THE BATTLE OF THE ATLANTIC EXPEDITION 2011:
THE BATTLE OF CONVOY KS-520
NORTH CAROLINA, 15 JULY 1942

FINAL REPORT

SUBMITTED TO:
United States Department of the Interior
National Parks Service
American Battlefield Protection Program
1201 Eye Street NW (2255)
Washington, DC 20005

GRANT NO. GA-2255-10-006

SUBMITTED BY:
John Bright
Nathan Richards, Ph.D.
Joseph Hoyt
John Wagner
Tom Allen, Ph.D.

JUNE 2012

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ABSTRACT

In the months following America's entry into World War II a protracted naval conflict waged between Axis U-boats and the merchant and Allied naval vessels along the U.S. eastern seaboard. At the center of this conflict were the waters off North Carolina, the closest the European theatre of war came to the Continental United States. By the end of August 1942, German submersibles had sunk or attacked 285 vessels in North American waters at the loss of only seven of their own. The area off North Carolina is, therefore, the only locale in US waters containing material representations of all participants in this conflict (Axis, Allied, and Merchant) within easily accessible recreational diving depths. In fact, sport and scientific divers have located and visited many of these sites for decades. Nevertheless, the location and state of preservation of many of thesubmerged cultural resources left in the wake of this naval conflict is, however, currently unknown. Building upon a previous study entitled, *The Battle of the Atlantic: An Archaeological Site Management and Environmental Risk Assessment Proposal* (Richards & Allen 2009, ECU Coastal Maritime Council), this project seeks to undertake a KOCOA military terrain analysis via the discovery and archeological assessment of sunken cultural resources associated with the North Carolina Theatre of the Battle of the Atlantic. In doing so, researchers also hope to commence the process of compiling a definitive archeological inventory to supplement historical records. In the process, this research will also serve to provide baseline evidence to initiate site preservation and interpretation activities and better define the boundaries of the conflict for future management and planning purposes.

This report outlines the results of Stages 1 and 2 of a 4-stage research expedition carried out during the summer of 2011. At the conclusion of acoustic survey, 293.892578 km² (113.472 mi²) of seabed had been inspected with 47 potential acoustic targets discovered, and one new shipwreck's location discovered and inspected. Details of these discoveries are outlined, followed by a KOCOA analysis of the KS-520 convoy battle (part of the greater Battle of the Atlantic) and concluding with recommendations regarding potential National Register eligibility.

ACKNOWLEDGEMENTS

This report would not have been possible without the deicated and diligent efforts of so many project collaborators and personnel. Mentioned throughout this report are the names of several federal, state, academic, and other agencies. The people working for these agencies brought a variety of essentially skills, expertise, and resources to the archaeological survey off the North Carolina coast. Enough thanks can be given to them for going above and beyond their responsibilities for the project. In particular, John McCord and David Sybert with UNC-CSI, David Alberg and Lauren Heesemann with NOAA-MNMS, Jim Delgado with NOAA MHP, Chris Horrell with BOEM, Clint with UT-ARL, John Kloske with SRI International, Martin Dean with ADUS, Bob Wallace, Jordan, and Pasquale with Cardinal Point Captains.

Additonal support for the project was provided by Stephen Sanchagrin, working with ECU and RENCI, by creating many of the 2-D and 3-D visualizations. Also, Dr. Lawrence Babits offered access to a wide array of historical sources, in addition to lending his own personal expertise on battlefield survey.

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GLOSSARY OF ACRONYMS

ABPP	American Battlefield Protection Program
ALS	Ahead-looking Sonar
ASW	Anti-Submarine Warfare
ATLAS	Autonomous Topographic Littoral Area Survey
AUV	Autonomous Underwater Vehicle
B.d.U.	Befhelshaber der Unterseeboote (U-boat Commander in Chief)
CESF	Commander Eastern Sea Frontier
CINCLANT	Commander-in-Chief, Atlantic Fleet
CNO	Chief of Naval Operations
COM5	Commandant Fifth Naval District
COM7	Commander Seventh Naval District
COMINCH	Commander in Chief, United States Fleet
ComScorn Nine	Commander, Scouting Squadron Nine
ESF	Eastern Sea Frontier
EWT	Eastern War Time
GIS	Geographic Information System
KS	Key West, South (Convoy Designation)
KTB	Kriegstagebücher (German War Diary)
NANCF	North Atlantic Naval Coastal Frontier
NARA	National Archives and Records Administration
OKM	Oberkommando der Kriegsmarine (Naval High Command)
ONI	Office of Naval Intelligence

ONR	Office of Naval Research
RCN	Royal Canadian Navy
RG	Record Group
RN	Royal Navy
RNC	Raster Nautical Chart
ROV	Remote Operated Vehicle
SLS	Side Looking Sonar
SOC	Standard Oil Company
SAS	Synthetic Aperture Sonar
USCG	United States Coast Guard
USN	United States Navy
USNR	United States Naval Reserve
VS-9	Scouting Squadron Nine

INTRODUCTION

Since 2008 NOAA's *Monitor* National Marine Sanctuary (MNMS) in conjunction with East Carolina University (ECU) and the Bureau of Ocean Energy Management (BOEM) has led archeological, biological, and historical surveys of World War II 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 of the *Monitor* National 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 U-boat, *U-701*. For nearly fifteen years the site was known to only a small group of divers who purposefully left the wreck's location undisclosed. In 2004 the location of *U-701* became known amongst the broader diving community. Despite being recognized as a significant underwater cultural resource *vis-a-vis* the minimal disturbance at the site, compared to the other frequented U-boat sites in North Carolina, *U-85* and *U-352*, an unknown group of individuals began illegally salvaging artifacts from *U-701*. 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 an 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 (ECU), the National Park Service (NPS), Bureau of Ocean Energy Management (BOEM), 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 World War II. The first of these expeditions focused on 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's ONMS and its partners returned to North Carolina to continue research on World War II 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 an 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 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 Archaeological 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, Archaeological, 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 II merchant vessels: *Empire Gem, E.M. Clark, Manuela, 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, was also 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) a Stephen Sanchagrin's *A View Through the Periscope: Advanced Geospatial Visualizations of Naval Battlefields of the Second World War* (Sanchagrin 2012) focusing upon visualization of naval battlefields (ECU and RENCI). Combined with funding sources oriented towards management goals corresponding to the 2008-2010 expeditions, a fourth expedition was completed in 2011.

This final report outlines Phases 1 and 2 of 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 was composed of four separate stages focused on the discovery, characterization, and documentation of submerged cultural resources from World War II, in particular the years 1942-1944. Funding sources for this research came from:

> *Phase 1:* ABPP (NPS); the Bureau of Ocean Energy Management (BOEM); 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's ONMS; ONMS' Maritime Heritage Program (MHP).
> *Phase 4:* NOAA's OER; NOAA's ONMS; National Parks Service Submerged Resources Center 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 came from:

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

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 global implications for eventual Allied victory. Furthermore, this extensive naval engagement between Allied, Axis, and neutral forces constituted the longest single operation of World War II, 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 (Figure 1). Three merchant ships, *J.A. Mowinckel*, *Chilore*, and *Bluefields*, were torpedoed by *U-576*. The first two escaped severely damaged, while the third sank in a matter of minutes. Over thirty men were injured during the attacks, two of which later died from their wounds. In the minutes following the attack, a simultaneous response from patrol aircraft and armed merchant vessels resulted in the sinking of the offending U-boat, with all hands lost. As the two damaged merchant craft were evacuated from the battlefield, 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).

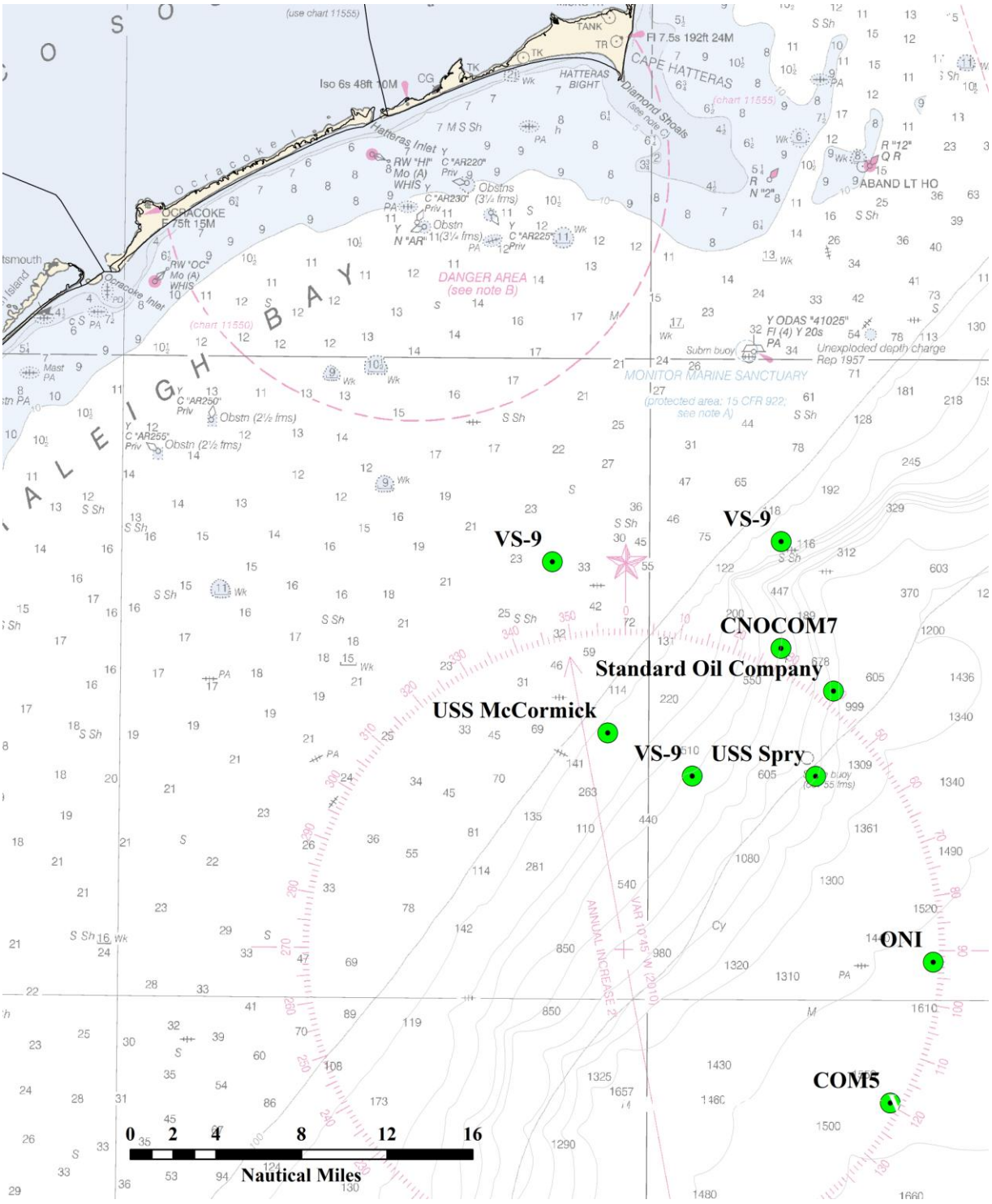

Figure 1. Approximate area of the KS-520 engagement. Positions denote locations of reports by combatants. Label translation: VS-9, Flight Commander from Scouting Squadron Nine; CNO, office of the Chief of Naval Operations; COM5,Commander, Fifth Naval District; COM7, Commander, Seventh Naval District; ONI, the Office of Naval Intelligence; Standard Oil Company (owners of *J.A.Mowinckel*); USS *McCormick* and *Spry*, correspondence from named ships (Image: John Bright).

Although only a single naval action of seemingly little consequence, especially considering the staggering Allied losses in American waters in months preceding mid-July 1942, KS-520 is in fact significant as a representation of broader strategic processes taking place during this stage of the Battle of the Atlantic. A shift in policy off America's eastern seaboard began in May with the institution of mandatory coastal convoy systems. In the seven months prior, U-boat operations had gone virtually uncontested in American waters, especially in the rich hunting grounds off Cape Hatteras. The result of the attack on KS-520, however, marked a culmination of Allied efforts to repel German U-boats. Though *U-576* succeeded in attacking the convoy, the vessel was consequently dispatched by escort forces, thus demonstrating the efficacy of coordinated aircraft and warship convoy protection. Throughout American waters, U-boats were hammered by Allied escort and patrol forces, compelling German U-boat Arm Commander, Admiral Karl Doenitz, to withdrawal his U-boat forces from the area. 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 them with such efficiency.

The primary focus of this expedition was the KS-520 convoy attack off North Carolina. Historical and archeological research on the events that unfolded around this convoy offer the potential to study adaptation and tactical behavior displayed by the American Navy in response to the German U-boat threat. This is integral to begin defining the Battle of the Atlantic from a strategic perspective. Additionally, this convoy may be considered a representative example of the 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 offered the opportunity to reassess 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).

The historic positions of several participants in this engagement are well known; however, none of these vessels have been located or positively identified. Thus, it was the intent of this study 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 follows 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 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 report outlines one of these approaches, named 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) (See Fryman 1995; Miller and Walsh 1995; 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; Harwood 2001; Alexander and Heckman 2002; Carr et al. 2002; Dixon et al. 2003; Haecker 2003; Watts and Lawrence 2003; Eckroth and Hagen 2004; Ellis 2004; Jaeger Company 2004; Johnson and Adams 2004 ; Bedell 2005 Cannell 2005; Ellis 2005a, 2005b; Legg et al. 2005; Emerson 2006; Strezewski et al. 2006; GAI Consultants and Hardlines Design Company 2007; Pratt et al. 2007; Tankersley and Espenshade 2007; Whisonant et al. 2007; Butler 2008; Emerson 2008; O'Dell and Powers 2008; McBride and Naumee 2009a, 2009b; Smith et al. 2009). These sources, in conjunction with other published battlefield survey work (Scott et al. 2009a, 2009b; Babits et al. 2010), greatly aided in understanding how KOCOA principles are applied to terrestrial and maritime sites, and thus assisted with how these terms may be translated into a 20th century marine environment.

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 battle that was the focus of 2011 fieldwork. The following 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. Concluding sections outline the results of remote sensing fieldwork followed by two sections of analysis.

HISTORICAL BACKGROUND

Beginning at 0430 EWT, on 14 July 1942, the 19 merchant ships and 5 escorts of convoy KS-520 prepared for departure from their anchorages at Lynnhaven Roads, Virginia (Fengar 1942a-1942u). Convoy code KS designated groups moving southbound, destination Key West, Florida, along the eastern seaboard (Hauge 2000:112). Once assembled beyond the minefield protecting the approaches to the Chesapeake, the convoy began making way at its assigned 8 knot speed and was expected to arrive in Key West by 21 July; a seven day cruise (Fengar 1942a-1942u). During this time, KS-520 would experience constant threat from German U-boats known to be operating in the mid-Atlantic, especially off the North Carolina coast. In fact, in the two preceding days, four aircraft reported attacks on U-boats east of Cape Hatteras (Blair 1996:626-627). The passage of KS-520 would surely not go uncontested.

As per standard procedure, a Convoy Commodore was assigned to direct convoy movement and oversee merchant vessels within the convoy. Additionally, an Escort Commander was placed in command of the naval and Coast Guard craft protecting the convoy. Captain N.L. Nichols USN (ret.) was considered a seasoned and cautious officer by his colleagues (Freeman 1987:416). Nichols was assigned as Convoy Commodore, and placed aboard Panamanian tanker *J.A. Mowinckel*, first ship in the middle column. His Vice Commodore was Commander H.R. Sobel USN (ret.). Lieutenant Commander Leland R. Lampman USN was assigned as Escort Commander, sailing aboard USS *Ellis*, DD-154 (Commander Fifth Naval District [COM5] 1942a, 1942b; USN 1942b).

Between 6 July and 13 July, 21 merchantmen received sailing orders from the Routing Officer stationed at Lynnhaven Roads, H.C. Fengar. His orders specified signal number and convoy position, time of departure, navigation instructions for safe exit of the Chesapeake minefield, and directions for convoy assembly and movement (Figure 2). Once 14 miles past the Chesapeake Lighted Buoy, a course change to 78 degrees, followed by a 32 mile transit to a whistle buoy, each vessel and escort would be clear of the mined channel and ready for assembly. Having been first to depart, the Convoy Commodore would hoist the HV signal flag once all ships were gathered, bringing the convoy into formation, and beginning his cruise to Key West at a maximum of 8.5 knots. Though some ships could move faster if attacked, this was the maximum speed of the convoy's slowest vessel, *Bluefields* (USN 1942a-1942u).

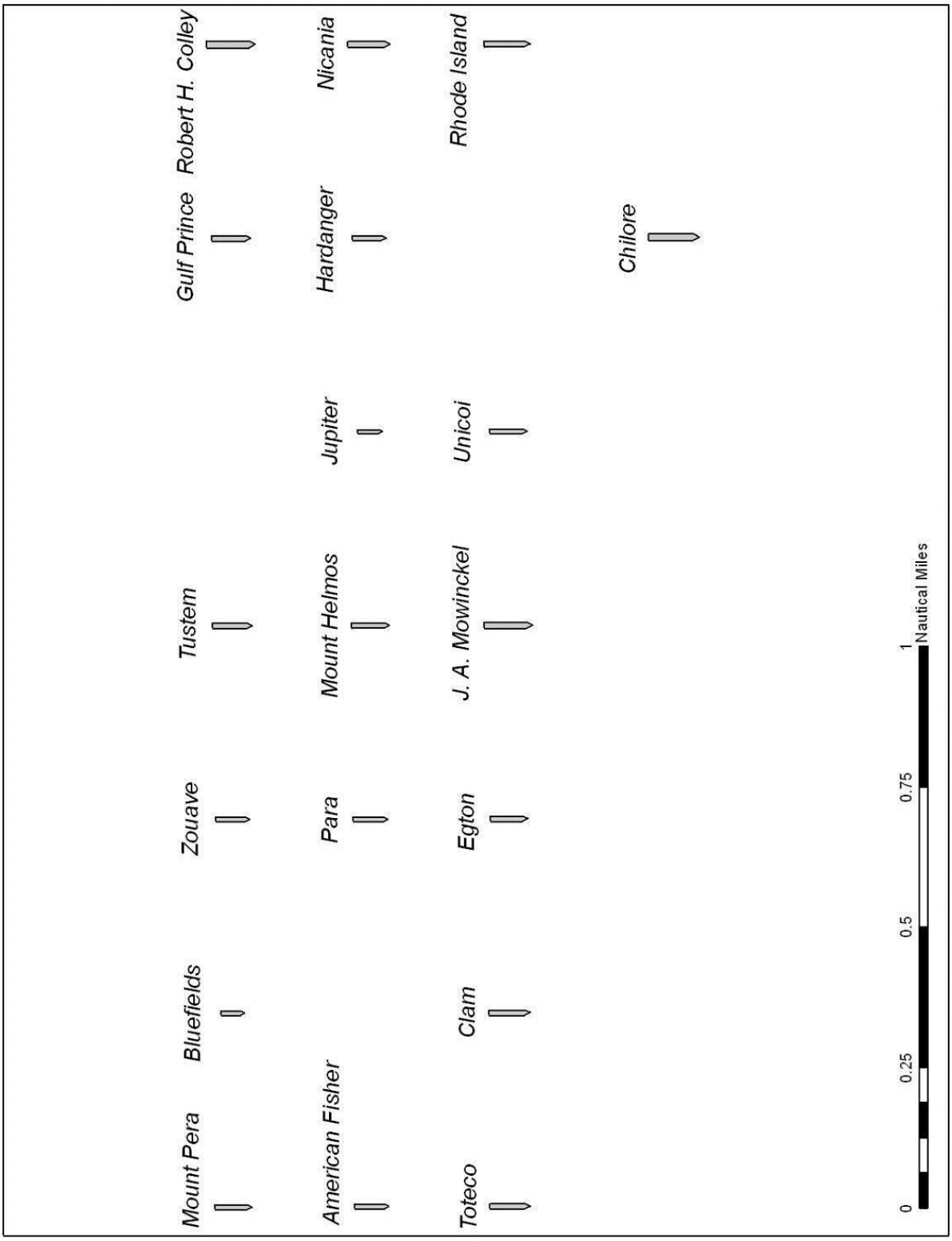

Figure 2. Scaled Representation of KS-520. (Drawn by Stephen Sanchagrin).

Meanwhile, five vessels received orders to form Escort Group Easy in protection of KS-520. These included two United States Navy destroyers, DD-154 and DD-223, United States Coast Guard cutters WPC-110 and WPC-116, and transferred British Flower-class corvette PG-64; USS *Ellis*, USS *McCormick*, USCG *Icarus*, USCG *Triton*, and former HMS *Hibiscus*, USS *Spry*, respectively (USN 1942b; Blair 1996:756). USCG *Icarus* had, two months prior, successfully engaged German *U-352* off the southern North Carolina coast, one of just three U-boats sunk in North Carolina's frenzied waters (Hoyt 1978; Hickam 1989; Gannon 1990:380-384; Blair 1996). Once signaled by the Convoy Commodore with a single 15-second horn blast on the morning of 14 July, confirming the commencement of vessel departure, Escort Group Easy was to begin covering the exit of the merchant vessels.

Meanwhile, *U-576* had been executing its fifth war patrol since 16 June (Blair 1996:718-733). *U-576* was built in Hamburg, Germany, by Blohm und Voss (Westwood 1984:12). The boat was commissioned under the command of Kapitanleutnant Hans-Dieter Heinicke and was sent on its first patrol in the Arctic between September and December of 1941. By 11 December 1941, *U-576* was back on patrol in the North Atlantic, but returned after twelve days. Again, the U-boat failed to sink any ships. Nearly a month later, *U-576* was ordered to participate in Operation Paukenschlag, and sailed for the US coast on 20 January 1942. In the early morning hours of 14 February, Heinicke torpedoed and sank the 6,900 ton armed British freighter *Empire Spring*. Heinicke returned from his third war patrol with his first kill on 28 February (Blair 1996:704-732).

Shortly thereafter, Heinicke and *U-576* were sent on their second American war patrol. Departing on 29 March, *U-576* took station off Cape Hatteras. There, he torpedoed and sank a 5,100 ton freighter carrying bauxite before heading north to Cape Cod. While passing New York, Heinicke fired a single torpedo at Norwegian *Tropic Star* and missed, with *Tropic Star* making good its escape. By the morning of 30 April, *U-576* was off Cape Cod when Heinicke spotted a north-bound convoy. Having few torpedoes left, he decided to fire a bow salvo at four over-lapping merchant ships. Only one torpedo hit, sinking 1,300 ton Norwegian freighter *Taborfjell*, *U-576's* third kill. As he began travel back to port, Heinicke spotted and tracked a large troop-transport convoy before losing contact on 3 May. *U-576* returned to port on 16 May with 2 more kills totaling 10,707 tons (Blair 1996:546-729).

U-576 entered St. Nazaire, France, the port of departure for its fifth war patrol, on 16

June 1942. As part of operational policy, U-boats were obliged to radio U-boat headquarters daily, relaying information regarding merchant sightings and operations, and also receiving operational orders (OKM 1942:32-39). Knowing their transmissions were vulnerable to monitoring, the Kreigsmarine devised a rather clever coded system whereby position information was relayed based upon a series of nested grid systems superimposed upon a chart of the world. John Wagner (2010:28) describes this system, known as the "Marine Quadratkarte," or MQK:

> The B.d.U. quadrants are overlays of the world's oceans using a grid system that breaks apart latitude and longitude into a series of letters followed by several numbers that corresponded to coordinates around the world. These grids allowed the U-boat command to track its U-boats and permitted vessel commanders to relay their locations without having to broadcast their position in the clear.

Not only were positions of U-boats conveyed in such a manner, but also sightings of merchant vessels. In this way, B.d.U. could quickly track U-boat and reported Allied convoy positions and thus bring as much of its force as possible to bear against Allied shipping (Hickam 1989:295-313).

The following day, 17 June, *U-576* was out to sea, setting a course for grid CA, Cape Hatteras, along with *U-402*. While underway, on 22 June, however, both boats were ordered to take up station in the central North Atlantic for two days based on a sighting reported by *U-406*. *U-576* remained for six days, spotting a large vessel 26 July in its area of operations. The vessel, though, was traveling too fast and slipped away from the U-boat. By 29 June, both *U-402* and *U-576* were re-routed back to grid CA, off Cape Hatteras (Befehlshaber der Unterseeboote [B.d.U.] 1942a:30308b).

On 1 July, *U-576* took on 8 days of additional supplies from *U-460*. Nine days later, on 10 July, the boat arrived at its destination, the waters off North Carolina. The following day, at 0230 hours *U-576* sighted a northbound convoy. Upon reporting the convoy, B.d.U. ordered Heinicke to attack and report any subsequent contacts to further direct other U-boats in the vicinity (B.d.U. 1942b:30309a). Historian Clay Blair (2000:626) described the ensuing pursuit

> When he reported it to Kerneval, he was told to attack and to bring up any other boats in the area. A likely helping hand was the veteran Siefried von Forstner in *U-402*, who was just then closing on Cape Hatteras. Heinicke trailed the convoy north toward Cape Hatteras, but he later reported he had lost contact before he

> could shoot and therefore he could not vector in any other boats. Von Forstner in *U-402* and Heinicke in *U-576* took up independent stations off Cape Hatteras.

In the following days, B.d.U. (1942b:30309b) received limited reports from *U-576*, noting on 19 July that

> In the sea area off Hatteras successes have dropped considerably. This is due to a drop in the traffic (formation of convoys) and increased defence measures. Of the boats stationed there in the recent period only two, U 754 and U 701 have had successes. On the other hand U 701 and U 215 have apparently been lost, and U 402 and 576 badly damaged by depth charges or bombs. This state of things is not justified by the amount of success achieved.

On 13 July, *U-576* reported damage to its main ballast tank, and the following day it reported damages irreparable and informed B.d.U. it was traveling with ballast tank 5 flooded. On 22 July, B.d.U. noted "no reply has been received from U 576 in spite of numerous calls. No attack reports from American aircraft or surface forces have been received, so no grounds exist for considering it lost" (B.d.U. 1942b:30309b). B.d.U., however, must have had some suspicions about the boat.

Of the 21 vessels slated for convoy in KS-520, only two, Panamanian freighter *Jeff Davis* and British freighter *Cavelier*, were unable to proceed from Lynnhaven Roads. Thus, on the morning of 14 July when Capt. Nichols, aboard *J.A. Mowinckel*, sounded the 15-second horn to initiate convoy operations, only 19 merchant vessels met with the 5 military craft of Escort Group Easy to exit the Chesapeake. Two less than originally ordered, KS-520 thus consisted of US freighters *Unicoi* and *Chilore*, and tankers *Rhode Island*, *Toteco*, *American Fisher*, *Tustem*, *Gulf Prince*, and *Robert H. Colley*; British freighters *Egton* and *Zouave*, and tankers *Clam* and *Nicania*; Norwegian registered freighters *Para* and *Hardanger*; Panamanian registered tanker *J.A. Mowinckel*; Dutch registered freighter *Jupiter*; Greek registered freighters *Mount Helmos* and *Mount Pera*; and Nicaraguan registered freighter *Bluefields* (USN 1942b).

Exiting Lynnhaven Roads was not without event. Aboard escort USS *McCormick*, twenty minutes after getting underway, a miscommunication resulted in the crew dropping the starboard anchor. It took *McCormick* an additional twenty minutes to heave the anchor, in the course of which it was discovered the anchor had been fouled. Between 0530 hours and 0600 hours, *McCormick* crew cleared the fouling on the anchor, and by 0605 the destroyer was at last underway. USCG *Triton* called general quarters at 0420 to get underway. One sailor was put on

report for standing an improper watch by 0515 hours when the cutter secured from general quarters. By early morning, the convoy passed the Chesapeake light buoy. Throughout the day, the vessels of Escort Group Easy performed fire drills, collision drills, steering casualty drills, abandon ship drills, general quarters drills, weapons drills and inspections, magazine inspections, and powder inspections (USCG 1942a, 1942b; USS *Ellis* 1942; USS *McCormick* 1942; USS *Spry* 1942). By 1330 hours, the convoy cleared the minefield protecting the Chesapeake approaches. The Convoy Commodore Nichols hoisted the HV signal, and the convoy formed

The remainder of 14 July was fairly uneventful, especially compared with the six days of convoy operations to come. As afternoon passed into evening, the convoy continued its 8 knot pace, while Escort Group Easy maintained aggressive anti-submarine patrol at its various patrol stations around the merchant craft. At 0700 on the morning of 15 July, KS-520 rounded Cape Hatteras, North Carolina. Through midday, the convoy proceeded within the hundred fathom curve, and by 1600 hours were 20 miles from Ocracoke Inlet (Freeman 1987:411). The Commanding Officers of *McCormick* and *Ellis* held Captain's Mast aboard their ships, awarding punishment to five sailors for various offenses. Similarly, *Icarus*, mustered in the mid-morning and noted one sailor absent without leave (USCG 1942a; USS *Ellis* 1942; USS *McCormick* 1942).

Unbeknownst, KS-520 was steaming right into the path of the damaged *U-576*. A severely damaged ballast tank and possibly ruptured saddle fuel tank left Kplt. Heinicke no choice but to abort his fifth war patrol. Having completed his first two patrols without a single kill, and making only marginal gains during his third and fourth patrols, Heinicke was no doubt disappointed. Not only had he missed the heyday of the first happy time in the North Atlantic, he was in the midst of the U-boat campaign's most fruitful months and still was not sinking ships. Once Heinicke spotted KS-520 he faced an arduous decision. In the face of such stiff resistance, any attack made by Heinicke would not go unanswered. Months prior spelled the demise of *U-85*, *U-352*, and *U-701* in these same waters. Furthermore, Heinicke himself was attacked the day prior; the damage sustained by his boat left him at disadvantage against the Allied escorts. Resonably, his decision to attack must have rested upon a sober assessment of the limitations of his boat and crew, the terrain and potential geometry of his attacks, his tactical advantages and disadvantages, and administrative pressure upon him to carry out his orders. However, were

Heinicke a cavalier and reckless Captain bent on success at all costs, then perhaps the fate of his boat and crew was sealed the moment KS-520 appeared upon the horizon.

At 1600 hours USCG *Triton*, patrolling in station 7 (Figure 3), picked up a contact with its Q.C. sonar gear and raised its crew to general quarters. Five minutes later, *Triton* dropped three depth charges over the contact, followed by five more depth charges at 1610 hours. The second depth charge attack apparently damaged the cutter's sonar gear, after which the sonar contact was lost (USCG 1942b). The convoy's aircraft escort observed freighter *Chilore* 600 yards ahead of its station in the lead of column two (Freeman 1987:411-412). Meanwhile, the other four escorts were at their stations. *Icarus* was patrolling in station 6, at the port outer screen of the convoy, while *McCormick* and *Spry* patrolled in Stations 2 and 4, respectively. Additionally, *McCormick* patrolled the port half of station 1, while *Ellis* patrolled along the starboard half, in addition to stations 3 and 5 (USCG 1942a, 1942b; USS *Ellis* 1942; USS *McCormick* 1942; USS *Spry* 1942).

In an instant, the monotony and routine of convoy operations setting in over the past 36 hours was shattered. Sometime between 1615 and 1620 hours, two torpedoes rocked *Chilore*. The first struck the freighter on the port bow, the second on its port quarter. A minute later, a third torpedo struck the port stern of the Commodore's flagship, *J.A. Mowinckel*. Barely a minute later, a fourth torpedo struck the *Bluefields* amidships on its port side (ComScorn Nine 1942; USCG 1942a, 1942b; USS *Ellis* 1942; USS *McCormick* 1942; USS *Spry* 1942). In less than five minutes, *U-576* fired a full bow salvo of four torpedoes, all of which hit their mark. KS-520 scattered. Aboard *Bluefields*, *Chilore*, and *J.A. Mowinckel*, the ordeal had only just begun. Over the next hour, Escort Group Easy, in concert with the patrol aircraft, hunted the offending U-boat. *Spry*, patrolling at the port stern of the convoy saw smoke immediately and made for the center of the convoy at full speed, raising the crew to general quarters. *McCormick*, slightly ahead of the convoy, reversed course to hunt for the submarine, noting the patrol aircraft were dropping depth charges near the port bow of *J.A. Mowinckel* as it came around to run a sound search. *Ellis* immediately changed course from its station on the port quarter of the convoy to make for the convoy's center. *Ellis*, however, did not have to go far. In less than two minutes, the destroyer made a sound contact off the convoy's port quarter of the convoy, near its patrol station and quickly dropped two depth charges. Stationed on the outer screen on each side of the convoy, *Icarus* and *Triton* each responded yet were far enough away that most of the action

passed before they arrived on the scene (USCG 1942a, 1942b; USS *Ellis* 1942; USS *McCormick* 1942; USS *Spry* 1942).

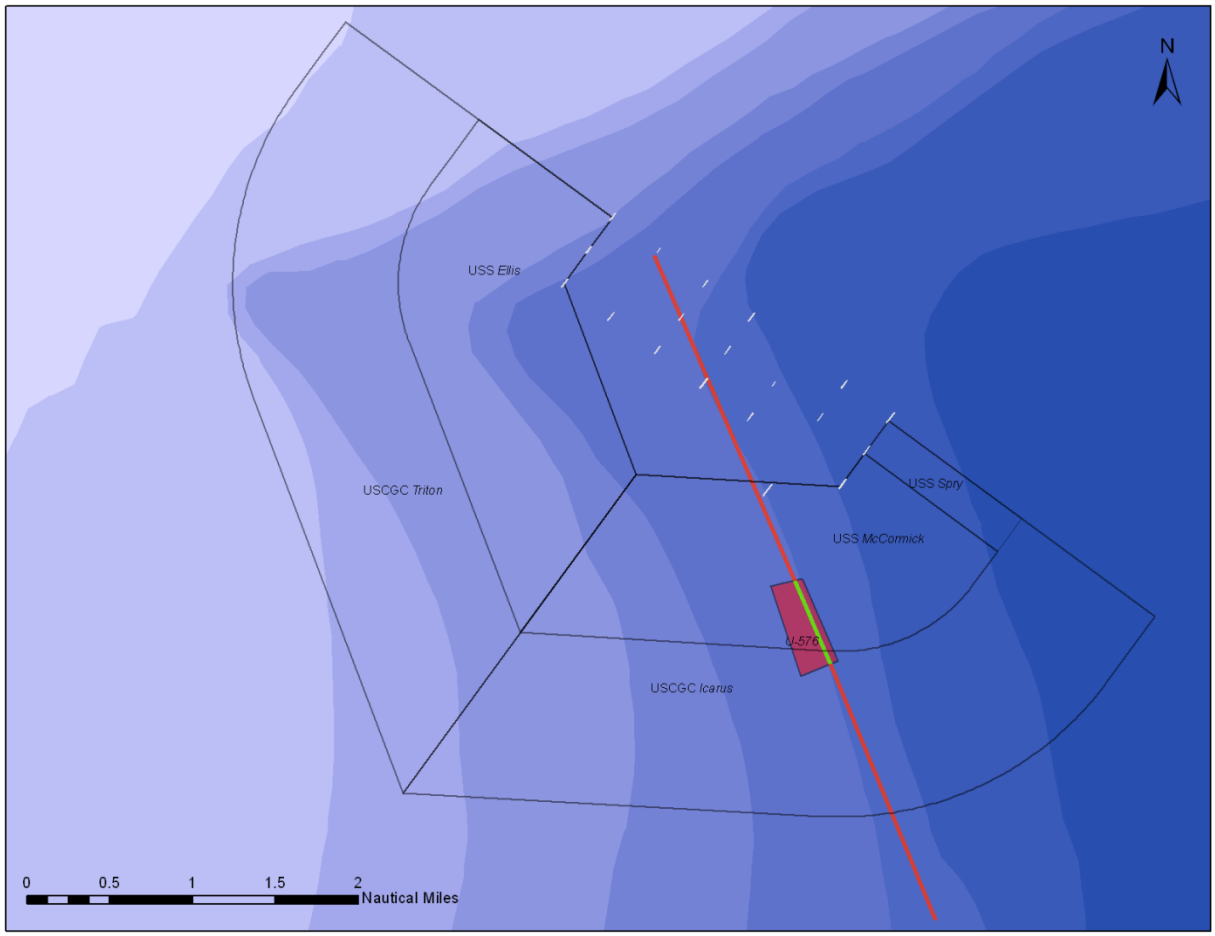

Figure 3. Scaled Representation of Convoy Formation and Escort Patrol Stations from the Afternoon of the Attack. (Drawn by Stephen Sanchagrin).

From 1641 to 1745 hours, *Ellis* pursued contact and made several depth charge runs. During the course of the hour, *Ellis* made four depth charge attacks along the convoy's port quarter, expending 13-15 depth charges (USS *Ellis* 1942). Despite *Ellis's* kinetic and diligent effort, it is doubtful the ship was responsible for sinking *U-576*. According to Captain Griffiths, Master of *J.A. Mowinckel*, "immediately following the explosion of the torpedo which struck the *Chilore*, a submarine partly surface, bow first. Possibly she was forced upward by the concussion" (Standard Oil Company [SOC] 1946:365). It is also possible increased buoyancy resulted from the decrease in weight at the expenditure of four torpedoes, combined with an already damaged buoyancy control system. Either way, upon surfacing, two Navy patrol aircraft from Scouting

Squadron Nine made a depth charge run against the surfaced submarine astern of *J.A. Mowinckel*. Pilots Frank C. Lewis and Charles D. Webb dropped two Mark XVII depth charges each, and reported the U-boat sunk. It is also reported armed US freighter *Unicoi*, stationed between *Chilore* and *J.A. Mowinckel* in the convoy, assisted in the fight. In concert with the aircraft, a *Unicoi* gun crew under M.K. Ames scored a solid hit on the conning tower of the U-boat. The force of depth charge attacks, combined with rounds from *Unicio's* deck gun, made quick work of *U-576* (ComScorn Nine 1942:1-2; SOC 1946:365; Hickam 1989:286; Blair 1996:627).

These historical accounts, however, are somewhat vague. To complicate matters, the most detailed firsthand accounts, those in the logbooks of Escort Group Easy, do not mention any visual contact with the U-boat. *Triton*, *Ellis*, *Spry*, and *Icarus* were at stations distant from the presumed origin of the attack: the convoy's port bow. The only escort in a position to have witnessed the U-boat was USS *McCormick*. The destroyer, however, reversed course and sped to the aid of sailors abandoning the rapidly sinking *Bluefields*. Aircraft from Scouting Squadron Nine report destroying, with four depth charges, a surfaced submarine in the middle of the convoy (Scouting Squadron Nine 1942). This is corroborated by the first-hand account from the Master of *J.A. Mowinckel*. Captain Griffiths (SOC 1946:365) later recalled

> The submarine's appearance was the signal for our escort to go into action. Planes dived over the spot. Our airplane escort continued to drop bombs or depth charges…credit for the kill was given to the Navy plane VS-9 and to a ship in the convoy, the SS *Unicoi*, owned by the War Shipping Administration.

Based on eyewitness accounts, this is likely the most reliable report. The *Eastern Sea Frontier War Diary* (Freeman 1987:412) records, to the contrary

> Soon after the torpedo hit the Mowinckel [sic] the two planes dropped out of the sky to plant their bombs near the stern of the vessel….As the other vessels came in from their positions on the flanks of the convoy the air was filled with the noise of engines and the sound of bursting charges. The waters boiled with high explosives and were churned to froth by racing propellers. Once, in the confusion of sound and movement, the submarine surfaced. Guns were trained, a few rounds fired, the planes dropped charges, but the U-boat dived to safety unharmed. Search was continued but the hunt, after 40 minutes led farther and farther away from the disorganized convoy.

The report of *U-576* diving safely after the barrage of aerial attacks insinuates *U-576* might have in fact survived its torpedo run against KS-520. Similarly, Edwin P. Hoyt's (1978:168) account in *U-Boats Offshore* reports

> The U-boat was in the middle of the convoy. The two planes came in to bomb near the stern of *Mowinckle* [sic]….Up to the surface came the U-boat, just yards from the convoy flagship, but almost immediately she went down again, apparently blown to the surface but not out of control. For 40 minutes, the ships of the convoy milled about while the escort searched for the enemy.

Again, the narrative insinuates the U-boat might have lasted beyond the retaliatory attacks.

Had *U-576* survived it audacious run on KS-520, it certainly never returned home. The U-boat was reported sunk with all hands down, and stricken from the KTB in the days following, as no transmission were received from the boat (KTB 1942c:30309b; Blair 1996:627). No Germans lived to tell the tale of *U-576's* final minutes. Kplt. Heinicke's decision to attack with a damaged boat, and surfacing in the moments following the attack, are quite puzzling; surfacing in the center of the convoy was probably not intentional, yet it is unclear if this resulted from mechanical failure precipitated by damage inflicted by aircraft or from the force of torpedo explosions, or perhaps an escape tactic. Archeological examination of the sunken U-boat might answer many of these questions.

Regardless, *U-576* never returned from its fifth war patrol. In the words of Captain Griffiths (SOC 1946:365)

> …wreckage and considerable oil sludge and slick were seen to rise to the surface. This evidence, combine with my observation of the speed and efficiency with which the depth charges were dropped, leaves absolutely no doubt in my mind but that the submarine was destroyed

Meanwhile, *Chilore*, *J.A. Mowinckel*, and *Bluefields* dealt with damage wrought by *U-576's* torpedoes. *Chilore* took two hits, but remained stable on the surface and, remarkably, sustained no casualties. The convoy flagship, second hit with a torpedo in its stern, was not as fortunate. The blast made a 20 by 20 foot hole, 8 feet below the waterline, into the steering engine room. The force of explosion damaged the steering engines, galley, capstans, mess rooms, and aft gun deck. A six inch hole in the aft bulkhead was pouring water into the engine room. Chief Engineer Cecil M. Guthrie quickly responded to the situation by placing all available pumps in the bilge and stuffing the hole with mattresses, bracing it in place. With the incoming water and bilges stabilized, and the engines still running, *J.A. Mowinckel* only structurally suffered a steering casualty. The flagship's crew, however, had suffered severely. Fifteen seamen and five navy gunners were wounded by the blast, one of which died in the midst of a blood transfusion aboard the tanker. Navy gunner Seaman Second Class Raymond V. Wolfe, on station at the rear gun

platform when the torpedo struck, would later die of his wounds (SOC 1946:365-372). Another sailor was blown off the stern of the vessel by the explosion and was picked up twenty minutes later by USS *McCormick* (USS *McCormick* 1942).

The opposite situation developed for *Bluefields*. The crew was generally unharmed when a torpedo slammed into the freighter's port side amidships. The vessel, though, quickly took a list to port. *Bluefields* sank by the stern in approximately ten minutes,. The vessels twenty-four crew, mostly Nicaraguan, hastily abandoned ship. By 1642 hours, USS *Spry* picked up two boatloads of survivors, twenty in all. This included the Master, Captain, Officers, and other crew. Four minutes later, USCG *Icarus* rescued the remaining four survivors. Many of the survivors sustained minor wounds: cuts, abrasions, and exhaustion. Suddenly, *Spry* picked up an underwater contact at 1652 hours. After dropping a single depth charge, the contact was lost (USCG 1942a; USS *Spry* 1942; USN 1942b).

Shortly after scattering, KS-520 reformed. *Chilore* and *J.A. Mowinckel*, though still afloat, had fallen behind. *Bluefields* was sunk. At this time, USS *Ellis* was still in the midst of its aggressive pursuit of underwater sound contacts. *McCormick* and *Spry* were busy assisting survivors, maneuvering around the damaged merchantmen, and *Icarus* came along to transfer rescued wounded survivors. *Icarus* was then ordered, along with *Triton*, to regain contact with the convoy and continue escort duty. For the next few hours, *Icarus* and *Triton* would be the sole guardians of KS-520.

In the meantime, *Spry* and *McCormick* attended to the merchantmen, working with Commodore Nichols to determine the appropriate course of action. It was resolved, since both *Chilore* and *J.A. Mowinckel* were still under power, to make for the closest safe port. *McCormick* came alongside *J.A. Mowinckel*, and, at the Commodore's request, transferred a doctor; Lieutenant E.P. Larkin USNR was put aboard the flagship at 1700 hours. Interestingly, USS *McCormick* did not transfer the crewmember it had earlier rescued to his ship. Since threat of U-boat attack was still present, *McCormick* left *Spry* with orders to escort *J.A. Mowinckel* and *Chilore* to safety at Hatteras Inlet, where necessary repairs could be affected. USS *McCormick* left the group at 1718 hours, and initiated a sound search for the submarine. USS *Spry* lead the column on a course of 315^{o}T, as ordered by Commodore Nichols, in a direct route to Hatteras Inlet, 20 miles distant. Behind *Spry* was *J.A. Mowkinel*, steering with it engines thus making slow headway, followed by *Chilore* as the flagship sailed away, command of the convoy was

passed from Commodore Nichols to Vice Commodore Sobel (SOC 1946: 368; USCG 1942a; USS *McCormick* 1942; USS *Spry* 1942; *Freeman* 1987:413).

Nerves were running high on the damaged ships, and caution prevailed, as more than a few U-boats were known to linger and finish merchantmen they failed to sink. At 1800 hours, as USS *McCormick* was developing a sound contact in the vicinity of the original attack, a crewmember aboard *J.A. Mowinckel* called out a U-boat sighting, which was radioed back to USS *McCormick*. The destroyer immediately dropped a depth charge on its sound contact and rushed to the crippled merchantmen. Yet, a few minutes later, *J.A. Mowinckel* radioed the contact was a false alarm. USS *McCormick* spent another twenty minutes trying to reacquire the sound contact, to no avail. At 1845 hours the destroyer made full speed for the convoy. USS *Spry* continued patrolling at 14 knots ahead of the merchantmen, while *J.A. Mowinckel* struggled to maintain its 5-8 knot pace. Making their way towards safety, the group steered on a collision course with yet another danger zone: the Hatteras minefield (SOC 1946:366-367; USS *McCormick* 1942; Freeman 1987:415).

Constructed in late May, the Hatteras minefield was established to provide safe anchorage for ships travelling in the vicinity of Cape Hatteras (Miller 1942). Lacking sufficient patrol craft to fully operate anti-submarine convoy patrol in the early months of 1942, the ESF command instead urged vessels to leapfrog down the coast. That is, to travel only during daylight, seeking refuge in a safe harbor at night. For the northern portion of the eastern seaboard this was a practical solution, though not the case for Cape Hatteras and south. The operational strategy for protecting merchant craft in early 1942, as compiled in the *Battle Report: The Atlantic War* by Commander Walter Karig, USNR, Lieutenant Earl Burton, USNR, and Lieutenant Stephen L. Freeland, USNR, (1946:92-93) went as follows

> A blackout was ordered the length of the coast [in May]. Eastern Sea Frontier studied charts and statistics. From Maine to Virginia the coast was indented by harbors….Between sunrise and sunset a ship could steam from the shelter of the Delaware Capes to the security of the Chesapeake's broad mouth, with relative safety from torpedoes. Merchant ships were ordered to leapfrog down the coast. Submarine captains watched the ships steam past while they lay at periscope depth, but at night the sea lanes were empty. The Germans…congregated around Hatteras for easy pickings again, south of the deep-water havens…. But ESF had anticipated the Germans' solution and was at work with another makeshift. Where nature provided no harbors, the Navy was making its own….With submarine nets and mine and great booms, pens were built at intervals of 125 miles from North Carolina to Florida, into which ships put at night like sheep behind and electric fence.

With this aim Captain C.C. Miller was placed in charge of Task Group 29.2 in May, 1942. In five days, between 20 and 25 May, he commanded a group of four minelayers, three escorts, three minesweepers, and four district patrol craft in laying 2,635 mines in an area approximately 100 square miles off the south of Cape Hatteras (Miller 1942).

The minefield consisted of two overlapping legs, surrounding a protected anchorage with space for 30 ships . Cutting through the western leg was a swept channel, marked with buoys, for safe passage in and out of the minefield. Additional navigation aids were placed around the outer limits of the minefield so as to delineate the extent of the mined area. For additional safety, a number of district patrol craft were stationed along the perimeter of the minefield to warn off any ships inadvertently trafficking too close to the danger area.

A memorandum was sent to the director of the Hydrographic Office in Washington D.C. on 28 April 1942. Sent from the Base Maintenance Division Director, R.W. Cary, the memo informed the Hydro office of the official establishment of a "danger area" in the vicinity of Cape Hatters (Cary 1942). On 7 May, and again on 13 May, the Hydrographic Office issued Restricted Notice to Mariners No. 9 and No. 12, respectively, detailing the establishment of the navigation aids associated with the minefield (Cary 1942). Additionally, the office issued Notice to Mariners 175 on 30 April 1942. Distributed to all registered American vessels, the notice described the location of a danger area established by the US Navy (Freeman 1987:415).

By mid-July 1942 the minefield had already claimed a casualty: Esso tanker *F.W. Abrams.* Travelling from Aruba to New York, the tanker was traveling alone and unarmed when it sought refuge in the minefield on the night of 10 June. *F.W. Abrams* was escorted into the minefield that evening by a Coast Guard patrol craft, and sat at anchor until 0400 hours the following morning when the patrol craft returned to secure safe exit from the minefield (SOC 1946:288-291). Losing sight of the escort in heavy rain, *F.W. Abrams* made a change of course to stand out to sea when an explosion rocked the ship from the starboard bow at 0640 hours. Drifting northward, the tanker was hit in the pump room thirty minutes later, and another explosion rocked the bow at 0739 hours. The Captain and crew believed they were under attack from a submarine, a few even reporting torpedo wakes. At 0740 hours, the Captain ordered the crew to abandon ship. All of the 37 crew were safely rescued and taken to Ocracoke Island, only one sailor sustained injuries. Review of the incident, including the location of the vessel as it strayed from its escort in foul weather, convinced Fifth Naval District officers that *F.W. Abrams*

had, in fact, strayed into the minefield. The Esso tanker sank not at the hands of German torpedoes, but Allied mines instead (COM5 1942c; Wagner 2010: 91-93).

Ironically, a similar fate awaited *J.A. Mowinckel* and *Chilore*. Like the Captain of *F.W. Abrams*, neither the Master nor Convoy Commodore aboard *J.A. Mowinckel* received Notice to Mariners 175 and were unaware of any danger area. *F.W. Abrams* was underway during the construction of the minefield and received no notification of its existence. *J.A. Mowinckel* was registered in Panama and its officers did not receive notices distributed by the US Navy. Commodore Nichols had access to Notice to Mariners, but in this case did not find reason to read them. For its part, *Chilore* was silent. Commanding Officer on board USS *Spry* certainly knew of the existence of the minefield, however, he was uncertain of his position. In fact, his dead reckoning was 60 miles west of their actual location. Although not atypical in escort vessels which daily boxed the compass around large swaths of sea adjacent to their convoys, USS *Spry's* uncertainty would prove disastrous in the hours to come (Hoyt 1978:169-170; Freeman 1987:414-415).

To complicate matters, the chain of command between the three ships prevented the Commanding Officer of USS *Spry* from effectively managing his detachment. Commodore Nichols, though retired, held the rank of Captain. Upon leaving the convoy, however, his authority was passed to Vice Commodore Sobel. As a matter of prudence, Commanding Officer of *J.A. Mowinckel* deferred to Capt. Nichols' experience and requested he continue supervision of actions aboard his ship. The Commanding Officer of USS *Spry* was an active Lieutenant Commander and was loath to assert authority over an experienced and highly respected, albeit retired, Captain (Hoyt 1978:169-170; Freeman 1987:414-416).

Nevertheless, uneasy about their proximity to the minefield, USS *Spry* radioed *J.A. Mowinckel* at 1800 hours. Recorded in the Eastern Sea Frontier War Diary (Freeman 1987:416-417), *J.A. Mowinckel* replied "My present position about 20 miles SE of Hatteras Inlet for which we are bound." USS *Spry* confirmed its fears when, after plotting their course relative to the position supplied and realized the ships were indeed heading for the minefield. At 1819, USS *Spry* radioed back to *J.A. Mowinckel*, requesting a change of course to a position at the entrance to the swept channel on the western side of the minefield. Unfortunately, the message was garbled upon receipt aboard *J.A. Mowinckel*. Thinking the position transmitted by USS *Spry* was a mistake, as it differed from their present destination by 60 miles, Capt. Nichols asked for the

message to be retransmitted. He got no reply. Left to interpret USS *Spry's* garbled transmission, Capt. Nichols and Master Griffiths conferred and decided the position sent by USS *Spry* was, in fact, an affirmation of their present course. He sent no reply. USS *Spry* never received a request to say again their request, and never received a reply from Capt. Nichols. The C.O. of USS *Spry* then settled with the assumption Commodore Nichols knew both their current position and its relation to the minefield, and therefore the course presently steered was safe. He would not question a superior officer a second time. No change of course was made (Hoyt 1978:169-171; Freeman 1987:414-417).

Just when the luck of these three ships could not seem to get any worse, the last line of defense against accidental entry to the minefield, stationed patrol craft, also failed. Not by inability to fulfill their duty, but rather they had been sent afield on various dispatches. On the night of 15 July, *PC-480*, only one of three patrol craft was on duty near the minefield. *PC-463* was ordered off on anti-submarine patrol, in response to a sighting made eight miles southeast of the minefield. The other patrol craft, *PC-462*, was dispatched to carry fuel to a YP-boat that had run out gasoline while on patrol. While on station near a wreck buoy, *PC-463* actually spotted the group pass at half a miles distance. Since the group was a significant distance from the minefield, and under direction of a naval vessel, *PC-463*, justifiably, did nothing. Returning from assisting the YP-boat, *PC-462* spotted the group dangerously close to the minefield at 1930 hours. The patrol boat sped toward the three ships signaling with blinkers, and firing its deck gun (Hoyt 1978:169-171; Freeman 1987:414-418).

It was too late. At 1953 hours, USS *Spry* reported an explosion on the starboard side of J.A. *Mowinckel*. The flagship immediately spotted an object 1100 yards off the port bow. Like the crew of *F.W. Abrams*, they believed they were under U-boat attack. USS *Spry* trained it guns on the object and fired. Further investigation revealed the object, obscured by waning daylight, was nothing more than an obstruction buoy adrift. Still searching for a U-boat, USS *Spry* dropped a pattern of four depth charges at 2000 hours. Ten minutes later, it spotted a floating mine; the corvette immediately changed course. Simultaneously, *Chilore* plows into a contact mine. Still suspecting a U-boat attack, both merchantmen give orders to abandon ship (USS *Spry* 1942). By this time, *PC-462* had reached the group and assisted the corvette in clearing the minefield. Realizing he could provide no additional assistance to the merchantmen as PC's were on the scene, USS *Spry* obtained accurate position information from *PC-462* and set a course to

rejoin KS-520. By 2100 hours the corvette was clear of the minefield and making 14 knots to reconnect with the convoy (USS *Spry* 1942; Freeman 1987: 418-419).

Back in the minefield, the quickening darkness hastened decision-making. Still thought to be under threat from a U-boat, Nichols and Griffiths decided to throw the anchors and abandon ship at 2050 hours. Wounded men were placed in boats as gently as could be arranged, while all secret documents were sealed in a weighted bag and thrown overboard. All four lifeboats from *J.A. Mowinckel* were safely launched, in addition to the boats from *Chilore*, whose crew was also abandoning ship. Coast Guard patrol craft towed many of the lifeboats to Ocracoke Island, while others moved under their own power. Once ashore, several of the seriously injured crew evacuated to Norfolk for medical treatment. In Norfolk's Marine Hospital on 21 July, Seaman Second Class Raymond V. Wolfe died from wounds sustained during the *U-576* attack (SOC 1946:367-368).

Once the shock of the crew's ordeal subsided, they realized in fact a U-boat had not attacked their boats. Like *F.W. Abrams*, they had strayed into an immense minefield. The following day, both *Chilore* and *J.A. Mowinckel* were still afloat in the minefield, having been anchored prior to abandoning ship. A salvage effort was undertaken, starting first with an assessment made by *J.A. Mowinckel's* Captain and Chief Engineer. Ferried out to the site on Coast Guard launches, along with some assistant engineers, radiomen, and naval personnel, Griffiths and Guthrie surveyed the damaged hulk. When they arrived, they observed "… J.A. Mowinckel had settled by the stern and listed to starboard so that part of her after deck was under water…. [A]ll valves, ullage plugs, and watertight doors were closed." That night, Lieutenant Commander Robert E. Permut ordered salvage tugs to retrieve the craft (SOC 1946:368-369).

Prior to establishing a tow, safe passage was need through the minefield. For the next two days aircraft dropped depth charges to countermine while minesweepers attempted to clear a channel. On 17 July tug *Relief* arrived at Hatteras. By 19 July, countermining and sweeping had established a safe channel, and tugs *Keshena* and *J.P. Martin* were dispatched. A successful outcome was expected. That afternoon, *J.P. Martin* had *J.A. Mowinckel* under tow, with *Keshena* taking a line off the stern to act as a rudder. At 1525 hours, *Keshena* strayed from the swept channel, struck a mine, and sank in 12 minutes. As *Keshena* went down two sailors perished. *Relief* and *J.P. Martin* were able, without further incident, to extricate both *Chilore* and *J.A. Mowinckel*. Once inside Hatteras Inlet, the ships were beached and underwent repairs to make

ready for tow back to Norfolk. On the outbound journey *Chilore* capsized and sank in the entrance to the Chesapeake Bay on 24 July 1942. *J.A. Mowinckel* made Norfolk and was eventually salvaged (COM5 1942e; COM7 1942b; Henderson 1942; SOC 1946:369-371; Hoyt 1978:171-172; Freeman 1987:419).

The convoy battle between KS-520 and *U-576* resulted in the loss of four Allied lives; one Naval Gunner, one merchant sailor, and two crewmen from tug *Keshena*. All forty-five hands aboard *U-576* went down with their vessel. Nearly twenty sailors from *J.A. Mowinckel* sustained injuries, half of which were serious enough for medical evacuation to Norfolk. A crewman about *Chilore* had also been injured. Many of the 24 sailors rescued from *Bluefields* were also treated for minor injuries. Three Allied ships, *Bluefields, Chilore,* and *Keshena* were lost as a result of the attack, as well as *U-576* itself.

The effects of the battle, however, reverberated throughout the Atlantic. As KS-520 steamed closer to Key West stiff Allied defenses in the area prompted Admiral Doenitz to order withdrawal of his remaining U-boats from the eastern seaboard (Blair 1996:626-627). Effectively, the Battle of the Atlantic off North Carolina followed a similar chronology as it had in late 1940 and early 1941 off Great Britain. Early U-boat success devastated Allied shipping. The learning curve of anti-submarine warfare, however, rapidly brought effective force to bear against the German Navy, and U-boats were driven from the waters they previously dominated. Perhaps one difference was the lumbering pace at which the USN implemented these means. Indeed, in the interim of USN establishing effective means of protecting merchant shipping, U-boats enjoyed their most fruitful operational phase. Once anti-submarine measures came online in full force in the Eastern Atlantic, however, German U-boats would never again enjoy operational supremacy during the BOA. Once driven from Great Britain in 1941, American waters in 1942, and from far-afield station in the South Atlantic and Caribbean by 1943, the Battle of the Atlantic was all but lost for the Germans.

