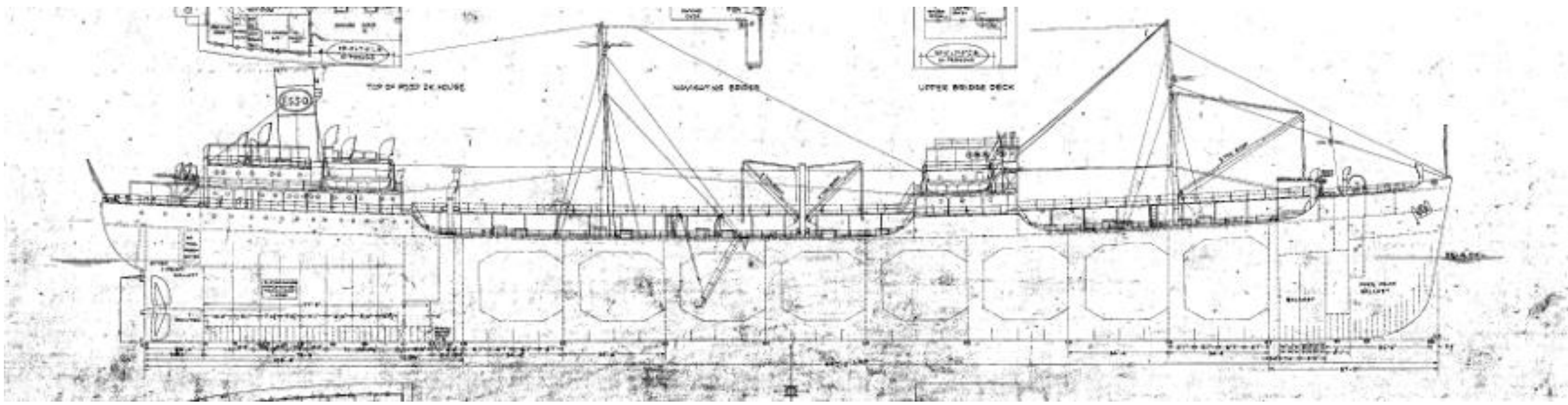

Figure 15: Segment of the S.S. *R.W. Gallagher* original ship's profile plan (Bethlehem Shipbuilding 1938). Image Courtesy of Avery Munson via Evans et al. *2013*.

Of the nine crew members that were killed aboard *R. W. Gallagher,* seven have publicly available records; all nine are listed in the table in Appendix A (Table 7). The casualties with no known available documents were First Assistant John J. Smart and Second Mate Frederick Austin. The Chief Mate, 45-year old Alexander S. Krass, was documented on the second to last voyage from New York on 22 June 1942 as a crew member (U.S. Customs Service 1942e). Daniel C. MacPhee, a 38-year old Able Bodied Seaman, was reported seriously burned during rescue, and died at Marine Hospital in New Orleans, Louisiana, on 21 July 1942 (Standard Oil Company 1946:357). The crew member with the most publicly available information was Herman W. Reuss, a 30-year old Able Bodied Seaman who died during the attack. Reuss' son, who manages a website dedicated to his father, details the history of the event that surrounded the death of Reuss on 13 July 1942 (Reuss 2007). The website includes a picture of his father standing with other seamen in Ambrose Light, New York (Reuss 2007) (Figure 16).

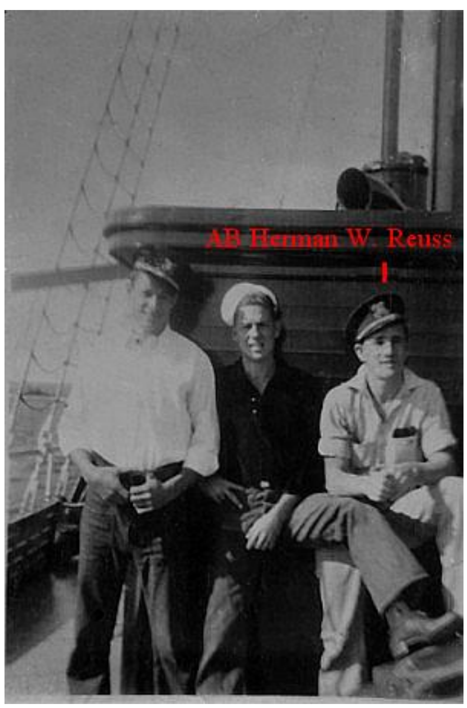

Figure 16: AB Herman W. Reuss sitting with fellow seamen in Ambrose Light, New York (Reuss 2007).

Four other crew members appear on the vessel's 22 June 1942 crew list: 43-year old machinist James C. Kennedy, 42-year old wiper Henry P. Miller, and 65-year old second cook Peles Donyoso (U.S. Customs Service 1942e).[5] Present on the 16 April 1942 crew list is 56-year old Oiler, Leonard E. Mills. Mills exhibits a pattern that some men continued their service with a single vessel through time (U.S. Customs Service 1942g) (Table 7, Appendix A).

R.W. Gallagher is presumed to rest in 30.48 msw (100 fsw) on the seafloor. The wreck lies approximately 72.4 kilometers (45 miles) south of the mouth of the Atchafalaya River. As mentioned earlier, *R. W. Gallagher* was more heavily armed than *Cities Service Toledo* by a single three-inch gun. Similarly, the armament on the *R.W. Gallagher* proved to be insufficient in protecting its crew or cargo.

Both *Cities Service Toledo* and *R. W. Gallagher* now lay face down in the sediment that makes up the seafloor. Although they are large vessels, longer than the depths at which they lie, they turned upside down during the sinking or settlement process. These vessels were specifically planned and shaped to efficiently cut across the surface of the ocean at maximum velocity right-side up like a bathtub, lending little to the interpretation of how they ended up lying in the opposite direction. This phenomenon will be better explained during the discussions chapter.

Theoretical Foundations

Battlefield archaeology is the term used for identifying key components that may isolate the process of conflict between two opposing sides. With this theory, several battlefields may

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5 Note: Mr. Donyoso's naturalization papers and passenger lists for *R. W. Gallagher* are also on file in the United States National Archives, he was a veteran crew member of the ship when it sank in 1942.

represent a similar pattern or similar behaviors, though they represent completely isolated events within one period of time (Sutherland 2005:2). Battlefield archaeology allows for a dynamic identification of the space and time relationship between archaeological remains, historical documentation, and the individual people involved on both sides of a conflict. Battlefield theory used here involves study using advanced analysis of and incorporation of similar WWII-era merchant vessel shipwrecks into a common distribution pattern. In 1939, the world was cast into a war centered in Europe, which is divided into several theaters, and by 1942 the waters along the eastern United States were subject to battles that ended in many casualties on both sides of the conflict. The two WWII ships in this study served an essential purpose in bridging a connection to the various political and economic systems present at the time. The general patterns they followed fall under what Scott et al. (1989:5, 6) explain as the special rules and paradigms that humans characterize in their most destructive state of war. These patterns are clearly represented in the historical documentation of zig-zag patterning, near-shore shipping lanes, and blackouts like Operation Dimout which attempted to protect targeted ships from being attacked. Conversely, the direct actions of U-boat captains are recorded within their war diaries at the time of action and represent a broad pattern of German military movements in the Gulf of Mexico as well as individual actions that can be verified archaeologically. The complex relation of the variables discussed above takes the analysis of documents and artifacts to the next level of interpretation. As with other shipwreck analyses, behavioral distinctions can be made from the archaeological record by understanding the patterns behind material remains (Gould 1983:134). Taken one step further, these types of maritime battlefield sites exhibit expansive areas of conflict-induced war graves. By isolating these two vessels as battlefields and extending the value of their interpretation to other merchant marine casualties in the Gulf of Mexico, a broader interpretation of the Gulf of Mexico as a theater of war, the location of 52 specific battlefields and inherent war graves can be made (Rohwer 1983; Wiggins 1995) (Figure 17).

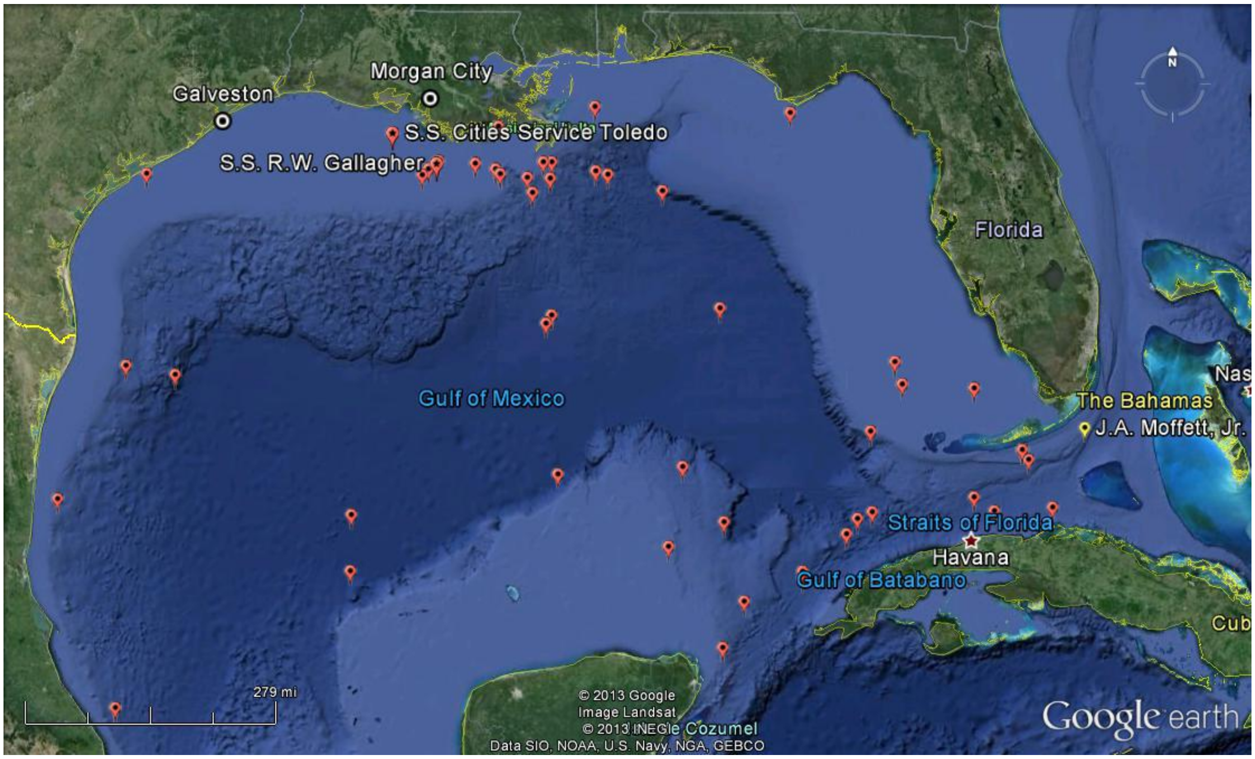


Figure 17: Map of each of the 52 recorded sunken merchant vessel sites (Note that the S.S. *J.A. Moffett, Jr.* was towed in to port, but its point of sinking is still demarcated) in the Gulf of Mexico in 1942. These sites should all be considered war graves and qualify as battlefield sites from World War II (Locations drawn from Rohwer 1983 and Wiggins 1995 documented locations).

As the threat of marine attacks was present along the east coast of the United States in 1942, perseverance and industrial production led to two examples of battlefield casualties that represent both a gross and dynamic aspect of the American and German conflict during World War II. To accomplish the task of defining these sites as battlefield sites using battlefield theory, the theater of war present in the Gulf in 1942 must be defined as a series of marine battlefields. Examples drawn from Civil War and terrestrial battlefield archaeology provide a basis for identifying the Gulf of Mexico as a theater of war and, by proxy, each individual wreck (or several related wreck sites in an area) associated with a military encounter by merchant ships in 1942 may be considered the location of a battlefield (Andrus 1999; Commonwealth of Virginia 2009; Conlin and Russell 2006; Hiatt 2003; NPS 2009; Scott et al. 1989). Though the current theory in explaining battlefield events occurs over large parcels of terrestrial land, isolating military strategy via OCOKA[6] philosophy and written documentation, this cross-disciplinary strategy is beginning to be applied to marine battlefields. Once the initial definition of the Gulf of Mexico as a theater of war is established, the two sunken vessels, *R.W. Gallagher* and *Cities Service Toledo,* will serve as "Study and Core Areas" to represent the location of two separate battlefields within that theater (Commonwealth of Virginia 2009:14).

In the case of this study, the Gulf of Mexico will serve to confine the battlefields to a specific region that is notably different than other regions in strategy and conflict behaviors. The confinement of these battlefields should be specified as being part of the "theater" of the Gulf of Mexico. To better define the boundary of a battlefield under these standards, the Civil War Sites Advisory Commission (a division of the National Park Service) coined the terms "Study Area" and "Core Area" in 2009 to help identify larger themes associated with battlefield sites. A Study Area is defined as "the historic extent of the battle as it unfolded across the landscape," and a Core Area is defined as "the areas of fighting on the battlefield" (Commonwealth of Virginia 2009:14). The battleground theoretical basis must first begin with establishing the Study Areas in the Gulf of Mexico as the area surrounding where the ships currently lie on the seafloor. Utilizing the historic German grid coordinates for the location of the attacks and the sightings

6 OCOKA is an acronym meaning: O – Observation and Fields of Fire, C – Cover and Concealment, O – Obstacles, K – Key Terrain, A – Avenues of Approach (NPS 2009)

will serve to adequately define this area as 123.48 km^2 (66.67 nm^2) (Rohwer 1983:380-381). The Core Areas are defined as the immediate location of the shipwrecks as they lie today, along with their surrounding associated debris field. The Gulf of Mexico served as a specific theater of war, definitively isolated by the *Kriegsmarine* and subsequently the War Shipping Administration. Therefore, the broad context of establishing battlefield engagement points as Study Areas, then further isolating the integral remains of the battlefield as the wreck sites and their surrounding areas as the Core Areas is justified under the same standards used to set up National Register Boundaries by the National Park Service's American Battlefield Protection Program (Andrus 1999). The Study Area for these two particular wrecks is limited to the specific geographical region in which each attack took place; in this case, latitudinal and longitudinal locations in conjunction with U.S. Government-owned lease blocks form the ideal modern boundary of these areas.

These larger areas of water within the Gulf Theater where specific military engagements took place are a part of “gross patterning” associated with battlefield sites (Scott et al. 1989:147). Gross patterning seeks to identify broad identifications such as “archaeological identification of battle events, that is, combatant positions and the correlation, to the extent possible, of these phenomena with the historical record” (Scott et al. 1989:147). This only sets up the primary purpose of further isolating the current spatial organization of remains for each vessel as the Core Area. These centralized wreck locations form the premise for explanations of “dynamic patterning” outlined by Scott et al. when investigating the Battle of Little Bighorn (1989:148). Dynamic patterning is defined by Scott et al. as the analysis that “allows confirmation, modification, or refinement of the behavioral-spatial nature of battle events observed in gross patterning... provid[ing] the basis on which these events can be sorted in time. The key to dynamic patterning is based on modern firearm-identification methods that allow resolution of individual positions and movements across the battlefield" (Scott et al. 1989:148)

Understanding the concept of gross patterning is important when explaining how these areas may be considered battlefields. In 2006, Conlin and Russell took the concepts of this theory and applied it to the battle of the C.S.S. *H.L. Hunley* and the U.S.S. *Housatonic* (Conlin and Russell 2006). Conlin and Russell establish that identifying archaeological evidence through observation can lead to hypotheses on what tactics were used and if these hypotheses concur with historical documentation (Conlin and Russell 2006). This method of analysis leads to the same isolated observations made for the Study and Core Areas surrounding both *R.W. Gallagher* and *Cities Service Toledo*. Both remote-sensing and diver observed data remain contiguous with static interpretation of these sites in comparison to historical records and will be discussed later.

In the official report presented by Hiatt in 2003 on the Guilford Courthouse site, broad "sectors" of government-owned property can be effectively utilized to encompass several battlefields for purposes of protection and public interpretation (Hiatt 2003). In this case, the Guilford Courthouse battlefield was studied as a landscape of a 320 acre battle (Hiatt 2003:1). The current 220.25 acre park was absorbed as the city's property in 1984, and has been managed by the city for nearly 30 years (Hiatt 2003:1). As part of a developing part of the city of Greensboro, North Carolina, the site is being protected as a battlefield site, which allows for particular protection of the resources associated with the Guilford Courthouse battlefield site (Hiatt 2003). It is unequivocal that the two marine sites discussed in this study also rest upon government-controlled submerged lands and are not limited to these two particular wrecks, but expand into a larger protection area for a number of property sectors that contain WWII battlefields in the Gulf of Mexico. The ultimate conclusion that these sites are representative of

WWII battlefields is first established through the broader context of occurrences within the shipping lanes of the Gulf.

The historical events that led to the formation of the battlefield sites in this study also provide a background for creating a dynamic patterning of the sites' conditions to explain the specific tactics used by individuals associated with the battlefield. The dynamic patterning structure, originally developed by Scott et al. (1989) to illustrate individual movements of opposing sides to explain the entire Battle of the Little Bighorn through time, cannot be established on Conlin and Russell's investigation of *Housatonic* because of the limited amount of documentation that could further be “temporally” linked to the events that are seen archaeologically (Conlin and Russell 2006:22). However, the dynamic patterning structure is potentially attributable to the two WWII battlefields in this study because of the wealth of historical and archaeological data available. In fact, the type of patterning presented in the Conlin and Russell study shows that the methods in which they produced the historical corollaries that isolate the cause of the *Housatonic*'s sinking is satisfactory enough to delimit the area to being a battlefield (Conlin and Russell 2006:22). The synthesis of facts that is produced through the investigation of the two oil tankers in this study explains the passage of time at the Core Areas of the two sites. This thesis possesses enough strength to not only determine the events that took place during each sinking, but the convergence of the historical documentation with archaeological data provides information about previously unclear individual actions during the attacks. This relationship provides a pattern that helps to flesh out the timeline of activities that occurred in relevance to the battlefields. Furthermore, dynamic patterning would be consistent with identification of the wrecks, had there been sufficient time to determine if War Shipping Administration armament was present on these vessels. The reasoning behind this would be the capability to isolate the type, year, and model of weaponry mounted to each vessel. This specific identification would create a broader dynamic pattern that could then be cross-examined with other WWII casualties in the Gulf of Mexico sunk by U-boats.

This research utilizes the emphasis placed on oil shipping by highlighting the perceived need to protect United States' petroleum and the behavioral traits of government action in relation to the events that took place prior to and following the sinking of each vessel. The result supports battlefield theory in being representative of conclusive broad patterns that both military powers and individual crew members represent when faced with a violent event. Using several documentary resources, the written record aids in interpreting the condition of the archaeological remains present on the seafloor. The United States' and German wartime behavior will therefore be explained in relation to how it is expressed materially. The combination of historical documentation with physical site remains poses a significant benefit, as archaeological data alone does not have temporal (time-oriented) consistency. Through this theoretical section, the goal is to provoke awareness of the convergence of fact that occurs within the patterns of human activity on this type of marine battlefield. The results and conclusions are only an indication of the likelihood of the identification of these vessels, and the raw data suggests how these data line up with historical documentation, thus aligning the distributive patterns that battlefield sites exhibit. By recording the findings and creating a publicly accessible report, the multi-disciplinary approach used here will lend itself to the protection of these and other similar wrecks as battlefields.

Historical accounts and records are located across major archives that store documentation of government ship reports. By associating these sites as military battlefields, a goal of expressing the significance of these vessels to United States history can be accomplished and their ultimate importance to families and communities may be adequately expressed. Applying an anthropological analysis to these vessels is not limited to just individual patterns, but the patterns that can be drawn from analysis on WWII in the Gulf of Mexico in general. These ships were transformed from shipping vessels to battlefield landmarks, much like the evolving representation and honor bestowed upon the "hallowed ground" of Gettysburg (Andrus 1999; Spooner 2010). The analysis of these wrecks demonstrates the dynamic nature of maritime culture in the United States through researching their original histories to observing their archaeological context in a comparative relationship.

In regards to establishing a comparative relationship, comparisons between contemporary studies makes this study more comprehensive. In the following chapter, the connection between this study and previous research projects will be made clear. A better understanding of WWII battlefield sites has been established by identifying the many projects that have been conducted in the Gulf of Mexico over the last three decades. The battlefield theoretical perspective becomes more thorough in this study by establishing a connection between *R.W. Gallagher* and *Cities Service Toledo* to other similar wrecks in the Gulf of Mexico. These connections begin with research that has been conducted under contracts with MMS, BOEMRE, and BOEM in the past. Though these projects involved other wrecks, the baseline model for battlefield explanations is established through these cross comparisons.

CHAPTER III: RESEARCH BACKGROUND

Previous Investigations

The philosophy of researching cultural heritage and biological ecosystem protection continues to influence many projects in the Gulf of Mexico today as major oil-drilling projects and fishing lanes significantly affect the integrity of these resources. With the advancement of technology, remote-sensing can provide computer-generated imagery that minimizes any direct site impact involved with these projects. In the realm of archaeological shipwrecks, sites serve as artificial reefs, ecological habitats, fishing spots, and important reminders of aspects of United States history. This thesis focuses on the archaeological aspects of cultural resources in the Gulf of Mexico. In addition to the protection of resources, war graves such as WWII U-boat victims may be adequately documented and honored in their resting place with these types of research projects. Engaging in proactive studies and protection programs aids in managing these sites and protecting them from looting.

Researchers and government agencies like BOEM and BSEE improve upon understanding of a catalog of shipwrecks in the Gulf of Mexico (Bureau of Ocean Energy Management (BOEM) 2012). Acoustic technologies allow better imaging than ever. Optical imaging brings high-definition images to a screen hundreds of meters away. Global Positioning Systems (GPS) and Geographic Information Systems (GIS) technologies are being used more in everyday practice. Computer programs are becoming more sophisticated to better analyze and interpret strings of complicated data. Lastly, Remotely Operated Vehicles (ROVs) are able to take human researchers to places that no one has ever imagined possible before. It is through maritime archaeology that this technology is paving the future for investigating the greatest technology of the past. Using these facets of survey, data collection, and analysis, World War II battlefield shipwrecks in the Gulf of Mexico leads to effective research and growing capabilities in future archaeological studies on the subject.

Reconnaissance and archaeological investigations have been conducted on *R.W. Gallagher* since 1984. It was also observed, in a navigation hazard mission after the sinking, that an oil slick spanned several miles from the wreck's location (Henderson 1942). The wreck was first reported by local fishermen to MMS, and the first geophysical survey of the site was performed in 1989 by John Chance (Evans et al. 2013:33). The MMS analysis identified the wreck as the S.S. *Heredia*, later to be corrected in 2010 (Evans et al. 2013:33; Floyd and Callahan 1989) (Figure 18).

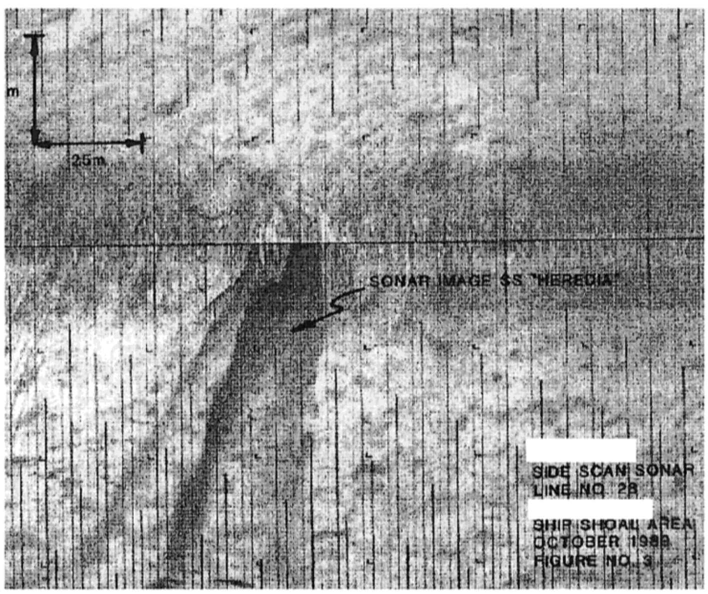


Figure 18: Side-scan sonar image from the 1989 survey of the area near the proposed S.S. *R.W. Gallagher* that named it the S.S. *Heredia* (Floyd and Callahan 1989).

The United States Coast Guard contracted divers to repair an oil leak reported to be coming from the vessel in 1992, though the vessel was still identified as the *Heredia*. (Christ 2005:93; Evans et al. 2013:33; Treadway 1992). Oil was also discovered to still be leaking from the vessel during dive operations in 2010. A thin sheen was documented as visible for several miles by dive crews during this study. Cochrane Technologies, Inc. conducted a geophysical lease survey for MMS in 1996, and their report indicated that the vessel was either *R.W. Gallagher* or *Heredia*, both of which sank in the same general vicinity. In their report, they indicated that remote sensing data revealed diagnostic elements such as deck railings on the 137.16 m (450 ft.) long 18.29-22.86 m (60-75 ft.) wide wreck site (Saltus and El Darragi 1996). This study included the use of echosounder, magnetometer, and sub-bottom profiler, which provided very poor imagery for the site, aside from identifying the 7.01 m (23 ft.) of relief that the site created on the seafloor (Saltus and El Darragi 1996) (Figure 19).

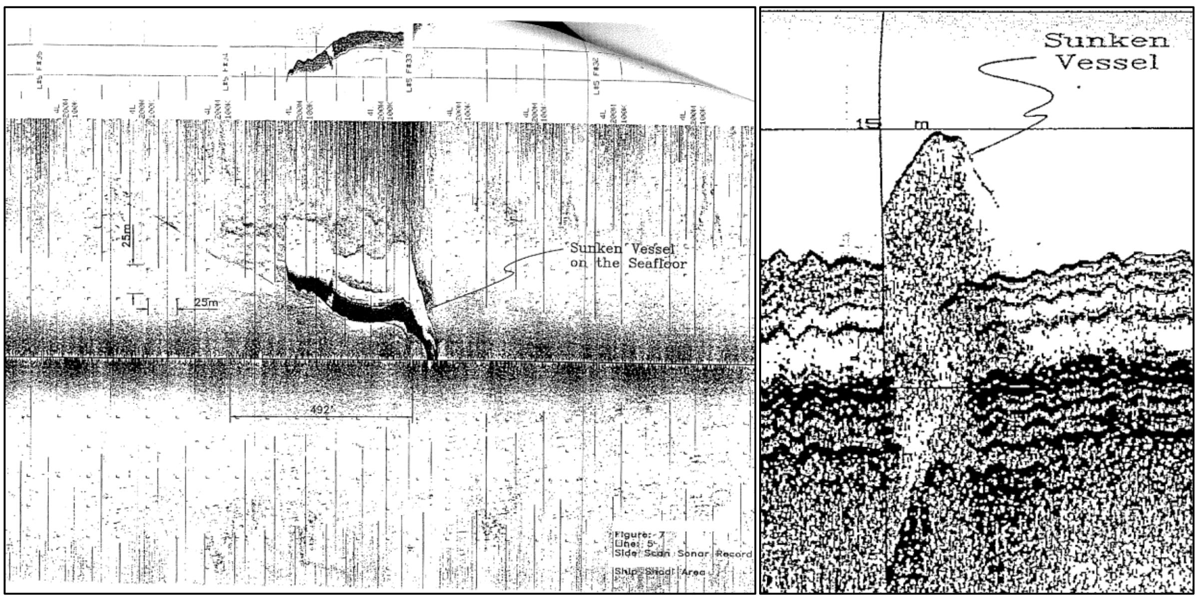


Figure 19: Side-scan sonar and sub-bottom profiler images from the 1996 survey of the area near the S.S. *R.W. Gallagher* (Saltus and El Darragi 1996).

Cities Service Toledo was discovered by Laura Landry and Jeffery Thomas during a geophysical lease survey in 2002. Through magnetometer and side-scan sonar survey, the Landry and Thomas' report indicated that a 128.02 m (420 ft.) long, 19.81 m (65 ft.) wide, 8.53 m (28 ft.) high shipwreck was detected lying hull-up on the seafloor (Landry and Thomas 1992: 20). The report offers contrasting information regarding the length of the vessel (it is also mentions a dimension of 137.16 m [450 ft.] for length) and only briefly mentions the possibility of this as being a U-boat victim (Evans et al. 2013:60). The BOEM database indicates that the site had previously been identified in the 1970s by recreational divers. The informant, C.J. Christ, reported that the *Cities Service Toledo* had been identified to them by local fishermen. He also described the vessel as single-screw driven, missing its propeller, but possessed an intact rudder (Evans et al. 2013:60) (Figure 20).

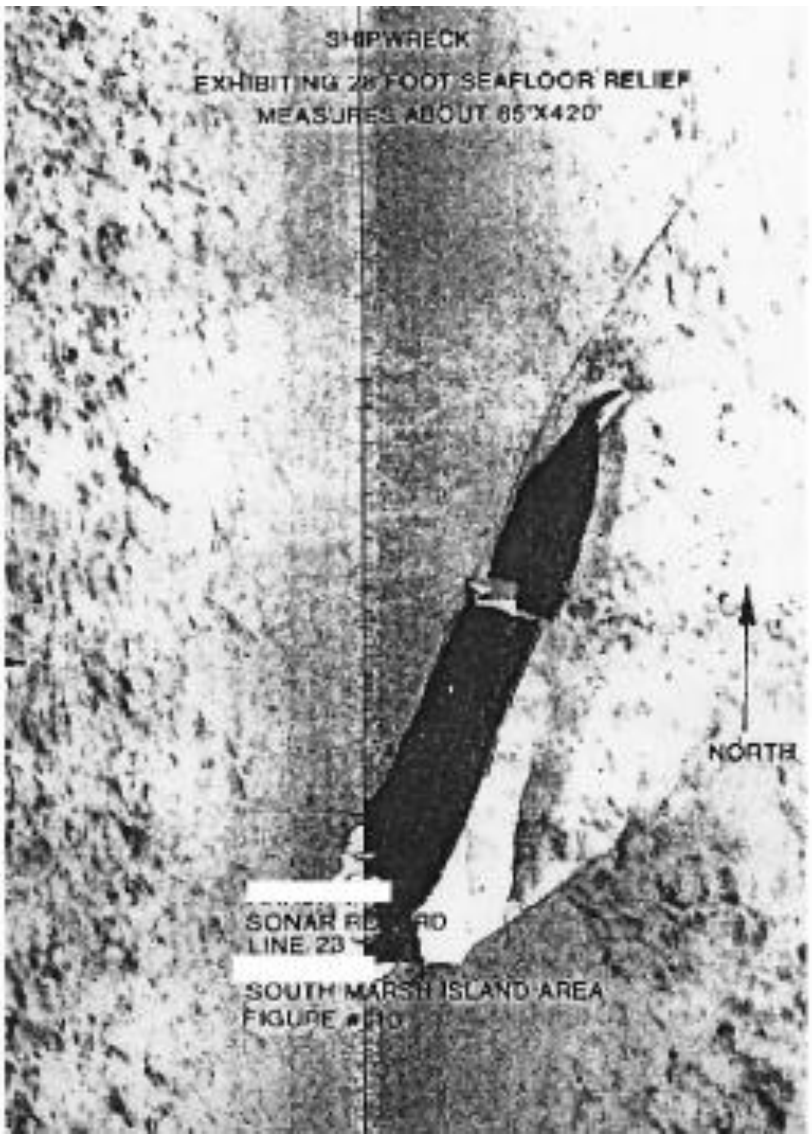


Figure 20: Side-scan sonar image from the 1992 survey near S.S. *Cities Service Toledo* (Landry and Thomas 1992).

Additional studies of WWII sites include evaluations of several shipwrecks in the Gulf of Mexico for their importance to the cultural heritage dominating the continental shelf (Enright et al. 2006). This PBS&J report provides insight into how each of the sites was remotely located, previously documented, and analyzed. As a comprehensive study of environmental, biological, and contextual elements that surround the wreck sites, the report provides clarity as to how the ships varied in historical significance and how they represent cultural features along the United States' Outer Continental Shelf today.

Most notably, in relation to *R.W. Gallagher* and *Cities Service Toledo,* the study began with the utilization of remote-sensing technology to locate anomalies that could then be investigated by divers or ROVs. Side-scan sonar and magnetometer were used, and the differences in the capabilities of technology in five years are apparent with the Tesla Offshore project in 2010, which used more sophisticated remote-sensing equipment. The study set an important precedent for activities that would continue in the Gulf of Mexico under contracts and environmental assessment surveys as the oil industry grew throughout the decade.

Several vessels in the PBS&J study are contemporary to the vessels investigated in 2010, and S.S. *R.M. Parker, Jr.* is among them. *R.M. Parker, Jr.* was an oil-burning 7,000 gross ton oil tanker built in June 1919 in response to the need for cargo ships during World War I (Enright et al. 2006:43). As a surplus tanker built at the end of the war, it was contracted and commissioned for transport throughout the Atlantic Ocean and Gulf of Mexico by several companies. As WWII approached, the vessel was contracted by the United States via the Merchant Marine Act of 1936. *R.M. Parker, Jr.* met a similar fate as *R.W. Gallagher* and *Cities Service Toledo* when it was torpedoed off the coast of Louisiana by DKM *U-171* on 12 August 1942. The attack occurred while *R.M. Parker, Jr.* was carrying only ballast and crew without an escort (Enright et al. 2006:46-47). In the PBS&J study, project archaeologists were able to narrow down the location of the *R.M. Parker, Jr.* by examining and cross-referencing locations and reports in a way that aided with the 2010 study of *Cities Service Toledo* and *R.W. Gallagher*.

The PBS&J diver investigation of *R.M. Parker, Jr.* began with interpretation of the side-scan data they had previously collected at the site location to determine its current condition. Analysis of remote-sensing data by the archaeologists allowed them to determine that, due to the nature of the explosive and cargoless sinking event, the vessel split transversely (port to starboard) at amidships, leaving the aft portion of the vessel upright and the forward section listing to starboard. Though a keel-down condition is preferable in identifying superstructure and equipment present on a vessel, the upside-down condition of *R.W. Gallagher* and *Cities Service Toledo* also exhibits several identifying features. An important note on the findings of the PBS&J study of *R.M. Parker, Jr.* is that no deck guns were located and evidence of torpedo damage was not clear after remote-sensing and diver ground-truthing. The resulting National Register nomination was deemed appropriate based on historical documents, location, and the remote-sensing with diver ground-truthing alone; factors of historical cultural remains such as deck guns and torpedo-blast remnants were not necessary for inclusion (Enright et al. 2006:56).

Additionally in the 2006 PBS&J study of shipwrecks in the Gulf of Mexico, the WWII tanker *Sheherazade* was studied and potentially identified through field investigations. The surprising similarities of this wreck in its current condition, its sinking event, and its time of sinking compared to *R.W. Gallagher* and, more importantly, *Cities Service Toledo* are beneficial to understanding the effect of time, environment, and archaeological processes surrounding these types of sites. In fact, the U-boat that sank *Sheherazade, U-158* commanded by Rostin, was the same U-boat that sank *Cities Service Toledo* the next day. Both merchant ships lay upside-down underwater within 6.1m (20 ft.) of the same depth and express similar torpedo-blast holes in their outer hulls (Enright et al. 2006:79).

A very large vessel, *Sheherazade* was a 12,217.06 metric ton (13,467 gross ton), twin-screw, diesel-powered oil tanker built in 1935 in Le Trait, France (Enright et al. 2006:85). This ship was boasted as the biggest tanker in the world at 175 m (574 ft.) in length, 21.92 m (71ft 11in) breadth, 9.42 m (30 ft. 11 in) draft, and 16,810.13 metric tons (18,530 deadweight tons) (Enright et al. 2006:85). Interestingly, this vessel was a part of an unspoken competition among shipbuilders to see who could construct the largest oil tanker on the planet (*Dothan Eagle* 1950:1). The United States had already taken requisitioning actions with 84 voluntary inactive ships by presidential order on 8 September 1939, months before the turmoil that led to the takeover of France by a German-controlled Vichy administration. *Sheherazade*, representative of this class of vessel, was seized by the U.S. Coast Guard 18 November 1941 and contracted for use under the War Shipping Administration 7 February 1942 (Enright et al. 2006:89). The tanker then served Allied shipping interests fitted with a three-gun compliment: one 4-inch breech-loaded .50 caliber gun, and two Browning .50 caliber machine-guns. Fifteen armed Navy guards were also provided to protect the merchant ship. The vessel was serving Allied shipping interests at the time of its sinking, 11 June 1942 (Enright et al. 2006:90).

Sheherazade was sunk in a very similar fashion to that of *Cities Service Toledo*, which allowed researchers to study similar conflict patterns exhibited on the two vessels. Historic documentation regarding the attack on the *Sheherazade* reveals that the methods Rostin used in attacks against Allied shipping in the Gulf of Mexico were specific and repetitive. The fact that Kapitänleutnant Rostin's personal war-diary is available for verifying these accounts allows researchers to make these assertions and cross-reference physical evidence for torpedo attacks to the historical record. In the case of the *Sheherazade*, the U-boat commander fired three torpedoes amidships, blowing open the oil-filled cargo holds. He followed up with surface deck gun bursts to complete the destruction of the ship (Enright et al. 2006:92). An important similarity between the two different attacks is the fact that Rostin circled the sinking vessels to perform what loosely translates to a *coup de grâce* against the disabled ship, an important fact that will be discussed later. Additionally, both recorded attacks appear to disregard crew members' lives as they were abandoning the tankers. In comparison to the number of crew fatalities previously noted on *Cities Service Toledo,* the *Sheherazade* only lost Second Cook Thomas Chapman during the engagement (Enright et al. 2006:92).

In a second study conducted in 2007, Robert Church with the Partnering Anthropology with Science and Technology (PAST) foundation examined several historic wreck sites using a complex multi-disciplinary approach. While examining each wreck site's environment, geology, biology, formation process, history, likelihood of being previously recorded wrecks, and remote-sensing with diver investigation results, the study sets a unique standard for future research projects to improve upon. Of the seven individual sites investigated during this study, six of the wrecks are relevant to WWII history and research. In addition to the historical investigation performed on these vessels, environmental and chemical analyses supplemented the archaeological research. This report successfully demonstrates the possibilities of research in the Gulf of Mexico on deep or shallow WWII-era battlefield sites.

Church's objectives involved identifying the importance of WWII shipwrecks in the Gulf of Mexico. There were specific archaeological objectives including identifying individual wrecks, determining their current and past conditions, assessing impacts contributing to site deterioration, and considering their eligibility for inclusion on the National Register. The next set of objectives are delimited by biological processes involved with the site, how the environment surrounding each site is characterized, determining the importance of these wreck sites as artificial reefs, and to see the success or failure of living ecosystems in the shipwreck areas (Church et al. 2007a:1). These two sets of objectives make up a significant portion of studies that take place in the Gulf of Mexico today, and this study is not an isolated report. In fact, the study of *R.W. Gallagher* and *Cities Service Toledo* are related through time and space via the significance of the shipwrecks to United States history, and they differ only by the environmental study that was conducted by Church (Church et al. 2007a:1-2).

In Church's particular study, the use of an array of several remote-sensing tools ranging from GPS to ROVs shows that remote-sensing survey is essential in the archaeological analytical process. The study utilized the operation of an ROV to gather data on deeper sites since the depths in which the shipwrecks lie prevented safe diver investigation. The benefit of using the ROV was increased bottom-time, which increased the number of relative tasks that could be performed during each deployment. The ROV documented sea and sediment conditions, retrieved water samples, collected sonic data via a mounted sector-scanning sonar, and took video of wreck, sea, and environmental features.

A potential issue that faces individuals studying dissolved oxygen collected remotely is the risk of contamination after removal of the water from its natural environment. The Church study utilized a Seabird Seacat Conductivity, Temperature, and Density (CTD) profiler with a dissolved oxygen sensor to counteract the issue of possible contamination (Church et al. 2007a:14). The CTD profiler was able to measure temperature, salinity, density, and dissolved oxygen in real-time on each site, providing several strings of redundant information. This process is preferable when conducting this type of analysis. Core samples were also taken by the

ROV using a push core sampler, and placed within a basket of other data samples taken from the site. Biological traps were laid around the sites to sample local fauna. In addition to the previously mentioned survey techniques, the study employed the use of side-scan sonar, magnetometer, subbottom profiler, echosounder, and video footage as remotely gathered information used in analysis (Church et al. 2007a:15).

The archaeological and biological methods used by the team placed priority on identifying unknown vessels, mapping and documenting the current condition of each site, creating a complete site plan, measuring the effect of biological and chemical processes on the degradation of metals, as well as study specific biological life formations on or around each wreck. The use of the ROV for accurate documentation of the site involved fly-overs with video and still photography in 15 m (49.21 ft.) transect lines from 1-3 m (3.28-9.84 ft.) above the seafloor (Church et al. 2007a:16). This method was conducted to mosaic the entire site boundaries for later documentation. The team placed several metal "coupons" around specific locations at each wreck site to measure the rates of microbiological decay processes occurring on the different types of ship materials commonly found on wrecks in the Gulf of Mexico. The study had particular interest in the effect of oxidation on shipbuilding materials, and the effect of electro-magnetic force (EMF) on the rate of material degradation of these materials (Church et al. 2007a:16-17). Biological batteries (containers for the previously mentioned coupons) were deployed near several materials to simulate the effect of these EMFs from electronic components present on shipwrecks from the WWII era. EMFs are of particular interest for studies involving the degradation of specific metals or the growth of specific biological masses on those metals over time. Sediment cores were used for their ability to trap and investigate invertebrate life. Ichthyologic observation by the ROV and through fish traps also revealed important information on the ecosystems created by these sites. Sediment cores were also able to detect hydrocarbon levels present in the sediment. Each core was tested for levels of benzene, ethyl benzene, toluene, xylene, hydrocarbon C6-36, and total petroleum hydrocarbon content (Church et al. 2007a:26). These tests differ from the testing conducted during the 2010 Tesla Offshore study in the fact that the cores were detecting materials that could indicate well leakage or isolate areas of potential interest for drilling activities.

The first relevant WWII wreck investigated in this study was the S.S. *Virginia*. Constructed in Norfolk, Virginia, this 152.8 m (501 ft.) long, 21.3 m (69.8 ft.) wide oil tanker was carrying 180,000 barrels of gasoline on its final voyage (Church et al. 2007a:27). As it traveled from Baytown, Texas, to Baton Rouge, Louisiana, it stopped momentarily to pick up its pilot to navigate the mouth of the Mississippi River with the cargo of fuel. The historical account made by the pilot reveals that torpedoes were fired beneath the pilot boat while unloading the captain. Much like the events that sank *R.W. Gallagher* and *Cities Service Toledo, Virginia* was engulfed in a gasoline-fueled fire that made escape for the crew nearly impossible. As an effective cross-referencing technique used by Church in his study, the German war diary of DKM *U-506* revealed that the responsible U-boat captain was Korvettenkapitän Harro Schacht from *U-507* (Church et al. 2007a:28). The value of the available German war diaries to studying these types of vessels is unmatched when trying to identify a sunken oil tanker in the Gulf of Mexico.

In the particular survey that identified the current location of *Virginia*, several methods were used to analyze its current condition. Geophysical analysis conducted in 2003 by Marmaduke indicated that a massive sediment flow was causing the location of the wreck site to move along the seafloor. By 2006, the location of the site seems to support this theory in the fact that the ship's location had migrated 365.76 m (1,200 ft.) down-slope from its initially recorded position before hurricane Ivan struck in September 2004 (Church et al. 2007a:28). If the impact of natural events and sediment movement along the seafloor has had significant impacts on wreck sites like this, the primary focus of researchers should be to document and monitor their condition regularly. In the Secretary of the Interior's standards for preservation, sites like this, "[d]epending upon existing conditions and the results of the site inspection, field monitoring may be required. Field monitoring can include... temperature monitoring, documentation of structural movement and vibrations, light level monitoring, and other environmental monitoring" (NPS 2012). This wording is important in regard to sites that hold significant historical value, serve as a place of war casualties, and are impacted as significantly as these shipwrecks are by natural and commercial activities. The intention of this thesis, this study, the research performed on PBS&J's previously cited report, and Church's study, is to protect these very WWII shipwrecks in their current environments, as well as monitor environmental and site integrity changes through time.

As a part of the initial investigation performed by Church on *Virginia*, site conditions, artifacts, and integral structure were recorded and detailed in the report. All of these findings were included in the nomination process for the inclusion of *Virginia* on the National Register of Historic Places. As will be discussed later in the results and discussion chapters, the environment surrounding the *Virginia* resembles that of *R.W. Gallagher* as well as *Cities Service Toledo*. The flocculated sediments suspended in the water column caused poor visibility near the seafloor surrounding the wreck. The site lies in an average of 26.52 msw (87 fsw), well within physical dive limits for scuba divers (Church et al. 2007a:31). Though diving was conducted on the site, the use of the ROV provided longer bottom-time and recorded visual inspections that could be revisited several times later for further analysis. Another contemporary issue that all vessels in this region of the Gulf of Mexico face is the intrusion of fishing nets and entanglement hazards from the fishing industry. These hazards pose a significant risk to ROV equipment and human divers. The risk associated with entanglements can be minimized with adequate training or by avoiding close contact with particular hazards by divers or ROV pilots. In the case of *Virginia*, minimal video was taken due to these dangers.

Mosaic images and site maps of diagnostic features, such as the ship's telegraph, provide significant information for archaeologists to make deductions on overall site integrity. In fact, it was determined by the C & C group in Church's study that the site was in a state of very poor preservation (Church et al. 2007a:34). Some of the most valuable information gleaned from the *Virginia* was the effect of biological processes on the site. Rusticle growth accounted for approximately 10-15 mm (0.39-0.59 in) of the surface of the iron-composed wreck site (Church et al. 2007a:35). Though the growth was found covering the entire site, a lack of significant concretions or solid destructive elements indicates that the integrity of the metal on the site was less of an electrolytic process of degradation and more a rate of biological degradation. The results from the biological study of *Virginia* revealed that a high amount of coral growth, meiofauna (small animals), and macrofauna (large animals) had successfully colonized the wreck site. Research suggests that the site has provided a safe environment for fish and other marine species to inhabit. Biological processes were recognized in the analysis of the sediment core samples, as well, which only revealed a <1 ug/g count of hydrocarbon C6-C36 from the wreck site to 305 m (1000.66 ft.) away, indicating an anaerobic environment (Church et al. 2007a:50). An anaerobic environment is ideal for the preservation of archaeological materials.

