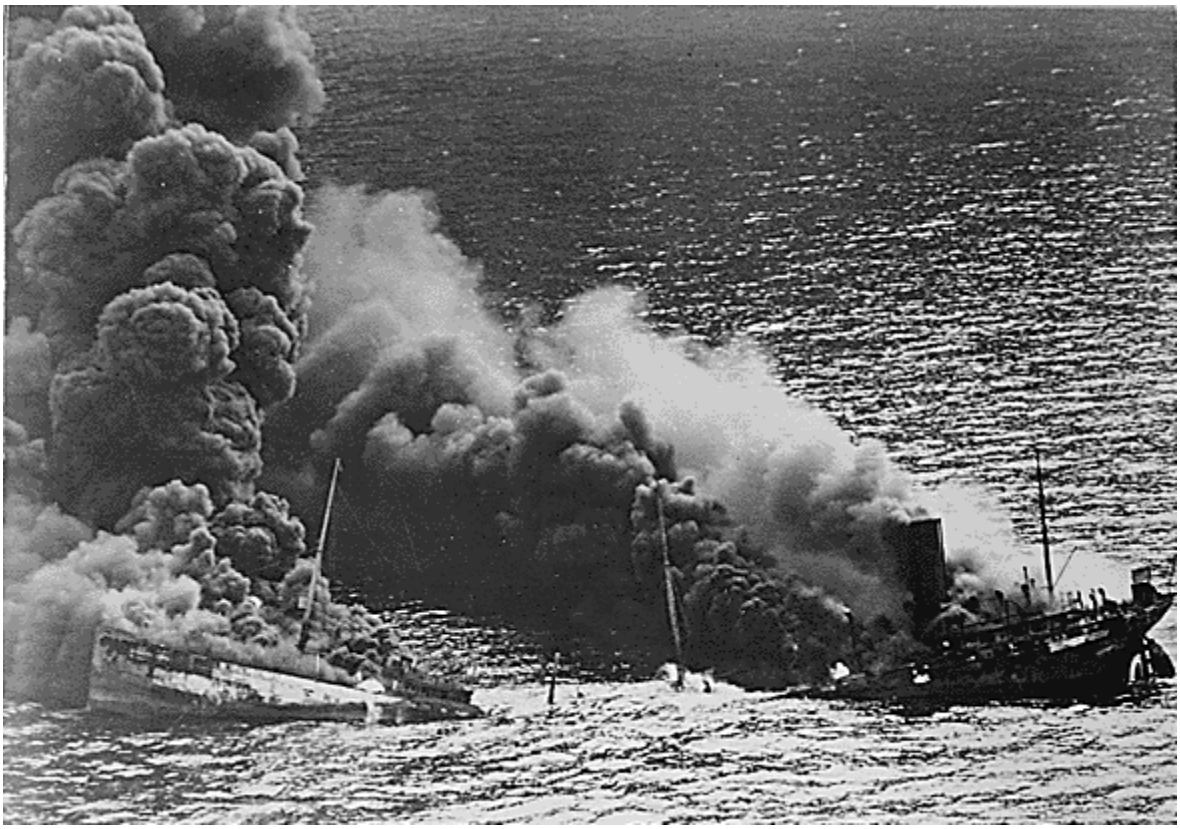
RESEARCH DESIGN:

BATTLE OF THE ATLANTIC EXPEDITION 2011

THE BATTLE OF CONVOY KS-520

[ABPP Grant# GA 2255-10-006]



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Cover Image: Allied tanker *Dixie Arrow* sinks after being torpedoed by *U-71*, 26 March 1942 (Source: U.S. National Archives and Record Administration)

ABBREVIATIONS

ABPP	American Battlefield Protection Program (NPS)
ADUS	Advanced Underwater Surveys, Limited
ALS	Ahead-Looking Sonar (ALS)
AIVL	Advanced Imaging and Visualization Laboratory (WHOI)
ARL-UT	Advanced Research Lab, University of Texas
ATLAS	Autonomous Topographic Littoral Area Survey
AUV	Autonomous Underwater Vehicle
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BOTA	Battle of the Atlantic
CAD	Computer-Aided Design
CESF	Commander Eastern Sea Frontier
CIOERT	Cooperative Institute for Ocean Exploration Research and Technology
ComFive	Commandant Fifth Naval District
COMINCH	Commander in Chief, United States Fleet
ECU	East Carolina University
ESF	Eastern Sea Frontier
EWT	Eastern War Time
GIS	Geographical Information System
KOCOA	Key Terrain, Observation and Fields of Fire, Cover and Concealment, Obstacles, Avenues of Approach
KS-520	Key West, South Convoy Number 520
METT-T	Mission, Enemy, Terrain, Troops and Time available
MHP	Maritime Heritage Program (NOAA)
MMS	Minerals Management Service
MNMS	*Monitor* National Marine Sanctuary (NOAA)

NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OER	Office of Ocean Exploration and Research (NOAA)
ONR	Office of Naval Research
ONMS	Office of National Marine Sanctuaries (NOAA)
PMS	Program in Maritime Studies (ECU)
PPW	Potentially Polluting Wreck
REMUS	Remote Environmental Monitoring Units
RENCI	Renaissance Computing Institute (UNC)
ROV	Remotely Operated Vehicle
RUST	Resources and UnderSea Threats (NOAA)
SAS	Synthetic Aperture Sonar
SLS	Side Looking Sonar
SRI	SRI, International
UNC-CSI	University of North Carolina-Coastal Studies Institute
USBL	Ultra Short Baseline
WHOI	Woods Hole Oceanographic Institution

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INTRODUCTION

Since 2008 NOAA's *Monitor* National Marine Sanctuary (MNMS), in conjunction with East Carolina University (ECU), has lead archeological, biological, and historical surveys of World War Two heritage resources off the North Carolina coast. This effort was undertaken to determine baseline preservation values, initiate and support ongoing historical and archeological research in North Carolina, and to evaluate the significance of this collection in consideration of expansion in the Marine Sanctuary off North Carolina. Previous work included diver surveys and mapping to generate site-plans and photomosaics, as well as remote sensing surveys using multibeam and Remotely Operated Vehicle (ROV) technology.

The genesis for the project came after any outcry from the local diving community regarding looting on German World War Two U-boat, *U-701*. For nearly fifteen years the site was known to only a small group of divers who purposefully left the wreck undisturbed. In 2004, however, the site became known to the broader diving community and was privileged with the respect of the local diving community, recognizing the resource significant *vis-a-vis* the lack of disturbance upon the site, especially in relation to the two other frequented U-boat sites in North Carolina: *U-85* and *U-352*. Unfortunately, an unknown group of individuals began illegally recovering artifacts from the site. This outraged the diving community, which had hoped to establish a preserve around the site (Allegood 2004; Kozak 2004).

In early 2008, MNMS Superintendent David Alberg received reports of another group planning to illegally recover more material from the site. This information demonstrated the need for a systematic approach to collect baseline data on the site. Subsequent requests for action from Thomas Prőpstl, Consul General at the German Embassy in Washington, D.C., further increased the necessity of carrying out an investigation to proper archeological standards.

In addition to these critical cultural and political factors, natural forces also justified this project. The site of *U-701*, located in Diamond Shoals off Cape Hatteras, is in an extremely dynamic environment. It is believed, prior to Hurricane Isabel in 2003, the majority of the site

was buried under sand. In 2008, however, the site was reported as uncovered to an extent rarely seen, thus offering a exceptional opportunity for this type of investigation.

Therefore during the summer of 2008, NOAA's Office of National Marine Sanctuaries (ONMS) in collaboration with East Carolina University, the National Park Service (NPS), Minerals Management Service (MMS), UNC's Coastal Studies Institute (CSI), and the State of North Carolina initiated a series of underwater archeological field expeditions to examine the remains of vessels lost during the Battle of the Atlantic (BOTA) in the Second World War. The first of these expeditions was aimed at concerns surrounding the site formation of German U-boats off North Carolina. In particular, the sites investigated were *U-85*, *U-352*, and *U-701*, sunk by US forces in engagements that proved to be very important, but largely forgotten parts of American history. This was the closest European theatre of war to the continental United States and one of the only places in the world where one can visit remains of both Axis and Allied vessels within recreational diving limits. These sites are recognized as valuable cultural, historical, and economic resources for the United States and the state of North Carolina (Farb 1992; Casserley et al. 2008).

In 2009, NOAA ONMS and its partners returned to North Carolina to continue research on World War Two casualties. The focus of the 2009 expedition was on allied military losses. A remote sensing survey aboard NOAA ship *Nancy Foster* re-located and positively identified the remains of USS *YP-389*, a US Navy patrol craft sunk by *U-701*. The site rested in deep water and survey utilized a ROV (Hoyt 2009). Additionally, 2009 fieldwork archeologically documented the site of HMT *Bedfordshire*, a British anti-submarine trawler, sunk by *U-558* off Cape Lookout, North Carolina. Also during the 2009 field season, with the support of NOAA, researchers at ECU were awarded seed funding by ECU's Coastal Maritime Council for the proposal *The Battle of the Atlantic: an Archeological Site Management and Environmental Risk Assessment Proposal* (Richards and Allen 2009). This award supported the research of John Wagner, and culminated in an MA thesis entitled *Waves of Carnage: A Historical, Archeological, and Geographical Study of the Battle of the Atlantic in North Carolina Waters*

(Wagner 2010). Wagner input archeological and historical data into a Geographic Information System (GIS) and performed spatial analyses to delineate the battlefield area and centers of activity therein. The dataset collected by Wagner serves as the foundation upon which this present study builds.

A third year of survey in 2010 was aimed at cataloging site significance and identifying degrading impacts from both environmental and cultural factors upon a collection of World War Two merchant vessels: *Empire Gem, E.M. Clark, Manuela, Malchace, Dixie Arrow, City of Atlanta* and *British Splendour,* as well as the US Navy Tug *Keshena* lost off North Carolina (Hoyt 2010). From this project it was hoped to obtain combined historical and archeological assessments of the resources observed. This preliminary investigation established a baseline for future monitoring of the sites as cultural and economic resources and as a foundation for future research. Also during 2010, the research undertaken by Richards, Allen, and Wagner led to the preparation of a proposal to the American Battlefield Protection Program (ABPP-National Park Service) which proposed to extend Wagner's historical research to greater archeological scrutiny via a theoretically explicit battlefield analysis of the North Carolina segment of the Battle of the Atlantic. This funding, awarded in fall 2010, will also be used to support two MA thesis projects within ECU, John Bright's *Stalking the Gray Wolf: A KOCOA Terrain Analysis of the Battle of the Atlantic off the North Carolina Coast* (Bright 2011) and an as yet unnamed project focusing upon visualization of naval battlefields by Stephen Sanchagrin (ECU and RENCI). Combined with funding sources oriented towards management goals corresponding to the 2008-2010 expeditions, a fourth expedition is now planned for 2011.

This document is a research design for the 2011 Battle of the Atlantic Expedition. Over the course of 2010-2011, various partners have successfully received financial and in-kind support to further resource management and research goals already stipulated. In 2011, the expedition is composed of four separate stages focused on the discovery, characterization, and documentation of submerged cultural resources from World War Two, in particular the years 1942-1944. Funding sources for this research have come from:

- *Phase 1:* ABPP (NPS); the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE); and the Office of National Marine Sanctuaries(ONMS).
- *Phase 2*: CIOERT, NOAA OER; a grant from the Local Programming Development Initiative (GovEd TV, Dare County, NC); and ONMS.
- *Phase 3:* NOAA ONMS; ONMS Maritime Heritage Program (MHP).
- *Phase 4:* NOAA OER; NOAA ONMS; and CIOERT.

These funds were awarded to East Carolina University, the UNC-Coastal Studies Institute, and the *Monitor* National Marine Sanctuary. Additional significant in-kind support has come from:

- Program in Maritime Studies, East Carolina University
- The University of North Carolina-Coastal Studies Institute
- The Renaissance Computing Institute

The importance of the Battle of the Atlantic, though not well known to the public, has been extensively studied by historians, and is generally viewed as a keystone to allied victory in Europe. For example, naval historian Michael A. Palmer (2007:259) has noted, "without victory in the battle of the Atlantic, there never would have been a second front in Europe," and "had the Allies failed at sea, the impact along the Russian front would have been enormous." In other words, the conflict precipitated by U-boat predations on Atlantic commerce had massive potential global implications for eventual Allied victory. Furthermore, this extensive naval engagement between Allied, Axis, and neutral forces constituted the longest single operation of the Second World War, and was "the longest, largest, and most complex naval battle in history" (Syrett 1994:ix).

On 15 July 1942, a merchant convoy consisting of 19 merchantmen and 5 military escorts was attacked south of Cape Hatteras. Three merchant ships, *Bluefields*, *Chilore*, and *J.A. Mowinkel*, were torpedoed by *U-576*. Two escaped with severe damage, while the third sank in a matter of minutes. Nearly thirty men were injured during the attacks, one of which would later

die from his wounds. In the ensuing pursuit, a coordinated attack between aircraft and armed escort and merchant vessels resulted in the sinking of the offending U-boat, with all hands lost. In the hours that followed, a series of miscommunications resulted in the damaged merchant ships erroneously navigating into the Hatteras minefield. They were severely damaged yet again. After clearing a path to the stricken vessels, three tugs, *Keshena*, *Relief*, and *J.P. Martin* were dispatched to tow their hulks from the minefield. While participating in salvage operations, *Keshena* also struck a mine and sank, with the loss of two lives (Standard Oil Company 1946: 363-372; Hoyt 1978:168-172; Freeman 1987:411-421; Hickam 1989:285-287; Blair 1996:626-627).

Constituting a single naval action of seemingly little consequence, especially considering the months preceding mid-July 1942, KS-520 represents more than the fruits of dedicated service and courage on behalf of the merchants, sailors, coastguardsmen, and pilots involved. KS-520, in fact, marks a shift in strategic initiative off America's eastern seaboard. In the seven months prior, U-boat operations had gone virtually uncontested in American waters, especially in the fertile hunting grounds off Cape Hatteras. With the passing of KS-520, however, allied institution of a strict and aggressive convoy system, accompanied by air escort, proved too daunting for German raiders. The significance of this shift would reverberate throughout the entire Atlantic. Once the Allies gained the advantage in American waters, never again would German U-boats assail the Allies with such gruesome efficiency.

The primary focus of this expedition is the KS-520 convoy attack off North Carolina. Historical and archeological research on the events that unfolded around this convoy (Figure 1) offer the potential to study adaptation and tactical behavior displayed by the American Navy in response to the German U-boat threat, a shoehorn to begin defining the Battle of the Atlantic from a behavioral perspective. Additionally, this convoy may be considered the iconic interaction of combatants off the North Carolina coast with structures and debris from both sides believed to still lie on the seabed in immediate geospatial and temporal association. This expedition offers the opportunity to reassess its history, as well as analyze the archeological

record regarding the progression of events during the conflict, and the relationship of human interactions (tactics and responses) with natural parameters within the landscape (currents, water temperature, bottom topography, and water depth).

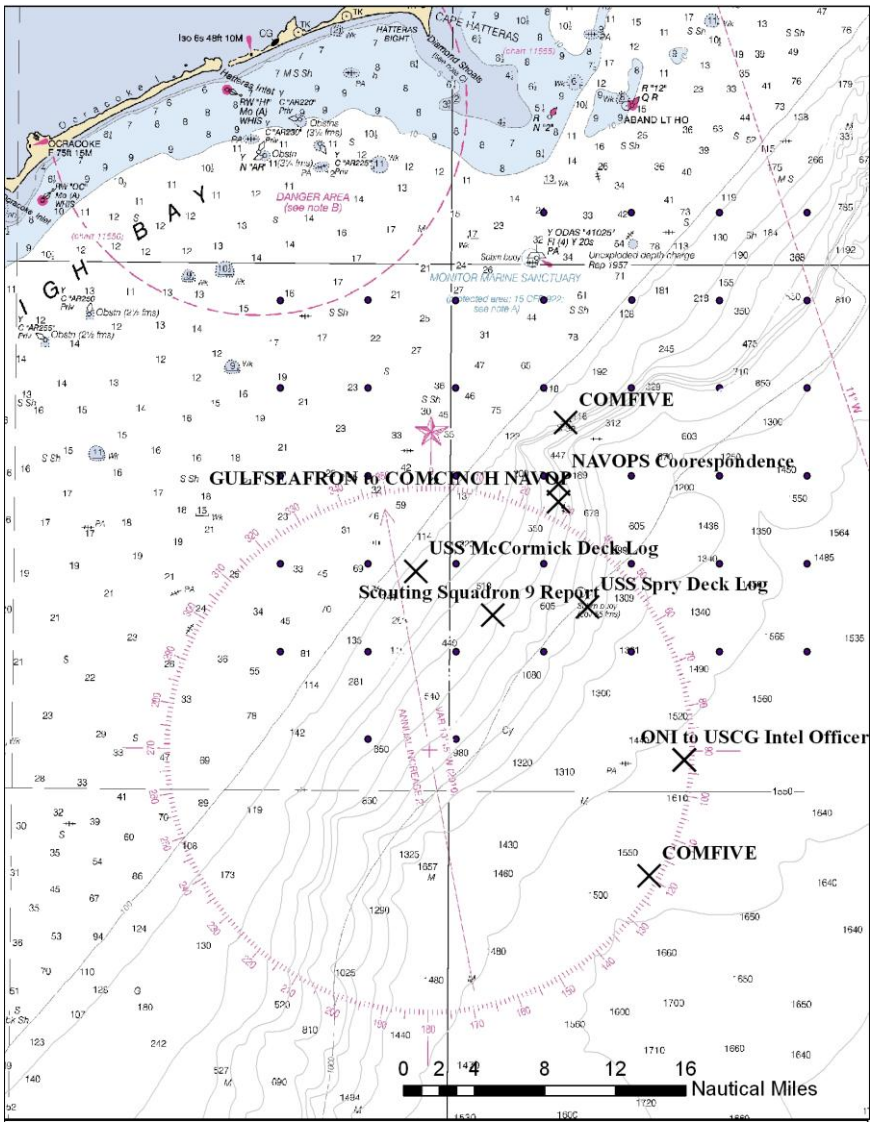

FIGURE 1. Historical positions for activity during the KS-520 engagement. Label translation: COMFIVE: Correspondence of the Commander, Fifth Naval District; NAVOPS: Naval Operations; GULFSEAFRON to COMINCH NAVOPS: Commander of Gulf Sea Frontier to Commander in Chief of Naval Operations; ONI to USCG Intel Officer: Office of Naval Intelligence to US Coast Guard Intelligence Officer (Image: John Bright).

