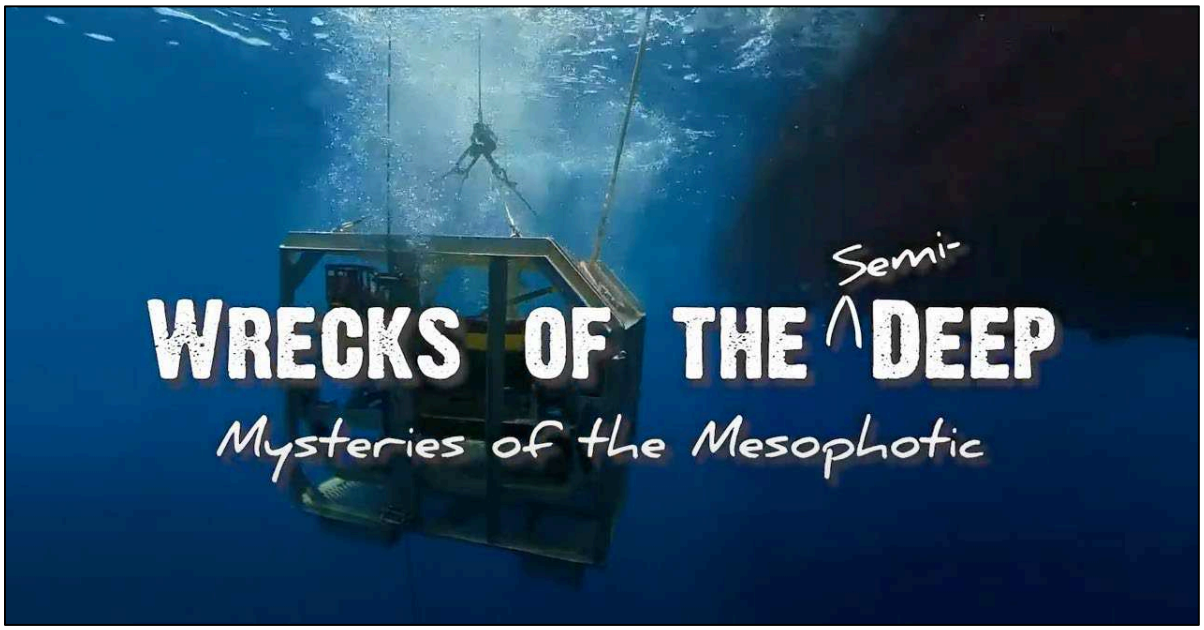
OCS Study
BOEM 2025-014

Data Gap: Characterizing the Seafloor in the Mesophotic Zone



U.S. Department of the Interior
Bureau of Ocean Energy Management
New Orleans Office
New Orleans, LA

BOEM
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Data Gap: Characterizing the Seafloor in the Mesophotic Zone

December 2024

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Prepared under Co-operative Agreement M20AC10011-00
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ERRATA

This report corrects errors made in the previous version, which, in a few instances, confused semi-demersal fish with pelagic fish. 22 July 2025.

DISCLAIMER

Study collaboration and funding were provided by the U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM), Environmental Studies Program, Washington, D.C., under Agreement Number M20AC10011-00 with University of Rhode Island and the Woods Hole Oceanographic Institution. This report has been technically reviewed by BOEM, and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of BOEM, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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CITATION

Mather R, Meyer-Kaiser K, Sorset S, Barlow-Diemer A, Coleman D, O'Connor R, Mires C (University of Rhode Island, Kingston, RI). 2025. Data gap: characterizing the seafloor in the mesophotic zone. New Orleans (LA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 112 p. Obligation No.: M20AC10011-00. Report No.: BOEM 2025-014.

ABOUT THE COVER

Opening image of the project video documentary "Wrecks of the Semi-Deep" showing the deployment of the project ROV in the Gulf of America (formerly Gulf of Mexico). Credit: Patrick Flanagan, Inner Space Center, University of Rhode Island.

ACKNOWLEDGMENTS

The field work for this project took place when COVID-19 restrictions still impacted daily life. Special thanks to everyone involved for their cooperation in keeping project personnel safe and healthy.

This study was part of a cooperative agreement (M20AC10011-00) between the University of Rhode Island, Woods Hole Oceanographic Institution and the U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM), Environmental Studies Program, Washington, D.C. It was structured under the Cooperative Ecosystem Studies Units (CESUs).

Scott Sorset (BOEM) was the inspiration for the project, Co-PI, and also the Project Program Officer at BOEM. Special thanks to Doug Jones, formerly of BOEM currently of BSEE, for assistance with background research, particularly on *C. P. Baker*, and participation in the research cruise. His expertise and guidance was invaluable.

The project would not have been possible without the assistance of Evan Kovacs, Director of Marine Imaging Technologies. Evan led the reconnaissance diving expedition in 2021 and at sea he managed ROV imaging and data management. He was assisted by David Ullman. Evan and David made things happen when it looked like we might falter.

URI's Inner Space Center was key to success of the project. Dwight Coleman led the efforts. Patrick Flanagan's role was critical. He participated in the cruise; filmed, directed, and produced the mini documentary "Wrecks of the Semi-Deep;" and hosted the special education and outreach programs for students. Thanks also to Holly Moran who so ably organized and coordinated the education and outreach program, and also thanks to Ryan Campos.

When the project needed a last-minute replacement ROV, Joe Caba, owner of Reliant Robotics, Covington, Louisiana came to our assistance and was a pleasure to work with. He was admirably assisted by Glenn Romano. In a similar vein, Aqueos Corporation was willing to work with the project at short notice and provide the vessel for the cruise MPSV, *Sea Scout*. Bradley Parro and Erik Zawacki at Aqueos helped negotiate and manage the deal. The negotiations with Aqueos would not have been possible without the assistance of URI retained attorneys Carol Connolly and Richard Sayer and Risk Manager Pamela Hallagan. On board *Sea Scout*, it was a real pleasure to work with captains William Sutliff and Grady "Snake" Seaman whose old school expertise in keeping a vessel balanced and on station during ROV operations without use of dynamic position was outstanding. They were ably assisted by engineer Jesus Alaniz, cook Terriell Williams and deckhands Steven Haley and Lindan Barr. At URI, additional historical and archaeological research was provided by graduate students Riley O'Connor and Aidan Barlow-Diemer. Finally, managing the project at URI would not have been possible without administrative assistance from Leslie Dancy.

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List of Abbreviations and Acronyms

Short Form	Long Form
4K	Horizontal screen resolution of around 4000 pixels
A/B	Aktiebolag - Swedish term meaning limited liability stock company
A/S	Aksjeselskap - Norwegian term meaning limited liability stock company
APE	areas of potential effect
AVI	audio video interleave
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement.
C&C	C & C Technologies
CESU	Cooperative Ecosystem Studies Units
COI	Mitochondrial Cytochrome C Oxidase I
DEA	David Evans and Associates, Inc.
DESCO	Diesel Engine Sales Company
DNA	deoxyribonucleic acid
DVR	digital video recorder
EEZ	Exclusive Economic Zone
HD	high definition
ISC	University of Rhode Island, Inner Space Center
MATS	Military Air Transport Service
MITech	Marine Imaging Technologies
MOV	digital container file developed by Apple Computer, Inc.
MSG	message
MPSV	multi-purpose support vessel
M/V	motor vessel
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NRHP	National Register of Historic Places
NTP	Network Time Protocol
OCSLA	Outer Continental Shelf Lands Act
OFUR	Office of French Undersea Research
OSV	offshore supply vessel
PCR	polymerase chain reaction
POS	position orientation system
PVC	polyvinyl chloride
RAID	Redundant Array of Independent Disks
RULET	Remediation of Underwater Legacy Environmental Threats
RR	Reliant Robotics
R/V	research vessel
S/V	survey vessel
SD	Standard Definition
TB	terabyte
TED	turtle excluding device
UDP	User Datagram Protocol
USBL	ultra-short baseline
URI	University of Rhode Island
UTC	Coordinated Universal Time
WHOI	Woods Hole Oceanographic Institution

1 Introduction

The University of Rhode Island (URI) and Woods Hole Oceanographic Institution (WHOI), working in cooperation with the Bureau of Ocean Energy Management (BOEM) as part of the North Atlantic Cooperative Ecosystem Studies Unit (CESU), investigated, evaluated, and characterized four shipwrecks and three associated hardbottom habitats in the vicinity of Fishnet Bank, which is approximately 80 miles off the coast of Louisiana. All sites were in the mesophotic zone, i.e. between 40 and 150 meters (130–490 feet) of water depth. This is an area that BOEM has identified as a significant data gap for their Environmental Studies Program (ESP). The agency awarded the project to URI in September 2020. Fieldwork, analysis, and interpretation were carried out between 2021 and 2024. This report contains the primary deliverables that include detailed historical investigations and Phase II archaeological characterizations of the four shipwrecks; investigations and characterizations of biological communities of invertebrates and fish on the four shipwrecks and the three associated hardbottom habitats; and, to the extent possible, high-definition orthomosaic maps and 3D models of each shipwreck and hardbottom site. URI managed the project and conducted the archaeological and historical studies; WHOI conducted the biological studies; Marine Imaging Technologies (MITech) led the remotely operated vehicle (ROV) survey and videography operations; and BOEM archaeologists took the lead in developing the orthomosaic maps and 3D models. While the project experienced significant logistical and technological challenges, it also achieved noteworthy objectives, and the results provide BOEM with an enhanced understanding of archaeological and biological resources in the mesophotic zone.

1.1 Background

In the Gulf of America (formerly the Gulf Mexico) (Gulf), research and the study of underwater cultural heritage, such as shipwrecks, has tended to focus on shallow depths under 40 meters (130 feet) which are accessible to divers, or over 200 meters (656 feet), which require remote or autonomous surveying equipment. This has created a knowledge gap for the baseline characterization of sunken vessels in the mesophotic zone (40–150 meters), such as site patterning or essential diagnostic characteristics. The lack of scientific data has created problems for BOEM managers faced with the requirements of the National Historic Preservation Act (NHPA), the National Environmental Policy Act (NEPA), and the Outer Continental Shelf Lands Act (OCSLA). A shortage of data complicates agency decisions designed to preserve, mitigate, and avoid historic cultural resources during BOEM- and Bureau of Safety and Environmental Enforcement (BSEE)-permitted activities. Instances of human activity in the mesophotic zone–such as drilling for oil and gas, marine minerals extraction, movement of pipelines, and fishing–generates a higher probability of damaging historic shipwrecks. Additionally, shipwrecks form critical habitat for obligate hardbottom species. Harming these communities may alter natural site formation processes and increase ecological and cultural instability, adversely affecting the long-term preservation potential of archaeological sites (Moore 2015). Without essential scientific data, managers are limited in their ability to develop and implement best management and appropriately tailored avoidance strategies. Therefore, it is critical for BOEM "to characterize seafloor features, including shipwrecks, hardbottom habitat, and pinnacles, and their ecological role to develop proper management and avoidance strategies based upon their ecological community structures" (U.S. Department of the Interior 2020).

To meet this goal, this study proposed an innovative, multidisciplinary exploration and survey to provide initial characterization of cultural and natural resources in the mesophotic zone in the Gulf. The project team documented four shipwreck sites and three hardbottom communities in the mesophotic zone in order to 1) identify diagnostic features for archaeological analysis, 2) evaluate historical and archaeological significance, 3) assess variability in overall site condition, 4) measure material and benthic distribution, and 5) characterize cultural and natural site formation. These sites were selected in collaboration with

BOEM staff and leveraged BOEM's array of geophysical data, survey information, and a database containing 175 potential sites. In order to survey and document these archaeological and hardbottom sites, a ROV supplemented with a camera capable of collecting ultra-high-definition (4K) video and high-resolution (45MP) still images was employed. The team intended, but had limited success, in collecting data that allowed for scaled orthomosaic maps and 3D models of archaeological and hardbottom sites, which were developed, processed, and visualized by BOEM. These investigations and accumulative raw and rendered data offered an initial seafloor characterization of cultural and natural resources in the mesophotic zone. In the absence of detailed 3D orthomosaic models, the team expanded the historic investigations of the shipwreck sites. This included extensive review of published and unpublished primary sources and records preserved at the National Archives in Washington, D.C. and Fort Worth, Texas. Historical research provided significant and enhanced understanding. This study contributes to well-informed management of the rich and valuable resources in the Gulf by providing BOEM with up-to-date information on the state of historic shipwrecks and an understanding of their site formation processes, including cultural transformations (c-transforms) such as fishing gear and marine debris, and natural transformations (n-transforms) such as colonization by benthic organisms. The study found the anthropogenic impacts of fishing gear to be particularly significant in the mesophotic zone.

Shipwrecks are akin to time capsules because they occur in a discrete moment in time, but they are truly multi-faceted, dynamic databases that may be studied as artifacts themselves, a carrier of artifacts, a microcosm of maritime cultures and associated systems, or a combination of all the above (Gould 1983; Murphy 1983; Lawrence et al. 2015). In this way, shipwrecks are tangible connections to the past that allow us to examine the maritime human experience in a way not possible in history books or archives. The vast array of wrecks in the Gulf represent hundreds of years of maritime history, architecture, technology, industry, and culture–and are testaments to a most universal human condition: striving to tame nature, but ultimately succumbing to its power (Lawrence et al. 2015). More than 70 years of oil and gas exploration in the Gulf has left an imprint on the submerged cultural landscape. As this study shows, elements of that landscape have become historically and archaeologically significant.

Shipwrecks become critical habitat for obligate hardbottom species. They increase habitat heterogeneity where there was previously only mud, silt or sandy sediment, providing hard structure for sessile organisms such as corals and anemones. The remains are attractive to mobile invertebrates including sea stars, crustaceans, and fish. In many ways, shipwrecks can be thought of as unplanned artificial reefs. However, shipwreck communities do not directly replicate natural hardbottom communities. Wrecks are isolated, island-like systems, especially at greater depths, so the communities that inhabit them have different dynamics than natural hardbottom fauna (Meyer et al. 2017).

Studying shipwreck communities provide numerous insights into the process of community assembly, which includes larval dispersal, recruitment, interspecific interactions, and succession (Meyer 2017). Wrecks may be colonized by different species than natural hardbottom habitats and augment the biodiversity of a region (Amaral et al. 2010; Lira et al. 2010). Because they are isolated and island-like, shipwrecks provide an excellent opportunity to study environmental connectivity. They typically have lower diversity than natural communities, allowing pairwise species interactions to be examined in detail (Pawlik et al. 2008). By being much younger than natural hardbottom communities, wrecks can also show the process by which a community develops over time, especially if the sinking date is known (Perkol-Finkel et al. 2005; Perkol-Finkel et al. 2006).

Previous studies of mesophotic shipwrecks in the Mid-Atlantic Bight and in Stellwagen Bank National Marine Sanctuary showed that wrecks were much more densely colonized by sessile invertebrates, particularly sponges and anemones, as compared to low-lying habitats such as natural boulder reefs (Meyer et al. 2017, 2021). The wrecks also host abundant populations of fishes, including commercial species such as cod (*Gadus morhua*), pollock (*Pollachius virens*) and Acadian redfish (*Sebastes fasciatus*) and serve as nursery habitats for species such as chain dogfish (*Scyliorhinus rotifer*) (Ross et al. 2016).

The Mid-Atlantic Bight and Stellwagen Bank research has demonstrated shipwrecks' critical role as habitats on the seafloor.

In addition to their value as biological and cultural resources, shipwrecks also allow for interdisciplinary educational and outreach opportunities. The dramatic visual appeal of a submerged hull covered in colorful fauna, or in an advancing state of destruction, captures audience interest and opens the conversation about maritime heritage and biological resources. The intersection of archaeology and biology provides crosscutting and unique educational experiences using shipwrecks as the centerpiece.

1.2 Objectives and Hypotheses

1.2.1 Historical and Archaeological Goals

The Gulf includes some of the most historically and culturally significant waters in the United States. This intersects with the region's history of exploration, warfare, commerce, piracy, fishing, resource extraction, and recreation. At different times, merchant ships carried bullion, enslaved persons, sugar, timber, fish, and fossil fuels across Gulf waters. The Gulf saw naval action during the Revolutionary War, the War of 1812, the Mexican-American War, the Civil War, and the Spanish American War. During World War II, the Gulf became a battleground in a *guerre de course* as American, Allied, and neutral shipping attempted to run the gauntlet of Germany's formidable U-boats. During the second half of the twentieth century, oil and gas exploration left deep imprints on the cultural landscape of the Gulf (Sledge 2019).

The historical and archaeological objectives of the project were:

- Conduct archaeological and historical investigations of up to four shipwrecks.
- Produce scaled, 3D orthomosaic models of shipwrecks with the highest degree of accuracy possible, within the limits of the technology and environmental conditions.
- Provide a baseline characterization of chosen sites.
- Place each site in its appropriate archaeological and historical context.
- Determine each site's eligibility for nomination to the National Register of Historic Places.
- Identify the form and function of each site, and its date and cultural affiliation. Where possible, establish each shipwreck's identity, or independently corroborate or refute that identity if the site is already "known."
- Evaluate the archaeological integrity of each site.
- Examine each shipwreck's state of preservation, stability, and understand the site formation processes in play.
- Assess the extent and boundaries of any observed BOEM- and BSEE-permitted impacts. This would assist in estimates of buffer zones and Areas of Potential Effect (APE).

1.2.2 Biological Goals

Shipwrecks hold immense potential for ecological community research, but the vast majority of wrecks in the U.S. EEZ remain undocumented and unidentified. In the Gulf, the mesophotic zone (40–150 meters depth) is sandwiched between the upper continental shelf, which hosts reef-building coral communities, and the continental slope, which is home to cold-water corals including *Lophelia pertusa* and *Madrepora oculata* (Jaap 2015; Schroeder et al. 2005; Cordes et al. 2008). Previous investigations have shown shipwrecks in the mesophotic zone to be dominated by scleractinian and black corals, similar to shallower reefs (Church et al. 2009). Crustaceans and reef fish are also common (Kilgour and Shirley, 2009; Church et al. 2009).

The research team proposed to survey shipwrecks and natural hardbottom reefs in the mesophotic Gulf to characterize the biological communities of invertebrates and fish. We expected that community composition on shipwrecks will follow similar bathymetric patterns to natural hardbottom reefs, with a reduction in species richness with depth and high species turnover at ~60 meters (197 feet) and ~120 meters depth (394 feet) (Jaap 2015; Semmler et al. 2017). However, we expected that the unique characteristics of shipwrecks will lead to some distinct differences. Specifically, we aimed to test the following three hypotheses for invertebrates and fish:

Hypothesis 1: Species with long pelagic larval duration (PLD) and long-range larval dispersal will be more abundant on shipwrecks compared to natural hardbottom habitats. Isolated, island-like habitats like shipwrecks are not colonized by all of the same fauna on nearby natural hardbottom habitats (Meyer et al. 2018). Many hardbottom marine organisms disperse only short distances because their larvae have short duration or are demersal and remain near the natal habitat (Pechenick 1999). The research team anticipated that many species with short-range dispersal would be underrepresented in shipwreck communities, simply because they cannot reach the habitat. Species with long-duration larvae and long-range dispersal would be overrepresented as a result.

Hypothesis 2: Species that colonize shipwrecks will occur in much greater density than they do on natural hardbottom habitats, as a result of refuges from predation or competition. Because not every species can disperse to a shipwreck site, those species that do successfully colonize the wreck may have much greater densities in the absence of their usual predators or competitors. For example, some of the best sessile invertebrate competitors (colonial ascidians and sponges) have short-duration larvae and may be unable to disperse to shipwreck sites. Alternatively, larvae dispersing to a shipwreck may settle at higher densities, simply because the wreck provides the only hardbottom habitat in the area (Pineda and Caswell 1997).

Hypothesis 3: Community composition on shipwrecks will be more varied than natural hardbottom reefs. In other words, the group of species that lives on a shipwreck will be different from one shipwreck to the next. The first species to reach a new habitat and colonize it strongly influences how the community develops over time–a concept called “multiple stable states” (Sutherland 1974). Depending on their distance from a natural hardbottom reef, shipwrecks are likely to be colonized by a sub-set of the local species pool and may be dominated by just a few species that colonize early. The colonization of hardbottom habitats surrounded by an established community is largely deterministic, but for isolated habitats, the resulting community is more variable (Keough 1984).

2 Methods

2.1 Study Area

The study area for this project was the water around Fishnet Bank off the coast of Louisiana, approximately 80 nautical miles south of Marsh Island, Louisiana in water depths between 40–150 meters (130–490 feet) (Figure 1). Within this area, the project team originally selected five shipwrecks which were paired with three hardbottom habitats; however, only four of the five shipwrecks were visited during this study. The objective was to identify shipwrecks and hardbottom habitats in close proximity to one another. All paired shipwrecks and hardbottom habitats were in similar water depths and environments. Distances between paired shipwrecks and hardbottom habitats ranged from 66 meters to 21.07 kilometers (see Table 2).

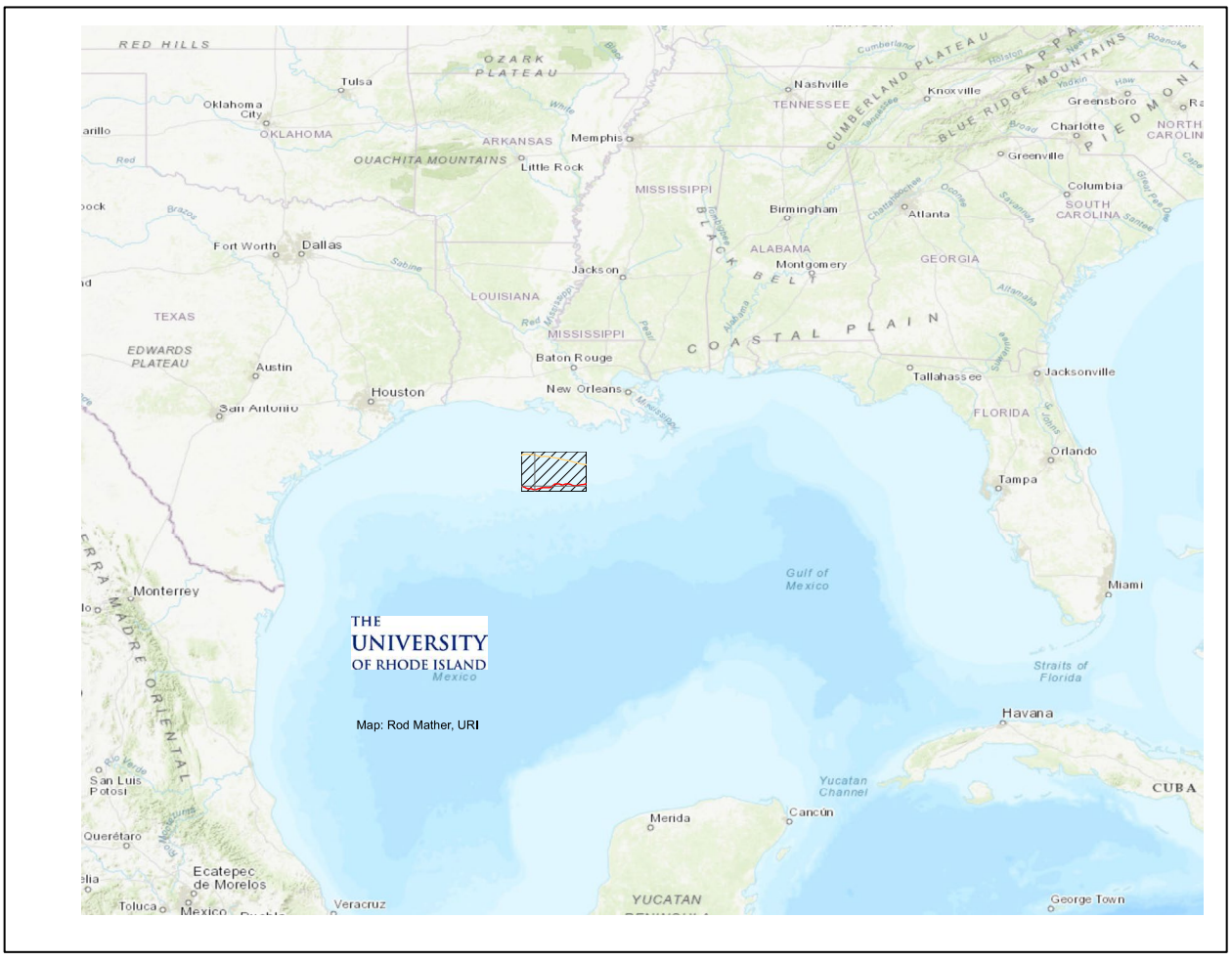


Figure 1. Project location map.

2.2 Personnel and Partners

The University of Rhode Island (URI) and Woods Hole Oceanographic Institution (WHOI) worked in cooperation with the Bureau of Ocean Energy Management (BOEM) as part of the North Atlantic CESU. Data management, video production, education and outreach were provided by URI's Inner Space Center. Imaging, ROV video acquisition, and technical diving were led by Marine Imaging Technologies (MITech) of Cataumet, Massachusetts. ROV equipment and operations were provided by Reliant Robotics (RR) of Covington, Louisiana. The platform for the research cruise was a catamaran-style, multi-purpose support vessel (MPSV) named *Sea Scout*, owned and operated by Aqueos Corporation out of Amelia, Louisiana. Geophysical services and data were provided by Cardinal Point Captains (subcontracted to David Evans and Associates) under a vessel services contract with BOEM. Principle project personnel for the Data Gap study were:

- Rod Mather, Archaeologist, Historian and Lead PI, URI
- Dwight Coleman, Marine Geologist, Director of the ISC and CO-PI, URI
- Patrick Flanagan, Media and Production, URI ISC
- Holly Morin, Manager for Education and Outreach, URI ISC
- Aidan Barlow-Diemer, Archaeology Graduate Student, URI
- Riley O'Connor, Archaeology Graduate Student, URI
- Kirstin Meyer-Kaiser, Associate Scientist, Marine Biologist and CO-PI, WHOI
- Calvin Mires, Archaeologist and CO-PI, WHOI
- Evan Kovacs, Director of MITech and CO-PI, MITech
- David Ullman, Engineer, MITech
- Scott Sorset, Project Program Officer and CO-PI, BOEM
- Doug Jones, Marine Archaeologist, BOEM
- Joe Caba, Owner of RR and ROV Pilot, RR
- Glenn Romano, ROV Tender, RR

2.3 Site Selection

Site selection went through three iterations: a preliminary list of study sites, a revised list, and a final list (Table 1). From September to December 2020, URI and BOEM archaeologists and biologists reviewed existing geophysical data and industry reports to identify appropriate study sites. This resulted in a preliminary list of five priority and five backup shipwrecks, along with associated hardbottom sites. The top two priority shipwrecks sites were *C. P. Baker* and the motor vessel (M/V) *Hamlet*. These sites remained on all subsequent lists of study sites. *C. P. Baker* was an early catamaran-style oil drill vessel, which was involved in a major accident and natural gas blowout on June 30, 1964 that led to the vessel sinking. Twenty-one of the 43-member crew were killed and a further 22 were injured. M/V *Hamlet* was a Norwegian motor tanker, built in Sweden in 1934, and sunk by the U-*753* on May 27, 1942.

In early 2021, the preliminary list was revised. Some sites were removed and additional hardbottom habitats added. The resulting revised list contained five priority shipwrecks, three backup shipwrecks, and four associated hardbottom habitats.

The revised list of priority shipwrecks, backup shipwrecks, and associated hardbottom habitats was used as the basis for acquisition of additional geophysical survey data during the Spring of 2021. These data were obtained through a separate services contract between BOEM and Cardinal Point Captains, Inc. (subcontracted to David Evans and Associates) and are described in Section 2.4 below. The geophysical survey data combined with further research helped create a final list of study sites which were numbered,

or in some cases renumbered, to show a direct pairing between shipwrecks and hardbottom habitats. The final list is shown in Table 1 and Figure 2.

2.4 Geophysical Survey

In January 2021, BOEM contracted Cardinal Point Captains, Inc. to collect side scan sonar, multi-beam bathymetric, and magnetometer data at the Data Gap shipwreck and hardbottom habitat sites. This work, sub-contracted to David Evans and Associates, Inc. Marine Services Division (DEA), was completed in May 2021 (Redmayne and Laverty 2021). The survey team used the 82-foot aluminum catamaran survey vessel (S/V) *Blake* owned by DEA as a platform and employed an Edgetech 4200 300/600 kHz side scan sonar system, a Marine Magnetics SeaSpy 2 magnetometer, and a Teledyne Reason T50R multibeam echosounder system to gather information for site characterization. Data was delivered to the Data Gap project team in June 2021 (Figure 3). The new data included high-resolution geophysical imagery and improved location and orientation information for Priority Shipwreck 1 (*C. P. Baker*), Priority Shipwreck 2 (M/V *Hamlet*), Priority Shipwreck 3, Priority Shipwreck 4, Hardbottom 1, Hardbottom 2, and Hardbottom 4 (Figure 3). DEA was unable to obtain geophysical data for Priority Shipwreck 5. Note that the DEA's orientation of the Shipwreck Priority 2 (M/V *Hamlet*) is incorrect. They identified the stern as the bow and vice versa (Redmayne and Laverty 2021).

Table 1. Final list of priority shipwrecks and associated hardbottom habitats for Data Gap study

Site	BOEM Database Number	Dimensions (feet)	Water depth (feet)	Notes
Priority Shipwreck 1	549	335 X 182 X 18	183–191	*C. P. Baker* Wreck, Associated with Hardbottom 1
Priority Shipwreck 2	15322	500 X 70	Circa 150–200	M/V *Hamlet*, Associated with Hardbottom 2
Priority Shipwreck 3	15253	88 X 23 X 11	Circa 150–200	Paired with Hardbottom 1
Priority Shipwreck 4	15419	60 X 19 X 14	260	Paired with Hardbottom 4
Priority Shipwreck 5	15420	80 X 27	320	Paired with Hardbottom 4
Hardbottom 1	N/A	Unknown	Unknown	Paired with Priority Shipwrecks 1 & 3
Hardbottom 2	N/A	Unknown	Unknown	Paired with Priority Shipwreck 2
Hardbottom 4	N/A	Unknown	Unknown	Paired with Priority Shipwrecks 4 & 5

Note: data in this table represents best available information before the study.

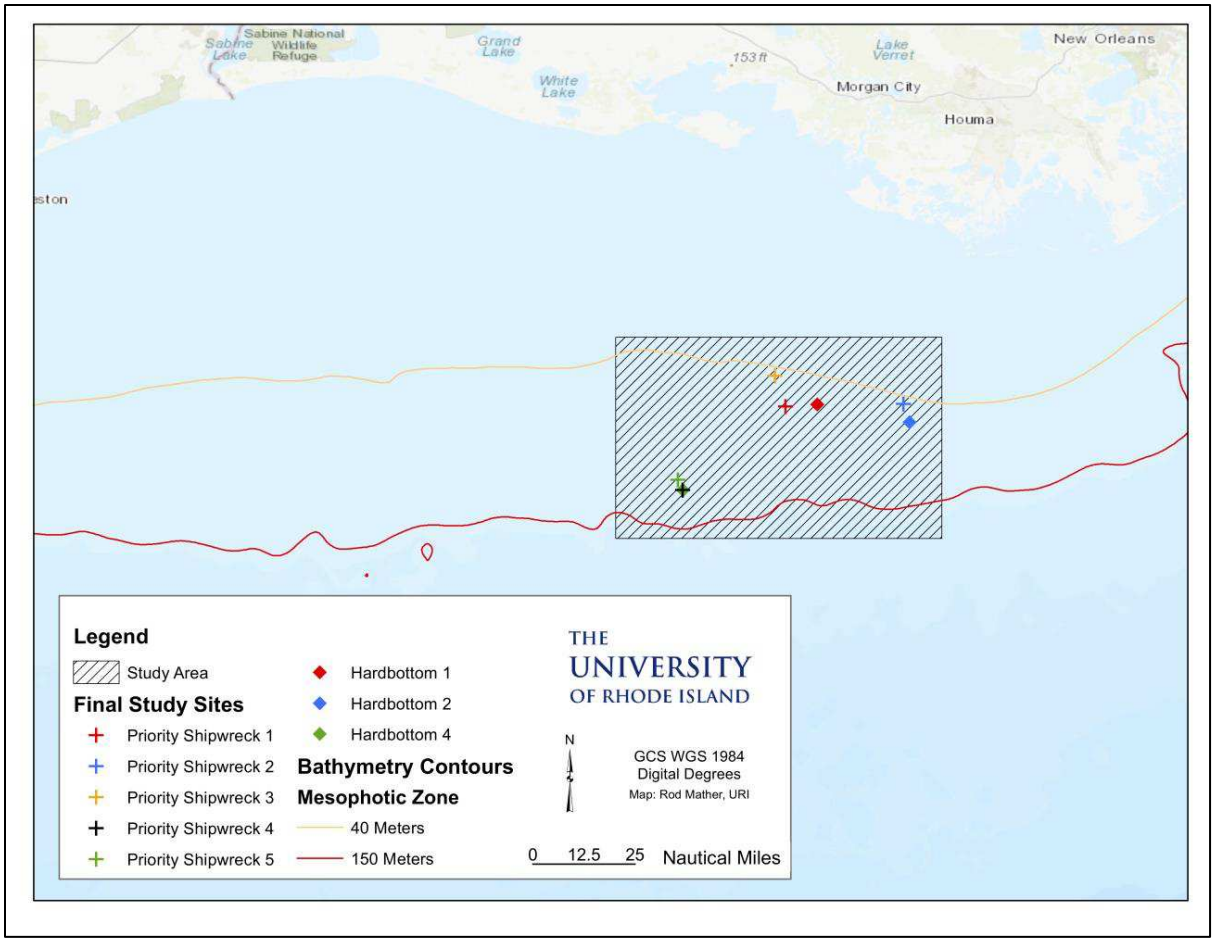


Figure 2. Final priority shipwrecks and associated hardbottom habitats for Data Gap study.

Table 2 shows the paired sites and distances in kilometers between each of the eight sites (five shipwrecks and three hardbottom). Paired site distances are highlighted in green.

Table 2. Distance in kilometers between eight study sites

Site	Priority Shipwreck 1	Priority Shipwreck 2	Priority Shipwreck 3	Priority Shipwreck 4	Priority Shipwreck 5	Hardbottom 1	Hardbottom 2	Hardbottom 4
Priority Shipwreck 1	-	47.05	14.55	55.84	54.31	12.47	49.86	55.90
Priority Shipwreck 2	47.05	-	52.85	96.49	96.45	34.61	8.61	96.54
Priority Shipwreck 3	14.55	52.85	-	63.42	60.92	21.07	57.58	63.49
Priority Shipwreck 4	55.84	96.49	63.42	-	4.92	66.18	95.67	0.06
Priority Shipwreck 5	54.31	96.45	60.92	4.92	-	65.16	96.06	4.97
Hardbottom 1	12.47	34.61	21.07	66.18	65.16	-	37.81	66.23

Site	Priority Shipwreck 1	Priority Shipwreck 2	Priority Shipwreck 3	Priority Shipwreck 4	Priority Shipwreck 5	Hardbottom 1	Hardbottom 2	Hardbottom 4
Hardbottom 2	49.86	8.61	57.58	95.67	96.06	37.81	-	95.71
Hardbottom 4	55.90	96.54	63.49	0.06	4.97	66.23	95.71	-

Note: distances only shown in kilometers; no nautical mile equivalents are provided.

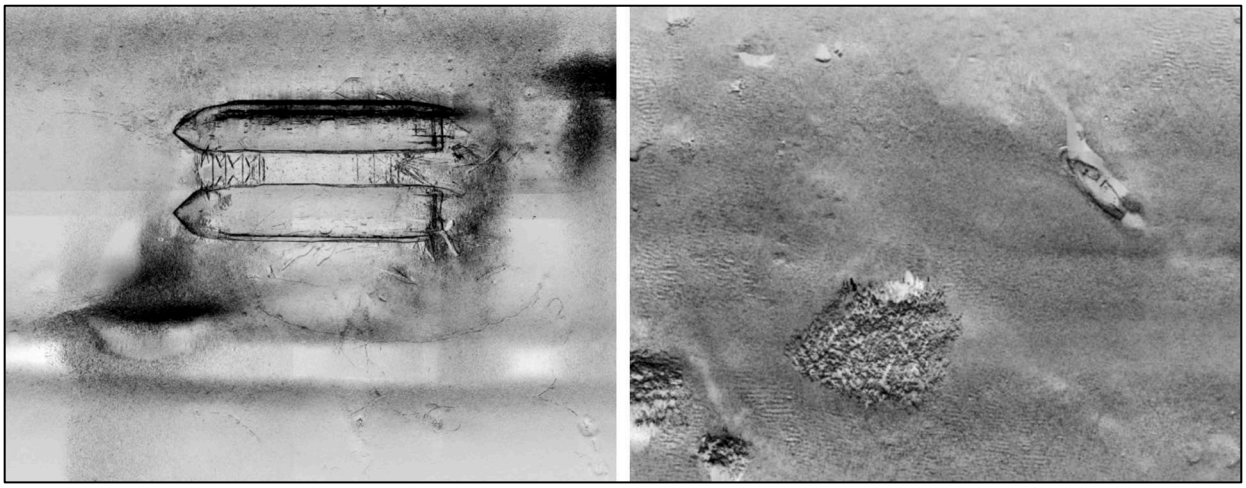


Figure 3. Side scan sonar images of *C. P. Baker*, Shipwreck 4, and Hardbottom 4.
Left: Side scan sonar mosaic of Priority Shipwreck 1, *C. P. Baker*; Right: Side scan data of Shipwreck 4 and Hardbottom 4. Data for both images from David Evans and Associates geophysical survey in May 2021.