The second site mentioned in the Church study is the oil tanker the S.S. *Halo*. The ship was built by Bethlehem Shipbuilding Corporation to be used for shipping by the Cities Service Oil Company, the very same constructor and owner of *Cities Service Toledo*. *Halo* began shipping in 1920 when the need for petroleum across the United States, and the world, was skyrocketing. *Halo* was a 132.97 m (436.35 ft.) long, 17 m (55.77 ft.) wide diesel-powered, single-screw oil tanker that was unarmed at the time of its sinking (Church et al. 2007a:51). The ship was sunk on 19 May 1942 carrying 63,000 barrels of crude oil bound for New Orleans, Louisiana, from Galveston, Texas. Struck by two torpedoes fired by Kapitänleutnant Erich Würdemann on board *U-506*, the tanker sank within 15 minutes while oil continued to burn on the surface for hours. Only 23 of the 42 original crew members were able to abandon ship and were left adrift for days before they were rescued. Most of these men died at sea while awaiting rescue. By 27 May only three survivors remained, and they were only able to contribute minimal information to the historical record (Church et al. 2007a:52).

C & C Technologies had previously investigated the site through a remote-sensing survey in 2000, and the 2007 study amended the previously recorded archaeological information available. Due to the site's depth of 143 m (469.16 ft.), the ability for scuba divers to investigate its condition is extremely limited and not cost-efficient (Church et al. 2007a:52). Church's crew investigated *Halo* remotely with their Triton XL11 ROV. The ROV was able to search the poor visibility for diagnostic elements of the wreck including a windlass, catwalk, hand-rails, superstructure, vent structures, the mast, deckhouses, and several ladders (Church et al. 2007a:55-56). Damage to the site most likely occurred due to the weight of the vessel collapsing the port-side of the hull upon impact with the seafloor. Torpedo blast damage was not observed on *Halo*, and it was determined that the damage is most likely covered by sediment (Church et al.

2007a:55). A comprehensive site plan was made of the vessel showing many structural components of the ship that remain exposed above the sediment, as well as the intrusion of net material from the local fishing industry. Utilizing the ROV allowed researchers to take their time in searching for site extents, which helped to record the structural components of the ship, such as the lifeboat davits which match comparably to historic ship's plans.

In regards to preservation of *Halo*, it appears to be in fairly good condition in places where net fouling and sediment coverage has not prevented investigation of structural components. Fish nets appeared to have hindered accurate visibility of specific ship components (Church et al. 2007a:58). The effect of biological processes on *Halo* seems to be similar to that of the previously mentioned *Virginia*, leaving a 5-15 millimeter (0.2 inch) layer of brown growth throughout the entire site (Church et al. 2007a:58). The major difference in biological degradation of *Halo*, versus that on *Virginia*, was the discovery of concretions covering the site, indicative of a faster rate of degradation. Video recorded by the ROV on site allowed researchers to document the amount of meiofauna and macrofauna located on the wreck. Coral life present on *Halo* resembled that documented on *Virginia* (Church et al. 2007a:61). The results of the macrofauna on the wreck were very detailed, and fish life present on the site appeared to be flourishing with success. With the sampling of hydrocarbons around the site, trace amounts of C10-C14 were found in 4.9 ug/g levels immediately adjacent to the wreck, remained consistent to 30 m (98.43 ft.) from the site, dropped to a negligent level at 152 m (498.69 ft.), and increased to 14 ug/g at 305 m (1000.66 ft.) from the site (Church et al. 2007a:76). The presence of evidence that this is an aerobic environment indicates that degradation of the vessel located at this site will be higher than that of a site buried in an anaerobic environment.

The third wreck site investigated by R. Church in 2004 was the S.S. *Gulfpenn. Gulfpenn* was constructed as the S.S. *Agwihavre* in 1920 by Sun Shipbuilding Company in Chester, Pennsylvania. It measured 146.5 m (480.6 ft.) in length, 20 m (65.6 ft.) in breadth, 11.2 m (36.7 ft.) in hold depth, and weighed 9,004.21 metric tons (8,862 gross tons) (Church et al. 2007a:77). The ship's owners transferred ownership of *Agwihavre* to the Gulf Oil Corporation and it was renamed *Gulfpenn* in 11 March 1942. Prior to its name change the vessel had rescued crew members of the S.S. *Oregon,* which was torpedoed and machine-gunned by DKM *U-156* on 28 February 1942 (Church et al. 2007a:77). On 13 May 1942, *Gulfpenn* set out on its last voyage from Port Arthur, Texas, to Philadelphia, Pennsylvania, carrying 90,000 barrels of gasoline. The vessel was struck by a single torpedo from *U-506* while traveling with the S.S. *Gulfprince,* which had been previously attacked by *U-506* earlier in the day. Though *Gulfprince* survived its three-torpedo attack, *Gulfpenn* was struck in its engine room, causing it to sink in five minutes. A total of 25 survivors were rescued three hours after the attack with no sign of *U-506* in the area afterwards (Church et al. 2007a:79).

While surveying, Church's crew utilized their Triton ROV to record several days’ worth of data. In 1994, Texas A&M University had also investigated *Gulfpenn* site using side-scan sonar. The study identified the site’s depth at approximately 533.71 msw (1,751 fsw) (Church et al. 2007a:79). For purposes of the 2004 survey, the team's objectives included an attempt to identify the current condition of the vessel. The detailed site plan indicates that the wreck lies upright on the seafloor, severely bent but mostly intact, significantly covered in coral growth. The top decks of the vessel showed significant deterioration, leading to several portions of the site to be collapsed inward (Church et al. 2007a:82-86). Coral appeared to have prevented significant identification of smaller diagnostic elements located on the site. The portion of the vessel that appears to be one of the most significantly deteriorated areas is the amidships area where collapse and structural failure of major sections of the hull is clear (Church et al. 2007a:87). It is apparent that the stern of the vessel sustained the most significant structural deterioration and damage most likely from the torpedo strike and the impact of the ship landing on the seafloor. The main deckhouse has nearly completely deteriorated, leaving scattered elements of the vessel resting on the still-intact aft sections. One remaining artifact is the docking helm control, which rests on the deck floor (Church et al. 2007a:88). The smoke stack and a lifeboat were discovered using the ROV around the starboard side of the vessel during an area search for anomalous structural materials. Both stacks appear to have collapsed off of the wreck over time (Church et al. 2007a:88). The rate of deterioration of this site is less than that of *Virginia* or *Halo*.

The biological investigations that took place on *Gulfpenn* exhibit several differences in the site from other wrecks in the study. These investigations yield important information regarding site formation processes, such as brown rusticles that appeared to be more abundant during observations on the wreck, though concretions seemed to occur in lower numbers than the other two vessels. The invertebrate count on this deeper wreck was higher than the more shallow sites. Coral growth was observed to be massive and site-encompassing. Several macrofauna were observed and recorded on the wreck and it was apparent that the site was a safe location for several species of fish. Sediment cores taken from the *Gulfpenn* site was identical to the data recovered from *Virginia* at <1 ug/g at a distance of 0-305 m (0-1000.66 ft.) from the wreck (Church et al. 2007a:89-109). This fact complements the assertion that anaerobic environments tend to cause a slower degradation of cultural material remains over time.

The 2004 study headed by Church utilized some very important methods and principles that have developed in maritime archaeology over the years. Though the oil tankers previously specified were not the only focus of the study, they are relevant to the advancement of knowledge and understanding of the site formation processes surrounding *R.W. Gallagher* and *Cities Service Toledo.* The utilization of remote-sensing equipment and technology, the use of hydrological sample testing, the historical look at the identities of these ships, and the archaeological practice involved in their documentation all serve a critical purpose in understanding the integrity of similar sites in the Gulf of Mexico. Andy Hall of the PAST Foundation utilized 3-dimensional modeling in constructing an artistic rendering of *Anona* in the report (Church et al. 2007a:197) (Figure 21).

Figure 21: Hull profile of Steam Yacht *Anona* (Church et al. 2007a). Image courtesy of Andy Hall, illustrator.

It should be noted here that the use of 3-dimensional modeling has extremely powerful capabilities beyond artistic rendering, and may be used for complete visual analysis that is not physically available to researchers. These methods will be discussed and demonstrated in later chapters of this thesis. As projects expand throughout the region, reports like this will continue to incorporate more information and better representations of the events that transpired in the Gulf of Mexico will contribute to archaeologists' understanding of the battlefields involved.

Though the methods established for comparative reasons began with this chapter, the following chapter will establish the specific methodologies used in this project. While spanning three primary modes of explanation, the methods used are broken into historical, archaeological, and post-processing sections. The purpose of this division is to establish the three major steps taken to establish a research model conducive to linking historical documentation to archaeological analysis. Within each section, the dynamic connections between each of these three modes are established, and then elaborated upon in later chapters. The study was formulated in this manner to remain relevant for the particular chapter objectives, while expounding upon ideas during appropriate times later in the text.

CHAPTER IV: METHODOLOGY

Introduction

This study involved three phases of work: historic research, archaeological investigation with diver ground-truthing, and post-fieldwork research and analysis. Prior to in-depth archaeological investigation, historical records are evaluated on positive remote sensing anomalies. This conditions the project to focus on potentially identifying the anomalies as shipwrecks. Second to the historical research, physical investigation and remote sensing surveys are conducted to collect archaeological data that exists for the anomalous features. Finally, analysis of the historical and archaeological data can lead to further documentary research along with organizing the raw field data into a manageable report with figures, 3-dimensional computer generated models, and comparative illustrations to support the identifications of the vessels being studied.

Researching two WWII-era shipwrecks in a manner that will help understand their current condition, as well as their history, is complex. Not only does the documentation prove to be scattered throughout several archival sources, but the archaeological evidence also exhibits its own interpretive challenge in terms of condition and context. Due to the specific nature and purpose of underwater data recovery, significant planning must be made to ensure that an efficient use of time and resources goes into data collection. Determining the appropriate amount of information that will answer each research question is critical. To do this, critical analysis of all of the available data to make deductions on archaeological context and identifying specific shipwrecks is part of the research planning process. The methodology involved with *R. W. Gallagher* and *Cities Service Toledo* has been broken down into three separate sections in order to identify and determine their cultural significance. To ensure continuity, the historical information will be presented with all research methods and findings together in the same sections.

Historical Research Methodology

The full breadth of documentation that exists for WWII Merchant Marine shipwrecks exists in several sources throughout the United States. To begin with, the reported anomalies that made up the whole of the "Archaeological Analysis of Submerged Sites on the Gulf of Mexico Outer Continental Shelf" project headed by BOEM[7] were researched as to any previously documented information within their database (Evans et al 2013). Any information gathered from this database was analyzed to provide leads as to these sites' possible identities. To accurately identify the location of each shipwreck named in previously conducted National Oceanographic and Atmospheric Administration (NOAA) and MMS studies, several resources were consulted and the accuracy of each shipwreck's location was determined by the reported area where the wreck occurred. The historical documentation serves as a beginning source to locate shipwrecks in relation to their reported location at the time of sinking.

While determining the exact location of the shipwrecks is important, understanding their history also plays an essential role in the archaeological process. Historical research for this project proved particularly critical, as a central goal of the research was to determine nomination eligibility for each wreck to the National Register of Historic Places (NRHP). To identify their

7 Note: The Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE), the Bureau of Ocean Energy Management (BOEM), the Bureau of Safety and Environmental Enforcement (BSEE), and the Minerals Management Service (MMS) all represent the same government agency in this study, and has changed titles several times over the last decade. All references to these titles are crediting the agency for its research conducted under its working name at the time those studies were conducted.

specific histories, the shipwrecks were isolated via public record and “historical research at these locations focused on confirming or refuting the[ir] preliminary identifications” (Evans et al. 2013:7). Surviving documentation exists in several different forms, filed in collections at the United States National Archives, the United States Mariners' Museums, and in private collections that were acquired upon the closing and restructuring of the companies that originally owned the vessels and their records. These resources exist as evidence of the specific use of the vessels, allowing research to be conducted on the physical and legal processes that were involved in the time that the vessels were used to serve the needs of war. Though critical for the physical investigation of the ships' remains, manifests and ship's logs do not tell the individual stories of the crew members that served on them. The record that exists in these types of documents tells only of the bureaucratic needs of those who interacted with the vessels as they operated in port and at sea.

For purposes of assigning cultural significance to these vessels under United States law, they must meet specific criteria for inclusion on the National Register of Historic Places. The National Register is listed under U.S. Title 36 CFR 60.4 and eligibility hinges on objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and

A. Be associated with events that have made a significant contribution to the broad patterns of our history;
B. Be associated with the lives of persons significant in our past;
C. Embody distinctive characteristics of a type, period, or method of construction, or represent the work of a master, or possess high artistic value, or represent a significant and distinguishable entity whose components may lack individual distinction;
D. Have yielded, or be likely to yield, information important in prehistory or history.

The recommendation for inclusion on the National Register typically follows the complete archaeological and historical analysis on similar projects. The findings will be discussed in Chapter V along with several discussions on the project as a whole.

In regards to protecting these sites from damage or looting, there are two federal support systems. First, the American Battlefield Protection Program run by the National Park Service has an ongoing outreach program for protecting battlefield sites in the United States through the American Battlefield Protection Act of 1996. Second, legal protection of these sites falls under the Sunken Military Craft Act listed under U.S. Title 32 CFR part 767 under authority of the Secretary of the Navy. The protection offered to these sites by this act is granted within 10 U.S.C. 1401-1408. Civil penalties incurred for violating the integrity of U.S. military-contracted vessels can amount to $100,000 per day of activities that are in violation as well as the continuous cost of preservation of any articles damaged by offending activities. Since these vessels were contracted by the U.S. War Shipping Administration, contained U.S. transported Lend-Lease aid, and employed merchant mariners and navy gunners they qualify for protection under this act regardless of the condition of the wreck sites.

Historical documentary research involving WWII Merchant Marine vessels is widespread and relatively easy to find in comparison to other shipwreck documentation. The documentary resources necessary for adequate research are located in many places, regulated by strict viewing times, and constitute time-consuming accession processes. In the case of finding resources in the National Archives, the relevant record files were cataloged in Washington, D.C. and College Park, Maryland. The records present in the District of Columbia are relevant to the U.S. Coast Guard reports of their rescue missions conducted on vessels that were attacked during the 1940s. In College Park, the majority of relevant information was located in volumes of reports located in Armed Guard Reports, War Shipping Administration Files, American Bureau of Shipping General Correspondence, Bureau of Marine Inspection and Navigation Official Number Files, Maritime Commission Central Correspondence Files, Shipping Board Files, Maritime Commission Cargo, Mail and Passenger Reports, and microfilm copies of U-boat diaries and logbooks. During post-fieldwork research, it took two researchers five days to locate, record, and scan the additional records necessary to complete analysis of the breadth of available documents that exist on file for the vessels being researched. As many as 120 individual primary sources were located at the National Archives. The ships' plans and images were not held in the Archives' collections due to the fact that the vessels originally belonged to private companies. These essential images and drawings were acquired from private collectors and/or companies associated with the original owners of the oil tankers.

Archaeological Methods

The next step in studying the two vessels involved the use of remote-sensing technology and archaeological diver investigations that tested the original reported location and determined the current location of each shipwreck. The two shipwreck locations were noted within historic documentation as mentioned previously, and remote sensing was conducted in these areas. The remote sensing technologies that Tesla Offshore utilized to perform this task were a Marine Magnetics SeaSpy© total field magnetometer, an Edgetech 2400-FS© 120 & 410 kHz dual frequency side-scan sonar, an Odom EchoTrac Mk III© 24 & 200 kHz dual frequency single beam echosounder, an Edgetech SB-216© 2-16 kHz chirp subbottom profiler, and a R2 Sonic 2024© 200-400 kHz multi-beam echosounder (Evans et al. 2013:11) (Figure 83, Appendix A).

These tools were employed along planned survey-line intervals around the reported areas of each shipwreck. In addition to the previously mentioned remote sensing tools used to locate the oil tankers, a CODA 3-D Echoscope 3D sonar was used to define more detailed anomalies located around the proposed site of *Cities Service Toledo*, and a Mesotech MS1000 unit was deployed on a tripod mounted system on each site during dive operations to provide real-time remote sensing data for dive teams (Figure 83). These data were collected and anomalies were analyzed to generate data files on each site, and this information was used for planning the order and priorities for archaeological investigations. The results of these surveys and remote sensing data will be discussed in Chapter IV along with other findings.

As Tesla Offshore, LLC. prepared for the physical investigation of the two possible shipwrecks, it was determined that an experienced dive crew would need to be assembled for physical investigations. The University of West Florida (UWF) was contracted for assembling a dive crew with the capabilities of efficient data collection in the sometimes challenging underwater conditions of the Gulf of Mexico. Nine graduate students, two faculty members, and the university's Dive Safety Officer (DSO) were selected to serve as the dive crew representing UWF for this project. Each graduate student and faculty member that participated in the project was specially trained for the conditions that exist in the Gulf of Mexico just downstream from the mouth of the Mississippi River.

The remote sensing data revealed that the sites posed significant danger for entanglements due to the high volume of commercial shrimping conducted in the region. Shipwreck sites tend to snag shrimp nets and tear them from the fishing boat, thus creating entanglements for divers. The entanglements collect sediments and biological life that mask the hazard. To help prepare for these obstacles, divers were given specialized training in several advanced diver training sessions. The workshops were organized by UWF's DSO, Fritz Sharar, to include depth acclimation for the deepest anticipated sites, entanglement exercises, and field trials to employ a coring device for sediment sampling. Training was given for redundancy scuba systems and personal dive computers issued to each diver for the project.

The UWF dive crew met with Tesla Offshore's project managers, Dr. Amanda Evans and Matt Keith, at their headquarters in Baton Rouge, Louisiana, and was briefed on the project prior to the trip. The entire project consisted of 11 targets of interest, and each target was described in detail during a preliminary meeting. After meeting with the Tesla Offshore team, the project crew was transported to Morgan City, Louisiana, to rendezvous with M/V *Spree*, a 30.48 m (100 ft.) crew boat chartered for the trip. While in Morgan City, the entire dive team was joined by BOEM archaeologists, Dr. Christopher Horrell and Melanie Damour, to accompany and oversee the project for the next 17 days. The project crew was given one day to acclimate to the research vessel and *Spree* left for the first target on the project's agenda.

As the team conducted dive operations in the Mississippi River discharge zone of the outer-continental shelf, tasks were planned with respect to each target every morning. Supplemental planning was also made throughout the work day. Operation leaders presented their briefing on-site every morning, and a safety briefing was given to familiarize each diver with the possible conditions they would face during the day. The morning briefing began with a review of the remote sensing and historical data available for each site by Keith; divers could thus be prepared for the most likely situation they would encounter during their operation. A safety briefing by Sharar was presented to inform the crew of site-specific hazards and protocol to follow in case of emergencies. All factors that contributed to this safety brief involved a combined analysis of the remote sensing and bathymetry data, along with weather and oceanographic information gathered through observations and via *Spree*'s pilot house. Condition monitoring, diver safety protocol, and constant vigilance from topside operations was consistent regardless of the time of day, and proved to aid in the efficiency of the project on several occasions. Morning meetings were concluded by an archaeological dive plan presented by Dr. Greg Cook. Objectives for each site varied depending on the type of vessel, likelihood of diagnostic feature recording, the size of each vessel, and site priority. The general dive plan was presented to give each dive crew an idea of what to expect while conducting data recovery, and what responsibilities they would have when it came time for them to work. The primary focus of each dive was to locate and record diagnostics. Divers were directed to pay attention to smaller details that could not be analyzed with remote-sensing equipment.

Remote-sensing data collected on these sites provided sufficient means for accurate large-scale analysis of site margins. The use of echosounder and sonar data provided site extents, overall vessel length, and prodigious measurements beyond a safe scuba diver-workable area. These data were used to detail the known broad archaeological remains on each site. The sector-scanning sonar also allowed divers to become familiar with the sites remotely in real-time.

Topside operations followed standard UWF diving procedures throughout the project by maintaining an accurate log of every dive. Each dive team was listed on the topside form that detailed their Enriched Air Nitrox Oxygen (Nitrox) percentage and total pounds per square inch of compressed gas contained in each of their tanks. Each team routinely recorded their total cylinder gas pressure and Nitrox percentages each time their tanks were filled, and the topside manager recorded each water entry and exit time for each individual diver. Before each dive team entered the water, the topside manager (a crew member available who had been trained under a professional dive association for advanced rescue diving) would record their time of surface departure for precise record keeping.

The training that each diver received prior to the trip kept each individual accountable and confident in themselves prior to each dive, which ensured that efficiency was maintained for the entirety of their time underwater. While each shipwreck had its own site specific hazards, safety and planning remained consistent during the project. After each two member dive team completed their task, they offered as much data as possible to the dive teams that followed them, allowing for consistency to be maintained in data collection. As new diagnostic elements for each ship were discovered, recorded, and reported on the surface, dive teams were able to form a dive plan that could better record or anticipate where the next task would be performed. With this efficient method of adaptive and evolving dialogue for daily tasks, the majority of sites for the overall project were completed in one day of dive operations, allowing the dive platform to travel to the next site overnight. This research specifically focuses on two of the vessels that were a part of this project, *R.W. Gallagher* and *Cities Service Toledo*, and only the methodologies regarding these vessels will be addressed.

On 15 August 2010, the research team reached the location of *R.W. Gallagher,* approximately 70.811 km (44 miles) 180º south of the Louisiana coastline. The crew was briefed on the information available for the shipwreck by Keith at 07:00. The crew was given very detailed information on the appearance of the vessel according to remote-sensing data that was available, what to expect underwater, and a detailed mylar printout of the general shape and orientation of *R.W. Gallagher* as it lay underwater (Figure 22). *Spree*'s captain, Frank Wasson, briefed the dive teams on current conditions, the appearance of the shipwreck from *Spree*'s depth-finder, and what his crew would be doing throughout the day. Cook described the archaeological goals of the day, defining key elements likely to be located on the wreck, such as draft marks, hull plating patterns, rivet patterns, name plaques, ship's dimensions, and stern details. As the brief finished, each respective two-diver team was separated in an arbitrary order for sequential tasks.

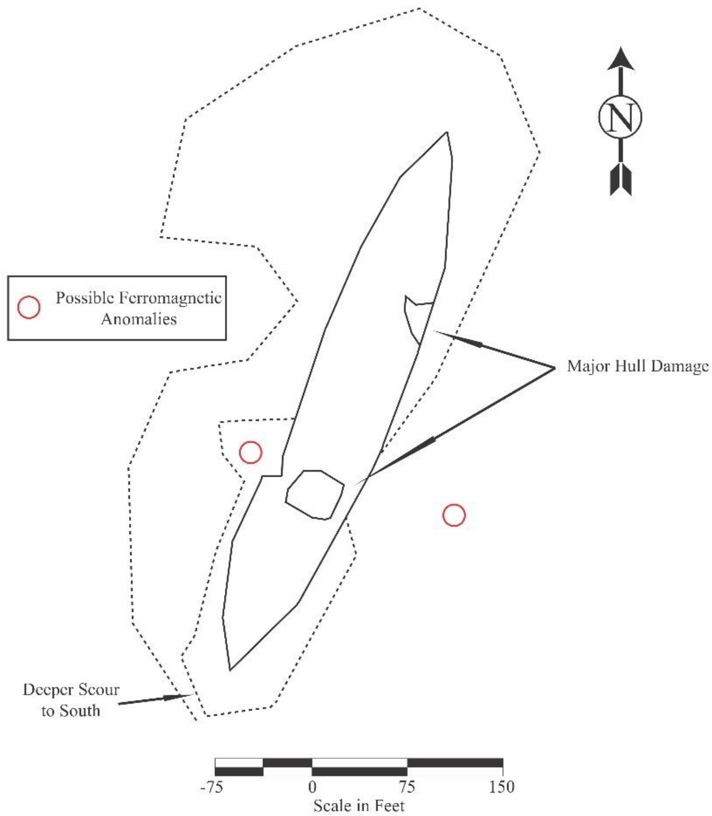


Figure 22: Site template of the S.S. *R.W. Gallagher* on mylar used for diver reference during archaeological investigation. The image was reversed for context in the field.

Dive teams entered the water in succession, each team returning with information that would aid future dive teams in their task. Diving on this vessel was a challenge for BOEMRE, Tesla Offshore, and UWF dive teams as its extensive length made it impractical to examine the entirety of the vessel's hull in one dive. Since the vessel was approximately 129.54 m (425 ft.) long, dives were coordinated to locate and isolate specific diagnostic features on *R.W. Gallagher*. Each team was limited to these isolated features, and planning was very dependent on the previous dive team's findings. Cook and Sharar were the first dive team in the water, tasked with finding the shipwreck, establishing a down-line to a safe location on the shipwreck, evaluating the site for hazards, and diagnostic recording priorities. With a maximum depth of 25.908 m (85 ft.), each dive team was limited to a single dive time of under an hour. With this information in hand, the dive teams proceeded to investigate the overturned oil tanker.

Cook and Sharar entered the water at 08:49 and located the vessel relatively quickly at a depth of 25.908 m (85 ft.). The team returned to *Spree* at 09:12. The next two dive teams were tasked with securing the buoy line to the shipwreck so that the rope would not chafe and sever, causing a loss of the visual location of the wreck from the surface. Eric Swanson and Norine Carroll measured the width of the two major hull breaches to verify the hull break dimensions indicated in the remote-sensing data, and made notes of the relative condition of the hull at the point where the buoy line met the wreck. The next two dives consisted of data recovery tasks, locating and recording diagnostic elements of the vessel that would be essential in deducing its identity, and taking core samples that would determine the specific site-formation processes that have occurred around *R.W. Gallagher* through time. Several components of the vessel were documented and located, such as its present state, orientation, length, and condition. For the final dives on the vessel, teams were tasked with locating and documenting the plating of the vessel, the vessel's draft marks, the rivet patterns on the hull, the dimensions of the propeller, the dimensions and diagnostic elements of the rudder, measuring the bilge keel, and photographing these elements to accurately document the site. Each team conducted their tasks, building upon the data that was recovered on previous dives. The work day ended at 17:19 with the recovery of divers, equipment, and the removal of the buoy line that was attached to the wreck. The data recovered from physical observations on the wreck was thorough enough to end dives on the site and continue to the next site location.

The project crew arrived at the reported location of *Cities Service Toledo* on 18 August 2010, approximately 39.268 km (24.4 miles) southwest of the Louisiana coastline. The primary briefing at 07:00 by Keith was similar to that of the briefing given for *R.W. Gallagher*, in that each team was briefed on its history, its appearance underwater, and the known data previously collected through earlier research. Each team was given a mylar printout based on the remote-sensing data collected on *Cities Service Toledo* as it lies on the seafloor (Figure 23). Wasson gave another briefing on conditions of the area, water depth, and the appearance of the wreck on *Spree*'s depth-finder, following a tumultuous storm that had delayed the research trip on the previous day. Sharar briefed the team on the possible dangers and safety protocols set as standard for UWF for the trip, and each team was divided into arbitrary groups of two.

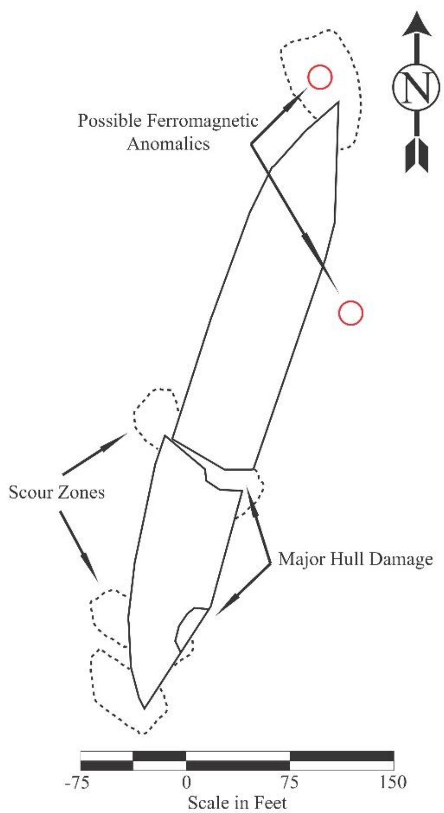


Figure 23: Site template of the S.S. *Cities Service Toledo* on mylar used for diver reference during archaeological investigation.

Dive teams utilized constant communication and data comparisons with each other to aid in efficient recording of diagnostic features. As Cook described in the morning brief, due to the fact that this wreck is approximately 146.304 m (480 ft.) long, each dive team was given a specific area from which to collect and record data. The maximum depth for this shipwreck was 27.432 m (90 ft.), so teams were limited to a maximum bottom time of one hour. With the understanding of the limitations present on the shipwreck, the teams set out to begin dive operations though currents and storm clouds threatened the ability for the crew to operate. Conditions eventually worsened, and the operation was halted, in hopes of better conditions the next day.

On 19 August 2010 at 07:00, the morning briefing was held, incorporating data recovered from the previous day's work, and dive teams quickly assembled for operations on the aft deck of the *Spree.* The first dive team, Cook and Sharar, entered the water at 07:15 and secured the buoy line to the stern of the vessel. A sediment core was also taken immediately following the first dive at 07:53 to collect data essential to documenting the site formation processes present around the wreck. Due to the first team finding that both the rudder and the propeller were missing from the stern of the vessel, dive operations for each subsequent team were focused on locating and recording diagnostic features on that section. The task of recording the propeller shaft dimensions was made a high priority. These measurements were used in a specific comparison to the propeller shaft drawn on the original ship's plans. This dimension led to a better determination of the vessel's identity. Additional work included recording the hull plating and rivet pattern in the stern and an examination for draft marks or other distinguishing features (Figure 24).

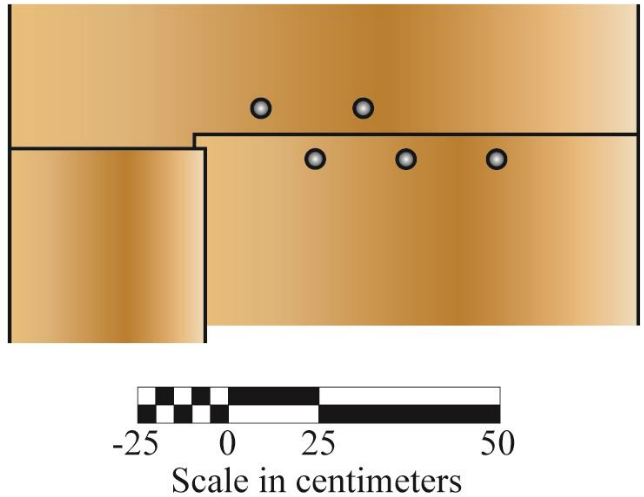


Figure 24: Illustration of the observed hull plating pattern present on the S.S. *Cities Service Toledo*.

Attempts to locate the missing propeller and rudder were given to the final dive teams, but ultimately these could not be located and were presumed salvaged. Detailed drawings and measurements were compared by each dive team prior to the following team's dive operation, and efficient use of communication allowed for all dive operations to be completed at 16:19. The temporary marker buoy was removed from the site at this time. All data collected was sufficient enough to justify moving to the next target of interest in the project, and the team left the resting place of *Cities Service Toledo*.

Post-Processing Methodology

The data collected from the field were analyzed and compared to the historical record to make an assessment on the significance of the two vessels to United States' culture regarding their eligibility for inclusion on the NRHP. Ships' historical documentation was compared with information that divers had recovered to determine what additional information was needed to complete all necessary research. Each individual photograph and video taken on the trip was checked and labeled for accurate documentation and relation to its location near or on each vessel. The dive crew's scale drawings of each recorded diagnostic portion of the vessel were analyzed for metric continuity, hand-inked, and digitized. Divers' field notes and drawings were compiled in a folder for each wreck, and all relevant information was transcribed, digitally recording each method and finding during the field project. Individual dive times, site information, diver tasks, and detailed conditions were recorded to aid in the general environmental interpretation of what existed on the site at the time of the project. Nominations for inclusion on the National Register of Historic Places were made for each vessel by Tesla Offshore's archaeological team.

Tesla Offshore also conducted and completed analysis of the site environment from several tests taken in the field (Evans et al. 2013:16-22). Each water sample taken in the field was analyzed for its salinity, pH, and dissolved oxygen. The geologic core samples taken in the field were analyzed at separate times for several factors that apply to the geologic environment and site formation processes. The first core test involved lithology and grain size. The test analyzed the shear strength, or the amount of resistance against penetration, of the sediment cored from each site as well as the pH level of the water within each core. The lithology and grain size test was used to determine the chemical, physical, and biological variables present on each site, and how these elements can affect the site over time. In addition to this test, radioisotope analysis was conducted to analyze the linear accumulation rate of sediments in the core using the Pb-210 method. The Pb-210 method involves taking a small sample of the sediment core removed from the seafloor around each site and separating it to count ^{210}Pb and ^{137}Cs volume in each section. The sampled elements taken in each core can reveal significant depositional events that occurred in the area over an approximately 100 year period. This test can allow researchers to find a significant impact event like a shipwreck, and also give details related to sedimentary depositional patterns that have occurred on and around the archaeological sites over time. Tesla Offshore also completed an oceanographic analysis of the effect of hurricanes on scour and site-formation processes.

While the analysis of physical observation and environmental sampling supplements the historical record, additional tools were used to provide a more robust model for conducting this type of research. It was determined that creating a comparative 3-dimensional model of these vessels would aid in accurately deducing the identity of the wrecks. These models were built using the remote sensing data along with the ships' historical documents. The process involved using two separate 3D rendering software packages, *Rhinoceros 3D* and *Google Sketchup*. Dimensions from historical ship's plans were taken and given a point and line theme located on three axis planes in *Google Sketchup* (Figure 25).

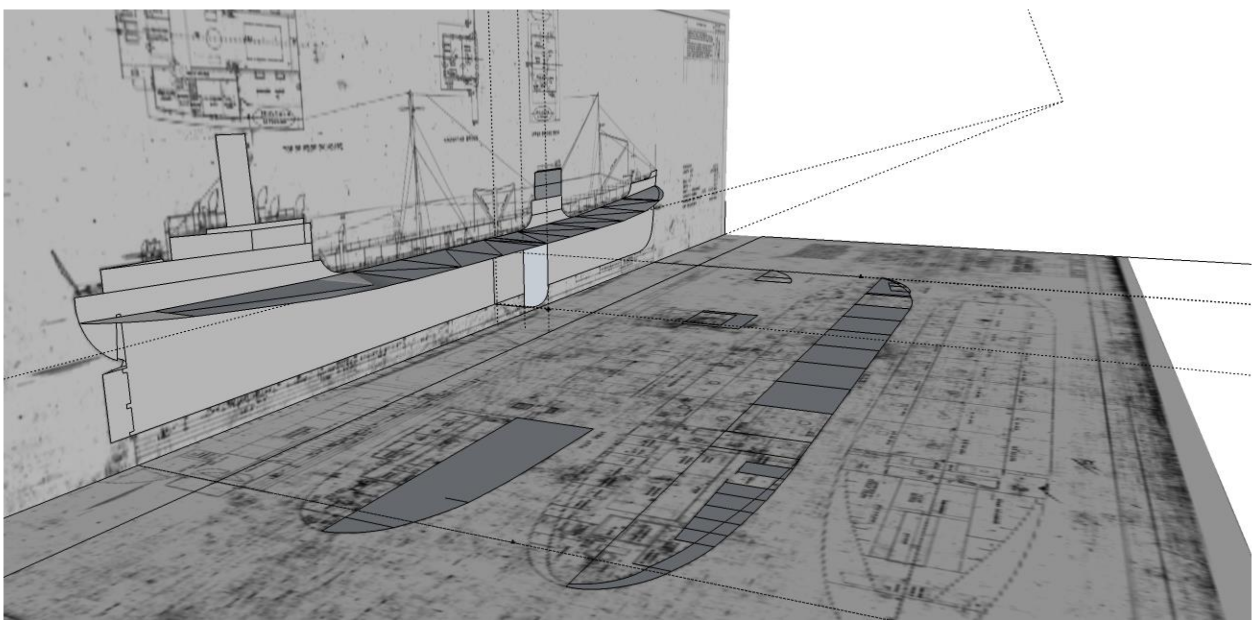


Figure 25: Point-and-line modeling process utilizing to-scale historical ship's plans for the S.S. *R.W. Gallagher.*

The plans were then “draped” over the point theme and given a 3-dimensional appearance that could be manipulated by the software. In addition to the historical plans, the point cloud data acquired from remote-sensing was input into *Rhinoceros 3D* to create another theme that relates the current condition of each vessel underwater (Figure 26). Details were mathematically “draped” as a solid rendering over the point clouds based on individual diver drawings and measurements, in conjunction with the historic plans, showing the potential relative location of essential diagnostic features on the wrecks (Figure 27).

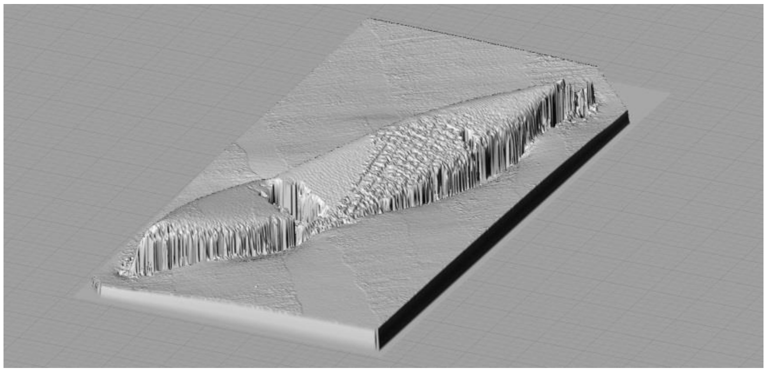


Figure 26: Simple draping method in *Rhinoceros 3D* to verify the site extents of the S.S. *R.W. Gallagher* for comparative analysis.

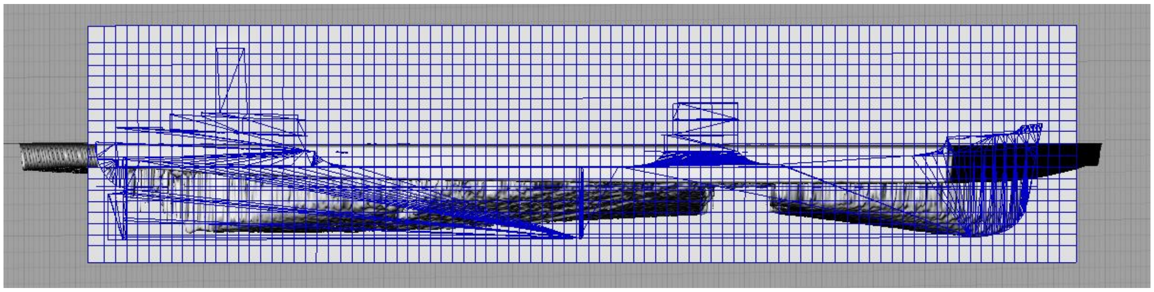


Figure 27: Preliminary simple scale comparison of the S.S. *R.W. Gallagher*’s historical blueprint to the physical data’s point-cloud “mesh.”

Utilizing these data will aid in further advancement of modeling in underwater archaeology by demonstrating the capabilities of modern computer rendering software. The use of advanced remote-sensing technology, computer software, and researching techniques has greatly improved the quality of maritime archaeology over time. This study incorporated as many of these tools as possible to create a robust view of these two shipwrecks. By using the most complete and multidisciplinary approach possible, the approaches taken to research *R.W. Gallagher* and *Cities Service Toledo* provide the evidence necessary to deduce their identities from historic, as well as archaeological, data. The methods used in this project also represent a pluralistic approach to archaeology that does not limit it to isolated variables, but opens interpretation to be derived from several different academic fields. The diagnostic evidence used for this investigation will provide valuable information for inventorying and protecting WWII shipwrecks in the Gulf of Mexico, as well as provide information to aid other researchers in the future. Through compiling the results of this study, each of the research objectives and outcomes from the previously mentioned research methods come together seamlessly. The next chapter will discuss these results in detail, and begin to assert the explanation as to what events caused the ships to sink.

CHAPTER V: RESULTS

Introduction

The two particular vessels mentioned within these chapters have come vividly alive through both historical and archaeological research. Isolating the key dynamic cultural aspects of these vessels from an individual level to a battlefield level has led to a narrative created with historical documentation in conjunction with archaeological data. This narrative is essential in specifying the importance of archaeological research. It is clear that the focus of the United States' government was aimed towards winning large-scale naval conflicts, with only a peripheral focus on the defense of merchant shipping. Naval protection increased with the threat of Japanese attacks in the Pacific and the escalation of European conflict. The representation of two shipwrecks in this study within the frontier environment of the Gulf of Mexico is paramount as a descriptive element to supplement current knowledge of WWII along the U.S. coast. This chapter outlines the results of this study, and it will be made clear that technology has made it possible to answer several dynamic research questions when approaching a multi-disciplinary subject.

Findings

In this section, the multidisciplinary avenues of research conducted on these vessels will be detailed and presented across several media. Beginning with the historical background, results derived from historical documents will be reviewed. Results from remote-sensing will then be reviewed for the particular data collected at each site. The specific information gathered from diver ground-truthing will be presented with questions leading into further discussion. Then, results from 3-dimensional scale modeling and visualization tests will be explained. It is important to note that each individual set of results does not by any means detail the wrecks or their histories to complete summation, as this task would be impossible to achieve in the amount of time that has been allotted to research. This study has identified each wreck for its importance to U.S. culture-history and has been delimited to the tools available to achieve that goal. With continued investigation and monitoring of these sites, a more complete and robust understanding of these wrecks may be accomplished.

Historical Background

Because these ships were contracted by the U.S. War Shipping Administration, ample documentation is stored at the U.S. National Archives in Washington, D.C. and College Park, Maryland. In these archives, record groups containing documents from the American Bureau of Shipping General Correspondence, Armed Guard Reports, Bureau of Marine Inspection and Navigation Official Number Files, Maritime Commission Central Correspondence Files, Maritime Commission Cargo, Mail and Passenger Reports, Shipping Board Files, and United States Coast Guard Reports provided the basis in which documents related to the sinking of each of the vessels were found. These record groups were consulted for information regarding passenger/crew lists, commission dates, sinking events, and survivor reports. All correspondence regarding the vessels as they were contracted with the U.S. government were also visited; such as armament installation, insurance claims, deceased crew wages paid, and notifications of the deceased and missing in action. Though these reports provided details that led to identifying the individuals present on the ships at the time of their sinking and the survivors' statements of the attacks, not all deceased individuals could be thoroughly identified. By utilizing the U.S. Census data spanning from 1920 to 1930, crew members that were killed or lost in action were investigated to help add depth to the complete site evaluation and narrative.

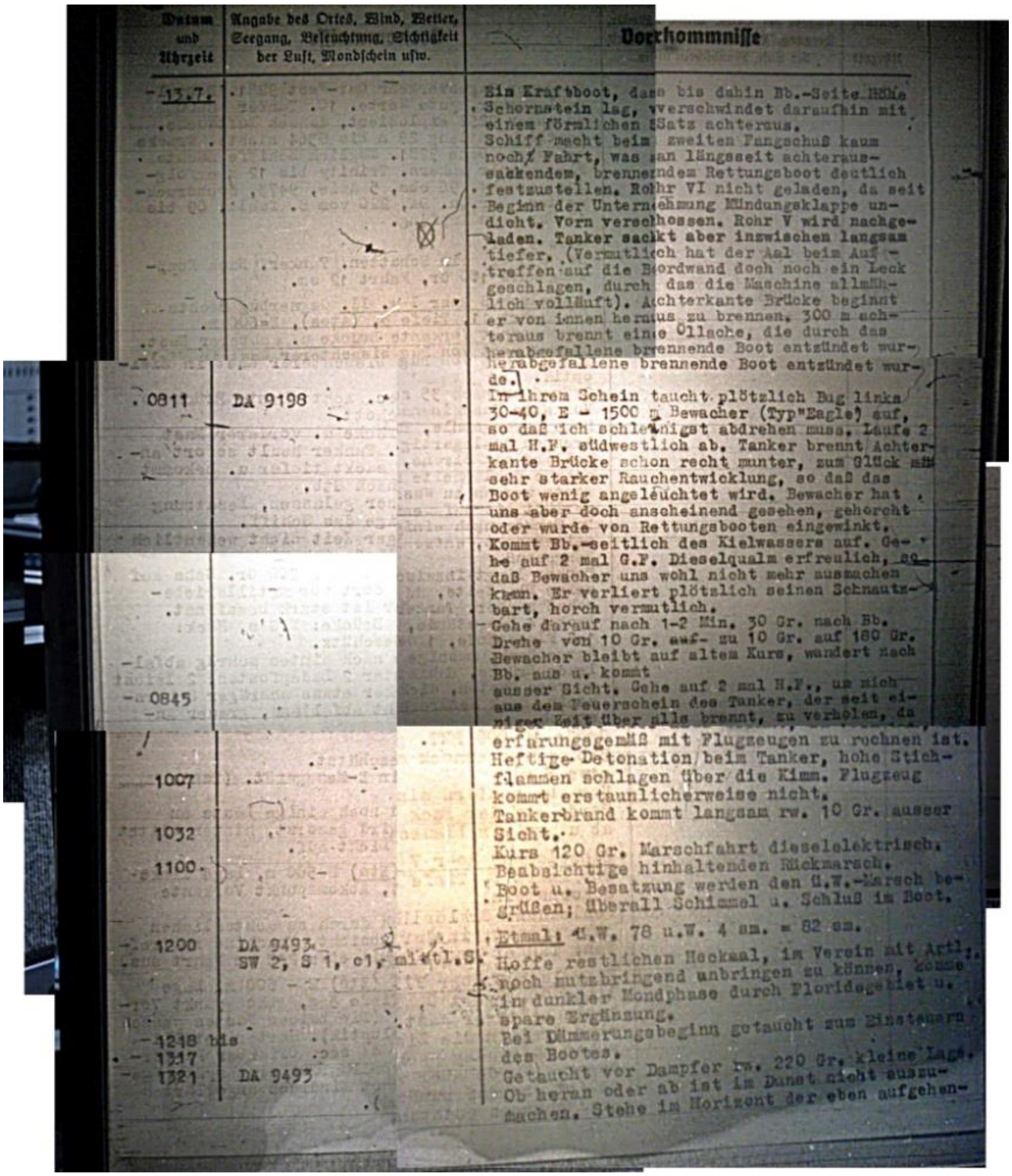
The cultural importance of these ships as war graves is undeniable as each ship's condition and historical narrative serves as portions of information needed for the nomination of a site to the National Register of Historic Places.

