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Searching for *Bonhomme Richard*, Flagship of John Paul Jones

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There are few ships of the Revolutionary War which hold as high a degree of historic significance as *Bonhomme Richard*, commanded by American naval hero John Paul Jones. *Bonhomme Richard* (Figure 1) had been lent to the U.S. by France and was named in honor of Jones' friend Benjamin Franklin, who at that time represented America in France and was instrumental in acquiring the ship. On September 23, 1779, Jones engaged the British ship HMS *Serapis* in one of the most memorable battles in U.S. Naval History. It was during this three and a half hour fight, most of it taking place at point blank range, that Jones shouted his legendary words, "I have not yet begun to fight!" Ultimately, he emerged victorious and took control of *Serapis*. Although *Bonhomme Richard* had served him well, Jones watched his ship disappear beneath the waters of the North Sea 36 hours later, succumbing to the wounds of the battle. Jones' victory was a turning point in the Revolutionary War because it showed the world that the young Continental Navy was a formidable force, and

Figure 1. *Bonhomme Richard*. (William Gilkerson)

strengthened vital French support for the war. Locating the remains of this warship would rekindle public enthusiasm for America's naval heritage, allow for further studies on the construction of Revolutionary War vessels, and present the only means for interpreting the lives of *Bonhomme Richard*'s crew members, of which little is known.

Project Background

A collaborative search for *Bonhomme Richard* began in 2005. The Ocean Technology Foundation (OTF), a small non-profit organization, partnered with the Naval Historical Center, known today as the Naval History and Heritage Command (NHHC), to launch a multi-year effort in search of the shipwreck. Locating and identifying *Bonhomme Richard* would memorialize Jones's great accomplishments, do great service for U.S. Naval history and rekindle public enthusiasm for America's rich naval heritage. The project objectives are the following:

- Produce a Geographic Information Systems (GIS) map and database of potentially significant cultural resources, surface geologic features, and distribution of bottom sediments in the project area.
- Create a computerized drift model which synthesizes all of the historical data collected.
- Interpret and prioritize individual magnetic anomalies, anomaly complexes, and acoustic targets according to potential cultural significance and association to *Bonhomme Richard*.

- Promote awareness and appreciation in students, educators and the public of Captain John Paul Jones, the Battle of Flamborough Head, and the historical significance of the battle.

During the first year of the project (2005) the OTF created the appropriate project team, which represented a combination of industry, academia, and government. In addition to the NHHC, the team included JMS Naval Architects and Salvage Engineers, a firm that had experience in naval architecture and hydrodynamic modeling, and faculty and students at the Center for Coastal and Ocean Mapping at the University of New Hampshire, who created a Geographic Information System (GIS) map that allowed for viewing the locations and information about other shipwrecks in the survey area. The team also included independent historian Peter Reaveley, who is considered an expert on the battle between *Bonhomme Richard* and *Serapis*, and who had conducted extensive research on the events leading up to *Bonhomme Richard* 's sinking.

Historical Research

During more than thirty years of research, Reaveley has performed numerous literature searches, and combed archives and technical libraries around the world to identify all available data relating to the vessel's construction, operations, and loss. This data includes more than 30 eyewitness accounts of the battle, all available information on weather, winds, visibility, tides, and sea-state up to and at the time of sinking, damage assessments of *Bonhomme Richard* and *Serapis*, hourly accounts of the crew's actions, hourly plots of the most probable position up to the time of sinking, and a detailed summary of *Bonhomme Richard's* ballast mound. Building on this information, faculty members at the U.S. Naval Academy have developed a computerized model that examines the hydrodynamic drift pattern of *Bonhomme Richard* after the battle and until its sinking (Guth, 2009).

Where History Meets Technology: Geographic Information System Mapping

The events that transpired from the end of the battle until *Bonhomme Richard*'s sinking 36 hours later are critical to tracking the vessel's route, and ultimately locating its final resting place. A comprehensive Geographic Information System (GIS) map was created to visualize the project data geographically. Information on individual shipwrecks and reported obstructions off the coast of the United Kingdom was obtained through the U.K. Hydrographic Office (UKHO) Wrecks Information service, and was plotted in the GIS database. Each entry was hyperlinked to an information sheet which included the wreck's location, water depth, scour, debris field, sonar contact length, surveying details, and general comments. The majority of these wrecks have been