2.5 Diver Reconnaissance

In July 2021, the top two priority shipwrecks, *C. P. Baker* and M/V *Hamlet,* were visited, photographed, and filmed by project team technical divers, led by Evan Kovacs of Marine Imaging Technologies (Figure 4). This data set was designed to supplement rather than replace the ROV operations planned for the following year.

Visibility was good and the team acquired 24 minutes 8 seconds of high-resolution video at *C. P. Baker* and 38 minutes 36 seconds at M/V *Hamlet*. *C. P. Baker* sits upside down on her house decks in approximately 186 feet (57 meters) of water. Both catamaran hulls are largely intact. Investigations started at the stern of the port hull and moved the length of the ship to the port bow. From there, divers examined the forward area between the hulls including the steel support struts for the helicopter pad. Around midships on the starboard hull, the divers discovered holes in the house deck that allowed penetration all the way through the structure. Inside were pipes, a hatch that allowed a brief examination of the lower hull, and a transfer pump. Upon exiting the starboard hull, the divers investigated the underside of the starboard hull before returning to the surface. A full description and analysis of the site can be found in Section 3.1.

M/V *Hamlet* sits upright on the ocean floor in approximately 150 feet (46 meters) of water. The hull is severed midships creating two distinct sections. There is also substantial damage and a V-shaped gouge in the starboard bow. Archaeological reconnaissance diver investigations started in the stern on the port side. The team captured good imagery of the vessel's 3"/50 caliber low-angle stern gun which was retrofitted to M/V *Hamlet* in November 1941. The gun and gun mount are well preserved. Moving forward, divers

filmed the port stern where sets of bits and degaussing wires were observed. Much of the ship's original wooden decking in the stern is degraded, revealing the remains of the underlying metal deck beams. The remains of the smokestack were observed along with the open engine room hatch, which provided access to the machinery spaces. The afterdeck house survives up to the poop deck, but the boat deck is missing.

Diver reconnaissance progressed on the upper deck down the starboard gunnel. The team observed several places where large amounts of fishing net drape on the hull and then used video to document the transverse break across the shipwreck (Figure 5). On the other side of the break, the divers swam along the upper deck and under the remains of the forward deck house which remains intact to the bottom of the bridge deck. It appears that above the bridge deck, M/V *Hamlet* had an upper bridge (or perhaps a boat deck) and a flying bridge, but both of these structures are missing. Forward of the deck house, torpedo damage was readily apparent. The team videoed the V-shaped gouge in the starboard bow and the debris outboard of the damaged area. The bow has suffered significant damage, but the windless survives on the remains of the forecastle deck and is still connected to anchor chain. Considerable modern commercial fishing gear was observed in this area. The divers were able to penetrate the forecastle deck to record the hatch and chain locker.



Figure 4. Archaeological diver reconnaissance of *C. P. Baker*.
Photo by MITech.

Aft of the forecastle deck is a winch which serviced the forward boom and a hawser reel and cable. The team videoed the port bow, which is better preserved than the starboard side. They crossed the break, swam back along the upper deck, and then back to the poop deck. The final observations were made in the engine rooms, which were accessed through the engine hatch in the poop deck. M/V *Hamlet* was a twin-screw tanker, driven by 12-cylinder, 561 nominal horse power, diesel engines. A full description and analysis of the site can be found in Section 3.2.



Figure 5. Archaeological diver reconnaissance of M/V *Hamlet* showing fishing net.
Photo by MITech.

2.6 Research Cruise

2.6.1 Logistics

The research cruise took place June 16–22, 2022. It built upon the earlier geophysical survey and diver reconnaissance efforts. The initial project plan called for a research cruise in June/July 2021 using the Florida Institute of Oceanography's research vessel (R/V) *Hogarth*, along with Marine Imagining Technologies' ROV *Pixel*. Unfortunately, a problem with the R/V *Hogarth*'s dynamic positioning system caused a delay to the cruise and the project was rescheduled for summer 2022. As a result of these logistical issues, URI requested and BOEM/BSEE approved, a no-cost, 1-year extension to the project's period of performance.

In March 2022, the Florida Institute of Oceanography informed URI that issues with the R/V *Hogarth's* dynamic positioning system were not going to be fixed. This prompted the project team to initiate emergency plans for alternative vessels. Most research vessels identified were either not well appointed for the work, not within budget, or not available. In May 2022, URI secured the 134-foot catamaran style multi-purpose support vessel (MPSV) *Sea Scout*, owned and operated by Aqueos Corporation out of Amelia, LA (Figure 6). The vessel was a good platform with highly skilled operators, but it did not have dynamic positioning. This was an unfortunate, but unavoidable, compromise.



Figure 6. MPSV *Sea Scout*.
Photo courtesy of Aqueos Corporation.

On June 9, 2022, six days before the research cruise, an electrical short developed in one of the thrusters on Marine Imaging Technologies' ROV *Pixel.* This blew the control side of all the thrusters, leaving the vehicle inoperable. After a rapid search for a replacement ROV, Marine Imagine Technologies identified a SeaRover mid-class ROV that was owned and operated by Reliant Robotics of Covington, Louisiana (Figure 7). In order to obtain the required imaging specified for the project, the project team supplemented the SeaRover's HD camera with an additional 4k camera. This was an important readjustment, and it allowed the project to progress, but the solution was not ideal. Problems with the research platform and ROV compromised data quality, and this was felt most acutely in 3D orthomosaic modelling.

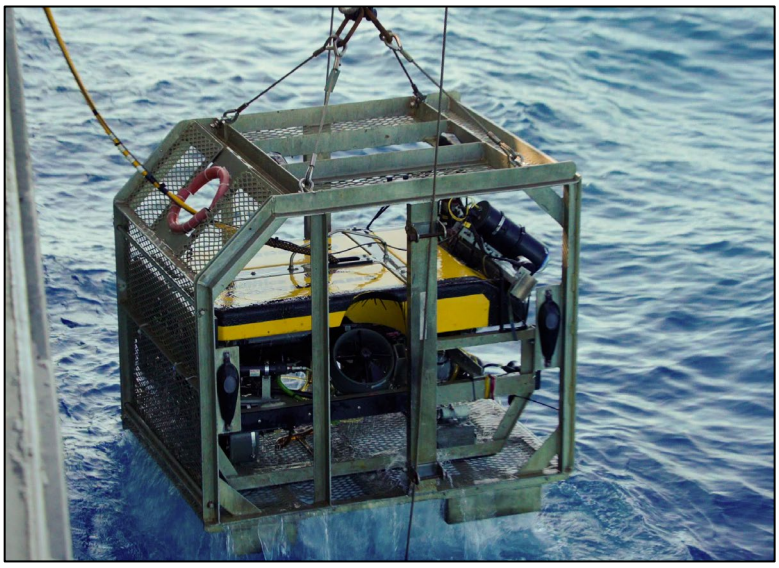


Figure 7. SeaRover mid-class ROV owned and operated by Reliant Robotics, Covington, Louisiana.
Photo taken during the study cruise by Patrick Flanagan.

Cruise participants were as follows:

- Rod Mather, URI
- Dwight Coleman, URI ISC

- Patrick Flanagan, URI ISC
- Kirstin Meyer-Kaiser, WHOI
- Calvin Mires, WHOI
- Evan Kovacs, MITech
- David Ullman, MITech
- Scott Sorset, BOEM
- Doug Jones, BOEM
- Joe Caba, RR
- Glenn Romano, RR
- William Sutliff, Captain, Aqueos
- Grady "Snake" Seaman, Captain, Aqueos
- Jesus Alaniz, Engineer, Aqueos
- Terriell Williams, Cook, Aqueos
- Steven Haley, Deckhand, Aqueos

2.6.2 Narrative

On the night of June 15, 2022, Aqueos moved MPSV *Sea Scout* from its homeport in Amelia, Louisiana to Broussard Brothers Dock in Intracoastal City, Louisiana. On June 16, all team members boarded the ship. On the same day, the ROV arrived on a flatbed, and a crane transferred it, along with a control van and a ROV winch, onto the *Sea Scout's* aft deck. Launch and recovery of the ROV required modifications to the ship's starboard A-frame which were also completed on June 16. At the same time, tabs were welded onto the ROV van so that it could be bolted down to the *Sea Scout's* work deck. Marine Imaging Technologies added a 4k camera to the ROV and set up imaging acquisition and capture in the ship's dry lab. BOEM archaeologists set up a 3D orthomosaic computer station in the same space, and URI's Inner Space Center (ISC) set up a data capture and storage station. The ISC also provided personnel and technology for documenting the cruise for subsequent education and outreach efforts. Due to cost restrictions, the team did not plan any live broadcasts during the cruise. Set-up took all of June 16 and the following morning.

Transit to the first site (Priority Shipwreck 5) commenced around midnight on June 16. The first dive took place at 18:40 CT on June 18. The team completed a total of 11 dives over the subsequent 5 days and recorded data for 7 of the 8 project sites, which were Priority Shipwreck 1 (*C. P. Baker*), Priority Shipwreck 2 (M/V *Hamlet*), Priority Shipwreck 3, Priority Shipwreck 4, Hardbottom 1, Hardbottom 2, and Hardbottom 4. Despite three attempted dives on Priority Shipwreck 5, the team was unable to gather any video or photographic data for the site. The issues were a combination of a bad fiber connector and a recurring overcurrent alarm on the ROV thrusters which compromised ROV maneuverability. Both issues were mitigated by the end of June 19. The last dive ended at 15:56 CT on June 21. *Sea Scout* arrived back at Broussard Brothers Dock around 7 am on June 22. Debriefing, data backup, and demobilization were completed that same day.

Given project personnel and space restrictions, it was only possible to conduct daylight operations. Each day started with a pre-dive briefing which outlined daily objectives and personnel duties. During each dive, at least one archaeologist and one biologist were in the dive van assisting the ROV pilot, guiding operations and recording observations electronically and in a handwritten dive log. The team provided the *Sea Scout* captain with coordinates for the dive, and a monitor showing ship and vehicle position as determined using Hypack software.

2.6.3 Data

2.6.3.1 Sealog (and OpenRVDAS)

The team used the a logging tool called Sealog to record data, observations, and events/milestones during the dives. This allowed for co-registering of events, images and data. Several categories of templates were set up with click buttons to make logging easier - “Archaeology,” “Biology,” “Vehicle” and “Video.” Dives were setup in the system for all 11 ROV dives during the expedition. Both vessel and vehicle data were also sent to the Sealog Server to be logged. Vessel data included the live feeds from the Trimble GPS system - latitude/longitude position and vessel heading. Vehicle data included the live feeds from the Sonardyne USBL system - latitude/longitude position and depth (as computed by USBL [ranges and bearings]) and translated by the Sonardyne software into geographic coordinates.

Sealog data were organized by Dive Number according to the naming convention GM-20-02 followed by -01 through -11 for the 11 dives. The RAW data from the USBL system was stored in an OpenRVDAS subfolder and raw subfolder as PSIMSSB files, which represents the UDP strings sent by the Sonardyne computer that includes vehicle position. In the Sealog subfolders, event logs for every event for every dive were logged. A CSV was generated that had every event for each dive with a UTC time stamp and GPS vehicle position. Other files contained JSON strings from the database.

2.6.3.2 Hypack Files

Vessel and vehicle navigation data was also controlled and recorded in the hydrographic software package Hypack 2022 Q1. The resulting files were readable as text, but needed to be displayed either in Hypack or post-processed and imported into other software. The .RAW files contained, among other information relative to Hypack, the ship’s position and heading and the vehicle’s position and depth.

The .RAW files contained approximately 16 lines of header information at the beginning of each file (until the EOH marker), and then contained logged position and heading messages and the raw GGA navigation strings from the Trimble GPS receiver (every 0.5 seconds). Ship’s heading was stored in the GYR string and GPHDT sentence messages (MSG). QUA strings were GPS receiver signal quality factors which were not utilized.

GPZDA messages were GPS time (in UTC). These directly correlated to Sealog entries (NTP time) and the embedded linear time code on the 4K video. POS 0 messages were the UTM position of the ship in eastings and northings (X,Y meters) - last two numbers. POS 2 messages were the UTM position of the vehicle in eastings and northings (X,Y meters) - last two numbers. The first number after POS 0 or POS 2 was the time of day in seconds past midnight (UTC time). There are 86,400 seconds in a day. Start time and date are were the header. The value 2 was assigned based on the fact that we were using the USBL (Sonardyne Ranger) beacon #2 to track the vehicle. The Hypack driver to log the USBL data was set up that way (Tracklink II driver) with target number 2. POS 2 values did not appear in the file until later, after the start of the dive, because it took time for the USBL beacon to initialize.

2.6.3.3 4K Video Files

The 4K video files were organized by Dive Number to correlate with the Sealog data. The Dive-01 4K video files had the camera setting overlay turned on. This was because MITech had a fiber optic issue with the camera and it did not behave properly causing breaks in the recordings. For the rest of the dives the vehicle obtained clean 4K video data.

The video codec was ProRes 422 - 29.97p with a Quicktime .MOV wrapper. The camera was a Panasonic Lumix BGH-1 in a deep-sea-rated housing. It was mounted on the ROV aiming down at an approximately 45-degree angle. A tactical fiber optic cable was married to the ROV tether and broken out in the lab as a

separate feed. Recordings were collected using an Atomos Shogun Flame device set to take the fiber optic signal converted to HD-SDI as input. Video cards (SanDisk Extreme PRO Solid State Drives: 256, 480, and 512 Mb) were used to store the data locally and move the data to a backup workstation. Silverstack Offload Manager was used to offload the cards and store the data on G-Speed RAID array devices.

File naming convention chosen based on the Atomos Shogun Flame requirements was: GM2002_S002_S001_T001.MOV. This corresponded to: CRUISEID_DIVE#_CARD#_SEQUENCE#.MOV. The example file named above stored footage from Dive02, Card01 (4K), 1st sequence of the dive. The team had no control over the S, S, and T prefixes (from film industry scene, shot, take) or forced labeling by the Atomos device.

2.6.3.4 SeaRover Video Files

SeaRover video was recorded by two systems: 1) The Sea Rover ROV DVR in the control van; and 2) A second Atomos Shogun Flame recorder in the main lab that took a feed off the ROV SD camera. The DVR data were files that only recorded time stamped .AVI files. The Atomos recorded video (with overlay) was broken out topside and fed via fiber to the lab and set up as ProRes 422 HD MOV files. The DVR clock was set to UTC manually but was off a few seconds from actual UTC. Those video files were stored in subfolders according to date. They were sequential with start times in the file name and segmented every 10 minutes. Unfortunately, the Atomos HD recordings could log only elapsed time, but the start of each file was accurate to UTC time. The DVR files were from two cameras: the SD with overlay and raw HD. Both cameras were out of focus except when the focal length was very short.

2.6.3.5 Scanning Sonar Files

The team obtained partial sector scanning sonar data. The SeaRover ROV had Blue View and Mesotech (Imagenix) sector scanning sonars, but they were only turned on to record at select times, not continuously. The resulting files were created in a proprietary format. The Imagenix files were readable by free software available on the Mesotech web site, but special and unavailable software was required to read and visualize the Blue View data. The files had the date of the dive in the file name. Since more than one dive was typically conducted per day, Sealog and/or the time code was used to identify the exact dive. It appears the date on the logging computer was set incorrectly on June 18, 2022. In addition, the computer that logged the scanning sonar data was set to local time, not UTC, so all that data was off by 5 hours (U.S. Central Daylight Time offset).

2.6.3.6 3D Orthomosaic Models

During the cruise, BOEM archaeologists set up a mobile workstation loaded with Agisoft Metashape Professional Edition Version 2 photogrammetry software. They took samples of the video and photographic data to develop low-resolution models of the sites. After the cruise, they used a high-power workstation to refine the models. Unfortunately, 3D modelling was only partially successful. Data quality for 3D models was compromised by absence of dynamic positioning on the MPSV *Sea Scout*, difficulty in controlling the SeaRover ROV, intermittent faults with the ROV, poor visibility, and most importantly inadequate lighting mounted to the substitute vehicle.

2.6.3.7 Data Copies and Archive

In August 2022, the research team held a series of collective and individual meetings to organize, copy, and transfer field data. Four full copies of the data were archived. The URI and WHOI systems were 36 TB G-Speed RAID devices. The BOEM LaCie RAID system was a 96TB device. Copies of the data were held by:

1. Applied History Lab URI (Mather)

2. ISC, URI (Coleman)
3. Woods Hole Oceanographic (Meyer-Kaiser)
4. BOEM (Sorset)

2.6.4 Biological Analysis Methods

Video recordings from the 2021 diver reconnaissance and from the 2022 cruise were viewed, and all fish were counted and identified. Videos were also converted to frame grabs to enable discrete counting and identification of invertebrates. All invertebrates in frame grabs deemed eligible for analysis (i.e. not too bright, not too dark, non-overlapping) were counted. This methodology resulted in good representation of the community; most, but not all invertebrates in the video, were represented or counted in a frame grab. Species identifications were made by reference to published guides (Humann and DeLoach 2002; Humann and DeLoach 2013; Humann et al. 2013).

Zooplankton samples were taken using a net (150 μm mesh, 1 m diameter) above each site and preserved in 20% buffered dimethyl sulfoxide at sea. Following the 2022 cruise, samples were sorted using a dissecting microscope. All larval forms of benthic species were removed and photographed. Representative specimens of each morphotype were used for DNA barcoding. DNA was extracted using the HotSHOT method (Truett et al. 2000). The COI locus was amplified using "universal" primers for PCR (Folmer et al. 1994). Successful PCR products were sent to Sequegen, Inc. (Worcester, Massachusetts) for sequencing, and sequences were compared to the public database GenBank for identification.

2.6.5 ROV Dives

The team completed a total of 11 ROV dives during the research cruise and recorded data for 7 of the 8 project sites - Priority Shipwreck 1 (*C. P. Baker*), Priority Shipwreck 2 (M/V *Hamlet*), Priority Shipwreck 3, Priority Shipwreck 4, Hardbottom 1, Hardbottom 2, and Hardbottom 4. Despite several efforts, the team was not able to film, record, or photograph Priority Shipwreck 5. Dive data for each site is provided below (Figures 8–18).

2.6.5.1 Dive 1

Data Name: GM 20 02 Dive 01
Target: Shipwreck 5 (BOEM Identifier: VID 15420).
Coordinates (NAD 27): Redacted
Date: 17 June 2022. Friday (local)
Dive Times:

- Dive Start: 00:40 (UTC) - 18:40 (CT)
- Decent Start: 00:50 (UTC) - 18:50 (CT)
- On Bottom: 01:05 (UTC) - 19:05 (CT)
- Ascent Start: 01:21 (UTC) - 19:21 (CT)
- On Surface: 01:31 (UTC) - 19:31 (CT)
- Dive End: 01:45 (UTC) - 19:45 (CT)

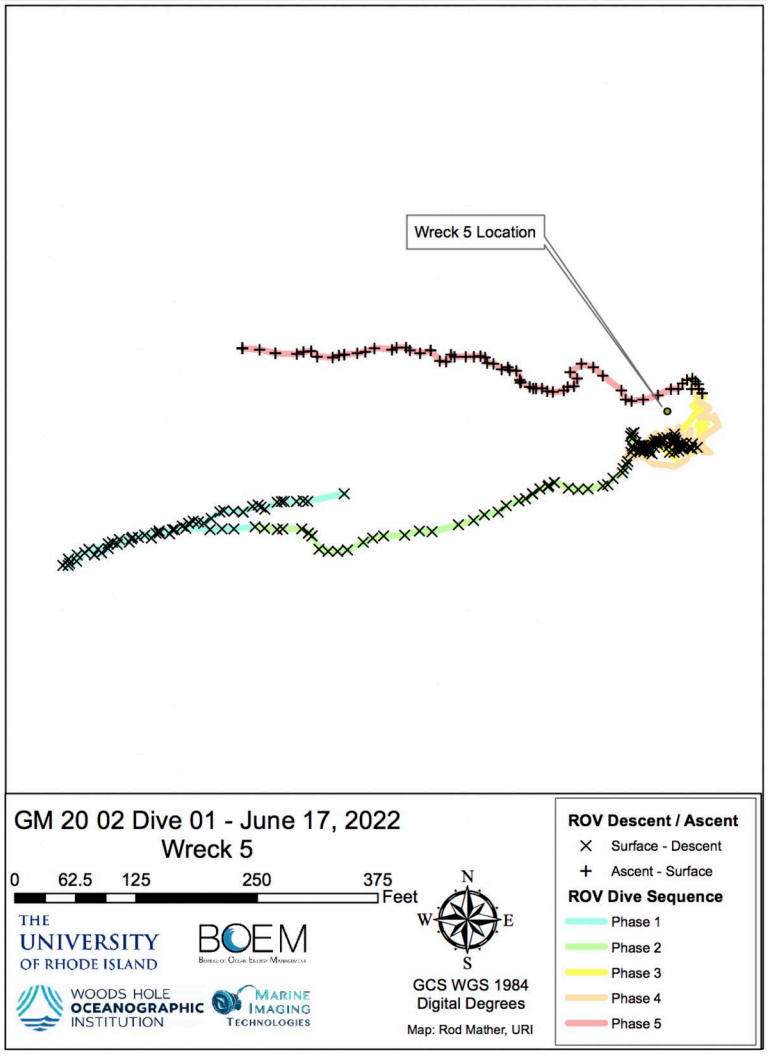


Figure 8. Dive 1 – Technical Details.
No base image available for this figure.

2.6.5.2 Dive 2

Data Name: GM 20 02 Dive 02
Target: Shipwreck 4 (BOEM Identifier: VID 15419) and Hardbottom 4
Coordinates (NAD 27): Redacted
Date: 18 June 2022. Saturday (local)
Dive Times:

- Dive Start: 16:56 (UTC) - 10:56 (CT)
- Decent Start: 17:37 (UTC) - 11:37 (CT)
- On Bottom: 17:53 (UTC) - 11:53 (CT)
- Ascent Start: 19:47 (UTC) - 13:47 (CT)
- On Surface: 19:53 (UTC) - 13:53 (CT)
- Dive End: 20:02 (UTC) - 14:02 (CT)

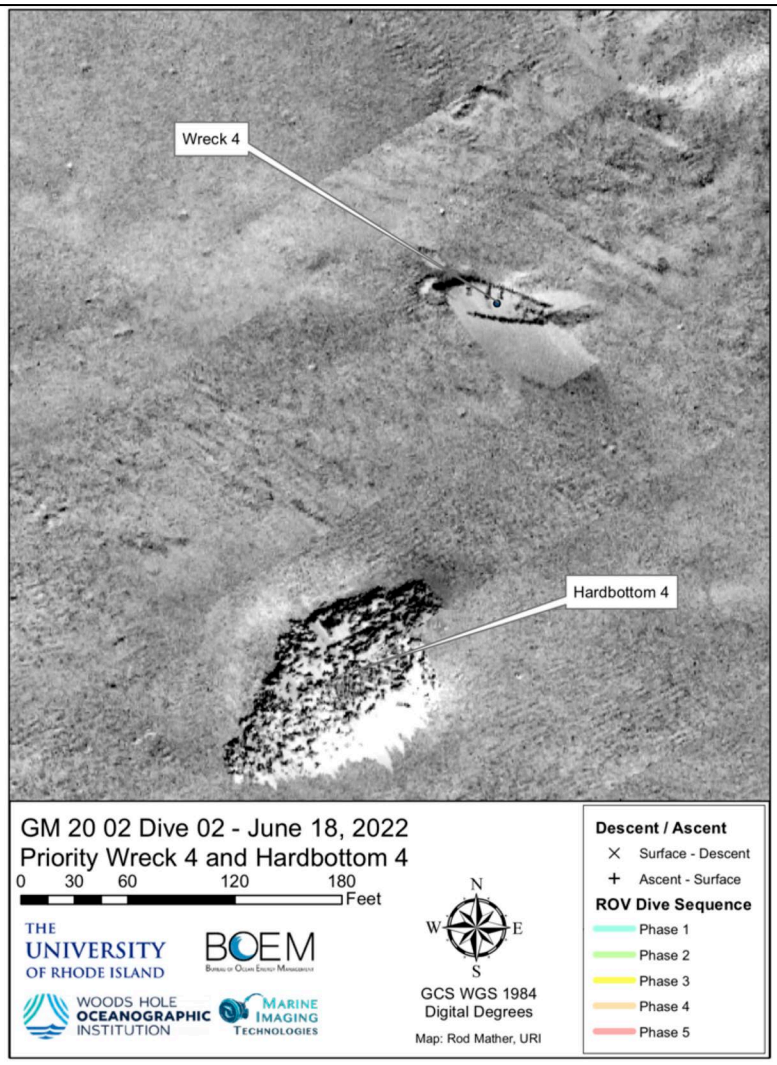


Figure 9. Dive 2 – Technical Details.
No dive sequence data available for this dive.

2.6.5.3 Dive 3

Data Name: GM 20 02 Dive 03
Target: Shipwreck 5 (BOEM Identifier: VID 15420)
Coordinates (NAD 27): Redacted
Date: 18 June 2022. Saturday (local)
Dive Times:

- Dive Start: 21:31 (UTC) - 15:31 (CT)
- Decent Start: (UTC) - (CT)
- On Bottom: (UTC) - (CT)
- Ascent Start: (UTC) - (CT)
- On Surface: (UTC) - (CT)
- Dive End: 21:57(UTC) - 15:57 (CT)

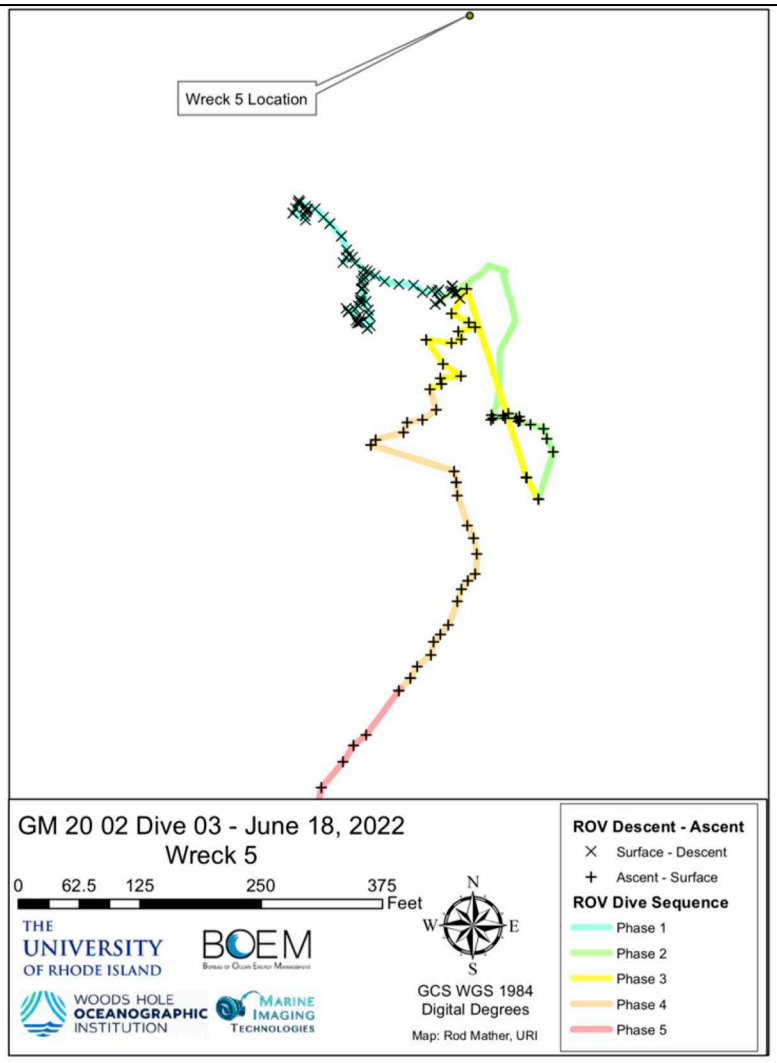


Figure 10. Dive 3 – Technical Details.
No base image available for this figure.

2.6.5.4 Dive 4

Data Name: GM 20 02 Dive 04
Target: Shipwreck 5 (BOEM Identifier: VID 15420)
Coordinates (NAD 27): Redacted
Date: 18 June 2022. Saturday (local)
Dive Times:

- Dive Start: 23:02 (UTC) - 17:02 (CT)
- Decent Start: 23:10 (UTC) - 17:10 (CT)
- On Bottom: 23:19 (UTC) - 17:19 (CT)
- Ascent Start: 23:32 (UTC) - 17:32 (CT)
- On Surface: 23:47 (UTC) - 17:47 (CT)
- Dive End: 23:52(UTC) - 17:52 (CT)

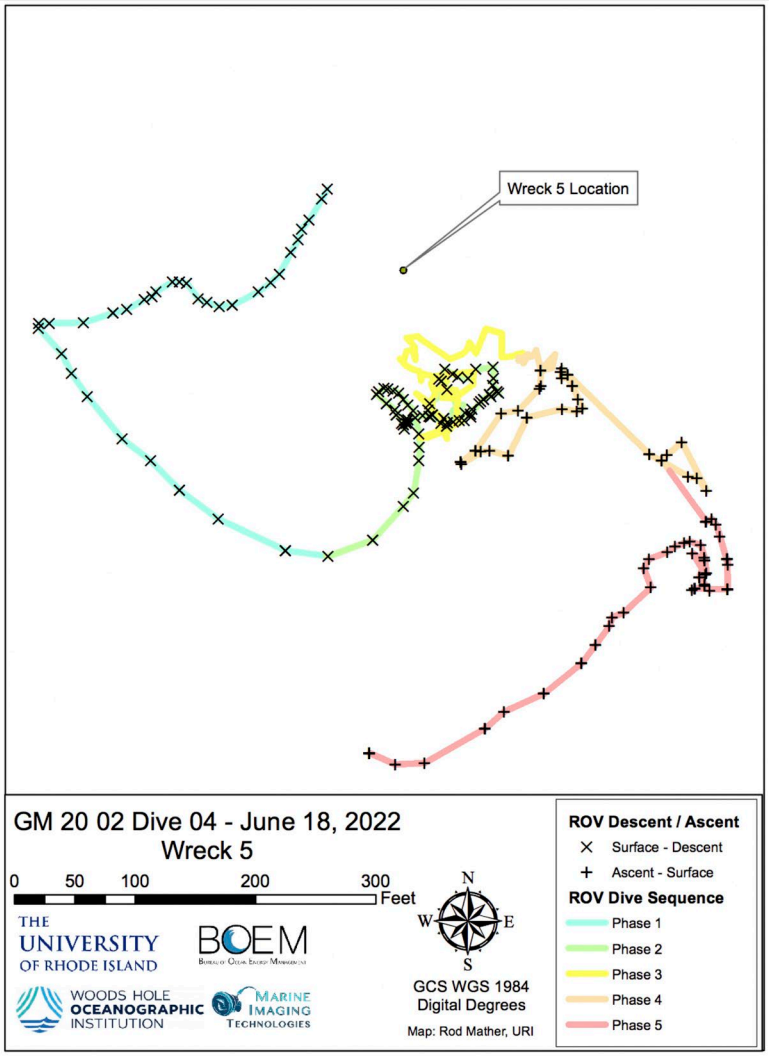


Figure 11. Dive 4 – Technical Details.
No base image available for this figure.

2.6.5.5 Dive 5

Data Name: GM 20 02 Dive 05
Target: Hardbottom 1
Coordinates (NAD 27): Redacted
Date: 19 June 2022. Sunday (local)
Dive Times:

- Dive Start: 17:05 (UTC) - 11:02 (CT)
- Decent Start: 17:11 (UTC) - 11:11 (CT)
- On Bottom: 17:17 (UTC) - 11:17 (CT)
- Ascent Start: 18:42 (UTC) - 12:42 (CT)
- On Surface: 18:47 (UTC) - 12:47 (CT)
- Dive End: 18:54(UTC) - 12:54 (CT)

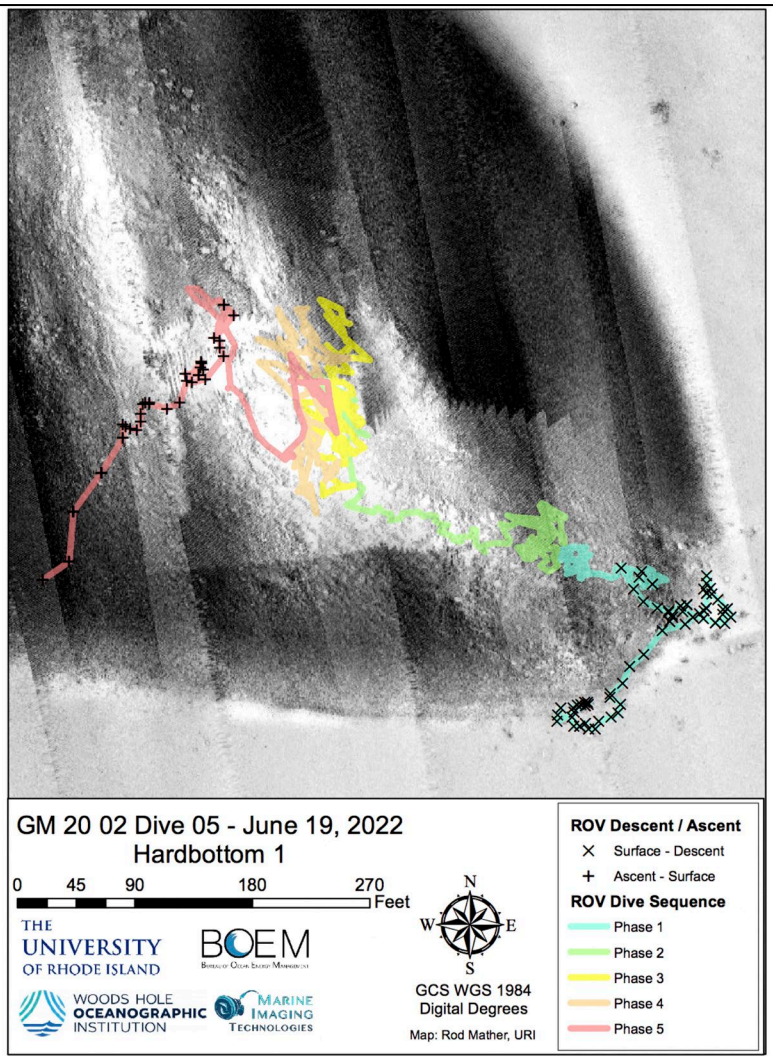


Figure 12. Dive 5 – Technical Details.

2.6.5.6 Dive 6

Data Name: GM 20 02 Dive 06
Target: Shipwreck 1 - *C. P. Baker* (BOEM Identifier: VID 6856)
Coordinates (NAD 27): Redacted
Date: 19 June 2022. Sunday (local)
Dive Times:

- Dive Start: 20:51 (UTC) - 14:51 (CT)
- Decent Start: 20:52 (UTC) - 14:52 (CT)
- On Bottom: 20:58 (UTC) - 11:17 (CT)
- Ascent Start: 23:58 (UTC) - 17:58 (CT)
- On Surface: 00:07 (UTC) - 18:07 (CT)
- Dive End: 00:09 (UTC) - 18:09 (CT)

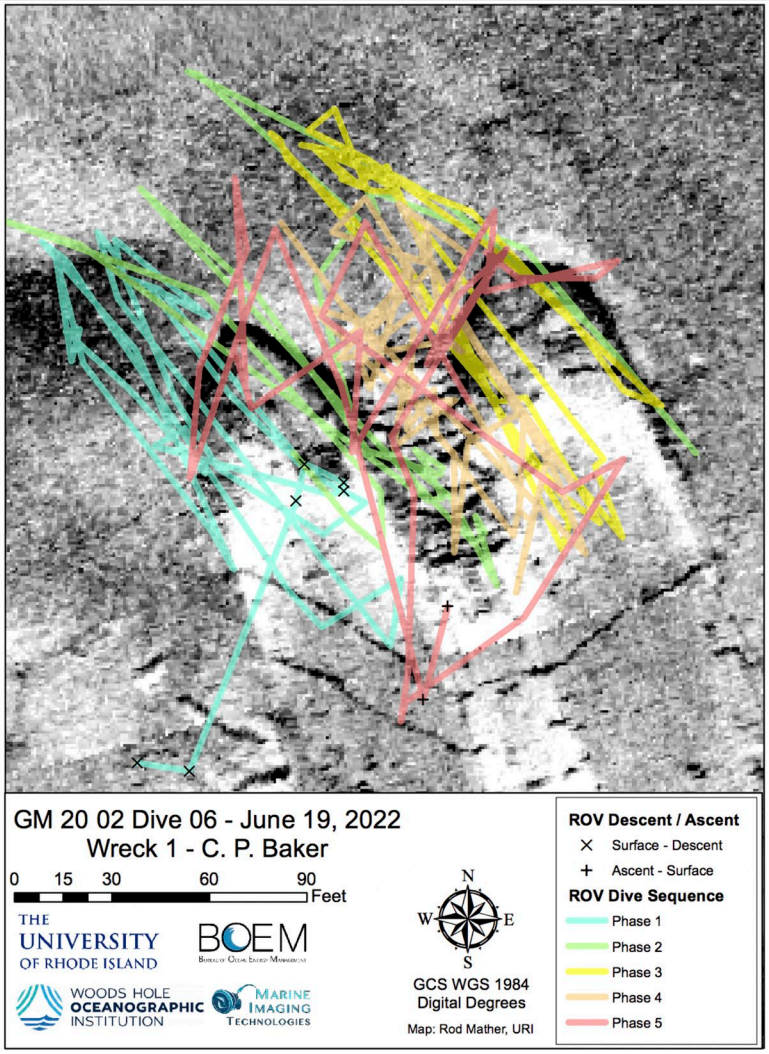


Figure 13. Dive 6 – Technical Details.

