2008 Battle of the Atlantic Survey Methodology

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Abstract

During the summer of 2008, the Monitor National Marine Sanctuary partnered with several federal, state and academic institutions to record the remains of three German U-Boats lost off North Carolina during WWII. The goals of this project were to gather baseline data for future monitoring and management recommendations, as well as public outreach and education. The scope of this project was limited to a Phase II non-invasive pre-disturbance survey. Most of the traditional field methodology employed on maritime archaeological sites is designed for comparatively shallow or benign environments. The nature of this project dictated that we remain within recreational dive limits and conduct non-decompression dives, as well as respect varying environmental conditions and cultural conditions. However, the work took place in a dynamic oceanic environment in a depth range of 100-120 fsw providing limited bottom time to accomplish time consuming tasks. As a result of the limitations it was impractical to use exclusively traditional archaeological recording methods. The practices on this project employed a hybridization of methodology borrowed from traditional methods, and from deep-water survey methods in standard use at other sites in the National Marine Sanctuary System. This paper describes the diving and archaeological methods used and hopes to stimulate discussion that could lead refining these practices.

Keywords: in situ preservation, liveboating, National Marine Sanctuaries, NOAA, North Carolina, photomosaic, shipwrecks, U-boats, U-352, U-701, U-85

Research Design

During the project planning phase, the authors of this report generated a research design. The purpose of this document was to organize thoughts, propose research questions, structure methodology, provide a background history, outline personnel roles, and serve as a general guide for operations during the course of the fieldwork. The research design identified several goals and questions to be addressed during the investigation. The goals proposed included:

1) Assess the historical significance and archaeological integrity of each individual site;
2) Determine if resources were eligible for nomination to the National Register of Historic Places;
3) Identify to what degree is site preservation influenced by environmental formation processes and cultural impact;
4) Determine whether or not the sites warrant further investigation;
5) Complete a thorough exterior survey of each site and artifact inventory;
6) Produce a site map of each site for interpretation and as a representation of baseline data for use in follow-up inquiry and future monitoring at the sites; and
7) Complete detailed video and photographic surveys of the sites.

In order to answer these questions, the survey goals were designed to recover data that would identify the sites, and contribute to their nomination to the National Register of Historic Places. Only through
site documentation and the recording of diagnostic features and artifacts can the nomination process be completed.

**Scope and Limitations**

Production of the research design was essential to provide detailed boundaries for the scope of the project. This project was designed to be a completely comprehensive investigation, and should be viewed as a preliminary baseline assessment, upon which future research can be founded. Without this baseline information it is difficult to know what questions to ask because the resource is generally undefined until this type of survey is completed. So the questions posed in this project are of a general nature with the intent to provide a more solid basis for formulated advanced questions.

The location of each site posed several limitations on efficiency. Accessing each site required anywhere between 15 and 40 miles transit offshore of North Carolina. This consumed a great deal of time getting to and from the sites, but it also meant that the sites were in locations that could only be accessed in mild weather conditions. As conditions off North Carolina vary, predicted days of inactivity were built-in and personnel spent time processing data sets during this time.

Additionally, the sites location also posed limitations underwater. High and variable currents were present, particularly at the site of the U-701, and visibility varied from zero to more than one hundred feet. These factors produced differing degrees of in-water efficiency from day-to-day. Furthermore, the depth of the sites, ranging from 90-115 ft deep, greatly limited the amount time that could be spent on site each day.

The sites being designated as war graves also presented some limitations that were meticulously observed. Chief among these was the inability to penetrate the site to complete an artifact inventory of the hull's contents. This limited the survey to exterior observations only. In addition, the research team did not conduct any exterior work that would impact or disturb the site in any way. This precluded sampling of ferrous materials, establishing permanent baselines or removing or manipulating anything onsite.

**Fieldwork Schedule**

The field component of the survey was conducted over a twenty day period from July 6 through July 26, 2008. This time was selected to take advantage of optimal conditions in diving off North Carolina. The distance between the sites necessitated two distinct legs of the project, based out of different locations.