The *R.W. Gallagher* had nine individuals perish in the attack on 13 July 1942. One of these individuals, Herman W. Reuss, is currently honored on his son's website (Reuss 2007) (Figure 16). Upon hearing of the *R.W. Gallagher*, Reuss' grandson expressed interest in the subject. This singular example shows how the expression of the events that occurred on the day that these individuals were lost is woven into U.S. culture at a local and familial level. Evidence of individual interest is not limited to the *R.W. Gallagher* alone. In fact, the potential for these types of local and familial interest points for battlefield sites is also expressed through the *Cities Service Toledo.* Upon consulting the genealogical website Ancestry.com, research into the individuals that perished on this ship on 12 June 1942 was supplemented with family documentation. The argument that commitment to honor those family members that perished while serving U.S. interests is essential to building a case for inclusion of a site to the National Register. Of the 10 individuals who perished on the *Cities Service Toledo,* one crewman's gravestone was etched with a remembrance of his service. This individual, Everett B. Hatch, also demonstrates the cultural significance of this site to U.S. history. The fact that social and genealogical websites offer such capabilities of revealing the importance of singular events like these to the nuclear family, as well as local cultures, must be continued to be pursued in research projects like this.

Although considerable research on the loss of the *R.W. Gallagher* and the *Cities Service Toledo* has been conducted in the National Archives and genealogical research on crew members was made on Ancestry.com, many documents that should exist on these wrecks are not readily contained in these sources. For example, each ship's blueprint designs and plans were consulted to help in identifying the explicit location of each torpedo strike, which will be discussed later. These ships' plans were either located in a museum that documented U.S. Merchant Marine history, or were held by the inherited owners of these plans. In the case of the *R.W. Gallagher,* the plans utilized for analysis included the original deck plan provided to Tesla Offshore LLC. by Avery Munson, a private collector of historical marine documents related to sunken vessels (Figure 15). The *Cities Service Toledo*'s plans were copied by Erin Voisin from the Hagley Museum in Wilmington Delaware. The plans were titled for the vessel's original name as the S.S. *J.A. Bostwick* (Figure 14).

In these plans, the deck, rudder, propeller, and draft-line drawings were extremely beneficial to identify key components that led to informed archaeological identification after diver ground-truthing. When supplemented with modeling, these ships' plans provided a diagnostic element that merged historical documentation with archaeological investigation and experimentation. It should be stressed that utilizing ships' plans for analysis of shipwrecks of this era will supplement the historical account of attack location to provide an additional line of evidence in support of proper identification of the wreck sites.

In conjunction to the aforementioned resources, an important record of the accounts representing these two ships was found while researching at the National Archives in College Park, Maryland. While gathering information regarding direct correspondence about the ships, it was discovered that microfilm copies of the German Officers' war diaries were available on location. The opportunity to fact-check the information provided in the survivor's statements taken by the U.S. Navy revealed some astonishing results. The investigation of the war-diary of each captain responsible for the sinking of the two merchant ships in this study resulted in considerable insights as to how these ships were attacked. The account by Müller-Stöckheim, captain of the *U-67*, contained similarities to the story told by survivors of the attack on the *R.W. Gallagher*, apart from a few critical details (Henderson 1942; Moore 1983:231; Müller-Stöckheim 1942; Wiggins 1995:103-104) (Figure 28).


Datum und Uhrzeit | Angabe des Ortes, Wind, Wetter, Seegang, Beleuchtung, Sichtigkeit der Luft, Mondschein usw. | Vorkommnisse

13.7.
Ein Kraftboot, dass bis dahin Bb.-Seite Höhe Schornstein lag, verschwindet daraufhin mit einem förmlichen Satz achteraus.
Schiff macht beim zweiten Fangschuß kaum noch Fahrt, was an längsseit achteraus-sackendem, brennendem Rettungsboot deutlich festzustellen. Rohr VI nicht geladen, da seit Beginn der Unternehmung Mündungsklappe undicht. Vorn verschossen. Rohr V wird nachgeladen. Tanker sackt aber inzwischen langsam tiefer. (Vermutlich hat der Aal beim Auftreffen auf die Bordwand doch noch ein Leck geschlagen, durch das die Maschine allmählich vollläuft). Achterkante Brücke beginnt er von innen heraus zu brennen. 300 m achteraus brennt eine Öllache, die durch das herabgefallene brennende Boot entzündet wurde.

0811 | DA 9198 |
In ihrem Schein taucht plötzlich Bug links 30-40, E - 1500 m Bewacher (Typ "Eagle") auf, so daß ich schleunigst abdrehen muss. Laufe 2 mal H.F. südwestlich ab. Tanker brennt Achterkante Brücke schon recht munter, zum Glück mit sehr starker Rauchentwicklung, so daß das Boot wenig angeleuchtet wird. Bewacher hat uns aber doch anscheinend gesehen, gehorcht oder wurde von Rettungsbooten eingewinkt. Kommt Bb.-seitlich des Kielwassers auf. Gehe auf 2 mal G.F. Dieselqualm erfreulich, so daß Bewacher uns wohl nicht mehr ausmachen kann. Er verliert plötzlich seinen Schnautzbart, horcht vermutlich.
Gehe darauf nach 1-2 Min. 30 Gr. nach Bb. Drehe von 10 Gr. auf- zu 10 Gr. auf 180 Gr. Bewacher bleibt auf altem Kurs, wandert nach Bb. aus u. kommt außer Sicht. Gehe auf 2 mal H.F., um mich aus dem Feuerschein des Tanker, der seit einiger Zeit über alle brennt, zu verholen, da erfahrungsgemäß mit Flugzeugen zu rechnen ist.

0845
Heftige Detonation beim Tanker, hohe Stichflammen schlagen über die Kimm. Flugzeug kommt erstaunlicherweise nicht.

1007
Tankerbrand kommt langsam rw. 10 Gr. ausser Sicht.

1032
Kurs 120 Gr. Marschfahrt dieselelektrisch.

1100
Beabsichtige hinhaltenden Rückmarsch. Boot u. Besatzung werden den U.W.-Marsch begrüßen; überall Schimmel u. Schluß im Boot.

1200 | DA 9493 SW 2, S 1, c1, mittl.S. |
Etmal: ü.W. 78 u.W. 4 sm. = 82 sm.
Hoffe restlichen Heckaal, im Verein mit Artl. noch nutzbringend anbringen zu können, komme in dunkler Mondphase durch Floridagebiet u. spare Ergänzung.

1218 bis 1317
Bei Dämmerungsbeginn getaucht zum Einsteuern des Bootes.

1321 | DA 9493 |
Getaucht vor Dampfer rw. 220 Gr. kleine Lage. Ob heran oder ab ist im Dunst nicht auszumachen. Stehe im Horizont der eben aufgehen-

Figure 28: Photograph mosaic of the war diary of DKM *U-67*, written by Günther Müller-Stöckheim during his service in 1942.

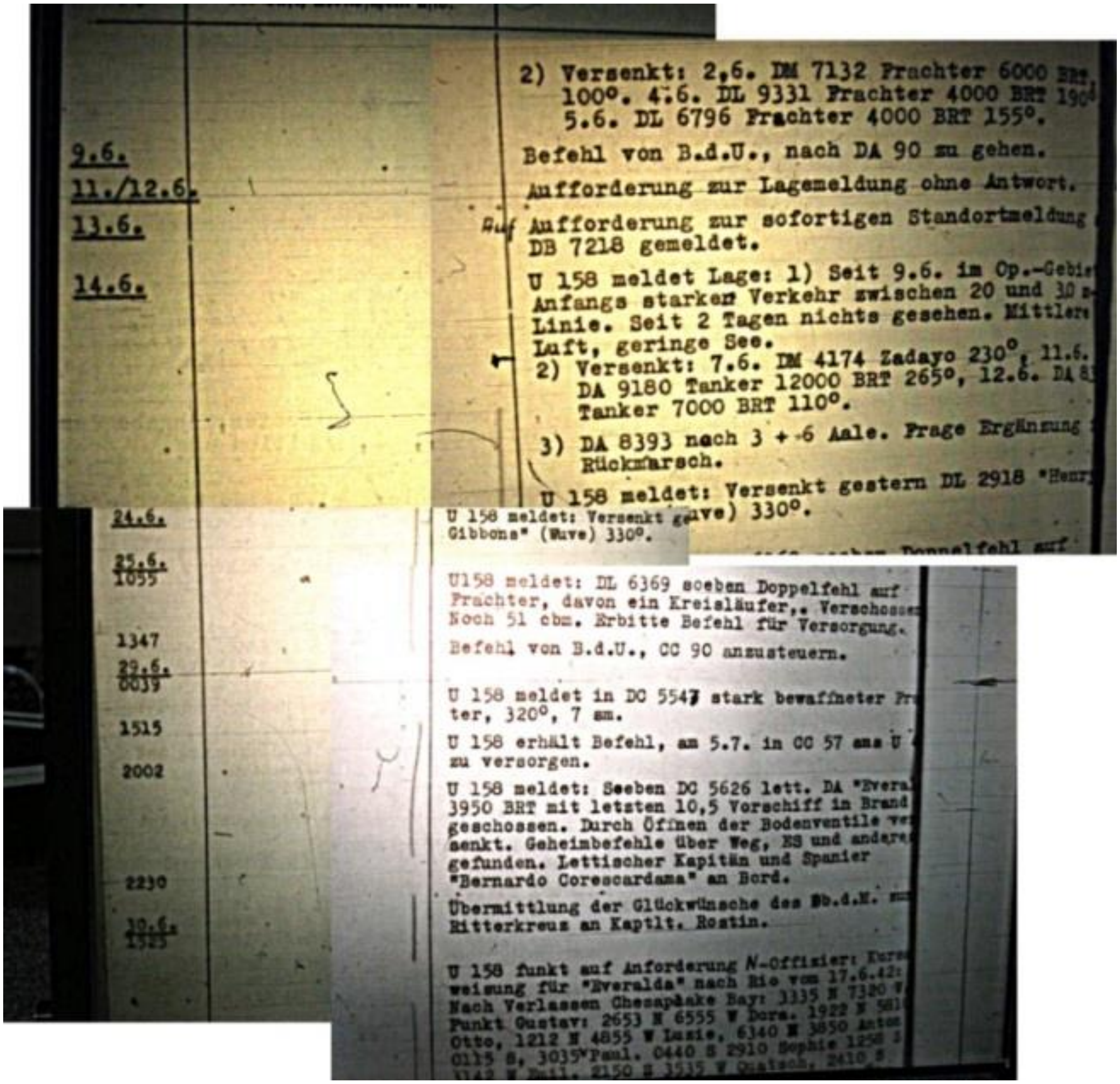
Müller-Stöckheim estimated the vessel that he attacked as 10,000 tons, not extremely close (though accurate for a visual estimate) to the actual 7,989 gross tons (8,117.2 metric tons) that the *R.W. Gallagher* was registered as; this inconsistency will be discussed later (Treasury Department 1942:525). The documented time of Müller-Stöckheim's attack was 07:35, while the survivor's statements indicated the attack occurred at 01:40 CWT. This could indicate that Müller-Stöckheim was using German-military time synchronization (Greenwich Mean Time [GMT]) at the time of the attack, which is in favor of making a clear connection between *U-67* and *R.W. Gallagher* because of the time difference between longitudes (six hours). The next discrepancy in the account by Müller-Stöckheim is that *U-67* fired two torpedoes first (a statement corroborated in the survivors' summaries), but then fired two additional torpedoes along the port-side of the merchant ship. One of these torpedoes struck below the forward smoke stack, but did not explode, and the second torpedo, a "failure," struck around the "angled eighth mast."[8]

The summary of statements of the survivors from the *R.W. Gallagher* does not make mention of the two latter strikes, while Müller-Stöckheim's account clearly indicates that the reason this vessel sank was the torpedo opening its forward holds to the open ocean. A possibility for the discrepancy in information is the severe confusion that occurs during a night attack combined with the fact that the ship had caught fire immediately after the second torpedo had caused explosions that ignited the life boats and oil-covered water. The account does mention the amount of armament present on the *R.W. Gallagher*, which provides supporting

8 Translations of the transcribed documents were provided by Dr. Derek Zumbro of the University of West Florida, History Department.

evidence for its current location in the Gulf of Mexico. In the end of Müller-Stöckheim's account associated with the 13 July 1942 attack, he indicates that an “Eagle Class” escort ship emerged from the northeast, causing him to “change course.” There is no clear indication that the *R.W. Gallagher* was being escorted by any ships, or even part of a convoy during this encounter, and the claim that an escort was present presents a problem with validating the *U-67* as the assailant of the *R.W. Gallagher*, where it is now proposed to be located. It is possible these discrepancies only indicate that during war, clear details as to the events that occurred may be misleading. It is also possible that Müller-Stöckheim needed to provide an excuse in not pursuing the life-boat that had fled the scene of the burning tanker. In some cases, U-boat captains were known to be compassionate to those individuals that survived torpedo attacks, offering to treat their wounded, and at other times U-boat captains were known to take advantage of prisoners to spread psychological fear to the mainland by the stories told by the surviving crews (Standard Oil Company 1946:234-240, 313-314). Though more questions arise from the translation of this document, it is a perfect example as to why archaeological investigations are critical to verifying the validity of historical accounts.

When associating the survivor's statements aboard the *Cities Service Toledo* with that of the *U-158* war diary, very little information is capable of being compared. Unlike that of the *U-67*, the account written by Rostin of *U-158* is very brief on details regarding its activities during the month of June in 1942 (Figure 29).


2) Versenkt: 2,6. DM 7132 Frachter 6000 BRT,
100°. 4.6. DL 9331 Frachter 4000 BRT 190°
5.6. DL 6796 Frachter 4000 BRT 155°.

9.6. Befehl von B.d.U., nach DA 90 zu gehen.

11./12.6. Aufforderung zur Lagemeldung ohne Antwort.

13.6. Aufforderung zur sofortigen Standortmeldung
DB 7218 gemeldet.

14.6. U 158 meldet Lage: 1) Seit 9.6. im Op.-Gebiet
Anfangs starken Verkehr zwischen 20 und 30
Linie. Seit 2 Tagen nichts gesehen. Mittlere
Luft, geringe See.
2) Versenkt: 7.6. DM 4174 Zadayo 230°, 11.6.
DA 9180 Tanker 12000 BRT 265°, 12.6. DA
Tanker 7000 BRT 110°.
3) DA 8393 nach 3 + 6 Aale. Frage Ergänzung
Rückmarsch.

U 158 meldet: Versenkt gestern DL 2918 "Henry
Gibbons" (Wave) 330°.

24.6. U 158 meldet: Versenkt gestern DL 2918 "Henry
Gibbons" (Wave) 330°.

25.6. 1055 U158 meldet: DL 6369 soeben Doppelfehl auf
Frachter, davon ein Kreisläufer,. Verschossen
Noch 51 cbm. Erbitte Befehl für Versorgung.

1347 Befehl von B.d.U., CC 90 anzusteuern.

29.6. 0039 U 158 meldet in DC 5547 stark bewaffneter Frach-
ter, 320°, 7 sm.

1515 U 158 erhält Befehl, am 5.7. in CC 57 aus U
zu versorgen.

2002 U 158 meldet: Soeben DC 5626 lett. DA "Everalda"
3950 BRT mit letzten 10,5 Vorschiff in Brand
geschossen. Durch Öffnen der Bodenventile ver-
senkt. Geheimbefehle über Weg, ES und anderes
gefunden. Lettischer Kapitän und Spanier
"Bernardo Corescardama" an Bord.

2230 Übermittlung der Glückwünsche des Ob.d.M. zum
Ritterkreuz an Kaptlt. Rostin.

30.6. 1525 U 158 funkt auf Anforderung N-Offizier: Kurs-
weisung für "Everalda" nach Rio vom 17.6.42:
Nach Verlassen Chesapeake Bay: 3335 N 7320 W
Punkt Gustav: 2653 N 6555 W Dora. 1922 N 581
Otto, 1212 N 4855 W Luzie, 6340 N 3850 Anton
0115 S, 3035 W Paul. 0440 S 2910 Sophie 1258 S
3142 W Emil. 2150 S 3535 W Quatsch, 2410 S

Figure 29: Photograph mosaic of the war diary of DKM *U-158*, written by Erwin Rostin during his service in 1942.

The only narrative information given for the date of the *Cities Service Toledo*'s sinking, 12 June 1942, is mention of a successful attack on a 7,000 gross ton (7,112.33 metric ton) vessel. Because this diary does include the fact that U-boat captains were using gross tons, it can be inferred that Müller-Stöckheim meant the same when reporting the weight of his targets. Rostin's claim of his 12 June sinking, though, is much more accurate to the 8,192 gross ton

(8,323.46 metric ton) *Cities Service Toledo* than that of what was reported by Müller-Stöckheim on the *R.W. Gallagher*.[9] This variation in accuracy among captains could be a product of poor visibility due to combat and nighttime conditions, over-estimation of wartime success, or perhaps Müller-Stöckheim's desire to be more highly received for his attack by increasing the tonnage. Regardless of the purpose for inaccuracies, both of these accounts demonstrate that veracity of reporting must always be compared to several sources before claiming them as fact.

Research utilized the expertise of a fluent German war historian, Dr. Derek Zumbro of the University of West Florida history department in conjunction with a 2005 Oxford-Duden German Dictionary German-English/English-German. The photographed and mosaicked diary pages were transcribed and these documents were then translated by Dr. Zumbro.

Remote-Sensing

A critical component of this study was the use of remote-sensing equipment to collect data on the shipwreck targets prior-to and during diver ground-truthing. As reviewed previously, the survey that located each specific target of interest involved a specialized crew boat, the M/V *Nikola*, equipped to survey the contracted site search areas by Tesla Offshore, LLC. (Evans et al. 2013:8-10). As Evans et al. mentions in the study, MMS archaeologists have had a consistent reputation for refining the use of magnetometers in finding shipwrecks (Evans et al. 2013:8-10). This study included the use of magnetometer data, but also participated in perfecting the use of acoustic sensors in detecting and identifying site details. The acoustic sensors used in particular for the *R.W. Gallagher* and the S.S. *Cities Service Toledo* in 2010 included side-scan sonar, sub-bottom profiler, multi-beam bathymetry, single-beam bathymetry, sector-scanning sonar, and a

9 Note: Kapitänleutnant Rostin mentions his receiving of the Knight's Cross on 30 June 1942 in his diary.

CODA 3-D Echoscope.[10] The initial analysis of data collected during the preliminary survey by Tesla Offshore, LLC. was performed by Pete Henstridge, James Collier, Kyle Edmonds, and Matt Keith. Later processing of the acoustic data in 3D manipulation software was conducted by Eric Swanson.

The initial results recovered from the *R.W. Gallagher* were encouraging as to the identification of the site as an oil tanker. Multi-beam data exhibited a large, over-turned vessel, oriented 204° south-southwest and 23° north-northeast (Evans et al. 2013:35). This data, collected in a point cloud, also reveals a large breach in the lower hull and scour zones up to 29.6 m (97 ft.) deep (Evans et al. 2013:35). Multi-beam data analyzed through QPS QINSy and QPS QLoud data processing software also provided acoustic returns in high-resolution, which revealed possible structural components within the hull breach (Evans et al. 2013:36) (Figure 30).

This information was also input to *Rhinoceros 3D* drafting software in conjunction with historical documentary blueprints, and will be discussed in the next chapter. Initial analysis of the remote-sensing data indicated that the target measured around 140 m (458 ft.) long, 22 m (72 ft.) wide, and rises around 7.3 m (24 ft.) above the seafloor, while the major hull breach measures 12 m (40 ft.) wide and 10 m (33 ft.) long (Evans et al. 2013:36). The use of high-resolution sonar imagery returned acoustic images that show high levels of detail of the rudder, propeller, and the vessel's stern (Evans et al. 2013:35) (Figure 31).

10 Echoscope data was only collected on the S.S. *Cities Service Toledo* site.

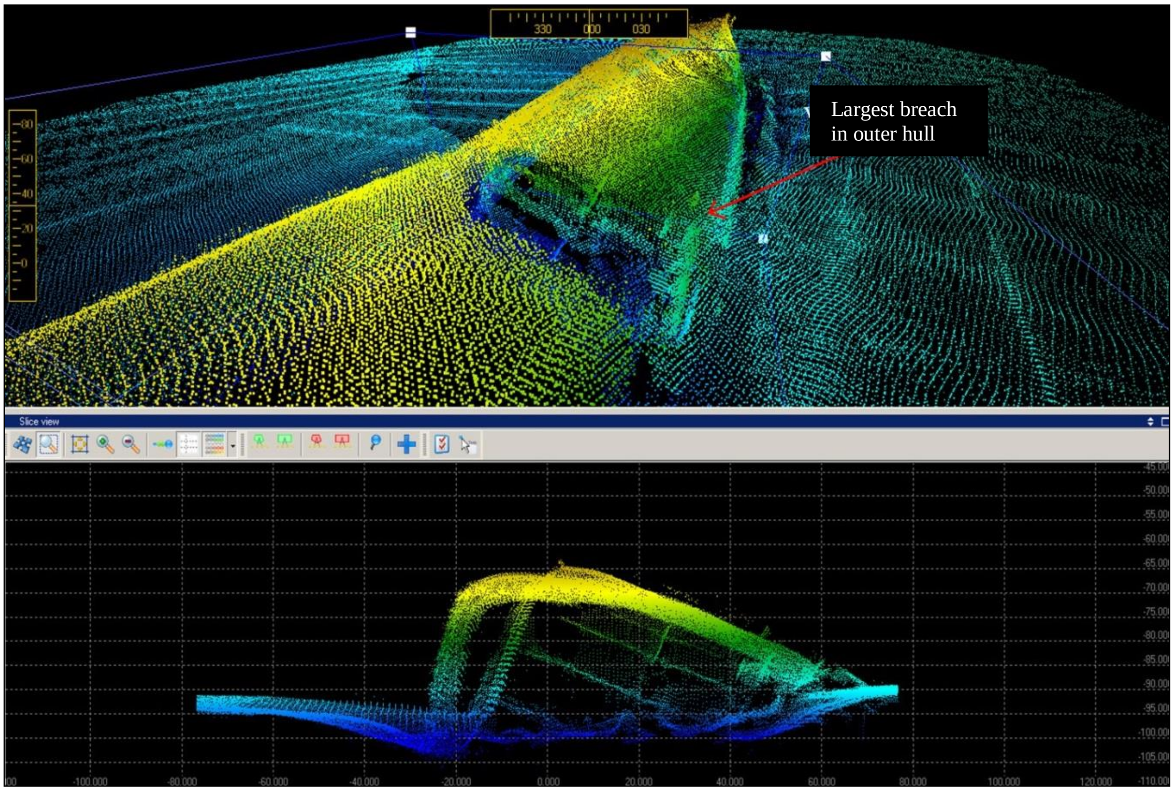


Figure 30: Image of multi-beam bathymetry data collected on the S.S. *R.W. Gallagher* site (Evans et al. 2013:43).

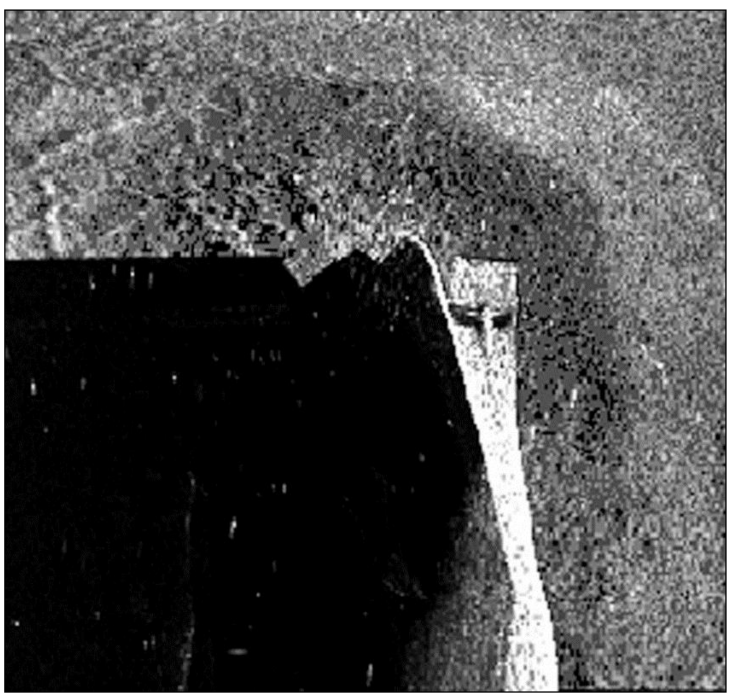


Figure 31: Image of sonar data collected on the stern portion of the S.S. *R.W. Gallagher* site (Evans et al. 2013:41).

Sub-bottom profiler data recovered by Tesla Offshore, LLC. revealed a typical stratigraphic profile for the region at 14-18 m (45-60 ft.) deep, only disrupted by the large scour zone surrounding the wreck (Evans et al. 2013:36) (Figure 32).

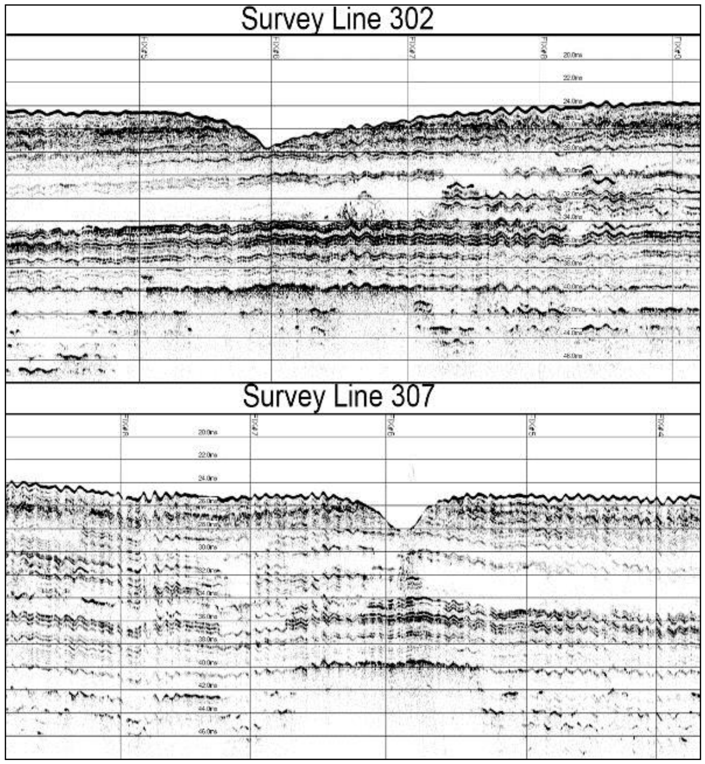


Figure 32: Image of sub-bottom data collected on the S.S. *R.W. Gallagher* site (Evans et al. 2013:44).

Magnetometer data indicated a potential debris field, showing significant magnetic returns spanning an area nearly 150 m (492.126 ft.) wide by 200 m (656.168 ft.) away from the wreck site. Two alternative magnetic anomalies are also present east and northeast of the wreck. To the east, a 10 positive (+) nanoTesla (nT) and 51 negative (-) nT return did not compare with any acoustic imaging. This could indicate material that is either part of the wreck or intrusive to the site (Evans et al. 2013:37). The northeastern anomaly includes individual readings ranging from 315 – nT to 153 dipolar nT, which has been associated with “a span of pipe or cable that measures 12 m (40 ft.) in length above the seafloor” (Evans et al. 2013:37) (Figure 33).

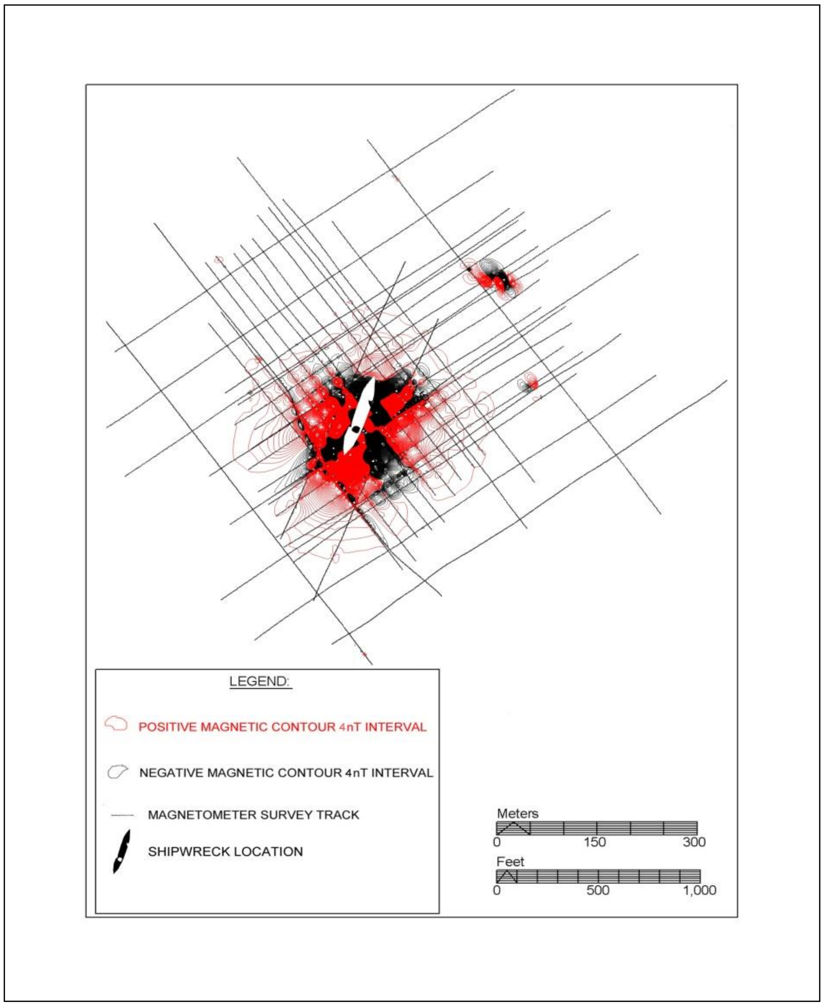


Figure 33: Magnetometer contour mosaic with 4 nT contour intervals collected on the S.S. *R.W. Gallagher* site (Evans et al. 2013:46).

In addition to the survey that isolated the *R.W. Gallagher*, sector-scanning sonar was deployed on site to gather real-time information as divers investigated the wreck. The Mesotech sector-scanning sonar was dropped without an internal compass, so exact direction was not discernible in real-time, though it could be inferred from the visual display on the computer. The most detailed scan was recorded on 15 August 2010 at around 19:00, around 21.95 m (72 ft.) north of the wreck. This scan also provided the crew with significant detail of the ship's rudder, propeller, a dense accumulation of sediment deposition, and debris scattered around the wreck site (Figure 34).

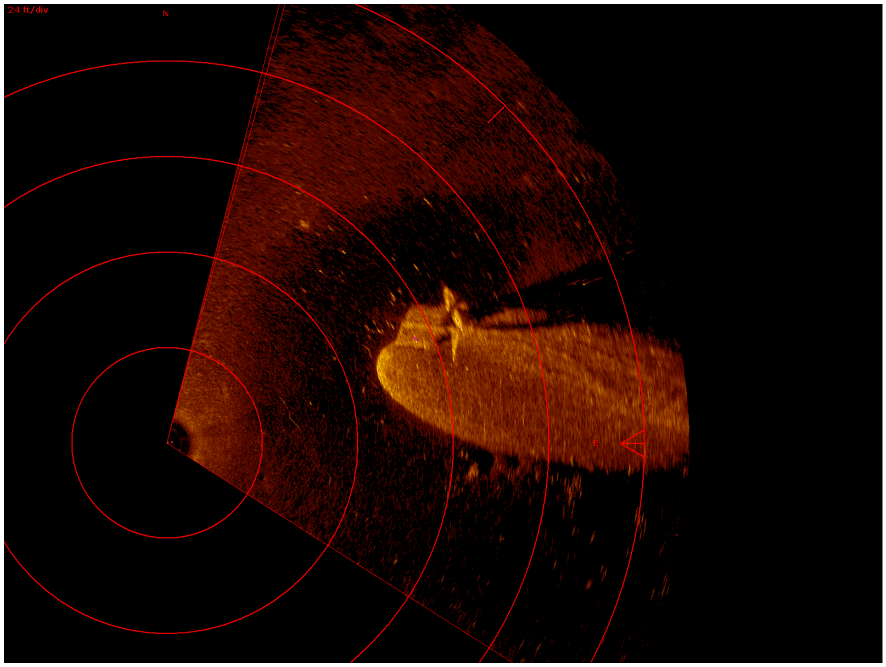


Figure 34: Image of sector-scanning sonar data collected on the stern of the S.S. *R.W. Gallagher* site with 24 ft. offset circles.

The results of remote-sensing on the *Cities Service Toledo* site yielded comparable data to that of the *R.W. Gallagher* with the benefit of the additional echoscope survey. To supplement the remote-sensing work that had been completed in 1992 and 2002 on the site, Tesla Offshore, LLC. surveyed the area in 2010. Like the *R.W. Gallagher* site, multi-beam survey revealed the vessel had a significant hull breach amidships, was lying hull-up on the seafloor, exhibited 6.7 m (22 ft.) of relief, and scour zones surrounding the wreck reaching 28 m (92 ft.) of depth (Evans et al. 2013:62). Multi-beam and single-beam sonar data indicate that the wreck is oriented 17° north-northeast by 197° south-southwest (Evans et al. 2013:62) (Figure 35).

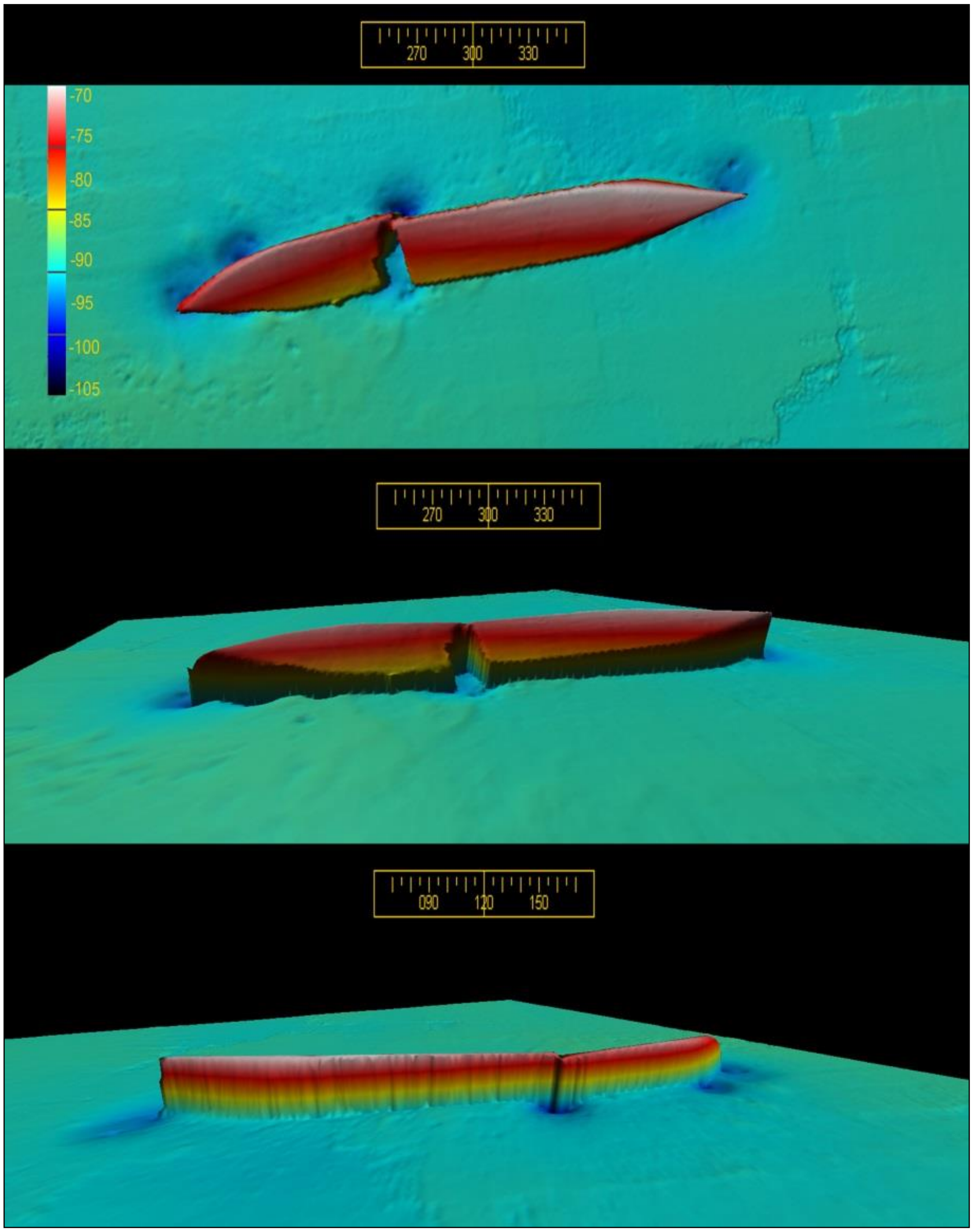


Figure 35: Image of multi-beam data collected on the S.S. *Cities Service Toledo* site (Evans et al. 2013:68).

In the analysis of these acoustic data, it was estimated that the wreck's dimensions are 141 m (463 ft.) long by 19.8 m (65 ft.) wide with the hull break measuring 18.2 m (60 ft.) long by 6 m (20 ft.) wide (Evans et al. 2013:62) (Figure 36).

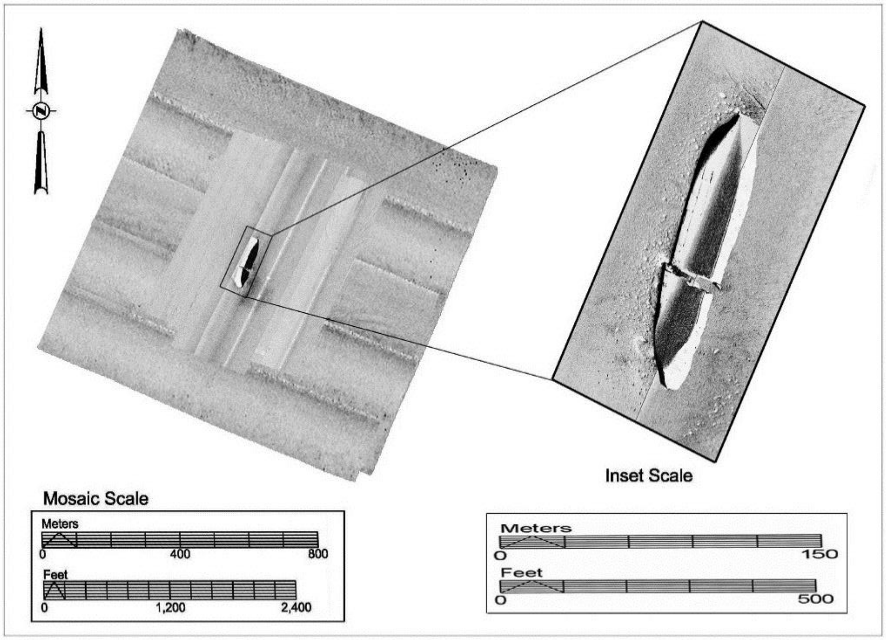


Figure 36: Image of sonar data collected on the S.S. *Cities Service Toledo* site (Evans et al. 2013:69).

The echoscope data recovered from survey revealed another break in the hull of the vessel on its south end. It is postulated that this is indicative of torpedo damage (Evans et al. 2013:62) (Figure 37).

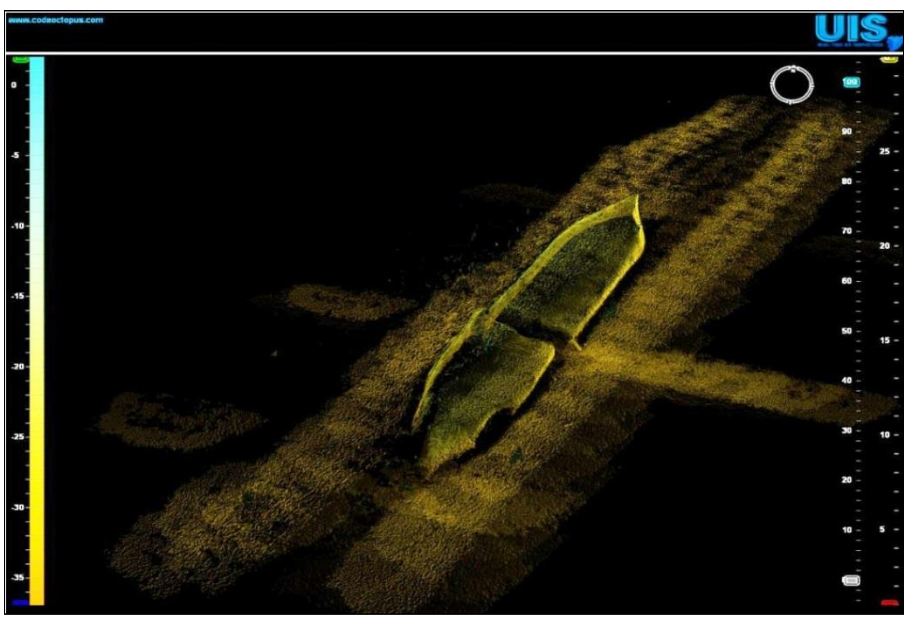


Figure 37: Image of 3D echoscope data collected on the S.S. *Cities Service Toledo* site (Evans et al. 2013:70).

Sub-bottom profiler data revealed a significantly reflective stratigraphic zone around 1.5 m (5 ft.) thick below the seafloor, indicative of high sediment compaction or thick sedimentary deposits, and is incongruent with the data collected from the *R.W. Gallagher* site due to its location in the Gulf of Mexico being less impacted by fluvial sedimentary deposition (Evans et al. 2013:63) (Figure 38).

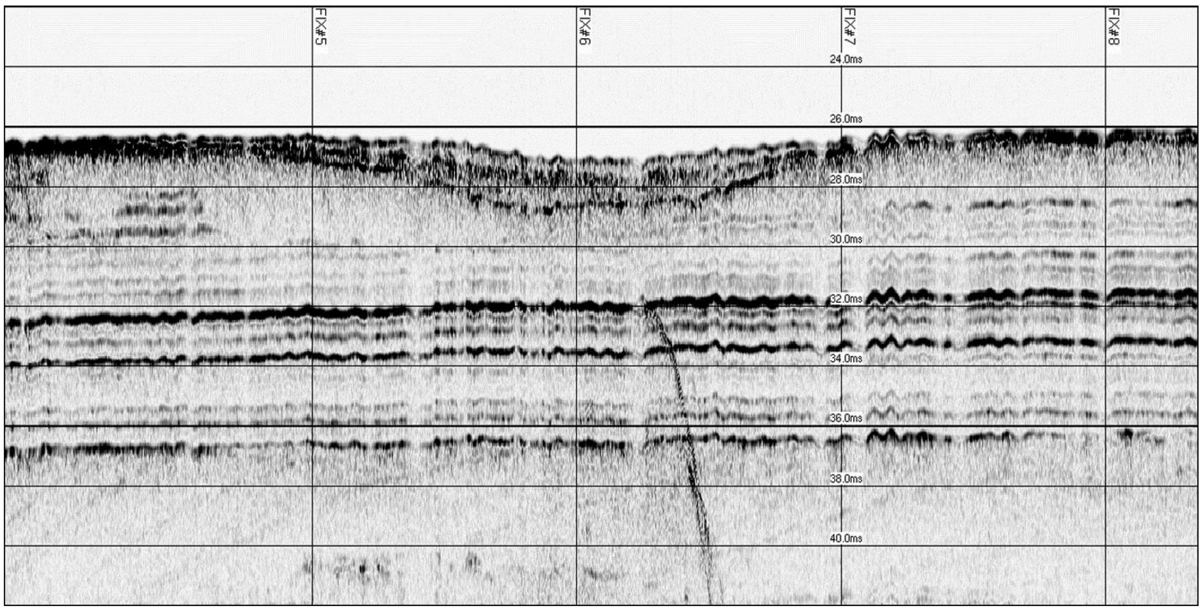


Figure 38: Image of sub-bottom data collected on the S.S. *Cities Service Toledo* site (Evans et al. 2013:71).

Magnetometer data was consistent with a massive ferrous shipwreck, indicating that several anomalous returns were detectable within the immediate vicinity of the ship (Evans et al. 2013:63). One significant cluster of magnetic signatures measuring 15 – 404 nT approximately 370 m (1,215 ft.) northwest of the wreck site is claimed to most likely belong to a recorded oil pipeline that was installed in that location, though it appears to be 128 m (420 ft.) east of the reported location of the pipe (Evans et al. 2013:63-64) (Figure 39).