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 or lie within accessible range. While many of North Carolina's submerged World War II sites 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 may not need 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 II sites in the Gulf of Mexico (see Church et al. 2007), and it is possible that sites discovered during the summer 2011 expedition would lend themselves to future comparison of taphonomic processes acting on deepwater submerged cultural resources.

Indeed, as much as the methodology for this project emerged from the specific environmental variables posed to researchers working in the ocean, it was 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 had the potential to constitute a third "hybrid" type of conflict – one where elements of a wide area transitory battlefield littered with the debris of moveable structures were 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, an important consideration was that actions during naval engagements, depending on the time period, took place proximate to safe anchorages, shore batteries, minefields, straits, protected convoys, as well as in open 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, present elements of both siege and transitory-type sites in the archeological record.

Nevertheless, the methodology for the study involved 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 was collected from various primary and secondary sources, completing a rubric of goals outlined below. The goal of archeological work was 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. This data, imported into a GIS was used in subsequent KOCOA analysis, following a methodology 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 proximity 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, dictated historical research focus 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 were found in handbooks and training materials issued to sailors and their officers. The third is to evaluate previous KOCOA battlefield surveys for methodological and analytical insight.

Several historical archives were 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 were merchant ship files regarding staffing and provisioning of armed merchant vessels.

Though historical research leaned heavily upon primary sources, several secondary sources were also useful in fulfilling the three historical research goals. Several publications were 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) (Figure 4).

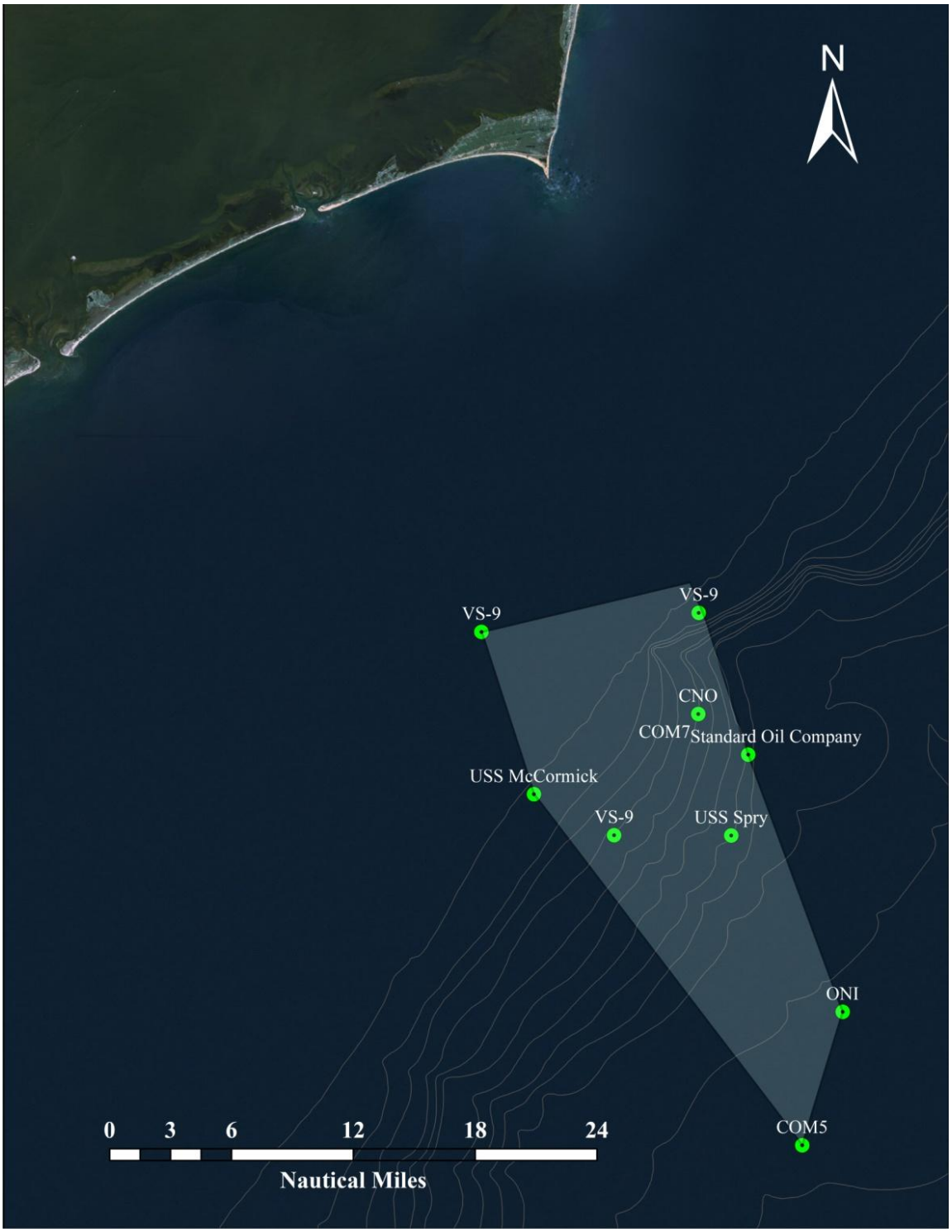

Figure 4. Distribution of Historical Sources (Source: John Bright).

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; McBride 2009; Sutherland and Richardson 2009; Geier et al. 2011; Hanna 2011; Pollard 2011). Archeological methods adopted for this project focused on remote sensing (in particular acoustic survey) and non-invasive inspection of vessels remaining on the battlefield. In addition to the fact that project personnel did not seek permission from original owners (the USA and German governments, merchant vessel owners, or marine underwriters) excavation was not required due to the priority of discovery, and a lack of research questions requiring disturbance.

Archeological data gathered during the survey served two functions. Firstly, 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 also served 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 were not known. Only the location of *Keshena* and *Chilore* are currently known, thus a major component of fieldwork involved remote sensing survey to locate the remaining two vessels.

Overall, the 2011 Battle of the Atlantic Expedition survey was 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 was made available via various funding sources, with vessel remains documented by insonification. Should shipwrecks be discovered in depths acceptable for diving (less than or equal to 300 feet), the plan allowed for divers to utilize photographic and video survey methods (though not needed during the expedition). Previous work on *Keshena,* completed during NOAA's 2010 Battle of the Atlantic

expedition, in addition to previous research (such as Wagner 2010), was also utilized as part of the archeological data set.

Stage One: Wide Area Survey

The Stage One survey methodology was designed around two separate remote sensing packages. Primarily, the wide area survey utilized an ATLAS (Autonomous Topographic Littoral Area Survey) sonar developed by Applied Research Laboratories at the University of Texas at Austin (ARL-UT) in conjunction with the Office of Naval Research (ONR). The ATLAS system is built into a 12-3/4" x 10' REMUS 600 Autonomous Underwater Vehicle (AUV) owned by the 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 5). As a secondary package, during AUV deployment, a Geometrics G-882 Cesium magnetometer owned by the Program in Maritime Studies, East Carolina University was planned to be used but was not utilized due to incompatibilities between the equipment and AUV deployment and vessel speed.

This instrumentation suite allowed for 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 could 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 passed through the sensor's field-of-view were "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 6). This allowed 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 provided an autonomous search capability in a small package and could be launched from a ship or pier by crane. During operations, the AUV's position and health was monitored via an ultra-short baseline (USBL) to the support craft, which was stationed near the survey area.

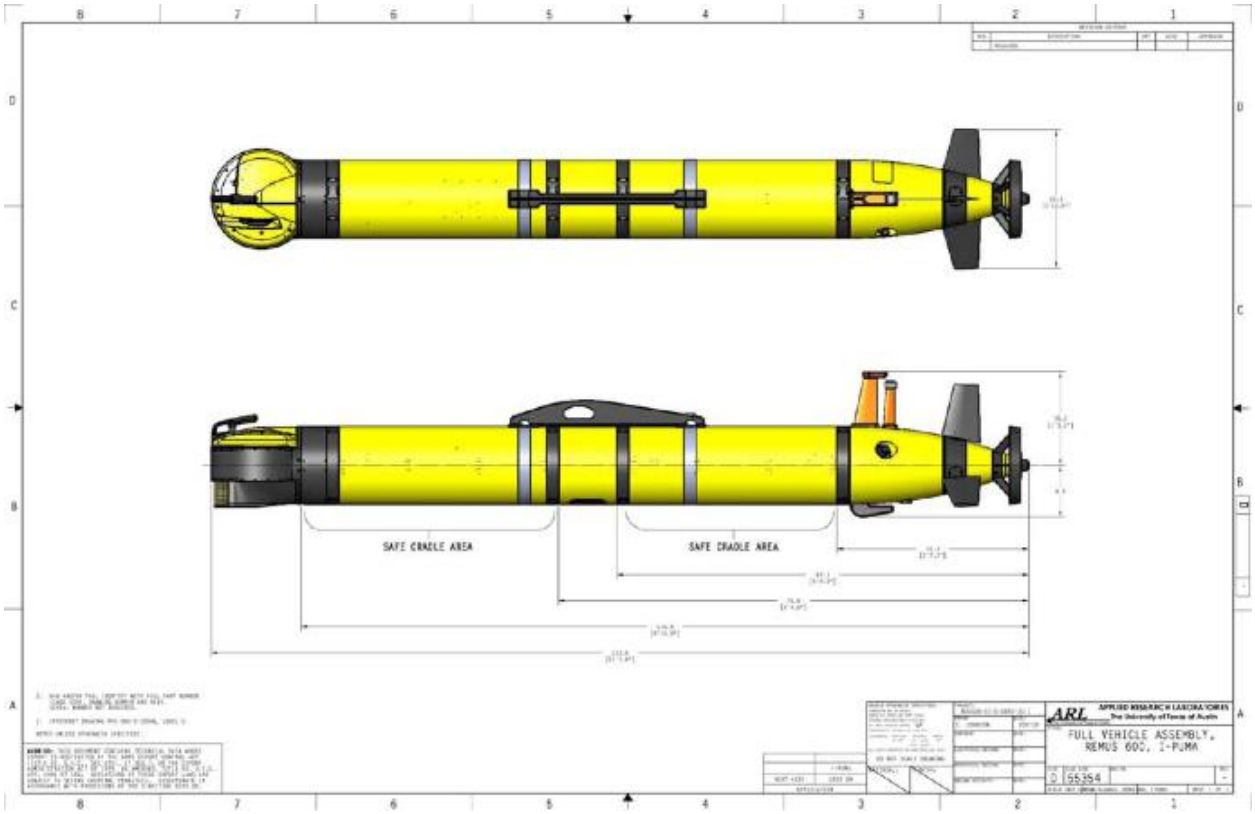

Figure 5. ARL:UT's modified REMUS 600 outfitted with Synthetic Aperture Sonar Array (Image: ARL-UT).

During this stage, the vehicle was planned to operate in water depths of 100 to 1,500 ft. With the current configuration of batteries, the vehicle ran surveys up to 16 hours per day and travelled at 3-4 knots (3.5-4.6 miles/hour) for an approximate coverage of 28-46 miles^2 per day. Taking into account weather days, this stage called for seven days of deployment (covering an estimated 196-322 miles^2 over project duration). After each deployment, the research vessel (R/V *SRVx*) retrieved the AUV for data download and processing, battery re-charging, and re-programming. Imagery and bathymetry were integrated into the project geo-database. This methodology went to plan with two exceptions. First, operation time was extended in some instances to a maximum of 16 hours. Second, strong currents restricted the depth the AUV was able to reach to 250 meters (700 feet). 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

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	Research
John Bright	ECU	Research
John McCord	UNC-CSI	Videography
Mark Fowler	Wildlife Prod.	Documentary Director

Stage 1 focused on the area depicted in Figure 7. 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.

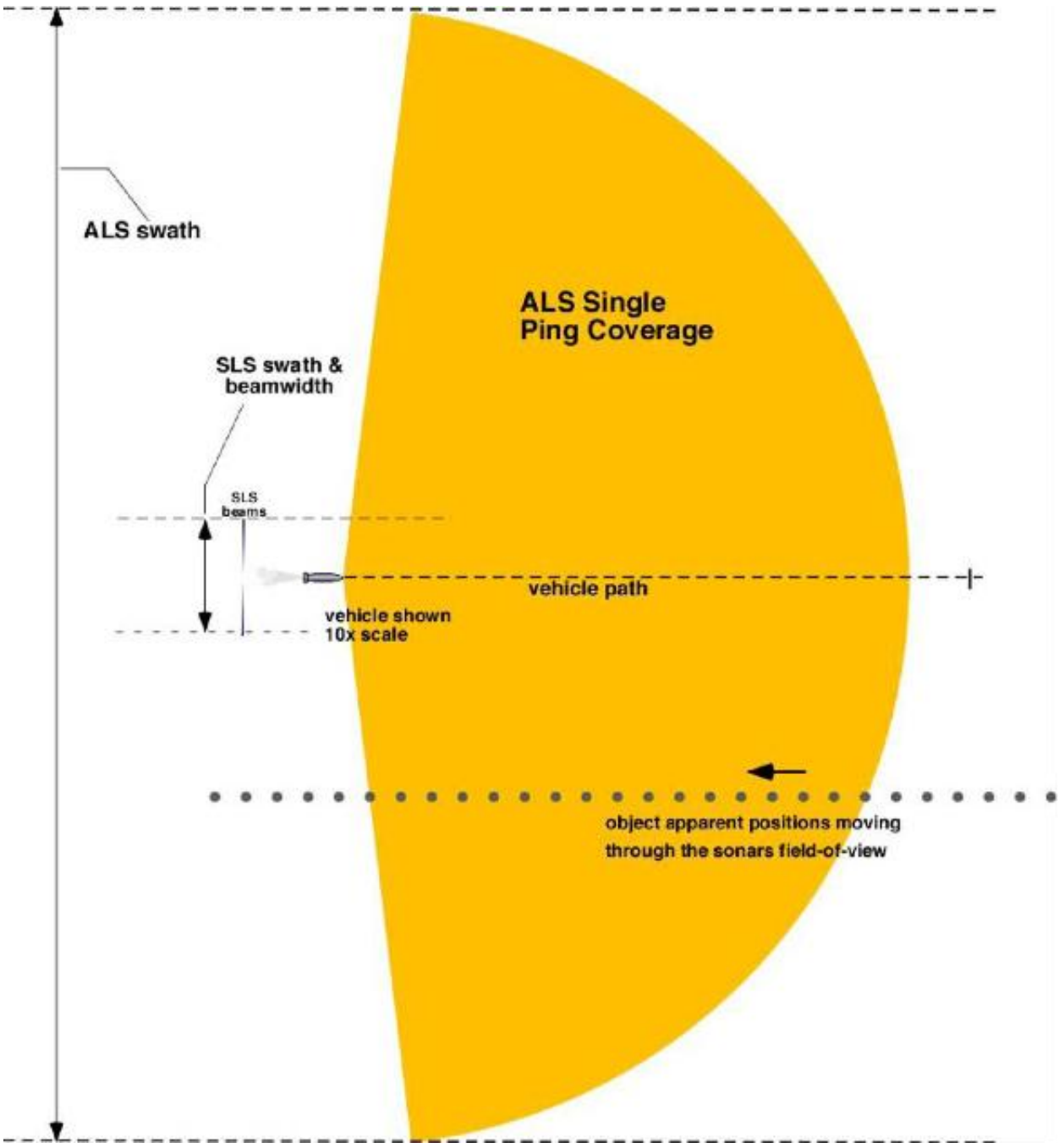

Figure 6. ALS Single-Ping Field of View and Swath Width (Image ARL-UT and ONR).

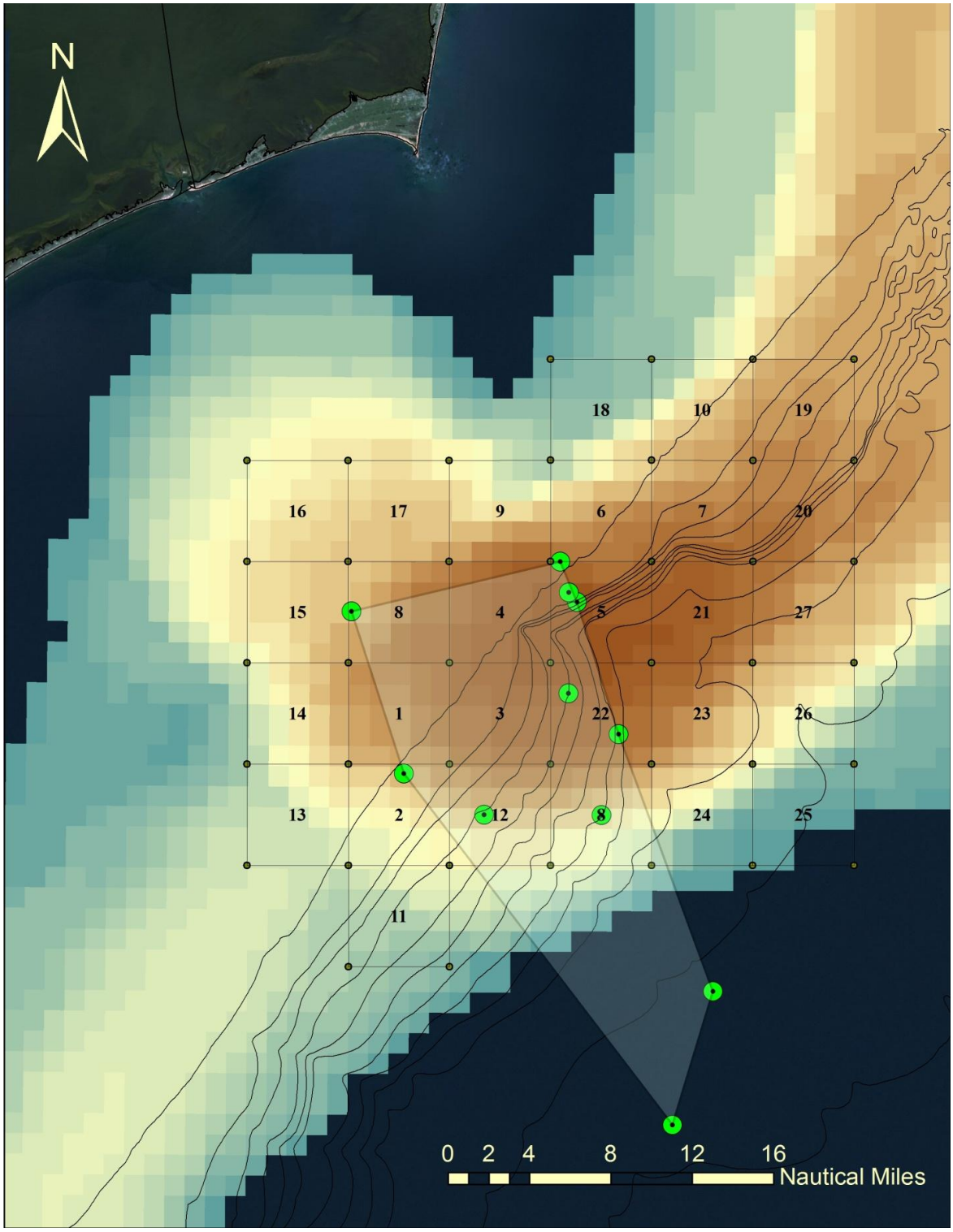

Figure 7. Prioritized survey areas (5 x 5 nautical miles) for stage 1 operations according to spatial density mapping. Soundings in meters represented in meters from sea-level (Image: John Bright).

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. As will be shown the next section, 293.892578 sq kms. were covered, and 47 sonar targets were extracted from the sonar dataset for investigation in Stage Two and during future expeditions.

Target categorization and prioritization occurred according to the following rubric:

Viewing the 1 meter resolution data, sonar coverage was systematically analyzed and interpreted according to the following procedure.

I. Each sonar mission was imported as a separate file into ArcMap; using 1 meter resolution data, the data frame was zoomed in to the extent only a single pass was visible.

II. A table, listed in Appendix B, was created to catalogue anomalies, including fields for day, run number where days had multiple missions, and decimal degree reporting of position.

III. Also in the table, a listing of evaluation criteria:

a. Reflection: Qualitative measure of light coloration in sonar target, a representation of the intensity of acoustic return from target, and indicative of the material composition of target. Ranked as high (white coloration), medium (whites and grays), or low (grays).

b. Scour: A conspicuous disturbance of bottom substrate associated with a possible anomaly. Indicated as either present or absent.

c. Shadow: Acoustic shadow resulting from object extending off the seafloor and thus blocking sound waves on the side opposite of the incidence. Associated with reflection. Ranked as present or absent.

d. Length: Axial measure of target as projected in GIS data frame. Reported in meters, length assists target prioritization based on similarity of dimensions to *Bluefields* or *U-576*.

e. Isolation: Indicates if target is distinguished from surrounding bottom substrate. Reported as isolated, associated, or confused.

f. Bottom Type: General estimate of substrate. Either sandy, rocky, or mixed.

g. Perspective: Used to interpret ghosted and/or duplicated imagery resulting from the composite of SLS, SAS, and ALS sonar. Also could account for distortion in imagery.

h. Centerline (CL) Range: Distance, in meters, of target from the track of AUV fish. As distance increases, the possibility of distortion also increases. Targets more than 500 meters from centerline were thus considered suspect.

Stage Two: Targeted Survey

Whereas the emphasis of Stage One was to cover a large area in order to increase the probability of locating the wreck sites, the goals of Stage Two focused on the relocation of discovered targets and their characterization with a different set of instrumentation. A proposal to record World War II hazardous wrecks had been prepared by John Kloske (SRI International) (see Kloske 2010), from which the following information was been sourced.

Similar to Stage One, Stage Two relied upon the deployment of a remote sensing package integrated into a Bluefin AUV chassis (12.5” x 10’) (Figure 8). Following the relocation of a

sonar target, the AUV was planned to 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 involved 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 9). Dive two would utilize a BlueView MB1350 (1.35 mHz) multibeam sonar for the purpose of creating more detailed three-dimensional images (Figure 10). Dive three would 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 undertook transects across the target area with a 50% sonar overlap to ensure adequate coverage. Multibeam data collected from wreck sites found during the survey was then combined into a single dataset (3D point cloud), culminating in a geo-rectified three-dimensional model.

The survey prioritized sites discovered during Stage One. Due to multiple deployment and retrieval events, a maximum of two sites per day were planned to be recorded (maximum 22 sites recorded). As previously mentioned, in the event that Stage One was unsuccessful in locating some or all of the KS-520 targets, archeological work would shift to document other Allied and Axis casualties from the greater conflict (Table 3). As will be discussed in the next section, due to equipment breakdown, two sites were successfully investigated. 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 8. Bluefin AUV used during Stage 2 survey (Kloske 2010:2).

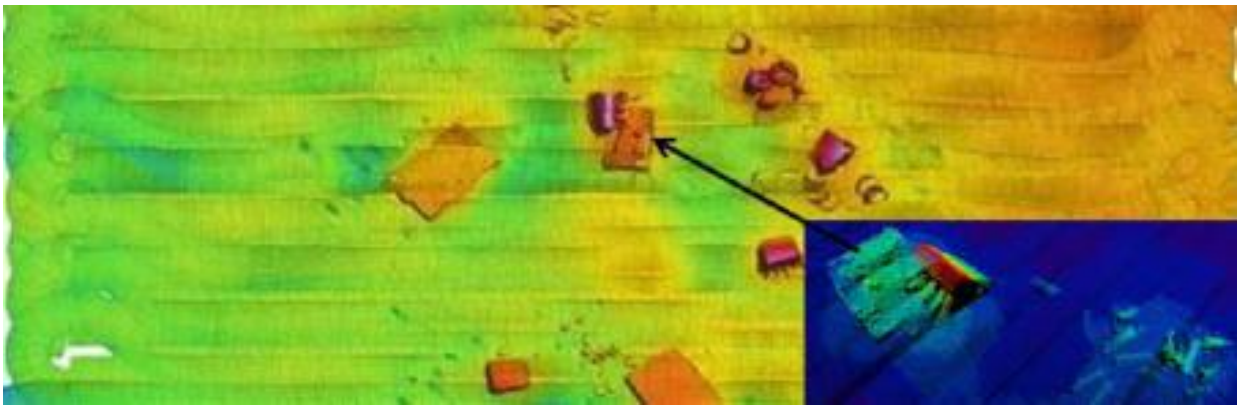

Figure 9. Example of Imagenex Delta T-260 kHz date from AUV (Kloske 2010:2).

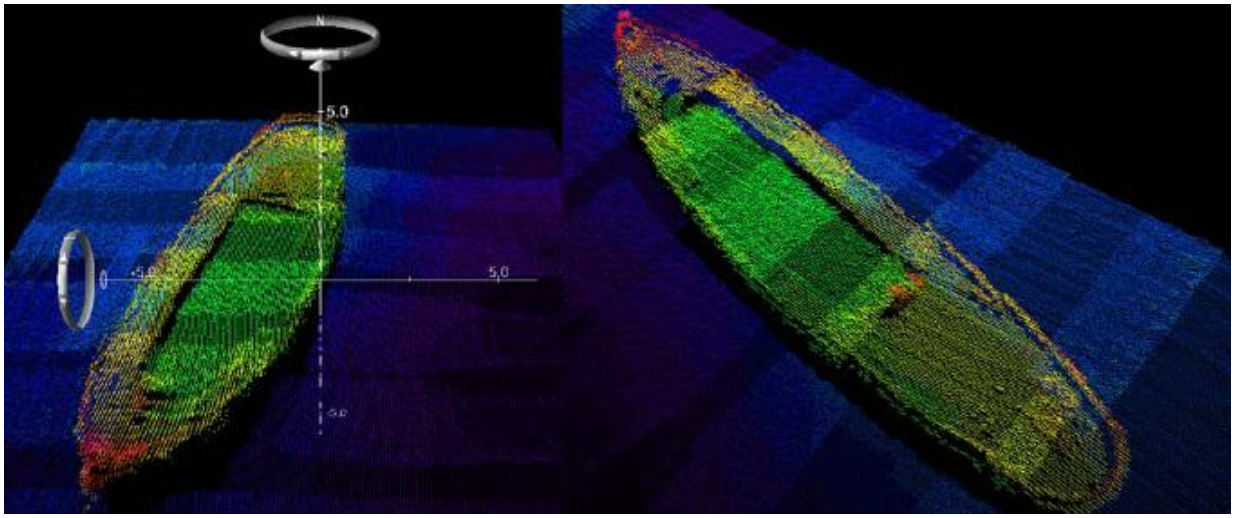

Figure 10. Example of imagery from BlueView MB1350 (1.35 mHz) multibeam sonar showing 20m long wreck (Kloske 2010:3).

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
Steve Untiedt	SRI	Survey Tech
Charlie Cullins	SRI	Survey Tech
Nathan Richards	UNC-CSI & ECU	Site determination
John Bright	ECU	Site determination
John Wagner	NOAA RPT	Site determination

RESULTS OF REMOTE SENSING

Remote sensing operations were spread over two stages. Stage One, constituting a rapid, wide area survey formed the foundation for all Stage Two operations, which focused on separate missions to inspect potential targets. Following setup and diagnostics, sonar acquisition undertaken in Stage 1 occurred over the period June 3-9. During this time sonar operations were governed according to battery use cycle and recharge times (1 hour of battery charge equated to 1 hour of battery use), and culminated in run times between 1 and 16 hours. Missions were labeled by the date of their commencement, and culminated in the following areas covered (see Figure 11):

- June 3: 33.047055 km² (12.7595 mi²);
- June 4: 46.640632 km² (18.0080 mi²);
  (night operation straddled June 4 and 5)
- June 6 : 136.198197 km² (52.5864 mi²)
  (night operation included two runs straddling June 6 and 7):
- June 8: 107.1680852 km² (41.3778 mi²);
- June 9: 54.334537 km² (20.9786 mi²).

While this equals, 377.3885062 km² (145.710 mi²), accounting for overlap, the total area covered was 293.892578 km² (113.472 mi²) (see Figure 12). While this is still a very large area covered in a short period of time limitations discovered in the field reduced the efficiency of the AUV. In particular, there were numerous attempts to make the REMUS vehicle dive to depths beyond 200 meters that were unsuccessful. Though originally thought to be due to technical problems, inspection of data following retrieval indicated that t was soon found that it was actually due to extremely strong currents (in some cases believed to be cross-currents) running through the water column and on the seabed beyond this depth which meant that the vehicle was unable to maintain its programmed depth, altitude and track line causing it to abort its mission. Following this discovery, all missions were programmed to follow bathymetric contours equal to or less than the 200 meter bathymetric contour. All subsequent excursions to depth were successful and the only remaining limitation became battery recharge times and occasions of poor sea state where waves and/or research vessel pitching and rolling precluded AUV launching or recovery.

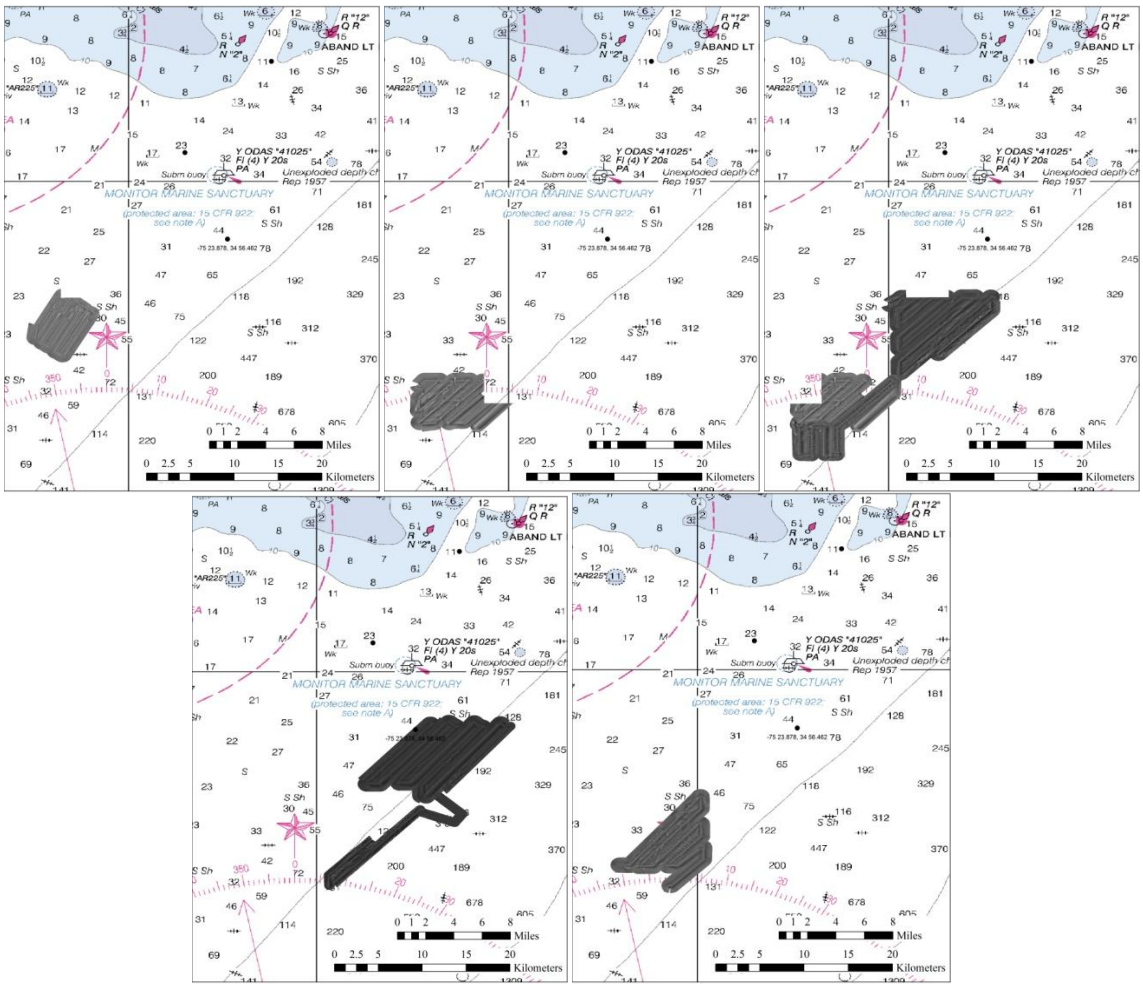

Figure 11. Area coverage by day, showing area coverage on June 3, 4, 6, 8 and 9 respectively (Image: Nathan Richards).

Results of Stage One

Following the inspection of raw sonar data from Stage One, 47 targets were identified as suspicious (see Figure 13) based on degree of reflection, presence of scour, length, and isolation on seabed (see Table 6). Due to time limitations in Stage Two, only a small number of these sites could be inspected. For this reason, once the entire dataset was tabulated and ranked, seven targets were extracted from this dataset as the most likely to represent shipwreck remains, and then prioritized again to determine a dive order (see Table 7). Each sonar target is described below in order to account for the logic of decision making in the transition to Stage Two, and also indicate the large number of additional likely targets available for inspection in future surveys. Individual georectified sonar tiles are also displayed in Figures 14-59.

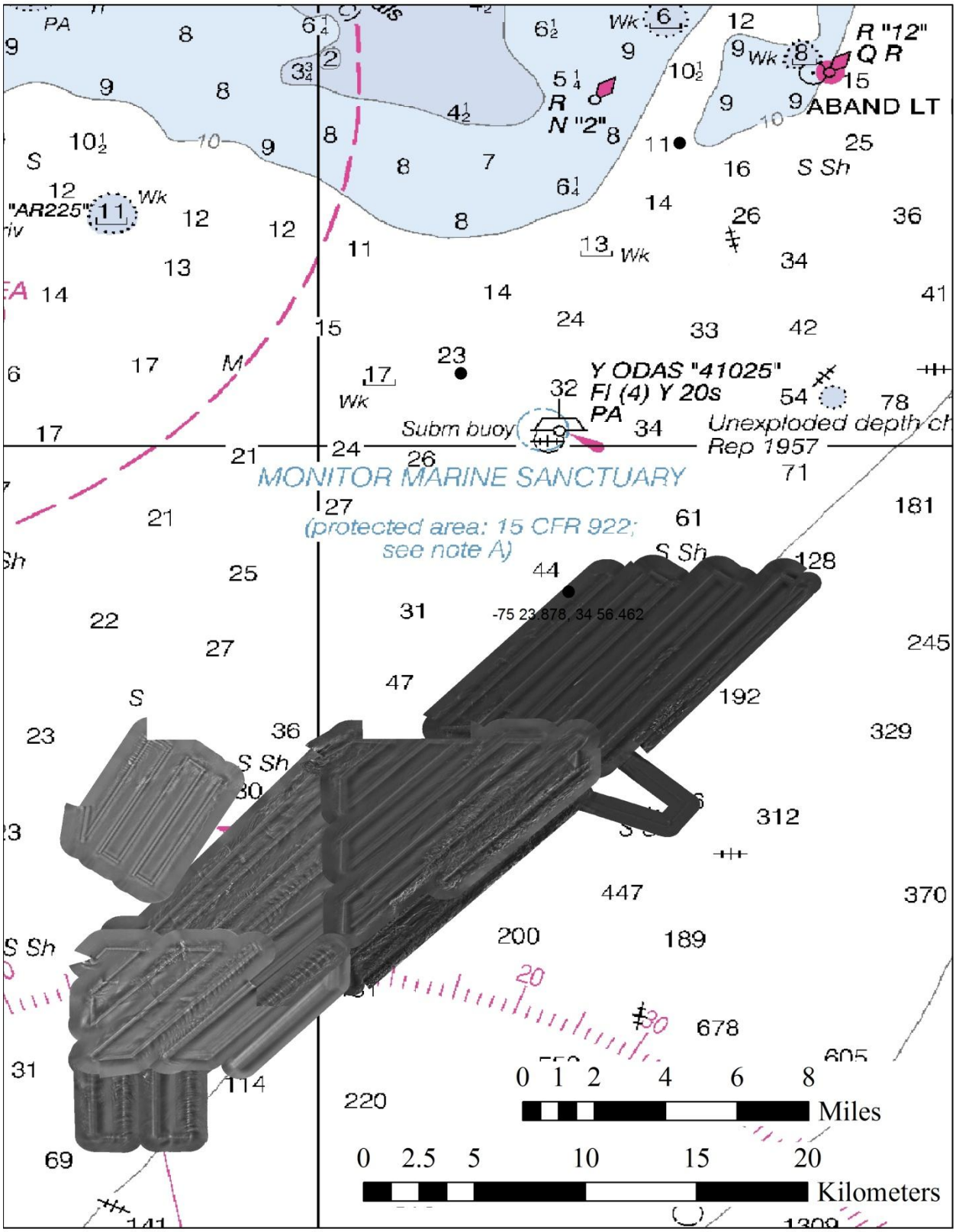

Figure 12. Overall coverage area of Stage 1 survey (Image: Nathan Richards).

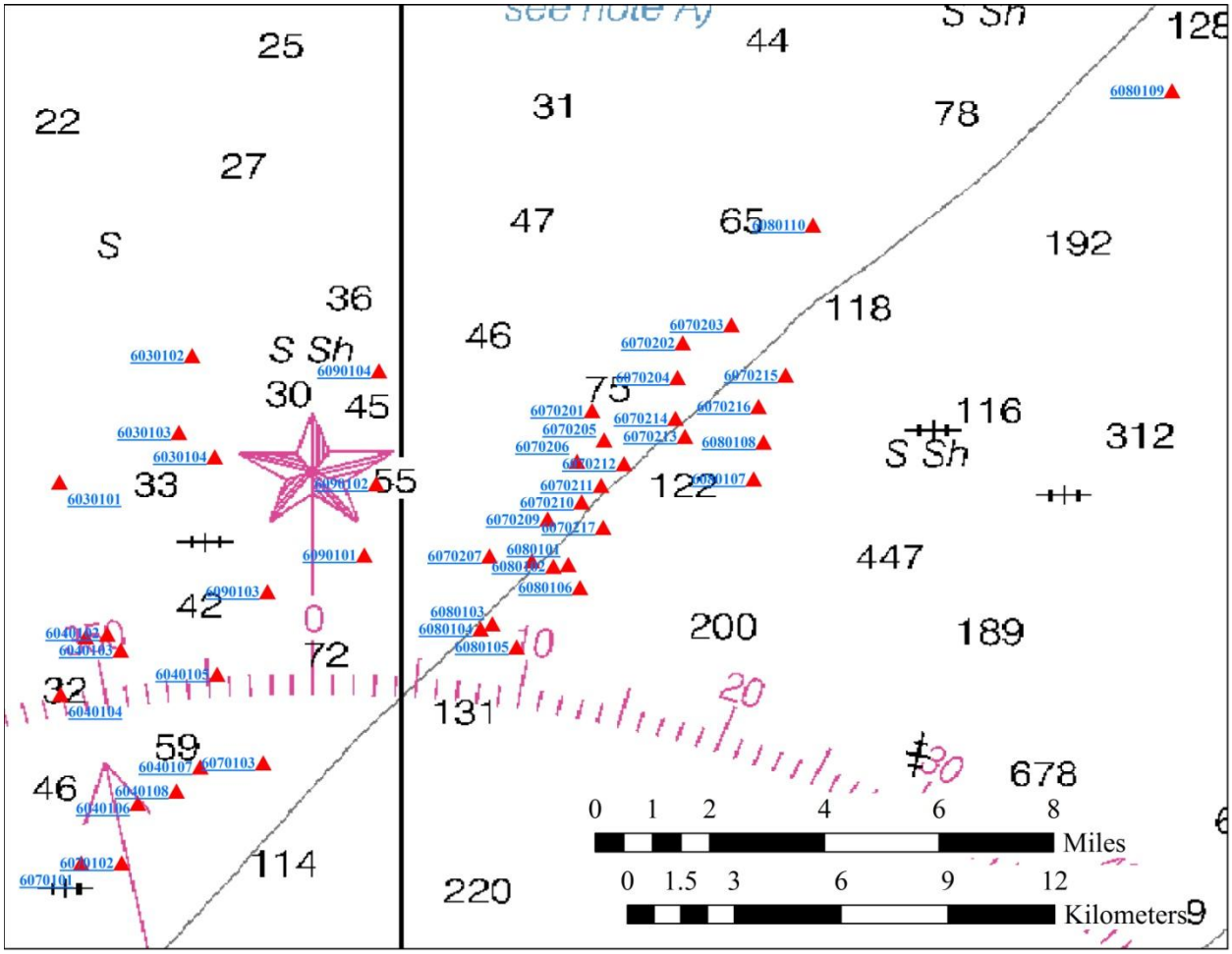

Figure 13. Geographical depiction of sonar anomalies located during Stage One operations (Image: Nathan Richards).

Table 6. List of sonar anomalies located during Stage One operations (coordinates in WGS84 UTM Zone 18 meters).

Filename	Longitude	Latitude	Reflection	Scour	Shadow	Length (m)	Isolation	Bottom
6030101	-75.58589623	34.83823225	High	None	None	5	Yes	Sand
6030102	-75.55239733	34.87023543	Medium	None	Yes	93	Yes	Sand
6030103	-75.55574437	34.85080105	Low	None	Yes	55	Yes	Sand
6030104	-75.54665983	34.84462898	Low	None	None	16	Yes	Sand
6040101	-75.57921477	34.79908367	High	None	None	9	Yes	Sand
6040102	-75.57380662	34.79975492	High	None	None	14	Yes	Sand
6040103	-75.57043817	34.79568407	High	None	Yes	18	Yes	Sand
6040104	-75.58563312	34.78451988	High	None	None	9	No	Sand
6040105	-75.54608745	34.78957903	Medium	None	Yes	23	Yes	Sand
6040106	-75.56611270	34.75694607	High	None	None	7	Yes	Sand

6040107	-75.55033295	34.76616772	High	Yes	Yes	58	No	Mixed
6040108	-75.55634565	34.76005630	High	None	Yes	52	Yes	Mixed
6070101	-75.58039028	34.74188542	Medium	Yes	Yes	89	Yes	Sand
6070102	-75.57020140	34.74188542	High	Yes	Yes	111	Yes	Sand
6070103	-75.53448732	34.76721428	High	None	None	150	Yes	Sand
6070201	-75.45139793	34.85632382	Medium	None	Yes	103	Yes	Sand
6070202	-75.42849493	34.87349577	Medium	None	Yes	22	Yes	Sand
6070203	-75.41620425	34.87802838	Medium	None	Yes	43	No	Sand
6070204	-75.42980583	34.86469168	High	None	None	53	Yes	Sand
6070205	-75.44832627	34.84891418	Low	None	None	170	Yes	Sand
6070206	-75.45516878	34.84351018	Medium	Yes	Yes	150	Yes	Sand
6070207	-75.47731527	34.81952413	Medium	Yes	Yes	55	Yes	Sand
6070208	-75.46657857	34.81830785	Medium	Yes	Yes	30	Yes	Rock
6070209	-75.46261763	34.82884843	Medium	None	Yes	45	No	Sand
6070210	-75.45400785	34.83318487	High	None	Yes	105	No	Rock
6070211	-75.44910158	34.83739865	High	None	Yes	86	No	Rock
6070212	-75.44333027	34.84290805	High	None	Yes	48	No	Rock
6070213	-75.42792670	34.84980667	Medium	None	Yes	105	No	Rock
6070214	-75.43033207	34.85437337	Medium	None	Yes	46	No	Rock
6070215	-75.40246488	34.86528583	High	Yes	Yes	110	No	Rock
6070216	-75.40936520	34.85737128	High	None	Yes	16	No	Rock
6070217	-75.44857990	34.82675968	Medium	None	Yes	94	No	Mixed
6080101	-75.45740068	34.81733975	High	Yes	Yes	49	Yes	Mixed
6080102	-75.46117208	34.81689348	High	None	Yes	95	No	Rock
6080103	-75.47660867	34.80235622	High	None	Yes	52	No	Rock
6080104	-75.47957562	34.80103958	High	Yes	Yes	27	No	Mixed
6080105	-75.47043698	34.79650570	High	Yes	Yes	67	No	Rock
6080106	-75.45443942	34.81153493	High	Yes	Yes	80	No	Rock
6080107	-75.41058892	34.83907048	High	None	Yes	48	No	Rock
6080108	-75.40806400	34.84836832	High	Yes	Yes	78	Yes	Rock
6080109	-75.30493737	34.93720805	High	Yes	Yes	37	Yes	Sand
6080110	-75.39563317	34.90327510	High	Yes	Yes	70	Yes	Sand
6090101	-75.50891462	34.81974598	High	None	None	18	Yes	Sand
6090102	-75.50592942	34.83783488	High	Yes	None	40	Yes	Sand
6090103	-75.53341163	34.81050337	High	Yes	None	81	Yes	Sand
6090104	-75.50519723	34.86639820	Medium	Yes	Yes	76	Yes	Sand

Sonar Target 6030101

Figure 14 shows an acoustic image of a highly reflective object (approximately 5m long) sitting on a sandy bottom. While isolated on the seabed, no scour or shadow was associated with the object.

Due to its short length (not corresponding with the dimensions of any vessel being sought), this anomaly was deemed low priority and excluded from Stage Two survey.

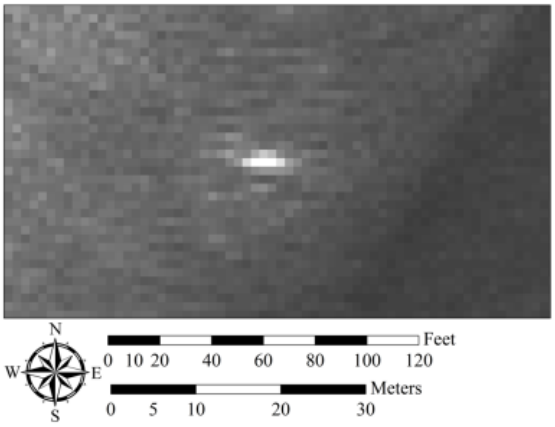

Figure 14. Image of sonar target 6030101.

Sonar Target 6030102

Figure 15 shows an acoustic image of an isolated object with some degree of reflection and shadowing sandy bottom approximately 93 meters long. While isolated on the seabed, no scour or shadow was associated with the object.

As the object had lacked defined features, it it was deemed to be a low priority site, and was excluded from Stage Two survey.

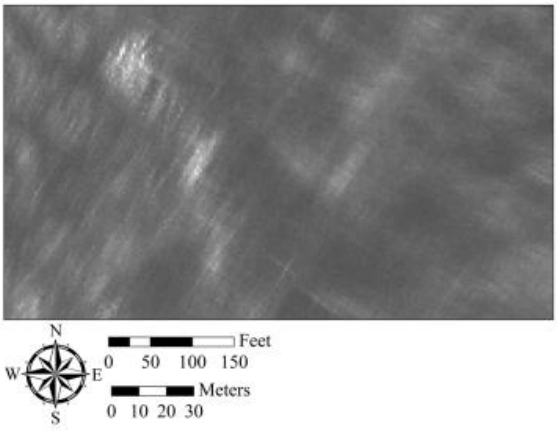

Figure 15. Image of sonar target 6030102.

Sonar Target 6030103

Figure 16 shows an acoustic image of an isolated object about 55 meters long with low reflection and no shadowing sitting on a sandy bottom. While isolated on the seabed, no scour or shadow was associated with the object.

As the object lacked defining features, it was deemed to be a low priority site and was excluded from Stage Two survey.

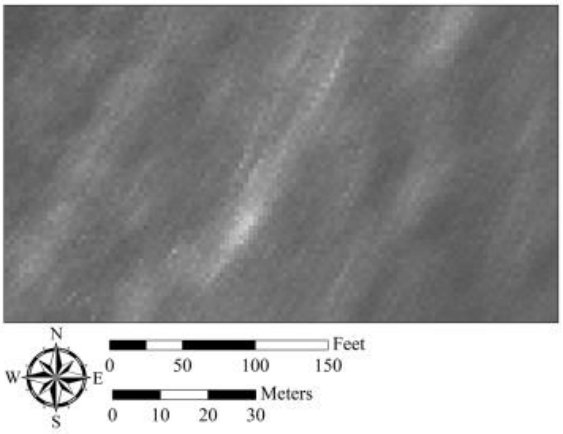

Figure 16. Image of sonar target 6030103.

Sonar Target 6030104

Figure 17 shows an acoustic image of an isolated object about 16 meters long sitting

on a sandy bottom.with low reflection, no significant shadowing and no obvious scour patterns.

As the object had a lack of defined features, it was deemed to be a low priority site and was excluded from Stage Two survey.

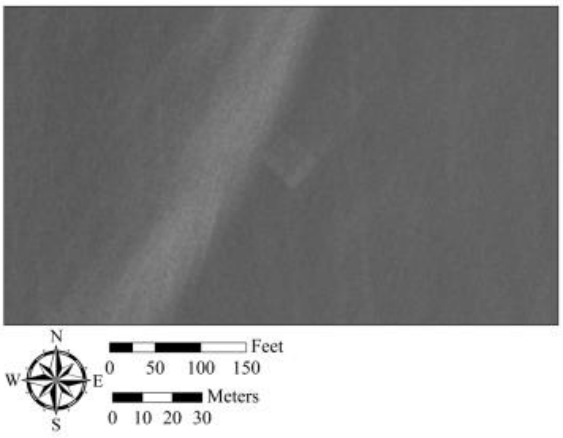

Figure 17. Image of sonar target 6030104.

Sonar Target 6040101

Figure 18 shows an acoustic image of an isolated object on a sandy bottom about 9 meters long with high reflection but no significant shadowing or associated scour patterns.

As the object lacked defined features, it was deemed to be a low priority site and was excluded from Stage Two survey.

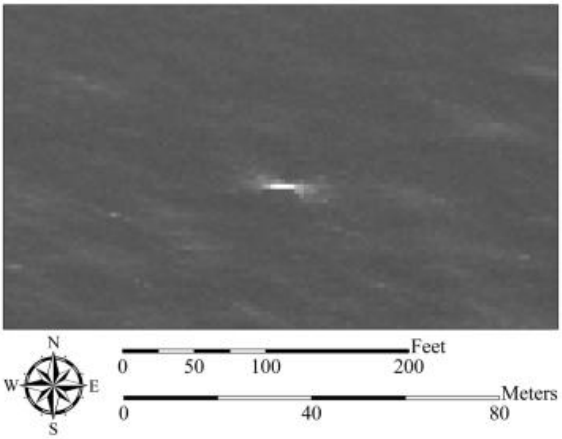

Figure 18. Image of sonar target 6040101.

Sonar Target 6040102

Figure 19 shows an acoustic image of an isolated object on a sandy bottom about 14 meters long with high reflection but no significant shadowing or associated scour patterns.

As the object lacked defined features, it was deemed to be a low priority site and was excluded from Stage Two survey.

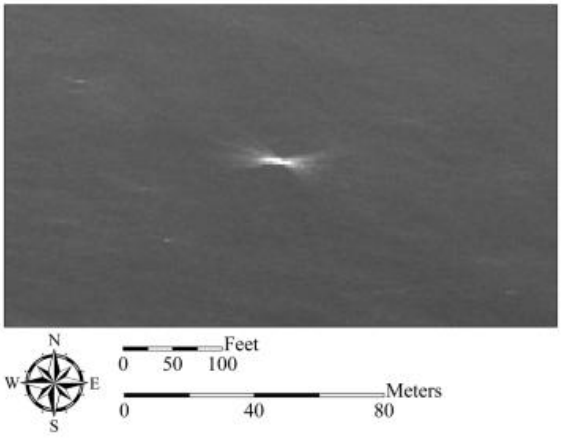

Figure 19. Image of sonar target 6040102.

Sonar Target 6040103

Figure 20 shows an acoustic image of an isolated object on a sandy bottom about 18 meters long with high reflection, some degree of shadow, but no associated scour patterns.

Object shape, and lack of scour patterns culminated in its exclusion from Stage Two survey.

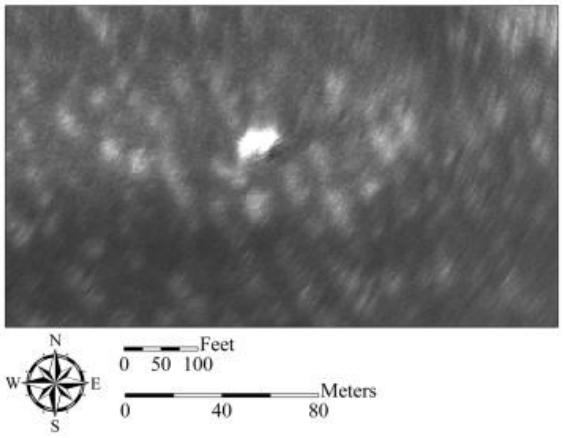

Figure 20. Image of sonar target 6040103.

Sonar Target 6040104

Figure 21 shows an acoustic image of a series of objects (each around 9 meters in length) lying in close proximity on a sandy bottom. Each object appears to be highly reflective, but none cast significant shadows or have scour patterns associated with them

Object shape and size, and lack of scour patterns culminated in their exclusion from Stage Two survey.

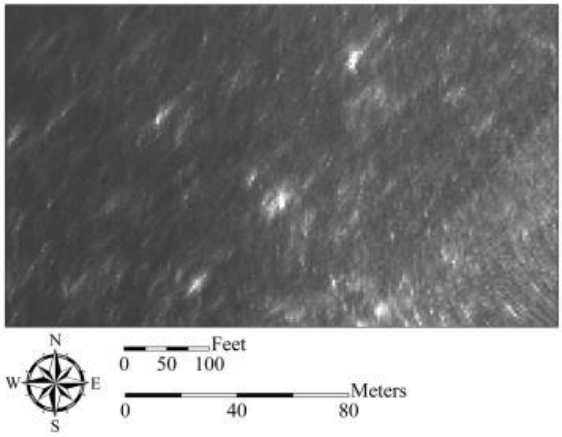

Figure 21. Image of sonar target 6040104.

Sonar Target 6040105

Figure 22 shows an acoustic image of an isolated object (around 23 meters long) lying on a sandy bottom. The object, while having a degree of reflection does not have associated shadow or scour patterns.

While object shape potentially made this a target of interest, the lack of a discernible scour pattern and a short length excluded it from Stage Two survey.

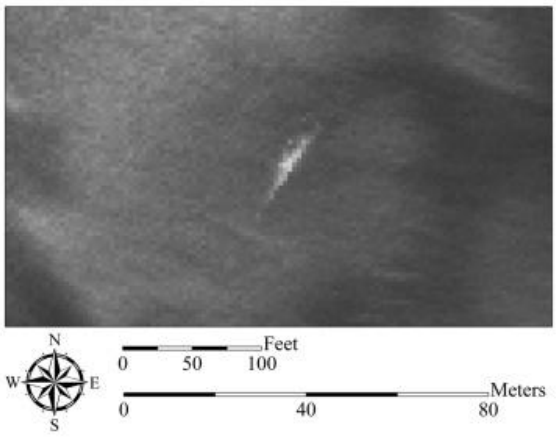

Figure 22. Image of sonar target 6040105.

Sonar Target 6040106

Figure 23 shows an acoustic image of an isolated object (around 7 meters long) lying on a sandy bottom. While the object is highly reflective, it does not have associated shadow or scour patterns.

Object shape, size and lack of scour patterns culminated in its exclusion from Stage Two survey.

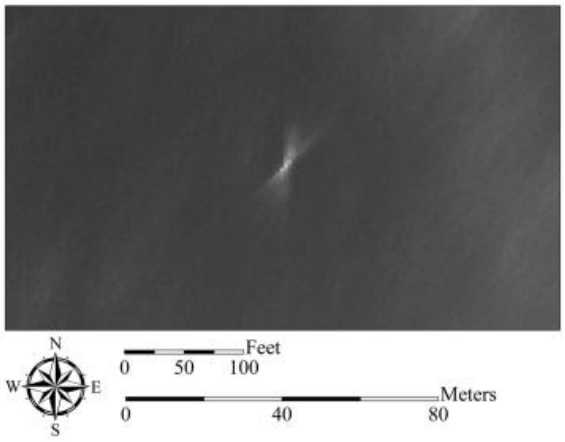

Figure 23. Image of sonar target 6040106.

Sonar Target 6040107

Figure 24 shows an acoustic image of an apparent debris field lying on a substrate mixed with sand and rocks. Within this area six highly reflective components appear, all of which are highly reflective, and also contain significant shadow and scour patterns associated with them.

Object shape and size did not correspond with research regarding World War 2 casualties, and hence the site was excluded from Stage Two survey.

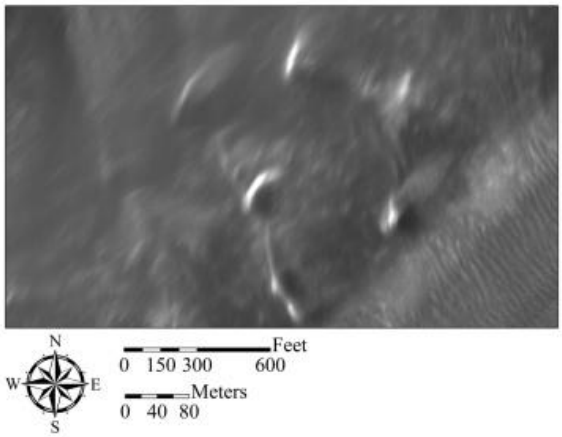

Figure 24. Image of sonar target 6040107.

Sonar Target 6040108

Figure 25 shows an acoustic image of an isolated object (around 52 meters long) lying on a bottom of sand and rocks. The object has associated shadows but no evidence of scour patterns.

While object shape and size potentially made this a target of interest, the lack of a discernible scour pattern culminated in its exclusion from Stage Two survey. It may be considered at the top of a ranked list of targets deemed low-priority in 2011.

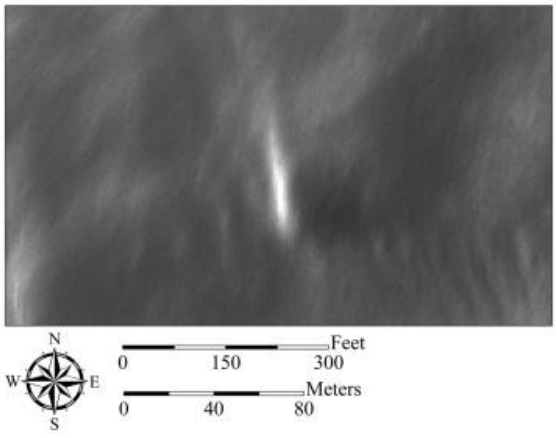

Figure 25. Image of sonar target 6040108.

Sonar Target 6070101

Figure 26 shows an acoustic image of an isolated object (around 89 meters long) lying on sandy substrate. The object is associated with traces of acoustic reflection as well as shadow and a scour pattern.

While many aspects of this target made it a site of interest, the strength of the return culminated in ranking it towards the top of a list of targets deemed low-priority in 2011. Like target 06040108, it is a target worthy of future investigation.

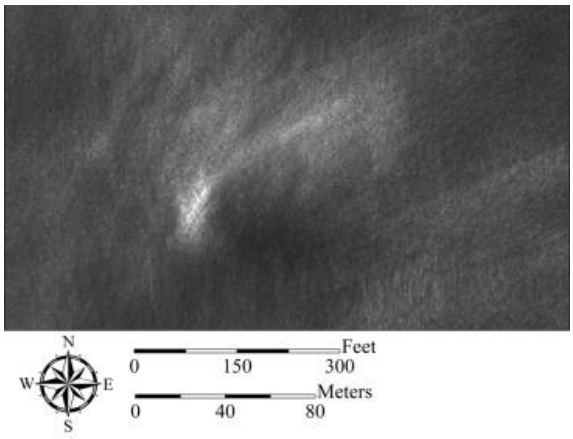

Figure 26. Image of sonar target 6070101.