The historic positions of several participants in this engagement are well known; however, none of these vessels have been located or positively identified. It is the intent of the 2011 expedition to employ a wide area survey to search for these vessels. The discovery of remains of Nicaraguan Tanker *Bluefields* and the German *U-576* would add a great deal to the cultural landscape of North Carolina and lend a better understanding of the Battle of the Atlantic through the adaptation and application of battlefield analysis techniques (to be discussed).

This project intends to follow the "multi scalar explanatory approach" endorsed by Conlin and Russell (2011:41-42) as well as the procedures outlined by Lowe (2000) and Babits et al. (2010:5) by utilizing the survey methods pioneered for analysis of terrestrial battlefield sites concerned with understanding the relationship of military theory and landscape features to the actions of opposing forces. This includes the KOCOA analysis (an abbreviation of Key terrain, Observation and fields of fire, Cover and concealment, Obstacles, and Avenues of approach/retreat) (Lawhon 2002:36) that has become the preferred analytical technique of the American Battlefield Protection Program (ABPP).

Several battlefield studies have been published under the auspices of the ABPP. Many of these studies utilize a KOCOA approach on either 18th or 19th century conflicts: the Revolutionary War, War of 1812, the American Civil War, or conflicts involving Native American groups (Fryman 1995; Miller and Walsh 1995; Brent and McBride 1996; Cubbison et al. 1998; Greene 1998; Adams et al. 1999a and 1999b; Bevan 1999; Abbass 2000; Cruse 2000a, 2000b; Reuwer 2000; DeRenaucourt and Meiring 2001; Alexander and Heckman 2002; Carr et al. 2002; Dixon et al. 2003; Haecker 2003; Watts and Lawrence 2003; Eckroth and Hagen 2004; Elliot 2004, 2005a, 2005b; Jaeger Company 2004; Johnson and Adams 2004 ; Bedell 2005 Cannell 2005; Legg et al. 2005; Emerson 2006; Strezewski et al. 2006; GAI Consultants and Hardlines Design Company 2007; Pratt and Rutter 2007; Tankersley and Espenshade 2007; Whisonant et al. 2007; Butler 2008; Emerson 2008; O'Dell and Powers 2008; McBride and Naumee 2009a, 2009b, 2009c; Smith et al. 2009). One study deals with a 16th century battlefield (Damp 2005), and one from the 20th century (LaLande 2004). Several studies document naval

sites, though a maritime terrain analysis is not conducted (Watts 1998; Graves et al. 1999; Green 2002; University of Hawaii at Manoa 2002; Conlin and Russell 2006; Panamerican Consultants, Inc. 2005; Cohn et al. 2007). These sources, in conjunction with other published battlefield archeology work (Scott et al. 2009a, 2009b; Babits et al. 2010), will greatly aid in understanding how military theory and KOCOA principles are applied to terrestrial and maritime sites, and thus ways in which these terms may be translated into a marine environment.

KOCOA itself, however, is nested within broader military theory, incorporating strategy, tactics, operation, logistics, METT-T (Mission, Enemy, Terrain, Troops and Time available), and the principles of war (Babits et al. 2010:5) and borrows from traditional military terrain assessment techniques (known presently as OCOKA in the military). To date, only a single study has attempted to translate these terms into a naval framework (Babits et al. 2010). Thus, one of the main goals of the 2011 Expedition is to integrate site discovery and interpretation data pertaining to the KS-520 convoy action as a case study in adapting KOCOA terrain analysis techniques for the analysis of a 20th century naval engagement, with consideration of the broader application of principles of war, strategy, tactics, operations, logistics, and METT-T in this context. The benefit of a theoretically-inclined archeological investigation of the battlefield relates to Scott et al.'s (2009b: 434) explanation regarding what battlefield archeology has to offer to our understanding of the past:

> The value of archeological research and the recovery and documentation of physical evidence of past conflict lies not in the artifacts alone, but in the context in which they are found. Archeology can enhance the oral testimonial and documentary record, but that is not its real power. That power lies in the pure fact that archeological evidence, properly recorded and documented, is a truly independent data source.

The following section outlines the historical background to the Battle of the Atlantic off the North Carolina coast with specific attention paid to the KS-520 convoy that is the focus of the 2011 fieldwork. Following this, discussions of theoretical concepts at the core of the project are

outlined. Finally, the methodology discusses the approach to historical research (sources and repositories of research), and archeological activities (survey area site selection, equipment, and operation), as well as analysis.

HISTORICAL BACKGROUND

The Battle of the Atlantic began mere hours after Britain declared war on Germany in September 1939, and would last until Germany's surrender in May 1945. This extensive naval engagement between Allied, Axis, and neutral forces constituted the longest single operation of the Second World War, and was "the longest, largest, and most complex naval battle in history" (Syrett 1994:ix). Civilians, sailors, soldiers, marines, and coastguardsmen engaged in combat, and in turn gave their lives, in a dire struggle for seapower in the Atlantic. Retired Royal Navy escort group commander, Donald MacIntyre (1961:11), wrote of the battle's importance to the entire Allied war effort

> [as] an aspect of naval warfare, which on account if its often hum-drum nature is apt to be looked upon as a side-show, a back-water of the main stream of naval operations, yet which is in fact the whole purpose of seapower and in which an island power must either decisively win or be driven to abject surrender.

He could not have been more correct. The flow of war materiel into Great Britain via the Atlantic was the lifeline of the Allied war effort against Germany, and Germany nearly severed it. Though the Battle of the Atlantic was not witness to spectacular fleet engagements like those fought in the Pacific, it was nonetheless of supreme strategic importance. At stake was the last bastion of resistance in Europe to Hitler's dreadful war machine.

Following America's entry into the Second World War, German U-boat raiders attacked merchant shipping off the United States' east coast with astonishing success. What ensued came to be known as the "American turkey shoot," with nearly 200 merchant vessels sunk between January and April of 1942 (Cheatham 1990:11). Inaugurated by Germany's initial offensive, code named "Operation Paukenschlag," this "Atlantic Pearl Harbor" was the prelude to nearly five months of unchecked German commerce raiding (Gannon 1990:xvii-xviii) on the east coast. Slowly, though, combined Allied naval forces resisted, and ultimately forced withdrawal of

German forces haunting American waters. Hard fought, yet far from over by the end of 1942, the Battle of the Atlantic all but left the eastern shores of the United States.

What follows is a historical account of one engagement during the Battle of the Atlantic: the KS-520 convoy battle off the North Carolina coast. A great deal of writing has already dealt with many aspects of the battle (Morison 1947; MacIntyre 1961, 1971; Hughes and Costello 1977; Hoyt 1978, 1984; Gibson 1986; Hoyt 1987; Gannon 1990; Syrett 1994; Blair 1996; Kaplan and Curry 1997; Kemp 1997; Gannon 1998; Kaplan and Curry 1998; Wiggins 1999; Blair 2000; Hague 2000; Miller 2000; Showell 2002; Brennecke 2003; Ireland 2003; Westwood 2003; Blake 2006; Showell 2006; White 2006; Brown 2007; Williamson 2010); these sources discuss the battle in its totality, its tactics and technology, regional histories, or personal accounts. Unlike previous studies, however, the present narrative seeks to connect the larger strategic objectives and operations of the Battle of the Atlantic to the battlefield area off the North Carolina coast. In particular, in so much as these provide the context to understand the often skimmed over KS-520 convoy battle. Though only a single naval action, KS-520, in fact, marks a shift in strategic initiative off America's eastern seaboard. The significance of this shift would reverberate throughout the entire Atlantic. Once the Allies drove German U-boats from American waters, German hopes of dominating Atlantic seapower were lost.

Convoy KS-520

At 0430 Eastern War Time (EWT) the morning of July 14, 1942, 19 ships in convoy KS-520 left port near Hampton Roads, Virginia, for a voyage south through the waters of the Eastern Sea Frontier (ESF). By 0700 EWT the next morning, the ships had rounded Cape Hatteras and continued south. Maintaining a course just inside the 100-fathom curve, the convoy passed 20 miles outside Ocracoke inlet at 1600 EWT without any problems. Five minutes later, a contact was picked up and bombed by the convoy escort USCG *Triton* without result (United States Coast Guard [USCG] 1942). This contact aroused the suspicion of the other four escorts and extra vigilance was put into scanning the horizon for submarines. Despite this extra vigilance, a

torpedo struck *Chilore,* lead vessel in the second column of ships at 1620 EWT, sending a geyser of water over the vessel, which momentarily obscured it from the air escorts. Unable to react quickly enough and alter course, *Chilore* was struck by a second torpedo one minute later. Moments after the second torpedo rocked *Chilore*, *J.A. Mowinckel,* lead vessel of the convoy, was shaken by a violent explosion (Freeman 1987:411-412). The blast of the torpedo was devastating:

> The shock of the blow ran down through the entire ship, breaking china in the galley, overturning chairs and tables, knocking men off their feet. Black water shot in a great plume over the poop deck. Dense, pungent smoke poured into the after compartments bringing with it the smell of gas and powder. The steering machinery was carried away as the explosion blasted a hole 20 by 20 in the stern of the Mowinckel. One man was killed outright, while 20 were injured, some severely (Freeman 1987:412).

As the convoy began to break apart to avoid additional attack, a torpedo struck *Bluefields*. The submarine carried out its entire attack in less than six minutes before popping to the surface in the middle of the convoy and being fired upon, aerial bombed, and depth charged in an attack that, depending on the account, may have sunk the German Submarine *U-576. Chilore* and *Mowinckel* despite being severely damaged were still afloat, but *Bluefields* slipped beneath the surface by 1700 EWT. After securing the corvette *Spry* as an escort for the two stricken vessels, they were permitted to run for the safety of the North Carolina shoreline while the convoy continued south. Since the attack destroyed *Mowinckel's* steering machinery, the master had to steer using its engines, which caused the vessel to follow a wavering course. With *Spry* in the lead, the vessels began their journey towards shore (Freeman 1987:411-421; Hickam1989:285-287; Blair 1996:626-627).

The route chosen by the commodore to take the vessels to shore put them on a direct path to Hatteras Inlet. This path, also led them directly through the danger area discussed in Notice to Mariners 175. Unfortunately, the notice only referred to a danger area and many mariners simply thought this zone had become a graveyard of sunken ships and underwater hazards, not a

minefield. While *Spry's* commander knew the danger area was a minefield, he did not know exactly where he was since he had taken part in the hunt to find the submarine that attacked the convoy. By doing so, he had made so many changes in position and speed that he could not plot *Spry's* exact location. Using dead reckoning in attempting to figure out where they were, the commander accidently positioned all three vessels 60 miles south of where they actually were (Figure 2). Had the vessels really been at this point, the course of 315° the vessels followed would have allowed them to reach shore south of the danger area (Eastern Sea Frontier [ESF] 1943:10,chap. 5; Freeman 1987:413-415). Adding to the confusion was that the Convoy Commodore aboard *Mowinckel* knew exactly where the ships were but had a rather hazy recollection about anchoring around Hatteras, and the master of *Mowinckel* claimed he was told the restrictions around Hatteras no longer applied (Freeman 1987:415).

With this misinformation, the three vessels took the most direct course toward land. As the vessels continued towards shore, the commander of *Spry* became uneasy about the route's proximity to the minefield and radioed *Mowinckel* to get their position. *Mowinckel* responded that they were 20 miles SE of Hatteras Inlet. Fearing the ships would end up in the minefield, *Spry's* commander suggested a route change that would bring the ships well south of Hatteras. The crew aboard *Mowinckel* heard this transmission incorrectly and when they plotted the course they heard transmitted, realized it would take them north of Hatteras and through dangerous waters, so they kept their heading and did not send a response to *Spry*. Although still uneasy about the situation, the commander of *Spry* decided not to resend his transmission because he did not want to question the Convoy Commodore's decision since the Commodore, although retired, was a senior officer. Shortly after, the three vessels passed one of the patrol boats stationed on the outskirts of the minefield.

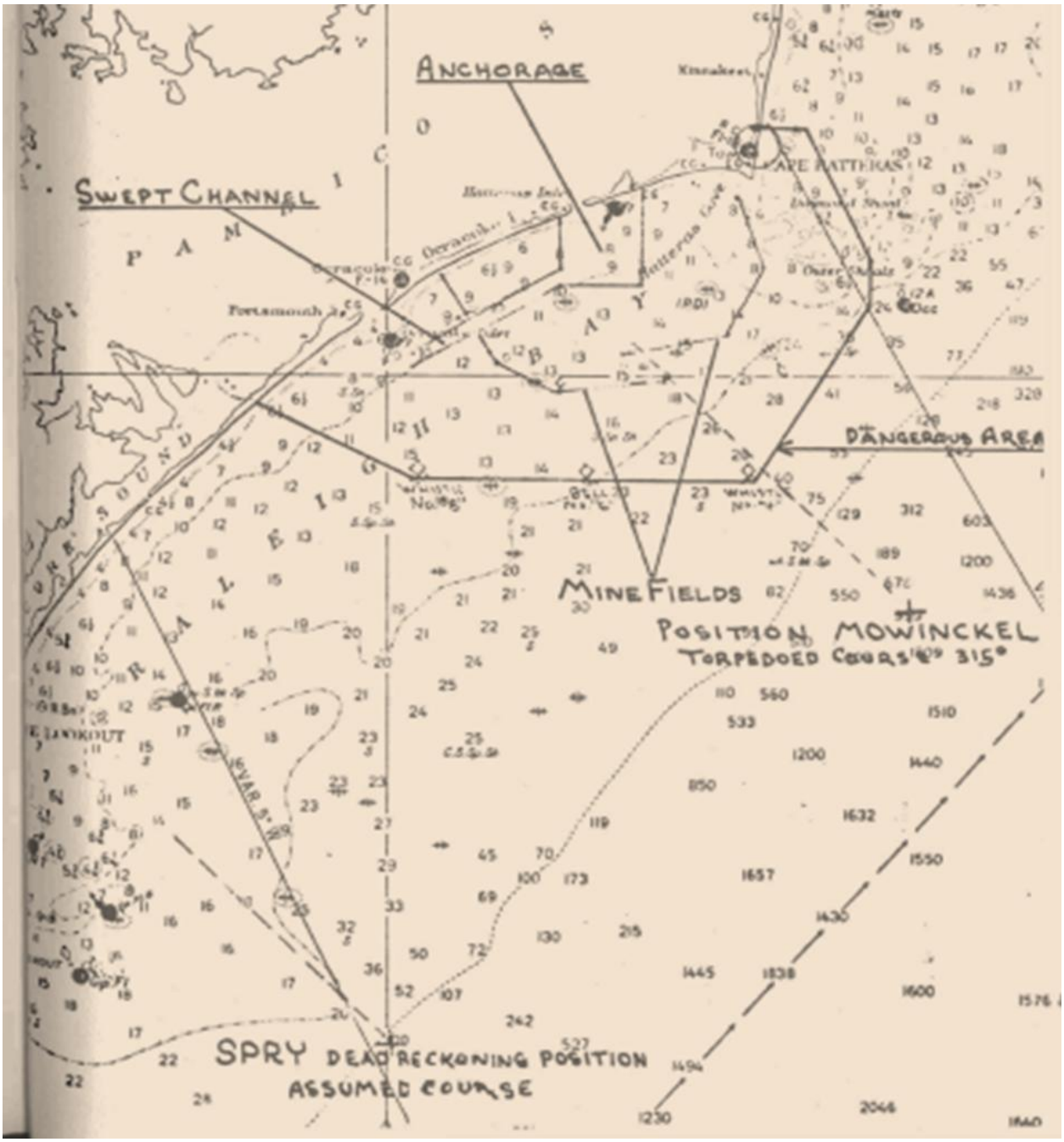

FIGURE 2. Paths of *Spry*, *Chilore*, and *Mowinckel* leading into the Hatteras minefield (Freeman 1987:421b).

Seeing that the merchant ships were led by a naval vessel, the patrol boat decided not to contact the small convoy and resumed its patrol. As the ships closed on the minefield, a blimp began dropping smoke bombs to alert the convoy to the danger they were heading toward, but the Commodore assumed the blimp was just warning them that submarines were in the vicinity and continued steaming ahead.

In a final warning, the crew of patrol boat *PC-462,* which had just returned from taking gasoline to a YP boat that ran out of fuel at sea, attempted to chase down the three vessels, signaling as fast as they could and even firing the boat's guns into the air. Unfortunately, the vessels continued on their way and at 2000 EWT, several loud explosions shook the night air. *Chilore* and *Mowinckel* had both passed over contact mines in the Hatteras minefield and been shaken by explosions, while *Spry* escaped danger. While the two merchant crews, fearing they had been torpedoed, abandoned ship, *PC-462* caught up to *Spry* and informed the commander of the danger. The commander of *Spry,* realizing for the first time where he actually was, knew he could do nothing for the merchant ships and followed *PC-462* out of the minefield before heading south to regain convoy KS-520.

The crews of *Chilore* and *Mowinckel* soon reached shore in lifeboats, while the merchant ships remained afloat within the minefield. Over the next few days, channels were swept to the vessels so that they could be towed in and salvaged. On July 19, three tugs were sent to recover the merchant ships, but at 1630 EWT, one of these, *Keshena*, struck a mine and sank almost instantly. Finally, the remaining tug removed *Chilore* and *Mowinckel* from the minefield and brought them to Ocracoke for basic repairs before they were sent to Hampton Roads for salvage. Unfortunately, the *Chilore's* terrible saga was not complete until 1700 EWT on July 23, when the vessel capsized and sank while being towed past Cape Henry. *Mowinckel,* on the other hand, made it safely to Norfolk (ESF 1943:8, chap. 5; SOC 1946; Freeman 1987:415-419).

These events were the last needed to convince the Commandant Fifth Naval District (ComFive) to begin lobbying for removal of the minefield. ComFive suggested to Admiral Adolphus Andrews, Commander Eastern Sea Frontier (CESF), that the minefield could be

replaced with anti-torpedo netting. Admiral Andrews agreed with this suggestion and on July 21, 1942, forwarded the proposal on to Admiral King, Commander in Chief, United States Fleet (COMINCH), with his personal approval. Andrews further stated that he had never been in favor of the minefield and its usefulness was obsolete. In fact, the convoy system along the coast had been initiated before the minefield was completed, nearly relegating it pointless from the beginning. CESF also added that the term danger area might be giving merchant captains a false sense of security because they did not realize the area was mined. Admiral King sent his response on August 4, stating that anti-torpedo netting was not practical in the waters around Hatteras and the minefield would remain. He did capitulate, however, that the area could be declared mined so that merchant shipmasters would understand the severity of straying into those waters. An additional problem with the minefield soon became evident as well.