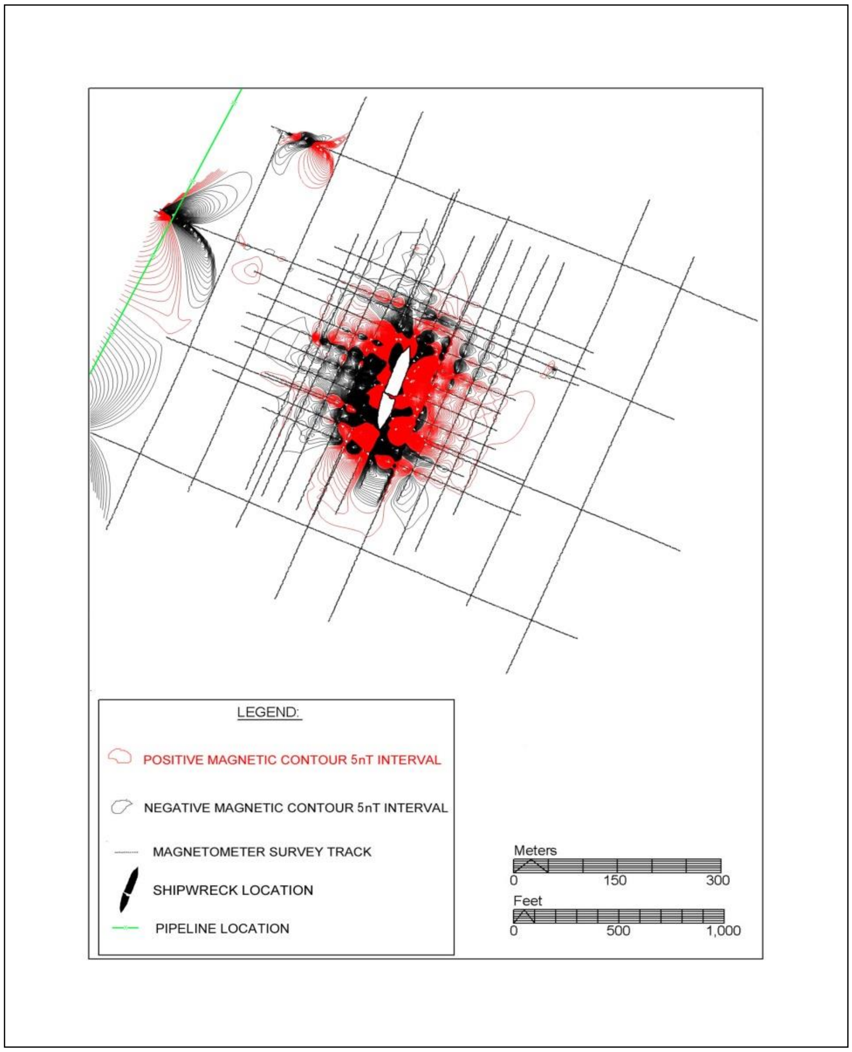


Figure 39: Magnetometer contour mosaic with 5 nT contour intervals collected on the S.S. *Cities Service Toledo* site (Evans et al. 2013:72).

Sector-scanning sonar was deployed approximately 57.91 m (190 ft.) west of this wreck during dive operations in August 2010.[11] The highest resolution scans of this wreck from the sonar revealed very little diagnostic information useful for interpretation. The scan was later determined to be of the stern of the tanker, and will be discussed in the next chapter (Figure 40).

11 The unit was lacking a gyroscopic compass at this time as well.

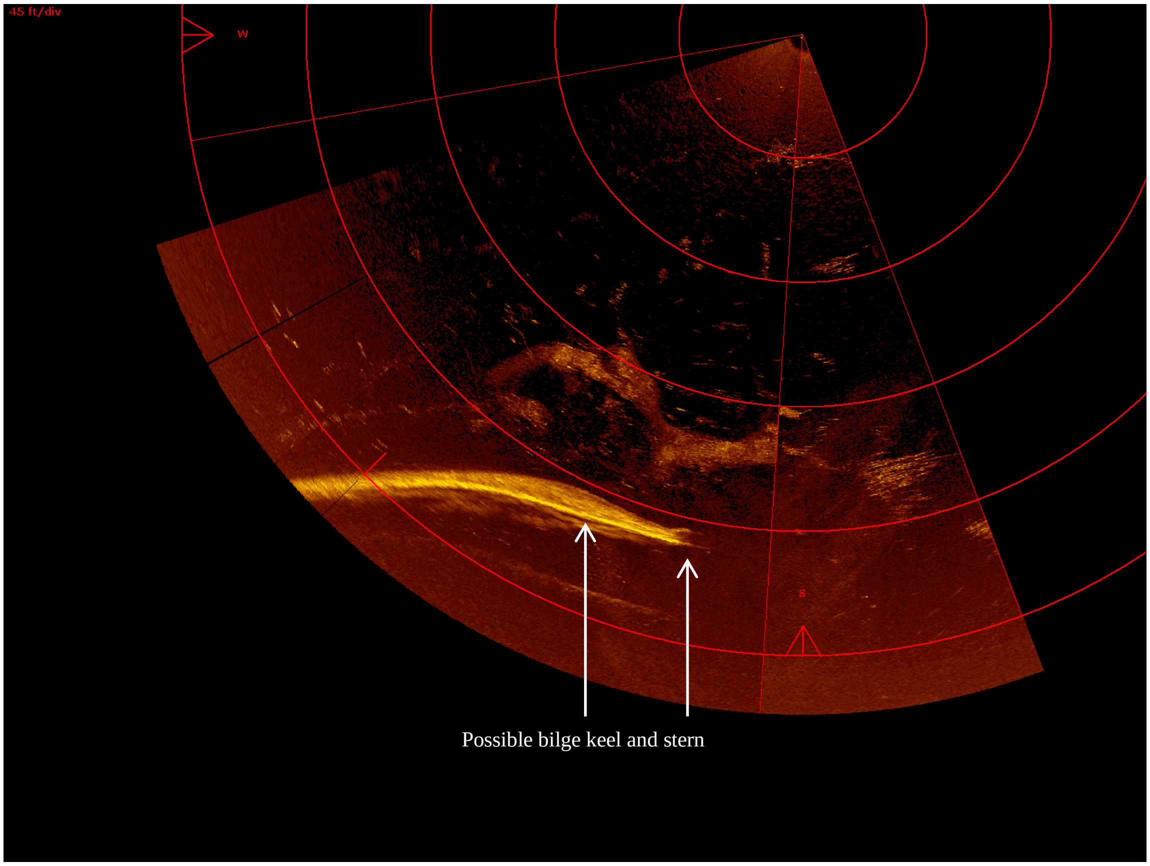


Figure 40: Image of sector-scanning sonar data collected on the stern of the S.S. *Cities Service Toledo* site with 13.72 m (45 ft.) offset circles.

Environmental data were also collected on these wreck sites with water and sediment core samples. The environmental analyses from these two wrecks help to gauge important aspects of site formation that allow for an adequate interpretation of conditions impacting the site, as well as provide a model for future impacts on these types of sites. On each site Amanda Evans and Matt Keith of Tesla Offshore, LLC. collected the data within the immediate vicinity of the target, and subsequently sealed and secured the samples safely on board the M/V *Spree* for transportation. The sediment core samples were split and logged by Amanda Evans and Matt Keith upon completion of dive operations and samples were sent to Dr. Mead Allison at the University of Texas for radioisotope analysis and to Dr. Patrick Hesp at the Louisiana

Universities Marine Consortium for analysis of grain size (Evans et al. 2013:17). As an important environmental aspect of the project, Amanda Evans tested each water sample for pH, salinity, and dissolved oxygen (Evans et al. 2013:18). These tests were run using an Amprobe WT-30 salinity meter, ExStik DO600, and ExStik EC500 pH/Conductivity/TDS/salinity meter.

Results from the analysis of environmental samples retrieved from the proposed location of the *R.W. Gallagher* site were important in the perspective of a site-formation model. Sediment cores were taken in two locations on the east and west side of the wreck. The western core was taken approximately 16.2 m (53.15 ft.) from the site which resulted in a shallow 22 cm (8.66 in) sample, most likely due to impact of the core with metal debris below the surface, and the eastern core was taken approximately 30 m (98.43 ft.) from the wreck which resulted in a 75 cm (29.53 in) sample that would later be used for full environmental analyses (Evans et al. 2013:46-47). Grain sizes from these samples resulted in an observation that larger grains remained at the surface, becoming smaller in size with depth (Evans et al. 2013:47). Shear strength of the western core resulted in averaged force ranging from 1.532 kPa (0.032 ksf) near the surface to 13.837 kPa (0.289 ksf) near the bottom of the core (Table 2) (Evans et al. 2013:47). This indicates that the sediments present in this location are incohesive and do not necessarily allow for a solid compaction around the site. This can result in scouring around the site itself, and prevents accumulation from burying the wreck quickly. The sedimentary deposition rate around the site will continue to allow for the structure to be impacted by the surrounding aerobic environment with time (Evans et al. 2013:204).

TABLE 2
AVERAGE SEDIMENT SHEAR STRENGTH AT THE S.S. *R.W. GALLAGHER* SITE, DRAWN FROM EVANS ET AL. 2013.

Depth below seafloor (cm)	Shear strength (ksf)
5	0.032
10	0.032
15	0.128
20	0.192
25	0.218
30	0.230
35	0.256
40	0.282
45	0.256
50	0.256
55	0.243
60	0.282
65	0.289
70	0.256
75	0.218

Radioisotope analysis of the core samples implied that a disturbance occurred in the area from an estimated 78 to 98 years prior to sampling, indicating a sediment accumulation rate of around 0.17 cm (0.07 in) per year (Evans et al. 2013:48). This data corroborates with the identity of this site as a WWII-era shipwreck site. Water samples taken from both the cores and the water column were analyzed by Amanda Evans in Baton Rouge, Louisiana. Taking the results from both 0.24 L (8 oz.) samples taken from the field, pH levels averaged at 7.802, salinity at 32.4 ppT and dissolved oxygen at 6.885 mg/L (Evans et al. 2013:46). Results coming from the water collected in the sediment cores averaged a pH of 7.5,[12] salinity of 36 ppT, and dissolved oxygen at 6.097 mg/L (Evans et al. 2013:47) (Table 3).

12 It is noted by Evans that the pH was higher farthest down Core 2 at 7.9.

TABLE 3
AVERAGE SALTWATER ANALYSIS DATA COLLECTED FROM THE S.S. *R.W. GALLAGHER* SITE, DRAWN FROM EVANS ET AL. 2013.

Within water column		Within sediment cores	
Salinity (ppT)	32.4	Salinity (ppT)	36
pH	7.802	pH	7.5
Dissolved O_2 (mg/L)	6.885	Dissolved O_2 (mg/L)	6.097

The pH levels within these samples allow for sulfate-reducing bacteria to function in the oxidation process of iron, thus increasing the corrosion rates of the structure. Though the increased pH at depth may prevent these bacteria from thriving, more alkaline environments can be increasingly more corrosive to metal materials (Cronyn 1990:169; Evans et al. 2013:204; Keith 2004:26; Kuang et al. 2007; Robinson 1981:6-7). The salinity levels in both the water column and within the core samples are above-average, and also contribute to increased chemical oxidation of the vessel's structure. The dissolved oxygen levels in the samples taken in the field also seem considerably high for the area, and may contribute to accelerated deterioration of site integrity, though further samples could determine a baseline data set for the area (Evans et al. 2013:194-195).

Environmental samples collected on the *Cities Service Toledo* site were taken in the same manner as those taken on the *R.W. Gallagher*. Sediment coring took place approximately 86.31 m (283.17 ft.) directly southeast from the northernmost point on the wreck, resulting in a 58 cm (22.83 in) sample (Evans et al. 2013:70). Grain size analysis determined that finer sediments exist on the seafloor, increasing in size further downcore; shear strength was not possible to be tested on the small sample (Evans et al. 2013:70). Radioisotope analysis determined that the sample did not contain enough of a linear direction in Pb-210 decay rates to isolate sediment accumulation rates or site disturbance activity (Evans et al. 2013:70). Water sampling was only taken from one 0.24 L (8 oz.) water container filled from the water column immediately adjacent to the wreck site. The water sample measured a pH of 8.013, salinity of 30.8 ppT, and dissolved oxygen of 7.45 mg/L (Table 4).

TABLE 4
AVERAGE SALTWATER ANALYSIS DATA COLLECTED FROM THE S.S. *CITIES SERVICE TOLEDO* SITE, DRAWN FROM EVANS ET AL. 2013.

Within water column		**Within sediment cores**	
Salinity (ppT)	30.8	Salinity (ppT)	N/A
pH	8.013	pH	N/A
Dissolved O_2 (mg/L)	7.45	Dissolved O_2 (mg/L)	N/A

This sample indicates that the previously mentioned sulfate-reducing bacteria will not thrive well in the alkaline environment around the *Cities Service Toledo* site, which may help to preserve site integrity longer than that of the *R.W. Gallagher*. The lower salinity of the site in comparison to that of the *R.W. Gallagher* will also favor the longevity of structural integrity. These factors do not outweigh the strongest factor in oxidation, and subsequently corrosion of the site, which is the higher level of dissolved oxygen. These higher levels of oxygen will degrade the structure of the vessel faster over time (Evans et al. 2013:212; MacLeod 1989).

Diver Ground-Truthing

As a part of a larger project contracted to Tesla Offshore by BOEMRE, the diver investigations that took place in August 2010 were conducted under the University of West Florida's standards for scientific diving. During the collaboration, marine archaeologists conducted 246 scientific dives that accounted for nearly 120 hours of total bottom time (TBT) on the two vessels cited in this study. The information that accompanied each dive was reviewed at the surface for methodological and diagnostic purposes. Timing each dive, tracking and managing each dive team, documenting each diagnostic element of the sites, still and video photography, diver sketching, drafting, and written field journals all aided in writing a complete summary for each location. These data were recorded, scale drawings were completed by hand, and the information was archived at the University of West Florida. The data from all available field documentation were compiled by Eric Swanson under direction from Dr. Greg Cook from the end of field collection until the end of 2011. Final ink drawings were completed by Dr. Greg Cook, and 3D modeling and digitization of the drawings related to the *R.W. Gallagher* and the *Cities Service Toledo* sites were finished by Eric Swanson. Each site had its own unique set of diagnostic elements important to the identification of these vessels, and each dive was conducted under this premise.

The S.S. **R.W. Gallagher**

The first site investigated was the purported location of the *R.W. Gallagher*. The project team arrived on location on 15 August 2010. Due to the massive size of the wreck site and its observed depth of around 25.91 m (85 ft.), divers were restricted to limiting their dives to record specific diagnostics. A total of 10.32 hours was spent on this vessel, each dive averaging 25.79 minutes. Visibility varied immensely depending on observation depth, location on the wreck, and environmental factors. Nearest to the seafloor, visibility was under 0.31 m (1 ft.), increasing to 3.05-6.1 m (10-20 ft.) at a depth of around 24.38 m (80 ft.), with visibility clearing to approximately 18.29 m (60 ft.) at 21.64 m (71 ft.) of depth. Orientation of the wreck was recorded as 24° north-northeast by 204° south-southwest. An oil sheen was observed at the location of the wreck site and was observed coming from the hold of the wreck (Figure 41).

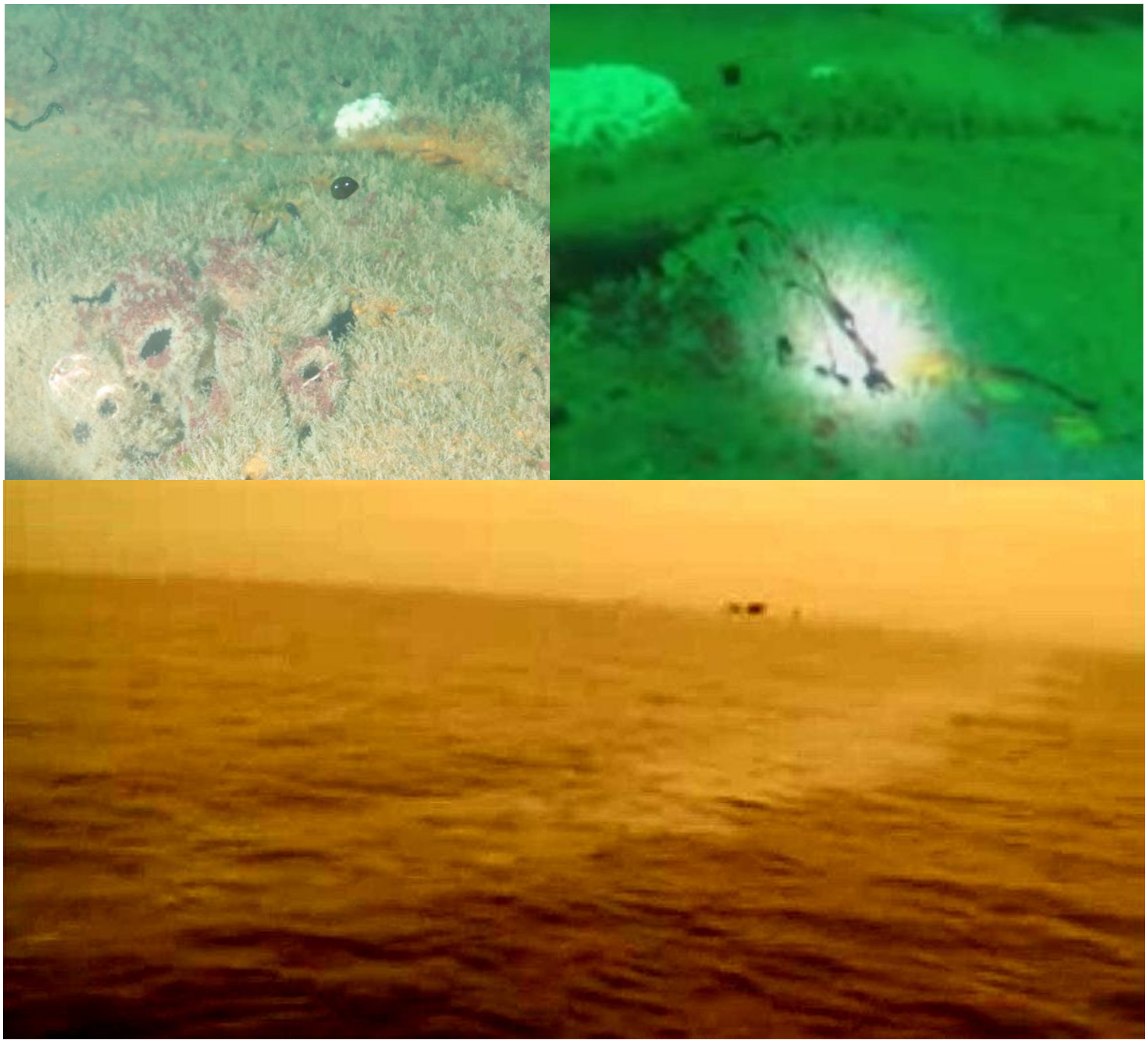


Figure 41: Oil droplets escaping the outer hull of the vessel at 3 atmospheres of pressure, expanding to an oil slick seen on the surface for several miles from the S.S. *R.W. Gallagher* site. Oil slick photograph enhanced by a U/V filter and contrast enhancement for clarity. The photograph and video images are courtesy of Colm O'Reilly 2010.

After deliberation on the importance of specific features on this site, it was determined that the bilge keel, hull plating, rudder, and propeller would be the most important diagnostic elements to focus diver-specific drawings and measurements. As noted in Chapter IV, divers descended on the massive hull breach located amidships. This massive breach measured 4.3 m

(14.11 ft.) immediately west of the down line and 8.4 m (27.56 ft.) immediately east of the down line. While measuring the large hull break, it was observed that the exterior metal on the eastern side of the wreck was curved inward toward the center of the vessel. A loose chain was located alongside the bilge keel and was determined to be intrusive to the site. A dive team extended a baseline 45.4 m (148.95 ft.) to the bow of the vessel, running along the curvature of the hull where the bilge keel is present. It was observed that the bow was rounded with evidence of significant damage that caused sections of hull plating to be missing from the foremost region of the wreck. Measurements of the bilge keel indicated that it varied in height from 20-36 cm (7.87-14.17 in) and was possibly 47 cm (18.5 in) thick. Heavy biological and concreted masses inhibited precise measurements to be taken of hull plating or rivet patterns along the hull (Figure 42).

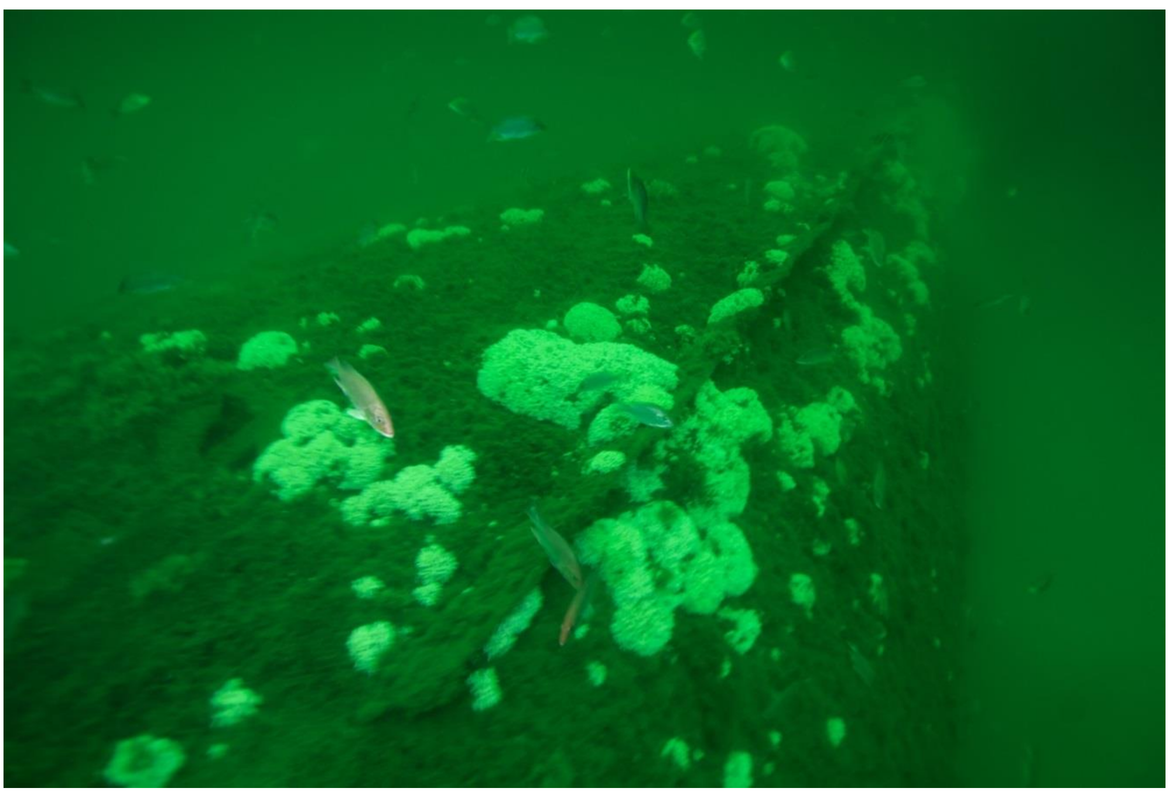


Figure 42: The bilge keel with white coral and rusticle growth on the S.S. *R.W. Gallagher* site (O’Reilly 2010).

Dive teams recorded diagnostics at the stern of the vessel, including a four-bladed propeller complete with what appears to be a streamlined double-bladed rudder. A discussion on this type of rudder will be conducted in the next chapter. The propeller blades measured to be approximately 2.5 m (8.2 ft.) long and about 1.34 m (4.4 ft.) wide. The highest visible rudder blade in the water column measured around 3 m (9.84 ft.) wide by approximately 3 m (9.84 ft.) tall (Figure 43). The visibility below that blade prohibited an accurate measurement, but these measurements will be later addressed in the discussion on the rudder. A diagnostic diver sketch by Dr. Chris Horrell was enhanced in an ink drawing by Dr. Greg Cook (Figure 44). A digitized drawing and 3D digital model created by Eric Swanson were later used to determine distinctions in the variability of accuracy to historic blueprints and diver-recorded video observations.

Figure 43: The propeller and conditions on the S.S. *R.W. Gallagher* site (O'Reilly 2010).

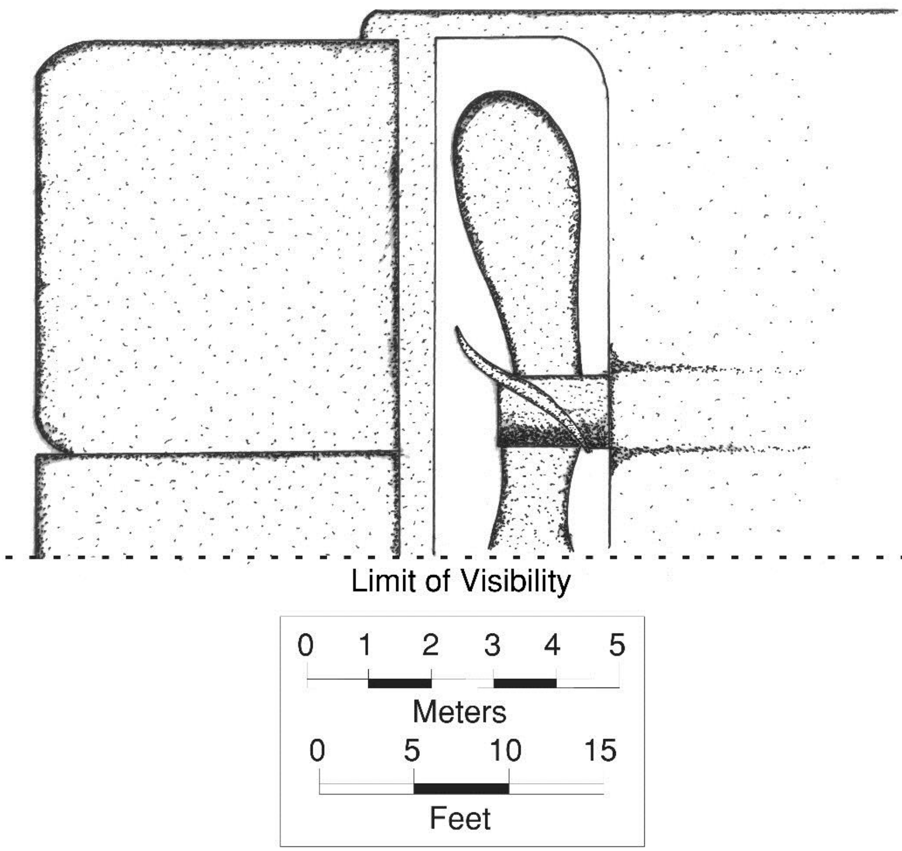


Figure 44: Scale ink drawing (Dr. Greg Cook) drawn from data gathered on the stern section of the S.S. *R.W. Gallagher* site.

The S.S. **Cities Service Toledo**

The research team arrived at the potential location of the *Cities Service Toledo* wreck on 18 August 2010 and continued research on location until 19 August 2010. Similar in size to the *R.W. Gallagher* and at an observed depth of 24.38-27.43 m (80-90 ft.), the environment around the *Cities Service Toledo* offered the same challenge to divers by reducing their activity to a single diagnostic task at a time. Divers recorded 6.63 hours TBT that averaged 23.41 minutes of dive time per person on this site. Visibility varied on this wreck as well, depending on location, time of day, and depth. On the seafloor, visibility peaked at 0.31-0.91 m (1-3 ft.) for all divers regardless of location, divers noted visibility at 21.34-24.38 m (70-80 ft.) depth ranged from

3.05-6.1 m (10-20 ft.), and, when current was stronger, divers recorded visibility greater than 6.1 m (20 ft.) regardless of their location. Discussion of the implications of these observations will be reviewed later. Visibility limitations and the effect of the large ferromagnetic tanker on compass instruments prevented any direct observations on the orientation of the wreck.

Goals of diver-specific diagnostic observations were set to record the hull plating, rivet patterns, rudder, propeller, and any other possible construction markers that would yield identifiable information. The sediment core obtained at this site was taken at a distance from the stern of the wreck. Initial investigation of the stern of the vessel indicated that the propeller and rudder were completely missing. Upon further searching up to 15 m (49.21 ft.) in a semi-circular arch from the center point of the propeller shaft, no evidence of the rudder or propeller could be located in the surrounding scour zone. In referring to the historic blueprints for the vessel, a wood or brass fitting would have been used where the propeller shaft extended from the stern of the ship, but no clear indication of these materials were present upon investigation; this will be discussed in the next chapter. It was observed, however, that the propeller shaft had a “brassy” tint beneath a heavy brown biological growth (Figure 45).

Hull shell plating patterns were recorded near the stern of the overturned tanker, indicative of either a clinker plating system or a raised and sunken plating system, both commonly used at the time (Figure 74). Rivets over these shell plates measured 30 cm (11.81 in) on the aft-most rivet and 25 cm (9.84 in) on the forward rivets, both rivet sets appeared to have rounded heads (Figure 24 and Figure 46). The uses of these rivets will be discussed in the next chapter.

Figure 45: Profile photographs of the propeller “shaft” on the S.S. *Cities Service Toledo* site. Scale bar is in 2 cm increments (10 cm total).

Figure 46: Hull plating with buttonhead rivet on the S.S. *Cities Service Toledo* site.

A small fastener was observed on the lowest point of the rudder brace, which would have been the top-most section near the rudder's stock when the ship was upright. Dimensions of this fastener were not taken. Photographs and video were taken at the stern of the vessel and aided in the interpretation of diver drawings. The propeller shaft measured approximately 0.61 m (2 ft.) in diameter. An initial scaled sketch was made of the propeller shaft and sheared rudder brace by Dr. Chris Horrell and was later inked in detail by Dr. Greg Cook (Figure 47). These drawings were later digitized and amended by Eric Swanson during 3D modeling to base comparative analysis of the original blueprint designs and 3D models to archaeological findings.

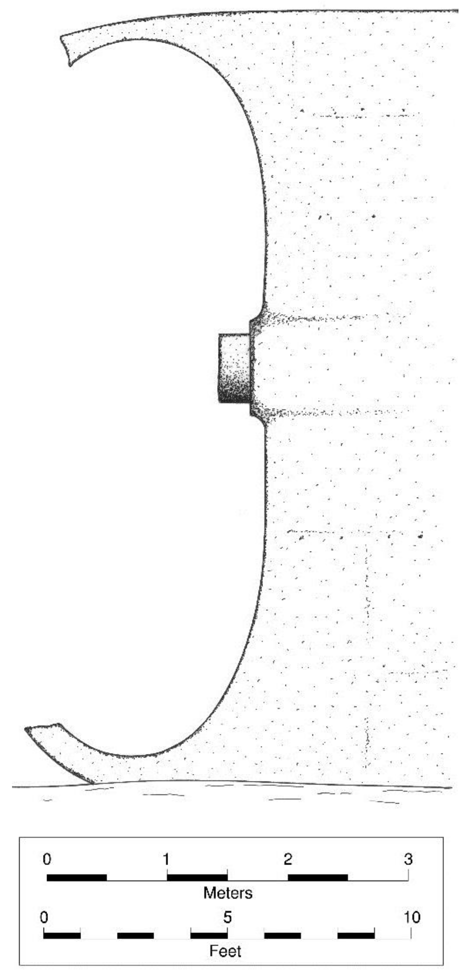


Figure 47: Scale ink drawing (Dr. Greg Cook) drawn from data gathered on the stern section of the S.S. *Cities Service Toledo* site.

Modeling

The emergence of 3D modeling software with the advent of the personal computer has revolutionized the world of engineering, and, for the purposes of archaeological research, reverse engineering. For this project, much of the data collected in the field via remote-sensing was represented digitally in formats easily read by modern 3D modeling software. Not only did the use of 3D modeling software aid in the replication of the vessels with their original blueprints as guidelines, but also allowed a medium in which to apply and manipulate remote-sensing data to examine components of each wreck with details that could not be recorded during the diver observation period. Furthermore, the process that allowed the digital reconstruction of ship models based on their blueprints also allowed for these models to be directly compared to their current context underwater. The advantages of this software comparison method and analytical capability will be discussed in the next chapter with more detail.

Two primary software programs were used in this process, *Google Sketchup 8* (*Sketchup*) and *Rhinoceros 3D Non-Uniform Rational Basis Spline (NURBS) Modeling 4* (*Rhino*).[13] Both of these software packages have advantages and disadvantages, and these will be discussed in detail later. This portion of research offered a methodological comparison of the reconstruction quality between the two software packages. Models were digitally constructed, piece by piece, over the original ships' blueprints in each program and gauged on their accuracy and ease of construction. Next, the remote-sensing data was imported to the programs to test their capabilities of representing the data accurately. Finally, the data and models were compared side-by-side, sometimes overlapping, to gauge their similarities to the shipwrecks and to determine if this method is accurate and efficient in comparing, or identifying, unknown shipwrecks of this time period. The first models were drawn within *Sketchup* to test construction method, accuracy, and 2-dimensional data input. Constructing the initial form of the vessels proved to be simple as *Sketchup* allowed lines to be placed on top of the image of the blueprints (Figure 25 and 48).

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13 NURBS modeling utilizes a mathematically derived 3-dimensional space that conceptually allows endless surfaces. This makes drafting smoother and easier to manage than linear, fixed-space drawings.

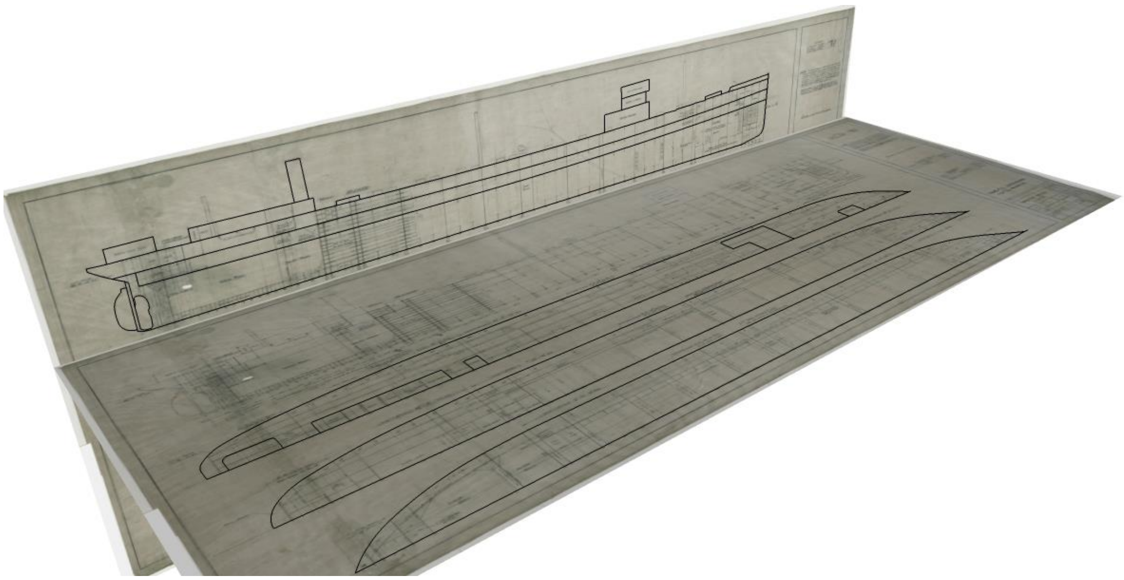

Figure 48: Point-and-line modeling process utilizing to-scale historical ship's plans for the S.S. *Cities Service Toledo*.

Though the linear geometrical functions that the program uses to create 3-dimensional objects from 2-dimensional designs is beneficial in the formation of direction-based solid objects, creating the complicated curvature of ships' hulls is next to impossible, taking hours to construct individual frames that would account for the exact curvature of the ships. These frames were not included in the original blueprints and had to be drawn from construction manuals in conjunction with trial and error in the software to represent ships' lines (Figure 49).

The implied inaccuracy of this does not affect the interpretation of the exact locations within the hull that the torpedo strikes took place, but it is disrupting. It is the goal of researchers to be as accurate as possible, and taking this leap led to an imperfect representation of the blueprints' concepts. The test of importing remote-sensing data failed in *Sketchup* as the software was unable to handle the amount of data points collected in the field. The final determined capabilities of *Sketchup* were minimal and abandoned for any useful purpose aside from developing accurate digitized scale ship's lines for use in *Rhino.*

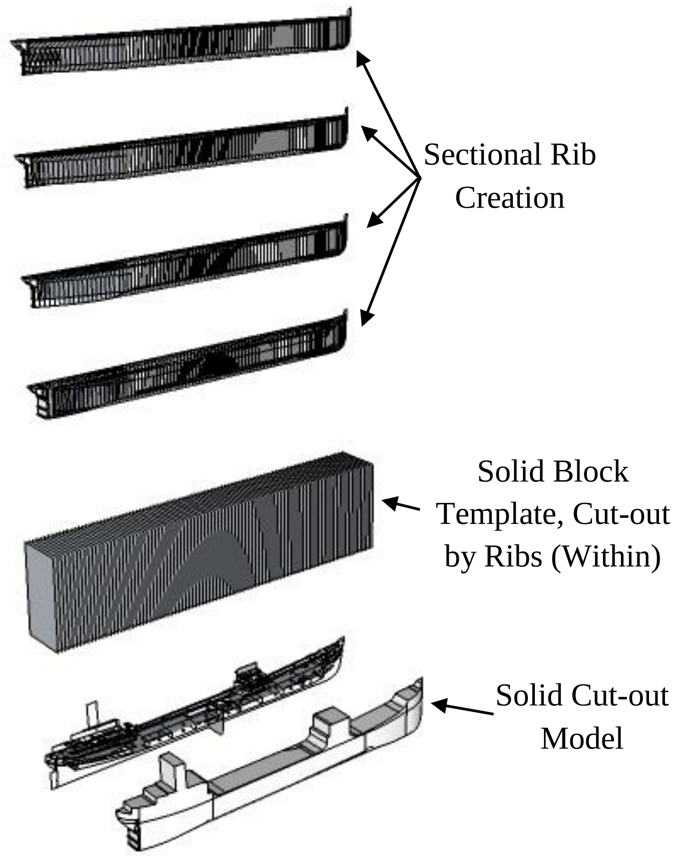

Figure 49: Rib construction in *Sketchup* to form an accurate outer hull on the S.S. *R.W. Gallagher*.

The models used for this study were made using *Rhino* software with the same intention of modeling as performed in *Sketchup* with the addition of importing the remote-sensing data for comparison. Initially, constructing rigid lines that followed the exact contours and design that the shipwrights had included on the original blueprints posed a challenge on the software that runs geometrical mathematics under an infinite series of points through 3-dimensional space. The NURBS modeling design only posed this initial problem, but did not inhibit an accurate representation of the original intention of the architects due to the ability for *Sketchup* digital blueprints to be imported accurately to scale.

Next, the process involved creating accurate curvature of the ships' hulls originally intended by the shipwrights. The 3-dimensional workspace in *Rhino* allowed the modeling process to move unhindered by 2-dimensional mathematics and the outer hulls were created with relative ease (Figure 50 and Figure 51). The completed models could be exported, bisected, and printed in 3D, and the results were extremely smooth and accurate to the ships' plans (Figures 52-54).

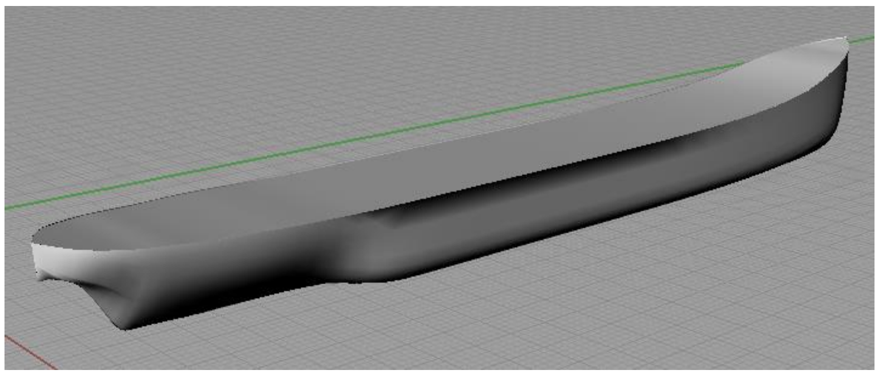

Figure 50: Initial hull shape of the S.S. *R.W. Gallagher* built in *Rhino*.

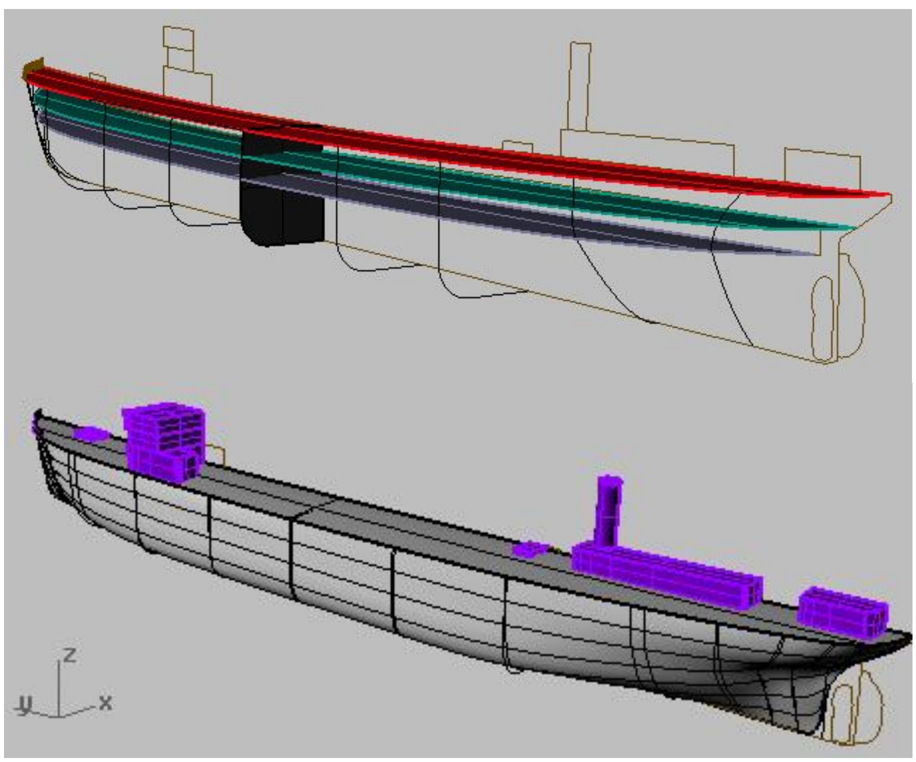

Figure 51: Rib-formation process and initial hull shape of the S.S. *Cities Service Toledo* built in *Rhino*.

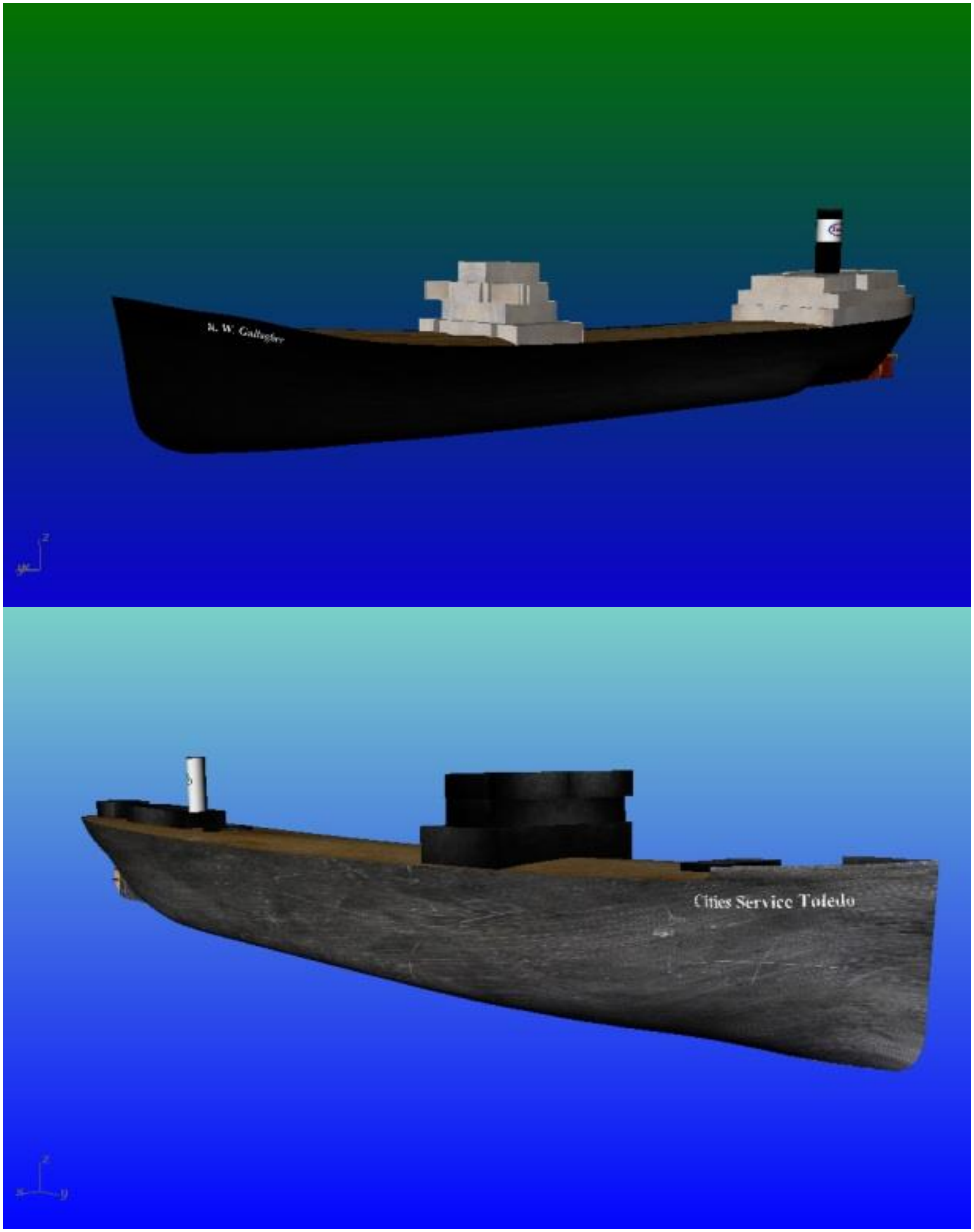

Figure 52: Final rendered models of the S.S. *R.W. Gallagher* and the S.S. *Cities Service Toledo*.