Sonar Target 6070112

Figure 27 shows an acoustic image of an isolated object (around 111 meters long) lying on sandy substrate. The object is associated with all of the hallmarks of a shipwreck site – high reflection and very noticeable shadows and scour patterns.

This site was placed on the list of targets for investigation during Stage Two. The location of this site corresponds with NOAA chart position for a site known as "Powell" (believed to be a vessel sunk in 1920).

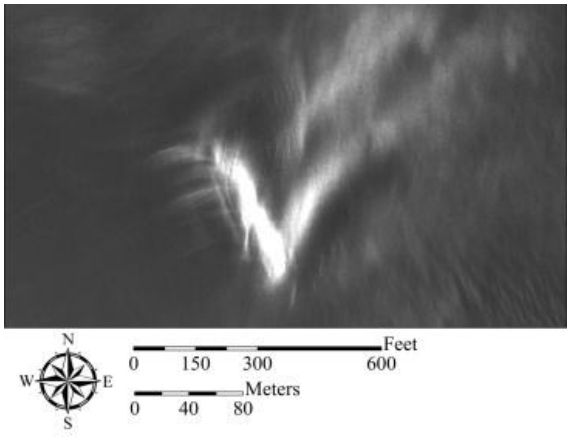

Figure 27. Image of sonar target 6070102.

Sonar Target 6070113

Figure 28 shows an acoustic image of an isolated object (around 150 meters long) lying on sandy substrate. While exhibiting areas of high reflection, negligible shadows and a lack of scour patterns are also noted.

Elongated object shape and a lack of strong shadows and scour pattern culminated in its exclusion from Stage Two survey.

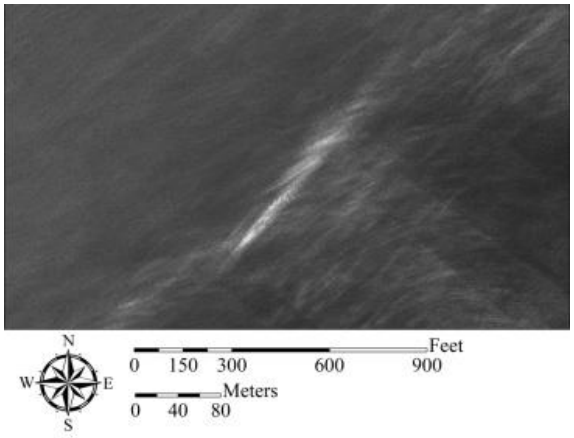

Figure 28. Image of sonar target 6070103.

Sonar Target 6070201

Figure 29 shows an acoustic image of an anomalous area of seabed (around 103 meters across) within a sandy substrate. Interpreted as having some reflection and some associated shadows, the area does not show any scour patterns.

While potentially belonging to an area of low-lying debris, the lack of strong reflection and target symmetry culminated in its exclusion from Stage 2 survey.

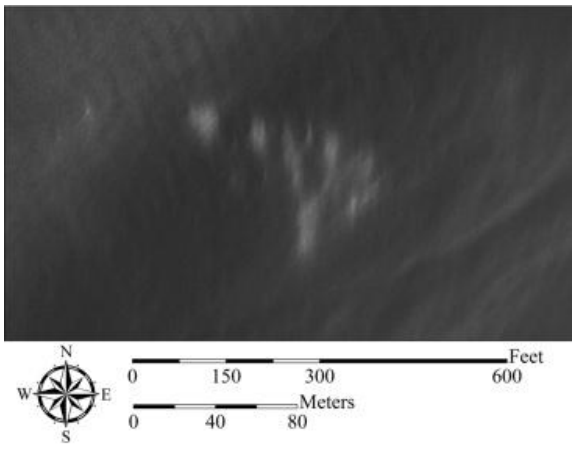

Figure 29. Image of sonar target 6070201.

Sonar Target 6070202

Figure 30 shows an acoustic image of an isolated object (around 22 meters long) lying on a sandy bottom. While the object is highly reflective, and has associated shadow, it is devoid of strong scour patterns.

Object shape and size, and lack of scour patterns culminated in its exclusion from Phase 2 survey.

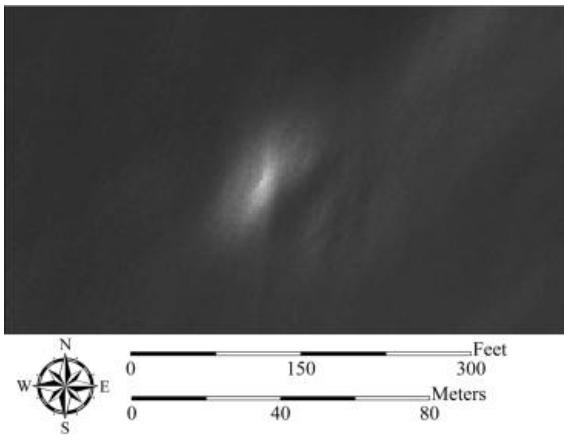

Figure 30. Image of sonar target 6070202.

Sonar Target 6070203

Figure 31 shows an acoustic image of anomalous area of sandy seabed encapsulating two slight returns of potential component targets (each around 43 meters across). Interpreted as having some reflection and some associated shadows, each component does not display significant scour patterns.

While potentially belonging to an area of low-lying debris, the lack of strong reflection and target symmetry culminated in its exclusion from Stage Two survey. Additionally, similar looking objects were noted adjacent to the location, increasing the likelihood that the objects were natural formations.

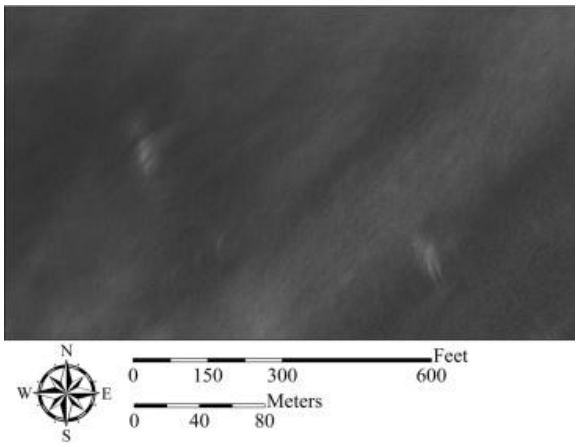

Figure 31. Image of sonar target 6070203.

Sonar Target 6070204

Figure 32 shows an acoustic image of a highly reflective area about 53 meters across lying on a sandy seabed. While highly reflective, shadows adjacent to the target do not appear to be cast from it (rather denoting bathymetric changes around the target), and there is no discernible scour.

The target was deemed likely to be a natural feature, and therefore was excluded from Stage Two survey.

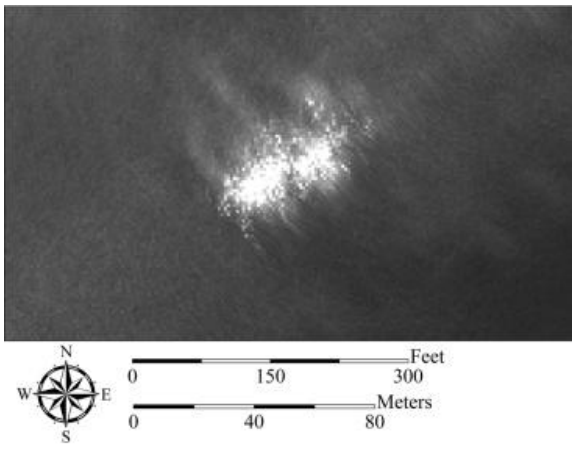

Figure 32. Image of sonar target 6070204.

Sonar Target 6070205

Figure 33 shows an acoustic image of ghosted shape lying on a sandy substrate. The 170 meter long image has little to no shadow or scour patterning, but nevertheless is intriguing because of its approximate "ship shape."

The target, however, was excluded from Stage Two survey because of the weakness of the acoustic return, as well as its very large size (too large to belong to known World War II casualties).

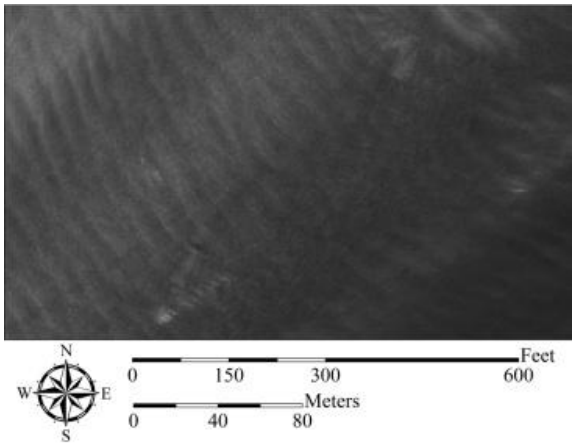

Figure 33. Image of sonar target 6070205.

Sonar Target 6070206

Figure 34 shows an acoustic image of ghosted shape lying on a sandy substrate. The 150 meter long image has some degree of acoustic reflection, some shadow, but no real scour patterning.

The target was excluded from Stage Two survey because of the weakness of the acoustic return.

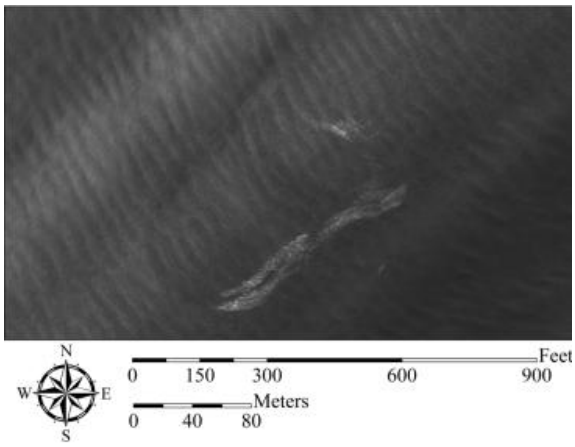

Figure 34. Image of sonar target 6070206.

Sonar Target 6070207

Figure 35 shows a blurry image of an object about 55 meters long lying on sandy seabed. The object has some degree of acoustic reflection and shadow, and may display some scour patterns.

The anomaly was not included in Stage Two survey due to the fact it is a known shipwreck site. NOAA and East Carolina University evaluated this site in 2009. The site is believed to be a nineteenth century wooden vessel with a copperclad bottom. The utility of this allowed the authors to better interpret acoustic anomolies.

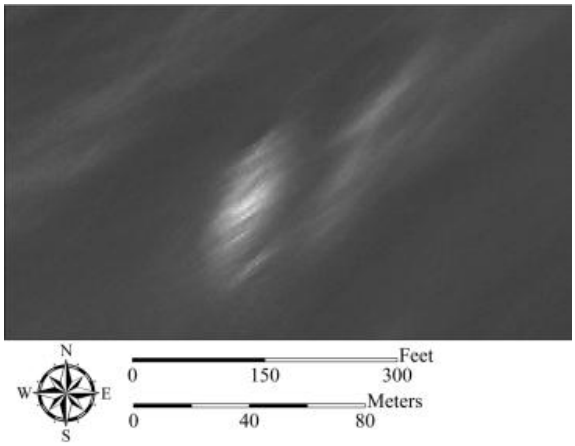

Figure 35. Image of sonar target 6070207.

Sonar Target 6070208

Figure 36 shows an acoustic image of an area of debris (around 30 meters long) lying amidst a rocky seabed. The anomaly is composed of a number of reflective components, each with associated shadow and scour.

Despite its relatively small size, this image resembles side scan sonar imagery from previous surveys of U-boat sites, and was placed on the list of targets for investigation during Phase 2.

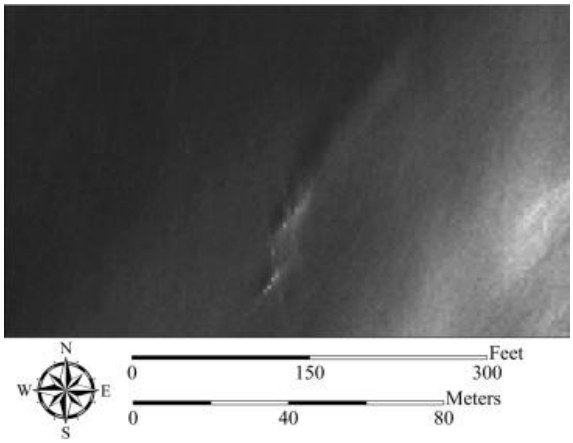

Figure 36. Image of sonar target 6070208.

Sonar Target 6070207

Figure 37 shows a blurry image of an object about 45 meters long lying on sandy seabed. The object has some degree of acoustic reflection and shadow, and may display some scour patterns.

The anomaly was not included in Stage Two survey due to suspicion that it was a product of overlapping sonar traces.

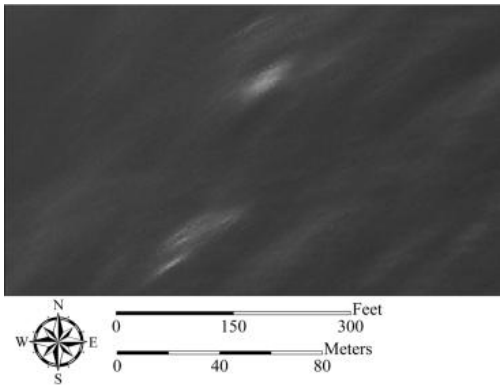

Figure 37. Image of sonar target 6070209.

Sonar Target 6070210

Figure 38 shows an acoustic image of an area of rocky bottom (approximately 110 meters across), within which an object about 40 meters long sits. Many objects in the general area exhibit a similar acoustic signature. Sitting close to the edge of the underwater shelf, the site was tagged although it may be a natural formation.

Despite its relatively small size this image arguably resembled side scan sonar imagery from previous surveys of U-boat sites, and was placed on the list of targets for investigation during Stage Two in order to potentially assist with bottom type characterization.

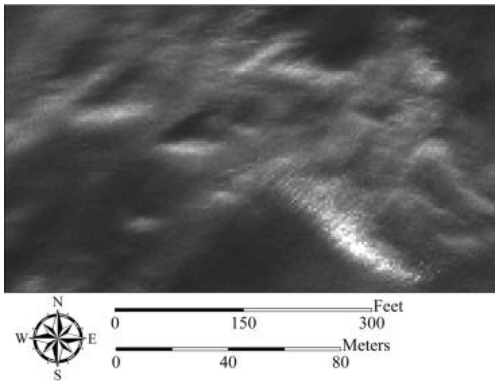

Figure 38. Image of sonar target 6070210.

Sonar Target 6070211

Figure 39 shows an acoustic image of a highly reflective area with multiple components about 86 meters across lying amidst a rocky seabed. While many parts are highly reflective, patterns of shadows suggest that some are cast from elevated bottom features while others shadows denote bathymetric changes. Additionally, few scour patterns may be associated with elevated bottom features.

The target was deemed probably belong to a natural feature, and therefore was excluded from Stage Two survey.

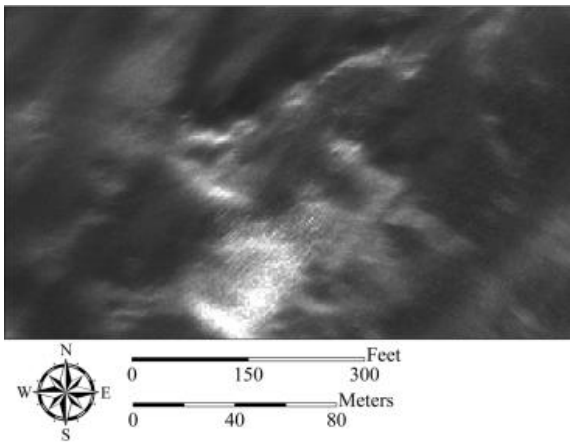

Figure 39. Image of sonar target 6070211.

Sonar Target 6070212

Figure 40 shows an acoustic image of a potential multi-component area many hundreds of meters wide as well as a separate elongated shape 86 meters across (lying amidst rocky seabed). While many parts are highly reflective, patterns of shadows suggest that some are cast from elevated bottom features while others denote bathymetric changes. Additionally, few scour patterns may be associated with elevated bottom features.

The isolated target was deemed to probably correspond to natural features, and was excluded from Stage Two survey.

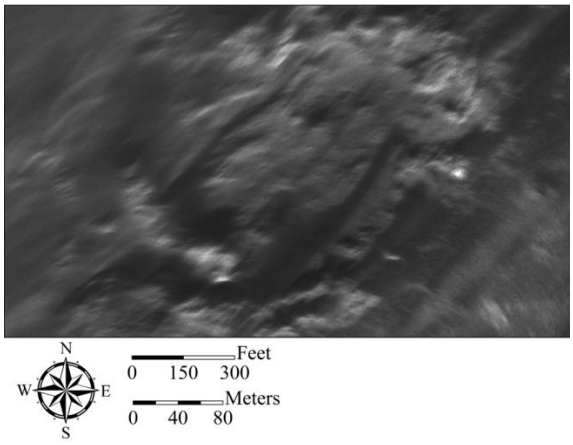

Figure 40. Image of sonar target 6070212.

Sonar Target 6070213

Figure 41 shows an acoustic image of an isolated elongated formation (around 105 meters long) lying amidst a rocky bottom. The object has associated shadows but no evidence of scour patterns.

While object shape and size potentially made this a target of interest, the lack of a discernible scour pattern culminated in its exclusion from Stage Two survey.

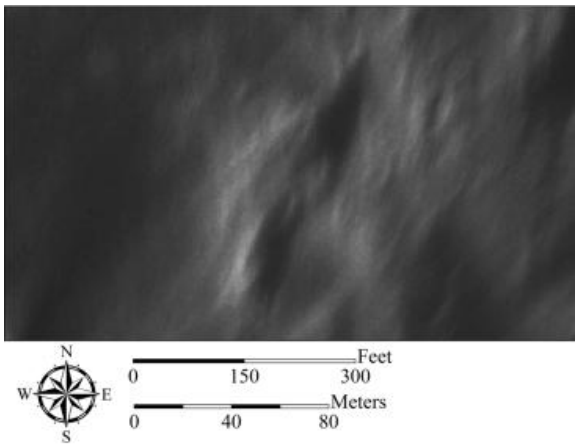

Figure 41. Image of sonar target 6070213.

Sonar Target 6070214

Figure 42 shows an acoustic image of a ghosted shape lying on a sandy substrate. The 46 meter long image has little to no shadow or scour patterning, but nevertheless is intriguing because of its approximate "ship shape."

The target, however, was excluded from Stage Two survey because of the weakness of the acoustic return.

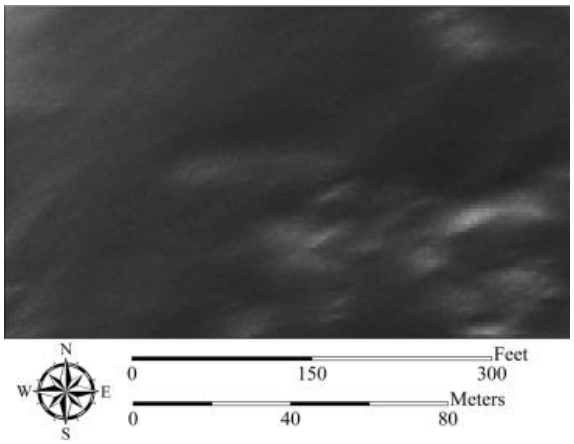

Figure 42. Image of sonar target 6070214.

Sonar Target 6070215

Figure 43 shows an acoustic image of an isolated object (around 110 meters long) lying on sandy substrate. The object is associated with all of the hallmarks of a shipwreck – high reflection and very noticeable shadows and scour patterns. In this case the target also has tight clusters of anomalies within close proximity to one another.

This site was placed on the list of targets for investigation during Stage Two.

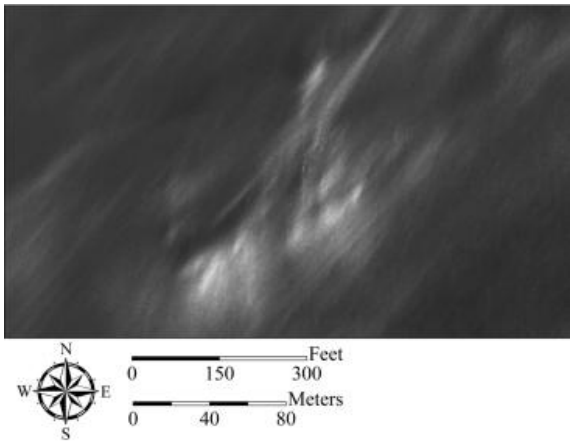

Figure 43. Image of sonar target 6070215.

Sonar Target 6070204

Figure 44 shows an acoustic image of a highly reflective area about 16 meters across lying on a rocky seabed. While highly reflective, shadows adjacent to the target do not appear to be cast from it (rather denoting bathymetric changes around the target), and there is no discernible scour.

The target was deemed likely to belong to a natural feature, and therefore was excluded from Stage Two survey.

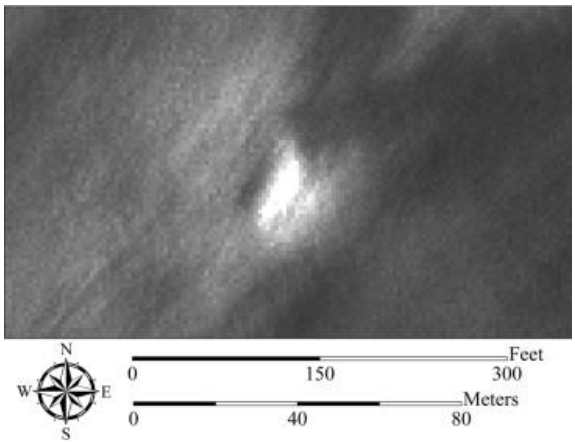

Figure 44. Image of sonar target 6070216.

Sonar Target 6070217

Figure 45 shows an acoustic image of a potential multi-component area many hundreds of meters wide with separate components on the seafloor (which is a mix of rock and sand formations). While many parts are highly reflective, patterns of shadows suggest that some are cast from features in some places, while others probably denote bathymetric changes around other components. Likewise, few areas could be interpreted as scour patterns associated with structure.

The isolated target was deemed likely to be a natural feature, and therefore was excluded from Stage Two survey.

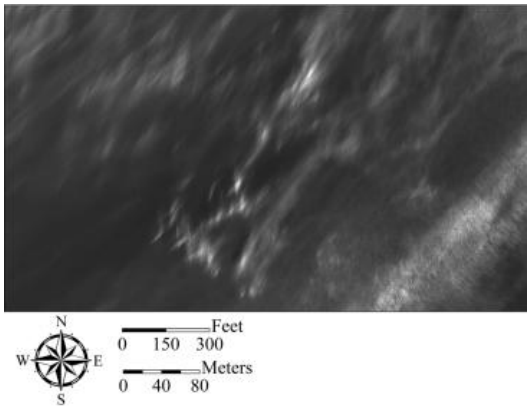

Figure 45. Image of sonar target 6070217.

Sonar Target 6080101

Figure 46 shows an acoustic image of an isolated object (around 49 meters long) lying on a bottom of sand and rock. The object is highly reflective, and has associated shadow and scour patterns.

Object shape and size culminated in its exclusion from Stage Two survey.

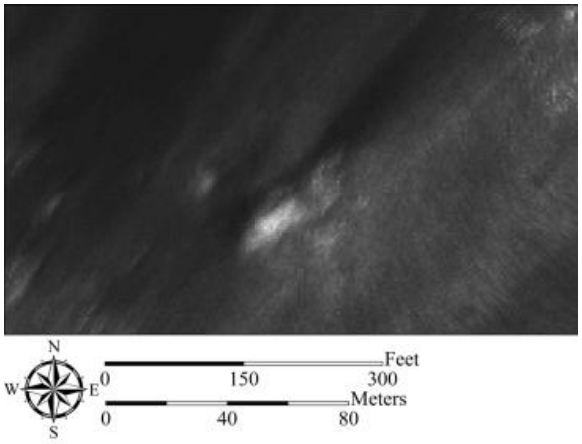

Figure 46. Image of sonar target 6080101.

Sonar Target 6080102

Figure 47 shows an isolated highly reflective formation (approximately 95 meters long) within a rocky area of seabed. The anomaly shows associated shadow, but no scour patterning.

The most likely interpretation for this area is that the reflective component is a part of the surrounding natural seabed. As such, it was excluded from Stage Two survey.

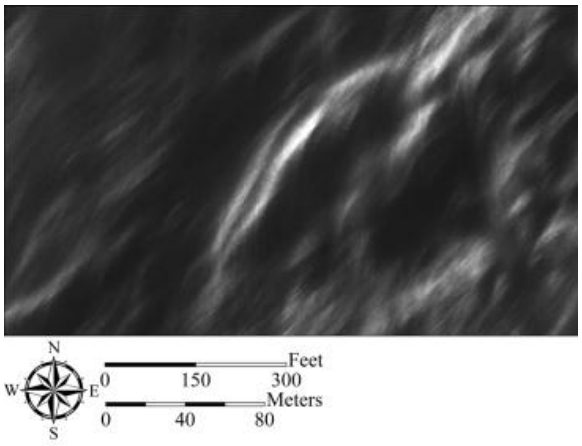

Figure 47. Image of sonar target 6080102.

Sonar Target 6080103

Figure 48 shows twin highly reflective formations (each approximately 52 meters long) within a rocky area of seabed. The anomalies are highly reflective with associated shadow, but no prominent scour patterning.

The most likely interpretation for this area is that the reflective components are a part of the surrounding natural seabed. As such, the area was excluded from Stage Two survey.

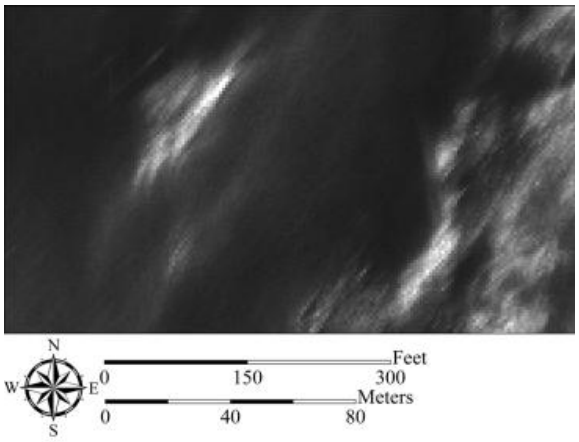

Figure 48. Image of sonar target 6080103.

Sonar Target 6080104

Figure 49 shows an acoustic image of an isolated object (around 27 meters long) lying on a bottom mixed with sand and rocks. The object is highly reflective has associated shadow and scour patterns appear, but are not distinctive

Object shape and size culminated in its exclusion from Stage Two survey.

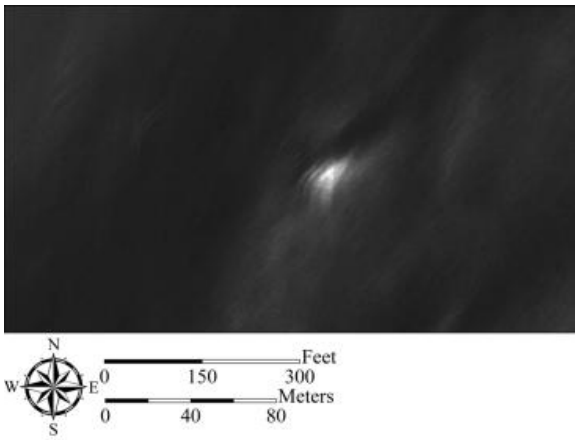

Figure 49. Image of sonar target 6080104.

Sonar Target 6080105

Figure 50 shows an acoustic image of a 67 meter long formation lying amidst a rock laden seabed. The object has high acoustic reflection and associated shadow but does not have defined scour patterns.

While object shape potentially made this a target of interest, the lack of a discernible scour pattern excluded it from Stage Two survey.

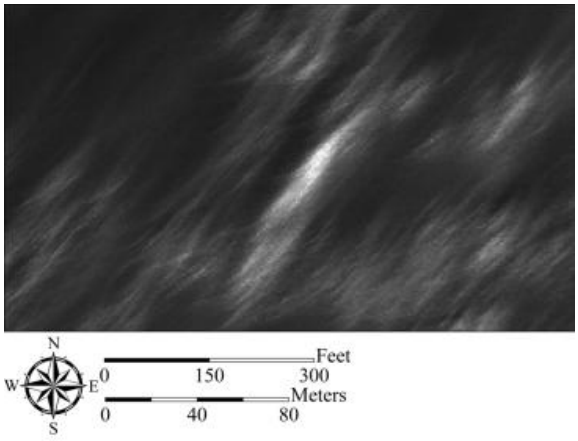

Figure 50. Image of sonar target 6080105.

Sonar Target 6080106

Figure 51 shows an acoustic image of an 80 meter long formation lying amidst a rock laden seabed. The object is associated with all of the hallmarks of a shipwreck – high reflection, very noticeable shadows and some potential scour patterns.

Due to the inclusion of these features, in addition to its size, this site was placed on the list of targets for investigation during Stage Two. It was also selected as a test site for a series of similar looking objects (see Figures 22, 25, 52-56).

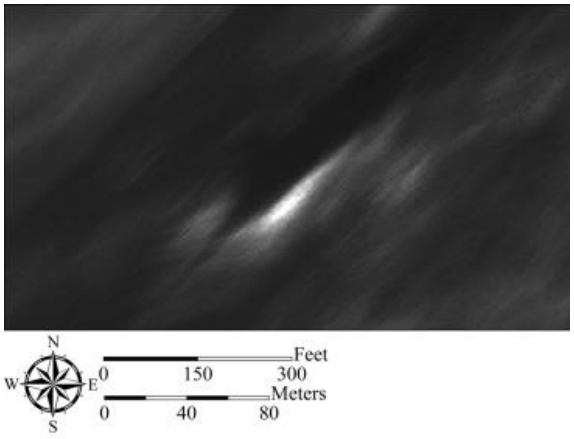

Figure 51. Image of sonar target 6080106.

Sonar Target 6080107

Figure 52 shows an acoustic image of a 48 meter long formation lying amidst a rock laden seabed. The object is associated with all of the hallmarks of a shipwreck – high reflection and very noticeable shadows (and some potential scour patterns.)

Despite resembling Target 6080106, its size as well as the absence of well defined scour culminated in its exclusion from Stage Two.

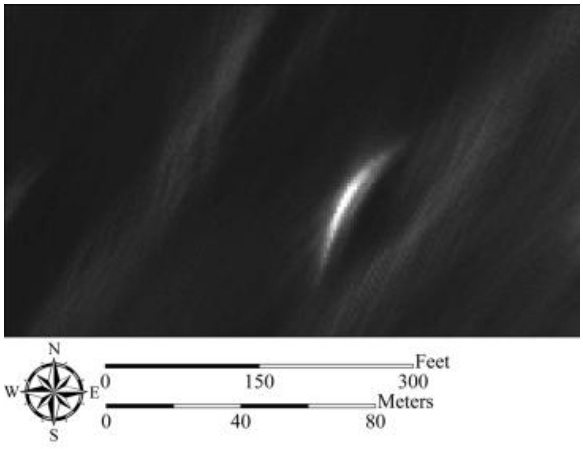

Figure 52. Image of sonar target 6080107.

Sonar Target 6080108

Figure 53 shows an acoustic image of a 78 meter long formation lying amidst a rock laden seabed. The object is associated with all of the hallmarks of a shipwreck – high reflection, very noticeable shadows and some potential scour patterns. Additionally, small details in the image were reminiscent of a multi-component debris field.

Due to the inclusion of these features, in addition to its size, this site placed on the list of targets for investigation during Stage Two.

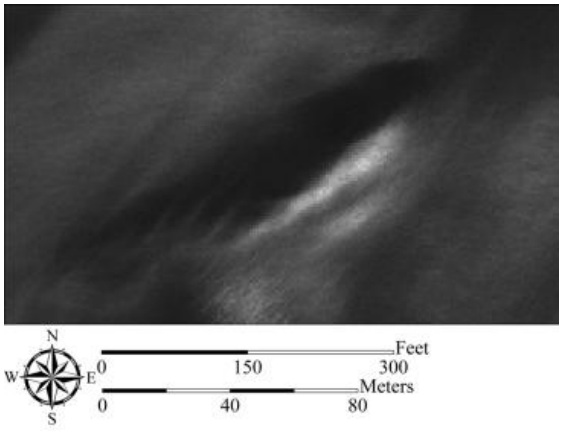

Figure 53. Image of sonar target 6080108.

Sonar Target 6080109

Figure 54 shows an acoustic image of a 37 meter long formation on a sandy substrate. The object is associated with all of the hallmarks of a shipwreck – high reflection and very noticeable shadows (and some potential scour patterns.)

Despite its resemblance to similar looking targets picked for further investigation, it was excluded from Stage Two survey due to its size.

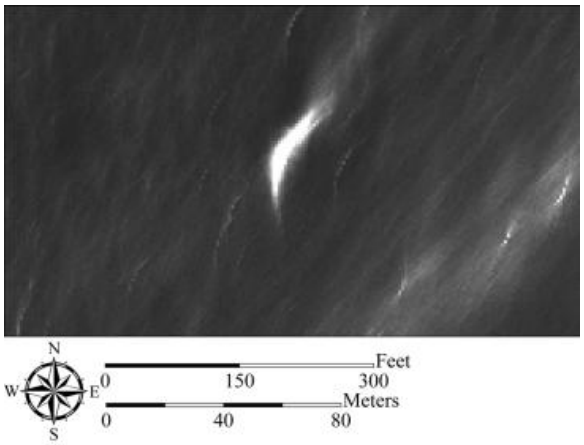

Figure 54. Image of sonar target 6080109.

Sonar Target 6080110

Figure 55 shows an acoustic image of an isolated object (around 70 meters long) lying on sandy substrate. The object is associated with all of the hallmarks of a shipwreck – high reflection and very noticeable shadows and very distinctive scour patterns. Additionally, the detail within the image suggests height variation within the site.

This site was believed to be the remains of a shipwreck, and was placed at the top of the list of targets for investigation during Phase 2.

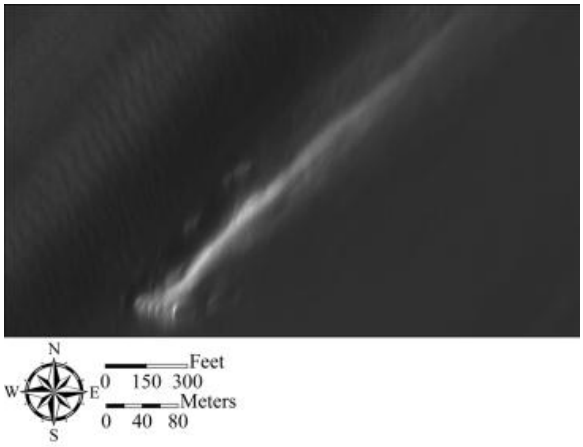

Figure 55. Image of sonar target 6080110.

Sonar Target 6090101

Figure 56 shows an acoustic image of a highly reflective area about 18 meters across within a large sandy seabed. While highly reflective, there are no shadows adjacent to the target and no obvious scour patterns.

Following acquisition, the target was interpreted as something within the water column (such as a large school of fish), and therefore was excluded from Stage Two.

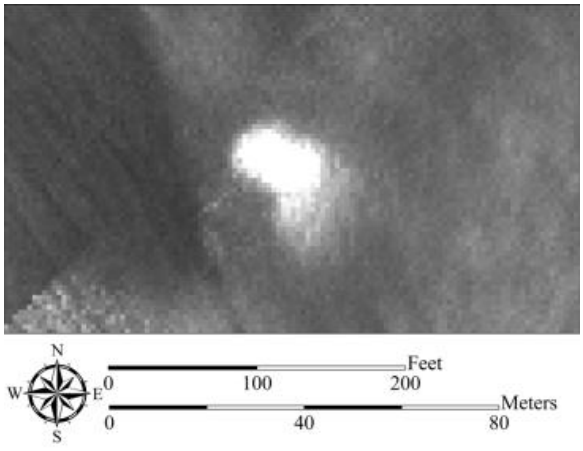

Figure 56. Image of sonar target 6090101.

Sonar Target 6090102

Figure 57 shows an acoustic image of a 40 meter long formation on a sandy substrate. While the object is associated with all of the hallmarks of a shipwreck – high reflection and noticeable shadows and potential scour patterns, the degree of parallelism between it and surrounding sand berms suggest it is a raised natural feature of sand or rock.

Despite the inclusion of features used to select other targets, its size culminated in its exclusion from Stage Two.

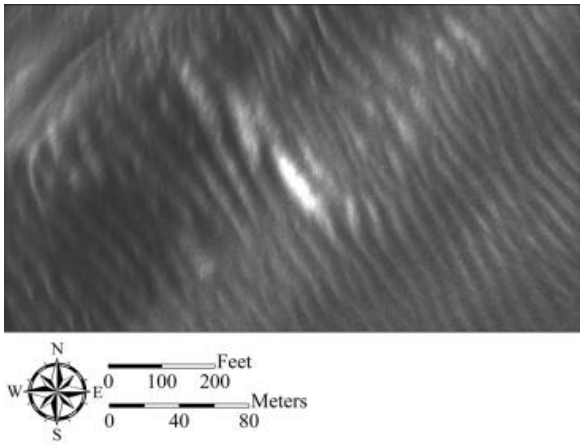

Figure 57. Image of sonar target 6090102.

Sonar Target 6090103

Figure 58 shows an acoustic image of an 81 meter long formation on a sandy substrate. This anomaly was difficult to interpret due to the possibility that it was an amalgamation of two sonar passes which created the appearance of a complex highly reflective target. While complex, the target does not exhibit marked shadows or scour, and could also be interpreted as representing something floating within the water column.

Nevertheless, due to the complexity interpreted in the image, it was selected as

the lowest-tier priority one target for investigation during Stage Two.

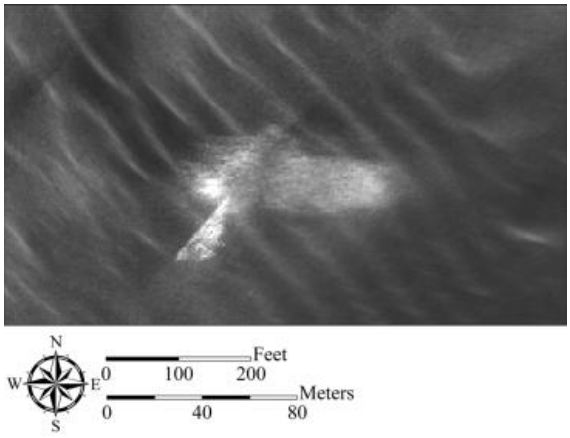

Figure 58. Image of sonar target 6090103.

Sonar Target 6090104

Figure 58 shows an acoustic target of some degree of complexity sitting on a sandy seabed. The site does not exhibit the same degree of acoustic reflection as other targets, but due to its length (76 meters), appearance of shadow as well as potential scour patterns, it was deemed to be of interest.

Due to the existence of more defined, highly reflective targets, it was not selected for investigation during Stage Two.

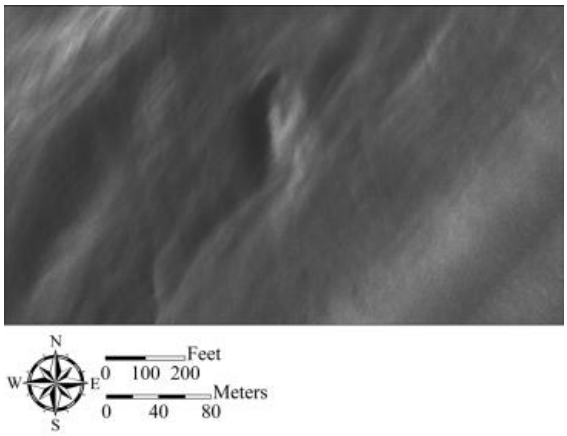

Figure 59. Image of sonar target 6090104.

At the conclusion of the survey, seven targets were selected as the most likely to conform to the remains of World War II shipwrecks and be accessible for further investigation in the time allotted for Stage 2. These seven sites were further prioritized based on compelling features and ranked hierarchically from 1-7 in descending order of interest (also an indication of the preferred Stage 2 AUV mission order) (see Table 7).

Table 7. Prioritized table of targets.

Priority	Filename	Longitude	Latitude	Length(m)	Quad
1	6080110	-75.39563317	34.90327510	70	9
2	6070102	-75.57020140	34.74188542	111	1
3	6080106	-75.45443942	34.81153493	80	4
4	6070208	-75.46657857	34.81830785	30	4
5	6080108	-75.40806400	34.84836832	78	4
6	6070215	-75.40246488	34.86528583	110	4
7	6090103	-75.53341163	34.81050337	81	8

Results of Stage Two

Stage Two of the 2011 Battle of the Atlantic Expedition involved a planned series of AUV missions over 8 days to investigate anomalies. Seven targets from the 47 identified during Stage One were identified as the highest priority targets the research crew hoped to investigate with SRI International's Bluefin AUV.

Due to depth, and a need to adjust settings it was decided to test run the AUV over a shallower Stage 2 contigency site (see Table 3) named *Empire Gem* (approximately 150 feet of water). Here, the AUV experienced technical difficulties to begin with due to currents and weather, but after two days, successful dives on the site culminated in detailed 3D point clouds from both multibeam systems (Figure 60). Following this, the research crew moved onto the first new site, 06080110, which became known as "Target 1."

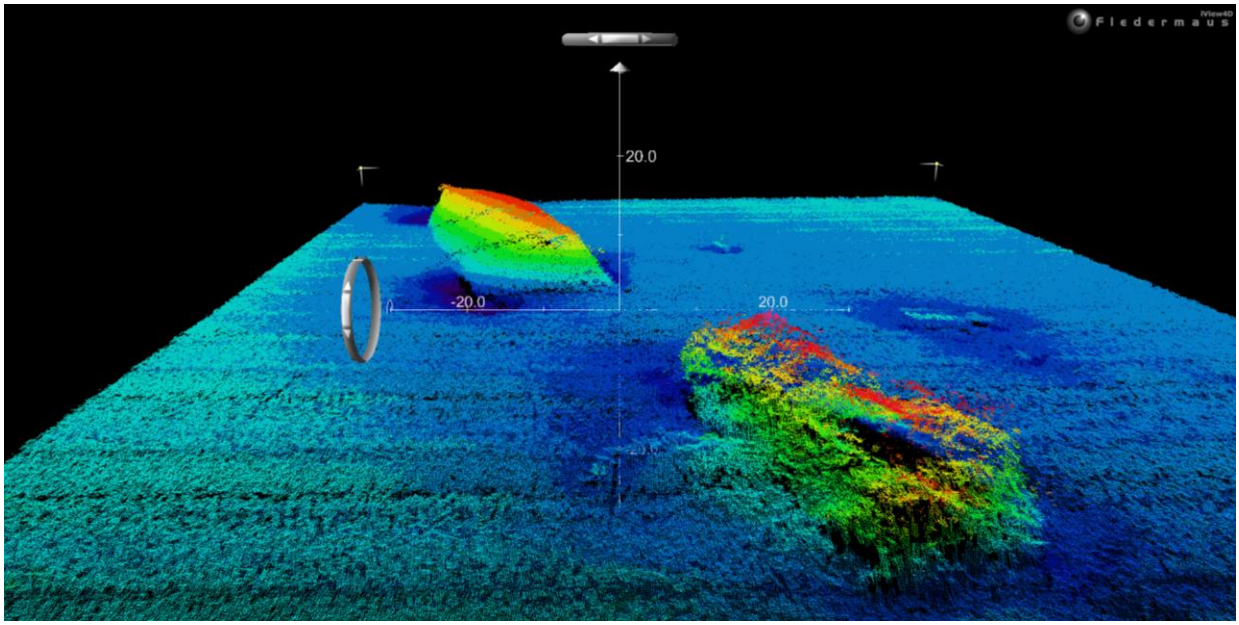

Figure 60. Processed BlueView MB1350 multibeam imagery of *Empire Gem* (Image: SRI International, Ltd).

On day three, the AUV was programmed for a mission on Target 1 and the initial dive employing the Imagnex Delta-T multibeam was successfully made during a poor seastate. Upon recovering the fish from this first mission, however, the propulsion system was badly damaged, suspending further AUV operations indefinitely. Data collecting during this dive, however,

revealed the presence of a shipwreck, as seen in Figure 61. From this imagery it was possible to take basic dimensions of a newly imaged submerged cultural site.

SRI International processed the raw data from the AUV, providing the project with GeoTIFFs and a three-dimensional ASCII XYZ file format. When the GeoTIFFs were input into the GIS they offered the archeological team the ability to project and measure the images within the chart space. Resting in approximately 470 feet of water, the site is clearly a shipwreck as indicated by the overall shape, presence of acoustic shadowing, high reflectivity, and scour patterns of sediment in and around the site. The wreck is approximately 230 feet long by 43 feet wide. The western end of the site appears buried, and it is possible portions of the wreck are beneath the sediment in that area. According to the *Lloyds Register of Shipping* (1942/43a), *Bluefields* was 250 feet long by 42 feet in beam, making this a promising candidate for the lost Nicaraguan freighter. Further investigation was not possible, however, as a result of damage sustained to the AUV's propulsion system during a failed retrieval of the system following this dive. As a consequence, the authors feel that any correlation of "Target 1" with that of *Bluefields* cannot be stated positively.

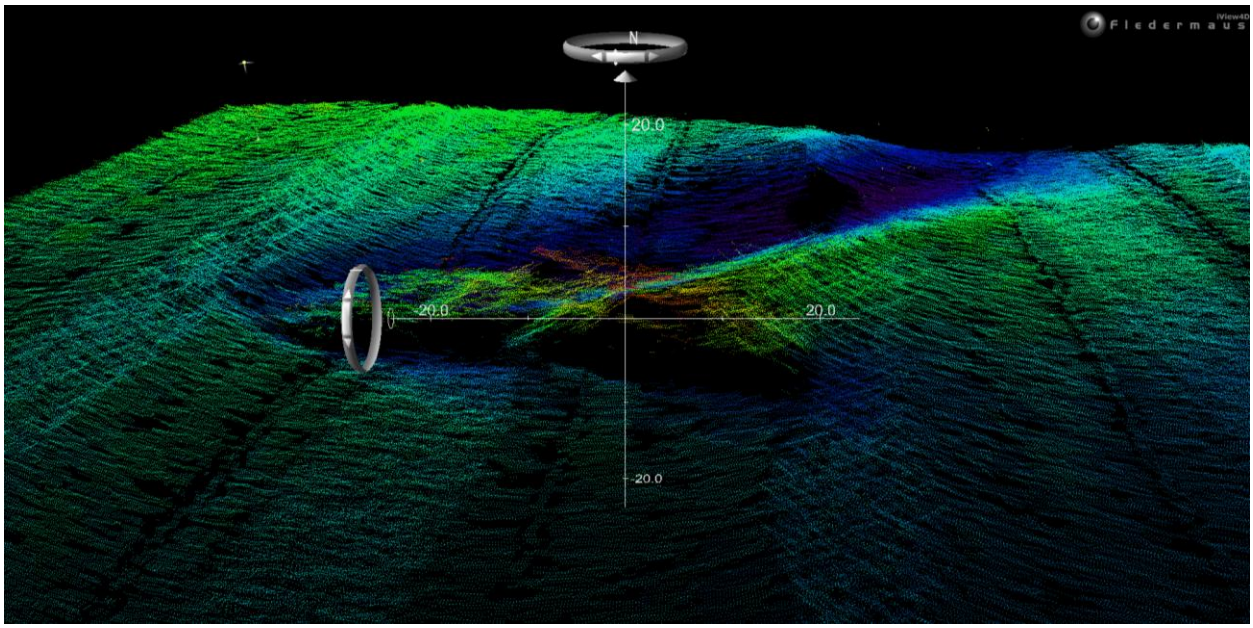

Figure 61. Processed Imagenex Delta-T 260 kHz multibeam imagery of "Target 1" (Image: SRI International, Ltd).

Archeological data collection ended prematurely after the AVU was damaged beyond repair. This in turn prevented detailed investigation of the other sonar targets, including any high resolution scans of target one. Nevertheless, the imagery obtained from the first target provides a promising prospect for future investigation. Given that a shipwreck was identified during Phase Two validates the interpretation of the wide-area data collected during Phase One. This suggest that subsequent investigation of other sonar targets could also yield new shipwrecks. Unfortunately, however, the premature ending of Phase Two required a new approach to pinpoint the attack site within the landscape. This was accomplished by returning to the GIS for additional spatial data processing.

FEATURES OF THE LANDSCAPE

The spatial extent of combat related activities resulting from *U-576*'s attack upon convoy KS-520 is extensive. It is comprised of an interconnected web of natural, military engineering, and bureaucratic terrain features through which Allied and Axis participants engaged. Natural features include the coastal geography of the Outer Banks, prevailing ocean currents, and weather conditions during the battle. Military engineering features include the ports and anchorages proximate to the battle area, the Cape Hatteras minefield, and the airfield from which air cover launched to provide convoys with protection. Bureaucratic features, unlike natural and military engineering elements, had no actual physical manifestation. Instead, these elements were divisions of the ocean and coastal space into various administrative zones through which both Allied and Axis navies attempted to route and control the movement of ships.

These features, in addition to the combatant's vessels, weapons, and tactics are here described individually in such a manner as to contextualize and facilitate the METT-T and KOCOA analyses in the next section. Though discussion will range from coastal geomorphology to mid-20th century naval weaponry and anti-submarine tactics, these topics are only developed in terms of their relevance to the KS-520 battlefield and combatants at the exclusion of broader thematic treatment. For example, the naval weaponry utilized by Allied and Axis forces during the attack and counter-attack will be described, omitting any wider discussion of naval weaponry during World War II.

The battlefield is herein defined as any area in which combat or combat related activity occurred. Referred to by Scott and McFeaters (2010:114) as the "battlespace," this area includes

> Encountered conditions and can be addressed in terms of both spatial subdivisions and facilities. Spatially, it includes an *area of operations*, the immediate area occupied by a combat force for which the commander is responsible. Around that space is the *area of influence*, the zone a commander can directly influence by maneuver or fire. Farther out is the *area of interest*, which is relevant to a commander's mission although it is controlled by enemy forces [or no forces at all]. These three "areas" are at least generally geographic in that they can be located in real space and tied to specific places and features.

Specific definitions and visualizations of the battlespace, area of operations, area of influence, and area of interest are provided in the next section. Here, the geographic "places and features"

to which these areas are related are described. Further Scott and McFeaters (2010:114) also note that the "[b]attlespace also includes concrete facilities." They refer to these as "*Home Stations,*" which are described as "permanent bases from which combat forces may be mobilized" (Scott and McFeaters 2010:114). These would include shore installations, minefields, and airfields from which Allied combatants assisted in the engagement against *U-576* and the rescue of sailors resulting from the attack upon *J.A. Mowinckel*, *Chilore*, and *Bluefields*.

In total, this area encompasses the geographic space (both upon and below the ocean's surface) of the approaches of convoy KS-520 and *U-576*, their intersection and subsequent engagement, the path of retreat and rescue of merchant craft *J.A. Mowinckel* and *Chilore*, and the area of aircraft coverage provided by Scouting Squadron Nine, all shown in Figure 62. *Bluefields*, *U-576*, *Keshena*, and *Chilore* are represented as archeological materials on the seabed. Additionally, the reconstruction of these spaces was based upon historical records via GIS where archeological remains were not present (or currently have unknown locations). The battlefield is not a two dimensional expanse. Enemy forces engaged from beneath, upon and above the ocean's surface and therefore bathymetric, oceanographic, and atmospheric data added a third dimension to the battlefield terrain.

As this area is characterized by a multi-dimensional interface between undersea, ocean surface, and airborne space, it is believed to be representative of broader Battle of the Atlantic battle spaces. The nature of submarine warfare during World War II, and the technologies developed as anti-submarine measures, for the first time brought naval warfare into both sub-surface and airborne spaces. For this reason, description and analysis of the attack upon convoy KS-520 is conceived as a representation of the manner in which naval actions throughout the Atlantic occurred, thus making these analysis techniques relevant when applied to other combat activity during the Battle of the Atlantic, regardless of the specific time period and locale.

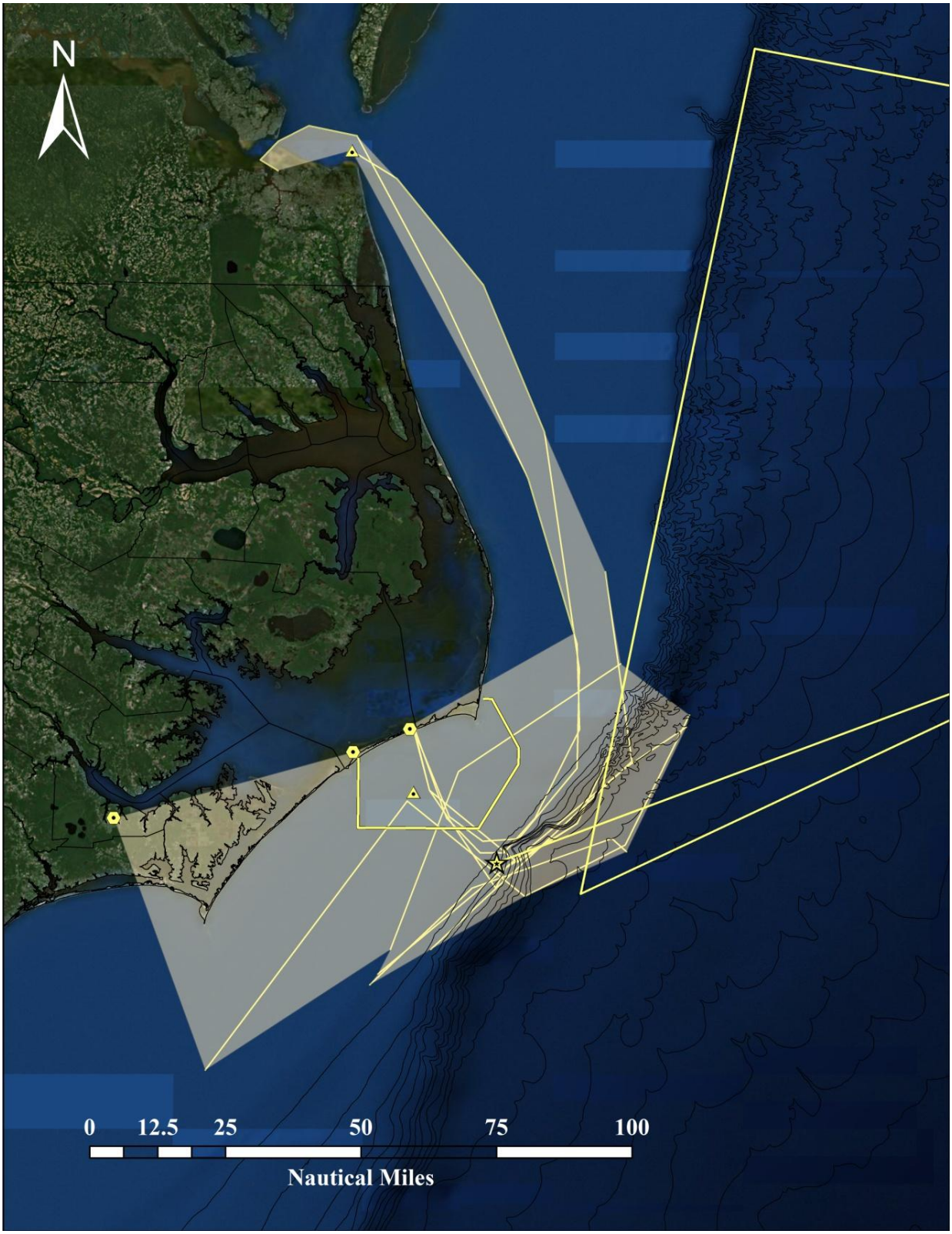

Figure 62. Total Area of the KS-520 Convoy Attack. (Image: John Bright).

Natural Features

A distinction is made in battlefield archeology between the terms landscape and terrain. As described by Carman and Carman (2009:42-43), "[b]attlefield terrain generally consists of those features considered relevant or important to military purposes. Landscape, by contrast, is all those features present regardless of their military usefulness." In the case of KS-520, multi-dimensional utilization of space by opposing forces required combatants to interact with a wide array of geographic, climatic, and oceanographic terrain features. Nevertheless, only certain elements of the landscape off North Carolina's coast were relevant in terms of military purpose. Bathymetry, prevailing ocean currents, coastal geography, and climatic patterns all factored into the interaction between Allied and Axis craft, while features such as sediment transport, barrier island migration, and biological communities, though distinctive components of the Outer Banks landscape, had little bearing on the naval actions of 15 July.

Additionally, the placement of military engineering features such as fortifications and anchorages were determined at the behest of natural landscape features. The placement of anchorages and coastal installations was predicated upon the presence of inlets with sufficient depth to allow the safe passage of small vessels. Similarly, fortifications erected to protect merchant vessels we so placed as a result of the dearth of deep-water anchorages near Cape Hatteras. Aids to navigation were disturbed across dangerous shoals as a warning to mariners. Furthermore, the preference of U-boat commanders to hunt in the area off Cape Hatteras was largely driven by a constellation of natural terrain features offering significant advantages to the safety and success of the U-boat during its mission (Oberkommando der Kriegsmarine [OKM] 1989:31; Ireland 2003:80). Thus, understanding the natural terrain is central to understanding the role of military engineering and bureaucratic landscape features.

The waters off North Carolina's Outer Banks are a unique and dynamic area. Witness to over four hundred years of European maritime activity, beginning with the Roanoke voyages in 1584, and centuries of prior Native American activity, they served as the backdrop for fleets of fishermen, merchantmen, and ships of war alike. Through the centuries North Carolina's characteristic shoals, jutting forth from three large capes and swept by the turbulent mixing of two vast ocean currents, played havoc on ships attempting passage. As related by North Carolina historian David Stick (1952:1):

> You can stand on Cape Point at Hatteras on a stormy day and watch two oceans come together in an awesome display of savage fury; for there at the Point the northbound Gulf Stream and the cold currents coming down from the Arctic run head-on into each other, tossing their spumy spray a hundred feet or better into the air and dropping sand and shells and sea life at the point of impact. Thus is formed the dreaded Diamond Shoals, its fang-like shifting sand bars pushing seaward to snare the unwary mariner. Seafaring men call it the Graveyard of the Atlantic.

As European development in the New World accelerated in the 17th century, proximity to colonial settlements and its presence along east coast shipping lanes "…have conspired to force many [mariners] to sail along the North Carolina coast if they wanted to sail at all" (Stick 1952:1).

As conveyed by David Stick, North Carolina's coastal space is not a monolithic landscape. Instead, it is a kinetic relationship between land, sea, and air. The outer banks, both above and below the water, are an ever-changing land mass driven by the dynamic geomorphological processes of converging oceanic currents. Thrust upon the land and sea are coastal weather patterns characterized by annual cycles of hurricanes and northeasters. It is an area that presents more hazards than havens to mariners, yet passage through which is ultimately unavoidable.

For the sake of systematic description, this natural landscape can be categorized into three separate regions. The first of which is the coastal landmass off North Carolina, which includes dry land above the ocean, sandbars and shoals in the inter-coastal zone, and the seafloor extending out to and beyond the continental shelf. The second is an oceanographic zone extending from the seafloor through the water column and to the ocean's surface. Third is an atmospheric zone extending from the ocean's surface into airspace (including associated weather and climate) through which patrol aircraft flew.