2.6.5.7 Dive 7

Data Name: GM 20 02 Dive 07
Target: Hardbottom 2
Coordinates (NAD 27): Redacted
Date: 20 June 2022. Monday (local)
Dive Times:

- Dive Start: 13:19 (UTC) - 07:19 (CT)
- Decent Start: 13:36 (UTC) - 07:36 (CT)
- On Bottom: 13:41 (UTC) - 07:41 (CT)
- Ascent Start: 15:59 (UTC) - 09:59 (CT)
- On Surface: 16:05 (UTC) - 10:05 (CT)
- Dive End: 16:08 (UTC) - 10:08 (CT)

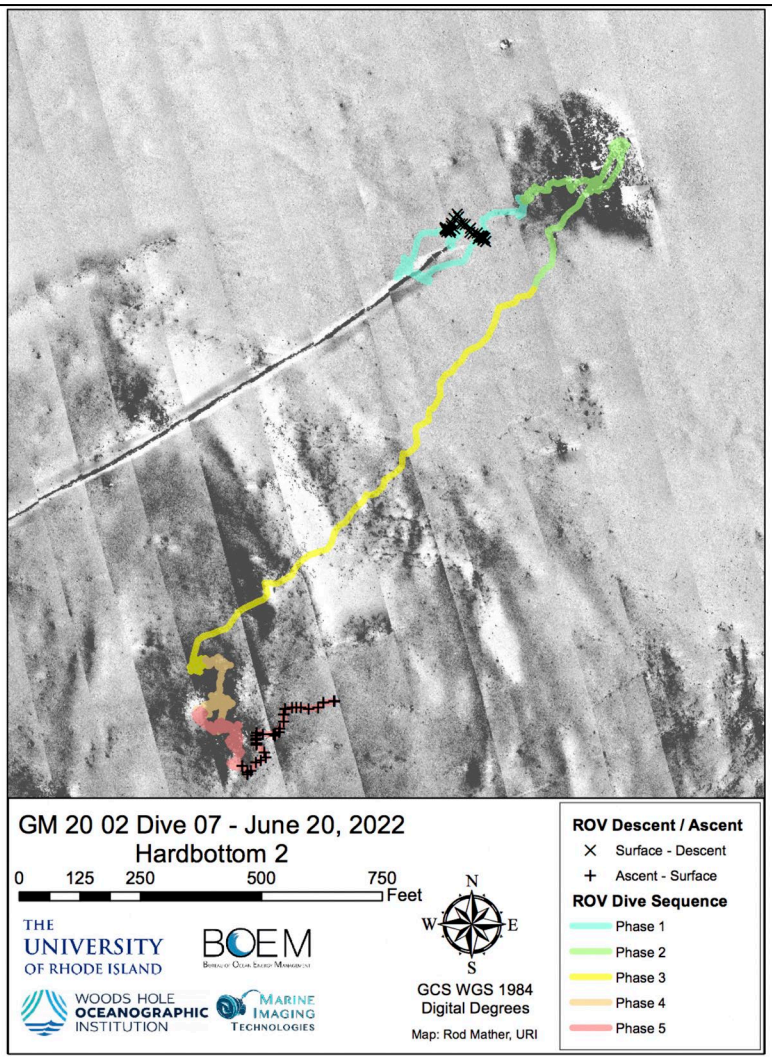


Figure 14. Dive 7 – Technical Details.

2.6.5.8 Dive 8

Data Name: GM 20 02 Dive 08
Target: Shipwreck 2 - M/V *Hamlet* (BOEM Identifier: VID 15322)
Coordinates (NAD 27): Redacted
Date: 20 June 2022. Monday (local)
Dive Times:

- Dive Start: 17:46 (UTC) - 11:46 (CT)
- Decent Start: 17:49 (UTC) - 11:49 (CT)
- On Bottom: 17:53 (UTC) - 11:53(CT)
- Ascent Start: 18:20 (UTC) - 12:20 (CT)
- On Surface: 18:24 (UTC) - 12:24 (CT)
- Dive End: 18:27 (UTC) - 12:27 (CT)

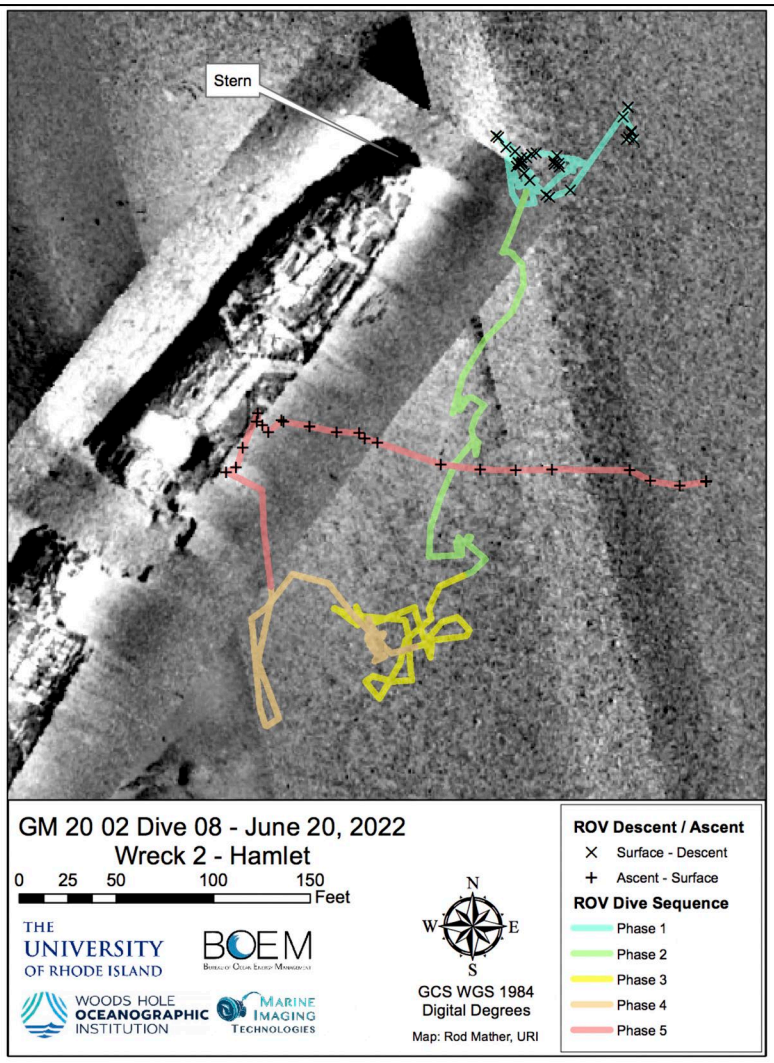


Figure 15. Dive 8 – Technical Details.

2.6.5.9 Dive 9

Data Name: GM 20 02 Dive 09
Target: Shipwreck 2 - M/V *Hamlet* (BOEM Identifier: VID 15322)
Coordinates (NAD 27): Redacted
Date: 20 June 2022. Monday (local)
Dive Times:

- Dive Start: 13:30 (CT) - 19:30 (UTC)
- Decent Start: 13:49 (CT) - 19:53 (UTC)
- On Bottom: 13:53(CT) - 19:56 (UTC)
- Ascent Start: 16:34 (CT) - 22:34 (UTC)
- On Surface: 16:39 (CT) - 22:39 (UTC)
- Dive End: 16:49 (CT)- 22:49 (UTC)

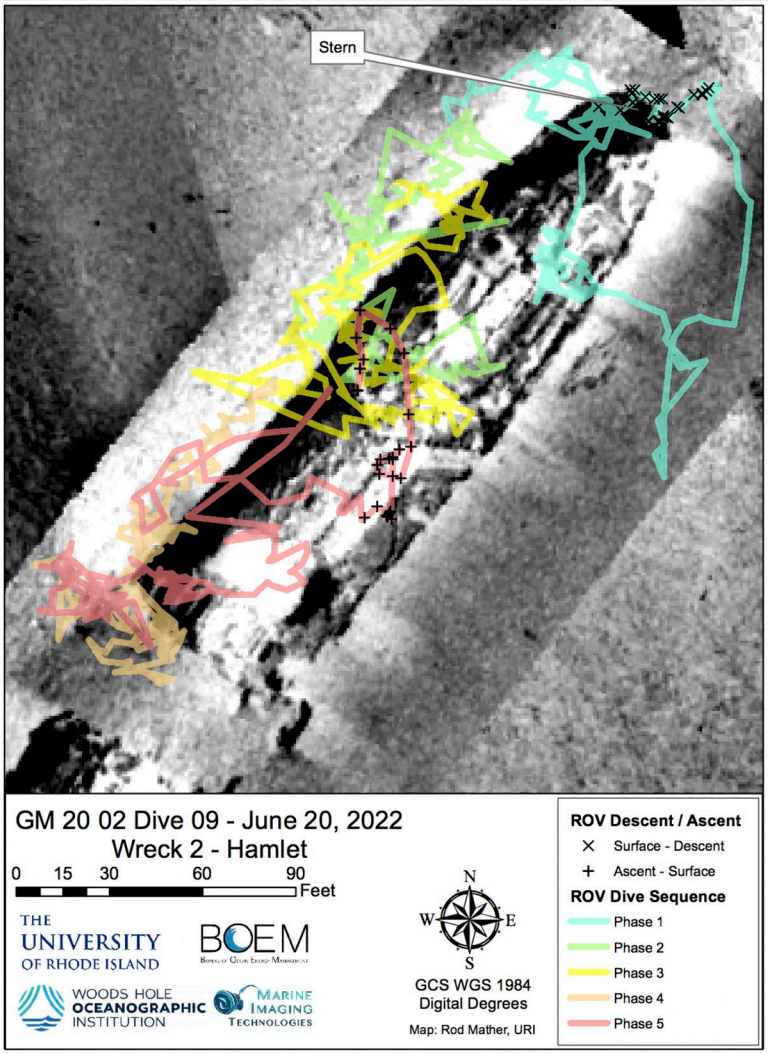


Figure 16. Dive 9 – Technical Details.

2.6.5.10 Dive 10

Data Name: GM 20 02 Dive 10
Target: Shipwreck 2 - M/V *Hamlet* (BOEM Identifier: VID 15322)
Coordinates (NAD 27): Redacted
Date: 21 June 2022. Tuesday (local)
Dive Times:

- Dive Start: 07:05 (CT) - 13:05 (UTC)
- Decent Start: 07:07 (CT) - 13:07 (UTC)
- On Bottom: 07:11 (CT) - 13:11 (UTC)
- Ascent Start: 08:40 (CT) - 14:40 (UTC)
- On Surface: 08:46 (CT) - 14:46 (UTC)
- Dive End: 08:50 (CT)- 14:50 (UTC)

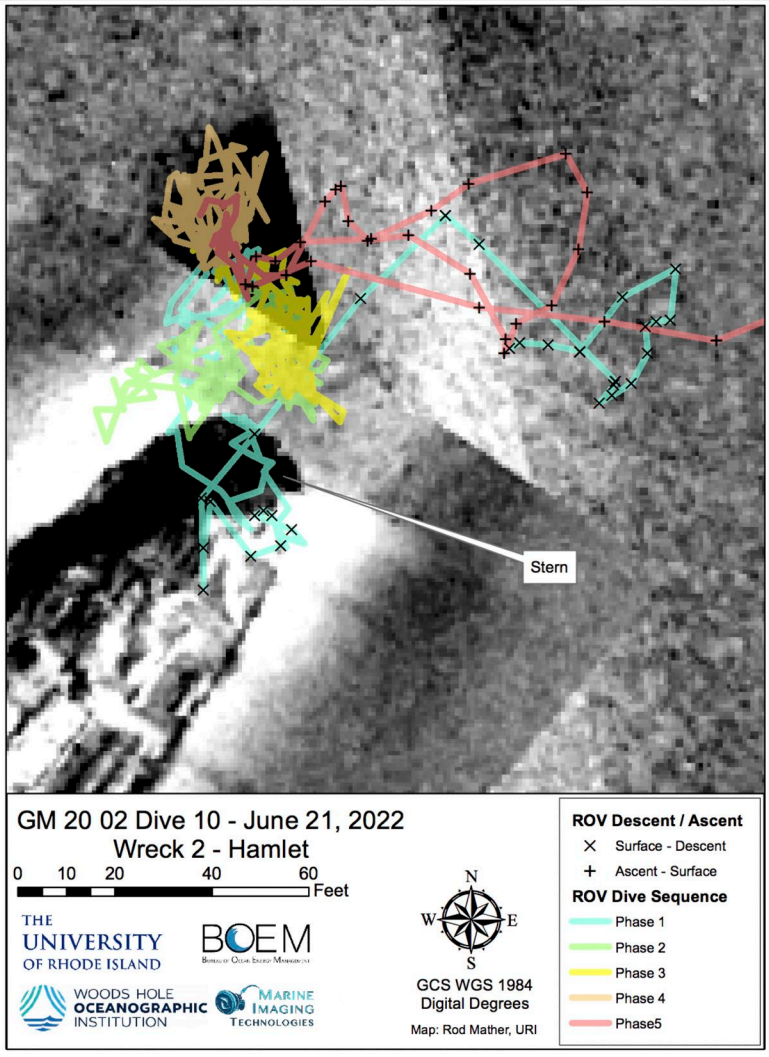


Figure 17. Dive 10 – Technical Details.

2.6.5.11 Dive 11

Data Name: GM 20 02 Dive 11
Target: Shipwreck 3 (BOEM Identifier: VID 15253)
Coordinates (NAD 27): Redacted
Date: 21 June 2022. Tuesday (local)
Dive Times:

- Dive Start: 13:08 (CT) - 19:08 (UTC)
- Decent Start: 13:27 (CT) - 19:27 (UTC)
- On Bottom: 13:29 (CT) - 19:29 (UTC)
- Ascent Start: 15:35 (CT) - 21:35 (UTC)
- On Surface: 15:41 (CT) - 21:41 (UTC)
- Dive End: 15:46 (CT)- 21:46 (UTC)

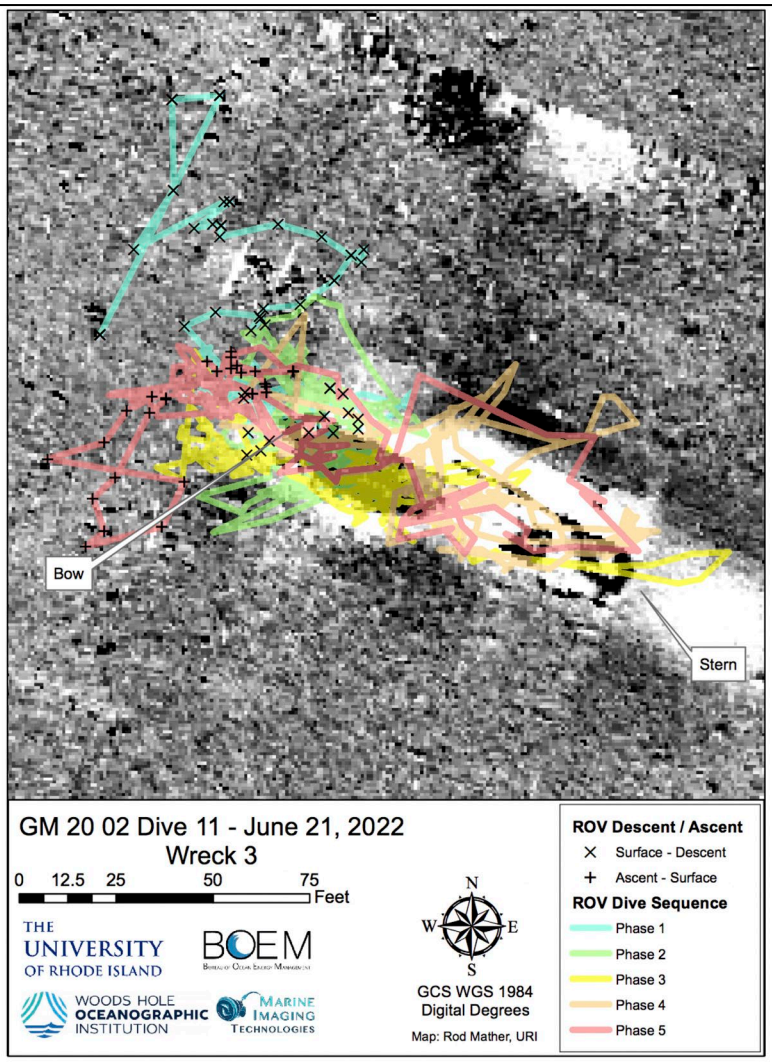


Figure 18. Dive 11 – Technical Details.

3 Results: History and Archaeology

3.1 Shipwreck 1: *C. P. Baker*

3.1.1 Overview

C. P. Baker, official No. 289043, is located in the Eugene Island Area in approximately 186 feet (57 meters) of water. The location is about 80 miles off the coast of Louisiana. During the night of June 30th, 1964, *C. P. Baker* was engaged in oil well drilling operations when it was involved in a major blowout that led to the vessel sinking, injuring 22 and killing 21 of the 43 crewmembers. The non-powered, catamaran-type, oil drilling vessel was the first of its kind, and was registered at 3891 gross net tons. It was 260.4 feet in length, 126.1 feet in the beam and 14.2 feet in depth (as measured from tonnage deck amidships to the bottom of the draft). *C. P. Baker* was built in 1962 by Levingston Shipbuilding Company out of Orange, TX for Reading & Bates Offshore Drilling Company, New Orleans, Louisiana. It was constructed by joining two former U.S. navy YF-type barges together, which were originally built in 1945. The current extent of the site includes the wreck of *C. P. Baker*, which lies on its decks with the keels pointing upwards and with the bows facing Northwest, as well as a major debris field lying to the west of the main body of the wreck. *C. P. Baker* is well preserved and archaeologically and historically significant.

3.1.2 Historic Context

There are three historical contexts relevant to *C. P. Baker.*

1. The early history of the offshore oil industry in the Gulf including the transition from submerged rigs, to jackup rigs, to floating rigs, along with the associated history of the offshore rig and/or drilling vessel construction industry.
2. The history of the Levingston Shipbuilding Company.
3. The history of Reading & Bates Offshore Drilling Company.

Of particular interest in these contexts is the repeated use of ex-navy, World War II-era, YF covered lighters or barges in the early history of offshore oil and gas activities in the Gulf.

3.1.2.1 Early History of the Offshore Oil Industry and the Rig and/or Drilling Vessel Construction Industry

In 1911, Gulf Refining Company drilled a well called Ferry Lake No. 1 on Caddo Lake, Louisiana. The company used fixed wooden platforms, constructed using floating pile drivers, and serviced by barges and tugboats. This inaugurated free standing (i.e. not connected back to the shore with piers), over-water, oil drilling platforms on inland waters in the Gulf states (Jones 2023; American Oil & Gas Historical Society n.d.). Drilling on the open ocean, without piers back to shore, was much more difficult and was still several decades away. On March 18, 1938, Pure Oil and Superior Oil Company started production of oil from Superior-Pure Gulf of Mexico State No. 1 which was located about 1.5 miles off Creole, Louisiana. The company's platform was situated in about 14 feet of water. One of the Gulf's pioneer shipbuilders, Brown & Root (Houston, Texas) built the platform. The legs, pilings, and 180 x 320 foot deck were all constructed of timber protected with creosote. Wooden construction reduced costs, which was particularly important since the platform could not be moved or reused. A pipeline allowed for the transfer of oil to shore. Since the platform had no living quarters, workers commuted on shrimp boats from the nearest port, Cameron, Louisiana, which was about 10 miles away. Over the next 25 years, Superior-Pure Gulf of Mexico State No. 1 produced four million barrels of oil (Offshore 2014; American Oil & Gas Historical Society n.d.).

World War II slowed development of offshore oil and gas production in the Gulf. The combination of U-boat activities and a shortage of workers and materials stifled growth (Jones 2023). After the war, offshore oil production increased rapidly and was accompanied by innovation, exploration, and a revolution in drilling. Although early platforms were all non-movable, companies did adopt different approaches. One strategy was to use a small platform supported by a tender. This was the system Kerr-McGee used in 1947 with the construction Kermac 16, located 10.5 miles off Terrebonne Parish, Louisiana and 43 miles south of Morgan City, Louisiana. The platform came online on November 14, 1947, inaugurating oil production in the Gulf "out of sight of land" (Offshore 2014). The small platform allowed for reduced costs, while the tender provided worker accommodations, supplies, and equipment which could be reused at other sites (Offshore 2014). Kermac 16 remained in operation until 1984 by which time it produced 307 million cubic feet of natural gas and 1.4 million barrels of oil. Other companies followed this same small platform and tender approach, and some of the most common tender types were repurposed World War II navy YF covered lighters. For example, Kerr-McGee's plans (and photographs) for converting *YF-892* to a mobile tender to be used in conjunction with a small fixed platform have survived (Schwartz 1949:7 and Figs 17–22). Schwartz when describing the tender writes:

> The craft is designed for stores and equipment for drilling a 12,000 foot well with all equipment on hand before drilling starts. In addition, it furnishes quarters for the drilling crews and seamen, a galley complete with freezing units, a hospital, a lounge and recreation room, FM radio transmitter and receiver, and a ship-to-shore radio telephone (Schwartz 1949, 46–47).

When it was first built, *YF-892* was virtually identical to the YF lighters that were later used to construct *C. P. Baker.* The use of ex-navy YF barges in the oil industry was well established by the late 1940s and continued throughout the 1950s and early 1960s.

As an alternative to the small platform and tender approach, other companies developed large, permanent, exploratory drilling platforms. The advantages were strength and longevity, but they lacked mobility. Magnolia was the first company to build one of these large offshore platforms. Completed in 1946, it featured metal-frame-reinforced timber piles, but it never struck hydrocarbons and was a substantial commercial failure. Industry experts recognized that mobile rigs were necessary.

Mobile drilling rigs evolved in the 1950s and early 1960s starting with submersible rigs (initially sunken drill barges), then jackup rigs and finally floating rigs (Howe 1967:120). This progression was accompanied by increasing use of metal structures, prefabrication on shore, installation at sea, and significant variety in design (Offshore 2014).

Submersible drill barges and/or rigs were introduced in 1949. The first was Barnsdall-Hayward's *Breton Rig 20*. The technology was adapted from drill barges, developed in the early 1930s, which sat on bottom of inshore marshes and saltwater ponds. *Breton Rig 20* was towed to its offshore site and sunk. It was supported by pontoons which remained on the surface of the water while the barge was flooded and lowered to the sea floor. Once the barge was in place, the pontoons were also submerged. The barge was connected to a platform that remained above the surface of the water. Further iterations of submerged drill barges were developed during the 1950s. All were near shore systems, limited to use in waters less than 80 feet deep (Howe 1967:121–124). Submersible rigs were prone to instability, particularly when subject to high wave action. One solution was to add skirts to the outside of the hull or use spuds to help secure the barge. Another solution, introduced by Kerr-McGee on *Rig 46* in 1956, was to use inverted bottle shaped pontoons, which would also later be used in semisubmersible rigs (Howe 1967:124; Offshore 1997).

The first jackup rig was Magnolia's *Delong Rig No. 1*, which was built in 1950 and installed in 1953 (Howe 1967:125). Further iterations of the rig type were developed in the 1950s. Jackup rigs were towed to the desired location. A series of steel piles or legs were then deployed on the ocean floor and the

platform was raised out of the water. Early jackup rigs could operate in water up to about 100 feet deep; later versions could be used in water 3 times that depth, and modern jackups have been built for 500-foot water depth operations (Howe 1967; Offshore 2004). Some of the initial platforms had as many as 12 piles, but following the development of Zapata Offshore's *Scorpion* in 1956 the three-legged, tripod version was widely adopted. One of the problems with jackup rigs was "excessive leg penetration in soft soils" (Howe 1967:125). A solution was to "to add large-diameter 'cans' near the lower end of the cylindrical legs" (Howe 1967:125). This approach was first used in 1955 with The Offshore Company's *No. 51*. Another solution was to attach all the legs to a wide area steel hull or mat which sat on the ocean floor. The mat was constructed and launched separately from the rig. Another problem with jackup rigs was pressure on the legs while the rig hull was still in the water. Weave action on the hull added stress to the legs sometimes causing them to bend or break. According to Howe (1957:134) jackups in the 1950s and 1960s accounted for 61% of oil industry mishaps in the Gulf, as defined as an incident costing at least $1 million. The majority of these mishaps occurred while moving, installing, or preparing to move the jackup rig.

Floating rigs were also developed in the early 1950s. There were two types: 1) surface vessels and 2) semisubmersible floating platforms. Surface vessels can be further subdivided into self-propelled ships and non-self-propelled barges. Barges, which preceded ships, sometimes had the drill rig cantilevered over the side and other times it was mounted over a well on the centerline of the vessel. The first over the side coring barge was Cuss Group's *Submarex* built in 1953 and the first centerline barge was Socal's *Western Explorer* built in 1955. In some instances, for example Zapata Offshore's *Nola 1*, ex-navy YF barges were converted to over the side rigs. *C. P. Baker* was the first catamaran barge. Although it is often referred to as a drillship, it was not self-propelled. *C. P. Baker* was constructed using 2 surplus YF barges. An ex-navy YF barge was also used for the construction of the world's first self-propelled drillship, Global Marine's *CUSS 1*. Built in 1956, it was originally non-self-propelled, but it was modified in 1961 to accommodate 4 outboard engines, one on each corner of the ship, which were controlled from a center console. This early form of dynamic positioning allowed the ship to be both self-propelled and to hold station. In 1962, Global Marine launched *CUSS II* also called *Glomar II*. This was the world's first design-dedicated, newly constructed, self-propelled drillship (Howe 1997; Offshore 1997).

Ocean engineering studies in the late 1950s and early 1960s indicated that much of the motion that surface vessels experienced due to wave action might be reduced if the hull was semisubmerged. In 1961, Blue Water converted their *Rig No. 1* into a semisubmersible system. Designers incorporated floodable inverted bottle-shaped pontoons that had been developed earlier for submersible rigs/barges. Pitching and rolling motion on *Rig No. 1* was greatly reduced (Offshore 1997; Howe 1997). One advantage of semisubmersibles was that they allowed for deployment of a disconnected conductor or free-standing riser which in turn separated the "motion of the conductor pipe from the hull" (Offshore 1997). The design also facilitated the placement of the blowout preventer on the seabed rather than the deck (Offshore 1997). Semisubmersible rigs increased in size over the subsequent decades and design improvements made deep water drilling possible.

The history of offshore drill vessel construction companies in the Gulf is fairly well understood. A major contribution is the work of Able and Taylor (2008:192–218). Using newspaper articles and industry journals combined with secondary sources, the authors laid out the development of the ship and rig construction industry by decade. During the 1950s, a relatively large number of shipbuilders obtained contracts for a combination of mobile rigs and/or offshore supply vessels (OSV). Two operators - Brown & Root (Houston, Texas) and J. Ray McDermott (New Orleans, Louisiana) secured major shares of the market, but others competed including Ingalls Shipbuilding (Pascagoula, Mississippi), Todd Shipyards (Galveston, Texas), Arnold V. Walker Shipbuilding (Pascagoula, Mississippi), Gulfport Shipbuilding Corporation (Port Arthur, Texas), Bludworth Shipyard (Houston, Texas); Platzer Boat Works, Inc. (Houston, Texas), Port Houston Iron Works, (Houston or Pasadena, Texas), Sprague Welding & Machine

Works/Marine Fabricating & Engineering Co. (Houston, Texas) and Burton Construction & Shipbuilding Co., Inc (Port Arthur, Texas) (Able and Taylor 2008:193–197). The 1960s and 1970s saw significant consolidation in the Gulf rig construction sector with four operators taking the lion's share of the market. "Increased costs of construction and technological sophistication of mobile rigs and their cost" drove industry concentration (Abel and Taylor 2008:197). The four companies that dominated the industry were Bethlehem Shipbuilding (Beaumont, Texas); Levingston Shipbuilding Company (Orange, Texas); R.G. LeTourneau (Vicksburg, Mississippi); and Avondale (New Orleans, Louisiana). From the 1980s onwards, foreign companies began to compete successfully in the offshore oil and gas platform market, as well as the support vessel and infrastructure business. The largest foreign competitors were from Norway and Japan and they benefitted from national government subsidies and lower costs, particularly with respect to their payroll (Abel and Taylor 2008:197–203). The Levingston Shipbuilding Company is particularly important for this study.

3.1.2.2 Levingston Shipbuilding Company

Samuel H. Levingston was born in 1830 in County Antrim, Ireland (today part of Northern Ireland; some sources list 1832 as Levingston's date of birth). His family, including his father, two brothers David and John, and his sister Margaret, moved to Port St. Joe, Florida in 1838. Samuel's father died in 1843 (*The Daily Leader* 1909; Williams 1988).

As a young adult, Samuel Levingston fought in the Seminole Wars and worked as a steamboat builder in St. Louis, Missouri. He married Asenath Moore in Apalachicola, Florida in 1852. Samuel and his brothers moved to Orange, Texas in 1859 where they purchased a shipyard from John Fielding and operated it under the name J. H. Levingston Slipways. At the outbreak of the Civil War, all three brothers served the Confederacy primarily as shipwrights on Confederate transports and warships in New Orleans. Samuel was part of the crew that built Confederate ram *Mississippi*. He also served on at least two blockade runners: steamer *Florida* and schooner *Annie Gibson* (*The Daily Leader* 1909; Williams 1988:149–157). When New Orleans fell to the Union in late April 1862, the Levingston brothers returned to Orange and continued the war effort by both building boats and running the blockade.

After the war, Samuel Levingston continued building ships in Orange on the banks of the Sabine River. He and Asenath had seven children. One, George M. Levingston, born in 1874, became his father's business partner (*The Daily Leader* 1909; Williams 1988:149–157). George ran the shipbuilding business after his father retired in 1893 and then took it over completely when his father died in 1911. In 1919, George Levingston expanded operations in Orange as a sole proprietor of a new shipyard at Moss Street. He further expanded his businesses in 1930 with another shipyard at Front and Mill Streets. Between 1919–1933, Levingston built at least 27 ships (Levingston Shipbuilding 2022). In 1933, short of money and suffering from the economic downturn of the Great Depression, George Levingston obtained financial support from E. W. Brown, Jr. and set up Levingston Shipbuilding Company as a corporation. In 1945, George Levingston and E. W. Brown, Jr. sold a controlling interest in the company to Edward T. Malloy who was then vice-president of the corporation (Williams 1988:156–157; Texas State Library and Archives Commission n.d.). Between 1933 and 1985, when Levingston Shipbuilding closed operations, the company built at least 760 ships (Levingston Shipbuilding 2022). It was a major supplier of tugs, barges, and tankers for the U.S. Army and U.S. Navy during World War II, building 157 vessels (Texas State Library and Archives Commission n.d.). After the war, the company constructed a large number of submersible rigs, jackup rigs, and floating rigs for the offshore oil industry. In 1955, Levingston built its first fixed platform tender and its first self-contained drill barge. In 1957, it built its first fixed platform and the following year its first pipelaying barge (Taylor and Abel 2008:199). The company developed a reputation for high quality innovative work. In 1962, Levingston built the world's first catamaran drill vessel, *C. P. Baker*. Its customer was Reading & Bates Offshore Drilling Company.

3.1.2.3 Reading & Bates Offshore Drilling Company

In 1937, J. W. "Jack" Bates, Sr. and George M. Reading founded Reading & Bates Drilling Company. This was a land-based oil company headquartered in Tulsa, Oklahoma. The owners started with three rigs which they purchased on credit. Bates was a graduate of Dartmouth College. In 1910, after obtaining his degree, he entered the oil industry in California as a teamster. He worked his way up through the ranks and by 1914 he was general superintendent of Roxanna Oil Company. Bates' partner, George M. Reading, earned a mine engineering degree from the University of California, after which he worked as a mining superintendent in Arizona. Later, he ran a trucking operation in Texas. George Reading and Jack Bates met in Texas in 1930. At that time, Bates was still serving as superintendent for Roxanna Oil and Reading was working as one of his trucking contractors. In 1937, they decided to go into business together and formed Reading & Bates Drilling Company (Franks 1980:209–212). The company expanded and diversified after World War II.

Bates' son J. W. Bates, Jr., also graduated from Dartmouth College. During World War II, he served as a navy pilot. After the war, he and business partner, Clyde P. Baker, formed B & B Drilling Company. Clyde Baker was a tall, jovial man, perhaps 6 foot 6 inches tall, who was deeply affected by the loss of the ship that bears his name (Lujan 2024). In 1949, Bates Jr. took over as president of Reading & Bates. Shortly thereafter, he and Baker decided to merge B & B Drilling with Reading & Bates. In 1951, C. E. "Charlie" Thornton, joined the team. Thornton, a trained petroleum engineer, headed a Canadian-based subsidiary of Reading & Bates. On October 19, 1955, the team of Bates Jr., Bates Sr., Reading, Thornton, and Baker incorporated Reading & Bates Offshore Drilling Company. The initiative was driven by the younger Bates and Thornton, both of whom travelled to Louisiana to explore business opportunities. The partners sold stock in Reading & Bates Offshore to raise capital (TODCO, n.d.; John Wesley "Jack" Bates Jr. n.d.).

The firm's first two vessels, both built by Levingston Shipbuilding Company and launched in 1956, were the 260' non-self-propelled drill tenders *George M. Reading* and *J. W. Bates.* These may have been converted YF hulls. This started a tradition of naming ships after the company's leading personnel. Levingston also built an identical tender called *Dolphin* for Warren Marine Drilling Company out of Wilmington DE. In 1960, Reading & Bates purchased *Dolphin* off Warren Marine Drilling and renamed it *J. W. Nickle* (United States Treasury Department, Bureau of Customs 1961, 275, 1059; United States Treasury Department, Bureau of Customs 1962:827, 1110). These tenders "accommodated fifty-two men, and had storage facilities for water, mud, cement and fuel. Drilling operations were carried out by a multiple well derrick 140 feet high and a rotary drilling rig with a 465-ton capacity. At the time, [they] represented some the most advanced offshore drilling technology" (Franks 1980, 211). The company was both financially and technologically innovative. It had at least three subsidiaries and eventually owned tenders, platforms, jackups, and drill ships. In 1958, the company took possession of a low-cost 149.9 foot mobile offshore drilling platform named *C. E. Thornton* (Offshore 1958a:15–20). A year later, the company leased *Mr. Louie*, which could drill below 20,000 feet. At the time, *Mr. Louie* was "one of the biggest and costliest marine drilling rigs ever built" (Offshore 1960:21–34). Among the company's other assets were two drill ships. One was also called *J. W. Bates.* The other was the world's first catamaran style drill vessel, *C. P. Baker*, which was built in 1962. In 1965, a year after the loss of *C. P. Baker*, Reading & Bates took possession of another, Levingston-built, catamaran style drill ship, the *E. W. Thornton*. This vessel was built from scratch rather than converted from two ex-navy YF hulls. The company drilled under contract and, over time, expanded operations to encompass oil fields all over the world including the North Sea and Middle East (Franks 1980:209–212).

3.1.3 Vessel Construction



Figure 19. *C. P. Baker*.
C. P. Baker in 1962 shortly after construction at the Levingston Shipbuilding Company facilities, Orange, Texas. Courtesy of Ed T. and Marjorie H. Malloy photograph collection. Sam Houston Regional Library and Research Center, Texas State Library and Archives Commission.

Levingston Shipbuilding Company delivered *C. P. Baker* to Reading & Bates in August 1962 (Figure 19). The catamaran-type vessel was the first of its kind. It was registered at 3891 gross net tons, 260.4 feet in length, 126.1 feet in width and 14.2 feet in depth (U.S. Coast Guard 1962). Levingston Shipbuilding Company constructed *C. P. Baker* from two former U.S. Navy YF-type lighters and/or barges that were, in turn, acquired from the Magnolia Petroleum Company (Figure 20). Magnolia was headquartered in Dallas, Texas, but its offshore operations were based out of Morgan City, Louisiana (Craik et al. 1964). The port hull was *Magnolia Drilling Barge No. 2*, and the starboard hull was *Magnolia Drilling Barge No. 4*. Each barge had a covered main deck and a hold. Levingston tied the two hulls together using a tubular steel framework. Located aft, they built a drilling derrick that straddled both hulls. Forward, they constructed a helicopter platform that likewise straddled the hulls. One level above the main deck, Levingston built pipe racks extending the entire breadth of the rig. Access from one hull to the other was provided by all the athwartship structures as well as a series of catwalks.

The starboard hull of *C. P. Baker* was *Magnolia Drilling Barge No. 4*, official number 251202. It was originally built as *YF-1076* by American Bridge Company in July 1945 at Ambridge, Pennsylvania for 9th U.S. Naval District (U.S. Coast Guard 1945a) (Figures 21 and 22). On July 18, 1945, "*YF-1076* departed Ambridge, Pennsylvania for New Orleans" (World War II War Diaries 1945). It was joined by several other YF lighters constructed at the same yard. After the war, *YF-1076* was declared surplus. The federal government, through the auspices of the U.S. Maritime Commission, sold the barge to Coast Transportation Company of New Orleans, Louisiana. Coast Transportation Company registered their new barge on December 6, 1946, but within two years they sold it to Magnolia. Magnolia registered the vessel as *Magnolia Drilling Barge No. 4* on December 22, 1948.