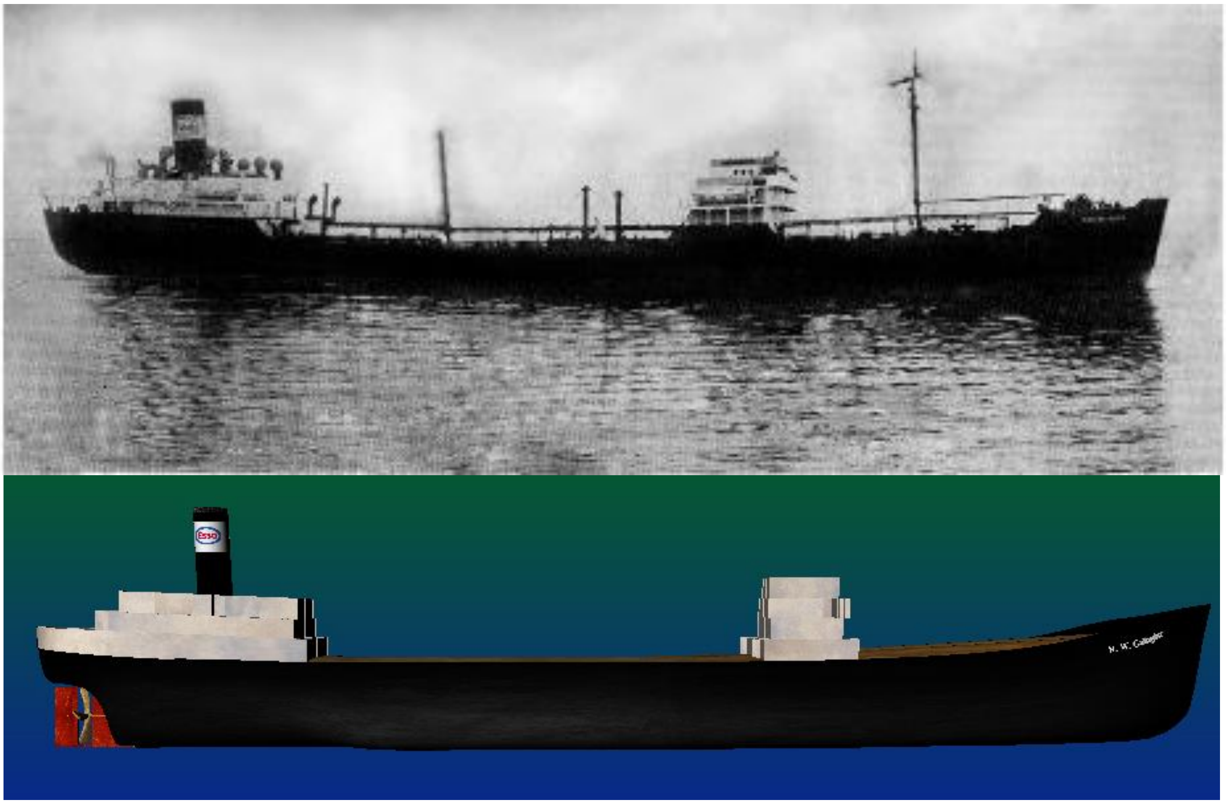

Figure 53: Historical photograph of the S.S. *R.W. Gallagher* (Standard Oil Company 1946:357) and the blueprint-reconstructed 3D model.

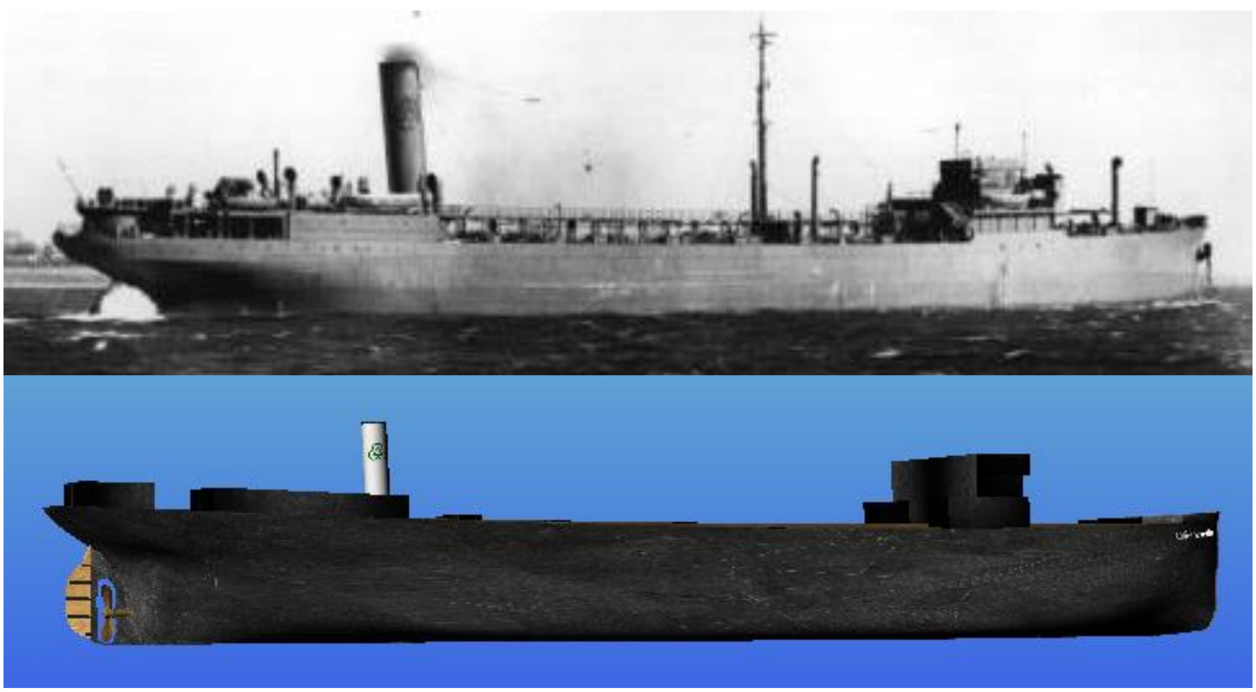

Figure 54: Historical photograph of the S.S. *Cities Service Toledo* (unsourced USCG 1942) and the blueprint-reconstructed 3D model.

The final test implemented through *Rhino* was the input of remote-sensing data into the program. This test was largely successful, and subsequent data analysis was made easier when comparing damage estimates with the models. A replicated model of each wreck site was then mathematically constructed using the point cloud data collected by the remote-sensing equipment (Figure 26 and Figure 55).

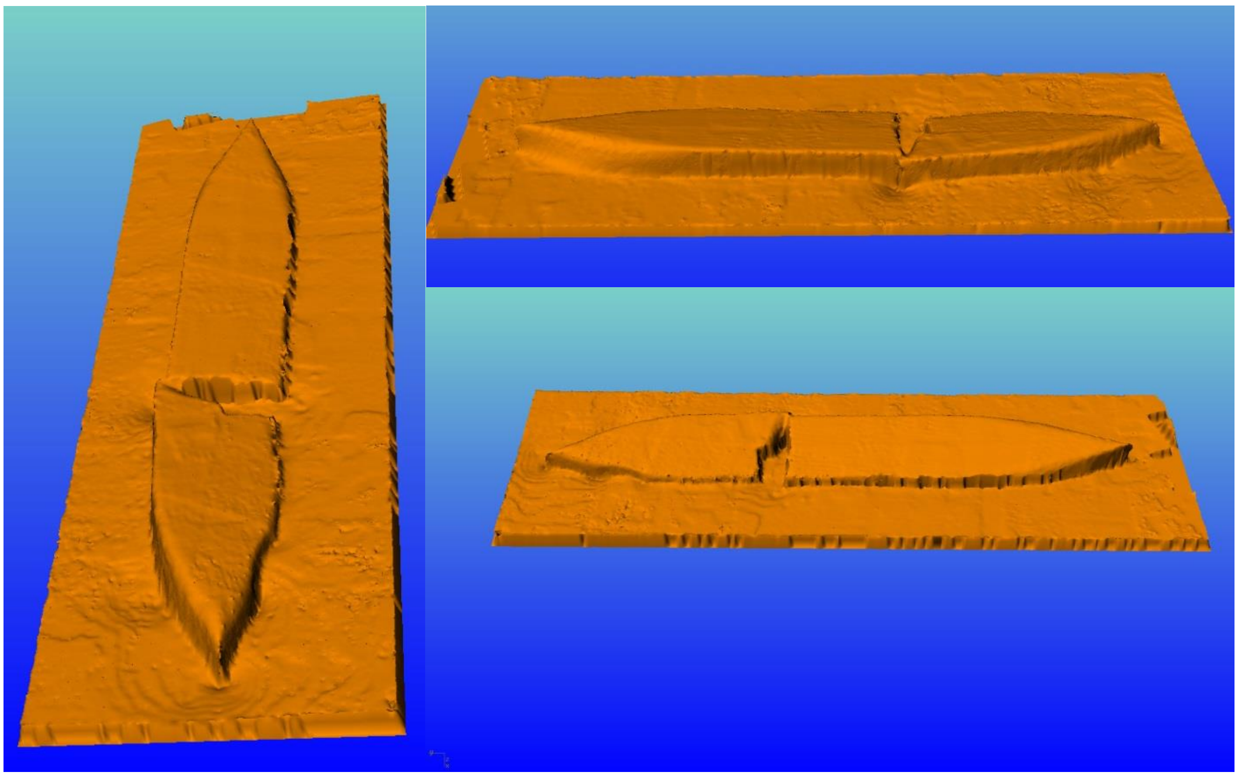

Figure 55: Rendered multi-beam data from the S.S. *Cities Service Toledo* site.

Point clouds collected with the multi-beam echosounder on both sites placed millions of collected points in simulated space based on their geophysical location on Earth. These points were then converted into a mesh that connected points at varying frequencies and at varying intensities based on user trial and error for accuracy of connections. Higher frequencies yielded more detailed meshes that isolated smaller elements of the wrecks, such as internal structure, where lower frequencies were essential in observing a larger pattern over the hull of the ship and the scour zones surrounding it (Figure 56).

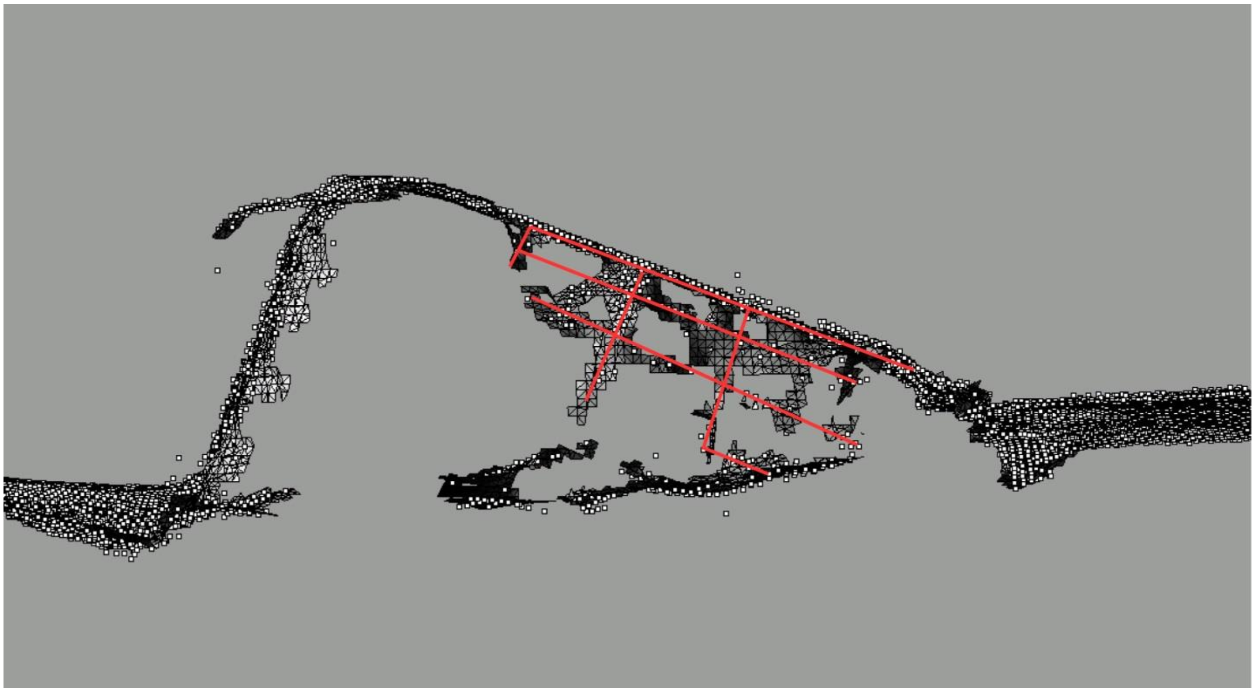

Figure 56: High-frequency multi-beam mesh revealing visible internal structure on the S.S. *R.W. Gallagher* site.

These data were then virtually wrapped with a mathematically formulated surface that visually represented the current condition of the vessels more accurately than singular points. The meshes and surface-rendered points were then compared and overlapped with the blueprint-originated 3D models and were analyzed for the accuracy in which they represented the historical account of torpedo damage. This evidence was cross-examined with remote-sensing data to determine the reliability of these hypotheses (Figure 57 and Figure 58).

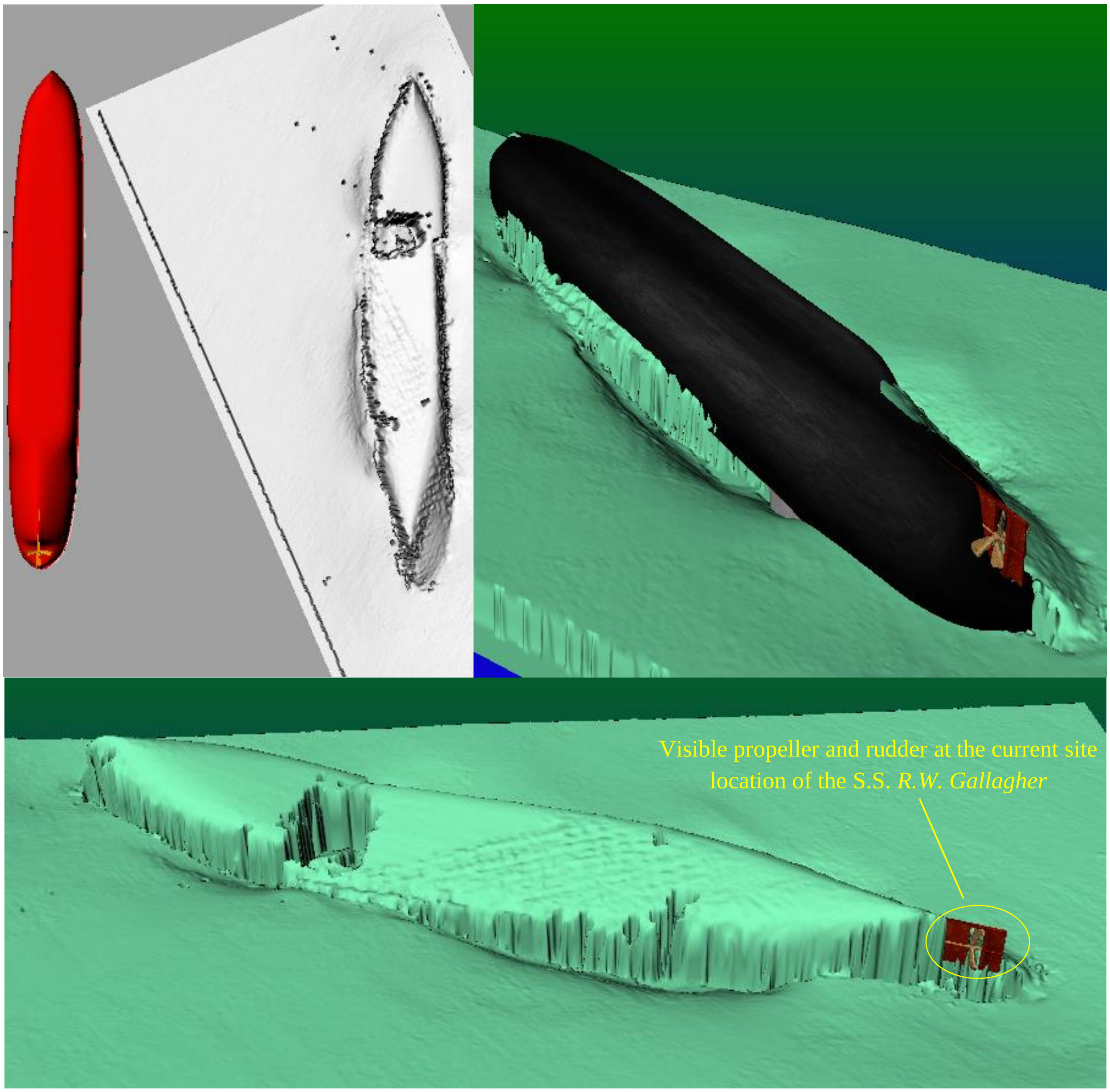

Figure 57: Comparison of the historical 3D model and remote-sensing data collected at the S.S. *R.W. Gallagher* site.

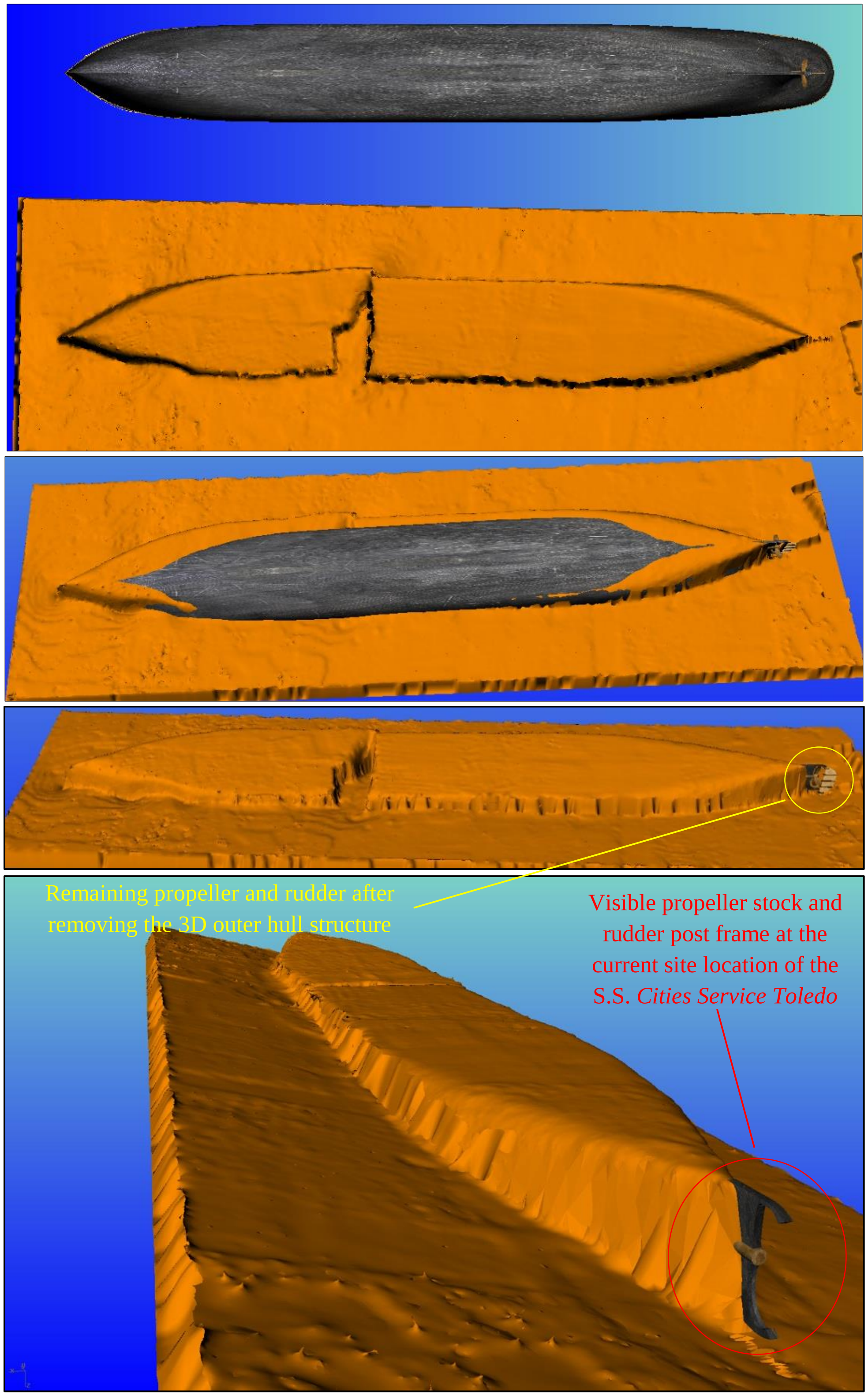

Figure 58: Comparison of the historical 3D model and remote-sensing data collected at the S.S. *Cities Service Toledo* site.

The final results of this test in model building in an archaeological setting were critical to the interpretation and understanding of the wreck sites studied. The reconstructed models and point-cloud models can also be represented to the public through the medium of 3D printing or augmented reality, an emerging technique that provides detailed 3D models to the public within their own homes, public locations, or mobile devices.

CHAPTER VI: DISCUSSION

Introduction

Included within this brief examination of two World War II tankers, the *R.W. Gallagher* and the *Cities Service Toledo*, is a dialectic that combines the most important aspects of interpreting historic wreck sites, namely historic documentation and archaeological investigation. The historical documentation includes survivor statements, U-boat commanders' action diaries, ships' plans, census records, transaction history, crew and passenger lists, and United States military command history. These aspects of research are essential to demonstrate the importance of these wrecks to U.S. history, and they all fit together to explain a rarely discussed portion of World War II history. As a whole, the documents are only as complete as authors could record during a battle. In addition to the historical research, archaeological investigation expands the understanding of these wrecks and their final moments on the battlefield at sea. The physical data collected from these two archaeological sites has contributed to the larger historical context by placing individual material remains in context with evidence of strategy and events that sank these two oil tankers. A critical review of the historical documentation indicates that not every detail is consistent in every account. It is here that the archaeological data presents the clearest representation of the battle that occurred in the respective location of each wreck and which accounts and historical reports represent the clearest explanation of what happened at each war grave. Each of these will be discussed in detail following the information collected throughout this study.

In order to initiate the dialectic staged in historical comparisons,[14] a modular comparison[15] can be used to identify specific elements individually. In order to remain brief, this process is best achieved by following the theoretical foundations of battlefield archaeology. The theoretical model contends that evidence of battlefield tactics and individual actions and movements can be traced through the archaeological record when placed in direct comparison to historical documentation. This model will be expressed in the following text, explaining the particular references located within the historical documentation, as well as how these accounts compare to the archaeological data collected in the field. It is hoped that the research will demonstrate how a theoretical model based on battlefield archaeology can be applied to archaeological investigations of World War II wreck sites like the remains of the *R.W. Gallagher* and the *Cities Service Toledo.*

Historical Accounts

Available historical documentation on these two oil tankers remains consistent on several details, as discussed in Chapter II. However, inconsistencies do exist between several historical documents, and will be discussed in this section with correlations and disagreements placed in dialectical arms with archaeological evidence that supports or refutes either claim. This discussion will ultimately reflect the critical relevance of battlefield archaeology to identify and investigate these wrecks in the future.

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14 The dialectic, referenced in earlier chapters regarding gross and dynamic patterns, is indicated by Scott et al. 1989 as a part of the structure of establishing battlefield patterns in archaeology.

15 Taking the previous dialectic into consideration, Fraga's 2004 paper on creating a modular (several written and illustrated records each serve as different recorded models) format in reconstructing ships in 3D also follows the dynamic patterns described by Scott et al in 1989 with battlefield archaeology. The connection is clearly made through this thesis, though both of these concepts were developed separately, at different times, for different purposes.

The first series of historical inconsistencies that will be discussed are a review of claims made by the U-boat command in their respective diaries on the hours and days that both of the oil tankers were sunk and the following summary statements made by the crews of the vessels that sank. The account of *U-67* by Müller-Stöckheim in his official war diary and the statements made by crew members aboard the *R.W. Gallagher* will be compared. Isolation of historical context with data collected in the field reveals dynamic patterning that helps provide a more in-depth picture of what occurred on both ships. For the *R.W. Gallagher*, engine-room workers were essentially trapped within the holds from combustion-led fires and explosions, and gun-emplacements were unable to be utilized for return fire. In addition, a crippling fire emerging from breached cargo tanks that divided the ship into three sections engulfed the *R.W. Gallagher*. These factors all likely contribute to discrepancies in the historical documentation between sources and may also explain why the final torpedo strikes were recounted in the U-boat diary, but not recorded by survivors.

Archaeological data is essential to isolating the specific areas where torpedoes struck, a significant corollary to both accounts. History books that reference the sinking of the *R.W. Gallagher* refer to the individual stories presented by individuals after the time of the attack and do not include physical investigations of these wrecks or archaeological findings on them (Browning 1996:140; Moore 1983:54; Standard Oil Company 1946; Wiggins 1995). Analysis of the archaeological data collected in the field determines that the torpedo strikes corroborate with the reported attack. It is through this muti-disciplinary approach that specific individual accounts coupled with archaeological proof of battlefield movements allow for near certain identification of the *R.W. Gallagher*, and offers specific linking to the identity of the *Cities Service Toledo.*

Archaeological evidence proves invaluable to the understanding of the sinking of the *R.W. Gallagher*. In the survivors' statements, specific torpedo-strike locations were cross-examined with 3D reverse-engineered models of the *R.W. Gallagher* and remote-sensing data and proved to corroborate with the historical accounts to provide a dynamic pattern for establishing the identity of the wreck. According to the survivors' statements from the sinking of the *R.W. Gallagher*, Second Assistant Engineer Tenant L. Fleming reported the first torpedo striking starboard tank number 3, followed by Captain Aage Petersen's account of the second torpedo striking between starboard tank number 8 and the engine room (Standard Oil Company 1946:356). When these accounts are compared to the results from the remote-sensing point-cloud data and the 3D reconstructed model from the *R.W. Gallagher*'s original blueprints, the significant damage to the outer hull is precisely where tank number 3 would have been on the starboard side of the wreck. A smaller hull gap is also present on the starboard side, directly in the center of where tank number 8 would have been on the *R.W. Gallagher* (Figures 59-61).

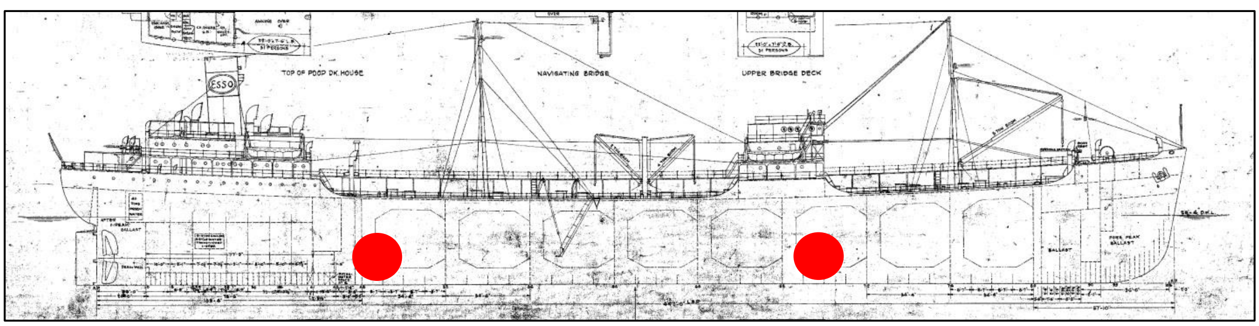

Figure 59: Starboard torpedo strikes on the historical blueprints of the S.S. *R.W. Gallagher* based on historical accounts.

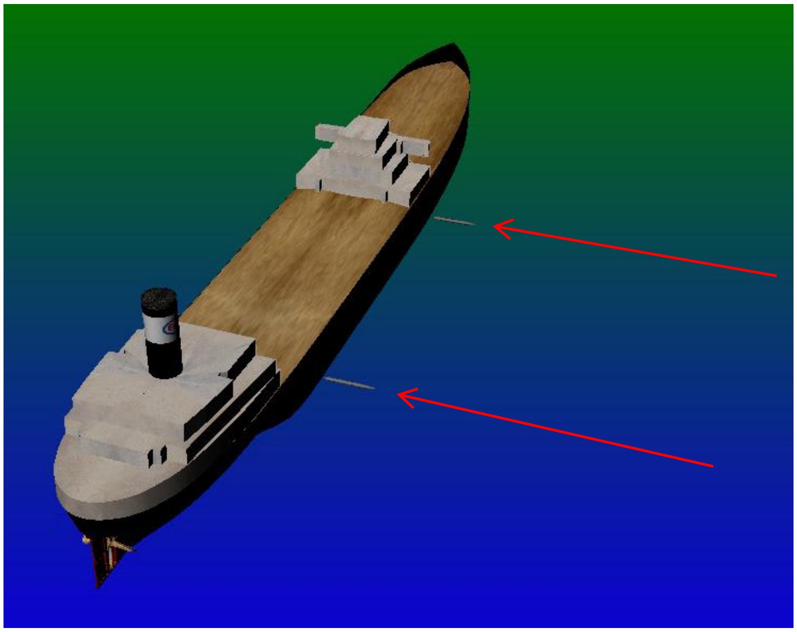

Figure 60: Starboard torpedo strikes on the 3D model of the S.S. *R.W. Gallagher* based on historical accounts.

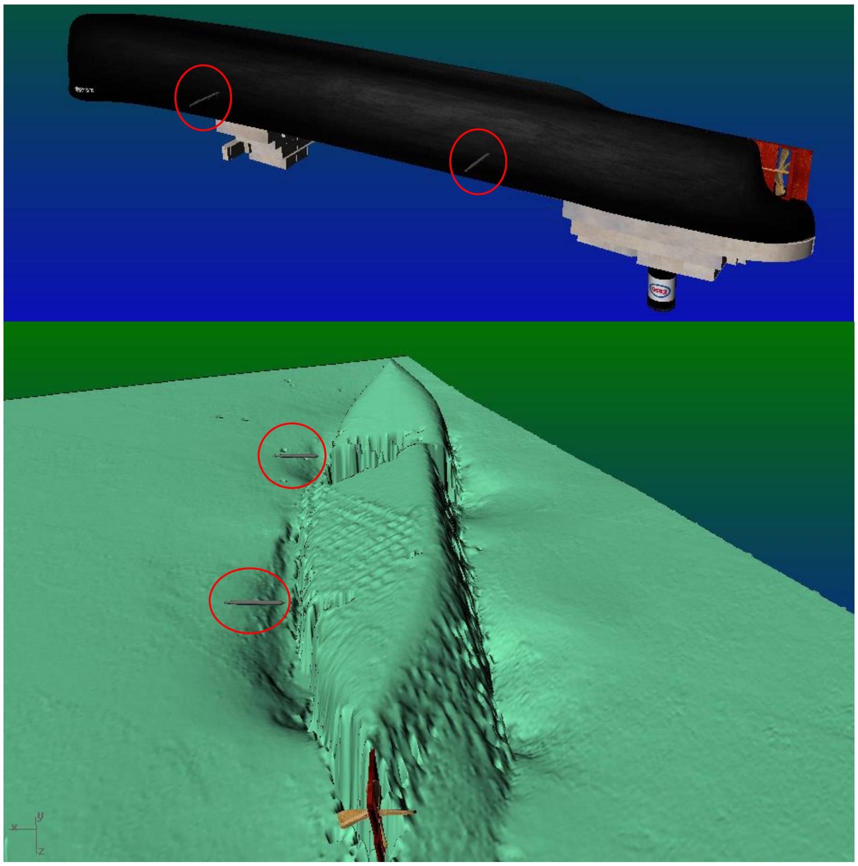

Figure 61: Starboard torpedo strikes on the hybrid 3D model and 3D multi-beam data of the S.S. *R.W. Gallagher* based on historical accounts and verified through archaeological evidence.

Tank number 8 is located immediately forward of the boiler room, which led directly into the engine room. Because outer hull damage visible near where tank 8 would have been in the remote-sensing data was minor, and no damage was directly observed in the same area by divers during operations in 2010, it is believed that the explosive expansion of energy from a deeply penetrated torpedo could have proceeded to blow out the boiler room bulkhead walls. The defining physics behind Archimedes' Principle supports this theory. The enclosed hull contained a constant 1 atmosphere (1 BAR) of pressure, restraining a tank filled with oil at the same ambient pressure that suddenly came in contact with the open ocean that, at approximately 2 atmospheres (2 BAR) of pressure, exhibited double the amount of pressure. This sudden increase of pressure caused the explosion to move in the direction of least resistance (open air), toward the stern of the vessel. In the survivors' statements, both Fleming and Petersen note the loss of power and electricity to the oil-covered vessel (Standard Oil Company 1946:356). It is suggested here that the explosion that occurred within tank number 8 caused more interior damage following the second torpedo strike than understood at the time. During diver ground-truthing on the site, a large section of the stern was observed and photographed with a large hole leading into the engine compartments of the lower holds. If this damage was sustained during that second blast, it would better explain why the second torpedo blast did not cause the amount of damage observed in the forward hull of the wreck. Though one set of historical accounts corroborating with the archaeological data will suffice in understanding that the wreck site is most likely the *R.W. Gallagher*, the survivors’ accounts do not alone summarize the dynamic battlefield characteristics of the altercation.

The largest discrepancies in the historical documentation posed a significant problem. While examining the diary of Müller-Stöckheim, in command of *U-67* at the time of the attack, some general inconsistencies were apparent. While reviewing the historical documentation to verify the identity of the U-boat that sank the *R.W. Gallagher*, many documents credited the *U-67.* Müller-Stöckheim's war diary, transcribed from microfilm and later translated into English, contained many valuable statements that corresponded well with the survivors' statements and the archaeological data. Müller-Stöckheim recorded that his first two shots struck below the bridge and the forward engine space, respectively.[16] Müller-Stöckheim seemingly shares a brief moment of unification with Peterson, describing a signal flash (Petersen documented seeing the U-boat's periscope while signaling S.O.S.) coming from the bridge (Müller-Stöckheim 1942; Standard Oil Company 1946:357). Though the account and the survivors' statements do not diverge until this last instance and the times recorded by both parties were determined to correlate once the German diary account was adjusted to U.S. Central Standard Time (-6 GMT), three historical statements are made that do not appear anywhere else in the documents.

The first inconsistency in the *U-67* diary begins with the phrase, "[I make the decision to fire a] *Fangschuß*." This phrase has been translated to mean a "finishing shot" or "*coup de grâce*." Finishing shots were not uncommon and were protocol, as set by the Kriegsmarine in the *Submarine Commanders Handbook* if it appeared as though the target was making headway or not sinking (High Command of the Navy (HCN) 1943:171-174). The *Handbook* further instructs commanders to fire their finishing shots along the opposite side of the initial strike near the bow or stern, so Müller-Stöckheim's claim of striking the forecastle and aft mast were

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16 Note: Certain phrases and words in the German used in this diary offered alternative translations, particularly with the word, "achterer" which means "abaft" or "toward the stern," though it could be interchanged with "achter" meaning "eight." "Achterer mast" could either mean "eighth mast" or "abaft mast" depending on context.

textbook kill shots (HCN 1943:172; Müller-Stöckheim 1942). All reviewed survivor statements do not mention these final torpedo strikes, possibly due to the chaos surrounding the burning ship and many survivors having abandoned ship by this time. Müller-Stöckheim later notes that the attempted *coup de grâce,* thought to be a failure, may have been effective in increasing the vessel's list and may have actually exploded upon penetration of the forward hull. This statement was examined archaeologically using the battlefield gross patterning platform. As discussed earlier, the forward hull breach observed in the remote-sensing and diver-recorded data was extremely large and widens up the starboard side as well as port. On the port side of the breach, sediment deposition has decreased in slope as resistance against the free-surface sediment lessens where it may freely pass through the wreck. Near the stern of the vessel, a smaller breach is associated with the second starboard torpedo strike. Immediately opposite this small breach is a large depression in the sediment that contradicts the sediment accumulation immediately adjacent to it. This depression could be the effect of scour in the area, but the fact that it has two rolling slopes seems to indicate that this could also be the location of free-surface transmission of sediment through a breach in the hull (Figure 67). It is possible that the final shot on the aft mast penetrated the hull at this location or at a similarly smaller hole in the bottom of the hull, later causing this anomalous representation on the sediment floor and on the hull of the ship (Figure 62).

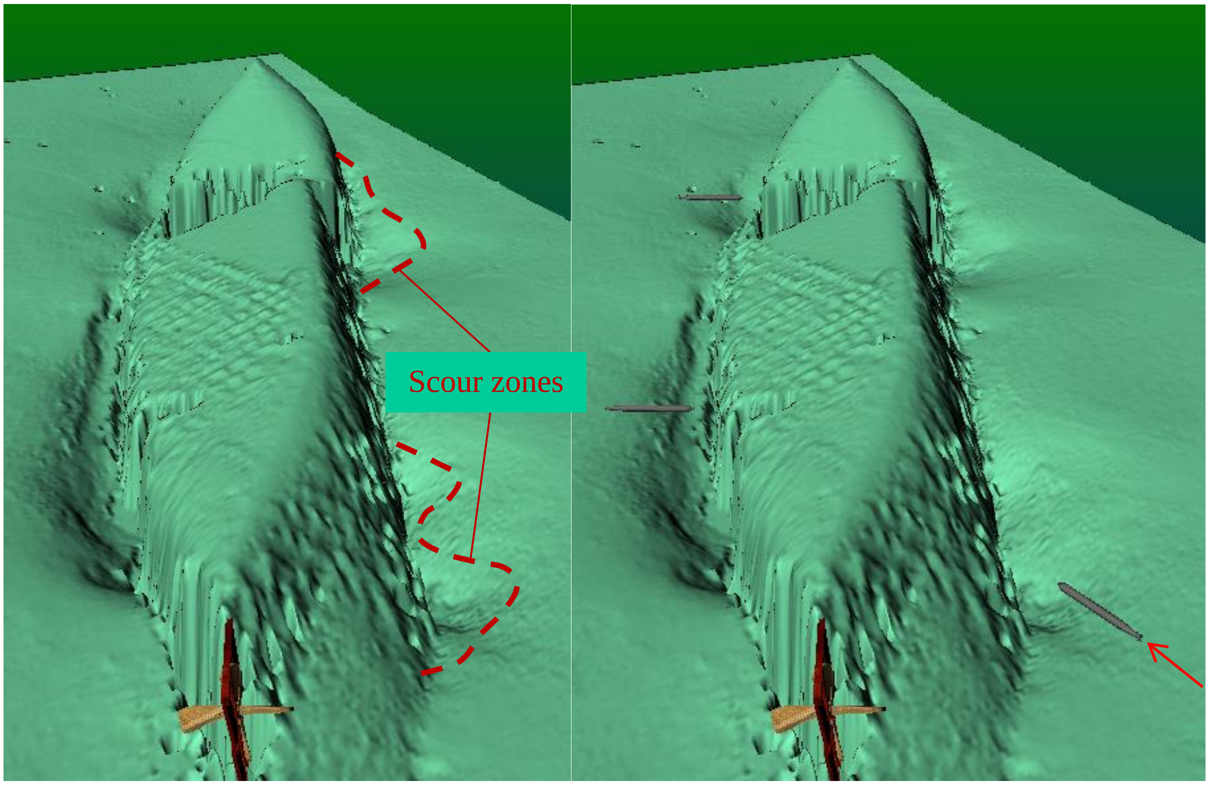

Figure 62: Archaeological evidence suggesting the location of the historically documented “killshot” on the port side of the S.S. *R.W. Gallagher*.

Additionally, the expanded breach toward the port-bow of the wreck could be the direct result of the final shot that tore open the hull structure, allowing for the final free-surface exchange of its cargo and sea water, causing it to settle upside down on the bottom (Figure 62). This physical process will be discussed later in the chapter under “Turning Turtle.” The sedimentary depressions located on the port side of the wreck indicates a possible connection with the kill shot account, as the accumulation of sediment in this area would fill the void created in the hull of the vessel, and decrease the effect of sediment mounding against the hull. To be certain, exploratory research of this area of the wreck could determine the theory's feasibility. Because this site is a war grave, this type of intrusive research is not recommended. Following the battlefield model, the theory that a correlation exists between the written accounts and physical evidence represents dynamic patterning that demonstrates individual unit movements, orders, and verifiable evidence leading to the identity of both sides of the engagement.

The second possible discrepancy in the Müller-Stöckheim diary account is the reference to "*Bewacher (Typ"Eagle')* [sic]," which indicates an escort by an Eagle Class patrol craft. According to every investigated historical document available for this study, no record of an escort ship exists in the case of the *R.W. Gallagher*. In effect, two questions arise from this statement: was Müller-Stöckheim with *U-67* the true assailant of the *R.W. Gallagher* on 13 July 1942 or was he mistaken in his observation among the dense smoke from the burning oil tanker? Upon investigation of all four of the U-boats that recorded successful sinking attacks on this day, *U-67* was the only one to record an attack on the DA naval grid square (Rohwer 1983:109) (Figure 63 and Table 5).

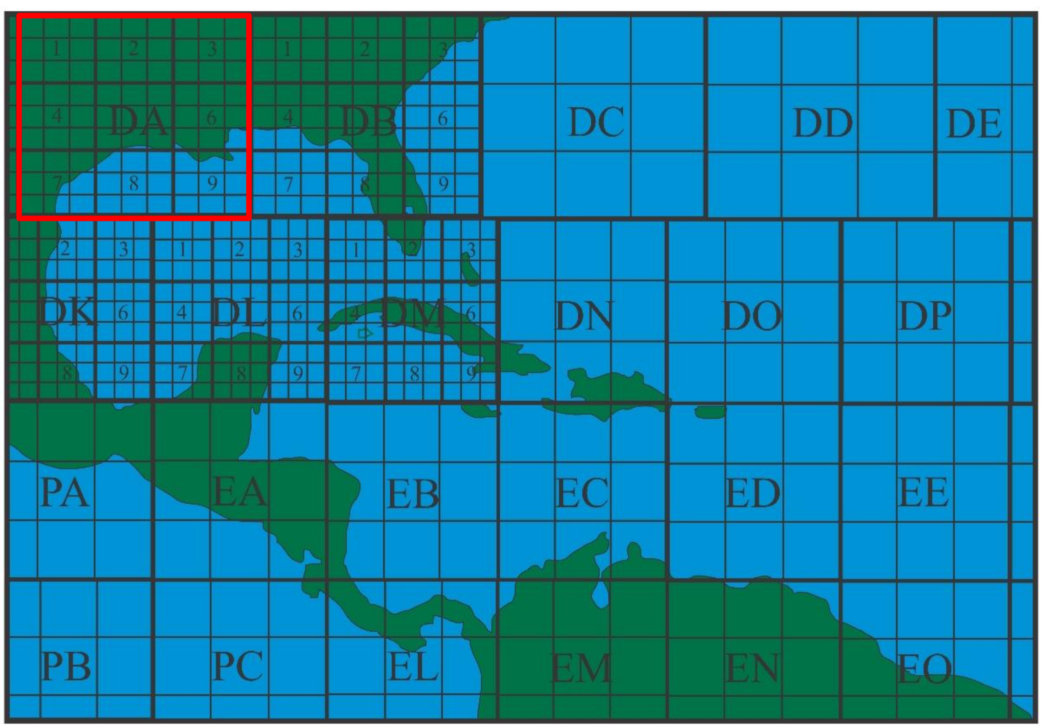

Figure 63: Naval grid square system used to identify German positions during WWII (Drawn from Rohwer 1983).

TABLE 5
ATTACKS ON 13 JULY 1942 IN THE GULF OF MEXICO AND THE ATLANTIC OCEAN (ROHWER 1983)

U-boat	Grid Square	Time of Attack	Vessel Sunk	Tonnage
U-201	DG9552	N/A	*Sithonia*	6723
U-84	DM5283	0230	*Andrew Jackson*	5990
U-67	**DA9198**	**0540**	***R.W. Gallagher***	**7989**
U-166	DN	1610	*Oneida*	2309

Additionally, no other record could be found for attacks on 13 July 1942 aside from the four mentioned above. Earlier in the diary, it is noted that a wreck buoy was observed at DA 9173, which is very close to the site of the *Cities Service Toledo*, which sank a month before. This correlation adds to the evidence surrounding the identification of the other wreck in this study. This leaves the question as to Korvettenkapitän Müller-Stöckheim's potential misidentification of an Eagle Class ship patrolling or escorting the *R.W. Gallagher* on this day, as the location matches up to the wreck that was investigated in 2010. Some investigation was made on the number of Eagle Class ships patrolling the U.S. eastern coastline and whether there was an Eagle Class vessel in the Gulf of Mexico that had previously been omitted from public knowledge. Though all accounts have corroborated with the archaeological evidence at this time, Müller-Stöckheim states that this escort appeared at 01:11 U.S. Central Standard Time, while Petersen's account states that he jumped overboard at 02:20. It wasn't until 05:30 that the *Boutwell* was able to locate and recover the life boat deployed from the *R.W. Gallagher*. Surely, the Captain of the *R.W. Gallagher* and the nearby life boat would have noticed or have been recovered by the Eagle Class escort as they transmitted an emergency signal from the craft at the same time the U-boat was able to make this observation. This example of time discrepancy is common when comparing the historical accounts of DKM operatives during attacks, and a number of factors has lead researchers to accept times that correspond with a time of day when using times recorded by U-boat captains (i.e. pre-dawn versus afternoon, GMT, etc.) (Rohwer 1983:xv). The case still remains that the only known vessel in the area around the time of the attack was the *Boutwell*. It is postulated that Müller-Stöckheim, upon observation of the *R.W. Gallagher* while it was sinking at approximately 04:30, witnessed the *Boutwell* searching the area for both the attacker and survivors of the attack. His account also makes mention that the escort ship potentially broke course from "pursuing" *U-67* because of signals coming from the life boat. The Korvettenkapitän's decision to flee the scene, following protocol set by the DKM in regards to encountering armed escorts, was justified in his report, though his observations were most likely flawed (HCN 1942:229).