Outer Banks Coastal Zone

North Carolina's Outer Banks must be understood through the lens of geological time. A narrow strip of sandy islands running the length of North Carolina's coastline, the banks are in a constant state of flux at the behest of a milieu of natural geological processes. Specifically, the dual action of wind and waves, accentuated by seasonal storms, drive sustained erosion and sediment transport, which constantly alter the shape of North Carolina's barrier islands. Both above and below the water, the location of shoals, inlets, and the islands themselves, respond to the constant

action of wind and water. Though much slower in relation to the alteration of inlets and shoals, the configuration of seafloor topography, known as bathymetry, and the continental shelf are similarly the product of these geological forces. Thus, the geomorphology of the Outer Banks as experienced by both Allied and Axis combatants were merely a snapshot of a landscape in a constant state of change.

From a geological perspective the distinctiveness of the banks is described by University of North Carolina Marine Science professor Dirk Frankenberg (1995:1) as follows:

> The Outer Banks of North Carolina are unique among the world's coastal landforms in their distance from the mainland and their distinct shape. Scientists have labeled such offshore islands barrier islands because they serve as barriers between the wave and tidal energy of the ocean and the mainland shoreline. Barrier islands extend along the coast of the United States from Maine to Texas, but none are situated as far from the mainland as the Outer Banks and few have a shape that differs from that of the coast they parallel. The Outer Banks are 20 to 40 miles offshore and have a shape all their own. They have been shaped by the ocean into long, crescentic beaches stretching between four major capes. Such landforms, called cuspate forelands, usually form between rocky headlands, such as those along the coast of Brazil. The Outer Banks are unique in that their cuspate forelands have developed between the massive sandy shoals that extend seaward from each cape.

Over the course of millions of years, periodic sea level fluctuations, corresponding with global climate changes, alternately submerged and uncovered large coastal areas. In the case of North Carolina, the fall of sea level during the last glacial maximum prompted the deposition of massive amounts of sand and sediment from the area's rivers and estuaries. As sea levels began to rise, these areas became submerged, resulting in the transformation of these deposits into barrier islands, the outer limit of which delineated the continental shelf (Schoenbaum 1982:10; Pilkey et al. 1998:40-41).

Through time, the natural state of these barrier islands is to slowly shift and migrate in response to wind and water-driven erosion. In addition to the migration, periodic breaches, known as inlets, also occur at discrete points as currents and storms over-wash and scour out paths through the islands. Though transient within the scale of geological time, these inlets play a critical role in the evolution of North Carolina's barrier islands. Through the interplay of wind, tidal currents, and periodic storms, inlets facilitate a greatly accelerated movement of sediment in

and around barrier islands, causing, in some cases, the elongation of terminal sand spits (Schoenbaum 1982:12; Frankenberg 1995:4). This is evidenced by the presence of long sand bars extending seaward from capes along North Carolina's Outer Banks; the most dramatic of which is adjacent to Cape Hatteras. Mariners refer to these sandbars as shoals, as they are significantly shallower than surrounding waters despite persisting for miles out to sea, and represent a treacherous hazard to navigation.

It is estimated the islands migrate between 50 to 200 linear feet per century. Inlets, on the other hand, can shift and change as the result of a single storm, and often migrate within the span of months and weeks (Schoenbaum 1982:12-13; Frankenberg 1995:4). Human settlement, particularly from the 20th century onward, utilized various means to stabilize and mitigate the effects of these natural processes. Focused mostly on maintaining navigation channels through inlets, these efforts produced little, if any, effect upon the sandy shoals extending seaward from the Outer Banks' capes. Lack of deep, consistent, clearance through these inlets to the present day prevents the passage of large ships. Nevertheless, dredge boats operated along the Outer Banks starting in the 1930s, with dredging activities increasing during World War II to ensure safe passage for USN and USCG vessels stationed at Ocracoke Island (O'Neal 2001:18).

Thus the shape of the North Carolina coast during 1942 was a snapshot of geological processes millions of years in the making. The barrier islands remained generally in the shape first experienced by European explorers in the 16th century, though shoals and inlets were constantly shifting. Oregon Inlet, along the northern Outer Banks, as well as Hatteras and Ocracoke Inlets south of Diamond Shoals, offered safe passage for small craft only. In fact, several Coast Guard and district patrol vessels were stationed within the latter inlets. Diamond Shoals remained unpredictable and dangerous; mariners kept warily to seaward, giving the shifting sand bars a wide berth when rounding Cape Hatteras. This natural feature is one of the elements, which dictated the practice of convoys, such as KS-520, following the 100-fathom curve.

Due to the nature of the inlets, North Carolina could not offer inter-coastal anchorages comparable to ports in the Chesapeake or New York. Instead, North Carolina offered mariners more hazards than sanctuaries, with limited assistance available from small boats stationed inside the banks' shallow inlets. This was primarily the impetus for the construction of the Hatteras Minefield in May of 1942: creation of a safe anchorage for merchant craft in the area.

Apart from the geomorphology of the banks and their inlets, another terrain feature factored prominently into naval actions off the North Carolina coast: bathymetry. Diamond Shoals extended to within 15 feet of the ocean surface. For safe passage, merchant and naval ships needed no less than 30 feet of depth. Along most of the eastern seaboard, shoals were avoided by conservatively navigating seaward of them. Avoiding Diamond Shoals, however, came at both the economic loss of the increased expenditure of fuel and time clearing a large protruding sand bar, as well as the security risk presented by transiting over deeper waters off the continental shelf. Thus, a narrow corridor existed through which ships could travel to minimize loss of time and resources and simultaneously maintain security from U-boat attack.

The continental shelf slope is located approximately 20 miles off Cape Hatteras, and approximately 26 miles from Ocracoke Island to the south. As the shelf extends out, depths range from 60 feet near shore, to 600 feet near the shelf break. Off the break, however, the seabed is thousands of feet beneath the ocean's surface. In the area of the attack upon KS-520, the break is 1-3 miles from the hundred fathom curve. In addition, close to the shelf break are strong, turbulent currents. This essentially creates a perfect hiding spot for submarines since deep water, erratic currents, and temperature variables help conceal them from sonar. Additionally, deep water allowed u-boats access to depths where they could avoid depth charge barrage. Historian Bernard Ireland (2003:80) described how U-boat commanders chose Cape Hatteras

> Following five weeks [for the Americans] to anticipate [the German] attack, the defence was expected to be brisk, if inexperienced. Skippers were apprehensive that, with the continental shelf waters being wide and shallow, they would have to operate the big Type IXs in perhaps twenty fathoms, where a minimum of fifty was advisable. Only around Hatteras did deep water lie close to the coast and, with the Cape being a notable waypoint, the area became a favoured billet with boats lying submerged by day and moving inshore by night.

Flanked on the west by treacherous shoals and on the east by an ideal brooding point for enemy submarines, only a narrow bottleneck of shipping lanes remained through which craft could pass.

Moving from the banks outward, a series of landmass features generated several obstacles to Allied ships. The first were narrow, shifting inlets, which forbade passage of large merchant vessels and necessitated the construction of the Hatteras Minefield. Next were shallow, unpredictable shoals extending from the terminus of the Outer Banks islands. The largest and most dangerous, Diamond Shoals, stood directly in the path of shipping lanes along the east

coast and was an ever-present threat to mariners since the late 16th century when they began navigating along the North Carolina coast. Moving offshore, the continental shelf slope offered German U-boats quick access to deep water in which they could hide from Allied forces.

Oceanographic Zone

The area directly off Cape Hatteras is a confluence site of two major ocean currents. Emanating from the Gulf of Mexico via the Straits of Florida, the Gulf Stream is a powerful warm water current which tracks north and east along the southern Atlantic coast of the United States. Originating off the northeastern Canadian coast, the Labrador Current is a cold-water current traveling southward along the Northern and mid-Atlantic coasts of Canada and the United States. These two currents meet off Cape Hatteras resulting in an unpredictable stratigraphic mixing of the water column based upon the various temperatures, salinity, and densities resulting from the convergence of these currents (Spitsbergen 1983:6-8).

The movement of these currents affected maritime activity since Europeans first reached the New World. Both currents served as natural conveyor belts to aid in the movement of shipping in their respective directions. Furthermore, the mere presence of each served as a natural aide to navigation. Traveling along each current served to hasten vessel speed, reducing time in transit, and ultimately increased the efficiency of maritime operation. As these currents combine, however, they produce dangerous and unpredictable shoaling of ocean bottom off Cape Hatteras. Far from a benefit to maritime activity, this area known as Diamond Shoals quickly became a graveyard for ships.

A further feature resulting from the mixing of these currents was realized as submarine warfare emerged in the early 20th century. Concurrent with the development of effective submarine craft during the First World War was the means by which to detect these craft from the ocean surface. Namely, the use of acoustic waves to sense objects within the water column. This technology was dubbed Sound Navigation And Ranging and is now commonly known as sonar. For this technology to work effectively a continuity of medium is required for the propagation of sound waves. In other words, acoustic waves need to travel through a uniform body of water in order to discernibly detect underwater objects. The convergence of the Gulf Stream and Labrador Currents results in a water column stratified by various temperature, salinity, and density layers. Stratification disrupts the continuity of the water column, rendering sonar technology much more

difficult to operate as sound waves are distorted through thermoclines.

German submariners were keenly aware of this landscape feature, and often used it to their advantage when operating off the coast of North Carolina (Oberkommando der Kriegsmarine [OKM] 1989:31) during World War II, noting

> Formation of layers of varying density ("stratification") of the water of the sea occurs after a long spell of sunshine on a calm sea, and also in a high degree in places where there is mingling of different kinds of water, for example, at the confluence of the brackish waters of the Baltic with the salt water of the North Sea…and on the confines of the Gulf Stream, in the Gulf Stream itself…

Thus, the oceanographic terrain offered a distinct advantage to German U-boats operating in the area. It is perhaps this terrain feature that accounts for *U-576's* undetected approach upon KS-520.

Atmospheric Zone

The atmospheric zone is the space extending from the ocean's surface upward, including the area in which aircraft operated. Conditions therein were primarily associated with visibility, be it from the U-boat's periscope, from naval and merchant vessels across the ocean's surface, or from aircraft downward. The position of the sun, presence and force of wind, and lateral visibility associated with atmospheric clarity would all affect the ability of opposing forces to observe one-another.

At the time of *U-576's* attack, 1625 hours on 15 July 1942, the USN was operating on EWT, Greenwich Mean Time plus minus-hours (COM7 1942a,b). Initiated in 1918, the United States would have also been on daylight savings time. Thus, during this time of day the sun would be deascending from its zenith into the western sky. As reported by USS *Ellis* and USS *McCormick*, winds were blowing from the southwest and west-south-west throughout the day, from a force 4 during mid-day to a force 2 by the time of the attack (USS *Ellis* 1942; USS *McCormick* 1942). This would equate to winds at 15 knots subsiding to 6 knots, and could have left white-caps upon the surface of the water. The general conditions of the day were later recorded in the *Eastern Sea Frontier War Diary* (Freeman 1987:411):

> All that day a fresh breeze blew…driving before it a thin haze that partially

> obscured the sun. Visibility, however, was not bad. Lookouts on the bridge could see four or five miles. Only a slight swell troubled the calm surface of the sea.

This synopsis was similar to that given by Standard Oil Company (1946:365) from the *J.A. Mowinckel*, "the weather was clear, with a light breeze and moderate sea." With these conditions, the surface vessels should have had visibility enough to view one-anther, as well as to observe a surfaced submarine. Clearly, corresponding with all accounts, *U-576* attacked submerged. Analysis of the attack geometry, however, will be necessary to understand the specific direction of *U-576's* approach and how these corresponded to the direction of wind-driven waves and the position of the sun.

From the vantage point of the aircraft, the report was of calm seas and light surface wind, making "conditions ideal for detecting torpedo wakes and periscopes" (Commander Scouting Squadron Nine [ComScoron Nine] 1942:1). Ensign Frank C. Lewis, USNR, leader of the two-plane section covering the convoy at the time of the attack, reported flying at an altitude of 800 feet and about 2 miles from the port beam of the convoy (ComScoron Nine 1942: A1-2). Thus, if surface vessels reported 4-5 miles of visibility, and the aircraft had at least 2, and probably more, visibility did not limit the ability of opposing forces to observe one another as the engagement unfolded.

Thus, atmospheric visibility would not have limited the ability of forces to observe, maneuver, and engage one another. Uncertainty exists, however, as to whether or not *U-576* observed the aircraft covering the convoy prior to surfacing after the attack. The position of the sun, along with the directional force of wind-driven waves, could have aided the U-boat in remaining concealed beneath the surface of the ocean and abetted its attack upon the convoy.

Bureaucratic Features

Just as the tangible features of the battlefield influenced the course off naval actions off the North Carolina coast, so too did intangible features. Namely, these are the bureaucratic delineations of space in which actions took place. Though the connection is not immediately evident, bureaucratic influences ultimately explain why Allied ships and Axis submarines were deployed into the area off Cape Hatteras. The United States' government centrally directed convoy routing and assignment of naval escorts and similar centralized control was exercised in the direction of U-boat activities. Though these features have no actual spatial existence, much

like political borders on a chart, they constitute a portion of the meta-narrative through which specific actions are understood.

US Naval Command and Control

On 30 December 1941, Admiral Ernest J. King was appointed Commander in Chief of the United States Fleet and three months later was made Chief of Naval Operations (CNO); Admiral King was the first Admiral in United States history to hold both offices simultaneously [see Appendix A for German and American Naval officer ranks and equivalences]. The United States' offshore waters were divided into a series of subordinate naval commands with the eastern seaboard being broken into four Sea Frontiers (Ireland 2003:78). Prior to America's entry into World War II, the large swath of ocean where the North Atlantic met the east coast was under the jurisdiction of the United States Navy's North Atlantic Naval Coastal Frontier (NANCF). These frontiers were further subdivided into Naval Districts. NANCF contained the First, Third, Fourth, and Fifth Naval Districts. The NANCF was renamed the Eastern Sea Frontier (ESF) and with the addition of the Sixth Naval District, the Frontier's boundaries extended from the border between Maine and Canada south to the border between St. Johns and Duval Counties in Florida (King 1946:32; Wagner 2010:34). These boundaries are shown in Figure 63.

Admiral King, in April of 1942 "…delegated to Commander Eastern Sea Frontier (CESF) 'all necessary authority to integrate [a coastal convoy] plan and to deal directly with agencies concerned'" (Morison 1947:256). In doing so, CESF Admiral Adolphus Andrews' command could directly organize coastal convoys and naval escorts via control over the naval districts through which convoys would pass. It was under this chain of command that the Commander of the Fifth Naval District oversaw the assembly and departure of Norfolk to Key West merchant convoy KS-520.

More specifically, the CESF placed an escort commander in control off all the vessels within a convoy, both the warships and merchant vessels. Further, "the ships under the escort's protection, usually merchant ships, were under the command of the commodore of the convoy, [and] in most North Atlantic convoys this was a retired RN flag officer, who was embarked on a merchant ship with a small staff" (Syrett 1994:13).

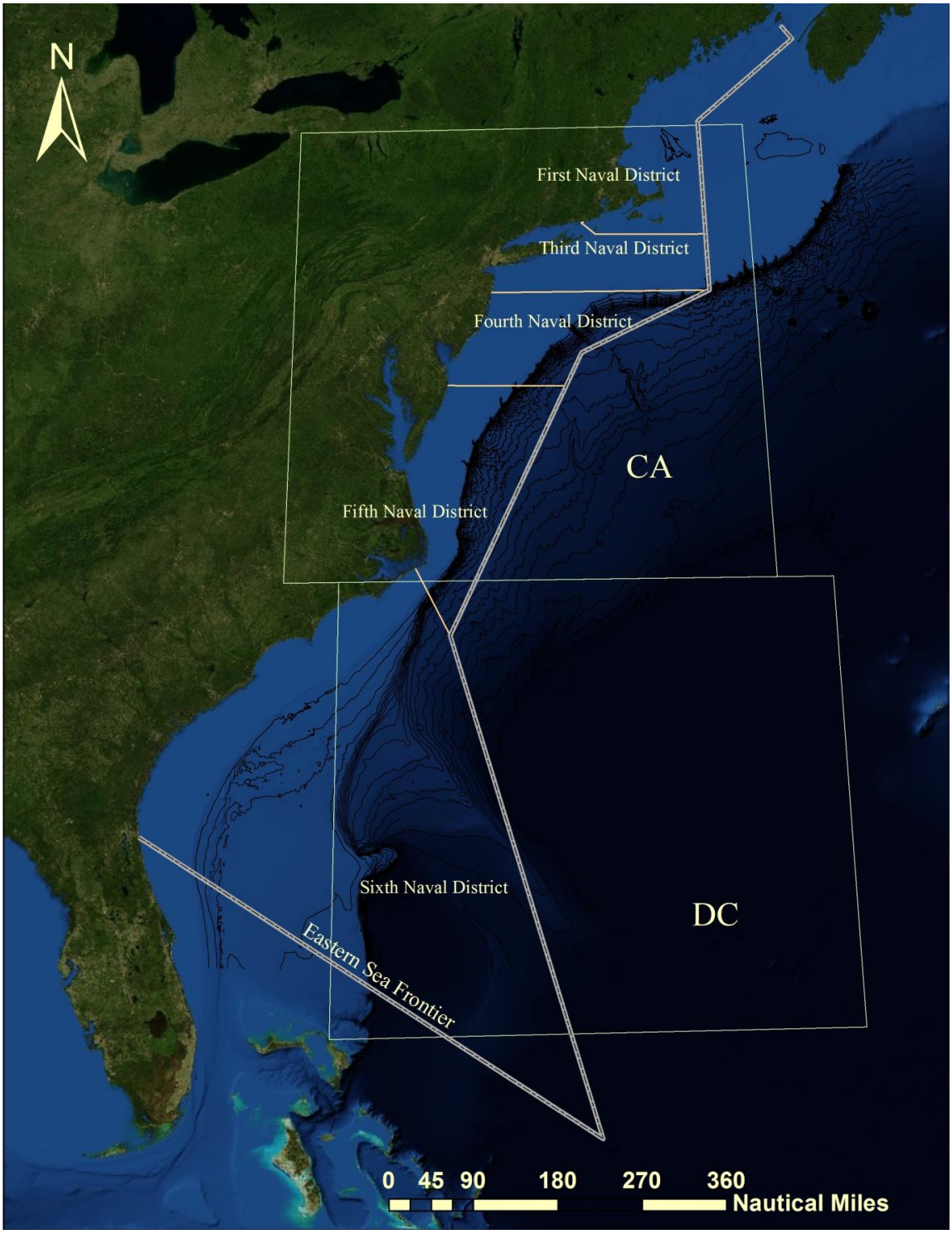

Figure 63. Bureaucratic Boundaries along the American Eastern Seaboard. (Image: John Bright).

As formal escort groups were organized in the fall of 1942 they trained in coordinated anti-submarine tactics and became quite efficient at ASW warfare. Unfortunately during the summer of 1942, escorts lacked this prior training. Nevertheless, the efficacy of US convoys during this time was greatly increased by the CESF coordinating aircraft escort in addition to the warships (Syrett 1994:12-14). With the bureaucratic framework in place and necessary ships available by May of 1942, the United States was ready to implement a proper convoy system (Hague 2000:28).

Convoy Routes

The success of German U-boats against Allied forces in the North Atlantic made the need for additional naval protection apparent. According to John Wagner (2010:79)

> Given that the number of naval vessels available within the NANCF was so severely limited, Admiral Andrews determined that one of his first orders of business, in the event the U-boats crossed the Atlantic, was to route merchant vessels through corridors that were easier to patrol and protect.

The existing shipping lanes were many miles offshore and already known to the Germans. As German U-boats made the first approach upon the American shore, CESF Andrews had at his disposal "20 vessels and 103 aircraft to guard a coastline of 1,500 miles" (Hoyt 1984:137). To make matters worse, "the largest vessel at his disposal was a 165-foot Coast Guard cutter, which could make sixteen knots. Most of the others were tugs, trawlers, and yachts. Some were so small that they could not mount…guns. Nearly all the aircraft were obsolete" (Hoyt 1984:137).

Admiral King (1946:80) described the desperation of this situation

> We prepared…by gathering on our eastern seaboard our scant resources in coastal antisubmarine vessels and aircraft, consisting chiefly of a number of yachts and miscellaneous small craft taken over by the Navy on 1940 and 1941. To reinforce this group the Navy accelerated its program of acquiring such fishing boats and pleasure craft as could be used and supplied them with such armaments as they could carry. For patrol purposes we employed all available aircraft-Army as well as Navy…. It may have interfered, too, to some extent with the freedom of u-boat movement, but the heavy losses we suffered in coastal waters during the eary months of 1942 gave abundant proof of the already well known fact that stout hearts in little boats can not handle an opponent as tough as the submarine.

By mid-1942, however, several measures were taken to establish a coastal convoy system, the "effect of these measures" were "quickly felt in the Eastern Sea Frontier… where they were first applied" (King 1946:80).

The first of these measures, implemented between February and April of 1942, was ultimately debased by a lack of appropriate escort craft. Nevertheless, a 'Bucket Brigade' strategy was developed by Admiral Andrews as the only feasible immediate solution (Morison 1947:254). Historian Samuel Morison (1947:254) described that this "partial convoy system was inaugurated whereby ships moved from anchorage to anchorage [during daylight] escorted by such local craft as were available in the various Naval Districts under the direction of the Command Eastern Sea Frontier." Where safe anchorage was not accessible within a day's sail, improvised anchorages were established via nettings and minefields, including the Cape Hatteras minefield. In this way, merchant ships could make four daylight runs to go between Jacksonville, Florida, and New York (MacIntyre 1961:145; Brown 2007:81).

Despite these efforts, "[continued] U-boat depredations soon made it evident that these protective measures were inadequate" (Morison 1947:255; MacIntyre 1961:145). Admiral Andrews needed to institute complete coastwise convoys. March of 1942 saw a rate of sinking which totaled the combined numbers from January and February. As the situation was becoming desperate, Great Britain sent a contingent of armed trawlers on 1 April. With the arrival of these ships, Admiral King "ordered convoys to begin between Hampton Roads and Key West, and a convoy system was put into effect early in April" (Hoyt 1984:149-150). With few proper escorts, however, these convoys suffered unacceptable losses and the program was cancelled indefinitely (Hoyt 1984:150).

Meanwhile, as Samuel Morison (1947:255-256) noted

> Admiral King appointed an informal board, consisting of representatives of Cominch, Cinclant, and commanders Eastern, Caribbean and Gulf Sea Frontiers, to lay plans for more extensive convoy operations. This board submitted recommendations on 27 March 1942 to Admiral King, who on 2 April wrote, "The principles enunciated and the general procedure suggested in this excellent report are concurred in." After making a few minor changes in the report, Cominch delegated to Commander Eastern Sea Frontier "all necessary authority to intergrate this plan and to deal directly with agencies concerned.

This plan laid the groundwork for the interlocking convoy system, which would organize and

operate ocean convoys between Halifax and Cuba, and coastal convoys between New York and Key West, Florida. The only missing piece, suitable escort vessels, were gained through a re-assignment of US Atlantic naval forces by Atlantic Fleet Commander Admiral Ingersoll (Morison 1947:256-257; Hoyt 1984:152-153).

Thus, from mid-May onward mandatory coastal convoys operated along the US east coast. John Wagner (2010:33) describes the shipping routes in place prior to the war as large corridors through which ships passed. After inception of hostilities, by February, shipping lanes were narrowed to direct lines between navigation buoys, with merchant vessels advised to follow ocean depth contours in between. The method of direct navigation between buoys with the assistance of bathymetric contours persisted throughout 1942, and guided the routes taken by coastal convoys when made mandatory in May. The construction of the Hatteras minefield required changes in convoy routing in the vicinity of Cape Hatteras, and formed the convoy route assigned to KS-520 in 1942 (Wagner 2010:26). These routes, as prescribed by the USN, are shown in Figure 64. As John Wagner (2010:15) found during his research, "while shipping routes represent the ideal, merchant shipmasters undoubtedly exercised some leeway in how strictly they followed these routes."

Several tactical principles influenced the manner in which convoys were organized and protected. These included formation and speed, as well as the arming of merchant vessels with guns and naval gun crews. As this section deals with the organization and command of the convoy system, tactical principles relating to the physical arrangement of convoys are discussed herein. The tactical application of gunnery and the principles governing patrol escorts are discussed in the following section describing participants and their weapons.

In general, convoys were formed by arranging ships in a broad front; that is in a series of shallow columns. Analysis of U-boat attack geometries, namely the restrictions placed upon the maneuverability of the boat by its slow underwater speed, revealed that U-boats could only attack from a position along the forward beam of the target as demonstrated in Figure 65 (see Pye 1918; Welles 1917c, 1918b). Expecting attacks from the forward beam, the convoy formation was thus made as shallow as possible, reducing the space available to a U-boat to align for attack. Space between vessels varied throughout the war, but was usually between 400-800 yards (Hague 2000:26-27).

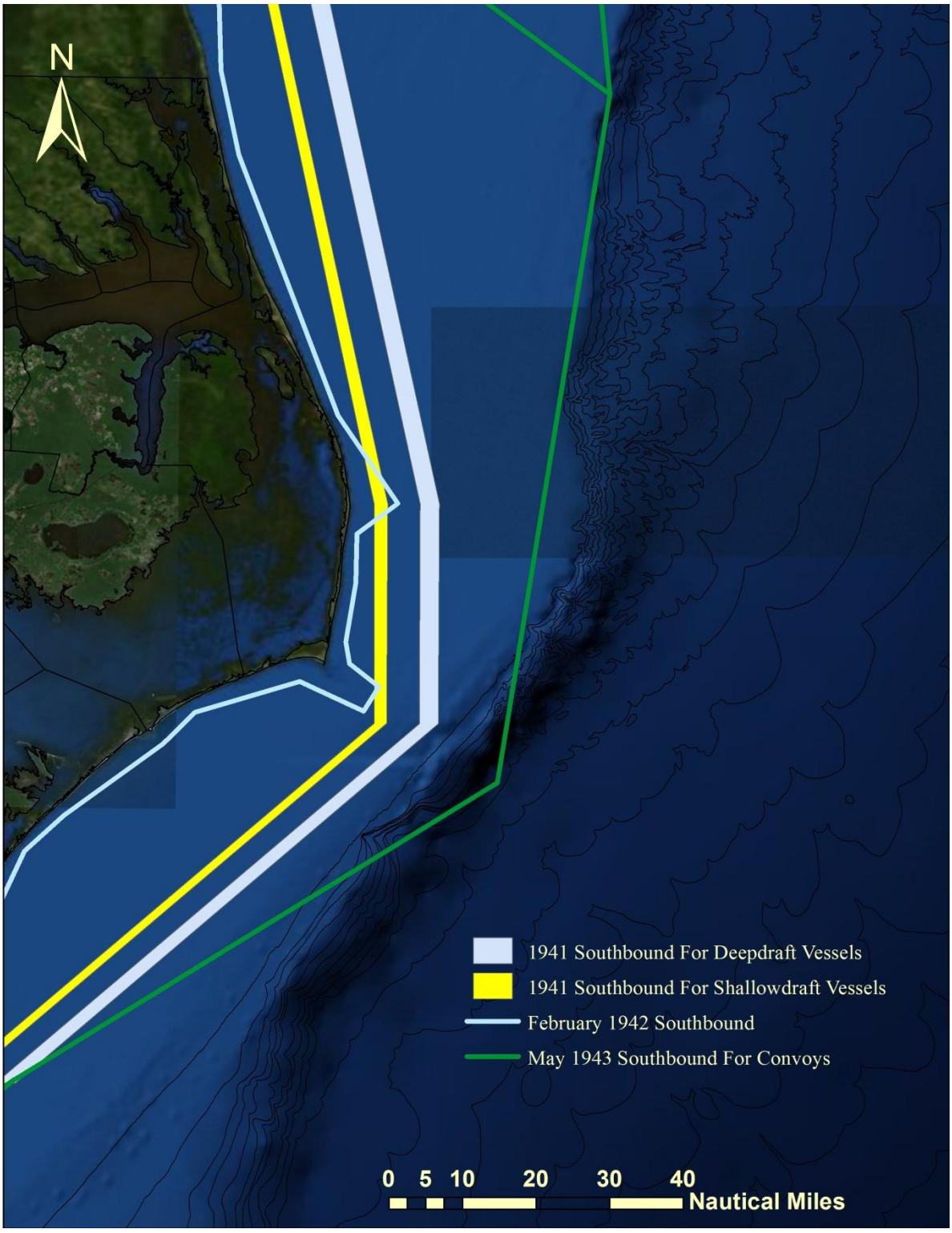

Figure 64. Convoy Routes for Transit around Cape Hatteras during 1942. (Source: Wagner 2010; Image by John Bright).

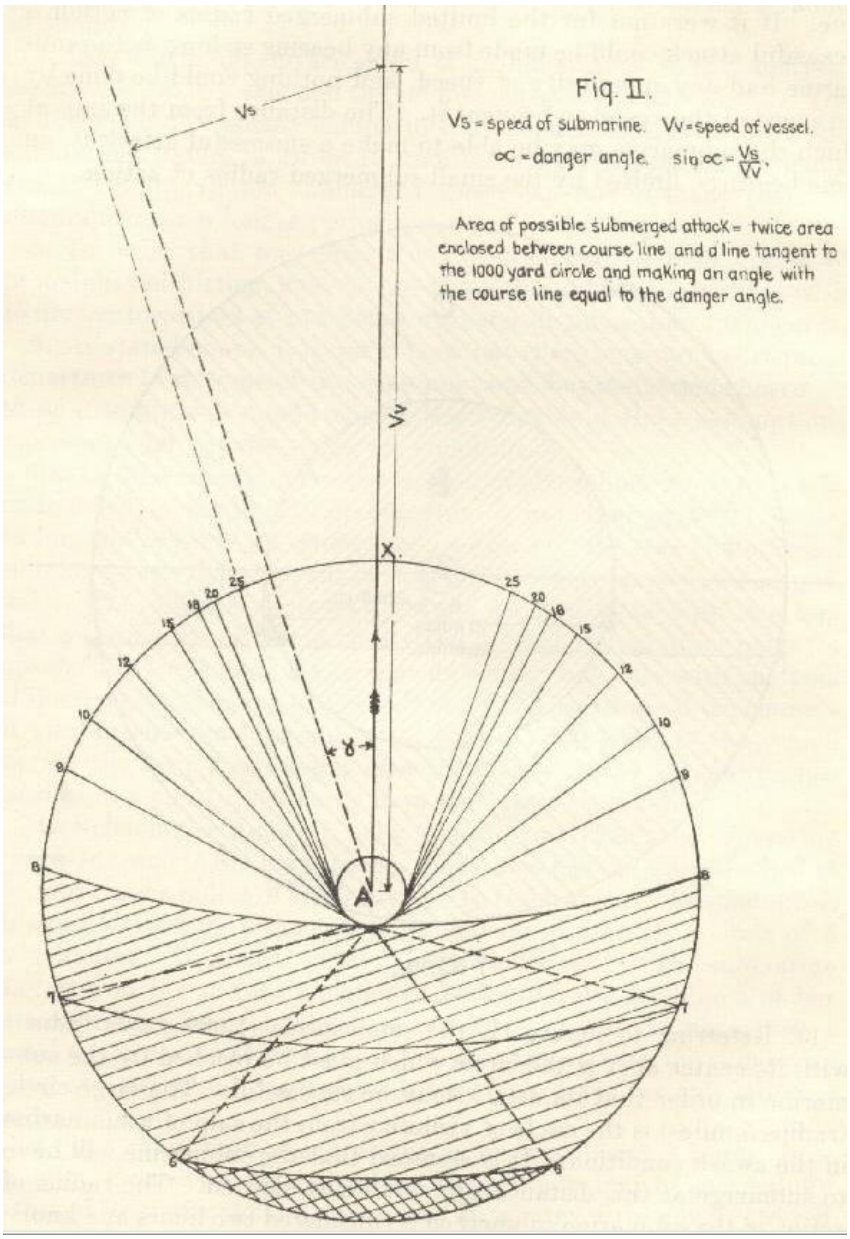

Figure 65. Angle from which U-boat Attack may Originate as Dicated by Speed of Merchant Vessel. As Vessel Speed Increases, Angle of Possible Attack Narrows (Source Pye 1918:8).

Another tactical factor was speed. As described by Commander W.S. Pye (1918:5) amidst the First World War

> The first factor to be considered is the number of hours of daylight, or moonlight,

> spent in the submarine danger zone, and it may be said without question that this number should be reduced to the smallest possible amount consistent with obtaining the most advantageous conditions. *This will be accomplished by…using maximum speed on the straightest course* (emphasis added).

As in the prior example of convoy formation, the speed of vessels is directly related to vulnerabiilty to U-boat attack. As described by the United States Navy during the First World War "the success of a submarine attack depends almost entirely on whether the submarine is in, or can reach, an advantageous position for attack, and in consequence, high speed may be taken as the most important factor in protection against submarine attack" (Welles 1971b:17). For this reason, groups of vessels were encouraged to travel as quickly as possible when moving through areas where a threat of attack by submarine existed. While underway, the navigation, speed, and maneuvering of the convoy was ensured by the convoy commodore, himself under the direction of the escort commander.

Kriegsmarine Classification of Area

At its highest levels, bureaucratic organization of the Kriegsmarine was not dissimilar from that of the United States. During 1942, the Oberkommando der Kriegsmarine (OKM), or Naval High Command, was administered by Grossadmiral Erich Raeder who commanded both fleet and submarine operations. Through the Befhelshaber der Unterseeboote (B.d.U.), or U-boat Commander and Chief, Fleet Admiral Raeder controlled the Ubootwaffe, or U-boat Command. Until 1943, Admiral Karl Doenitz served as B.d.U. , before replacing Raeder at OKM, leaving afterwards to succeed Hitler as leader of Germany in the closing days of the war (Doenitz 1959; Gannon 1990:74; Blair 1996:53-54; Wagner 2010).

At lower levels, however, the U-boat Commander and Chief exerted very centralized direct control over the operations of individual boats. Organization of Doenitz's command centered on a seven man staff. His Chief of Operations (B.d.U. -Ops) Kapitan zur See Eberhard Godt directly oversaw the deployment and movement Germany's U-boats. KptzS Godt in turn relied upon six officers, designated A-1 through A-6. Their duties were as follows: A-1, First Operations Officer; A-2, Mining Operations Officer; A-3, Intelligence Officer; A-4, Communications Officer; A-5, Personnel Officer; and A-6, Logistics Officer (Gannon 1990:69-70).

Together, B.d.U. directed the movement of all operational U-boats. Each U-boat was

required to transmit, via wireless telegraphy, both their daily position and any additional information crucial to overall U-boat operations. According to the *U-boat Commander's Handbook* (OKM 1989:35-36), this additional information included:

1.) Enemy reports which make it possible to send other submarines into action.
2.) Warnings referring to the positions of enemy submarines or minefields….
3.) Reports on the situation in the theater of operation, traffic, possible use of armed forces, description and strength of patrols.
4.) Weather reports.
5.) Position (station) and reports on movements of ships, insofar as the transmission of these reports is required by Headquarters, or seems necessary to enable them to assess the position.
6.) Reports called for by Headquarters…

With this data B.d.U. staff could subsequently direct U-boats to areas where their force would be most effective. Both solo and wolfpack forces were directed in such a manner, the later often operating first in a 'patrol line' formation to maximize the search-capabilities of the U-boat force. In short, positioning of U-boats was not random; rather their movements were rigorously controlled by BdU in an effort to maximize the economy of the U-boat force. Operating in such a way later proved quite problematic for the U-boats as Allied forces devised means to monitor and decode transmissions (Syrett 1994:6; Palmer 2005:275-279).

Knowing their transmissions were vulnerable to monitoring, the Kreigsmarine devised the coded MQK grid system. *U-576* received constant orders to route and take station in various areas during its fifth war patrol. Not only did B.d.U. direct the operation of the boat, but also received intelligence from Kplt. Heinicke. Twice during the fifth war patrol, *U-576* relayed convoy sightings to B.d.U. . Further, by this system of communication, B.d.U. directed the underway replenishment which permitted *U-576* to remain on station so far afield. The grid designations for the waters of Cape Hatteras are shown in Figure 63.

By means of centralized control of individual boats and the requirement of U-boat commanders to report all sightings of merchant craft, Doenitz and his staff methodically orchestrated the war against Allied shipping. For this reason, the movement of U-boats was not random but instead a kinetic process under the influence of a constant stream of intelligence into

B.d.U. Thus, the placement of *U-576* off the North Carolina coast was ultimately directed by Doenitz and his staff at B.d.U. Similarly, the centralized operation of merchant convoys off the eastern seaboard assembled and moved shipping along pre-determined routes under protection of naval and aircraft escort. Thus, the paths leading to the approach of these opposing forces were determined in the offices of Allied and Axis command staffs. Though no tangible trace of these bureaucratic features existed on the battlefield, save the transient navigation aids placed by the USN to direct vessel traffic, they are part of the meta-narrative through which two opposing forces found themselves in conflict on 15 July 1942.

Military Engineering Features

The United States Navy and Coast Guard put several features of the battlefield landscape in place. The most conspicuous of these features was the Cape Hatteras minefield. The minefield was directly responsible for extensive damage to two merchant vessels, and resulted in the loss of tug *Keshena* and two crewmen. The airfield at Cherry Point Marine Corps Air Station (MCAS) was the launching point for the planes of Scouting Squadron Nine (VS-9) who assisted in the sinking of *U-576*. On Ocracoke Island, two US Coast Guard installations and one USN installation housed the sailors and guardsmen who responded to the distressed mariners once their ships were abandoned in the minefield. These areas are described by Scott and McFeaters (2010:114) as "home stations." In particular

> Home stations are permanent bases from which combat forces may be mobilized. They function as staging areas and have the facilities to sustain deployed forces with logistic, communication, intelligence, security, or other support. Generally, home stations are removed from the area of operations, so functionally, that means fighting does not occur at home stations.

Though not proximate to the hostilities, the importance of these home stations is obvious. Without the constant aircraft coverage, KS-520 would have been significantly more vulnerable to U-boat attack. Likewise, the closeness of USN and USCG personnel to intervene and affect a speedy rescue of the merchant crews no doubt saved many lives.

Hatteras Minefield

Constructed in May 1942, the Cape Hatteras minefield was an attempt by the USN to temporarily provide safe anchorage for merchant vessels transiting along the eastern seaboard of

the United States while in the vicinity of Cape Hatteras. Though the minefield only remained until September of that same year, it nevertheless played a significant role in the naval actions on 15 July 1942. In fact, the Cape Hatteras minefield was infamous for the four casualties it caused during its brief existence, all of which were Allied ships. Three of these casualties resulted when *U-576* attacked convoy KS-520.

After the opening months of 1942, during which German U-boats exacted an astounding toll on merchant shipping along the American coast, the USN desperately needed a means to protect merchant craft. The initial government response, to convert fishing trawlers and pleasure craft to anti-submarine patrol vessels *en masse*, proved futile; they lacked the means to effectively hunt submarines and the firepower to combat them in the event of a showdown, evident in the engagement between *U-701* and *YP-389* (see Hoyt 2009). Furthermore, sector-patrol based anti-submarine warfare was itself an inefficient tactic (see Welles 1918:16; Grove 1957). Instead, the Navy needed to emulate the strategy and tactics of anti-submarine warfare already refined by the British: merchant convoys under the protection of well-armed surface escorts and patrol aircraft. Yet in the early months of 1942 the USN simply did not possess the quantity of craft necessary to implement this strategy. Though these anti-submarine craft were hastily under construction, the Navy devised an intermediary solution.

Since military craft were not yet available to actively protect convoys of merchant ships, the USN instituted a system whereby merchant vessels would leapfrog between deep water ports during daylight hours (Karig et al. 1946:92-93; King 1946: 79-81; Morison 1947:254). Though these vessels were still largely unprotected during daylight, they could take refuge in safe harbor during night, when U-boats were more likely to attack. In areas where deep-water ports were further than a single day's cruise, such as between the Chesapeake Bay and Charleston, South Carolina, safe anchorages were fashioned from anti-submarine netting and minefields. One such anchorage, large enough to accommodate a convoy of 30 ships, was ordered for construction in late May, 1942 off Cape Hatteras (Miller 1942).

USN Captain C. C. Miller was placed in charge of a task force which, operating from Yorktown, Virginia, constructed the entire minefield between 20-25 May, 1942. Capt. Miller commanded a task group consisting of four minelayers, three destroyer escorts, three minesweepers, and four district patrol craft. The field was situated in the form of two overlapping crescent shaped legs just south of Cape Hatteras with a total of 2,635 Mark 6 mines,

as seen in Figure 66. The span of the minefield covered Hatteras Inlet, and at its western extent was three and a half nautical miles away from Ocracoke Inlet. Within the field a safe anchorage and fishing area were established, the limits of which were marked with buoys. Further, an entrance channel was swept on the western site of the minefield, also marked with buoys. In addition, several buoys were placed along the perimeter of the minefield as well as notice to mariners issued to prevent Allied craft from inadvertently entering the area (United States Navy [USN] 1942; Miller 1942).

Developed during the First World War, the Mark 6 (Figure 67) was an antenna mine that experienced ubiquitous usage by the USN during World War II. Unlike its predecessors, which were 'horned' contact mines effective only within a few feet, the Mark 6 was instead equipped with a long copper antenna which, when contacted by the steel hull of a passing ship, would send an electric current triggering detonation. The Mark 6 mine was 34 inches in diameter and carried a 300-pound TNT charge. Deployed from the surface, the mine was fixed to an anchor, which held it to the ocean bottom (Campbell 1985:167; Friedman 1988:111-112).

On 19 May, at the Naval Mine Depot in Yorktown, Virginia, Gunners Mates from minelayers *Keokuk* (CM-8), *Miantonomah* (CM-10), *Monadnock* (CM-9), and *Wassuc* (CMc-3) came to inspect the Mark 6 mines slated for deployment off Cape Hatteras. Of the nearly 2,650 mines only 14 were found with defects. A newly fitted anti-sweeping device, however, aroused the suspicions of the Gunners Mates who feared it would interfere with the mine's deployment from its mooring once in the water. Their suspicions were confirmed after the first leg of the minefield was laid, and they were promptly removed prior to running of the second leg. Nevertheless, the following day, 20 May, the minesweepers arrived in Yorktown and began loading the 1,440 mines to be used in the construction of the southwest leg of the minefield (Miller 1942).

The construction of the minefield was an excellently choreographed operation. The detachment of minesweepers and mine layers traveled under the protection of seven escorts: four district patrol craft, destroyers DD-422 and DD-421, *Mayo* and *Benson*, respectively, and tug AT-66, *Cherokee*. The entire task force, expecting enemy U-boats to be present, moved in convoy formation down the coast of North Carolina while maintaining strict radio silence and vigilantly monitoring underwater sound and radio direction finding apparatus. Once on station, minesweepers would clear the area of any potential enemy mines, as well as maintain the swept

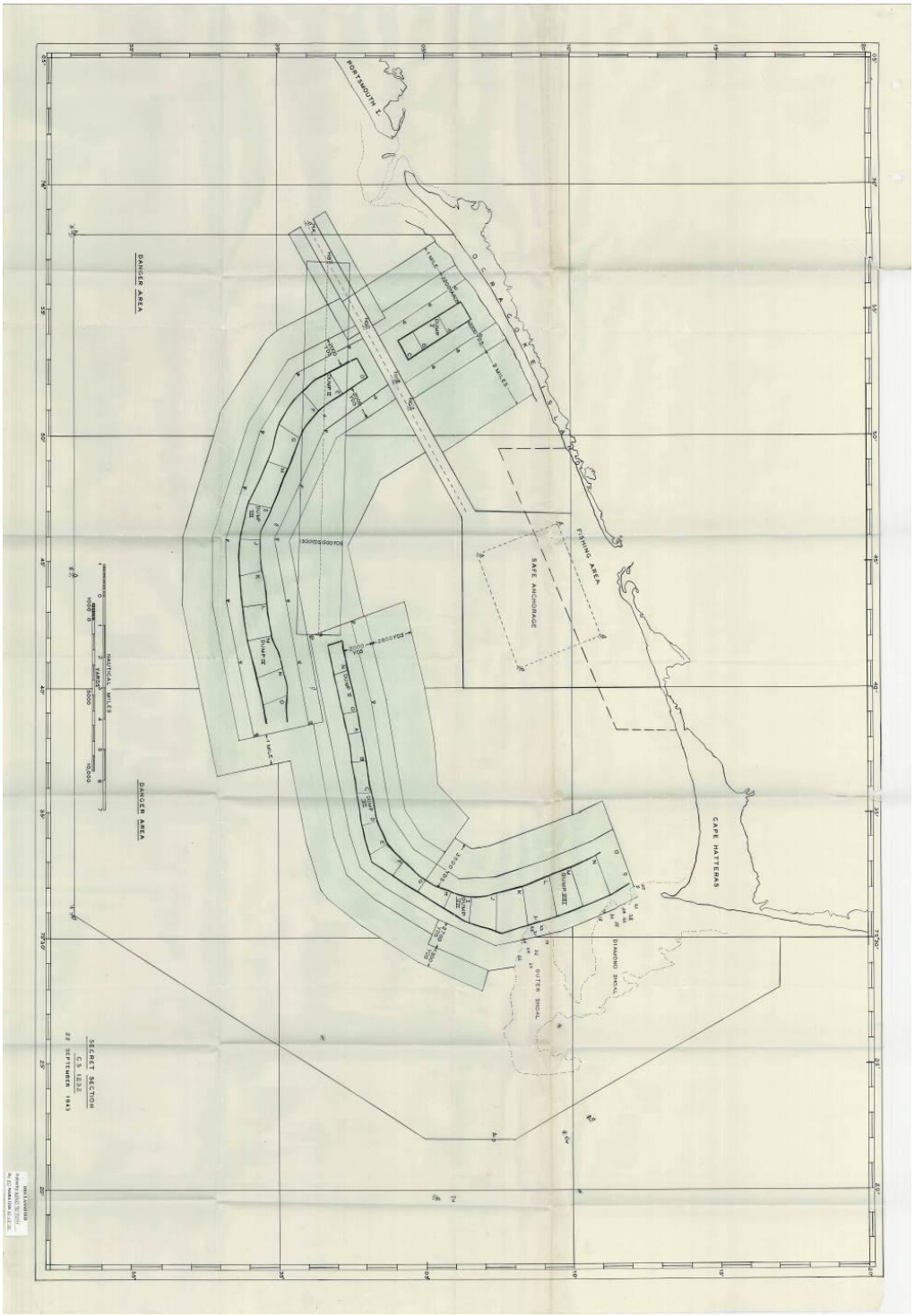

Figure 66. Cape Hatteras Minefield, including aids to navigation and 1942 location of Diamond Shoal. (Source: USN 1942a)

Figure 67. Naval Crew Deploying a Mark 6 Mine. (Source Friedman 1988:112).

channel through the Allied mines as they were placed, under the protection of the district patrol craft. After securing the area, the four mine-layers would deploy each leg under protection from *Mayo*, *Benson*, and *Cherokee*. The task force returned to Yorktown on 23 May to load the remaining 1,195 mines. Due to its small size, *Wassuc* experienced great difficulty handling the rough seas while laying leg one, and was ordered to remain in port during the second leg of operations. With that exception, the next two days proceeded as had the first three days, and by 25 May the Hatteras Minefield was complete (Miller 1942).

As early as 28 April, the Hydrographic Office in Washington D.C. was informed by the USN of the pending construction of a minefield south of Cape Hatteras (Cary 1942). In the weeks leading up to the inception of mine placement, the Hydrographic Office received detailed coordinates and descriptions of the minefield, with which they were to publish an official notice to mariners. Corresponding with the completion of the minefield on 25 May, the Hydrographic Office did just that. No mention, however, was specifically made of a minefield. Rather, coordinates were listed demarcating a danger area south of Cape Hatteras. This specific detail played havoc on USS *Spry*, *J.A. Mowinckel*, and *Chilore* as they steamed for safe harbor

following the attack of *U-576*, when the Convoy Commodore aboard *J.A. Mowinckel* recollected hearing about a danger area off Hatteras, but presumed it referred to the prevalence of U-boat activity in the area (Freeman 1987:413-415).

These vessels would not be the first casualty claimed by the minefield. On the morning of 11 June, tanker *F.W. Abrams* was leaving the safe anchorage inside the minefield after spending a night there while *en route* to New York. Rough seas and visibility less than a quarter of a mile caused the tanker to lose sight of the escort vessel assigned to lead it out of the minefield. Mindful of the surrounding danger, the Captain of *F.W. Abrams* held his course, but to no avail. In the ensuing hours, the tanker suffered three hits from mines, and ultimately the ship was lost. All crew members escaped the damaged tanker and only one was injured (COM5 1942c; SOC 1946:372).

The ordeal of *F.W. Abrams* was only a harbinger of things to come. Poor conditions, miscommunication, and navigational errors all conspired against *J.A. Mowinckel* and *Chilore*. As the hulks of these two vessels were being salvaged the Commander of the Fifth Naval District sent a correspondence to the Commander in Chief of the US Fleet requesting the minefield off Cape Hatteras be replaced with anti-submarine netting (COM5 1942d). The following day, USN tug *Keshena* sank during salvage operations as a result of striking a mine. The minefield was scheduled for removal in September.

By late summer in 1942, the fervent building efforts of the Navy brought hundreds of anti-submarine craft to bear upon the U-boats. This, in combination with equally rapid development of aircraft and airfields along the east coast, proved insurmountable for the German U-boats. The aerial attacks upon all U-boats operating between Cape Lookout and Cape Cod between 12 to 14 July, along with the sinking of *U-576* on 15 July, was motivation enough for Doenitz to withdraw his U-boats from the mid-Atlantic coast of the United States. Just as the convoy system came of age along the Atlantic coast of the United States, the Cape Hatteras minefield passed into obsolescence.

Nevertheless, for its brief existence it constituted a major feature of the landscape south of Cape Hatteras. Bounded on all sides by buoys delineating a danger zone, the minefield left a narrow swath of ocean between its outer boundary and the main shipping lane around Diamond Shoals, the hundred fathom curve. This swath was nine nautical miles at its widest, four and a half at its narrowest, and is shown in Figure 68. This effectively created a bottleneck through

which all shipping was to pass, and an obstacle in the way of any Allied force attempting safe passage around the shoal, or into the safety of Ocracoke or Hatteras inlets. Given the aversion of U-boats to traffic in such shallow water, the minefield presented less of an obstacle for the movement of submarines.

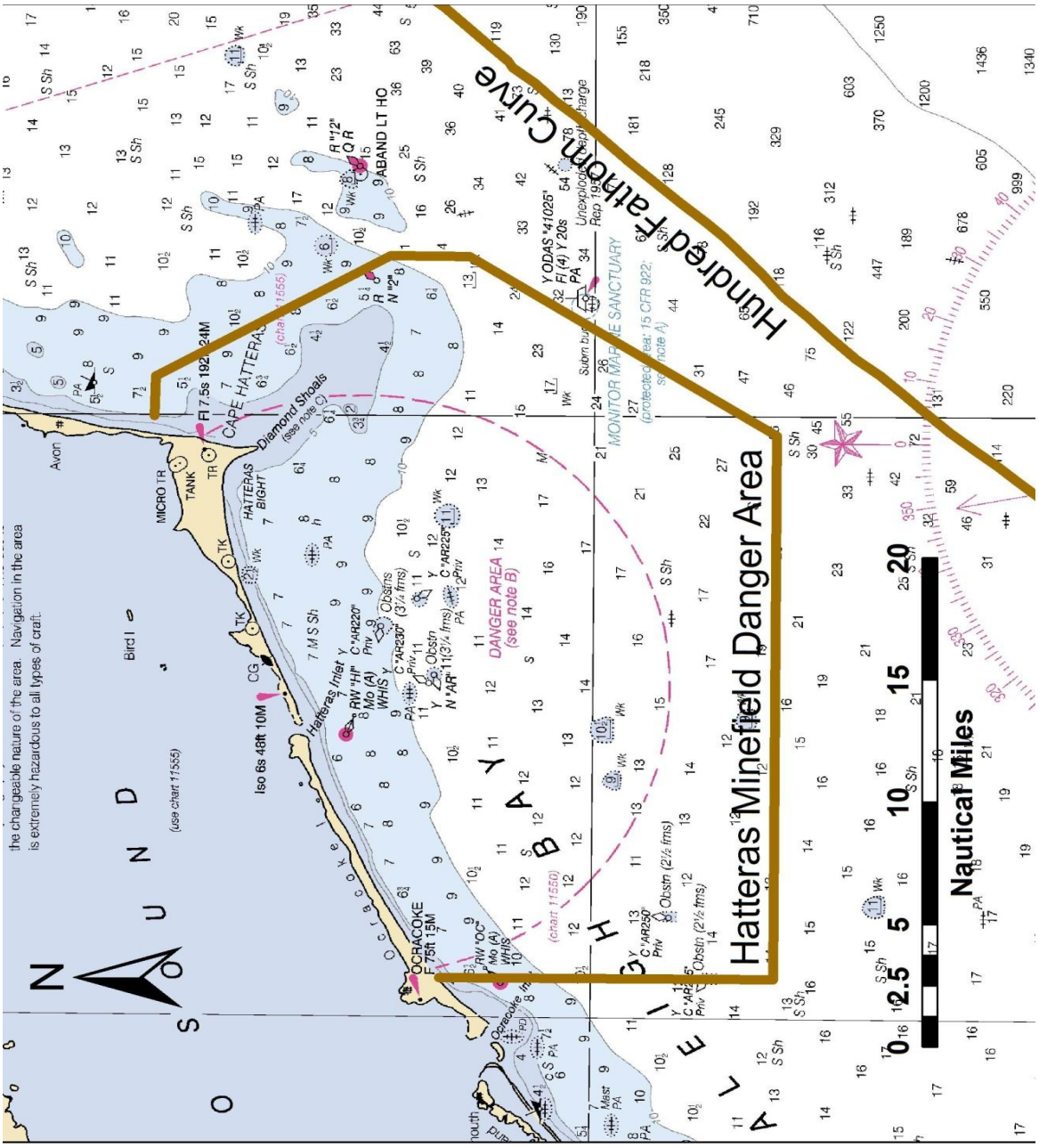

Figure 68. Shipping bottleneck between the Cape Hatteras minefield, Diamond Shoals, and the hundred fathom curve (Source: NOAA RNC, Drawn by John Bright).

Ocracoke Island Military Installations

Ocracoke Island was the nearest and most actively involved landmass in the KS-520 convoy battlescape. Flanked on its north and south sides by Hatteras and Ocracoke Inlets, the island was home to both US Navy and Coast Guard installations throughout the war. On the south end of the island, in what is now referred to as Silver Lake, a US Coast Guard Station and US Navy Section Base were constructed in May of 1942. The north end of the island, adjacent to Hatteras Inlet, housed the Coast Guard's Hatteras Inlet Station. These installations, under the authority of the US Navy, played an integral role in assisting the extrication of damaged merchant craft *Chilore* and *J.A. Mowinckel* in the aftermath of the KS-520 battle (O'Neal 2001:15-69).

To maintain consistent depth in both inlets, starting in 1933, dredges were used "so that bigger boats could get into the stores and fish houses" (O'Neal 2001:18). During the war, the US Navy brought two additional dredge boats to Ocracoke to maintain the inlets in accommodation of the larger military craft used at the bases. Through the course of 1942 a variety of craft moored at these bases. These included commissioned sailing vessels – part of the Coast Guard Reserve's 'Hooligan Fleet'- which were no longer in use after 1943, as many as 18 Coast Guard patrol boats, and 10 US Navy PT boats. Other military vessels, such as district patrol craft utilized during the construction and maintenance of the Cape Hatteras Minefield, made stops at Ocracoke while on duty (Miller 1942; O'Neal 2001:47-49).

World War II brought an era of change to the lifestyle of the small island community. Most conspicuous, perhaps, was the 600 additional men brought to the island by to serve at the Navy and Coast Guard bases. In addition to the flood of people, the USN also built the first paved roads, connecting the base with an ammunition dump built on the sound side of the island (O'Neal 2001:xi-19). Through the increase in personnel and infrastructure on the island, the USN was able to maintain constant patrol along the newly constructed minefield and also to lend assistance to mariners in the vicinity of Cape Hatteras.

In the late hours of 15 July 1942, the distressed crews of *Chilore* and *J.A. Mowinckel* abandoned their vessels. On the approaches to Hatteras Inlet a series of explosions rocked each damaged merchant craft. Fearing another U-boat attack, the master of *J.A. Mowinckel* recounted:

> It was getting dark. We had a number of wounded men aboard, all injured by the first explosion, and I was afraid that we might again be attacked. After consultation with Captain Nichols, I decided to abandon the vessel. The *J.A. Mowinckel* was anchored to prevent drift and in the hope that she might later be salvaged…

> In the meantime, the *Chilore*, which had also been damaged in the mine field, was abandoned, so that there was a considerable flotilla of lifeboats on this area of sea.
>
> During the night No. 4 boat was found and taken in two by a Coast Guard patrol craft. At 1 a.m., July 16, the same vessel encountered lifeboat No. 2, which was headed for Morehead City. Both boats were towed to Ocracoke Inlet, where they arrived at 4:30 a.m. Lifeboats Nos. 1 and 3 had landed there about an hour and a half earlier (SOC 1946:367).

Immediately, the men were taken into the medical care of the USCG. Many of the merchant-men and naval gunners were wounded during the U-boat attack, and many others were suffering from exhaustion and exposure. Several of the severely injured were evacuated to Norfolk, Virginia (SOC 1946:368).

After returning to investigate the damaged hulks, LCDR Robert E. Permut, USN at the Naval Section Base, ordered mines cleared in the vicinity of the merchant vessels, and tugs dispatched to conduct a salvage operation. On 17 July, the first of three tugboats arrived for salvage operations. Owned by Merritt-Chapman and Scott Corporation, 889-ton tugboat *Relief* began the operations by ferrying engineers to and from the merchant craft in preparation for tow (Lloyds Register of Shipping 1942/43b: T). Two other tugboats, *Keshena* and *J.P. Martin* arrived in the following days, and were ready for salvage operations by 19 July (SOC 1946:369).

Research through *Lloyds Register of Shipping* was unable to locate information on *J.P. Martin*. It is known from the first-hand account given by Standard Oil Company the tug was responsible for towing *J.A. Mowinckel* from the field and running the merchant hulk aground at 0300 hours on 20 July. During this operation, tugboat *Keshena* acted as a rudder off the stern of *J.A. Mowinckel*. Attempting to steer the hulk, *Keshena* swung out of the cleared channel in the minefield, struck a mine, and sank in 12 minutes (SOC 1946:369). *Keshena* was transferred to the War Shipping Administration from Southern Transportation Company in early 1942, and was thus under contract of the US government while conducting salvage operations off Ocracoke (Lloyds Register of Shipping 1941/42b:KER-KIK, 1942/43b:KER-KIH).

