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ORIGINAL ARTICLE

The Mardi Gras Shipwreck Project: Overview of Methods and Tools

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Abstract The Mardi Gras Shipwreck Project was not intended to be a full recovery and documentation of an historical shipwreck 1220 m (4,000 ft.) below the surface, rather, it was a mitigation of impacts in order to comply with federal law. The principal goal was to reduce the surface visibility of the site while documenting the archaeological provenience of the artifacts and determining, as much as possible, the age, cultural affiliation, function, and historical significance of the site. This goal dictated the method of data recovery and the tools selected to meet the objective. In an extreme environment, where such a project had never been attempted before, methods and tools had to be adapted to meet the challenge. Some of the methods were successful and others were not. Ultimately, the project succeeded in its mission, and both successes and failures have informed subsequent archaeological recovery work in very deep water.

Extracto El proyecto del buque naufragado Mardi Gras no tuvo como fin ser una recuperación y documentación completas de un buque naufragado histórico a 1 220 m (4 000 pies) por debajo de la superficie. Más bien, fue una mitigación de los impactos con el fin de cumplir con la legislación federal. El principal objetivo fue reducir la visibilidad superficial del emplazamiento documentando al mismo tiempo la procedencia arqueológica de los objetos y determinando, todo lo posible, la antigüedad, la afiliación cultural, la función y el significado histórico del emplazamiento. Este objetivo dictó el método de recuperación de datos y las herramientas seleccionadas para cumplir con el objetivo. En un entorno extremo, en el que un proyecto de este tipo nunca se había intentado con anterioridad, los métodos y las herramientas tuvieron que ser adaptados para satisfacer el desafío. Algunos de los métodos fueron satisfactorios y otros, no. Finalmente, el proyecto tuvo éxito en su misión, y tanto los éxitos como los fracasos han conformado los trabajos subsiguientes de recuperación arqueológica en aguas muy profundas.

Résumé Le projet de l'épave du Mardi Gras n'avait pas pour but d'être une récupération complète et une documentation d'une épave historique à 1 220 m sous la surface, mais était plutôt une atténuation des effets pour se conformer à la loi fédérale. L'objectif principal était de réduire la visibilité en surface du site tout en documentant la provenance archéologique des objets anciens et déterminer, autant que possible, l'âge, l'appartenance culturelle, la fonction et importance historique du site. Cet objectif a imposé la méthode de récupération des données et les outils choisis pour atteindre l'objectif. Dans un environnement extrême, où un tel projet n'avait jamais été tenté auparavant, les méthodes et les outils devaient être adaptés pour relever le défi. Certaines méthodes ont porté leurs fruits, d'autres pas. Finalement, le projet a réussi sa mission, et tant les réussites que les échecs ont donné des informations sur les travaux de récupération archéologique en eau très profonde.

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Introduction

In 2004, archaeologists with the Minerals Management Service (MMS—then within the U.S. Department of the Interior and charged with oversight of the oil and gas industry in federal waters on the outer continental shelf) were faced with a dilemma: how to mitigate the effects of a pipeline that had been laid within feet of an unreported historical shipwreck in 1220 m (4,000 ft.) of water some 64 km (40 mi.) off the Louisiana coast. In 2006 during negotiations with the operator of the pipeline, a crew inspecting the pipeline following Hurricane Ivan attempted the unauthorized removal of several artifacts on the site, destroying them. Fearing that the exposed site, even at that depth, would continue to suffer damage from unregulated incursions by remotely operated vehicles (ROVs) servicing the pipeline, a plan was worked out with the Advisory Council for Historic Preservation in Washington, D.C., to reduce, as much as possible, the visibility of the site by recovering as many of the remarkably intact surface artifacts as possible.

The Mardi Gras Shipwreck site was characterized by large and small diagnostic artifacts and features within a discrete area of the silty, mostly flat seafloor approximately 20 m (65 ft.) long by 4.5 m (15 ft.) wide. The largest artifacts were an anchor; a cannon; a ship's stove; and a wooden chest containing an assortment of small arms, including pistols, firearms, and swords. Small artifacts included glass bottles, creamware and salt-glazed stoneware, navigation instruments, and metal features. A large, amorphous concretion was present in the stern. The remains of the ship's hull were visible in certain areas, but the majority of the ship appeared either to have eroded and/or been buried under the soft, unconsolidated sediment. The small size of the site, together with preliminary analysis of recovered artifacts, suggested that the wreck represented the remains of a small commercial vessel or privateer/pirate vessel dating between 1780 and 1820. The site appeared to be well preserved, although deflated through natural processes of deterioration. The artifact assemblage appeared also to have maintained its integrity of placement within the hull and was unlikely to have suffered any post-depositional mixing owing to the site's great depth, which is well below the effects of storm surge. Research potential for the site was considered high, as no analogous sites had, at the time, ever been reported in federal waters on the outer continental shelf of the Gulf of Mexico. As a result, Site 16GM01 was considered eligible for inclusion in the National Register of Historic Places under Criterion D of Department of the Interior regulation 30 CFR §60.4.