The port hull of *C. P. Baker* was *Magnolia Drilling Barge No. 2*, official number 256698. It was originally built as *YF-896* by Willamette Iron & Steel Corporation in Portland, Oregon and was taken into service by the 13th Naval District on June 19, 1945 (Figures 21 and 22). The hull was subsequently transferred to the 12th Naval District (U.S. Coast Guard 1945b; World War II War Diary 1945b; World War II War Diary 1945c). Some confusion surrounds *YF-896*. Official published U.S. Navy records suggest the *YF-896* was built not by Willamette in Portland, but by the U.S. Navy at its yard in Puget Sound, Washington (Navy Department, Bureau of Ships 1946:525). Although repeated in multiple online databases, the Puget Sound information is inaccurate (Shipbuildinghistory.com n.d.; NavSource Online n.d.). Documents from "RG 38: Records of the Office of the Chief of Naval Operations" at the National Archives in Washington, D.C. show that while the construction of *YF-896* was originally assigned to the Navy Yard at Puget Sound, it was subsequently transferred to Willamette Iron & Steel Corp in Portland, Oregon (World War II War Diaries 1945c; World War II War Diaries 1945d; World War II War Diaries 1945e; World War II War Diaries 1945f). Furthermore, official registration documents for *C. P. Baker* explicitly state that it was built from the former *YF-896* and *YF-1076* lighters (U.S. Coast Guard 1962). After the war, *YF-896* was declared surplus. On August 7, 1946, the federal government, through the auspices of the U.S. Maritime Commission, sold the barge to Matson Navigation Company. Maston intended to use the lighter for the transportation of sugar between refineries in San Francisco Bay. However, when Maston received estimates of the cost of conversion, the company changed plans and sold the barge to Magnolia. The sale took place on March 12, 1948 (Stindt 1982; U.S. Coast Guard 1945b). Magnolia then registered the vessel as *Magnolia Drilling Barge No. 2*.

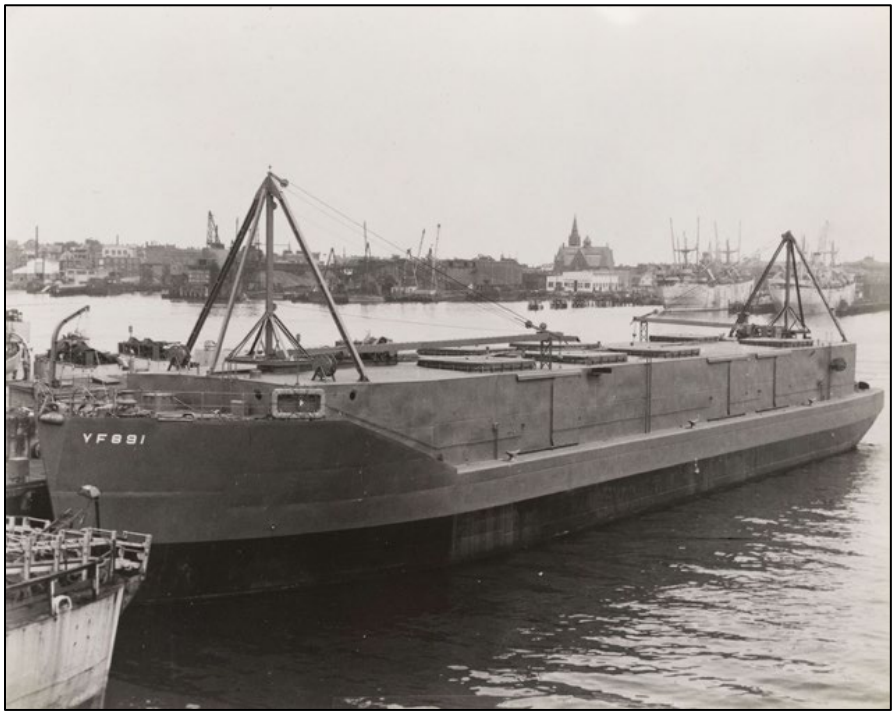


Figure 20. *YF-891* later *Magnolia Drilling Barge No. 1*.
This lighter was virtually identical to *YF-896* and *YF1076* used to construct *C. P. Baker*. USN Navy photo # BOSTS-14789, U.S. National Park Service, Charlestown, Boston Naval Shipyard, Navource.org.

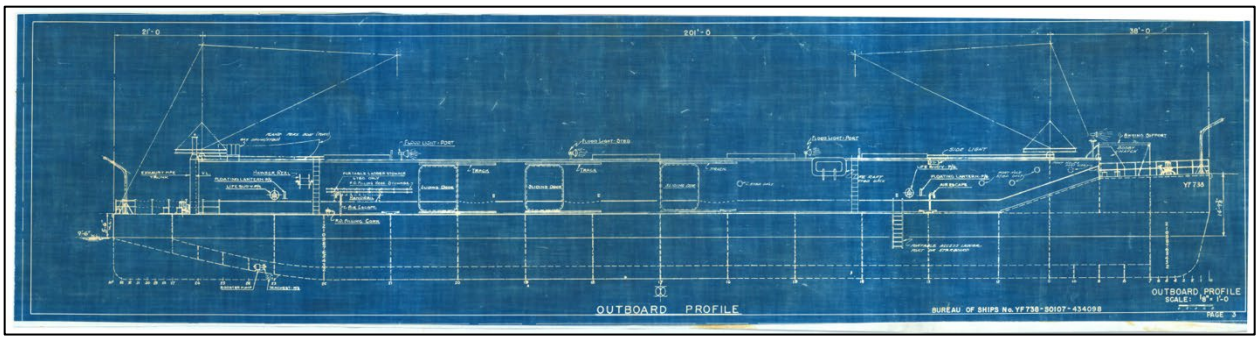


Figure 21. Outboard profile U.S. 2000 ton covered lighter, *YF738, 739* & *740* (Similar to *YF-896* and *YF-1076*).
Image from RG 19, Hull Series, National Archives, College Park, MD.

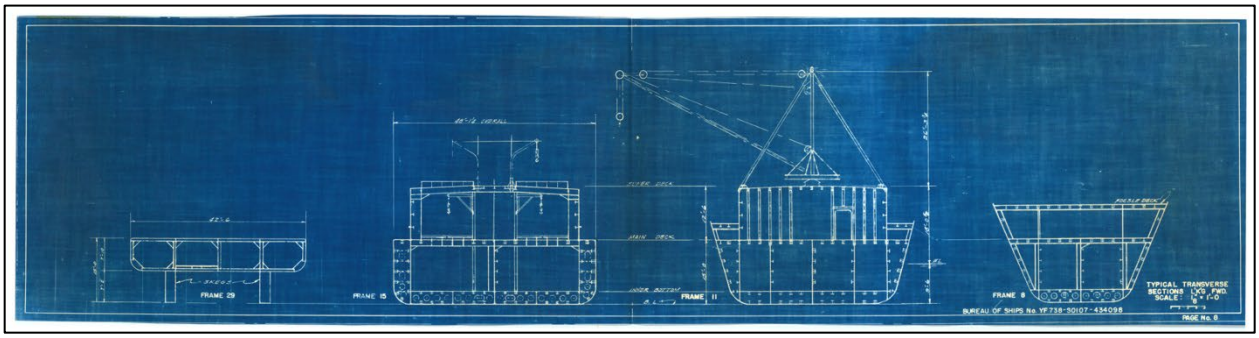


Figure 22. Typical transverse sections, U.S. 2000 ton covered lighter, *YF738, 739* & *740* (Similar to *YF-896* and *YF-1076*).
Image from RG 19, Hull Series, National Archives, College Park, MD.

Details of the two hulls are presented in the table below.

Table 3. The YF hulls used in the construction of *C. P. Baker*

Official No.	U.S. Navy Name	Merchant Vessel Name	Gross Tons	Length (ft)	Breadth (ft)	Depth (ft)	Year Built	Where Built	Crew
256698	*YF-896*	*Magnolia Drilling Barge No. 2*	1914	260.4	48.1	12	1945	Portland, OR	4
251202	*YF-1076*	*Magnolia Drilling Barge No. 4*	1908	259.1	48.1	12	1945	Ambridge, PA	3

Note: Data from RG26, National Archives, Washington D.C. and Untied States Treasury Department, Bureau of Customs, Merchant Vessels of the United States, 1952 [and others], Washington, D.C.: United States Government Printing Office, 1953.

In 1948, the Magnolia Petroleum Company purchased seven virtually identical, former navy YF-type non-self-propelled, covered lighters, which they designated Magnolia Drilling Barges No. 1 through No. 7. In the late 1940s and 1950s, it was fairly common to use former navy YF barges as drilling tenders (Offshore 1955a). Each of the Magnolia Drilling Barges was approximately 260' long. Data for these barges are presented in Table 4 (United States Treasury Department, Bureau of Customs 1949:323, 698; United States Treasury Department, Bureau of Customs 1950:326, 630, 832; United States Treasury Department, Bureau of Customs 1952:333, 646, 727; United States Treasury Department, Bureau of

Customs 1955: 316, 865; United States Treasury Department, Bureau of Customs 1956:319, 641, 720, 870; United States Treasury Department, Bureau of Customs 1963: 1143).

Table 4. Magnolia Petroleum Company former U.S. Navy YF lighter acquisitions

Former Navy Lighter Name	Magnolia Petroleum Co. Name	Official Registration Number
YF-891	*Magnolia Drilling Barge No. 1*	259024
YF-896	*Magnolia Drilling Barge No. 2*	256698
YF-897	*Magnolia Drilling Barge No. 7*	253684
YF-1068	*Magnolia Drilling Barge No. 5*	251254
YF-1075	*Magnolia Drilling Barge No. 6*	251201
YF-1076	*Magnolia Drilling Barge No. 4*	251202
YF-1078	*Magnolia Drilling Barge No. 3*	251204

In 1959, Magnolia Petroleum Co. merged into Socony Mobil Oil Company, Inc. of Morgan City, Louisiana. Thereafter, ownership of *Magnolia Drilling Barge No. 2* and *No. 4* passed to Socony. On 31 October 1961, Socony sold *Magnolia Drilling Barge No. 2* and *Magnolia Drilling Barge No. 4* to Armco Steel Corporation, of Pittsburg, PA. The selling price for each hull was $10. However, this was simply a pass-through transaction, since on 16 November 1961, Armco sold both hulls to Reading & Bates. Again, the selling price for each barge was $10. On August 3, 1962, Reading & Bates borrowed $1.5 million from Armco, by mortgaging the hulls for five years. The resulting funds were used to pay Levingston $1.5 million for the construction of *C. P. Baker* using the two barges. On 16 July 1964, just over two weeks after the loss of *C. P. Baker*, Reading & Bates paid off the mortgage to Armco, possibly using insurance money (U.S. Coast Guard 1962).

C. P. Baker, constructed by Levingston Shipbuilding Company, was certified in August 1962 by the Marine Inspection Office at Port Arthur, Texas, and was delivered to Reading & Bates Offshore Drilling Company (U.S. Coast Guard 1962). Certification of the ship raised three questions which required adjudication from the Bureau of Customs in Washington, D.C. The first issue was whether the new ship should retain the registration number of either of the original Magnolia Drilling Barges, or whether it be assigned a new registration number. The Bureau of Customs decided that although the new vessel was to be classified as "rebuilt," it would not retain the identify of either of the original drilling barges. The papers for *Magnolia Drilling Barge No. 2* and *No. 4* were to be withdrawn and a new official number issued. On this, the Bureau of Customs offered the following guidance: "The reason for surrender of the documents of the original barges … should be shown as 'Out of documentation, vessel lost identity; determined to be part of (name and official number of resulting vessel)'" (U.S. Coast Guard 1962). *C. P. Baker*, therefore, set the precedent for certification of ships constructed out of materials from two or more previously registered vessels. The second issue was that since *C. P. Baker* was officially "rebuilt," what should be the year and place listed for the original built vessel? On this, the Bureau of Customs ruled that the official documentation should list the "year and at the place and by the builder of the older of the two original barges" (U.S. Coast Guard 1962). That made sense, except Customs officials in Louisiana did not know which of the original barges was older. The guidance for solving this came from the regional Customs Office in Texas:

> It will be noted that the Bureau said that the year of build would be the year of build of the oldest of the original barges and since these barges were originally the YF 896, and the YF 1076, respectively, and they were both built in 1945, it is assumed that the YF 896 was built first because of the smaller number. This might not be correct, but we had no other way of determining which was built first (U.S. Coast Guard 1962).

The third issue was how to calculate the tonnage and dimensions of *C. P. Baker*. Here the Bureau of Customs in Washington ruled:

> The capacity under tonnage deck of the resulting barge [i.e. *C. P. Baker*] should be the sum of the present capacities of the original hulls. If the tubular trusses joining the twin hulls together are so enclosed in that they resemble tanks, the volume of the trusses should be included in the gross tonnage. The registered breadth should be measured from the outboard surface of one hull to the corresponding place on the other hull at the place of greatest breadth. This will be approximately 126 feet (U.S. Coast Guard 1962).

With these rulings a new vessel "Certificate of Admeasurement" and registration was issued for *C. P. Baker* (U.S. Coast Guard 1962). In August 1963, the ship also underwent a mid-period re-inspection at the Marine Inspection Office, New Orleans, Louisiana, where it was found to be seaworthy and was granted an extension of the date by which dry dock examinations were required (Craik et al. 1964).

3.1.4 Sinking

On Sunday, June 28th, 1964, *C. P. Baker* was moored on a southeast heading in approximately 186 feet (57 meters) of water in the Eugene Island Area, Gulf, at approximately latitude 28° North and longitude 91° West. It was a clear, calm night, with light swells. On board, a 13-man drilling watch were working on *C. P. Baker's* twenty-second well since its construction and the fourth well in the block of its sinking. Two vessels were tied alongside *C. P. Baker* abreast of one another. Inboard was M/V *Delta Service*, official No. 0293491; outboard was M/V *Mr. Jake*, Official No. 276466. Both were supply vessels providing standby services, equipment, stores, and crew transportation (Craik et al. 1964).

Drilling commenced sometime after noon on June 29. At approximately 3:00 a.m. on June 30, drilling had progressed to the point where a 30-inch guide casing had been sunk to a level of 121 feet below the mud line. Beyond that, a 26-inch diameter hole to accommodate a 20-inch conductor pipe, had been drilled to a level of 461 feet below the mud line (Craik et al. 1964). The depth of water was 186 feet and the height above the water to the rotary drive bushing was 37 feet. Using the rotary table at the well platform level as a reference point, the well's depth, therefore, was 684 feet. The proposed casing program called for the 20-inch conductor pipe to be cemented once drilling reached 750 feet. After this, a 20-inch riser assembly containing the 2000 psi Hydril annular type blowout preventer was to be installed. Geological Survey U.S.C.G. Order No. 2 at the time only required a "blowout preventer be installed before drilling beyond 3000 feet (true vertical depth)" (Craik et al. 1964:2). As the 26-inch hole approached the 750 feet mark (it was at 684 feet), the thirteen-man crew started preparing to sink and cement the 20-inch casing. Of the thirteen-man crew on duty, only two were located on the derrick floor at the time of the disaster. One was in the port crane, and the others in various places such as the cement room and pipe rack decks preparing to sink and cement the 20-inch casing. The remainder of the crew were asleep, mostly in accommodations in the port bow (Craik et al. 1964).

The first sign of an issue was a "bubbling," "boiling," or "geysering" of the water between the two hulls of the catamaran, together with a "trembling" of the vessel, which extended some distance around the ship (Craik et al. 1964:2). Water rose between the hulls high enough to strike the bottom of the derrick platform with great force and then fall back onto the two hulls. Shortly after the geysering was noticed, *C. P. Baker* lost electrical power and lighting. The water erupting from the blowout onto the hulls flooded the ship resulting in the vessel trimming severely aft. Before personnel could be organized and any direct response to the blowout instituted, there was a massive explosion or instantaneous series of explosions followed by an intense fire. Witnesses described the explosion and fire as encompassing the whole vessel and not localized in any particular section. Covering an area approximately 75–100 feet in and around the vessel, the fire burned with varying degrees of intensity and height. Some crew members were able to

make their way to the side of the ship and jumped overboard. Most survivors escaped via the port bow (Craik et al. 1964).

The crew of *Mr. Jake* were "awakened by the explosion and its concussive effect on their vessel" (Craik et al. 1964). Realizing the dire situation, they moved the vessel away relatively quickly. The crew of *Delta Service,* alerted by shouting and the commotion before the explosion, untied their lines. They were preparing to pull away when *C. P. Baker* exploded, critically burning one of their crew who died later in hospital (Craik et al. 1964). The cable of *C. P. Baker*'s port crane was still attached to a section of 20-inch casing on board the *Delta Service*. With the vessel still partially tied alongside *C. P. Baker*, the captain of the *Delta Service*, put his engines in reverse and used the resulting propeller wash to assist people at the bow of *C. P. Baker* to move away from the burning area. He then put his engines into full ahead, breaking his last line and moving away from the stricken drill ship. The section of 20-inch casing still attached to *C. P. Baker* crane dragged violently across the stern of *Delta Service* and overboard. Afterward both *Mr. Jake* and *Delta Service* rescued survivors (Craik et al. 1964).

Witnesses estimated that the time between the start of the "geysering" and the explosion that engulfed *C. P. Baker* was around 5 minutes. Estimates of the time between the explosion and the sinking of the ship vary between 15 minutes and 45 minutes. *C. P. Baker* was observed to sink by the stern, but the captain of the *Delta Service*, who had a good vantage point, testified that the vessel also heeled to port while sinking by the stern (Craik et al. 1964).

The survivors from the disaster were transferred to *Mr. Jake* for transportation to the nearby drilling barge *J. W. Nickle,* which was also owned by Reading & Bates. From there, they were taken to hospital facilities by helicopter. Of the 43 crew members aboard *C. P. Baker* at the time of disaster, 21 were killed and 22 were injured. Among the crew of *Delta Service,* one was killed, and another was injured. The breakdown of the casualties in shown in Table 5 (Craik et al. 1964).

Table 5. *C. P. Baker* and *Delta Service* casualties, June 30, 1964

Vessel Name and Type of Casualty	Number of Personnel
C. P. Baker - Confirmed dead and bodies recovered	7
C. P. Baker - Critically injured and subsequently died	1
C. P. Baker - Missing and presumed dead	13
C. P. Baker – Injured	22
Delta Service - Critically injured and subsequently died	1
Delta Service – Injured	1

Almost immediately, authorities and news outlets reported that a gas pocket had caused the explosion. This was later confirmed by a Coast Guard inquiry (Milliner 1964; *The Orange Leader* 1964; Craik et al. 1964). After *C. P. Baker* sunk, gas continued erupting with some severity. The fire continued to burn for approximately 13 hours. Some bubbles continued to rise after the fire stopped for a period of approximately 24 hours after the initial sinking (Craik et al. 1964).

3.1.5 Previous Investigations

After the disaster that sank *C. P. Baker*, U.S. Coast Guard divers located and explored the wreck. Diving commenced on July 1, 1964, after the "bubbling" had decreased considerably. The divers found the vessel upside down on the seafloor, with the catamaran's bows facing Northwest, the reverse of the ship's heading while afloat. The helicopter platforms supported the bow, which was 10–20 feet higher than the stern. As the diver's primary objective was to locate the bodies of the missing and deceased personnel, they did not conduct a detailed physical survey of the wreck, but they did note the condition of the areas they visited. On several occasions, while traversing the bottom of the port hull (*Magnolia Drilling Barge*

No. 2) from bow to stern, the bottom of the starboard hull was visible. The derrick was never sighted nor was the drive pipe. The only damage to the hull observed was the bow sheave for the number seven anchor cable (port hull, bow), which was partially torn from the deck, and one of the derrick support beams was torn away from the port hull aft. It was not possible to enter all compartments because of entrapment by shifting debris and the physical and spatial problem of the ship being upside down. In total, only five bodies were recovered, but other human remains likely stayed within the stricken vessel. The divers also found three craters, approximately in a straight line, two small ones (about 7–8 feet across and 5–6 feet deep) and one large crater (about 10 feet deep, oblong in shape, and 15–20 feet across). The larger crater was still emitting small gas bubbles (Craik et al. 1964).

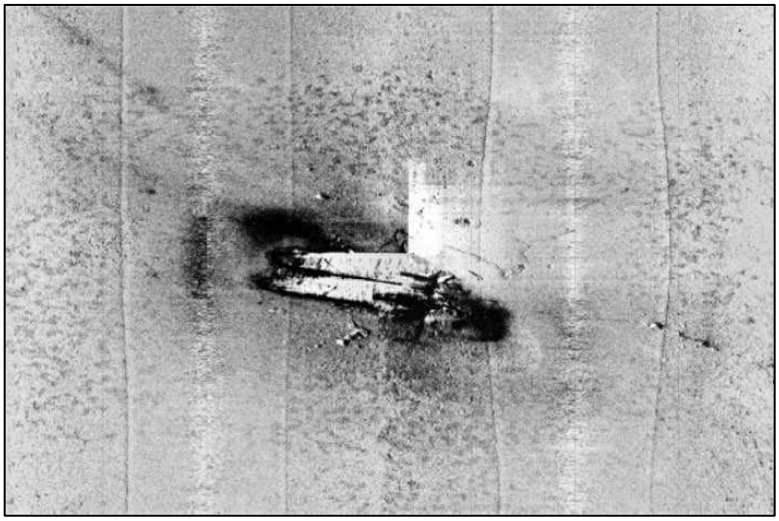


Figure 23. Side scan sonar mosaic of *C. P. Baker* from the 2013 C&C Technologies study.
Image from (Warren 2013).

In 2013, Apache Corporation (Apache) contracted C & C Technologies, Inc. (C&C) to perform an archaeological survey near the wreck site "to identify potential archaeological resources that might be impacted by artificial reef development activities" (Warren 2013). Field operations, on June 14, 2013, were conducted from R/V *Suncoaster*. The survey grid consisted of 17 track lines. Of those, 15 were primary lines with 50-meter spacing running east-west. The remaining two lines were 900-meter spaced tie lines running north-south. Surface positioning was controlled using HYPACK Hydrographic Survey Software, and the geophysical instrumentation included an "EchoTrac MkIII Single Beam Fathometer; a Klein System 3000 Digital Side Scan Sonar; a Marine Magnetics SeaSpy Overhauser Magnetometer; and an Edgetech X-star Subbottom Profiler" (Warren 2013). Data acquisition and processing software included Sealink, SonarPro, SonarWiz, and ESRI. Using these geophysical systems, C&C was able to identify the wreckage and remains of *C. P. Baker*. Five magnetic anomalies and five sonar contacts were associated with the wreck (Figure 23). The hull remains "measured roughly 334.5 feet in length, 181.5 feet in width, and had 17.7 feet of seafloor relief" (Warren 2013). Because *C. P. Baker* represented a historic shipwreck, the archaeologists recommended an avoidance zone with 700-foot-radius (Warren 2013:10).

3.1.6 Site Description

The Data Gap project collected three sets of data related to *C. P. Baker*. In May 2021, David Evans and Associates, Inc. (DEA) Marine Services gathered side-scan sonar and multi-beam bathymetric data. DEA was sub-contractor for Cardinal Point Captains, Inc. (see Section 2.4). In July 2021, Marine Imaging Technologies conducted diver reconnaissance videography at the site (see Section 2.5), and from June

16–22, 2022, the Data Gap team conducted ROV dives on four shipwrecks and three hardbottom habitats, which included *C. P. Baker* (see Section 2.6).

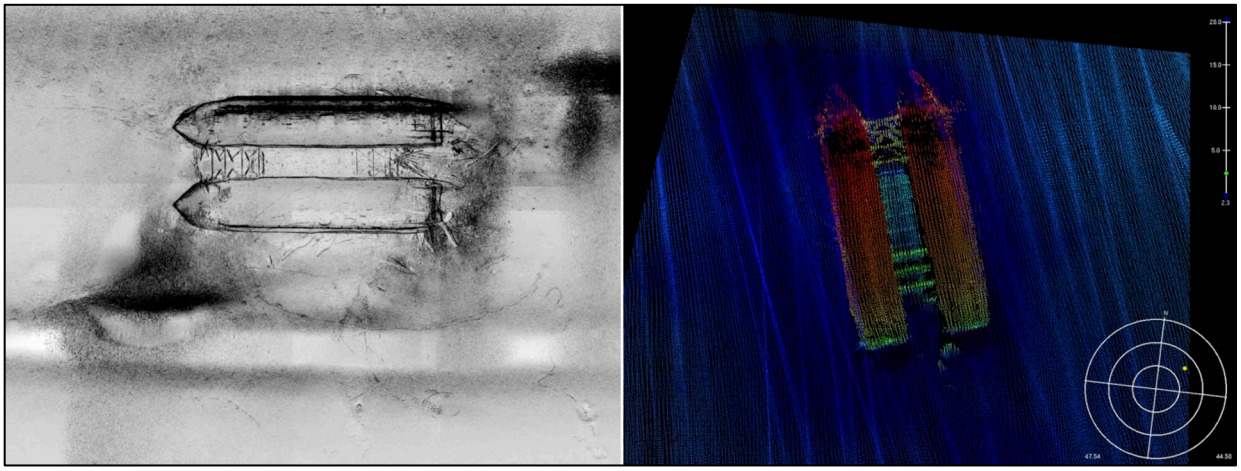


Figure 24. Acoustic images of *C. P. Baker*.
Left panel: side scan sonar mosaic of *C. P. Baker* (lying at 340 degrees); right panel: multibeam image of *C. P. Baker.* Both images from David Evans and Associates geophysical survey in May 2021.

C. P. Baker sits in approximately 186 feet (57 meters) of water. The twin hulls are inverted with their lower hulls pointing up into the water column. The 260 x 126 foot wreck is largely intact and is orientated at 340 degrees. Cultural material covers an area of approximately 400 x 300 feet. The geophysical survey by DEA in May 2021 clearly shows the remains of *C. P. Baker* and associated archaeological features (Figure 24) (Redmayne and Laverty 2021). Acoustic data also shows the presence of two small craters off the port hull and one larger one forward of amidships off the starboard hull (Figure 24). It is possible that these craters are associated with the blowout in 1964, although it is also possible that the backscatter might be associated with "deposits of relatively coarser sediments," potentially the product of prevailing currents encountering the wreck causing the "winnowing of finer sediments" (Redmayne and Laverty 2021:13). The port hull is to the east and the starboard hull to the west. The port hull is relatively free of debris; there is more debris on the starboard hull, particularly toward the stern. There are a series of ropes and lines crossing the hulls amidships, but overall the wreck is relatively free from fishing gear, especially compared to other sites in the mesophotic zone. The cross bracing and struts that supported the helicopter pad and the drilling derrick survive and are in place. The remains of the broken derrick and the associated debris is located in between the hulls at the stern, immediately aft of the vessel, and towards the southwest. One of the eight anchors is also located southwest of the wreck. A cable originates at the anchor and snakes to the east and then the north. The remains of two other anchors are to the north (see white arrows in Figure 25).

The Data Gap study collected archaeological observations, video footage, and photographs for the port hull, both bows, the struts that supported the helicopter pad, and the starboard hull from midships forward. There are holes in the starboard house deck that allowed penetration of the hull. In those areas, the remains of piping and what appear to a transfer pump are visible. An open hatch in the main deck allows for observation of the lower starboard hull and one of the longitudinal watertight bulkheads.

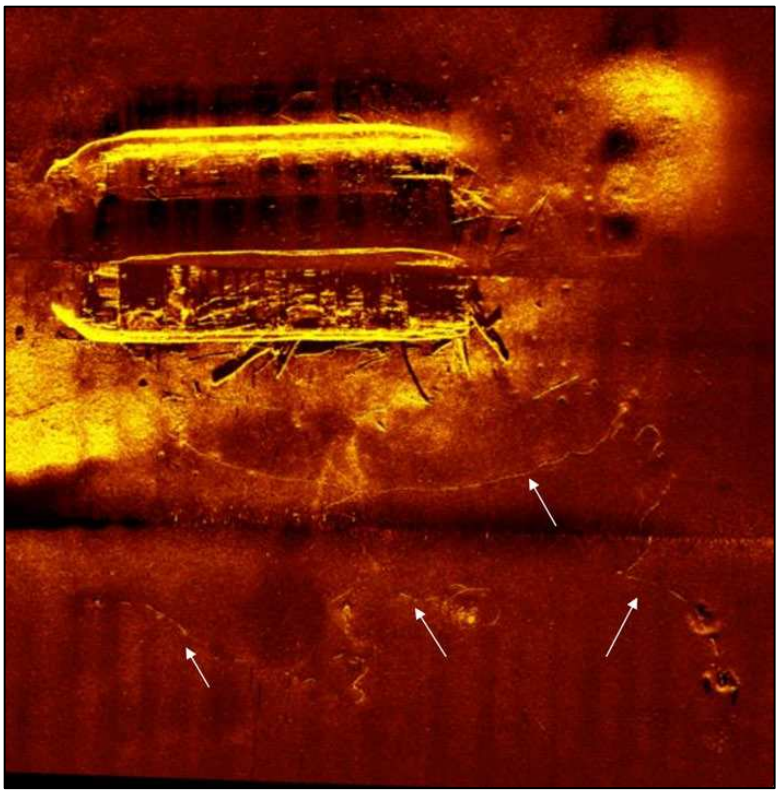


Figure 25. Side scan sonar mosaic of *C. P. Baker* (lying at 340 degrees).
Image from David Evans and Associates geophysical survey in May 2021.

The stern of each hull confirms that *C. P. Baker* was a non-self-propelled barge. There is no evidence of propulsion systems or steering mechanisms. Each hull has two skegs. Side skegs such as those on each of *C. P. Baker* hulls significantly decrease yawing, especially compared to a single center skeg (Kim et al. 2015). Plans for U.S. Navy YF barges show the presence of the same skegs, indicating that these were not constructed as part of *C. P. Baker* rebuild.

Along the full run of the bilge, the port hull is largely intact. Several lines run across the hull amidships and extend into the area between the hulls and over to the starboard side. Forward of midships on the port hull, there are a series of fittings along the turn of the bilge. At least seven are evenly spaced on the outboard edge of the hull and others inboard (Figure 26). There appear to be others in the stern. These may have accommodated sacrificial anodes which were fairly common on steel drilling structures during 1950s and 1960s, and magnesium anodes were often used. Alternatives included zinc, Duriron, and graphite (Offshore 1955b; Offshore 1958b). The bows of the port and starboard hulls are intact.

Between the hulls in the bows, the cross bracing and struts that supported the helicopter pad are still largely in place. The underside of the pad itself was not visible in the available video footage. The struts sit on and are supported by the upper edge of the inner bulwarks of each hull. Some of the cleats on the main deck bulwarks are visible (Figure 26). Aft of the helicopter pad the underside of the pipe racks which straddled the entire wreck are visible.

On the starboard hull, around midships there are holes in the sides of the house that protected the main deck. These openings allow penetration through from one side of the starboard hull to the other (Figure 27). Inside, there are a series of pipes and machinery that sat on the main deck. On the outboard edge of the starboard hull, on the main deck, there is an open hatch that allows access to the lower hull. Looking inside this hatch reveals an empty hold with little visible other than a tire and one of the ships longitudinal

watertight bulkheads. Aft of the hatch is the remains of a transfer pump with its intake facing the bow. This may have been used for the transfer of water, diesel or mud. Another possibility is that the device was used either to bring onboard seawater to pump down the hole if drilling without a riser, or to mix with drilling mud if drilling with a riser and a normal mud system (Figure 27).

Orthomosaic imaging of the bow of *C. P. Baker* was marginally successful (Figure 28). Figure 28 showing the starboard bow provides the best output. The issues with modelling are described in section 2.6.3.6.

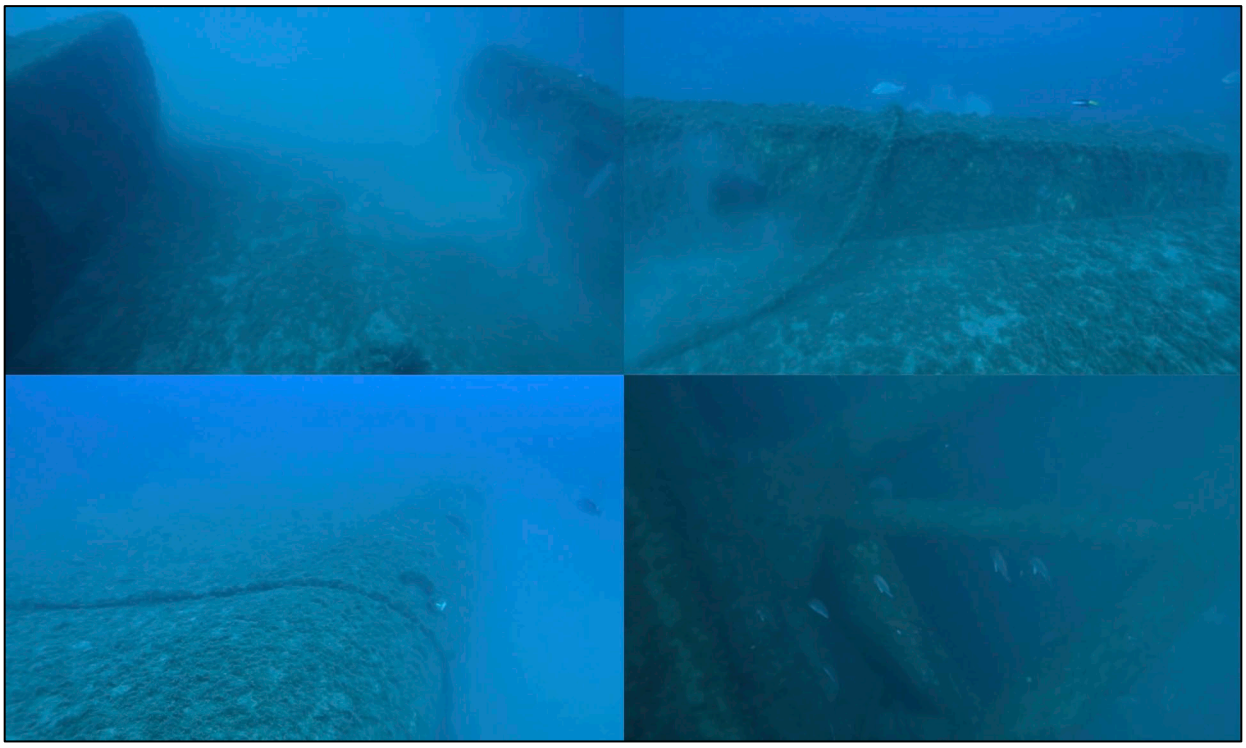


Figure 26. External hull details of *C. P. Baker*.
Top left panel: Skegs of port hull; Top right panel: Forward end of inboard skeg on port hull; Bottom left panel: Possible sacrificial anode fittings on outboard edge of port hull; Bottom right panel: Helicopter pad support braces.



Figure 27. Internal hull details of *C. P. Baker*.
Top left: Cleat on inboard side of port hull (image rotated 180*º*); Top right: Opening in starboard hull (image rotated 180*º*); Middle left: Piping inside starboard hull (image rotated 180*º*); Middle right: Transfer pump starboard hull (image rotated 180*º*); Bottom left: Hatch on main deck on starboard hull (image rotated 180*º*); Bottom right: Hold of starboard hull showing longitudinal bulkhead.

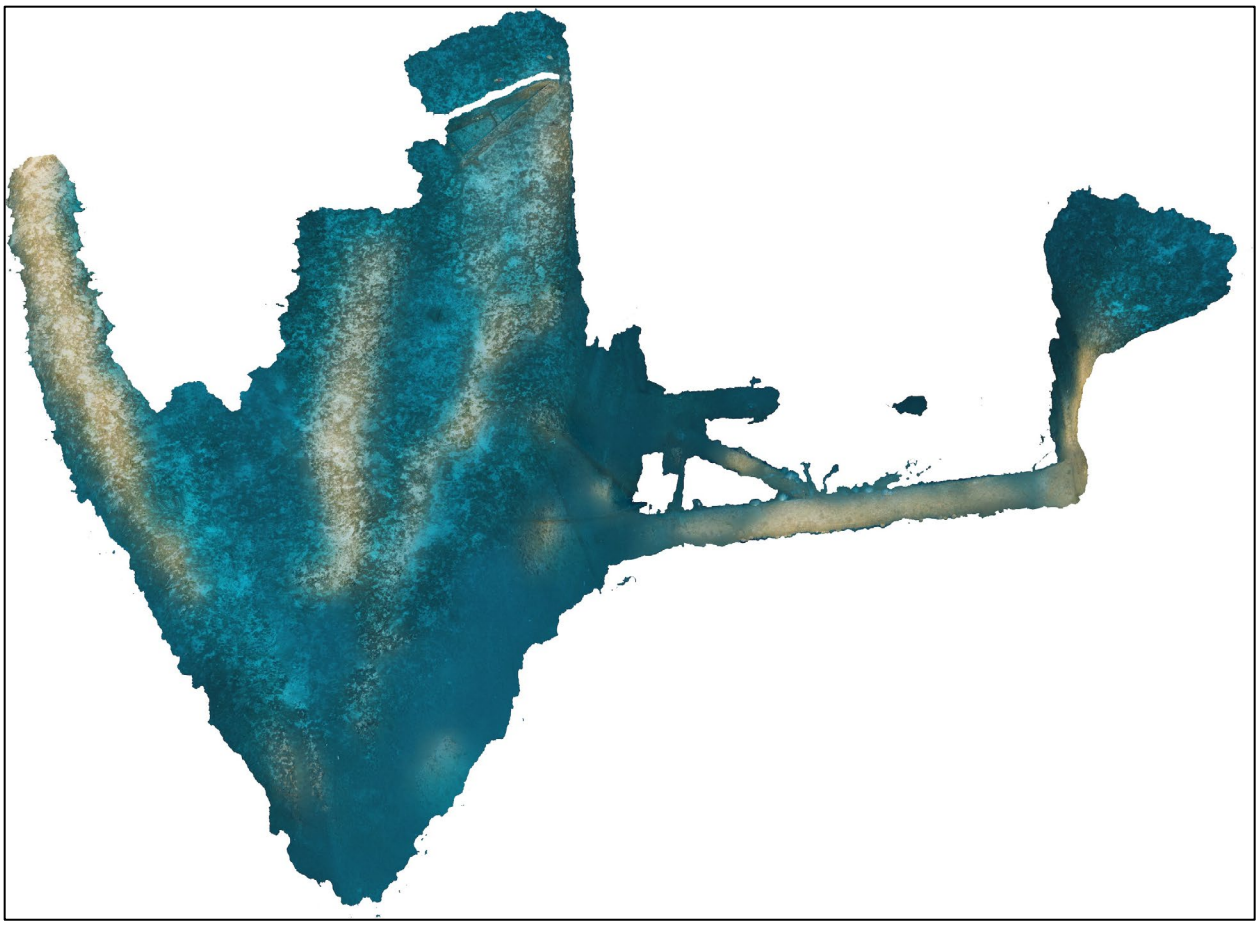


Figure 28. 3D Orthomosaic of *C. P. Baker* starboard bow.
Image processed by Scott Sorset, BOEM.

