OCS Study
MMS 2007-015

Archaeological and Biological Analysis of World War II Shipwrecks in the Gulf of Mexico

Artificial Reef Effect in Deep Water

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MMS U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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Archaeological and Biological Analysis of World War II Shipwrecks in the Gulf of Mexico

Artificial Reef Effect in Deep Water

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ABOUT THE COVER

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PROJECT OVERVIEW

1.0 INTRODUCTION

During World War II German U-boats wreaked havoc on merchant shipping along the American Coast. The Gulf of Mexico contains one of the greatest concentrations of Allied vessels lost to German U-boats worldwide. These casualties include oil tankers, cargo vessels, passenger ships, and fishing boats. The significant role played by these vessels and their crews during an important period in American and World history, paired with their presence on the seafloor for over 50 years makes them eligible for inclusion in the National Register of Historic Places. In addition, a Presidential Proclamation signed January 19, 2001, states that "the United States will use its authority to protect and preserve sunken state craft of the United States and other nations, whether they are located in the waters of the United States, a foreign nation, or in international waters" (Bush 2001). Since many of these vessels carried U.S. Navy gun crews and were chartered by the United States government to transport oil and fuel for the war effort, many are likely to be considered "state craft." At present, the remains of eighteen (18) such vessels and the only known German U-boat sunk in the Gulf, *U-166*, have been identified in Federal waters as a result of the United States Department of the Interior, Minerals Management Service (MMS) required oil industry surveys. Taken together, these sites represent an underwater battlefield, and a vital historical resource documenting a little studied area in a crucial period in American History. These sites preserve information vital to scholarly and popular understanding of the U-boat war's impact in the Gulf of Mexico, on the American home front, and the global conflict. In addition, these sites represent artificial reefs from well-documented dates of a similar time period thereby offering biologists a unique opportunity to study the "artificial reef effect" of man-made structures in deepwater (USDI MMS 2004).

This multidisciplinary study focuses on the biological and archaeological aspects of seven World War II era shipwrecks in the north-central portion of the Gulf of Mexico. Six of the vessels (*Virginia*, *Halo*, *Gulfpenn*, *Robert E Lee*, and *Alcoa Puritan*) were lost to wartime activity between early April and late July 1942. The seventh vessel, the Steam Yacht *Anona*, was lost to an accident in 1944 after all the U-boats had left the Gulf of Mexico. All seven shipwrecks were discovered during Oil and Gas surveys and reported to the MMS as required by Federal regulations. Water depth at the investigation sites ranges from 87 to 1,964 meters. Each shipwreck was investigated to determine site boundaries, National Register eligibility, preservation state and stability, and the potential for man-made structures or objects to function as artificial reefs in deepwater.

1.1. Project Objectives

1.1.1 Archaeological Objectives

1. Confirm each shipwreck identity and establish its type and date of construction, nationality, ownership (past and present), use history, mission, and cargo at time of loss.
2. Determine each vessel's past and present condition, state of preservation, assess any environmental impact caused by the wreck, and make observations relating to its deterioration and future research potential.
3. Determine the visible extent of the debris fields surrounding each casualty.
4. Analyze imagery and historical documentation to determine nomination eligibility for the National Register of Historic Places.
5. Assess the impacts of bio-fouling communities to these shipwrecks to determine the site's stability.
6. For vessels determined to be eligible for nomination, prepare a National Register nomination form.

1.1.2 Biological Objectives

1. Characterize the environment at each site (e.g. water depth, bottom sediment type, currents, etc.)
2. Determine the biological effects of shipwreck artificial reefs at selected sites, and include detailed imagery surveys of the sites at a variety of scales.
3. Determine the extent of physical and biological modification of sediments in the immediate area of wreck sites compared to sediment conditions at sites distant from wreck areas. Sampling will include sediment coring close to and distant from wrecks to determine any "artificial reef effect."

4. Conduct limited sampling of fauna attached to hard substrate for taxonomic and other potential analyses such as isotope studies.
5. Analyze imagery and sample collection to address spatial heterogeneity of any fouling community and motile fish and invertebrate association with wrecks.

Microbiological

The main focus of the microbiological component of this investigation was the form and level of microbial activities observable through imaging and detection using three different methodologies. On-site experiments were deployed to examine the rates at which ship's metals are compromised by microbial activities and the functional ability of the indigenous microbes to manipulate and impress electrical charges through biofouling. These experiments used both steel test platforms and bio-battery platforms with each being deployed on four wreck sites (*Halo*, *Gulfpenn*, *Robert E Lee*, and *Alcoa Puritan*). Recovered concretion and rusticle samples were the subject of laboratory investigations to determine the microbial loadings and chemical composition. Additionally, laboratory investigations were conducted to determine differences related to depth and potential nutrient loading at the wreck sites. This report includes an interpretation of the on-site observations and subsequent laboratory investigations. A prime interest was the determination of whether there were significant differences between the ships in the form of attached microbiological growths from dendritic concretions (shallower depths) to very mixed growths including aggressive sea anemone populations (deeper depths) to a virtual dominance of rusticles and concretious growths on the deepest ship *Alcoa Puritan*, at 1,964 meters.

Marine Invertebrates

The primary objective of the invertebrate component was quantifying the use of deep-water shipwrecks by macrofaunal invertebrates. Geological or biogenic outcrops of hard substrate are rare in the northern Gulf of Mexico; shipwrecks represent hard substrate and might best be considered as surrogates for artificial reefs. Considering the rarity of hard substrate, the question is whether macroinvertebrate assemblages colonizing shipwrecks will differ from fauna adjacent to the wrecks. Do invertebrate fauna (or their larvae), specialized for attachment and utilization of hard substrates, exist in sufficient quantity to represent distinct faunal assemblages? A related question addressed colonization rates by fauna on hard substrate in the otherwise level bottom, soft habitat. Determining the age of many invertebrates is notoriously difficult because of the lack of retention of structures with ontogeny. Shipwrecks of known age provide a 'natural' experiment to answer questions about colonization rates, growth rates of individuals and community development. Another question concerned the effect of depth on invertebrate diversity and abundance. Is bathymetric zonation evident for species, faunal assemblages, or different life history stages? With these considerations in mind, the objectives of the invertebrate portion of the study were to: 1) compare the composition, species richness, and abundance of macroinvertebrate assemblages associated with the shipwrecks, to the adjacent macroinvertebrate fauna on level bottom sediments away from the shipwrecks; 2) compare differences in composition, species richness, and abundance of macroinvertebrates as a function of bathymetry.

Marine Vertebrates

The goal of the marine vertebrate component of the project was to document the utilization of deep-water shipwrecks as fish habitats. Artificial reefs in shallow (< 100 meters) continental shelf environments have been studied extensively in the last few decades because of their hypothesized positive effect on rebuilding depleted fish stocks by alleviating hardbottom habitat limitation. A growing scientific debate has ensued, however, as to whether artificial reefs in shallow environments produce novel biomass or merely aggregate fishes from surrounding natural habitats (Bohnsack 1989). In the northern Gulf of Mexico, this debate has centered around the ecology of commercially exploited species and the fact that artificial reefs constitute only a small percentage (i.e., < 5%) of the total hardbottom habitat on the shelf (Bohnsack 1989; Bortone 1999; Parker et al. 1983; Patterson et al. 2001a and 2001b; and Patterson et al. 2003). It seems there is greater potential for hardbottom habitat to be limiting to structure-associated fishes in the southeastern U.S. slope rather than shelf environments due to the perceived paucity of hardbottom substrates beyond the upper slope (Gardner et al. 2001; Reed 2002; Sulak et al. 2001). Few data on deepwater hardbottom habitats and their associated fish communities in the northern Gulf of Mexico exist to evaluate the hypothesis that habitat is limiting for structure-associated fishes. Therefore, the objectives of this portion of the study were to 1) examine the community structure of fishes associated with deepwater shipwrecks in the northern Gulf of Mexico; 2) perform gut content analysis to examine trophic structure within the fish community; 3) analyze stable isotopes of carbon and nitrogen in fish tissue to estimate source(s) of carbon to wrecks and corroborate trophic structure inferred from gut content analysis; and, 4) estimate age and growth rates of abundant species via examination of otolith microstructure.

1.2 Geographic Overview

The Gulf of Mexico is a semi-enclosed small ocean basin that formed by Late Triassic to Early Jurassic rifting followed by Late Jurassic to Early Cretaceous seafloor spreading. The Gulf has been receiving sediment influx dominated by the Mississippi River since Late Jurassic. Sediments accumulated along the Gulf of Mexico's northern margin during the Mesozoic and the Cenozoic have attained a thickness in excess of 14.9 kilometers. Rapid deposition along the northern margin of the Gulf of Mexico during the Tertiary and the Quaternary resulted in the accumulation of particularly thick sedimentary sequences and an up to 296 kilometers basinward migration of shelf edge since the Cretaceous at an exceptionally high rate of 4.8 to 5.9 millimeters/year (Coleman et al. 1991).

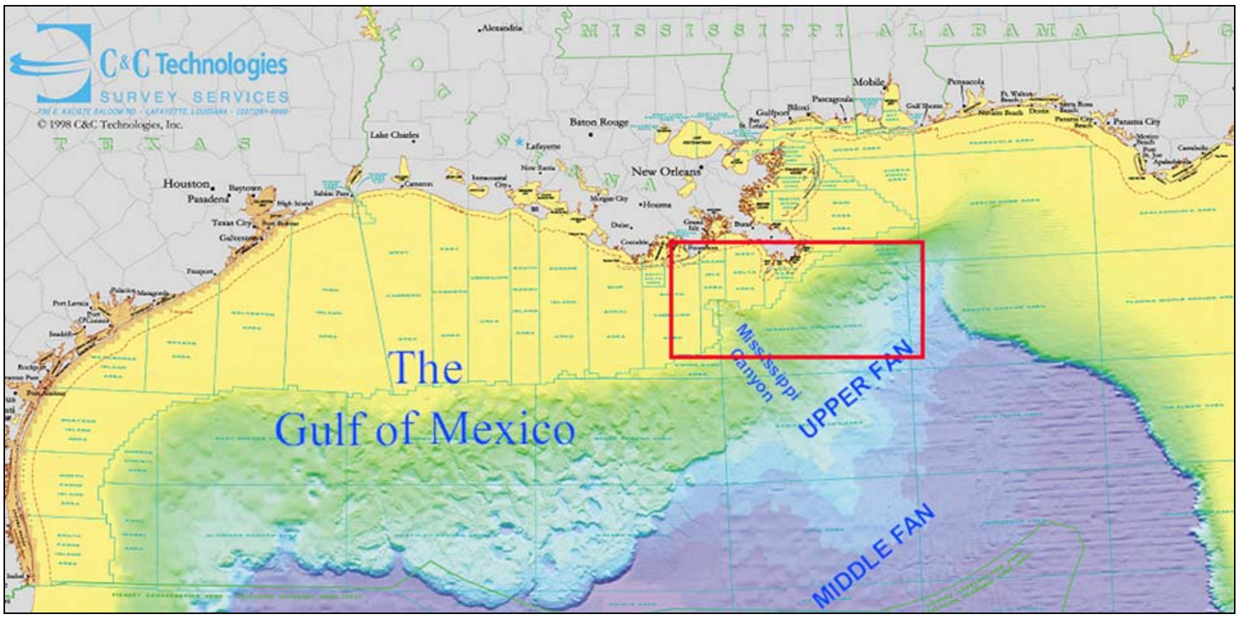


Figure 1.1. Overview Map.

Mississippi Canyon and Fan Region

The Mississippi Canyon is the conduit for source materials moving seaward into the Mississippi Fan. Bouma describes the Mississippi Canyon as a major erosional and partially filled structure. Initial development of this canyon is suggested to have begun about 50,000 to 55,000 years ago in the middle continental slope and retrogressed onto the shelf 25,000 to 27,000 years before present. Retrogressive large scale slumping on an unstable shelf-slope area during a sea level low stand or during the initial sea level rise are believed to have caused the canyon to widen and lengthen further up-shelf. Several other smaller scale canyons create fans by similar processes east and west of the Mississippi Canyon on the shelf-slope area (Bouma et al. 1985).

In the east-central Gulf of Mexico, a large regional, deep-water feature exists that is identified as the Mississippi Fan. This feature was the subject of the Deep Sea Drilling Project Leg 96 in 1983 and was interpreted as a channel-levee-overbank complex. The Fan is approximately 560 kilometers long and up to 600 kilometers wide. It extends southeast from the base of the continental slope at a depth of approximately 300 meters, across the continental rise and onto the abyssal plain, to a point roughly halfway between the Campeche Escarpment and the Florida Escarpment. The Mississippi Fan is bounded by the Texas Louisiana Slope region to the west and the Florida Escarpment to the east. Water depths for the Mississippi Fan range from approximately 300 meters at the base of the slope to 3,200 meters on the abyssal plain. The fan has been described as a broad arcuate submarine fan comprised of a number of fan lobes separated by pelagic oozes or muddy sediment (Bouma et al. 1985).

In 1989, following an examination of the most recently deposited fan lobe Bouma and others suggested a sea-level driven model which effectively divided the Mississippi fan into three sections for descriptive purposes: upper fan, middle fan, and lower fan. The upper Fan has a slightly convex shaped surface with a wide channel at its apex flanked by laterally discontinuous reflectors believed to be overbank deposits. The middle fan holds the greatest accumulation of sediment and is imaged on sonar data as a leveed, sinuous channel complex that averages 1.2 to 2.5 kilometers in width. Less prominent channel complexes that undergo rapid channel abandonment define the lower fan. It can be assumed similar fans have been active during the geologic past in the entire Mississippi Canyon, Atwater Valley, and Lund Areas. Channel deposits consist of fining upward turbidite sequences (gravel to clay size) with the base of the gravel representing the time of the episodic event (Bouma et al. 1989).

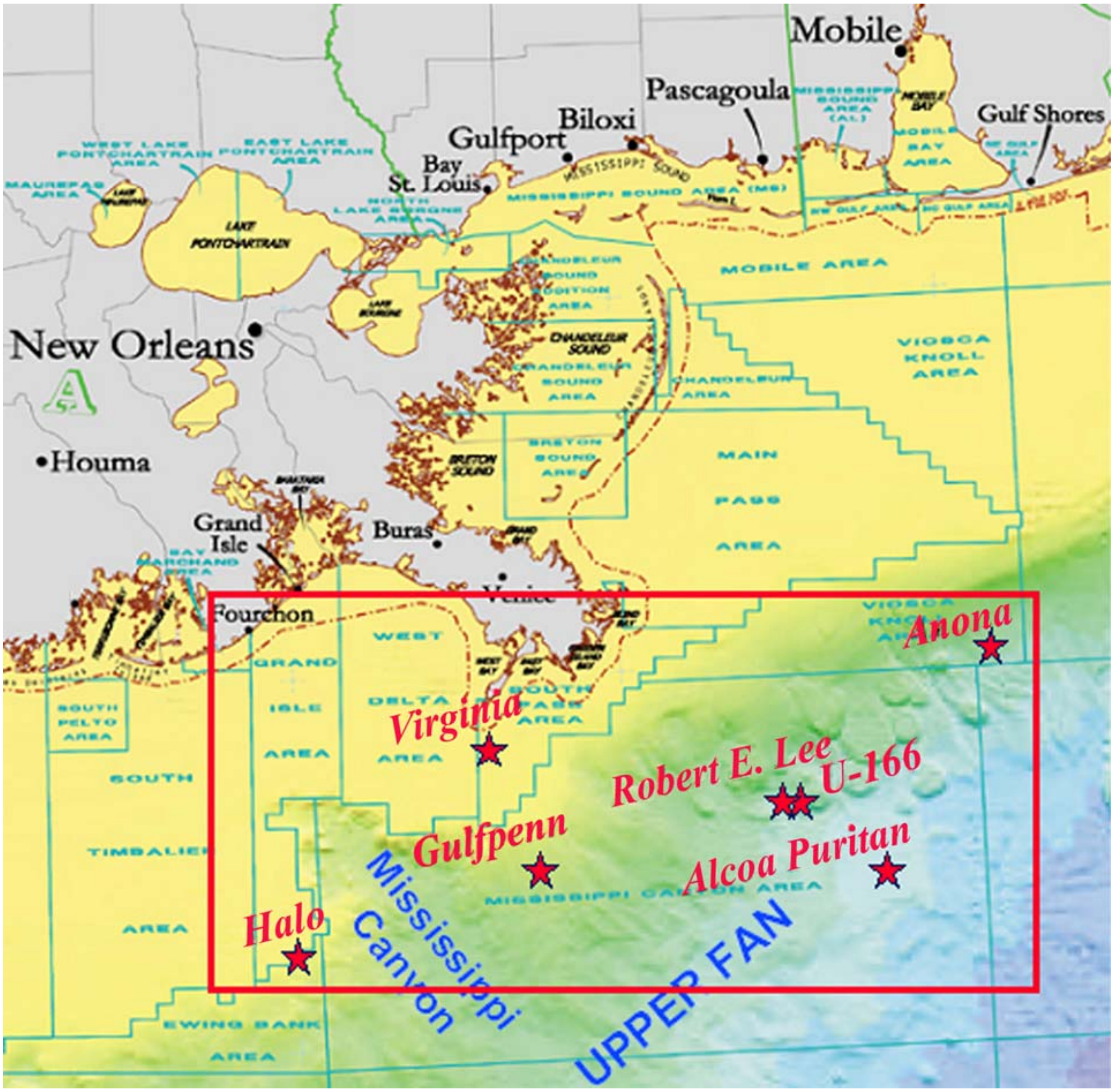


Figure 1.2. Project Area Map.

1.3 Project Organization

The MMS and the National Oceanic and Atmospheric Administration's Office of Ocean Exploration (NOAA OE) organized the study under the auspices of the National Oceanographic Partnership Program (NOPP). C & C

Technologies, Inc. (C & C), the primary contractor for the study oversaw the survey and archaeological analysis. C & C contracted the following organizations and individuals for the biological analysis: Droycon Bioconcepts, Inc. (DBI), William Schroeder with the University of Alabama/Dauphin Island Sea Lab (UA/DISL), University of West Florida (UWF) and University of Alaska, Fairbanks (UAF). C & C contracted the PAST Foundation (PAST) for the educational outreach component of the project. PAST partnered with Montana State University to provide the media team for field operations. C & C made agreements with Texas A&M University and the University of Rhode Island for two PhD candidates in deepwater archaeology and a molecular biologist from The Institute for Genomic Research (TIGR) to participate in the study. The Key Personnel for the project are listed in the following tables.

Table 1.1

Project Principal Investigators.

Personnel	**Title**	**Organization**
Robert Church, MA	Chief Scientist/Marine Archaeologist P.I.	C & C
Daniel Warren, MA	Marine Archaeologist Co-P.I.	C & C
Roy Cullimore, PhD	Microbiologist P.I.	DBI
Lori Johnston, MS	Microbiologist Co-P.I.	DBI
Thomas C. Shirley, PhD	Invertebrate Zoologist P.I.	UAF
William Schroeder, PhD	Invertebrate Zoologist Co-P.I.	UA/DISL
William Patterson, PhD	Vertebrate Zoologist P.I.	UWF
Annalies Corbin, PhD	Education Outreach Director	PAST
Dennis Aig, PhD	Film Producer/Media Coordinator	MSU

Table 1.2

Project Field Personnel.

Personnel	**Title**	**Organization**
Government		
Jack Irion, PhD	Contract officer Technical Representative	MMS
Daniel "Herb" Leedy, MS	Biologist	MMS
Michael Overfield, MA	Cruise Coordinator	NOAA
Ian Zelo	Project Specialist	NOAA
Archaeology		
Robert Church, MA	Chief Scientist/Archaeologist P.I.	C & C
Peter Hitchcock, MA	Archaeology Intern (PhD Candidate)	TAMU
James Moore, MA	Archaeology Intern (PhD Candidate)	URI
Biology		
Lori Johnston, MS	Microbiologist, Field-P.I.	DBI
William Schroeder, PhD	Invertebrate Zoologist Co-P.I.	UA/DISL
William Patterson, PhD	Vertebrate Zoologist P.I.	UWF
Nicole Morris	Vertebrate Zoologist (MS Candidate)	UWF
Aaron Baldwin, MS	Invertebrate Zoologist, Field P.I.	UAF
Morgan Kilgour	Invertebrate Zoologist (MS Candidate)	UAF
Garry Myers, MS	Molecular Biologist	TIGR
Education and film		

Personnel	Title	Organization
Dennis Aig, PhD	Film Producer/Media Coordinator	PAST/Hunter Neil/MSU
Keene Haywood, PhD	Assistant Producer/Film Intern (MFA Candidate)	MSU
Korey Kaczmarek	Sound Mixer/PA	MSU
Lansing Dreamer	Director of Photography	MSU
Survey		
Ryan Larsen	Surveyor (Acoustic Specialist)	C & C
John Petterson	Surveyor (Acoustic Specialist)	C & C
ROV		
Joey Lekovich	ROV Superintendent	Sonsub, Inc.
Mike Stephens	ROV Supervisor	Sonsub, Inc.
Phillip Spearman	ROV Supervisor	Sonsub, Inc.
Chris Talasek	ROV Pilot & Technician	Sonsub, Inc.
Wes Fenner	ROV Pilot & Technician	Sonsub, Inc.
Lucas Cribley	ROV Operator	Sonsub, Inc.
Bryan Whipple	ROV Operator	Sonsub, Inc.

Table 1.3

Other Key Personnel.

Personnel	Title	Organization
Tony George	Geophysicist/Geosciences Manger	C & C
Kimberly Eslinger, MA	Marine Archaeologist	C & C
Bruce Samuel, MS	Marine Geologist	C & C
Lynn Samuel	Marine Geologist	C & C
Charlie Broussard	Cartographer	C & C
Tim Badeaux	Cartographer	C & C
Shelley Smith, PhD	Education Outreach Coordinator	PAST
Dave Ball, MA	Senior Marine Archaeologist	MMS
Chris Horell, PhD	Marine Archaeologist	MMS

2.0 HISTORICAL BACKGROUND

2.1 World War II in the Gulf of Mexico

Three factors have influenced the Gulf of Mexico's role in trade, economic development, and maritime commerce: exploration, warfare, and natural resources. Deep canyons mark the Gulf region's submerged bottomlands. Natural resources around the Gulf of Mexico including cotton, tobacco, and petroleum products have driven the Gulf's economy and shipping since the sixteenth century. Shipping routes follow traditional patterns, and shipwrecks are often found near those trade routes. The Gulf of Mexico is no exception, and shipwrecks from the age of exploration through modern day have been located near traditional shipping lanes (Garrison et al. 1989).

World War I saw an increase in Gulf of Mexico tanker traffic as petroleum products became more important to American industry. The Gulf's maritime community was affected little during the First World War, but World War II was different. During World War II, several German U-boats operated in the Gulf of Mexico using shipping lanes and navigational beacons to locate and torpedo unsuspecting prey (Blair 2000:467, 498).

In 1942, the world was at war and Germany controlled most of Europe. Hitler launched Operation Drumbeat under Admiral Karl Dönitz's command. Using Germany's *Unterseebootes* (U-boats), Operation Drumbeat brought the war to United States coastlines, just as in World War I. The U-boat mission was simple: disrupt Allied supply lines. World War II U-boats struck shipping along the Atlantic coast, and infiltrated the United State's undefended backyard - the Gulf of Mexico. U-boat's specifically targeted tankers carrying valuable petroleum products from the Gulf coast to American refineries and abroad. During the early war years Americans had a false sense of security created by the vast oceans that kept the war at a distance. When U-boats entered the Gulf of Mexico many German commanders noted coastal lights burned as in peacetime.

The spring of 1942 was an opportune time for U-boats in the Gulf of Mexico. The Commander of the Gulf Sea Frontier had not yet ordered mandatory convoys and naval escorts. Likewise, many merchantmen sailing Gulf waters were unarmed and unaware of the U-boat threat. Until July 1942, the Gulf remained a German pond where the U-boats hunted and attacked at will (Blair 2000: 588).

U-507, under Korvettenkapitän Harro Schacht's command, claimed the first vessel sank in Gulf waters on May 4, 1942 when she torpedoed the freighter *Norlindo* off Key West Florida (Wiggins, 1995). *Norlindo*'s sinking unleashed a wave of destruction in the Gulf of Mexico. Korvettenkapitän Harro Schacht's crew aboard *U-507* sank eight vessels in the Gulf of Mexico, making it one of the most successful U-boats in this theater of war. *U-507*'s fourth victim was the cargo freighter, *Alcoa Puritan*. *U-507* also sank the tanker, *Virginia* on May 12 (Schacht 1942: 13, 32, 52). In May 1942, *U-506* joined the Gulf campaign, sinking the tankers, *Gulfpenn* on May 13 and *Halo* on May 20, and six other merchant vessels (Würdemann 1942: 12, 22, 30).

Within twelve months, twenty-four German U-boats entered the Gulf. Seventeen U-boats sent 56 merchant vessels to the bottom and badly damaged 14 others (Church et al. 2002). *U-166*, commanded by Kapitänleutnant Hans-Günther Kühlmann, joined the fray in July. *U-166* took position off the Mississippi River's mouth in operational area DA-90. The U-boat's mission was to lay mines and attack merchant shipping (War Diary 1942: 36, 53, 92; and Blair 2000: 633). Although the nine TMB mines were successfully laid only a few hundred yards off the jetties in the Southwest Pass of the Mississippi River, none detonated. Kühlmann sank the passenger freighter SS *Robert E. Lee* approximately 45 miles southeast of the Mississippi River on July 30, 1942. PC-*566*, the naval vessel escorting the freighter then sank *U-166* (Blair 2000: 633; and USS PC-566 1942). Deep water and conflicting first hand accounts from 1942 hid *U-166*'s actual location for nearly 60 years. Although 75 percent of all U-boats were sunk by the war's end, only one was lost in the Gulf of Mexico, *U-166* (Blair 2000:704).

By July 1942, the United States increased efforts to protect shipping in southern waters. Coastal lights were shut off, lighthouse beacons were dimmed, and strict information blackouts enacted. Aerial reconnaissance and radio listening posts helped American naval and Coast Guard units track the U-boat threat. Merchant vessels were ordered to travel in convoys with naval escorts. These efforts diminished the number of vessels sunk by U-boats by August 1942 and turned the tide of the U-boat threat in American coastal waters. For 56 ships, the American response to German U-boat attacks in the Gulf of Mexico came too late. Hundreds of merchant mariners lost their lives and ships to German torpedoes. Many tankers became floating bombs when torpedoes ignited the petroleum products in the holding tanks leaving the crews either entombed in a fiery hull, or afloat in the blaze. The Gulf of Mexico war zone was a submerged and surface war front for military and non-military vessels alike. The German U-boat freely hunted these waters until late 1942, when American antisubmarine measures improved and helped turn the tide (Blair 2000: 696).

2.2 Oil and Gas Development and Shipwreck Discovery

The oil and gas industry by far supports the largest percentage of commercial marine surveys in the Gulf of Mexico. The increased interest in developing deepwater prospects has also led to significant advances in marine survey technology and equipment such as sophisticated deep-tow survey systems, improved Remote Operated Vehicle (ROV) technology, Autonomous Underwater Vehicles (AUV), and precision acoustic positioning systems. The development and use of these systems has made easier the identification of potentially significant shipwrecks, biological life forms, and geological formations. The increased deepwater oil and gas exploration in the Gulf's deepwater areas has also increased shipwreck discoveries. The shipwrecks investigated for this study were found on oil and gas related surveys and further significant discoveries can be expected as the search for natural resources moves into increasingly deeper waters.

2.3 Regulatory Role of the Minerals Management Service

Increases in deepwater oil and gas exploration, development, and production coexist with the development of new technologies that reduce operational costs and risks and the discovery of high volume oil and gas reserves. Examples of extraordinary solid platforms include the Cognac and Bullwinkle platforms in 311 meters (1,023 feet) and 412 meters (1,353 feet) of water, respectively. The use of subsea completions is rapidly increasing. The number of subsea completions have risen from 4 per year in 1990 to 23 in 2001 with more than half of these occurring in deepwater (>300 meters) (USDI MMS 2004).

Expanding deepwater commercial development brings increasing challenges for managing Submerged Cultural Resources on the Outer Continental Shelf and Slope. The MMS requires a clearer understanding of the size of debris fields that can be expected around deepwater wrecks, as well as their state of preservation and research potential to fulfill obligations stipulated by Section 106 of the National Historic Preservation Act of 1966 (36 CFR 800). This information is critical for determining disturbance avoidance areas. Part 36 CFR 800.4(c) states that "the Agency Official shall make a reasonable and good faith effort to identify historic properties that may be affected by (an) undertaking and gather sufficient information to evaluate the eligibility of these properties for the National Register." Sufficient documentation must be provided to the MMS on each site to carry out an adequate evaluation of National Register of Historic Places (NRHP) criteria (USDI MMS 2004).

The MMS played an instrumental role in the development of the Rigs-to Reefs program in the Gulf of Mexico. The Agency's efforts led to the National Fishing Enhancement Act of 1984 and publication of the National Artificial Reef Plan in 1985. Converting offshore oil and gas structures is well accepted as beneficial to fisheries on the continental shelf of the entire Gulf of Mexico. Forty-nine (49) structures have been converted to artificial reefs from a total of 383 structure removals between 1999 and June 2002. In the near future, decisions will be required for the removal of structures located in waters beyond the continental shelf. Current guidelines outlined in 30 CFR Part 250.1728 allow the MMS Regional Supervisor to approve alternate plans for removal of structures when the water depth is greater than 800 meters (2,624 feet). Removal options for shallower depths have previously relied on the concept that the structure left behind serves a positive fisheries enhancement or other beneficial environmental function. The MMS now needs information that will help describe the ecological role (if any) man-made structures may have in the deepwaters of the Gulf of Mexico (in this case, greater than 91.4 meters (300 feet) (USDI MMS 2004).