The same day *J.P Martin* ran *J.A. Mowinckel* aground, Standard Oil Company's Port Engineer arrived in Ocracoke, and began piping steam from *Relief* over to operate pumps aboard *J.A. Mowinckel* to remove water from the ship's pump room, and then from cargo tanks. The following day the merchant hulk was ready for tow, until dragging anchor back into the minefield and striking another mine on the early morning of 22 July. Later that day, however,

pumping cleared the water from the newly damaged tank, and the vessel was under tow by 23 July. *Relief* towed *J.A. Mowinckel* to meet a USN ocean-going tug and several naval escorts, and the small convoy made its way back to Norfolk, Virginia.

Simultaneously, salvage operations were also extricating *Chilore* from the minefield. Standard Oil Company (1946:370-371) relayed the following account of the vessel's salvage:

> While the operation of salvaging the *J.A. Mowinckel* was going forward, a similar effort was being made to save the *Chilore*. After being crippled by a torpedo in the first attack, this vessel had struck several mines. She was later taken in tow, the intention being to bring her to Norfolk. The *Chilore* had reached the entrance to Chesapeake Bay when she capsized and sank on July 24, 1942.

The function of the Ocracoke Island Coast Guard stations and Naval Section Base were integral in the rescue of these merchant crews and salvage of these merchant vessels. These installations supplied the forces necessary to secure and extricate these damaged merchant craft. In the process, friendly fire claimed tugboat *Keshena*, operating at the time under contract with the US government.

Cherry Point Marine Corps Air Station

Credited with the sinking of *U-576* were two pilots from US Navy Scouting Squadron Nine (VS-9) along with the gun crew aboard American freighter *Unicoi* (ComScoron Nine 1942:1-3). These two pilots, Ensign F.C. Lewis, USNR, and Ensign C.D. Webb, USNR, flew naval patrol planes, most likely Vought OS2U-3 Kingfishers, from the airstrip located at Cherry Point Marine Corps Air Station (MCAS). Though the specific aircraft flown by these pilots is unknown, for the purposes of the analysis, it was assumed the pilots were flying Kingfishers, as this was the most common naval patrol aircraft at the time (Murphy and McNiece 2009).

Ground broke on 6 August 1941 for what would become Cherry Point MCAS. Prior to its commissioning on 20 May 1942, the installation was referred to as Cunningham Field, in honor of Lieutenant Colonel Alfred A. Cunningham, the Marine Corps' first naval aviator. The base incorporated 11,135 acres into airstrips, roads, and support facilities, situated between Hancock and Slocumb Creeks along the Neuse River in Craven County. In 1946 the base was proclaimed both the largest Marine Corps Air Station and the largest runway area in the United States (Carraway 1946:3-4).

The decision to locate Cherry Point at its present location, shown in Figure 69, rested upon a myriad of factors. According to historian Gertrude S. Carraway (1946:13)

> A committee of Marine Corps officials earlier had carefully inspected many available sites along the entire South Atlantic and gulf coasts and had chosen Eastern North Carolina as the most suitable place for the center of Marine activities. A major factor in their decision was the long stretch of ocean beach in Onslow County which could be utilized for practice landings of amphibious Leathernecks.

Within North Carolina, the decision to place Cherry Point along the Neuse in Craven County was influenced by its proximity to Camp Lejeune Marine Corps Base and the seaport in Morehead City, as well as the convenience of adjacent roadways and railways (Carraway 1946:13).

During World War II, two Marine Aircraft Wings were established at the base. The first, the Third Marine Aircraft Wing, was created in November 1942, and the second, the Ninth Marine Aircraft Wing, in April of 1944. Prior to the establishment of the Third Wing, United States Navy reconnaissance craft operated from the base, patrolling for German submarines off the North Carolina coast. Though not originally envisioned for this role, Cherry Point's location "…in a strategic part of the vulnerable coast of North Carolina…" made the base a "…vital operations center for American airplanes fanning far and wide over coastal areas in search of enemy submarines, which for some months did considerable damage to Allied ships…" (Carraway 1946:20). In particular, the Navy's Scouting Squadron Nine operated there in the intervening months.

Of the many patrol aircraft operating from this base in early 1942, perhaps the most utilized by the US Navy was the Vought OS2U Kingfisher. Originally introduced in 1940, over 1,300 individual units were produced for the Navy by the end of the war. Lightly armed, the Kingfisher had a range in excess of 800 miles, making it ideally suited for anti-submarine patrol off the North Carolina coast (Murphy and McNiece 2009:207). With Cherry Point MCAS situated proximate to the coast, the area of operation for these craft extended well beyond Cape Hatteras and the adjacent shipping routes.

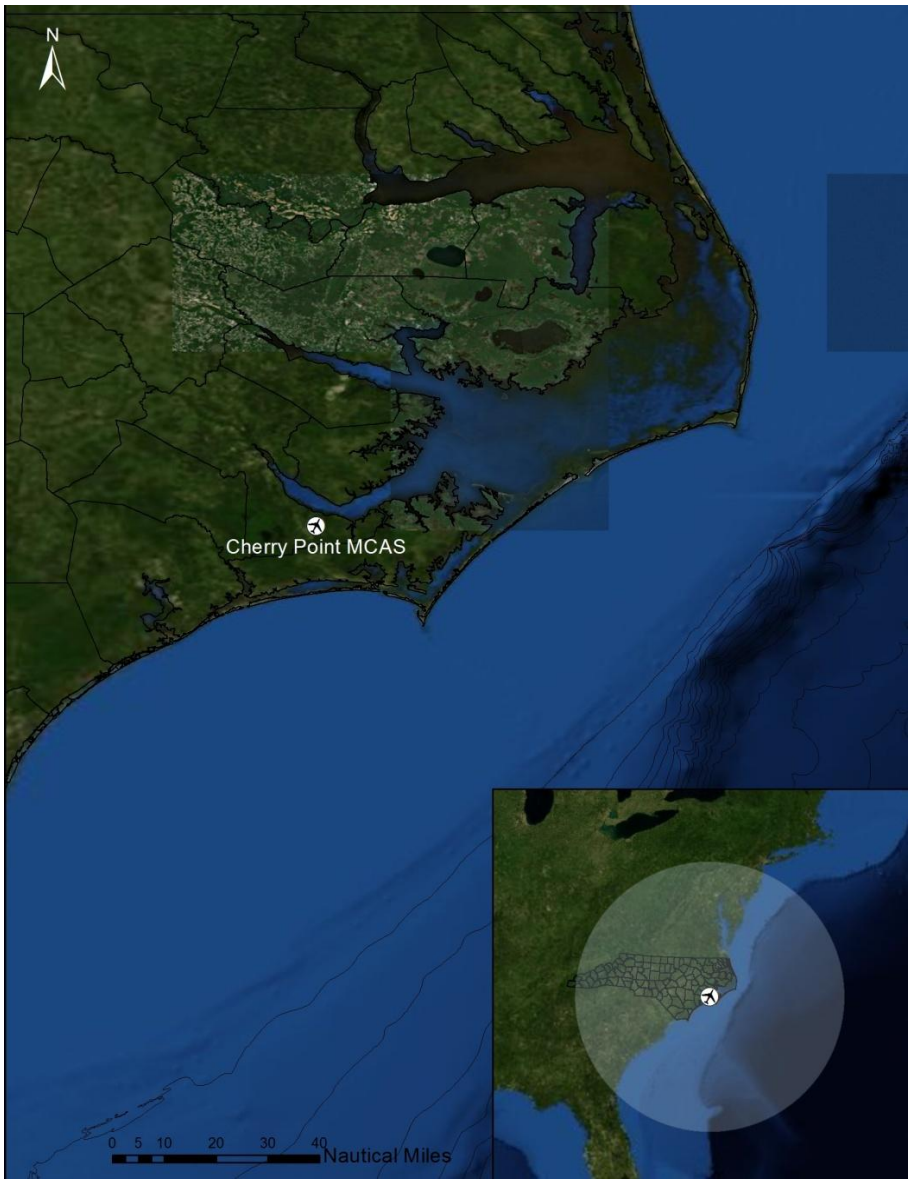

Figure 69. The location of Cherry Point MCAS along the North Carolina coast and radius of available air coverage (inset) of US Navy Vought OS2U Kingfisher Aircraft. (Source Murphy and McNiece 2009; Image: John Bright).

The importance of Cherry Point as a strategic feature along the North Carolina coast was realized prior to the KS-520 convoy battle and sinking of *U-576*. In fact, as author Homer Hickam Jr. (1989:284-285) reported,

> It could arguably be said that both the sinking of the *U-85* and the *U-352* had been mere flukes. But the *U-701* had been sunk by a well-trained pilot and crew who knew exactly what to do after a U-boat was found. Admiral Andrews felt quite rightly that his command could take credit for that. They had, after all, fought all

> the bureaucratic battles that brought Harry Kane and his squadron to the Atlantic seaboard. They had also placed the bombers at Cherry Point and determined their patrol route. Now, with the destruction of the *U-701*, Andrews and his staff sensed that more victories were about to follow.

And follow they did. According to Homer Hickam (1989:285) the two pilots who possibly attacked *U-576* on 14 July were flying Kingfishers out of Cherry Point. The following day, two more pilots from Cherry Point, along with a gun crew aboard *Unicoi*, dealt the U-boat its death blow.

Participants

The attack on convoy KS-520 involved 19 merchant vessels of various nationalities, 5 American Naval and Coast Guard surface escorts, 2 tugboats contracted by the US Navy, 2 American patrol planes, and a single German U-boat; a total of 29 craft. Nearly two thirds, 19 of 29, were civilian vessels, many of which were registered in non-belligerent nations. As a result of *U-576's* attack, two of these merchant craft would be sunk, a third severely damaged, a tugboat lost, and the complete loss of *U-576*. Total loss of life includes up to 60 hands aboard the German submarine, depending on the number of rates and officers aboard, two sailors aboard *J.A. Mowinckel* who died from wounds sustained, one of which was a member of the naval gun crew, and two sailors aboard *Keshena* unable to escape the tug when it went down in the Hatteras minefield.

Aboard these craft were an array of weapons systems, those typical for *guerre de course* and anti-submarine warfare during the Battle of the Atlantic during mid-1942. The manner in which combatants brought these weapons to bear and, conversely, the manner in which they defended themselves against their enemies' weapons are referred to as tactics. Technical specification of weapons and their tactical application, according to codified treatise, are discussed. According the principle of inherent military probability standardized tactical principles serve as a metric for the actions of combatants trained in those principles and are thus a means to qualitatively examine the events of a specific battle. This section discusses weapon specifications and the prescribed institutional doctrines of *guerre de course* and anti-submarine/convoy warfare as codified by the United States and German Navies. Discussion of the actual attack in relation to these principles follows in the next two Sections.

Axis Participants

During World War II, German seapower was almost entirely invested in submarines. Though exchanges between Allied and Axis capital ships, such as the sinking of *Bismarck* (1940-1941) and *Admiral Graf Spee* (1936-1939), resonate throughout the historical memory of the war, the burden of naval warfare rested almost entirely upon the shoulders of Germany's U-boats. Their strategy was simple: lacking naval parity with Great Britain, Germany would instead send forth a fleet of U-boats with the sole purpose of blockading England. The intent was not only to halt the flow of war materials into Britain, but also to deny the island as a foothold for American involvement in the Allied war effort (Westwood 2003:7).

Originally, Hitler and his naval command envisioned a joint force of surface ships and submarines with which to attack Allied shipping. Conceived as the 'Z Plan' in January, 1939, a mere 233 U-boats were to be constructed as a complement to battleships, heavy and light cruisers, and aircraft carriers; Admiral Doenitz requested a fleet of no less than 300 operational U-boats to complete the task (Doenitz 1959:37-42). Several factors, including British naval superiority and air supremacy over the approaches to Britain, made the German surface fleet largely ineffective. This burden instead fell upon Doenitz and the U-boat arm.

Under the Treaty of Versailles, Germany was forced to scrap the submarine fleet built during the First World War. Construction of new U-boats did not begin until 1935, when Hitler denounced any restrictions placed upon Germany by the Treaty (Showell 2006:70). By this time, the Kriegsmarine had 34 U-boats of three different types either completed or under construction. These included the short-range Type I and Type II boats, and ten of the medium-range Type VII (Figure 70) boats (Doenitz 1959:29). Throughout the war many additional types of U-boats were developed to fulfill various roles. The Type II proliferated as a coastal patrol boat, operating in the western approaches to Great Britain and the Black Sea. Developed in 1938 and 1939, the double-hulled, open-ocean Type IX U-boat was brought into production and over 250 were built by war's end. The largest U-boat produced by the Kriegsmarine was known as the Type X, developed as a minelayer. To refuel attack U-boats while underway, the Type XIV was brought into production in late 1941. Developed too late to impact the war effort, the breathtaking complexity of the Type XXI and XXIII U-boats would drastically alter the course of submarine development during the Cold War that followed. No U-boat type, however, rivals the Type VII in either numbers built or combat effectiveness (Miller 2000:18-72; Showell 2006:74-104).

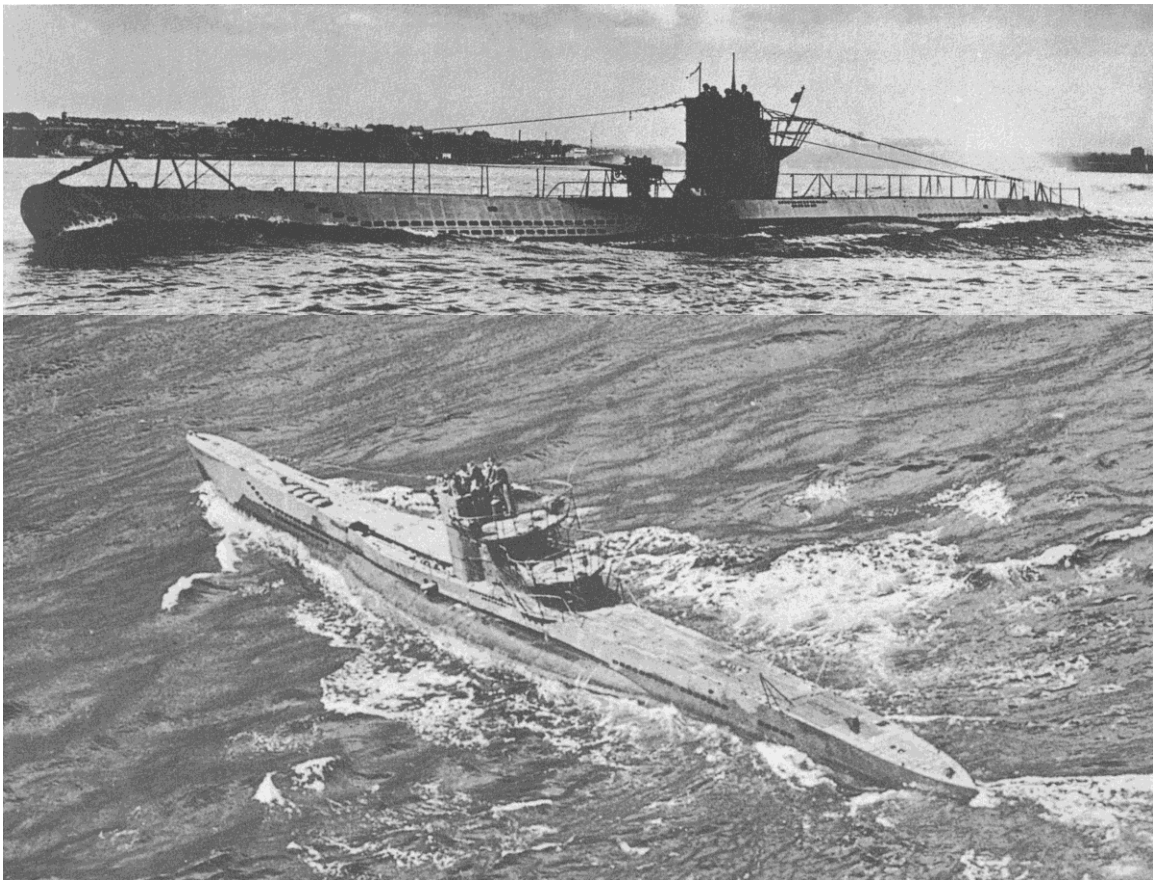

Figure 70. Top: Type VII U-100 underway in harbor, and Bottom: A Type VIIC under command of the RN, on its way to be scuttled. (Source: Westwood 2003:19-24).

In total, approximately 705 Type VII U-boats, consisting of 5 varieties, were built during World War II. These boats were 61 percent of the entire German submarine force in the decade between 1935 and 1945 (Westwood 1984:9; Miller 2000:24). The success of the Type VII rested in its ability to balance range, armament, seaworthiness, and maneuverability. The boat had a single-hull, and was constructed from eight separate modules. Two torpedo rooms, at the bow and stern, totaled five torpedo tubes; four forward and a single aft. All tubes were stored loaded while underway, with an additional torpedo for each tube left inside the torpedo room. These 10, combined with as many as four stored outside the pressure hull, meant a Type VII could arm itself with 14 torpedoes (Westwood 1984:11-12; OKM 1989:4-24; Hague 2000:48-49; Miller 2000:27).

During the early years of the Second World War, Germany primarily utilized a 7 meter long, 53.3 centimeter diameter torpedo, referred to as the G7. The most common of these was the G7a, a compressed air powered weapon with a range between 800 and 14,000 meters, depending

on the speed of travel. Introduced in 1939, the G7e torpedo utilized an electric propulsion system, allowing ranges between 5000 and 5700 meters. Though shorter ranged than the compressed air types, these electric torpedoes left behind them no visible wake, a feature of immense benefit to the attacking U-boat. Starting in late 1942, the Kriegsmarine developed complex guidance systems that allowed torpedoes to maneuver autonomously after a preset distance was reached following launch. These systems, however, were not in place during the assault on American shipping in early 1942 (Westwood 1894:14; Campbell 1985:260-268; Hague 2000:48-49; Miller 2000:86-97; Showell 2006:123-134).

Both G7a and G7e torpedoes carried an identical 300-kilogram warhead. The explosive used was similar to the hexanitrophenylamine (HND) trinitrotoluene (TNT) mix developed during the First World War. It was found that adding aluminum to the mixture increased the explosive power of the warhead, thus aluminum comprised nearly a quarter of the total weight of each warhead. The explosive was activated by one of two types of pistol: contact or magnetic. Throughout 1939, 1940, and 1941, German U-boat Command was plagued by chronic failures among each type of pistol. Many torpedoes were outfitted with a combination contact/magnetic trigger. This allowed the torpedo to detonate either by hitting the side of a ship or, more effectively, passing underneath the ship and allowing magnetic variation to trigger an explosion. Combined with the warhead, pistol, propulsion and guidance systems, G7a and G7e torpedoes weighed 1528 and 1603 kilograms, respectively (Westwood 1894:14; Campbell 1985:260-268; Miller 2000:86-97; Showell 2006:123-134). The USN pilots from Scouting Squadron Nine stated no torpedo wakes were present during *U-576's* attack, indicating the U-Boat was most likely firing G7e torpedoes (Figure 71) (ComScoron Nine 1942:1).

Torpedoes were the primary weapon of the German U-boat's attack on merchant shipping. While surfaced, the U-boat was immensely vulnerable to enemy fire. Type VII boats were equipped with a SKC/35 88 millimeter gun (Figure 72) forward of the conning tower, and an assortment of anti-aircraft guns mounted aft of the conning tower (Figure 73), however, these guns served mainly a defensive role. Small merchant craft, or those already disabled, could be attacked with the 88 millimeter gun. Anti-aircraft machine guns were meant to ward off attacking aircraft should the boat be caught on the surface and unable to dive to safety.

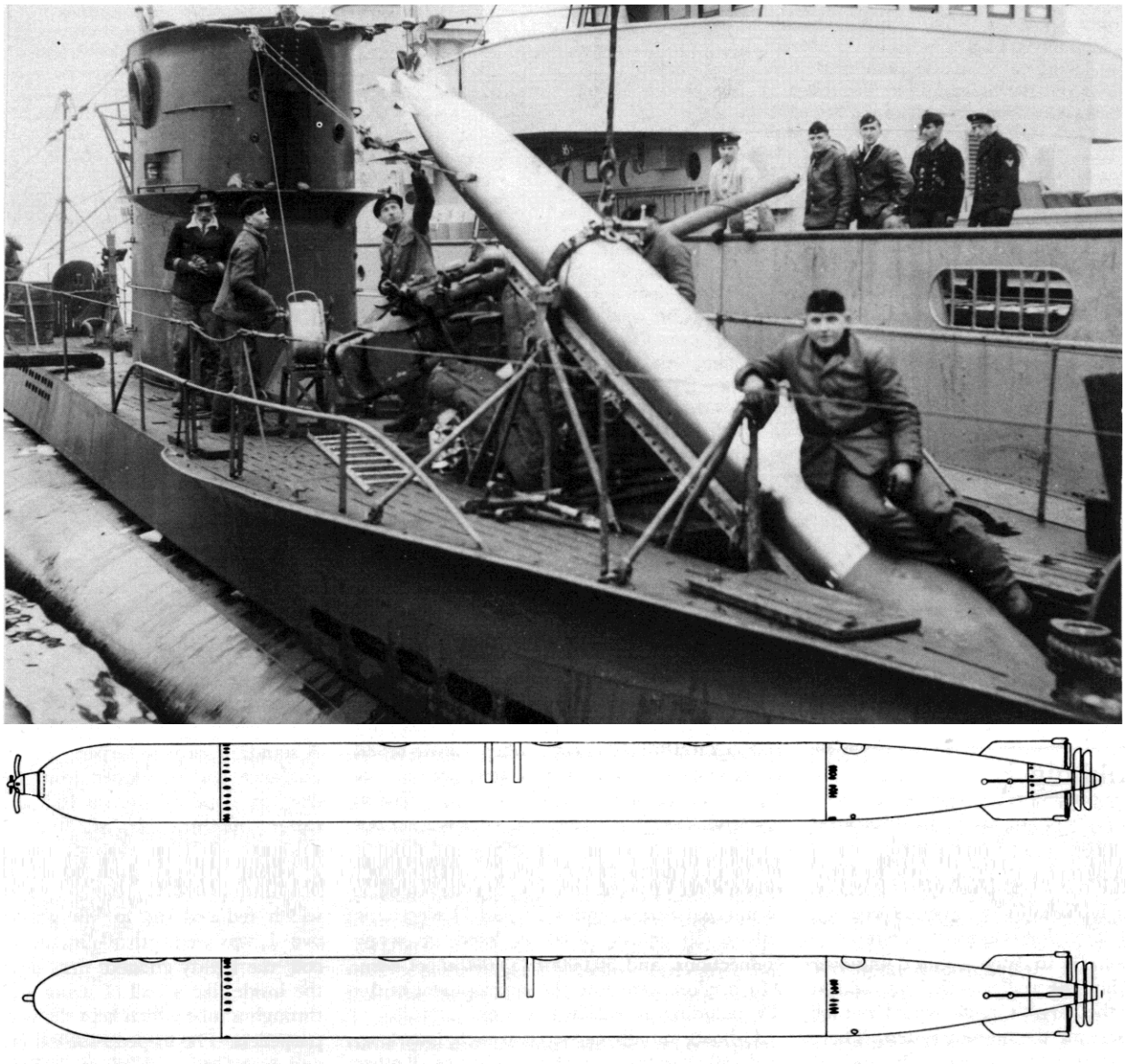

Figure 71. The German G7e electric torpedo. Top: A torpedo is being loaded into the U-boat via the forward torpedo loading hatch. Bottom: A schematic of the G7e. (Source Campbell 1985:261-263).

These weapon systems were not generally used during an attack, as they required the U-boat to be surfaced, thus negating any element of surprise it might have had; the exception being to engage an already damaged merchant vessel or to sink an obviously indefensible one.

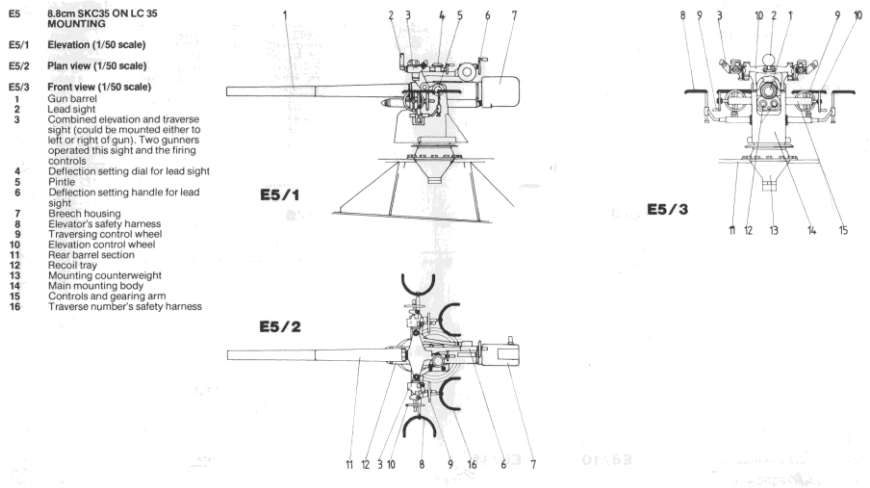

Figure 72. The 88mm SKC/35 gun commonly utilized by German U-boats. (Source: Westwood 2003:91).

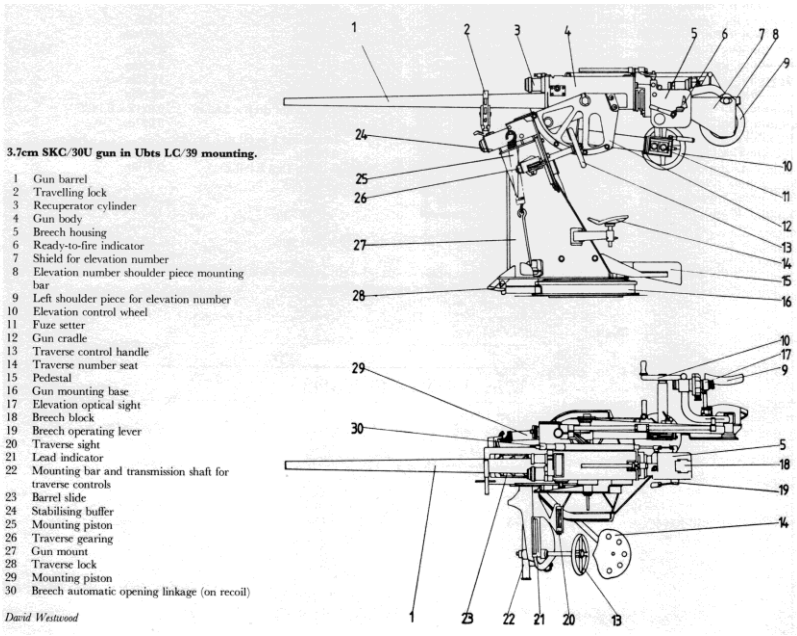

Figure 73. The SKC/30U machine gun commonly used on German U-boats. (Source Campbell 1985:256).

Of the Type VII U-boats, 94 percent were the VIIC variety, including *U-576*. These boats were 66.5 meters long, 6.2 meters wide, and 1,070 tons fully loaded. Surfaced these boats could move 17.2 knots and travel nearly 8,500 sea miles if kept at a speed of 10 knots. They were powered by two Germaniawerft diesel engines, each producing 2,800 to 3,200 horsepower. Submerged, these boats were powered by two 750 horsepower Siemens-Schuckert-Werke electric motors. These motors could move the boat 7.6 knots maximum, or 130 miles if kept to 2 knots. On board

were four officers and fifty-six enlisted crew (Westwood 1984:12).

Surfaced and submerged speed, weakness of its guns compared to surface warships, vulnerability to enemy attack when surfaced, the range and effectiveness of torpedoes, and the reliance upon diesel engines to charge its electric motors for submerged running all dictated the manner in which the U-boat was handled. This is true of both daily operations and combat tactics. The daily operation of the boat was dominated by the limitations of its propulsion system. As described by historian David Syrett (1994:13)

> Unlike modern nuclear submarines, World War II U-boats were not true underwater craft. Instead, the German vessels operated best on the surface and were capable of staying underwater only for a limited amount of time. They could steam at 17 knots on the surface, but, underwater, could cruise at only 2 or 3 knots for limited periods of time.

The ramifications of these limitations were numerous. Limited battery life compelled the U-boat commander to operate the boat judiciously while underwater, and inevitably required the boat to surface and run on the surface. Further, tracking and engaging targets required a great deal of calculated maneuvering both on the surface and submerged, all of which placed the submarine at risk of being detected and attacked by warships or aircraft, as well as being spotted by merchant craft.

These limitations, namely slow submerged speed and the need to remain undetected, also placed several specific constraints upon a U-boat's ability to engage a target. While submerged the Type VIIC U-boat could travel no faster than 7.6 knots. In practice, though, several factors compelled the commander to move his boat much slower. First, while submerged the U-boat commander was dependent upon the periscope to monitor surface activity and track targets. Travelling at a high submerged speed resulted in a highly visible periscope wake. Speeds around 2-3 knots, or periodically moving even slower, were therefore required to reduce the visibility of the periscope. Second, while submerged the U-boat depended upon battery-powered electrical engines for propulsion. Moving at maximum speed would drain these batteries within three and a half hours. If the U-boat commander anticipated needing to stay submerged for long periods, for example to avoid retaliatory action by warships following a successful torpedo attack, he was again compelled to travel at low submerged speed to maximize battery duration; travelling at 2 knots, the submarine could remain submerged in excess of 50 hours (Welles 1917a:6, 1918b:1-

15; OKM 1942:4-49).

Thus, it was necessary for a U-boat to submerge at a sufficient distance from a target to avoid being spotted on the surface. Once submerged, the boat was limited to low speeds, again to avoid detection, in this case from a periscope wake. This low speed of approach limited the direction from which a U-boat could engage a target. Even a slow merchant vessel, perhaps traveling at 8 knots, could easily outrun a submerged U-boat traveling 2-3 knots. For this reason, it was critical for the U-boat to position itself ahead of the target in such a way that it could intercept the vessel and effect a torpedo attack.

To deal with this situation, a series of tactics were developed to press as much advantage as possible for the U-boat. What follows is a tactical description of a 'text-book' U-boat attack upon a merchant vessel or merchant convoy by means of a bow torpedo attack. Many techniques were developed by U-boat commanders to attack from various angles, and from their stern torpedo tube, as well as hunting in packs. Many examples of U-boat attacking merchant vessels with their deck guns, or engaging aircraft with their anti-aircraft armament exist as well. Since the historical record clearly indicates *U-576* made a solo bow torpedo attack against KS-520, this form of attack is herein tactically described for the sake of the analysis. Additionally, a great deal could be written about U-boat tactics in general, discussing technological advancements and the like; this is not an exhaustive review of the subject. Further, many of these tactics were developed from the experiences of German U-boats during the First World War. A great deal of literature was generated by the Royal Navy from their observations of German tactics and information gained by captured vessels. This literature is drawn upon here as it generally represents the manner in which submarine attacks were executed during the early years of World War II.

Upon detecting merchant vessels, the U-boat commander was instructed to place his boat into a position to exploit any opportunity for attack, often engaging in a tactic known as overhauling. The object of this procedure was to determine the speed and direction of the merchant vessels while surfaced without being detected. In doing so, a U-boat commander would steer his boat in such a direction as to bring the merchant vessels in visibility just over the dip of the horizon, providing a view of the uppermost structure of the vessels. Once a speed and direction were determined, the U-boat commander could then steer slightly away from the vessels, allowing them to disappear over the horizon and his boat to slip from their view.

Repeated, this process allowed the U-boat commander to track the merchant vessels for long periods of time, during which this information could be radioed back to B.d.U., allowing other U-boats to direct themselves to engage and also allowing the U-boat to establish an appropriate attack position. Alternately, if the U-boat was converging with the merchant vessels, the commander could steer his vessel to intercept the merchant vessels and proceed to the intercept while submerged (Welles 1917b:8; Frost 1918:1-2; OKM 1989:47-48; Williamson 2010:18-28).

A direct bow attack would require the U-boat to achieve a station on the forward beam of the convoy or merchant vessel, from which a nearly perpendicular torpedo shot can be taken. This would be achieved either by converging on the vessel from abeam its course, or closing the distance to an on-coming vessel or convoy, based upon previous observation of the vessel's speed and direction. From this position, the submarine would submerge and initiate the torpedo attack run, using one of a few attack geometries depending on the nature of the convergence of the boat with its target. Considerations of wind speed and direction, sea state, sun position would be made with regard to masking the U-boat's approach while also maximizing the visibility of its target. Ideally, the U-boat would be able to approach out of the sun and/or out of a force 2-3 wind, with seas only a few feet high to conceal the periscope and wake of the vessel (Welles 1917a:6, 1917c:9; OKM 1989:40-51; Williamson 2010:10-13).

Ultimately, the object of the underwater torpedo attack was to "…discharge a torpedo with the certainty of hitting, but without warning and at short range" (OKM 1989:40). While shorter range ensured a greater probability of hitting the target it came at the expense of the greater probability of being detected. Thus, during the attack run a U-boat commander was required to assess a bewildering volume of information. The geometry of the attack, angle and speed of the target, angle and speed of his vessel, maintenance of concealment upon approach, optimal distance at which to fire, all required consideration and were conducted from a submerged boat closing on enemy vessels. To verify speed and direction of the target, the commander needed to continually observe the target upon approach. In an effort to prevent detection of the submarine via its periscope as it neared, commanders employed another tactic called "sparing." Sparing involved raising the periscope at short intervals, long enough to verify or adjust speed and range, and then withdrawal it to the level of the water's surface. In doing so, the wake from the periscope was minimized while the commander was able to maintain contact and observation of the target (Welles 1917a:6; Frost 1918:1-2; OKM 1989:48-49).

The commander would begin sparing at a range of 5000 to 4000 meters, the maximum range at which a G7e torpedo could be launched. To further reduce the wake of the periscope and any visible disturbance of the water from the boat's propellers or steering rudders, the U-boat would slow to just a few knots; the final approach was conducted at very low speed. Expenditure of torpedoes was guided in an effort to maximize damage to the target. When close and certain of the attack geometry commanders were encouraged to fire multiple discharges at different parts of the target to ensure sinking it. At ranges greater than 1000 meters, and where the aiming data was in doubt, commanders were instead taught to fire a spread of shots dispersed across the boundaries of the target to ensure at least one hit (Frost 1918:1-2; OKM 1989:49-60; Williamson 2010:10).

Following a torpedo attack, the submarine commander was taught to remain at periscope depth to observe the damage to the target, the movement of additional ships, and the actions of escorts if possible. If warships or other enemy vessels presented an immediate threat, the U-boat was instructed to dive and proceed at full speed away from the vessels and the angle at which the torpedo was fired. If warships did not present an immediate threat, however, commanders were obliged to remain at periscope depth and assess whether additional engagement with the original target was necessary, or opportunity existed to engage other targets. If enemy warships were present, but not threatening immediate danger, the commander could also observe them and exploit any opportunity to slip past their defenses (Welles 1917b:11; OKM 1989:63-65; Williamson 2010:57-60).

Allied Participants

Allied participants constitute an overwhelming majority of the combatants in this engagement. Between the five warships and two patrol aircraft there were nearly 458 American sailors, guardsmen, and aviators present during the attack, not including the naval gun crews aboard many of the merchant vessels. The sailors and guardsmen stationed on Ocracoke Island assisted in the rescue of the crews from *Chilore* and *J.A. Mowinckel* and manned the patrol boats monitoring the minefield throughout their extrication. There were also full crews aboard each of the tugs operated by the War Shipping Administration tasked with extracting the merchant hulks from the minefield, in addition to the crews aboard the minesweepers clearing a path for them while in the minefield. In comparison, as many as 56 ratings and 4 officers aboard *U-576* were

the only Axis participants (Westwood 2007:12). In addition, there were an unknown number of civilian participants amongst the crews of the 19 merchant vessels of which KS-520 was comprised. This high ratio of Allied to Axis participants is most likely characteristic of any Battle of the Atlantic convoy battle. The opposite, however, is true regarding loss of life: only four Allied lives were lost while the Germans suffered the loss off as many as 60 men aboard the U-boat.

The naval aviators and men stationed onshore who assisted in the defense, rescue, and extrication of the damaged vessels were discussed in the prior sections on Cherry Point MCAS and the Ocracoke Island installations. Described here are the Allied participants onboard ships during the attack and counter-attack against *U-576*. This includes Escort Group Easy, the detachment of naval and Coast Guard vessels assigned to escort the convoy to Key West, Florida, the two aircraft from Scouting Squadron Nine, and the merchant vessels themselves. Emphasis is placed upon specifications regarding these vessels relevant to the METT-T and KOCOA analyses. Size, speed, weapons capabilities, and tactics are described omitting additional discussion on such things as detailed service histories.

Escort Group Easy

Assigned to protect KS-520 were five military escort vessels: Escort Group Easy. Under the command of Lieutenant Commander L.R. Lampman, commanding aboard destroyer USS *Ellis,* were USS *McCormick*, USS *Spry*, USCG *Triton*, and USCG *Icarus* (USN 1942b). Commissioned on 7 June, 1919, USS *Ellis* was among the many *Wickes* Class destroyers built for the USN following the First World War. Similar in configuration, USS *McCormick* was a *Clemson* Class destroyer commissioned 30 August 1920, and built by the same builder as USS *Ellis*, William Cramp and Sons Company in Philadelphia, Pennsylvania (Whitley 1988:256-259). Both USCGC *Icarus* and *Triton* were 165-Foot patrol boats originally built to combat smuggling during prohibition and were later converted to submarine chasers for service during World War II (Scheina 1982:37). USS *Spry*, formerly HMS *Hibiscus*, was transferred from the RN to the USN on 2 May 1942 (Radigan 2005).

Destroyers of the *Wickes* Class were nearly obsolete before all 111 were delivered to the USN. The basic design was essentially a *Caldwell* Class ship with the addition of more powerful machinery. Depending on the builder, however, two variants emerged, further complicated by the installation of different machinery in individual boats. The result was a class of vessels with

variable performance and range, few of which ever actually saw combat. By 1940, 32 of the original 111 had been stricken, another 22 transferred to the RN and RCN, being replaced by newer additions to the fleet. Nevertheless, the need for anti-submarine vessels in the Atlantic led to widespread conversion of the remaining destroyers, starting in December of 1940. In the process, the destroyer's original armament was replaced with six 3-inch guns, four machine guns, additional depth charge equipment, and the removal of all torpedo tubes. To increase the endurance of the destroyers, additional fuel bunkers were added (Whitley 1988:256-257).

The *Wickes* Class ships displaced 1090 tons, with an overall length of 314 feet 4 inches, a beam of 30 feet 10 inches, and a draft of 9 feet 2 inches. Powered by a series of steam engines, on two shafts, the *Wickes* ships could make 35 knots, with a range of 2,500 nautical miles at 20 knots. One of the first American vessels to engage a German U-boat in the North Atlantic, USS *Greer*, was a *Wickes* Class Destroyer. Also, the first USN vessel to sink a U-boat off the East Coast, USS *Roper* destroying *U-85* of Nags Head, North Carolina, was a *Wickes* Class destroyer. Built between 8 July 1918 and 30 November 1918, USS *Ellis* (DD-154) was commissioned 7 June 1919. The destroyer was briefly decommissioned between 1922 and 1930, and was decommissioned again between 1936 and 1939. Brought back into service to serve on neutrality patrol, *Ellis* underwent a series of conversions to prepare the vessel for anti-submarine service in 1940. With a crew of 103, under command of LCDR Leland R. Lampman, USS *Ellis* served until 1945 (Figure 74), and was ultimately sold by the USN after the war (Whitley 1988:256-258; Willshaw 2011a).

Coming into production less than a year after the *Wickes* Class destroyers, the *Clemson* Class vessels were "an attempt to rectify the gross inconsistencies in the endurance of the earlier class, but were otherwise very similar" (Whitely 1988:258). A total of 144 destroyers of this class were built, though, much like Wickes boats, most were scrapped, sold, transferred, or converted prior to World War II. In September 1923, seven of these destroyers ran aground off the California coast and precipitated the largest peacetime disaster for the USN. By 1940, 57 boats were scrapped, 14 converted to seaplane tenders, 4 converted to minelayers, 9 converted to minesweepers, and 20 transferred to Great Britain. In preparation for escort duty in the North Atlantic, the remaining *Clemson* Class boats underwent a suite of modifications similar to those done on the *Wickes* Class (Whitley 1988:258-259).

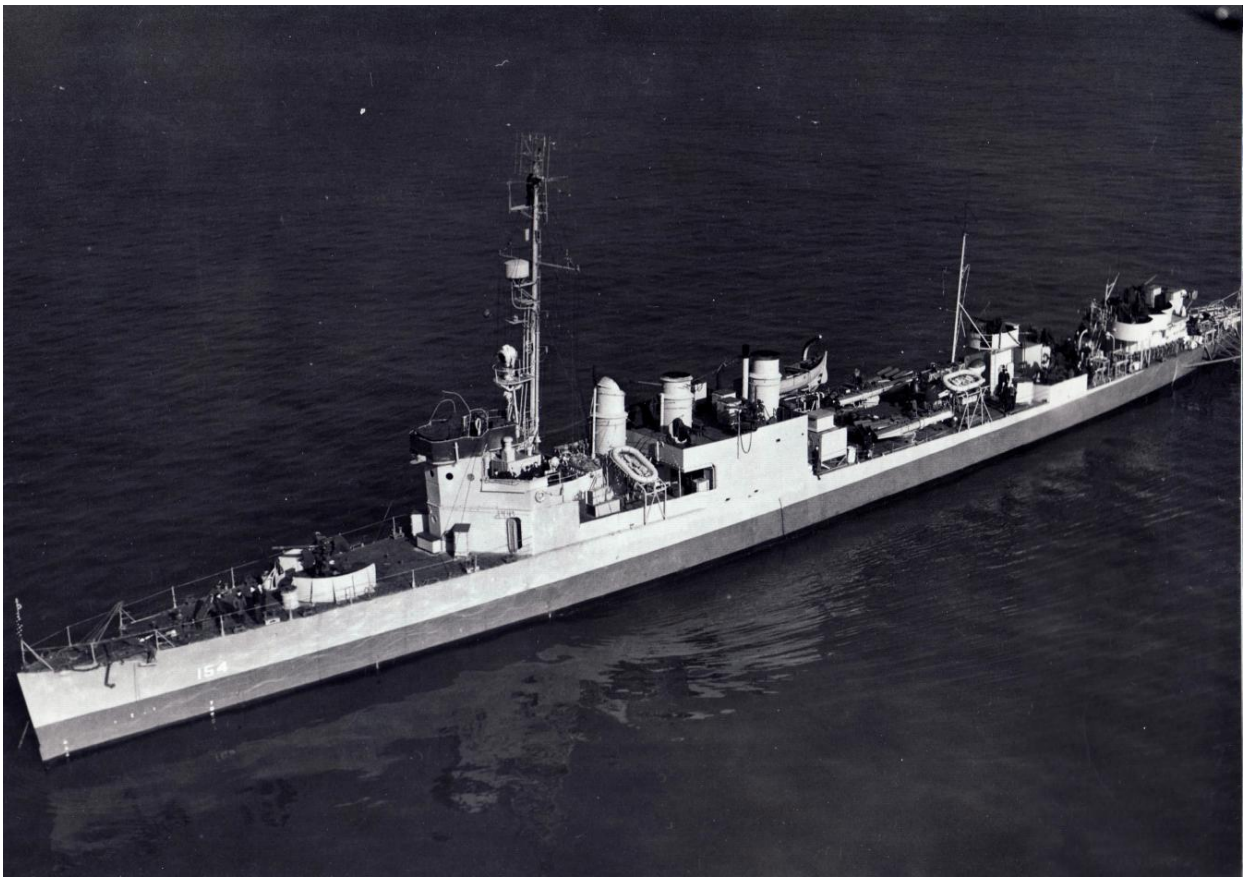

Figure 74. USS *Ellis* (DD-154) in late 1943. (Source: National Archives).

USS *McCormick* (DD-223) (Figure 75) was built between 11 August 1919 and 22 January 1920 by William Cramp and Sons in Philadelphia, Pennsylvania. Like the vessels of the *Clemson* Class, *McCormick* displaced 1,210 tons, was 314 feet 4 inches in length overall, 30 feet 10 inches in beam, and 9 feet 10 inches in draft. As a result of improvements made on the *Wickes* Class design, *McCormick* had an approximately 35 percent greater fuel capacity and an approximate range of 4,900 nautical miles at 15 knots, nearly double that of the *Wickes* boats. USS *McCormick* could obtain a maximum speed of 35 knots, and carried a crew of 114. Commissioned on 30 August 1920, the destroyer was decommissioned between 1938 and 1939, recommissioned and modified for service in Destroyer Squadron 31 in the North Atlantic during 1941. From 1941 through late 1942, USS *McCormick* was under the command of LCDR Eugene S. Sarsfield. The destroyer was decommissioned and sold shortly after the war (Whitely 1988:258-259; Willshaw 2011b).

Figure 75. USS *McCormick* (DD-223) in early 1944. (Source: NAVSOURCE).

In addition to the two USN destroyers, the navy also assigned patrol gunboat USS *Spry* to Escort Group Easy. The vessel was originally under construction in Belfast, Northern Ireland, for the French Navy, in the design of the British *Flower* Class corvettes. The fall of France in 1940, however, resulted in the transfer of the vessel to British ownership where its construction continued as HMS *Hibiscus*. On 2 May 1942, the vessel was transferred to the USN at Leith, Scotland, and recommissioned USS *Spry* (PG-64). The vessel served until 1945, when the USN sold it. The vessel displaced 1,375 tons, with 205 feet 2 inches in length, 33 feet in beam, and 14 feet 7 inches draft. USS *Spry* could make 16.5 knots and carried a crew of 87. Further, the vessel was armed with one 4 inch gun, one 3 inch gun, two 20mm machine guns, and four depth charge racks, as seen in Figure 76 (Radigan 2005).

In response to escalating hostilities between American and German naval forces in the North Atlantic, the United States Coast Guard was placed under control of the United States Navy on 1 November 1941, as is customary during time of war (Galecki 2005:78). In doing so, a number of 125 foot and 165-foot patrol boats came into the service of the USN. Originally designed for law enforcement during prohibition, these craft underwent a series of modifications prior to service in World War II and constituted the only functional submarine chasers owned by the Coast Guard (Scheina 1982:37; see Galecki 2005). The 165-foot large submarine chasers were contracted in the 1930s, a total of 18 being commissioned by 1934. These vessels displaced

350 tons, with an overall length of 165 feet, 25 feet 3 inches in beam, and 7 feet 8 inches in draft. Each was powered by twin diesel engines, capable of making 16 knots. At cruising speed of 11 knots, however, the cutters had a range of 3,000 nautical miles, and could make 6,417 nautical miles at 6 knots. The cutters were outfitted with radio direction finding and sonar equipment, in addition to a 3-inch gun, 1 Y-gun, and 2 depth charge racks. These vessels had a total complement of between 44 and 75 men (Figure 77 and Figure 78) (Scheina 1983:37-38)

Figure 76. USS *Spry* (PG-64) from June of 1944. Note the depth charge racks along the stern, light caliber guns on the bow and stern, and machine guns amidships. (Source: NAVSOURCE).

Figure 77. USCGC *Triton* (WPC-116) in June of 1944. (Source: National Archives).

Figure 78. USCGC *Icarus* (WPC-110) in Charleston, SC, offloading prisoners rescued from U-352 following the battle between the two in May of 1942. (Source: United States Coast Guard).

Each cutter served in a variety of capacities, mostly as escort vessels along the US coasts. Two of these, *Icarus* (WPC-110) and *Triton* (WPC-116) served along the east coast during 1942. *Icarus* achieved notoriety as the first USCG vessel to sink a German U-boat when it caught and destroyed *U-352* on 9 May 1942 off the North Carolina coast. Stationed at Staten Island, New York, the cutter patrolled and escorted convoys along the entire east coast, before being transferred in 1945. Similarly, *Triton* was stationed at Key West, Florida, and served along the eastern sea frontier from 1941 to 1945 (Scheina 1982:37-40).

Thus, under the command of LCDR Lampman were five naval escorts modified for use as anti-submarine platforms. Though none were originally built for the task, by 1940 each vessel had in place 3-inch guns, depth charges, and machine guns. A typical 3-inch gun aboard a naval vessel fired a 13-pound projectile out to 14,500 yards (Figure 79).

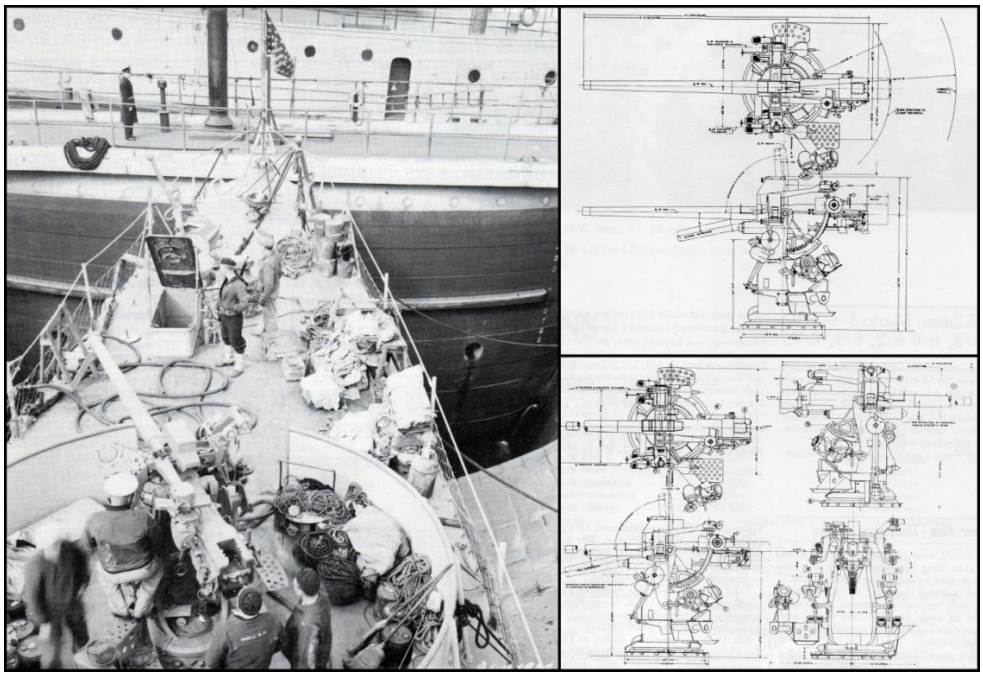

Figure 79. One of the 3in/50cal guns aboard USS *McCormick* (DD-223), with additional schematics. (Source: Campbell 1985:145-146).

A smaller variant of standard naval Mark 21 gun was the Mark 2/1 common aboard Coast Guard craft and merchant vessels. This variety had a maximum range out to 7,000 yards. Machine guns (Figure 80) would likely have been 20 millimeter, and useful at close ranges (Campbell 1985:145-155). A typical U-boat attack began at a range of 5,000 meters, and would come as close as 300 meters, bringing the submarine well within the range of the ships' ordnance (see OKM:40-74).

Figure 80. Images of the three types of machine guns used aboard the ships in Escort Group Easy. 5.19a is the 20mm Oerlikon, 5.19b is the Browning M2, and 5.19c is the 40mm Bofors. (Source Campbell 1985:148-153; Friedman 1988:75-79).

Investigation of photographs reveals each escort vessel had stern-mounted depth charge racks, and both cutters were outfitted with Y-gun depth charge launchers (see Friedman 1988:101). Without forward launching anti-submarine ordnance, common later in the war, the surface vessels were at a disadvantage when making an attack run. This was beacuase "depth charges sank relatively slowly, and as a ship accelerated to drop her charges over the estimated position of the submarine, she lost sonar contact…" (Friedman 1988:101). Corrected with a suite of improved weapon systems later in the war, in mid-1942 these problems were just being realized by American crews.

In July of 1942, these vessels were most likely supplied with Mark 6 or Mark 7 type depth charges. Both were redesigns of World War One systems. The Mark 6 utilized a hydrostatic pistol to detonate a 300-pound TNT charge. The total weight was 420-pounds and it sank at 8 feet per second. Modifications in the design increased the sinking speed to 12 feet per second, and increased the maximum depth from 300 to 600 feet. The Mark 7 was essentially a larger version of the Mark 6, employing a 600-pound TNT at a total weight of 768 pounds (Figure 81). Prior to the development of the Mod 1 variant in August 1942, the Mark 7 sank at a rate of 9 feet per second, and could operate between 30 and 300 feet of depth (Campbell 1985:163). With either of these depth charge types, each individual destroyer, cutter, or patrol gunboat could have brought an overwhelming depth charge attack upon a U-boat.

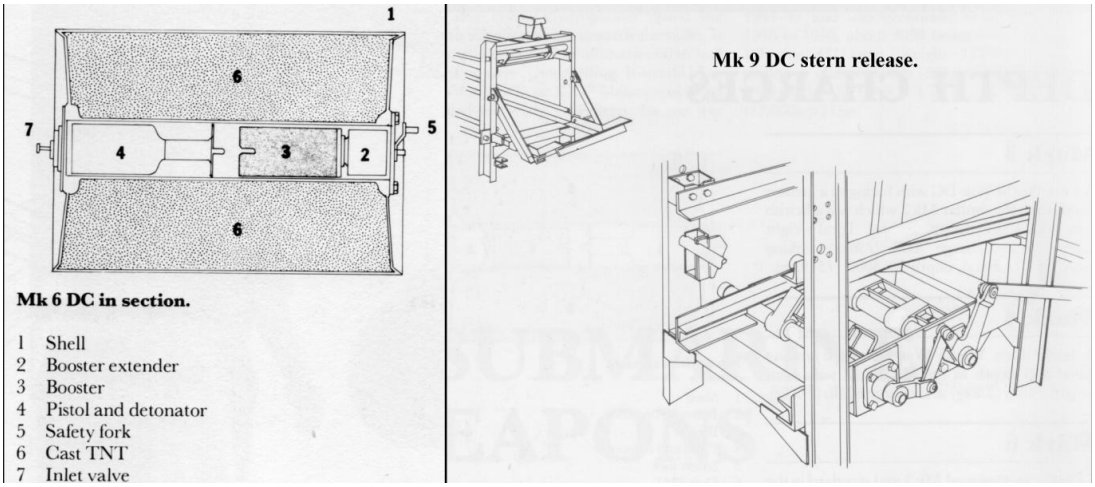

Figure 81. Schematic of the Mk6 depth charge and the stern-mounted launching mechanism for the Mk9 depth charge. The Mk9 and Mk 7 depth charges were very similar and size, thus the racks shown would be nearly identical to those used to deploy the Mk 7. (Source Campbell 1985:162-164).

In addition to ordnance, many of the escort vessels were also equipped with radio direction finding and underwater sound equipment, be it active or passive. Photographs of USS *Ellis* and USCG Cutter *Triton* reveal the presence of radio-direction finding gear. Also, sonar was standard issue among the 165-foot cutters. Thus, both *Triton* and *Icarus* would have active QCO sonar apparatus, and the capability to detect submarines (Scheina 1982:38). During the engagement with *U-576, Triton* reported damage to the QC apparatus resulting from the concussion of depth charges. From entries in the logbooks of USS *Ellis*, USS *McCormick*, and USS *Spry* it is clear they were also equipped with underwater sound apparatus, most likely sonar (USS *Ellis* 1942; USS *McCormick* 1942; USS *Spry* 1942). Depending upon conditions, such as the presence of thermoclines, these machines could effectively detect submerged U-boats from a range of 2,000 yards ahead of the escort vessel. Once the escort reached a range of 300 yards, however, the orientation of equipment forward and the nearly simultaneous return of the sonar ping effectively created a blind-spot (Williamson 2010:50). This was problematic, as previously mentioned, since an escort had to overtake a submarine prior to dropping depth charges from stern-mounted gear.

Nevertheless, these craft presented formidable opposition to a U-boat. Assigned to protect the convoy, warships utilized a number of tactics to achieve this end. To fulfill their role, escort patrols were compelled to harass and hunt U-boats. By positioning themselves within the area forward of the convoy from which U-boat attacks would originate, escorts would screen in an effort to reduce as much as possible the U-boats freedom of movement. Further, if the escort

could intercept the U-boat far enough ahead the U-boat could be driven away before even getting to spot the merchant vessels within the convoy. The best positioning was determined by "consider[ing] the submarine's diving capabilities, since these govern the angle on the bow within which a diving submarine is dangerous" (Welles 1917c:5).

These protection tasks were elaborated during the First World War, after analysis of German submarine attacks. The USN described the objectives of patrol vessels as:

> (a) To limit the submarine's freedom of action on the surface and prevent his sighting the convoy in time to steam on the surface to a good position for attack.
> (b) To make as difficult as possible for a submarine sighting the convoy from astern or abaft the beam to steam round it into a position favorable for attack.
> (c) To sight on the surface any submarine that does not dive immediately on sighting the patrol vessel, and save the convoy by diverting it in time to avoid attack (Welles 1917c:5).

Inherent in this task is a means by which to visualize submarines. In this case, visibility was achieved through the combination of lookouts and acoustic listening apparatus. Once sighting was achieved, the escort had at their disposal numerous weapons. Chief among them were depth charges and light-caliber guns. On the surface, the submarine would be no match for the escort in a gun fight. If the submarine submerged, the escort could pattern depth charges while using sonar to methodically track and destroy the U-boat. If depth charges failed to sink the U-boat, then the prolonged engagement could deplete the U-boat's batteries, forcing it to surface and again making the boat vulnerable to gunfire (Welles 1918).

In the event a U-boat slipped past the escorts "the opportunity normally presented for effective action against enemy submarines immediately following an attack upon a convoy is so good as to warrant unusual efforts to take advantage of it" (Welles 1918:17). In this particular situation, there were many advantages for the escort craft, namely:

> (a) There is present a large concentration force of anti-submarine craft.
> (b) The position of the enemy submarine is near and is usually known within narrow limits.
> (c) His probable immediate action may be predicted with fair accuracy.
> (d) His battery power is usually reduced considerably.
> (e) Usually the water is too deep for bottoming.
> (f) Immediate further danger to the convoy has been eliminated, except in the

> very rare case of another submarine being in the near vicinity. This possibility is so remote as not to justify serious consideration until at least several hours have passed (Welles 1918:17).

Under these circumstances, the USN advised use of the entire escort force in search of the U-boat. Though the moments following an attack were chaotic, it was precisely then to counter-attack. In all aspects of escort duty, and especially in this critical moment, air support was vital.

Scouting Squadron 9

In addition to permanent surface vessel escort, the USN arranged nearly constant aircraft coverage for KS-520 as it moved down the coast. When rounding Cape Hatteras, aircraft could launch from airfields at Weeksville Naval Air Station, Manteo Naval Air Station, Chowan County Marine Corps Air Station, Elizabeth City Coast Guard Station, Ocracoke Naval Air Station, Cherry Point Marine Corps Air Station, and the US Army Bluethenthal Field (Powell 2006:1232). In fact, in the days prior to KS-520 sailing, aircraft patrols were keeping quite busy off the NC Coast. As relayed by historian Clay Blair (2000:627)

> Over the next forty-eight hours, July 12 to 14, four aircraft patrolling Cape Hatteras reported attacks on U-boats. On July 12 a Coast Guard plane, piloted by E.B. Ing, straddled a U-boat with two 325-pound depth charges from an altitude of 200 feet. The next day an Army Air Forces B-17 Flying Fortress, piloted by A.H. Tuttle, also flying at 200 feet, straddled a U-boat with six depth charges. On July 14 two Navy aircraft, piloted by William R. Jemison and George L. Schein, dropped four shallow-set Mark XVII depth charges on a U-boat from low altitude. All four aircraft reported probable damage or certain kills or heavy damage.