To be certain of the reporting error, an investigation of Eagle Class patrol boats reveals that only eight craft of this class were active along the East Coast in July 1942. None of these were stationed in Louisiana at the time of attack. In fact, only the Atlantic coastline had received orders from the Commander of the Eastern Sea Frontier, Rear Admiral Adolphus Andrews, to order escort ships and begin a comprehensive convoy system on 15 May 1942 (Andrews 1942). This convoy system was to span from Key West, Florida, north to Chesapeake Bay, Maryland, and was severely limited in its escort capabilities early in the war. The Gulf Sea Frontier, under the command of Rear Admiral James L. Kaufman in May 1942, was tasked with protecting the U.S. coastline from Jacksonville, Florida to Texas (U.S. Coast Guard Aviation Association 2006). Kaufman moved the Gulf Sea Frontier district offices to Miami when he took his position and ordered a dim-out of the Gulf of Mexico by merchant vessels (U.S. Coast Guard Aviation Association 2006). Andrews wrote in a letter to the chief commanders of the Navy on 29 April 1942 that there would be only one Eagle Class escort available in the Gulf Sea Frontier in July

(Andrews 1942). After identifying the eight Eagle Class patrol boats in the Atlantic, the only known documented Eagle Class boat available from Key West, Florida, for escorts would have been the U.S.S. *PE-27*, which was involved in the sinking of *U-157* along with Coast Guard Cutter *Thetis* (Cianflone 1973:78). References to Eagle boats active in 1942 restrict them to being active as support in sonar schools and patrols like that of the *PE-27* out of Key West in the Caribbean (Andrews 1942; Cianflone 1973:76-80). To make a direct comparison, it is most likely that the 38.1 m (125 ft.) *Boutwell*, known to be active in the area that rescued the survivors of the attack, could have been mistaken for a similarly shaped 61.2 m (200.8 ft.) Eagle Class escort vessel like the *PE-27* from nearly a mile away at a distance of 1,500 m (4,921.26 ft.) (Figure 64).

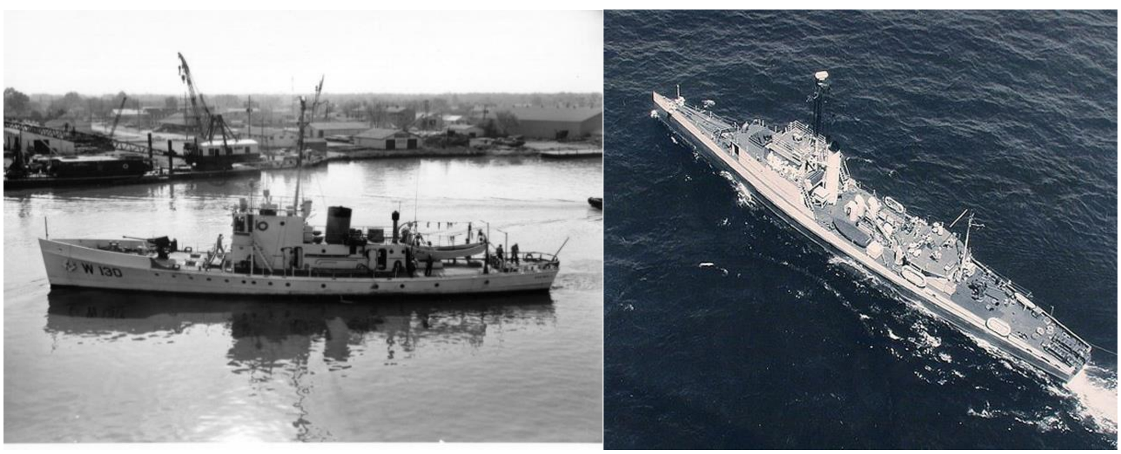

Figure 64: Coastguard Cutter *Boutwell* (left) and Eagle-Class PE boat (right) (Flynn 2012:20; Henson 2007).

The final point of deducing the identity of the U-boat responsible for the sinking of the *R.W. Gallagher* comes from the afternoon log from *U-67* on 13 July 1942. At approximately 10:36, a "*Flugboot*" or seaplane was spotted flying 6 nautical miles from *U-67* at DA 9843 while stalking a potential merchant target. An hour and 20 minutes later at 11:56, the seaplane was spotted 3.5 nautical miles and approaching at an average altitude. Müller-Stöckheim reported that it was a twin-engine, single-tailed seaplane equipped with around 3 bombs. An hour and 26 minutes later at 13:25, the seaplane was spotted again at low altitude with a direct course for the U-boat; *U-67* was put on alarm and quickly submerged to 30 m (98.43 ft.) where it remained out of sight. When the U-boat surfaced at 16:10 it broke an attack course from its target, the seaplane and tanker were gone, and it continued on its mission. This testimony could potentially be verified by researching flight logs by seaplane patrol craft present in the area on 13 July 1942.

Since Müller-Stöckheim noted that this aircraft to bore a United States insignia, the flight log by the aircraft would theoretically contain affirmation of this as an attempted airstrike. Because aerial operations in this frontier were conducted from the Coast Guard air station in Biloxi, Mississippi, documentation from this station would likely lead to the information necessary for this affirmation. The twin-engine, single-tail, armed aircraft available for patrols out of Biloxi, Mississippi, at this time were two JRFs and five J4Fs (U.S. Coast Guard Aviation Association 2006). Since the J4Fs available for anti-submarine missions could carry only one aerial depth charge at a time, this makes them unlikely candidates, unless the diary account mistook the pontoons for bombs. These J4Fs operated out of Houma, Louisiana, a grass landing strip extension of the air station in Biloxi, and was manned by a small detachment of airmen. Before August of 1942, these seven seaplanes were the only air patrol craft operating from Mobile Bay, Alabama, to Galveston, Texas (Morris 2006). They would have been moored to buoys between their four-hour patrols, which would roughly account for why the plane was no longer visible when *U-67* surfaced nearly five hours after spotting the aircraft. Reviewing each of the logs of these aircraft was beyond the financial and time restrictions of this study, but further research at the U.S. National Archives to locate the aviation logs for that day in July 1942 might help answer this question. Though this final evaluation of historical record regarding the attack on the *R.W. Gallagher* is inconclusive, the supporting evidence, the location, date, torpedo-strike locations, and observations by both sides of the conflict, support the identification of the vessel investigated by archaeologists in 2010.

In the case of the *Cities Service Toledo,* there is alternative historical documentation regarding the specific battlefield actions taken during the sinking event. Though the same information was collected, the reported attacker, *U-158* has a more limited record of the attack. The only attacks reported by Rostin in grid square DA were on a 12,192.56 metric ton (12,000 gross ton) vessel and a 7,112.33 metric ton (7,000 gross ton) vessel on 14 June 1942.[17] Rostin sank the *Sheherazade,* a 13,683.1 metric ton (13,467 gross ton) vessel, on 11 June 1942, leaving the only other vessel to be the *Cities Service Toledo*.[18] In fact, when researching all of the merchant vessels sunk within the area surrounding the reported location, both Rostin's and the survivors' statements by the crew of the *Cities Service Toledo* report locations farther to the northwest than any other known merchant casualty within the DA naval grid square. Without a means to compare any statements made by Rostin to survivors' statements, the unique reported location of the attack is enough to tentatively verify that *U-158* sank a tanker in roughly the same area that was surveyed in 2010.

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17 Note: Several U.S. sources refer to Kapitänleutnant Erwin Rostin as "Erich" Rostin. German documents refer to him as "Erwin" Rostin, and this study has determined to refer to him by his actual name (Beckmann 2006).

18 Note: Kapitänleutnant Rostin's attack record should be mentioned to be one of the highest two patrol records of any U-Boat commander during World War II at 15 ships sunk at a 94,342 tons, nearly 10% of the total sunk vessels by German U-Boats in the region (Blair 1996:612, 767). This honor earned him the *Ritterkreuz,* or Knight's Cross of the Iron Cross, the second highest honor given by Germany to its military leadership in World War II. He was killed in action with his crew aboard the DKM *U-158* on 30 June 1942, having only learned of his award two days earlier (Blair 1996:612-613).

Survivor statements made by the crew that escaped the sinking *Cities Service Toledo* place the attack on 12 June 1942. Survivors claimed that two torpedoes struck starboard tanks number six and seven in a five-second succession at around 0200 (Browning 1996:140; Moore 1983:54; Wiggins 1995:244).[19] The basic pattern of merchant vessel proximity to the coastline expresses the ease of these ships to be targeted by U-boats during this period. In these waters, U-boat captains were well aware of the techniques used by merchant ships during dim-outs and varying navigation patterns. The presence of 18 reported vessel sinkings in the Mississippi delta area indicates the clear gross pattern that merchant ships travelled both close to the shoreline, and through the area frequently during this period of the war, confirming that these tankers were easy targets (Figure 5).

The two torpedo strikes immediately destroyed a lifeboat and caused the vessel to list to starboard (Browning 1996:140; Moore 1983:54; Wiggins 1995:91). The second set of torpedoes reportedly struck starboard tanks number four and five, the latter contact causing an incendiary burst across the oil-covered deck and oil-covered water, igniting everything the oil touched (Browning: 1996:140; Wiggins 1995:93). Upon review of these records involving the location of the strikes, historic ship's plans for the *Cities Service Toledo* were used to create a 3D model to be directly compared to the accounts and remote-sensing data. The results of these comparisons led to a similar interpretation as to that of the *R.W. Gallagher*. The most visible damage present on the wreck site is located near amidships on the starboard side, around what should be starboard tank number three. It is not written historically, but the most visible damage on the wreck site is present on what would be tank number five (Figures 65-67).

19 In Wiggins' 1995 book, senior gunner James Handy reports that it was a single torpedo strike.

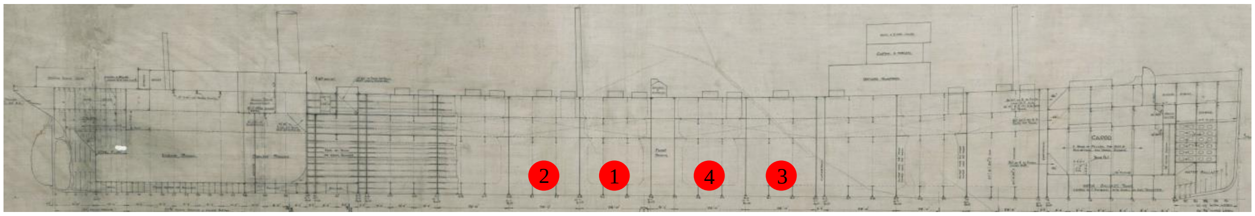

Figure 65: Starboard torpedo strikes on the historical blueprints of the S.S. *Cities Service Toledo* based on accounts.

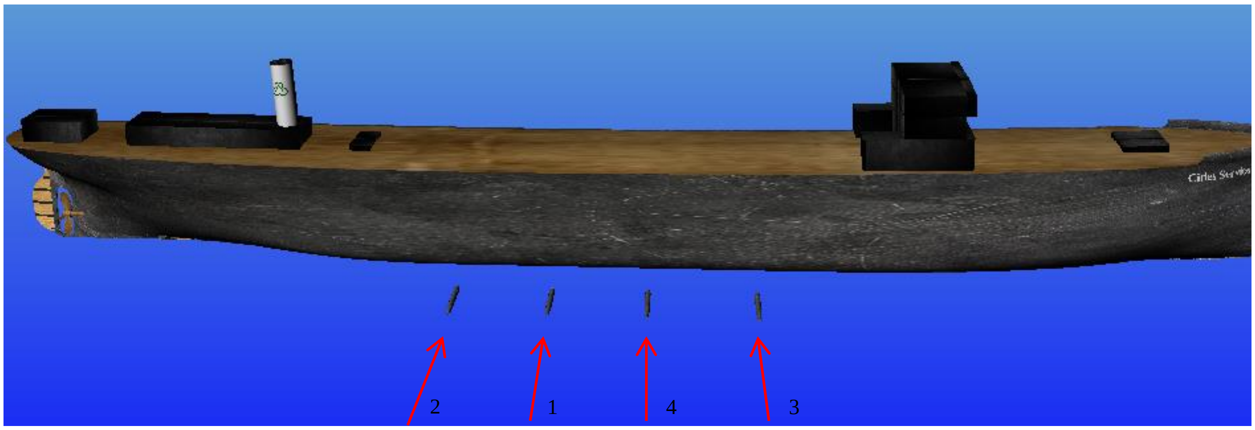

Figure 66: Starboard torpedo strikes on the 3D model of the S.S. *Cities Service Toledo* based on historical accounts.

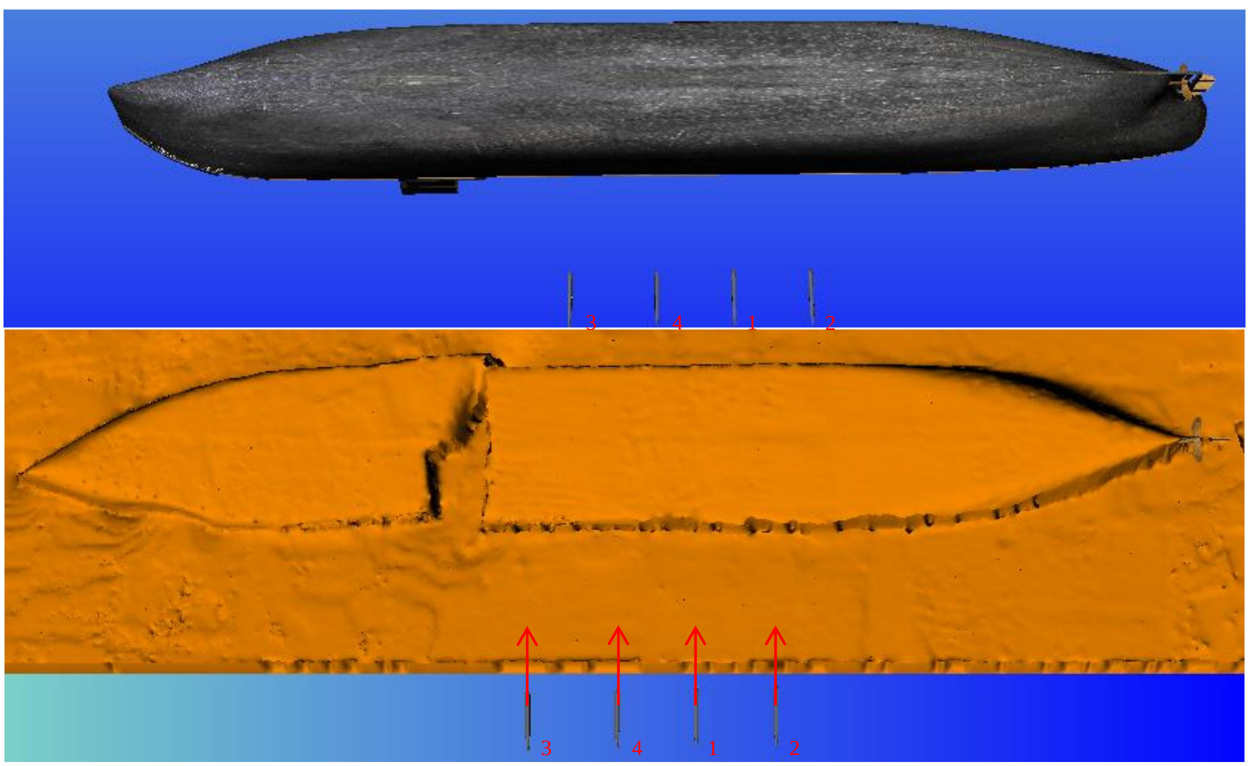

Figure 67: Starboard torpedo strikes on the hybrid 3D model and 3D multi-beam data of the S.S. *Cities Service Toledo* based on historical accounts and verified through archaeological evidence.

The torpedo strikes must have been fired at an angle sufficient to cause a forward explosion within the cargo holds. It is estimated that the angle would have been from around 65º from the stern as *U-158* approached from behind (Figure 74). At this angle, the direction would have been sufficient enough for the final torpedo to further expand the previously opened hole in the *Cities Service Toledo*'s hull. This angle was determined by using 3D rendering software to examine the centerline of the wreck according to the point cloud data, and offset the angle that the hole in the hull is facing. The center line of the vessel, from the point of damage and projected penetration, converges roughly at the number four tank as well. Given this string of logic, the initial starboard torpedo strikes are not visible archaeologically due to the significant list of the overturned vessel on the seafloor (Figure 68). This could be explained simply by the fact that the amount of structural damage to the starboard side of the vessel would collapse over time due to the remaining poor structural integrity.

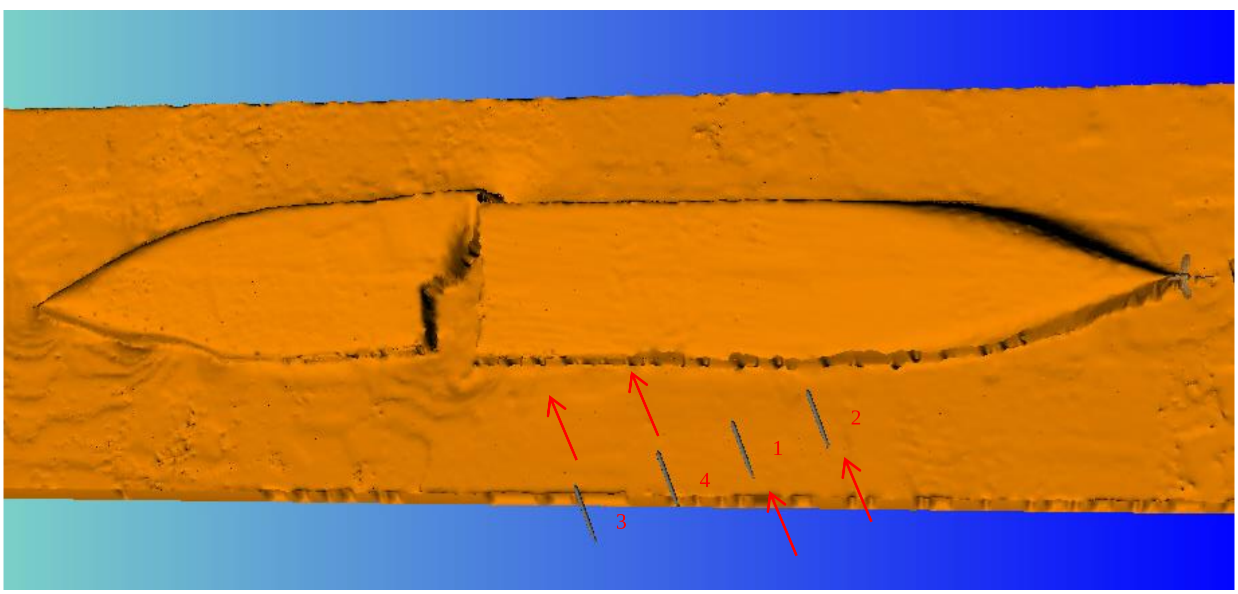

Figure 68: Proposed angle of torpedo strikes to explain structural damage direction on the S.S. *Cities Service Toledo*.

The final two strikes, occurring notably later, represent the same type of dynamic patterning corresponding to a final shot, also present at the location of the proposed *R.W. Gallagher*. The defining determination for this is the specific 65º angle of the estimated torpedo entry point on the starboard bow. A two-torpedo strike is contemporaneous of final shots, supported by the case of the *R.W. Gallagher* and the *Submarine Commander's Handbook* (HCN 1943). Based on archaeological and model comparison, the third strike likely entered the starboard bow, forward of tank number four, and proceeded into the hull. The final blow to the vessel would have struck the hull just aft of the third torpedo, exploding upon contact with the hull between tank number four and five. This final strike appears to have ruptured the integrity of the latitudinal supports, causing the vessel to later break apart around tank number four when striking the seafloor (Figure 68).

The account of the five-inch gun failure states that shots were aimed at the U-boat, but missed and caused the gun crew to jump overboard without a means to defend it (Browning: 1996:140; Wiggins 1995:93). All but one lifeboat was destroyed in the attack either by the explosions themselves or by the ensuing fire that engulfed anything wooden, including the mast (Browning: 1996:140; Wiggins 1995:92-94). These two specific details indicate an important part of the historical record that could theoretically be proven to be true archaeologically. Following the assumption that the wreck surveyed in this study is the *Cities Service Toledo*, it is possible that projectiles fired from the five-inch gun would leave a slight magnetic return on magnetic-field detecting instruments like a magnetometer (Breiner 1999: 42).

Evidence of the lifeboat that burned in the final moments of the ship's evacuation may be present, but due to the fact the wooden boat was engulfed in flames, the probability of finding more than minor debris scatter is extremely improbable. Because the vessel is overturned, significant diagnostic evidence that can be taken from historical accounts, like the location of the deck guns or specific locations of torpedo strikes, cannot be compared to the archaeological data. Because this study involves the use of isolating gross and dynamic patterning through the multi-disciplinary approach of identifying comparable historical and archaeological data together in Fraga's three-module method, additional historical modules were used in comparison to the archaeological data to determine more specific correlations between the two. These lines of evidence prove to be much more accurate in the case of the *Cities Service Toledo.*

Remote Sensing

Remote sensing has proven to be invaluable in the research behind the *R.W. Gallagher* and the *Cities Service Toledo*. The data discussed previously is the perfect example of how utilizing several disciplines in the search for answering archaeological questions are mandatory with the amount of information and technology available today. Remote sensing instruments are sometimes easier to use, more efficient, and more powerful when recovering information than what one diver can accomplish in the same amount of time. Large-scale site mapping, potential long-range artifact distribution, site orientation, and general site integrity can all be determined with the remote-sensing instruments found in this study. The additional benefit of these data being stored without manipulation or change in a raw format that can be accessed by several individuals at any time after the initial survey also allows research to remain consistent throughout the project. Consistency is critical in these types of studies, and remote-sensing offers one of the most consistent methods of data recording available.

Remote-sensing on this project in particular was able to identify essential patterns used to make final conclusions on both of the wreck sites. These tools correlate the significant magnetic signatures, coupled with the size of the vessels, to contemporary 20th century oil tankers. The magnetometer readings around each wreck were also able to determine the gross-patterning site distribution and study area outlined by battlefield theory. Multi-beam echosounder imagery revealed the most damaging torpedo holes in each vessel's hull. Multi-beam and echoscope data also revealed essential interior structural components contemporaneously present on inner holds of other oil tankers struck by torpedoes in 1942, revealing several similarities (Figure 69).

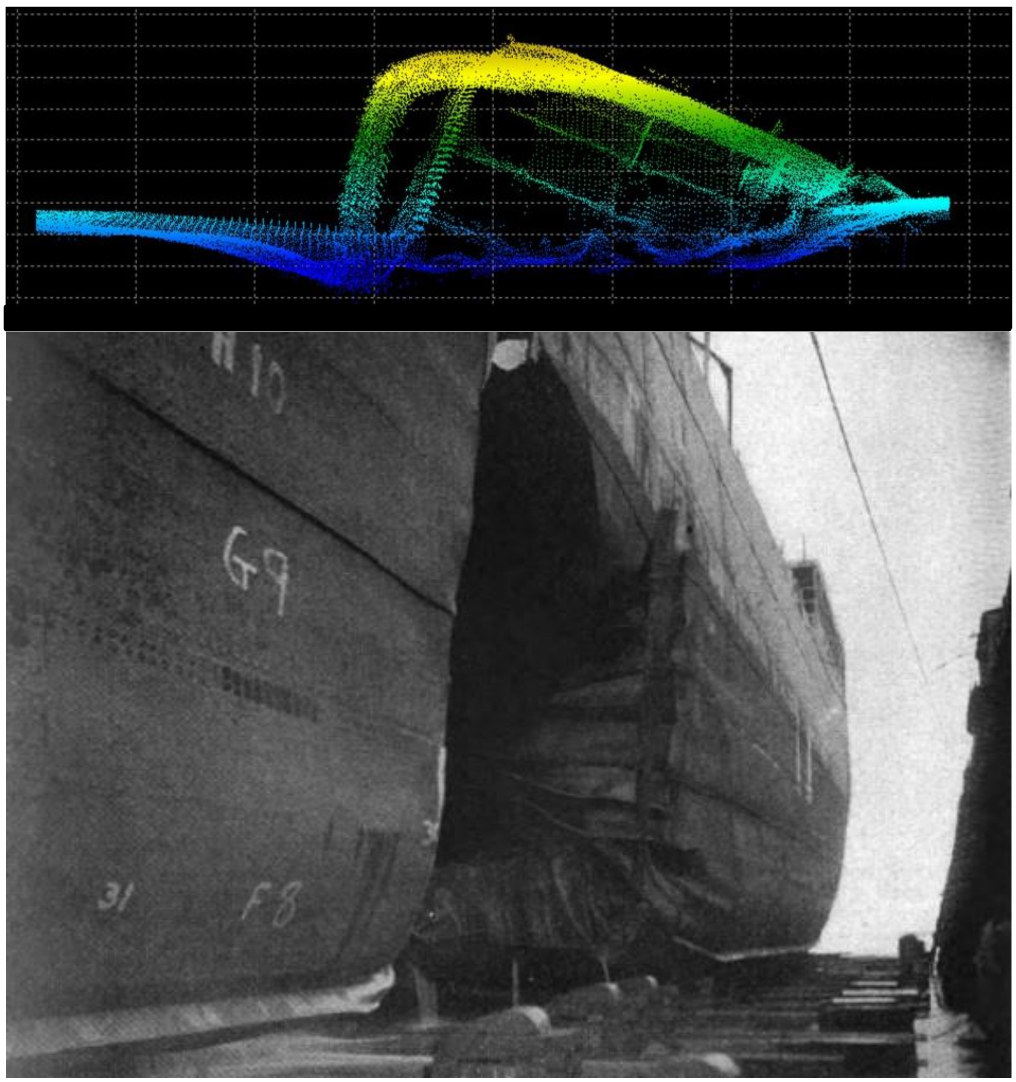

Figure 69: Multi-beam echosounder slice of the major hull breach on the S.S. *R.W. Gallagher* site (Evans et al 2013:43) in comparison to the major 20 ft. x 30 ft. hull breach in the S.S. *Paul H. Harwood* in dry-dock ca. 1942 (Standard Oil Company 1946:328). This image is just one of many examples of the damage that torpedoes caused to merchant shipping vessels. This example correlates with the same damage observed on the *R.W. Gallagher* site.

All of the data collected remotely provided gross and dynamic patterning that essentially places the era, type of damage, type of ship, attack pattern, and the direct sinking process for both of these ships. These various sets of data illustrate the point that remote sensing is essential for finding and researching World War II conflict-oriented ships in the context of a battlefield study. The isolation of this theoretical model can be utilized for any ship sunk in military conflict. Though the battlefield approach may help to explain why and how a wreck has reached its current condition, this approach does not limit the research to these questions. The benefit of using remote-sensing to answer these questions also allows for periodic evaluation of site conditions, integrity, environmental analyses, and site preservation. Though the questions regarding these wrecks may change with time, answering as many questions as possible now, with minimal impact to the sites themselves is essential.

Archaeological Investigations

The final dynamic analysis involves comparing the historical documentation with the archaeological data. Critical investigation of documentary evidence of each ship's construction in comparison to the archaeological data collected in the field was conducted after all materials were collected and evaluated. As the remote-sensing data analysis provided some of the most important examples of what could be determined as both gross and dynamic patterning during the battle that both the oil tankers and their respective U-boat assailants were engaged in, these answers merely present a series of events in a chronology that helps to explain why the wrecks have ended up on the seafloor. The diver ground-truthing of the sites helps to verify the specific details that identify the shipwreck sites. Because many vessels of this specific construction type were present in the region for over a 30-year period of time, diagnostic elements of their construction must be compared to archaeological remains to add to the body of data that this study uses to identify the vessels. This type of cross-comparison additionally fits into the dynamic pattern, discussed previously, that is discussed as present on terrestrial battlefield sites.

By comparing additional historical documents involving the nuances contained within the construction of the vessel, archaeologists can better understand the dynamic setting that surrounded the ships themselves at the time of sinking. Take, for example, the subtleties involved with drawing an individual ship's plans and the focus of the designer on details that are intended for the overall final construction of the ship. These gross pattern designs will give particular focus to details involving the macro construction of the vessel and how it will perform overall in the water. Shipbuilders also made observations and orders in the form of documents relating to specific pieces of machinery or structural parts that aided the vessel on a smaller level. These smaller facets of construction were recorded by these builders and were followed by factory equipment orders or by ground construction crews. These details can be seen in the individual rivet patterns, propeller type, or even the rudder, presenting researchers with the most important task of investigating the smaller diagnostic elements present on a shipwreck through diver ground-truthing.[20]

S.S. **R.W. Gallagher**

Archaeologists focused on the most important potential diagnostic elements during field diver investigations, so there was an increased efficiency of diver rotations which targeted documentation of specific characteristic features. For the *R.W. Gallagher*, divers were tasked with isolating and recording diagnostic elements, and found the most critically identifiable

20 These concepts developed from Fraga's 2004 paper offers a complex look at a simple concept of utilizing several sources in creating a comparative model, especially when using this model in a battlefield case.

markers to be the bilge keel, torpedo holes, rudder, rivet pattern, and propeller. Visual inspection of the largest hull breach present on the wreck corroborates with torpedo damage occurring on the starboard side of the vessel. The damage present on the vessel also closely resembles damage photographed on several Esso oil tankers that survived German torpedo attacks during World War II (Figure 69). The fact that this damage impacted an entire cargo hold, bowed the hull inward, affected the limited reinforced plating, and opened the vessel's interior so broadly to the open ocean closely resembles the damage on the *R.W. Gallagher*.

The bilge keel was measured at its least corroded points. This part of tankers' ship design was used to help keep the ship steady in periods of high roll, to keep them balanced along their transverse lines (Manning 1942: 283). The bilge keel typically was not included on the historic blueprints, but represents an aspect of ship construction that was widespread at the time of the *R.W. Gallagher's* construction. The fact that it is present archaeologically represents the dynamic pattern regarding construction decisions made by Bethlehem Shipbuilding Co., much like that of the torpedo-strike damage being representative of Müller-Stöckheim's battle strategy and execution (Figure 70).

Figure 70: Bilge Keel on the S.S. *R.W. Gallagher* site (courtesy of Colm O'Reilly 2010) compared to the bilge keel on the U.S.S. *New Jersey* (Landgraff 1999).

The next diagnostic feature investigated during diver ground-truthing was the *R.W. Gallagher's* four-bladed propeller. Though common practice of the time was to clearly stamp the name of the ship, plan number, hull number, and builder on the hub of the propeller, no distinguishable markings were observed through the heavily concreted surface (Osbourne 1943:23-29). The proposed *R.W. Gallagher*'s propeller dimensions are recorded as being the same dimensions as that on the ship's plans (Figure 71).

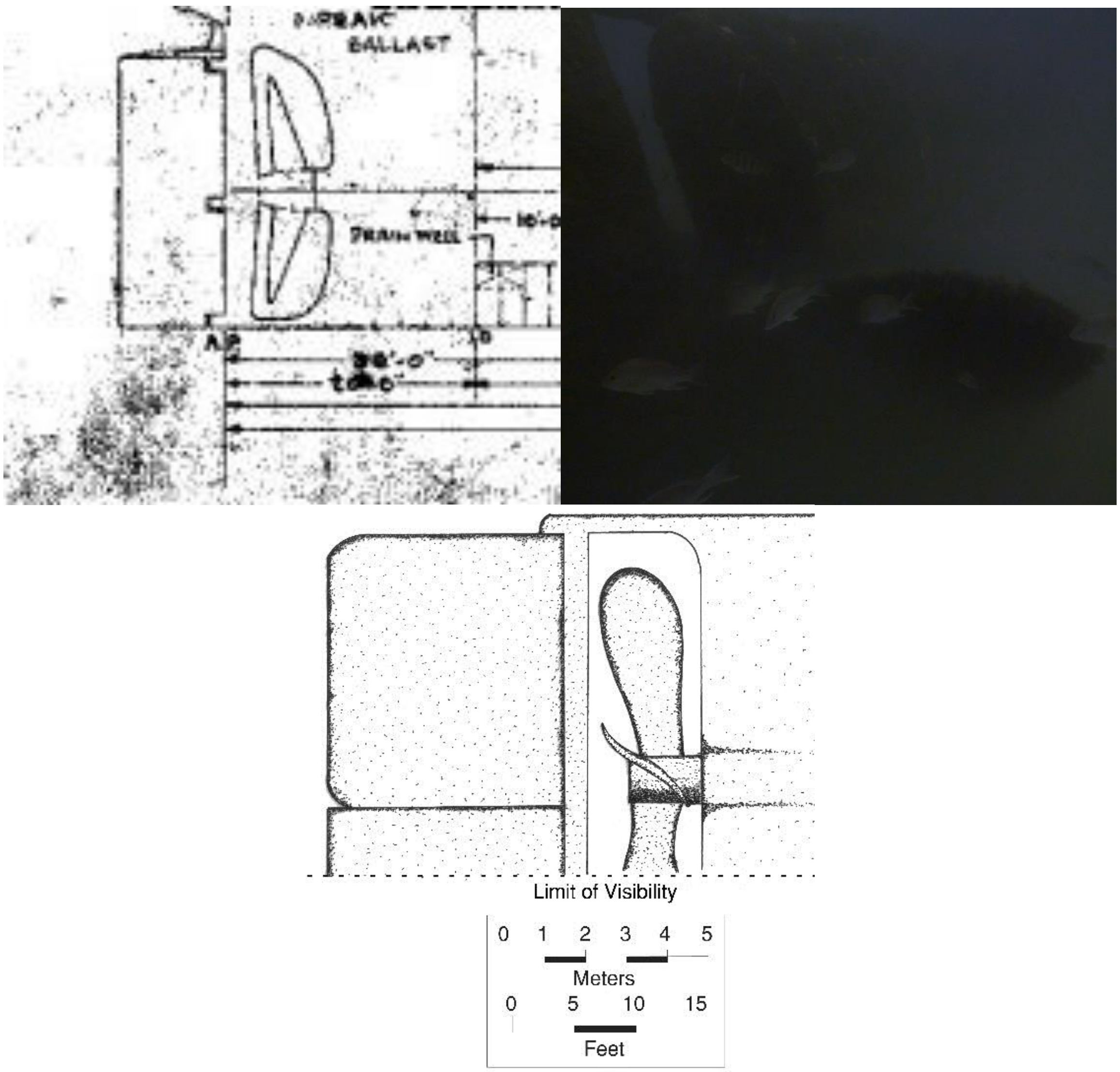

Figure 71: Propeller images captured from ship's plans (Bethlehem Shipbuilding 1938), field photograph (O'Reilly 2010), and ink drawing by Greg Cook of the S.S. *R.W. Gallagher* and related archaeological site.

In comparing the propeller's drafting in the ship's plan with archaeological data and correspondence from the Bethlehem Shipbuilding Co., the diagnostic feature association with the four-blade single-rotation propeller is apparent. The correspondence states that “Standard Shipping Tankers” of 12,000 DWT should have a “Contrapropeller,” which, by the 1930s standard, was advanced and expensive (Bethlehem Shipbuilding Corporation, Ltd. 1936). The design behind contrapropellers was revolutionary for the time, and is still used today.

Archaeologically, this estimated 13,000 DWT vessel does suggest this type of propeller. This single-hubbed propeller stock is also represented on the ship's plan. A contra-guide propeller used hydro-dynamic physics to reduce drag and wake impact by curving the rudder just after the propeller in an “S” shape (Figure 73). In addition to the curvature of the rudder just behind the propeller, a contra-guide rudder also bears an “S” curvature at its aft-most end. This propeller would have been an expensive piece of machinery in the 1930s, and through the dynamic pattern seen archaeologically, as well as with alternative historical documentation, it is clear that such a sophisticated piece of equipment was included in the ship's design, supplemented by the fact that the parent company had publically called for their fleet to be equipped with such equipment.

The next diagnostic feature that helps to identify the *R.W. Gallagher* is the rivet patterning present across the outer hull shell. In the “Standard Shipping Tankers” correspondence mentioned earlier, riveting was ordered to be flush along the outer hull shell. This would require the use of an inside weld, using countersunk rivet heads facing away from the hull. These rivets would have been flush with the hull plating and would have been watertight. Because the amount of growth on the hull of the *R.W. Gallagher* did not reveal any clear rivet patterns immediately, divers scraped a small portion of the hull in an attempt to locate any pattern. After significant scraping for 15 minutes, no obvious panhead or buttonhead rivets were found, indicating that flush countersunk rivets were used on this hull plating, though the use of these rivets was not immediately obvious to divers on the wreck (Figure 72).

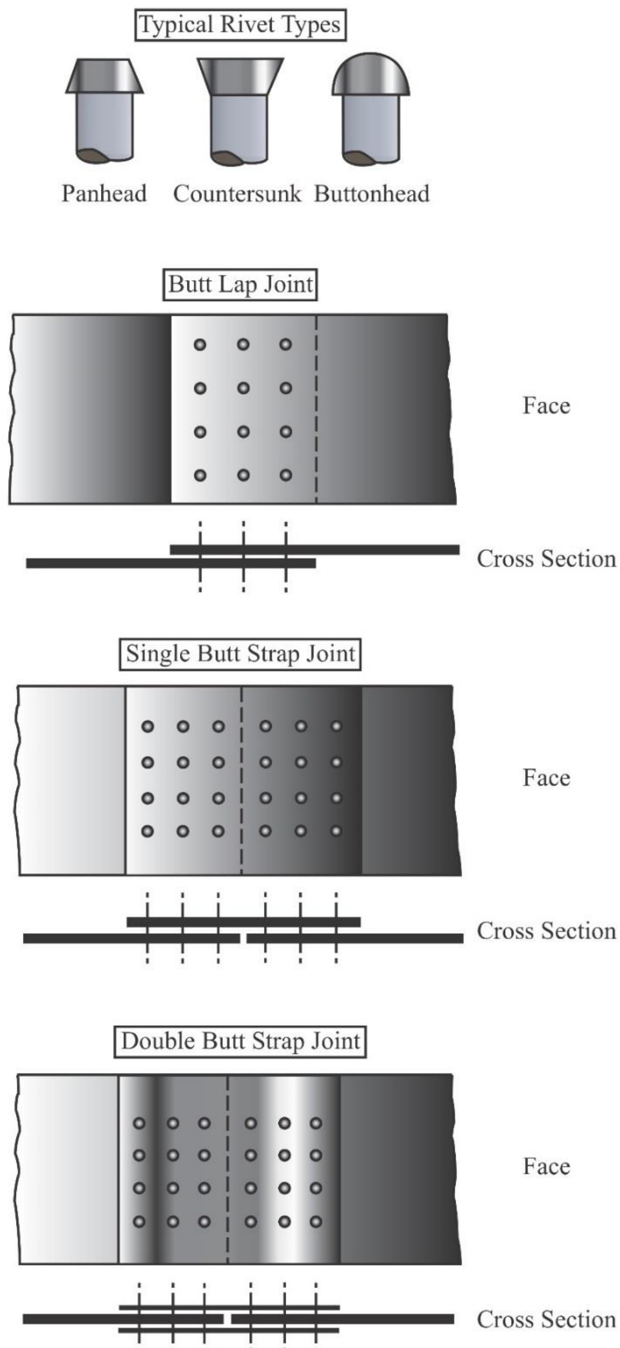

Figure 72: Contemporary rivet and joint styles and patterns ca. 1942 (Drawn from Manning 1942:41).

The final major diagnostic feature investigated by divers in 2010 on the *R.W. Gallagher* was the wreck's rudder. Divers observed, mapped, and photographed the contra-guide rudder. The contra-guide rudder was not described in either the ship's plans or the commission correspondence. Though this is an inhibiting factor regarding a verification of historical aspects of the ship, it is an affirmative guide to the construction techniques ship manufacturers employed throughout the first half of the 20th century. This dynamic pattern present on the *R.W. Gallagher* shows that the shipbuilders made an effort to modernize the unbalanced, single-plated rudder present on many earlier vessels at this time. Though the contra-guide rudder was not as sophisticated as a balanced double plated rudder, it offered a contemporary construction method that reduced draft and increased propeller output efficiency (Manning 1942:182-183; Osbourne 1943:23-2) (Figure 73).

These subtle, yet essential dynamic construction techniques, elements, and patterns show evidence that correlates the archaeological with the historical evidence associated with the *R.W. Gallagher*. These data imply that the wreck investigated for this study in 2010 was the *R.W. Gallagher*, though some historical documentation seems to contradict this as well. Further investigation of the interior of the vessel, or the propeller hub would reveal additional information that could answer the question of its identity. Through establishing these modular patterns, further research will benefit from this study by following the techniques used to identify this wreck.

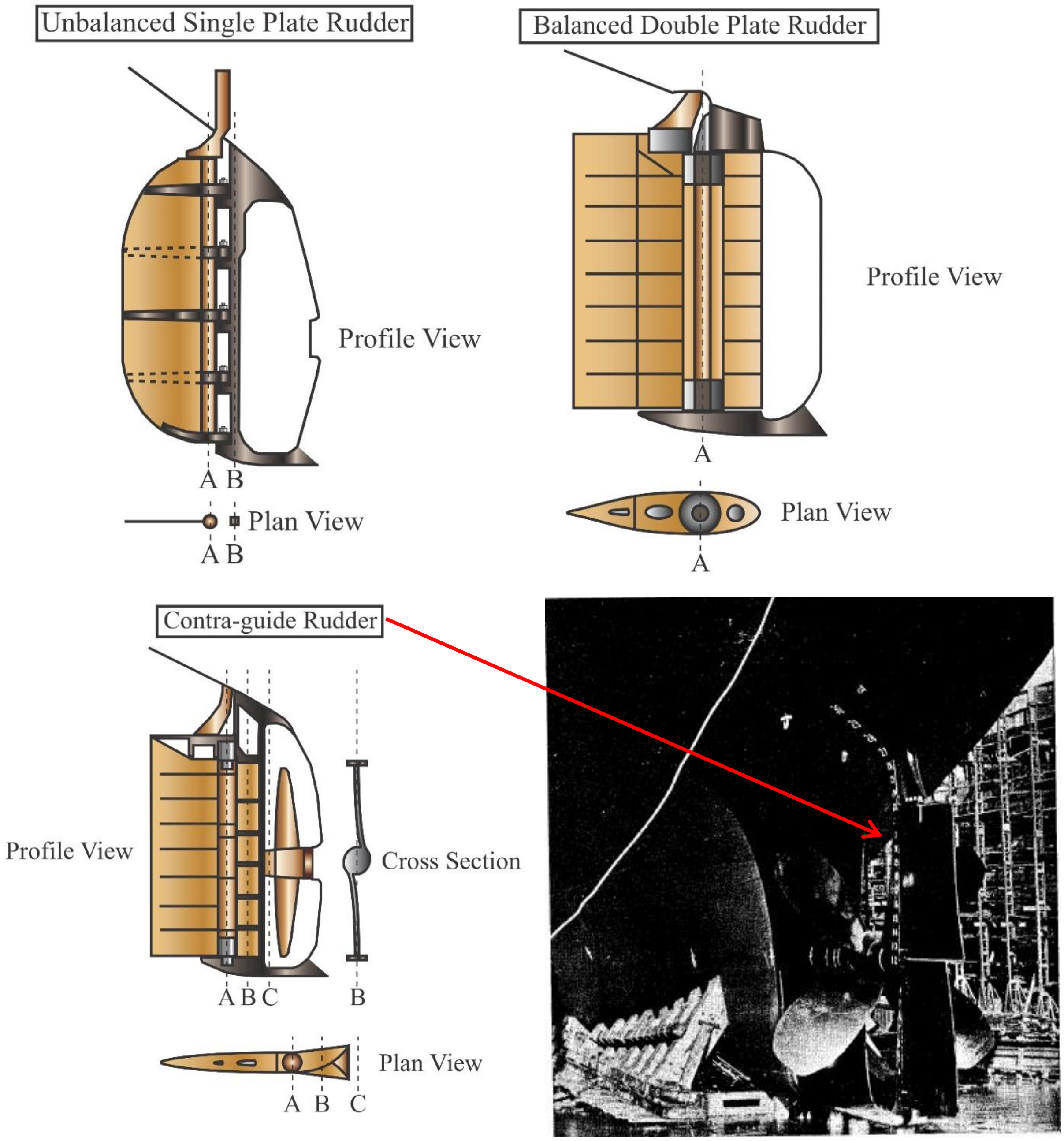

Figure 73: Contemporary rudder styles ca. 1942 (Drawn from Manning 1942:41; Osbourne 1943: 23-2).

S.S. Cities Service Toledo

The circumstances surrounding the wreck site of the proposed *Cities Service Toledo* proved to be a challenge logistically and archaeologically. Difficulties present during the field research of the wreck site included the challenging diving considerations taken and the fact that diagnostic elements of the vessel proved to be in poor condition or completely absent from the site itself. A synthesis of all available resources proved to be beneficial to answer research questions that bridged that gap between documentation and archaeological evidence. The major diagnostic elements divers investigated in 2010 were very similar to that of the *R.W. Gallagher*'s proposed site. Teams were tasked to find the features that would likely yield information leading to a positive identification of the ship, and these included hull plating, rivet patterns, potential torpedo damage, propeller, and rudder. Because the propeller and rudder were absent from the wreck site, diagnostic measurements were taken of the distinct curvature of the rudder mount and the propeller shaft. This site offered a unique glimpse into the profile of the stern of the vessel that was beneficial to feature mapping, because of the *Cities Service Toledo*'s distinct difference in the rudder shape and style from the *R.W. Gallagher,* mounting components of these features led to an alternative view on deducing the types used on this wreck.

The discussion of diagnostic features on the *Cities Service Toledo* will begin with hull plating and rivet patterns. While investigating the wreck site, the adopted standard procedure of recording the hull plating and rivet patterns proved to provide important details relevant to the dynamic pattern of ship construction. The rivet type used on this vessel resembled the buttonhead rivet style commonly used on vessels that welded their outer hull plating from the outside (Figures 24, 46, and 72). This pattern potentially indicates an older method of ship construction that would have been used prior to the 1938 construction methods used on the *R.W. Gallagher*. Since the *Cities Service Toledo* was constructed as the *J.A. Bostwick* in 1918, by the same Bethlehem Shipbuilding Co. that built the *R.W. Gallagher,* the secure interior-oriented countersunk rivets designed to avoid leaking were not included in the ship's design. Leaking was commonly associated with buttonhead and panhead rivets extruding from the outer hull shell. Additionally, the planned unbalanced single plate rudder style planned for the *J.A. Bostwick* is indicative of an older construction style as of 1942 (Manning 1942: 41) (Figure 72). This corroborating evidence seems to indicate that this site is an older tanker design than the previously investigated wreck and, through the dynamic pattern investigation, supports the argument for the identity of both vessels. Additionally, the hull plating itself follows a pattern associated with a "raised and sunken system of plating" (Manning 1942:20-21), unlike that of the proposed *R.W. Gallagher*, which is a flushed plating system (Figure 74). This raised and sunken system of plating was very clearly fastened with a butt lap joint, and based on historical documentation, the exact type of raised and sunken plating construction could be isolated if divers observed a parallel liner in the field (Manning 1942:20-21). This would have constituted physically removing a section of hull plating and is not absolutely necessary for identification, though future research may benefit from this understanding of construction methodology (Figure 74).