3.0 METHODS

3.1 Survey Methodology

Each site was systematically investigated using an acoustically positioned Remote Operated Vehicle (ROV) following a pre-established survey grid (See Section 3.3 Archaeological Methodology). The ROV survey was designed to maximize the efforts and time for both the archaeological and biological studies. It carried the necessary equipment (See Section 3.2) to obtain high quality imagery, accurately measure artifacts and biological organisms, document seafloor conditions or features, and analyze water column attributes (e.g. depth, temperature, pH, salinity, etc.). Detailed visual inspections provided needed data to document each wreck's cultural and biological characteristics. Although different specific elements were of interest to the biologists and the archaeologists, the video footage collected was used for both the biological and archaeological studies undertaken.

A monitoring station was available for all key personnel during each of the comprehensive shipwreck inspections to insure video data was adequate to meet study objectives. A minimum of one archaeologist and one biologist were available at all times to monitor and document the investigations ensuring important features were not missed. Direct communication was available between each scientist and the ROV operators during operations. Video footage was recorded continuously during ROV operations at each site and digital still photographs or screen captures were taken of pertinent archaeological and biological features.

3.1.1 Support Vessel and Remote Operated Vehicle

ROV operations were conducted from Sonsub's vessel M/V HOS *Dominator*. *Dominator* is 72.54 meters in length, 16.46 meters at the beam, and displaces 1,815 gross tons. The vessel is powered by a 4,520 horsepower caterpillar engine with two 800 horsepower bow thrusters and one 800 horsepower stern thruster. There is 752 m^2 of deck space and a 30-ton stern mounted A-frame. The vessel was fitted with three science labs and additional crew quarters to accommodate the project's science personnel.

Triton's XL 2500-meter ROV was utilized for this project. The Triton XL is a 100-horsepower system measuring 3.13 meters long by 1.50 meters wide and 1.84 meters high. It utilizes a bottom enter (top hat) tether management system. It was equipped with multiple cameras forward and aft, a five-function and a seven-function manipulator, and sector scanning sonar. The ROV was also equipped with a variety of other specialized equipment and sensors (See Section 3.2.3 Sampling Equipment).

3.1.2 Marine Survey

Survey control was maintained using the C-Nav globally corrected differential GPS. C-Nav's GPS receiver combines a dual-frequency geodetic grade GPS receiver with an integrated L-BAND communication RF detector and decoder integrated into a microprocessor. Using a series of reference stations around the globe C-Nav provides accuracies on the order of 0.1 meters. The technique, developed by the Jet Propulsion Lab for the National Aeronautics Space Administration, uses a global network of reference stations to track the entire constellation of GPS satellites. The GPS observations are transmitted via the internet to a network control center where the satellite orbital corrections and clock-offset values are calculated and modeled in real-time. These corrections are universally valid and can be applied to GPS measurements from any location on earth (C & C Technologies, Inc. 2005).

Survey personnel tracked the ROV using a Sonardyne, Inc. model 7784 Ultra-Short BaseLine (USBL) acoustic tracking system mounted on a through-hull ram. The system measures a beacon's range and direction relative to the transceiver's known location and orientation. The USBL transducer head contains three or more elements that can both transmit an interrogation and receive the acoustic reply. The elements are positioned in a phased array describing an equilateral triangle in which the separations between each element are known (C & C Technologies, Inc. 2005).

The support vessel's position was established using C-Nav. The ROV's position was acoustically triangulated from the vessel position using the USBL system. Navigation control was processed on a PC using WinFrog integrated navigation software. The ROV's positioning accuracy was calculated at each site using a static accuracy test (only one test was conducted at the *U-166* and *Robert E. Lee* sites because of their proximity and similar water depth). The overall accuracy of the signal was calculated as a percentage of water depth at each shipwreck site and is included in the discussion.

At the *Virginia* site an accuracy test (scatter plot) was conducted in 87.5 meters of water depth. While the ROV hovered stationary, 80 USBL positions were recorded with an average standard deviation of 0.28 meters. The maximum deviation of all recorded positions from the mean position was 1.08 meters. Thus, the survey accuracy at the *Virginia* site is calculated to be between 0.32 percent (.0032) to 1.24 percent (.0124) of water depth (Figure 3.1).

At the *Halo* site an accuracy test (scatter plot) was conducted in 146.3 meters of water depth. While the ROV hovered stationary, 283 USBL positions were recorded with an average standard deviation of 0.26 meters. Maximum deviation of all recorded positions from the mean position was 1.17 meters. Thus, the survey accuracy at the *Halo* site is calculated to be between 0.18 percent (.0018) and 0.80 percent (.0080) of water depth (Figure 3.2).

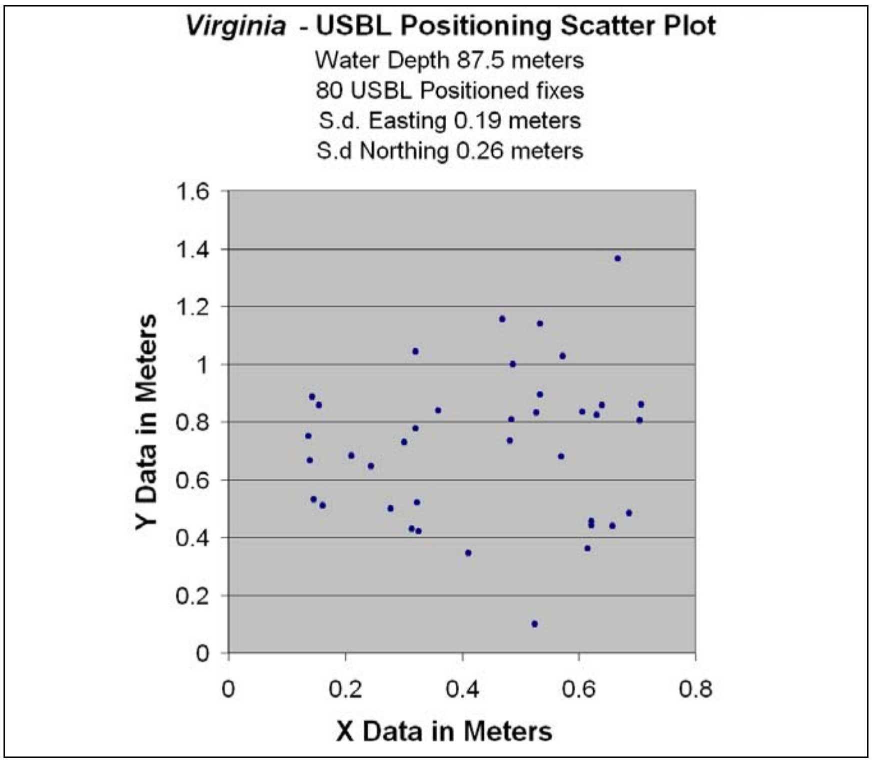


Figure 3.1. Scatter plot of USBL position accuracy at the *Virginia* site.

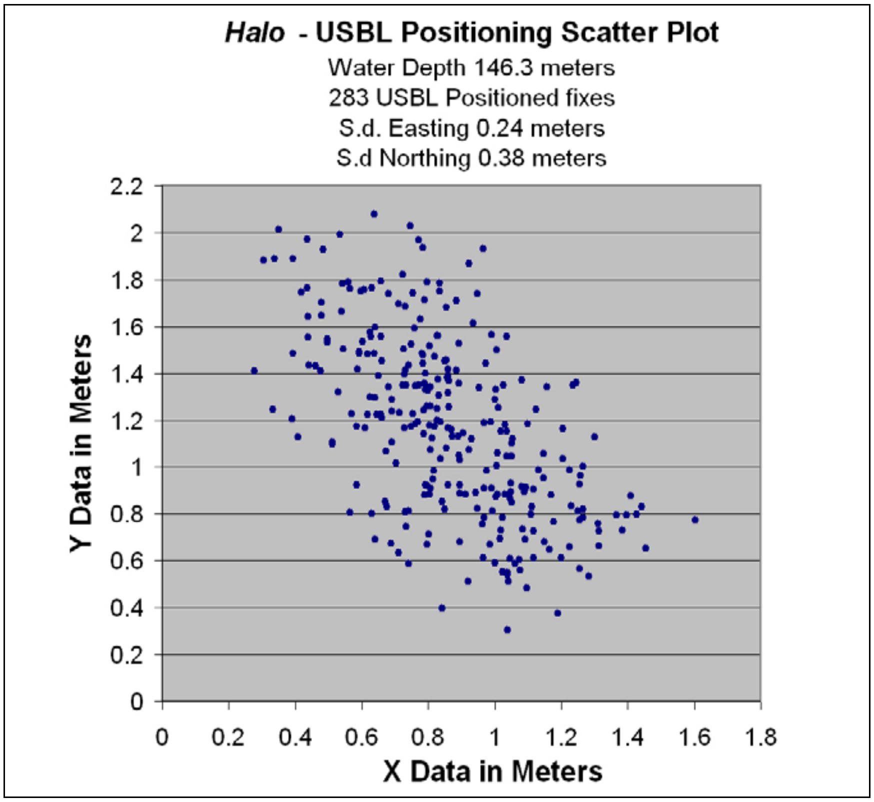


Figure 3.2. Scatter plot of USBL position accuracy at the *Halo* site.

At the *Gulfpenn* site an accuracy test (scatter plot) was conducted in 550 meters of water depth. While the ROV hovered stationary, 265 USBL positions were recorded with an average standard deviation of 0.35 meters. Maximum deviation of all recorded positions from the mean position was 1.97 meters. Thus, the survey accuracy at the *Gulfpenn* site is calculated to be between 0.06 percent (.0006) and 0.36 percent (.036) of water depth (Figure 3.3).

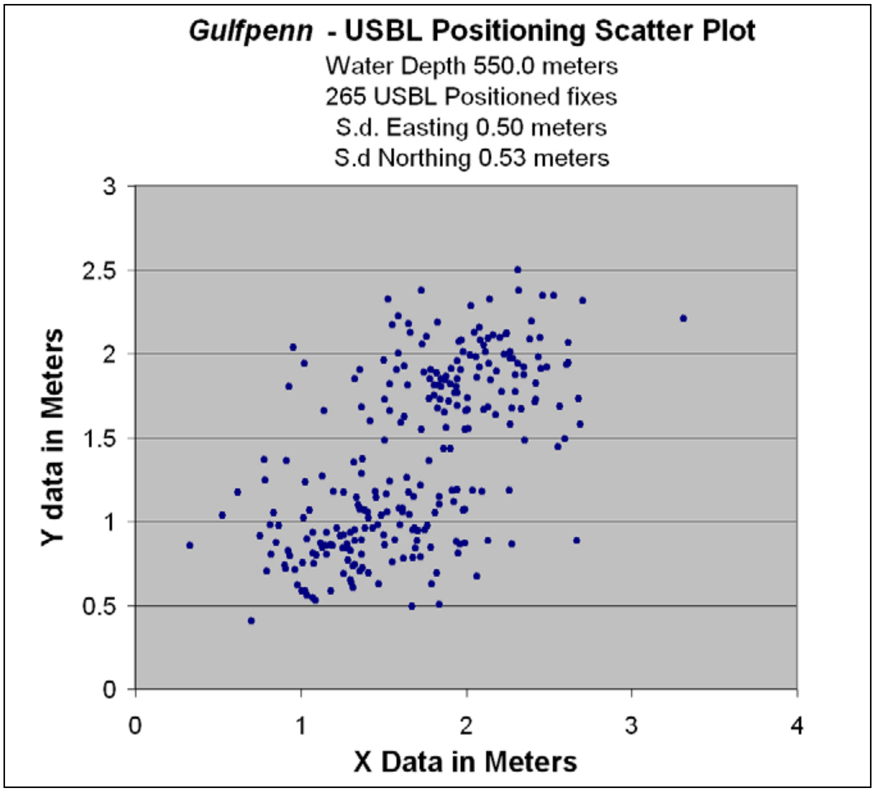


Figure 3.3. Scatter plot of USBL position accuracy at the *Gulfpenn* site.

At the *U-166* and *Robert E. Lee* sites an accuracy test (scatter plot) was conducted in 1,457.3 meters of water depth. While the ROV hovered stationary, 64 USBL positions were recorded with an average standard deviation of 0.56 meters. Maximum deviation of all recorded positions from the mean position was 2.48 meters. Thus, the survey accuracy at the *U-166* and *Robert E. Lee* sites is calculated to be between 0.04 percent (.0004) and 0.17 percent (.0017) of water depth (Figure 3.4).

At the *Alcoa Puritan* site an accuracy test (scatter plot) was conducted in 1,963.4 meters of water depth. While the ROV hovered stationary, 527 USBL positions were recorded with an average standard deviation of 1.03 meters. Maximum deviation of all recorded positions from the mean position was 4.73 meters. Thus the survey accuracy at the *Alcoa Puritan* site is calculated to be between 0.05 percent (.0005) and 0.24 percent (.0024) of water depth (Figure 3.5).

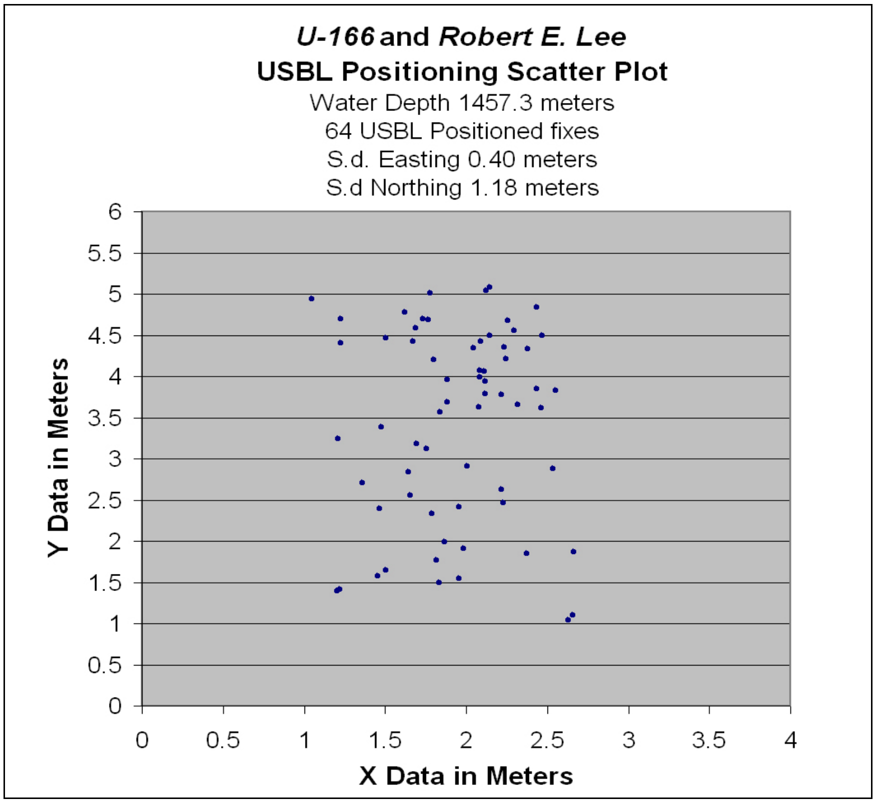


Figure 3.4. Scatter plot of USBL position accuracy at the *U-166* and *Robert E. Lee* sites.

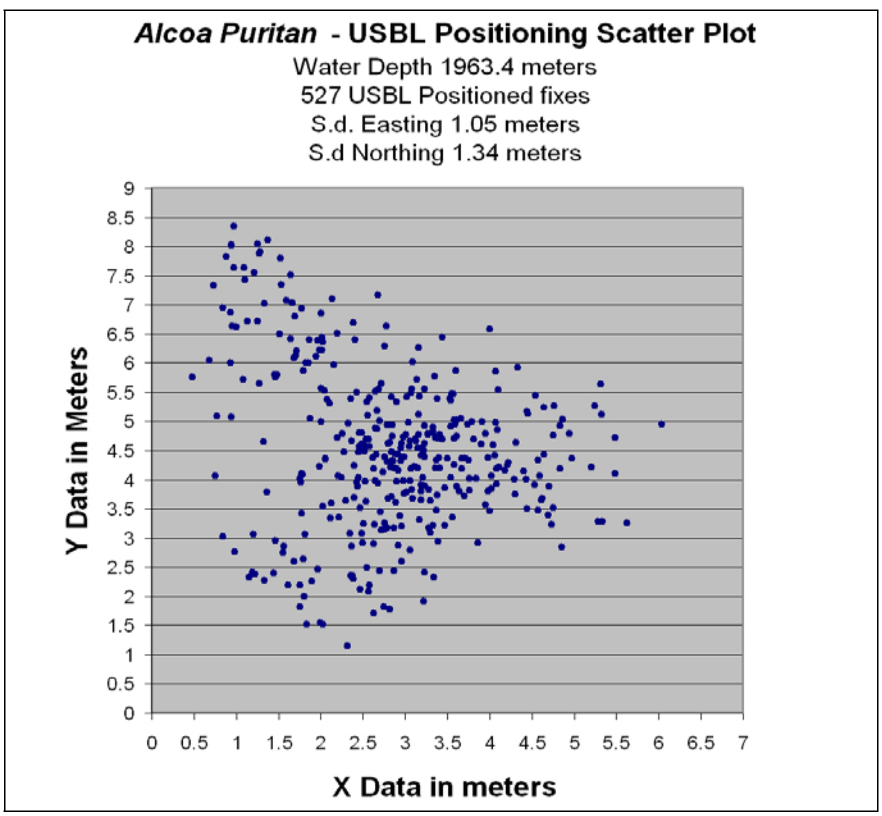


Figure 3.5. Scatter plot of USBL position accuracy at the *Alcoa Puritan* site.

3.1.3 Sampling Equipment

A Seabird Seacat CTD profiler with dissolved oxygen sensor was used to measure temperature, salinity, density, and dissolved oxygen (CTD and DO2 profiles and data are provided in Appendix A). The CTD profiler was mounted to the ROV to provide continual real time data logging and sensor communication at each site.

The ROV was equipped with multiple cameras for navigation, tether management, and biological collection monitoring. The three main cameras used for scientific data collection included the West Tech SD3000 Digital Still Camera, Kongsberg Simrad OE14-121 3CCD color camera, and two Remote Ocean Systems (ROS) Color Cameras. Both the SD3000 digital still camera and OE14-121 3CCD camera malfunctioned during the expedition and could not be repaired. As a result, the majority of the video data was collected with the ROS Color Cameras.

Sediment core samples were collected at each site. Sediment core samples were taken with the ROV using a push core sampler (Figure 3.6). The push core samplers were lowered to and recovered from the seafloor using a drop basket sent down on a cable from HOS *Dominator*. The ROV retrieved each core labeled barrel from a holster on the basket (3.6 a & b), took the core at the designated location (3.6 c & d), and then return the core to its corresponding holster.

A variety of methods were employed for biological sampling. A total of four vertebrate and five invertebrate traps were deployed at each site. The traps were lowered to the seafloor in the same basket as the push cores and then set by the ROV at designated locations (Figure 3.7). A suction sampler, attached to the ROV, was used to collect small vertebrates and invertebrates. The sampler intake nozzle was held by the ROV's five-function manipulator. The samples were deposited into a clear collection box fixed to the aft portion of the ROV. Operators monitored the contents using a camera mounted above the box. Some samples, such as coral and rusticles were collected with the seven-function manipulator or by using collection containers carried in the manipulator claws. The Sonsub crew constructed many of the collection devices in the field. One specifically built for collecting rusticles is shown in Figure 3.8.

Figure 3.6. Sediment push core taken using the Triton XL ROV.

Figure 3.7. The vertebrate and invertebrate traps in the basket about to be lowered off the stern of HOS *Dominator*.

Figure 3.8. Multi-chambered rusticle collection container.

3.2 Archaeological Methods

3.2.1 Field Methods

Standardized investigation methods were used at each study site. The archaeologist's priorities varied depending on whether previous inspections had positively identified the shipwreck. At unidentified shipwreck sites (e.g. *Virginia*, *Halo*, and *Gulfpenn* sites) the first priority was vessel identification, mapping the site boundaries/extent, and producing an accurate site plan. At previously identified shipwreck sites the priority was mapping the site boundaries/extent and producing an accurate site plan. Site maps were produced using real-world coordinates to allow importation into a GIS database.

The investigation methodology used all available information and survey data for each site to plan field operations. The survey data included side scan sonar, magnetometer, subbottom profiler, bathymetric data, and video footage.

Previously acquired survey data was key to determining the "expected" boundaries of each site and developing an efficient survey plan.

The ROV surveys began with a comprehensive visual inspection of the wreck's main structure, documenting pertinent vessel features for later analysis. The ROV then conducted a systematic survey of the seafloor around the main wreckage. The area survey extended at least 30 meters beyond the observed debris field, but was not less than 33,500 m^2 centered near the main wreck structure per the MMS project specifications, except at the *Virginia* and *Alcoa Puritan* sites (See Section 3.3.2 Exceptions to the Survey Plan). Fifteen meter line spacing was maintained to the greatest extent possible during the area survey. The ROV was acoustically tracked using an Ultra Short Base Line System (USBL) to minimize coverage gaps. The operators flew the ROV along pre-established track lines at an altitude of 1 to 3 meters depending on visibility. Video imagery was collected continuously along each survey line and sector-scanning sonar was monitored to insure any outlying debris was investigated. Investigation lines were extended to document additional materials observed outside the planned survey area. When key artifacts were encountered the ROV hovered over the object as operators took close-up video images and a position fix. The ROV then resumed the grid survey repeating this process for each new target.

Following the systematic area survey, video mosaic lines were run over the wreck's main structure and key site features. In some cases a complete plan view mosaic was impossible because of entanglement hazards. In this event, plan view mosaics of key wreck site features and vessel profile mosaics were attempted.

3.2.2 Exceptions to the Survey Plan

Extremely poor visibility at the *Virginia* site made an area survey and a main structure mosaic impractical. Poor visibility and entanglement hazards also prevented mosaicing all of *Halo's* remains. In August 2004, Tropical Storm Bonnie, followed by Hurricane Charlie, entered the Gulf of Mexico. The storm tracks cut short operations at the *Alcoa Puritan* site and canceled planned operations at the *Anona* site.

3.3 Biological Methods

3.3.1 Field Methods

Microbiological Field Methods

Two Mark IB steel test platforms were deployed on *U-166* in 2003. These platforms included a mixture of metal and wood coupons. Metal coupons included three low carbon steel, high carbon steel, and aluminum coupons, along with mahogany and oak coupons. For the metal coupons, one was the control while a second was twisted longitudinally through 180 degrees and the third was subjected to hammering at 3,000 psi. One platform was placed within the bow's severely damaged section forward of the explosion point. The second platform was placed on the deck members in front of the conning tower of the submarine's stern section. Due to stability problems with the Mark IA platforms, which were set vertically on sites during various other projects, the Mark IB platforms were laid laterally so the coupons formed a shallow staircase. Both platforms were examined *in-situ* for bio-deterioration.

Mark II steel test platforms were deployed on four ships in 2004. These platforms were an improved version of the Mark I platforms, which suffered several key design failures related to stability, cross growth of rusticles between coupons as well as between the ABS supporting panels, and losses to rusticle growth assessment due to spent rusticles breaking off and gathering under the platform. Mark II steel coupons were hung vertically within separate enclosures to prevent connective (bridging) growth and allow all spent rusticles to drop into a confining chamber. To study the importance of the oxidation-reduction potential (ORP) on rusticle growth the coupons were placed with one major surface directly exposed to the marine environment (oxidative). A vertical ABS tube confined the coupon's other large vertical surface, rendering it more reductive. To improve stability the platform was weighted with pea gravel inside an ABS pipe beneath the platform.

Ships lost at sea have the potential to develop significant electro-magnetic forces (EMF) where electrically dissimilar metals are in close proximity. The EMF could be particularly significant in the ship's electrical generating and battery rooms. Given that EMF are likely present within a shipwreck, they are a potentially important factor driving the ship's deterioration from two primary points of view: (1) strong EMF is likely to affect

the location of rusticle activity with a tendency for these organisms to cluster at anodic sites; and (2) the rate of metal loss from the structure is likely to be severely compromised by any electrolysis associated with EMF. To examine EMF potential, biological batteries were deployed on several vessels in the study.
The biological batteries consisted of sixteen 1" x 1" coupons of various 1/4" metal alloys. The coupons were arrayed laterally on a plastic supporting frame with each having an intimate contact with the neighboring coupons. Arrangement of the metals (Table 3.1) was based on attempting to gain the maximum electrochemical differences between neighboring coupons.

The biological battery platforms were deployed on four wrecks while the ROV work was performed at those sites (one to three days). The primary objectives were to determine whether there was any biological focusing of activity (observable as slimes or encrusted growths), and whether there were detectable voltages when the platforms were recovered.

A 6" x 6" mild steel coupon coated with "Royal Copper," a mixture of copper flakes in an epoxy binder, was also tested. The coating is used widely on surface vessels to prevent fouling on the hull's exterior and between the double hulls. Many ships are now treated with this hard non-leaching and abrasion-resistant coating. Given the extreme nature of the deep-sea environment at *Alcoa Puritan*, the microbiologists decided to separately deploy a Royal Copper coupon at that location at the same time as the bio-battery. Exposure time at the site was two days before the coupon was recovered.

Table 3.1

Position of Metal Coupons on Bio-Battery Deployed 2004.

C12L14 Low Carbon Steel	Brass	Cast Iron 65-45-12 Ductile iron	1045 Carbon Steel
HR Flat Bar	ZA12	4140 Alloy steel	Stainless Steel T-316
Stainless Steel T-304	EN30B Ni-Cr-Mo alloy	Aluminum 6061	Aluminum Bronze 954
01 Tool Steel	Beaver Tool Steel	Copper	D2 Tool Steel

Note: the array in the table reflects the relationship of the coupons to each other.

An initial challenge for biologists is to develop a unique and robust classification system for the types of microbially influenced growths (MIG) visible on the various shipwrecks in the cluster. While, over the course of history, extensive systems for biota classification have been developed, no such attention has been directed to the MIG that range in form from tight encrustations through various commonly layered forms of biofilm to a range of suspended particulate structures dominating the biocolloids in the marine environment. A novel classification system for the MIG based primarily upon form and function will allow a qualitative and semi-quantitative evaluation for each vessel that is part of this investigation. A common feature of all of the MIG accounted for is that the growth is either directly attached to some viewable part of the ships' structure, or located in a fixed position in close proximity to the ships' hull or superstructures. Based upon this limitation a MIG classification is proposed that will utilize the characteristics listed in Table 3.2.

From examination of video imagery from the project wreck sites, it is apparent that the six ships included in the 2004 study exhibited different forms of microbiological infestation when classified in the manner presented in Table 3.2. Each ship will be assessed by the qualitative and semi-quantitative level of the various microbial groups observed associated with the shipwreck with emphasis on determining the similarities and differences among the ships.

Laboratory Microbiological Methods

Evaluation of the bio-batteries was performed immediately upon recovery. Each coupon's metal surfaces were tested using a Model DM-301 multimeter. Any coupon combination showing a charge was recorded. This methodology allowed scientists to measure the electrical potentials being created at the millivolt (mV) level between the coupons. During bio-battery recovery, composite rusticle samples from different areas of the ship were collected for ICP (Inductively Coupled Plasma) analysis using an AES (atomic emissions spectrometer). ICP-AES analysis was conducted under the standard methods ISO 17025 as a part of the Canadian Association for Environmental Analytical Laboratories (CAEAL).

Table 3.2

Proposed Classification of Deep Sea Attached and Associated Microbiological Growths on Steel Shipwrecks

Type	Characteristics	Common Name
C1	Iron rich encrustation that coats a surface but can also hang down from a supporting iron structure	Brown rusticle
C2	Aluminum, calcium or silicate rich encrustation that coats a surface but can also hang down from a supporting iron structure	White rusticle
C3	Amorphic concretion that tends to attach to a surface with diffuse or dendritic (finger-like) extensions into the water	Dendritic and amorphous slimes
C4	Columnar concretious structures commonly resembling tubes often with extensive branching and resembling tree branches in form	Microbial Concretions
B1	Biofilms forming a thin generally tightly attached growth that can include fungal mats that generally do not become thick nor develop as encrusted growth	Slimes
B2	Stable biocolloidal structures that have a clear form and appear to be attached to nearby solid objects including various forms of life. Generally these structures last a matter of hours before spontaneously dispersing.	Blobs
B3	Stable biocolloidal structures that have some control of buoyancy and appear to float within the water at a relatively constant height above the sea floor.	Slime clouds
B4	Dense particles that contain microbes as an intrinsic part of the structure and adopt a distinctive form as a sphere, thread, irregularly shaped object, or a long often spirally shaped structure.	Sea snow

Invertebrate Zoology Methodology

Scientific observers interpreted video and recorded notes during each ROV dive. The videos were reexamined later in more detail for substrate type, slope, depth, biological data, and identification and biota counts. To standardize methodology and allow count comparisons between research groups, the videos analyzed for macroinvertebrates were the same as those analyzed for vertebrate zoology; attributes of the transects, including number, location, lengths, and widths are in Table 3.3. Voucher specimens collected with the ROV or in traps were identified prior to quantification for many organisms recorded on the videos. Substrate type was determined by estimation of particle size, following the Wentworth scale when applicable, at each 30-second interval or per linear distance of transect. These categories may include soft substrate including sand, silt, possibly clay and granules, (<4 millimeter particle size), pebble (4-64 millimeters), cobble (64-264 millimeters), boulder (>264 millimeters), and wall (near or vertical bedrock). All substrate was tentatively identified as silty clay. Slope was estimated by determining the distance of the 20-centimeter laser separation on the video screen and the submersible's distance off the bottom. Slope was classified into categories, e.g., flat (0°), 1° -10° slope, 11°-20° slope, 21°-30° slope, 31°-40° slope, 41°-50° slope, 50°-75° slope, and walls (>75°). Most slopes were flat or low angles.