3.1.7 National Register Eligibility

In order for a property to be eligible for nomination to the National Register of Historic Places (NRHP), it must be at least 50 years old and have "historic significance," "historic integrity," and appropriate "historic context" (U.S. Department of the Interior 1985). Historic significance is determined in accordance at least one of four criteria.

- Criterion A: Association with events that have made a significant contribution to the broad patterns of our history.
- Criterion B: Association with the lives of persons significant in our past.
- Criterion C: Properties that embody the characteristics of a type, period, or method of construction; represent the work of a master; possess high artistic value; or represent a significant whole whose parts may lack individual distinction.
- Criterion D: Properties that have yielded or may yield important information about prehistory or history.

Historic context is "Background information gathered and used to frame and evaluate the significance of a historic property in terms of the history of the relevant geographical area, the history of associated historical themes or subjects, and within a historical and contemporary timeframe" (U.S. Department of Transportation, n.d.).

Historic integrity is "The ability of a property to convey its significance. To be eligible for inclusion in the National Register of Historic Places, in addition to being significant, a property must retain sufficient integrity to convey its significance. The National Register of Historic Places identifies seven aspects of historic integrity: location, design, setting, materials, workmanship, feeling, and association" (U.S. Department of the Interior 1997; U.S. Department of Transportation, n.d.).

C. P. Baker is eligible for nomination to the NRHP. The vessel is largely intact, satisfying the requirement for historical integrity, and can be nominated under Criteria A, C, and D.

3.2 Shipwreck 2: M/V *Hamlet*

3.2.1 Overview

M/V *Hamlet*, a Norwegian World War II oil tanker, was sunk by the U-*753* off the coast of Louisiana in May 1942. The ship was built by Swedish boatbuilder Götaverken A/B in 1933. At the time of its sinking, the vessel was owned and operated by Bruusgaard, Kiosterud & Co. out of Drammen, Norway. The remains of the ship lie in 150 feet of water (46 meters) in the Ship Shoal Area, about 70 miles off the coast of Louisiana. The shipwreck is in good condition and offers high levels of archaeological integrity. The main anthropogenic threat to the site comes from snagged commercial fishing gear. Historically, M/V *Hamlet* highlights the critical importance of Norwegian shipping to Allied success during World War II, and the significance of the extension of the U-boat war into the Gulf in 1942.

3.2.2 Historic Context

There are two broad historical contexts relevant to M/V *Hamlet*.

1. The rise of Norwegian shipping in the decades before World War II, and the contributions of Norway to Allied shipping efforts during the Battle of the Atlantic.
2. The U-boat actions and activities during the Battle of the Atlantic, particularly in the Gulf.

3.2.2.1 Norwegian Shipping Before and During World War II

On the eve of World War II, Norway operated the world's fourth largest merchant marine. It was a modern fleet fitted with the latest technology. Many ships were less than a decade old. In terms of specifically tanker fleets, only Britain and the U.S. had a greater number of ships. During World War II, Allied forces and strategy relied heavily on Norway's merchant fleet and its sailors, and from Norway's perspective its merchant marine and "war sailors" represented the country's greatest contribution to defeating the Third Reich. Oil supplies were critical for the Allied victory. Between April 1940 and April 1942, Norwegian tankers transported at least 30% and perhaps as much as 60% of oil imports into Britain (Rosendahl 2017: 20; Thowsen 1994:62). Churchill allegedly claimed, "Norwegian sailors were worth more than a million soldiers" (Tenold 2019:134). Norway dispatched 1,172 merchant ships and tankers during the war, manned by approximately 27,000 sailors (Rosendahl 2017:20; Thowsen 1994:68). The ships and crew paid a high price. Germany sank approximately 700 Norwegian merchant ships globally (Tenold 2019:133). M/V *Hamlet* is one of two Norwegian World War II wrecked tankers identified in the Gulf.

Norway's merchant marine was not always strong. Before World War I, Norway controlled only 4% of the world's merchant fleet. After the war, its share was 3% (Tenold 2019:94–95). Because of ship losses during World War I, many shipbuilders and shipping companies anticipated a post-war boom. Initially, they were right. Shipping demand rose and newly constructed vessels found profitable service. Then, by early 1921, the market collapsed. The war depressed global trade, and international merchant marine services suffered under high tariffs and commercial restrictions. In summer 1921, half the world's fleet

sat idle and freight rates dropped by 75% (Tenold 2019:97–99). As the international shipping slowly recovered in the late 1920s and 1930s, Norway advanced significantly against its competitors. This was even true against the backdrop of the Great Depression. Between 1923 and 1939, world tonnage remained stagnant, but Norwegian tonnage doubled. Other countries with expanding merchant marines during the interwar period were Greece, Japan, Germany, and Panama (Tenold 2019:102–105). By comparison, Great Britain and the U.S. lost ground. In the case of Britain, this was due to a relative decline in British shipbuilding and government overestimates of its capacity to fulfil merchantship and tanker needs in case of war (Thowsen 1994:62; Tenold 2007:254).

Norway made a strategic decision in the interwar period to invest in new tanker technology and diesel-powered motor vessels. On the eve of World War II, 60% of the Norwegian tonnage were tankers driven by diesel engines whereas globally less than 25% of the world's merchant fleet had similar technology. In 1920, tankers comprised 6% of world fleet, of which 90% was owned and controlled by British and American oil companies, but by 1937, the percentage of tankers in the world fleet had grown to 15% and only half of it was controlled by British and U.S. interests. At this time, Norwegian shipping companies owned 20% all tanker tonnage; Norway had the third largest tanker fleet (Tenold 2019:100–101).

The number of Norwegian tanker-owning companies increased from 11 in 1919 to 107 in 1939. Most of the companies operated out of Oslo. In the early 1920s, Norwegian shipowners purchased British tankers, primarily vessels from the Anglo-Saxon Shipping Co. (Tenold 2019:112–113). By the end of the decade, patterns had changed. Rather than purchasing from Britain, the vast majority of new Norwegian shippers ordered tankers built in Sweden (35% of new tanker tonnage) and to a lesser extent Denmark (15% of new tanker tonnage). This pan-Scandinavian alliance was mutually beneficial. Scandinavian governments and Swedish shipbuilders helped provide financing (Tenold 2019:112; Tenold 2007:255). M/V *Hamlet*'s shipbuilder, Götaverken, played a key role.

> One of the main drivers behind the tanker investments was Hugo Hammar, managing director at Götaverken in Gothenburg, who walked around Oslo like a missionary, selling tanker tonnage as the economically attractive escape route from the depressed shipping markets. Helped by eager Oslo brokers, a substantial pressure was built up from the supply side, where both ships and mortgages were on offer. [And government] authorities ... eager to ensure employment in their shipyards, contributed by offering generous financing that limited the need for Norwegian equity and enabled the entry - or re-entry - of companies with meagre resources. The credits offered by Hammar and Götaverken were initially 50 per cent over five years, but in the 1920s they were increased to 70 per cent, at the same time as the repayment period was increased (Tenold 2019:112–113).

Norwegian ships were younger than the global average. In 1939, Norwegian merchant ships were on average 13 years old, whereas the global international fleet was on average 17 years old and getting older. Newer ships were safer and less prone to loss. They were better constructed, and were generally equipped with short wave radios, better medicine, refrigeration, electricity, and improved sanitation (Tenold 2019:106–107).

Conflict broke out in Europe in September 1939; Germany invaded Poland, and Britain and France declared war. Initially, Norway avowed neutrality. This lasted seven months from September 1939 to April 1940. This time corresponds with a period sometimes referred to as the "Phoney War" due to the lack of action, but dangers were very real for Norwegian sailors. Sixty Norwegian ships were sunk during this period and at least 377 sailors were killed. That number may be higher, perhaps in excess of 400 (Rosendahl 2017:17; Tenold 2019:135–135).

In the run-up to war, the British government had consistently overestimated the nation's shipping and tanker capacity, and the availability of neutral tankers in the event of a conflict. In April 1939, Britain

finally acknowledged the potential shortages; and only then did the government consider subsidizing new construction. Subsidies were provided under the Merchant Shipping Assistance Act of July 1939, but these were only for freighters, not tankers. Britain assumed it might purchase used tankers, but the price the government was willing to pay fell far short of market value - so "not a single [tanker] had been purchased when war broke out" (Thowson 1992:62). Desperately short of tanker capacity, Britain turned to the third largest tanker-owning nation in the world - Norway.

In 1939, 450,000 gross register tons of Norwegian shipping was already chartered by British interests. The British government wanted an additional 150 tankers, along with a formal charter agreement between the two countries. Norwegian negotiators served as agents for both the shipowners and the Norwegian government. In September, the first attempt at a deal failed. The sides tried again and made more progress in the Fall 1939. On November 11, the British and Norwegian delegations reached a "Memorandum of Agreement," commonly referred to as the "Scheme." In order to protect Norway's theoretical neutrality, no documents were signed, and the Scheme appears to have been sealed with a handshake. The agreement placed 150 Norwegian tankers (1.2 million gross register tons) under British control at agreed freight rates, in addition to another 150,000 gross register tons of tramp shipping. This new tonnage, when combined with preexisting charters, placed 40% of the Norwegian merchant marine at British disposal. Freight rates were fixed, which initially seemed beneficial for Norway, but as the war became more dangerous for shipping, the fixed rates significantly benefitted Britain. If Norway reneged on the Scheme, Britain planned to forcibly requisition Norwegian ships using the controversial Admiralty Law right of "angary", the right of belligerents to requisition neutral shipping within their jurisdictions. During the Scheme negotiations, Norway had failed to obtain a desired broader general trade and supply agreement, but talks continued and they were successful by March 1940 (Tenold 2019:137; Thowsen 1994:65–66).

In Spring 1940, both Britain and Germany recognized Norway's strategic and military importance. Neither nation genuinely respected Norwegian neutrality. On February 16–17, 1940, HMS *Cossack* boarded the German naval auxiliary *Altmark* as it passed through Norwegian waters headed for Germany. On board *Altmark* were 299, mostly British, prisoners of war; victims of ships sunk by the German warship *Admiral Graf Spee* which had sunk seven British merchantships before the end of 1939. In hand-to-hand fighting on board *Altmark*, sailors from HMS *Cossack* killed seven German sailors and wounded 11 more. The British prisoners were liberated. Norwegian warships protested the violation of national neutrality but did not intervene (Doherty 2003:187–192; Bisschop 1940:67–69; Frischauer and Jackson 1955).

Adolf Hitler had already made the decision to invade Norway, a plan he put into effect in April 1940 under the code name Operation Weserübung. His motives included providing a base for German submarines, preventing Britain gaining greater control of the North Sea, and securing German access to Swedish iron ore exported from Narvik (Tenold 2019:137–138). The attempted British defense of Norway was unsuccessful, but the sinking of the German transport ship *Rio de Janeiro* and the cruiser *Blucher* along with mining action in Norwegian waters slowed the German invasion sufficiently for King Haakon VII and the Norwegian government to move north, then escape to Scotland, before moving on to London. This created a viable Norwegian government in exile (Tenold 2019:137–138).

Control of the Norwegian merchant fleet was critical. Germany immediately seized ships in Norwegian ports and a handful in neighboring Sweden. In total this was about 15% of the Norwegian merchant marine, but more than 1,000 vessels remained out of reach in overseas ports or foreign waters. In charge of Bergen and Oslo Radio, German operatives issued instructions for Norwegian captains to return home or put into ports in Spain or Italy. On April 22, the exiled Norwegian government, now firmly allied with Britain, requisitioned all Norwegian ships larger than 500 gross registered tons (Tenold 2019:139–140). Lloyds of London agreed to insure the Norwegian fleet, allowing the British to issue the following advice to Norwegian captains: "Your ship is held covered by the British Government against War and Marine risks on the values and conditions under which she is present insured." Insurance coverage was

conditional on Norwegian captains heading to British or Allied ports. All Norwegian captains outside direct control of Germany acquiesced to British and exiled Norwegian government instructions. Each telegraphed the following message "I hold the vessel on behalf of the Royal Norwegian Government." This became the "free fleet" as opposed to the ships already under contract to the British (Thowsen 1994, 67; Tenold 2019:142–146).

To manage and administer its requisitioned merchant fleet, the Norwegian government in exile established the Norwegian Shipping and Trade Mission, also known as Nortraship. Instantly, Nortraship became the world's largest ship owner, a moniker it held until the end of the war. At its inception, Nortraship controlled 1,172 ships totaling 4.4 millon gross register tons, including 252 tankers totaling 2 million gross register tons. During the war, profits from Nortraship, amounting to approximately £80 million, made the Norwegian government in exile economically independent. Øivind Lorentzen, a leading shipowner, was appointed director. Nortraship's London headquarters was at 144 Laddenhall Street, but this location proved too small, so the office subsequently moved to Sunningdale. A second headquarters was established in New York on Broad Street. This office managed about a third of the fleet. Significantly, Nortraship was present and active in the U.S. before America entered the war. Nortraship eventually established satellite offices in 26 countries round the world. It was a massive commercial transportation operation that proved critical to the Allied war effort (Tenold 2019:139–146; Rosendahl 2017; Thowson 1992:67–68).

Britain and the U.S. provided Norwegian ships with enhanced lifesaving and defensive equipment including armor, defense against mines, guns, and additional lifeboats. Norwegian ships also sailed under the projection of Allied convoys, as those developed. Nevertheless, more than 700 Norwegian ships were sunk and around 3600 Norwegian sailors were killed including 70 women (Tenold 2019, 145–146). M/V *Hamlet* was among the ships equipped with additional protection - specifically the 3"/50 caliber low-angle stern gun fitted in November 1941(Hamlet Registration Card 1942). Fortunately, none of the tanker's sailors were killed when the vessel was sunk by U-*753* in May 1942. M/V *Haml*et represents and memorializes Norwegian contributions to victory in World War II.

3.2.2.2 U-boats, the Battle of the Atlantic, and the Gulf of America

The Battle of the Atlantic, stretched from September 1939 to May 1945, and was the longest and one of the most critical military campaigns of World War II. At its core, the battle was a struggle between Allied warships and merchant vessels (mostly British, American, Canadian and Norwegian) and Nazi Germany's U-boat fleet. At stake was the vital flow of supplies, military equipment, and fuel across the Atlantic, which sustained the Allies' war efforts, particularly in Europe. The campaign spanned vast geographical areas, including the North Atlantic, South Atlantic, the Caribbean, the Gulf, and the Arctic, with both Allied warships and merchant vessels as prime targets. German U-boats sought to sever enemy supply lines, while the Allies worked tirelessly to defend them (Morison 1947:ix–xi; Keegan 1989:103–123).

The human cost of the Battle of the Atlantic was significant. More than 30,000 British merchant sailors perished, and nearly 3,500 Allied merchant ships were lost, including 700 from Norway (Blair 1998; Hughes & Costello 1977; Tenold 2019:133). Germany, in turn, lost 765 U-boats and about 28,000 submariners. The death rate among U-boat crews reached 70–75%. This made service aboard German submarines one of the most dangerous military roles of the war (Keegan 1988:265; Roskill 1960; Blair 1996). Allied merchant ship losses peaked in 1942, after which a combination of improved intelligence, increased protection for shipping routes by the British, expanded U.S. and Canadian naval capabilities, enhanced air patrols, and the development of new depth charge technologies began to turn the tide in favor of the Allies. By late spring 1943, the balance had shifted in favor of the Allies, ultimately leading to a crucial victory in the overall war effort (Keegan 1989:103–123). Despite serious damage and losses to Allied shipping during the Battle of the Atlantic, one leading historian of the U-boat war has claimed

that Germany never seriously threatened to cut Allied supply lanes in the North Atlantic (Blair 1998:707). If true, this was a testament to the Allied war efforts.

Between December 1941 and the end of August 1942, the Kriegsmarine dispatched 184 patrols to American waters, sinking 610 ships totaling of 3.125 million gross tons (Blair 1996:727–732). Code named "Operation Drumbeat," the campaign significantly damaged Allied shipping tonnage. Early on, Allied protection was weak, leading German commanders to refer to the period as "American Shooting Season." One of the first victims in U.S. waters was the Norwegian tanker *Norness*, which the U-*123* under commander Reinhard Hardegen sank off the coast of Long Island, New York on January 14, 1942 (Blair 1996:460; Hardegen 1942; National Oceanic and Atmospheric Administration 2013b; Wiggins 1995:16). Supplies of oil and aviation fuel were of particular strategic importance to the Allied cause in Europe. This brought oil fields and refineries in the Southern Caribbean and the Gulf into sharp focus. The German navy's application of unrestricted submarine warfare to the region took place under the code name "Operation Neuland." Operations in the Caribbean started in February 1942 when U-boats attempted to cut off Allied oil supplies from the Venezuelan Oil Fields and the refineries at Trinidad, Curacao, and Aruba (Wiggins 1995:17–18; Logo and Eagle, n.d.). The U-boat campaign arrived in the Gulf at the end of April 1942 and focused largely on strategic points of navigation including the Straits of Florida, the Yucatan Channel and Mississippi Delta. In late April 1942, U-*507*, under commander Harro Schacht, passed through the Straits of Florida, and on May 5, the Kriegsmarine claimed its first victim in the Gulf when the U-*507* sunk the American freighter *Norlindo* near the west end of Cuba (Wiggins 1995:22–23, 49–50). The U-boat campaign in the Gulf lasted almost exactly 20 months, ending on December 3, 1943, when the U-*193* claimed the last victim of the campaign. This was the U.S. tanker *Touchet*, sunk as it headed for the Yucatan Channel. In between the attacks on the *Norlindo* and the *Touchet*, a total of 17 U-boats entered the Gulf Sea Frontier. They were, in order of appearance, U-*507*, U-*506*, U-*103*, U-*106*, U-*753*, U-*158*, U-*67*, U-*129*, U-*154*, U-*571*, U-*84*, U-*171*, U-*508*, U-*166*, U-*183*, U-*155*, and U-*193*. Most of the literature states that these submarines initiated 70 attacks in the Gulf resulting in 56 sinkings and 14 vessels damaged but not sunk (Wiggins 1995:228–229, 233–238; Church et al. 2007; Church and Warren 2008; Enright et al. 2006). These numbers appear to be slightly inaccurate. We calculate the numbers as 55 vessels sunk and 15 damaged (Wiggins 1995:233–238). The vast majority of the U-boat attacks in the Gulf occurred between May and September 1942. Thereafter, there were only four sinkings: one in March 1943, two in May 1943, and the final victim in December 1943 (Gannon 1990; Wiggins 1995:233–238). Among the hunters was the *U-753*, and among the victims was the Norwegian tanker M/V *Hamlet*.

3.2.3 Vessel Construction

M/V *Hamlet* was a petroleum, bulk tanker, built in Yard Number 465 by Götaverken A/B, in Gothenburg, Sweden. Launched in 1933, it was 408.5 feet long, 55.2 feet in the beam, and had a depth of 33.9 feet (Figure 29). Götaverken A/B also built the ship's twin diesel engines. These were 12-cylinder, 4 stroke (cycle), single acting engines with a 21 21/32 inch bore and a 39 3/8 inch stroke. They produced 561 nominal horse power. The ship was registered at 6578 tons - the poop was listed as 225 tons, the deck houses as 197 tons, and the forecastle as 87 tons (Lloyds Register 1933, 1934, 1937, 1942, 1943). When loaded, it drew 26.8 feet and had a cruising speed of 10.5 knots (Hamlet Registration Card 1942). The ship was originally named *Eidsvold* (Eidsvold is a Norwegian municipality just north of Oslo) and was built for Norwegian shipping company A/S Eidsiva. Eidsiva was founded in 1930 by Sverre Ditlev-Simonsen (Lloyds Register 1933–1934; Shipbuilder 1942:358). The company operated out of Oslo and still exists today as an electrical power and communications enterprise (Eidsiva.no n.d.). Sverre Ditlev-Simonsen came from a prominent Norwegian shipping family. His older brother and father, both named Olaf, were also wealthy and successful ship owners. Eidsiva's merchant flag was "swallow-tailed, asymmetrical, red with a white diagonal stripe charged with SDS, the founder's initials, in blue" (Flags of the World Web Site n.d.).

In March 1934, soon after M/V *Eidsvold* was completed, Ditlev-Simonsen sold the ship to Skibs A/S Abu (Magnus Konow & Co) also based in Olso. It was renamed *Abu* (Lloyds Register 1933, 1934, 1937, 1942, 1943). Then, in 1937, Skibs A/S Abu sold M/V *Abu* to Bruusgaard, Kiosterud & Co based in Drammen, Norway who renamed it *Hamlet*. In November 1941, M/V *Hamlet* was fitted with a 3"/50 caliber low-angle stern gun. It also carried three machine guns (Hamlet Registration Card 1942).

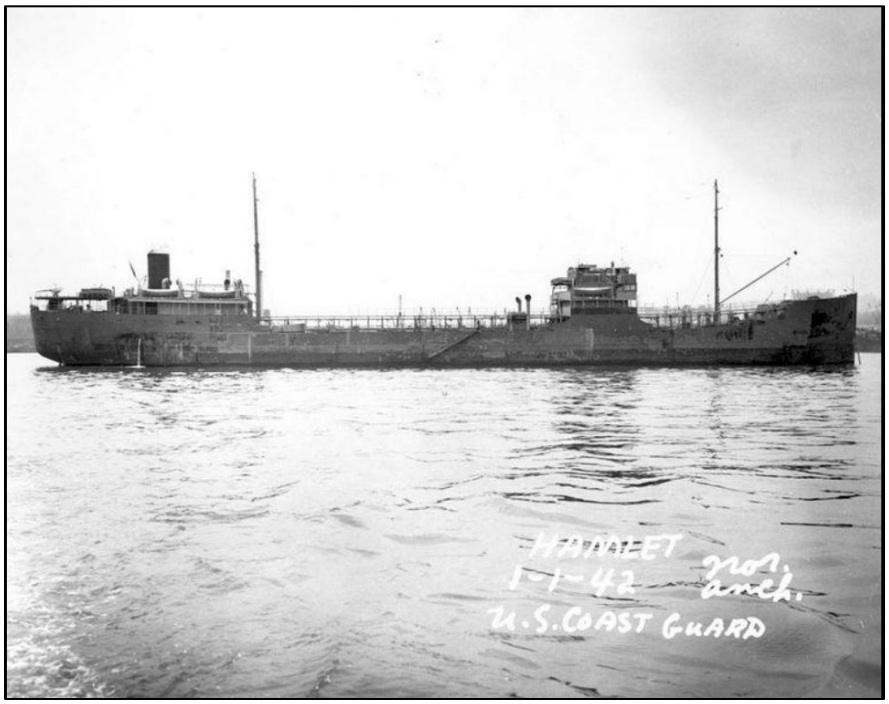


Figure 29. M/V *Hamlet*.
Photo courtesy of the U.S. Coast Guard.

3.2.4 Voyages and Sinking

3.2.4.1 Voyages

From 1939 to May 1942, when M/V *Hamlet* was sunk, the tanker was primarily employed in transporting oil from Aruba to ports in the Greater Antilles (Cuba and Puerto Rico), the East Coast of the United States, and Europe. Aruba served as a refining and transshipment station for crude oil extracted from the rich reserves in the Maracaibo Lagoon, Venezuela. There were two refineries in Aruba. One, the Arend Petroleum Maatschappi refinery (Eagle Petroleum Company) was near Oranjestad on the Island's northwest coast. The second and larger facility was the Lago Refinery located at Sint-Nicolaas harbor on the south end of the island. At the outbreak of World War II, Lago was owned and operated by Standard Oil of New Jersey. The refinery's production of aviation fuel was of strategic importance to the Allies during the war. In 1942, a submarine attack force comprising five German and two Italian vessels attacked the Aruba refineries (Logo and Eagle, n.d.).

M/V *Hamlet*'s voyages comprised three different phases or patterns that mirrored changes in World War II and the Battle of the Atlantic. The first was from 1939 to summer 1940, the second was from summer 1940 to Fall 1941, and the third was from Fall 1941 to Spring 1942 (M/V *Hamlet* n.d.).

3.2.4.1.1 1939–Mid-1940

At the outbreak of war in Europe in 1939 until mid-1940, M/V *Hamlet* undertook three, long distance, multi-port voyages. This was the time of the "Phoney War" when Norway was technically neutral. The first was a trip from Aruba to Kirkwell, Scotland, from there to Abo, Nigeria, then to Talara, Peru, on to Rio de Janeiro, Brazil before finally returning to Aruba. The second was a voyage from Aruba to Gibraltar, then into the Mediterranean and Adriatic with stops at Trieste and Monfalcone, Italy, before returning to Aruba via Gibraltar. The third trip was from Aruba to Baltimore, Maryland back to the southern Caribbean with a stop at the oil terminal in Caripito, Venezuela before going to Bahia, Brazil, north to Pernambuco, Brazil, south to Buenos Aries, Argentina, and north to Trinidad. This was followed by a trip across the Atlantic to Freetown, Sierra Leone, before finally returning to Aruba (M/V *Hamlet* n.d.).

3.2.4.1.2 Summer 1940–Fall 1941

Starting in late summer 1940 and extending into the fall of 1941, M/V *Hamlet* undertook a series of bi-directional trips starting at Aruba and visiting one or two ports before returning to the island. Ports visited included Jacksonville, Florida; Cartagena, Columbia; Charleston, South Carolina; Boston, Massachusetts; Montevideo, Uruguay; Cienfuegos, Santiago, and Havana, Cuba; New York, New York; San Juan and Mayaguez, Puerto Rico; Pernambuco, Brazil; Hampton Roads, Virginia; and Baltimore, Maryland. On the last of these voyages, M/V *Hamlet* departed Aruba on August 30, 1941. It then visited New York and Boston, before sailing for Houston, Texas where it arrived on October 26, 1941(M/V *Hamlet* n.d.).

3.2.4.1.3 Fall 1941–Spring 1942

From Fall 1941 until May 1942, when it was sunk by U-*753*, M/V *Hamlet* sailed as part of the trans-Atlantic convoy system. On October 29, 1941, it departed Houston, Texas for Halifax, Nova Scotia. It crossed the Atlantic as part of Convoy HX160 arriving at Lock Ewe, a temporary naval base on the west coast of Scotland, on November 28, 1941. M/V *Hamlet* then sailed from the west coast to the east coast of Scotland before returning to Lock Ewe and sailing westbound across the Atlantic as part of Convoy ON46. It was during this voyage, either in Halifax or Scotland, that M/V *Hamlet* was fitted with its 3"/50 caliber low-angle stern gun (Hamlet Registration Card 1942). For its second transatlantic trip under the convoy system, M/V *Hamlet* sailed from New York, New York to Halifax, Nova Scotia and from there to Reykjavik (as part of Convoy HX172), arriving in Iceland in early February 1942. On the return convoy, ON67, M/V *Hamlet* detached and headed to Curacao, arriving in the southern Caribbean on March 9, 1942. On its third and last successful transatlantic trip, M/V *Hamlet* departed Curacao for Halifax, Nova Scotia on March 11; sailed from Halifax with Convoy HX182 on March 27; and arrived in the Clyde, Scotland on April 8. It returned as part of Convoy ON89, putting into New York, New York, Hampton Roads, Virginia, and then sailing for Beaumont, Texas. It departed Beaumont at 07:20 a.m. on May 26, headed for Britain, via Key West and Halifax. During the night of May 26 and 27, the U-*753*, sighted, attacked and sank M/V *Hamlet* off the coast of Louisiana. Note that times recorded by German submarines and frequently replicated in online sources, including Uboat.net, are in German time. The same times occasionally find their way into official reports including for example NOAA Risk Assessment for M/V *Hamlet* (National Oceanographic and Atmospheric Administration 2013a). In the case of M/V *Hamlet*, uncorrected times give the false impression that the attack happened during the day; it did not. When M/V *Hamlet* was sunk, German time was seven hours ahead of local time (M/V Hamlet n.d.; U-753 Log 1942).

M/V *Hamlet*'s cargo on its last voyage consisted of 8,927 long tons of crude oil (Hamlet Log 1971). NOAA's Risk Assessment for M/V *Hamlet* lists its cargo at 64,139 barrels (National Oceanographic and Atmospheric Administration 2013a). These two sets of figures are closely allied if the oil weighed 0.1392

tons/barrel, which is certainly possible. At 42 gallons per barrel, M/V *Hamlet* had carried approximately 2,693,838 U.S. gallons of crude, plus and unknown quantity of fuel oil (diesel).

3.2.4.2 U-*753* Attacks M/V *Hamlet*

U-*753* was a Type VIIC submarine: 220 feet 2 inches (67.1 meters) in length and 20 feet 4 inches (6.2 meters) in the beam. Type VII U-boats were the most common German submarine in World War II and are well understood. They had a range of 6,500 miles, which could be extended by refueling. This allowed them to operate in the Gulf. U-*753* had four 21-inch torpedo tubes in the bow and one in the stern. It also had a 3.46 inch (8.8 cm) deck gun and a 0.79 inch (2 cm) C/30 anti-aircraft gun (Uboat.net n.d.b).

During the night of May 17, 1942, U-*753* approached the Straits of Florida. It had a skull and cross bones painted on its conning tower and the moto "Noch und Noch" ("Again and Again") written underneath (Figure 33). Its commander, Alfred von Mannstein, had received a radio message directing him to attack shipping in the area south of the Mississippi Delta where another German submarine, U-*506* under Erich Würdemann, was also operating (U-753 Log 1942; Wiggins 1995:64). Navigation off the southeast coast of Florida was hazardous. American patrols and air defenses were considerable, and U-*753* endured several attacks from bombs and depth charges. On May 18, Mannstein spotted a convoy, heading west through the Straits, zigzagging, and arranged in three columns. He attempted to attack, but as he maneuvered, one of the steamers passed over him and sucked his vessel upward about 7 meters, whereupon it struck the bottom of the merchant ship. Mannstein headed south to assess the damage. His deck gun and bow net deflector were broken, but the submarine was otherwise operable. Mannstein then attempted to catch up with the convoy as it continued at low speed travelling west. He was hampered by planes circling overhead and a rattling noise from the net deflector that made him more vulnerable to acoustic detection (U-753 Log 1942; Wiggins 1995:65–67). Later, the crew tied down the net deflector and cannon. The submarine commander assumed the convoy was headed for the Yucatan Channel so he set off in pursuit. On May 20, Mannstein spotted, attacked, and sunk the U.S. freighter *George Calvert* travelling alone and headed for the Persian Gulf via South Africa. He used four torpedoes in the attack which occurred off the northwest end of Cuba. He then turned northeast. Early in the morning on May 21, the crew of U-*753* witnessed the U-*106* attack and sink the Mexican tanker *Faja de Oro*. Mannstein identified another target and joined the attack, but his first torpedo missed and a second misfired (U-753 Log 1942).

Then on May 21 at 10:08 p.m. local time (5:08 a.m. May 22 German time), 55 miles west of Key West, the U-*753* attached a British 3-masted schooner *E. P. Theriault* (Figure 30). The ship was built in Nova Scotia and registered in Bridgetown, Barbados. Keen to preserve torpedoes and give his crew "artillery" practice, Mannstein used the submarine's machine guns to stop the schooner, board it, and then set it alight with incendiary devices. The schooner and its cargo of wood burned but did not sink and was later salvaged (U-753 Log 1942; Wiggins 1995:65–67; Uboat.net n.d.a; Note: Wiggins says the ship was sunk in their text, but lists it as damaged in their Appendix). After this, U-*753* set course for the mouth of the Mississippi looking for targets along the established steamer routes (Figure 31). The U-*753* passed by the U-*506* as it exited the Gulf (U-753 Log 1942).

On May 25, off the Southwest Pass, Mannstein attacked and damaged the Norwegian tanker *Haakon Maunan*. The tanker survived the attack aided by the arrival of a PC boat. Mannstein then headed to hunting grounds west of Ship Shoal - offshore and south of Morgan City, Louisiana. He drew a series of maps (preserved at the National Archives in Washington D.C.) plotting his voyage to the Gulf, the tanker and freighter routes, navigational markers, and his attacks. Off the coast of Louisiana, he noted that the PC boats and sub chasers were hidden among the fishing fleet (Figure 32).

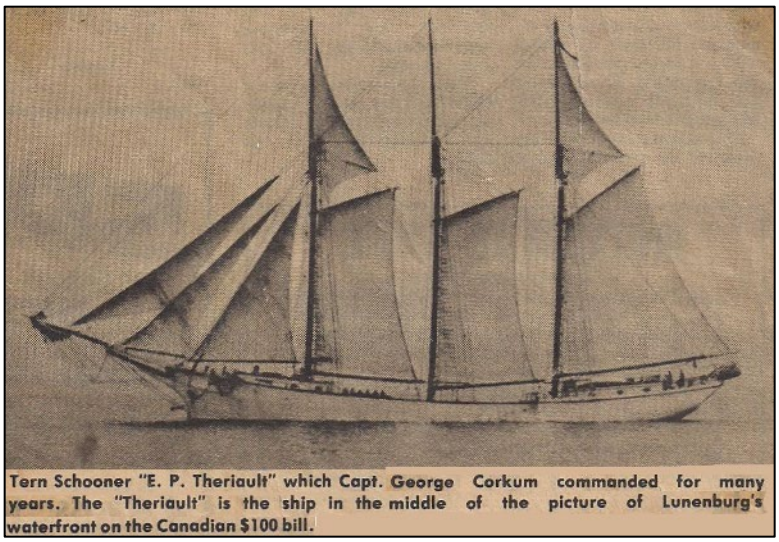


Figure 30. *E. P. Theriault*.
Image from Uboat.net, https://uboat.net/allies/merchants/ship/1692.html

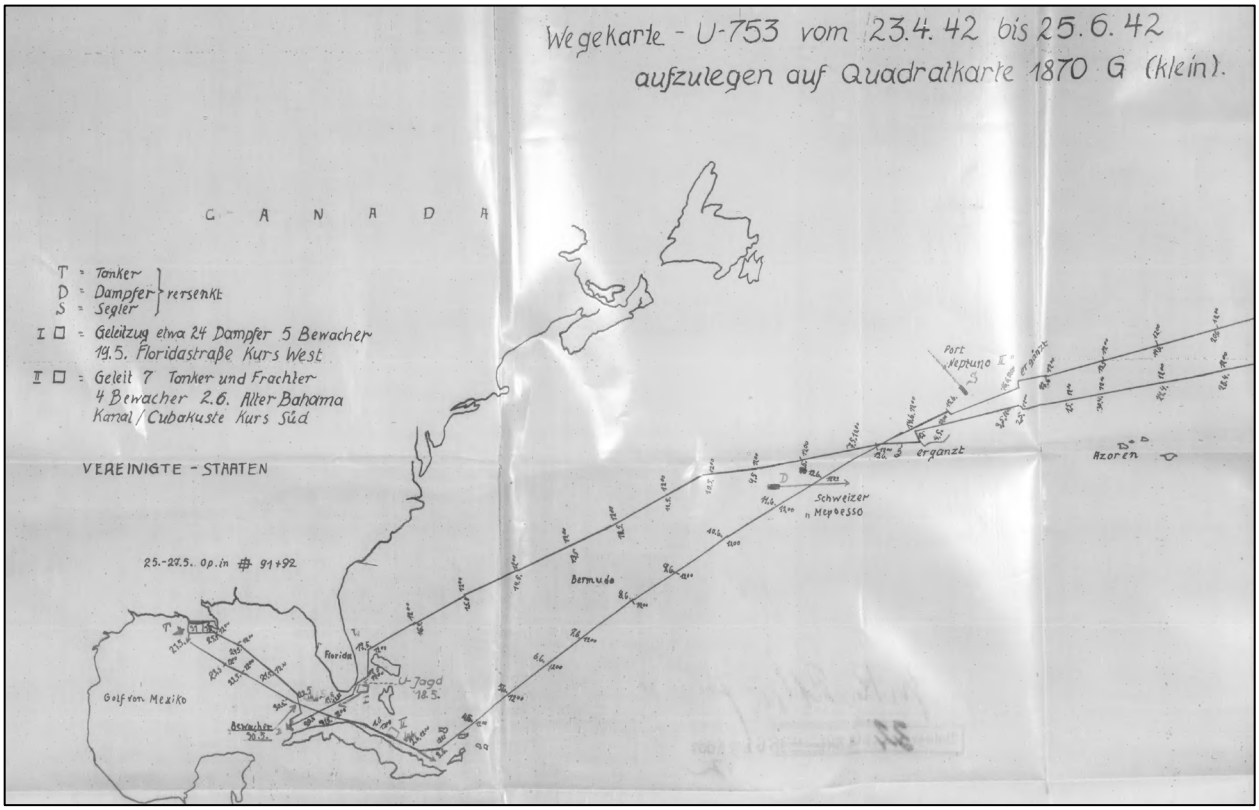


Figure 31. Route Map: U-*753* from April 23, 1942 to June 25, 1942.
Image from U-753 Log 1942, Record Group 242, National Archives Collection of Foreign Records Seized, T1022-3389, National Archives, College Park, Maryland.