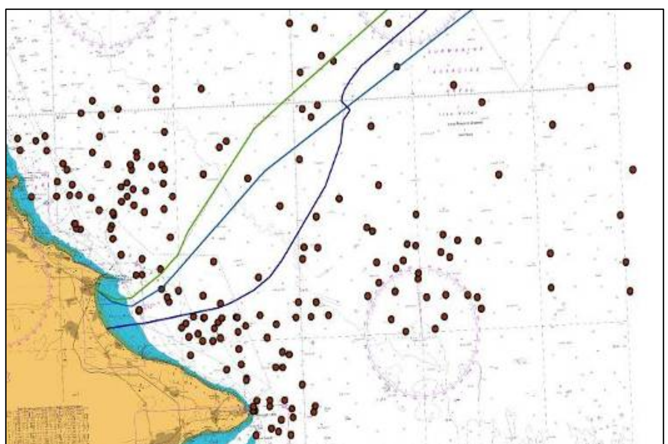

Figure 2. Representative data layers in the GIS map. Individual points depict shipwreck locations, and linear features indicate pipelines. (Ocean Technology Foundation)

identified, but for some, very little information exists. The database also includes information on seabed composition and topography, pipelines, wellheads, previous search areas, and contacts derived from previous surveys (Figure 2).

This GIS resource raised survey efficiency by allowing the search team to bypass known wrecks and closely examine unidentified ones. The boundaries of the survey area were also entered into the map, which allowed the area to be correlated with locations of known wrecks and other data such as the historic sightings of Jones' squadron. The map is a constantly evolving product intended to establish new protocols for integrating GIS and historical information into marine archaeological surveying.

Although it is likely that as an archaeological resource, various environmental and human factors (e.g. fishing), past and present, have impacted *Bonhomme Richard*'s site integrity, its discovery would nonetheless prove a significant contribution to the maritime heritage of England, France and the United States.

The research methodology alone is justification for continuing investigations into *Bonhomme Richard*'s battle with *Serapis* and its subsequent loss. The synthesis of archival and historical research with modern geophysical survey data into a GIS, along with the hydrodynamic drift modeling, illustrates a newly adopted scientific approach to archaeological investigations and site significance assessments. Project partners are using advanced GIS spatial modeling and analysis tools to derive new information about the Battle of Flamborough Head and *Bonhomme Richard*'s final resting place in the North Sea.

What Remains of *Bonhomme Richard*?

The preservation of *Bonhomme Richard* is anticipated to be dependent upon the immediate environment and geology where the wreck came to rest. In 200 feet of water the wreckage may be better preserved than shipwrecks located inshore, and if buried deeply in the sediment the hull and artifacts could have degraded little. However, if the wreck rests on a hard sea bottom, all that may be preserved is the ballast mound with the hull underneath and iron cannon and ordnance scattered over the top of the mound. In such a case, trawling may have scattered some of the wreckage, creating a debris field around the ballast mound. *Bonhomme Richard*'s ballast was primarily iron kentledge (pig iron or scrap metal) and should be distinctive, as should the 9-, 12- and 18-pound cannon. The ship's construction included the use of iron knees (instead of wood), an uncommon feature exceptional to *Bonhomme Richard*. The size of frames and other hull timbers and the pattern of framing will also prove useful in identification. It is likely that no single feature alone will positively identify the vessel but taken together, several characteristics can indicate a strong likelihood of a positive identification.

The Tools at Hand

While marine archaeologists often utilize qualified divers to conduct visual surveys and assess archaeological sites, in recent decades the field has borrowed tools from other marine sciences that make searching for sites in large areas more efficient, and searching in deeper waters possible. Such tools include the side-scan sonar, the multi-beam echo sounder, the magnetometer, the remotely-operated vehicle, and the autonomous underwater vehicle.

Side-scan Sonar

Side-scan sonar technology uses an acoustic beam emitted from a tow vehicle, a small instrument which, as its name implies, is towed behind the vessel. The acoustic beam pulses out at a right angle from the direction it is being towed in (straight down), concentrated in a narrow band on both sides of the tow vehicle. The topography of the ocean floor and any foreign objects that may be present reflect part of the signal back to hydrophones, or receivers, located on the tow vehicle. In turn, the signals are sent to the ship for amplification and processing, resulting in an image that shows the strength of the returned acoustic signal over the area that was scanned (DOSITS 2004c;2004d). The resolution of a side-scan system is mainly governed by the shape of the acoustic beams and the length of the transmitted pulse (Jones 1999:40). As with the multibeam echo sounder examined below, a skilled eye is required in order to be able to distinguish rock from artifact.