The small vessels that were patrolling the minefield required constant maintenance at the section base on Ocracoke and often could not put to sea if the weather worsened. The wear and tear on the vessels and crews also seemed superfluous since only one merchant ship used the anchorage between August 6 and November 6. Andrews again petitioned Admiral King on November 6 to allow the minefield to be swept and deactivated, but to allow the area to still be referred to as a danger area on charts and not reveal the mines were gone (ESF 1943:8-11,chap. 5). King retorted, saying that minesweepers could not be spared because they were in such constant demand at the time for maintaining swept channels at the entrance to important harbors and that the matter would be taken up again the following spring (ESF 1943:11,chap. 5). In April 1943, CESF again pressed the matter with COMINCH, this time employing an entirely new tactic. Andrews noted that no vessel had been lost to U-boats in Frontier waters since July 15, 1942, and that the minefield was destroying the economy of the Outer Banks. The later argument was based on the Department of the Interior's Deputy Coordinator of Fisheries stating that restrictions on fishermen in the area had already decreased the catch by a staggering 80,000,000 pounds.

On April 21, 1943, Admiral King agreed that the minefield should be removed but left removal of the mines to the Fifth Naval District. Removal was begun on June 7 and, despite the fact that many mines would not fire and heavy storms hindered the operation, the work was completed by September 25. Although only 1,303 of the 2,500 mines originally laid were recovered, CESF considered the operation a success. Due to the undetonated mines, however, the area continued to be labeled a danger area through the rest of the war and is still labeled as such today. With the sweeping of the minefield, a destructive chapter in Fifth Naval District waters was closed (ESF 1943:11-13,chap. 5). The ESF would sum up the minefields history most succinctly:

> Thus ended the Battle of the Hatteras Mine Field. In retrospect, it is easy enough to consider that the sanctuary failed to accomplish its intended purpose of saving ships from submarines; that to the contrary, four ships were lost. On second thought, however, it is clear that the project was undertaken at a time when one could not predict the manner in which the U-boat campaign would develop; the simple fact was that there were not enough escort and patrol vessels or planes to drive the subs from our shore, and that some kind of defense had to be made as a stop-gap. That was exactly the function of the Hatteras mine-protected sanctuary. Considering the outcome, it is fortunate that the shift of U-boat concentrations permitted the well-intentioned sanctuary to pass into ―innocuous desuetude (ESF 1943:13,chap. 5).

Although the Hatteras Minefield never lived up to the expectations placed upon it by the naval high command, it was not necessarily because the minefield was not effective but more likely because the minefield was replaced by the more effective coastal convoy system.

THEORY

According to Phillip Freeman (2011:149), archeologists have approached the research of battlefields in three ways:

> The oldest, and most commonly deployed, is to use archeology to embellish the accepted story of the events that has been derived from written sources that are, in turn, based on eyewitness accounts. Where there are several accounts of the same battle, certain sources are often emphasized over others. Here, archeology is used to clarify details or add to the historical framework. A second use of archeology is to illuminate poorly reported engagements while the third approach is a halfway position. In this middle ground, archeology is used to reconcile the problematic aspects of an engagement, or to correct conventional interpretations.

All three approaches, arguably, are fraught with problems for a researcher, and can be critiqued based on the degree to which preconceived notions of one sort or another may seep into the process of research design. Part of this relates to the degree to which we can determine the "bias" or "cultural construction" of historical documents and archeological interpretations (discussed by Conlin and Russell 2011:42). Another reason is because battlefield archeology, a relatively new field of study, has until recently been of "limited theoretical inclination" (Scott et al. 2009a:1) and has been defined by antiquarian or culture-historical (particularist) approaches focused on the description of battlefields, the paraphernalia of conflict, experimental/forensic analyses of weapon capabilities and site formation, and the reinforcement of established historical chronologies (see Mandry 2009; Scott and Haag 2009; Sivilich 2009; Wilbers-Post 2009; Scott 2011).

Much of this research, because of its strong culture-historical leanings is also arguably infused with nationalistic themes focused on the celebration of victors. As Silverstein et al. (2009:417), notes, "On a national level, battlefields take on meaning as places of pride and communal identity, where the sacrifice and courage of those who fought become symbols of duty to the state and of cultural solidarity." This is less of a critique, and more of an observation

noting that battlefield archeology has, essentially, developed along the same lines as most archeological sub-fields, with scholars first requiring an understanding of the material culture left in the wake of conflict before venturing into more complex theoretical studies focused on landscapes and behaviors. In other words many of the particularistic, forensic, and experimental studies cited above have had to occur in certain historic contexts in order to more adequately link "discrete historical events into a coherent chain though the use of archeological data" (Carson-Drexler 2009:61). These links have greatly informed the archeological process of understanding battle landscapes, and have in turn fueled discussion about other potential processes for analysis.

However, aside from more text-dependant non-archeological study of sites, "battlefield archeology can give unique insight into the anthropology of war, one of the most pervasive aspects of human behavior, and can provide data on how decisions are made in the heat of battle" (Conlin and Russell 2006:21; 2011:40). Moreover, when "the archeological record is viewed as an independent data set that can be compared to historical documents, participant accounts, maps, and other sources" (Scott et al. 2009b:429), the conception of a particular battlefield can be greatly enhanced, and perhaps even altered in light of material evidence. In combination with historical research, battlefield archeology offers the potential to greatly enhance our understanding of conflict and warfare. Furthermore, "combatants fight as they are trained and under the rules of that culture's perception of warfare behavior" (Scott et al. 2009b:433), and as a result, battlefield archeology illuminates patterned human behavior during a ubiquitous human activity.

Since the publication of Scott et al's. work on the "dynamic patterning" of the archeological battlescape at the Battle of Little Bighorn (1989), scholars have been increasingly drawn toward more sophisticated theory-laden research. Indeed, recent writings reflect an "opening up" of scholarship, with various authors considering processual and postprocessual approaches (Scott et al. 2009b) or endorsing a diverse offering of specific theory for consideration, including landscape archeology (Foard 2009), phenomenological approaches (Carman and Carman 2009), analyses of inherent historic military probability (Lowe 2000:221;

Foard 2009), Marxist perspectives (Scott et al. 2009b) and the integration of explicit behavioral concepts (such as the role of social cohesion) in determining battle success or failure (see for example Haecker et al. 2009). This emphasis on behaviors and tactics has also led to an expansion of the types of sites likely to be considered a part of conflict by archeologists to include ancillary and support sites not located on the battlefield itself such as field hospitals, campsites, and supply depots (see Balicki 2009; Dasovich and Busch 2009). There is also potential adaptation of battlefield study to other hitherto untapped theoretical approaches, such as landscape analysis from the perspectives of environmental determinism, structuralism, and the English landscape tradition of scholarship, as well as more empirical articulations (see Johnson 2007).

These studies, whether implicitly or explicitly theoretical, are also increasingly comparative and behavioral, focusing on how factors such as conflict duration and combatant movement across time may culminate in the similar contextual arrangement of structures from encounters. In this way, scholars may be able to see common presence and absence patterns across battlefields separated in time and space, regardless of the very different kinds of weaponry. For example, Pratt's (2009:5) analysis of short-lived battles during the War of 1812 suggests battlefield element (i.e. structures and material culture) absence and presence patterns that could apply to battlefields from different locations and times—and illuminate common thought processes in the preparation and practice of warfare. This approach goes well beyond the normal taphonomic preoccupations focusing on how ongoing environmental processes and human tampering events (such as looting) have scrambled and filtered archeological deposits within battlefields (see Rost 2009).

So too, although the archeological study of a maritime battle site is predisposed to both particular events as well as generalization, or the "multi-scalar explanatory approach" discussed by Conlin and Russell (2011:41), most studies have been of a decidedly fetishistic and descriptive flavor, focused on the presence of naval vessels during terrestrial skirmishes, or the histories of individual vessels of war and associated details such as ship construction techniques,

historical accounts of use, and famous individuals associated with military engagement. This particularistic tendency was recently identified by Conlin and Russell (2011:40-41) in their separation of naval-themed maritime archeology into "studies of naval battlefield components" (e.g. Veyrat and L'hour 1994; Bratten 1996, 2002; Rodgers et al. 1998; Jeffery 2004; Papatheodorou et al. 2005), "studies of individual ships lost in battle" (e.g. Spirek 1993; Olson 1995; Peebles 1995; Delgado 1996), "individual vessels lost during non-combat" (e.g. Arnold et al. 1992), "vessels scuttled for defensive purposes (e.g. Broadwater 1980, 1992; Broadwater et al. 1985; Gould 1990; Delgado et al. 1991; Delgado 1996; Riess and Daniel 1997; Hunter 2004) and "non-combat vessels lost during military support operations (e.g. Arnold et al. 1999, 2001a, 2001b; Birch and McElvogue 1999). To this list, we must also add the last three seasons of the Battle of the Atlantic Project (BOTA). Previous BOTA projects focused on site-specific data gathering and focused on surveying to National Historic Preservation Act (NHPA) standards with the primary data analyses focused on cultural resource management needs rather than explicit archeological or anthropological questions and interpretation. As such, focusing on individual German U-boats, allied surface craft, and merchantmen without any comparative theoretical framework in place, or any explicit theoretical considerations, has been equally particularistic. While some authors (see Broadwater 2011:177) cite the application of "naval landscape" approaches in the cases of the 1588 Spanish Armada (Martin and Parker 1999), 1781 Battle of Yorktown (Sands 1983, 1988), 1862 Battle of Hampton Roads (Davis 1975; Holtzer and Mulligan 2006), and 1941 attack on Pearl Harbor (Prange 1986; Weintraub 1991), examination of these studies indicates a similar tendency towards description, reliance on historical records, and absence of explicit theoretical framework. In other words, in comparison to terrestrial battlefields, we notice an almost complete absence of comparative or landscape studies that can be considered theoretically-inclined. This has already been noted by maritime archeologists, and is alluded to by Conlin and Russell (2011:39) who articulate the comparative and anthropological potential of naval battlefields:

> Battlefield archeology is fundamentally about looking beyond individual sites and small scale activity areas to larger contexts. These larger contexts encompass a series of events and human behaviors that may have a very short time span but that typically involved larger areas than most archeologists consider when looking at sites. This fact is particularly interesting when looking at the archeology of naval battlefields, since underwater archeologists have traditionally focused on the tightly constrained "time capsule" nature of individual shipwrecks instead of looking at broader patterns of wrecks considered as groups.

We also see comparative, theory-laden concepts emerging within the recent work of historians. One example of this is the scholarship of Michael A. Palmer, whose book *Command at Sea: Naval Command and Control since the Sixteenth Century* (2007) examines the story of changing naval strategy, focusing on the various innovations and consequences of "centralized" and "decentralized" tactics and the way they culminate in "order" or "disorder" during naval conflict. Palmer's work focuses on what is defined as "Command and Control" (often abbreviated as "C2"), and considers many of the factors that make up the "fog of war," including command personalities, naval doctrine, the role of individual initiative during conflict, and C2 obstacles. However, of most interest to this research is his characterization of transitions in technology – whether relating to changes in propulsion, armor, weaponry, or communication, as well as considerations of the reliability of all technology during combat. His work also places the Battle of the Atlantic into context, by describing the tactical advantages and disadvantages emerging during the First World War:

> The tempo of naval battles under steam was much faster than that of the age of sail. The end of reliance on the wind for mobility, the marked increase in the speed of ships, and the ever lengthening ranges of the big guns placed a premium on rapid decision making. Naval warfare remained two-dimensional and dominated by the now-steam-driven and armored ships of the line, but torpedo boats and destroyers, which had no place in the line, had become important elements of the fleet (Palmer 2007:230).

Palmer also speaks specifically as to the technological context and economic consequence of U-boat activities against Allied nations during World War One. His words hold true as well in the Second World War:

> The U-boat campaign of 1917 and 1918 marked a major change in naval command and control. Wireless telegraphy allowed the Germans, for the first time in history, to profitably coordinate – to centralize – a *guerre de course*. Ironically, this coordinate was offset to a fair degree, not by any denial of initiative to the individual U-boat commanders, but by a new factor in the command and control equation: the vulnerability to interception and decoding of centralized systems reliant on electronic signaling (Palmer 2007:234).

Of course, the innovations in the First World War were taken into the Second World War However, Palmer points out another innovation in strategy – one that sets it apart: "When war began in 1939, aircraft (including the ships, aircraft carriers, from which they operated) and submarines dominated the naval battlefield" (Palmer 2007:256). Additionally,

> During the Second World War the technology of naval command and control came of age. Wireless communications became a critically important tool in the shaping of naval strategy, operations, and tactics.

This post-1918 three-dimensional, technologically-rich context (also noted by Palmer 2007:252) illustrates just how research design, as well as choosing appropriate method and theory for studying a twentieth century naval conflict connected with a *gueurre de course*, both sets a study of the Battle of the Atlantic apart from other battlefield analyses as well as provides ample opportunity for innovation.

Recent research, however, points toward one set of explicitly theoretical approaches with potential to infer behavioral aspects of conflict, and in turn assist in reconstructing or redefining the strategies and tactics utilized in combat. These approaches can be seen as increasingly *idealist* – focused on how battlefields and the residues of battle are as much a reflection of the *ideas* of combat as they are the *actions* associated with warfare. This focus on the strategic-

psychological aspects of combat, to a large degree propels battlefield archeology toward more anthropological approaches to the study of conflict, and significantly curtails the potential of nationalistic interpretations.

Embracing the recent movement toward increasingly comparative and behavioral trends in research, a group of battlefield archeological and operational military theories already utilized in numerous terrestrial battlefield studies (see Bedell 2005; Dautartas et al. 2005; Strezewski et al. 2006; GAI Consultants Inc. and Hardlines Design Company 2007; Pratt et al. 2007, 2010; Whisonant et al. 2007; Butler 2008; Fonzo 2008; Seibel et al. 2008; Stull 2008; McBride 2009; McBride and Naumee 2009a, 2009b; Reeves and Trickett 2009; Brent et al. 2010; Kenny and Crock 2010; Mangum and Moore 2010; Outlaw et al. 2010) will be adapted and applied to the Battle of the Atlantic. These approaches share a common goal of analyzing the decisions made by combatants in the preparation and operation of conflict and adhere to the general principles of war defined by the United States Army. They also consider concepts such as objectives, offensive, mass, economy of force, movement, surprise, security simplicity, and co-operation; the METT-T evaluation of Mission, Enemy, Terrain analysis (i.e. KOCOA), Troops available, and Time; and the broader considerations of strategy, tactics, operations, and logistics (Babits et al. 2010:5-12). As Lawhon (2002:36) notes, researchers utilize

> … the time-honored military methods of terrain analysis. Known today by the acronym KOCOA, this method analyzes:
>
> - Key terrain
> - Observation and Fields of Fire
> - Cover and concealment
> - Obstacles (both natural and man-made)
> - Avenues of approach and retreat

With a single exception (Babits et al. 2010), these elements of terrestrial analyses have yet to be explicitly defined in terms of a naval battlefield. Furthermore, the Battle of the Atlantic off the North Carolina coast is distinguished from 18th and 19th century naval actions described by Babits et al. in that they involve, in addition to surface craft, both submarines and aircraft. This

type of multifaceted engagement expands the analysis, and visualization thereof, to include more than just the plane of the sea, but forces one to consider such things as the range and visibility of aircraft, and the interactions of a vessel within the water column and bottom topography as well as the surface. Additionally, the machinery of warfare and its ability to allow enemies to observe and engage one another is considerably different during the Battle of the Atlantic than what is described by Babits et al. during the Revolutionary War and War of 1812. Finally, the Battle of the Atlantic off North Carolina is not a traditional naval battle, but rather a mixing of civilian and military elements, challenging the definition of public and private vessels, in addition to merchant seaman and combatants as participants.

As such, the present study seeks to draw upon these emerging theoretical developments in archeological battlefield study. In particular, the expedition aims to adapt conventionally terrestrial concepts of battlefield survey to the study of an open-ocean naval engagement; a task heretofore unaccomplished. Many aspects of North Carolina's battlefield landscape lend themselves to such a task, with the KS-520 convoy battle offering an ideal case study. First, the location of the battle positions it proximate to multiple marine 'landscape' features, including a deep water column, steep bathymetry, numerous coastal inlets and safe anchorages, and a large minefield. Second, many of the technological instruments and tactical behaviors described by Palmer are present: aircraft escort, an aggressive and well-armed convoy system featuring both armed naval and merchant craft, employment of anti-submarine technologies such as sonar and hydrophones, and a centrally directed German submarine. In combination, a wealth of potential exists whereby systematic archeological survey might reveal considerable knowledge of human behavior and decision making. Furthermore, the archeological record off this section of North Carolina's coast has been largely undisturbed since 1942, creating immense potential for forensic analysis of archeological remains, and reducing the possibility of destructive site formation in the years intervening since the battle event. Additionally, the cartographic methodology foundational to a naval terrain analysis was pioneered using the Battle of the Atlantic off the North Carolina

coast (Wagner 2010), allowing the present study to build upon these previous efforts, data, and methodology.

By the conclusion of the study, the researchers hope to have engaged in the kind of comparative "dynamic-patterning" created by Scott et al. (1989: 148-149) and acknowledged by Conlin and Russell (2011:42) as being "not easily applied to navel engagement" but being capable of indentifying "tactics and results of specific actions."

METHODOLOGY

The methodology adopted for the 2011 Battle of the Atlantic Expedition has certain methods that overlap with traditional terrestrial battlefield analysis as well as techniques peculiar to deep-water marine survey. Whereas both terrestrial and maritime archeologists must be concerned with the ongoing environmental processes acting upon their sites following the conflict event (i.e. their deposition or "loss"), terrestrial battlefield archeologists and maritime battlefield archeologists have different considerations when dealing with potential human-sourced site formation processes.

Whereas the negative effects of relic hunters on terrestrial battlefields is well-understood (see for example Legg and Smith 2009), similar activities undertaken by souvenir hunters and salvers interacting with submerged cultural resources is less extensively researched, and also likely to vary depending upon whether shipwreck sites have been discovered or not. While many of the sites within the study area for this project have suffered significantly from illicit salvage activities (such as *U-352* and *U-85)*, the large area of seabed beyond recreational diving limits (approximately 130 feet) as well as technical diving limits (approximately 300 feet) means that archeological sites in this area should be in a good state of preservation. Additionally, even if the seabed has at some stage been used, maritime archeologists are unlikely to have to consider seabed use history in the same way as terrestrial archeologists. Whereas the potential integrity of naval battlefields may have suffered due to anchoring, fishing practices, or in certain instances seabed development (such as the installation of oil rigs) these factors are less recurrent than the agricultural, industrial, and settlement uses of terrestrial sites, and the integrity of deepwater sites may be assumed to be comparatively less disturbed. Some of these biologically- or environmentally-induced site formation forces have been the subject of study on analogous World War Two sites in the Gulf of Mexico (see Church et al. 2007), and it is possible that the

sites discovered during the summer 2011 expedition will lend themselves to future comparison of taphonomic processes acting on deepwater submerged cultural resources.