Sediment cores were collected at varying distances from the wreck site's main structure (e.g., near, midway, and far). The cores were collected in such a manner as to have minimum disturbance of the surficial sediments, i.e. the sediment-water interface, where smaller biota are typically most abundant. The upper 5 centimeters of a subsample of each core was examined for meiofauna, metazoans that pass through a 500-µm mesh sieve but are retained on a 63-µm mesh sieve. Staining with Rose Bengal was used for quantitative extraction and identification of meiofauna. Another core subsample extending to 5 centimeters depth was sieved for macroinfauna, those metazoans retained on a 500-µm mesh sieve. Comparisons of meiofaunal assemblages were analyzed for distance from wreck sites, between sites, and by depths. Sediment cores were also used to verify substrate types estimated from photography and the sample's degree of enduration.

All macrofaunal species observed from videos were identified to the lowest possible taxon, or placed in broad categories when identification was not possible. For some taxa such as large crabs, sex and reproductive state was recorded, when distinguishable. In addition, the number, sizes, and distribution patterns of the sessile megafauna (e.g., *Lophelia pertusa*, gorgonians, and antipatherians) on the various wrecks were compared to similar assemblages that occurred on natural substrates at comparable depths. Other relevant observations included observations of macroinvertebrates coincident with other taxa for consideration of predator-prey or commensal relationships. Species richness, diversity, and abundance of macrofauna were calculated for each wreck site and comparisons made for distance from the wreck, between sites, and with depth and other hydrographic variables. Numerical classification techniques, e.g., multivariate techniques such as clustering and ordination, were utilized for analytical comparisons of assemblages within and between sites after all video identifications were made.

Collection of voucher specimens is crucial to validation of species identification for many taxa. Sessile, sedentary or slow moving macroinvertebrates were collected with the ROV's manipulator, placed in a basket, and brought to the surface for examination, photographic documentation, narcotization, and fixation, as appropriate for each taxon. Specimens or subsamples were preserved in ethyl alcohol or frozen to facilitate their potential use in genetic and other studies. Appropriate measurements for specimens of different taxa were recorded to the nearest millimeter with vernier calipers. Identification of some macrofauna required dissection in the laboratory. Final identification of some specimens required submission to individual taxonomic experts.

Although it was not logistically feasible to collect larger macrofauna with traps suitable for deployment with the ROV, some smaller macrofauna such as shrimps, isopods, and amphipods, were collected with small baited traps. Small, inverted-cone, minnow traps equipped with small mesh (e.g., 0.250 millimeter) were effective for collecting both smaller invertebrates and fish at depth. The fish traps were perhaps the most effective method of collecting motile macroinvertebrates, especially crustaceans. Voucher specimens collected with baited traps were treated in a manner similar to those collected with the manipulator arm.

Vertebrate Zoology Methodology

Community structure of fishes associated with shipwrecks was examined to determine if significant differences in the fish community existed among the wrecks, and to test if significant differences existed over ships versus nearby natural bottom habitats. Community structure was estimated primarily with video from ROV transects. Using ROV-collected video to estimate fish community structure at deep wreck sites suffers from similar limitations to video collected with divers or ROV's in shallower environments. Some fishes may avoid the ROV because of the noise it generates, or its lights may cause fishes to move away from a sampling transect when the ROV approaches. Other fishes may be attracted to the noise and lights. Small cryptic species may be overlooked because of scale of sampling and the ROV's altitude as transects are flown. Turbidity may also affect video sampling of small site-attached fishes, as well as large gregarious ones. In high turbidity environments, thus low visibility, fishes maintaining a moderate distance from the ROV might not be seen. A secondary effect of high turbidity is the ROV pilot may fly transects at higher altitude to avoid contact with the wreck, which is mainly detected with sonar and not video when visibility is poor. Despite video sampling limitations, others have successfully utilized video to examine community structure of deep-sea ichthyofauna (e.g., Felley and Vecchione 1995; Krieger and Wing 2002). In the current study, trap and suction sampler voucher specimens aided species identification seen on the video.

Sampling the fish community during primary visits to all wreck sites followed a standard methodology. (Note: Fish sampling during second and third visits to sites was conducted principally to collect additional tissue and otolith samples and did not precisely follow methods described below). Once the archaeological survey of a given wreck was completed, two standard Marine Resources Monitoring Assessment and Prediction Program (MARMAP) chevron fish traps (dimensions = 150 centimeter width x 180 centimeter length x 60 centimeter height; opening = 44.5 centimeter x 10 centimeter; mesh = 5 centimeter plastic coated wire) and two small baitfish traps (dimensions = 75 centimeter width x 75 centimeter length x 50 centimeter height; opening = 10 centimeters x 10 centimeters; mesh = 2.5 centimeter plastic coated wire) were baited with menhaden and squid, and fished for between 5 and 15 hours (Table 3.3). One small and one large trap were set immediately adjacent to the wreck and the second pair of traps was set approximately 300 meters away from the wreck. While traps were soaking, ROV transects (n = 3) were flown over the ship's long axis. Video was also recorded over transects immediately adjacent to the wreck (n = 3) and approximately 300 meters away from it (n = 3) to estimate the biological communities at varying distances (over, adjacent, and distant) from the ship's main structure (Table 3.4). During biological transects, attempts were made to sample encountered fishes with the ROV's suction sampler. The size of the suction sampler opening limited sampling to fishes less than 12.5 centimeters deep or wide.

Table 3.3

Properties of Chevron (large) and Baitfish (small) Fish Trap Deployments Adjacent (ship) to and 300 Meters from (distant) Shipwreck Sites.

Wreck Site	Date	Trap Type	Location	Time Start	Time End	Total Time Fished (hh:mm)
Virginia	31 July – 1 Aug	Large	Ship	11:38	0:01	12:23
		Large	Distant	8:11	21:17	13:06
		Small	Ship	13:13	0:43	11:30
		Small	Distant	8:48	21:01	12:13
Halo	2 Aug – 3 Aug	Large	Ship	18:35	4:55	10:20
		Large	Distant	17:00	6:07	13:07
		Small	Ship	19:04	4:42	9:38
		Small	Distant	17:08	6:00	12:52
Halo (2)	14 Aug	Large	Ship-bow	0:17	8:32	8:15
		Large	Ship-stern	0:09	8:13	8:04
Gulfpenn	4 Aug	Large	Ship	8:00	23:45	15:45
		Large	Distant	7:18	22:16	14:58
		Small	Ship	8:15	23:43	15:28
		Small	Distant	7:14	21:55	14:41
Gulfpenn (2)	11 Aug – 12 Aug	Large	Ship	19:25	6:00	10:35
Robert E Lee	8-Aug	Large	Ship	13:36	2:00	12:24
		Large	Distant	12:05	3:28	15:23
		Small	Ship	13:23	1:57	12:34
		Small	Distant	12:11	3:28	15:17
U-166	6 Aug – 7 Aug	Large	Ship	18:15	23:12	4:57
		Large	Distant	17:22	0:24	7:02
		Small	Ship	18:34	23:17	4:43
		Small	Distant	17:18	0:37	7:19
Alcoa Puritan	9 Aug	Large	Ship	2:49	13:52	11:03
		Large	Distant	1:19	14:42	13:23
	9 Aug	Small	Ship	2:51	14:05	11:14
		Small	Distant	1:25	15:01	13:36

(*X*) Designates the number of visit.

Table 3.4

Properties of Transects Flown by the ROV to Document the Fish Community Over, Adjacent to, and 300 Meters from Shipwrecks.

Site	Transect Line	Relation to Ship	Date	Time Start	Time End	Total Time	Distance m	Average Width m	Total Area m^2
Virginia	321	Over	31 Jul	3:59:47	4:26:03	0:26:16	162.80	2.19	357.20
	322	Over	31 Jul	3:34:23	3:58:55	0:24:32	163.10	2.19	357.90
	323	Over	31 Jul	3:02:56	3:30:40	0:27:44	171.00	1.71	291.90
	300	Distant	31 Jul	5:31:47	5:42:28	0:10:41	151.50	1.07	161.60
	301	Distant	31 Jul	5:22:25	5:32:58	0:10:33	151.80	1.28	194.30
	302	Distant	31 Jul	5:08:43	5:22:00	0:13:17	152.70	1.16	176.90
Halo	119	Over	1 Aug	22:35:01	22:42:38	0:07:37	15.20	1.73	26.30
	120	Over	1 Aug	16:11:09	16:17:54	0:06:45	59.40	2.23	132.80
	121	Over	1 Aug	18:34:53	18:49:14	0:14:21	53.00	2.88	152.60
	122	Adjacent	2 Aug	4:41:53	4:51:28	0:09:35	137.50	1.52	209.00
	123	Adjacent	2 Aug	5:04:01	5:08:59	0:04:58	138.40	1.39	192.40
	124	Adjacent	2 Aug	5:22:47	5:27:55	0:05:08	135.90	1.24	168.50
	138	Distant	2 Aug	10:57:08	11:32:14	0:35:06	178.90	1.02	182.10
	139	Distant	2 Aug	11:35:50	12:15:32	0:39:42	147.50	0.94	138.50
	140	Distant	2 Aug	12:19:30	13:04:24	0:44:54	139.00	1.02	141.50
Gulfpenn	225	Over	4 Aug	6:39:18	6:41:37	0:02:19	28.70	2.54	72.70
	226	Over	4 Aug	4:22:18	4:49:47	0:27:29	136.90	3.66	500.60
	227	Over	4 Aug	5:51:29	6:00:24	0:08:55	65.20	6.43	419.70
	222	Adjacent	4 Aug	9:29:13	9:38:13	0:09:00	142.30	4.04	574.90
	223	Adjacent	4 Aug	8:02:39	8:13:48	0:11:09	142.00	3.05	433.10
	224	Adjacent	4 Aug	7:47:13	7:53:49	0:06:36	145.10	4.11	596.40
	200	Distant	4 Aug	22:45:32	23:07:38	0:22:06	160.60	2.47	397.10
	201	Distant	4 Aug	23:09:57	23:29:56	0:19:59	161.50	2.15	348.10
	202	Distant	4 Aug	23:31:24	23:51:34	0:20:10	163.10	2.00	326.50
R.E. Lee	420	Over	7 Aug	7:11:43	7:25:26	0:13:43	114.50	8.89	998.80
	415	Adjacent	7 Aug	12:55:19	13:07:56	0:12:37	121.30	4.31	522.80
	416	Adjacent	7 Aug	12:05:32	12:21:06	0:15:34	122.20	5.99	732.00
	417	Adjacent	7 Aug	11:40:20	11:49:55	0:09:35	118.90	6.67	793.10
	438	Distant	8 Aug	0:49:28	1:07:43	0:18:15	207.90	5.42	1,127.50
	439	Distant	8 Aug	1:10:35	1:38:55	0:28:20	229.20	7.14	1,636.90
	440	Distant	8 Aug	1:43:54	2:01:17	0:17:23	226.80	4.91	1,112.80
U-166	1	Over	6 Aug	7:24:33	7:40:00	0:15:27	55.50	4.11	228.30
	2	Over	6 Aug	7:40:00	8:11:58	0:31:58	51.80	4.18	216.50
	3	Over	6 Aug	8:20:39	8:29:12	0:08:33	3.00	6.22	19.00
	446	Distant	6 Aug	13:29:09	13:35:12	0:06:03	57.90	2.52	146.20
	447	Distant	6 Aug	13:37:15	13:44:20	0:07:05	61.00	2.88	175.60
	448	Distant	6 Aug	14:38:45	14:42:56	0:04:11	57.60	2.38	137.00
Alcoa P.	519	Over	9 Aug	15:35:19	15:44:16	0:08:57	10.40	11.43	118.50
	520	Over	9 Aug	12:53:01	13:00:01	0:07:00	114.00	8.63	984.30

Site	Transect Line	Relation to Ship	Date	Time Start	Time End	Total Time	Distance m	Average Width m	Total Area m^2
	521	Over	9 Aug	14:26:47	14:27:43	0:00:56	6.10	1.34	8.20
	516	Adjacent	9 Aug	20:03:01	20:14:23	0:11:22	132.90	5.05	671.10
	517	Adjacent	9 Aug	19:25:33	19:39:18	0:13:45	131.40	3.16	415.20
	518	Adjacent	9 Aug	18:18:21	18:29:22	0:11:01	131.40	4.32	567.60
	500	Distant	9 Aug	22:18:09	22:57:08	0:38:59	167.90	5.94	998.20
	501	Distant	9 Aug	23:01:11	23:28:05	0:26:54	150.00	6.85	1,028.00
	502	Distant	9 Aug	23:33:57	23:53:24	0:19:27	142.30	6.18	879.40

Fish traps were collected from the seafloor and brought to the surface upon completion of biological transects. Fishes were removed from traps and placed on ice until biological samples were extracted. Similarly, fishes collected with the ROV suction sampler were removed from the sampler basket and placed on ice. Individuals from both collection systems were identified to species and measured to standard and total length. Following species identification, three types of biological samples were extracted from each individual. Otolith samples for age estimation were removed from the braincase with steel chisels and forceps, and then stored in centrifuge tubes or small plastic Ziploc bags (Figure 3.9). Stomachs were extracted and preserved with 10% buffered formalin in plastic bottles for gut content analysis. Last, up to 100 grams of muscle tissue was dissected from each fish's lateral white musculature for stable isotope analysis. Samples were placed in plastic Ziploc bags and frozen after skin was removed. Samples larger than 5 grams were subsampled such that approximately half the sampled tissue was frozen and the other half preserved with ethanol in plastic bottles as a backup.

Fish Community Structure

Scientific personnel analyzed the video in the Fisheries Laboratory at the University of West Florida with a computer system dedicated to estimating fish community structure from video. Fishes were identified to the lowest taxonomic level possible and enumerated using the Min/Max Method developed by the National Marine Fisheries Service for analysis of Southeast Assessment and Monitoring Program Reef Fish Survey video (USDC, NMFS 1989). Fish of a given species were counted two different ways with this method. The most fish seen in any video frame is the estimate of the minimum number of individuals present, or the min count. The total number observed throughout a transect's video constitutes the estimate of the maximum number of fish present, or the max count. The max count is likely an accurate estimate of inactive, site-attached or benthic fishes occurring along a transect. For gregarious species that follow the ROV, the min count is likely to be more accurate than the max count because double counting is avoided for fishes moving with the ROV and in and out of the video. Total length was estimated for fishes observed whose profile was hit by both ROV-mounted lasers. This was accomplished by dividing the length of the fish on the video monitor by the measured distance between lasers on the monitor and then multiplying by the known distance between lasers (12.7 centimeters).

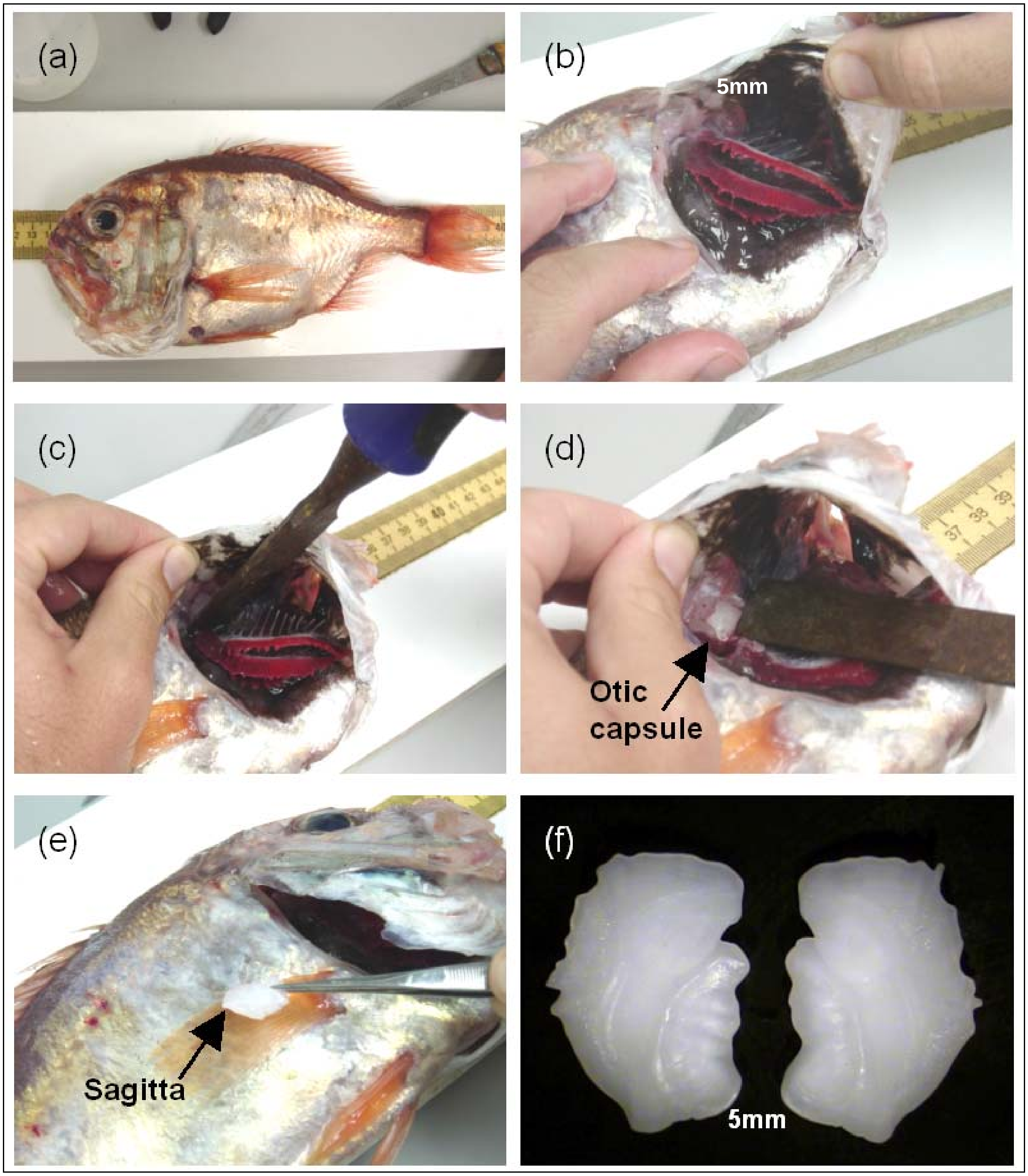


Figure 3.9. Digital images of a) a 270-millimeter slimehead, *Hoplostethus occidentalis*, collected at the *Gulfpenn*, b) opening the fish's opercular cavity and exposing the gills, c) scraping the gills free of the braincase, c) opening the otic capsule, e) removing the right sagitta, and f) a pair of extracted sagittae.

Video analysis was performed for biological transects and for all video footage collected at each site (Table 3.5). Statistical tests of community structure were performed on transect data, and the additional video was analyzed mainly to document other species present at sites but not seen in the biological transect video. For transects, fish density was estimated by dividing min or max count estimates by the area covered on a given transect. Density derived from max counts was used for most species to provide statistical analysis of community structure, however, there were a few species on the shallower sites that obviously followed the camera. Density estimates computed from min counts were used in statistical analysis for those species. Once density estimates were computed, analysis of similarity (ANOSIM) was used to test for differences in fish community structure among wreck sites and transect locations (Clarke 1993; Clarke and Gorey 2001). Density data first were square root transformed. A Bray-Curtis similarity matrix then was computed among all transects with the Primer software package (Clarke and Gorey 2001). Last, a two-way nested ANOSIM model was computed with site (wreck) and transect locations nested within the site as factors. Results were evaluated at a significance level of 5%.

Table 3.5

Total Video Time Analyzed for Fishes Presence
from ROV Video During Shipwreck Site Visits for Biological and Archeological Sampling.†

Site-Visit	Biological Transect Time (hh:mm:ss)	Additional Video Time (hh:mm:ss)
Virginia	1:53:03	22:19:58
Halo	2:48:06	36:39:39
Halo (2)	Not applicable	8:39:20
Gulfpenn	2:07:43	38:55:13
Gulfpenn (2)	Not applicable	10:58:51
Gulfpenn (3)	Not applicable	4:10:13
Robert E Lee	2:16:19	36:51:55
U166	1:13:17	15:28:37
Alcoa Puritan	2:25:21	28:04:50

† Multiple visits to single sites were analyzed separately.
(*X*) Designates the number of visit.

Diet and Stable Isotope Analysis

Gut contents were identified to lowest taxonomic level possible with the aid of a dissecting microscope. Prey were separated by taxa, dried, and weighed. The mean percent of total diet that prey taxa constituted was plotted to compare differences among fishes captured at each site.

Gut content analysis provided direct evidence of fish diet but only yielded information of prey consumed within a time span of hours to days. Stable isotope analysis of muscle tissue, on the other hand, integrates a diet signature over a time span of weeks to months (Fry and Sherr 1984; and Fry 1988). Another advantage of using a stable isotope approach to infer diet and trophic position of deep sea fishes is that fishes coming from depths even as shallow as the outer shelf tend to have everted stomachs due to gas bladder expansion, thus gut contents are lost. When possible, combining stable isotope analysis with gut content analysis allows one to investigate the source(s) of production, trophic level, and specific diet of a given species.

Sample preparation for stable isotope analysis of muscle tissue occurred at the Center for Environmental Diagnostics and Bioremediation at the University of West Florida. All frozen muscle samples (n = 113) were lost because of a power failure during Hurricane Ivan in September 2004. Therefore, the backup samples preserved in ethanol (n = 79 fish and 28 invertebrates) were processed and analyzed. Fish samples were removed from the ethanol and associated bone removed. Likewise, shell was removed from all but the smallest invertebrate samples. All samples were rinsed with distilled water for 30 seconds and placed in glass vials to soak in distilled water for 24-48 hours. Samples were removed from vials, rinsed again with distilled water, and placed in pre-weighed aluminum drying cups. Cups were weighed and placed in a drying oven where samples were dried at 60° C for 48 hours or until dry. Dried samples were weighed and stored in glass vials. Stable isotopes of C, N, and S were analyzed by Iso-Analytical, a contract analytical chemistry laboratory in Cheshire, England, with a Europa Scientific GSL/Geo 20-20 isotope ratio mass spectrometer. Analytes included $\delta^{13}C_{V\text{-}PBD}$ ($\delta^{13}C$), $\delta^{15}N_{Air}$ ($\delta^{15}N$), and $\delta^{34}S_{V\text{-}CDT}$ ($\delta^{34}S$). International Atomic Energy Agency (IAEA) standard reference materials (SRMs) were run periodically to assess machine performance (Table 3.6). Analytical precision was estimated from duplicate analysis of 20 randomly selected samples. Mean difference (± SD) between replicate sample runs was 0.05 ‰ (± 0.18) for $\delta^{13}C$, 0.03 ‰ (± 0.11) for $\delta^{15}N$, and -0.03 ‰ (± 0.32) for $\delta^{34}S$.

Table 3.6

Analysis of International Atomic Energy Agency Standard Reference Materials for $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$.

Analyte	IAEA SRM	Accepted Value	Replicates	Mean Analysis Value (± SD)
$\delta^{13}C_{V\text{-}PBD}$	IAEA-CH-6, Cane Sugar	-10.43 ‰	8	-10.39 ‰ (± 0.10)
$\delta^{13}C_{V\text{-}PBD}$	IA-R005, IA-Beet Sugar	-26.03 ‰	8	-26.02 ‰ (± 0.04)
$\delta^{15}N_{Air}$	IAEA-N1, Ammonium Sulfate	0.40 ‰	6	0.21‰ (± 0.10)
$\delta^{15}N_{Air}$	IAEA-R007, Ammonium Sulfate	7.39 ‰	6	7.09‰ (± 0.05)
$\delta^{34}S_{V\text{-}CDT}$	IA-R027, Whale Baleen	16.30 ‰	12	16.45 ‰ (± 0.34)

Stable isotope analysis results were used to infer source of production and trophic position of fish and invertebrate samples. Typical oceanic phytoplankton ranges of -20 to -18 ‰ for $\delta^{13}C$, 5 to 9 ‰ for $\delta^{15}N$, and 18 to 20 for $\delta^{34}S$ were assumed (Fry 1988; MacAvoy et al. 2002) for the northern Gulf. Trophic fractionation (enrichment) from prey to consumer was assumed to average 1 ‰ for $\delta^{13}C$ and 3 ‰ for $\delta^{15}N$ (Fry et al. 1984; Fry and Sherr 1984; Fry 1988); fractionation was assumed not occur for $\delta^{34}S$ (Connolly et al. 2004). Thus, trophic level was inferred from apparent enrichment of $\delta^{13}C$ and $\delta^{15}N$ values. Values of $\delta^{34}S$ were used to estimate if the source of production for shelf species was pelagic or benthic, as benthic production imparts a $\delta^{34}S$ signature depleted relative to pelagic phytoplankton (Connolly et al. 2004). In the deep ocean, both $\delta^{13}C$ and $\delta^{34}S$ were used to infer the relative importance of chemosynthetic versus phytoplankton production as the base of the food web. MacAvoy et al. (2002) reported consumers associated with western Gulf seep environments where significant sulfate reduction occurred had very depleted $\delta^{13}C$ (~ -30 ‰) and $\delta^{34}S$ (~ -7 ‰) values, while an area with significant production from methanogenic bacteria imparted depleted $\delta^{13}C$ (~ -55 ‰) and $\delta^{15}N$ values (~ -12 ‰).

Age Estimation

Sagittal otoliths were extracted from adult and juvenile fishes collected with traps and the ROV suction sampler. Sagittae were prepared for age estimation by first embedding them sulcus side down in epoxy resin. Once the epoxy hardened, samples were mounted on microscope slides and sectioned with an Isomet slow-speed diamond-bladed saw, with the resultant thin sections being approximately 500 µm thick. Sections were secured to microscope slides with Cryastalbond thermal setting epoxy. Final preparation included polishing first with 3200 grit sandpaper and then 0.3 µm alumina suspension on a felt polishing cloth. Opaque zones in otoliths were counted by two readers under a microscope with reflected and transmitted light (Figure 3.10).

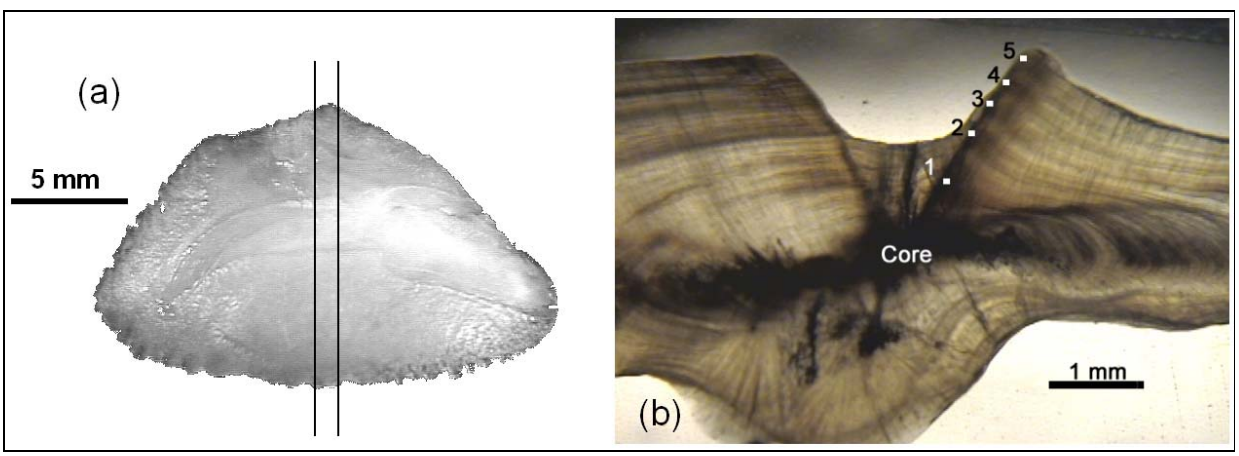


Figure 3.10. a) Region of transverse section made through the core of a 683-millimeter TL red snapper sagitta and b) the resulting thin section. Five opaque zones are apparent in the thin section.

Juveniles of several Anthiinae bass species were captured over *Gulfpenn* with the ROV suction sampler (see section 6.5.3). Otoliths from those individuals were mounted sulcus side up on microscope slides with epoxy. Otoliths were sanded to near the core with 3200 grit sandpaper and then polished with 0.3-µm alumina suspension on a felt polishing cloth. Daily growth rings were counted by two readers as above.