A number of research questions were developed to guide recovery and analysis, but the principal goal remained the reduction of the elevation of the site to conform to the natural contours of the surrounding seabed and to remove any readily visible artifacts or features from the seafloor in order to make it less visible to sonar or visual inspection from the vicinity of the nearby pipeline. The 100% recovery of the shipwreck was never anticipated.

Following almost a year of negotiation over budget and scope of work between MMS and Okeanos Gas Gathering Company (OGGC), the operator that had installed the pipeline, an agreement was finally put in place on 6 April 2005. The Department of Oceanography at Texas A&M University, the contractor selected by OGGC to perform the work, requested a delay in the start of work until the following August. MMS recommended against planning the start of fieldwork in the height of hurricane season, which proved prescient with the arrival in the Gulf of Mexico of Hurricane Katrina, which made landfall on 29 August 2005. The center of this massive storm passed less than 20 mi. from the wreck site; a weather buoy even farther to the east, 119 km (74 mi.) south of Dauphin Island, Alabama, measured a peak significant wave height of 16.76 m (55 ft.). The resulting storm surge breached New Orleans's storm protection levees, flooding the city. Katrina was closely followed by Hurricane Rita on 24 September, which wreaked havoc on the offshore oil industry by destroying platforms and tearing up pipelines. Although the storm had no direct effect on the site itself, the vessels and equipment that were needed to support a deepwater project were occupied with hurricane recovery and, with costs skyrocketing, the Mardi Gras Shipwreck Project was suspended for two years.

When marine archaeology was first developed as a discipline some 55 years ago with the excavation of a Bronze Age shipwreck off Cape Gelidonya, Turkey, in 1960; the raising of the Swedish warship *Vasa* in 1961; and the excavation of the Viking Skuldelev ships at Rothskilde, Denmark, in 1962, the challenge for humans was the application of archaeological techniques underwater while depending upon life-support systems (Bass 1972). When a site is in 1220 m (4,000 ft.) of water, well below where it is possible to sustain human life outside a pressurized submersible, archaeologists must turn, instead, to robotics as a substitute for human eyes and hands. Although its application to archaeological recovery had never before been attempted in the Gulf of Mexico, the ROV is a commonly used tool in Gulf oilfields. ROVs had become an essential tool by the 1980s, more than a decade after they were first introduced in military applications, as offshore development of oil and gas deposits exceeded the reach of human divers. Common tasks include inspecting subsea structures, pipelines, and platforms; turning subsea valves; surveying the seafloor with video and acoustic instruments; collecting samples; and operating a wide variety of underwater tools. Much of the same functionality can, with minimal alteration, be adapted to perform archaeological tasks with an acceptable degree of precision and delicacy. Arguably the first noncommercial (i.e., treasure salvage) archaeological use of an ROV to map, survey, sample, and excavate an historical shipwreck in deep water was the investigation of the Ormen Lange shipwreck in Norway in 2003 (Søreide and Marek, 2005). The Mardi Gras Shipwreck excavation, conducted in water almost eight times deeper, nonetheless applied many of the techniques and procedures developed at Ormen Lange.