Both U-boats operating in the area, *U-576* and *U-402,* reported being damaged (Blair 1996:627). According to historian Homer H. Hickam, Jr. (1989:285), it was Jemison and Schein, presumably in a Vought OS2U-3 Kingfisher patrol craft that attacked *U-576*.

Without a doubt, *U-576* was severely damaged as convoy KS-520 rounded Cape Hatteras. At 1430 hours a two-plane section of Scouting Squadron Nine (VS-9) took off from Cherry Point MCAS under command of section leader Ensign F.C. Lewis, USNR, and wingman Ensign C.D. Webb, USNR. Also along were radio operator Airman Third-Class W.G. Walters, USNR, and observer Lieutenant Alfred D. Lindley, USNR. An hour later, at 1530 hours, the section relieved the previous patrol and took station on the port and starboard of the convoy

(COM VS-9 1942:1).

Ensigns Lewis and Webb piloted Vought OS2U-3 Kingfisher aircraft (Figure 82). According to Murphy and McNiece (2009:207):

> Vought developed the design from their O3U biplane, and produced a monoplane spanning 35 ft 11 in, with length of 33 ft 10 in, and height of 15 ft 1 in. The frame was mathched with a 450 hp Pratt & Whitney R-985 Wasp Junior power plant, which afforded a maximum speed of 165 mph, with service ceiling of 13,000ft, and range excess of 805 miles.

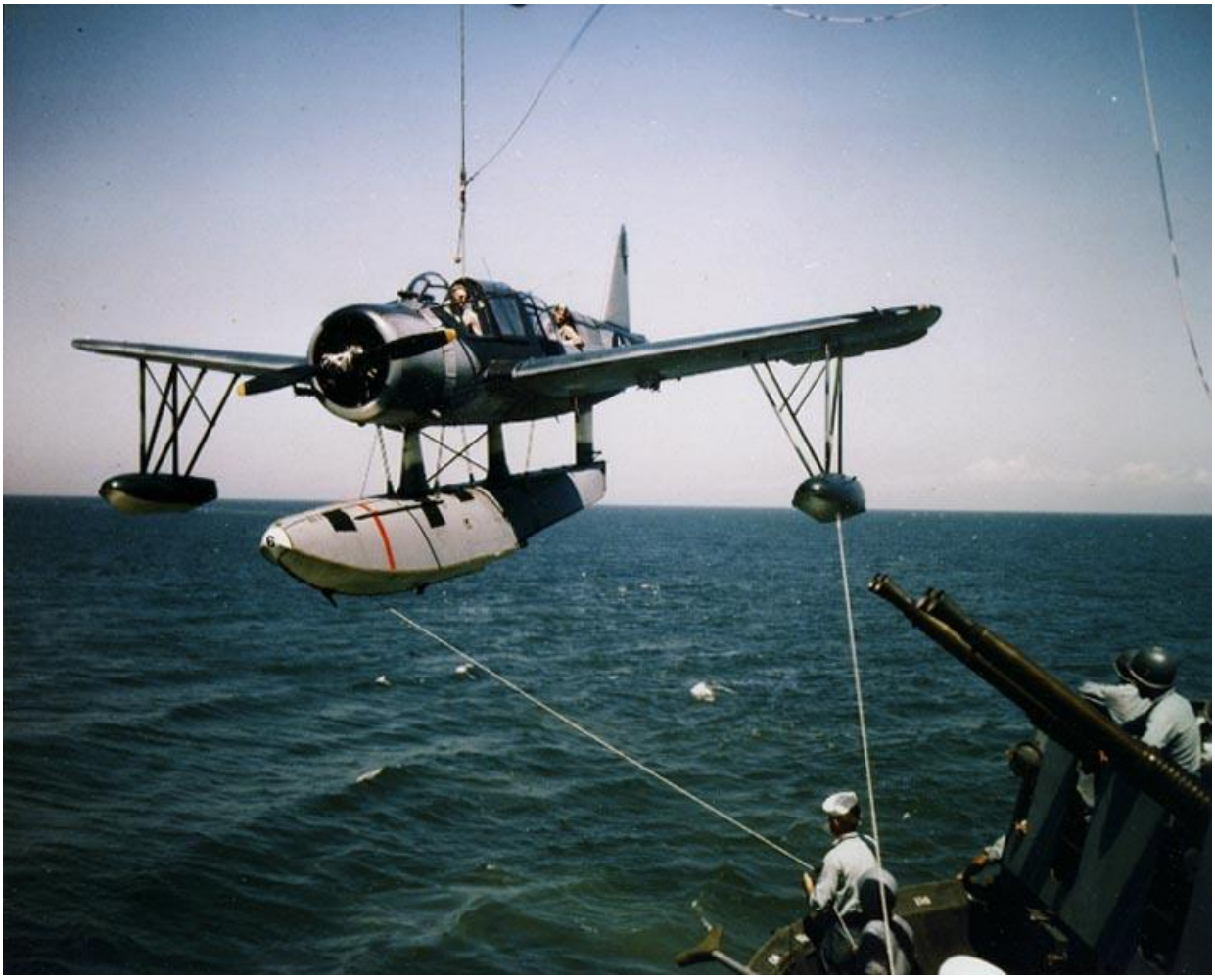

Figure 82. The Vought OS2U Kingfisher Aircraft as Configured for Sea Launch and Recovery. (Source: National Archives).

Additionally, these planes could carry a payload of two Mark 17 aerial depth charges (Figure 83). These were produced and made available in large quantity by April 1942 as the USN quickly

realized the value of aircraft in anti-submarine activities. With a total weight of 325 pounds, the Mk 17 carried a 234-pound TNT charge with both an impact nose fuse and tail-mounted hydrostatic fuse. Originally designed with a rounded nose, the depth charge was prone to ricochet if the pilot managed a direct hit on their target (Campbell 1985:165). Ensigns Lewis and Webb delivered a counter-attack against *U-576* with four Mk 17 depth charges.

Figure 83. A Mk 17 aerial depth charge being unloaded from a patrol aircraft. (Source Campbell 1985:165).

From a tactical standpoint, patrol aircraft were the perfect anti-submarine weapon. Their visibility was perhaps the best of any combatant on the battlefield. Second, aircraft had nearly endless maneuverability and, while operating off the US east coast, had little threat of being attacked themselves. Further, by moving around the flanks of the convoy at approximately 1,000 feet of elevation, they could conceal their presence from the eyes of a U-boat. Having only one means of attacking a submarine, their aerial depth charges –and only two, at that—patrol aircraft

were somewhat limited in their ability to engage in a prolonged struggle against a submarine. Nevertheless, their superb visibility and fast maneuvering allowed the patrol aircraft to quickly bring its weapons to bear upon a U-boat, once sighted.

Merchant Craft

Nineteen ships formed convoy KS-520. Three were casualties of action on 15 July 1942. The remaining sixteen ships made safe passage to Key West, thereafter continuing onto their final destinations. The convoy was a multi-national mix of freighters and tankers, mostly traveling in ballast. It is unknown, without additional research, if all these merchant vessels survived the war. They are each briefly described, in alphabetical order, in Table 8. More detailed information for each vessel was located in the *Lloyds Register of Shipping* (1930/1931, 1937/38a, 1937/38b, 1938/39, 1939/40, 1940/41a, 1940/41b, 1941/1942a, 1941/42b, 1942/43a, 1942/43b, 1943/44a, 1943/44b, 1944/45).

In total, there were nineteen merchant ships from eight different nations. These included the United States, who mostly owned tankers bound for the Gulf of Mexico, Great Britain, Greece, the Netherlands, Norway, Nicaragua, and Panama. All the tankers within the convoy, a total of 9 ships, were travelling in ballast. The remaining freighters carried a variety of cargoes. In addition to cargoes, many of the American vessels – including *J.A. Mowinckel* who, though registered in Panama, was owned by an American company—also carried light armaments and US naval gun crews. On board *Unicoi*, *J.A. Mowinckel* (Figure 84), *Chilore* (Figure 85), *American Fisher*, and *Tustem* were small, dedicated US naval gun crews. These crews manned an array of light armaments, including machineguns, and four and five-inch light caliber guns (Port Director, Newport News 1942a, 1942b; McCormick 1942; Ward 1942; Dalton 1944). *Bluefields* (Figure 86), however, was not armed. In the moments following the attack, both gun crews aboard *Chilore* and *Unicoi* sprang into action.

The naval crew aboard *Chilore*, however, only managed to get off a few rounds before disorder descended upon the freighter following the second torpedo hit. The opposite, however, was true aboard *Unicoi*. Unlike the other merchantmen in the convoy, *Unicoi* was the only merchant vessel owned by the United States government. Before the attack, *Unicoi* was stationed between *Chilore* and *J.A. Mowinckel* in the first row of the convoy. The torpedoes that sailed into *Chilore*, 600 yards ahead of its station, and *J.A. Mowinckel* very likely came close to hitting

Unicoi. Despite this, the gun crew aboard the freighter was ready at their guns as *U-576* surfaced just ahead of the first row of the convoy. Immediately, the naval gun crew opened fire and scored a hit on the U-boat. Subsequently, aircraft from VS-9 quickly dropped aeriel depth charges resulting in the destruction of the U-boat (Henderson 1942; ComScorn Nine 1942:1-2; SOC 1946).

Table 8. Description of merchant vessels sailing in KS-520, where T=Tanker; F=Freighter; Br.=British; Nic.=Nicaraguan; Am.=American; Nor.=Norwegian; Pan.=Panamanian; Dut.=Dutch; Grk.=Greek. (USN 1942b).

Vessel Name	Built	Builder	Length	Beam	Draft	Tons	Max Speed	Type	Nationality	1942 Owner
American Fisher	1912	Fore River Ship and Engine Building	370	52	27	4747	10	T	Am.	Republic Transportation Corporation
Bluefields	1917	Manitowoc Shipbuilding Co.	250	43	20	2063	8.5	F	Nic.	A. Garcia & Cia. Ltd.
Chilore	1922	Bethlehem Shipbuilding Corp.	549	72	40	8310	10	F	Am.	Ore Steamship Corporation
Clam	1927	Nederlands Scheepsbouw Maatschappij	440	59	32	7404	9.5	T	Br.	Anglo-Saxon Petroleum Co.
Egton	1938	W. Pickersill and Sons	398	53	24	4363	9.5	F	Br.	Rowland and Marwood's Steamship Co.
Gulfprince	1921	Union Shipbuiliding Corporation	419	56	29	6561	11	T	Am.	Gulf Refining Corporation
Hardanger	1924	Lithgow's Ltd.	375	52	23	4000	10	F	Nor.	Westfal-Larson and Company A/S
J.A. Mowinckel	1930	Cantiere Riuniti dell'Adritico	520	70	38	12323	11	T	Pan.	Panama Transport Co.
Jupiter	1928	N.V. Maschinefabriken Scheepswerf van P. Smit, Jr.	265	38	16	1464	10	F	Dut.	N.V. Kloninklijke Nederlandsche Stoomboot Maatschappij
Mount Helmos	1923	J. Brown and Company Ltd.	412	55	25	6481	10	T	Grk.	Kulukundis Shipping Co.
Mount Pera	1918	Cammell Laird and Company	400	52	28	5214	9	F	Grk.	J.A. Cosmetto and Kulukundis Shipping Co.
Nicania	1942	Hawthorne, Leslie and Co.	465	59	33	8179	12	T	Br.	Anglo-Saxon Petroleum Co.
Para	1921	N.V. Rijkee and Co.	376	51	22	3986	9.5	F	Nor.	A/S J. Ludwig Mowinckels
Rhode Island	1937	Sun Shipbuilding and Dry Dock Company	490	65	34	8580	13.5	T	Am.	The Texas Company
Robert H. Colley	1938	Sun Shipbuilding and Dry Dock Company	523	70	39	11651	13	T	Am.	Atlantic Refining Co.
Toteco	1916	Union Iron Works Company	435	56	33	6752	9.5	T	Am.	Mexico Trading and Shipping Co.
Tustem	1921	Moore Shipbuilding Co.	425	57	33	6882	10	T	Am.	Atlantic Refining Co.
Unicoi	1920	Oscar Daniels Co.	401	54	31	5958	9.5	F	Am.	United States Maritme Commission
Zouave	1930	Burntisland Shipbuilding Co.	370	51	25	4253	9	F	Br.	Turner, Brightman and Co,

Though these merchant vessel crews are not generally considered equal to combatants in the same sense as sailors aboard a warship, the presence of naval gun crews; active engagement with the enemy; the obligation by law to obey the Convoy Commodore, and, by default, the USN; the carriage of supplies necessary for Allied war effort; and the mere fact a belligerent enemy was purposefully seeking them out and attacking call into serious doubt any attempt to deny their combatant status (see Gibson 1986).

In fact, the practice of placing armed guards aboard merchant vessels originated in the First World War in response to German commerce raiding. The ultimate purpose was to offer protection to merchant vessels traveling alone, especially to prevent U-boat from attacking merchantmen with their gunnery. Within a convoy system the arming of merchantmen merely enhanced security. In the summer of 1942, prior to the extension of convoys into the Gulf and Caribbean, these armed guards were necessary for the merchant vessels to proceed beyond Key West. The installation of guns aboard these vessels and the assignment of additional sailors to man them offered several advantages to the merchant vessel.

Tactically, the merchant vessel then adopted several practices. The first was systematic lookouts. These were considered a first line of defense, as "…detecting the submarine when it shows it periscope while getting into position for firing, [the merchantman] can alter course to avoid danger" (Miles 1917:5). If spotted in time, the greater speed of the merchant vessel versus the submerged U-boat would distance the vessel and deprive the submarine of the position necessary for attack. Additionally, the lookouts could potentially spot torpedo wakes, allowing the vessel to affect evasive maneuvering.

The armed merchant vessel's next option was to employ gunnery. Outfitted with several guns crewed by naval gunners, a merchantman could use the guns for offensive or defensive purposes. Gun crews were taught to diligently maintain their weapons, practice regularly, and to always remain at station, taking meals on deck and rotating shifts during nighttime. Readiness was essential, as the necessity to fire upon a submarine could come within an instant (Miles 1917:5-13). Similarly, the same considerations of speed and reduction of time spent in the danger area were prescribed to ensure maximum security for merchant vessels.

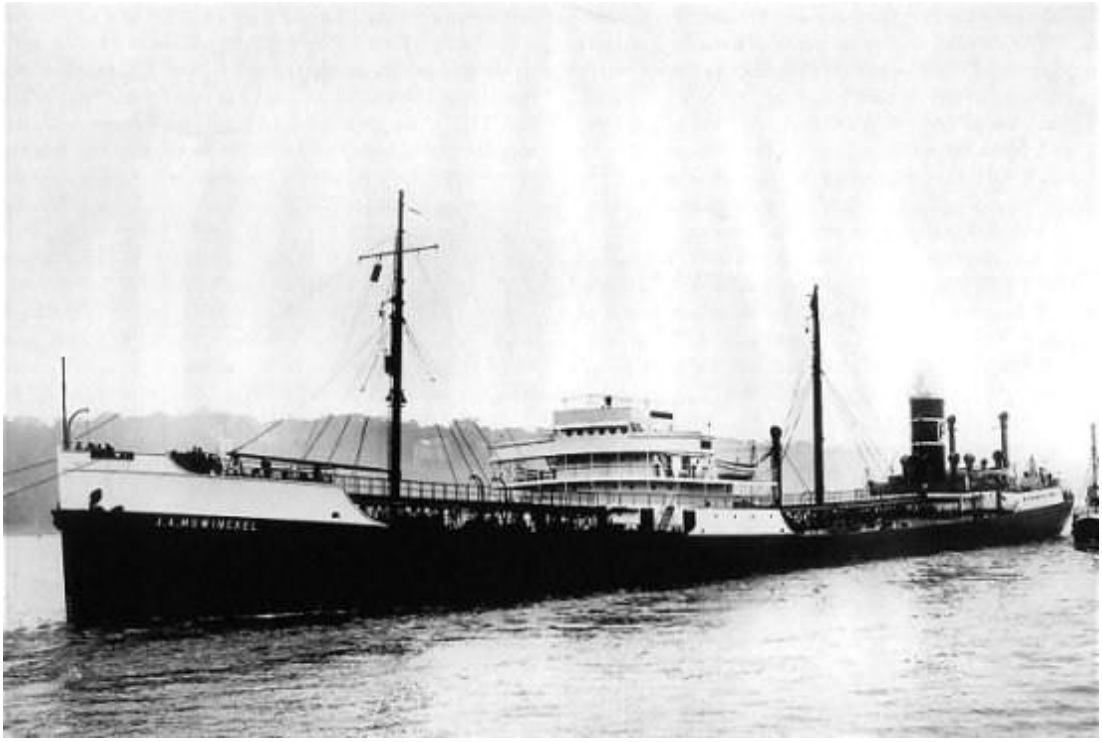

Figure 84. Image of Panamanian tanker *J.A. Mowinckel*. (Source: uboat.net).

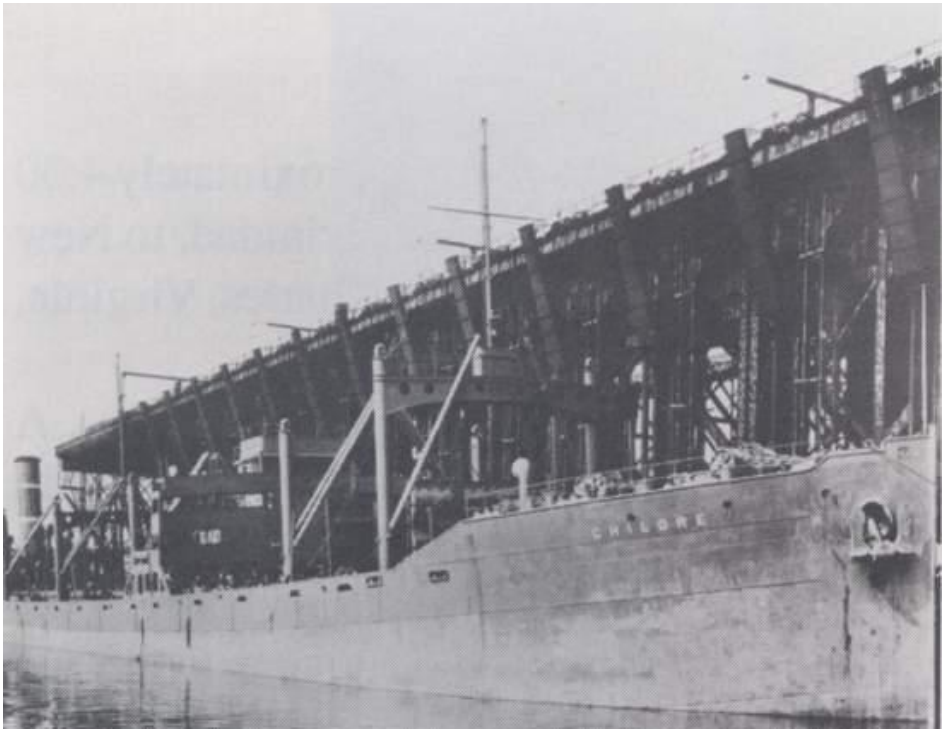

Figure 85. American freighter *Chilore*. (Source: uboat.net).

Figure 86. Nicaraguan freighter *Bluefields*, formerly *Ormindale*. (Source: Bowling Green State University).

Conclusion

As the attack upon KS-520 unfolded, hundreds of people – sailors, guardsmen, submariners, pilots, officers, rates, and civilians participated in the activities -- attending the sinking of merchant vessel and a U-boat, the salvaging of two additional merchant craft, and the rescue of dozens of sailors and civilians. These people, aboard their ships, boats, airplanes, lifeboats, and at their shore stations, engaged in what was an offshoot of a war taking place across the entire globe. In discussing the attack on KS-520 as a representation of this struggle, the natural landscape, engineered landscape, bureaucratic landscape, the ships, weapons, and tactics of the participants, as well as the historical context of the engagement have been so far described.

The conspicuous omission thus far has been discussion of the actual people involved. As a battlefield analysis, the ultimate goal of the present study is to inform questions on human behavior. Yet, with the exception of administrative leaders and vessel commanders, none of these agents have been identified or described. Besides title and responsibility, neither have administrators and commanders. To truly understand human behavior a psychological analysis of each participant would be necessary; this would be literally hundreds of biographies. Though possible, such an exposition is beyond the scope of this study.

Instead, forces are referred to as groups of agents working towards common tactical or operational goals. As military historian John Keegan (1976:28) noted of ship' crews, "all being

in the same boat, a ship's company generally does as its captain directs, until all are sunk together…." Tactical principles were codified on the small unit or ship-level. Unity of command aboard a vessel ensured the actions of all participants were the will of the commander, and the commander's will an extension of his mission and objective, considering the resources and terrain at their disposal. This is an oversimplification, to be sure, assuming a continuity of purpose and action among a crew in excess of 100 sailors aboard a single vessel. Nevertheless, during the present study it is necessary to prescribe a human unit to which actions and behavior can be ascribed.

KOCOA ANALYSIS OF THE KS-520 BATTLEFIELD

As demonstrated in the preceding sections, battlefield survey draws upon a wide array of historical, archeological, and geographical data. The purpose of this survey was not only to compile historical and archeological information on KS-520, but also to integrate this data into a broader academic framework by discussing the attack from a generalist archeological perspective. The military theory of KOCOA, used by battlefield archeologists, provided the means with which to interpret the interactions of opposing forces across the landscape. This served the purpose of not only ground-truthing events and movements described in historical sources, but also provided an independent dataset to evaluate aspects of the narrative. In addition to establishing baseline resource monitoring information, this study develops the foundation for academic analysis by adapting the KOCOA protocol to this specific maritime event. It is hoped this will be a valuable model through which other Battle of the Atlantic naval engagements can be evaluated.

When considering terrain features, military leaders are taught the acronym KOCOA (actually OCKOA in military usage) to evaluate key terrain, obstacles, cover and concealment, observation and fields of fire, and avenues of approach and retreat (Lowe 2000:7; Scott and McFeaters 2010:115; Babits et al. 2011:7-9; Richards et al. 2011:31-32). These terms are further defined as

> (a) *Observation and fields of fire.* The leader considers ground that allows him observation of the enemy throughout his area of operation. He considers fields of fire in terms of the characteristics of the weapons available to him; for example, maximum effective range, the requirement for grazing fire, and the arming range and time of flight for antiarmor weapons.
> (b) *Cover and concealment.* The leader looks for terrain that will protect him from direct and indirect fires (cover) and from aerial and ground observation (concealment).
> (c) *Obstacles.* In the attack, the leader considers the effect of restrictive terrain on his ability to maneuver. In the defense, he considers how he will tie in his obstacles to the terrain to disrupt, turn, fix, or block an enemy force and protect his own forces from enemy assault.
> (d) *Key terrain.* Key terrain is any locality or area whose seizure or retention affords a marked advantage to either combatant. The leader considers key terrain in his selection of objectives, support positions, and routes in the offense, and on the positioning of his unit in the defense.

> (e) *Avenues of approach.* An avenue of approach is an air or ground route of an attacking force of a given size leading to its objective or key terrain in its path. In the offense, the leader identifies the avenue of approach that affords him the greatest protection and places him at the enemy's most vulnerable spot. In the defense, the leader positions his key weapons along the avenue of approach most likely to be used by the enemy (United States Army 1992:2-2).

As defined, these terms were clearly formulated with terrestrial combat in mind. Nevertheless, these basic combat principles are equally informative when applied to naval combat. The necessary link between these codes and human behavior on the battlefield was provided by military historian John Keegan (1976:34) in a principle called "inherent military probability," whereby historical accounts can be evaluated and actions even reconstructed by an educated "estimate of what a trained soldier [or sailor] would have done in the circumstances."

This approach first focuses upon the identification of battlefield resources and delineation of significant spaces, satisfying the needs of resource identification and documentation. Historical sources are used in conjunction with archeological remains to link individual battlefield events with actual positions in the landscape. Next, battlefield resources, mainly shipwreck remains, are used to clarify and or ground truth these historical accounts. The second part of the battlefield survey, the KOCOA analysis, then synthesizes this archeological, geographical, and historical data to examine how the landscape in which the battle took place influenced its outcome.

As per their protocol, the various components of the ABPP survey matrix will be addressed and fulfilled in order. This starts with outlining battlefield resources. The *Battlefield Resources* section essentially sets the stage for the historical narrative and archeological review. First, the natural, cultural, and military-engineered features, in addition to artifacts, within the geographic space of the battlefield are defined. Then the historical landscape in which the battle took place is digitally reconstructed. Having determined features along the battlefield and characterized the historical landscape, a hypothetical discussion of military significant terrain establishes the basis of physical battlefield survey. The *Battlefield Survey* section begins by identifying and briefly reviewing historical sources. Next, a list of defining features is populated by geo-referencing previously described battlefield resources within the historical landscape based upon historical sources. This is followed by a visual survey of the battlefield that is related in the *Methodology* section, which is followed by a terrain analysis to review and ground-truth

historical accounts. Lastly, features were charted and delineated for the core study area and potential National Register areas (Lowe 2000).

Battlefield Resources

The first step of battlefield survey is to establish the historical landscape in which the battle took place. This begins with identifying all relevant battlefield resources; the natural, cultural, and military engineering features across the landscape, and the artifacts resulting from combat activity. Collectively, the distribution of battlefield resources across a landscape defines both the boundaries of the battlefield and guides surveyors to specific sites or locations within it. Once the extent of the battlefield landscape is understood, consideration is then given to any natural or cultural induced changes to the landscape in the time since the battle. This in effect re-creates the historical landscape through which combatants moved. With the historical landscape established, a brief, hypothetical discussion regarding the military significance of this terrain orients the researcher. This provides an understanding of the landscape, as it would have tactically appeared to the combatants.

This section details the completion of each of these three tasks. In a terrestrial battlefield, identifying battlefield resources is often confounded by alterations to the landscape over time as a result of human activity. In the ocean, however, there is generally little affect asserted by humans on the landscape and archeological record. There are some minor exceptions including alterations to biological communities or discrete areas of human industry (i.e. trawling, pollutants, etc…)., as such, much of the substrate and, therefore, the archeological record, remain largely undisturbed. In the case of the KS-520 battlefield this is partially true. The natural features, as per ongoing geological and oceanographic processes, undergo constant transformation and would expectantly differ to a degree from those in 1942. These processes include, for example, sediment transport, natural degradation of ferrous material in a seawater environment, and temperature fluctuation. On the other hand, such changes are minor in scale and mariners would presumably conceive of the risks presented by Cape Hatteras and Diamond Shoals in the same way now as they did during the war. Similarly, some military engineering features were altered in the time since the attack on KS-520, such as the Hatteras Minefield being dismantled in September of 1942. The Naval Section Base on Ocracoke Island was also demobilized, though the Coast Guard base remained in operation, as did Cherry Point MCAS.

No conspicuous cultural features existed in 1942 since the only significant human activity in the area, fishing, leaves little discernible trace on the landscape. Artifacts in this case are the shipwreck remains resulting from combat activities. Though many battlefield resources are no longer present, digital cartography can reconstruct those features along with those still present in the landscape to delineate boundaries, define the historical landscape, and allow researchers to orient themselves to the military significance of terrain features. These individual features, the historical landscape, and the military significance of the terrain within the landscape are described prior to the historical survey.

Battlefield Resources

According to Lowe (2000:7-10) there are four types of battlefield resources. These are natural features, cultural features, military engineering features, and artifacts. The natural features are all those discussed in the previous section. Cultural features are defined as elements within the battlefield created by humans without an intended military purpose, such as roads, buildings, or agricultural fields. Military engineering features are structures erected by soldiers or workers under direction of a combat force and are specifically designed for a military purpose. The paraphernalia left over from conflicts are artifacts. These constitute the majority of the archeological dataset on the battlefield, and contain an array of information based upon systematic study.

The natural features were discussed in the previous section and asserted a great deal of influence over the movement of opposing forces across the battlefield. These include the landmass of the Outer Banks, including the shoals and inlets, as well as the bathymetric morphology and continental shelf slope. The water column was itself a natural feature, providing the depth in which the U-boat maneuvered, as well as the stratified currents,which the U-boat possibly utilized for concealment from sonar detection. Above the water, atmospheric conditions also influenced the battle. Foremost, the airspace above sealevel was the area through which the patrol craft maneuvered and achieved their vantage point. Additionally, the position of the sun, ambient wind speed and the resulting sea state provided concealment for the approaching U-boat, while the clarity of the atmosphere allowed miles of visibility for Allied lookouts aboard ships and patrol aircraft.

Cultural features are nearly inevitable in terrestrial conflict as combat typically occurs in areas already occupied and used by humans. Even agricultural fields or cleared land constitutes human alteration of land, and will thus be a cultural feature of a battlefield. In more developed areas, roads and buildings are present within the battlefield. In the waters off North Carolina, however, human alteration is, relative to terrestrial sites, minimal. Human usage of this space is limited to pre-war dredging, fisheries or mineral extraction, which typically only locally affect shipwreck sites. In the area off Cape Hatteras, however, no mineral extraction was occurring during 1942. A robust fishery existed, but would not have left any conspicuous trace on the battlefield to affect the manner in which the attack on KS-520 took place. Some cultural features, namely deposition of fishing gear on shipwreck sites, deliberate removal of artifacts (i.e. *Keshena* and *Chilore*), and destruction of sites as navigation hazards (i.e. *Chilore* and *Keshena*) may have occurred in the time since the battle.

Military engineering features, a subset of cultural features, were discussed in the section of the same name in the *Features of the Landscape* chapter. Namely, these are the Hatteras Minefield, Cherry Point Marine Corps Air Station, and Ocracoke Island military installations. The Hatteras Minefield influenced both the movement of Allied ships around Cape Hatteras and also significantly altered the rescue and extrication of men and ships from the battle by interrupting the safe passage of *Chilore* and *J.A. Mowinckel*, causing both crews to abandon their ships into the dark sea. The shore installations and airfield were the staging point for support forces, including the aircraft responsible for the swift counterattack against *U-576* and the Coast Guardsmen who labored throughout the night and early morning of 15th and 16th.

Several artifacts remain on the battlefield, all of which are contained within shipwrecks. These wrecks were all the result of *U-576's* attack. Including the U-boat itself, *Bluefields*, *Chilore*, and *Keshena* all sank during the battle and subsequent rescue operations. *J.A. Mowinckel*, though heavily damaged, was successfully salvaged and returned to Virginia. These vessels designate discrete areas of activity, as well as contain forensic clues to better understand the narrative of the battle. In addition, *U-576* and *Keshena* suffered loss of life as a result of their sinking, marking them as war graves within the battlefield. The specifics of each vessel were given in the Participants section of *Features of the Landscape* section.

Historical Landscapes and Battlefield Boundaries

After describing battlefield resources, the next step in battlefield survey is defining the landscape as it existed at the time of the attack and the limits of combat activity based on historical sources and cadastral survey. This includes identifying important landmarks in addition to salient features within the landscape, all of which are later cartographically represented. Once a general boundary is developed, subsequent survey is designed to create three distinct areas: the study area, or total area of combat and combat related activities, the core area which is the area of combat, and potential National Register boundaries. The main purpose of determining battlefield boundaries, however, is to describe the landscape as it was during the attack for the purpose of identifying important military terrain within the battlespace.

As a landscape, the area in which the attack upon KS-520 took place will have little visible to the naked eye besides empty seas. At the point of attack, the battlefield was entirely composed of natural features. Combat support activities in near shore areas, however, involved several military engineering features like Cherry Point Marine Corps Air Station and the United States Coast Guard Station on Ocracoke Island. Throughout the open ocean and near shore areas, however, salient features dominated the historical landscape. Convoy routes taken by the merchant vessels, aids to navigation, the minefield, the Ocracoke Naval Section Base, and the Hatteras Inlet Coast Guard Station formerly on Ocracoke are no longer present in the landscape. In either case, these cannot be seen by merely visiting the battlefield area upon the surface of the ocean. Instead, digital cartography is essentially the only means by which to represent and view these features in relation to one another.

The predominance of salient features along the battlefield, however, is indicative of the limited human use of the particular space. In general, very little human alteration occurred along the seas adjacent to Cape Hatteras. Near shore areas, by means of beach nourishment, land development, and dredging have noticeably changed, though this development is insignificant in terms of redefining the land-sea interface during World War II. This is fortunate in the sense that a dearth of human interaction has left the landscape in much the same way it was during 1942.

The challenge imposed by the necessity of representing these natural and salient features, however, is also fruitful insomuch as it makes this study unique. By synthesizing historical, geographical, and archeological data into a cartographic representation of a historical landscape, this study incidentally explores the validity of geographic information science and battlefield

visualization as keystone battlefield archeological methodologies. In a more general sense, since the battlefield contained features common to most Battle of the Atlantic battlefields, the historical landscape of the attack on KS-520 is in many was a representative sample of Atlantic-based naval conflict during World War II.

Nevertheless, the present task of describing the landscape as it existed during 1942 is merely a recapitulation of the discussion of several battlefield elements described in the *Features of the Landscape* section. The natural features were discussed along with the military engineering features and the participants. Thus, the historical landscape was the combination of natural terrestrial and oceanographic features in proximity to the Hatteras Minefield and three shore installations on the island of Ocracoke. Further, Cherry Point MCAS, though far removed from the site of combat activities, was the staging point for air support covering the convoy. The site of the battle was an open ocean space buttressed to the west by an immense obstacle, the Hatteras Minefield, and to the east by the deep waters just off the continental shelf. The convoy travelled along a sort of bathymetric knife-edge, the 100-fathom curve, in an attempt to safely pass Diamond Shoals and the minefield, while not straying into deep waters haunted by hostile U-boats.

Beyond the horizon, to the west across the minefield, was a large Allied search and rescue force. This was comprised of the Sailors and Guardsman of the two Coast Guard Stations, one on each Inlet of Ocracoke Island, and the Navy Section Base. These men crewed dozens of patrol and rescue boats. During the afternoon of the attack, the landscape was also significantly affected by weather. The effect of wind over water, and of ambient light and sun position on visibility, were inextricably linked to the operation of both Allied and Axis forces. All of these features were digitally represented as a precursor to distinguishing the military terrain from the general landscape.

Military Terrain

The battlefield surveyor utilizes the KOCOA analytical approach to understand the military significance of features within the landscape where the battle took place. This analytical technique has become the mainstay of terrestrial battlefield surveys, yet to date, these components have not been described in any way relating to a mid-20th century naval engagement. The KS-520 attack involved surface warships, armed and unarmed merchant

vessels, a submarine, and aircraft. The technical capabilities of each craft, as well as the technical specifications of their weapons systems and relevant tactics are known and were already described in the *Features of the Landscape* section. Synthesizing this information into ideas relating to military terrain is done here in accordance with the principle of Inherent Military Probability. This principle is based on the notion that military actions can be archaeologically understood by approximating what the trained soldier (or vessel commander) would have done given the particulars of their weapons, ships and understanding of their enemies.

At the outset of this study, it was anticipated that several modifications would be necessary to the KOCOA technique to address the particular elements of conflict in a marine environment. This was done by modifying the survey protocol established by the ABPP, utilizing their definitions of the KOCOA components. According to the ABPP survey manual (Lowe 2000:7) key terrain is defined as "…ground—typically high ground—that gives its possessor an advantage." In the case of an open ocean naval engagement this definition is somewhat problematic. Along the surface of the water, no such high ground exists. Further, the various forces involved in convoy and submarine warfare occupy several distinct spatial zones above, below, and upon the ocean's surface. As a result, there are separate perceptions of key terrain features for each type of naval combat force. For this reason, the key terrain for each needed to be described individually then discussed as a composite of spaces across the battlefield.

For a U-boat, surprise and concealment define the vessel as a naval tool. Key terrain, therefore, is any landscape feature offering concealment. By remaining submerged in the presence of enemy ships, a U-boat can then attack with surprise and is unencumbered by its otherwise inferior speed and weapon capabilities. More specifically, key terrain translates into any oceanographic, atmospheric, or astronomical feature that assists the U-boat in remaining hidden while in the presence of the enemy. This includes concealment in the dark, the use of ambient wind and sun positions to hide the wake of a periscope, the use of depth or temperature gradients of the water column for camouflage against acoustic sensing devices and couter-attack, or conversely, the use of shallow water to rest silently upon the bottom. These features, however, are largely situation-dependent. In the vicinity of Cape Hatteras, concealment for a U-boat would include the deep, thermally stratified waters off the continental shelf as they can prevent detection by sonar. The ambient wind direction, sea state, and sun position would also be exploited to help conceal the submarine during an attack. As will later be seen, this utilization of

space overlaps with many of the other KOCOA parts resulting primarily from the primacy of concealment in the operation of the U-boat.

Upon the ocean's surface there is no actual landscape feature offering a tactical advantage for the warships or merchant vessels, per se. The ocean's surface is a flat, homogenous plane with nowhere to hide and no high ground to occupy. Were the convoy to enter into a port or safe anchorage, they would occupy a safe area with a reduced threat of attack by submarine, yet safe anchorages do not necessarily offer an advantageous attack position against submarines and therefore, by definition, are not likely to be considered key terrain in this instance. Furthermore, as KS-520 travelled along the North Carolina coast no such refuge was readily available to the surface ships. Therefore, these participants had no key terrain in this regard.

Working in conjunction with military escorts along the east coast of the United States, patrol aircraft had one mission: patrol, track, and engage submarines. These aircraft were not expected to fight enemy surface ships or aircraft, but rather to detect and attack submarines. This required little armament and most carried only anti-submarine aerial depth charges. With complete freedom of movement and little chance of counter-attack at this point in the war, key terrain for patrol aircraft was mostly defined by visibility. Anywhere offering an optimal vantage point to view the waters in and around of the convoy gave the patrol aircraft an advantage against a U-boat, especially if the aircraft could approach the U-boat in such a way as to prevent the U-boat from detecting it and taking evasive action. Generally, these aircraft operated at around 1000 feet elevation, patrolling on the port and starboard flanks of the convoy to achieve an optimal vantage point. As with key terrain for submarines, the precise conditions during a particular engagement, such as cloud cover, sun position, and atmospheric visibility, is situation-dependent. In this case, the aircraft itself constitutes an artificial, or technologically created, high ground.

Thus, the key terrain only existed for the Allied aircraft and the German U-boat. Key terrain for escorts and merchant vessels simply did not exist along the ocean's surface. Instead, these vessels were left vulnerable to a U-boat operating concealed beneath the surface. For the submarine, the key terrain was the various landscape features which offered concealment to the boat including, atmospheric conditions, darkness, and the water column itself. Allied aircraft

enjoyed nearly unlimited freedom of movement over the water, which allowed them to occupy whichever optimal vantage point they saw fit, which constitutes high ground in sense.

The next military terrain feature considered during analysis is obstacles. Obstacles are defined as "terrain features that prevented, restricted, or delayed troop movements," which is herein expanded to include naval forces as opposed to simply troops (Lowe 2000:7). In the KS-520 attack, there were several obstacles limiting the movement of combatants, both natural and military-engineered. As with any vessel trafficking off the North Carolina coast, the shifting shoals and barrier islands were an ever-present hazard to navigation. Convoy routing established a wide berth around Cape Hatteras and Diamond Shoals, extending the route out into deep water near the continental shelf. Similarly, the shallow inlets along the northern Outer Banks prevented large vessels from berthing there, limiting the degree to which shore installations could support and assist passing convoys. These considerations were also relevant to *U-576*, as the commander no doubt endeavored to keep his U-boat out of shallow waters where the depth prevented the boat from quickly diving.

Besides natural features, there were additional features within the landscape influencing the movement of ships. The most conspicuous was the Hatteras Minefield. Allied convoy routing, obviously, directed ships to avoid friendly casualties from ships sailing through the field. It is unknown if the Kriegsmarine was aware of the minefield, however, the placement of the field within shallow water most likely precluded the presence of U-boats in that area in the first place. The presence of the minefield, instead, forced convoys to stay further out to sea, closer to the continental shelf, and may have placed these vessels in greater danger from patrolling U-boats. In the case of Allied aircraft the only landscape feature limiting their movement was the surface of the ocean itself. This is self-apparent, yet in the context of the KS-520 attack the presence of a submarine, and the potential for that submarine to dive beneath the surface, constituted possible limitations in the ability of the aircraft to engage the enemy. Aside from this, there were no other barriers to the movement and operation of Allied aircraft.

Cover and concealment are the third military terrain consideration. Cover is the use of the landscape for protection from enemy fire while concealment similarly uses the landscape to avoid being observed by the enemy (Lowe 2000:7). Comprised of a large group of vessels traveling along the ocean's surface, the Allied convoy was offered no cover or concealment from the landscape during daylight, as there were no means to prevent observation once the enemy

was within line of sight, or even further away if the vessels produced large amounts of smoke from their engines. This includes both the warships and merchant vessels.

On the other hand, the U-boat's daily operations, in addition to the execution of an attack, revolved around maintaining cover and concealment within the water column. The inferior gunnery aboard a U-boat, combined with its inherent vulnerability to enemy gunfire, dictated the boat do everything necessary to avoid confrontation with enemy forces. Thus in day-to-day operations, the U-boat implemented a number of means by which to conceal itself from enemy observation. This prevented the U-boat from being involved in an unnecessary surface battle, as well as allowed it to maneuver into attack position when engaging merchant vessels. Concealment was the dominant rule governing the execution of attacks. Were the boat to be spotted while traveling underwater, the target could simply outrun the U-boat and thwart the attack. Likewise, if warships spotted the boat, they would quickly overwhelm the submerged boat, disrupting the attack run at best and sinking the U-boat at worst.

For this reason, U-boats often executed attacks at night, but would also make daytime attacks while submerged. In fact, the U-boat would submerge at great distance from its target, miles away, to avoid being spotted by surface lookouts. The U-boat's slow submerged speed greatly constrained the maneuverability of the boat, but was the necessary trade-off to prevent being detected and destroyed. Once submerged, the U-boat would travel at a minimum speed, slowing even more to raise its periscope to make periodic observations. Again, the slow speed was crucial to prevent the wake of the periscope from compromising the boat's concealment. U-boat commanders also used the sparing technique to further reduce the visibility of their boats. In addition to reducing the visual signatures of their boats, U-boat commanders also considered the vulnerability of their boats to sonar detection. In daily operations this meant granting a wide berth to warships. During an attack, the U-boat commander could exploit thermal water stratification, such as that off the NC coast, to conceal themselves under heterogeneous water layers.

Maintaining concealment in the moments following an attack was as crucial as in the time leading up to it. Allowing the position of the boat to be known after attacking a vessel could spell disaster if the vessel was travelling with armed escorts ready to respond. U-boat commanders were advised to remain at periscope depth and observe the disposition of the target, as well as the movement of warships. If necessary, however, the U-boat could quickly dive deep,

away from the point of attack to seek cover from enemy retaliation. In summary, the landscape offered cover and concealment to the U-boat throughout the water column. Thermal stratification assisted in the concealment of the boat in deeper water, while atmospheric conditions assisted in the concealment of the boat when at periscope depth during an attack.

Cover and concealment are more difficult to define for Allied aircraft during the attack. Cover, protection from enemy fire, isn't necessarily relevant at this stage in the war. During the later stages of the broader Battle of the Atlantic, as the Kriegsmarine became more aware of the threat posed by Allied aircraft, U-boats were equipped with an array of anti-aircraft weapons. During early 1942, however, and especially in American waters, U-boats were not yet consistently clashing with aircraft. Instead, most aircraft encountered by U-boats were scouting planes. The threat posed by these planes was simply that it would relay the U-boat's position to a nearby warship. Therefore, U-boats preferred to avoid, rather than engage, Allied aircraft at this time. Incidentally, this increased the importance of concealment for Allied aircraft. In order to spot and engage U-boats, pilots needed to prevent being observed by the U-boat in time for the U-boat to dive to safety. Thus any feature within the landscape concealing the aircraft would aid its mission. At the time of the KS-520 attack, limited vertical visibility, as well as light cloud cover, could have obscured the patrol planes from the U-boat's observation.

A corollary to cover and concealment is observation and fields of fire, the next military terrain consideration. A military force would ideally remain concealed and covered from the enemy while simultaneously being able to observe and bring fire upon them. Also, key terrain is often deemed as such in terms of the ability of a particular feature or space to offer observation and fire upon the enemy while also covering its occupants. While stalking merchant convoys, a U-boat would observe targets through one of two periscopes. The total lack of cover and concealment available to surface vessels on the ocean did not, however, mean U-boats had unlimited observation. Instead, the viewshed of the submarine was constrained by the inherent limits of viewing vessels from the periscope. The periscope was near to the water's surface, providing a limited vantage point. Thus, the U-boat commander might not have been able to view the convoy in totality or be able to view surrounding escorts and aircraft. In this sense, the landscape limited, rather than enhanced, the U-boat's observation.

Conversely, surface vessels maintained observation along the water's surface in all directions at all times, the observable area a function of the number of lookouts and their height

above the water. Eye above sea, as it is known, depended entirely upon the elevation of an observation platform, and is therefore more a function of vessel construction than landscape features. Nevertheless, the flat surface of the ocean offered an unimpeded view of the surrounding space for surface vessels. In addition to visual observation, military vessels also observed beneath the water's surface by means of sonar. Unlike visual observation, though, the field of view provided by a given sonar apparatus was constrained by the physical properties of both the sonar system and the water and were generally quite limited. Patrol aircraft also used visual observation to detect surfaced submarines or a wake left by the submarine while submerged; those from the U-boat's periscope, steering gear, or torpedoes. For nearly all participants, observation was more of a function of the ability of their craft to place them in an ideal observation post, such a crow's nest on a ship, or the altitude of an aircraft, more so than combatants occupying a particular feature of the landscape.

Much like a man-o-war in the age of fighting sail, the orientation of the U-boat is essential to bring its main weapons system, torpedoes, to bear on targets. Therefore, the field of fire for a submerged U-boat using G7e torpedoes is defined by the direction the boat is facing, or can be positioned to bring the bow or stern torpedo tubes to bear. On the surface, the U-boat can achieve a wide arc of fire using the light-caliber guns on the deck. Against warships, armed merchant vessels, or patrol aircraft, however, such an engagement was inadvisable as the U-boat would be severely out-gunned and extremely vulnerable to incoming fire. When attacking a convoy during daylight, the underwater torpedo attack was the only feasible tactic. As a result, the field of fire for the U-boat's primary weapon, torpedoes, is inextricably linked to the maneuverability of the vessel, especially in 1942, prior to the advent of pattern-running torpedoes, though ideally the U-boat could bring its torpedoes to bear in any direction it desired.

Warships, on the other hand, could bring their light-caliber guns to bear in nearly any direction. The main anti-submarine weapon, however, was the depth charge. During 1942, these were stern-deployed and required the forward motion of the boat over the area of the target submarine. This weapon system placed a similar constraint upon the fields of fire of the surface vessel, requiring the entire vessel to properly orient itself prior to attack. Unlike the field of fire of a U-boat, a horizontal cone fanning out from the bow of the submarine, the field of fire for the warship, with respect to depth charge attack, is a single vertical column off the stern of the

vessel. The field of fire from the gunnery would consist of a series of overlapping arcs around the vessel, extending outward to the maximum effective range of the particular weapon.

The same field of fire, with regards to light caliber guns, was obtainable by the armed merchant vessels within the convoy. Numerous guns placed around the ship would enable gun crews to broadcast firepower throughout a range of arcs and distances defined by the characteristics of the weapons. Attacking from above with aerial depth charges, the patrol aircraft would have a field of fire extending in a zone vertical through the water column, depending upon the depth setting on the depth charge, and the ability of the pilot to place the weapon at a point of their choosing. Nevertheless, the freedom of movement available to the patrol aircraft would enable them to bring these depth charges to bear wherever they wanted. Thus, with a flat and unimpeded landscape, observation and fields of fire were mainly defined by the particular characteristics of the weapon systems involved, not features of the landscape.

The last components of military terrain are the avenues of approach and retreat through the landscape. In terrestrial battles, these are usually the surrounding transportation infrastructure or areas where security can be maintained moving to and from the battlefield. These are also the lanes linking supplies to combatants. On the water, however, these lanes are not as conspicuous. When departing for a cruise ocean going vessels were provisioned with necessary supplies and did not require support in the same way as ground troops. Thus, the merchant vessels, warships, and U-boats would have carried the food, water, fuel, ammunition, and other supplies required to complete their objectives, freeing them from cumbersome supply lines. In some cases, re-supply U-boats were sent into American waters to increase the duration of boats deployed on combat missions. These supply U-boats can be considered as a form of supply line, but they had little effect on the tactical operations of individual U-boats.

Unlike ground forces, though, some important distinctions dictate the support and movement of water-borne forces. As a self-contained vessel, the sailor or guardsmen is independent of resupply until reaching their destination. If this vessel were to become disabled or sink the crew aboard would be left to the mercy of the sea. Thus, if a ship or boat is lost in combat, the forces aboard are nearly helpless when left adrift in the sea. This is in stark contrast to ground troops, who will more readily have the option to move and retreat to safety if able-bodied. Similarly, the vessel itself would become stranded and founder if disabled at sea, losing the ship and cargo in a manner not quickly recoverable. For this reason, a network of bases and

shore installations proximate to heavily trafficked areas were established to offer timely assistance and safe haven for damaged vessels at sea, such as the shore installations on Ocracoke Island, proximate to Cape Hatteras.

Nevertheless, ocean-going vessels moved and approached combat as a self-sufficient group. Rarely did these vessels require unanticipated assistance with respect to supplies and materials. Therefore, they are independent of maneuvering through the landscape as dictated by access to resources. Were this vessel to become damaged, however, the crew would be severely disadvantaged in extricating the vessel from danger and reaching safety. To safely retreat from battle, naval combatants relied upon friendly forces for assistance, be it from other vessels in the fleet or support from shore to salvage damaged vessels and rescue crews from the sea, or both.

Moving in a convoy formation, these craft did not go to sea to seek out combat, per se. Instead, the mission of a convoy was to safely convey crucial war material to its destination. Anticipating submarine attack, armed escorts and aircraft were deployed to protect merchant vessels and their cargo. Though they expected combat, they did not choose the time and place to attack the enemy, but instead seized upon the enemy as it attempted to attack them. Therefore, convoys did not necessarily approach combat, but instead were heavily armed in anticipation that combat would approach them. Thus, the avenue of approach for KS-520 was merely the path of the convoy around Cape Hatteras. After being attacked, however, retreat was defined by the proximity of assistance ashore in Ocracoke, with the vessels simply taking what they perceived was the quickest route to get there.

The approach of *U-576* into attack position is determined somewhat by speculation. Position information on the U-boat is limited to two sets of coordinates: the position at which *U-576* reported being attacked on 14 July, and the presumed site of the attack itself. The movement in between these points and the specific approach of *U*-576 to the convoy is also uncertain. Based upon damage to the U-boat reported to BdU after surviving the aerial attack, it is presumed the U-boat was proceeding damaged on the surface, steering a course to return to its port in France. Upon spotting the convoy, Kplt. Heinicke must have felt compelled to attack. It is likely the U-boat was travelling on a converging course with the convoy, allowing Kplt. Heinicke to easily move into a favorable attack position as the convoy overtook his position. Several attack geometries would have been possible, but it is difficult to determine exactly how the U-boat came into firing position against KS-520. Several textbook attack patterns are shown

in Figures 87-91. Ideally, the physics and geometry governing a U-boat attack, those discussed in the *Axis Participants* section of preceding chapter, would have also shaped *U-576's* approach.

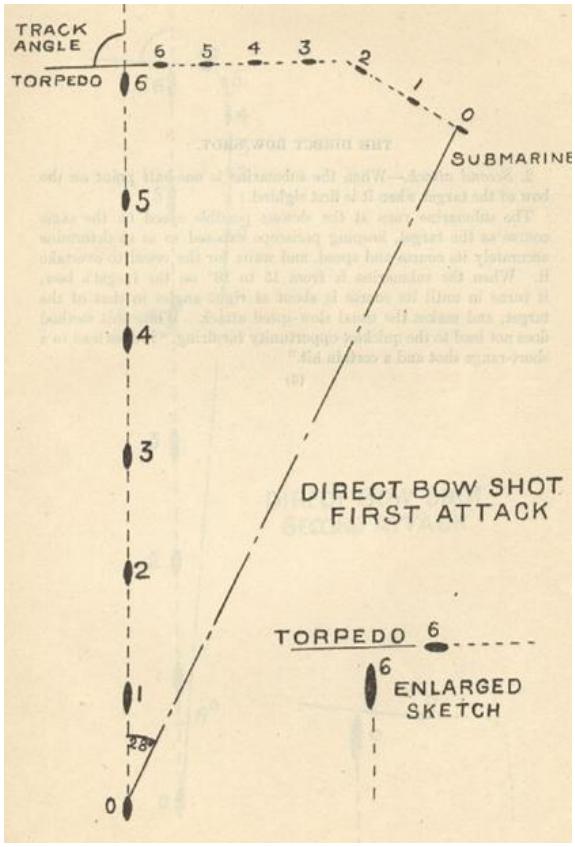

Figure 87. First Attack Pattern. (Source: Frost 1918:5).

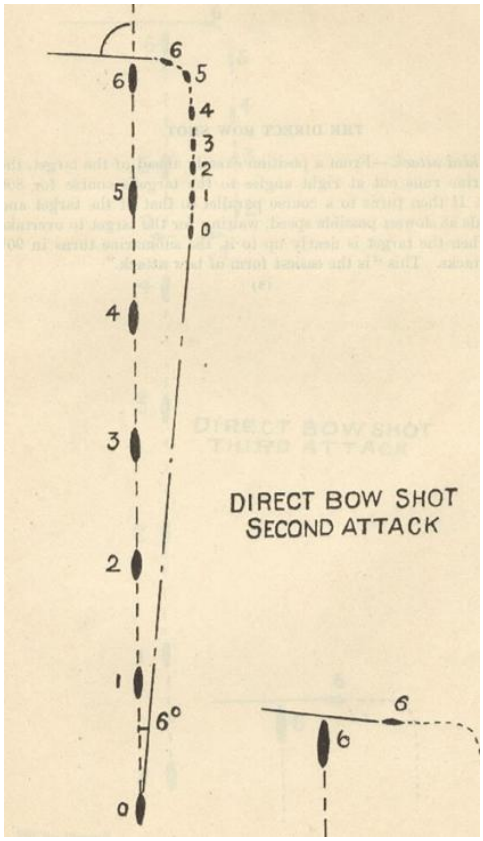

Figure 88. Second Attack Pattern. (Source: Frost 1918:7).

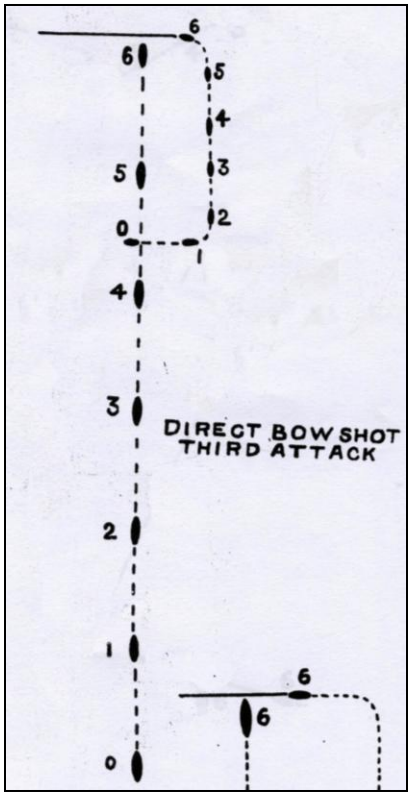

Figure 89. Third Attack Pattern. (Source: Frost 1918:9).

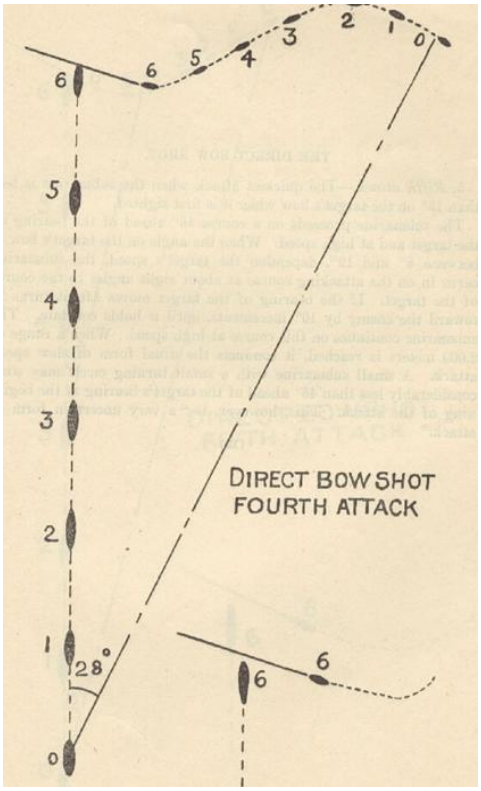

Figure 90. Fourth Attack Pattern. (Source Frost 1918:11).

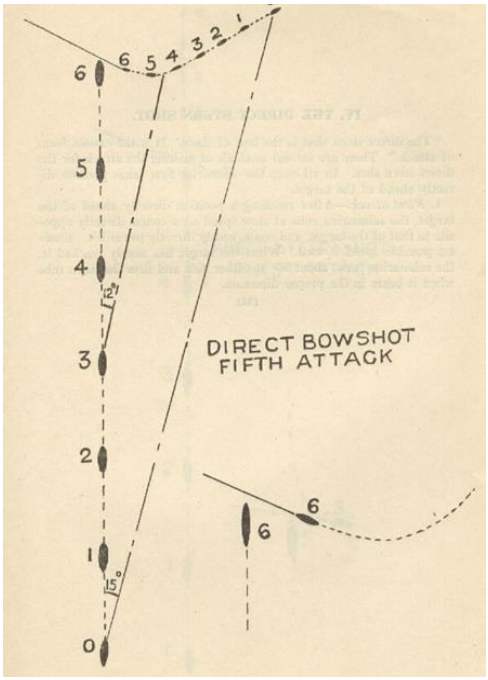

Figure 91. Fifth Attack Pattern. (Source Frost 1918:13).

These attack geometries are ideal representations of situations where vessel speed and distance are the primary consideration. Environmental factors such as wind, sea state, and sun position, would also factor into the determination of the ideal approach in any given situation. These factors would be the main landscape features affecting the U-boat's chosen avenue of attack.

Allied aircraft approached combat as an adjunct to the surface vessels. Thus, just as the convoy travelled in anticipation of attack, aircraft also patrolled vigilantly watching for U-boats. If spotted, the aircraft would maneuver into position to deploy its depth charge payload, essentially dive-bombing the submarine. Therefore, there was essentially no avenue of approach for the aircraft. The aircraft simply deployed their weapons and returned to their base. Thus, the approach and retreat were mostly dependent on navigating the most efficient route between the airfield and the patrol station.

All five KOCOA components are summarized in Table 9. Distinguished by spatial zones—the submarine zone, occupied by the U-boat; the surface zone, occupied by warships and merchant vessels; and the aerial zone, occupied by patrol aircraft—each has a unique set of features that describe significant terrain. Terrain for submarine forces is primarily defined by the need to remain concealed from the enemy. Surface vessels are offered little in the way of advantageous terrain, with the exception of observation, upon the ocean. Terrain for aerial forces on the other hand, is inextricably linked to visibility across the battlefield.