The U-352, is located off of Cape Lookout and is most accessible from Beaufort Inlet. To facilitate easy access, the first portion of the project was based in the Morehead City/Beaufort, North Carolina area. From July 6 through 11 the fieldwork focused exclusively on the site of the U-352. Researchers were headquartered at the University of North Carolina's Institute for Marine Science. Our dive platform was the 41 foot R/V *Hildebrand* supplied by NOAA's National Center for Coastal and Ocean Science in Beaufort, North Carolina. As a result of inclement weather, only three of the planned five survey days allowed us to get on site. Fortunately, as some poor weather days were expected, the critical components of the survey were able to be completed. For the second leg of the fieldwork operations were moved to the Nags Head, North Carolina on the Northern Outer Banks. At this point the team also switched dive platforms, utilizing a 32 foot RIB, the R/V *Sam Gray* of Gray's Reef National Marine Sanctuary, and a new National Marine Sanctuaries 41 foot catamaran.
The vessels were kept at the Oregon Inlet United Sates Coast Guard Station. Operating out of Oregon Inlet provided us with the ability to access both the U-85 and the U-701. As the U-701 was located near Diamond Shoals, the weather conditions had to be ideal to access that site. Though it was farther to the site from Oregon Inlet than from Hatteras Inlet, it was decided that operating out of Oregon Inlet would provide the team with the ability to access the U-85 easily and to access the U-701 only when weather permitted, thus not dedicating a block of time which only afforded the ability to access the U-701. From July 12-26 the team focused alternately on the U-85 and U-701 depending on environmental variability. Using this model minimized the days we were inoperable due to weather.

**Personnel and Equipment**

The overall project was planned and conducted by the NOAA, Office of National Marine Sanctuaries Maritime Heritage Program, the Monitor National Marine Sanctuary, and East Carolina University. East Carolina University provided dive support and supplemental survey equipment.

Equipment used included traditional survey instruments such as fiberglass measuring tapes, slates, mylar sheets, clinometers, and straight edge scales. These instruments were used to recover detailed measurements of the plan and the data was later transferred to a master site plan. Photographic and videographic data was recovered using a range of instruments.

Field project personnel were divided into four teams dependent on their tasks and responsibilities during the field survey and subsequent post-field summation and report. The four teams were designated Alpha, Bravo, Charlie and Delta.

Team Alpha: Responsibilities included photo-mosaic surveys, still photography, site mapping, reports, National Register nomination, and overall project coordination. Alpha members included Tane Casserley, Nathan Richards, Joe Hoyt, Dave Alberg and Bruce Terrell.

Team Bravo: Responsibilities included on-scene site mapping and documentation, and generating site plans. Bravo members included Dave Ball and John Wagner.

Team Charlie: Responsibilities included high-definition video, still photography, development of education and outreach products, and coordination with media/web team and education personnel. Charlie team members included John McCord, Shannon Ricles, Lauren Heeseman and Jeff Johnston.

Team Delta: Responsibilities included diving medical support, diving support, stand-by diver and boat support. Delta team members included Dr. Craig Cook, Steve Sellers, Chad Meckley, Todd Recicar, Roger Mays and Chad Smith.

**Site Location and Environment**

All of the German U-boats included in this study lie off the coast of North Carolina's Outer Banks in an area commonly known as the Graveyard of the Atlantic (Figure 1). All three U-boats, the U-352, U-701, and U-85 lie outside of North Carolina state waters, but within 24 nautical miles of shore in federally controlled waters and are therefore all subject to the 2004 Sunken Military Craft Act.

While position data is freely available in many formats, these are presented in degrees-decimals-minutes and are based on the WGS84 datum.