Indeed, as much as the methodology for this project emerges from the specific environmental variables posed to researchers working in the ocean, it is also determined by site-type classifications defined within battlefield archeology. As Scott et al. (2009b: 432) note,

> Whatever the underlying theory used to study a battlefield there are essentially two types of battlefields—siege and transitory … The archeological evidence will be similar in some respects; that is, the evidence of warfare and conflict. The siege site can be expected to be associated with towns or fortifications where one of the combatant parties fortified themselves and where the other party was attempting to acquire that locale …
>
> The transitory battlefield, which is probably the most common, is more ephemeral in nature. Normally these involve a limited engagement of opposing forces both in time and space. This battlefield type should not be associated with permanent fortifications, but temporary breastworks may be found … Camps and burial areas may be found near the battle site. Even the route of retreat or movement can sometimes carry an archeological signature.

However, Conlin and Russell (2011:41) pointed out significant differences when comparing terrestrial and naval battlefields, the consequences of which must be considered when devising a research methodology:

> Unlike terrestrial battlefields, remains from naval battlefields will not typically consist of individual artifacts distributed across a landscape. However, multi-scalar analysis of individual site components and the site as a whole can illuminate the progress of the battle and be used to evaluate overall patterns.

In other words, a study of the remnants of 20th century naval warfare off the coast of North Carolina may constitute a third "hybrid" type of conflict – one where elements of a wide area transitory battlefield littered with the debris of moveable structures are more akin to a siege battlefield due to the concentration of various forms of firepower and fortification (i.e. submarines, naval surface craft, and merchantmen are serving as transitory fortified structures).

Moreover, actions during naval engagements, depending on the time period, took place proximate to safe anchorages, shore batteries, minefields, straits, protected convoys, as well as inopen water. Quite possibly the mixing of terrestrial fortifications and naval sites, as well as open-ocean naval engagements taking place between large, heavily armed naval forces, will present elements of both siege and transitory-type sites in the archeological record.

Nevertheless, the methodology for the present study involves a combined historical and archeological approach analogous with any battlefield survey with the goal of creating an accurate spatial dataset to be imported into a GIS for analysis. As with any other battlefield survey, historical data will be collected from various primary and secondary sources, completing a rubric of goals outlined below. The goal of archeological work is to locate and survey vessel remains left on the battlefield, both as a test of historical data, as well as to fill gaps and answer questions within the historical narrative. Once data has been imported into a GIS, the analytical task of adapting military principles and KOCOA protocols will begin. This methodology follows one utilized by National Park Service maritime archeologists during their examination of the *H.L. Hunley* and *Housatonic* sites in Charleston Harbor, South Carolina which maintains a three-stage approach of, 1) documenting "the relative position, orientation, spatial organization, and level of integrity of … major site components," 2) identifying and controlling for site formation processes, and 3) comparing "archeological data to historical documents to illuminate specific events documented by participants and observers during the course of battle" (Conlin and Russell 2011:43).

Historical Methodology

Research regarding the Battle of the Atlantic is both extensive and varied. Numerous works have focused on the general conflict (Morison 1947; Macintyre 1961, 1971; Hughes and Costello 1977; Gannon 1990; Howarth and Law 1994; Syrett 1994; Gannon 1998; Ireland 2003; Williams 2003; White 2006) while others the development and operations of German and allied craft (Frank 1955; Willoughby 1957; Scheina 1982; Hoyt 1984, 1987; Blair 1996; Grove 1997; Kaplan and Currie 1997; Kemp 1997; Kaplan and Currie 1998; Wiggins 1999; Blair 2000;

Hague 2000; Miller 2000; Showell 2002; Westwood 2003; Showell 2006; Watson 2006; Brown 2007). Several studies dealt specifically with the eastern seaboard and the North Carolina Coast (Stick 1952; Hoyt 1978; Gentile 1989; Hickam 1989; Cheatham 1990; Gannon 1990). Additionally, due to the adjacency of the Gulf Stream, the concentration of historically significant and recreationally accessible wrecks has attracted shipwreck divers to the area since the 1960s. As a result, numerous popular dive guides were written for divers in North Carolina, often containing thorough research into individual vessel histories and positional information (Farb 1992; Gentile 1992, 1993, 2006; Bunch 2003; Galecki 2005).

The goals of a digital site reconstruction and tactical terrain analysis, however, dictate historical research focusing on three areas not comprehensively available in the previously mentioned secondary sources. First, and of primary importance, is the collection of spatial data relating to ephemeral battlefield elements (vessel movement and routing instructions), as well as natural and artificial landscape features. Second are treatises on contemporaneous German and Allied naval strategy, tactics, technology, training, operations, and logistics. Mainly these are to be found in handbooks and training materials issued to sailors and their officers. The third is to evaluate previous METT-T and KOCOA battlefield surveys for methodological and analytical insight.

Several historical archives will be accessed for primary documents during this project. National Archives and Records Administration (NARA) maintains multiple repositories with documents relating to the Battle of the Atlantic. The National Archives Building, in downtown Washington, D.C., houses records of the United States Coast Guard in Record Group (RG) 26. Of interest are vessel logs, and operational reports. The National Archives II in College Park, Maryland, houses analogous records for the United States Navy. These holdings include:

RG 19: Records of the Bureau of Ships, 1940-1966

RG 24: Records of the Bureau of Naval Personnel (including deck logs)

RG 38: Records of the Office of the Chief of Naval Operations

RG 74: Records of the Bureau of Ordnance

RG 181: Records of Naval Districts and Shore Establishments, 1784-1981

Furthermore, Archives II houses still photography and cartographic records for the United States Navy and Coast Guard, including maps, and photographs of ships, installations, and miscellaneous operations. The National Archives Mid-Atlantic Region facility in Philadelphia contains records from the Philadelphia and Norfolk Navy Yards, in addition to records from the Fifth Naval District, as part of its holdings within RG 181. Of particular interest would be merchant ship files regarding the manning and provisioning of armed merchant vessels.

Though historical research leans heavily upon primary sources, several secondary sources will also be useful in fulfilling the three historical research goals. Several publications can be utilized for additional spatial data (Gentile 1992, 1993; Wagner 2010). Numerous sources have been written regarding German and Allied naval technology, tactics, and training (Morison 1947; Stick 1952; Frank 1955; Willoughby 1957; MacIntyre 1961,1971; Hughes and Costello 1977; Scheina 1982; Hoyt 1984, 1987; Gentile 1989; Hickam 1989; Cheatham 1990; Gannon 1990; Cheatham 1994; Howarth and Law 1994; Syrett 1994; Blair 1996; Grove 1997; Kaplan and Currie 1997; Kemp 1997; Kaplan and Currie 1998; Wiggins 1999; Hague 2000; Miller 2000; Showell 2002; Westwood 2003; Ireland 2003; Williams 2003; Showell 2006; Watson 2006; White 2006; Brown 2007).

Archeological Methodology

The mainstays of battlefield archeology are surface survey, remote sensing (various technologies, but particularly metal detection, ground penetrating radar, and magnetometry), and excavation (see Burt et al. 2009; Johnson 2009; Sutherland and Richardson 2009; Geier et al. 2011; Hanna 2011; McBride and McBride 2011; Pollard 2011). Archeological methods adopted for this project will focus on remote sensing (acoustic and magnetic survey) and non-invasive inspection of vessels remaining on the battlefield. In addition to the fact that project personnel have not sought permission from original owners (the USA and German governments, merchant

vessel owners, or marine underwriters) excavation is not currently required due to the priority of discovery, and a lack of research questions requiring disturbance.

Archeological data gathered during the present survey will serve two functions. First, it will be used to ground-truth historically based accounts and positions to increase the accuracy of spatial analysis, and also to identify the locations of sites for future management purposes. Secondly, archeological survey of individual vessel sites will also serve as a forensic tool to diagnose the circumstances of the vessel's loss, thus further informing questions regarding the chronology and events of the engagement; this can enhance, or even correct, historical accounts of the battle. Establishing a baseline condition of each vessel also informs managers as to decisions over National Historic Register nominations and battlefield management.

Despite the wealth of available primary source data, and numerous secondary analyses, the locations of all vessel casualties are not known. Only the location of *Keshena* and *Chilore* are at currently known, thus a major component of fieldwork will involve remote sensing survey to locate the remaining two vessels. During search operations, the possibility exists that remains of the lost vessels cannot be accessed due to constraints on the operational envelope of the gear deployed

The 2011 Battle of the Atlantic Expedition survey is separated into four separate stages with separate goals focused on the location and noninvasive survey of various submerged cultural resources. Given the possibility of extreme depths in the vicinity of the battle's historical location, the use of remotely operated vehicles has been made available via various funding sources. Vessel remains will be documented via photographic and video survey. Should the vessels be located in depths acceptable for diving (less than or equal to 300 feet), the same photographic and video survey methods will be employed, though conducted by divers. Previous work on *Keshena*, completed during NOAA's 2010 Battle of the Atlantic expedition, in addition to previous research (such as Wagner 2010), will also be utilized as part of the archeological data set.

Another possibility is that survey fails to locate the remains of the vessels in the KS-520 convoy battle. Should this be the case, archeological work will shift to document other U-boat actions off the North Carolina coast, namely the sinking of *U-85*, *U-352*, and *U-701*. The position of each U-boat is known, as are some of their Allied victims (NOAA 2008, 2009; Wagner 2010). From historical and archeological data, the movements and actions of each of these vessels can be recreated in GIS, incorporating similar nautical terrain features of the KS-520 battle. Furthermore, if it is operationally feasible, an auxiliary survey to attempt to locate the remains of *William Rockefeller* (sunk by *U-701*) will be attempted. The result would be a similar KOCOA analysis, though not confined to a single engagement.

Stage One: Wide Area Survey

The Stage One survey methodology is designed around two separate remote sensing packages. Primarily, the wide area survey will utilize an ATLAS (Autonomous Topographic Littoral Area Survey) sonar out of the Applied Research Laboratories at the University of Texas at Austin (ARL-UT). The ATLAS system is built into a 12-3/4" x 10' REMUS 600 Autonomous Underwater Vehicle (AUV) owned by the Office of Naval Research (ONR). It carries a high-frequency 1200 MHz Marine Sonics Side Looking Sonar (SLS), a Kongsberg Synthetic Aperture Sonar (SAS) and an iPUMA ahead-looking sonar (ALS) (multi-ping) (Figure 3). As a secondary package, during AUV deployment, a Geometrics G-882 Cesium magnetometer owned by the Program in Maritime Studies, East Carolina University will be deployed (Figure 4).

This instrumentation suite will allow the collection of bathymetric data and the coverage of large areas of seafloor, as well as the detection of large and small objects on the seafloor and the creation of three-dimensional terrain. At lowest resolution, the Wide Area Survey package can cover a 1000 meter wide swath (500 meters/channel) with 100% coverage (no water column). The AUV has a battery life (endurance) of 10-20 hours and is rated to 600 meters (1800 feet) depth. As the vehicle traverses an area, objects that pass through the sensor's field-of-view are "seen" dozens to hundreds of times. In contrast, side-looking sonars tend to have narrow swaths and only view an object from a single aspect angle (Figure 5). This will allow for

comprehensive coverage of a large area of bottomland at low resolution, with the option of returning to potential targets to acquire a higher resolution 600 kHz side-scan sonar image. The vehicle and sonar provide an autonomous search capability in a small package and can be launched from a ship or pier by crane. In current operations, the AUV's position and health is monitored during the survey via ultra short baseline (USBL) to the support craft, which is stationed near the survey area.

During this stage, the vehicle will operate in water depths of 100 to 1,500 ft. With the current configuration of batteries, the vehicle should be able to run surveys for 8 to 10 hours per day and travel at 3-4 knots (3.5-4.6 miles/hour) for an estimated coverage of 28-46 miles^2 per day. Taking into account weather days, this stage calls for seven days of deployment (covering an estimated 196-322 miles^2 over project duration). During this time, the research vessel will follow the AUV and deploy a Geometrics magnetometer owned by the Program in Maritime Studies, East Carolina University. After 8 hours, the research vessel (R/V *SRVx*) will retrieve the AUV for data download and processing, battery re-charging, and re-programming. Imagery and bathymetry will be integrated into the project geo-database. Table 1 outlines a breakdown of the components of this stage. The core scientific team required to operate aforementioned instrumentation is outlined in Table 2.

TABLE 1. Components of Stage 1 operation 31 May – 12 June 2011.

Description	Begin date	End date	Duration	Location
Mobilization	30 May 2011	31 May2011	2 days	Norfolk, VA
Field operations	1 June 2011	10 June 2011	10 days	Ocracoke, NC
De-mobilization	11 June 2011	12 June 2011	2 days	Ocracoke, NC

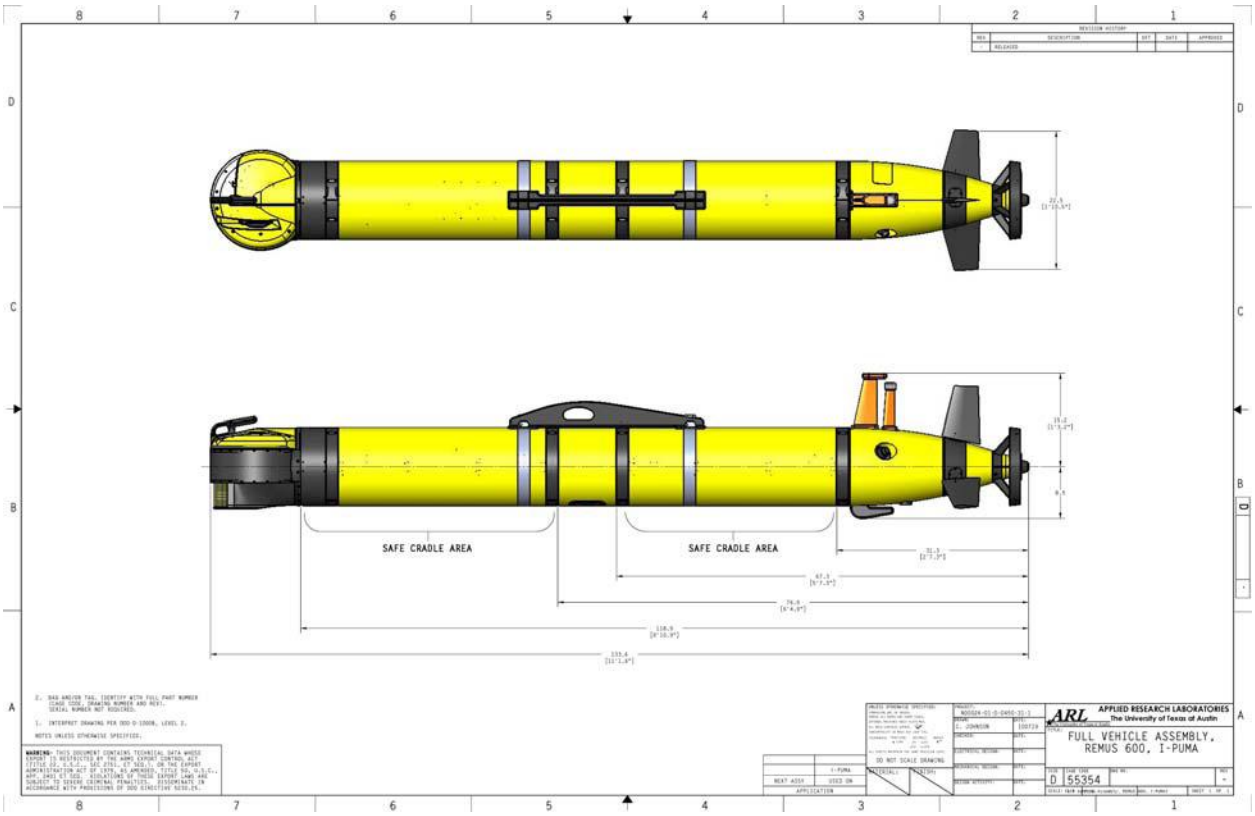

FIGURE 3. ARL:UT's modified REMUS 600 outfitted with Synthetic Aperture Sonar Array (Image: ARL-UT).