Texas A&M University's selection of a suitable ROV was largely dictated by cost and availability in the post-Katrina Gulf of Mexico. Ultimately, Veolia Environmental, a French firm that was relatively new to the Gulf of Mexico ROV market, was contracted to provide a Perry Triton XLS-17 ROV, support vessel, and crew (Ford et al. 2008). The XLS-17 was a large 150 hp work-class ROV controlled by pilots from the surface via a fiber-optic cable (Fig. 1). The ROV was equipped with two manipulator arms, one robust "five-function" arm for heavy lifting, and one more dexterous "seven-function" arm capable of more refined and intricate movement. In addition, the ROV mounted sector-scanning sonar, video and still cameras, lights, a hydraulic system for powering various tools carried by the manipulators, and a water pump that could be used to either blow away sediment or excavate with a dredge. Despite its large size, the XLS-17, is, like most ROVs, positively buoyant, so thrusters mounted on top of the vehicle push it downward, which allows it to hover close to the bottom without disturbing soft bottom sediments. It also has a slightly buoyant cable that prevents it from being dragged through the site and is deployed from a tether management system, or "top hat," that both serves as a down weight for the cable to the surface and isolates the ROV itself from the up-and-down movement of the ship. The XLS-17 performed well for excavation and recovery of artifacts entirely due to the skill of Veolia Environmental's pilots.

The ROV was equipped with a variety of tools and sampling devices that could be deployed using the vehicle's manipulators. These included suction devices, hydraulic actuators, core sample tubes, and a variety of scoops, rakes, and forks that could be grasped in the manipulator's claw. However, pre-dive planning was key to a successful operation, since decisions related to the selection of tooling had to be made before dives that, ideally, would extend for more than a 24 hr. period. Since it required as much as an hour to recover, the ROV and procedures dictated a 4 hr. window for routine maintenance on deck with another hour to dive the ROV to the bottom; one recovery could easily eat up a quarter to half of a 24 hr. workday. Thus, in order to accomplish the tasks outlined in the scope of work, recovery of the ROV had to be kept to a minimum to maximize bottom time. As might be expected, there was something of a learning curve for the academically trained archaeological staff that was unused to the reality of industry procedures and grueling 24 hr. work schedules and watches.

One of the most difficult challenges faced by the project staff from Texas A&M was the mapping of the site, which was made even more complicated by an unexpected failure of the ship's navigation software to link to a planned long baseline (LBL) array. An LBL array consists of a series of four acoustic transponders that triangulate to a receiver mounted on the ROV to derive a very accurate location on the seafloor. Without this array, the ROV's position is determined by the ship's ultrashort baseline (USBL) transducer linked to the ship's differential global positioning system (DGPS). USBL is accurate to within 0.5% of the water depth, or in this case, about 6.5 m (21.5 ft.). To compensate for the lack of the LBL, a series of prominent points around the wreck were selected to serve as datums. The ROV was then positioned above each datum for a period of time to collect several minutes of positioning data that could then be averaged to derive an accurate position. These positions, along with points triangulated using the ROV's sector-scanning sonar, were then used to georectify images collected to prepare a photomosaic of the site.

Collecting the photomosaic images also proved a challenge, and the full process is described in Ford et al. (2008). Unlike ROVs today that have been purpose-built for research, such as the Ocean Exploration Trust's vehicle *Hercules* (Bell et al. 2012), the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean Exploration and Research's new 6000 m rated *Deep Discoverer*, or Woods Hole Oceanographic Institution's *Jason* (Ballard 1993), the XLS-17 lacked several features that would have improved the collection of mosaic images. These include a Doppler velocity log (DVL), which compensates for position drift, computerized pitch and roll control, autopilot, and elevation control. The XLS-17 had auto-heading, -depth, and -altitude available, but the pilot still controlled it. Without the LBL array, the pilot had to fly a straight line using a compass heading, watching the "breadcrumb trail" behind him on the navigation screen and controlling the vehicle's attitude and altitude. Basically, the vehicle was flown by a joystick and a steady hand.

The full mosaic, composed of over 2,500 separate, 7 MP images, was not completed for months after fieldwork ended. As a result, a coarser image was used in the field as a base map. The site was divided into six discrete sections based on natural divisions in the hull and groupings of artifacts (Ford et al. 2008:27). As artifacts were collected, they were numbered sequentially according to the section from which they were removed and placed in a numbered bin for recovery to the surface (Fig. 2). Although time consuming, this process resulted in confidence in the accurate positioning of artifacts within the site and in the overall mapping of the site itself. In the future an opportunity may arise to re-map the remains using equipment that was unavailable in 2007, such as a camera-equipped autonomous underwater vehicle (AUV).

Fig. 1 The Perry Triton XLS-17 ROV employed in the Mardi Gras Shipwreck recovery. (Photo by Alexis Catsambis, 2007.)

Recovery of small finds, most of which were exposed on the surface of the ocean bottom, was relatively easy, although it required care, patience, a steady hand on the seven-function manipulator controls, and the right tool for the job. Techniques are generally described in the original report (Ford et al. 2008), but a few additional observations are offered here.