On May 26, Mannstein moved south and patrolled the 20-meter contour. Then he spotted a tanker approaching. Initially, it was too bright to attack, but as the clouds passed in front of the moon conditions improved and he fired one torpedo. It struck the tanker near the bow. Mannstein fired again and missed, but a third torpedo was devastating and a fourth torpedo finished the job. M/V *Hamlet* sank by the stern

with the bow almost upright out of the water. The following day, American air assets attacked U-*753*, but Mannstein escaped. Now in need of refueling, U-*753* exited the Gulf and headed for Europe. Its captain celebrated with a beer when he returned to La Pallice, France on June 25, 1942 (Figure 33). Mannstein reported that the Gulf off the Louisiana coast offered good prospects for continued attacks. There were still single ships to target, but through the Straits of Florida the convoys and air defenses made attacking Allied shipping more difficult (U-753 Log 1942; Wiggins 1995:65–68).

The attacks by U-*753* and U-*106* in May 1942 intersected with the highpoint of German success in the Gulf. That month, the U-*507*, U-*506*, U-*106*, U-*103*, and U-*753* sunk 20 and damaged an additional 5 ships in the Gulf, most of them off the mouth of the Mississippi, the east coast of Florida and the Yucatan Channel (Wiggins 1995:233–238).

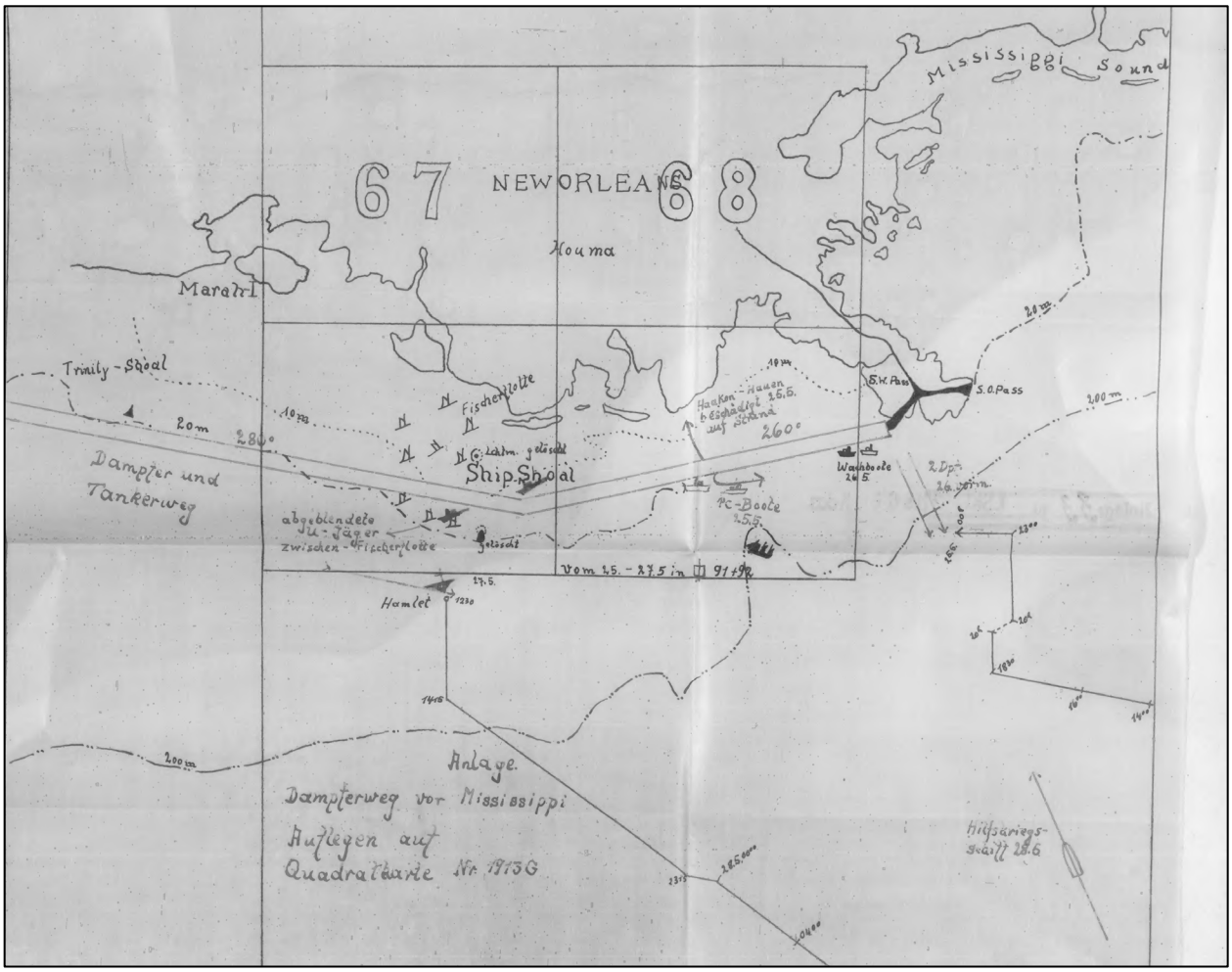


Figure 32. Route Map: U-*753* off Louisiana.
Image from U-753 Log 1942, Record Group 242, National Archives Collection of Foreign Records Seized, T1022-3389, National Archives, College Park, Maryland.

3.2.4.3 M/V *Hamlet* Sinks

According to M/V *Hamlet*'s log, the ship was hit at 4:10 a.m. when located at approximately latitude 28 25 N, longitude 91 00 W (Hamlet Log 1971). The first torpedo struck toward the forward end of No. 10 tank. Captain Nils Ambjørnsen ordered the engines all stop, sounded the alarm, and directed the gunners to man the ship's defenses. The lifeboats were made ready, but the crew hoped to stay on board until

daylight when efforts might be made to save the ship. The attack damaged the telegraph antenna, preventing calls for help. At 4:40 a.m., while an emergency antenna was being erected, a second torpedo stuck M/V *Hamlet* and the ship started to sink fast. The captain issued an order to abandon ship. Two motorboats and two rowboats were launched. Most of the crew made it to the boats; the remainder were picked up out of the water. There were no casualties (Hamlet Log 1971). At 4:55 a.m., a third torpedo hit the ship, this time between tanks No. 13 and 15. M/V *Hamlet* quickly sank by the stern with only the poop protruding above the water at an angle of 45 degrees. After the last torpedo struck the ship, the crew saw the U-boat on the surface. M/V *Hamlet*'s four lifeboats remained on station close to the almost sunken ship until daybreak. At 6:30 a.m. local time, M/V *Hamlet*'s officers confirmed that all ship's personnel were safe and accounted for. They then set course for the nearest land. At 9:30 a.m., several fishing cutters offered M/V *Hamlet*'s lifeboats assistance. As they made their way to shore, the stricken tanker's crew feared that the U-boat might surface and attack them with gunfire. But by 9:00 p.m. with lifeboats in tow, the fishing boats arrived at Morgan City (Hamlet Log 1971).

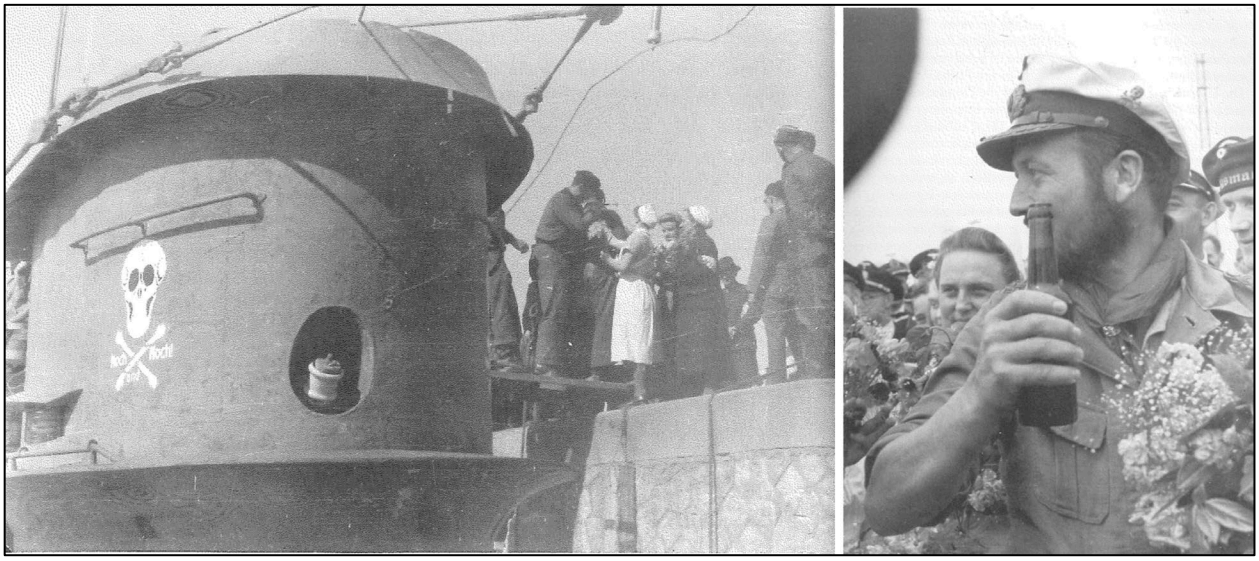


Figure 33. U-*753* conning tower and commander.
Left: Conning tower of U-*753*; Right: Commander Mannstein celebrating upon his return to La Pallice, France. Photos from (Wiggins 1995:65, 68).

Twenty-three of the 36 people on board M/V *Hamlet* the night of May 27, including all the officers, were Norwegian. The remainder were made up of a British radio officer, an American radio officer, an American signalman, two Canadian able seamen, a Dutch able seaman, two British ordinary seamen and/or gunners, a Swedish steward, two British mess boys, and a British galley boy. All survived the submarine attack (M/V *Hamlet*, n.d.).

Table 6. M/V *Hamlet Crew*

Name	Nationality	Rank
Nils A. Ambjørnsen	Norwegian	Captain
Aake Andersen	Norwegian	1st Mate
Aage L. G. Ludvigsen	Norwegian	2nd Mate
Olaf J. Johansen	Norwegian	3rd Mate
Gunnar J. Pettersen	Norwegian	1st Engineer

Name	Nationality	Rank
Jens Røsland	Norwegian	2nd Engineer
Kristian Larsen	Norwegian	3rd Engineer
Kenneth Fleming	British	Radio Operator
William Clay	U.S. Navy	Radio Operator
Gunnar N. Nilsen	Norwegian	Carpenter
Olaf Larsen	Norwegian	Boatswain
Olaf Finvik	Norwegian	Able Seaman
Thorbjørn Solbakken	Norwegian	Able Seaman
Frithjof Olsen	Norwegian	Able Seaman
Allan J. Collier	Canadian	Able Seaman
Adrian Fase	Dutch	Able Seaman
Alf Gunnar Haug	Norwegian	Able Seaman
Frederick Egner	Canadian	Able Seaman
Olav M. Sørensen	Norwegian	Able Seaman
Jacob Lilleheim	Norwegian	Ordinary Seaman
Arthur Thomas Denyer	British	Ordinary Seaman/Gunner
John Henry Clarke	British	Ordinary Seaman/Gunner
Thorleif Reinemo	Norwegian	Assistant
Harald Oftedal	Norwegian	Mechanic
Walter Eugen Svendsen	Norwegian	Mechanic
Frithjof Larsen	Norwegian	Mechanic
Søren Eriksen	Norwegian	Mechanic
Odd Lugård Jørgensen	Norwegian	Mechanic
K. F. Halvardsen	Norwegian	Mechanic
Harald K. Amundsen	Norwegian	Pump Man
Olaf Anderson	Swedish	Steward
Håkon Johansen	Norwegian	Cook
Edward C. Butghart	British	Galley Boy
Peter Webster	British	Mess Boy
Robert Walker	British	Mess Boy
Charles Burianck	U.S. Navy	Signal Man

Note: Data from (M/V *Hamlet* n.d.).

3.2.5 Previous Investigations

The location of M/V *Hamlet* was unclear at the time of its sinking in 1942, and it remained so until about 2015. For many years, BOEM's submerged cultural resource database contained unverified information

about the wreck and its location. Part of the issue was that the historic reported location in U.S. sources from 1942 turned out to be 20.8 nm from the eventual confirmed location of the wreck. Previously, Shipwreck 3 in this study was misidentified as the remains of M/V *Hamlet*, including within the BOEM shipwreck database (C&C Technologies 2015).

In September 1990, Gulf Ocean Services submitted a "High Resolution Geophysical Survey Report" to Unocal Exploration Company. The area was approximately 91 miles south of Morgan City, LA. Water depths ranged from 136–165 feet. During the survey the contractor identified a shipwreck of undetermined length in both the side scan and magnetometer data. Approximately 15 years later, this vessel was identified as the remains of M/V *Hamlet*, although neither the contractor nor MMS (predecessor to BOEM) recognized this at the time (Gulf Ocean Services 1990).

M/V *Hamlet* was the subject of a Remediation of Underwater Legacy Environmental Threats (RULET) report in 2013. At that time, NOAA was unable to confirm the exact location of the site.

3.2.6 Site Description

The Data Gap project collected three sets of data related to M/V *Hamlet*. In May 2021, David Evans and Associates, Inc. Marine Services gathered side scan sonar and multi-beam bathymetric data (Figure 34). This work was completed under a sub-contract for Cardinal Point Captains, Inc. (see Section 2.4). In July 2021, Marine Imaging Technologies conducted diver reconnaissance videography at the site (see Section 2.5). During the research cruise, June 16–22, 2022, the Data Gap team conducted ROV dives on 4 shipwrecks and 3 hardbottom habitats which included Shipwreck 2 (M/V *Hamlet*) (see Section 2.6). The highest quality video data for site assessment came from the July 2021 diver reconnaissance. Additional useful video data was obtained from ROV Dive 9 in July 2022.

M/V *Hamlet* sits upright on the ocean floor in approximately 150 feet (46 meters) of water. Its bow is on a bearing of 215 degrees. The hull is severed midships creating two distinct sections and a transverse break. There is also substantial damage and a V-shaped gouge in the starboard bow.

The vessel's 3"/50 caliber low-angle stern gun which was retrofitted to M/V *Hamlet* in November 1941 survives. The gun and gun mount are well preserved. On the port stern are sets of bits and degaussing wires. Much of the ship's original wooden decking in the stern is missing revealing the remains of the metal deck beams. The remains of the smokestack are present along with an open engine room hatch which allows access to the machinery spaces. The ship's 12-cylinder, 561 nominal horse power, diesel engines have survived and are in an excellent state of preservation. The shaft is also present (Figure 35). The afterdeck house survives up to the poop deck, but the boat deck is missing.

There is considerable fishing net caught on M/V *Hamlet*, including a substantial amount on the starboard gunnel (Figure 38).

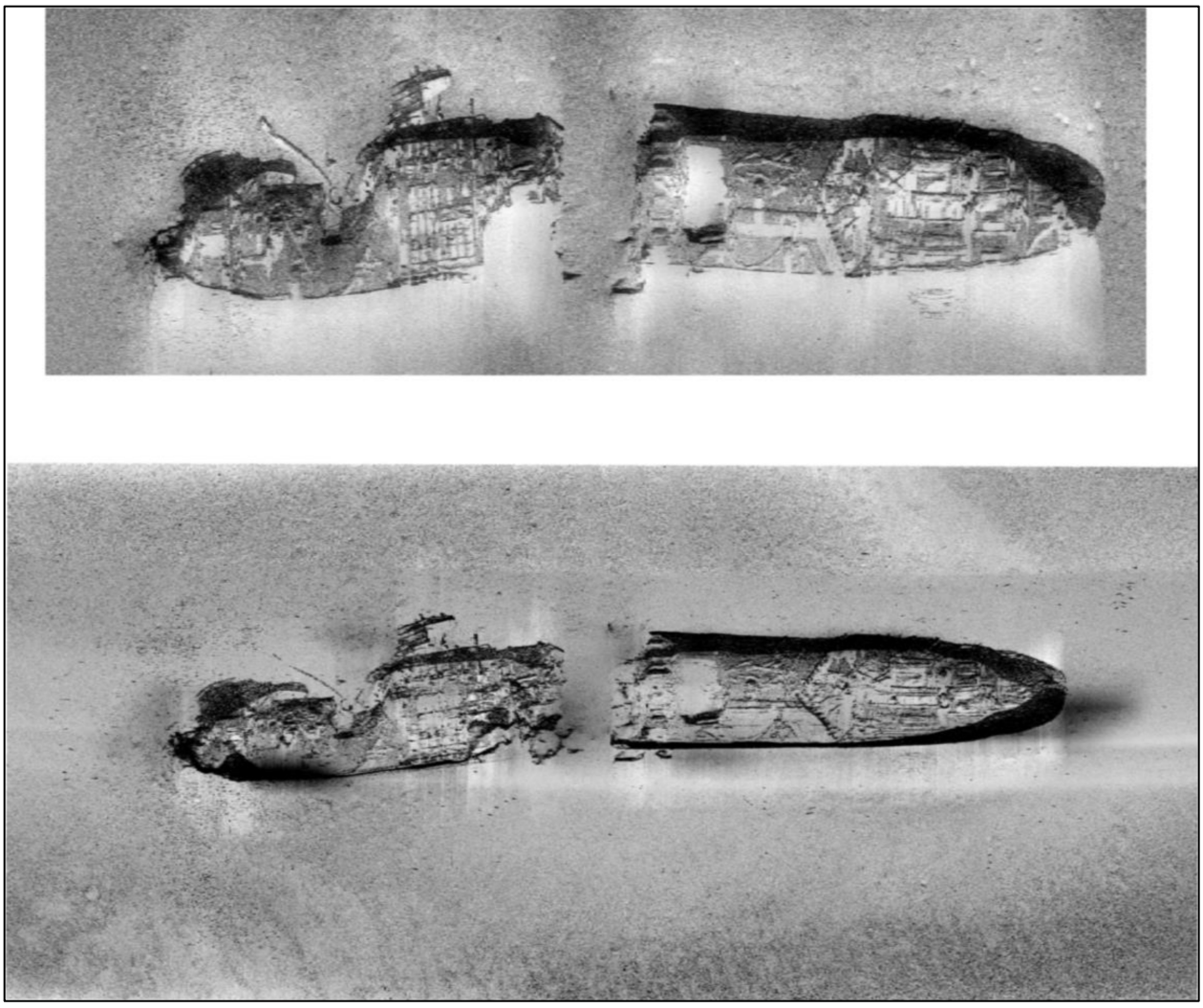


Figure 34. Side scan sonar images of M/V *Hamlet*.
Images from David Evans and Associates geophysical survey in May 2021.



Figure 35. Stern details of M/V *Hamlet*.
Top left: Stern gun; Top right: Bits and degaussing wires; Bottom left: Deck beams; Bottom right: Engine room.



Figure 36. Midships details of M/V *Hamlet*.
Left: Forward deck house; Right: Forward face of transverse break in hull.

In bow section of the ship, the remains of the forward deck house have survived up to the bottom of the bridge deck. It appears that above the bridge deck, M/V *Hamlet* had an upper bridge (or perhaps a boat deck) and a flying bridge, but these are missing (Figure 36). Forward of the deck house, torpedo damage is readily apparent. There is a V-shaped gouge in the starboard bow and the debris outboard of the damaged area. The bow suffered significant damage, but the windless survives on the remains of the forecastle deck and is still connected to anchor chain. A considerable amount of commercial fishing gear is caught on the wreck in this area. Inside the forecastle deck there is a hatch and chain locker.



Figure 37. Forward hull details of M/V *Hamlet*.
Left: Windlass; Right: Hawser reel, cable, and winch.

Aft of the forecastle deck is a winch which was used to service the forward boom and a hawser reel and cable. The port bow is better preserved than the starboard side (Figure 37).



Figure 38. Fishing net snagged on M/V *Hamlet*.
Left: Fishing net at stern; Right: Fishing net at bow.

3D orthomosaic imaging of sections of M/V *Hamlet* was marginally successful. During ROV dives on June 20 and 21, the team concentrated on obtaining imagery the stern gun (Figure 39). Figure 39 provides the best output. The issues with modelling are described in section 2.6.3.6.

Visibility was poor during the ROV dives on M/V *Hamlet*. Towards the end of Dive 9 on June 20, the ROV cable became entangled on wreck towards the forward end of the stern section. After successful efforts to release the ROV were complete, some oil was released from the shipwreck. This was observed as sheen on the surface. Scott Sorset reported this to NOAA's Remediation of Underwater Legacy Environmental Threats (RULET) team in May 2023.

3.2.7 Identification

The M/V *Hamlet* site lies within the sector identified by the U-*753* commander as indicating the location of the attack, DA9423, and it is 5.4 nm from the location recorded in *M/V Hamlet*'s Log (U-753 Log 1942; Hamlet Log 1971). Details of the wreck match narratives from the U-boat and the tanker. Likewise, the dimensions and configuration of the hull match historic documentation of the vessel. There appears to be little doubt that the shipwreck studied is the remains of M/V *Hamlet*.



Figure 39. 3D Orthomosaic of M/V *Hamlet* stern gun.
Image processed by Scott Sorset, BOEM.

3.2.8 National Register Eligibility

M/V *Hamlet* is eligible for nomination to the NRHP. The vessel is largely intact, satisfying the requirement for historical integrity, and can be nominated under Criteria A, C, and D.

3.3 Shipwreck 3

3.3.1 Overview

Shipwreck 3 sits in 150 feet (46 meters) of water. It is located in the Eugene Island area of the Gulf, approximately 70 miles south of Morgan City, Louisiana. In the 1990s and early 2000s, the site was misidentified as the remains of M/V *Hamlet*. Side scan sonar data from two surveys showed the wreck to be a relatively modern ship, approximately 87–90 feet long and 23–24 feet wide (Warren 2013; (Redmayne and Laverty 2021). Poor visibility during ROV operations at the site on June 21, 2022 led to low quality video documentation. This hampered site identification. Since the vessel resembled a fishing boat and was covered in net, the archaeological assessment at sea was that the wreck was as a shrimp boat. As a result, most of the initial context and identification work focused on commercial fishing. Later, post cruise analysis of data raised other possible interpretations. Given the location of the wreck and its features, the team considered three possible vessel types–a commercial fishing boat, an offshore oil and gas exploration vessel, and an offshore supply vessel (OSV). Tugboats were discounted, since they seldom had wheelhouses combined with long open aft decks that matched Shipwreck 3. In the final stages of writing this report, the team established that the most likely identity for Shipwreck 3 is either *Lady Ada* an OSV sunk in 1978 or *Dino C*, an OSV sunk in 1979. If Shipwreck 3 can be shown to be the remains of *Dino C,* BOEM may want to take additional action to protect and study the site. *Dino C* had a notable and important history and in 2029 (50 years after its sinking) may become potentially eligible for nomination to the National Register of Historic Places. *Lady Ada* is less likely to become eligible for nomination to the National Register of Historic Places.

3.3.2 Historic Contexts

Three historic contexts are appropriate for an analysis of Shipwreck 3.

1. Commercial Fishing
2. Seismic Survey
3. Offshore Supply

3.3.2.1 Commercial Fishing

Up until the 20th century, consumption of shrimp in the U.S. South was generally tied to local fishing communities along the coast (Blount 2000:298–299). This pattern was true for the Gulf coast. Advances in transportation and refrigeration technology during the 1930s built demand for shrimp beyond local markets. Fishers caught shrimp in shallow waters with seine nets. This began to change in Louisiana between 1915–1917 with the introduction of trawling (Becnel 1962:1–17). Within the north central Gulf areas, the first trawlers worked shallow waters and were built with the wheelhouse aft and the work deck forward. A single trawl was towed from riggings mounted forward. Trawlers built in the eastern and western areas of the Gulf were different. They had the position of the wheelhouse and the deck reversed, and the winch was attached aft of the wheelhouse with two blocks attached to a main boom. This kind of vessel design eventually led to double-rig trawling (Juhl 1966:43). The term "trawl" refers to a net design that is dragged across the ocean floor while attached to the boat from above. The net takes the shape of a funnel, with the opening spread apart by two flat boards–otter boards–at opposite ends of the net entrance. Like most nets, a trawl net has a cork line to keep the top of the net floating and a lead line to sink the bottom half of the net (Becnel 1962:1–17). In Louisiana, trawling allowed fishermen to push the fishery into deeper waters, farther offshore, which provided greater yields than previously exploited on inshore grounds. The trawl also made fishers less reliant on the seasonality of shallow water shrimp (Becnel 1962:18–21). Commercial shrimp trawling continued in this way until World War II. The war effort called for new supplies of watercraft, which in part facilitated changes in construction patterns by regional boatbuilders drawing them away from fishing vessels. Louisiana was selected by the Maritime Commission to provide both warships and support vessels for the United States Navy (Piston 1988:170–172). The shifts in shipbuilding also altered the nature of Louisiana's shipyards. Small scale shipyards had been able to operate successfully until the demand for steel vessels grew. The startup costs for steel production were much higher and required a greater specialization of skills, so the shipyards able to compete in this industry edged the smaller ones out (Peebles 1988:8–11).

After World War II, Gulf shipbuilding continued to grow, driven by the expansion of oil and gas in the region. This caused declines in fishing boat construction in the region. Early in the twentieth century, most fishing boats had wooden hulls, but during the 1940s an increasing number were made from steel or aluminum. Steel boats were also designed to handle the demand for offshore hydrocarbon exploration, and began to increase in size, ranging from 60–90 feet (Captiva 1966:24). Vessel designs continued to be influenced by oil exploration in the 1950s (Theriot 2014:1–9). Overall, Louisiana vessel construction declined significantly between the late 1950s and early 1960s. In addition to changes in hull construction, other design trends in trawler construction in the last century included winches, engines, crew quarters, electric controls, and interchangeable parts (Captiva 1966:25–27).

3.3.2.2 – Seismic Survey

In the first half of the twentieth century, oil companies hired local fishing boats and workboats to support oil and gas exploration. Louisiana fishermen modified their boats for seismic work, transportation, and supply. Gradually, oil and gas vessels became more specialized, but from the 1930s to 1960s it remained common for shrimpers to use their vessels for both fishing and to support oil and gas exploration.

In the 1950s, oil and gas companies, interested in finding new hydrocarbon reserves, investigated the extent to which gas seeps might help establish prospective drilling locations. Early technology was based on obtaining water samples. High concentrations of methane in sea water might indicate proximity to gas seeps which in turn might lead to natural gas reserves. For detection, survey vessels ran perpendicular to

the current and attempted to detect subsurface gas plumes. In the early 1960s, petroleum companies, such as the Atlantic Refining Company, developed water sampling equipment that was economical and easy to mount on vessels ranging from 14–65 feet. Existing workboats and commercial fishing boats were sometimes modified for these surveys (Offshore 1961a:11–12).

At the same time as gas seep detection technology was emerging, marine geophysicists developed seismic systems which offered even greater potential for hydrocarbon exploration. In the U.S., development of seismograph technology began on land in Oklahoma in 1921 when a group of physicists and geologists used dynamite to generate seismic waves and a seismograph to record geological features and surfaces. Subsurface images, including boundaries between rock layers, were recorded, demonstrating the technology's capacity to detect geological features tied to oil and gas exploration. Seismic technology, however, did not make serious strides until 1929. By then, the price of oil had recovered from an earlier decline to the point where investment in new equipment for detecting hydrocarbons was justified (Dragoset 2005:46–48). Seismography was also potentially useful for offshore oil exploration, but early initiatives were stalled by the onset of World War II. After the war, with growing demand for hydrocarbons, oil companies restarted their experiments with seismographs (Theriot 2014:74–76).

Early mid-century offshore seismic survey equipment was the same gear as used on land but modified for the marine environment. Cables with hydrophones were towed behind boats as detecting systems, and intermittently the vessel's crew set off dynamite as a source of seismic energy. By the 1960s, these cables were replaced by streamers that were kept buoyant by small amounts of oil in them. The streamers contained hydrophone wires and sensors, all of which were connected to data recording systems on deck (Dragoset 2005:50–51). Weaknesses in early seismograph technology included problems generating high quality reflection signals, difficulty in creating accurate images of the geological features, and inadequate methods for placement of the shots and receivers and/or hydrophones (Dragoset 2005:47–48). Initially, dynamite was used as the source for seismic energy, and in marine exploration it was detonated between a few feet and tens of feet below the surface. However, explosives were not ideal for underwater surveys because they produced multiple signals making analysis difficult. Up until the 1960s, a way to circumvent this was to detonate the dynamite at shallow depths, but this reduced the amount of energy available for geological detection. During the 1960s, air guns were developed, and by the 1970s they were used on more than 50% of seismic vessels (Dragoset 2005:51–54). Socony Mobil developed a cheap system of seismic exploration that employed a detonation gun installed on the side of the boat, with a detector cable towed from the stern. The gun was built out of steel, was 20 feet long and had a 6-inch diameter. It utilized propane and air for fuel, which was ignited by a spark in the gun's submerged end. The gun emitted a shock underwater, which was then picked up by hydrophones in the detector cable. These streamlined plastic detector cables used a float and sinker in order to ensure towing at a constant depth (Offshore 1961b:23–25). The gear for recording seismic data was housed and deployed on the back deck of the vessel. The streamers for collecting data were wound up on a reel and deployed over the side or the stern of the vessel. The energy sources were also stored on the back deck, except air compressors which were typically stored off deck. As technology advanced, streamers became longer, and survey vessels no longer used dynamite or combustible materials as energy sources (International Association of Geophysical Contractors 2002:5–8). Some early seismic survey vessels were converted fishing boats.

3.3.2.3 Offshore Supply

Several studies have suggested that the history of offshore supply vessels (OSVs) in the Gulf began in 1956, with the *Ebb Tide,* the first such ship to be deployed in the Gulf. The *Ebb Tide* was 127 feet long, with a forward wheelhouse and an elongated working deck aft. It was used to deliver bulk cargo to offshore oil facilities. While it is true that *Ebb Tide* was a blueprint for many OSVs in the Gulf, others built around the same time were similarly pioneering (Angkatan 2018). It took time for OSV design regulations to materialize and mature. In the early 1960s, the U.S. Coast Guard was reluctant to issue

licenses for OSVs longer than 65 feet (Austin 2008b:153). These were newer vessels with unique operations, which required distinctive management (USCG National Center of Expertise 2020:1–2). Today, OSVs are used for a wide range of support services including supply, towing, anchor handling, and crew transportation.

U.S. Coast Guard reports on the sinking of early OSVs in the Gulf from the late 1950s and early 1960s show that larger OSVs were more prone to righting issues. Their larger beams meant high GMs (metacentric height) for the vessels (usually considered beneficial), but this did not correlate with high stability or righting capabilities due to the low freeboards. During the inquiry into the loss of *El Faro* in 2015, Dr. Jeffrey Steller, a professor of naval architecture at the U.S. Navy Academy, testified as to the issues with early OSVs.

> Following the capsizing and sinking of eight offshore supply vessels in the Gulf of Mexico between 1956 and 1963, it was realized by the Coast Guard that vessels like offshore supply vessels, with larger beams and lower freeboards, could have large GMs, and easily meet GM criteria but have comparatively low range of stability and area on the righting arm curve, or righting energy. As a result of this series of capsizings, the Coast Guard began to apply more stringent stability criteria to offshore supply vessels, adapting criteria based on righting arms. These criteria are generally applied, in 46 Code of Federal Regulations Section 170.173, to vessels under 100 meters in length, or for other vessels of unusual proportion and form (USA National Transportation Safety Board 2015:148–149; 46 CFR § 170.173).

It is likely, then, that the issues with low freeboard in early OSVs made them more prone to capsize. Compounding this problem was instability related to mud tanks, which were positioned on these vessels' working decks. In the 1950s and 1960s, OSVs generally housed two 1,000 cubic foot tanks that held cement and bulk mud for offshore construction and drilling. It was not until the 1970s that OSVs builders started placing these tanks below deck (*Professional Mariner Forum* 2018).

3.3.3 Previous Investigations

In August 2015, C & C Technologies submitted an archaeological assessment report for the decommissioning of Black Elk "A" Platform. The work was completed under contract with JAB Energy Solutions. Data acquired included multibeam bathymetry, side scan sonar, magnetometer, and sub-bottom profiler. Of the sonar targets, one represented the remains of an unidentified shipwreck (Figure 40). This vessel corresponds with Shipwreck 3 of our study (C&C Technologies 2015). C&C measured the wreck at 87.7 feet in length and 23.2 feet in the beam.

C&C summarized the potential cultural resources in the survey area. Analysis of BOEM and C&C records suggested that there were two shipwrecks and two additional archaeological features within five nautical miles of the survey area. One shipwreck was unidentified; the second was *Lady Ada* which "sank while tied to an offshore platform in 1978" (C&C Technologies 2015:8–9). The two additional archaeological features were a Bell 206A JetRanger Helicopter and a Mobil 10,000 lb anchor.

3.3.4 Site Description

The Data Gap project collected two sets of data related to Shipwreck 3. In May 2021, David Evans and Associates, Inc. Marine Services gathered side scan sonar and magnetometer data (Redmayne and Laverty 2021). This work was completed under a sub-contract to Cardinal Point Captains, Inc. (see Section 2.4). In addition, from June 16–22, 2022, the Data Gap team conducted ROV dives on 4 shipwrecks and 3 hardbottom habitats. This included an ROV dive on Shipwreck 3 (see Section 2.6).

Side scan data from the David Evans and Associates' survey revealed a shipwreck approximately 90 feet in length with the bow pointing at 300 degrees. The vessel's superstructure was prominent on the bow. The starboard side was exposed, and the port side partially buried. The stern appeared to be curved (Figure 41).

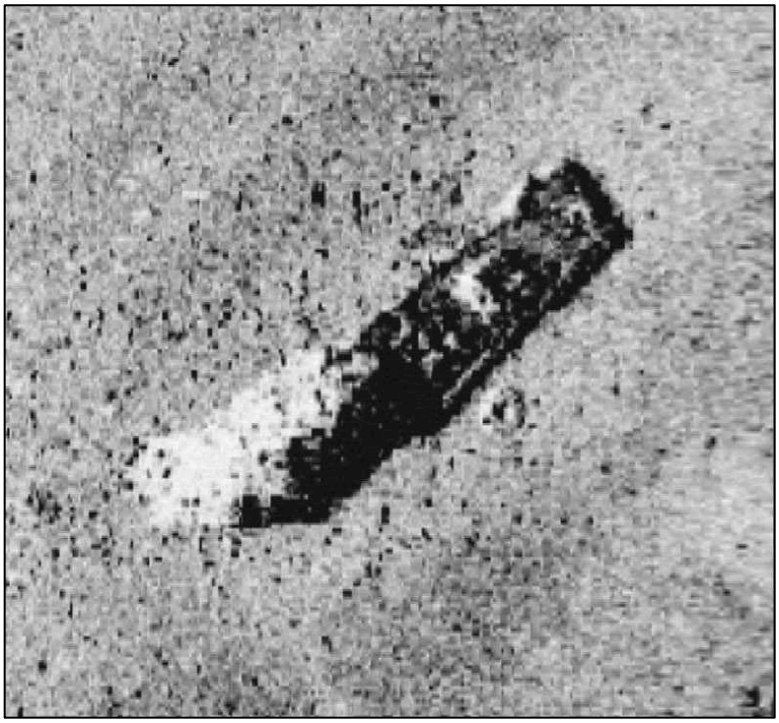


Figure 40. Shipwreck 3 identified as Sonar Contact No. 6 by C&C Technologies.
Image from (Warren 2013).

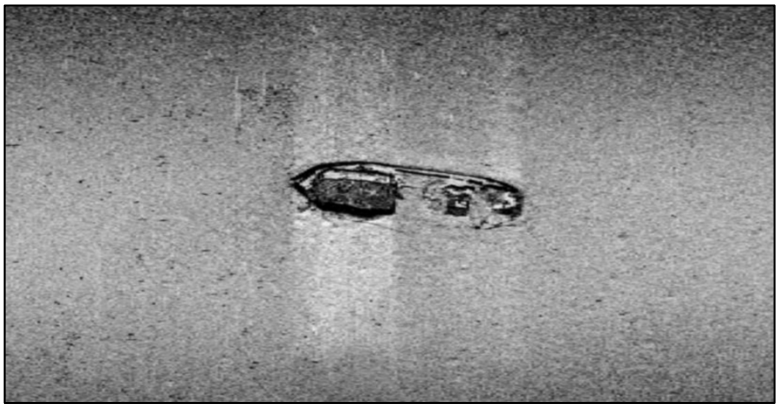


Figure 41. Side scan sonar image of Shipwreck 3.
Image from David Evans and Associates geophysical survey in May 2021.