The visible damage on the proposed location of the *Cities Service Toledo* is located just forward of amidships on the starboard side of the wreck. Dive operations were focused on visually inspecting the entirety of the vessel very briefly, and an initial orientation of the wreck site included ground-truthing the direction that the vessel lays. Upon inspection of the southern region of the wreck, divers observed, but did not record, the large hull breach. Researchers remotely collected data points and other information digitally to illustrate this breach. The advantage of physically ground-truthing this probable torpedo impact point is that it allows divers to make observations as to the integrity of the vessel at this point and to make real-time adjustments to observations while interacting with the site itself. Divers observed the curve of

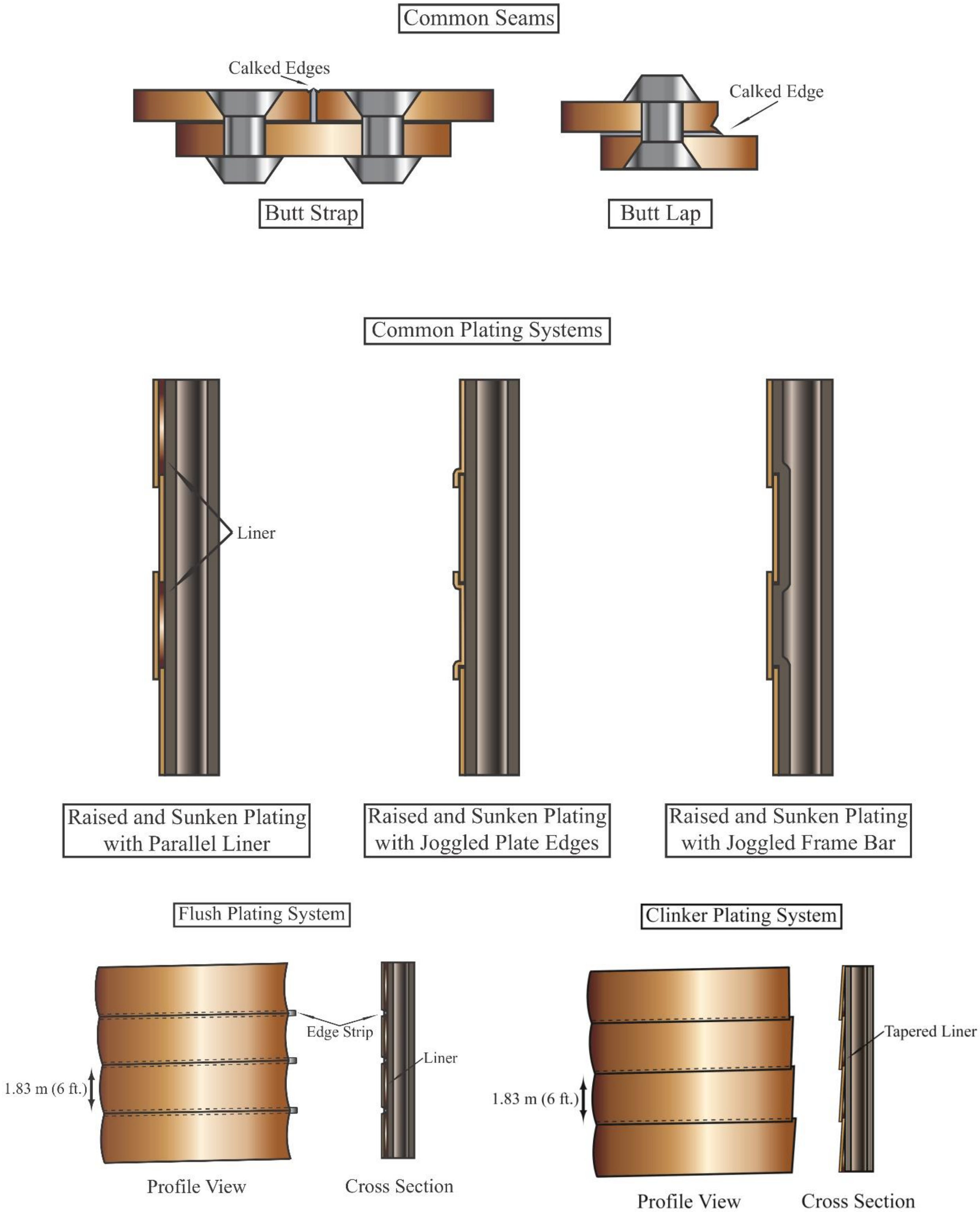

Figure 74: Contemporary butt joins and plating systems ca. 1942 (Drawn from Manning 1942:20-21).

the hull bowed inward, which could indicate the direction of the torpedo strike and direction of the blast or deterioration of the iron hull over time.

The final discussion involving the archaeological diver survey of the possible *Cities Service Toledo* falls to the stern of the vessel and the diagnostic elements of the propeller shaft and rudder assembly. In contemporary oil tanker construction at the time, propeller shafts were fitted with a lubricated sleeve, and that sleeve was, in turn, placed within what is called the “stern tube” (Manning 1942:306). Though the term “propeller shaft” has been used consistently throughout this study because of its relative ubiquitous understanding, the wreck site at the potential location of the *Cities Service Toledo* contains no visible elements of the propeller shaft, propeller shaft sleeve, or any exterior propeller mechanism. The stern tube of vessels constructed at this time were made of a component that was primarily iron for structural rigidity, and it is likely that this facet of ship construction is all that remains on the wreck site (Manning 1942:306). Though this could be perceived as a discouraging data set, the value of the measurements of the stern tube proves to be beneficial in confirming the vessel's identity. In fact, in cross-referencing the dimensions outlined in the ship's plans for the *J.A. Bostwick,* the proposed dimensions of this stern tube compare exactly to the diameter measured in the field. The “rough bore” diameter, where the propeller shaft would have entered the stern of the vessel, was designed to be 55.88 cm (22 in), the exact measurement taken in the field (HHC 1916) (Figures 45, 47, and 75). Additionally, the stern frame width was designed to be 21.59 cm (8.5 in), also consistent with field measurements (Figures 45, 47, and 75). The unique shape of the rudder main post and the stern frame are also unmistakably similar in design, representing a single, unbalanced rudder system that could easily allow for salvage removal (Figure 73).

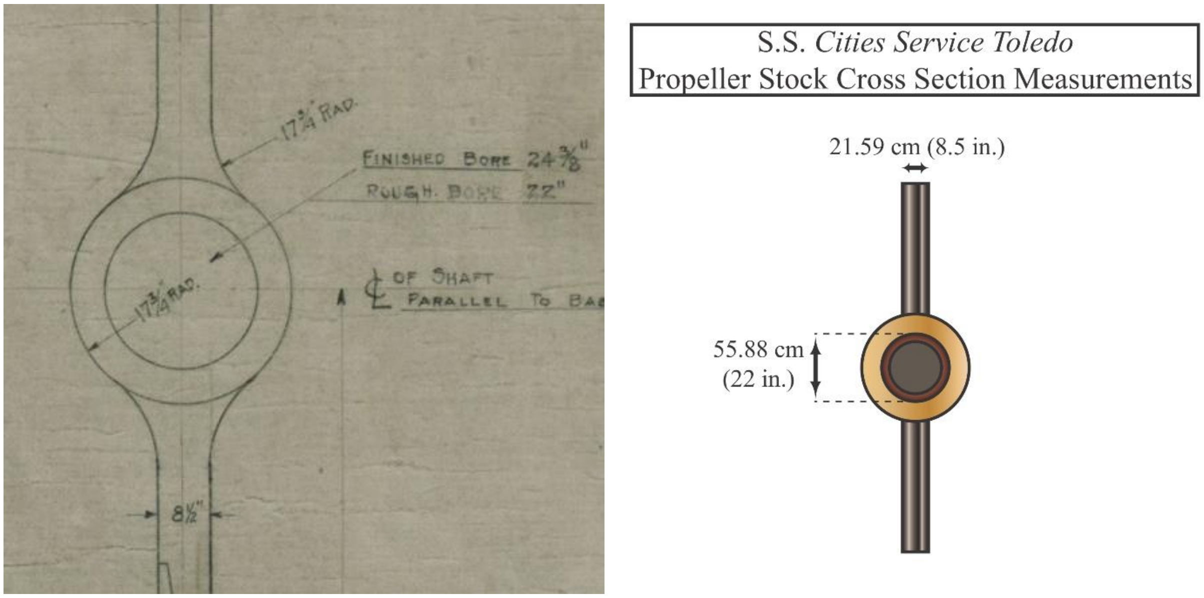

Figure 75: Original planned propeller stock and field measurements on the S.S. *Cities Service Toledo*.

The fact that this unbalanced rudder system could be easily removed, exposing the propeller and propeller shaft, offers an explanation as to why they are both missing from the wreck site. The lack of these components indicates looting of the site for its metal or cultural value or a military salvage operation to recover the propeller and rudder for future use or sale. Though records for naval salvage may exist on this wreck site, they are not directly correlated with the documentation available for the *Cities Service Toledo,* and further research is required to answer this question. The potential for looting further creates a need for this site to be protected, monitored, and registered on the National Register of Historic Places to preserve its integrity as a significant location of cultural heritage as well as assign significance in an effort to protect it as a war grave. The overwhelming dynamic evidence present when applying a cross-comparison of the historical and archaeological evidence together virtually confirms that this vessel is, in fact, the *Cities Service Toledo.* The process used to cross-examine the evidence on both of these wrecks seamlessly integrates the gross and dynamic patterning used in battlefield archaeological theory. These concepts make critical correlations that allow for the near absolute identification of World War II wreck sites and would not be possible without the historical, archaeological, and remote-sensing information compared together in a dynamic format.

Previous Investigations

The primary focus of this study was to determine identities, clearly state the processes involved with wrecking events, determine their cultural significance, and explore new ways of approaching a study of World War II tanker casualties in the Gulf of Mexico. The latter of these objectives may be applied to other shipwreck sites of the period as well if approached through a battlefield theoretical model. By comparing the approaches that were taken in both the PBS&J and C&C studies on similar wrecks, this study seeks to formulate a method in which future research problems and questions may be better addressed prior to investigation.

The methods and tools utilized by both previous studies varied slightly from those used on this investigation. In the study by C&C Technologies (Church et al. 2007a), a team was tasked with locating and documenting the condition of historic shipwrecks dating to around the World War II period. The project involved both archaeological and biological objectives and evaluated shipwrecks both culturally and environmentally. Though these wreck sites were located in deep water, objectives included recording their condition and establishing their eligibility for inclusion on the National Register.   This goal was similar to those of this thesis. The primary differences in the C&C study was the use of remotely and/or autonomously operated vehicles and a complex biological study of the artificial reefs formed by the wreck sites. The use of deep sea robotic instruments greatly benefits a research project through the ability to store remotely collected photographic and video information for later analysis. The amount of time an ROV/AUV may stay underwater allows for this information to outnumber the amount of photographs and video that can be taken by divers in the same number of days on site, assuming divers can physically reach a dive site safely. There is a significant cost to this technology, however. Not only can a dual manipulator ROV cost near $6 million, but they also must be custom designed and assembled for scientific research. The overall cost of owning one of these systems can be extremely high, and research groups are more likely to rent or produce these robotic instruments themselves to avoid costs that would outweigh funds available for research purposes of these projects. In the case of the C&C study, the benefit of using these robotic instruments allowed for several sites to be researched with a multidisciplinary approach that could justify such a high level of project cost. Though the project was able to collect samples at depths unreachable by divers and collect more information regarding biological processes, physical investigation of sites by divers can take less overall time at a reachable depth and include individual observations that are not as easily observed by ROVs.

In the 2010 study of the *R.W. Gallagher* and the *Cities Service Toledo*, divers were able to intuitively react to site conditions and interpret diagnostic elements while interacting with the sites in a way that cannot be reproduced mechanically. Though the physical interactions and observations made on the wreck sites are limited to interpretation by whatever divers physically recorded, several dive rotations were able to counteract error in observations significantly. The cost of using diver ground-truthing in this study was much less than if the study used an ROV.

In the C&C study, the investigation of metal corrosion rates and biological processes on or around the shipwreck sites was a good use of the available technology. Had the 2010 study employed the use of an ROV or adapted diver-deployable environmental research objectives, supplemental environmental sampling could have been taken on the *R.W. Gallagher* and the *Cities Service Toledo*. For future site monitoring, the C&C study serves as a model for the applicability of leaving metal material samples to determine the effect of corrosion, electrolysis, and biological interaction with the wreck sites. The 2010 and 2007 studies used two different sampling methods. The 2010 study utilized a sediment coring approach to date site formation processes while the 2007 study sampled the effect of natural biological processes on wreck sites. It would benefit future investigations to incorporate both of these study types to safeguard natural and cultural resources. When establishing a site as essential for environmental protection, researchers should study biological processes that surround artificial reefs like these to strengthen arguments for protecting them.

In addition, the National Register nomination process requires an assertion of integrity regarding the criteria that make these sites eligible for inclusion. By establishing the date of the wreck site's formation, researchers can evaluate and monitor site degradation and loss of integrity over time as well as the effect the site has had on the surrounding environment. Most importantly, in wreck sites that involve possible toxic contamination of the environment around them, these environmental and geological surveys of site conditions can reveal the potential danger that chemicals leaking from the hulls of these wrecks pose to the surrounding environment. In certain cases, arguments for protection and mitigation of cultural and environmental sites like these can only benefit from further study as humans continue to affect the environment around them. Researchers could find that cargo materials (like oil) sunk in wrecks like these could later be recovered and re-used or be removed safely to prevent further damage to the site or the environment around it. A better understanding of the effects of the interaction between humans and their environment throughout time and into the future using cross-disciplinary studies like the C&C study in 2007 and the Tesla Offshore study in 2010 will help safeguard valuable non-renewable resources.

In addition to the two aforementioned studies, the 2006 PBS&J study provided an additional resource for documenting World War II sites in the Gulf of Mexico. In this project, a directed study objective isolated the historical components of both of the *R.M. Parker Jr.* and the *Sheherazade* and compared them to archaeological data. The intensive study of the historical information available on each wreck creates a balanced narrative that aids in illustrating the value of these wreck sites as war graves and important cultural resources. This method is continued in the 2010 study used throughout this thesis, and is supplemented by other geophysical, chemical, and conceptual practices. This method should be continued in future studies, as the historical value connects a dynamic pattern to the battlefields that these wreck sites inhabit. These individual battlefields will continue to form a larger database to understand World War II wrecks, and gross patterns will begin to reveal more scientific evidence of site formation processes, environmental impacts, site integrity, and dynamic patterns of the individuals who served on these vessels, served on German U-boats, and interacted with the vessels directly and indirectly for nearly a century. These studies all help to establish a theoretical foundation of the battlefield principles used on other archaeological sites, mostly associated with the American Civil War, and apply them to marine World War II sites. This application not only benefits future research, but it also makes invaluable use of studies like the C&C, PBS&J, and Tesla Offshore reports as the building blocks for studying sites like this within the overall battlefield of the Gulf of Mexico and beyond. These studies can ultimately serve to construct preservation models and research catalogs across the Atlantic and Pacific oceans and enhance the expanding interest in World War II studies in the future. These national and international war graves can all be established as battlegrounds, thus securing funds, security, and education programs that have been formed through previous legislation intended to protect national cultural resources. As the use of innovative technology grows, public knowledge and involvement in this process will grow and continue to pique interest in cultural heritage many generations into the future. One technological technique that has grown public and scientific favor is 3D modeling, and this technology can be expected to generate more interest from these demographics in the future.

"Turning Turtle"

One intriguing physical observation of these two wreck sites is the fact that they both lie upside down on the seafloor. Explanations as to why this happens can be found in two key documentary sources. These sources represent mariners' and naval salvers' knowledge of this occurrence both in the past and the present. The first source is the book *Manual of Ship Construction* by George C. Manning. In Chapter 5, Principles of Stability, Manning introduces the key concepts that will serve to illustrate the explanation of the ships' capsizing: Center of Gravity, Center of Buoyancy, and Metacentric Height (1942:118-120). These three factors are the most critical aspects of a ship's balance in regard to its design. When they are pushed past their critical point of stability, the ship will overturn. This is best illustrated through mathematical principles of stability outlined below. These principles lead to the answer as to why ships like this ultimately "turtled," or overturned in a manner that resembles a turtle shell, on the seafloor.

For the purpose of this study, discussion on the specifics of the actual sinking events will focus on the transverse principles of stability involved with the *R.W. Gallagher* and the *Cities Service Toledo*. Transverse balance (side-rolling) on a ship involves the principle concept of the interactivity between the three principles of stability mentioned in Manning's work, and the metacentric height involved with a rolling ship. The equation involved with this problem is derived from the "moment of force." The moment of force is the product of its distance by its point of application (Manning 1942:119). This is represented as the following equation, where F is the force at A or B, and O is the distance from A or B to the point of that force:

$$F_A \times OA = F_B \times OB$$

In a ship, the center line of the vessel acts as the center of both its gravity and buoyancy when at rest. The action of centering gravity and buoyancy upon the center line ensures that the vessel is balanced properly and can function as an open, floating object. Its center of gravity is the point that the weight of the ship will be supported horizontally at the water line, hence the center line of the ship. The center of buoyancy will equal the weight of the displaced water that is supporting the weight of the ship and, to be in balance, will lie below the center of gravity. For the *R.W. Gallagher*, the center line of the ship weighed 8,117.2 metric tons (7,989 gross tons), which represents its center of gravity and its center of buoyancy as well as the moment of force. The vessel had a 19.51 meter (64 foot) beam. The collective amount of force acting on either side of the vessel is known as the "arms of force." By using the above equation, the arms of the force exhibited vertically at either side of the ship equal 693,224,293.71 newton-meters (255,648 foot-tons [511,296,000 foot-pounds]). For the *Cities Service Toledo*, the center line of the ship exhibited a weight of 8,323.46 metric tons (8,192 gross tons) with a beam of 18.29 meters (60 feet). The arms of the force acting on either side of this ship are totaled at 666,411,637.96 newton-meters (245,760 foot-tons [491,520,000 foot-pounds]). In both vessels, these two arms serve as a couple that interacts by pulling and pushing in opposite directions. If this couple interaction were to become unbalanced in one way or another, these forces will act continuously in one direction until met with an opposite force. In the case of a transverse rolling, one arm has a decrease in gravitational force while another faces an increase in buoyant force.

The turning of the center axis of the balance of the ship causes the center of buoyancy to no longer be directly impacted by the equal center of gravity. The equal forces will continue to move in their dynamic physical direction parallel to one another until the arms of the force are balanced once again (Figure 76 and Figure 77).

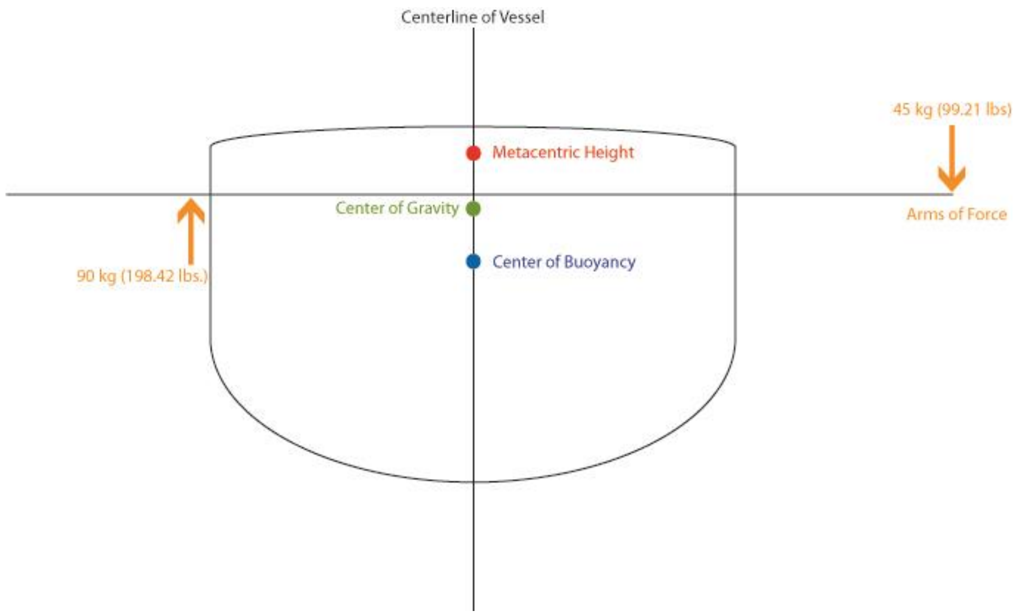

Figure 76: Illustration of the basic principles of stability and an example of acting arms of force.

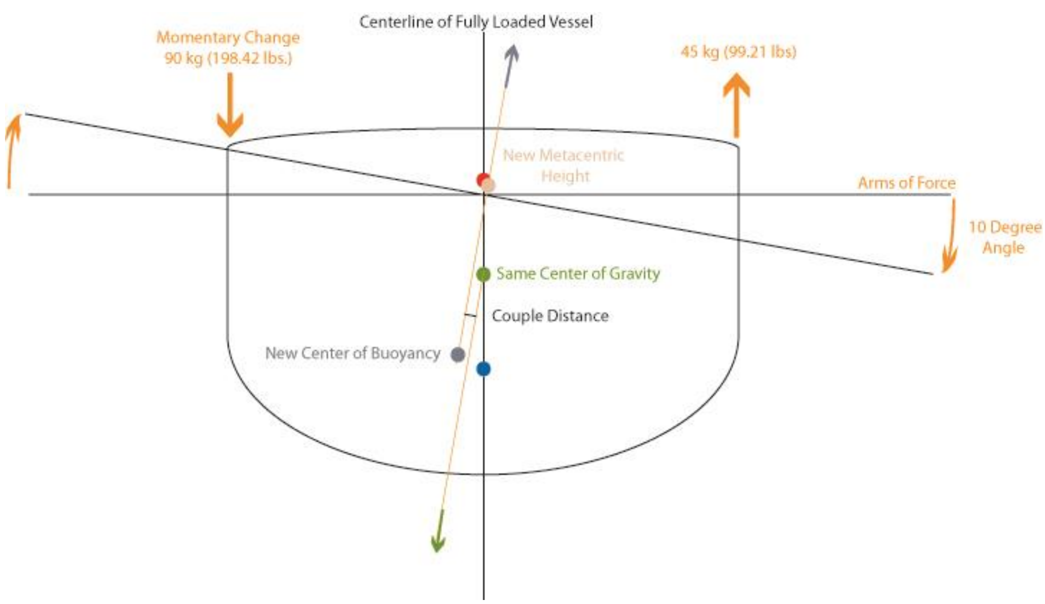

Figure 77: Illustration of the principles of stability while being acted upon by an example of movement (i.e. waves).

It is appropriate to now discuss the effect of a loss of balance following the example that illustrates the variables involved with transverse stability. Because the final outcome of both the *R.W. Gallagher* and the *Cities Service Toledo* was their turning over and resting on the seafloor, it is important to explain the reason why they turned upside down. The forces of gravity and buoyancy are constantly working against each other as are the arms of force on both the port and starboard side. These principles of balance work for the vessel while it is displacing its own weight, but when it is carrying a "free surface" (a material that will spread evenly until it reaches a point of equilibrium based on the principles of gravity, such as water, sand, or oil), the equilibrium of the vessel is more complicated. Because a free surface will naturally assume a horizontal state regardless of its surroundings, it will assume its own metacentric height based off the center line of the ship that is carrying it. While a ship lists to port or starboard, the free surface will lower the vessel's overall metacentric height by maintaining its own horizontal orientation, resisting the arm of force on the opposite side of the vessel. As metacentric height on a vessel is lowered, stability becomes less manageable, and the ship will freely turn in the direction of the most applied force. If the center of buoyancy ever rises above the center of gravity, the ship will capsize as it will if the metacentric height is ever below the center of gravity. These reactions are all caused by the principles of stability.

The effect of the free surface's movement on the stability of the vessel's list is diminished in vessels that have a partitioned longitudinal division of its cargo holds as the free movement of liquids is confined to a tighter space. By examining both the blueprints and archaeological remains of the proposed *R.W. Gallagher* and the *Cities Service Toledo,* these longitudinal barriers were planned for both vessels, but not directly observed in the field. It is assumed that longitudinals were present on the shipwrecks investigated in 2010 and could be verified with site monitoring or further research in the future. If longitudinals are not present on ships at the time of their attack, it can be clearly deduced that radical movement of the free surface cargo would cause an expedited process of this type of sinking. Because it was reported that both vessels sank over a long period of time, it is probable that these longitudinal partitions protected the ships from sinking more quickly and allowed for the surviving crew members to escape and deploy life boats when they did.

The mathematical formulas associated with trigonometric angles and the stability of a square prism is useful in seeing the effect of a change in metacentric height and stability in a marine vessel. At rest, the prism's center of gravity and weight is flat against a surface, returning an equal amount of force against it, so the prism remains at rest. As the prism is lifted on to one edge slightly, the focus of the prism's weight is centered on that edge, though the center of gravity remains at the sine of the angle from the perpendicular corner between the center of the prism's center of gravity and the vertical point above the edge at rest. The center of gravity remains as a greater righting arm of force against the angle of rise formed by the lifting of one side of the prism, so the prism will return to its original upright and stable position. If the prism were to continue to be lifted along the same edge, the center of gravity would reach a point immediately above that of the center of its weight along the balancing edge, and that arm of force would be equal to the force of the angle the prism is being lifted from. The prism would be in perfect balance and would remain static until any slight force was to act on it in either direction. Once the prism is lifted at a higher angle, the center of gravity is then beyond that of the center of its supported weight point and it will continue to fall onto its side. As long as the prism is kept within the angle that maintains its center of gravity towards its original center of gravity, the prism will remain in equilibrium (Manning 1942:124-125) (Figure 78).

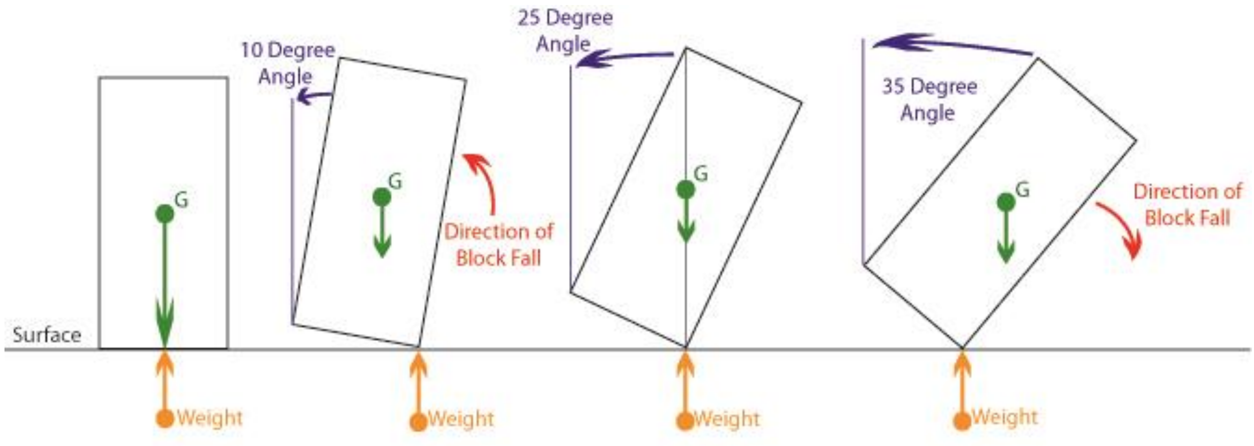

Figure 78: Illustration of the principles of stability applied to a block or prism.

This same basic principle of stability is applied with the transverse movements of a vessel in the water and ultimately explains why a vessel capsizes in cases like those of the *R.W. Gallagher* and the *Cities Service Toledo*. It has been discussed that if the center of gravity rises above that of the metacentric height, a vessel will capsize. This effect can happen in two ways, either an external force pushes the vessel past its angle of stability, or an internal force creates that same instability. As discussed with the movement of a free surface, once that critical angle is reached, the vessel will turn upside down.

Another danger is the addition or removal of weight that lies below that of the center of gravity on a vessel. Over time, the gradual loss of weight from the cargo holds of a vessel will raise its center of gravity above that of the water line. When this happens, the center of gravity will follow the water line in the direction of the vessel's lean. This will exacerbate any list that the vessel is already facing, and if left uncorrected, the list will pass the angle of equilibrium, and the ship will capsize. Conversely, if the vessel's center of gravity decreases to the point of its buoyancy or past its freeboard, the vessel will sink.

The equation regarding this aspect of Archimedes' principle is as follows, where KG = height of the center of gravity prior to weight change, KG^1 = height of the center of gravity after weight change, Δ = displacement to waterline prior to weight change, and Δ^1 = displacement to waterline after weight change (Manning 1942:142):

$$KG^1 = (\Delta \times KG)/\Delta^1$$

When associated with a ship that can allow control of free communication of a damaged hold with the outside water source to raise the metacentric height while bilging excess ballast to balance the vessel, righting a ship that may be on the verge of capsizing may be handled quickly and efficiently by a familiar crew. If a crew is unable to control the equilibrium of a vessel that is listing at the edge of its angle of equilibrium, the center of gravity will exceed and, therefore, be lower than the center of buoyancy, and flooding will ultimately lead to a sinking vessel. Additionally, an increased equilibrium cap due to a hull breach will lower the metacentric height in the damaged vessel, thus increasing the effect of any rolling motion. This scenario is perfectly illustrated by oil tankers that took several hours to sink due to the gradual loss of their free surface cargo through open communication with the sea. Because oil, as a free surface, is dynamically going to adjust to its state of equilibrium horizontally, free communication with the ocean allows the lighter oil (~800 kg/m^3 [49.94 lb./$ft.^3$]) to escape each vessel while freely allowing the heavier seawater (~1025 kg/ m^3 [63.99 lb./$ft.^3$]) to replace it. The gradual loss of oil cargo lowers the center of gravity while also lowering metacentric height and the freeboard of a vessel. The angle of list passes the angle of equilibrium and/or the freeboard eventually submerges and the vessel capsizes transversely. This dynamic change follows a simple equation.

The following mathematical relationship illustrates this effect by using the free surface flooding equation regarding liquid equilibrium, where h_i = oil depth with head equivalent to seawater head, $\gamma_{g, sw}$ = the specific gravity of seawater, $\gamma_{g, i}$ = the specific gravity of oil, and h_{sw} = depth to tank penetration/local draft for bottom rupture (United States Navy (USN) 1997:1-59) (Figure 79):

$$h_i = [(\gamma_{g, sw})/(\gamma_{g, i})]h_{sw}$$

By determining the maximum height the seawater will reach during a hull breach, assuming the waterline was consistent with the original ships plans, one can deduce the approximate weight of the oil lost by each ship and determine the potential rise of gravity in relation to how it would affect the angle of the vessel's list. The *R.W. Gallagher*'s originally proposed draft is 8.63 m (28.33 ft.), and the *Cities Service Toledo*'s originally proposed draft is 7.77 m (25.5 ft.). From this, the change in draft and weight displacement can be calculated from the exchange of the two liquids, this is known as the "equivalent oil head." By inputting the specific gravity of seawater (1.025 SG [63.99 lb./ft.^{3}]) and oil (0.8 SG [49.94 lb./ft.^{3}]) into the above equation, the adjusted equivalent oil head can be determined. For the *R.W. Gallagher*, the equivalent oil head is 11.06 m (36.29 ft.), and for the *Cities Service Toledo*, the oil head is 9.96 m (32.68 ft.). This measurement assumes that equilibrium will be reached with a replacement of the lost oil by sea water, so a calculation of the difference in the oil heads from the volume of water that would equalize the damaged tanks, shows the change in weight in each hold. Based on the difference in the equilibrium depths added to original draft (h_i-h_{sw}+$h_{i)}$, each completely damaged tank's oil would partially be replaced with seawater, specifically, to a hold depth of 6.2 m (20.34 ft.) on the S.S. *R.W. Gallagher* and 5.58 m (18.31 ft.) on the S.S. *Cities Service Toledo*.

Calculating the weight change caused by this interaction is simple using the following equation, where $\Delta\gamma$ = The total change in weight in the affected hold, V_{eh} = The volume of the damaged hold after calculating the equivalent oil head $[(h_i\text{-}h_{sw}+h_i)lw]$, γ_i = The weight of oil, and γ_{sw} = the weight of saltwater (Figure 79 and Figure 80):

$$\Delta\gamma = (V_{eh} \text{ x } \gamma_i) - (V_{eh} \text{ x } \gamma_{sw})$$

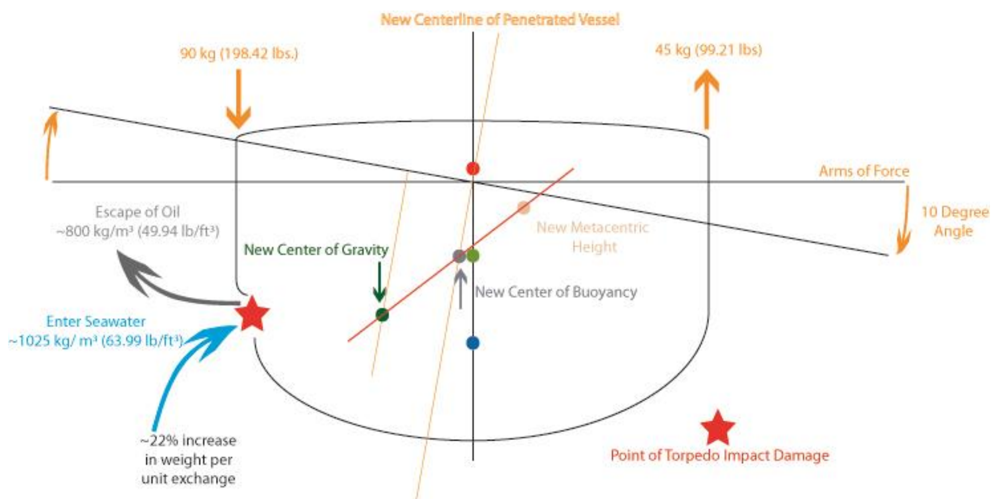

Figure 79: Illustration of the principles of stability applied to an oil tanker struck by a torpedo.

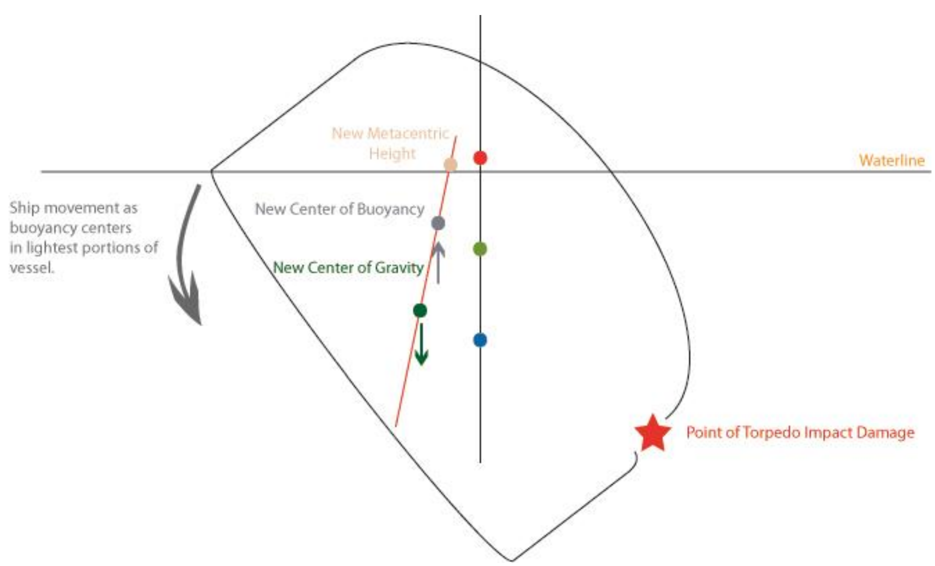

Figure 80: Illustration of the principles of stability applied to an oil tanker capsized after an attack.

By following this conservative equation regarding the determined change in weight and considering the probability that more holds on one side of the center line of both vessels were damaged in each attack, the shift in balance in each vessel can be expressed clearly. Each completely damaged (determined through the calculated equivalent oil head) cargo hold on board the *R.W. Gallagher* would have added 142.69 metric tons (157.29 tons) of weight per flooded hold with an oil head equalized at 634.02 m^3 (22,390.27 $ft.^3$). According to the United States Navy, it takes around 20 minutes to completely replace an oil-filled hold with seawater (USN 1997:1-59). Because three holds were known to be damaged, this calculation conservatively amounts to a total of 428.07 metric tons (471.87 tons) added to the tanker within the first 20 minutes of sinking. The arm of force from this resulting weight change would be the product of the equivalent oil head's difference from the original draft with half of the vessel's beam, or 9.75 meters (32 feet). The resulting change in the arm of force for the starboard side would be 13,648,422.72 newton-meters (5033.28 foot-tons [10,066,560 foot-pounds]) negative after canceling out two opposing tank strikes (679,575,870.98 newton-meters [250,614.72 foot-tons] to port versus 665,930,159.89 newton-meters [245,582.44 foot-tons] to starboard). This makes the starboard side significantly more susceptible to its listing and the overall center of gravity on the ship much lower after adding 428.07 metric tons (471.87 tons) of total weight. The resulting change in list would be at least 1.97% on this side of the keel. This means that, conservatively, a single, flooded, starboard hold that has not been affected by other variables to increase the amount of open sea communication on the *R.W. Gallagher* would amount to a 7.09° list to starboard, leaving only ~0.61 meter (~2 feet) of freeboard above the surface if the vessel were at its proposed draft. The addition of a total of 428.07 metric tons (471.87 tons) were added to each hold that was significantly damaged, and additional weight lowered the ship's center of gravity, and the ship, more than 0.61 meters (2 feet). With the minimum 7.09º unbalanced list on the starboard side freeboard of the *R.W. Gallagher* led to its submergence below the waterline. The *R.W. Gallagher* passed its point of equilibrium and proceeded with an inverted relationship between the center of gravity and center of buoyancy as oil escaped the submerging vessel, ultimately resulting in its final sinking condition. Once water began to flood the interior of the vessel, the fluid exchanges would have increased the rate of sinking, and once the ship had completely turned over, it settled on the seafloor (Figure 81). The curvature of the hull would have placed significant stress on its beams with the tanker's full weight resting on the bottom, and sagging most likely exaggerated the amount of damage visible on the hull. Because the vessel remains overturned on the seafloor, oil trapped in previously undamaged holds when the ship capsized continues to escape into the Gulf of Mexico as the hull deteriorates over time.

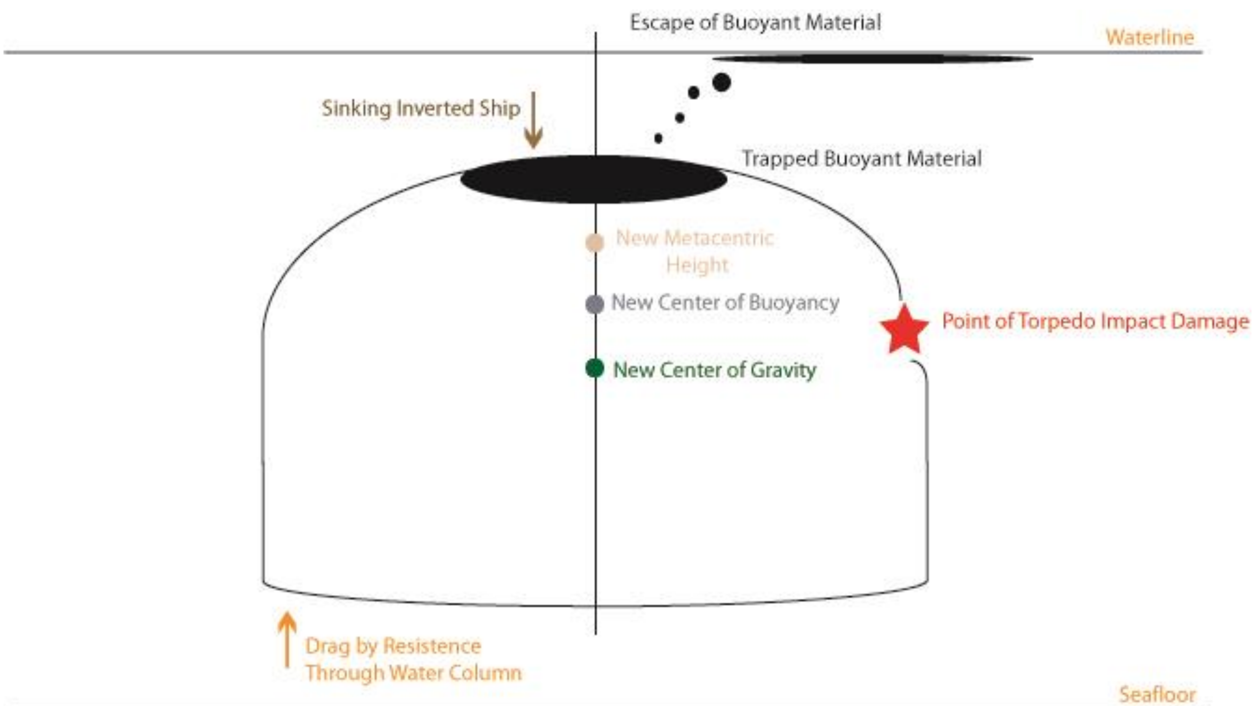

Figure 81: Illustration of the principles of stability applied to a sinking, open-hulled, capsized oil tanker.

This study ends its mathematical discussion by applying the same previously discussed equations with the event that sank the *Cities Service Toledo*. The equalized oil head differences in the *Cities Service Toledo* equaled at least 290.35 m^3 (10,253.6 $ft.^3$), which would have meant a minimum increase of 65.34 metric tons (72.03 tons) per completely damaged cargo hold. On this tanker, it was observed archaeologically that at least two holds on the starboard side were damaged, allowing free communication with the sea. This transaction would mean a minimum of 130.63 metric tons (144.06 tons) of weight was added to the starboard side alone. When multiplied by the starboard beam, this equals a total of 11,719,392.06 newton-meters (8,643,780 foot-pounds [4321.89 foot-tons]) of force being exerted on this arm. Out of the total force of the *Cities Service Toledo's* balanced arms of force, this calculation is a 1.76% negative starboard change in the list of the ship. This change is a 6.33º list at a minimum for the tanker, which would have brought the starboard-side freeboard to a similar list to that of the *R.W. Gallagher*, reducing freeboard by around 1.22 meters (4 feet).

All of these figures would be at least doubled if the reported amount of four holds were completely damaged during the battle. This damage would have resulted in a 12.66 º list in the vessel, which would have significantly expedited the capsizing of the *Cities Service Toledo*. It is further possible that the vessel had sustained more significant damage than to the four reported holds, as archaeological evidence seems to support a torpedo strike that would have flooded air space within the vessel. This would have increased the angle of list over 20º and would coincide with the survivor's statements of a heavy starboard list, causing them to jump 9.14-12.19 meters (30-40 feet) overboard from the port-stern (Wiggins 1995:93). Again, this accurately illustrates how and why the *Cities Service Toledo* sank, much like the *R.W. Gallagher*. Once the starboard list of the vessel exceeded the angle of equilibrium, caused by an increasing amount of saltwater intrusion to the interior of the vessel, the center of gravity continued to turn until it became lower than the center of buoyancy, and the vessel continued to sink upside down, the center of balance no longer supporting a floating vessel, but a sinking one. Again, these effects become increasingly destructive due to the lowering of the center of gravity and the lowering of metacentric height at the same time, eventually leading to a complete capsizing of the ship. Researchers can archaeologically see visible effects of sagging from nearly 70 years of resting on the seafloor in the completely broken and sheared hull at the large breach on the site. Researchers inferred, from the significantly small amount of oil still seeping from the hull of the wreck, further evidence of a higher oil-to-water exchange due to extreme damage in battle. If the *Cities Service Toledo* were to have taken damage to a similar volume of holds to that of the *Gallagher*, it would be expected to observe a similar amount of oil coming from the wreck. Because this is not the case, one argument is that more oil was lost during the sinking, which implies more damage to this vessel during the attack.

In optimal maritime conditions, an experienced crew can correct these imbalances relatively easily; however, this ease of correction is not the case on a battlefield. When associated with a torpedo attack during a battle, situations arise that prevent the crew from controlling the equilibrium of a ship, such as explosions, fires, inaccessibility, instrument damage, and death. While all of these destructive forces were present on both the *R.W. Gallagher* and the *Cities Service Toledo*, it can be safely determined through dynamic patterning that the crew was unable to control the effects of instability present at the time of the U-boat attacks. This instability was a direct result of the dynamic torpedo attacks that caused an increase of weight, a lowering of metacentric height, a lowering of the center of gravity, a loss of freeboard, and the eventual surpassing of the angle of equilibrium, which caused both vessels to turn on their transverse lines and sink with their center of gravity below that of their center of buoyancy. This scenario is the reason why these tankers, and other vessels like them, lie upside down on the seafloor, and also establishes a model for explaining this occurrence on shipwrecks of this type.

Armament

The first historical discussion that is presented in this study begins with the issue of armament on each of the vessels and the implications of arming them. It is clear that previous questions over the specific reasons for arming ships at this time must be broadened beyond the scope of just the *R.W. Gallagher* or the *Cities Service Toledo*, but to the purpose of why and how they were armed altogether. The priority of arming these particular vessels for the war was low, and any increase related to specific time, type or class over this brief period of time is inconclusive. The weapons present on these tankers were surplus weapons developed around the World War I era and were considered less effective than weapons that were being fitted on contemporary naval vessels in the United States Navy (Campbell 1985:147-154).