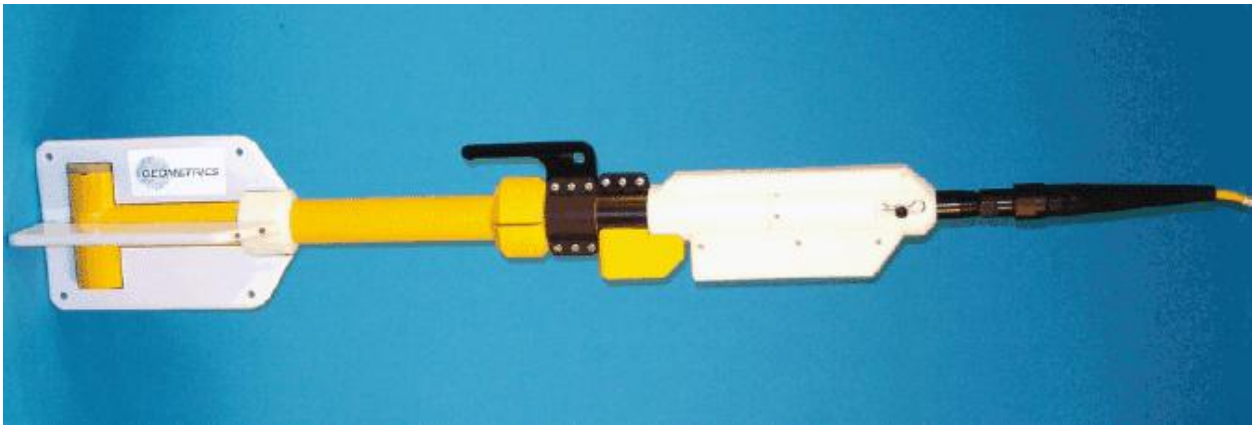

FIGURE 4. Geometrics G-882 Cesium Magnetometer (Image: Geometrics)

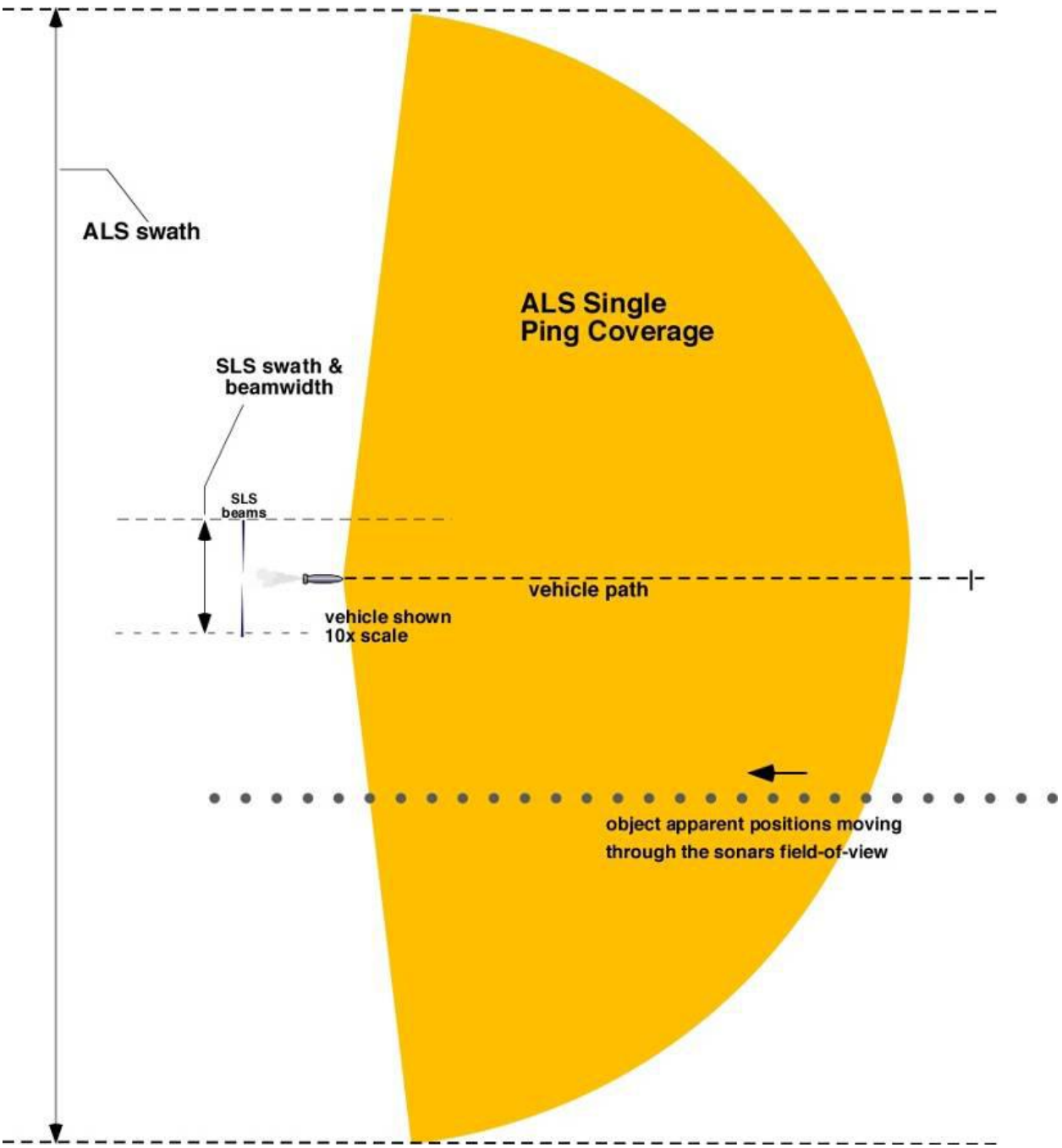

FIGURE 5. ALS Single-Ping Field of View and Swath Width (Image ARL-UT and ONR).

TABLE 2. Core scientific personnel for Stage 1 operations 31 May - 12 June 2011.

Name	Affiliation	Duties
Joseph Hoyt	NOAA MNMS	Stage coordination
Charles Loefler	ARL-UT	AUV and sonar overall coordination
Clinton Johnson	ARL-UT	AUV and sonar
Jonathan Hartjer	ARL-UT	AUV and sonar
Mark Story	ARL-UT	AUV and sonar
Nathan Richards	UNC-CSI & ECU	Primary magnetometry
John Bright	ECU	Secondary magnetometry
John McCord	UNC-CSI	Videography
Mark Fowler	Wildlife Prod.	Documentary Director

Stage 1 will focus on the area depicted in Figure 6. Search areas were determined according to the following data stream:

1. Data acquisition: Three components
    a. Collection of primary source historical data (transfer of coordinates from historical records into x, y coordinates that were imported into *ArcGIS* as point features). This data was annotated with tabular information relating to the events of the battle such as vessel name, position, date, and historical source.
    b. Acquisition of previously refined data from John Wagner's dataset (convoy route lines and event points were imported into *ArcGIS*). These exported polylines (shapefiles) were separate files including route location of vessels involved in the KS-520 convoy.
    c. Collection of open source government-sourced data (bathymetry, NC boundaries, and geo-rectified NOAA charts). These sources served as basemaps upon which later models were placed.
2. Data processing: 5 components
    a. NAD1927 projection. All datasets were projected according to the map datum used by the American Navy during 1942-1944 operations off North Carolina.

b. Sorting. Data from 1a was sorted by route points or attack events. The route points were then merged into line features using a Hawth's Tools extension. Line features were merged with route lines from 1b. Each line represented a hypothetical vessel route based on various historical sources.

c. Line Density Analysis. Data from 2b was subjected to a line density analysis. This analysis outputs a raster image coded by proximity of lines to one another. Areas of higher density were presumed more likely to represent the actual area of the attack and were thus used to prioritize search area designation.

d. Prioritization. Attack events from 1a and 1b were overlaid as point features on the density map to guide the placement and prioritization of search grids.

e. Determination of search grids. Search grids of 5 x 5 nautical miles were drawn, and placed in a matrix according to two factors. First, proximity to most reliable attack-related positions and density map areas, and second, according to bathymetric profiles within operational limits of remote sensing instrumentation.

3. Re-projection

a. The data-frame of the *ArcGIS* map was re-projected into the most recent geographical datum (WGS 84). This datum will be used during all phases of the summer 2011 survey.

At its maximum extent, this area is 30 by 30 nautical miles, with individual grids comprising a total of 675 square miles. Not all of this area will be surveyed during remote sensing, but quad numbering allows researchers to adjust survey strategy according to last minute alterations, or additional historical information.

Stage Two: Targeted Survey

Whereas the emphasis of Stage One is to cover a large area in order to increase the probability of locating the wreck sites, the goals of Stage Two focus on the relocation of discovered targets and their characterization with a different set of instrumentation. A proposal to record World War

Two hazardous wrecks has been prepared by John Kloske (SRI International) (see Kloske 2010), from which the following information has been sourced.

Similar to Stage One, Stage Two will rely upon the deployment of a remote sensing package integrated into a REMUS 600 AUV chassis (12-3/4" x 10') (Figure 7). This platform and its components are owned by SRI International (SRI). In this instance, the AUV will be deployed three times on each submerged cultural resource for the purpose of characterizing the target and debris within its general vicinity (approximately 500 by 500 meters). Dive one involves the deployment of an Imagenex Delta-T 260 kHz multibeam sonar for the purposes of collecting bathymetry and three-dimensional images (0.5-1.0m resolution) (Figure 8). Dive two will utilize a BlueView MB1350 (1.35 mHz) multibeam sonar for the purpose of creating more detailed three-dimensional images (Figure 9). Dive three will utilize an underwater mass spectrometer or polyaromatic hydrocarbon fluorometer for the purpose of determining each site's status as a potentially polluting shipwreck (PPW).

During the surveys, the AUV will undertake transects across the target area with a 50% sonar overlap to ensure adequate coverage. Multibeam data collected from wreck sites found during the survey will be combined into a single dataset (3D point cloud) which will culminate in a geo-rectified three-dimensional model.

The survey will prioritize sites discovered during Stage One. Due to multiple deployment and retrieval events, a maximum of two sites per day will be recorded (maximum 22 sites recorded). As previously mentioned, in the event that Stage One is unsuccessful in locating some or all of the KS-520 targets, archeological work will shift to document other Allied and Axis casualties from the greater conflict (Table 3). A breakdown of the components of this stage is shown in Table 4. The core scientific team required to operate aforementioned instrumentation is outlined in Table 5.

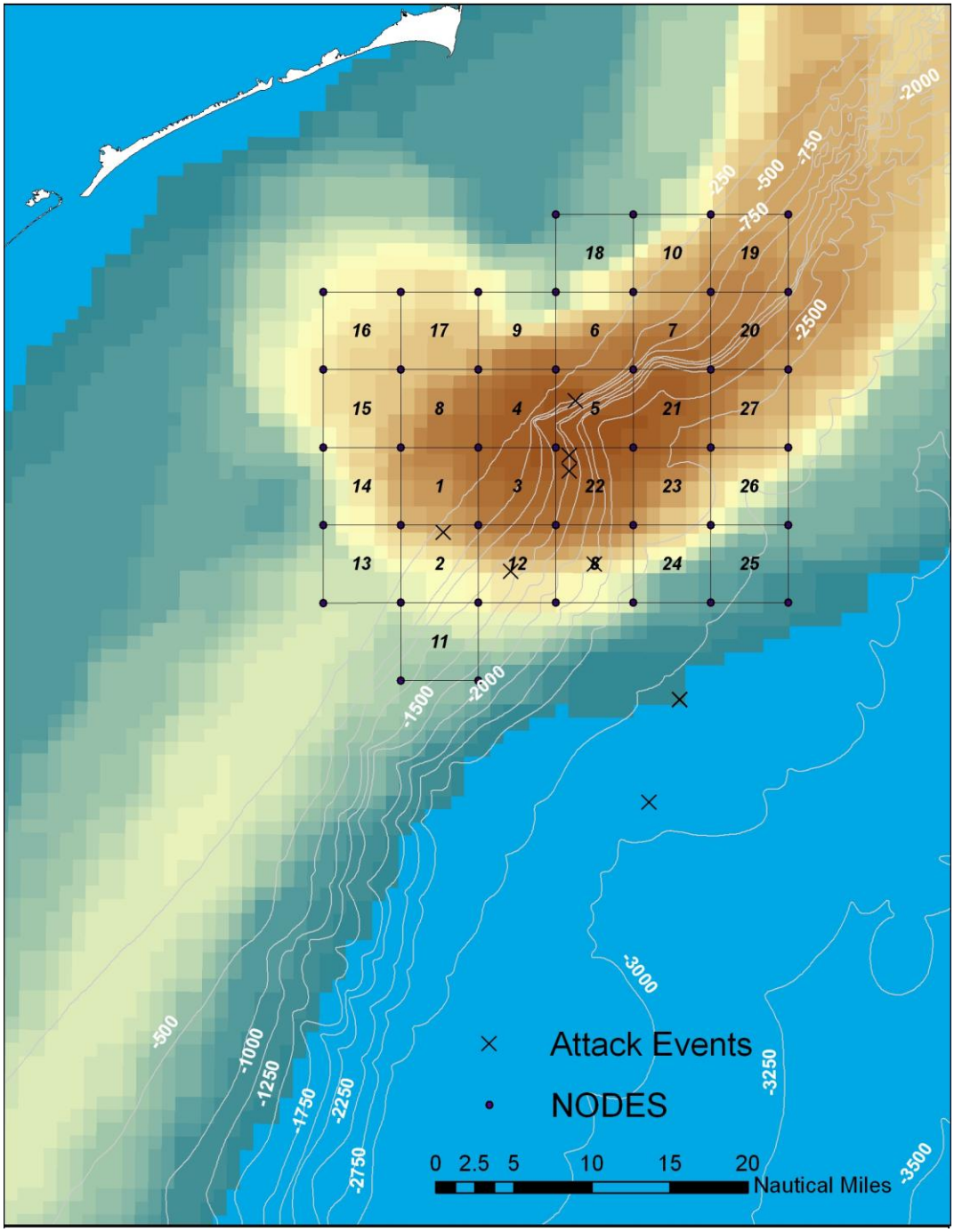

FIGURE 6. Prioritized survey areas (5 x 5 nautical miles) for stage 1 operations according to spatial density mapping. Soundings in meters represented in meters from sea-level (Image: John Bright).

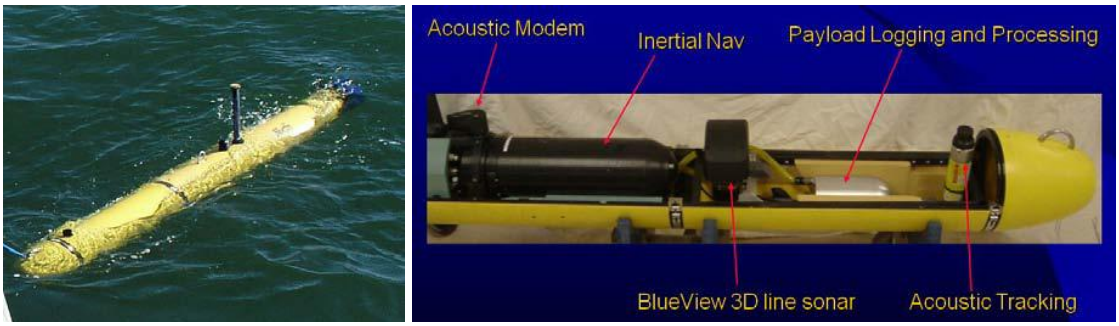

FIGURE 7. REMUS AUV used during Stage 2 survey (Kloske 2010:2)

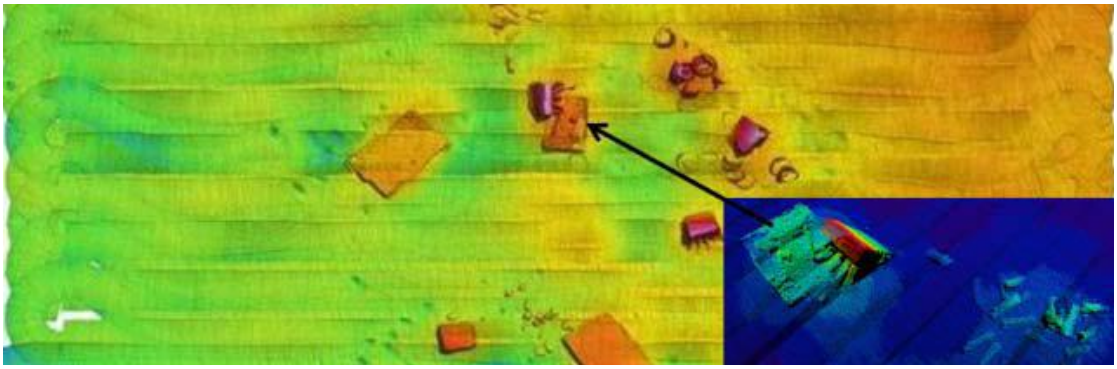

FIGURE 8. Example of Imagenex Delta T-260 kHz date from AUV (Kloske 2010:2)

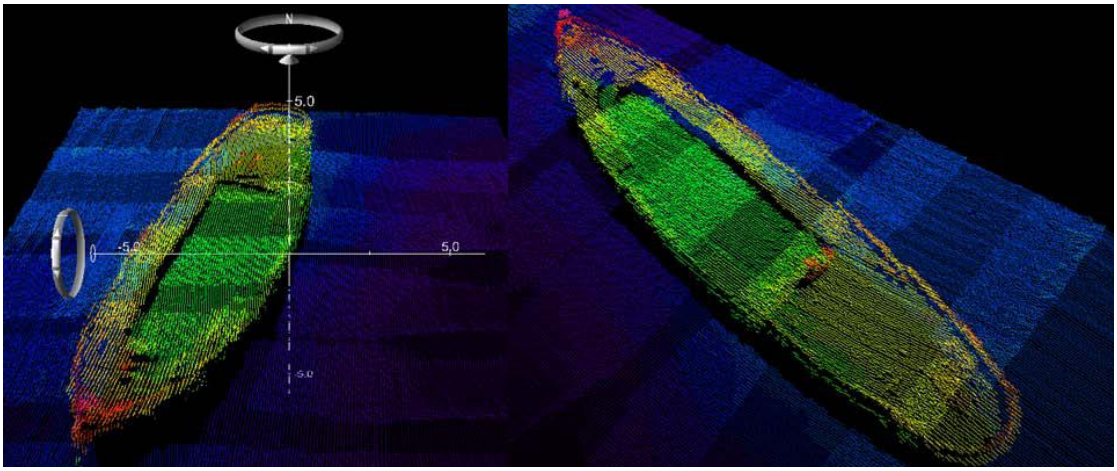

FIGURE 9. Example of imagery from BlueView MB1350 (1.35 mHz) multibeam sonar showing 20m long wreck (Kloske 2010:3)

TABLE 3. Prioritized list of sites for Stage 2 contingencies (by priority order).

Site name	Depth	Priority Order	Limitations	Location
Unknown targets	Variable	1	Unknown	Unknown
E.M. Clark	260’	2	High site relief	34 50.564 75 32.276
Empire Gem	150’	3	Wreck is upside down	35 01.831 75 28.630
YP-389	320’	4	Depth	Withheld

TABLE 4. Components of Stage 2 operation 11-24 June 2011.

Description	Begin date	End date	Duration	Location
Mobilization	11 June 2011	12 June 2011	2 days	Ocracoke, NC
Field operations	13 June 2011	22 June 2011	8 days	Ocracoke, NC
De-mobilization	23 June 2011	24 June 2011	2 days	Ocracoke, NC

TABLE 5. Core scientific personnel for Stage 2 operations 11-24 June 2011.

Name	Affiliation	Duties
Joseph Hoyt	NOAA MNMS	Stage coordination; Site determination
John Kloske	SRI	Survey Director and AUV operator
TBD survey tech	SRI	Survey Tech
TBD survey tech	SRI	Survey Tech
Nathan Richards	UNC-CSI & ECU	Site determination
John Bright	ECU	Site determination
John Wagner	NOAA RPT	Site determination
Andy Shepard	UNCW/CIOERT	Hydrocarbons and water sampling

Stage Three: High-resolution multibeam sonar survey

Following the completion of wide area assessments, the scientific team will return to selected targets for high-resolution site specific multibeam data. This system developed by ADUS, utilizing a pole-mounted Reson SeaBat 8125 (6mm depth resolution) (Figure 10 and 11), will allow the survey team to generate extremely detailed georectified 3D point cloud models of the

sites and render them in a visualization program that allows for three dimensional viewing and manipulation. The primary targets in this phase will be unknown targets identified during the wide area assessment (Table 6). In lieu of new targets for detailed mapping, we have developed a prioritized list of known targets for which we have little data.