The Data Gap study team completed an ROV dive (Dive 11) on Shipwreck 3 on June 21, 2022. Data quality was poor due to severely limited visibility. ROV footage included close ups of the inside and outside of the hull's starboard side. There were several portholes visible. A considerable amount of netting was present on the starboard side aft of the wheelhouse, which extend all the way to the stern. The corks on the netting appeared to be polyvinyl chloride (PVC) and cone shaped. The vessel's wheelhouse was forward. Aft of the wheelhouse was a possible winch, what appeared to be a hatch, and a long

working deck (Figure 42). There also seemed to be beams or the remains of a data and navigation mast that collapsed into the deck just aft of the wheelhouse. Two bollards were identified on the starboard side, one adjacent to the aft end of the wheelhouse and the second close to the stern. The wheelhouse was a single-story structure with doors leading inside, and portholes forward. A helm was identified in the wheelhouse. The shape of the stern was not as discernible, but it was possibly rounded, and it might have had an upward crest at the center. Shipwreck 3 is believed to have a *terminus post quem* of 1950 based on its steel hull and construction. If the net and PVC corks are associated with the wreck, a similar *terminus post quem* can be drawn since these types were not introduced to the industry until the 1950s. No Turtle Excluder Device (TEDs) were found in the netting, indicating that it was most likely manufactured before the 1980s. An anchor roller would be helpful in identifying the date of the vessel, but unfortunately it seems that it and hawse pipes were wrapped up in the net. A propeller was not identified in the video.

3.3.5 Identification

Features identified on the wreck are its steel hull, wheelhouse, ship's wheel, riggings, possible winch, bollards, long aft deck, portholes, data and navigation mast, net, and PVC corks. These characteristics might be consistent with a fishing vessel, an exploration or seismic survey boat, or an OSV. They are not consistent with a tug, cargo ship, or recreational vessel. There is no evidence of catastrophic damage to the site such as an explosion, collision, or hull fracture.

3.3.5.1 Fishing Vessel

It is possible that Shipwreck 3 is a fishing vessel - either a seiner or a trawler. A seine boat seems less likely since Shipwreck 3 does not appear to match seine boats' size and construction. For much of the 20th century, and at least until the 1970s, seine boat design changed little. They usually had two wheelhouses, one forward and the other aft, with boat's fish hold in between (Whitehurst 1973:27). This hull configuration does not match Shipwreck 3. In addition, davits, required for seining, appear to be absent on the wreck. The vessel is certainly not a seiner skiff used to haul in fish.

It is more likely that Shipwreck 3 is an offshore shrimp trawler. The shape, configuration, construction and presence of net are all consistent with a trawler. If Shipwreck 3 is a trawler, it is possible that it was built in a neighboring Gulf state, particularly Florida. During the latter half of the twentieth century, areas in Florida, such as St. Augustine, experienced a boom in shrimp trawl construction, thanks to boatyards such as Diesel Engine Sales Company (DESCO). However, DESCO transitioned from wooden boats to fiberglass boats and was not known for building steel or aluminum hulls (Burke 2009:1–5). Starting in the 1940s, most offshore vessel construction in Louisiana serviced on oil exploration and extraction rather than the fisheries. However, if Shipwreck 3 was built in Louisiana, it is possible that it was constructed in Morgan City, considering the shipwreck's proximity to the area (Theriot 2014:1–9).

There is insufficient diagnostic evidence to categorically identify Shipwreck 3 as a shrimper. Indeed, some of the evidence suggests otherwise. The bollards on the starboard side are atypical of shrimp boats. No otter boards or TEDS were observed on the nets, a necessary prerequisite for shrimp trawling. It is also possible that the net is not associated with the wreck. It is relatively common for fishing net to get snagged on and wrapped around wrecks in the mesophotic zone post sinking. Morgan City, once "shrimp capital of the world," did not have any shrimp-processing infrastructure in the 1970s. Its economy had become heavily dependent on oil (Theriot 2009:3). Besides the net and the shape of the boat, no other gear on the wreck suggests commercial fishing, with the possible exception of a hatch on the working deck.



Figure 42. Hull details of Shipwreck 3.
Top left: Porthole on starboard side; Top right: Fishing net and floats; Bottom left: Collapsed structure aft of the wheelhouse; Bottom right: Ship's wheel and gears.

3.3.5.2 Modified Fishing Vessel or Seismographic Vessel

Another possibility is that Shipwreck 3 was built as a shrimp trawler, but it was subsequently converted to a vessel for offshore oil exploration. During the second and third quarters of the twentieth century, it was common for shrimp boats to be modified for service in the oil industry (Austin 2008a:94). They were periodically used for seismic surveys, offshore supply, and transfer of personnel. In this scenario, the net on Shipwreck 3 would be intrusive, snagged post sinking.

There is insufficient diagnostic evidence to categorically identify Shipwreck 3 as a shrimp boat modified for oil exploration or seismic survey. Towing gear on the deck, such as a reel for cables, might have indicated seismic use, but there was none observed. ROV footage does show posts that may have collapsed onto the deck, and possibly used for towing, but again this is not definitive evidence.

3.3.5.3 Offshore Supply Vessel

Shipwreck 3 has features that are similar to early OSVs. The *Ebb Tide*, built in 1956, is commonly considered one of the first OSVs (Figure 43). It is very similar to Shipwreck 3, with its low freeboard, long working deck aft, and single-story wheelhouse forward. Shipwreck 3 also has two bollards on the starboard side, one adjacent to the aft end of the wheelhouse and one close to the stern (Figure 44). These are also characteristic of OSVs (USA National Transportation Safety Board 2013). It is also possible that Shipwreck 3 had mud tanks and that the remains of them are partially visible aft of the deckhouse, in the area originally identified as a deck hatch.

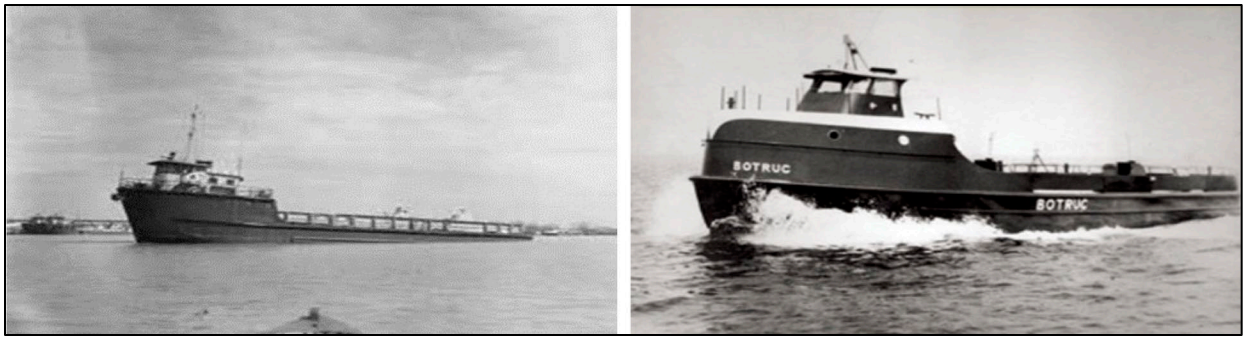


Figure 43. Early offshore survey vessels.
Ebb Tide (1956) left from USCG, Outer Continental Shelf National Center of Expertise https://www.dco.uscg.mil/OCSNCOE/Support-Vessels/Regulatory-History/; *BoTruc* (1956) right from botruc.com https://www.botruc.com/tradition.html



Figure 44. Bollards on Shipwreck 3.
Left: Aft bollard; Right: Forward bollard.

The location of Shipwreck 3 increases the likelihood of it being an OSV. Starting in the mid-twentieth century, Morgan City was one of main hubs supporting the oil industry in Louisiana. It was known for building offshore oil rigs and supplying vessels (Gramling and Hagelman 2005:124).

3.3.5.4 Candidates for Shipwreck 3

Establishing the identity for Shipwreck 3 is not straightforward. It was made more complicated by poor quality video data during ROV operations. The team searched BOEMs submerged cultural resource database and the Global Maritime Wrecks Database for all wrecks within 20 nautical miles of Shipwreck 3. The BOEM database was most useful. From this, two vessels emerged with reported locations relatively close to Shipwreck 3 and with dimensions and characteristics that are similar to the site. These were both OSVs–*Lady Ada* and *Dino C*–described below.

Because of the scale of maritime activities in the Gulf, and the under reporting of fishing vessels and work boats in official records, the Data Gap team conducted a search of southern Louisiana newspapers for stories of fishing vessel, seismic vessel, and OSV losses from the years 1950–1980. The newspapers consulted included - *The Daily Review*; *Morgan City Review; Crawley Post Signal; Shreveport Journal; Daily World; Daily Advertiser; Lake Charles American Press; Bastrop Daily Enterprise, Monroe News Star;* and *The Town Talk.* The results of this work are presented in Table 7.

Table 7a. Possible Vessel Identities for Shipwreck 3: Fishing Vessels

Name of Vessel	Date of Sinking	Comments
Northsea	Oct. 8, 1948	65-foot shrimp trawler sunk off Louisiana, crew brought into Morgan City
G. Mo. Marconi	Mar. 4, 1959	Sprang a leak and sank 2.5 miles south of Eugene Island Light
Philomene	Mar. 5, 1959	72-foot vessel collided with barge.
Longhorn	Mar. 16, 1960	65-foot vessel, 100 miles southwest of New Orleans
Cathy & Barney	Sep. 16, 1963	57-foot shrimp boat, 50 miles south of Morgan City
Courageous	Feb. 3, 1964	Shrimp trawler sunk off in the vicinity of Eugene Island
Betty J	Oct. 30, 1967	Sunk 45 miles off Louisiana coast.
Friendship	Aug. 27, 1970	Shrimp boat burned 90 miles southwest of Morgan City
Coral City	Dec., 1972	Possibly sunk offshore south of New Orleans
Sandy Point	Jun. 26, 1985	165-foot vessel struck obstruction south of Cameron. One man died.

Table 7b. Possible Vessel Identities for Shipwreck 3: Seismographic Vessels

Name of Vessel	Date of Sinking	Comments
Beck II	Sep. 5, 1967	Exploded 60 miles southwest of Morgan City. 9000 lbs of explosives on board.

Table 7c. Possible Vessel Identities for Shipwreck 3: Offshore Survey Vessels

Name of Vessel	Date of Sinking	Comments
Dahlia	Feb. 17, 1952	Cabin cruiser leased to Magnolia Petroleum Co. as crew boat.
Fearless	Mar. 8, 1961	Sunk Eugene Island Block 141
Diversity	Jan. 23, 1963	120-foot "oil exploration boat" capsized in rough seas
Offshore	Dec. 14, 1963	Sunk in West Cameron Block 181
Cleo C	May 11, 1977	Sunk 73 miles south of Morgan City.
Lady Ada	1978	90 foot. Sunk while tied to platform
Dino C	Feb. 5, 1979	90 foot. Swamped. 60 miles south of Morgan City.

Historical, database, and archaeological research has revealed two OSVs that closely match Shipwreck 3 in terms of reported location, size, and features. These are *Lady Ada* and *Dino C*.

3.3.5.4 *Lady Ada*

Lady Ada, official number 297146, was a steel-hulled OSV built in New Orleans in 1964 and owned by Abdon Callais. The ship, registered as an oil exploration vessel, was 86.8 feet in length, 24 feet in the beam and had a 9.6 foot draft. Side scan sonar data of Shipwreck 3 indicate a shipwreck that was 87–90 feet in length and 23–24 feet in the beam; a close match to *Lady Ada*. The reported location of *Lady Ada*'s loss is 3.72 nm from Shipwreck 3, but the accuracy of the historic reported location is unknown. According to the BOEM shipwreck database and a C&C Technologies report, *Lady Ada* "sank while tied

to a platform in 1978" (C&C Technologies 2015). This information may be inaccurate: *Lady Ada* was still listed in *Merchant Vessels of the United States* in 1978, 1979 and 1981, although it was absent in the next version of the publication which did not come out until 1989 (United States Department of Transportation, United States Coast Guard, 1978, 1979, 1980, 1981, 1989). There are no references in *Merchant Vessels of the United States* to *Lady Ada* being lost, including in the years 1978 to 1981. In 1981, *Lady Ada* was listed as owned by Callais, Abdon Boat Rental Inc. (United States Department of Transportation, United States Coast Guard Vol 2 1981). The closest platform to Shipwreck 3 was Black Elk "A," but this could not have been the platform that *Lady Ada* was tied to when it supposedly sunk in 1978, since the platform was not installed until 1983. Black Elk "A" was 0.8 nm from Shipwreck 3. Research using historical regional newspapers failed to provide any references to *Lady Ada*, either in service or sinking. Neither did the National Archives in Washington, D.C. nor Fort Worth, Texas have official consolidated vessel documentation files for *Lady Ada*. The ship was not listed in Lloyds Register of Shipping.

Abdon Callais was born in 1908 and died in 1973. He was married to Ada Bruce Callais, and presumably *Lady Ada* was named after his wife. Abdon's sons, Ronald and Harold, followed their father into the family fishing and offshore supply boat business. Abdon Callais started supporting offshore oil and gas in 1948, when he converted a shrimp boat into an OSV (Austin 2008b:152–155). In 1965, Callais' business was registered in Golden Meadow, Louisiana, on Bayou Lafourche. He had two ships, *Lady Ada* and *David Charles*. After Abdon Callais passed away, *Lady Ada* was registered to Callais Abdon Boat Rental Inc based in Houma, Louisiana (United States Treasure Department, Bureau of Customs 1964, 1965, 1979). At the time, the company had three ships: *Lady Ada*, *Abdon J. Callais* and *O. P. Callais* (United States Department of Transportation, United States Coast Guard 1973, 1974).

Abdon Callais came from a family of boat builders and marine operators. His brothers, Fornest, Weber, Joseph, and Harris, as well as his sisters, Inez, Pearl, and Velma, were all involved in fishing and marine services. Abdon's brother, Weber, was particularly well established in maritime trades and petroleum industries in the Gulf. Weber Callais was friends with Edison Chouest and helped him break into the oil industry supply vessel business. Like many of the early oil and gas industry support service pioneers, the Callais family started as shrimpers. Later they operated in multiple maritime sectors in the Gulf, including boatbuilding, transportation, and supply. Abdon, like his siblings, often worked for oil companies at the end of shrimp season. The Callais family were suspicious of maritime regulations and Coast Guard inspections. This may explain the absence of official records for the *Lady Ada* (Austin 2008a:90–94; Austin 2008b:152–154).

3.3.5.5 *Dino C*

Dino C, official number 269027, was a steel hulled OSV built by Burton Construction and Shipbuilding in Port Arthur, TX in 1955. Originally named *Tilman J*, it was registered as an oil exploration vessel. Its owner, Tilman J. Falgout, worked out of Galveston, Texas. The vessel's 880 hp engine plant was built by General Motors in Detroit, Michigan and supplied by Stewart & Stevenson Services Inc of Houston, Texas. At the time of its loss on February 5, 1979, *Dino C* was owned by Offshore Painting Contractors, Ltd., out of Houma. Louisiana. *Dino C* was 95 feet in length, 25 feet the beam, and had a 10.4 foot draft (U.S. Coast Guard 1955; U.S. Coast Guard 1971). Side scan sonar data of Shipwreck 3 indicates a shipwreck 87–90 feet in length and 23–24 feet in the beam; a close match to *Dino C* and well within the margin of error. Side scan data also shows features on the work deck that may match *Dino C*. The reported location of *Dino C*'s loss is 6.0 nm east northeast of Shipwreck 3. The accuracy of this location is unknown.

The mid-1950s were a time of innovation in OSVs. *Ebb Tide*, often considered the first OSV, was launched in 1956, but it was not alone. There were a series of other early innovative OSVs built around the same time including *Cliffe Tide* (1955), *Rip Tide* (1955), *Tilman J* (1955), and *BoTruc* (1956)

(Rusman and Westerwal 2020:106). *Tilman J,* launched in 1955, created quite a stir. Answering the call for "larger, more seaworthy craft to service offshore oil well drilling operations, which [were] constantly moving farther and farther out to sea," the vessel was considered cutting edge in terms of its speed, versatility, endurance, and power plant (Diesel Progress 1955) (Figure 45). *Tilman J* was fitted with twin screw tandem 6-110 diesel engines. Each shaft was driven by two engines which meant that "in the event of a shutdown of one of the two engines in a tandem unit, the vessel [could] continue operation without loss of speed on three engines" (Offshore 1955c:25–27). To increase range and endurance, the vessel could operate economically on a single engine using one shaft (Offshore 1955c:25–27). Many of the vessel's features match Shipwreck 3. *Tilman J* was 95' long vessel, with steel construction, a similar alignment of port windows, a long working deck aft, and bollards at the aft end of the wheelhouse and close to the stern (Offshore 1955c:25–27).

In 1963, Tidewater Louisiana, Inc. purchased *Tilman J* for oceanographic research, and renamed it *Hugh Tide* (United States Treasury Department, Bureau of Customs 1965; U.S. Coast Guard 1971). It spent several years working in the Pacific participating in significant oceanographic projects. In 1964, *Hugh Tide* was used to host oceanographic research missions for Jacque Cousteau's submersible known as *Soucoupe* (*Diving Saucer)* (Figure 45). These missions originated from research interests of the Underseas Division of Westinghouse Electric Corporation, which had transitioned from building underwater torpedoes to small submersibles for ocean exploration in the early 1960s. Westinghouse reached out to the Office of French Undersea Research (OFUR), directed by Captain Cousteau, for assistance in designing a submersible. Cousteau already had success with *Soucoupe* and was willing to assist Westinghouse with building a similar vessel. In the meantime, Westinghouse brought *Soucoupe* over to the U.S. and used it to peak interest and expose American scientists to the value of submersibles for underwater human exploration. Their contract involved the U.S. Navy, and they used the Military Air Transport Service (MATS) to fly the saucer from France to America (Shenton 1968:57–62). In 1964, MATS transported *Soucoupe* to America and American oceanographers based at Scripps were given research access for a month. Fifty-seven dives were completed. The research was so successful that plans were made for the *Diving Saucer* to return in 1965 (Shenton 1968:23–26). F. P. Shepard et al.'s 1964 article "Submarine Geology by Diving Saucer," published in *Science*, is one of the foundational studies of submarine canyons (Shepard et al. 1964).



Figure 45. Historic images of *Dino C.*
Left image is *Tilman J* from (Offshore 1955c); Right image is *Hugh Tide* from Charlie Dean Archives, Diving Saucer | Cousteau - 1965 Oceanographic Research, https://www.youtube.com/watch?v=ZfbDy5ykyls&t=607s

In his book, *Exploring the Ocean Depths: The Story of the Cousteau Diving Saucer in the Pacific*, Edward Shenton describes the way the vessel *Hugh Tide* supported operations. He also describes the vessel as having features that are similar to those of Shipwreck 3. *Hugh Tide* had a forward wheelhouse

that extended to midship, and an aft cargo hatch and long working deck. Shenton also noted that *Hugh Tide* was originally designed as a workboat but was well appointed for oceanographic purposes. Workspace was somewhat limited, but sufficient to carry out oceanographic missions. The submersible was stored on the center of the deck and was lowered into the water with a crane. The crew kept anything that was not suited for deck storage–such as batteries, chargers, and scuba gear–below in the cargo space that was accessed through a deck hatch. The bridge did not offer much storage space, either, so the team kept other equipment in the lower cabin (Shenton 1968:62–63).

In 1971, Edison Chouest purchased *Hugh Tide* and renamed it *Dino C*, presumably after his grandson Dino Chouest (Lloyds Register 1978). The company, E & G Chouest Marine Service Inc. based in Houma, LA was still in its infancy. The officers were Edison Chouest, Mrs Delores Chouest, and Edison's son Gary Chouest (U.S. Coast Guard 1971). Edison and Gary were both listed as masters of the vessel. Edison Chouest was a pioneer in offshore oil and gas exploration and an important figure in the history of the industry. *Dino C* played an integral part in the development of the company. In August 1978, Edison Chouest sold *Dino C* to Offshore Painting Contractors Inc, out of Houma LA. The company's president, William A. Patrick, took out a $50,000 mortgage to pay for the vessel but did not change its name. *Dino C* sank in heavy seas around 11 pm on February 5, 1979, in the Eugene Island area of the Gulf (U.S. Coast Guard 1971). The ship sprang a leak, the Coast Guard dropped pumps for the crew to try and keep the vessel afloat, but with 7–9 foot seas and 35-knot winds they were unsuccessful. All nine crew members survived the sinking (*The Shreveport Journal* 1979).

3.3.6 National Register Eligibility

If Shipwreck 3 is confirmed as *Dino C*, it is potentially eligible for nomination to the NRHP once it becomes 50 years old. The vessel is largely intact, satisfying the requirement for historical integrity, and can be nominated under Criteria A, C, and D. If the wreck is the *Lady Ada*, the shipwreck is less likely to be eligible for nomination to the NRHP. Absolute identification of the vessel is currently unavailable.

3.4 Shipwreck 4

The team was unable to obtain video documentation useful for historical or archaeological studies of Wreck 4. Based on the acoustic imaging, the vessel is likely modern.

4 Results: Biology

The series of shipwrecks and hardbottom sites are presented in Table 8. Shipwreck 1 is *C. P. Baker* and Shipwreck 2 is *M/V Hamlet*.

Table 8. Shipwreck and hardbottom sites surveyed in the mesophotic zone.

Working name	Description	Dimensions (m)	Depth (m)	Paired with…
Shipwreck 1	*C. P. Baker*, early drilling rig, sank 1960s	102 x 55 x 5.5	58	Hardbottom 1
Shipwreck 3	Unidentified modern OSV or shrimp trawler	27 x 7.0 x 3.3	42	Hardbottom 1
Hardbottom 1	Low-lying boulder reef	145 x 58.5 x 1	51	Shipwrecks 1, 3
Shipwreck 2	M/V *Hamlet*, Norwegian freighter, sank WWII	152 x 21 x 4.0	60	Hardbottom 2
Hardbottom 2	High turbidity reef with boulders and consolidated mud	81 x 57 x 1	50	Shipwreck 2

Working name	Description	Dimensions (m)	Depth (m)	Paired with…
Shipwreck 4	Small unidentified hull	18 x 5.8 x 4.3	79	Hardbottom 4
Hardbottom 4	Low-lying boulder reef	19 x 46 x 1	76	Shipwreck 4

4.1 Shipwreck 1: *C. P. Baker*

4.1.1 Fish

The fish community around the shipwreck *C. P. Baker* was mostly characterized by semi-demersal, reef-associated species. Red snapper (*Lutjanus campechanus*) was the most abundant species and occurred on the upper part of the shipwreck, in the water column above and around the pontoons. Other species observed above and around the pontoons included greater amberjack (*Seriola dumerili*), Atlantic creolefish (*Cephalopholis furcifer*), Atlantic spadefish (*Chaetodipterus faber*), gag grouper (*Mycteroperca microlepis*), and gray triggerfish (*Balistes capriscus*). A sandbar shark (*Carcharhinus plumbeus*) was observed swimming in the water column above the shipwreck. Coral heads on the outer slopes of the pontoons were surrounded by small reef fish, including purple reeffish (*Chromis scotti*) and regal demoiselle (*Neopomacentrus cyanomos*). Between the pontoons were other small reef fish, including spotfin hogfish (*Bodianus pulchellus*) and goldface toby (*Canthigaster jamestyleri*). *C. P. Baker* hosted two non-native fish species: regal demoiselle (*Neopomacentrus cyanomos*) and lionfish (*Pterois volitans*) (Figure 46).

4.1.2 Invertebrates

C. P. Baker was characterized by a number of sessile invertebrate species. The most common species was the non-native orange cup coral (*Tubastrea coccinea*), which occurred primarily on the scaffolding between the pontoons. A black coral (*Antipathes* sp.) and a wire coral (*Stichopathes luetkeni*) were very common on the scaffolding and on the pontoons. Other cnidarians on *C. P. Baker* included the colorful sea rod (*Diodogorgia nodulifera*) and a soft coral (*Telesto* sp.). Two calcifying corals were observed on *C. P. Baker*, the delicate ivory brush coral (*Oculina tenella*) and a cup coral (*Phyllangia americana*). Two unidentified encrusting sponges were common on the inner sides of the pontoons, while the upper surfaces of both pontoons were covered in masses of unidentified hydroids and numerous bearded fireworms (*Hermodice carunculata*) (Figure 47).

4.1.3 Zooplankton

The most abundant species found in zooplankton samples collected above *C. P. Baker* was the larva of a spaghetti worm (*Loimia medusa*). Larvae of the marked goby (*Ctenogobius stimpsoni*) and several crustaceans were also found. These included blue crabs (*Callinectes* sp.), the thinarm clutch crab (*Ebalia stimpsoni*), the eastern tube crab (*Polyonyx gibbesi*), and an unidentified zoea (DNA sequence did not match to any sequence in public databases) (Figure 48).

4.2 Shipwreck 3

4.2.1 Fish

The most abundant fish species around the unidentified OSV or shrimp trawler were red snapper (*Lutjanus campechanus*) and Atlantic spadefish (*Chaetodipterus faber*), which swam in dense groups in the water column above the shipwreck. Closer to the shipwreck itself were tomtate (*Haemulon aurolineatum*) and whitespotted soapfish (*Rypticus maculatus*). Goldface toby (*Canthigaster jamestyleri*), gray triggerfish (*Balistes capriscus*), and gray angelfish (*Pomacanthus arcuatus*), were found around

Shipwreck 3. Two species of drum, black drum (*Pogonias cromis*) and highhat (*Pareques acuminatus*) occurred in small numbers (Figure 46).

4.2.2 Invertebrates

The most common invertebrate species on shipwreck 3 was the non-native orange cup coral (*Tubastrea coccinea*). This species occurred throughout the shipwreck, particularly on the sides of the hull and on entangled fishing gear. A white encrusting sponge and masses of unidentified hydroids were very common on the shipwreck surface. Soft corals (*Telesto* sp.), colorful sea rods (*Diodogorgia nodulifera*) and delicate ivory brush corals (*Oculina tenella*) occurred on some areas of the shipwreck, particularly on the edges of surfaces. For example, a rectangular hole in the side of the hull was surrounded by *O. tenella*, and a *D. nodulifera* colony grew into the negative space. A colony of *O. tenella* was observed on the helm of the shipwreck. Bearded fireworms (*Hermodice carunculata*) were very common on shipwreck 3, presumably feeding on the sessile cnidarians that inhabit the shipwreck surface (Figure 47).

4.2.3 Zooplankton

Similar to *C. P. Baker*, zooplankton samples from Shipwreck 3 had numerous spaghetti worm larvae (*Loimia medusa*). Blue crab larvae (*Callinectes* sp.) were also common. Several snail larvae (Gastropoda) and mantis shrimp larvae (Stomatopoda) were also found above Shipwreck 3 (Figure 48).

4.3 Hardbottom 1: Paired with Shipwreck 1 (*C. P. Baker*) & Shipwreck 3

4.3.1 Fish

The most abundant fishes inhabiting Hardbottom 1 were greater amberjack (*Seriola dumerili*) and red snapper (*Lutjanus campechanus*). Gag grouper (*Mycteroperca microlepis*) were also very common in the waters above and around Hardbottom 1. Several other species of reef fish were observed near the hard structures at this site, including spotfin hogfish (*Bodianus pulchellus*), gray triggerfish (*Balistes capriscus*), and goldface toby (*Canthigaster jamestyleri*). Juvenile damselfish (*Stegastes* sp.) were very common at Hardbottom 1 (Figure 46).

4.3.2 Invertebrates

Hardbottom 1 was densely populated by sessile species. White, orange, and red encrusting morphotypes, presumably all sponges, were very common on the boulders at this site. Two different black corals, the feather black coral (*Plumapathes pennacea*) and the bushy black coral (*Antipathes* sp.), were also very common. Hydroids, bryozoans, and crustose coralline algae formed a matrix of turf across most of the boulders. The branching tube sponge (*Aiolochroia crassa*) occurred in some areas of the site (Figure 47).

4.4 Shipwreck 2: M/V *Hamlet*

4.4.1 Fish

The fish community around M/V *Hamlet* was largely dominated by reef fishes, especially the regal demoiselle (*Neopomacentrus cyanomos*). This non-native species was observed around coral heads and in complex habitats provided by the shipwreck. Other common reef fish species around M/V *Hamlet* were goldface toby (*Canthigaster jamestyleri*) and purple reeffish (*Chromis scotti*). A number of juvenile grunts (*Haemulon* sp.) were observed around the shipwreck. Red snapper (*Lutjanus campechanus*) and tomtate (*Haemulon aurolineatum*) swam in the waters around the top of M/V *Hamlet* (Figure 46).

4.4.2 Invertebrates

By far the most common invertebrates on M/V *Hamlet* were hydroids, which formed a turf across much of the surface of the shipwreck. The delicate ivory brush coral (*Oculina tenella*) formed discrete coral heads on the barrel of the deck gun, the base of the deck gun, and other spots on the upward-facing portion of the shipwreck. Bushy black corals (*Antipathes* sp.) were common on much of the shipwreck surface. Cup corals (*Phyllangia americana*) dotted the vertical surfaces of the shipwreck, particularly on the sides. M/V *Hamlet*'s interior and overhanging surfaces were dominated by orange cup corals (*Tubastrea coccinea*), which are not native to the Gulf. Bearded fireworms (*Hermodice carunculata*) were very common on M/V *Hamlet* and presumably fed on the abundant cnidarians (Figure 47).

4.4.3 Zooplankton

The most common larvae collected in zooplankton samples above M/V *Hamlet* were larval blue crabs (*Callinectes* sp.). Small numbers of mantis shrimp larvae (Stomatopoda), spaghetti worm larvae (*Loimia medusa*), and marked goby larvae (*Ctenogobius stigmaticus*) (Figure 48).

4.5 Hardbottom 2: Paired with Shipwreck 2 (M/V *Hamlet*)

4.5.1 Fish

The fish community at Hardbottom 2 was very sparse. There were only three individuals observed during the ROV dive: a goldface toby (*Canthigaster jamestyleri*), a red snapper (*Lutjanus campechanus*), and a whitespotted soapfish (*Rypticus maculatus*) (Figure 46).

4.5.2 Invertebrates

Hardbottom 2 was low-lying, with hard substrata consisting largely of small boulders and consolidated mud. The water during the ROV dive was extremely turbid. Therefore, the visibility of invertebrates was limited. The community largely consisted of hydroids and cup corals (*Phyllangia americana*), which colonized the sides of boulders. A few hard corals were observed: the eight-ray finger coral (*Madracis formosa*) and the delicate ivory bush coral (*Oculina tenella*). Bearded fireworms (*Hermodice carunculata*) also occurred in small numbers.

4.6 Shipwreck 4

4.6.1 Fish

Shipwreck 4 was quite small and had a sparse fish community. One goldface toby (*Canthigaster jamestyleri*) and one red snapper (*Lutjanus campechanus*) were observed. The most abundant species was the pigfish (*Orthopristis chrysoptera*), with four individuals (Figure 46).

4.6.2 Invertebrates

Shipwreck 4 was sparsely colonized by invertebrates. Hydroids were the most common taxon and primarily lived on the upper edge of the hull. Orange and white encrusting morphotypes, presumably sponges, were also observed on the shipwreck surface (Figure 47).

4.6.3 Zooplankton

All zooplankton individuals collected in the waters above Shipwreck 4 were crustacean larvae. The most common species was blue crabs (*Callinectes* sp.), followed by mantis shrimp (*Stomatopoda*). A larva of the thinarm clutch crab (*Ebalia stimpsoni*) and an unidentified zoea were also observed (Figure 48).

4.7 Hardbottom 4: Paired with Shipwreck 4

4.7.1 Fish

A community of structure-associated fish species was observed around Hardbottom 4. The most common species was the pigfish (*Orthopristis chrysoptera*), followed by red snapper (*Lutjanus campechanus*). Tomtate (*Haemulon aurolineatum*) and gag grouper (*Mycteroperca microlepis*) were common around Hardbottom 4. Yellowtail reeffish (*Chromis enchrysura*) and the non-native lionfish (*Pterois volitans*) were also observed (Figure 46).

4.7.2 Invertebrates

The angular boulders of Hardbottom 4 were primarily colonized by low-lying crustose coralline algae, an orange encrusting morphotype, and hydroids. Two types of corals, the delicate ivory brush coral (*Oculina tenella*) and the lace coral (*Stylaster roseus*), added complexity to the habitat by contributing 3-dimensional structures to the sides of boulders. Wire corals (*Stichopathes luetkeni*) spiraled away from the stones. Hardbottom 4 is the only site where feather stars (*Davidaster rubiginosus*) were observed (Figure 47).

4.8 Comparisons among Sites

Species richness was highest for Hardbottom 1, Shipwreck 1 (*C. P. Baker*), and Shipwreck 2 (M/V *Hamlet*). These three sites consistently had the highest species richness for fish and invertebrates, and Shipwreck 2 (M/V *Hamlet*) had the highest species richness for zooplankton. The lowest species richness for fish, invertebrates, and zooplankton occurred at Shipwreck 4 (Figure 50).

Non-metric multidimensional scaling shows the differences in the species composition between the sites (Figure 49). For the fish, a cluster of points indicates very similar species composition for Hardbottom 1, Shipwreck 1 (*C. P. Baker*), and Shipwreck 2 (M/V *Hamlet*) and Shipwreck 3. The other sites had much more unique species composition and did not cluster together. For the invertebrates, Shipwrecks 1, 2, and 3 again clustered together, indicating very similar species composition. Hardbottom 1 was very similar to Hardbottom 4, and the other two sites showed more unique species composition. For the zooplankton, all four shipwreck sites had distinct species composition and did not cluster together.

The similarities in community composition reflect differences in habitat size and proximity. Shipwreck 1 (*C. P. Baker*) and Shipwreck 2 (M/V *Hamlet*) were the largest sites included in this study, and Shipwreck 3 also had some vertical relief. Hardbottom 1 was located in close proximity to Shipwreck 1 (*C. P. Baker*) and Shipwreck 3. On larger sites with high vertical relief, larger semi-demersal fishes, such as red snapper and greater amberjack can use the habitat for shelter and enhanced foraging opportunities. Vertical structures also provide refuges for suspension-feeding invertebrates, providing them access to more particulate food sources in the water column. The clustering among Shipwreck 1 (*C. P. Baker*), Shipwreck 2 (M/V *Hamlet*), and Shipwreck 3 likely reflects these dynamics, while Hardbottom 1 may have had similar fish composition based on proximity to Shipwreck 1 (*C. P. Baker*) and Shipwreck 3. Variations in zooplankton community composition indicate that there is only a weak connection between species that live on a benthic habitat and the species dispersing in the water column above.

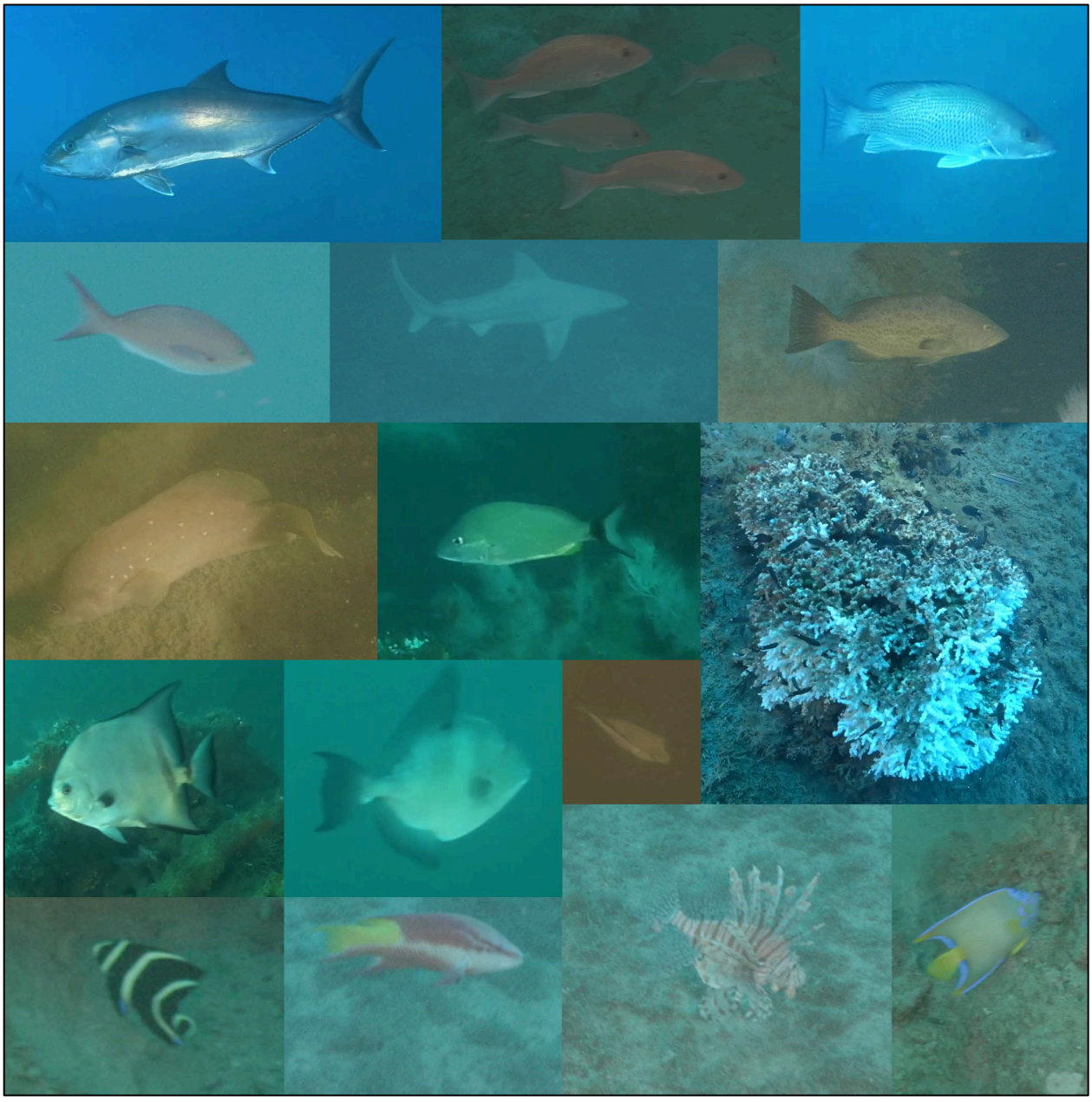


Figure 46. Fish in the mesophotic zone.
Top row left, greater amberjack *Seriola dumerili*; top row middle, red snapper *Lutjanus campechanus*; top row right, grey snapper *Lutjanus griseus*; second row left, Atlantic creolefish *Cephalopholis furcifer*; second row middle, sandbar shark *Carcharhinus plumbeus*; second row right, gag grouper *Mycteroperca microlepis*; third row left, whitespotted soapfish *Rypticus maculatus*; third row middle, tomtate *Haemulon aurolineatum*; third row right, regal demoiselle *Neopomacentrus cyanomos*; fourth row left, Atlantic spadefish *Chaetodipterus faber*; fourth row middle, gray triggerfish *Balistes capriscus*; fourth row right, goldface toby *Canthigaster jamestyleri*; bottom left, gray angelfish juvenile *Pomacanthus arcuatus*; bottom second from left, spotfin hogfish *Bodianus pulchellus*; bottom second from right, lionfish *Pterois volitans*; bottom right, queen angelfish *Holacanthus ciliaris*. Panels are not to scale.