Multibeam Echo Sounder

The multibeam echo sounder system is an advanced version of the single beam echo sounder system, commonly used to record depths. In the echo sounder system a transducer, usually mounted on the hull of a vessel, sends sound pulses perpendicularly through the water. The sound reflects off the seafloor and returns to the transducer. The time it takes the sound pulse to return is used to calculate the distance to the seafloor (DOSITS 2004a). The faster the sound pulses return to the transducer, the shallower the water depth is and the higher the elevation of the sea floor. The sound pulses are sent out regularly as the ship moves along the surface, which produces a line showing the depth of the ocean beneath the ship.

In the case of a multibeam echo sounder, a single system can have hundreds of transducers. These are arranged in precise geometrical patters and send out a swath of sound that covers a distance on either side of the ship equal to multiple times the depth (DOSITS 2004b). All of the signals that are sent out reach the seafloor at different angles and return at slightly different times, which allows for the possibility of mapping in three dimensions. As the difference in the time it takes for each of the pulses to return is minute, the water sound velocity for a given area needs to known. Thus the multibeam data is calibrated using environmental data recovered from a sound probe. These environmental factors include temperature, salinity and pressure/depth, all of which can affect the speed of sound (Jones 1999:32-34). The result of the calibration is high-resolution bathymetry data throughout the survey area, providing full coverage of the sea floor. With this system, a traveling ship can produce a swath, rather than a line, of water-depth information (WHOI 2004). Systems need to compensate for pitch and roll (the movements of a boat and hence the transducers due to water conditions) (Kongsberg 2004b). Besides three-dimensional mapping of seabed morphology, which requires a certain degree of interpolation, multibeam systems may also represent data in real time as 'backscatter image', similar to sonograms produced by side-scan sonar systems. Naturally, the relatively flat seafloor of the North Sea is a great benefit as anything protruding from the surface will most likely be detected.

Magnetometer

A magnetometer is a scientific instrument used to measure the strength and direction of magnetic fields. In archaeological contexts, it is used to locate ferrous-containing objects. These instruments, which can employ numerous different technologies, are capable of measuring the external magnetic field detected by theirs sensor with great accuracy. Through these precise measurements, any anomalies in the magnetic field can be detected and usually signify the presence of a ferrous-containing object. Magnetometer swaths are usually significantly narrower than side-scan or multibeam echo sounder swaths. At the same time, given certain conditions such as close proximity to the sea floor, cesium magnetometers are capable of detecting objects that contain as little as 1 ounce of iron (Geometrics 2004), although this also depends on the density and shape of an object. Although it takes longer to cover a particular area with this method, it is the only one employed in the project that is capable of 'seeing' under a sandy bottom. Magnetometers are not very effective in rocky areas as iron in the rocks may disrupt readings.

Remotely Operated Vehicles & Autonomous Underwater Vehicles

A remotely operated vehicle (ROV) is deployed off a platform such as a ship and is controlled remotely via tether. ROVs usually carry their own lights and may also carry remote sensing capabilities, such as a multibeam echo sounder, side-scan sonar or sub-bottom profiler. In addition, they are capable of sending a live video feed back to the platform, as well as acquiring high quality digital still images. A tool often used in reconnaissance operations, ROVs also carry navigation aids such as sector-scanning sonars so that in limited visibility a pilot can still receive information regarding what lies in front of the ROV.

An autonomous underwater vehicle (AUV) often carries similar equipment to ROVs, but is characterized by the fact that the vehicle remains tether-less and is not guided in real-time. Instead, the vehicle is pre-programmed to follow a certain path and collect certain types of data without human intervention. Once the assigned task is complete, the vehicle surfaces at a pre-determined location where scientists can retrieve it. Less platform and weather dependent than an ROV, AUVs offer the benefit of covering large areas, but are limited in their operation by the available batteries on board, given that their energy source needs to be self-contained.

Each of the Bonhomme Richard surveys employed an assortment of tools geared towards accomplishing the missions of each year's expedition.

Expedition 2006

The first expedition took place in 2006 and was a three-week survey utilizing side scan sonar and a magnetometer. NOAA's Office of Ocean Exploration provided some funding support for this mission, and the remainder was raised privately by the Ocean Technology Foundation.