By far the most effective means of recovering anything that had a smooth surface, such as bottles and ceramics, was through the use of the ROV's onboard reversible-flow water pump equipped with a suction cup on the nozzle end, known as a "sticky foot" (Fig. 3). The project was supplied with a variety of sizes of suction cups, although, of course, the decision had to be made as to which size to mount while the ROV was on the surface. The suction devices were surprisingly effective on everything from fragile glass "sand clocks" to heavy ceramic jars. Care had to be taken to use the appropriately sized suction cup in order to apply the minimum amount of force needed to achieve a seal. A bellows-type suction cup seemed to be the most effective at easily sealing on a variety of flat and curved surfaces. Using this device, the most delicate of artifacts could be recovered completely intact and undamaged. Recently,

Fig. 2 The artifact recovery box, showing individually numbered crates into which single artifacts were placed. The hinged lid would be closed for the ascent to the surface. (Photo by Amy Borgens, 2007.)

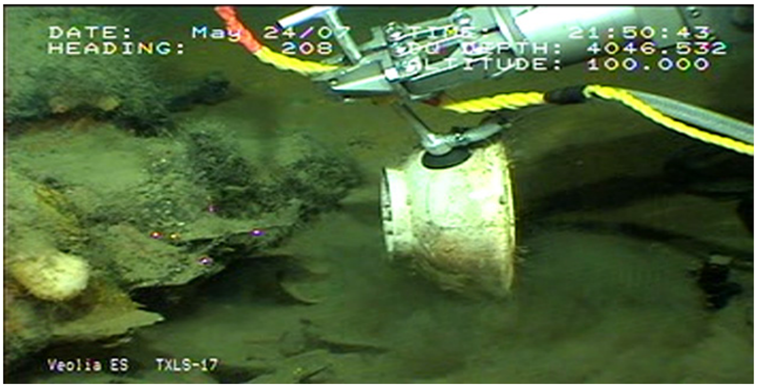

Fig. 3 A creamware cup during the process of recovery using a suction cup "sticky foot." (Photo courtesy Texas A&M University, 2007.)

Stephen Licht, associate professor of ocean engineering at the University of Rhode Island, using a membrane filled with glass microbeads, developed a type of gripper that can be draped over an object and then inflated to surround it. This method requires very little downward force on an object, which is spread over a large contact area and has, in the laboratory, been successfully applied to picking up a variety of irregularly shaped and surfaced artifacts (Stephen Licht 2014, elec. comm.).

Unfortunately, a ready-made tool kit for ROV excavation does not exist, and the fabrication of the right tool onsite from available materials is often necessary. Some effective devices can be constructed from tools readily available in the local hardware store with the addition of a T-handle that can be gripped by the manipulator claw and a strong magnet to secure it to the ROV frame. Paintbrushes, an ice scoop, a dustpan, and a small shovel proved useful as excavation tools. The archaeology team thought to try some pool leaf skimmers as well, which proved useful after some onsite modification (Fig. 4). Even a fry basket "liberated" from the galley was modified into a collection tool (Fig. 5). These tools may have appeared crude, but they were surprisingly effective at recovering small artifacts without harming them.

One of the greatest challenges faced by the archaeological team was the recovery of several large artifacts or features that could not be lifted by the ROV alone. These included a cannon; a ship's stove; a large concretion in the stern; and a wooden crate filled with muskets, pistols, swords, and other edged weapons. The cannon was relatively easy to bring to the surface using the large crane (Fig. 6) mounted on the aft quarter of the 80.5 m (264 ft.) ROV support-ship *Toisa Vigilant* using canvas straps and a spreader bar. The stove, the concretion, and the wooden crate were far more difficult challenges, and their recovery was accompanied by considerable discussion and angst. Working with Veolia's engineers, Texas A&M's archaeological staff developed devices that they somewhat euphemistically termed large-artifact retrieval tools (LARTs) (Fig. 7), but which were, for all intents and purposes, hydraulically actuated clamshell buckets. The LARTs were intended to be slowly

Fig. 4 A pool skimmer modified into a collection device with the addition of a "T-handle." (Photo courtesy Texas A&M University, 2007.)