Opaque zone formation has been validated in previous studies as forming on an annual basis for adults of several species captured during this study. For other species, annual opaque zone formation has only been validated for congeners or fishes within the same family. Ageing precision in this study was estimated by computing the average percent error (APE) between the two reader counts of opaque zones in both adult (hypothesized annuli) and juvenile (hypothesized daily formation) otoliths (Campana et al. 1995). In total, otoliths were prepared for 97 fish; 84 adults, and 13 juvenile Anthiinae basses. Average percent error among all samples was 3.61% (Figure 3.11). Typically, production-ageing facilities aim to produce APEs of less than 5 percent. The APE we report should be viewed as remarkable given the diversity of species (n = 37) sampled. Therefore, we are confident in the high precision of opaque zone counts for otoliths prepared in this study. The issue of whether opaque zones accurately reflect age (verification or validation) is discussed for individual taxa in wreck-specific vertebrate zoology sections.

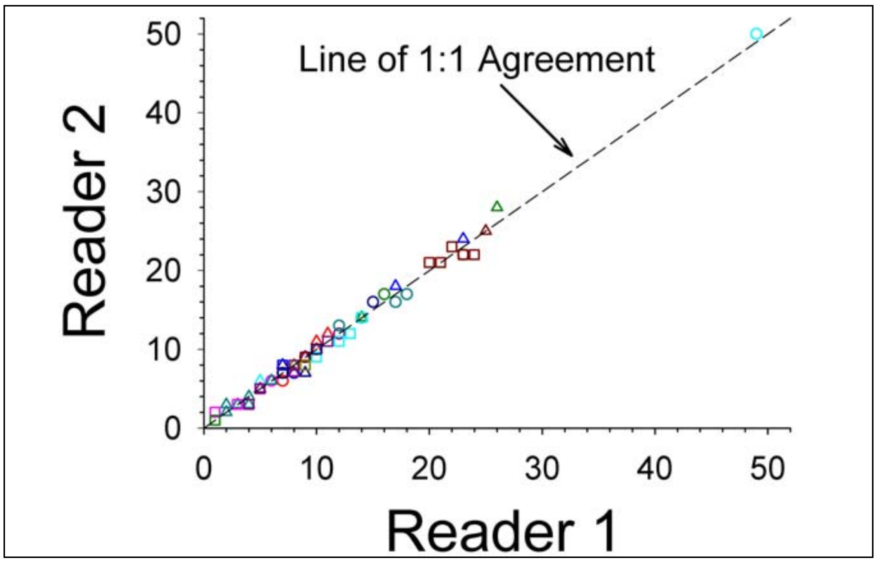


Figure 3.11. Plot of Reader 1 opaque zone counts versus Reader 2 opaque zone counts for otolith sections of 84 adult fish from 37 different species sampled from among all sites in this study. Symbol-color combinations are unique for each species sampled.

Methodology for Core Samples

At the designated sites, core samples were obtained for hydrocarbon component analysis. Each sample was tested for benzene, ethyl benzene, toluene, xylene, hydrocarbon C6-36, and the total petroleum hydrocarbon content. An accredited/certified laboratory was used for the organic chemistry analysis. Methods followed the recognized procedures from sources such as Environment Canada, the U.S. Environmental Protection Agency, and CANMET. The use of core samples for this analysis would indicate if any hydrocarbons have impacted the surrounding area. This impact could be benign, but the determination of the extent of hydrocarbons leaching from the sunken structures is still important for biological interpretation. These hydrocarbons either cause a beneficial or detrimental effect on the surrounding biota. Core samples were taken at four specific sites at the sunken structures: directly beside the structure, 30 meters, 152 meters, and 305 meters away. Samples taken by the ROV were brought to the surface and preserved for analysis.

SITE REPORTS

4.0 *VIRGINIA* SITE

4.1 Historical Background of the Tanker *Virginia*

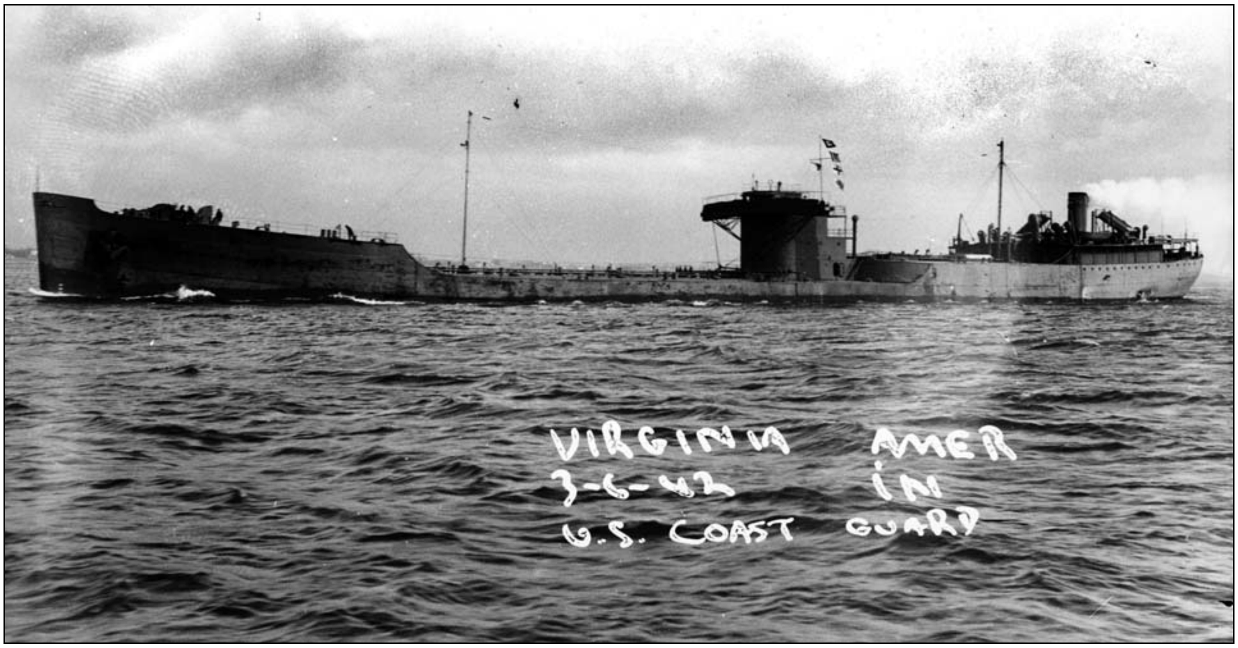


Figure 4.1. SS *Virginia*, United States Coast Guard photograph taken two months prior to the vessel's loss (Courtesy of Mariner's Museum, Newport News, Virginia).

Welding Shipyards, Inc. of Norfolk, Virginia constructed the bulk carrier *Virginia* (Official Number 40389) in 1941. The vessel was 501 feet (152.8 meters) long and 69.8 feet (21.3 meters) at the beam. *Virginia*, completed in March 1941, was the first ship delivered by the yard. National Bulk Carriers, Inc., a shipping firm established in 1936 by Daniel K. Ludwig, owned the tanker. Ludwig, who eventually became the owner of the world's largest bulk carrying fleets, founded Welding Shipyards, Inc. in 1940 soon after the beginning of World War II. The yard consisted of one berth 590 feet (180 meters) long and employed around 800 men. All vessels constructed at the yard were welded together and no riveting was employed during ship construction (Sawyer and Mitchell 1974).

During its short existence, *Virginia* was primarily utilized for carrying oil and petroleum. On May 12, 1942 the tanker transited from Baytown, Texas to Baton Rouge, Louisiana loaded with 180,000 barrels of gasoline. The weather was fair with calm seas and a light breeze. *Virginia* stopped near the sea buoy at the Southwest Pass of the Mississippi River waiting for a "bar pilot" to take her into the river (Burch 1942b).

The bar pilots were rowed to the ship from the pilot boat in a yawl boat, or a dory. The bar pilot then took the ship over the sand and mud bar at the river's mouth and up to Pilot Town. There the bar pilot exchanged with a river pilot who took the ship on up river. The same procedure was done in reverse for vessels coming down river and heading out to sea (Michell 2004).

Bar pilots Captain Albro Michell and Captain Paterson, who were working from the pilot boat *Jenny Wilson* on May 12, 1942, recalled the events related to *Virginia*'s loss. When *Jenny Wilson* was along the leeward side of *Virginia*, "not along side the ship, but right close," the pilot was lowered down in the dory to cross to the tanker. Just as the dory was crossing, two of three torpedoes passed under the pilot boat and struck *Virginia*. The first torpedo struck aft along the port side at the No. 8 tank, breaching the hull and spilling gasoline onto the sea. Within two minutes a second and third torpedo struck the ship causing tremendous explosions. *Virginia* was immediately engulfed in flames as the gasoline-filled tanker exploded. The flames spread over the water, surrounded the tanker, and made it nearly impossible for many of the crew to escape. Portions of the pilot boat and some of her crew were also covered with gasoline, but *Jenny Wilson* managed to escape the flames. The pilots circled the burning tanker searching for survivors. Out of a crew of forty-one only 14 men survived the encounter. Captain Michell learned two days later from a newspaper that his brother was among those lost (Michell 2001; Michell 2004; Peterson 2003; and Burch 1942b).

The vessel was still ablaze the following day. Witnesses reported the partially submerged superstructure was still visible in the flames. *U-506*, commanded by Kapitänleutnant Erich Würdemann, was waiting 56 kilometers away to rendezvous with *U-507* and wrote in his logs that he could see the glow of a burning tanker. Würdemann correctly guessed the flames were from a ship that the commander of *U-507*, Kapitänleutnant Harro Schacht had sunk (Schacht 1942; and Würdemann 1942).

In November 1942, Welding Shipyards launched another tanker of the same type and configuration as *Virginia*. The new tanker, hull no. 11, was given the name *Virginia*, to replace the one that was lost. The two tankers were similar in appearance except that the new tanker had guns mounted fore and aft (Figure 4.2).

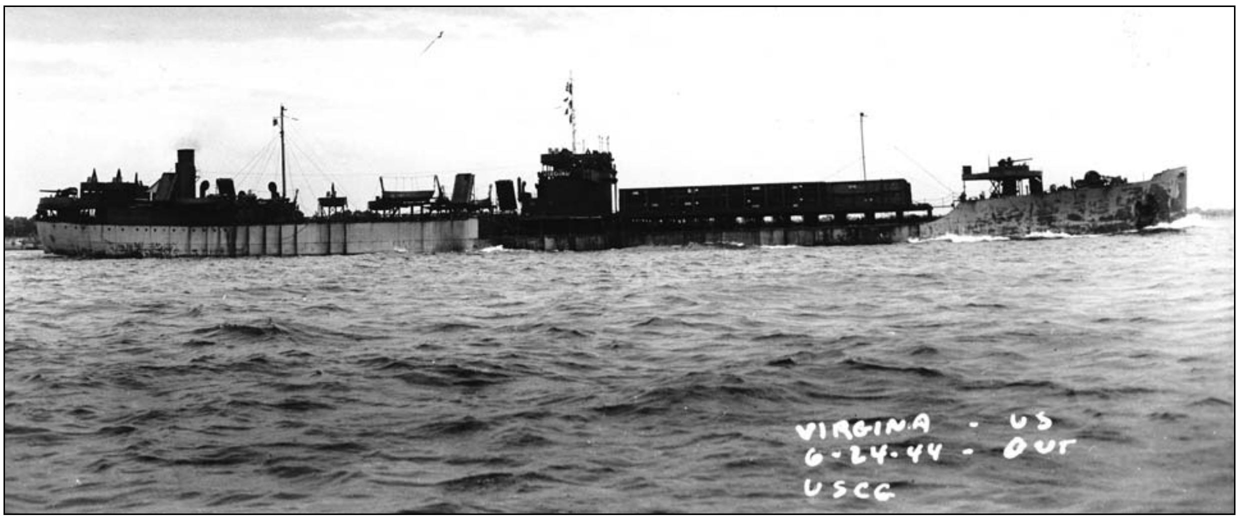


Figure 4.2. The second SS *Virginia*, U.S. Coast Guard photograph taken on June 24, 1944 (Courtesy of Mariner's Museum, Newport News, *Virginia*).

4.2 Previous Investigations

Marine archaeologist Dr. Rob Floyd identified a large shipwreck near the Mississippi River as the *Virginia* during an oil and gas survey in 2001. Gulf Ocean Services, Inc. conducted a survey of the area in the summer of 2003 for the Remington Oil and Gas Corporation. Sonar, magnetometer, and bathymetry data collected during the survey revealed a partially buried wreck with a debris scatter extending away from the vessel (Figure 4.3). Water depth at the wreck site averages 87 meters BSL. No video imagery was previously collected at this site. The archaeological assessment report from the 2003 survey indicated the shipwreck was possibly moving along the seafloor as a result of a mass movement sediment flow (Marmaduke 2003). A review of the shipwreck's recorded locations from three surveys over seven years (1997, 2003, 2004), however, indicated no obvious wreck movement since 1997. Evidence for the movement of the shipwreck is based on the vessel's reported location in 1950 according to the Automated Wreck and Obstruction Information System (AWOIS). It is more likely that the 1950's location is incorrect, than that the wreck moved 11.30 kilometers over 50 years. This hypothesis is supported by the fact that the wreck site's current location is at the edge of the Kriegsmarine's designated grid area reported in *U-507*'s logs for its attack on *Virginia*. The 1950 position is approximately 2.7 kilometers out side the designated grid area. Furgo Chance Inc., however, conducted the most recent survey of the area between December 22, 2005 and February 1, 2006 for ChevronTexaco. Hurricane Ivan had crossed near the area in September 2004 causing massive mudslides across this portion of the Gulf of Mexico. The post Ivan survey revealed *Virginia* was approximately 1,200 feet down slope of the previously recorded location. This evidence suggests the vessel may periodically progress down slope during mudslides instigated by larges storms or similar events (Henning 2006).

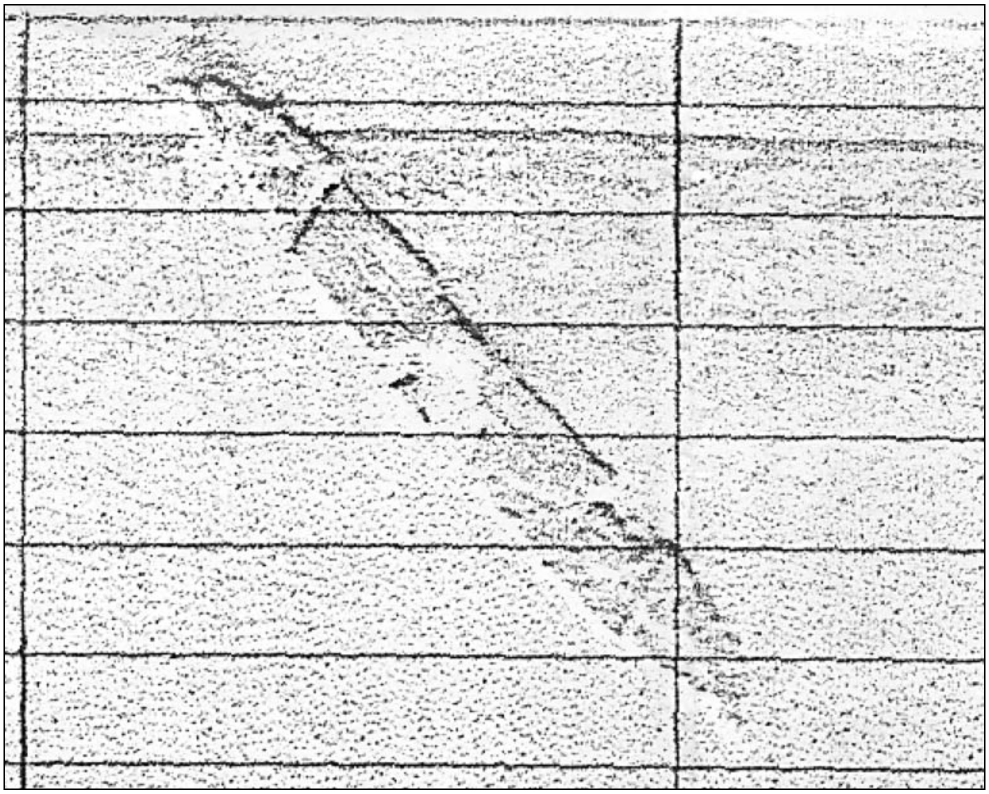
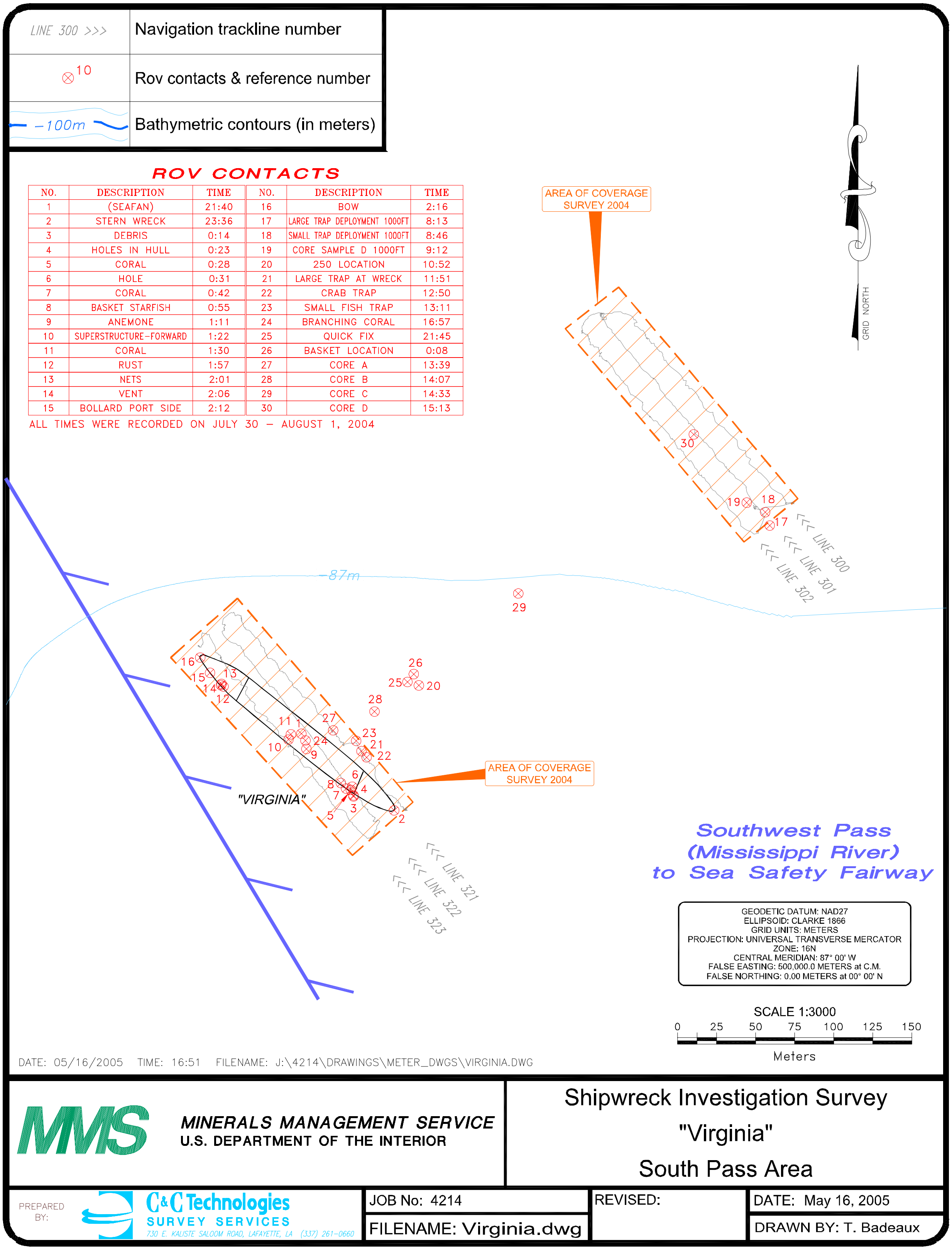


Figure 4.3. Side scan sonar image of the *Virginia* site, 2001 (submitted by Rob Floyd courtesy of KC Offshore LLC.).

Gulf Ocean Services' 2003 survey of the *Virginia* site and surrounding area utilized side scan sonar and magnetometer systems. The survey data did not indicate extensive debris scattered around the site. Only one sonar contact was noted approximately 400 meters east of the shipwreck, and a single magnetic anomaly was recorded approximately 650 meters south-southwest of the shipwreck. An unidentified sonar contact and three magnetic anomalies were also recorded approximately 1.5 kilometers south of the shipwreck's location (Marmaduke 2003). It was unclear before the ROV investigation whether the southern targets were related to the *Virginia* wreck site.

4.3 Geographical Setting

The site is located in the western portion of the South Pass Area of the northern Gulf of Mexico. It is approximately 11.4 kilometers south of the Southwest Pass of the Mississippi River and is located 108 meters inside the Safety Fairway. Near-surface geology and seafloor morphology in the region is strongly influenced by rapid deposition of deltaic sediments from the Mississippi River. The survey area is on the flanks of the delta platform approximately 11 kilometers southeast of the modern delta. High suspended sediment loads and similarly high rates of sediment deposition have constructed the modern Belize Delta over the last 1000 years and accumulated 90 to 120 meters of Holocene sediments (Coleman et al. 1991). There is a high sedimentation rate in this area of approximately 1 centimeter per year. The reported sediment type in this region is composed of clayey silt (USDI MMS 1978), which is consistent with the sediment recovered from the core samples taken at the site. The seafloor near the shipwreck site has a low gradient slope of approximately 0.4 degrees toward the south-southeast. A kilometer north and south of the shipwreck the slope gradient increases to as much as 2.6 degrees.



ROV CONTACTS

NO.	DESCRIPTION	TIME	NO.	DESCRIPTION	TIME
1	(SEAFAN)	21:40	16	BOW	2:16
2	STERN WRECK	23:36	17	LARGE TRAP DEPLOYMENT 1000FT	8:13
3	DEBRIS	0:14	18	SMALL TRAP DEPLOYMENT 1000FT	8:46
4	HOLES IN HULL	0:23	19	CORE SAMPLE D 1000FT	9:12
5	CORAL	0:28	20	250 LOCATION	10:52
6	HOLE	0:31	21	LARGE TRAP AT WRECK	11:51
7	CORAL	0:42	22	CRAB TRAP	12:50
8	BASKET STARFISH	0:55	23	SMALL FISH TRAP	13:11
9	ANEMONE	1:11	24	BRANCHING CORAL	16:57
10	SUPERSTRUCTURE-FORWARD	1:22	25	QUICK FIX	21:45
11	CORAL	1:30	26	BASKET LOCATION	0:08
12	RUST	1:57	27	CORE A	13:39
13	NETS	2:01	28	CORE B	14:07
14	VENT	2:06	29	CORE C	14:33
15	BOLLARD PORT SIDE	2:12	30	CORE D	15:13

ALL TIMES WERE RECORDED ON JULY 30 – AUGUST 1, 2004

Figure 4.4. *Virginia* site overview map.

Table 4.1

ROV Navigation Fix Points at *Virginia*

No.	Description	Corrected Time
1	Seafan	21:33
2	Stern Wreck	23:36
3	Remains Of Net	0:15
4	Holes in Hull plates	0:23
5	Coral	0:29
6	Window Opening Or Possible Hatch	0:32
7	Coral	0:42
8	Basket Starfish	0:57
9	Anemone	1:13
10	Superstructure-Forward	1:22
11	Coral	1:32
12	Possible Rust/Steel Sample	1:57
13	Nets	2:00
14	Possible Ventilation Cowl	2:06
15	Bollard Port Side	2:13
16	Bow	2:16
17	Large Trap Deployment 1000'	8:12
18	Small Trap Deployment 1000'	8:48
19	Core Sample D 1000'	9:13
20	250 Location	10:52
21	Large Trap at Wreck	11:51
22	Crab Trap	12:53
23	Small Fish Trap	13:14
24	Branching Coral	16:57
25	Quick Fix	21:45
26	Basket Location	0:08
27	Core A	13:39
28	Core B	14:07
29	Core C	14:33
30	Core D	15:13

4.4 Discussion of Archaeological Findings

4.4.1 Physical Site

The following wreck site description is based on fieldwork from 2004. The investigation was conducted with the Triton X11 ROV from July 30 to August 1, 2004. Site visibility was extremely poor, ranging from two meters over the shipwreck, and higher in the water column to less than half a meter near the seafloor. The average visibility during the project was approximately one meter.

The wreck site is oriented with the bow pointing northwest and stern southeast (Figure 4.4). Average water depth at the wreck is approximately 87 meters BSL. The site has approximately 14.6 meters of relief above the seafloor. Most of the superstructure is badly deteriorated with biofouling making many features difficult to identify. The bridge structure is gone, but the bridge telegraph remains *in situ* (Figure 4.5). The telegraph's handle is in a slightly forward position, likely indicating the engines were in "stand by" mode. The evidence is consistent with historical accounts stating *Virginia* was stationary awaiting a pilot when attacked, and that the engines were not engaged during the attack.

Limited usable video was obtained inboard on the wreck because of safety concerns. Nets, cables, and other debris represent entanglement hazards to the ROV. Low visibility restricted the ROV pilots' ability to see these hazards. The entanglement risk prevented the ROV from being flown close enough to collect clear video of most of the inboard parts of the vessel.

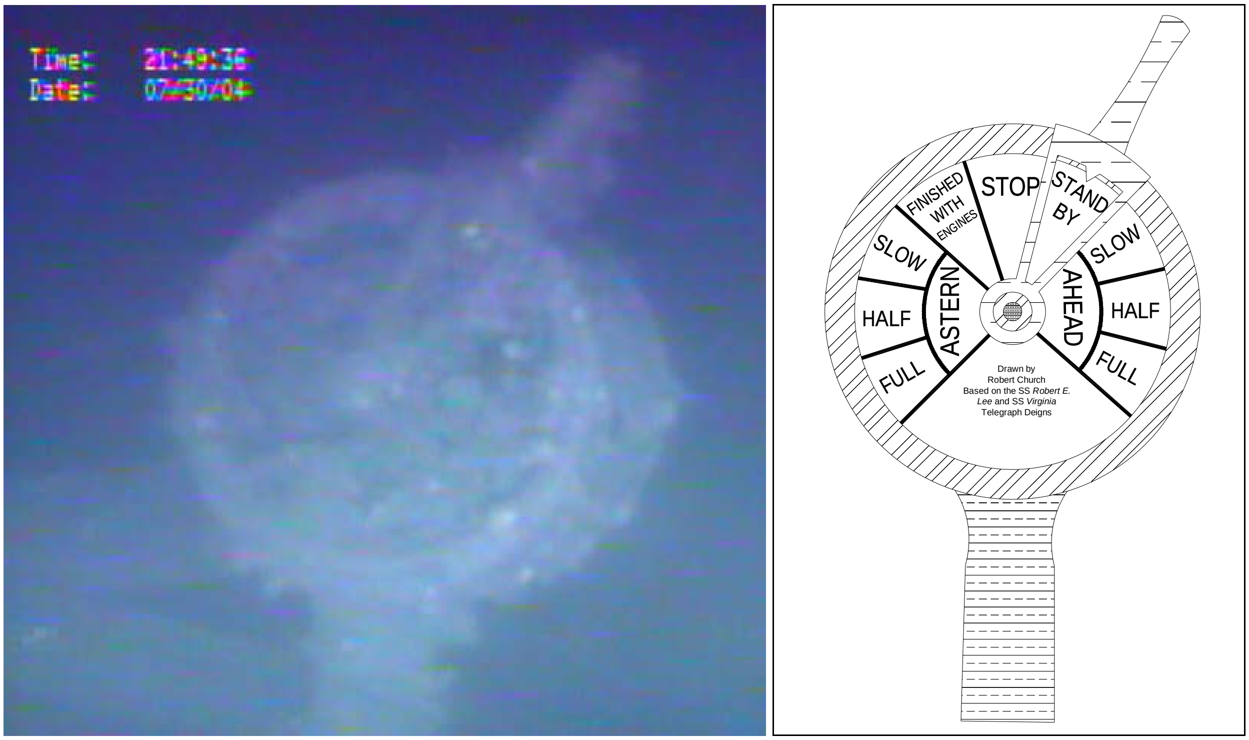


Figure 4.5. Starboard side of *Virginia's* bridge telegraph (left). Drawing indicates the handle's position (right).

Virginia's bow stands approximately 12 meters above the seafloor. There are fishing and/or shrimp nets wrapped around a vent on the port side of the forecastle. The bow appears to be reasonably intact except at the prow. There is damage at the bow that is not described in any of the historical accounts of the sinking (Figure 4.6). On the port bow, just beneath where the port bow hawsehole should be, there is a lateral indentation approximately 1.8 meters in length. The port bow hawsehole and a large section of the bulwarks on the port and starboard bow are missing. The starboard bow hawsehole is still present, but the starboard bulwarks are absent. It is possible this damage occurred after the sinking event. It appears the bow was struck by a heavy object that caught in the port hawsehole ripping it, and a large section of the bulwarks off the wreck. If this is a post-sinking event, it is relatively old damage based on the extensive befouling on the damaged regions. Since the wreck is inside a major safety fairway for large ships, it is possible an anchor or similar object from a large vessel caused this damage.