As a result of this survey, four priority shipwreck sites, or targets, were identified which warranted closer investigation during a subsequent expedition. The targets were prioritized based on their size, shape, and magnetic signatures, and appeared to be shipwrecks and/or man-made. Only one of the targets did not appear in the UKHO wreck database. The other targets were in the database, but little or no information was known about them. All were worthy of investigation in that they may have been wrecks of historical significance to Britain's or another

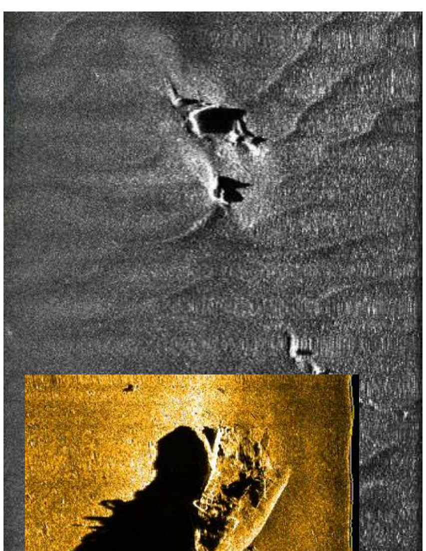

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Figure 4. A wooden vessel broken apart. (Ocean Technology Foundation)

country’s maritime history.

Target 1 (Figure 3) is a debris field spread over 200 meters with mostly buried features. Large features appeared to be a well-silted in, fitting one of the scenarios hypothesized for *Bonhomme Richard* —a buried wreck with an extensive debris field.

Target 2 (Figure 4) is a 50-meter long shipwreck broken in two pieces. It appears to be a wooden-hulled vessel with planking and frames clearly visible in the sonar images. The length of the wreck is a good match for the hull of *Bonhomme Richard*. Wreckage and debris is scattered at some distance from the main site, while portions of the wreck rise 2 to 3 meters above the sediment.

Target 3 (Figure 5) is a 10-meter long, partially-exposed sonar target. It protrudes a meter (1 m) above the sea-floor and does not appear to be a geological feature. The fourth target (Figure 6) is a wreck about 30 meters long and has a debris field.

Figure 5. A sonar image of Target 3. (Ocean Technology Foundation)

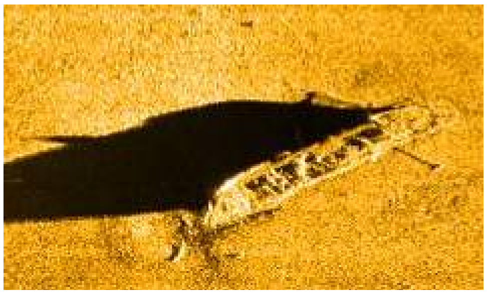

Figure 6. Target 4 is a partially intact wooden wreck. (Ocean Technology Foundation)

Expedition 2007

In 2007, the team partnered with the Office of Naval Research to conduct a five-day

Figure 7. The SeaEye Falcon, a remotely operated vehicle used in 2007. (M. Ryan)

expedition using a remotely operated vehicle to attempt to classify the priority targets located in 2006 (Figure 7). Representatives from English Heritage and Woods Hole Oceanographic Institution also participated in this expedition.

Limited time on site, inclement weather, and equipment failure allowed the investigation of only one of the targets from the 2006 search and a new target, which was a wellhead. Target One (Figure 3) appeared to be a debris field of large cut stone, possibly quarry material. Stones of various shapes littered the sea floor, but evidence of any iron, wood, or artifacts that could be associated with *Bonhomme Richard* were lacking. The remaining targets were investigated in 2008 (see below) and based on comparisons with *Bonhomme Richard* 's dimensions, structure, composition, and other factors, it was determined that none of the 2006 targets presented a compelling case for being *Bonhomme Richard.* However, the data gathered about these sites was shared with the UKHO and local organizations to help increase awareness and understanding of British maritime heritage.

Expedition 2008

During the summer of 2008, with the assistance of US Navy Deep Submergence Unit, the survey team utilized the nuclear research submarine NR-1 (Figure 8). During the last official mission for the US Navy prior to its deactivation, NR-1 played a key role in the 2008 survey efforts. Incorporating the sonar tools and continuous operational capabilities

Figure 8. NR-1 preparing for tow. (George Schwarz)

of NR-1, the team's objective was to survey several high-priority search areas which were plotted on ArcGIS.