U-352: Located at coordinates N34°13.67' W76°33.89' approximately 24 miles off the coast of Morehead City, NC. The extent of the wreck scatter is confined to an area within a 100-m radius of this point.
U-701: Located at coordinates N35°14.330’/W75°06.690’, approximately 22 miles off the coast of Buxton, NC. The extent of the wreck scatter is confined to an area within a 100-m radius of this point.

U-85: Located at coordinates N35°54.810’/W75°17.215’, approximately 14 miles off the coast of Nags Head, NC. The extent of the wreck scatter is confined to an area within a 100-m radius of this point.

Each site lies in a dynamically different environment. The waters off North Carolina, Cape Hatteras in particular, are an interface for two major oceanic currents. Coming down from the north are cold waters of the Labrador Current. From the south flows the warm waters of the Gulf Stream. The two currents carry with them different properties and support very different ecosystems. The position of the three U-boat sites is such that each lies within a distinct part of this interface (Figure 2).

The U-85 is most influenced by the Labrador Current and is not directly impacted by the Gulf Stream. U-352, the most southerly of the sites investigated, is just on the edge of the Gulf Stream in an area of relatively consistent conditions. The U-701 lies in a highly dynamic area where the Gulf Stream and the Labrador collide. This creates a high degree of variability in currents and has a noticeable effect on shifting sands, creating deep scours and deposits which shift continually. This is believed to cause periods of time when the site is buried and then uncovered.

Figure 1. Depiction of the site locations in relationship to North Carolina and the continental shelf.
Sea life at the sites of U-352 and U-701 was prolific and typical of a sub-tropical marine ecosystem. The wreckage of these sites has become an artificial reef, providing habitat for a variety of organisms in an otherwise barren sandy bottom. The site is heavily encrusted with coralline algae and supports an array of sessile colonial cnidarians. On the site of the U-352, the density of *Hemanthias vivanus*, commonly called red barbier baitfish, was such that it often hindered photographic documentation. A similar problem with the density of amberjack (*Seriola dumerili*) was present on the U-701.

As this is a preliminary survey, only a general description of the sites environment is presented. Depending on future management strategies, it may be valuable to establish more concrete scientific descriptions of the environment and ecosystems present at each site. Water quality and characteristics at each site would aid in the study of corrosion potential and help researchers understand more accurately site formation processes acting on these sites. Given their location in three dynamic areas offshore, close temporal association at the time of deposition, and nearly identical construction, these sites provide a rare opportunity for better understanding environmental impacts on submerged cultural heritage in North Carolina. Additionally, a comprehensive assessment of living resources on the sites will allow the sites to be treated as holistic resources in any future management decisions.

**Diving Procedure and Conditions**

All diving was conducted using open-circuit scuba equipment and utilized live-boat diving procedures. All dive equipment and breathing gasses conformed to NOAA Dive Program standards. The breathing gas used was a nitrox mixture of 32% oxygen. All dives conducted stayed within recreational limits and were strictly non-decompression. The dive teams conducted no more than two
dives per day. Due to the non-invasive methodology of the site survey, the research vessel did not anchor on the site. Live-boating allowed access to the site without impacting it in any way. A small buoy was deployed at each site's coordinates and was used to visually reference to the site's location on the surface, gauge the current's speed and direction, and act as a visual reference for the divers upon descent. The research vessel deployed divers as a group up current of the buoy and the divers would free-drift to the wreck site on the sea floor.

Current on the sites could be unpredictable, which complicated live boating. On occasion the research team encountered layered currents, where a surface current was going one direction, while the current on the bottom or in the middle of the water column moved in another. Upon reaching the bottom, divers were instructed to look for the site for no more than one minute. If the site could not be located in that time, a designated diver would deploy a lift bag which would be visible to the boat crew. The dive team could ascend safely on this line with the assurance that the boat was aware of their location. This procedure also allowed the redeployment of divers in the rare case of a missed descent.