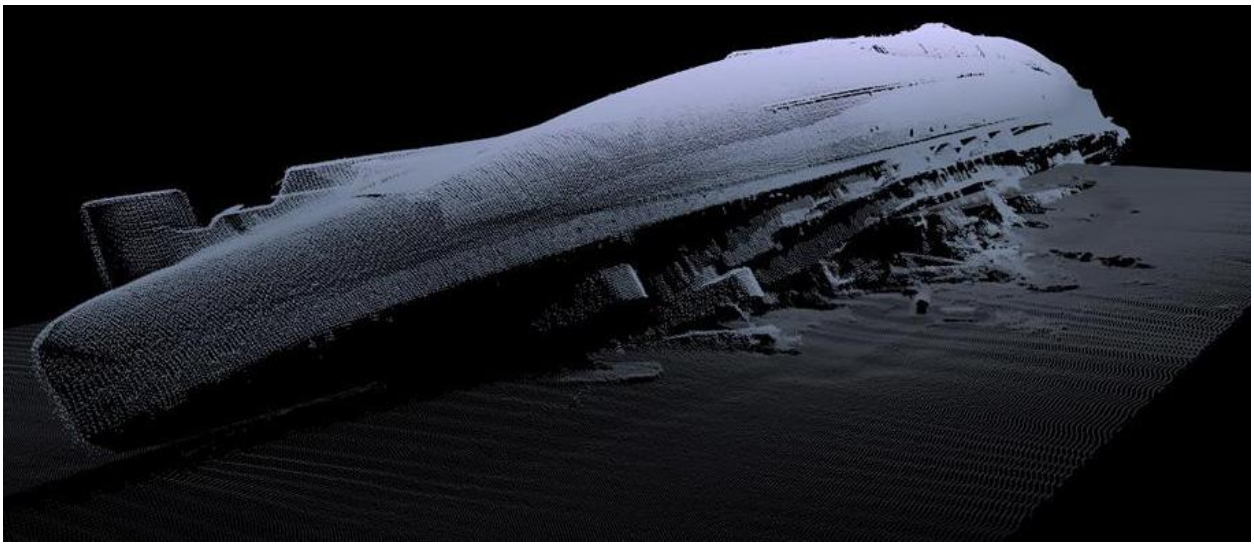

FIGURE 10. Results of 2006 multibeam survey of HMS *Royal Oak* (1939) (Image: ADUS).

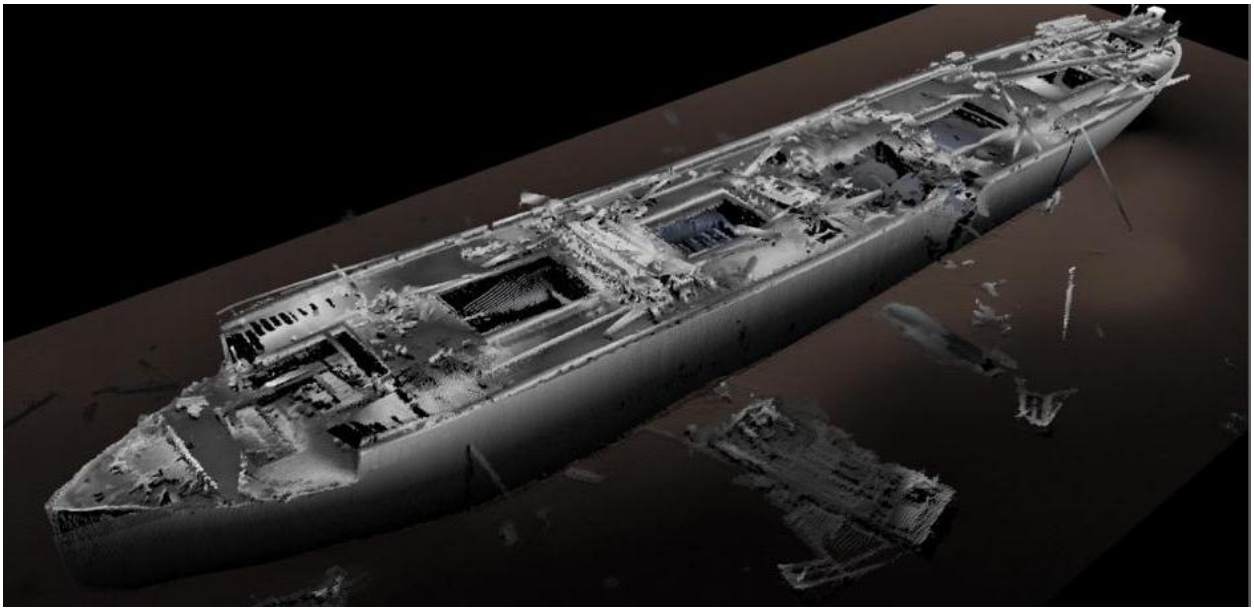

FIGURE 11. Results of 2010 multibeam survey of *Breda* (1940) (Image: ADUS).

This system will be pole mounted which limits the survey to approximate 60m (197 feet) of water. Sites deeper than this will lose resolution. Table 7 outlines specific components of Stage Three operations, and Table 8 outlines core scientific personnel.

TABLE 6. Prioritized list of sites for Stage Three contingencies (by priority order).

Site name	Depth	Priority Order	Limitations	Location
Unknown targets	Variable	1	Unknown	Unknown
U-701	120’	2	Current & sediment	35 14.330 75 06.690
Empire Gem	150’	3	High relief	35 01.831 75 28.630
U-85	95’	4	None	35 54.810 75 17.215
U-352	115’	5	None	34 13.670 76 33.890
Lancing	150’	6	Wreck is inverted	35 01.780 75 26.500
Keshena	80’	7	None	34 59.614 75 45.698
Chilore	70’	8	Shipping Lanes	36 57.503 76 00.036

TABLE 7. Components of Stage 3 operation 25 June – 8 July 2011.

Description	Begin date	End date	Duration	Location
Staging	25 June 2011	26 June 2011	2 days	Norfolk, VA (Nauticus)
Field operations	27 June 2011	7 July 2011	11 days	Hampton Roads (6/27) then Ocracoke, NC
De-mobilization	8 July 2011	8 July 2011	1 day	Ocracoke, NC

TABLE 8. Core scientific personnel for Stage 3 operations 25 June – 8 July 2011.

Name	Affiliation	Duties
Joseph Hoyt	NOAA MNMS	Stage coordination
Martin Dean	ADUS	Survey coordination
TBD Survey tech	ADUS	Survey coordination
TBD Survey tech	ADUS	Survey coordination
Nathan Richards	ECU	Site Determination
James Delgado	ONMS	Site Determination
David Alberg	ONMS	Site Determination

Stage Four: Three-dimensional visualization

Stage Four is the final in-water assessment that will be conducted by divers and an ROV (Figures 12 and 13). High Definition 3D video will be acquired in a format which will provide de-interlaced stereo pairs which can be exported from video files. These stereo pairs can be used for photogrammetric analysis and developing computer-aided design (CAD) models of individual artifacts and features. During this phase photomosaics of sites will be developed as well. Using a small penetration ROV, interior surveys will also be attempted. Here again, priority will be given to new targets identified during the wide area assessment. In the event no suitable targets are found or they lie in areas beyond the range of this technology, known sites will be prioritized and assessed (Table 9). Diving limits impose a 91 meter (300 foot) depth limit on sites. Site locations will be represented in *ArcGIS.* Table 10 outlines specific components of Stage Four operations, and Table 11 outlines core scientific personnel.

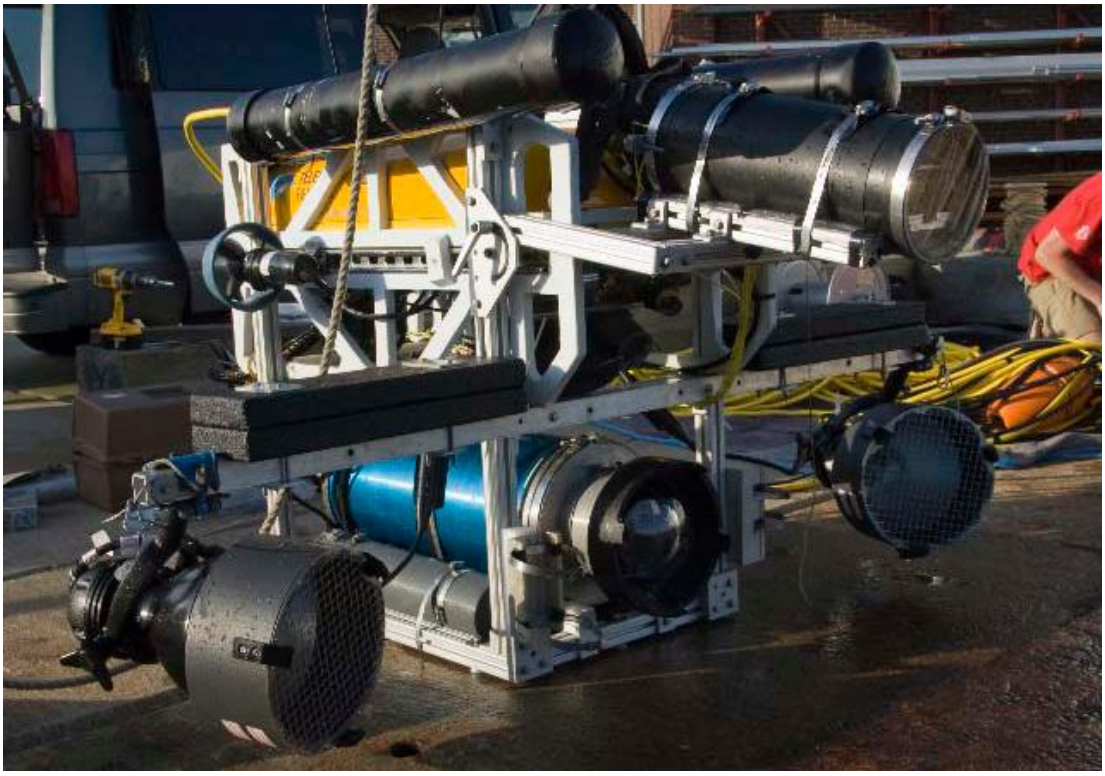

FIGURE 12. Modified Stingray ROV system with a 3D visualization payload (Image: WHOI:AIVL).

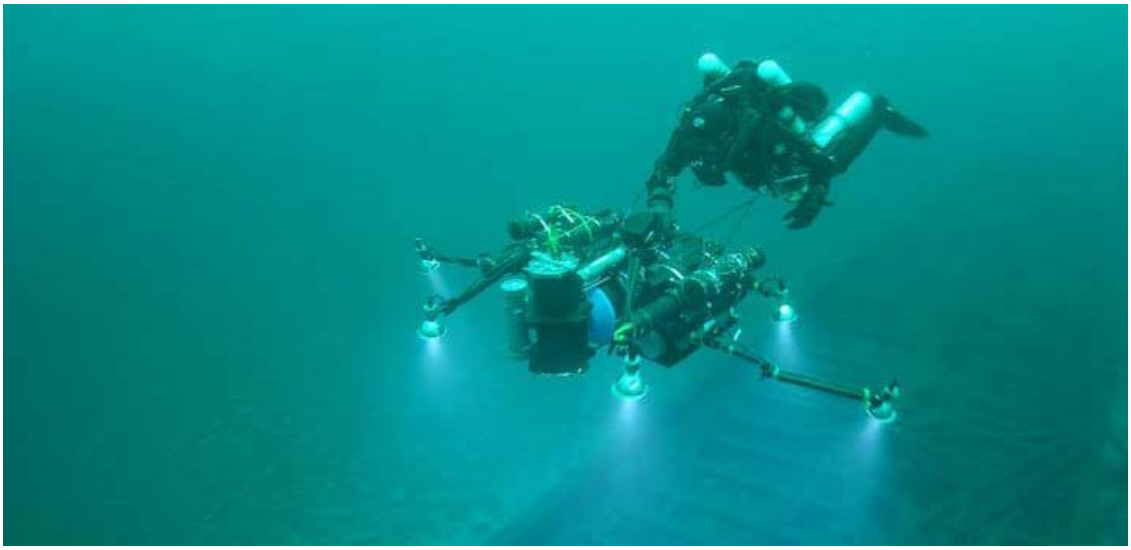

FIGURE 13. WHOI camera sled for 3D video and photomosaics (Image: WHOI:AIVL).

TABLE 9. Prioritized list of sites for Stage 4 contingencies.

Site name	Depth	Priority	Limitations	Location
Unknown targets	Variable	1	Unknown	Unknown
U-701	120’	2	Current & sediment	35 14.330 75 06.690
E.M. Clark	260’	3	High site relief	34 50.564 75 32.276
Empire Gem	150’	4	High relief	35 01.831 75 28.630
YP-389	320’	5	Depth	Withheld
U-85	95’	6	None	35 54.810 75 17.215
U-352	115’	7	None	34 13.670 76 33.890
Lancing	150’	8	Wreck is inverted	35 01.780 75 26.500
Keshena	80’	9	None	34 59.614 75 45.698

TABLE 10. Components of Stage 3 operation 1-14 August 2011.

Description	Begin date	End date	Duration	Location
Staging	1 August 2011	2 August 2011	1 day	Norfolk, VA
Field operations	2 August 2011	13 August 2011	11 days	Ocracoke, NC
De-mobilization	14 August 2011	14 August 2011	1 day	Ocracoke, NC

TABLE 11. Core scientific personnel for Stage 4 operations 1-14 August 2011.

Name	Affiliation	Duties
Joseph Hoyt	NOAA MNMS	Stage coordination
Bill Lange	WHO-AIVL	Director AIVL
Evan Kovacs	WHO-AIVL	Chief in-water 3D operator
Doug Kesling	UNCW-CIOERT	Diving Supervisor
TBD Technical Diver	UNCW-CIOERT	Dive Ops
TBD Technical Diver	UNCW-CIOERT	Dive Ops
TBD Safety Diver	UNCW-CIOERT	Dive Ops
TBD Safety Diver	UNCW-CIOERT	Dive Ops

Vessel Operations

The four stages of research will operate primarily out of Ocracoke Island, NC. This is the most convenient deepwater inlet to the study area. Some staging of equipment will occur in Norfolk, VA subject to the schedule of the research vessel. There will be a shore side facility on Ocracoke, NC for staging equipment and housing of VIPs and alternate researchers. All primary research operations will be self contained aboard the Office of National Marine Sanctuaries' R/V SRVx (Figure 14).

FIGURE 14. NOAA/ONMS R/V SRVx. Courtesy of NOAA.

The specifications of SRVx are:

- Design: Fiberglass sandwich core hull
- Length: 85 feet
- Beam: 23 feet
- Draft: 5 feet, 6 inches
- Speed at Best Efficient Power: 13 knots
- Speed at Full Power: 35 knots
- Max Displacement: 88 tons
- Fuel capacity: 3,500 gallons diesel
- Range (Efficient Power): 1,500 nautical miles
- Power: (2) 2,735 hp MTU World Engines
- Propulsion: Fixed-pitch propellers
- Ship Service Generator: (2) 32Kw
- Waste Water Capacity: 300 Gallons
- Fresh Water Capacity: 550 Gallons
- Max Day Scientists: 15
- Max Overnight Scientists: 8
- Crew: 3 (4 for 24-hour operations)

Remote sensing operations on board SRVx utilize the following deck equipment:

- Winch with 800 meters of 0.375" wire rope
- Winch with 450 meters of Rochester 0.322" conducting wire
- A-frame with block for 4,500 pounds at sea state 5; 12.5-foot clearance over cockpit deck; LCI-90 wire-out readout
- Knuckle boom crane for boat handling and cargo: 900 pounds of lift at full extension of 20feet; 4,000 pounds at close range
- Hydraulic "quick-connects" and deck mounts for use with itinerant winches and other equipment
- Electrical Power: 440/208 volt three-phase; 110 volt single-phase (15 amp)
- Saltwater and freshwater outlets

Analysis

Spatial data collected from archeological and historical sources will be imported into ESRI *ArcGIS*. Initially, the data analysis will focus upon management and arrangement of map layers and spatial features. Once both static and ephemeral battlefield elements are accurately represented, analysis will focus upon characterizing the hypothesized spatial extent of various

tactical features such as visibility, range of fire, extent of underwater listening and sonar equipment. Next, once these hypothetical spaces are represented, proximity of vessels, aircraft, and enemy craft can be analyzed *vis-a-vis* the METT-T and KOCOA protocols, utilizing spatial relationships to make inferences of battlefield decisions. Of particular interest is understanding the decision of *U-576* to attack. Concurrently, a yet to be named MA thesis project by Stephen Sanchagrin will incorporate historical and archeological data to construct battlefield visualizations.

In the primary phase of data analysis, static landscape elements, such as the location of coastal features (e.g. coastline, inlets and anchorages, bathymetry), the Hatteras minefield, and navigation aids, will be added as various layers. Natural coastal features are freely available online via numerous open source data clearinghouses, such as nationalatlas.com. Human placed static elements, like navigation aids and the Hatteras minefield, will be pulled from primary sources. Maps of the Hatteras minefield will be obtained, scanned, and imported into *ArcGIS* for geo-referencing. Next, ephemeral elements, such as the convoy route and escort tracks, will be plotted. These, in large part, can be derived from a combination of work completed in 2010 by John Wagner, and from collated primary source data.

The result will be a multi-layer data frame incorporating aircraft cover sectors, surface vessel positions, routing data, and submarine approach and attack positions superimposed upon a landscape of ocean contours, navigation aids, coastline, shoals, and inlets. An implicit temporal progression will be represented in the general north to south progression of vessels. An exception, of course, is the movement of damaged merchantmen *Chilore* and *J.A. Mowinckel* towards Hatteras Inlet following *U-576*'s attack.

Once all data has been input into a GIS, the METT-T and KOCOA analysis will begin first by defining the spatial extent of tactical features. For instance, an understanding of the range of both above water visibility (recorded in vessel logs) and underwater listening equipment, such as sonar and hydrophones, will be achieved by adding defined buffer zones around vessel point locations. The relationship between vessel positions, namely *U-576* in relation to convoy and

convoy escorts, and these detection envelopes will inform tactical questions regarding the ability of combatant vessels to detect one another and the selection of the submarine's approach and retreat paths. Ultimately, conclusions regarding the effectiveness of allied strategy, i.e. multi-escort anti-submarine convoy utilizing surface and aircraft escort, versus Axis strategy, total submarine warfare against enemy merchant vessels, will be gleaned from the tactical application of these strategies during the KS-520 convoy battle.

Additional analytical techniques include artifact density and patterning analysis, cumulative viewshed analysis, and other GIS-based techniques (see Carlson-Drexler 2009; De Meyer and Pype 2009; Heckman 2009; Sutherland and Richardson 2009). Spatial analysis of the discovered artifacts database will entail measurements within GIS to delimit their distribution, topology, and clustering. Discrete features will be analyzed to define a polygonal maximum envelope (area) of extent, center of distribution, and measures of spatial dispersion. Insofar as artifacts can be identified as to vessel or source, these measures can also be calculated by vessel. The pattern of artifacts measured in space allows the potential inference of tactical and physical events. The distance between objects, their relative orientation/direction from a presumed surface engagement and interspersion/juxtaposition of artifacts (comingled) can also be measured and reported.

Once the GIS dataset has been consolidated, it is possible that *Cumulative Viewshed Analysis*, a common analytical technique, may be attempted which will indicate how both sides of the conflict viewed the naval action from their various perspectives (see Carlson-Drexler 2009; Heckman 2009).