Building on research conducted over the past several years, drift models were generated to ascertain probable directions in which *Bonhomme Richard* was carried before its eventual sinking. The data provided by the UKHO included GIS positions for shipwrecks, bottom features such as sand waves and oil pipelines, trawl marks, and fishermen's obstructions. Using ArcGIS to plot the known wrecks in the predetermined search areas, the team was able to designate priority grids which could be relayed to the operators of the submarine via UHF radio.

NR-1 was equipped with an Obstacle Avoidance Sonar (OAS) as well as side-scan sonar. With this equipment the submarine was able to detect shipwrecks and debris fields, within the ranges of the sonar, that were lying partially buried in the sea bed. The submarine made systematic sweeps of the survey grid, initially at one knot with a 100 foot side-scan overlap. The OAS had a range of 125, 250, or 500 yards on either side of the sub, depending on the conditions. Ferrous obstacles showed up as amorphous red contacts on the OAS, indicating iron objects. As objects appeared on the sonar, the NR-1 crew and scientists marked and investigated the targets.

Investigation of each target involved making several passes around the shipwreck, taking extensive video, recording features based on video and observations from viewports, and capturing well-

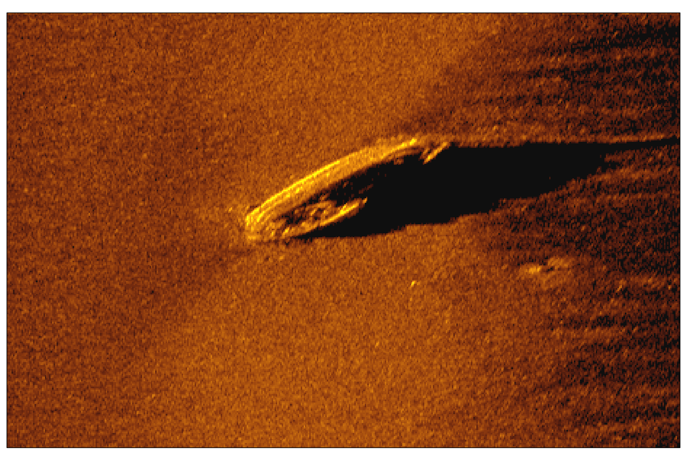

Figure 9. Side-scan sonar image of a shipwreck. (Ocean Technology Foundation/Naval History and Heritage Command)

defined side-scan images for dimensional comparison (Figure 9).

The nuclear submarine began the survey in the primary search grid, which was determined by the drift model research as the highest priority. This leg of the project took most of the following week, and was conducted at a slow speed (< one knot) to ensure complete coverage. Two wrecks in this area were considered to be possible *Bonhomme Richard* candidates, but upon further investigation were dismissed as a modern iron-hulled vessel and a wooden trawler. Once this grid was properly searched, the team directed NR-1 to numerous wrecks that were listed on the UKHO charts but were not identified. Several hours of video were taken of these wreck sites, but the shipwrecks have not yet been identified. The remaining days were spent surveying the secondary search areas that the team designated for NR-1. These grids were all systematically searched in the manner described above, but the OAS range was opened up to the maximum distance and the submarine was traveling at speeds of over three knots in order to cover as much ground as possible. The OAS picked up numerous contacts and the crew investigated them as necessary. Upon completion, NR-1 had surveyed over 400 square miles in the North Sea.

There were 11 crew members aboard NR-1, in addition to two survey team members. Much of the team members' time was spent at the controls where the OAS, side-scan sonar, and video cameras were located (Figure 10). While investigating potential wreck sites,

Figure 10. The controls and sonar equipment. (George Schwarz)

the team took detailed notes on shipwreck features and directed the submariners where best to position NR-1 for wreck observation and recording.

The amount of raw data that was collected during the survey is vast, and several days of continuous video were recorded for future analysis. The team has sorted through the data and prioritized potential *Bonhomme Richard* targets. Out of 18 contacts that were located, eight were found worthy of further investigation. Four were confirmed to have iron structural elements, and four appeared to have solely wooden hulls. The large intact vessels with strictly iron hulls were ruled out as the evidence presented itself, but there were still several wooden remains that needed to be examined more thoroughly for potential. Table one presents the eight targets and the accompanying data. The wooden wrecks that are partially buried were of the highest priority, and were assessed for diagnostic features associated with the expected remains of *Bonhomme Richard*. Some of these diagnostic features, as mentioned above, would include a wooden hull with limited iron reinforcements, a large assemblage of iron cannon and ballast, robust frames and other structural elements, and a deteriorated hull (due to poor preservation and heavy damage from the naval battle).