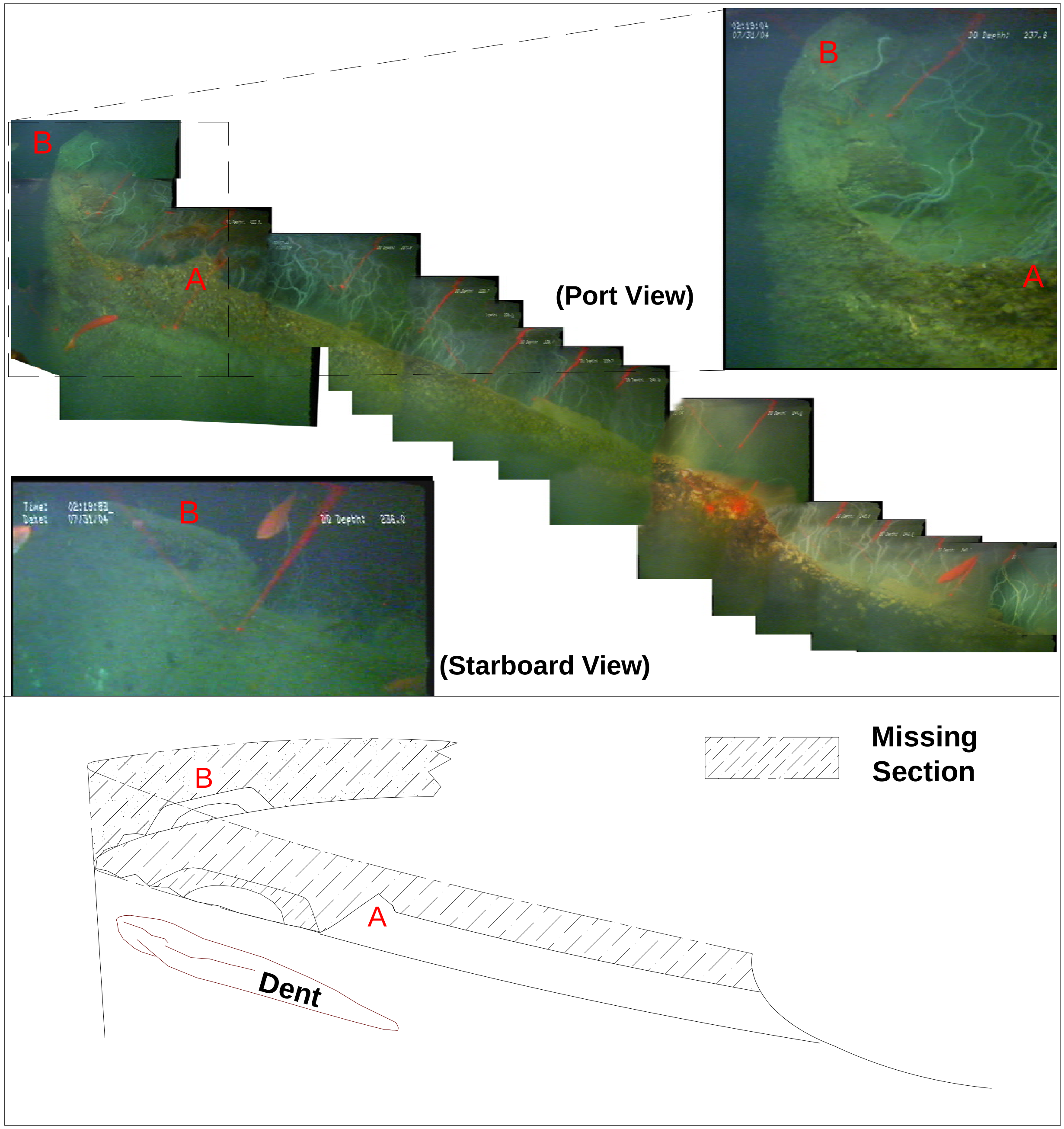


Figure 4.6. Photo mosaic of *Virginia*'s bow (top panel) with close-up of the damaged area (upper right – top panel) and close-up of the starboard bow hawsehole from a starboard view (lower left - top panel). The lower panel is an artistic representation of the bow highlighting the missing section. "A" = Point of torn jagged metal, and "B" = starboard hawsehole (Illustration by Robert Church).

The vessel's stern exhibited approximately 8 meters of relief above the ambient seafloor. The stern section is badly damaged. The aft deckhouse is a collapsed tangle of bent and broken metal. There are several nets ensnared over this section of the vessel, particularly on the port side, which make it difficult to assess this stern portion of the wreck.

There was almost no scattered debris recorded near the wreck site except materials lying next to the hull that have dislodged as a result of post-sinking deterioration or disturbance. An area survey was not attempted because of the restricted visibility. The single sonar contact and magnetic anomaly recorded during the 2003 geophysical survey were investigated but no debris was found at either location. Given the violent nature of the sinking of *Virginia*, debris should be scattered around the main hull wreckage. It is possible that the high sedimentation rate, paired with limited visibility obscured debris. Light wreckage dislodged from the vessel at the time of sinking may be buried under 0.3 meters of sediment, or may have been dragged away by trawling activities. It is also possible the vessel was torpedoed in a different location than where it finally settled to the bottom or that the wreck has moved down slope during periodic storm and mudslide events.

The unidentified sonar contact and three magnetic anomalies recorded approximately 1.5 kilometers south of the shipwreck during the 2003 geophysical survey were investigated during this study. At the location of one of the magnetic anomalies, three large seafloor depressions were observed. According to the 2003 data, the magnetic anomaly at this location had an amplitude of 3 gammas with a 71.6-meter duration. The depressions have vertical sides and measure approximately 6 meters square and 3.5 meters deep. The first two depressions are located 40 meters apart and the third was located 21 meters from the second. The depressions are located 600 meters outside the Safety Fairway. The depressions could have been produced by a jack-up rig leg or something similar, but are not likely related to the *Virginia*. No debris was located at either of the magnetic anomalies or sonar contact positions recoded from the 2003 survey.

4.4.2 Site Preservation

The wreck site is in a poor state of preservation. The most severely damaged areas are the main superstructure's upper area, the stern deckhouse, and the prow of the vessel. The limited visibility caused some incidental contact with the vessel by the ROV. These contacts, although seldom, made apparent the fragile nature of the hull. In addition to natural chemical and biological deterioration, the site's relatively shallow water depth has inadvertently subjected the vessel to periodic disturbances from other maritime activities. These activities have adversely impacted the site by causing unintentional damage.

4.5 Discussion of Biological Findings

4.5.1 Microbiology

Virginia lies in the South Pass Area at a depth of 87 meters BSL, in waters teeming with dense fish populations and turbid eutrophic waters. As a result, the visibility was challenging and it was impossible to survey the intensity of the attached microbial growth on this ship. Only general observations were possible given the conditions in which only the ship's telegraph could be quantified to some extent. From the limited images it appears the attached microbial growth was dominated by C3, a light brown relatively amorphous growth with dendritic edges and appeared to extend out from the hull. The gravimetric composition of a C1 rusticle recovered from *Virginia* is shown in Table 4.2. Here the dominant elements were iron (94%), sodium (3.6%), calcium (1.1%), and magnesium (0.3%).

Table 4.2

Gravimetric Elemental Composition of a (C1) Rusticle from *Virginia*

Iron	94.3910%		Molybdenum	0.0169%
Sodium	3.6516%		Vanadium	0.0083%
Calcium	1.1265%		Cadmium	0.0074%
Magnesium	0.3445%		Lead	0.0065%
Potassium	0.2411%		Boron	0.0033%
Aluminum	0.0810%		Barium	0.0016%
Phosphorus	0.0586%		Titanium	0.0016%
Manganese	0.0344%		Zirconium	0.0012%
Strontium	0.0241%		Chromium	0.0005%

Evaluation of the images of *Virginia* revealed the entire ship was coated with a 10 to 15 millimeter coating of C3 dense dendritic concretions routinely overlain with a 5 to 10millimeter layer of B1 biofilm [slime]. This created a brown fluffy surface area that was loose, probably with a high organic matter that may explain the extensive shoals of fish observed. Brown rusticles (C1) were observed mostly emerging through the C3-B1 growths and hanging down over one percent of the observed surface area. These were generally small ranging in length from 10 to 70millimeters and widths from 5 to 30 millimeters. No white rusticles (C2), concretions (C4), or blobs (B2) were observed. Likewise, an insignificant number of sea anemones were detected.

4.5.2 Invertebrate Zoology

High turbidity at the *Virginia* site prevented identification of macroinvertebrate species from video transects and hindered collections of specimens near and away from the site. Six video transects, three over the site, and three away from the site (300 meter) were conducted, totaling an area of 1539.8 m^2. The area surveyed over the *Virginia* was higher (1007 m^2 in comparison to 532.8 m^2 away from the site) because the average height of the transects was higher. Large numbers of nektonic (swimming) crustaceans could be observed in many of the video transects (that were not among those quantified), but whether the organisms were natant decapod crustaceans, mysid shrimp, euphausiids, or a mix of crustacean taxa, could not be determined. In one video transect away from the site (VI-10, not quantified), an unknown number of unidentified squid were observed. Because of the poor visibility, our characterization of the invertebrate fauna at this site should be considered as incomplete. The average depth at the *Virginia* was 87 meters BSL, but collections were made with the ROV from 70 to 85 meters BSL. This shallow site had the warmest water temperature (20.5 °C), high salinity (36.4), and relatively high dissolved oxygen (almost 6 mg l^{-1}). These hydrographic conditions should not be stressful for most invertebrate taxa.

Table 4.3

Density (number per 100 m^{-2}) of Invertebrates
Observed on Transects Over and Distant (300 m) from the *Virginia* Site.

	Transect Number					
	Distant			**Over**		
Virginia	**300**	**301**	**302**	**321**	**322**	**323**
Mollusks						
Unidentified mollusk	0.0	0.0	0.0	0.0	0.0	0.3

Sediment in the meiofauna samples was predominantly (>90 to 95%) silt and clay. A considerable amount (5-10%) of the sediment was biogenically reworked into fecal pellets, probably by deposit feeding polychaets. Almost no other shell material or substrate was present other than silt or clay, and the same sediment in pellet form. The only macrofauna encountered were very small polychaets, juvenile tanaidaceans, and caudofoveatan mollusks, all of which are included as meiofauna. Three of the four meiofauna cores averaged almost 1200 nematodes per 10 cm^2 suggesting that core A, closest to *Virginia*, was in some way compromised (Table 4.4). However, the number of harpacticoid copepods found in core A was similar to those found in the other cores. Polychaets, which are often approximately equal numerically to harpacticoids, were substantially more abundant and present in all cores than the harpacticoids. Two individuals of *Scutopus* sp., worm-like mollusks covered with calcareous spicules, which belong to the class Caudofoveata, an unusual class of Mollusca which are included in the class Aplacophora (commonly called solenogasters) by some authors, were found in two separate cores. Our specimens closely resemble those illustrated by Treece (1979) from the continental shelf of the south Texas coast. Treece provided excellent scanning electron micrographs of four aplacophoran species, but did not provide depths or locations of his collections, and also did not describe the species. A few miscellaneous other taxa, including kinorhynchs, gastrotrichs, ostracods, and even a recently metamorphosed ophiuroid, were found in the cores in low numbers.

Table 4.4

Density of meiofauna (numbers per 10 cm^2) from Sediment Cores Collected Adjacent to (Core A) and Progressively More Distant (Cores B to D) from *Virginia*.

Wreck	***Virginia***			
	Number per 10 cm^2			
Taxon	Core A	Core B	Core C	Core D
Harpacticoida	3.6	7.3	3.6	12.7
Nematoda	18.1	1171.3	1057.0	1367.1
Gastrotricha	0.0	0.0	3.6	0.0
Kinorhyncha	0.0	0.0	0.0	3.6
Ostracoda	1.8	0.0	0.0	0.0
Polychaeta	27.2	9.1	12.7	38.1
Polychaeta *Cossura* sp.	0.0	3.6	0.0	0.0
Mollusca - *Cyclostremella humulis*	1.8	0.0	0.0	0.0
Mollusca - *Scutopus* sp.	0.0	0.0	1.8	1.8
Ophiuroida	0.0	0.0	0.0	1.8

Table 4.5

Crustaceans, Mollusks, and Polychaets Collected from The *Virginia* Site.
(The collection of specimens listed as 'found in sediment' or 'in basket' were found within the ROV basket and are from unknown specific locations and depths; the depth range over which the ROV collected is listed.)

Virginia					
Specimen ID	**Number Near Wreck (< 61 m)**	**Number far from wreck (>61 m)**	**Unknown collection location**	**Substrate**	**Depth (m)**
Crustacea					
Alpheus sp.			2 in sediment		70-85
Munidae			1 in sediment		70-85
Xanthidae			1 in basket		70-85
Unidentified Barnacle			2 in sediment		70-85
Unidentified Shrimp			2 in sediment		70-85
Mollusks					
Siratus beauii	3			Silt	84
Pteria sp.	1			Wreck	70-85
Cancerellidae	1			Silt	84
Cephalopoda		1		Silt	83
Chama sp.	1			Wreck	70-85
Unidentified Mollusk			1 in sediment		70-85
Polychaeta					
Amphinomidae	1			Wreck	71

Identification and quantification of specimens at the *Virginia* site is restricted to those collected by the ROV (Table 4.5); many of these specimens were inadvertently collected and are from unknown locations, hence are listed as being 'in basket' or 'in sediment' within the basket of the ROV; poor visibility in the videos prevented the determination of exact locations or depths of collections. Many of the specimens are incomplete or damaged and identification to species could not be determined for most. Sixteen specimens belonging to 11 taxa were found near *Virginia*; five crustacean taxa, one polychaet (an amphinomid polychaet, or fireworm), and six mollusk (gastropods and bivalves) taxa were collected. *Siratus beauii* (Fischer and Bernardi, 1857) or Beau's murex (Fig. 4.7) is a common offshore gastropod in the Gulf of Mexico, reported from 201 to 366 meters depth (Information provided with the permission of The Academy of Natural Sciences, Philadelphia, PA; Online Biodiversity Databases); our collection at 84 meters is unusually shallow for this species. The *Pteria* sp. and *Chama* sp. (both closely related to oysters) were attached to the wreck. Both species require hard substrate for attachment and their ranges are probably limited by substrate availability. The *Pteria* sp. from this site appear similar to, but are not, the Atlantic wing oyster *Pteria colymbus* (Roding, 1798) which occurs from North Carolina through the West Indies to Brazil, and also in Bermuda, however *P. colymbus* is commonly found in shallow waters and sea grass beds only a few meters in depth. A single cephalopod mollusk (octopus) was found away from the wreck and is unidentifiable. Five shrimps, two crabs, a barnacle, and an unidentified mollusk were found in the ROV collection basket or in sediment from unknown locations near or around the site; specimens were collected between 70-85 meters depth.

Figure 4.7. *Siratus beauii* found on the *Virginia* wreck (Photo by Morgan Kilgour and Aaron Baldwin).

Scleractina, Antipatharia, and Gorgonacea

Very poor visibility, caused by high concentrations of suspended particulate material in the water column, prevented adequate examination and video documentation of this site. Consequently, the following description of the occurrence and distribution patterns of the Scleractina, Antipatharia, and Gorgonacea found on the tanker *Virginia* should be considered only a partial characterization of this wreck. Bottom water depths at this site are on the order of 87 meters and the hydrographic conditions measured at the time of the survey were: temperature ~20.5º C; salinity ~36.4 psu; and dissolved oxygen ~5.6 mg l^{-1}. All depths reported in the following text are the uncorrected ROV readings displayed on the video recordings.

Four scleractinians (*Madracis myriaster*, *Oculina varicosa*, *Paracyathus pulchellus*, and *Pourtalosmilia conferta*), two antipatharians (*Antipathes furcata* and *Stichopathes sp.* cf. *S. pourtalesi*), and one gorgonian (*Muricea pendula*) were collected from *Virginia* (Table 4.6). A noteworthy initial observation is that available surfaces on this wreck generally appeared to be either relatively densely colonized with combinations of these fauna or have had little or no colonization of these fauna at all.

Table 4.6

List of Scleractinia, Antipatharia, and Gorgonacea
Found on the Tankers *Virginia*, *Halo* and *Gulfpenn*.

The Scleractinia were identified by Steve Cairns, the Antipatharia by Dennis Opresko, and the Gorgonacea by Ted Bayer. All species, except *Oculina varicose*, have previously been reported from the Gulf of Mexico (see text).			
	Virginia	***Halo***	***Gulfpenn***
Scleractinia			
Lophelia pertusa (Linnaeus, 1758)			**X**
Madracis myriaster (Milne-Edwards and Haime, 1849)	**X**	**X**	
Oculina varicosa Lesueur, 1821	**X**		
Paracyathus pulchellus (Philippi, 1842)	**X**		
Pourtalosmilia conferta Cairns, 1978	**X**	**X**	**X**
Antipatharia			
Antipathes furcata Gray, 1857	**X**		
Stichopathes sp. cf. *S. pourtalesi* Brook, 1889	**X**		
Gorgonacea			
Muricea pendula Verrill, 1864	**X**		
Placogorgia rudis Deichmann, 1936		**X**	
Thesea sp. cf. *T. grandiflora* Deichmann, 1936		**X**	
Thesea sp. cf. *T. rubra* Deichmann, 1936		**X**	
Thesea sp.		**X**	
Unidentified Spices (from video record)		**X**	

The dominant species, in terms of numbers and possibly biomass, was the black wire coral *Stichopathes sp.* cf. *S. pourtalesi*. These whitish, slightly to moderately coiled monopodial colonies, up to 82 centimeters long, were observed attached mostly to horizontal to near-horizontal surfaces (Figure 4.8). From the video records it cannot be determined if one or more species are present, but from gross morphology and coloration characteristics it appears only one species is represented. If it is confirmed as *Stichopathes pourtalesi* then this will not be a new species to the Gulf of Mexico (NMNH Taxonomic Database 2003). Colonies were found throughout the wreck often in large field-like assemblages frequently attaining densities estimated at 400-500 colonies per square meter. In a few areas, for example on the forecastle deck, it appears that extremely dense concentrations have developed on the order of 80-100 colonies per 0.1 square meter (Figure 4.8). This closely spaced configuration of colonies can result in an open, loosely constructed vertical complex extending as much as 20-30 centimeters above the attachment surface that also includes a partial canopy formed when the top portions of the longer colonies lean over into a more horizontal plane (Figure 4.9).

Figure 4.8. *Stichopathes sp.* cf. *S. pourtalesi* black wire coral.

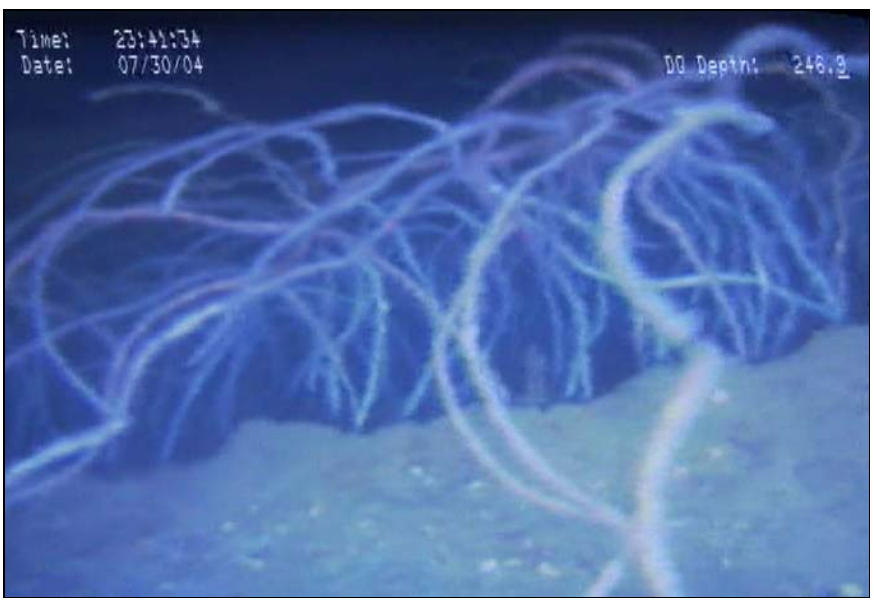


Figure 4.9. Extremely dense concentrations of *Stichopathes sp.* cf. *S. pourtalesi*.

The other antipatharian, the densely branched, fan-shaped black thorny coral *Antipathes furcata* (Figure 4.10), was also found throughout the wreck. Colonies, up to 30 centimeters tall, were observed attached to both horizontal and vertical surfaces as solitary individuals and in small, patchy, closely spaced clusters (Figure 4.11) often in association with the *Stichopathes sp.* cf. *S. pourtalesi* assemblages (Figure 4.12). *Antipathes furcata* has previously been reported from the Gulf of Mexico (Cairns et al. 1993; NMNH Taxonomic Database 2003).

Figure 4.10. The densely branched, fan-shaped, black thorny coral *Antipathes furcata*.


Figure 4.11. Small cluster of *Antipathes furcata*.

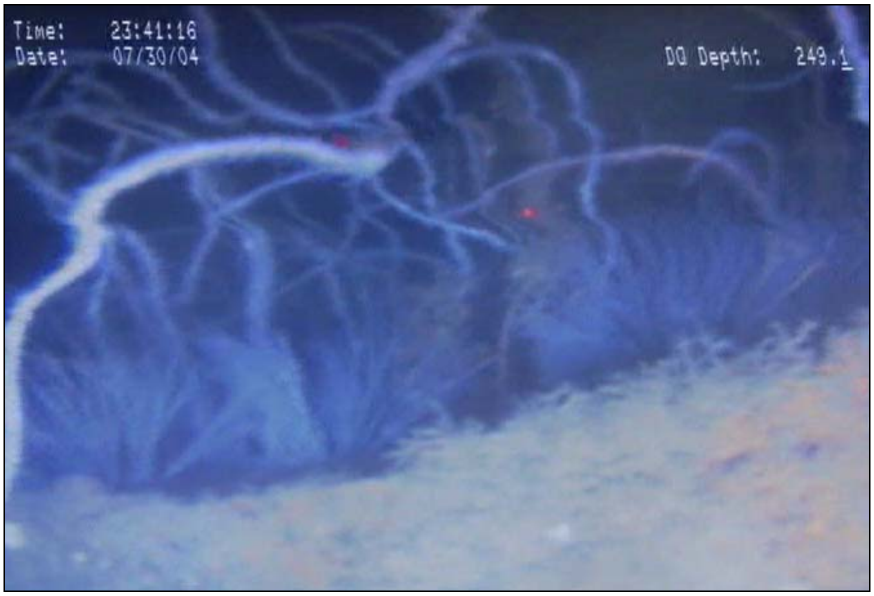


Figure 4.12. *Antipathes furcata* in association with a *Stichopathes sp.* cf. *S. pourtalesi* assemblage.

Colonies of two of the scleractinian corals, *Madracis myriaster*, the striate finger coral, and *Pourtalosmilia conferta* were observed throughout the wreck attached to all structure and surface types. *Madracis myriaster* was found to be present in two very different forms. The most common form was consistent with previous descriptions of this species (Cairns 1979, 2000); a robust, bushy, firmly attached colony usually irregularly branched, resulting in frequent anastomosis (Figure 4.13). It was observed to occur as isolated colonies (up to 12-15 centimeters across), small groups of aggregating colonies, and large clusters of both living and dead coral (Figure 4.14): some up to 95-100 centimeters in breadth. The other less common form, not found described in the literature, has a sturdy, thick, irregular shaped corallum with sunken corallites and clavate-like branches (Figure 4.15). This 'fat' form appears to develop into smaller colonies, up to 18-20 centimeters in breadth, with lower profiles. *Pourtalosmilia conferta* forms densely branched colonies up to 30 centimeters in height and diameter. A very compact and reinforced corallum is formed by the elongated and laterally anastomosing corallites (see Figure 4.16 and Cairns 1978). Both species are known to occur in the Gulf of Mexico (Cairns 1978, 2000).

Figure 4.13. A piece of a *Madracis myriaster* colony.

Figure 4.14. Colonies of *Madracis myriaster* and *Pourtalosmilia conferta* on a standpipe

Figure 4.15. An example of the sturdy, thick, irregular shaped form of *Madracis myriaster* with sunken corallites.

Figure 4.16. Examples of *Pourtalosmilia conferta*.

Three of the species collected, the ivory tree coral *Oculina varicosa* (Figure 4.17), the papillose cup coral *Paracyathus pulchellus* (Figure 4.18) and the drooping Muricea *Muricea pendula* (Figure 4.19), are represented by only one colony or an aggregate of colonies or one individual. What is either a single, large white colony of *O. varicosa* or a coalescing aggregate of two or more colonies (the poor visibility did not permit an unequivocal determination to be made from the video), measuring over 150 centimeters across and 140-150 centimeters in height, was found amidships near the top of the main superstructure at a depth of approximately 73 meters (Figure 4.20). This is the first confirmed occurrence of *O. varicosa* in the Gulf of Mexico, although it has previously been identified from video and photographic records on natural substrate and offshore gas production facilities in the eastern Gulf of Mexico (John Reed, personal communication). The water depth and hydrographic conditions at *Virginia* fall within the ranges reported for *O. varicosa* on the east coast of Florida (Reed 1980, 1981).

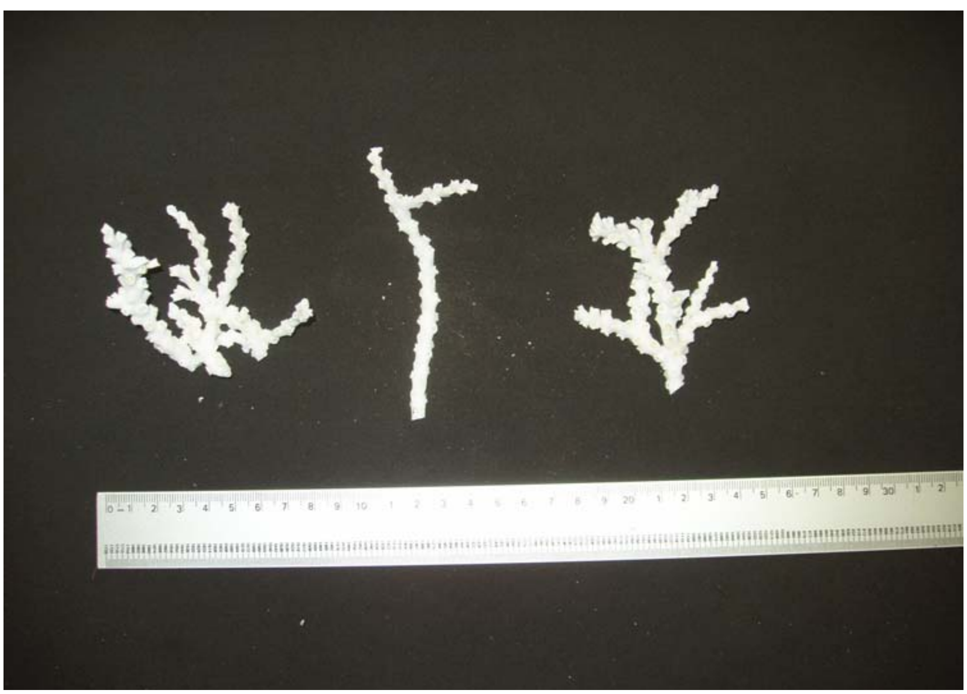


Figure 4.17. Examples of *Oculina varicosa*.

Figure 4.18. The cup coral *Paracyathus pulchellus*.

Figure 4.19. Section of a branch from a colony of *Muricea pendula*.

Figure 4.20. *Oculina varicosa* colony near the top of the main superstructure at a depth of ~73 m.

Nearby, colonizing the top of the main superstructure at a depth of approximately 71.0 meters, was a large white colony of *M. pendula* measuring approximately 91 centimeters across and 63.5 centimeters high (Figure 4.21). *Muricea pendula* is known to occur in the Gulf of Mexico, but this is the deepest it has been collected (NMNH Taxonomic Database 2003). The only cup coral recovered in the entire survey, *P. pulchellus*, was a small torchoid shaped specimen measuring 7.9 x 9.2 millimeters in calicular diameter, 10.5 millimeters high, and 4.9 millimeters in pedical diameter (Figure 4.21). It was found among the miscellaneous debris that accumulated in the sample collection box during attempts to collect fish and other invertebrates: therefore, the collection location is unknown. This species is also known to occur in the Gulf of Mexico (Cairns 1979; and 2000).


Figure 4.21. Large *Muricea pendula* colony on top of the main superstructure at a depth of ~71.0 meters.

4.5.3 Vertebrate Zoology

Fish Community Structure

Visibility was very poor at the *Virginia* site, which negatively affected video sampling the fish community. The mean visible width of transects was approximately 2 meters over the ship and was even lower away from the wreck (Table 3.4). Transects over the wreck were flown at a relatively high altitude such that the wreck frequently was out of view. No transects were flown immediately adjacent to the wreck due to poor visibility. Therefore, interpretation of ichthyofauna data collected from video at this site must be done with the caveat that it is unlikely data accurately reflect the fish community present.