Table 9. Summary of KOCOA Terrain Components Described for Each Spatial Zone of the Battlefield as Defined by ABPP Protocols.

Spatial Zone	Key Terrain	Obstacles	Cover and Concealment	Observation; Fields of Fire	Avenues of Approach; Retreat
Submarine	Maintain Concealment	Hazards to Navigation & Minefield	Subsurface/ Atmospheric Conditions	None; Orientation of Boat	Maintain Concealment; Maintain Cover
Surface	None	Hazards to Navigation & Minefield	None	Elevation; Orientation of Vessel	None; Proximity to Military Engineered Features
Aerial	Optimal Visibility	Land\Sea Interface	Obscure Presence to Enemy	Elevation; Orientation of Plane	None; None

Assessment of military terrain features within the historical battlefield landscape thus far reveals a number of trends. The first is that the U-boat enjoyed a number of natural features to assist its

operations. These derive mainly from using the water column to conceal its movements, obtain surprise during attack, approach and escape combat unscathed, and to observe and track enemy vessels. Similarly, Allied aircraft enjoyed a freedom of movement that allowed them to choose their ideal observation and firing position in relation to submarines. Surface vessels, on the other hand, obtained little assistance in the way of terrain features. The flat expanse of sea offered no cover or concealment, there was no high ground from which to attack and, by nature of convoy operations they had little choice in the time and place where combat occurred.

Thus, at first review military terrain seems to favor the submarine and aircraft. Returning to the goals of the survey—the resource management concerns and historical review of the attack—describing military terrain is the final step prior to the actual historical and archeological surveys. All the various resources within the geographic space of the battlefield were accounted for, and the chart space was prepared to represent the historical landscape as faithfully as possible. In the next section, historical and archeological data will be input and the results analyzed.

Battlefield Survey

The battlefield survey is a four-part task incorporating historical and archeological data with previously identified battlefield resources. This begins with a review of the historical sources used to develop the detailed narrative reported in the *Historical Background* section. Next, defining features of the battlefield were determined by connecting battlefield resources with events and locations in the historical narrative. This was achieved through both on-site survey and digital charting of features as well as the movement of combatants. After this, data was incorporated into the project GIS, where the terrain study discussed the battlefield narrative in light of this archeological and geographical data. At the conclusion of the survey, this dataset was exported to produce of series of inter-connected spatial boundaries across the battlefield. These are the study, core, and National Register areas. Once concluded, the survey deliverables represent a synthesis of historical, geographical, and archeological research surrounding the battle.

The most important component of this survey is the terrain study section. Effectively, terrain study is the venue in which qualitative assessments about the battle can be made. The first two parts of the survey, historical review and determination of defining features are essentially

pre-requisites for the terrain study. These establish the narrative itself and the features within the landscape to review the narrative as it pertains to military terrain. The last phase of battlefield survey, Chart Preparation and Spatial Delineation, in addition to satisfying the resource management needs of the survey, also serves to provide a quick reference guide for battlefield surveyors during subsequent research.

Historical Sources Review

The battlefield surveyor is directed first to eyewitness accounts of the battle to develop a historical narrative. In case of the KS-520 attack, these would include the deck logs from Escort Group Easy (USS *Ellis* 1942; USS *McCormick* 1942; USS *Spry* 1942; USCG 1942a, 1942b), the action report from Scouting Squadron Nine (ComScorn Nine 1942), the accounts from the survivors of *J.A. Mowinckel* and *Chilore* (Henderson 1942; SOC 1946), the German KTB's (B.d.U. 1941, 1942a, 1942b, 1942c), the Eastern Sea Frontier War Diary (Freeman 1987), the *Lloyds Register of Shipping* (1930/1931, 1937/38a, 1937/38b, 1938/39, 1939/40, 1940/41a, 1940/41b, 1941/1942a, 1941/42b, 1942/43a, 1942/43b, 1943/44a, 1943/44b, 1944/45) the memoirs of Admiral King and Admiral Doenitz (King 1946; Doenitz 1959), the report of Samuel E. Morison (1947), and the reports commissioned by Secretary of the Navy Knox and Forrestal written by Karig et al. (1946). These, in combination with an array of secondary sources (notably Stick 1952; Hoyt 1978; Campbell 1985; Friedman 1985; Hickam 1989; Cheatham 1990, 1994; Gannon 1990; Syrett 1994; Blair 1996; Ireland 2003; Westwood 2003; Palmer 2005; Blake 2006; White 2006; Wagner 2010; Williamson 2010) provided the historical context and detailed historical narrative for the attack on KS-520, as detailed in the *Historical Background* chapter. A historical sources list, used for quick reference during field survey, is given in Appendix A.

In summary, the historical narrative contextualizes the attack within the period of American naval operations along the eastern seaboard following the institution of ocean convoys in May 1942. Since January 1942, German U-boats operated with virtual impunity between Cape Cod and Cape Lookout, often focusing attacks off the North Carolina coast in the vicinity of Cape Hatteras. By August, the Germans sank over 285 merchant vessels in American waters. As 1942 progressed, however, the American Navy, with the assistance of the Royal and Royal Canadian Navies, implemented a coastal convoy system combining warship protection and patrol

aircraft. These convoys escorted Allied and Neutral merchant vessels between New York and Florida. With the institution of this system merchant shipping losses declined steadily and U-boat losses were inversely affected. The shift came in mid-July, as Allied warships and patrol aircraft hammered U-boats off the North Carolina coast, and elsewhere within the Eastern Sea Frontier. The final straw, however, was the loss of their fourth boat off the NC coast, *U-576*.

Through examination of primary sources, the individual forces, including their commanders and ships, were identified. Merchant vessel information was taken in large part from the *Lloyds Registers of Shipping*, between 1930 and 1945. The order of battle, the list of forces and their chain of command (Lowe 2000:14) is given in Figure 92 and Figure 93. Specific information regarding the details of ship sizes, construction, propulsion, speed, cargo, registrations, weapons, weapons capabilities, and general operation were given in the *Participants* section of *Features of the Landscape* chapter.

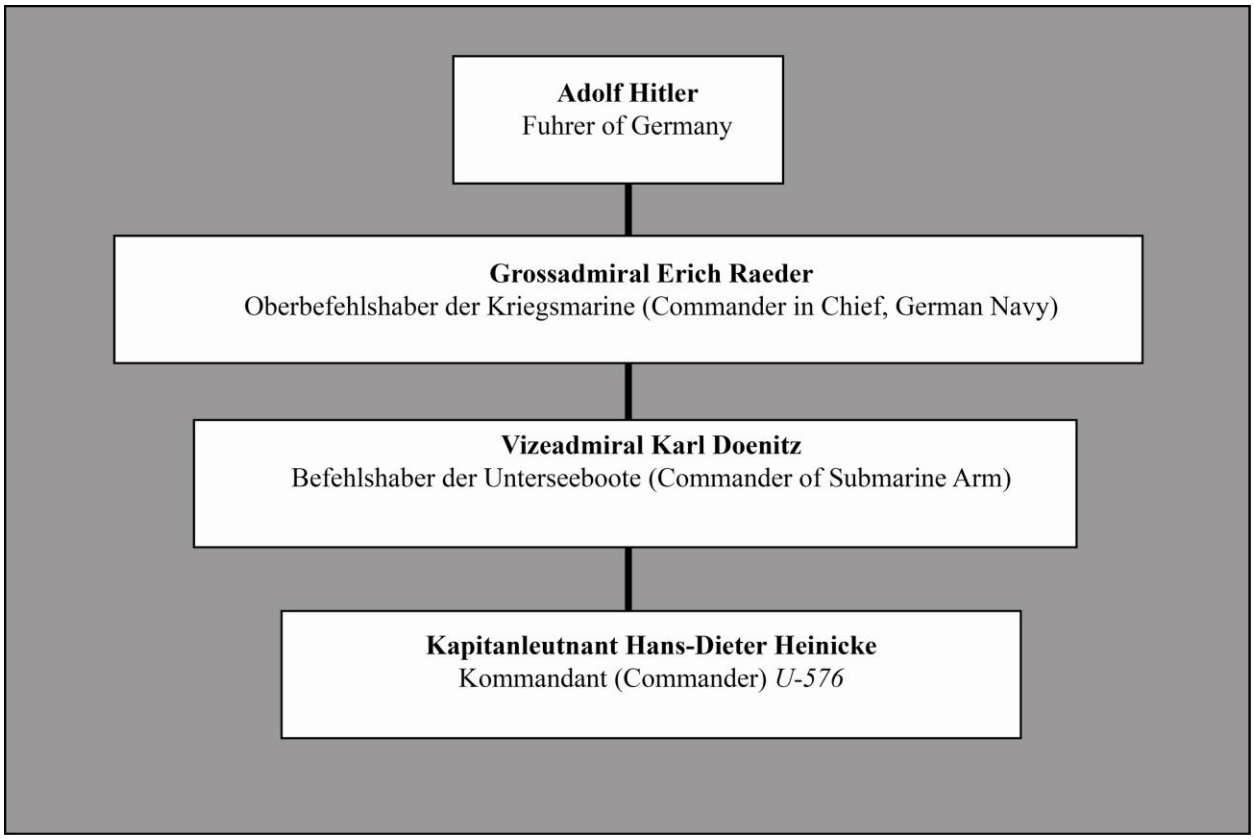

Figure 92. Order of Battle for Axis Forces during Attack on Convoy KS-520. (Source: Doenitz 1959; Gannon 1990:74; Blair 1996:53-627; Wagner 2010; drawn by John Bright).

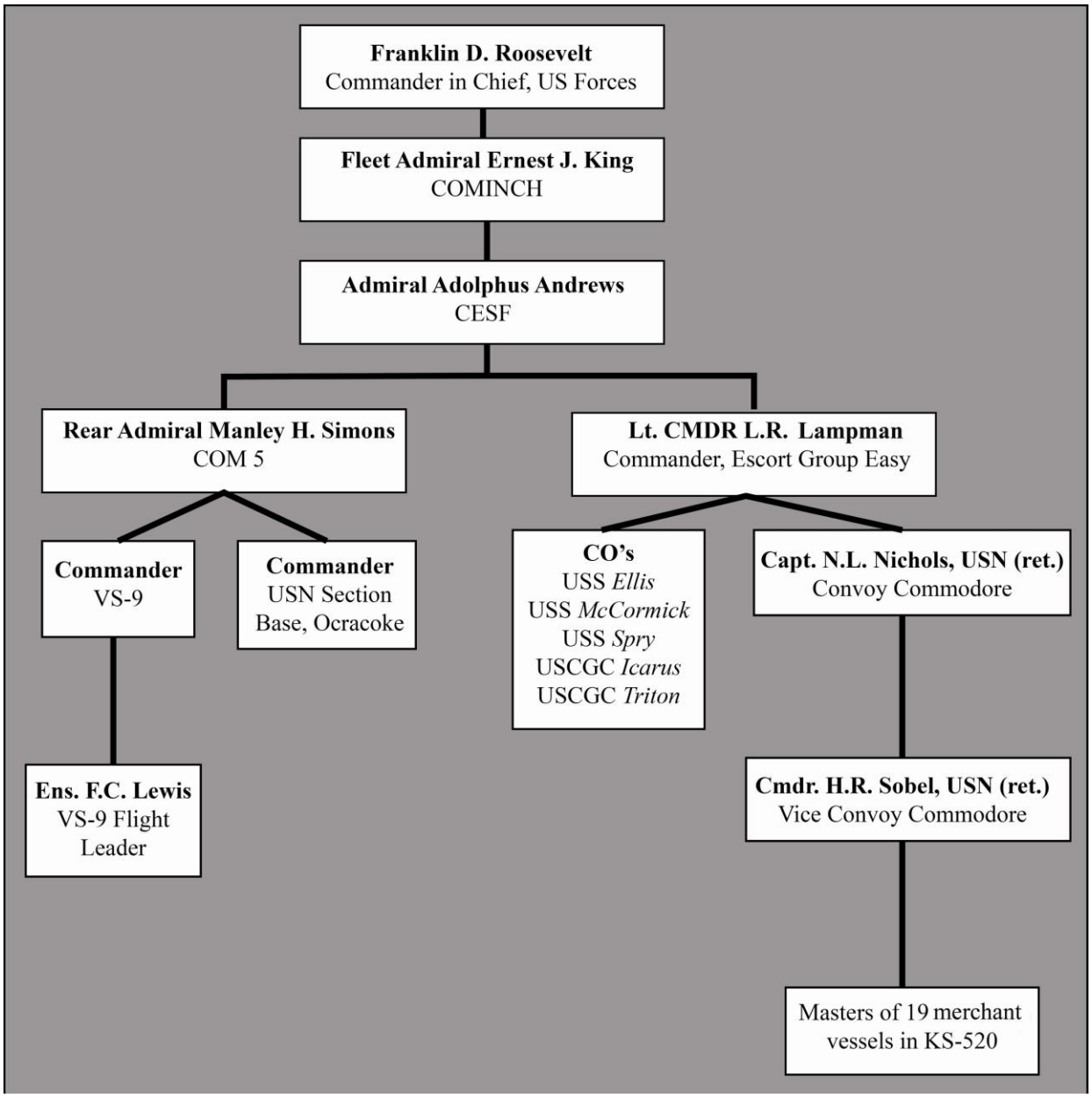

Figure 93. Order of Battle for Allied Forces during the Attack on Convoy KS-520. (Source: ComScorn 1942; USN 1942b; Carraway 1946; King 1946:32; Morison 1947:256; Syrett 1994:12-14; Ireland 2003:78; Wagner 2010:34).

Examining the orders of battle, it is clear there was a considerably larger Allied force involved than the Axis submarine. This is to be expected given the administration required to combine and direct both the Navy and Coast Guard, to combine fleet and air operations within, as well as to manage civilian and foreign merchant vessels. The Germans, on the other hand, merely had a

single submarine participating in the battle. On the other hand, Axis loss of life far exceeded that of the Allies, as *U-576* went down with all hands while only four Allied sailors lost their lives.

After identifying the forces involved, the battlefield surveyor must then attempt to locate historical charts of the conflict. To the author's knowledge, no original charts of the KS-520 convoy naval action exist, nor would be expected to exist. Unlike a terrestrial battle where the movement of troops was plotted across a series of charts, the merchant craft travelled along designated shipping routes and were responsible for their own navigation, the only record of their route plotted and recorded in individual vessel logs. German U-boats operated with a similar degree of latitude, being assigned sectors to patrol for targets of opportunity. As a result, the only spatial data relating to the attack was recorded in textual records. These are mainly the position locations recorded in vessel logs, action reports, and administrative correspondences. Survey charts of the North Carolina coast from the time period exist, as do those of the Hatteras Minefield. Therefore, the researchers generated charts of the battlefield by synthesizing textual records with the contemporary charts of the North Carolina coast.

Further, a battle chronology emerges from the historical narrative, a timeline of events that later provided the basis for establishing defining features by linking historical events with battlefield resources. The chronology is as follows:

14 July: 0600 Convoy departs moorings
1330 Convoy clears minefield at Chesapeake approaches and proceeds south
Afternoon: USN Patrol aircraft attack and damage surfaced *U-576*
U-576 reports damaged fuel and ballast tanks to B.d.U.; Irreparable

15 July: 0700 Convoy rounds Diamond Shoal

1600 Convoy 20 miles south of Ocracoke Island

Time Unknown: *U-576* spots large southbound convoy

1430 Two USN patrol aircraft of VS-9 take-off from Cherry Point MCAS to provide air cover for KS-520

1605 USCG Cutter *Triton* develops sound contact and drops two depth charge patterns; damaged Q.C. Sonar Apparatus and lost contact

1615 *U-576* unleashes a full bow salvo into heart of contact

1615-1620 Four torpedoes slam into *Chilore*, *J.A. Mowinckel*, and *Bluefields*

1620 *U-576,* for unknown reasons, surfaces in port area of convoy

1620-1630 VS-9 aircraft, in concert with Merchant Vessel *Unicoi,* attack surfaced U-boat with depth charges and gunfire; U-boat sinks into a slick of oil and debris, presumed lost with all hands

1641-1745 USS *Ellis* pursues sonar contacts with multiple depth charge attacks

1630 *Bluefields* sinks, crew abandons ship

1650 All survivors of *Bluefields* rescued by USS *Spry* and USCG *Icarus*

1718 *USS* Spry begins escort of *J.A. Mowinckel* and *Chilore* to Hatteras Inlet

1953-2010 *J.A. Mowinckel* and *Chilore* strike mines in the Hatteras Minefield, believing the attack to be another U-boat, the crews anchor and abandon the ships

2100 As merchant crews make for Hatteras and Ocracoke in lifeboats, USS *Spry* begins intercept course to regain convoy

16 July:

By early AM, all lifeboats secure at either Ocracoke or Hatteras Inlet USCG Stations; twenty sailors with serious injuries evacuated to Norfolk

Officers and Engineers return to *J.A. Mowinckel* and *Chilore* and determine the vessels are salvageable

16 July -19 July:

USN and USCG sweep and countermine area around damaged merchant hulks; initiate salvage operations

Tugs *Keshena, J.P. Martin, Relief,* depart to bring vessels into Hatteras for temporary repairs

1525-1537 *Keshena* strikes a mine and sinks, resulting in the death of two crewmen

By the evening *J.A. Mowinckel* and *Chilore* were beached and undergoing repairs, preparing the craft for tow back to Norfolk

21 July: Seaman Second Class Raymond V. Wolfe dies from wounds sustained during the *U-576* attack

22 July: *U-576* officially declared lost by B.d.U.

24 July: *Chilore* capsizes undertow and sinks in the approaches to the Chesapeake; *J.A. Mowinckel* returns to Norfolk and eventually salvaged.

From this chronology, several important battlefield areas emerge. Namely, these are the site of the first aerial attack upon *U-576*, the path of the convoy, the location of the submarine attack, and the area bounded by the Hatteras Minefield where days of rescue and salvage operations took place.

Defining Features

Defining features are both terrain (natural) features and objects otherwise considered landmarks or points of alignment for combatants on the ground, as well as conspicuous artifacts. These include structures used by combatants such as fortifications or supply points. Having generated the list, it is contingent upon the researcher to locate these features during survey of the battlefield. Once located, defining features serve a number of roles. The first is to situate action reports to a discrete location in the real world. In the present study, the position of vessel remains was sought to locate the precise position of the attack and peripheral activities, while digital cartography recreated ship movements and other features no longer present on the battlefield. Once linked to the landscape, terrain study is utilized to ground truth accounts based upon their conformity to applicable tactical principles regarding the use of military terrain.

Occurring in the open-ocean, many of these features are not visible to the naked eye. In fact, many of these features are intangible routes and boundaries, or were engineered structures dissembled by the military since the attack. The artifacts remaining, the shipwrecks themselves, can only be viewed individually via scuba diving or remote sensing equipment. The spatial distribution of these features, such as the distance between the airfield at Cherry Point MCAS and the attack location offshore, further increase the difficulty of viewing the battlefield as a discrete space. As a result digital cartography was required to view and understand these features in relation to one another. These charts and visualizations are essentially the only vehicle to view the various features of the KS-520 attack.

Nevertheless, as these features were described, delineations along the battlefield began to emerge. The defining features of the KS-520 battlefield are shown in Figures 94-96. These can be broken down into groups either based upon the battlefield resource type or by location. In each case, the defining features represent the interaction of opposing forces with the landscape. For example, at the sight of the attack, several defining features are the oceanographic components utilized by *U-576* to conceal its approach and attack. Others, such as the continental

shelf and 100-fathom curve, were crucial navigation aids to Allied forces as they rounded Cape Hatteras. The Hatteras Minefield, in its entirety, is a defining feature, yet specific features within and around it are also important constituents of the battlefield. These include the wreck of *Keshena*, marking the site where *Chilore* and *J.A. Mowinckel* struck mines and were abandoned by their crews, as well as the military installations on Ocracoke Island.

During the survey of the battlefield, as many of the tangible defining features as could be found were visited, including the wreck sites *Keshena* and *Chilore*, Cherry Point MCAS, and the Ocracoke Inlet Coast Guard Station. The two other wrecks, *U-576* and *Bluefields*, were sought during an archeological survey, yet their locations remained elusive. Instead, geostatistical modeling was used to predict the most likely position of the vessel remains, which were situated inside the original search grids, but beyond the area covered during Phase One of archeological survey as a result of depth and current restrictions upon the remote sensing apparatus. Similarly, the Naval Section Base and former Hatteras Inlet Coast Guard Station, as well as the Hatteras Minefield, no longer exist and therefore were digitally recreated from historic charts and photographs.

The intangible defining features, those with either no actual physical existence or those too remote to view, such as bathymetric contours, were acquired as digital chart layers within the GIS. Others, such as the water column, were generated as 3D visualizations. As a composite, these features cluster around two main spaces of the battlefield. These are the sites of the initial attack where *Chilore*, *J.A. Mowinckel* and *Bluefields* were attacked, and where *U-576* and *Bluefields* sank. In this area, combat was affected by obstacles such as Diamond Shoals and the Hatteras Minefield, as well as natural features like ocean currents, bathymetric contours, the continental shelf, the wind, the sun, and the sea state. The other area is within the Hatteras Minefield where rapid rescue efforts saved the crews of *Chilore* and *J.A. Mowinckel*, and multiday salvage work brought each ship from the minefield despite the loss of salvage tug *Keshena*.

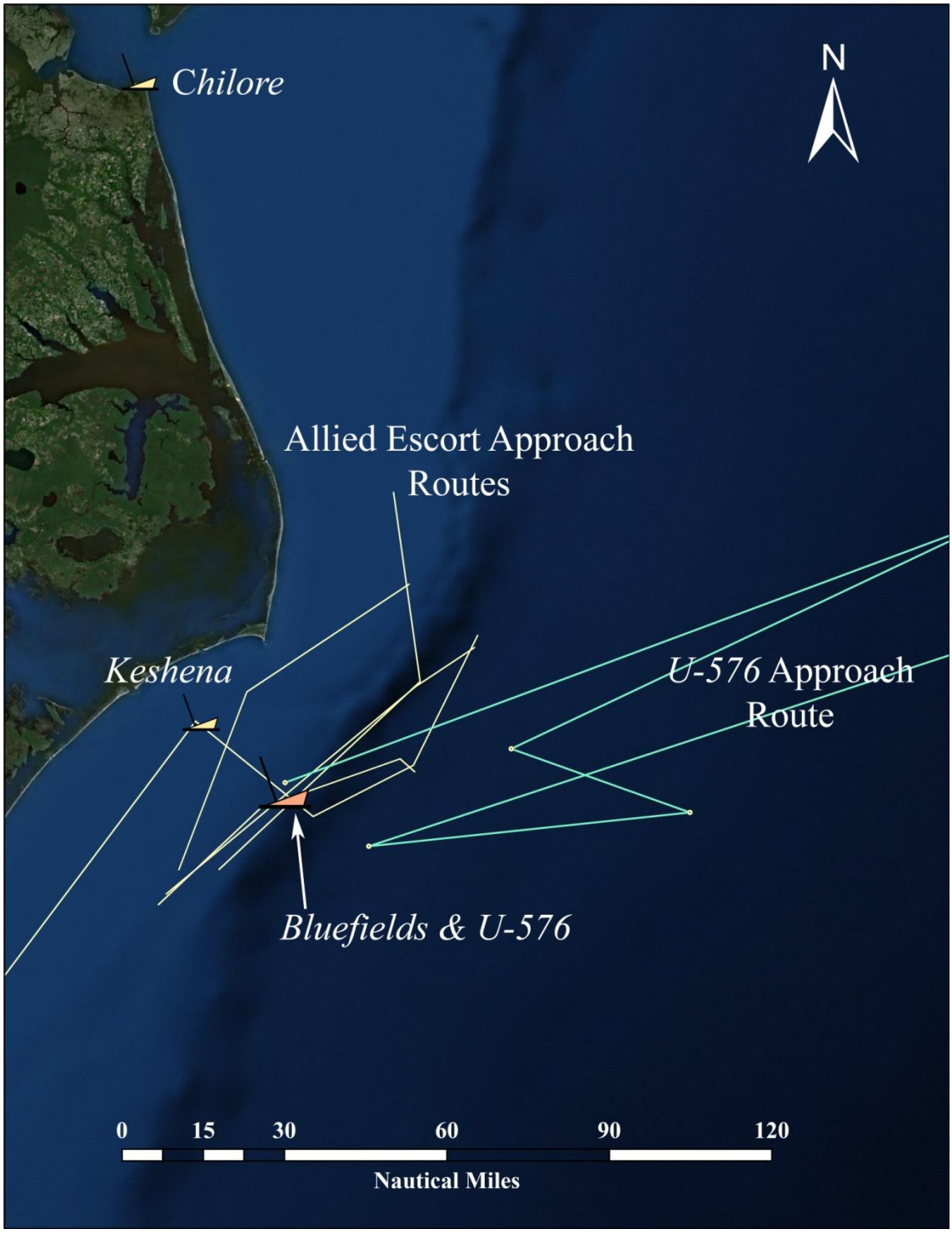

Figure 94. Artifact defining features (Image by John Bright).

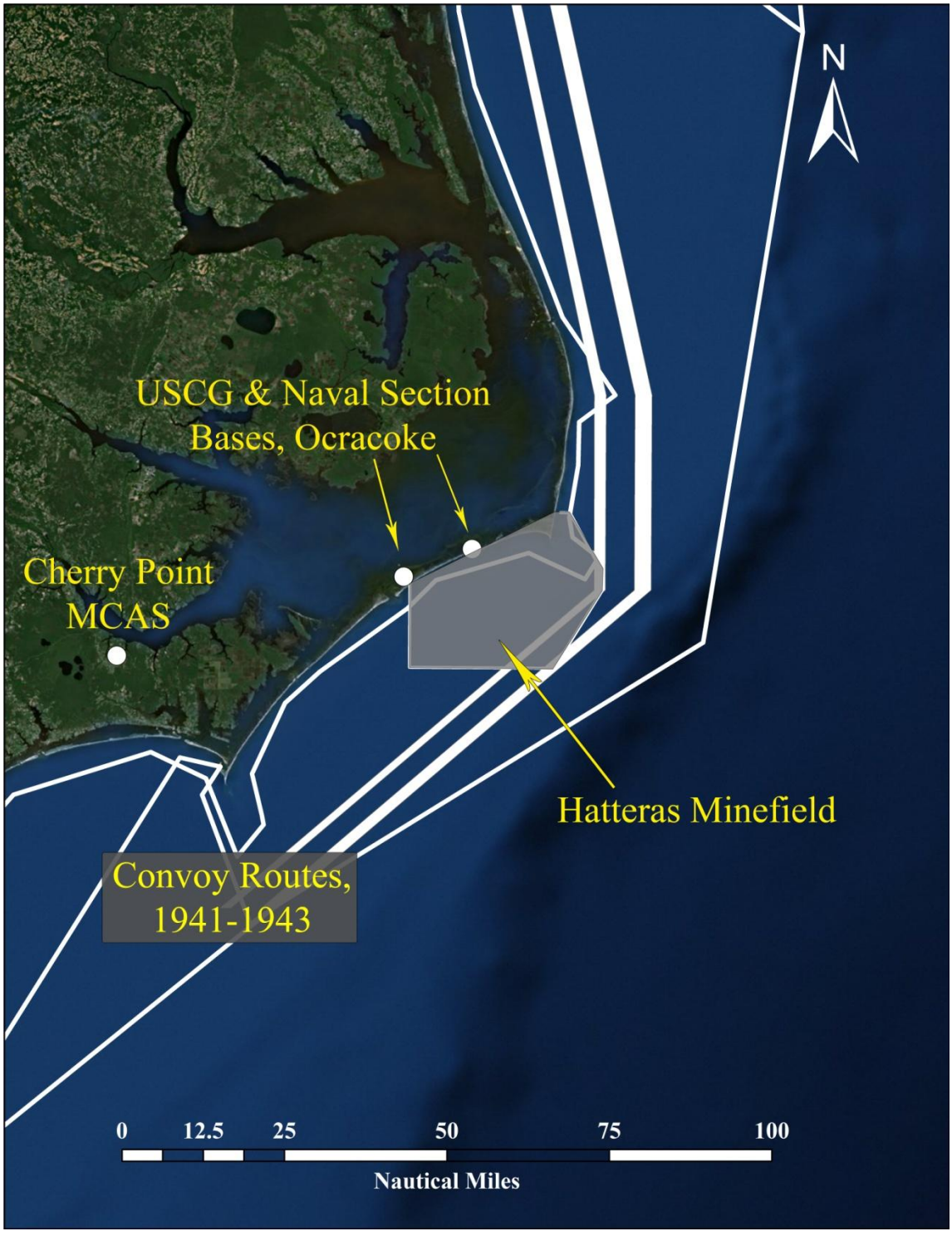

Figure 95. Military engineered defining features (Image by John Bright).

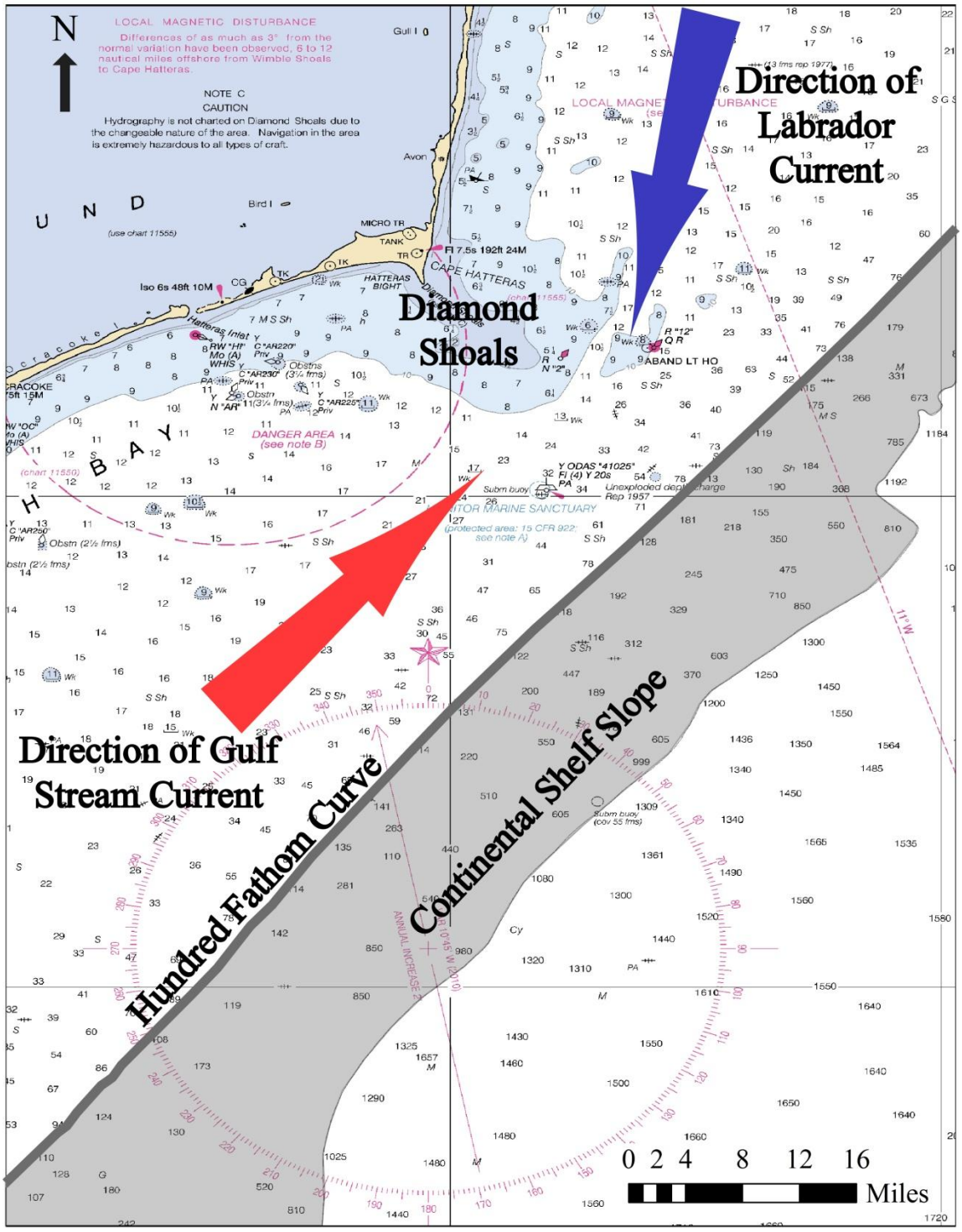

Figure 96. Natural defining features (Image by John Bright).

Terrain Study

On-site survey and digital cartography linked the battlefield narrative with the defining battlefield resources described previously. This served the purpose of ground-truthing specific actions, movements, and vessel dispositions described within the historical narrative. Analytical review of the narrative, however, stemmed from discussing it in terms of the significant terrain features through which opposing forces interacted. Artifact locations and geospatial charting provided the basis to determine the discrete locations of actions and movements. Once placed within the landscape, the theory of Inherent Military Probability was drawn upon to compare the description of actions in the historical record with the understanding of military terrain derived from study of contemporaneous tactics and weapons as they related to forces interacting within the landscape. Again, the placement of military engineering features, and the representation of some natural features such as ambient weather during the attack, no longer have any physical existence, thus the 'exploration' of these elements in the battlefield took place via representation in the digital chart-space.

The first task of terrain study, ground-truthing historical accounts by linking them with defining features referenced in historical sources, was confounded by several ambiguities within the historical data. Chief among them was the inability to determine the actual location of the attack from data in historical sources. Several sources offered position information for the attack, yet these reported positions are spread throughout a large area (see Figure 1). This distribution teeters along the break of the continental shelf, making the actual location of the attack crucial to understanding how combatants were moving with relation to steep bathymetric contours in the area. Historical records indicate convoys were instructed to travel along the 100-fathom curve while rounding Cape Hatteras. If KS-520 deviated from this path into deeper water, however, this might have enticed the U-boat to attack as the deeper water would have been advantageous for the submarine's retreat following the attack. Deep water proximate to shipping lanes was, for U-boat operations, akin to terrestrial forces seeking high ground.

The historical narrative reported that both *Bluefields* and *U-576* sank rapidly once attacked and, based upon this, it was inferred both were likely proximate to one-another (less than five kilometers apart) on the seafloor. It was assumed if the remains of these two vessels were located their positions would represent the location of the attack and therefore resolve ambiguity in the historical record. A remote sensing survey was designed and executed and

despite identifying 47 sonar anomalies, failed to conclusively locate the remains of either vessel due to a crucial equipment failure. As an alternative, a geostatistical approach was used to render the point of highest probability based upon the weight of historical evidence. This point represents the most systematic review of all available data pending the location of one or both of the vessels, and thus represents the most statistically significant hypothetical attack location, which is used for the remaining terrain study.

The other important location along the battlefield was the place where *J.A. Mowinckel* and *Chilore* struck mines and were abandoned by their crews. This location was the site of a massive rescue and salvage operation resulting in the loss of *Keshena* and two sailors. Just as *U-576* and *Bluefields* were sought to pinpoint the location of the attack event, the remains of *Keshena* were used to place these rescue and salvage operations upon the battlefield chart. A well-known and popular recreational site, the position of *Keshena's* remains has been publically known for years, and the wreck itself was documented during the 2010 Battle of the Atlantic Expedition (Figure 97).

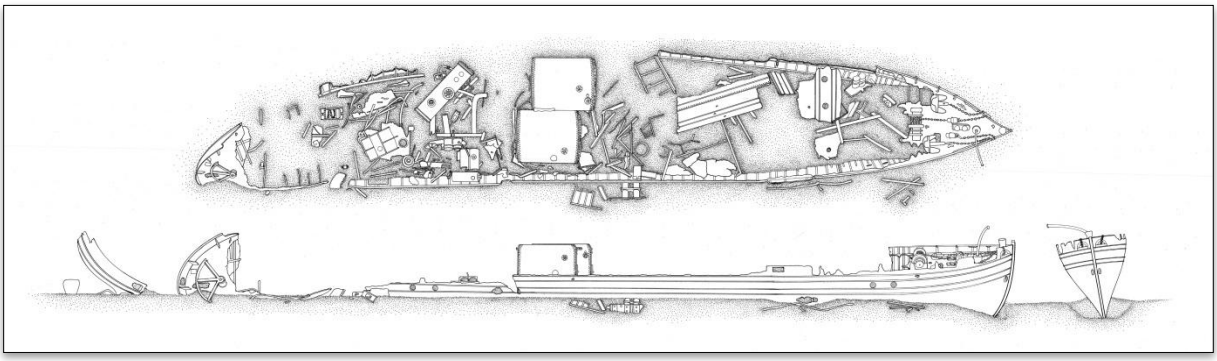

Figure 97. Site Plan of tugboat *Keshena* from 2010 Battle of the Atlantic Expedition (Source: Joe Hoyt, NOAA).

The next series of questions in the historical record regarded the disposition of individual vessels. Specifically, archeological evidence regarding the condition of *U-576* before and after the attack and the location of torpedo strikes on *Chilore, J.A. Mowinckel*, and *Bluefields* were required to ground-truth and test the validity of several historical accounts. Examination of *U-576's* remains was intended to illuminate the nature of damage experienced by the boat following the aerial attack on 14 July, as well as the accounts from *Unicoi* and VS-9 regarding their counter offensive against the boat on 15 July. Both the aircraft and the freighter report scoring hits on the U-boat after it surfaced inside the convoy, astern of *Unicoi*. If this account is

true, then gunnery and depth charge damage would be visible along the structure of the wreck to validate each account. In addition to reviewing damage to the U-boat, the remains of the merchant vessels were sought to determine the precise location of torpedo strikes on their hulls to assess the accounts contained in the ESF War Diary, the VS-9 action reports, as well as several administrative reports. Furthermore, all of this forensic information was central to subsequent reconstruction of vessel movements and locations during the attack, which in turn informed later tactical analysis.

Following the remote sensing operation to locate *U-576* and *Bluefields'* remains, a high-resolution multi-beam sonar survey was planned to generate detailed 3-D imagery of these wrecks in addition to the wreck of *Chilore* in the waters off Virginia. From these images, forensic analysis was planned by comparing the remains of the U-boat with engineering plans for the Type VIIC U-boat published by David Westwood (2003). These comparisons were intended to review accounts of damage to the ballast and saddle tanks of the boat prior to the attack, and to search for evidence of depth charge and gunnery damage to the boat after the attack. Evaluation of the ballast tanks would inform later assessment of the potential for these damages to hinder the combat effectiveness of the boat.

Similarly, examination of the hulls of *Chilore* and *Bluefields* were intended to determine the precise location of torpedo strikes. Historical accounts reported general locations of the torpedo strikes. Verifying these accounts, however, would enable a more accurate triangulation of the position of the U-boat in relation to the convoy as it fired its torpedoes. Specific constraints upon the geometry of a torpedo attack, relating to the submarine's maneuverability and weapon capabilities, allow the attack angle to be reconstructed with scaled visualizations incorporating the exact torpedo strike areas and relative positions of the merchant vessels. This would also further inform tactical assessment of how the commander handled his boat in relation to the reported positions of escorts and in regards to ambient environmental conditions and landscape features.

Unfortunately, for reasons already described in the *Results of Stage Two* section of the *Results of Remote Sensing* chapter, remote sensing operations were unable to locate either *Bluefields* or *U-576*. As a result only *Chilore* and *Keshena* were archeological investigated. Therefore these questions regarding the location and disposition of both the U-boat and *Bluefields* were left unanswered. Furthermore, the desired archeological information sought from

Chilore, the forensic evidence of two torpedo strikes, was unobtainable due to the level of degradation on the ship's remains since the site was demolished as a hazard to navigation (see Figure 98). Thus, a great deal of the forensic data needed to ground-truth these aspects of the historical narrative were not obtained during the present study. For this reason, the original historical accounts were relied upon to facilitate this aspect of the terrain study.

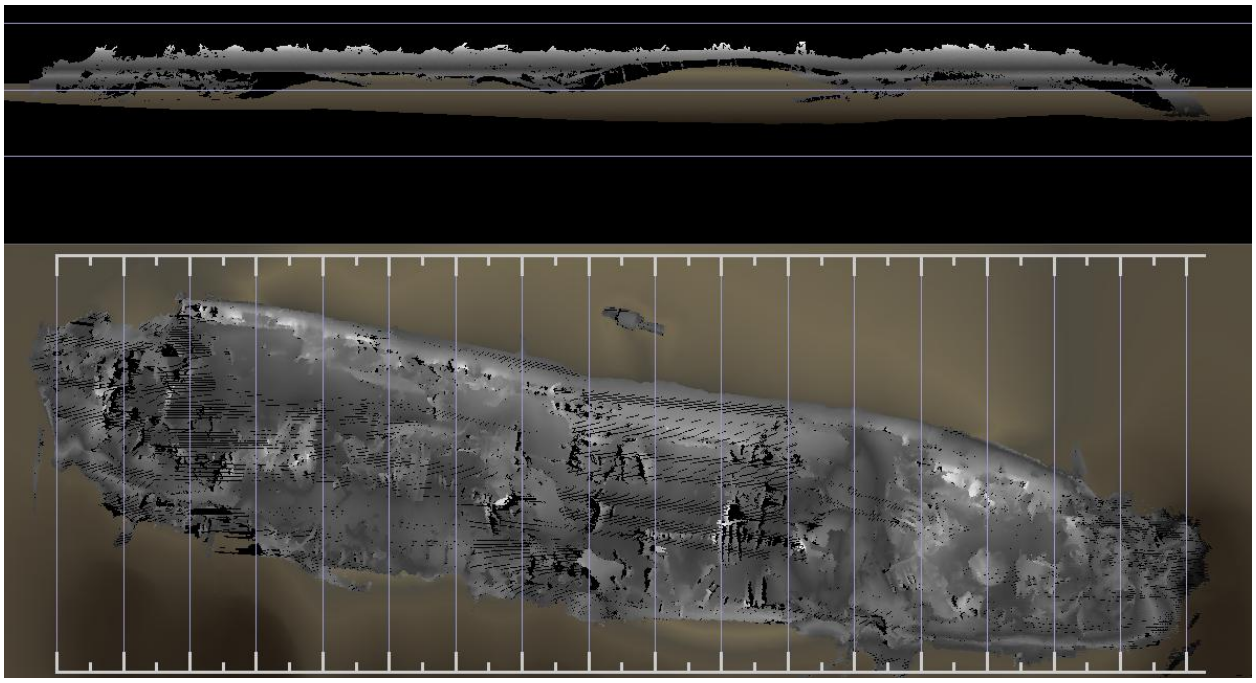

Figure 98. Image of *Chilore* from Phase 4 survey (Image: ADUS Ltd.).

Several historical accounts detail the location of the torpedo strikes on *Chilore*, *J.A. Mowinckel*, and *Bluefields*. Photographs in the Standard Oil Company's (1946) confirm the location of damage to *J.A. Mowinckel*. Examination of the remains of *Chilore* was inconclusive as the extent of site degradation precluded forensic examination of torpedo strikes. Assuming the accounts were reliable, however, it was still possible to geospatially determine the position of the U-boat based solely on historical accounts. A scaled model of the convoy (see Figure 2) was created based upon the USN records which assigned each merchant vessel a space within the convoy and established the row and column spacing between ships. In addition, the reports by the VS-9

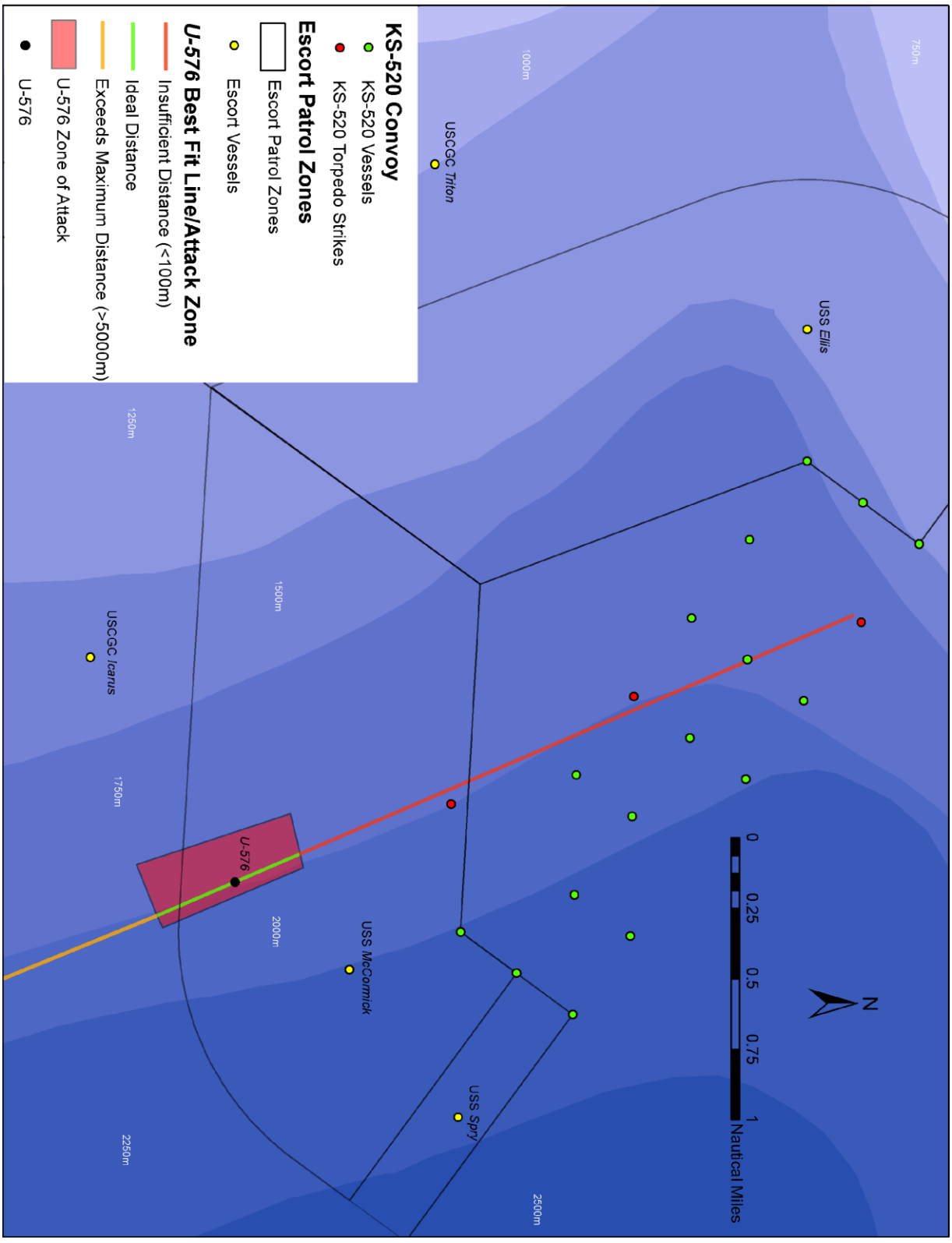

Figure 99. Most Likely Area from which *U-576's* Attack Originated (Drawn by Stephen Sanchagrin).

aircraft of *Chilore* being 600 yards ahead of station, further informed the model. Once the merchant vessels were rendered within the model, the approximate position of each escort vessel was also rendered based upon the established screening zones ahead and abeam of the convoy (Figure 99). The individual points for each of the four torpedo strikes were marked on the three merchant vessels and from these points the location of the submarine triangulated based upon the parameters of U-boat attack geometry and weapon's capabilities.

In addition to determining event locations and vessel dispositions, terrain study was also used to plot the movement and the distribution of forces during the main attack and counter-attack. In particular, the naval escort vessels recorded the movement of Allied warships three times a day. These coordinates were processed and digitally charted to represent the movement of the convoy from Virginia to Florida, through the point of attack. Several sources also detailed the movement of USS *Spry*, *J.A. Mowinckel*, and *Chilore* following the attack as they retreated to the safety and support of Ocracoke Island, North Carolina. These movements were ground-truthed by locating the remains of tugboat *Keshena*, lost to a friendly mine during salvage operations in the Hatteras Minefield, and *Chilore* lost off the Virginia coast (Figure 100).

Similarly, German naval records detailed the movement of *U-576* during its fifth war patrol, culminating in its operations off the North Carolina coast in the days leading up to the attack. During the day of the attack, however, the exact position and movement of the boat was unknown, as the records were lost when the boat sank. The exact position of the U-boat during the attack, therefore, was determined from a reverse analysis, as shown in Figure 100. Examining the avenue of approach of *U-576*, however, yielded an interesting alternative to the historical narrative. U-boat movements were centrally directed by a German naval command staff to a similar degree that Allied convoys were administrated. As plotted in Figure 101, records indicate the boat was ordered into the area off Cape Hatteras, MQK grid CA. At 0230 hours on the 11th of July the U-boat spotted a north-bound convoy moving near the continental shelf-break (Figure 101, position A), just south of Hatteras, around twenty miles from where the boat attacked KS-520 four days later (Figure 101, position E). *U-576* trailed the convoy for an hour before losing sight, spending the rest of the day searching for the ships (Figure 101, positions B and C). Remaining on station off Hatteras, sometime between the 13th and 14th, the boat was attacked by a patrol aircraft and moved offshore to assess the damage (Figure 101, position D).

Revisiting the historical narrative, it was found that after moving offshore and determining the damage to his U-boat was irreparable, Kplt. Heinicke aborted the war patrol. According to historian Homer H. Hickam, Jr. (1989:285-286)

> as it would later become clear, the U-576 had somehow survived the near-perfect air attack…. From the amount of oil reported by the navy pilots, there is little doubt that Heinicke also had lost a good amount of his fuel, probably out of a ruptured saddle tank. If so, he likely knew that he did not have enough fuel to return to France. In that case, there was only one solution. The trip back had to be started immediately with a milch cow rendezvous. But on 15 July, Heinicke spotted a convoy coming his way. He couldn't resist it.

This interpretation implies one critical detail: after his boat was damaged, Heinicke ended his war patrol and made for France. Plotting *U-576's* position data, however, shows that from the spot he reported attempting repairs, (D) in Figure 101, Kplt. Heinicke would have had to turn his boat around and travel southwest in order to have intercepted KS-520 the following afternoon. This suggests Kplt. Heinicke did not abort the patrol but instead took his boat back into combat. To take a damaged boat back into harm's way, where patrol aircraft harassed him the day before, in search of merchant vessels reinforces the notion that Kplt. Heinicke perceived certain terrain features as advantageous for attacking ships; a topic explored in the KOCOA analysis given shortly.

Thus far, terrain study focused simply upon ground-truthing facets of the historical narrative. This included using archeological remains and geospatial processing to pinpoint the location of the attack and abandonment of vessels in the Hatteras Minefield, reconstructing vessel movements in the battlefield chart using historical sources, and, where possible, using archeological remains as forensic clues to reviewing specific details in various historical accounts. Several important questions, however, were left unanswered as a result of being unable to locate the remains of *U-576* and *Bluefields* during the present study. Instead, historical sources were used to with the understanding that the results of the present analysis are preliminary, pending additional fieldwork to locate and document these vessels. Nevertheless, after ground-truthing these aspects of the historical narrative, the KOCOA analysis was needed

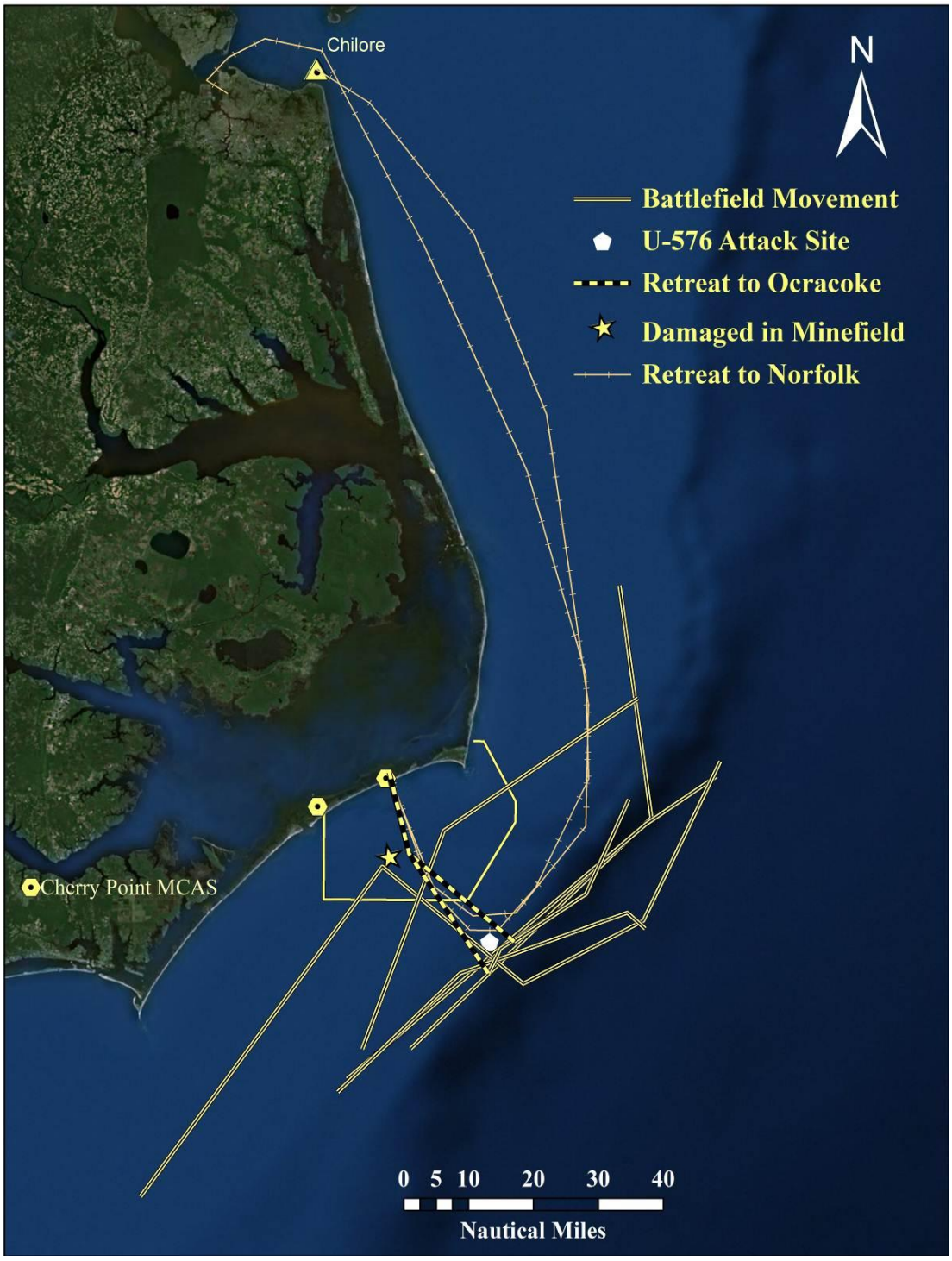

Figure 100. Distribution of Allied Ship Movements across the Battlefield. (Source: National Archives, Mine Warfare Section, Records of the Office of the Chief of Naval Operations, Record Group 38; USCG 1942a, 1942b; USS *Ellis* 1942; USS *McCormick* 1942; USS *Spry* 1942; Wagner 2010; Drawn by Author).

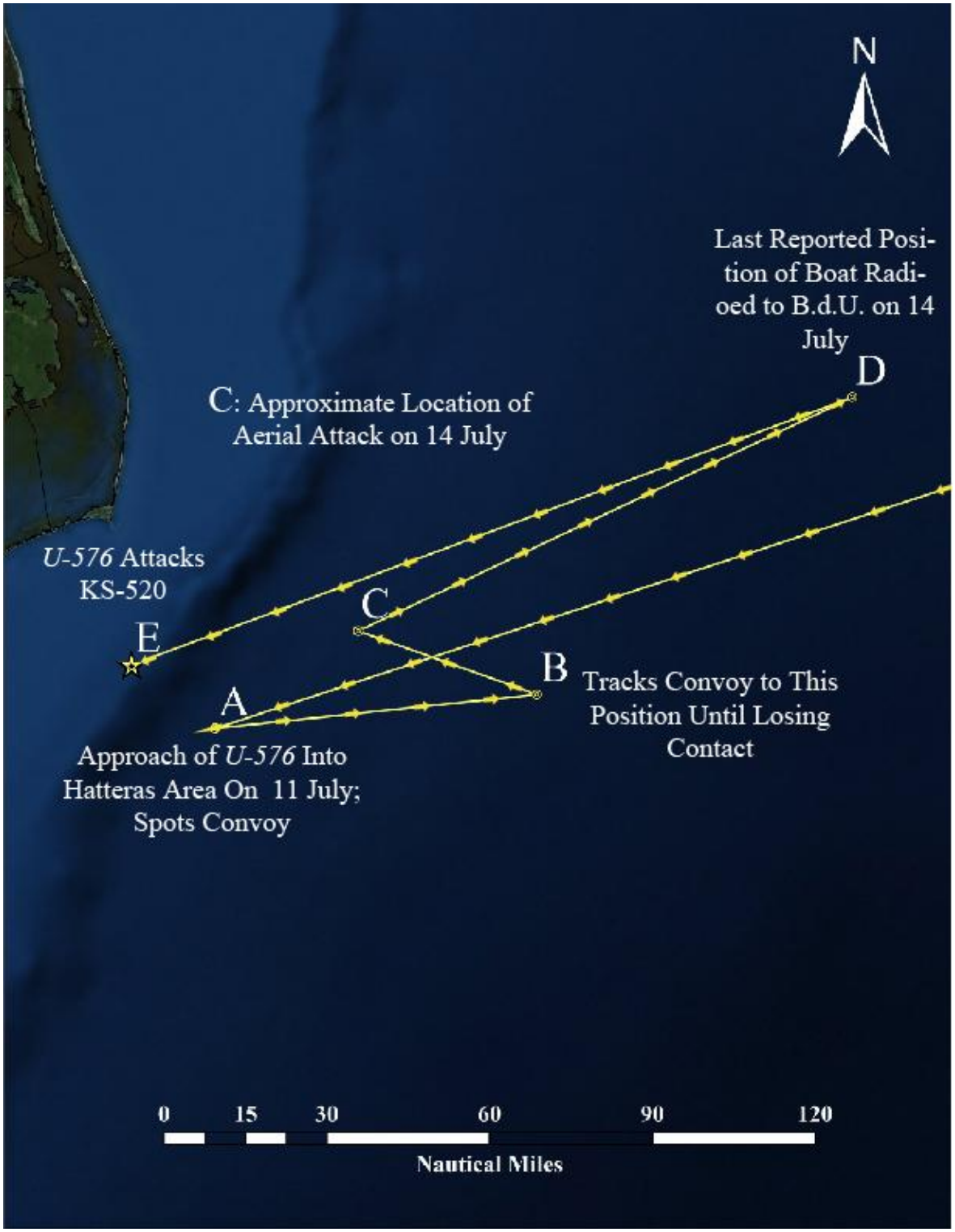

Figure 101. Plot of U-*576's* Reported Positions Between 11 and 15 July, Ending in its Attack Against KS-520. (Source: B.d.U 1942a, 1942b; Drawn by Author).

to review the battle in light of the archeological and geographical data collected thus far. In particular all battlefield data, be it historical, archeological, or geographical, are herein used define the KOCOA components and thereafter review the historical narrative.