Figure 11. Overhead view of target 1 showing mast opening and deck beams on the port side. (Ocean Technology Foundation/Naval History and Heritage Command)

From the available data, it initially appeared that targets 1 (Figure 11), 5, 7, and 8, were viable candidates for *Bonhomme Richard*, and in need of further investigation. Because the ballast would likely be buried with the lower part of

Bonhomme Richard's hull, it is possible that the large concentrations of iron would be concealed in the sub bottom. A magnetometer would provide more accurate details as to the presence/absence of iron and its distribution. A sub-bottom profiler may also be of use on these sites, and could relay such information as depth of burial and presence of other materials below the sea bottom.

Targets discovered on UKHO Charts	**Material of Visible Hull Remains**	**Distinguishing Features**	**Hull Remains**	**Length x Beam**
1	Wood	Long, narrow hull with sharp bow lines. Deck beams and planking are visible	Up to weather deck	39x7 meters
2	Wood/Iron	Well-preserved with some modern features-tires	Up to weather deck	28x8 meters
3	Wood/Iron	Long, narrow, well-preserved hull	Up to weather deck	40x6 meters
4	Wood/Iron	Pointed bow with some modern features-possible wheelhouse	Up to weather deck	34x8 meters
5	Wood	Large timbers, fouled by fishing nets	Possibly up to weather deck	31x8 meters
6	Wood/Iron?	Projecting stern piece, large timbers, possible cannonball damage	Up to weather deck in some areas; partially buried; 30-45 degree list	30x7 meters
7	Wood	Large timbers, hatchways, large debris field, fouled by fishing nets	Debris field with some unidentifiable hull structures	70x16 meters
8	Wood	Debris field with large timbers	Observed portions were significantly deteriorated	72x18 meters

Table 1. Wrecks that were deemed worthy of further investigation. Wrecks in bold type were of highest priority.

After months of careful review, analysis of the remote-sensing data ruled out all of the 2008 targets due to lack of collective distinguishing BHR characteristics such as iron ballast and robust timbers. Several of the wrecks, however, have the potential to exhibit historical significance and the acquired survey data will be included in the final report as guidance for future North Sea surveys.

2009 Expedition

In 2009, at the request of the U.S. Chief of Naval Operations, the French Navy invited three members of the *Bonhomme Richard* project team to accompany them on a mission to test a new survey technology within a search area determined by the data collected in previous seasons and fine-tuning of the drift model. Through its relationship with the French Embassy in the United States, the Ocean Technology Foundation had been briefing Embassy personnel on project results since 2006. French interest in the project stemmed from the importance of *Bonhomme Richard* to both U.S. and French maritime heritage. The 2009 survey employed a magnetometer to search a 50-square-mile area of seabed. The team also had the benefit of an experimental Autonomous Underwater Vehicle (AUV) equipped with side scan and multibeam sonar to classify any targets (Figure 12). Three shipwreck sites were investigated with the AUV, two of which were determined to be modern wrecks, one which appears to have been torpedoed with its bow broken off. The remains of the third target, a mostly buried wooden shipwreck, were also investigated, and this wreck has been deemed a priority for future investigation.

Figure 12. An Autonomous Underwater Vehicle (foreground) was used in a recent expedition. (Franck Seurot)

The Bonhomme Richard Project as an Educational Tool

Due to its interdisciplinary nature, the project lends itself well to teaching about science, engineering, math and technology within a historical theme. A website was developed to showcase the search for *Bonhomme Richard,* and includes synopses of the historical research, methodologies, updates on expeditions, and classroom-ready lesson plans for teachers (Ocean Technology Foundation, 2008). The lessons focus on the technologies used during expeditions, such as side-scan sonar and magnetometers. The process of mapping and excavating a shipwreck site is explored, and a lesson highlighting careers in marine technology is also available. During previous expeditions, weekly logs of mission activities were posted on the website, and students were encouraged to email the project team to ask questions. The website also hosts a "virtual field trip" to Flamborough Head, England, where survey team members speak on site about the battle and the expeditions.

Through the examination of numerous wrecks and their conditions, knowledge of site formation processes in the North Sea has been expanded, and detailed information on wrecks that may pose hazards to surface vessels has been provided to the UKHO.

The *Bonhomme Richard* Project represents much more than a search for a shipwreck. It serves to inspire people young and old to become aware of our maritime heritage, and to be proud of it, because it has helped to shape who we are today as a nation.

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