The fish community observed in video collected from transects over the wreck was dominated by vermilion snapper (*Rhomboplites aurorubens*) (Tables 4.7 - 4.10; Figure 4.22-a). (Note: Vermilion snapper appeared to follow the ROV, thus density estimates derived from their min counts were used in statistical analysis of community structure.) In some cases, fish observed over the wreck obviously were Lutjanids, but species identification could not be made. Red snapper (*Lutjanus campechanus*) were caught in traps and observed in video, but none were observed during biological transects (Tables 4.7 – 4.9; Figure 4.22-b). Vermilion and red snappers were the only fishes captured in traps set next to the wreck (Table 4.10). These species are among the most common reef fishes on hardbottom habitats in the northern Gulf, but is unlikely they were the only fishes associated with the wreck. Low dissolved oxygen on the Louisiana shelf can limit fish biomass, but during our sampling dissolved oxygen was measured to be nearly 6 mg l^{-1}. It seems more likely that poor visibility resulted in underestimation of the diversity of fishes present during biologic transects. In fact, several other reef, benthic, and demersal fishes, such as scamp (*Mycteroperca phenax*; Figure 4.23-a) and spotted soapfish (*Rypticus maculatus*; Figure 4.23-b) were observed during other sampling at *Virginia*, but only when small areas of less turbid (higher visibility) water was encountered (Table 4.8; Figure 4.22-b).

Table 4.7

Abundance and Density Estimates for Fish Taxa Identified from ROV Video From Biological Transects Over, Adjacent to, and 300 Meters Away from (distant) the *Virginia*.

Transect Line	Relation to Ship	Taxon	Min Count	Max Count	Min Density 100 m^{-2}	Max Density 100 m^{-2}
321	Over	*Rhomboplites aurorubens*	14	769	3.92	215.21
		Lutjanidae	19	689	5.32	192.82
		Perciformes	1	6	0.28	1.68
322	Over	*Rhomboplites aurorubens*	19	585	5.31	163.41
		Lutjanidae	21	515	5.87	143.86
323	Over	*Rhomboplites aurorubens*	27	678	9.25	232.22
		Lutjanidae	29	127	9.93	43.5
300	Distant	Teleost	1	1	0.54	0.54
301	Distant	*Trichiurus lepturus*	1	1	0.54	0.54
		Teleost	1	2	0.54	1.08
302	Distant	*Trichiurus lepturus*	1	1	0.54	0.54
		Centropristis sp.	1	1	0.54	0.54
		Teleost	1	6	0.54	3.24

Table 4.8

Abundance of Fish Taxa Identified from ROV Video at *Virginia*
From Sampling Other than Biological Transects.
Location Indicates if Video was Collected Over or Away from the Ship.

Location	**Taxon**	**Min Count**	**Max Count**
Over Ship	*Caranx crysos*	1	1
	Lutjanus campechanus	2	79
	Mycteroperca phenax	1	44
	Opsanus pardus	1	3
	Pogonias cromis	1	1
	Rhomboplites aurorubens	20	5,728
	Rypticus maculatus	2	16
	Trichiurus lepturus	2	101
	Lutjanidae	11	1,963
	Serranidae	1	6
	Trichiuridae	1	3
	Perciformes	3	128
	Teleost	2	40
Away from Ship	*Caranx crysos*	1	2
	Trichiurus lepturus	3	45
	Trichiuridae	1	1
	Pleuronectiformes	1	1
	Teleost	1	1

Table 4.9

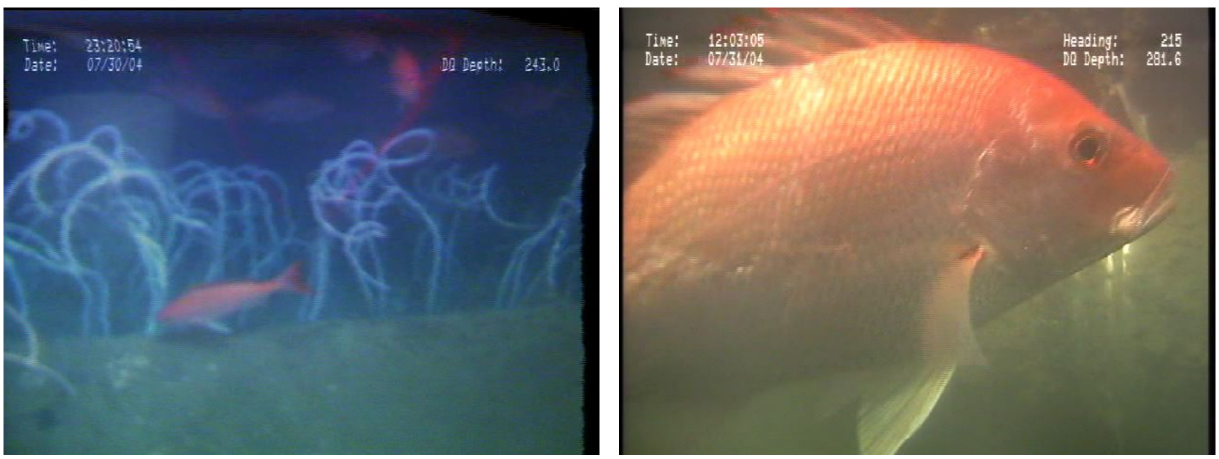
Estimated Total Fish Lengths Observed on ROV Video at the *Virginia* Site
with Both ROV-mounted Lasers Striking Them.

Taxon	**Number Measured**	**Mean TL mm**	**Standard Deviation**	**Range TL mm**
Rhomboplites aurorubens	74	522	101.3	318-683
Pogonias cromis	1	363		
Serranidae	1	342		

Table 4.10

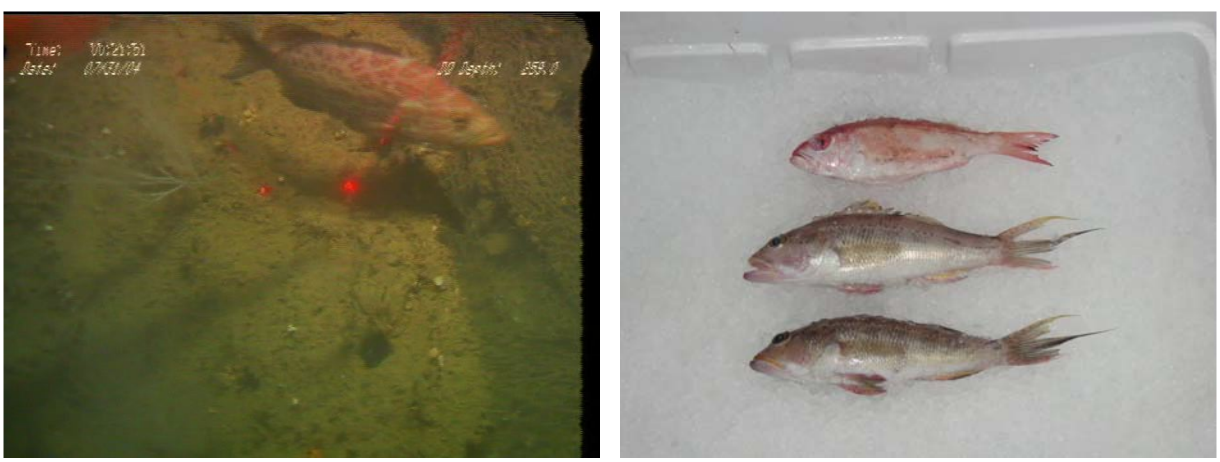
Fish Taxa Caught in Chevron (large) and Baitfish (small) Fish Traps Deployed Adjacent to (wreck) and 300 meters Away from (distant) *Virginia*.

Trap Type	Location	Species	Number
Large	Distant	*Centropristis philadelphica*	2
		Ophichthus rex	5
		Rhomboplites aurorubens	1
Large	Wreck	*Lutjanus campechanus*	7
		Rhomboplites aurorubens	2
Small	Distant	*Centropristis philadelphica*	1
		Ophichthus rex	1
		Rhomboplites aurorubens	1



(a) (b)

Figure 4.22. (a) A vermilion snapper and (b) a red snapper associated with the *Virginia*.



(a) (b)

Figure 4.23. (a) A scamp associated with the *Virginia* and (b) rock sea bass and vermilion snapper samples collected in fish traps.

Diet and Trophic Structure

Stomachs were dissected from 15 fish sampled at the *Virginia* site; 12 (80%) had food items present (Fig. 4.24). Gut content analysis indicated fish constituted a significant percentage of recent bank sea bass (*Centropristis philadelphica*), vermilion snapper, and red snapper diets. (Note: King snake eels from the *Virginia* were returned to the water alive). Several invertebrate taxa, however, also were present in the diets of all three fishes.

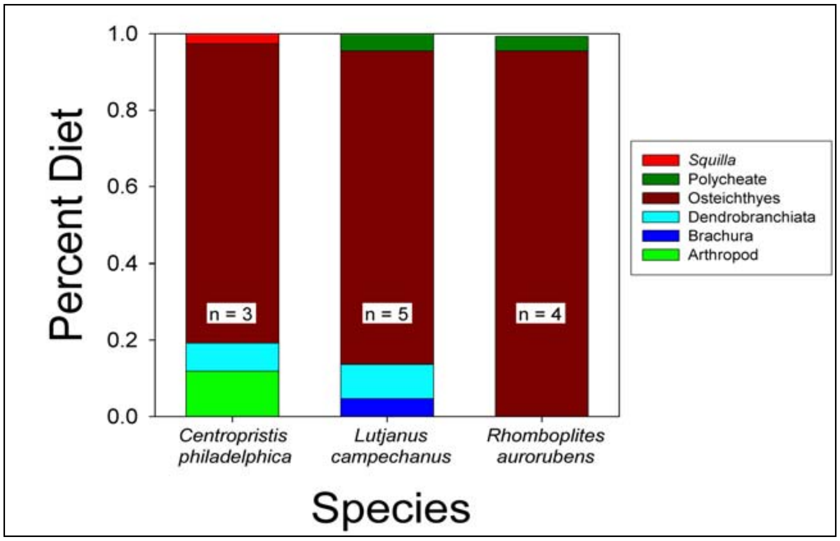


Figure 4.24. Prey taxa contribution to diets of fishes sampled at *Virginia*. Sample sizes indicated for each species.

Stable isotope analysis revealed trophic level and production source for vermilion and red snappers and rock sea bass. Rock sea bass displayed the least variance in $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values among individuals (Figure 4.25). Their stable isotope values indicated feeding on invertebrates ($\delta^{13}C$ and $\delta^{15}N$ each enriched approximately two trophic levels from primary production) and a benthic rather than pelagic production source ($\delta^{34}S$ depleted relative to phytoplankton). Vermilion snapper had some variance in $\delta^{13}C$ values, but their $\delta^{15}N$ values confirmed a similar, but somewhat lower trophic level than rock sea bass. Vermilion snapper are known to feed on pelagic zooplankton and invertebrates, and their $\delta^{34}S$ values were consistent with a pelagic production source. Red snapper fed at the highest trophic level among fishes sampled at the *Virginia* site. All red snapper had $\delta^{13}C$ and $\delta^{15}N$ values a full trophic level higher than vermilion snapper. The majority also had $\delta^{34}S$ values indicating a mostly benthic source of production.

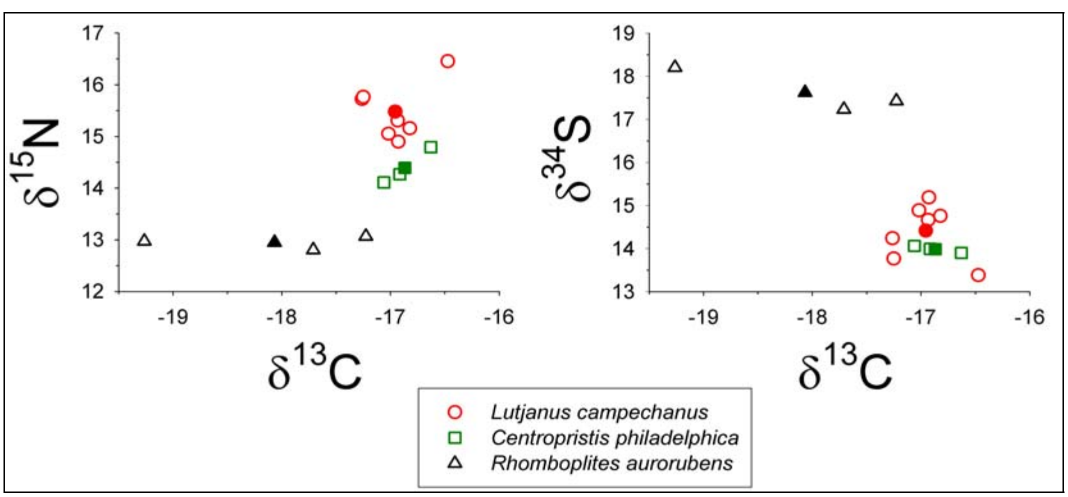


Figure 4.25. Results of stable isotope analysis of fish muscle samples collected during biological sampling at *Virginia*. Filled symbols are species-specific mean values.

Age Estimation

Opaque zones were counted in otolith sections prepared from 15 fish collected at the *Virginia*. Of the three species sampled, opaque zones have been validated as annuli for red and vermilion snappers (Allman et al. 2001; Patterson et al. 2001a and 2001b). While opaque zones in rock sea bass otoliths have not been validated as annuli, validation has been performed for the congener black sea bass (Centropristes striata) and there is no reason to believe rock sea bass otoliths do not form annual opaque zones (Hood et al. 1994). Therefore, opaque zone counts were taken as age estimates for all three species (Figure 4.26). The oldest fish were eight year-old rock sea bass, which were much smaller at age than a six year-old red snapper. All vermilion snapper samples were estimated to be one year-olds; however, only small individuals were caught in traps and it is likely most vermilion snapper present at the *Virginia* site were considerably older than one year (Table 4.9, Figure 4.26).

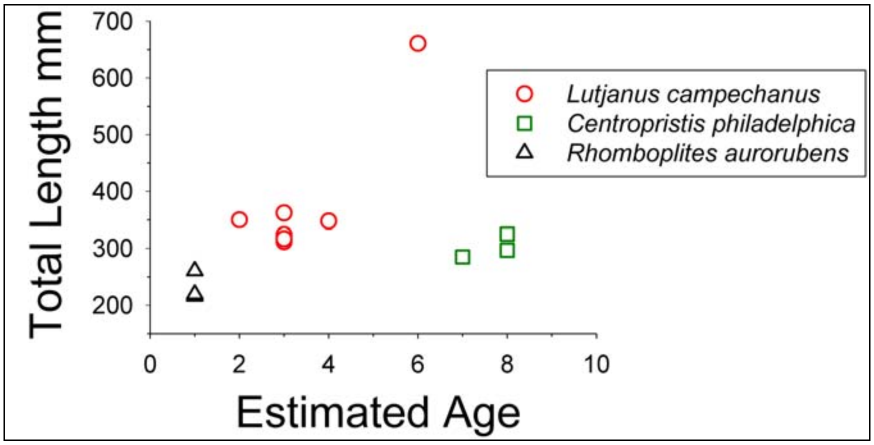


Figure 4.26. Total length versus estimated age (sagittal otolith opaque zone counts) in three reef fish species collected at the *Virginia*.

4.6 Sediment Core Analysis

Four samples were taken at the designated distance from the ship structure. Each sample, after surfacing was removed from the sampling device and stored in a clean glass container at approximately 4° Celsius. The *Virginia* site's core samples did not indicate any visible differences. They all appeared to be smooth, grey/black sediment with a sour smell. The sour smell is indicative of the anaerobic biological activity (sulfate reduction) normally found within sediment samples. Samples were sent to a certified laboratory for organic chemistry analysis. The *Virginia* site samples from each of the four cores all tested below detection levels for hydrocarbon C6-C36, as well as total petroleum hydrocarbons (Table 4.11).

Table 4.11

Virginia Core Analysis.

Site	Date	Sample Location	Concentration
Virginia	August 1, 2004	Beside Ship	<1 ug/g
		30 meters	<1 ug/g
		152 meters	<1 ug/g
		305 meters	<1 ug/g

5.0 *HALO* SITE

5.1 Historical Background of the Tanker *Halo*

Figure 5.1. Tanker *Halo*, photograph by the United States Coast Guard, May 1, 1942 (Courtesy of Mariner's Museum, Newport News, Virginia).

Halo was an American tanker built by the Bethlehem Shipbuilding Corporation. Launched in 1920, Cities Service Oil Company owned *Halo*. The vessel was 6,986 tons with a length of 436.35 feet (133 meters), beam of 55.77 feet (17 meters), and loaded draft of approximately 26 feet (8 meters). She had a straight stem and elliptical stern with a poop deck. The bridge was amidships with a full topgallant forecastle at the bow and engine at the stern. A triple-expansion engine drove a single 18 feet (5.5 meter) diameter four-blade propeller (International Marine Engineering 1919: 196-97; and Hocking 1969: 296). *Halo* was unarmed (Browning 1996: 113). A representation of this class tanker is illustrated in Figure 5.2.

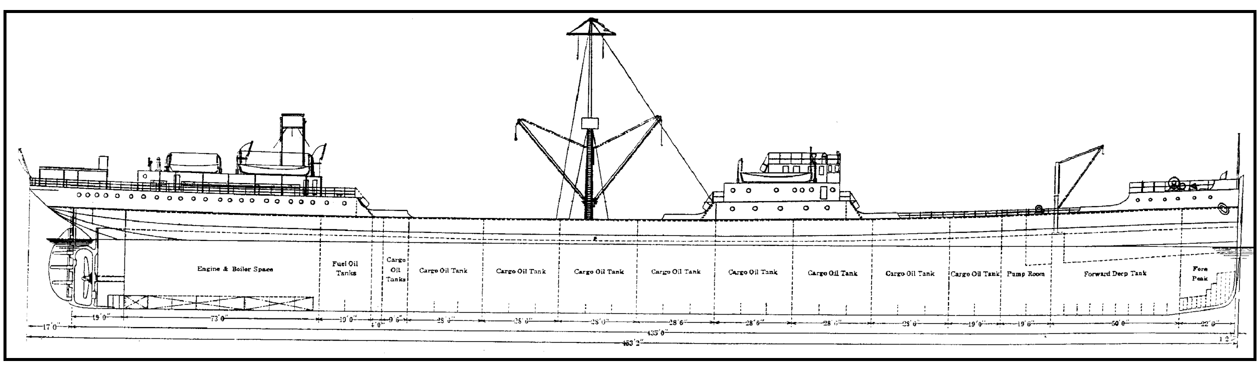


Figure 5.2. Drawing of Oil Tank Steamer similar to *Halo*, built by the Bethlehem Shipbuilding Corporation (Altered from Plate III in International Marine Engineering 1919).

On May 19, 1942, the tanker *Halo* weighed anchor at Galveston and headed toward New Orleans carrying 63,000 barrels of crude oil. It was a clear moonlit night, with calm seas, little wind, and good visibility. At approximately 1:00 A.M. on May 20, 1942, the tanker was about 80 kilometers from the Southwest Pass of the Mississippi River. The ship was running a zigzag course at 8 knots completely blacked out with a number of lookouts on duty when the torpedo struck. *Halo had* fallen victim to Kapitänleutnant Erich Würdemann, commander of *U-506*. *U-506* had attacked three ships that morning, two escaped, but *Halo* was not as fortunate (Powers 1942b; and Würdemann 1942).

The first torpedo hit on the starboard side under the bridge causing severe damage. Ten seconds later a second torpedo-hit the starboard side just aft of the bridge. The tanker sank in three to 15 minutes going down by the bow with the propeller still turning. The tanker was ablaze as it plunged beneath the water and the oil on the water continued to burn for the next six hours. The crew launched only one life raft before flames engulfed the ship. Out of a crew of 42 men, only 23 managed to escape, most by just grabbing life vests and jumping overboard. The men swam away from the sinking ship and huddled together for next several days. Several men remained near the area and on the third day debris began floating up from the wreckage. By this time, many of the men in the water had begun dying. Seven surviving crewmen used canvas from their life vests to tie boards from the wreckage together into a makeshift raft. A thick oil layer had formed on the surface enveloping the men. Each day planes were seen overhead; several at low altitudes, but none investigated the huge oil slick spread across the water. On May 25th, only two survivors remained as a destroyer circled them three times and left. Finally at 2:00 P.M. the Mexican steamship, *Oaxaca*, picked up the two men and a third man who had already died. The deceased man was buried at sea and one of the rescued men died shortly after reaching the hospital. On May 27th, the British tanker, SS *Orina*, picked up two more survivors in a life raft. After five to seven days in the water, only three of 42 men survived the ordeal (Powers 1942b; and Würdemann 1942).

5.2 Previous Investigations

Pogo Producing Company contracted C & C Technologies, Inc. to perform an Engineering and Hazard Study for a gas pipeline route extending from the Mississippi Canyon Area to the Grand Isle Area. During survey operations a shipwreck was located in 143 meters of water. Marine archaeologist Robert Church with C & C conducted an assessment and tentatively identified the vessel as *Halo*. The survey was conducted utilizing a Datasonic SIS1000 dual side scan and subbottom profiler deep-tow system (Figures 5.3). In the data example below, the SIS1000 crossed over the stern section of the shipwreck. A profile of the vessel was imaged with the subbottom system in the lower panel. The bridge is prominent in the acoustic shadow. The data indicated the shipwreck's bow is partially buried while the stern deck extends approximately 7 meters above the seafloor. This evidence concurs with the historical account of *Halo* sinking bow first (Church 2000).

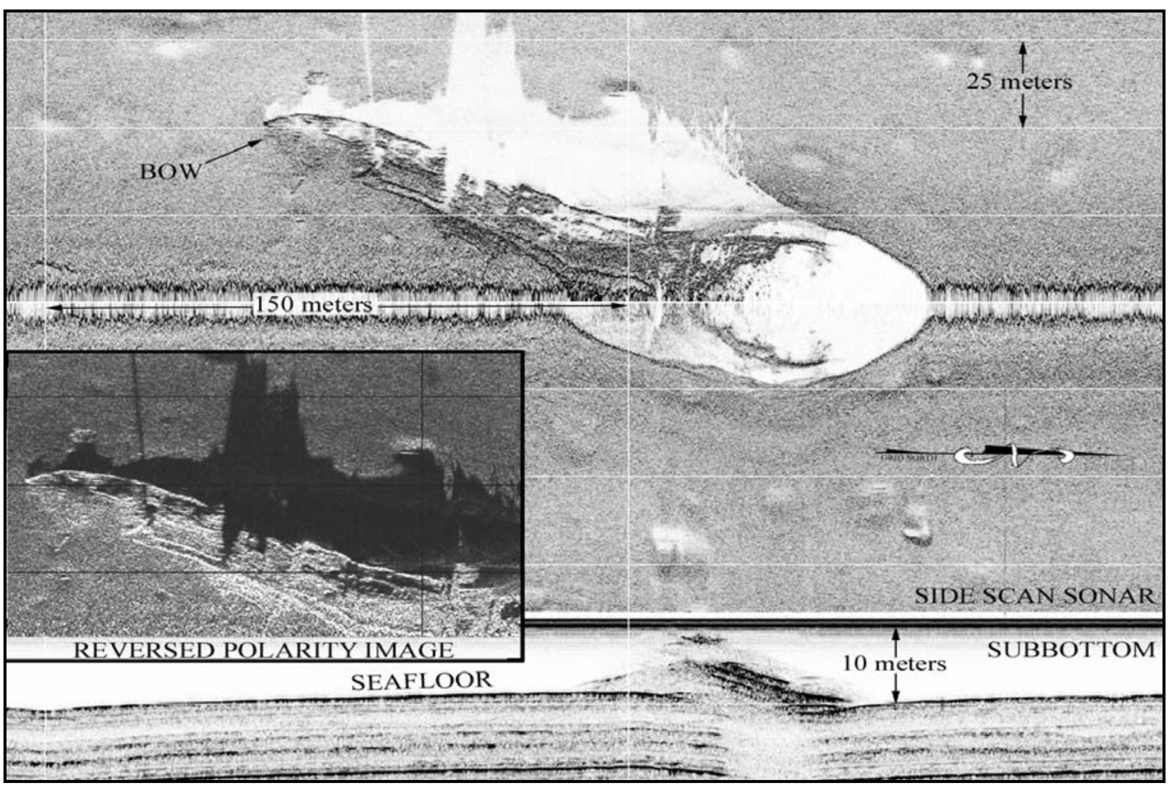
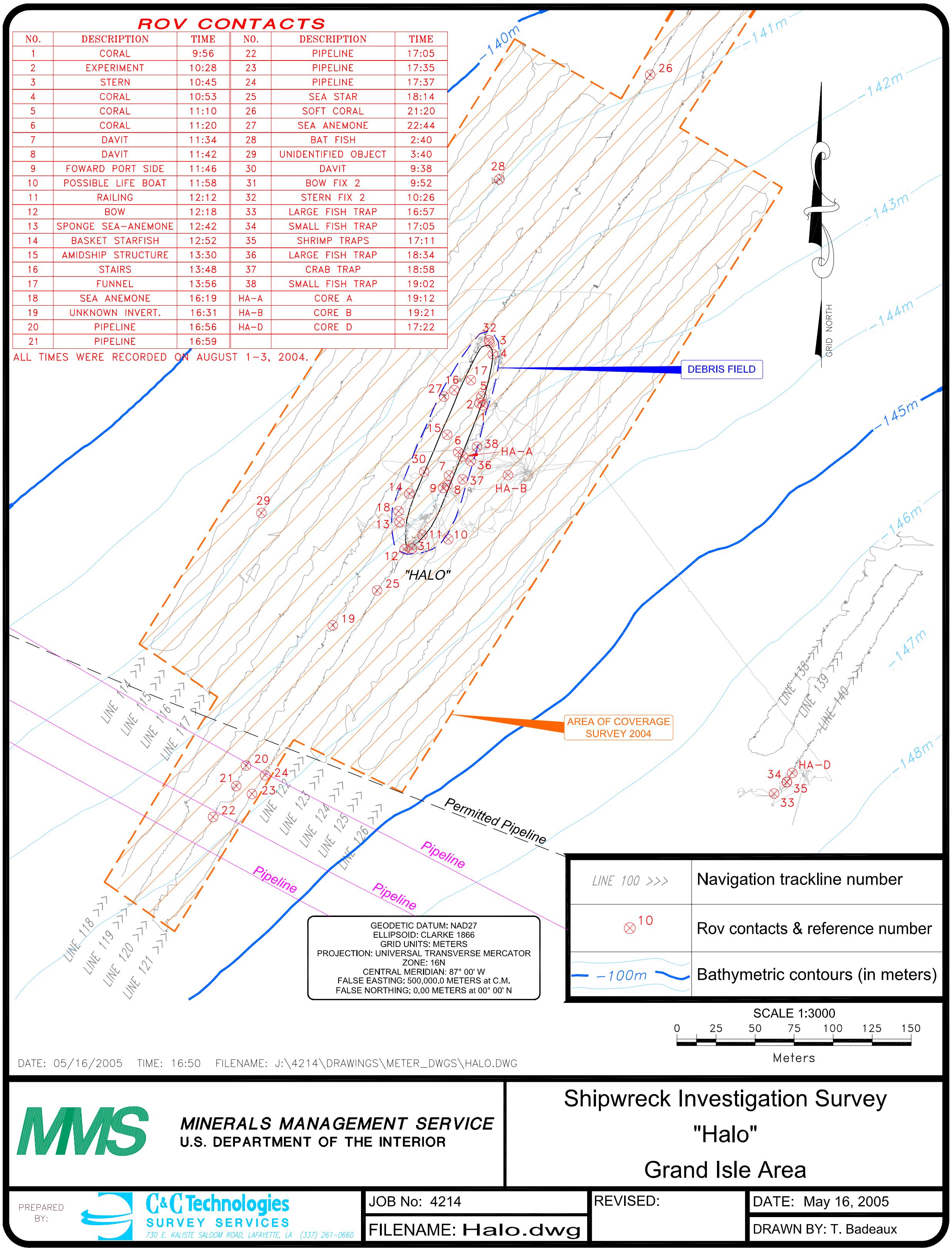


Figure 5.3. Side scan sonar and subbottom profiler images for *Halo* (Archaeological and Hazard Report prepared Pogo Producing Company).



ROV CONTACTS

NO.	DESCRIPTION	TIME	NO.	DESCRIPTION	TIME
1	CORAL	9:56	22	PIPELINE	17:05
2	EXPERIMENT	10:28	23	PIPELINE	17:35
3	STERN	10:45	24	PIPELINE	17:37
4	CORAL	10:53	25	SEA STAR	18:14
5	CORAL	11:10	26	SOFT CORAL	21:20
6	CORAL	11:20	27	SEA ANEMONE	22:44
7	DAVIT	11:34	28	BAT FISH	2:40
8	DAVIT	11:42	29	UNIDENTIFIED OBJECT	3:40
9	FOWARD PORT SIDE	11:46	30	DAVIT	9:38
10	POSSIBLE LIFE BOAT	11:58	31	BOW FIX 2	9:52
11	RAILING	12:12	32	STERN FIX 2	10:26
12	BOW	12:18	33	LARGE FISH TRAP	16:57
13	SPONGE SEA-ANEMONE	12:42	34	SMALL FISH TRAP	17:05
14	BASKET STARFISH	12:52	35	SHRIMP TRAPS	17:11
15	AMIDSHIP STRUCTURE	13:30	36	LARGE FISH TRAP	18:34
16	STAIRS	13:48	37	CRAB TRAP	18:58
17	FUNNEL	13:56	38	SMALL FISH TRAP	19:02
18	SEA ANEMONE	16:19	HA-A	CORE A	19:12
19	UNKNOWN INVERT.	16:31	HA-B	CORE B	19:21
20	PIPELINE	16:56	HA-D	CORE D	17:22
21	PIPELINE	16:59			

ALL TIMES WERE RECORDED ON AUGUST 1-3, 2004.