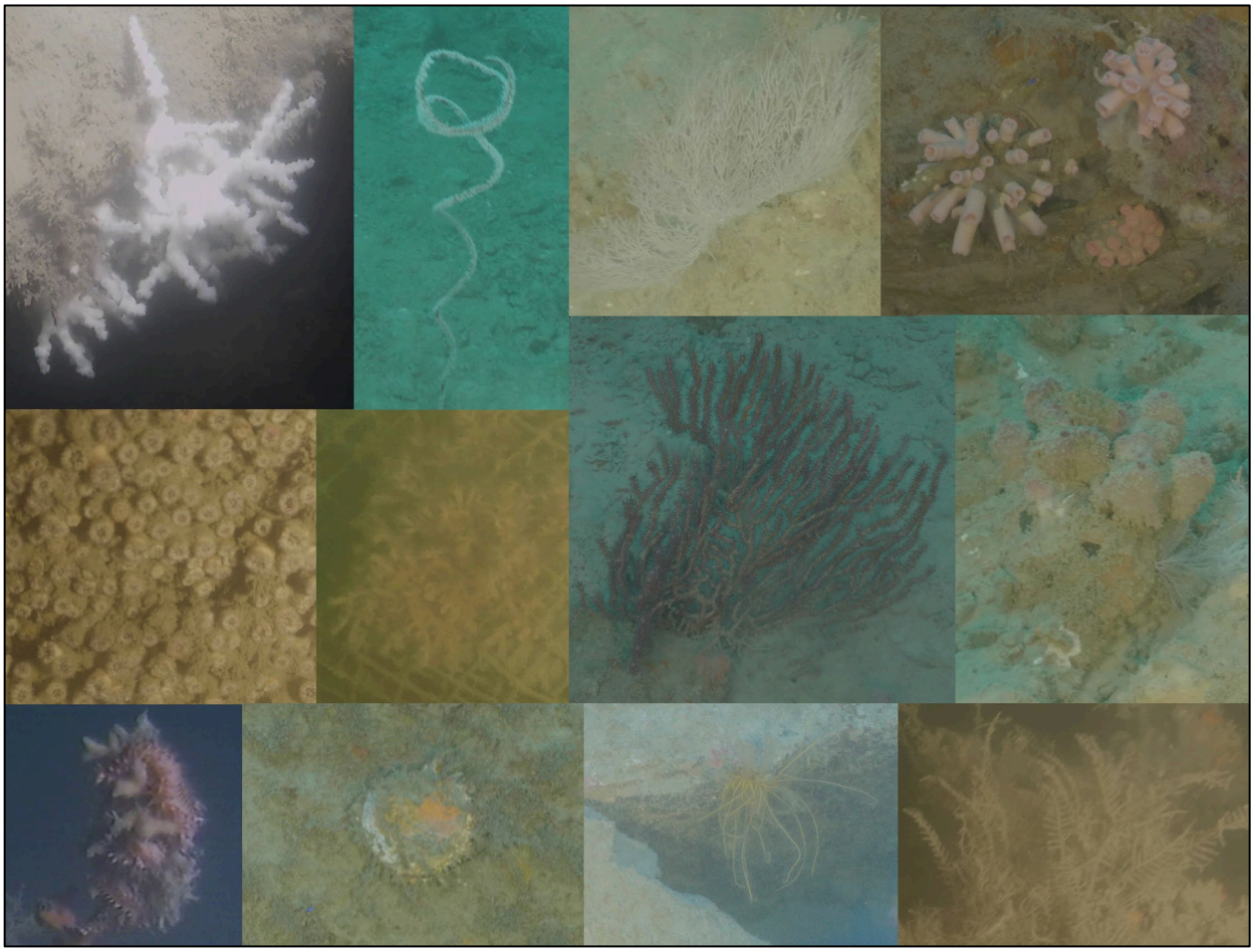


Figure 47. Invertebrates in the mesophotic zone.
Top row left, delicate ivory bush coral *Oculina tenella*; top row second from left, wire coral *Stichopathes luetkeni*; top row second from right, black coral *Antipathes* sp.; top row right, orange cup coral *Tubastrea coccinea*; middle row left, cup coral *Phyllangia americana*; middle row second from left, soft coral *Telesto* sp.; middle row second from right, colorful sea rod *Diodogorgia nodulifera*; middle row right, branching tube sponge *Aiolochroia crassa*; bottom row left, bearded fireworm *Hermodice carunculata*; bottom row second from left, thorny oyster *Spondylus americanus*; bottom row second from right, feather star *Davidaster rubiginosus*; bottom row right, unidentified hydroids. Panels are not to scale.

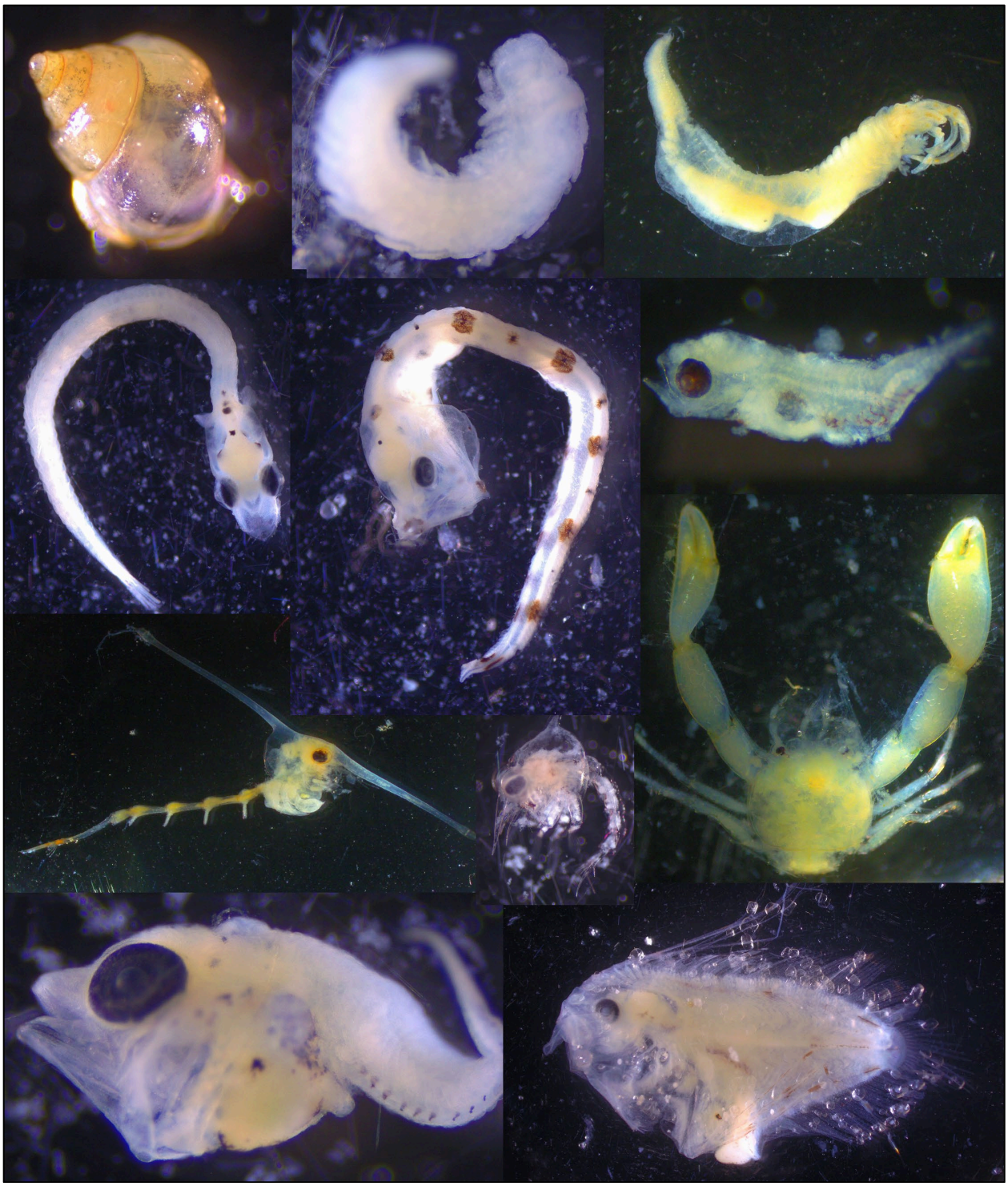


Figure 48. Zooplankton collected above mesophotic.
Top row left, snail larva Gastropoda sp.; top row middle, palolo worm Typhloscolecidae sp.; top row right, spaghetti worm *Loimia medusa*; second row left and middle, unidentified fish larvae; second row right, marked goby *Ctenogobius stigmaticus*; third row left, unidentified zoea; third row middle, blue crab zoea *Callinectes* sp.; third row right, eastern tube crab megalopa *Polyonyx gibbesi*; bottom row, unidentified fish larvae. Panels are not to scale.

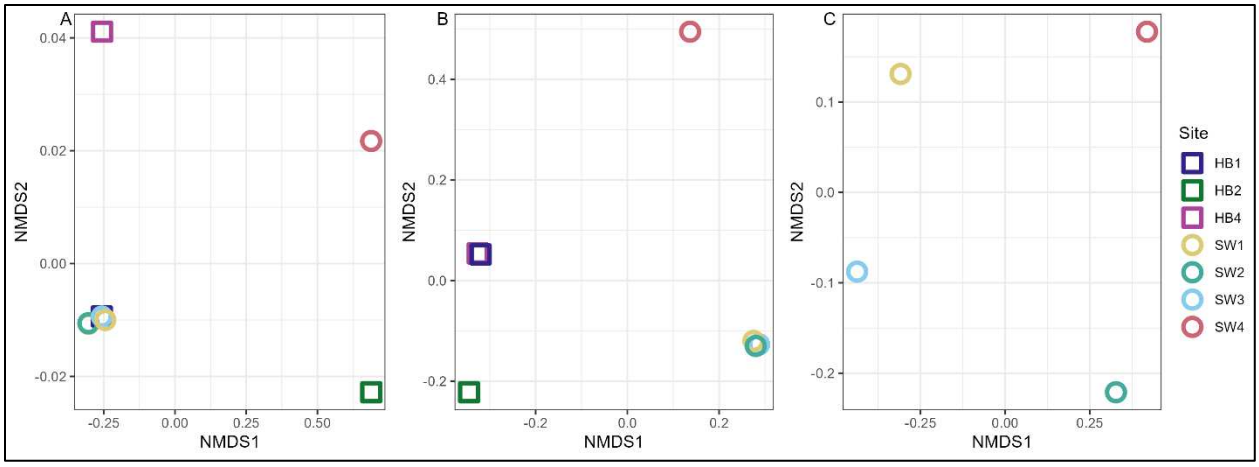


Figure 49. Non-metric multidimensional scaling plots showing differences in species composition between sites.
Left plot (A), fish; center plot (B), invertebrates; right plot (C), zooplankton.
Note: SW1 and SW2 are *C. P. Baker* and M/V *Hamlet* respectively.

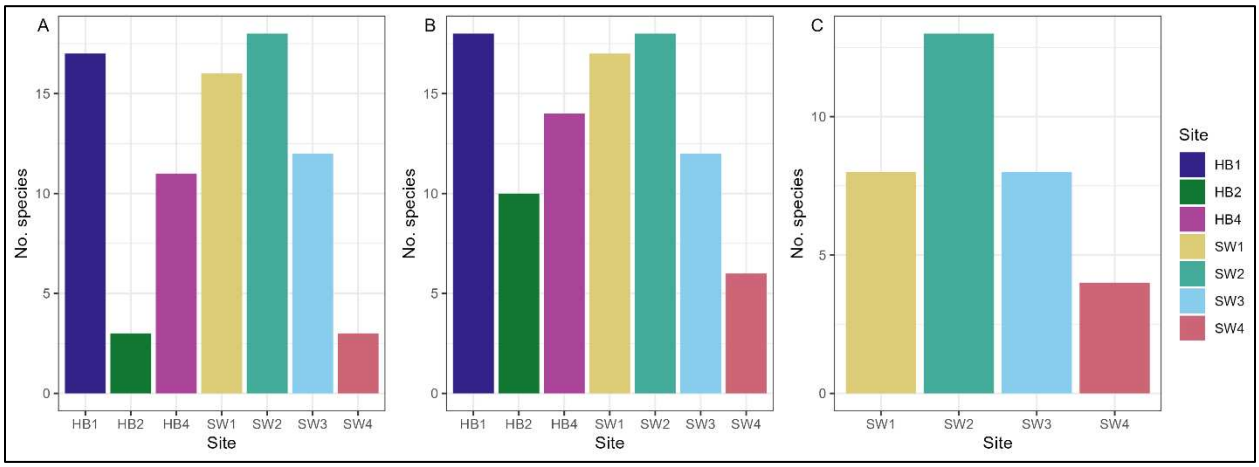


Figure 50. Species richness observed at each site.
Left graph (A), fish; center graph (B), invertebrates; right graph (C), zooplankton.
Note: SW1 and SW2 are *C. P. Baker* and M/V *Hamlet* respectively.

Table 9. Fish at each surveyed site in the mesophotic zone.

SW, shipwreck; HB, hardbottom. X indicates presence of a given species at a given site.

Common name	Scientific name	SW1	SW3	HB1	SW2	HB2	SW4	HB4
Reef butterflyfish	*Chaetodon sedentarius*	X	-	X	X	-	-	-
Gray angelfish (adult)	*Pomacanthus arcuatus*	X	X	-	X	-	-	-
Gray angelfish (juvenile)	*Pomacanthus arcuatus*	-	-	X	X	-	-	-
Queen angelfish	*Holacanthus ciliaris*	-	-	X	X	-	-	-
Greater amberjack	*Seriola dumerili*	X	-	X	X	-	-	X
Atlantic spadefish	*Chaetodipterus faber*	X	X	-	X	-	-	-
Grunt (juvenile)	*Haemulon* sp.	X	-	-	X	-	-	-
Tomtate	*Haemulon aurolineatum*	X	X	-	X	-	-	X
Pigfish	*Orthopristis chrysoptera*	-	-	-	-	-	X	X
Red snapper	*Lutjanus campechanus*	X	X	X	X	X	X	X
Grey snapper	*Lutjanus griseus*	-	X	-	X	-	-	-
Damselfish (juvenile)	*Stegastes* sp.	-	-	X	X	-	-	-
Beaugregory	*Stegastes leucostictus*	-	-	X	-	-	-	-
Purple reeffish	*Chromis scotti*	X	-	X	X	-	-	-
Yellowtail reeffish	*Chromis enchrysura*	-	-	-	-	-	-	X
Regal demoiselle	*Neopomacentrus cyanomos*	X	-	X	X	-	-	-
Grouper	Epinephelidae	-	-	-	-	-	-	X
Gag grouper	*Mycteroperca microlepis*	X	-	X	X	-	-	X
Rock hind (juvenile)	*Epinephelus adscensionis*	-	-	X	-	-	-	-
Atlantic creolefish	*Cephalopholis furcifer*	X	-	-	-	-	-	-
Whitespotted soapfish	*Rypticus maculatus*	-	X	-	X	X	-	-
Striped parrotfish (juve.)	*Scarus iseri*	-	-	X	-	-	-	X
Spotfin hogfish	*Bodianus pulchellus*	X	X	X	-	-	-	-
Bigeye	*Priacanthus arenatus*	-	-	-	-	-	-	X
Goby	Gobiidae	-	X	-	-	-	-	-
Lionfish	*Pterois volitans*	X	-	-	X	-	-	X
Goldface toby	*Canthigaster jamestyleri*	X	X	X	X	X	X	-
Gray triggerfish	*Balistes capriscus*	X	X	X	X	-	-	-
Black drum	*Pogonias cromis*	-	X	X	-	-	-	-
Highhat	*Pareques acuminatus*	-	X	X	-	-	-	X
Sandbar shark	*Carcharhinus plumbeus*	X	-	-	-	-	-	-

Note: SW1 and SW2 are *C. P. Baker* and M/V *Hamlet* respectively.

Table 10. Invertebrates at each surveyed site in the mesophotic zone.

SW, shipwreck; HB, hardbottom. X indicates presence of a given species at a given site.

Common name	Scientific name	SW1	SW3	HB1	SW2	HB2	SW4	HB4
Crustose coralline algae	-	X	-	X	X	-	-	X
White encrusting sponge	-	X	X	X	X	-	X	X
Orange encrusting sponge	-	X	X	X	X	X	X	X
Citron sponge	*Agelas citrina*	X	-	X	-	-	-	X
Red encrusting sponge	-	X	-	X	X	X	X	X
Purple encrusting sponge	-	-	X	X	X	-	-	-
Branching tube sponge	*Aiolochroia crassa*	X	-	X	X	-	-	-
Rope sponge	*Ptilocaulis* sp.	-	-	X	-	-	-	-
Vase sponge	*Callyspongia* sp.	-	-	X	-	-	-	-
Lace coral	*Stylaster roseus*	-	-	-	-	-	-	X
Hydroids	Hydroidea	X	X	X	X	X	X	X
Soft coral	*Telesto* sp.	X	X	-	X	-	-	-
Colorful sea rod	*Diodogorgia nodulifera*	X	X	-	X	-	-	-
Eight-ray finger coral	*Madracis formosa*	-	-	-	-	X	-	-
Delicate ivory bush coral	*Oculina tenella*	X	X	-	X	X	X	X
Scoly coral	*Scolymia* sp.	-	-	-	-	-	-	X
Cup coral	*Phyllangia americana*	X	-	-	X	X	-	X
Orange cup coral	*Tubastrea coccinea*	X	X	X	X	X	X	-
Feather black coral	*Plumapathes pennacea*	-	-	X	X	-	-	-
Bushy black coral	*Antipathes* sp.	X	X	X	X	-	-	X
Wire coral	*Stichopathes luetkeni*	X	X	X	X	X	-	X
Thorny oyster	*Spondylus americanus*	X	-	-	-	-	-	-
Bryozoan	Bryozoa	-	-	X	-	-	-	-
Bearded fireworm	*Hermodice carunculata*	X	X	X	X	X	-	-
Christmas tree worm	*Spirobranchus giganteus*	-	X	X	-	-	-	-
Arrow crab	*Stenorhynchus seticornis*	-	-	-	X	-	-	-
Long-spined sea urchin	*Diadema antillarum*	-	-	-	X	-	-	X
Feather star	*Davidaster rubiginosus*	-	-	-	-	-	-	X
Giant tunicate	*Polycarpa spongiabilis*	X	-	-	-	X	-	-

Note: SW1 and SW2 are *C. P. Baker* and M/V *Hamlet* respectively.

Table 11. Zooplankton found at each site.

SW, shipwreck. X indicates presence of a given species at a given site.

Common name	Scientific name	SW1	SW3	SW2	SW4
Blue crab	*Callinectes* sp.	X	X	X	X
Thinarm clutch crab	*Ebalia stimpsoni*	X	X	X	X
Unidentified zoea	-	X	-	-	X
Eastern tube crab	*Polyonyx gibbesi*	X	-	-	-
Mantis shrimp	Stomatopoda	X	X	X	X
Spaghetti worm	*Loimia medusa*	X	X	X	-
Palolo worm	Typhloscolecidae	-	X	X	-
Clam larva	Bivalvia	-	-	X	-
Snail larva	Gastropoda	-	X	X	-
Hairbelly	*Tetranchyroderma* sp.	X	-	X	-
Marked goby	*Ctenogobius stigmaticus*	X	X	X	-
Pipefish	Sygnathidae	-	X	-	-
Unidentified fish larva	-	-	-	X	-
Unidentified fish larva	-	-	-	X	-
Unidentified fish larva	-	-	-	X	-
Unidentified fish larva	-	-	-	X	-

Note: SW1 and SW2 are *C. P. Baker* and M/V *Hamlet* respectively.

5 Education and Outreach

The Data Gap team considered several options for education and outreach as part of the fieldwork and overall study. URI's Inner Space Center led these efforts. In late 2021 and early 2022, when the R/V *Hogarth* was the presumed research cruise platform, ISC director Dwight Coleman made several site visits to the vessel's homeport in Tampa, Florida. His purpose was to assess the possibility of broadcasting live during the cruise and establishing telepresence. This represented a major effort and undertaking. He made considerable headway in discussions about VSAT, Inmarsat and 4G connectivity, but the team had to switch their approach when the *Hogarth* became unavailable for the cruise. Telepresence was not possible on board the replacement vessel, *Sea Scout*.

The new education and outreach plan comprised two interconnected elements.

- Video: Production of an educational video for distribution post cruise
- Classroom Connection Events: Educational programming and Q&A sessions via planned zoom calls with grade schools in the Gulf Coast, South and Northeast.

URI ISC led both the education video and programming efforts. Patrick Flanagan was in charge of filming and interviews with project personnel at sea, post cruise video production, and hosting the Classroom Connection Events. Holly Morin organized the Classroom Connection Events.

5.1 Video Production

Wrecks of the Semi-Deep: Mysteries of the Mesophotic, is a 6-minute, 22-second long video introduction to the project (Figure 51). Its format, style, and music are aimed at a middle school through high school science class audience, and it is also suitable for younger students and audiences outside education. The video features all the main project personnel, including scientists from BOEM. It explains the concept of the mesophotic zone, the reasons why we study both archaeology and biology, the new information the project was gathering on wrecks in the mesophotic zone, and the technology used to obtain data. The video articulates the reasons why BOEM needs to better understand archaeology and biology in the mesophotic zone. It is available on YouTube and via the URI Inner Space Center. It can also be made available via BOEM's website. https://youtu.be/GRDGyurQUs4?si=ac2vRJPl6c6RzUI8

5.2 Classroom Connection Events

Aiming for middle- and high school audiences, URI ISC organized a series of four Classroom Connection Events, titled *Wrecks of the Semi-Deep*. The sessions led with the questions "What mysteries lie in the ocean's 'mesophotic zone'?" and "Why haven't we explored it more?"

Teachers were recruited for the sessions, provided information packs ahead of the sessions, and managed the Zoom calls. All sessions were free and required registration. Students and teachers engaged with project scientists, archaeologists, and engineers and learned more about the project's discoveries. Registrants were also given advanced access to the *Wrecks of the Semi-Deep* video. Each session was hosted by Patrick Flannigan and three project personnel. Project personnel taking part included Rod Mather, Kirstin Meyer-Kaiser, Scott Sorset, Doug Jones, Evan Kovacs and Calvin Mires. The team responded to questions from the host, students and teachers. Participants also posted questions in a chat forum and were encouraged to ask questions via email after the presentation. Connection was established using StreamYard.

The sessions were:

- Wednesday, November 9, 2022 at 12pm ET/11am CT
- Thursday November 10, 2022 at 11am ET/10am CT
- Tuesday, November 15, 2022 at 10am ET/9am CT
- Wednesday, November 16, 2022 at 12pm ET/11am CT

The programs were highly successful. The programming reached at least 1,000 students in at least 25 classes. Some schools and classes signed on at the last minute. Below is a partial list of participants and students.

- Minuteman Technical High School, Lexington, MA, 20 students (9th–10th grade), environmental science and technology
- Whitin Intermediate School, Uxbridge, MA, 22 students (4th grade), STEM
- Lexington Public schools, Lexington, MA, 1 middle school student (probably homeschooled), engineering
- Coventry High School, Coventry, RI, 20 students (10th–12th grades), forensic investigations class
- New Century Technology High School, Huntsville, AL, 20 students (10th–12th grades), immunology
- Waterview Learning Academy, Hampstead, NC, 4 students (10th grade), marine science
- Davisville Middle School, North Kingstown, RI, 71 students (entire 7th grade) general science
- Baker High School, Mobile, AL, 27 students (11th grade), marine science
- New England Science & Sailing Foundation, Stonington, CT 12 students (8–10th grade), marine engineering / on the water experience
- Andover High School, Andover, MA, 26 students (11–12th grade), marine science
- Lakewood High School, Marysville, WA, 27 students (11–12th grade), oceanography/marine biology.
- Ben C. Rain High School, Mobile, AL, 26 students (11–12th grade) marine science
- Moss Point Career & Technical Education Center, Moss Point, MS, 12 students (9–12th grade), engineering
- Wickford Middle School, North Kingstown, RI, 22 students (7th grade) geology
- Tohickon Middle School, Doylestown, PA, 22 students (8th grade) gifted class
- Norton Middle School, Norton, MA, 93 students (entire 6th grade) general science
- Hahnville High School, Boutte, LA, 28 students (9th grade) biology
- Boynton Beach, FL, 1 homeschool student
- Norfolk Agricultural High School Walpole, MA, 8 students (12th grade) marine ecology
- Baker High School, Mobile, AL, 28 students (11th grade), marine science
- Denton Magnet School of Technology, Mobile, AL, 46 students (6–8th grades), civics
- University of Southern Mississippi, Ocean Springs, MS, unknown number of students (grades unknown), underwater robotics/STEM group
- Moss Point Career & Technical Education Center., Moss Point, MS, 2 students (9–12th grades), engineering
- Chariho Middle School, Wood River Junction, RI, 68 students (entire 6th grade) science

ISC experts consider the participation, breadth of outreach, and results to have been "excellent." In some cases, student asked follow-up questions which the team answered in a Google Doc and via email. For example, students from Coventry High School, Coventry, Rhode Island asked: 1): Do shipwrecks decay over time? How does this impact your research? 2) How long does it take to investigate one shipwreck? 3) What are the best schools for marine biology? 4) How far would someone travel to contribute to research? 5) What are some of the types of animals that you see at shipwrecks? 6) If shipwrecks are providing an ecosystem, isn't that a good thing? Would introduction of more ship-like structures on the

seafloor be beneficial? 7) From a biological standpoint, as divers, have you seen the effects of climate change on the coral reef/ocean ecosystems?



Figure 51. Image from video "Wrecks of the Semi-Deep."

5.3 Information Transfer Meeting

Rod Mather and Kirstin Meyer-Kaiser each presented papers on the Data Gap project at BOEM's Information Transfer Meeting (ITM) in September 2022. Both presentations were virtual.

Mather's paper, "Characterizing Shipwrecks and Biological Communities in the Mesophotic Zone, Gulf of Mexico," was presented on Tuesday September 13, 2022. Meyer-Kaiser's paper, "Data Gap: Characterizing the Biological Communities on Shipwrecks and Hard-bottom Reefs in the Mesophotic Zone," was presented on Wednesday September 14, 2022

6 Discussion and Conclusion

At least two, and possibly three of the five shipwrecks investigated in this study are potentially eligible for nomination to the National Register of Historic Places. Although the study was biased in favor of historically significant shipwrecks, it is clear that the mesophotic zone off the Gulf of America contains a rich repository of submerged cultural resources that require protection and research. BOEM was correct in its assessment that the mesophotic requires additional study.

C. P. Baker and M/V *Hamlet* are both eligible for nomination to the National Register. Shipwreck 3 may also be eligible, a finding that was unexpected at the start of this work.

Investigations into *C. P. Baker* and Shipwreck 3 suggest that an increasing number of historic resources tied to early oil and gas exploration in the Gulf will become eligible for nomination to the National Register of Historic places in the coming decades. BOEM should expect and anticipate specific elements of the historic Gulf oil and gas infrastructure and cultural landscape, including platforms, shipwrecks, and helicopters, to require additional study and avoidance.

We hypothesized that the community composition of fish and invertebrates at our study sites in the mesophotic zone would be primarily driven by dispersal. Based on this, we expected to see two clear patterns: 1) similar species composition between paired shipwreck and hardbottom sites and different species composition between pairs, 2) more variable communities on shipwrecks compared to hardbottoms.

Each shipwreck was paired with a hardbottom site in close proximity. The only case of strong similarity in species composition between a hardbottom and its paired shipwreck was for fish at Hardbottom 1 and Shipwreck 1 (*C. P. Baker*) and Shipwreck 3. A clustering was also observed for Shipwreck 1 (*C. P. Baker*) and Shipwreck 3 for the invertebrate community, but the species composition was distinct from Hardbottom 1. No other pairs showed a clear similarity between the shipwreck and hardbottom species composition. Thus, our expected pattern of similar species composition for shipwreck-hardbottom pairs was not observed.

Communities on shipwrecks were not more variable than natural hardbottom reefs. Shipwreck 1 (*C. P. Baker*), Shipwreck 2 (M/V *Hamlet*), and Shipwreck 3 had very similar fish and invertebrate communities, as shown in the nMDS plot (Figure 49), whereas the hardbottom sites had more variable species composition. Because neither of our expected patterns was supported, we conclude that the communities on shipwrecks and hardbottom sites in the mesophotic zone are not driven primarily by dispersal. Because of the number of anthropogenic hardbottom structures in the Gulf, habitats may not be separated by large enough distances for dispersal to be limiting.

It was very interesting that none of the species collected in zooplankton samples above the shipwreck sites were observed as juveniles or adults on the shipwrecks. Because zooplankton samples were collected in the upper 30 m of the water column, the specimens in the samples may reflect broader dispersal patterns in surface waters, rather than distributions of shipwreck species. Further research into larval dynamics in the Gulf could help illuminate these patterns.

A more important factor structuring shipwreck and hardbottom communities in the mesophotic zone may be environmental stressors. Several of the ROV dives were characterized by low visibility and high turbidity of the water column. At the depths surveyed, light attenuation from the surface would preclude the existence of reef-building corals that rely on photosynthetic symbionts. In fact, the most common coral species observed, *Oculina tenella*, lives facultatively with or without symbionts. This species is thus

adapted to thrive in low-light environments. Other invertebrates, including sponges and hydroids, do not rely on symbiosis.

The size of a site may have an influence on what species can thrive. Shipwrecks 1 (*C. P. Baker*) and 2 (M/V *Hamlet*) are large, complex structures that provide solid habitats elevated off of the seafloor. Both of these shipwrecks had higher species richness than Shipwreck 3 and Shipwreck 4 (Figure 50). Elevation above the seafloor is advantageous for suspension feeding, and suspension-feeding invertebrates are often observed on the upper portions of large shipwrecks. Larger shipwrecks also provide more habitat for structure-oriented fishes, including semi-demersal species that swim above and around hard structures. The best example of this was Shipwreck 1 (*C. P. Baker*), which had dense swarms of red snapper (*Lutjanus campechanus*) and greater amberjack (*Seriola dumerili*).

Shipwrecks support unique biological communities that do not always match the species composition of surrounding natural hardbottom habitats. The unique structures and microhabitats provided by shipwrecks promote biodiversity. Of the shipwrecks surveyed here, *C. P. Baker* and M/V *Hamlet* have the most value for biodiversity. They provide substrata elevated above the seafloor (e.g., *C. P. Baker*'s pontoons) and protected interior spaces (e.g. M/V *Hamlet*'s interior). Furthermore, sites with similar size, intactness, and complexity should be protected because these shipwrecks support biodiversity in the mesophotic zone.

The anthropogenic threats to submerged cultural resources in the mesophotic zone may be slightly different from the threats in shallow water and deep water. While pressures on shallow water sites include looting, diver visitation, oil and gas infrastructure installation, and coastal development, and the threats in deep water may come largely from deep sea energy extraction, the most significant threats to historic properties in the Gulf mesophotic zone are:

- Lack of understanding and data related to the resources
- Accidental damage to sites from commercial fishing

This study documented considerable damage from fishing gear to both M/V *Hamlet* and Shipwreck 3. These wreck locations are less well known than the location of *C. P. Baker*, which appears to have experienced fewer anthropogenic impacts and damage from fishing gear than M/V *Hamlet* and Shipwreck 3. It seems likely that when fishers have better understanding of snags and hazards associated with submerged cultural resources, they are better able to avoid historic shipwrecks and the damage is limited. A similar pattern of damage was noted in studies of the Billy Mitchell Fleet off Norfolk Canyon, Virginia, and at Stellwagon Bank, Massachusetts (Ross et al. 2018; Meyer-Kaiser et al. 2021). BOEM currently does not reveal site locations. It is possible that a change in policy is warranted for the mesophotic zone. Publishing coordinates for select archaeological sites in the mesophotic zone may decrease damage from fishing gear. It is recommended that BOEM cultural resource specialists conduct or contract a cost benefit analysis of selectively publishing site locations in the mesophotic zone. Trawl damage appears to represent a greater threat to cultural resources than looting in these water depths. There are, of course, downsides to releasing site location information. Increase access to shipwrecks in the mesophotic zone by divers using rebreathers represents an important consideration and greater potential for looting in the future. This is certainly happening at the Billy Mitchell Fleet.

3D orthomosaic modeling in this study was unsuccessful. In part, this was due to a last-minute change in logistics. The study was unable to use the Florida Institute of Oceanography's R/V *W.T. Hogarth*, which had dynamic positioning. Greater control of the ship using dynamic positioning helps with 3D orthomosaic modelling. The team were assured that the vessel would be ready for the cruise, but it remained inoperable for more than a year. MPSV *Sea Scout*, though well appointed, did not have dynamic positioning.

The team was also unable to use the ROV *Pixel*, which had a major electrical malfunction a few days before the research cruise. *Pixel* would have allowed for greater control, higher resolution imaging, and better lighting. The alternative system was a mid-class SeaRover ROV operated by Reliant Robotics. This system did not have the necessary control, image resolution, and lighting for 3D orthomosaic modelling. BOEM should attempt 3D orthomosaic modelling again in the mesophotic zone. Modelling has developed into an essential tool for marine archaeology. Given appropriate equipment, platforms, and protocols, it will be successful. Further 3D orthomosaic modelling efforts should take account of the limitations of this study specifically to do with dynamic positioning, ROV control, image resolution and particularly lighting.

Despite the challenges of equipment and logistics, the research cruise was a substantial success. The team visited four of the five priority shipwrecks and all three of the associated hardbottom habitats. The cruise resulted in 11 ROV dives in five field days. The integration of biological studies and archaeological studies both at sea and in data analysis was likewise successful. The biological studies significantly enhance BOEM's understanding of communities in the mesophotic zone. It appears that shipwrecks and hardbottom habitats with substantial vertical relief have higher levels of species richness. The team has already submitted a paper to the Marine Ecology Progress Series that reports on the biological findings of the project.

Overall, the project revealed that large, intact shipwrecks with high vertical relief are the most valuable structures for biodiversity in the mesophotic zone. Sites such as Shipwreck 1 (*C. P. Baker*) and Shipwreck 2 (M/V *Hamlet*) in this study host high species richness and support critical taxa, such as reef-building corals and large pelagic fishes. Smaller sites, such as Shipwreck 4 and low-lying boulder reefs, have more variable communities and lower species richness. There does not appear to be a strong connection between species dispersing as larvae in the water column and those living on hardbottom habitats on the seafloor below. Based on these findings, it is very important to preserve large, intact shipwrecks such as Shipwreck 1 (*C. P. Baker*) and Shipwreck 2 (M/V *Hamlet*). The physical structure of the shipwreck itself and the waters immediately surrounding it (within tens of meters) should be protected from disturbance.

Historical and archival research significantly contributed to the project. In addition to published primary sources and historic newspapers, the team consulted records at the National Archives in Washington D.C, the National Archives in Fort Worth, Texas, and online archival sources in the U.K. and Norway. This study delineated the history and significance of *C. P. Baker* and M/V *Hamlet* and will result in the preparation of National Register of Historic Places nominations for both ships. Enhanced historical and archaeological understandings generated new information that will improve protection of both sites. Historical research into Shipwreck 3 also proved to be fruitful and may yet produce a National Register of Historic Places nomination.

The authors anticipate three peer-reviewed historical and archaeological papers and one biological paper (in press) resulting from this project. The historical and/or archaeological papers will be: one on *C. P. Baker*, one on M/V *Hamlet*, and one on Shipwreck 3. The latter will require additional work.

Graduate student training, education and outreach was a major success for the project. ISC produced a high-quality video and successful Classroom Connection Events. The programming reached least 1000 students in more than 25 classes. Two URI graduate students gained valuable experience as part of the project. One worked on the history, archaeology, and national register nomination for *C. P. Baker*; and a second worked on the history and archaeological identification of Shipwreck 3. Both graduate students have their names on this report and will be authors in subsequent publications.

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