REFERENCES

Abbass, D. K.

2000 *Rhode Island Marine Archeology Project Field Report: A Brief Report on the RIMAP Investigation of the Fleet of Ships Lost in Rhode Island During the American Revolution*. Rhode Island Marine Archeology Project, Newport.

Adams, Christopher D., Diane E. White, and David M. Johnson

1999a *Dark Canyon Rancheria Apache/Military Battle Site.* Lincoln National Forest, Alamogordo, NM.

1999b *Last Chance Canyon 1869 Apache/Calvary Battle Site, Lincoln National Forest, New Mexico*. Lincoln National Forest Heritage Program, Alamogordo, NM.

Alexander, Lawrence S., and Elsa Heckman

2002 *Archeological and Historical Survey and Preparation of a Battlefield Protection Plan for the Western Perimeter of the Lookout Mountain Battlefield, Hamilton County, Tennessee*. Alexander Archeological Consultants, Chattanooga TN.

Allegood, J.

2004 The U-boat, *News and Observer*, December 5, 2004.

Arnold, J.B. III, T.J. Oertling, and A.W. Hall

1999 The Denbigh Project: Initial observation on a Civil War blockade-runner and its wreck site. *International Journal of Nautical Archeology* 28(2):126-44.

2001a The Denbigh Project: Excavation of a Civil War blockade-runner. *International Journal of Nautical Archeology* 30(2):231-249.

2001b The Denbigh Project: Test excavations at the wreck of an American Civil War blockade-

runner. *World Archeology* 32(3):400-412.

Arnold, J.B. III, C.P. Weldon, G.M. Fleshman, C.E. Peterson, W.K. Stewart, and G.P. Watts

1992 USS *Monitor*: Results from the 1987 season. *Historical Archeology* 26(4):47-57.

Babits, Lawrence E., Christopher T. Ephenshade, and Sarah Lowry

2010 Battlefield Analysis: Six Maritime Battles in Maryland, Revolutionary War and War of 1812. Report to Maryland Historical Trust, Crownsville, MD, from New South Associates, Stone Mountain, GA.

Balicki, Joseph

2009 The Confederate cantonment at Evansport, Virginia, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War,* Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 255-277. Potomac Books Inc., Dulles, VA.

Bedell, John

2005 *Archeological and Historical Investigations of the Buckland Mills Battlefield, Buckland, Virginia.* The Louis Berger Group, Inc., Washington, D.C. GA-2255-04-001

Bevan, Bruce M.

1999 *A Geophysical Survey on the Spackman Farm, Brandywine Battlefield National Historic Landmark.* Geosite, Weems, VA.

Birch S., and D.M. McElvogue

1999 *La Lavia, La Juliana* and the *Santa Maria de Vision*: Three Spanish Armada transports lost off Streedagh Strand, Co Cligo: An interim report. *International Journal of Nautical Archeology* 28:265-76.

Blair, Clay

1996 *Hitler's U-Boat War: The Hunters, 1939-1942*. Random House, New York, NY.

2000 *Hitler's U-boat War: The Hunted, 1942-1945*. Random House, New York, NY.

Blake, Samuel

2006 A Comparative Study of the Effectiveness of German Submarine Warfare on the Eastern Seaboard of the United States in the World Wars. Master's Thesis, Department of History, East Carolina University, Greenville, NC.

Bratten, John R.

1996 The Continental Gondola *Philadelphia*: A new look at American's oldest surviving warship. In *Underwater Archeology: Proceedings form the Conference on Underwater and Historical Archeology,* S.R. James Jr., and C. Stanley, editors, pp.112-116. Cincinnati, Ohio.

2002 *The Gondola Philadelphia and the Battle of Lake Champlain*. Texas A&M Press: College Station.

Brennecke, Jochen

2003 *The Hunters and the Hunted: German U-boats, 1939-1945*. Bluejacket Books, Naval Institute Press, Annapolis, MD.

Brent, Joseph E., and W. Stephen McBride

1996 *Conflict, Occupation and Contraband: Corinth Mississippi in the Civil War.* Mississippi Department of Archives and History, Jackson.

Brent, Joseph E., Maria Campbell Brent, E. Stephen McBride, W. Hunter Lesser

2010 *The Camp Elkwater Project, Randolph County, West Virginia.* Mudpuppy & Waterdog, Inc., and McBride Preservation Services. GA-2255-08-018

Bright, John C.

2011 Stalking the Gray Wolf: A KOCOA Terrain Analysis of the Battle of the Atlantic off the North Carolina Coast. Master's Thesis Prospectus, Department of History, East Carolina University, Greenville, N.C.

Broadwater, John D.

1980 The Yorktown Shipwreck Archeological Project: Results from the 1978 survey. *International Journal of Nautical Archeology* 9(3):227-35.

1992 Shipwreck in a swimming pool: An assessment of the methodology and technology utilized on the Yorktown Shipwreck Archeological Project. *Historical Archeology* 26(4):36-46.

2011 Naval battlefields as cultural landscapes in *Historical Archeology of Military Sites*, Clarence R. Geier, Lawrence E. Babits, Douglas D. Scott and David Orr, editors, pp. 165-176. Texas A&M University Press, College Station.

Broadwater, John D., R.M. Adams, and M. Renner

1985 Yorktown shipwreck archeological project: An interim report on the excavation of shipwreck 44YO88. *International Journal of Nautical Archeology and Underwater Exploration* 14:301-14.

Brown, David K.

2007 *Atlantic Escorts: Ships, Weapons & Tactics in World War II*. Naval Institute Press, Annapolis, MD.

Bunch, Jim W.

2003 Germany's *U-85*: A Shadow in the Sea; A Diver's Reflections. Deep Sea Press, Nags Head, NC.

Burt, Richard, James Bradford, Bruce Dickson, Mark E. Everett, Robert Warden, David Woodcock

2009 Point-du-Hoc Battlefield, Normandy, France, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War,* Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 383-397. Potomac Books Inc., Dulles, VA.

Butler, Scott

2008 *Battlefield Survey and Archeological Investigations at the Eutaw Springs, South Carolina Revolutionary War Battleground* (8 *September* 1781). The Flank Company, Atlanta, GA. GA2255-05-007

Cannell, Kevin G.

2005 *Archeological Inventory of the Clearwater Battlefield*. Nez Perce Tribe Cultural Resource Program, Nez Perce, ID.

Carman, John and Patricia Carman

2009 Mustering Landscapes: What Historic Battlefields Share in Common, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War,* Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 39-49. Potomac Books Inc., Dulles, VA.

Carr, Robert S., Mark Lance, and W.S. Steele

2002 *An Archeological Assessment and Boundary Determination of the Okeechobee*

Battlefield, Okeechobee County, Florida. Archeological and Historical Conservancy, Miami, FL.

Carson-Drexler, Carl G.

2009 Finding battery positions at Wilson's Creek, Missouri, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War,* Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 58-74. Potomac Books Inc., Dulles, VA.

Casserley, Tane, Nathan T. Richards, and Joseph C. Hoyt

2008 Battle of the Atlantic 2008 Expedition: Expedition Research Design. NOAA National Marine Sanctuaries, Newport News, VA.

Cheatham, James T.

1990 *The Atlantic Turkey Shoot: U-Boats off the Outer Banks in World War II*. Delmar Printing Company, Charlotte, NC.

1994 The U-Boat War off the Outerbanks. In *To Die Gallantly: The Battle of the Atlantic*, Timothy J. Runyan and Jan M. Copes, editors, pp. 158-165.Westview Press, Boulder, CO.

Church, R., D. Warren, R. Cullimore, L. Johnson, W. Schroeder ,W. Patterson, T. Shirley, M. Kilgour, N. Morris, and J. Moore

2007 *A Study of Living History: Deep WWII Shipwrecks in the Gulf of Mexico.* PAST Foundation, Columbus, OH.

Cohn, Arthur B., Adam I. Kane, Christopher R. Sabick, Edwin R. Scollon, and Justin B. Clement

2007 *Valcour Bay Research Project: 1999-2004 Results From the Archeological Investigation of a Revolutionary War Battlefield in Lake Champlain, Clinton County, New York-Final Report*. Lake Champlain Maritime Museum, Vergennes, VT.

Conlin, David L., and Matthew A. Russell

2006 Archeology of a Naval Battlefield: *H.L. Hunley* and USS *Housatonic*. *The International Journal of Nautical Archeology* 35(1): 20-40.

2011 Maritime Archeology of Naval Battlefields in *Historical Archeology of Military Sites*, Clarence R. Geier, Lawrence E. Babits, Douglas D. Scott and David Orr, editors, pp. 39-56. Texas A&M University Press, College Station.

Cruse, J. Brett, Patricia Mercado-Allinger, Douglas D. Scott, and Pamela Folds

2000a *The Red River War Battle Sites Project, Phase 1*. Archeology Division, Texas Historical Commission, Austin.

2000b *The Red River War Battle Sites Project, Phase 2*. Archeology Division, Texas Historical Commission, Austin.

Cubbison, Douglas R., Lawrence S. Alexander, James Moore, and Charles R. Brown

1998 *Newtonia Battlefields Archeological Survey*. Newtonia Battlefields Protection Association, Newtonia, MO.

Dasovitch, Steve and Walter Busch

2009 Fort Davidson Battlefield, Missouri, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 278-313. Potomac Books Inc., Dulles, VA.

Damp, Jonathan E.

2005 *The Battle of Hawikku: Archeological Investigations of the Zuni-Coronado Encounter at Hawikku, the Ensuing Battle, and the Aftermath During the Summer of 1540*. Zuni Cultural Resource Enterprise, Zuni, NM.

Dautartas, Angela M., C. Clifford Boyd, Jr., and Rhett B. Herman, Robert C. Whisonant

2005 *A Research Design for the Investigation of the Battles of Saltville on October 2nd,* 1864, *and December 20th,* 1864. Radford University, Virginia. GA2255-04-007

Davis, W.C.

1975 *Duel between the first ironclads.* Stackpole Books: Mechanicsburg, PA.

Delgado, James P.

1996 *Ghost Fleet: The Sunken Ships of Bikini Atoll*. University of Hawaii Press, Honolulu.

Delgado, James P., Daniel J. Lenihan and Larry E. Murphy

1991 *The Archeology of the Atomic Bomb: A submerged cultural resources assessment of the sunken fleet of Operation Crossroads at Bikini and Kwajalein Atoll Lagoons*. Southwest Cultural Resources Center Professional Papers No. 37. U.S. Department of the Interior, National Park Service, Santa Fe, NM.

DeRegnaucourt, Tony, and Barbara Meiring

2001 *A Report on the Archeological and Historical Evaluation of the 1790's Historic Indian Battlefield, Fort and Camp Survey of Northwest Ohio*. Fort Recovery Historical Society, OH.

Dixon, Boyd, Robert Rogers, and Laura Acuna

2003 *Archeological Investigation at the Resaca de la Palma Battlefield National Historic Landmark, Site 41CF3, City of Brownsville, Cameron County, Texas*. PBS&J, Austin, TX.

Eastern Sea Frontier (ESF)

1943 War Diary Eastern Sea Frontier, September. Records Relating to Naval Activity During World War II, World War II War Diaries, East Sea Fron Jun 42 to Sept 43, Records of the Office of the Chief of Naval Operations, box 335, Record Group 38, National Archives at College Park, College Park, MD.

Eckroth, David, and Harold Hagen

2004 *Baker's Battle on the Yellowstone, August 14, 1872*. Frontier Heritage Alliance, Billings, MT.

Elliot, Daniel T.

2004 *Ebenezer Revolutionary War Headquarters: A Quest to Locate and Preserve.* The LAMAR Institute, Inc., Box Springs, GA.

2005a *Sansavilla Bluff: Survey at the Crossroads of the Colonial Georgia Frontier*. The LAMAR Institute, Inc., Box Springs, GA.

2005b *Sunbury Battlefield Survey*. The LAMAR Institute, Inc., Box Springs, GA.

Emerson, Stephen

2006 *Steptoe (Tohotonimme) Battlefield Survey*. Archeological and Historical Services, Eastern Washington University, Cheney.

2008 *Walla Wall (Frenchtown) Battlefield Survey, Walla Walla County, Washington*. Archeological and Historical Services, Eastern Washington University, Cheney.

Farb, Roderick M.

1992 *Shipwrecks: Diving the Graveyard of the Atlantic* 2ed. Menasha Ridge Press, Birmingham, AL.

Foard, Glenn

2009 English battlefields 991-1685: A review of problems and potentials, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War,* Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 133-159. Potomac Books Inc., Dulles, VA.

Frank, Wolfgang

1955 *The Sea Wolves: The complete story of German U-Boats at war,* Lt.Cmdr. R.O.B. Long, translator. Ballantine Books, New York, NY.

Fonzo, Stephen

2008 *A Documentary and Landscape Analysis of the Buckland Mills Battlefield (VA042).* Buckland Preservation Society, Gainesville, VA.

Freeman, Phillip

2011 History, archeology, and the Battle of Balaclava (Crimea, 1854), in *Historical Archeology of Military Sites*, Clarence R. Geier, Lawrence E. Babits, Douglas D. Scott and David Orr, editors, pp. 149-164. Texas A&M University Press, College Station.

Freeman, Robert H. (editor)

1987 *War Diary: Eastern Sea Frontier: January to August 1942.* Shellback Press, Ventnor, NJ.

Fryman, Robert J.

1995 *Engaged the Enemy Again: An Assessment of the 1862 and 1864 Civil War Battlefields at Newtonia, Missouri*. Garrow & Associates, Inc., Atlanta, GA.

GAI Consultants, Inc., and Hardlines Design Company

2007 *Fort Ethan Allen Cultural Landscape Documentation Report, Arlington, Virginia.* GAl Consultants, Inc., and Hardlines Design Company, Homestead, PA. GA-2255-05-001

Galecki, Brian

2005 *Rum Runners, U-Boats, & Hurricanes*: *The Complete History of the Coast Guard Cutters Bedloe and Jackson.* Pine Belt Publishing, Wilmington, NC.

Gannon, Michael

1990 *Operation Drumbeat: The Dramatic True Story of Germany's First U-Boat Attacks Along the American Coast in World War II*. Harper & Row Publishers, New York, NY.

1998 *Black May: The Epic Story of the Allies' Defeat of the German U-boats in May 1943*. Harper Collins, New York, NY.

Gibson, Charles Dana

1986 *Merchantman? Or Ship of War*. Ensign Press, Camdem, ME.

Gould, Richard A.

1990 *Recovering the Past.* University of New Mexico Press, Albuquerque.

Geier, Clarence R., Lawrence E. Babits, Douglas D. Scott, and David G. Orr

2011 " 'The time has come' theWalrus said, 'To talk of many things …' " in *Historical Archeology of Military Sites*, Clarence R. Geier, Lawrence E. Babits, Douglas D. Scott and David Orr, editors, pp. vii-ix. Texas A&M University Press, College Station.

Gentile, Gary

1989 *Track of the Grey Wolf: U-Boat Warfare on the U.S. Eastern Seaboard 1942-1945*. Avon Books, NY.

1992 *Shipwrecks of North Carolina from Hatteras Inlet South*. Gary Gentile Productions, Philadelphia, PA.

1993 *Shipwrecks of North Carolina from the Diamond Shoals North*. Gary Gentile Productions, Philadelphia, PA.

2006 *The Fuhrer's U-boats in American Waters*. Bellerophon Bookworks, Philadelphia, PA.

Graves, Michael W., Frank Cantelas, and Suzanne S. Finney

1999 *The Identification and Documentation of a Civil War Shipwreck thought to be Sunk by the CSS Shenandoah in April 1865*. Pohnpei State Historic Preservation Office, Pohnpei.

Green, Russell T.

2002 *The Devereaux Cove Vessel and the Penobscot Expedition of 1779: Historical and Archeological Interpretation of Vessel Remains at Devereaux Cove, Stockton Springs, Maine*. Department of History, East Carolina University, Greenville, NC.

Greene, Jerome A.

1998 *Reconnaissance Survey of Indian-US Army Battlefields of the Northern Plains*. National Park Service, Cultural Resources and the National Register Program Services, Intermountain Support Office, Denver, CO.

Grove, Eric J. (editor)

1997 *The Defeat of the Enemy Attack on Shipping 1939-1945*. Ashgate Publishing Company, Brookfield, VT.

Haecker, Charles, Elizabeth A. Oster, Angélica Medrano Enríquez and Michael L. Elliot

2009 Indian resistance in New Spain: the 1541 AD battlefield of Peñol de Nochistlán, an exemplar of Indian resistance in *Fields of Conflict: Battlefield Archeology from the*

Roman Empire to the Korean War, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 174-192. Potomac Books Inc., Dulles, VA.

Haecker, Charles M.

2003 *An Historical Archeological Perspective of the Battlefield of Palmito Ranch, The Last Conflict of the Great Rebellion*. Brownsville Community Foundation, Inc., Brownsville, TX.

Hague, Arnold

2000 *The Allied Convoy System 1939-1945: Its Organization, Defence and Operation*. Naval Institute Press, Annapolis, MD.

Hanna, William F.

2011 Geophysics: Some recommendations and applications, in *Historical Archeology of Military Sites*, Clarence R. Geier, Lawrence E. Babits, Douglas D. Scott and David Orr, editors, pp. 11-20. Texas A&M University Press, College Station.

Heckman, Elsa

2009 Battlefield viewsheds, or what the general saw: Lookout Mountain Battlefield, Chattanooga, Tennessee, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 75-83. Potomac Books Inc., Dulles, VA.

Hickam, Homer

1989 *Torpedo Junction: U-Boat War off America's East Coast, 1942*. United States Naval Institute, Annapolis, MD.

Holtzer, H., and T. Mulligan (editors)

2006 *The Battle of Hampton Roads: New perspectives on the USS* Monitor *and CSS* Virginia. Fordham University Press, New York, NY.

Howarth, Stephen, and Derek Law (editors)

1994 *The Battle of the Atlantic 1939-1945: The 50th Anniversary International Naval Conference*. Naval Institute Press, Annapolis, MD.

Hoyt, Edwin P.

1978 *U-Boats Offshore: When Hitler Struck America*. Stein and Day, Briarcliff Manor, NY.

1984 *The U-Boat Wars*. Arbor House, New York, NY.

1987 *U-Boats*. McGraw-Hill Book Company, New York.

Hoyt, Joseph C.

2009 Final Project Instructions for 2009 'Battle of the Atlantic' Remote Sensing Expedition (Cruise Number: NF-09-12, August 4-9, 2009). Proposal to NOAA Marine Operations Center-Atlantic, Manuscript on file.

2010 Battle of the Atlantic Research Expedition 2010 (8 June – 30 June): Archeological Survey and Operations Plan. NOAA National Marine Sanctuaries, Newport News, VA.