Figure 5.4. *Halo* site overview map.

Table 5.1

ROV Navigation Fix Points at *Halo*

No.	Description	Corrected Time	No.	Description	Corrected Time
1	Coral	9:57	22	Pipeline	17:06
2	Experiment	10:27	23	Pipeline	17:34
3	Stern	10:45	24	Pipeline	17:37
4	Coral	10:55	25	Sea Star	18:15
5	Coral	11:11	26	Soft Coral	21:21
6	Coral	11:24	27	Sea Anemone	22:46
7	Davit	11:36	28	Bat Fish	2:40
8	Davit	11:44	29	Unidentified Object	3:14
9	Forward Port Side	11:47	30	Davit	9:39
10	Possible Life Boat	12:01	31	Bow Fix 2	9:52
11	Railing	12:11	32	Stern Fix 2	10:26
12	Bow	12:18	33	Large Fish Trap	17:00
13	Sponge Sea-Anemone	12:43	34	Small Fish Trap	17:08
14	Basket Starfish	12:53	35	Shrimp Traps	17:14
15	Amidship Structure	13:33	36	Large Fish Trap	18:35
16	Stairs	13:49	37	Crab Trap	19:00
17	Funnel	13:57	38	Small Fish Trap	19:04
18	Sea Anemone	16:20	HA-A	Core A	19:13
19	Unknown Invertebrate	16:32	HA-B	Core B	19:22
20	Pipeline	16:57	HA-D	Core D	17:22
21	Pipeline	17:01			

5.3 Geographical Setting

The site is located at the southern end of the Grand Isle Area on the edge of the continental shelf in the northern Gulf of Mexico. The shipwreck rests along Mississippi Canyon's western rim. The Mississippi Canyon is a major erosional feature that is partially filled (Bouma et al. 1985). It is located in the central Gulf of Mexico southwest of the modern Birdfoot Delta. There is a moderate sedimentation rate in the wreck site area of approximately 3 millimeters per year. The reported sediment type in this region is composed of clay (USDI MMS 1978), which is consistent with the sediment recovered from the core samples taken at the site. The seafloor near the shipwreck site has a low gradient slope of approximately 1.4 degrees toward the southeast (Figure 5.4). A kilometer to the southeast the seafloor slope increases considerably to approximately 6.6 degrees.

5.4 Discussion of Archaeological Findings

5.4.1 Physical Site

The following description of the wreck site is from the 2004 field expedition. The investigation was conducted with the Triton XL11 ROV on July 30 to August 1, 2004. Visibility at the site was poor and averaged approximately two meters.

The wreck is oriented with the bow (Figure 5.5) pointing south-southwest and the stern to the north-northeast. Water depth at the bow is 142.7 meters and 143.3 meters at the stern. The vessel's bow is embedded deeper in the seafloor than the stern. The forecastle's upper region stands only three meters above the ambient seafloor as opposed to the stern, which has 7.3 meters of relief. Only half of the bow's windlass can be seen protruding from the sediment. The wreck lists approximately five degrees to port and the forward port gunwale is buried. The forward mast still stands and the top of the mast is approximately 16.5 meters above the ambient seafloor. Parts of the windlass that serviced the forward mast are visible immediately to its front. A section of catwalk, approximately six meters long, protrudes from the sediment along the vessel's starboard side. The cable handrails are mostly extant, but no grating or wood planking remain attached to the catwalk frame. The catwalk originally covered raised piping running from the bow to the main superstructure. The pipes were not visible along this section of the vessel. Other remains observed in this area include remnants of vent structures that had originally stood to either side of the forward mast and approximately four meters of the forward boom. The boom lies between the forward windlass and the forward mast (See Figure 5.6). An attempt was made to mosaic the vessel's bow, but poor visibility thwarted the effort.

Figure 5.5. Bow (starboard view) of *Halo*.

The vessel's superstructure and starboard side of the hull appear relatively intact, but many structural details are obscured by biofouling and several "shrimp" nets tangled around the starboard stern (Figure 5.7). There is severe damage to the deck and port side hull between the main superstructure and aft deckhouse. Approximately four meters forward of the aft deckhouse, a three to four meter tear along the ship's portside is visible. The deck is sheared away and collapsed forward of this hole. It is not known how far this deck damage extends because entanglement hazards prevented survey of the area forward of the break. The "raised" piping running from the main superstructure to the aft deckhouse has collapsed. The pipes are visible coming from the main superstructure, but are not visible at the aft deckhouse where the deck is collapsed. The starboard side ladder leading from the main deck up to the boat deck of the superstructure directly aft of the main superstructure is also missing. All other ladders fore and aft of the main superstructure and forward of the aft deckhouse appear intact. The impact damage caused by the two torpedoes that reportedly struck the starboard side of the vessel was not visible and is probably below the mud line. The breach on the vessel's port side and aft deck may be damage caused by stress on the weakened hull when the stern protruded into the air as the vessel plummeted bow first to the bottom.

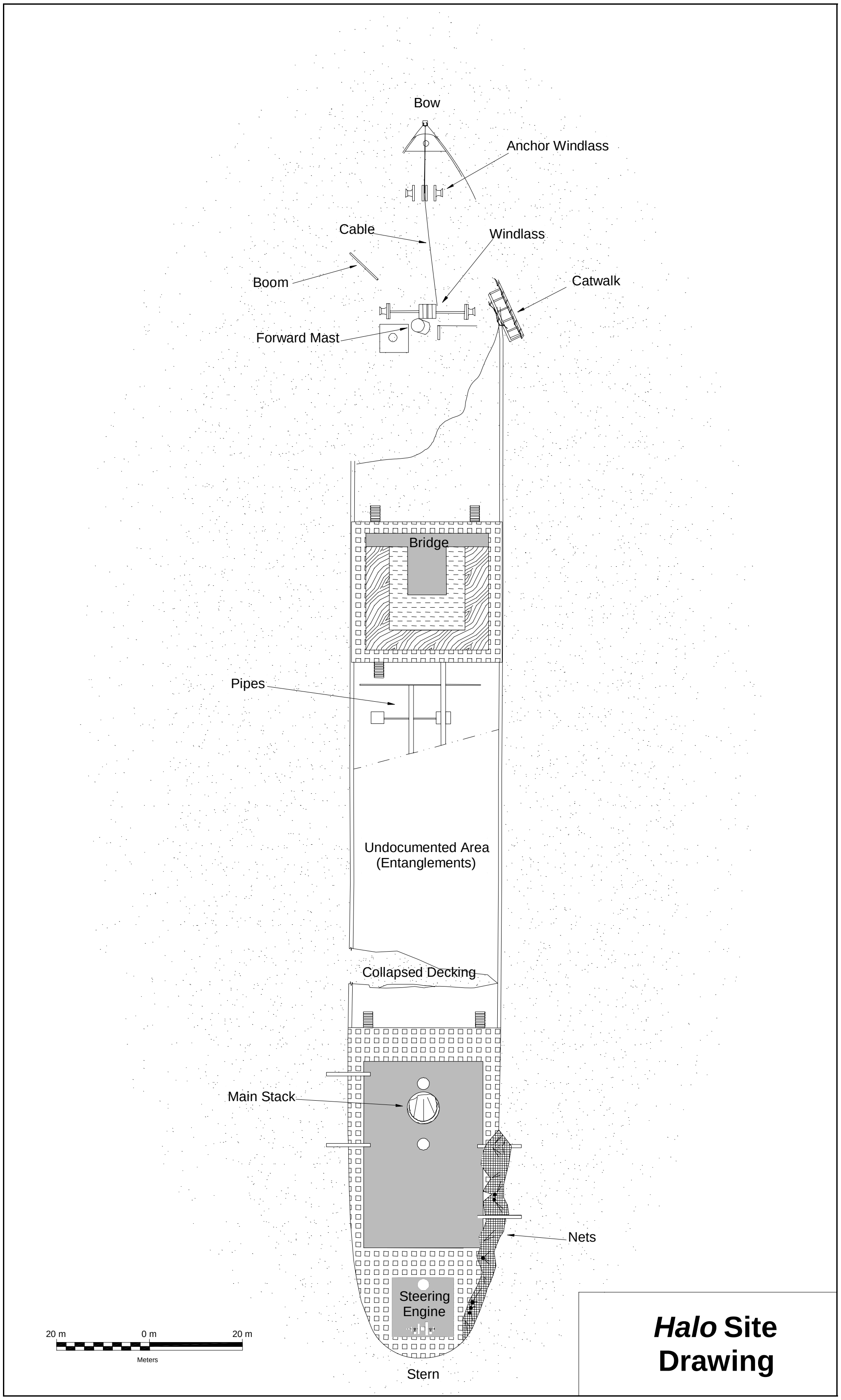


Figure 5.6. *Halo* site plan (Illustration by Robert Church).

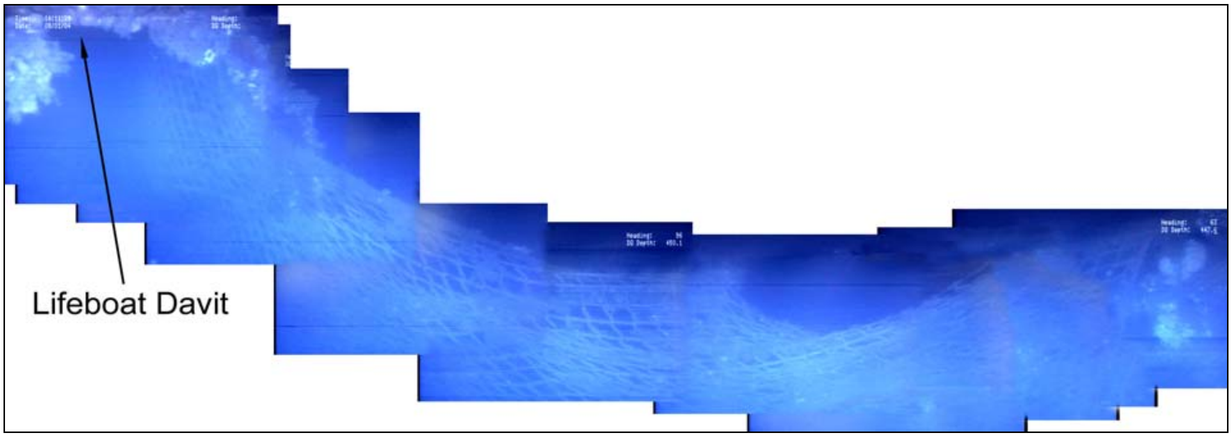


Figure 5.7. Nets tangled around *Halo*'s stern.

The aft deckhouse's main stack is folded in on itself and the upper part is badly damaged. Just forward of the stack, the smaller starboard vent is still intact, but the vent hood is gone. Nets are tangled around the aft starboard quarter, and cover the stern from just forward of the starboard lifeboat davits to the stern starboard hawsehole. At the stern, the small deckhouse for the steering machinery is present, but damaged. The steering engine is visible through the rear of the structure. Figure 5.8 shows a schematic of the stern superstructure and deckhouses. Only portions of *Halo*'s deck remains were documented because of safety concerns raised by low visibility and entanglement concerns.

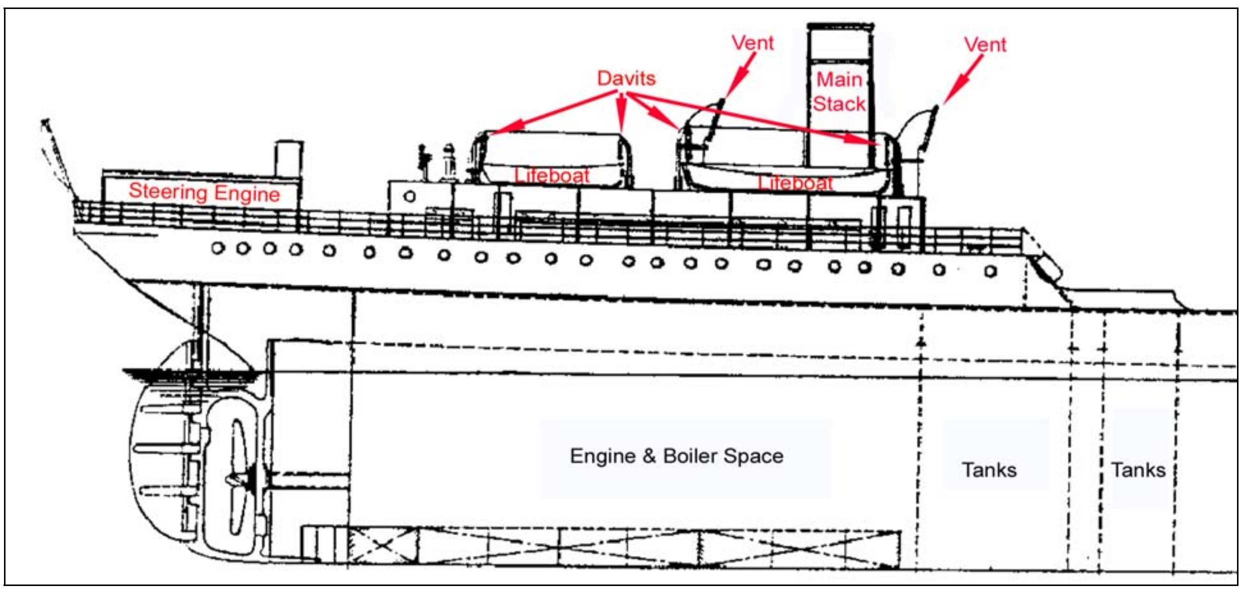


Figure 5.8. *Halo*'s stern section with key components labeled (Altered from Plate III in International Marine Engineering 1919).

Geophysical survey data did not indicate an abundance of debris surrounding the wreck site. An area visual survey was conducted after the initial reconnaissance of the main wreck site. Thirteen ROV survey lines were run near parallel to the wreck at 15-meter line spacing. Three-survey lines crossing the main wreck site were run the entire planned length of 760 meters. The remaining lines, five additional on each side, were at least 450 meters long. This created a survey grid approximately 180 meters by 450 meters with the shipwreck at the center. Three additional 180 meter long survey transects spaced 15 meters apart were run approximately 280 meters to the southeast of the wreck site for biological investigations. The observed debris was limited, as expected, to sparse objects scattered around the wreck site. No debris was observed beyond 15 meters from the wreck site. The furthest object from the main wreck site is a large section of debris, possibly the remains of a lifeboat, approximately 14 meters southeast from the port bow (Figure 5.9).

Figure 5.9. Possible capsized lifeboat, lying 14.3 meters off the port bow.

5.4.2 Site Preservation

The wreck site is in a moderate state of preservation. Much of the vessel's forward section is buried. The amount of biofouling and sediment covering the vessel made it impossible to distinguish many of the wreck's structural features. The visible areas were relatively intact, with damage to the lighter components such as the vent stacks and deckhouses.

5.5 Discussion of Biological Findings

5.5.1 Microbiology

Gravimetric elemental analysis using ICP-AES of the rusticles recovered from *Halo* is given in Table 5.2. Here it was found that the dominant four elements were iron (96%), sodium (2.8%), calcium (0.5%), and magnesium (0.3%).

Table 5.2

Gravimetric Elemental Analysis of a Brown Rusticle (C1) from *Halo*

Iron	96.1169%		Cadmium	0.0075%
Sodium	2.8237%		Aluminum	0.0073%
Calcium	0.5124%		Strontium	0.0073%
Magnesium	0.2618%		Molybdenum	0.0058%
Phosphorus	0.1010%		Lead	0.0036%
Potassium	0.0898%		Zirconium	0.0013%
Manganese	0.0355%		Barium	0.0007%
Boron	0.0142%		Chromium	0.0004%
Vanadium	0.0110%			

Halo was completely coated in a dendritic (C3) concretion 5 to 15 millimeters thick overlain with a relatively thin (2 to 5 millimeters) slime coating similar to the coating on *Virginia*. However, 5% of the surface coating had brown rusticles (B1) emerging through the concretions. The rusticles ranged in length from 5 to 300 millimeters and in width from 2 to 60 millimeters. Microbial concretions (C4) were observed coating 15% of the concretions as either attached branching whorls or as suspended structures. The latter structures appeared to be held in position by calcite tubes. No white rusticles (C2), blobs (B2), or sea anemones were observed. Significant electrical potentials were detected when the bio-battery platforms were recovered (Figure 5.10).

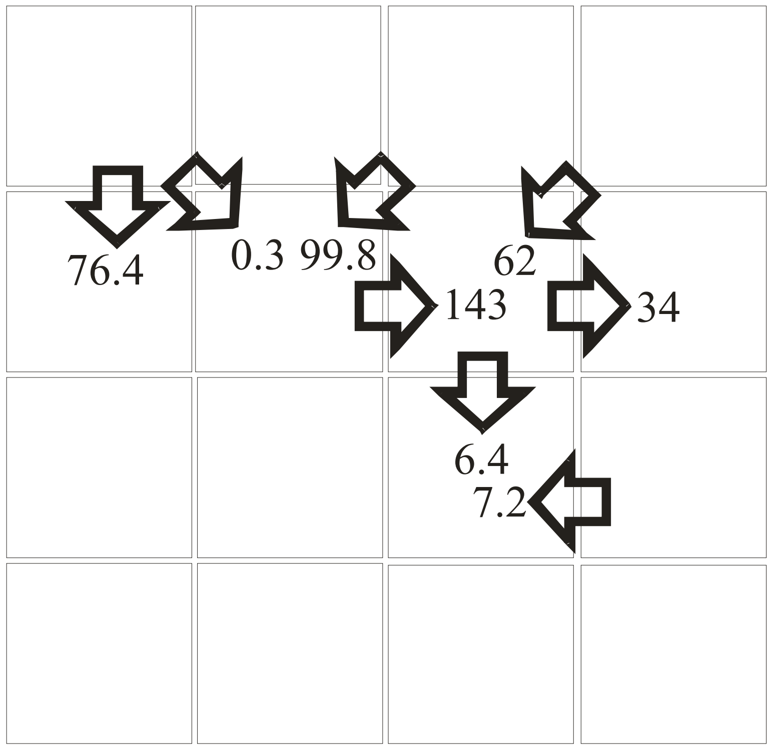


Figure 5.10. Voltages (millivolts) detected on bio-battery coupons deployed on *Halo*

5.5.2 Invertebrate Zoology

Visibility at the *Halo* site was substantially improved over that of the *Virginia* site, but was still marginal for identification of invertebrates from videos. Nine video transects were conducted at the site, with a total of 1343.7 m^2 surveyed (Table 5.3). The coverage was not equal among the three areas: three transects over the *Halo* totaled 311m^2, three transects adjacent to the *Halo* totaled 569.9 m^2, and three transects away (300 m) from the site totaled 462.1 m^2. The bias, i.e., the increased sampling area over the vessel site as compared to areas adjacent to or away from the site, was present at all vessel sites, as the ROV had to be navigated higher over the vessels than over barren sediment. Dissolved oxygen content (2.8 mg l^{-1}) was approximately half the concentration found at *Virginia*, but is still not considered hypoxic. This lower oxygen concentration is limiting or stressful for many fish species or actively swimming invertebrates with higher metabolism, but often has little effect on sedentary organisms and demersal invertebrates. Low oxygen areas serve as a refuge for many invertebrates, as predators may be excluded (Levin, 2003; Helly and Levin, 2004). The depths at which invertebrates were observed or collected at the *Halo* site varied from 131 to 145 m.

Invertebrates (other than corals) observed in the transect videos over *Halo* included three anemones, one *Chama* sp., and an unidentified hermit crab (Table 5.3). The transects adjacent to *Halo* included a Beau's murex, *Siratus beauii*, The transects away from *Halo* included two hermit crabs, possibly *Dardanus insignius*, three sea urchins (1 slate pencil urchin, *Eucidaris tribuloides* and 2 *Echinothrix* sp.), and six smaller mollusks and crustaceans.

Table 5.3

Density (number per 100 m-2) of Invertebrates Observed on Transects
Over, Adjacent and Distant (300 m) from the *Halo* site.

	Transect Number								
	Over			**Adjacent**			**Distant**		
Halo	**119**	**120**	**121**	**122**	**123**	**124**	**138**	**139**	**140**
Crustaceans									
Hermit crab	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
cf. *Dardanus insignus*	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.7
Shrimp	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified crustacean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Echinoderms									
Eucidaris tribuloides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Echinothrix sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.4
Mollusks									
Chama sp.	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Siratus beauii	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Buccinidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Unidentified mollusk	0.0	0.0	0.0	0.0	0.5	0.0	1.6	0.0	1.4
Cnidarians									
Anemone	0.0	0.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0

Sediment composition at *Halo* was similar to that found at *Virginia*. The meiofaunal composition also was similar, but numbers of organisms were considerably lower (Table 5.4). Nematodes predominated, but their density was less than half of the density found at *Virginia*. Polychaets again were more common than harpacticoid copepods, of which only four specimens were collected in both cores. Harpacticoid copepods are usually found in surficial, oxygenated sediments of the benthos; currents generated by prop thrust or even the bow wake of a core can displace the upper few millimeters of sediment and bias the observed density of harpacticoids (Fleeger et al. 1995). Nematodes are found throughout the sediment column and their densities are less affected by disturbance.

Table 5.4

Density of Meiofauna (numbers per 10 cm^2) from Sediment Cores
Collected Adjacent to (Core A) and Distant (Core C) from *Halo*.

Wreck	***Halo***	
	Number per 10 cm^2	
Taxon	Core A	Core C
Harpacticoida	1.8	3.6
Nematoda	460.5	524.0
Polychaeta	21.8	25.4

Eight crustacean taxa were collected at the *Halo* site: six near the wreck and two away from the wreck. None of these species were collected at the shallower *Virginia* site (Table 5.5). Four echinoderm taxa (a seastar, a brittlestar, and two urchin species) were collected at the site, with only the brittle stars being found away from the wreck site. Six molluscan taxa were collected: three near the wreck site, one away from the site, and several from sediments of unknown location.

Table 5.5

Macroinvertebrate Species Collected at the Halo Site
Including Number and Proximity to Wreck, Substrate and Depth.

***Halo* Wreck**					
Specimen ID	**Number Near Wreck (< 61 m)**	**Number far from wreck (>61 m)**	**Unknown collection location**	**Substrate**	**Depth (m)**
Crustacea					
Dardanus insignis	5			Wreck; silt	136-141
Dromia sp.	1			Wreck	131
Hippolytidae – *Saron* sp.		2		Silt	145
Pagurus sp.	1			Wreck	138
Grapsidae		2		Silt	145
Majidae a	1			Silt	141
Majidae b	1			Silt	140
Porcellanidae	1		1	On Majidae- b	
Echinodermata					
Astracme mucronata	1			Wreck	138
Ophiothrix sp.			2	Sievings	
Eucidaris tribuloides	1			Wreck	137-140
Echinothrix sp.	3			Wreck	136
Mollusca					
Siratus beauii	1		1	Wreck; found in basket	139
Coralliophila aberrans			1	Found in sediment	
Cymatium parthenopeum	1			Silt	142
Lima sp.	1			Wreck	131
Pteria sp.			2	Rusticle collection	
Cephalopoda		3		Silt	145

Coralliophila aberrans is a small (to 23 mm total length) gastropod commonly found associated with corals and seafans; our specimen was found away from *Halo* where no corals were present. The species is typically reported from shallow waters, but has been found as deep as 180 m, from the east coast of Florida and the Bahamas, through the Caribbean Sea to Brazil (Abbott 1974; ANS 2006). We collected a single specimen of *Cymatium parthenopeum* in sediment away from the wreck. At least 25 species of *Cymatium* have been reported from the western Atlantic. Flame scallops of the genus *Lima* have recently been revised into the genera *Ctenoides*, *Limaria,* and *Lima*; our specimens associated with *Halo* and other vessel sites differ from the 11 species reported from this complex in the western Atlantic. Flame scallops are mobile and move about by flapping their valves, and use fine byssal threads to attach; hence they are often difficult to collect intact. The specimen near *Halo* was lying immobile on sediment and collected with the suction sampler. Two winged oysters (*Pteria* sp.) were collected with the samples of rusticles; our specimens are not *Pteria colymbus*.

Gorgonicephalid basket stars such as *Astracme mucronata* are suspension feeders and are normally associated with sea whips, corals, or other erect or arborescent species or substrate that provide a feeding location above the benthos and the benthic boundary layer to increase feeding efficiency. Specimens in the archives of the United States Museum of Natural History are distributed from Cape Hatteras, North Carolina, the Bahama Islands, U. S. Virgin Islands, Florida Keys, and the Gulf of Mexico, at depths of 15 to 399 m (NMNH, Dept. of Systematic Biology 2006). The slate pencil urchin *Eucidaris tribuloides* found at this site is widely distributed in the western

Atlantic and Gulf of Mexico from 0 to 800 m (Hendler et al. 1995); this was one of the more widely distributed sea urchins in our study.

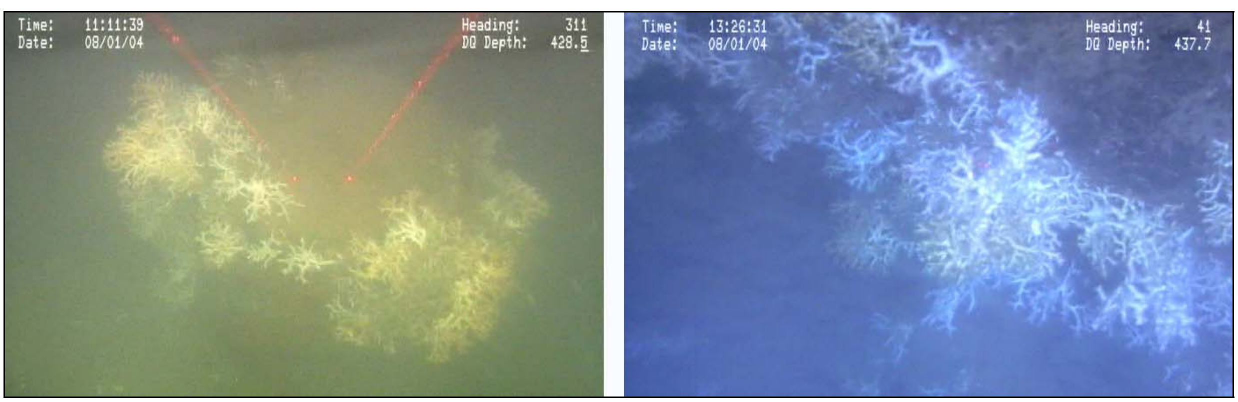
The red brochade hermit crab *Dardanis insignis* (Saussure, 1858) was observed and collected at several sites and is common in offshore marine waters from North Carolina, through the Gulf of Mexico and the West Indies to Brazil, in depths of 27 to 227 m (Williams 1984).

Scleractina, Antipatharia, and Gorgonacea

Poor to fair visibility at this site permitted only a marginally comprehensive examination and video documentation of the tanker *Halo*. Water depths at this site are on the order of 143 meters and the hydrographic conditions measured at the time of the survey were: temperature ~16.4° Celsius; salinity ~36.2 psu; and dissolved oxygen ~2.8 mg l-1. All depths reported in the following text are the uncorrected ROV readings displayed on the video recordings.

Two scleractinian species *Madracis myriaster* and *Pourtalosmilia conferta* and four gorgonian species (*Placogorgia rudis*, *Thesea sp. cf. T. grandiflora, Thesea sp. cf. T. rubra, and Thesea sp.*) were observed on and/or collected from this wreck (Table 4.6). All three gorgonian species have previously been reported from the Gulf of Mexico (NMNH Taxonomic Database 2003). Similar to the findings from *Virginia*'s available surfaces, Halo generally appeared either relatively densely colonized with combinations of these fauna or had little or no colonization of these fauna at all.

Madracis myriaster and *P. conferta* were observed colonizing surfaces over the entire wreck. Unlike *Virginia*, only the common bushy form of *M. myriaster* (Figure 4.16) was collected and observed in the video recordings. Examples of the cover and structure provided by clusters and assemblages of *M. myriaster* are illustrated in Figure 5.11. The largest colonies observed were in the order of 30-35 centimeters in breadth. In addition, broken fragments of *M. myriaster* colonies that have fallen off the wreck were observed living on the adjacent sediment (Figure 5.12). *Pourtalosmilia conferta* occurred less frequently than *M. myriaster* and was most often observed growing in solitary, nearly spherical colonies up to 85-90 centimeters wide (Figure 5.13). The co-occurrence of *M. myriaster* and *P. conferta* can result in the development of structurally complex cover (Figure 5.14). Additional complexity is contributed to this habitat when other encrusting epibenthic fauna colonize in association with these two corals (Figure 5.15).



a) b)

Figure 5.11. Examples of the cover and structure provided by clusters and assemblages of *Madracis myriaster*.

Figure 5.12. *Madracis myriaster* colonies living on the sediment adjacent to *Halo*'s hull.