After work was completed at the end of each dive, the team would begin their ascent as a group and inflate and deploy a lift bag attached to a line reel to indicate the divers' location to the research vessel and that the divers have begun their ascent. All divers left the bottom as a group and ascended as a group. When necessary, a buddy team occasionally left the bottom earlier than the planned bottom time, after communicating their intent to ascend to the rest of the dive team. In these instances, that buddy team would become their own independent dive team and inflate and deploy a lift bag to indicate their ascent and location to the research vessel, and begin their ascent.

The diving conditions were distinctly different at each site, and varied daily at each site. On the U-352, conditions were the most benign. Though some moderate current was occasionally present, it was negligible and did not interfere with underwater work. The maximum depth encountered was 115 fsw. Water temperature during the time we were present was ranged from 74-76ºF. Visibility was variable. On one day there was over 100 ft of horizontal visibility, while on other days it was as low as 30 ft.

On the U-701, diving conditions varied widely. Temperature was consistently in the 70+ºF range, however current and visibility fluctuated greatly. Currents experienced on site were from a moderate flow which remained constant through the water column at approximately one-half knot, up to 3-4 knots and moving in alternate directions at different depths. The strength and direction of current could not be ascertained until the site was reached, and in some cases it was difficult to determine until divers were deployed. If the surface current was negligible there could still be a significant bottom current. The only indicator of subsurface current conditions was the use of a drop line. The general practice was to observe a shot-line to see the affect the current had. In some cases the buoy could be completely pulled under by the force of the current, in which case diving operations would be postponed. Visibility on site ranged from over 100 feet down to near zero.

Conditions at the U-85 were very different. Being located North of Cape Hatteras, the site is influenced predominantly by the Labrador current. As such, the water is much cooler and ranged from the high 50sºF to low 60sºF. Current at this site was negligible during the duration of our project. However, visibility on this site was of much poorer quality. On average the visibility was less than 10 feet and approached near zero within a few feet off the bottom sediment. This made photographic and video documentation challenging, but did not hinder traditional survey techniques. Towards the end of the project, visibility cleared somewhat and the best visibility observed on site was approximately 40-50 ft.
Archaeological Methodology

The archaeological methodology consisted primarily of documenting the sites by generating detailed site plans, photo-mosaics, recording diagnostic hull features, intensive video and photo documentation, and documentation of ordnance and artifacts in situ. Due to the sites' dynamic environment and the nature of this non-invasive survey, permanent baselines were not established at the sites, though temporary tapes were carefully installed by non-invasive means. Most measurements were taken from known structural features on the U-boats' intact pressure hull, conning tower, deck gun, hatches, and exhaust systems and then compared to historic engineering plans from the U-boats' original construction. Given constraints of bottom time at depth and the duration of the project, a hybridization of methods was used to generate the site plans. A combination of video, scaled drawings, original design plans, and scale photographs were combined to generate a detailed exterior survey of each wreck site.

Divers were assigned specific sections along the hull aft and forward of the conning tower to document, which were then compiled to create an overall site plan. Simultaneous with the site mapping, a photographic/video survey was conducted to create photo-mosaics, document artifacts, ordnance, and diagnostic features of the site. The photographic/video documentation includes the outer hull structure, diagnostic structural features such as the conning tower, deck gun, hatches, and torpedo tubes, any damage or degradation to the hull structure, as well as artifacts and ordnance in situ. At no point during the survey was the hull structure or any feature of the wreck sites altered. The U-boat wreck sites were respected as war graves and survey team members did not penetrate the hull or disturb the sites in any way.

All survey goals were designed to recover data that will document the U-boat sites, augment their historical significance, and enhance their nomination to the National Register of Historic Places. The methodology followed on the project to accomplish these goals is outlined as follow:

In-Water Documentation

1. Document the U-boat sites by generating detailed site plans and recording diagnostic features:
   a) Identify and record diagnostic structural features such as deck machinery, hatches and torpedo tubes;
   b) Identify and record hull damage due to the sinking event;
   c) Identify and record hull damage caused to the U-boats post-sinking due to natural and/or man-made causes;
   d) Identify and record all exposed artifacts within the sites immediate vicinity;
   e) Identify, record and determine the extent of hazardous material and ordnance remaining on the site while maintaining all safety protocols.