The 8,117.2 metric ton (7,989 gross ton) *R.W. Gallagher* was armed on 3 May 1942 with a six-gun complement. The Browning .50 and .30 caliber machine guns were common in the U.S. Navy by the 1930s but were replaced by the newer 20 mm Oerlikon and eventually the 40 mm Bofors machine guns during World War II (Campbell 1985: 147-154). The Browning Mark II .50 caliber machine guns were earlier models commonly used on patrol craft, submarines, and merchant vessels at this time and were truly only considered a last-ditch defense effort in any engagement (Campbell 1985:154; DiGiulian 2007). The medium-caliber, five-inch, 51 caliber Mark 7 Modification 2 gun mounted on the stern of the *R.W. Gallagher* was fitted early in the war to Coast Guard, merchant, and light escort vessels and was originally intended for antitorpedo defense (Campbell 1985:136). This weapon was the heaviest gun used on both of the vessels and was developed during the 1910s through the 1930s (DiGiulian 2007). The forward gun mounted on the *R.W. Gallagher*, the three-inch 23 caliber Mark 14 Modification 0, was a light-caliber gun that was designated to low-priority vessels that would not be mounted with five-inch guns (Campbell 1985:145-146). The three-inch gun was primarily used on naval ships throughout World War I, and commonly accompanied landing craft during missions (DiGiulian 2007). This basic armament further demonstrates that the armament mounted to these "low-priority" merchant ships were surplus. Though the *R.W. Gallagher* complement included a five-inch 51 caliber gun; there is no documentary evidence to explain why this specific gun was used.

A cross-examination of the 8,192 gross ton (8,323.46 metric ton) *Cities Service Toledo,* armed on 19 May 1942, further illustrates the investigation of this case. The *Cities Service Toledo* was armed with two pairs of machine guns, two .50 caliber Mark II Browning machine guns and two .30 caliber Mark III Colt machine guns. As mentioned previously in the case of the *R.W. Gallagher*, these guns were used as a last-ditch effort in an attempt to defend the vessel against surface attacks and aircraft (which were not present). These machine guns would have had very little use in the event of any attack, and this position is supported by survivor accounts of the sunken vessels. In fact, the historical documentation refers to the other armament being used on the *Cities Service Toledo*, the five-inch 51 caliber Mark 8 gun. The arming of this ship with a medium-caliber gun is indicative of the lack of emphasis placed on merchant shipping in the Gulf of Mexico at the time. Though this is a higher-caliber gun emplacement than previously used on merchant vessels, which indicates an increase in awareness of the possible dangers of shipping in the Gulf of Mexico, it demonstrates that the outdated weapons were all the United States Navy felt were necessary to defend these tankers. The faulty gear mechanism that led to the failure of the five-inch gun on board the *Cities Service Toledo* during its battle with *U-158* correlates with the assertion that these ships were inadequately equipped for defending themselves with aging defense mechanisms at the time of their sinking (Browning 1996:140). It is proposed that components of these guns and their combined total of 10,372 unused rounds are still present on or near the present locations of the wreck sites and any further investigations should be aware of the danger associated with unexploded ordinance and oil tankers that still contain remnants of their cargo. Additionally, it is clear that armament quantity and date within the month of May 1942 is unrelated to vessel size. Though a general trend of increased armament, fleet transport, and weapon modernization is proposed to be present on vessels armed at later dates in the war, these two vessels should serve as a base model for this particular month in 1942 (Blair 1996; Browning 1996; Church et al. 2007a; Felknor 1998: 171-306; Gannon 1990; Gibson and Donovan 2000; Morison 1964; Wiggins 1995). It is also proposed here that undocumented circumstances such as political or economic influence of the parent companies (Standard Oil versus Cities Service Oil) or deck structure accommodation may have played a role in the increased armament present on the *R.W. Gallagher,* though this cannot be inferred strictly from individual cases, and further study of the two fleets could reveal more on the subject.

3D Modeling

In order to supplement the available information that was collected archaeologically, and in addition to available historical data, this study used post-processing tools that benefit a larger range of questions and anthropological linking. The real-time manipulation of data in three dimensions far outweighs the processing capabilities that a single, two-dimensional drawing can lend to establishing site-particular questions. Two specific questions that this modeling has been able to answer are directly associated with elements of the wreck sites that were not directly drawn by divers during site investigation. For example, divers could not have possibly been able to accurately create an in-depth drawing of the hull breaches in either wreck without dedicating more time than was available to study each site. Because the major hull breaches were easily recorded through the use of remote-sensing and were represented in three-dimensional point-cloud data sets, the post-processing only involved comparing the reconstructed 3D models to the actual archaeological context of the wrecks in their current state. This comparison not only answers questions about dynamic actions that occurred during the sinking event, but also lends to the current condition of the wreck and its integrity compared to its original working structure. The modeling process also allowed an examination of larger sediment deposition patterns that illustrated the scour and mounding effects that are present on each site. Though these site formation processes are important for illustrating the effect of geophysical site contributions, it also explained that some hull fractures may allow a free surface effect within cargo holds from holes that penetrate the outer hull of the vessel. The free transfer of sediment appears to have allowed scouring in areas that remote-sensing could not readily express visible holes in the hull structure. Future investigation of the site for integrity or structure evaluation would benefit from this study to estimate locations of possible weaknesses in the hull. These points could lead to an identification of oil leaks or places where the hull could collapse as the iron oxidizes. 3D modeling also offers an important chance for research such as this to be presented to the public and may engage communities in preserving remains of their heritage.

The 3D modeling process has been used recently in academic and public settings. This usage coincides with the previous assertion that this process will only help to garner public interest. In the 2007 C&C Technologies study, researchers used an image of the *Anona* based on a 3D model built by Andy Hall (Church et al. 2007a:197) (Figure 21). Though this was only a brief mention, more in-depth use of the technology is beginning to emerge in archaeology, aside from its use in this thesis.

Tiago Fraga used similar methods to assess dynamic construction patterns by reconstructing the frigate *Santo Antonio de Tanna* in his 2007 thesis (Figure 82). His particular method involved a carefully constructed tri-lateral qualitative and quantitative compilation of data regarding the ship. His individual measurements and modeling methods involved taking individual accounts and official documents to recreate as closely as possible the vessel he was working with in *Rhinoceros 3D*. As a similar method of reconstructing both the *R.W. Gallagher* and the *Cities Service Toledo*, it is essential to recognize that 3D modeling that involves data and observations taken archaeologically, ships' blueprints, and historical documentation are the closest that archaeologists can come to reconstructing a vessel through theoretical modeling methods like this at this time. 3D visual models expedited the analysis for the purposes of this thesis.

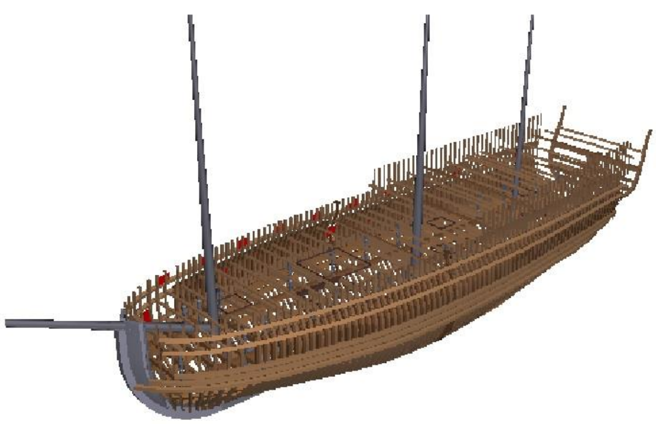

Figure 82: Still image of Fraga's interactive 3D reconstruction of the *Santo Antonio de Tanna* (2009).

This method also pushes the envelope of developing more advanced methods of 3D interpretation. Bringing this technology and capability to light is only the beginning, as it will take more researchers exploring these capabilities to refine theoretical, programmatic, and engineering models to perfect this extremely powerful tool. This tool offers a large boost from artistic 2D renderings and traditional 3D models with artistic license to a more critically and systematically broken down method for reverse engineering archaeological sites, allowing for advanced archaeological analysis.

As this chapter has discussed in detail the culmination of all research questions and how the methodological practice in this study led to specific results, the next chapter will discuss the final conclusions of this study. It is in the next chapter that the research questions will, again, be directly answered. The theoretical contribution of this thesis and future benefit of this study will also be summarized. This study will conclude with the suggestions for future researchers of the subject, as discussed in detail throughout the previous chapters.

CHAPTER VII: CONCLUSIONS

Research Answers

In the case of shipping casualties in the Gulf of Mexico, the particular objectives of this thesis focused on two oil tankers sunk in 1942, *R. W. Gallagher* and *Cities Service Toledo.* Victims of a larger plan for cutting off Allied shipping across the Atlantic by the *Kriegsmarine*, these vessels mark an important part of United States' cultural history as targets of attacks by U-boats. These ships were armed with surplus weapons from World War I, and inadequately protected from these types of attacks. As discussed earlier, little could be done when these vessels traveled alone, and many ultimately shared a similar fate of sinking. By using the battlefield archaeological approach in creating a gross and dynamic picture from historical and archaeological records and observations, the intricacies of the sinking events reveal more about these sites than either record could determine alone. The necessity of creating this dialogue between fields is clearly documented by this study and supplemented with additional examples of the tools that can make these comparisons possible. World War II archaeology has expanded to include computer technology and the use of 3D modeling in this thesis. The ability to express the use of these tools shows that they are readily available for the purpose of the expansion of archaeological theory and practice. Though this thesis has introduced and expounded upon critical concepts in the realm of mathematical sinking principles, modeling, and battlefield theory, it also serves as an important reminder that future research is critical in developing a further understanding of battlefield environments.

Of each of the research questions addressed in this study, the dynamic relationships between each question has been answered several times, and discussed in detail. These ships have historically and archaeologically been identified as oil tankers that sustained impact damage that led to their sinking. This impact damage is contemporaneous with other tankers that were sunk by German U-boats, and are in the direct proximity of documented U-boat attack sites. The gross pattern of site distribution around the Mississippi River Basin helps to establish a base model for the relationship between U.S. shipping and German U-boats in 1942. Described through the mathematical processes of capsizing events, their current condition has been explained in detail to aid further research examining site formation processes of similar vessels. By documenting these vessels with other vessels of their type at this time, preservation of their history can aid in protecting them as cultural resources and understanding other battlefield sites of this era across the world.

This study has identified the power and broad scope that remote-sensing provides in the realm of archaeology, while expressing the importance of diver ground-truthing during site investigations for a level of detail that is yet unmatched. The history of these vessels' lives, used by a broad range of people, as oil tankers, transport vessels, war supply vessels, reefs, fishing sites, and war graves all strengthen an argument to assign cultural significance under Criterion A in the NRHP. In addition to the continued corroboration of identifiable features on these wrecks, the dynamic patterns on the sites help to establish further arguments for Criterion C in the nomination process as well. Also illustrated earlier, these vessels are protected through the Department of Defense in conjunction with the Department of State through the Sunken Military Craft Act, regardless of their age or condition. Within U.S. Title 32 CFR part 767.5 (f), the Sunken Military Craft Act protects the material within the archaeological site even further by explicitly indicating that vessels under contract to United States military service are not excluded from protection. These two conditions greatly benefit and invoke the protection and preservation of these archaeological sites as battlefields in the future.

As an extension of several studies produced from research in the Gulf of Mexico, this thesis has added to the wealth of knowledge growing on World War II wreck sites and aids future research and National Register evaluation projects by establishing the importance of these sites on United States' cultural history and the future value of the information they can reveal. The amount of available information on World War II sites offers a unique chance for archaeological projects like this to develop base models in maritime battlefield archaeology. This is due to the vast amount of diverse information from both sides of conflict that can lead to the dynamic component relationships used by battlefield theoreticians. It is through this, and similar, models that development of new methods may aid in battlefield sites in the future.

Theory

The utilization of battlefield archaeological theory in this study presents a unique way of expanding the radius of this theoretical perspective to a maritime venue. Conlin and Russell proved the utility of this theory in their study on the *Housatonic* in 2006, and clearly it has applications for World War II sites as well. In order to establish a large-scale battlefield to express gross transit and military/merchant movement patterns throughout the Gulf of Mexico, the same techniques in establishing battlefield logistic analysis can be used as in Scott et al.'s methods used with the battle of Little Big Horn in 1989. The established focus on isolating gross and dynamic patterns allows for researchers to pinpoint individual functions associated with derivations of agency theory. The establishment of dynamic patterns using analyses of battle damage associated with individual U-boat commander decisions, and 3D modeling based on individual construction decisions observed historically and archaeologically can be applied to any of these types of shipwrecks in the Gulf of Mexico, or, the gross pattern battlefield. As a larger illustration of this applicability, each theater of marine engagement during World War II, or any maritime conflict for that matter, will contain these aspects of gross patterning that could extend beyond a specific regional study area. These theaters contain aspects of dynamic patterns that give agency to the individual people associated with war and battlefield decisions that are not traditionally represented through documentation. The fact that these analyses can lend a voice to aspects of battlefield engagements regarding the Merchant Marine stresses that this model offers a beneficial option to future researchers in search of a theory to build upon.

In the case of this study in particular, further isolation of historical context with data collected in the field reveals dynamic patterning that help provide a more in-depth picture to what occurred on the wrecks: engine-room workers were essentially trapped within the holds, gun-emplacements failed to return fire, and equipment exploded on both vessels. These issues led to discrepancies in the historical documentation and explain why the final torpedo strikes were not recorded by survivors but witnessed archaeologically on the wreck sites themselves. Additionally, mathematical formulation supplements the data collected on both fronts of this discussion to provide a dialectic that corroborates with dynamic historical documentation. Isolating the specific areas where torpedoes struck is also a significant corollary in both accounts. The additional torpedo hole in the stern of the *R.W. Gallagher* shows that the historical documentation present in the German war diary is accurate and expresses the specific individual choice of Müller-Stöckheim to fire a *coup de grâs* shot. The missing rudder and propeller on the *Cities Service Toledo* exhibits a possible salvage operation that is not documented in known records. This activity was performed subsequent to the event and shows the representative work of a dynamic pattern used by people who knew about the site.

Applications

This research will allow several new directions to be taken on these wrecks as well as other similar sites. The future of the tools, methods, and theories in this study is substantial with the proper amount of ambition. The effect of the use of 3D modeling and remote sensing data could lead to groups of sport divers, war veterans, the general public, or academic researchers to take part in an augmented reality tour of the wreck site or experience a visual tour of the ships before they sank. The modeling allows for those ships lost in the Gulf of Mexico to be represented with a new level of detail after 70 years of degradation on the seafloor. The data available in this study can lead to an increased knowledge of how ships sink in battlefield environments and what happened to these two wrecks in particular. Archaeologists can add the *R.W. Gallagher* and the *Cities Service Toledo* to a database of vessels lost in the Gulf of Mexico to later be used in broader research projects. Most important, because the government has formed protection trusts to protect battlefield sites across the United States, these wreck sites and World War II sites across the Gulf of Mexico should be added to protection trusts for the benefit of preserving and conserving cultural heritage. The methods utilized in this study were unique in that they provided a large amount of data collected in the field that enabled high-quality post-processing. Using trained archaeological divers to investigate these sites is essential to compile such a complete interpretation of these important parts of history. While utilizing the abilities of trained archaeologists on these sites in conjunction with specialized technology, the understanding and knowledge of the past can be increased for future researchers and the general public. Using these methods together is more effective in achieving this goal than either of them used independently. These methods should continue to contribute to the field of marine archaeology through the training of its constituents at the university level. The new cross-disciplinary method of building 3D models in conjunction with remote-sensing, hand-drawn detailed maps, mathematical explanations of sinking event physics, and the logistical expressions of these two World War II battlefield wrecks can only grow with future research and future understanding of the human environment.

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APPENDIXES

APPENDIX A

SUPPLEMENTAL TABLES AND FIGURES

TABLE 6
FINAL CREW LIST FOR S.S. *CITIES SERVICE TOLEDO* (THOSE KILLED IN ACTION IN BOLD)

Name	*Birthplace*	*Nationality*	*Age*	*Position*
K. Teivola	Finland	U.S.A.	50	Master (Captain)
James H. Tally	Nebraska	U.S.A.	48	Chief Mate
Evert A. Alanno	Finland	U.S.A.	49	Second Mate
Early Rawls	**Georgia**	**U.S.A.**	**35**	**Third Mate**
George Fr. Sabek	New York	U.S.A.	21	Radio
Frank Warner	**Pennsylvania**	**U.S.A.**	**29**	**Carpenter**
Ludwig Stockl	**Germany**	**U.S.A.**	**50**	**Boatswain**
James Smith	Michigan	U.S.A.	40	Able Seaman
John Simons	Michigan	U.S.A.	32	Able Seaman
Albert Ogran	Minnesota	U.S.A.	40	Able Seaman
Burt Anderson	**Norway**	**U.S.A.**	**50**	**Able Seaman**
Joseph L. Gorman	**Pennsylvania**	**U.S.A.**	**50**	**Able Seaman**
Charles D. Carvar	Massachusetts	U.S.A.	19	Ordinary Seaman
Stephen Skwarko	Pennsylvania	U.S.A.	22	Ordinary Seaman
Charles Bobuk	Pennsylvania	U.S.A.	22	Ordinary Seaman
George E Rickards	Pennsylvania	U.S.A.	44	Chief Engineer
Albert Baron	England	U.S.A.	39	First Assistant Engineer
Harold Jensen	Pennsylvania	U.S.A.	23	Third Assistant Engineer
Frank Hoffman	Pennsylvania	U.S.A.	25	Third Assistant Engineer
Stanlau L. Grieo	Mississippi	U.S.A.	26	Oiler
Harv[e]y Jorgensen	**New York**	**U.S.A.**	**22**	**Oiler**
Leuey Santo	Columbia	U.S.A.	37	Oiler

Eugene Keresctuve	Iowa	U.S.A.	19	Fireman
Spencer Mix	New York	U.S.A.	35	Fireman
Edward Oppenheimer	**New York**	**U.S.A.**	**26**	**Fireman**
Joseph Lengasel	Pennsylvania	U.S.A.	21	Wiper
Robert DeWolfe	New Jersey	U.S.A.	22	Wiper
George Howard	Indiana	U.S.A.	60	Steward
Walton Rudolph	Canada	U.S.A.	49	Chief Cook
Arthur Moreau	**Massachusetts**	**U.S.A.**	**44**	**Second Cook**
Charles Bretney	Ohio	U.S.A.	55	Utility
John F. Meyer	Penn	U.S.A.	30	Machinist's Mate
Edward C. Dunne	**New York**	**U.S.A.**	**19**	**Motorboatman**
Vincenso Gallidrio	New York	U.S.A.	33	Motorboatman
Thurlow J. [Morkan]	**New York**	**U.S.A.**	**20**	**Motorboatman**
Everett Hatch	**Michigan**	**U.S.A.**	**35**	**Engine Maintenance**
Noke Franklin	Georgia	U.S.A.	33	Engine Maintenance
Lesse David Handy	N/A	U.S.A.	N/A	Navy Seaman, Second Class
Theodore R. J. Hall	N/A	U.S.A.	N/A	Navy Apprentice Seaman
Nathan Haddad Jr.	**N/A**	**U.S.A.**	**N/A**	**Navy Seaman, Second Class**
Charles A. Hardie	N/A	U.S.A.	N/A	Navy Apprentice Seaman
Minor N. Ha[rd]in Jr.	**N/A**	**U.S.A.**	**N/A**	**Navy Apprentice Seaman**
O.R. H[a]rper	N/A	U.S.A.	N/A	Navy Apprentice Seaman
Thomas C. Harris Jr.	**N/A**	**U.S.A.**	**N/A**	**Navy Apprentice Seaman**
John E. Harry Jr.	N/A	U.S.A.	N/A	Navy Apprentice Seaman
James Du Vault	**N/A**	**U.S.A.**	**N/A**	**Navy Seaman, First Class**

TABLE 7
FINAL CREW LIST FOR S.S. *R.W. GALLAGHER* (THOSE KILLED IN ACTION IN BOLD)

Name	*Birthplace*	*Nationality*	*Age*	*Position*
Aage Petersen	Denmark	U.S.A.	47	Master (Captain)
Alexander S. Krass	**Russia**	**U.S.A.**	**45**	**Chief Mate**
Frederick Austin	**U.S.A.**	**U.S.A.**	**31**	**Second Mate**
Roy V. Denton	U.S.A.	U.S.A.	23	Third Mate
Reginald S. Patten	U.S.A.	U.S.A.	41	Chief Engineer
John J. Smart	**U.S.A.**	**U.S.A.**	**46**	**First Assistant Engineer**
Tenant L. Fleming	U.S.A.	U.S.A.	33	Second Assistant Engineer
Louis A. Gardner	U.S.A.	U.S.A.	35	Third Assistant Engineer
Clayton Knight	U.S.A.	U.S.A.	33	Radio Operator
Edward T. Brereton	U.S.A.	U.S.A.	34	Electrician
August Camp	Chile	U.S.A.	43	Steward
Manuel L. Vincente	Cape Verde	Cape Verde	48	Chief Cook
Harry R. Paquette	U.S.A.	U.S.A.	37	Boatswain
Charles Peregrin	U.S.A.	U.S.A.	29	Pumpman
H. G. Pfeiffenberger	U.S.A.	U.S.A.	43	Able Seaman
Chester Zemeski	U.S.A.	U.S.A.	25	Able Seaman
Edward P. Edwards	U.S.A.	U.S.A.	43	Able Seaman
Daniel C. McPhee	**Canada**	**U.S.A.**	**38**	**Able Seaman**
Francis M. Heffernan	U.S.A.	U.S.A.	44	Able Seaman
Herman W. Reuss	**U.S.A.**	**U.S.A.**	**30**	**Able Seaman**
John Coumou	Holland	U.S.A.	27	Able Seaman
John W. Lamb	U.S.A.	U.S.A.	22	Ordinary Seaman
Angelo DeMiles	U.S.A.	U.S.A.	20	Ordinary Seaman
Richard Preimmer	U.S.A.	U.S.A.	18	Ordinary Seaman
James C. Kennedy	**U.S.A.**	**U.S.A.**	**45**	**Machinist**

John J. Willadsen	U.S.A.	U.S.A.	25	Oiler
James W. McGregor	U.S.A.	U.S.A.	33	Oiler
Leonard E. Mills	**U.S.A.**	**U.S.A.**	**57**	**Oiler**
Arthur P. Hubbard	U.S.A.	U.S.A.	51	Storekeeper
Lynn J. Wyant	U.S.A.	U.S.A.	21	Fireman
John T. McAvity	U.S.A.	U.S.A.	23	Fireman
Allen C. Hiott Jr.	U.S.A.	U.S.A.	25	Fireman
Robert E. Smith	U.S.A.	U.S.A.	18	Wiper
Henry P. Miller	**U.S.A.**	**U.S.A.**	**32**	**Wiper**
Peles Donyoso	**Philippines**	**Philippines**	**66**	**Second Cook**
John A. Soderatron	Finland	Finland	32	Messman
Glen K. Rolston	U.S.A.	U.S.A.	29	Messman
George MacDougall	U.S.A.	U.S.A.	22	Messman
Thomas Rickman	England	U.S.A.	20	Messman
Manuel L. Laudermilk	U.S.A.	U.S.A.	18	Utility Man
John Nibouar	U.S.A.	U.S.A.	40	Chief Gunner
Curtis W. Thomas	U.S.A.	U.S.A.	19	Gunner
Arthus C. Thomas	U.S.A.	U.S.A.	33	Gunner
Roy R. Thomas	U.S.A.	U.S.A.	27	Gunner
James C. Thomas	U.S.A.	U.S.A.	31	Gunner
Henry F. Taylor	U.S.A.	U.S.A.	33	Gunner
Bennie B. Taylor	U.S.A.	U.S.A.	18	Gunner
Vincent P. Timpino	U.S.A.	U.S.A.	22	Gunner
George V. Sutton	U.S.A.	U.S.A.	23	Gunner
John L. Fakas	U.S.A.	U.S.A.	24	Gunner
Albert D. Bowen Jr.	U.S.A.	U.S.A.	17	Gunner
William O. Orr	U.S.A.	U.S.A.	22	Gunner
David C. Morris	U.S.A.	U.S.A.	18	Gunner

Figure 83: Remote sensing equipment used by Tesla Offshore, LLC. during the 2010 field survey.

APPENDIX B

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FIGURES 2 and 54: Pages 5 and 124 (unsourced USCG 1942)

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FIGURES 3 and 53: Pages 6 and 124 (Standard Oil Company 1946:357)

This photograph of the S.S. *R.W. Gallagher* comes directly from the company that owned the vessel in 1942, Standard Oil Company. The Standard Oil Company published a book in 1946 titled *Ships of the Esso Fleet*, in which they describe the events that surrounded attacks on their fleet during World War II. This book is no longer in publication, the publishing company no longer exists, and no specific author was credited for the work concerning the S.S. *R.W. Gallagher*. This particular image use should be considered fair-use.

FIGURES 8-9: Page 25 (Williamson 2002:Plate D)

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FIGURE 10: Page 28 (Lettens 2009)

The photograph of *U-158* was acquired through an enthusiasts' website on U-boats (http://www.wrecksite.edu). Through email correspondence with the original poster of the image, they could not indicate the original source. This was the only available image of the outside of *U-158* that could be found during research. The original poster did not think any copyright is retained on the image. No other source could be located on the image, after contacting several sources on the subject.

FIGURE 11: Page 28 (Wiggins 1995:105)

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Salitros, Linda <linda.salitros@tamu.edu> Fri, Dec 21, 2012 at 2:58 PM
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>

Eric Swanson <eas23@students.uwf.edu> Sat, Dec 22, 2012 at 8:17 PM
To: Linda Salitros <linda.salitros@tamu.edu>

Hello Ms. Salitros,

I would like to take a moment to thank you for getting back to me on

1/2

FIGURES 12-13: Page 29-30 (Bredow 2012)

These images were provided by courtesy from the Horst Bredow-Deutsches U-Boot-Museum via email. The images originated from the museum's private collection.

6/4/2014 Students at UWF Mail - Fwd: Aw: U-Boot-Verweis

University of West Florida STUDENTS

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Fwd: Aw: U-Boot-Verweis

1 message

Eric <eas23@students.uwf.edu> Sat, Feb 22, 2014 at 4:27 PM
Reply-To: Eric <eas23@students.uwf.edu>
To: "e.swanson@silvettigroup.com" <e.swanson@silvettigroup.com>

-------- Original message --------
From: Horst Bredow-Deutsches U-Boot-Museum <uboot-archiv-altenbruch@web.de>
Date: 12/12/2012 09:28 (GMT-06:00)
To: Eric Swanson <eas23@students.uwf.edu>
Subject: Aw: U-Boot-Verweis

Dear Eric,

my name is Peter Monte and I am one of the many volunteers at the German U-Boat Museum and Archive, helping its founder and managing director, Mr. Horst Bredow (being 88 years of age), to tackle the daily work at the museum and archive, in particular dealing with international correspondence.

Horst Bredow has asked me to thank you very much for your email below.

The Commanding Officer of U-158 was Kapitänleutnant Erwin Rostin.

Find attached some pics of both C.O.s as requested and feel free to use them in your thesis paper, however, don´t forget to refer to the German U-Boat Museum as source.

May I wish you much success with your paper.

Have a very Merry Christmas and a most successful 2013.

Best regards

Peter Monte

> **Gesendet:** Samstag, 01. Dezember 2012 um 23:05 Uhr
> **Von:** "Eric Swanson" <eas23@students.uwf.edu>
> **An:** uboot-archiv-altenbruch@web.de
> **Betreff:** U-Boot-Verweis
>
> Hallo,
>
> Mein Name ist Eric Swanson von der University of West Florida, USA. Ich schreibe einen Master Thesis auf zwei Opfer des Zweiten Weltkriegs. Sie wurden von U-67 unter Korvettenkapitän Günther Müller-Stöckheim und U-158 unter Kapitänleutnant Erwin Rostin versenkt. Mehrere Quellen Ich benutze siehe Erwin Rostin als "Erich" Rostin. Was ist richtig? Auch brauchen Sie keine digitalen Kopien der Bilder von diesen beiden Männern, oder ihre U-Boote, die ich in meiner Diplomarbeit verwenden kann? Ich für die schlechte Übersetzung entschuldigen, ich bin mit Google Translate. Vielen Dank für Ihre Zeit. Ich freue mich auf das Lesen Ihrer Antwort.

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FIGURE 14: Page 31 (Harlan and Hollingsworth Corporation (HHC) 1916)

This image was provided as a courtesy from the Hagley Museum and Library in Wilmington, Delaware during initial research (found in Evans et al. 2013), where materials were granted for use in research context. These materials were added to this thesis as the author was also included in the Evans et al. 2013 authors list.

FIGURE 15: Page 37 (Bethlehem Shipbuilding 1938)

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FIGURE 16: Page 39 (Reuss 2007)

This image was provided as a courtesy from Captain Edward Reuss from his website: http://www.nycop.com/Summer2006/DowntotheSeaInShips/body_downtotheseainships.html

6/7/2014 Students at UWF Mail - Permission and information about the SS R.W. Gallagher

University of West Florida STUDENTS

Eric Swanson <eas23@students.uwf.edu>

Permission and information about the SS R.W. Gallagher

Edward D Reuss <captainreuss@verizon.net> Tue, Nov 1, 2011 at 10:13 AM
To: eas23@students.uwf.edu

Eric,

Thanks for your interest in the R.W. Gallagher. I think that you can get a lot of information about all Merchant ships that were sunk during World War II from a great book entitled: "A Careless Word, A Needless Sinking" by Author Captain Arthur R. Moore. The account of the sinking of the SS. R.W. Gallagher is documented as well as the U-Boat that sank her. The GPS coordinates are list I believe.
If I can be of any assistance, let me know.

Best regards,

Edward D. Reuss
Captain, NYPD (retired)
Publisher
NY Cop Online Magazine
www.nycop.com
CaptainReuss@Verizon.net
917-273-8651

On 10/31/11, Eric Swanson<eas23@students.uwf.edu> wrote:
Hello Captain Reuss,

My name is Eric Swanson, graduate student at the University of West Florida in Pensacola, Florida. I am currently in the process of writing my Master's thesis on two oil tankers that sank in 1942 in the Gulf of Mexico, the SS Cities Service Toledo, and the SS R.W. Gallagher. I've been utilizing your web site as a reference point in aiding my research efforts. A little over a year ago, I was a part of a field research project that set to identify, evaluate, and record several shipwrecks in the region with the Bureau of Ocean Energy Management and Tesla Offshore, LLC. The R.W. Gallagher was a part of our survey, and we dove on we believe to be her. I have been compiling information to aid in the archaeological identification of this vessel, as well as provide a history of her lifetime, and her importance to the people who served aboard her decks. She was modified several times, and had many crew members that served on board. I am impressed to see the very rich details you have incorporated in honor of your father, AB Herman Reuss. I would love to hear more information, and perhaps get into a formal interview process that could benefit some of the critical anthropological information that you can share. I am currently in the process of finding the Gallagher's blueprints, and am hoping to find as many leads as possible. I'm sure you may have questions and plenty of comments, so please, let me know what your thoughts on all of this is, I truly look forward to hearing back from you soon. Thank you very much!

Best regards,

https://mail.google.com/mail/u/0/?ui=2&ik=9b34ae6879&view=pt&q=Reuss&qs=true&search=query&msg=1335fe7f4d637782&dsqt=1&siml=1335fe7f4d637782 1/2

FIGURE 18: Page 52 (Floyd and Callahan 1989)

This image was provided with permission from Dr. Rob Floyd, author of the original report, for research purposes. Permission was discussed in person before receiving email permission.

Eric Swanson

From:	Rob Floyd
Sent:	Thursday, June 5, 2014 1:56 PM
To:	Eric Swanson
Subject:	Re: Request for Permissions by BOEM/BSEE

Yes sir Eric
you have my permission to use all materials associated with those survey data and notes.

Thanks-
Rob
337-371-5472

On Jun 5, 2014, at 11:58 AM, "Eric Swanson" <e.swanson@silvettigroup.com> wrote:

> All is well. Think I'm getting a cold. Thank you. Do I have your permissions as well?
>
> -Eric
>
> Sent from my iPhone

FIGURE 19: Page 53 (Saltus and El Darragi 1996)

This image was provided with permission from Allen Saltus, co-author of the original report, for research purposes. Permission was obtained through Dr. Rob Floyd.

Eric Swanson

From:	Rob Floyd
Sent:	Thursday, June 5, 2014 8:07 AM
To:	Eric Swanson
Subject:	Fwd: Request for Permissions by BOEM/BSEE
Attachments:	image001.png

Thanks-
Rob
337-371-5472

Begin forwarded message:

From: <saltusa@bellsouth.net>
Date: June 4, 2014 at 10:48:29 AM CDT
To: Rob Floyd <r.floyd@silvettigroup.com>
Subject: Re: Request for Permissions by BOEM/BSEE

Rob,
I have no problem with Eric using this data but I can not speak for Dean, Cochrane or their client who funded the geophysical survey. Glad that the information is getting out. Hope all is well.
Allen

Sent from Windows Mail

1

FIGURE 20: Page 54 (Landry and Thomas 1992)

This image was provided with permission from Laura Landry, co-author of the original report, for research purposes. Permission was obtained through Dr. Rob Floyd.

Eric Swanson

From:	Laura A Landry <laura@lalandry.com>
Sent:	Thursday, July 10, 2014 10:31 AM
To:	Rob Floyd
Cc:	Eric Swanson
Subject:	Re: Request for Permission

Hi, Rob and Eric,

I'm sorry I didn't know about this sooner. It's possible that you had an old email address no longer in use. This address, laura@lalandry.com, is the best, and probably will be for a long time.

I have no problem with Eric referencing my name, Jeff Thomas, who is now deceased, and the survey. I'm not sure if you need clearance from the operator/client for use, as the job was prepared for them. I can't see that it would be any problem there either, especially as the BOEM has previously referenced the imagery, and theoretically received permission from the client.

Let me know if I can help in any other way.

Laura

On Wed, July 9, 2014 3:44 pm, Rob Floyd wrote:
> Hi Laura -
> I wrote you awhile back but may have gotten wrong address. Hope
> everything is good in your life. Eric Swanson is finalizing his
> Master's thesis at UWF as per info below. He simply is requesting our
> specific consent that he mention your name and reference on the wreck/survey below.
> He was an author in the writing group for the BOEM study but Melanie
> asked (below) that he get the additional permission as a professional
> courtesy.
> Could you drop him a quick note on this topic?
> e.swanson@silvettigroup.com<mailto:e.swanson@silvettigroup.com>
> Thanks
> Rob
> 337-371-5472
>
>
> From: Eric Swanson
> Sent: Friday, May 23, 2014 10:13 AM
> To: Rob Floyd
> Cc: eas23@students.uwf.edu
> Subject: Image Use Permissions for my Thesis
>
>
> Hey Rob,
>
>
>
> I was hoping that you could help me with your great connections. I

1

FIGURE 21: Page 68 (Church et al. 2007a)

This image was provided with permission from Andy Hall, the original illustrator of the *Anona*.

Eric Swanson

From: tigone@wtez.net
Sent: Thursday, May 15, 2014 5:48 PM
To: Eric Swanson
Subject: Re: Image Use Permission

Eric:

You're certainly welcome to use it, but I never finished that model for them and it's not (in my view) a very good representation of either my work or how digital modeling can augment the interpretation or public education aspects of nautical archaeology. I've done lots of other stuff.

Best,

Andy Hall

--- e.swanson@silvettigroup.com wrote:

From: Eric Swanson <e.swanson@silvettigroup.com>
To: "tigone@wtez.net" <tigone@wtez.net>
CC: "'eas23@students.uwf.edu'" <eas23@students.uwf.edu>
Subject: Image Use Permission
Date: Thu, 15 May 2014 21:56:52 +0000

Hello Andy,

My name is Eric Swanson, graduate student at the University of West Florida. I'm currently in the final phase of writing my thesis on two World War II shipwrecks in the Gulf of Mexico and wanted to use an image of the *Anona* that you had used in a report with Rob Church in 2007 in Deep Gulf Shipwrecks.

I made some historically accurate 3D models myself, but wanted to use a single image of what you had done in the past as a background example.

Can I obtain permission directly from you? Thank you for your consideration.

-Eric Swanson

1

FIGURE 64: Page 142 (Flynn 2012:20; Henson 2007)

The first image in this figure is of the Coastguard Cutter *Boutwell*, as used in Flynn 2012:20. No copyright holder could be located, and the original author did not return any correspondence. Since this is a United States Coast Guard image, it should be within the public domain.

The second image in this figure is of PE-19, as used in Henson 2007. No copyright holder could be located and the original author did not return any correspondence. Since this is a United States Coast Guard image, it should be within the public domain.

FIGURE 69: Page 150 (Standard Oil Company 1946:328)

This photograph of the S.S. *Paul H. Harwood* comes directly from the company that owned the vessel in 1942, Standard Oil Company. The Standard Oil Company published a book in 1946 titled *Ships of the Esso Fleet*, in which they describe the events that surrounded attacks on their fleet during World War II. This book is no longer in publication, the publishing company no longer exists, and no specific author was credited for the work concerning the S.S. *R.W. Gallagher*. This particular image use should be considered fair-use.

FIGURE 70: Page 153 (Landgraff 1999)

The use of this image was granted through the author, Tony Digiulian, of a website dedicated to several sources of naval information, http://www.navweaps.com. The image originated from an article written by Richard A. Landgraff of Dreadnaught Consulting.

Eric Swanson

From:	Tony DiGiulian <tonyd@navweaps.com>
Sent:	Thursday, May 15, 2014 5:49 PM
To:	Eric Swanson
Subject:	RE: Image Use Permission

Hi,

No problem, please credit Richard A. Landgraff of DREADNAUGHT CONSULTING (who wrote the essay this picture is attached to) with the copyright ownership.

Sincerely yours,
Tony DiGiulian
NavWeaps at http://www.navweaps.com

From: Eric Swanson [mailto:e.swanson@silvettigroup.com]
Sent: Thursday, May 15, 2014 6:27 PM
To: tonyd@navweaps.com
Cc: 'eas23@students.uwf.edu'
Subject: Image Use Permission

Hello,

My name is Eric Swanson, graduate student at the University of West Florida.

I want to obtain your permission to use the image of the New Jersey's Bilge Keel from your website:
http://www.navweaps.com/index_tech/tech-037_NJ_Bilge_Keel_pic.jpg

This image will be used in my Master's thesis project, and your permission (or a lead to the copyright holder) would be greatly appreciated.

This is a non-profitable research paper.

Thank you,
Eric Swanson

1

FIGURE 73: Page 158 (Osbourne 1943:23-2)

This image was taken from a book published by Alan Osbourne through Cornell Maritime Press. Heavy research into finding the copyright holder of Cornell Maritime Press' works led to identifying Schiffer Publishing, Ltd. as the publisher that obtained the rights to works that were still being published at the time of acquisition. Alan Osbourne is no longer living, and later versions of his book published by Everett C. Hunt did not include this image. No living family members of Alan Osbourne could be located to ask for image use permissions.

Eric Swanson

From:	Karen Choppa <karenc@schifferbooks.com>
Sent:	Monday, May 19, 2014 10:50 AM
To:	Eric Swanson
Subject:	Re: Image Use Permission

Dear Mr. Swanson,

Thank you for writing. When we purchased Cornell Maritime Press, we obtained the rights to only those books that were still in publication. Unfortunately, "Modern Marine Engineer's Manual" by Alan Osbourne was not one of them. Neither do we have any contact information for Mr. Osbourne, if he is still alive.

Sincerely,
Karen Choppa
Schiffer Publishing Ltd.

On 5/19/2014 11:00 AM, Eric Swanson wrote:

> Hello,
>
> My name is Eric Swanson from the University of West Florida. I am currently finishing my Master's Thesis on World War II archaeological sites. I am not receiving any payment, and the thesis is written in a non-profiting way.
>
> I would like to have your permission (whomever holds the appropriate copyrights), for one image I would like to use within my thesis.
>
> The image is Figure 1 on Page 23-2 (picture of a contra-guide rudder). The original work was *Modern Marine Engineer's Manual* by Alan Osbourne. The book was published by Cornell Maritime Press in 1943, which I believe was bought by your company.
>
> I will attach a copy of the image I would like to use. As I've said, I will not be receiving any payment, and the thesis is a non-profiting research paper.
>
> Thank you,
> Eric Swanson

FIGURE 82: Page 185 (Fraga 2009)

The permission to use this image was granted by the original author.

University of West Florida STUDENTS

Eric Swanson <eas23@students.uwf.edu>

Permission to use a screen-capture of your thesis' 3D model

fraga.tiago@gmail.com <fraga.tiago@gmail.com> Wed, Mar 5, 2014 at 1:13 AM
To: Eric Swanson <eas23@students.uwf.edu>

Hello Mr. Swanson
From a fellow graduate student, feel free to use what you need, and if you require any high resolution images, also feel free to request them.
So, for you paperwork requirements, this should be enough:

I, Tiago Miguel Fraga, give permission to Eric Swanson to utilize imagery from the Santo António de Tanná, for inclusion on his thesis and associated powerpoints and articles, with the requirement of inclusion of the following citation information "Fraga, 2012, work sponsored by Calouste Gulbenkian Foundation".
Best regards
Tiago Miguel Fraga
Ph.D Candidate with FCT scholarship
http://unl-pt.academia.edu/TiagoFraga
http://www.linkedin.com/pub/tiago-miguel-fraga/1b/59a/23b
Universidade Nova de Lisboa
Centro de História Além-Mar (UNL/UAç)
http://cham.fcsh.unl.pt/pages/eng/home.htm
+351 961 704 143
-------*Mensagem original*-------

De: Eric Swanson
Data: 03/05/14 06:57:32
Para: fraga.tiago@gmail.com
Assunto: Permission to use a screen-capture of your thesis' 3D model

Hello Mr. Fraga,

My name is Eric Swanson, graduate student at the University of West Florida. I am writing to request permission to use a screenshot of the 3D model you made of the *Santo Antonio da Tannå* for your Master's Thesis. I would like to use this image in my own thesis to demonstrate the use of 3D technology and modeling in archaeology (you would be cited of course!). This is a non-profit purpose. Thank you.

-Eric

FIGURE 83: Page 209

These images were all taken from public websites provided by survey equipment companies as advertising. Below are the source permissions for each image.

R2 Sonic 2024:

Eric Swanson

From:	Cris Sabo <csabo@r2sonic.com>
Sent:	Friday, May 16, 2014 1:29 PM
To:	Eric Swanson
Cc:	eas23@students.uwf.edu
Subject:	RE: Image Use Permission
Attachments:	2024mount-800.JPG; 2024mount_flange-800.JPG

Hi Eric,

Ok, no problem. Attached is jpeg of our Sonic 2024 receiver/projector in mount bracket as requested.

Cris

Mesotech MS1000:

Eric Swanson

From:	.Kjell .DEV Grøntoft <Kjell.DEVGrontoft@km.kongsberg.com> on behalf of Kjell Grøntoft <kjell.grontoft@km.kongsberg.com>
Sent:	Friday, May 16, 2014 2:54 AM
To:	Eric Swanson
Subject:	Re: Image Use Permission

Hello Eric,

Yes, this is no problem. Please use the image for your thesis. Good luck with it!!!!

Best regards
Kjell

KJELL GRØNTOFT
Web editor
Kongsberg Maritime

Phone +47 33 03 23 93
Mobile +47 99 20 38 11
kjell.grontoft@kongsberg.com
www.km.kongsberg.com

Eric Swanson ---16.05.2014 00:07:41---Hello, My name is Eric Swanson, graduate student at the University of West Florida.

From: Eric Swanson <e.swanson@silvettigroup.com>
To: "kjell.grontoft@kongsberg.com" <kjell.grontoft@kongsberg.com>
Cc: "'eas23@students.uwf.edu'" <eas23@students.uwf.edu>
Date: 16.05.2014 00:07
Subject: Image Use Permission

CODA 3-D Echoscope and Edgetech 2400-FS:

Eric Swanson

From: Mark Teles <Mark.Teles@seatronics-group.com>
Sent: Friday, May 16, 2014 9:46 AM
To: Eric Swanson
Cc: James Loftin; 'eas23@students.uwf.edu'
Subject: RE: Another Image Use Request
Attachments: email footer.png

Hi Eric,

You are more than welcome to use these images; unfortunately we do not allow operational pictures (as this goes against our clients NDAs).
Good luck with the thesis.

Regards,

Mark Teles
Vice President - USA Region
Seatronics Inc.
1319 West Sam Houston Pkwy N
Suite 150
Houston, Texas 77043
USA
T: +1 713 464 3311
F: +1 713 464 6111
M: +1 832 474 3494
W: www.seatronics-group.com

seatronics
The Marine Technology Specialists *an ACTEON company*

SUBSEA ASIA 2014

Marine Magnetics SeaSpy:

Eric Swanson

From: Tina Summers <tina@marinemagnetics.com>
Sent: Tuesday, May 20, 2014 4:17 PM
To: Eric Swanson
Cc: eas23@students.uwf.edu
Subject: RE: Image Use Permission

Hi Eric,

Thank-you for your email. I spoke to our president, Doug Hrvoic, who mentioned you know each other. Please feel free to use any of our SeaSPY images necessary for your thesis paper.

Should you have any questions, please do not hesitate to contact me.

Best of luck!

Kind regards,

Tina Summers

Marine Magnetics Corp
135 SPY Court, Markham, ON L3R 5H6 Canada
Tel: 905 479-9727 ext 232 Fax: 905 479-9484
www.marinemagnetics.com

Edgetech SB-216:

Eric Swanson

From: fhorgan@aol.com
Sent: Sunday, May 18, 2014 3:54 PM
To: Eric Swanson
Cc: eas23@students.uwf.edu; info@sonographics.com
Subject: Re: Image Use Permission

Eric,

You are authorized to use our image of the EdgeTech SB-216S.

Best Regards,

Rick Horgan
SONOGRAPHICS, INC.

Odom EchoTrac Mk III

Eric Swanson

From: info <info@geotechmabna.com>
Sent: Saturday, May 31, 2014 7:53 AM
To: Eric Swanson
Subject: RE: Image Use Permission

Hi
No problem
Please use it
Best regards

From: Eric Swanson [mailto:e.swanson@silvettigroup.com]
Sent: Friday, May 16, 2014 2:41 AM
To: info@geotechmabna.com
Cc: 'eas23@students.uwf.edu'
Subject: Image Use Permission

Hello,

My name is Eric Swanson, graduate student at the University of West Florida.

I want to obtain your permission to use the cover image of your Odom Echotrac MKIII in my thesis paper to illustrate equipment used during my thesis project.

This is a non-profitable research paper.

Thank you,
Eric Swanson