Fig. 5 One of the ROV pilots displaying an artifact retrieval tool modified from a fry basket. (Photo by Laura Landry, 2007.)

lowered by the ship's crane over the artifact or feature and then closed using the ROV's hydraulic "hot stab." After testing the device offsite, a LART was first applied to the large concretion in the stern area of the wreck. The LART succeeded in enveloping the concretion and removing it from the site en masse. Unfortunately, the weight of the LART caused it to bite more deeply into the substrate than anticipated. Despite first excavating around the concretion to recover any small finds and to try to ascertain whether hull structure lay beneath the concretion, the excavation had not proceeded deeply enough to fully establish the absence of structural remains. In fact, the LART bit into and removed frames and bisected part of the boom that lay buried to one side of the concretion. The concretion remained encapsulated in the steel LART until it was removed at the Texas A&M Conservation Research Laboratory, where it was carefully excavated. The stern concretion has proven to be a key element in the interpretation of the site, but the inability to control the vertical depth of the cut dissuaded the staff from using this method elsewhere on the site. The archaeological staff was acutely aware of the unorthodox appearance of the device, but ultimately deemed its use both justified and essential to accomplish the Section 106–driven goals of the project in much the same way a backhoe might be used on land.

However, a decision not to use a LART to recover either the stove or the weapons box was made in the field. In the case of the stove, it was determined that wooden hull structure lay underneath it and would likely have been destroyed by the LART's jaws. Instead, the ROV was rigged with a kind of impromptu forklift that was guided beneath the stove to raise it off the bottom. The stove was then transferred to a cargo net that was lifted into a basket and raised to the surface by the ship's crane.

Fig. 6 The onboard crane of the ROV support ship *Toisa Vigilant* in use transferring personnel from a crew boat. The crane also was used to raise artifacts from the seafloor. (Photo by Amy Borgens, 2007.)

Fig. 7 The large-artifact retrieval tool (LART). (Photo by Alexis Catsambis, 2007.)

Although it separated along its manufactured seams as it was lifted into the basket, all the pieces were recovered, and the stove was reassembled in the laboratory and restored to its original appearance.

Finally, the bulkhead adjacent and connected to the weapons box was determined to have been impregnated with iron. Attempts to remove the box through the use of lift straps were unsuccessful, as were attempts to separate the box from the hull. After thorough examination, the archaeological staff determined that there was no feasible means of recovering the box without risking injury to the artifact. This decision was made with regret because of the important information it undoubtedly contained. The weapons box remains on the seafloor to this day.

One of the unique features of "archaeology by ROV" is the fact that every minute of the operation is captured on video for posterity from the same vantage point the ROV pilots and the archaeologists directing them in the control van had. Imagine for a moment if every land archaeologist excavating a 1 × 1 m unit were equipped with a body camera. An impeccable record of every shovel-load of dirt would be created, but so would a massive storage issue for hours of video few would ever have an interest in viewing. The same is true of ROV video where large amounts of time are occupied in simply positioning the ROV, moving the ship into position, or accomplishing other mundane tasks. Like sailing, ROV archaeology often consists of hours of tedium punctuated by moments of adrenaline rush or sheer panic.

The recovery of artifacts from the Mardi Gras Shipwreck is stored on 38 DVDs. Other shipwreck investigations in which BOEM and NOAA have participated have yielded many terabytes of video and still images, as well as hydrographic, positioning, and text data, that must be archived and stored. NOAA is equipped to archive massive amounts of digital data; other federal or state agencies and academic institutions are not. The Louisiana Division of Archaeology, for example, which curates the artifacts recovered from the Mardi Gras Shipwreck, has not yet formulated a policy for storing digital data and currently accepts a variety of storage media, including CDs, DVDs, and portable hard drives. This is likely a growing problem in archaeology with no easy or cheap solution, although cloud storage might be an option. The issue has likely already overwhelmed many state preservation agencies.

During the field season from 21 May to 7 June 2007, almost 1,000 artifacts were recovered, mapped, and cataloged using a commercial oilfield work-class ROV. They were subsequently conserved at the Texas A&M Conservation Research Laboratory and transferred to their permanent home at the Louisiana Division of Archaeology in Baton Rouge. The last artifacts of the collection, including the 6-pounder cannon, arrived in Baton Rouge in March 2015, ending their 11-year journey from the seafloor. By and large, as a Section 106 undertaking, the project was considered successful in achieving the goals laid out in the site mitigation plan. The methods used in the recovery of the Mardi Gras Shipwreck artifacts have preserved that record for future analysis.

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