2. Create scaled photo-mosaics of the U-boat sites by generating plan and profile photo-mosaics and supplement with hull measurements:
   a) Conduct plan view photo-mosaic survey by video documenting sites using the photo-mosaic sled as a platform coupled with digital sonar to maintain a minimum of 30 ft above the subject;
   b) Conduct profile and oblique photo-mosaic surveys by video documenting sites using the photo-mosaic sled as a platform coupled with digital sonar to hold a constant distance from the U-boats and depth gauge to hold a constant depth while moving from bow to stern;
   c) Combine photo-mosaic data with the diver generated site plans.
3. Intensive video and photo documentation of the hull and diagnostic features:
   a) Video/Photograph hull and diagnostic hull features from all angles;
   b) Video/Photograph diagnostic artifacts from all angles with scaling device.

4. Identify and document areas on the U-boats to monitor hull and structural degradation over time:
   a) Select features on the U-boat's bow, amidships, and stern that would best illustrate hull and structural degradation over time;
   b) Document the extent of the features degradation;
   c) Clearly identify the features on the site plans for future reference;
   d) Document the U-boat's list on the sea floor by calculating the degree of angle with a clinometer to determine the current pitch and roll of the hull.

5. Document artifacts, any hazardous material, and ordnance in situ showing their spatial relationships viz a viz the rest of the shipwreck:
   a) Video, measure and record exposed artifacts, hazardous material, and ordnance in situ, and their relation to the rest of the site;
   b) Identify artifacts with diagnostic features and makers' marks.

Assessment

1. Identify the U-boats and make recommendations for future management:
   a) Identify U-boat name and type;
   b) Assess if historical accounts coincide with archaeological interpretations;
   c) Assess whether additional fieldwork is needed;
   d) Nominate the site to the National Register of Historic Places;
   e) Make suggestions for public interpretation.

2. Determine if remaining artifacts are threatened and/or have historical significance:
   a) Identify artifacts of historical significance or unique type;
   b) Identify artifacts of duplicative objects;
   c) Evaluate danger to artifacts if left undisturbed.

3. Determine if there are environmental hazards or ordnance remaining at the sites and make recommendations for their possible removal or neutralization:
   a) Identify environmental hazards at the site and contact the appropriate federal government oversight agency (i.e. U.S. Coast Guard);
   b) Identify ordnance at the site and contact the U.S. Navy, German Consulate and NOAA General Consul;
   c) Make recommendations for the possible removal or neutralization of any environmental hazards or ordnance that balances public safety with preserving the historical significance and integrity of the site.

4. Determine the site stability and integrity of each U-boat and make recommendations for its long term preservation:
   a) Assess site damage and determine if it was caused by the sinking event or post-sinking;
   b) Evaluate post-sinking hull damage/alterations and determine causes based on environmental and cultural considerations;
   c) Evaluate long-term hull integrity and make recommendations for site preservation.

In planning for factors beyond control (e.g., inclement weather, equipment breakdown, personal illness, poor visibility on the site, etc.) the task list was designed to provide flexibility and
adaptability. Dive tasks could require a single dive or multiple dives, but each task related to a discrete objective. The tasks were prioritized, and some tasks could not be conducted until others had been completed.

Operating within the conditions outlined above the archaeological investigation of these sites was undertaken. These environmental parameters established the conditions that were encountered on site and had an impact on the work conducted. The diving procedure also governed the scope and practicality of each goal set forth. Ultimately the research questions and goals in tandem with these other limitations and conditions guided the project. These conditions are important to understand in order to be able to recreate these conditions if the same parameters are to be used for future projects. Having knowable conditions is essential for creating comparative products, and will aid in potential long term monitoring of the site.