A hypothetical review of KOCOA components for early 1942 submarine and anti-submarine warfare, incorporating surface escorts and patrol aircraft, was given in Table 9. The specific terrain features for the area of the KS-520 attack are given in Table 10. Each of the spatial zones has a specific set of terrain advantages present during the KS-520 attack. When the *Military Terrain* section of this chapter was reviewed, it was concluded that the U-boat and aircraft were afforded much more assistance from the landscape than surface vessels. This remains true for the KS-520 battle. Considering that Allied convoys travelled along the US coast to transport war supplies, not to find and engage enemy vessels, the main task of terrain study is to understand why *U-576* decided to attack in the first place.

Kplt. Heinicke's decision to engage in combat precipitated multiple days of rescue and salvage activities. Yet at the core of all the activity was a brief exchange between *U-576, Unicoi*, and two aircraft from VS-9. Terrain study, therefore, seeks to illuminate why, especially with a reportedly damaged boat, Kplt. Heinicke decide to attack, how the landscape influenced the execution of his attack and the Allied response, as well as how terrain influenced Allied rescue and salvage efforts in the days which followed. As was discussed in the *Military Terrain* section, many of the KOCOA features overlap. For example, key terrain for the U-boat was in large part determined by cover and concealment that offered ideal avenues of approach and retreat. Thus, discussion of these features attempts to avoid redundancy by grouping these features as necessary during the analysis.

Clearly, *U-576* utilized many useful terrain features. At the core of the boat's operation was the need to maintain invisibility when in the presence of the enemy. Thus, the key terrain for the submarine was that which facilitated the cover and concealment of the U-boat. Off Cape Hatteras, shipping lanes were proximate to the continental shelf. This allowed U-boats to engage merchant vessels in the area while remaining close to a deep-water haven. This was certainly the case for *U-576*, as the attack occurred in very deep water. Another factor that aided in concealment of the submarine was the ambient wind speed and direction at the time (Figure 102). Blowing lightly from the southwest, the breeze could conceal the wake left by the

Table 10. KOCOA Terrain Components Defined for the KS-520 Attack.

Spatial Zone	Key Terrain	Obstacles	Cover & Concealment	Observation; Fields of Fire	Avenues of Approach & Retreat
Sub-marine	Maintain Concealment: *Area of deep water along the continental shelf break adjacent to the shipping lanes off Hatteras; direction of wind seas*	Hazards to Navigation & Minefield: *The Hatteras Minefield, Diamond Shoals, and shallow water near-shore*	Subsurface/ Atmospheric Conditions: *Remaining below the surface, the Southwest wind, thermally stratified water*	None; Orientation of Boat: *Observation through periscope, not dependent on landscape. Field of fire for G7e torpedoes fired from 4 bow tubes*	Maintain Concealment; Maintain Cover: *Approach along beam of convoy, using wind direction to conceal periscope wake*
Surface	None: *No advantageous terrain for surface vessels*	Hazards to Navigation & Minefield: *The Hatteras Minefield, Diamond Shoals, and shallow water near-shore*	None: *No landscape feature offered cover or concealment once spotted by a U-boat*	Elevation; Orientation of Vessel: *Observation controlled by position and height of lookouts, cones of sonar range in water column*	None; Proximity to Military Engineered Features: *Approach was not dictated by landscape; Retreat was determined by quickest route to proximate assistance on Ocracoke*
Aerial	Optimal Visibility: *Elevation above convoy*	Land\Sea Interface: *Surface of the Ocean, under which the U-boat can hide from air attack*	Obscure Presence to Enemy: *No specific atmospheric conditions at the time of attack to conceal the aircraft from* U-576	Elevation; Orientation of Plane*: Atmospheric visibility reported to be in excess of 5 miles, Fire can be brought to bear anywhere on the battlefield*	None; None: *No landscape feature influenced the movement of aircraft onto and off of the battlefield, simply the shortest flight path from the airfield to the convoy and vis-versa*

attack periscope as the U-boat moved into firing position. Coincidentally, the direction of the wind originated from the direction of deeper water, allowing *U-576* to approach from an area where, if spotted, the boat could quickly retreat to safety. Furthermore, the mixing of the Gulf Stream and Labrador Current in the area produced a stratified water column in which the boat could avoid acoustic detection. This is evident by the fact that all of the escourt vessels on the port beam of the convoy, USS *McCormick*, USS *Spry*, and USCGC *Icarus*, failed to detect the U-boat with their sonar apparatus despite their proximity to *U-576*.

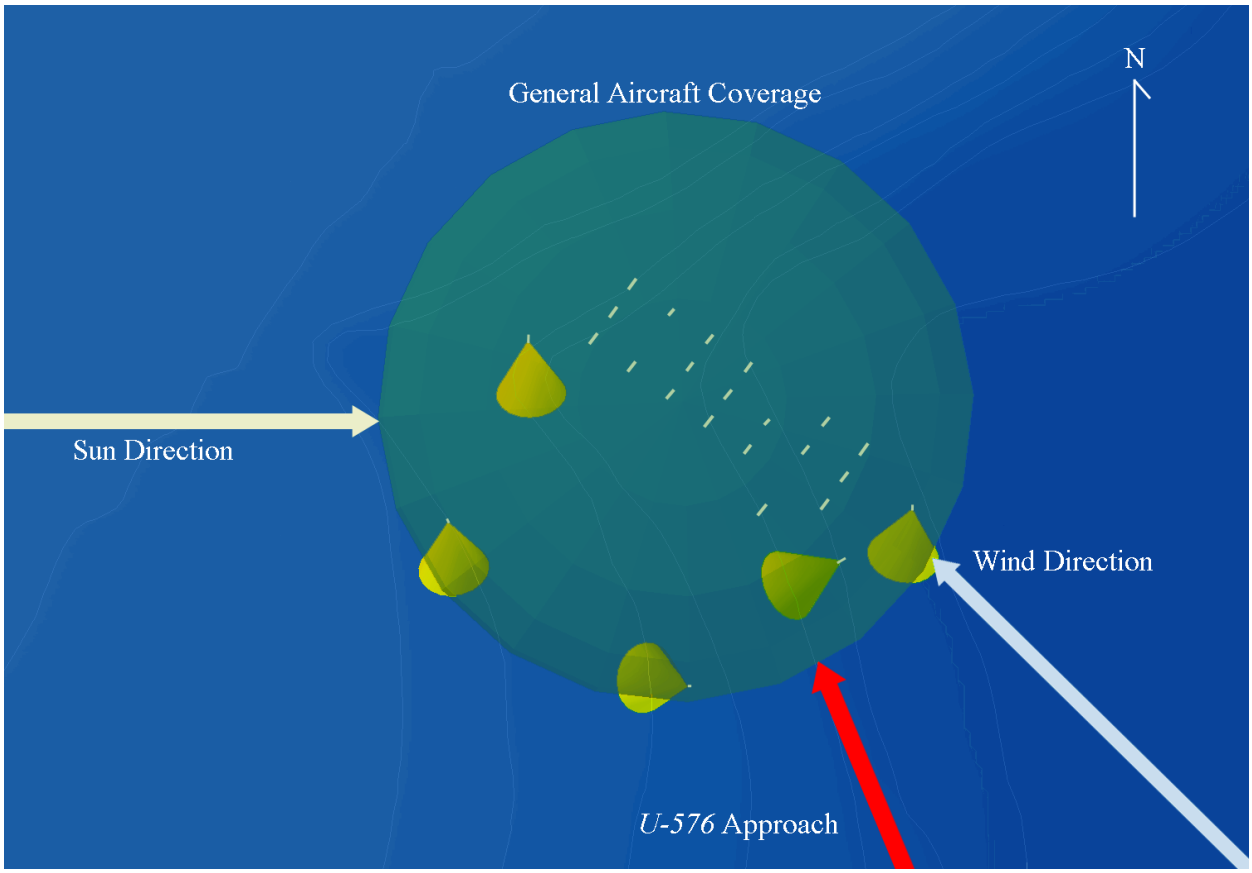

Figure 102. The Angle of Approach of U-*576* in Relation to Ambient Wind and Sun Direction (Drawn by Stephen Sanchagrin).

Obstacles for the U-boat were essentially the same as those hindering the movement of surface ships: shallow water, shoals, and minefields. In the deeper water offshore, these had little influence on the attack itself, though they became the main source of adversity during later rescue and salvage operations. Instead, cover and concealment, key terrain, and advantageous avenues of approach and retreat more likely impacted Kplt. Heinicke's decision to attack KS-520. In light of these advantages, it seems reasonable that *U-576* decided to attack a heavily armed convoy. The U-boat obviously attained a favorable attack position. The pattern of strikes upon *Chilore*, *J.A. Mowinckel*, and *Bluefields* indicates the U-boat attacked from a station to the port bow of the convoy (Figure 103). Further, since the aircraft pilots reported not seeing any torpedo wakes, the limitations of the G7e torpedo would require the U-boat to be no more than 5000 meters from its targets. Thus, to hit *Bluefields*, the ship farthest from the U-boat, *U-576* would have been no more than 5000 meters away, putting it less than 4000 meters from *Chilore*

and *J.A. Mowinckel*. In doing so, the U-boat would be required to slip through the screen of naval vessels protecting the merchant convoy.

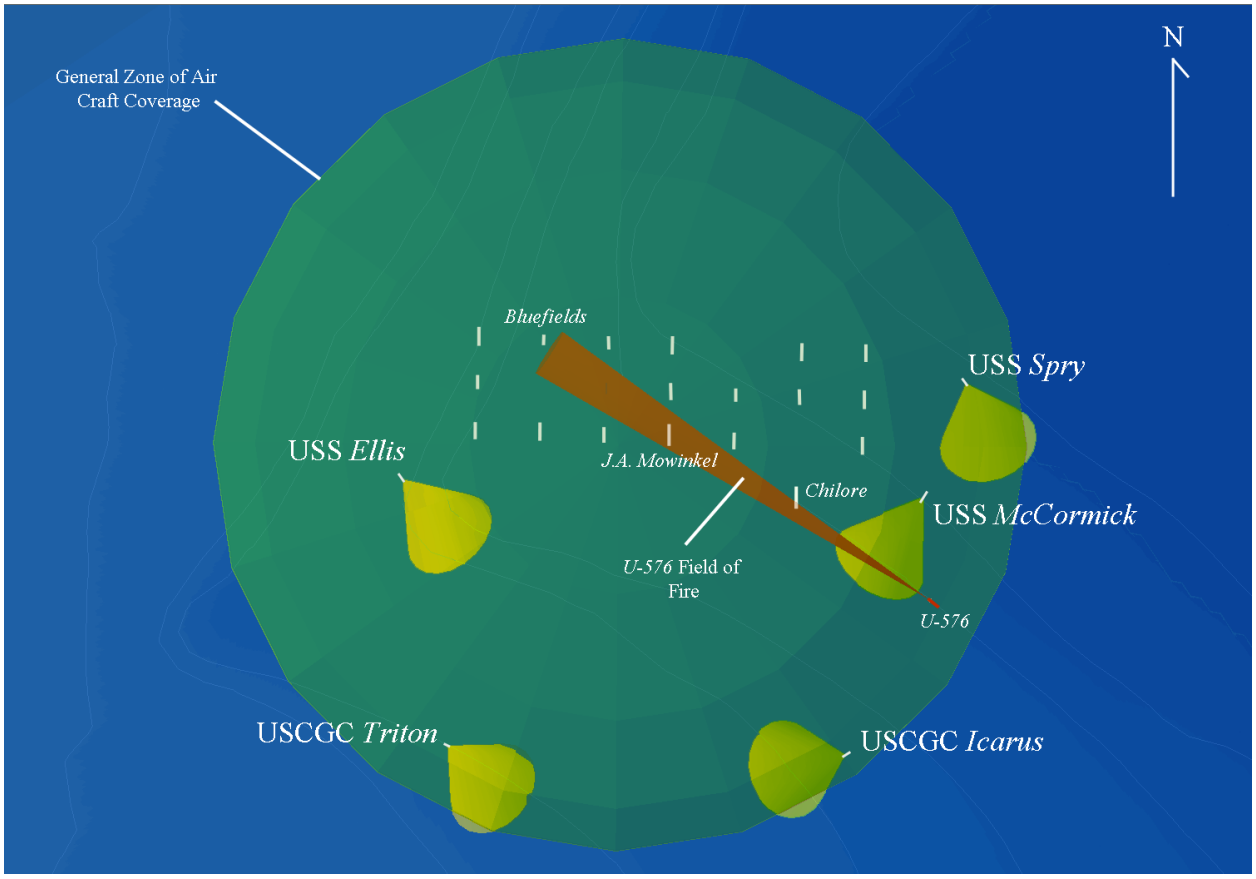

Figure 103. The Field of Fire of *U-576* in Relation to the Convoy and Escort Ships. (Map by Stephen Sanchgrin).

This is especially significant, given that the terrain study already revealed that, despite being damaged, *U-576* travelled back to Hatteras to continue its war patrol. Presumably, the nature of damage to the vessel did not impede the boat from maneuvering beneath the surface of the water. Therefore, assuming basic operation of the U-boat was still possible, the perception of the advantages offered by these terrain features would have outweighed the risk of taking a damaged boat into battle in the mind of Kplt. Heinicke. This is especially true given how close to the convoy and escorts *U-576* would have maneuver to bring its weapons to bear (Figure 104). His assessment of the damage to his boat, however, could very well have been erroneous and might explain why, after his attack, his boat surfaced in the middle of a highly protected convoy.

In short, although the extent of damage to the U-boat prior to the attack is not known at this time, it is posited that Kplt. Heinicke believed he could press the advantages offered by the local terrain to successfully execute his attack. In hindsight, he was correct in this belief, up until the point his boat surfaced amidst the convoy. By surfacing, Kplt. Heinicke negated all advantage offered by terrain and exposed his boat to incredible danger. Given the present understand of military terrain, it would follow that this occurrence was most likely unintended and could have resulted from a number of factors. As the submarine surfaced amidst the first row of merchant vessels, the naval gun crew aboard *Unicoi* and the VS-9 air patrol quickly counter-attacked and sank the U-boat.

Various reasons could explain why *U-576* surfaced inside the convoy, including a misunderstanding of the nature of damage to the boat resulting in an unforeseen increase in buoyancy as four torpedoes were expelled, damage to the battery banks which forced the submarine to surface as they lost power and could no longer propel the boat beneath the surface, a critical system failure, or an internal fire which required the boat to surface. In any case, the cause is presently unknown, though the result of this action is certain: Allied armed guards and aircraft escorts quickly exploited the U-boat's error and answered with a barrage of fire, further damaging and potentially destroying the U-boat. Regardless of the reason for *U-576* surfacing, an understanding of military terrain highlights the fact that *U-576* exploited an array of terrain features, and that many of these features also confounded Escort Group Easy's efforts to protect the convoy.

The distinction between the missions of German U-boats, to seek out and attack Allied shipping, and that of Allied convoys, to safely transport war materials, is critical to understanding why Allied vessels were positioned in such dangerous terrain. Allied convoy routes around Cape Hatteras were designed to prevent ships from grounding on Diamond Shoals, a prominent natural obstacle in the landscape. These convoy routes also directed ships away from the Hatteras Minefield after it was constructed in May 1942. To avoid these obstacles, convoys were directed to follow the 100-fathom curve while rounding Cape Hatteras.

The proximity of the continental shelf slope to the 100-fathom curve off Cape Hatteras, however, presented a dilemma for Allied ships. The obstacles preventing ships from steaming closer to shore forced these ships into a narrow area adjacent to the great depths off the continental shelf (see Figure 68 and Figure 96). Furthermore, in this area two large ocean

currents, the Gulf Stream and Labrador Current, converge. It was these natural features and obstacles that made the area an ideal hunting ground for U-boats. Travelling along this convoy route, KS-520 was vulnerable to U-boat attack. The landscape would offer no cover and concealment, nor would the landscape offer key terrain from which to observe or bring fire upon the enemy.

Understanding that merchant vessels were vulnerable to attack while moving along the East Coast, especially in the vicinity of Cape Hatteras, escort vessels were assigned to travel with and protect them. Thus, Allied forces relied upon these armed warships and aircraft escorts to detect and deter U-boats before they could make good an attack on any of the merchant vessels. Escort Group Easy occupied a series of overlapping zones ahead and abeam of the 19 merchant vessels in convoy KS-520. Within each zone, the five escort vessels would steer a revolving course to cover the entirety of the area, all the while maintaining visual lookouts and monitoring their sonar apparatus. Throughout the cruise south, the escorts continually drilled to general quarters in preparation for a quick response in the event a submarine was detected. Despite these efforts, however, *U-576* was able to slip into the convoy and fire four torpedoes at three ships. In the minutes before the attack, USCG *Triton* established a sound contact on the starboard side of the convoy, dropping a series of depth charges in response. Given the U-boat attack from the port beam, it is unlikely the cutter actually detected the U-boat. When USCG *Triton* dropped its pattern of depth charges, however, it damaged its sonar apparatus and subsequently lost the contact. Just a few minutes later, *U-576* attacked.

In the moments following the attack, chaos ensued. Ships disappeared behind columns of water blasted skyward, sailors aboard *Bluefields* abandoned their rapidly sinking ship, and escorts pursed sporadic sound contacts while releasing salvos of depth charges. During this time, *U-576* surfaced inside the convoy. In the action report that followed, the Commander of Scouting Squadron Nine (1942) gave the following summary:

> Submarine torpedoed three ships in convoy, then surfaced momentarily in the middle of convoy. Gun crew aboard the UNICOI commenced fire immediately and reported hitting the stern of the submarine. One aircraft attacked immediately from ahead and dropped two Mark 17 depth bombs, 50 ft. depth setting. Perfect straddle was obtained on conning tower; one charge actually slid off the starboard side of the submarine. The submarine was just under the surface. Sub was observed to veer right and list to starboard. Black oil and bubbles came to the surface. A second aircraft attacked shortly after the first explosion subsided. Attack made from starboard quarter. To Mark 17 depth bombs released and

> detonated very close to the submarine on the starboard side just forward of the conning tower. At this time submarine was sinking fast and was completely under at the time of the second set of explosions…

As described in *Historical Background* section, both *Unicoi* and the patrol aircraft were credited with sinking *U-576*. Several important terrain factors aided the Allied counter-attack. When *U-576* surfaced, Kplt. Heinicke lost nearly all of the advantageous terrain features. At once, his boat was spotted by Allied lookouts and was well within the field of fire of numerous surface vessels and aircraft. The U-boat had no cover while on the surface, and the ability to retreat from enemy fire was hampered by the time required to achieve a safe depth away from enemy fire.

At once, advantage shifted from the U-boat to Allied forces. In the moment following the attack several of the escorts began sporadic depth charge runs, heading away from the main group of ships, while other escorts quickly intervened to rescue survivors from the damaged merchant vessels. Their position around the perimeter of the convoy made attacking the U-boat the moment it surfaced nearly impossible. Though they occupied the terrain around the perimeter of the convoy, they were unable to detect and prevent *U-576* from attacking. In this regard, the presence of patrol aircraft in the convoy was invaluable.

The USN patrol aircraft maintained a station above and abeam the convoy offering superb visibility of the waters around the ships (Figure 104). Furthermore, the aircraft had no obstacles to impede their movement and could therefore maneuver freely above the convoy. As a result, the aircraft could observe and bring fire to bear across the entire battlefield. When the U-boat surfaced, it entered into the key terrain of the aircraft and was thus subjected to sequential depth charge attacks. Simultaneously, the U-boat was within range of the light-caliber guns placed aboard *Unicoi*. As the U-boat surfaced, it allowed Allied forces to exploit the few terrain features available to them—wide arcs of observation and fire with guns—which quickly resulted in a substantial amount of damage inflicted upon the boat.

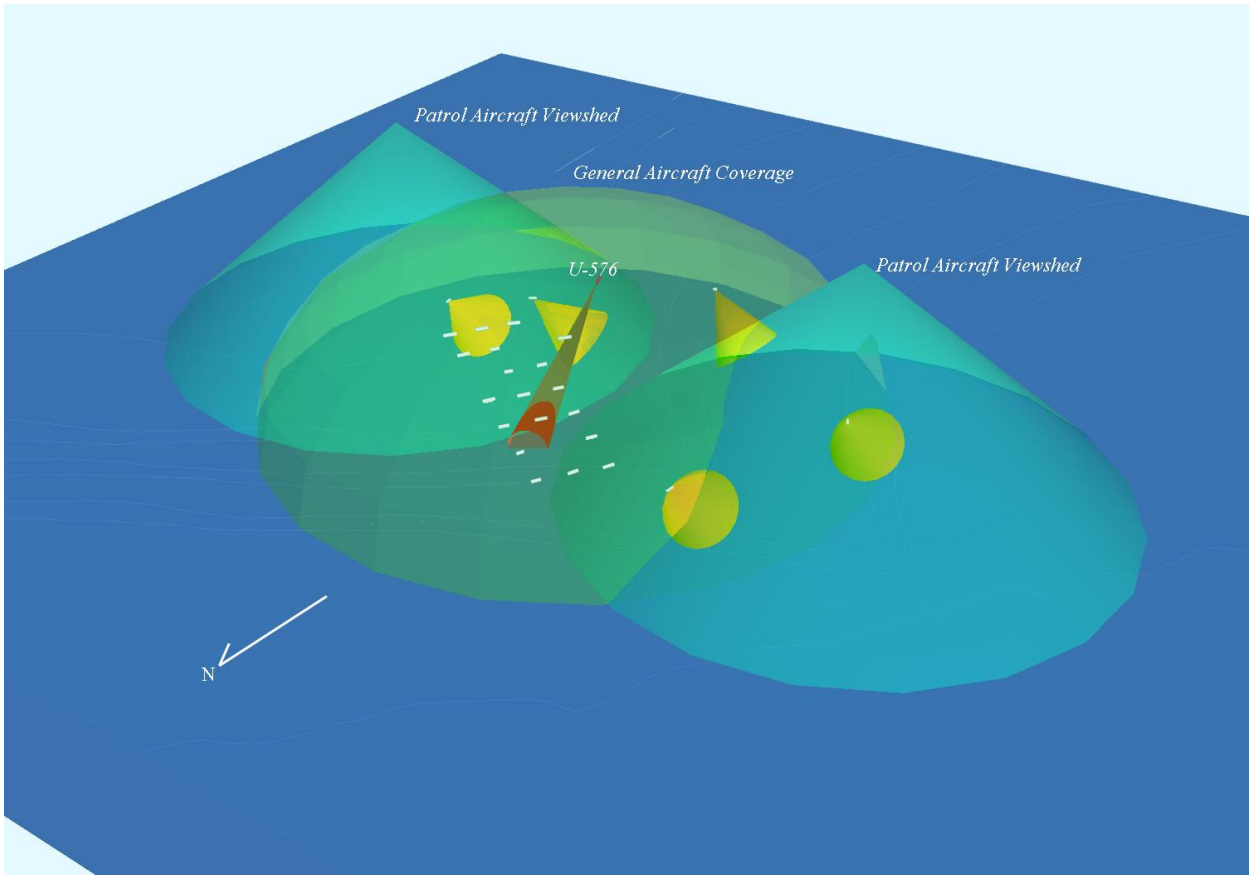

Figure 104. Patrol Station and Viewshed of USN Patrol Aircraft Around Convoy Formation. (Map by Stephen Sanchagrin).

After the attack, however, the landscape continued to confound the Allied convoy. The Hatteras Minefield, a large obstacle in the battlefield, blocked *Chilore* and *J.A. Mowinckel* in the ensuing retreat, continuing its counter-productive role in Allied strategy. After this event, the minefield had claimed a total of four Allied ships without damaging a single U-boat. Three of these casualties were a result of *U-576* attacking KS-520, and the other was tanker *F.W. Abrams*, lost a few weeks earlier. As a result of a navigation and communication failure, both *Chilore* and *J.A. Mowinckel* steamed directly into the minefield, where tug *Keshena* later struck a mine and sank during salvage operations. This resulted from the commanders aboard *J.A. Mowinckel* and USS *Spry* improperly negotiating this obstacle.

Once disabled at sea, various landscape factors immediately affect the injured forces. Wind and current would work to drive the damaged craft off station, while proximity to land and infrastructure determined the time to medical treatment and safety from the elements for sailors cast into the sea. In the case of KS-520, the attack occurred a great distance offshore. *Bluefields*

immediately sank, leaving over a dozen merchantmen adrift in the ocean. Quick action by USS *Spry* and USS *McCormick*, however, removed these men from danger and placed them safely aboard the warships. Merchantmen *Chilore* and *J.A. Mowinckel* were both severely damaged, yet each retained the ability to move under their own power. Twenty of the merchant sailors and naval gun crew aboard *J.A. Mowinckel* were injured, two of whom later perished. These damaged vessels and injured sailors needed quick extrication from the battlefield to the nearest safe anchorage: Ocracoke Island, with its two Coast Guard Stations and the Naval Section Base.

Moving slowly under their own power, escorted by USS *Spry*, these vessels departed for Hatteras Inlet. A series of miscommunications and navigation errors between the commander of USS *Spry* and the Convoy Commodore aboard *J.A. Mowinckel* resulted in the two merchant vessels mistakenly entering the Hatteras minefield. Seeing little he could do to render assistance without putting his own boat in danger, the commander of USS *Spry* left the vessels under the protection of a local Navy patrol boat and returned to the convoy. Fearing another U-boat was attacking, the merchant crews anchored and abandoned their vessels. Once in their lifeboats, they made way for Ocracoke Island. Motor lifeboats launched from the Coast Guard Stations quickly rounded up the lifeboats from the merchant vessels, bringing the stranded crews to safety. From the Naval Section Base, the injured sailors were evacuated to more advanced medical treatment facilities in Norfolk, Virginia.

In the ensuing days, a massive salvage operation was launched to remove the damaged hulks from the minefield with the intent of repairing and returning the vessels to Norfolk as well. First, the Naval Section Base dispatched minesweepers to clear mines in the vicinity of the hulks, and tugs were contracted to bring the vessels into the inlet for repairs. In the course of these salvage operations, tug *Keshena* struck a mine and sank with the loss of two crewmembers. Tug *Relief* concluded the operations, however, running the merchant vessels aground inside Hatteras Inlet for repairs. After these repairs were made, the vessels were pumped clear of water and secured for towing back to Norfolk. A series of patrol craft and tugs escorted the vessels to rendezvous offshore with ocean-going naval tugs that were to complete the towing operation back to Virginia. While underway in the approaches of the Chesapeake, however, *Chilore* capsized and sank. *J.A. Mowinckel* was the only ship to survive the attack of *U-576* and friendly fire in the minefield.

Several key generalizations result from this terrain study. During the time of the attack, a series of key shifts took place regarding the usage of key terrain. In the time leading up to the attack and in the moments of the first torpedo strikes, *U-576* commanded the terrain across the battlefield and therefore maintained surprise and initiative. Upon surfacing, however, the U-boat lost any advantage offered by the terrain, and instead allowed the superior observation and firepower of Allied surface ships and aircraft to overwhelm the vessel. In the aftermath of the attack, since the Escort Commander determined the best course of action, the landscape again offered no advantages to Allied forces. As USS *Spry* attempted to lead *J.A. Mowinckel* and *Chilore* to safety, obstacles littered the path of retreat and multiplied the damage caused by *U-576's* attack.

During the first phase, the time leading up to the attack, the convoy's approach into the battle was determined by administrative directive and was designed to reduce the danger posed by natural and military engineered obstacles, not enemy forces *per se*. This came at the cost, however, of placing ships in the key terrain of U-boats with the only protection coming from the superior firepower of armed escorts. The U-boat, on the other hand, had the advantage of choosing its particular avenue of approach, and could do so in such a way as to optimize the protection offered by an array of terrain features. Further, in the course of executing an attack, the U-boat could continue to exploit the terrain to affect a safe egress. *U-576*, however, failed to do so and therefore permited Allied vessels to take advantage of the landscape to retaliate and defeat Kplt. Heinicke.

Unfortunately, the avenue of retreat for the damaged Allied ships was equally as dismal as the myriad of landscape features already facing the convoy for it required passing through the Hatteras Minefield and risked stranding sailors offshore in the swift Gulf Stream which would carry them away from safety. Nevertheless, retreat to Ocracoke Island with the assistance of the Coast Guard and USN shore installations was critical to both extricating the vessels from danger and quickly conveying the injured men to safety. Though the convoy approached into an ambush along an assigned convoy route, the retreat of these forces was improvised, based largely on the presence of friendly forces nearby on Ocracoke Island. This was assisted by cooperative efforts between the USN and US Coast Guard. Though four sailors were lost, total loss of life was kept to a minimum by swift and skillful action.

Terrain study illuminated a great deal about the attack upon KS-520. It added further detail to the historical narrative while providing geographic locations for specific events and the movement of forces. More importantly, though, examining the events of the KS-520 from the perspective of military terrain illuminated the influence of the oceanographic landscape through which opposing forces engaged one another. Beyond merely detailing a chronological sequence of events, these insights offered some alternative suggestions to the narrative of the attack, namely Kplt. Heinicke's decision to take his boat back into combat following the aerial attack.

The perceived terrain advantages offered the U-boat were in stark contrast to the general lack of terrain advantages available to surface vessels. Since convoys were not immediately occupied with seeking and engaging enemy vessels, but rather with safely transporting necessary war material, they sought to ameliorate their perceived disadvantages through deployment of heavily armed escorts and patrol aircraft. Aircraft in particular, with their seemingly unlimited maneuverability and capacity for quickly bringing fire to bear anywhere in the battlefield compensated for the inability of surface vessels to achieve terrain advantage on the ocean's surface. In this sense, convoy and anti-submarine warfare represented a gamble on behalf of both forces. The submarine gambled against its inferior firepower and vulnerability to attack with the myriad of terrain features which offered concealment and stealth. Conversely, convoys gambled their vulnerability to surprise attack and inability to choose the time and place of combat with immensely superior firepower and combat effectiveness at the surface. During the KS-520 attack, this was a gamble *U-576* clearly lost.

In the most general sense, the previous section demonstrated how the components of KOCOA can be adapted to a marine environment. In doing so, however, differentiation was required to describe significant terrain from the point of view of forces occupying the submarine, surface, and aerial zones of the battlefield. Furthermore, it was revealed that in many cases these features are transient and situation-dependent, such as wind direction and atmospheric visibility. The ability of forces, namely the submarine and aerial combatants, to move in three dimensions considerably broadens the array of terrain features available to them. The applicability of specific terrain features, furthermore, is entirely dependent upon the type of naval forces involved. In particular, the technological characteristics of the naval craft and their weapon systems play a major role in defining significant military terrain during any given battle. For this reason,

additional adaptation may be required to apply the KOCOA principles to subsequent Battle of the Atlantic battlefield studies.

Chart Preparation and Spatial Delineation

The final phase of the battlefield survey is to package the results of the all the previous tasks into a series of standardized maps, or, in the case of the present study, charts. For the most part, components of these maps were presented individually throughout the preceding sections. The first charting task plotted the movement of combatants across the battlefield, in addition to charting defining features of the battlefield. The chart of Allied and Axis vessel movements was described and shown in the previous section, in Figure 100 and Figure 101, along with important defining features which could be cartographically represented. Several additional visualizations conveyed the other defining features, such as visibility, weather, and oceanographic features, in Figure 102, Figure 103, Figure 104, and Figure 106.

The ABPP protocol also calls for three specific spatial designations across the battlefield. These are the study area, core area, and potential National Register boundaries (Lowe 2000:23-27). Generally, designation of these areas is geared towards preservation and resource management initiatives coinciding with ABPP battlefield surveys. The study area contains all features, events, and movements along the battlefield (Figure 105). These include the natural features, the military engineering features, the artifacts, the location of the attack, the avenues of approach for both Allied and Axis forces, the retreat of allied forces, the area of rescue and salvage activity off Ocracoke Island, and the final path of retreat of *J.A. Mowinckel* and *Chilore* to Norfolk, Virginia. This area was delineated by encapsulating all these various features within a single bounded area in the battlefield GIS.

The core area was defined by the location of the attack and the distribution of Allied and Axis forces at the moment just prior to the attack of *U-576*. As the first torpedoes struck, *U-576* was converging on the convoy, ultimately entering into it. Meanwhile, as *Bluefields* sank and *Chilore* and *J.A. Mowinckel* foundered, warships rushed into the convoy to assist the merchant sailors cast into the sea from the force of the attack. Simultaneously, freighter *Unicoi* and patrol aircraft attacked the surfaced U-boat inside the convoy, hitting *U-576* with three gunshots and four depth charges. This area was previously depicted in Figure 3, Figures 102-104, discussed in the *Terrain Study* section, and shown in totality in both Figures 105 and 106

The third spatial designation required by the ABPP is a potential National Register

boundary. These areas "depict these portions of the historic battlefield landscape that continue to retain integrity as of the date of ground survey" (Lowe 2000:24). If the landscape and cultural materials within this boundary meet certain criteria, they can be set aside and preserved by United States federal and individual state authorities. According to the US National Park Service [2011], the criteria for inclusion are

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

In addition to these criteria, several additional considerations include

> **a.** A religious property deriving primary significance from architectural or artistic distinction or historical importance; or
>
> **b.** A building or structure removed from its original location but which is primarily significant for architectural value, or which is the surviving structure most importantly associated with a historic person or event; or
>
> **c.** A birthplace or grave of a historical figure of outstanding importance if there is no appropriate site or building associated with his or her productive life; or
>
> **d.** A cemetery that derives its primary importance from graves of persons of transcendent importance, from age, from distinctive design features, or from association with historic events; or
>
> **e.** A reconstructed building when accurately executed in a suitable environment and presented in a dignified manner as part of a restoration master plan, and when no other building or structure with the same association has survived; or
>
> **f.** A property primarily commemorative in intent if design, age, tradition, or symbolic value has invested it with its own exceptional significance; or
>
> **g.** A property achieving significance within the past 50 years if it is of exceptional importance.

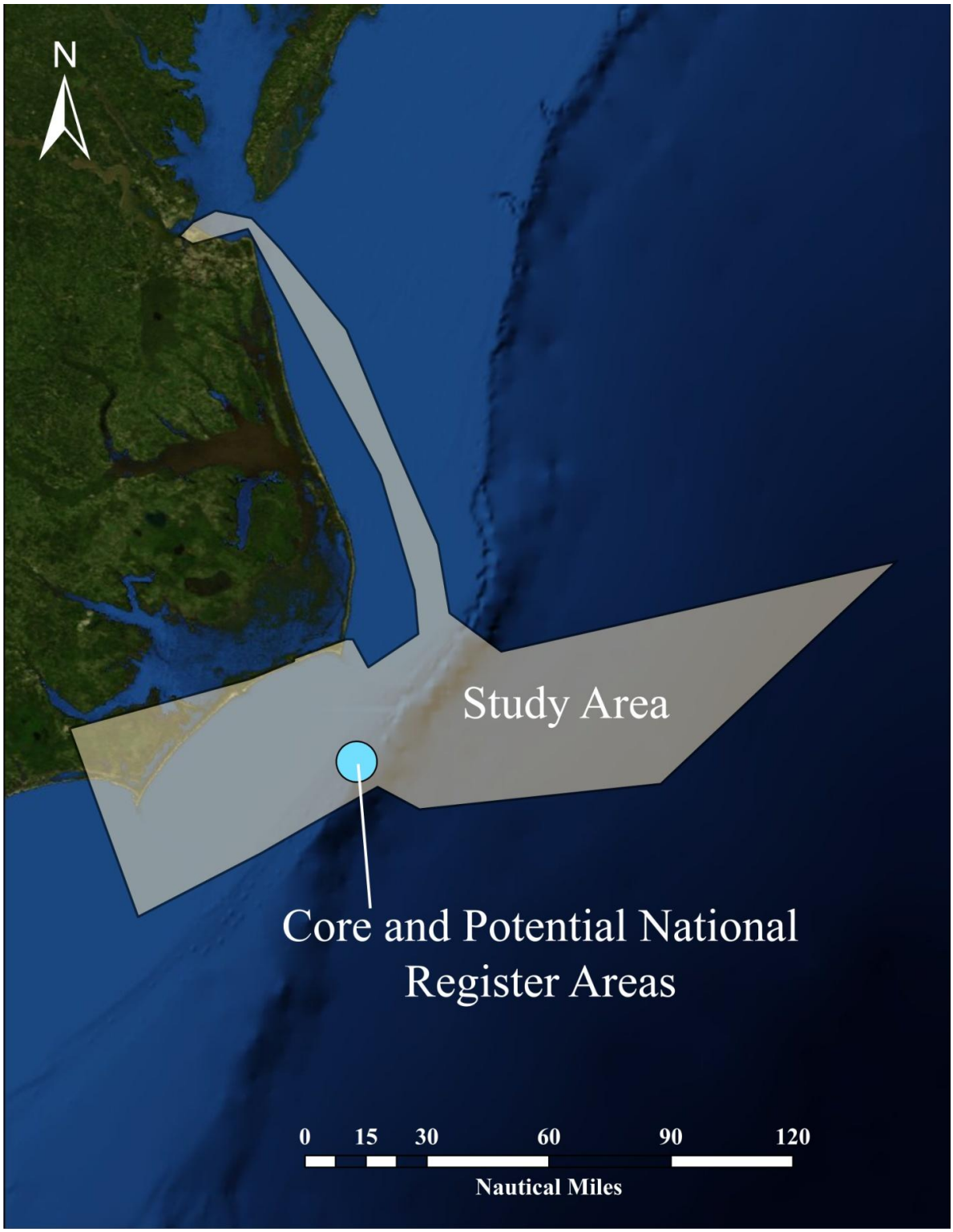

Figure 105. The KS-520 Battlefield Study Area, including the core and potential National Register areas. (Source: John Bright).

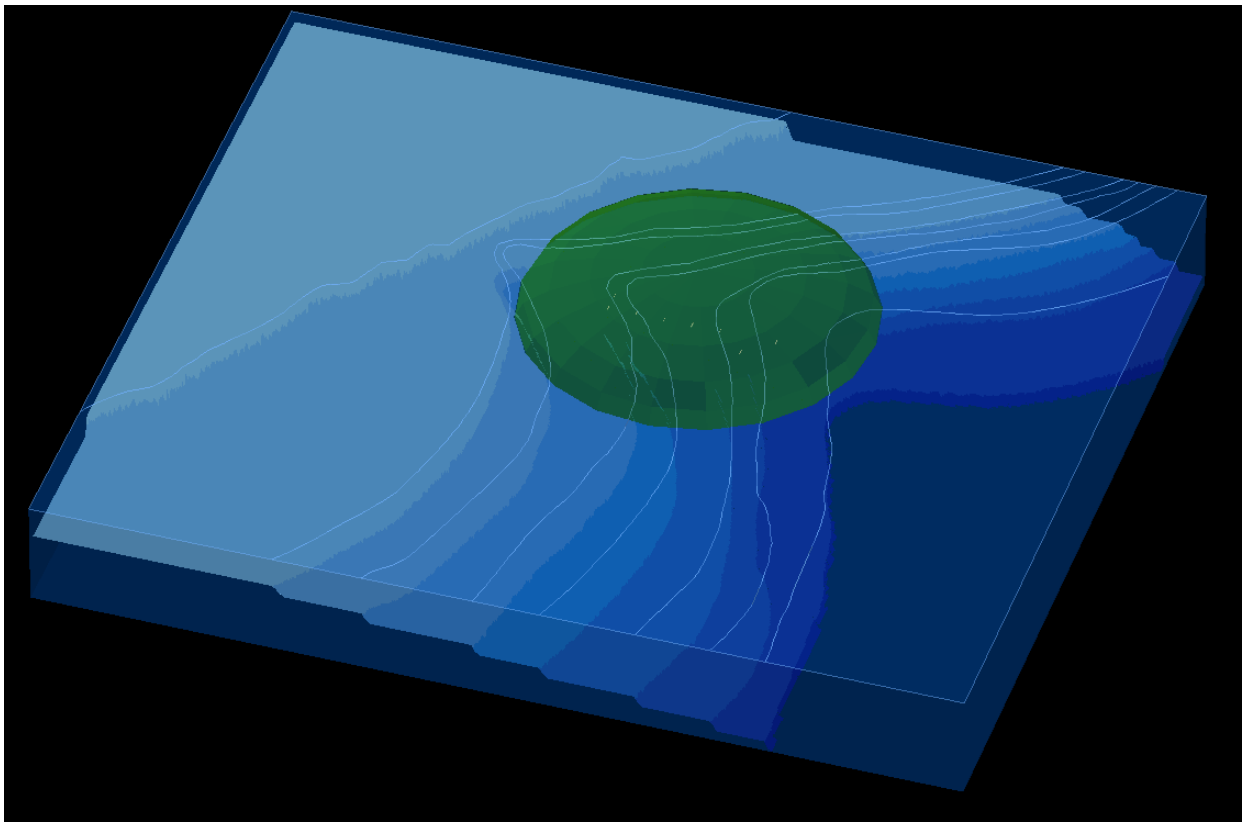

Figure 106. Alternate (isometric) view of the Core and National Register Areas of the KS-520 Battlefield as Defined by the Location of all Combatants at the Time of the Attack. (Map by Steven Sanchagrin).

In an indirect way, these criteria encourage the designation and preservation of academically significant materials. Nevertheless, these criteria are oriented more towards reinforcing nationalistic heritage themes as opposed to pursuing anthropological or archeological inquiry.

The battlefield, containing individual shipwrecks as artifacts, is most likely to satisfy aspects of the first four main criteria. Namely, the attack upon KS-520 was representative of the larger struggle occurring across the Atlantic throughout the entire Second World War. The struggle between the Allied navies and German U-boats constituted the largest, longest, and most complex naval operation in world history. Further, the success of Allied forces against the Germans was integral for Allied victory in Europe. Moreover, the shipwreck sites on the bottom of the ocean still retain their integrity as vessels of war and could be focal points for preservation efforts.

In the present study, the area which most appropriately satisfies these criteria is the Core Area. Within the Core Area are two wreck sites, those of *Bluefields* and *U-576*, each a physical representation of both opposing forces. Furthermore, these wrecks epitomize the nature of the conflict as it existed in American waters: lone U-boats stalking merchant vessels along the Eastern Seaboard. Within this area, natural features contributed to the centrality of Cape Hatteras as an area of activity: the continental shelf break; mixing ocean currents (as well as associated seawater temerature fluctuation); shoals and barrier islands; and ever-changing winds and weather. Thus, the Potential National Register Boundary is the same as that which bounds the Core Area, shown in Figures 105 and 106.

Conclusion

This survey went through a number of distinct phases. The first phase, the *Battlefield Resources* section was a data collection and organization task focused upon gathering historical sources, identifying important resources within the battlefield, and orienting oneself to the historical landscape. This generated an initial understanding of the landscape as it appeared to the combatants at the time of the battle and also of their perception of various tactical features present across this landscape. The second phase, *Battlefield Survey*, synthesized a historical narrative and order of battle from the historical sources gathered during the first phase. Next, the inventory of battlefield resources generated during the first phase was cross-referenced with this historical narrative to refine them into a list of defining features that influenced the outcome of the battle. This effectively linked the historical narrative to the actual landscape, essential for the subsequent terrain study. The theory of military terrain, articulated in the *Military Terrain* section, was applied to ground-truth and used to evaluate the historical narrative. This entailed placing specific events at specific locations, while simultaneously evaluating the validity of the accounts based upon tactical generalizations of what trained soldiers—in this case sailors—would have done in a similar situation. In the course of this analysis, the movement of combatants across the landscape was geographically represented along with defining features influencing the battle.

The first task accomplished within the ABPP survey was a comprehensive charting of static features across the battlefield. Particular emphasis was placed upon understanding the historical landscape as it appeared to combatants. In the present study, this was accomplished

through a combination of archeological survey and geospatial processing. The resulting charts detailed ship movements and the placement of military engineering features, which were super-imposed upon a myriad of natural features. In the event that historical and archaeological research did not result in locating features, geospatial processing provided statistically probable locations for these events and material remains. This served as the foundation for all other qualitative assessment.

The next task accomplished during the survey was evaluating the historical narrative of the attack. The importance of this task emanates from the fact that the historical account presented in the *Historical Background* section is the only narrative of the attack as synthesized from primary and secondary sources. Much of the primary source data consisted of locations and actions reports. Contained in the secondary sources, were various interpretations and conjectures meant to fill in the blanks left by primary sources. Historians also attempted to tease out reasons why the events unfolded as they did. By using historical, archeological, and geographical data to characterize the KS-520 battle, a more thorough and factually based account was generated to understand the various factors that influenced the engagement and aftermath.

The first step in adapting the KOCOA analysis into a mid-20th century maritime context was the terrain survey. Apparent from the outset was the need to distinguish the components of KOCOA among the submarine, surface, and airborne forces. Also apparent from the outset was the dearth of landscape 'features' available for surface forces to exploit by virtue of operating on a flat, homogenous ocean-surface. Instead, many of the terrain parameters were defined by the specifications of ship and weapon performance. Submarines and aircraft, moving in three dimensions, were designed to exploit terrain features, while surface ships experienced almost no advantage from military terrain while at sea.

Key terrain for a submarine was dependent upon a number of features, including bathymetric contours, ocean currents, water column stratigraphy, prevailing weather, and atmospheric conditions. Each of these, were situationally dependent. For patrol aircraft, key terrain exploited by achieving an ideal vantage point above the convoys. For surface ships, in the open-ocean there was no terrain from which they could achieve an advantage while engaging the enemy. Instead, emphasis was placed on superior speed and the firepower necessary to repel a submarine attack. Additionally, surface vessels were similarly influenced by prevailing weather and atmospheric conditions.

Several obstacles present across the battlefield were imposed upon submarine and surface ships alike. These include traditional natural hazards to navigation such as land, shallow water, and shoals, as well as naval-engineed obstacles such as minefields, submarine netting or blockades. Hazards to navigation have a similar effect as natural obstacles on land by diverting and re-directing combat forces. Naval-engineered obstacles, on the other hand, pose an imminent threat to the vessels that encounter them. For example, a minefield destroys a ship, whereas a terrestrial fortification may only slow the movement of terrestrial forces. Specific naval-engineered features, such as the Hatteras Minefield, also influenced water-borne forces. These obstacles did not, however, effect the operation of aircraft during the battle. While on patrol, aircraft enjoyed an almost unlimited freedom of movement across the battlefield.

Cover and concealment, as well as observation and fields of fire, were intimately linked with key terrain for the various forces. Submarines operated almost exclusively upon the principle of maintaining concealment, remaining submerged, when in the presence of enemy forces. As a result, German submarines were also configured to observe and bring fire to bear upon their enemies from cover and concealment. Submarines could also use various terrain features, such as wind direction and sea state, to enhance their concealment. Therefore, the sheer virtue of being submersible allowed German submarines to exploit these advantages and maximize the use of these two terrain principles.

Surface ships, on the other hand, had no means to achieve cover or concealment upon the surface of the ocean. No terrain feature, save fog or darkness, would prevent the enemy from spotting them once they were within line of sight. Conversely, the flat, unobstructed expanse of ocean allowed surface ships a long range of visibility over the surface of the ocean, depending upon atmospheric clarity and the height of the observer over the surface of the water. Modern gunnery, furthermore, allowed these ships to bring fire to bear in nearly any direction. Allied aircraft could achieve cover and concealment from the enemy by utilizing cloud cover or approaching from the direction of the sun, but these were dependent on prevailing conditions that were continually in flux. The freedom of movement granted aircraft, however, allowed them the optimal vantage point for observation and the ability to bring their weapons to bear anywhere across the battlefield they desired. This freedom of movement effectively endowed aircraft with unlimited control over observation and fields of fire.

The avenues of approach and retreat utilized by these forces were starkly different from those normally seen on terrestrial battlefields. Across the surface of the ocean there were no roads or built-up transportation networks in the traditional sense. Since the surface of the ocean was flat and featureless with respect to warships and merchant vessels, these ships were assigned pre-determined routes based on considerations specific to maritime movement (ocean currents, water depth, shoals, etc…) essentially creating a well-defined avenue for movement through a landscape, albeit with the unique ability to leave no physical trace upon it. Another conceptualization of an avenue of approach is the assembly of the convoy itself. The escort group and merchant vessels assemble with the specific intent of moving through these pre-determined avenues as a cohesive unit.

In convoy warfare, merchant vessels and their warship escorts did not leave port with the intention of seeking out the destruction of enemy vessels. Instead, as they moved between ports, the enemy approached them. German submarines also experienced a degree of administrative control over their movements, yet they had the latitude to determine the tactical application of their vessel as a weapon in a combat situation. Therefore, a U-boat was likely to pick the most advantageous avenue of approach and retreat for a favorable attack position, maintain concealment from the enemy, attack, and extricate itself from the area after ensuring its target was sunk.

As much as possible, the ABPP definitions of key terrain, obstacles, cover and concealment, observation and fields of fire, and avenues of approach and retreat were applied in the interpretation of the KS-520 attack. These elements account for the interactions of naval forces across an open-ocean landscape yet they fail to fully grasp the role of tactics and technology utilized by naval forces. Since surface forces had little in the way of terrain advantages, they had to utilize tactics and technology to fabricate key terrain, fields of observation, and makeshift obstacles to avoid and repel enemy U-boats. German submarine crews, on the other hand, were poised on a fine line, pitting the stealth and concealment of their vessels against the superior strength and firepower of Allied escorts. The ways in which both Allied and Axis forces utilized their strengths and attempted to overcome their weaknesses is clearly portrayed in the analysis of this convoy battle. The battle of KS-520, therefore, has proven itself a valuable historical conflict with which to evaluate the applicability of KOCOA

analysis to a maritime engagement that is represenatative of many of the convoy battles that took place during World War II.

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Appendix A: ABPP Historical Sources List

Battlefield: KS-520 Convoy Attack
Date of Conflict 15-Jul-42

Table 11. ABPP Historical Sources List for All Books, Reports, and Articles Relating to KS-520 Battlefield.

No.	Books/Reports/Articles
1	*Hitler's U-Boat War: The Hunters, 1939-1942*. By Clay Blair
2	*Hitler's U-Boat War: The Hunted, 1942-1945*. By Clay Blair
3	*A Comparative Study of the Effectiveness of German Submarine Warfare on the Eastern Seaboard of the United States in the World Wars.* By Samuel Blake
5	*Atlantic Escort: Ships, Weapons & Tactics in World War II*. By David K. Brown
6	*Naval Weapons of World War II*. By John Campbell
7	*The United States Marine Coprs Air Station Cunningham Field: Cherry Point, North Carolina.* By Gertude S. Carraway
8	*The Atlantic Turkey Shoot: U-Boats off the Outer Banks in World War II*. By James T. Cheatham
9	*The U-Boat War off the Outerbanks.* By James T. Cheatham
10	*Shipwrecks: Diving the Graveyard of the Atlantic, 2ed.* By Roderick M. Farb
11	*The Sea Wolves: The complete story of German U-boats at war.* By Wolfgang Frank
12	*US Naval Weapons: Every gun missile, mine, and toropedo used by the US Navy from 1883 to the present day.* By Norman Friedman
13	*Operation Drumbeat: The Dramatic True Story of Germany's First U-Boat Attacks Along the American Coast in World War II.* By Michael Gannon
14	*Black May: The Epic Story of the Allies' Defeat of German U-boats in May 1943.* By Michael Gannon
15	*Merchantman? Or Ship of War*. By Charles Dana Gibson
16	*Track of the Grey Wolf: U-Boat Warfare on the U.S. Eastern Seaboard 1942-1945.* By Gary Gentile
17	*Shipwrecks of North Carolina from Hatteras Inlet South.* By Gary Gentile
18	*Shipwrecks of North Carolina from the Diamond Shoals North.* By Gary Gentile
19	*The Fuhrer's U-boats in American Waters.* By Gary Gentile
20	*The Allied Convoy System1939-1945: Its Organization, Defence, and Operation*. By Arnold Hauge
21	*Torpedo Junction: U-Boat War off America's East Coast, 1942*. By Homer Hickam, Jr.
22	*U-Boats Offshore: When Hitler Struck America*. By Edwin P. Hoyt
23	*The U-boat Wars.* By Edwin P. Hoyt
24	*U-boats.* By Edwin P. Hoyt
25	*The History and Disposition of the U-701.* By Joe Hoyt
26	*The Battle of the Atlantic*. By Terry Hughes and John Costello
27	*Wolfpack: U-Boats at War 1939-1945*. By Philip Kaplan and Jack Currie
28	*Convoy: Merchant Sailors at War 1939-1945*. By Philip Kaplan and Jack Currie
29	*U-Boats Destroyed: German Submarine Losses in the World Wars.* By Paul Kemp
30	*The Battle of the Atlantic.* By Donald MacIntyre
31	*The Naval War Against Hitler*. By Donald MacIntyre
32	*U-Boats: The Illustrated History of the Raiders of the Deep.* By David Miller

33	*Military Aircraft 1919-1945: An Illustrated History of Their Impact.* Justin D. Murphy and Matthew A. McNiece
35	*Ocracoke Island: Its People, the U.S. Coast Guard and Navy Base during World War II*. By Earl W. O'Neal, Jr.
36	*Encyclopedia of North Carolina.* By William S. Powell
37	*USS* Spry. By Joe Radigan
38	*U.S. Coast Guard Cutters and Craft of World War II.* By Robert L. Scheina
39	*U-Boat Warfare: The Evolution of the Wolf Pack.* By Jak Mallmann Showell
40	*The U-Boat Century: German Submarine Warfare 1906-2006.* By Jak Mallmann Showell
41	*Graveyard of the Atlantic: Shipwrekcs of the North Carolina Coast.* By David Stick
42	*The Defeat of the German U-Boats: The Battle of the Atlantic*. By David Syrett.
43	*Waves of Carnage: A Historical, Archaeological, and Geographical Study of the Wrold War II Battle of the Atlantic in North Carolian Waters*. By John Wagner
44	*Anatomy of the Ship: The Type VII U-Boat*. By David Westwood
45	*Bitter Ocean: The Battle of the Atlantic 1939-1945.* By David Fairbank White
46	*Destroyers of World War II: An International Encyclopedia.* By M.J. Whitley
47	*U-Boat Adventures: Firsthand Accounts from World War II*. Melanie Wiggins
48	*The Battle of the Atlantic: Hitler's Gray Wolves of the Sea and the Allies' Desperate Struggle to Defeat Them.* Andrew Williams
49	*U-boat Tactics in World War II*. By Gordon Williamson
50	*The U.S. Coast Guard in World War II.* By Malcom F. Willoughby
51	*USS* Ellis. By Fred Willshaw
52	*USS* McCormick. By Fred Willshaw

Table 12. Listing of All Primary Source Material Used in the KS-520 Battlefield Analysis.

No.	Primary Source Document
54	*Kriegstagebücher, April 1942- June 1942, ONI, translator*. By B.d.U.
55	*Kriegstagebücher, July1942- September 1942, ONI, translator*. By B.d.U.
56	*Advisement of Establishment of Danger Area in the Vicinity of Cape Hatteras.* By R.W. Cary, Director of Base Maintenance Division
58	*Sailing Orders for KS-520.* From COM5
59	*Announcement of Vessels Less Than 15 Knots*. From COM5
60	*Report of* F.W. Abrams *Damaged in Hatteras Minefield.* From COM5
61	*Request to Replace Mine Protected Anchorage with Netted Anchorage at Hatteras.* From COM5
62	*Report of Attack and Rescue of* J.A. Mowinckel *and* Chilore. From COM5
63	*Report of Attack on Submarine and Submarine Attack on King Sail 520.* From ComScorn Nine
64	*Sinking Report of of M/V* Bluefields. By COM7
65	*Damage Report of* J.A. Mowinckel. By COM7
66	*S.S.* American Fisher *Armed Guard Information.* By C.C. Dalton, Office of the Fifth Naval District Port Director

67	*Admiral Doenitz Memiors: Ten Years and Twenty Days*. Grossadmiral Karl Doenitz.
68	*Eastern Sea Frontier War Diary, January to August 1942.* Edited and Published by Robert Freeman
69	*Routing Instructions, KS-520.* H.C. Fengar.
70	*German Submarine Attacks*. By LCDR H.H. Frost, USN, ONI
71	*The Defeat of the Enemy Attack on Shipping, 1939-1945: Revised Edition of the Naval Staff History Volumes 1A.* By Eric J. Grove
72	*Summary of Statements by Survivors of SS "Chilore."* Ens. E.D. Henderson, USNR
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74	*U.S. Navy at War: 1941:1945*. Fleet Admiral Ernest J. King, USN
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77	*Antisubmarine Warfare: Notes for the Use of Naval Armed Guards*. Lt. A.H. Miles, USN, ONI
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84	*USCGC* Icarus *Decklogs 1942*. USCG
85	*USCGC* Triton *Decklogs 1942*. USGC
86	*KS-520 Convoy Roster*. USN
87	*Charts of the Mined Anchorage at Cape Hatteras, North Carolina.* USN
88	*USS* Ellis *Decklogs, March 1942 to September 1942*. USN
89	*USS* McCormick *Decklogs, July 1941 to September 1942*. USN
90	*USS* Spry *Decklogs, May 1942 to October 1943*. USN
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92	*Notes on Anti-Submarine Defenses.* By. Capt. Roger Welles, USN, ONI
93	*Remarks on Submarine Warfare.* By Capt. Roger Welles, USN, ONI
94	*Remarks on Submarine Tactics Against Convoys.* By Capt. Roger Welles, USN, ONI
95	*Remarks on Protection of a Convoy by Extended Patrols.* By Capt. Roger Welles, USN, ONI
96	*German Submarines in Question and Answer.* By Capt. Roger Welles, USN, ONI
97	*Antisubmarine Tactics.* By Capt. Roger Welles, USN, ONI

Appendix B: ABPP Defining Features List

Table 13. ABPP List of Defining Features for the KS-520 Battlefield.

Battlefield: KS-520 Convoy Attack
Date of Conflict 15-Jul-42

Feature No.	Defining Feature	Feature Class	Source No.	Shown on Chart
1	Wreck: *U-576*	Artifact	1, 21, 22, 55	Figure 94
2	Wreck: *Bluefields*	Artifact	1, 21, 22, 57, 75	Figure 94
3	Wreck: *Keshena*	Artifact	1, 10, 21, 22, 57, 75	Figure 94
4	Wreck: *Chilore*	Artifact	1, 21, 22, 57, 75	Figure 94
5	Hatteras Minefield	Military Eng.	21, 22, 56, 78, 87	Figure 95
6	Diamond Shoals	Natural	42, 44	Figure 96
7	Gulf-Stream Current	Natural	42, 44	Figure 96
8	Labrador Current	Natural	42, 44	Figure 96
9	100 Fathom Curve	Natural	42, 44	Figure 68 Figure 96
10	Continental shelf slope	Natural	42, 44	Figure 96
11	Water Column	Natural	42, 44	n/a
12	Naval Section Base: Ocracoke	Military Eng.	35	Figure 95
13	USCG Station, Ocracoke Inlet	Military Eng.	35	Figure 95
14	USCG Station, Hatteras Inlet	Military Eng.	35	Figure 95
15	Cherry Point MCAS	Military Eng.	7, 63	Figure 69 Figure 95
16	Aircraft Coverage	Military Eng.	33, 63	Figure 69
16	1942 Convoy Routes	Military Eng.	44	Figure 64 Figure 95
18	Route of KS-520 into Attack	Artifact	58, 69, 84, 85, 86, 88, 89, 90	Figure 94 Figure 100
19	Route of *U-576* into Attack	Artifact	54, 55	Figure 94 Figure 101 Figure 102