Hughes, Terry, and John Costello

1977 *The Battle of the Atlantic.* The Dial Press/James Wade, New York, NY.

Hunter, James W. III

2004 The Phinney Site: The remains of an American armed vessel scuttled during the Penobscot Expedition of 1779. *International Journal of Nautical Archeology* 33(1):67-78.

Ireland, Bernard

2003 *Battle of the Atlantic*. Naval Institute Press, Annapolis MD.

Jaeger Company

2004 *Atlanta Campaign Historic Resources Survey Phase I*. Historic Preservation Division, Georgia Department of Natural Resources, Atlanta.

Jeffery, William

2004 World War II underwater cultural heritage sites in Truk Lagoon: considering a case for World Heritage listing. *International Journal of Nautical Archeology* 33(1):106-121.

Johnson, David M.

2009 Apache victory against the U.S. Dragoons, the Battled of Cieneguilla, New Mexico, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 235-254. Potomac Books Inc., Dulles, VA.

Johnson, David M., and Chris Adams

2004 *The Battle of Cieneguilla: A Jicarilla Apache Victory over the United States Dragoons Near Taos, New Mexico, March 30, 1854*. Carson National Forest/Lincoln National Forest, NM.

Johnson, Matthew

2007 *Ideas of landscape*. Blackwell Publishing, Oxford, United Kingdom.

Kaplan, Philip, and Jack Currie

1997 *Wolfpack: U-Boats at War 1939-1945*. Naval Institute Press, Annapolis, MD.

1998 *Convoy: Merchant Sailors at War 1939-1945*. Naval Institute Press, Annapolis, MD.

Kemp, Paul

1997 *U-Boats Destroyed: German Submarine Losses in the World Wars*. Naval Institute Press, Annapolis, MD.

Kenny, Kathleen M. and John G. Crock.

2010 *Historical Survey, Property Survey, and ABPP Documentation Project, Hubbardton, Rutland County, Vermont.* Consulting Archeology Program, University of Vermont. GA-2255-08-028

Kloske, John

2010 WW2 hazardous wreck surveys, SRI proposal for research 10-MAROPS-01. Proposal for NOAA's Monitor National Marine Sanctuary, on file at Monitor National Marine Sanctuary, Newport News, VA.

Kozak, C.

2004 Scuba diving thieves plunder rare unspoiled WWII submarine wreck *U-701*. *Virginia Pilot*, 8 September 2004.

Lawhon, Katie

2002 Gettysburg the Way the Soldiers Saw it in 1863. *Cultural Resource Management (CRM)* 4:36-39.

LaLande, Jeff

2004 *Report on an Archeological Survey of the Wheeler Ridge 1942 Japanese Aerial-Bombing Site*. Rogue River-Siskiyou National Forest, Medford, OR.

Legg, James B. and Steven D. Smith

2009 Salvaging data from a heavily collected battlefield, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 208-234. Potomac Books Inc., Dulles, VA.

Legg, James B., Steven D. Smith, and Tamara S. Wilson

2005 *Understanding Camden: The Revolutionary War Battle of Camden As Revealed Through Historical, Archeological, and Private Collections Analysis*. South Carolina Institute of Archeology and Anthropology, Columbia.

Lowe, David W., compiler

2000 *Battlefield Survey: American Battlefield Protection Program.* Unpublished manuscript, American Battlefield Protection Program, National Park Service.

MacIntyre, Donald

1961 *The Battle of the Atlantic*. BT. Batsford Ltd. London.

1971 *The Naval War Against Hitler*. Charles Scribner's Sons, New York, NY.

Mandry, Adrian

2009 Tatar, Cossacks, and the Polish Army: The battle of Zboriv, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 193-207. Potomac Books Inc., Dulles, VA.

Mangum, Douglas G. and Roger G. Moore

2010 *Archeological Investigations at the NRG Property, Harris County, Texas.* Moore Archeological Consulting, Inc.GA-2255-06-008

Martin, Colin and G. Parker

1999 *The Spanish Armada.* W.W. Norton, New York, NY.

McBride, Kevin.

2009 *Research Design, Site Identification and Documentation, Battle of Mystic Fort.* Mashantucket Pequot Museum and Research Center. GA-2255-07-011

McBride, W. Stephen and Kim A. McBride

2011 Methods in archeology of colonial frontier forts: Examples from Virginia and West Virginia in *Historical Archeology of Military Sites*, Clarence R. Geier, Lawrence E. Babits, Douglas D. Scott and David Orr, editors, pp. 123-133. Texas A&M University Press, College Station.

McBride, Kevin and David Naumee.

2009a *Battle ofMystic Fort Documentation Plan.* Mashantucket Pequot Museum and Research Center. GA-2255-07-0112009b *Final Program Performance Report "Battle ofMystic Fort Documentation Plan.* Mashantucket Pequot Museum and Research Center. GA-2255-07-0112009c *Technical Report "Battle ofMystic Fort Documentation Plan.* Mashantucket Pequot Museum and Research Center. GA-2255-07-011

Miller, David

2000 *U-Boats: The Illustrated History of the Raiders of the Deep*. Brassey's, Washington, DC.

Miller, Orloff, and Rita Walsh

1995 *Preservation Plan and Archeological Surface for Big Blue (Byram's Ford) Battlefield, Jackson County, Missouri*. Gray and Pape, Cincinnati, OH.

Morison, Samuel Eliot

1947 *History of United States Naval Operations in World War II*, vol. 1, *The Battle of the Atlantic: September 1939-May 1943*. Brown Little, Boston, MA.

National Oceanic and Atmospheric Administration (NOAA)

2008 Battle of the Atlantic Expedition. National Oceanic and Atmospheric Administration's National Marine Sanctuaries < http://sanctuaries.noaa.gov/ missions/battleoftheatlantic/>. Accessed 20 October 2010.

2009 Battle of the Atlantic Expedition. National Oceanic and Atmospheric Administration's National Marine Sanctuaries < http://sanctuaries.noaa.gov/ missions/battleoftheatlantic2/welcome.html>. Accessed 20 October 2010.

2010 Battle of the Atlantic Expedition. National Oceanic and Atmospheric Administration's National Marine Sancturaries < http://sanctuaries.noaa.gov/missions/ 2010battleoftheatlantic/welcome.html>. Accessed 20 October 2010.

O'Dell, Kevin C., and James Powers

2008 *Final Technical Report (Pubic Version): Archeological Investigations at Fetterman Battlefield (48SH127), Sheridan County, Wyoming*. ACR Consultants, Inc., Sheridan WY.

Olson, Chris

1995 Investigations of the CSS *Curlew*: A victim of the Battle of Roanoke Island, North Carolina. In *Underwater Archeology: Proceedings from the Conference on Underwater and Historical Archeology*, P.F. Johnson, editor, pp. 28-33. Washington D.C.

Outlaw, Alain C., Robert A. Selig, and Mary B. Clemons

2010 *Investigations of the Spencer's Ordinary* (26 *June* 1781) *and Green Spring Battlefields* (6 *July* 1781), *James City County, Virginia.* Archeological and Cultural Solutions, Inc., Williamsburg, Virginia. GA 2255-08-009.

Palmer, Michael A.

2007 *Command at sea: Naval command and control since the sixteenth century*. Harvard University Press, Cambridge, MA.

Panamerican Consultants, Inc.

2005 *Archeology of the Civil War Naval Operations on the Ogeechee River, Georgia*. Panamerican Consultants, Inc., Memphis, TN.

Papatheodorou, G., M. Geraga and G. Ferentinos

2005 The Navarino Naval Battle Site, Greece—an integrated remote-sensing survey and a rational management approach. *International Journal of Nautical Archeology* 34(1):95-109.

Peebles, M.D.

1995 CSS *Raleigh:* The history and archeology of a Confederate ironclad in the Cape Fear River. In *Underwater Archeology: Proceedings from the Conference on Underwater and Historical Archeology*, P.F. Johnson, editor, pp. 20-27. Washington D.C.

Prange, G.W.

1986 *Pearl Harbor: The verdict of history.* McGraw-Hill, New York, NY.

Pratt, G. Michael

2000 *The Battle of Buffington Island: The End of Morgan's Trail*. Center for Historic and Military Archeology, Tiffin, OH.

2009 How do you know it's a battlefield?, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 5-38. Potomac Books Inc., Dulles, VA.

Pratt, G. Michael, and William E. Rutter

2007 *Archeological Assessment of Selected Areas of the River Raisin Battlefield, Monroe, Michigan*. The Mannik & Smith Group, Inc., Maumee, OH.

Pratt, G. Michael, William E. Rutter, and Richard Green

2010 *The River Raisin Battlefield: Outside the Core, Archeological Survey of Peripheral Battlefield Areas.* Center for Historic al1d Military Archeology, Heidelberg University, Tiffin Ohio - Historic Archeological Research, Inc., West Lafayette, Indiana. GA 2255-08-008

Pratt, G. Michael, William E. Rutter, Theodore Ligibel, and Jeffrey Green

2007 *The River Raisin Battlefield- Outside the Core: Identification and Threat.* Center of Historic and Military Archeology, Heidelberg University, Tiffin, Ohio. GA-2225-07-010

Pollard, Tony

2011 Dissecting seventeenth- and eighteenth-century battlefields: Two case studies from the Jacobite rebellions in Scotland in *Historical Archeology of Military Sites*, Clarence R. Geier, Lawrence E. Babits, Douglas D. Scott and David Orr, editors, pp. 99-111. Texas A&M University Press, College Station.

Reeves, Matthews, Mark A. Trickett

2009 *Landscape Inventory of Civil War Sites in the "North Woods* JJ, *James Madison's Montpelier and Cultural Resource Management Plan for their Preservation.* GA-2255-08-012

Reuwer, David, and Scott Butler

2000 *Archeological Investigations at the Eutaw Springs Revolutionary War Battlefield (38OR219), Orangeburg County, South Carolina*. Restore America's Revolutionary Era (RARE), Sumter, SC, and Brockington and Associates, Inc., Atlanta GA.

Richards, Nathan T. and Tom Allen

2009 The Battle of the Atlantic: an Archeological Site Management and Environmental Risk Assessment Proposal. Proposal to the Coastal Maritime Council, East Carolina University.

Riess, Warren and G. Daniel

1997 Evaluation of preservation efforts for the Revolutionary War privateer *Defence. International Journal of Nautical Archeology* 26(4):330-38.

Rodgers, Bradley A., Wendy Coble and Hans Van Tilburg

1998 The lost PBYs of Kaneohe Bay, Archeology of the first casualties of Pearl Harbor. *Historical Archeology* 32(4):4-16.

Rost, Achim

2009 Characteristics of ancient battlefields: The battle of Varus (9 AD), in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War,* Douglas Scott,

Lawrence E. Babits and Charles Haecker, editors, pp. 50-57. Potomac Books Inc., Dulles, VA.

Sands, J.O.

1983 *Yorktown's Captive Fleet.* University Press of Virginia, Charlottesville.

1988 Gunboats and warships of the American Revolution. In *Ships and Shipwrecks of the Americas: A history based on underwater archeology,* George F. Bass, editor, pp. 143-68. Thames and Hudson, London, United Kingdom.

Scheina, Robert L.

1982 *U.S. Coast Guard Cutters and Craft of World War II.* Naval Institute Press, Annapolis, MD.

Scott, Douglas D.

2011 Military medicine in the pre-modern era: Using forensic techniques in archeological investigations to investigate military remains in *Historical Archeology of Military Sites*, Clarence R. Geier, Lawrence E. Babits, Douglas D. Scott and David Orr, editors, pp. 21-29. Texas A&M University Press, College Station.

Scott, Douglas and Lucien Haag

2009 "Listen to the minié balls": Identifying firearms in battlefield archeology, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War,* Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 102-120. Potomac Books Inc., Dulles, VA.

Scott, Douglas, Lawrence E. Babits, and Charles Haecker (editors)

2009a Introduction, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, pp. 1-4. Potomac Books Inc., Dulles, VA.

2009b Conclusion: Toward a unified view of the archeology of fields of conflict, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, pp. 429-438. Potomac Books Inc., Dulles, VA.

Scott, Douglas, Richard A. Fox, Jr., Melissa A. Connor, and Dick Harmon

1989 *Archeological perspectives on the Battle of Little Bighorn*. Oklahoma University Press, Norman.

Showell, Jak Mallmann

2002 *U-Boat Warfare: The Evolution of the Wolf Pack*. Naval Institute Press, Annapolis, MD.

2006 *The U-Boat Century: German Submarine Warfare 1906-2006*. Naval Institute Press, Annapolis, MD.

Seibel, Scott, Terri Russ, and Matt Postlewaite

2008 *Archeological and King's Grant Research for the Battle ofBlack Mingo.* Environmental Services, Inc. Raleigh, North Carolina. GA-2255-08-004

Silverstein, Jay, John Byrd, and Lyle Otineru

2009 Hill 209: The last stand of Operation Manchy, Korea, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War,* Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 417-428. Potomac Books Inc., Dulles, VA.

Sivilich, Daniel M.

2009 What the musketball can tell: Monmouth Battlefield State Park, New Jersey, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 84-101. Potomac Books Inc., Dulles, VA.

Smith, Steven D., James B. Legg, Mark J. Brooks, and Tamara S. Wilson

2009 *Archeological Investigations on Little Folly Island.* South Carolina Institute of Archeology and Anthropology, Columbia.

Spirek, James D.

1993 The USS *Southfield*: An historical and archeological investigation of a converted gunboat. Master's Thesis, Department of History, East Carolina University, Greenville, NC.

Standard Oil Company

1946 *Ships of the Esso Fleet in World War II*. Standard Oil Company, New Jersey.

Stick, David

1952 *Graveyard of the Atlantic: Shipwrecks of the North Carolina Coast*. The University of North Carolina Press, Chapel Hill.

Sutherland, Tim, and Simon Richardson

2009 Arrows point to mass graves: Finding the dead from the battle of Towton, 1461AD, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 160-173. Potomac Books Inc., Dulles, VA.

Strezewski, Michael, James R. Jones III, and Dorothea McCullough

2006 *Archeological Investigations at Site 12-T-59 and Two Other Locations in Prophetstown State Park, Tippecanoe County, Indiana.* Indiana University, Perdue, University at Fort Wayne, Fort Wayne. GA-2255-04-004

Stull, Scott D.

2008 *Archeological Investigation Draft Report: Fort Hardy and the Field of Grounded Arms, Town of Saratoga, Saratoga County, New York (HAA-3425).* Hartgen Archeological Associates, Inc., Rensselaer, New York. GA-2255-04-010

Sutherland, Tim and Simon Richardson.

2009 Arrows point to mass graves: Finding the dead from the battle of Towton, 1461AD, in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 160-173. Potomac Books Inc., Dulles, VA.

Syrett, David

1994 *The Defeat of the German U-Boats: The Battle of the Atlantic*. University of South Carolina Press, Columbia.

Tankersley, Wm. Matthew, and Chris Espenshade

2007 *Archeological Survey of the Battle of Brown's Mill, Coweta County, Georgia*. New South Associates, Stone Mountain, GA.

United States Coast Guard (USCG)

1942 *Triton* (WPC-116) Deck Logs 1942, Logbooks, Record Group 26, National Archives

Building, Washington, DC.

United States Navy (USN)

1942a *Ellis* (DD-154) Deck Logs March 1942 to September 1942, Box 3085, Deck Logs 1941-1950, Record Group 24, National Archives at College Park, College Park, MD.

1942b *McCormick* (DD-223) Deck Logs July 1941 to September 1942, Box 5689, Deck Logs 1941-1950, Record Group 24, National Archives at College Park, College Park, MD.

1942c *Spry* (PG-64) Deck Logs May 2, 1942 to October 1943, Box 8501, Deck Logs 1941-1950, Record Group 24, National Archives at College Park, College Park, MD.

University of Hawaii at Manoa

2002 *Submerged Cultural Resources Survey of Kane'ohe Bay*. University of Hawaii, Manoa.

Veyrat, E. and M. L'Hour

1994 The wrecks of the Battle of La Hougue (1692): evidence of French shipbuilding in the Royal Dockyards. In *Underwater Archeology: Proceedings from the Conference on Underwater and Historical Archeology*, R.P. Woodward and C.D. Moore, editors, pp. 25-31. Vancouver, British Columbia.

Wagner, John

2010 *Waves of Carnage: A Historical, Archeological, and Geographical Study of the Battle of the Atlantic in North Carolina Waters.* Master's thesis, Department of History, East Carolina University, Greenville, NC. ProQuest LLC, Ann Arbor, MI.

Watson, Bruce Allen

2006 *Atlantic Convoys and Nazi Raiders: The Deadly Voyage of HMS* Jervis Bay. Praeger, Westport, CT.

Watts, Gordon P.

1998 *Mobile Bay Shipwreck Survey, Investigation and Assessment of Civil War Shipwrecks off Fort Morgan Point, Mobile, Alabama*. East Carolina University, Greenville, NC.

Watts, Gordon P. and Richard W. Lawrence

2003 *An Investigation and Assessment of Civil War Shipwrecks off Fort Fisher, North Carolina*. East Carolina University, Greenville, NC.

Weintraub, S.

1991 *Long day's journey into war: December 7, 1941.* Dutton, New York, NY.

Westwood, David

2003 *Anatomy of the Ship: The Type VII U-Boat*. Naval Institute Press, Annapolis, MD.

Whisonant, Robert C., C. Clifford Boyd, Jr., and Rhett B. Herman

2007 *The Civil War Battles for Saltville: Inventory and Assessment of Battlefield Resources Using GIS/GPS Technology*. Departments of Geology, Sociology and Anthropology, Radford, Virginia. GA-2255-04-007

White, David Fairbank

2006 *Bitter Ocean: The Battle of the Atlantic 1939-1945*. Simon & Schuster, New York, NY.

Wiggins, Melanie

1999 *U-Boat Adventures: Firsthand Accounts from World War II*. Naval Institute Press, Annapolis, MD.

Wilbers-Rost, Susanne

2009 Total Roman defeat at the Battle of Varus (9AD), in *Fields of Conflict: Battlefield Archeology from the Roman Empire to the Korean War*, Douglas Scott, Lawrence E. Babits and Charles Haecker, editors, pp. 121-132. Potomac Books Inc., Dulles, VA.

Williams, Andrew

2003 *The Battle of the Atlantic: Hitler's Gray Wolves of the Sea and the Allies' Desperate Struggle to Defeat Them*. Basic Books, New York, NY.

Williamson, Gordon

2010 *U-boat Tactics in World War II*. Osprey Publishing, Long Island City, NY.

Willoughby, Malcolm F.

1957 *The U.S. Coast Guard in World War II*. United States Naval Institute. Revised and reprinted 1989 by Naval Institute Press, Annapolis, MD.