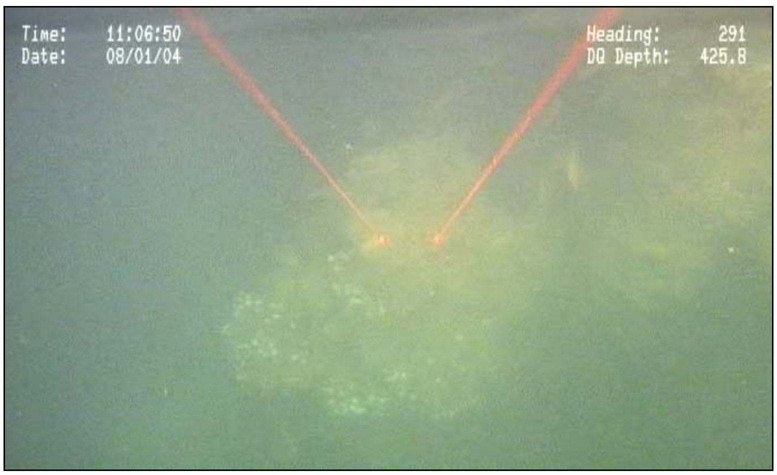


Figure 5.13. Large, solitary colony of *Pourtalosmilia conferta*.

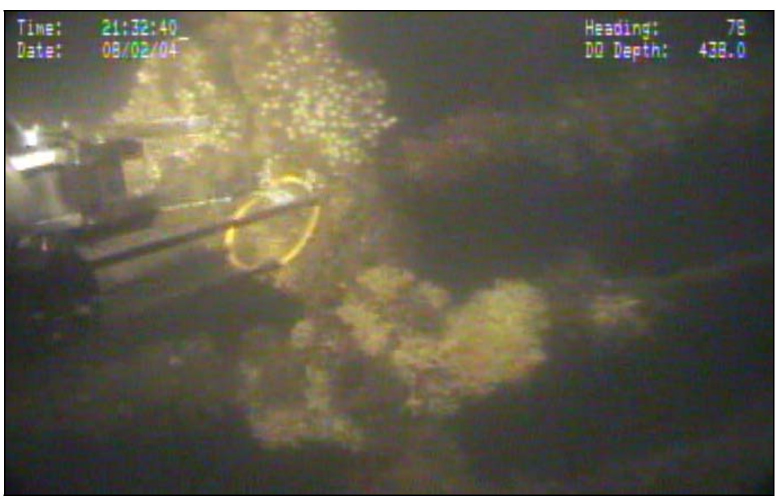


Figure 5.14. Structurally complex cover resulting from the co-occurrence of *Madracis myriaster* and *Pourtalosmilia conferta*.

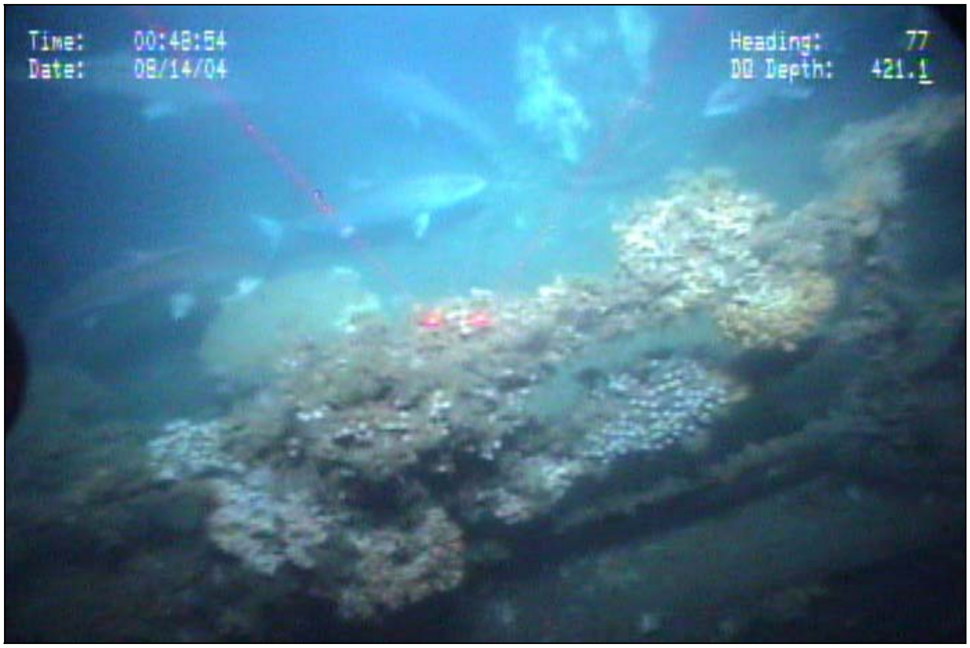


Figure 5.15. A complex habitat formed by *Madracis myriaster* and *Pourtalosmilia conferta* in association with other encrusting epibenthic fauna.

Generally, all gorgonian colonies were observed as either isolated individuals in small groupings of a few individuals, or in a widely spaced field-like pattern of either single or mixed species composition. Two species, *Thesea sp.* cf. *T. grandiflora* (Figure 5.16a) and *Thesea sp.* cf. *T. rubra* (Figure 5.16b), were most often seen colonizing on the hull as either isolated individuals or in the single or mixed species field pattern. The common size range for both species is estimated to be in the order of 15-18 centimeters wide and 12-15 centimeters high. *Placogorgia rudis* (Figure 5.17) occurred as isolated colonies on structures and debris throughout the wreck and in small clusters on, for example, the main superstructure (Figure 5.18) and at the top of the aft deck mast's standing portion (Figure 5.19). Colonies of this species often exceeded 50 centimeters in width and 75 centimeters in height; the largest measuring 72 centimeters wide and 121 centimeters high (Figure 5.20).

a) b)

Figure 5.16. (a) *Thesea sp. cf. T. grandiflora* and (b) *Thesea sp. cf. T. rubra*.

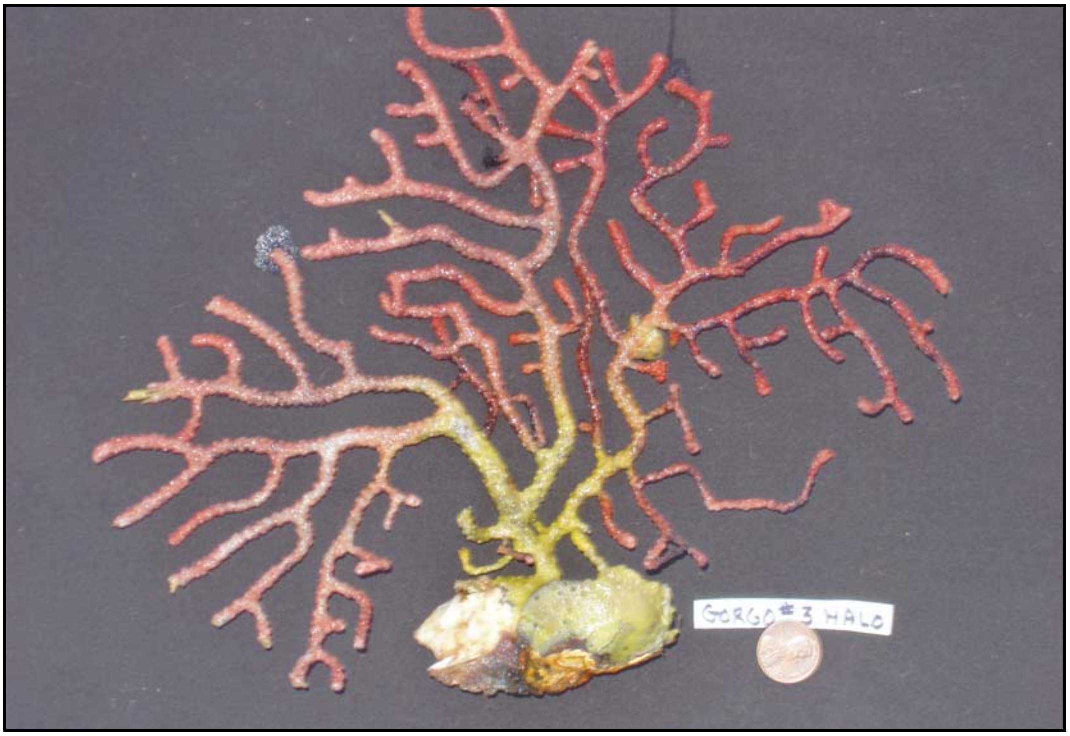


Figure 5.17. *Placogorgia rudis*.

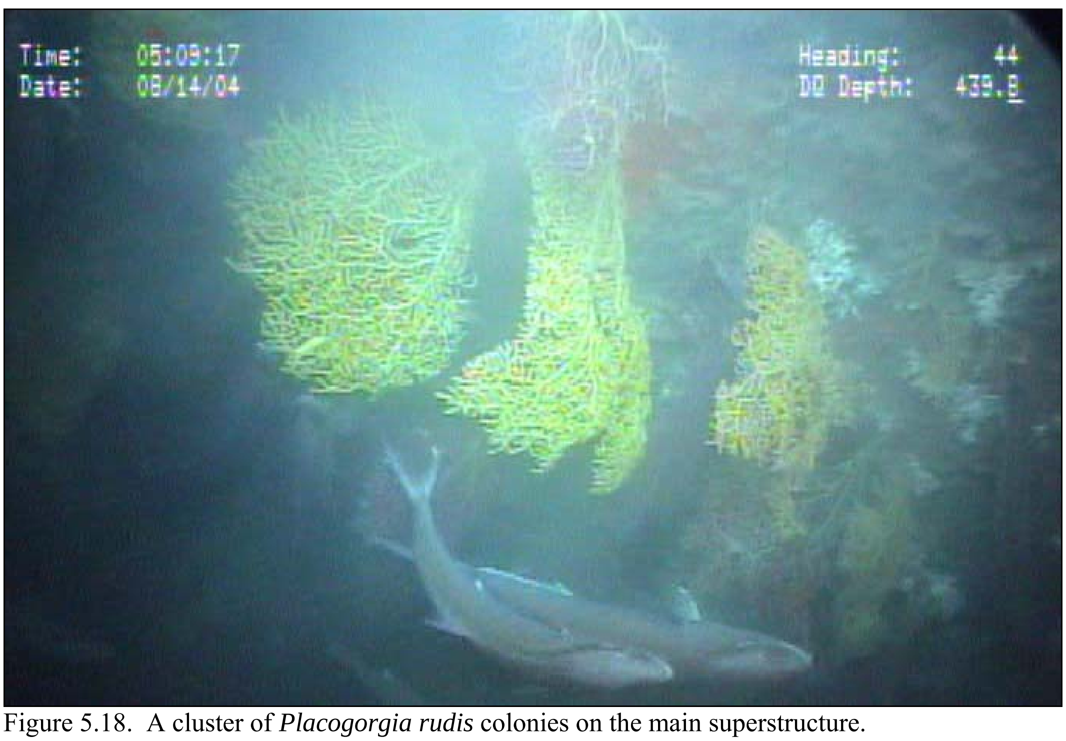


Figure 5.18. A cluster of *Placogorgia rudis* colonies on the main superstructure.

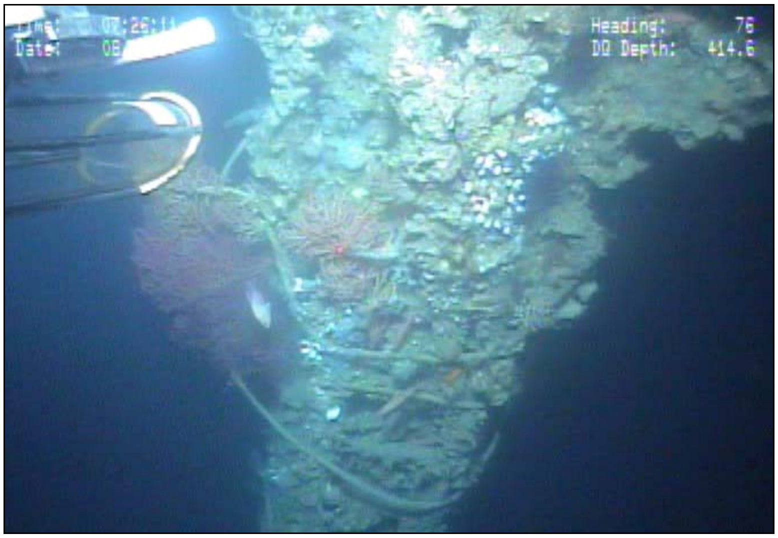


Figure 5.19. A cluster of *Placogorgia rudis* colonies on top of the standing portion of the mast on the aft deck.

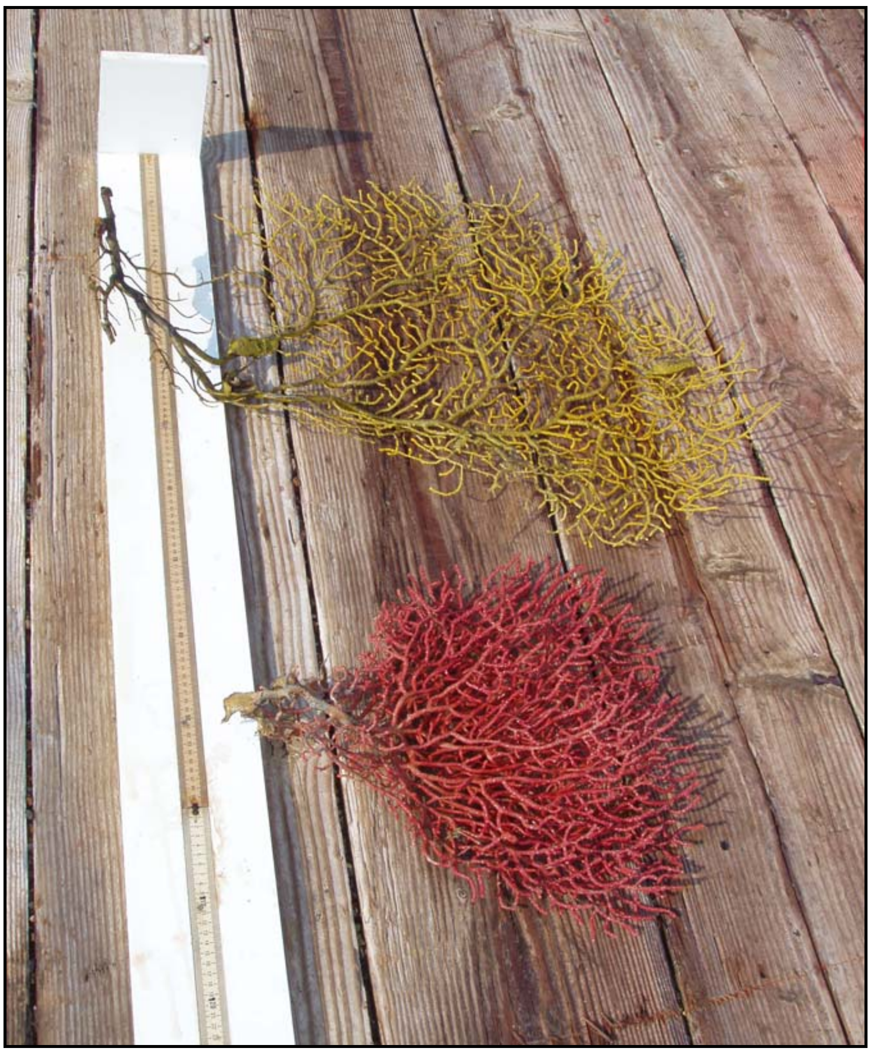


Figure 5.20. Large colonies of *Placogorgia rudis* on the deck of HOS *Dominator*.

The single colony of *Thesea sp.* (Figure 5.21) collected was inadvertently sampled during attempts to collect fish and other invertebrates: therefore, the collection location is unknown. Two colonies of an unidentified gorgonian, attached to a damaged hull section on the foredeck's starboard side, were recorded on video during the last phase of the second survey at the *Halo* site. The colonies have long, flexible, sea whip-like branches with some secondary branching, which is a different morphology than any of the collected specimens. One colony's height is estimated to be 120-125 centimeters.

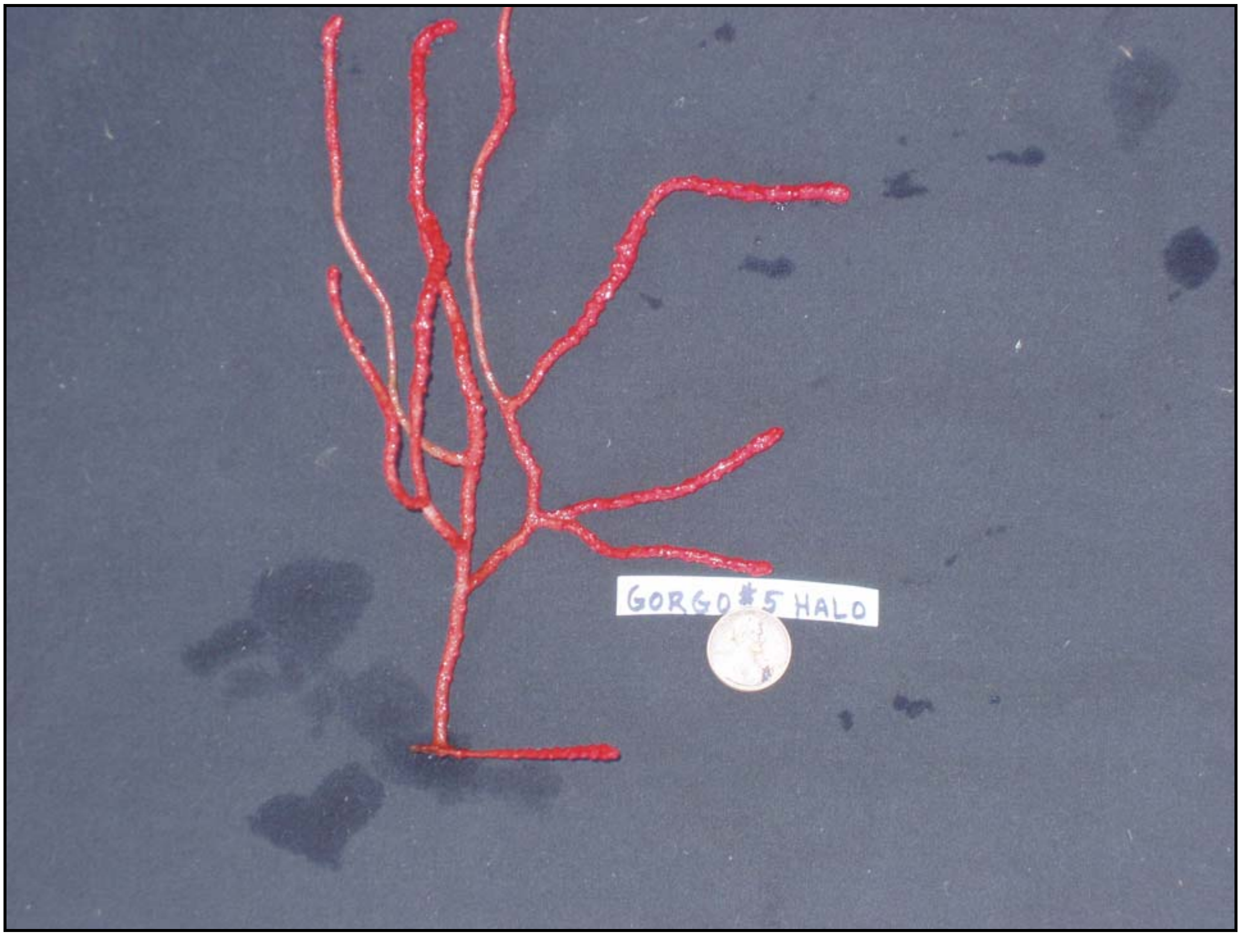


Figure 5.21. *Thesea sp.*

5.5.3 Vertebrate Zoology

Fish Community Structure

Visibility was poor at the *Halo* site, although not as poor as that encountered at *Virginia*. The mean visible width of transects was approximately 2.5 meters over the ship and was even lower away from the wreck (Table 5.6). Probably the most important physical parameter that may have affected community structure estimates was the low dissolved oxygen measured (< 3 mg l^{-1} during biological transects; > 4 mg l^{-1} during the second trip to *Halo*). Most fishes show signs of stress below 4 mg l^{-1} and few remain in an area with levels below 2 mg l^{-1}. Despite the low dissolved oxygen measured during biological transects, fish biomass was higher at *Halo* than any other site (Tables 5.6 – 5.10). Reef fish diversity and density also was highest at *Halo*.

Table 5.6

Abundance and Density Estimates for Fish Taxa Identified from Video Collected with the ROV During Biological Sampling Over, Adjacent to, and 300 Meters Away from (distant) at *Halo*.

Transect Line	Relation to ship	Taxon	Min Count	Max Count	Min Density 100 m^{-2}	Max Density 100 m^{-2}
119	Over	*Seriola dumerili*	2	30	7.59	113.86
		Pronotogrammus martinicensis	1	1	3.80	3.80
		Serranidae subfamily Anthiinae	8	19	3.80	3.80
		Myctophidae	2	18	7.59	68.32
		Teleost	2	4	7.59	15.18
120	Over	*Seriola dumerili*	8	26	6.02	19.58
		Epinephelus nigritus	2	2	1.51	1.51
		Epinephelus niveatus	1	1	0.75	0.75
		Serranidae subfamily Anthiinae	4	20	3.01	15.06
121	Over	*Setarches guentheri*	1	1	0.66	0.66
		Pronotogrammus martinicensis	1	1	0.66	0.66
		Rhomboplites aurorubens	1	1	0.66	0.66
		Seriola dumerili	3	5	1.97	3.28
		Serranidae subfamily Anthiinae	12	27	7.86	17.69
		Scorpaenidae	3	3	1.97	1.97
122	Adjacent	*Seriola dumerili*	2	18	0.95	8.61
		Teleost	1	9	0.48	1.91
123	Adjacent	*Ogcocephalus* sp.	1	1	0.52	0.52
		Seriola dumerili	1	8	0.52	4.17
		Teleost	6	60	3.13	31.25
124	Adjacent	*Seriola dumerili*	9	94	5.34	55.79
		Teleost	1	24	0.59	14.24
138	Distant	*Ophichthus rex*	1	1	0.55	0.55
		Ogcocephalus sp.	1	1	0.55	0.55
		Ogcocephalidae	1	1	0.55	0.55
		Bothidae	1	1	0.55	0.55
		Teleost	1	3	0.55	0.55
139	Distant	*Prionotus* sp.	1	1	0.72	0.72
		Bothidae	1	3	0.72	2.17
140	Distant	*Setarches guentheri*	1	1	0.71	0.71
		Ogcocephalus parvus	1	2	0.71	1.41
		Seriola dumerili	1	1	0.71	0.71
		Bothidae	1	5	0.71	3.53

Table 5.7

Abundance of Fish Taxa Identified from Video Collected at *Halo* During Sampling Other than Biological Transects.
(Location indicates if video was collected over or away from the Ship.)

Visit	**Location**	**Taxon**	**Min Count**	**Max Count**
Halo (1)	Over Ship	*Epinephelus nigritus*	4	118
		Epinephelus niveatus	1	23
		Gymnothorax kolpos	1	1
		Hemanthias leptus	1	2
		Mycteroperca phenax	1	3
		Paralichthys squamilentus	2	8
		Pareques iwamotoi	2	8
		Pogonias cromis	1	1
		Pronotogrammus martinicensis	5	154
		Seriola dumerili	8	4,326
		Zenopsis conchifera	1	2
		Epinephelus	2	42
		Bothidae	1	3
		Carangidae	9	318
		Lutjanidae	1	1
		Muraenidae	1	1
		Myctophidae	2	10
		Ogcocephalidae	2	8
		Scorpaenidae	2	12
		Serranidae	3	16
		Serrandiae Subfamily Anthiinae	55	6,638
		Perciformes	2	7
		Scorpaeniformes	1	4
		Teleostei	3	48
	Away From Ship	*Caranx crysos*	17	289
		Epinephelus nigritus	1	36
		Hemanthias leptus	1	1
		Monolene sessilicauda	1	2
		Neobythites gilli	1	1
		Ogcocephalus corniger	1	12
		Ogcocephalus parvus	1	3
		Prionotus stearnsi	1	2
		Seriola dumerili	6	186
		Trichiurus lepterus	1	6
		Mustelus sp.	1	1

Visit	Location	Taxon	Min Count	Max Count
		Prionotus sp.	1	1
		Bothidae	1	10
		Carangidae	1	17
		Ogcocephalidae	2	23
		Phycidae	1	2
		Scorpaenidae	1	8
		Trichiuridae	1	1
		Anguilliformes	1	5
		Aulopiformes	1	2
		Gadiformes	1	1
		Osmeriformes	8	346
		Perciformes	1	2
		Scorpaeniformes	1	5
		Teleostei	5	203
Halo (2)	Over Ship	*Epinephelus nigritus*	1	25
		Epinephelus niveatus	1	8
		Hemanthias leptus	1	3
		Hemanthias vivanus	1	1
		Pronotogrammus martinicensis	2	62
		Seriola dumerili	35	12,911
		Epinephelus sp.	2	18
		Serranidae Subfamily Anthiinae	8	360
		Carangidae	8	746
		Gobiodei	1	1
		Muraenidae	1	1
		Myctophidae	60	556
		Sciaenidae	3	3
		Serranidae	1	14
		Perciformes	1	17
		Scorpaeniformes	1	3
		Teleostei	1	4
	Away From Ship	*Caranx crysos*	79	275
		Seriola dumerili	7	31

(*X*) Denotes the visit number for sites examine multiple times.

Table 5.8

Estimated Total Lengths of Fishes Observed on Video at *Halo.*
(All individuals were captured on video with both ROV-mounted lasers striking them.)

Taxon	Number Measured	Mean TL mm	Standard Deviation	Range TL mm
Epinephelus nigritus	8	1,372	236.7	1,150-1,891
Hemanthias leptus	1	572		
Pronotogrammus martinicensis	2	185	33.5	161-208
Seriola dumerili	20	1,334	249.4	1,040-1,743
Ogcocephalidae	1	194		
Bothidae	7	185	29.6	148-218
Scorpaeniformes	2	394	41.4	365-423

Table 5.9

Fish Taxa Caught in Chevron (Large) and Baitfish (Small) Fish Traps Deployed Adjacent to (Ship) and 300 Meters from (Distant) *Halo*.

Wreck Site	Trap Type	Location	Species	Number
Halo	Large	Distant	*Ophichthus rex*	9
	Large	Ship	*Conger oceanicus*	1
	Large	Ship	*Epinephelus flavolimbatus*	1
	Large	Ship	*Gymnothorax kolpos*	2
	Large	Ship	*Pagrus pagrus*	1
	Small	Distant	*Urophycis regia*	5
	Small	Ship	*Gymnothorax kolpos*	1
Halo (2)	Large	Ship-bow	*Epinephelus flavolimbatus*	1
	Large	Ship-bow	*Epinephelus nigritus*	1
	Large	Ship-bow	*Gymnothorax kolpos*	3
	Large	Ship-bow	*Ophichthus rex*	1
	Large	Ship-stern	*Hemanthias leptus*	1
	Large	Ship-stern	*Ophichthus rex*	1

(*X*) Denotes the visit number for sites examine multiple times.

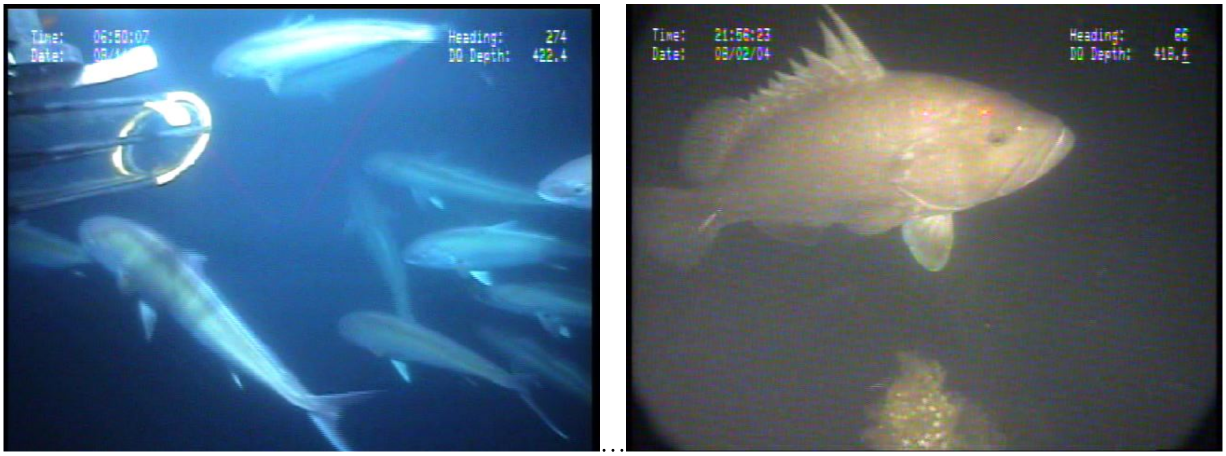
Table 5.10

Fishes Caught with the ROV Suction Sampler During Biological Sampling at the *Halo*.

Date	**Species**	**Number**
Aug 1 – Aug 3	*Anthias nicholsi*	6
	Helicolenus dactylopterus	1
	Hemanthias vivanus	10
	Monolene sessilicauda	4
	Ogcocephalus parvus	2
	Pronotogrammus martinicensis	3
	Zenopsis conchifera	1
Aug 13 – Aug 14	*Anthias nicholsi*	3
	Hemanthias vivanus	2
	Seriola dumerili (with ROV claw)	1

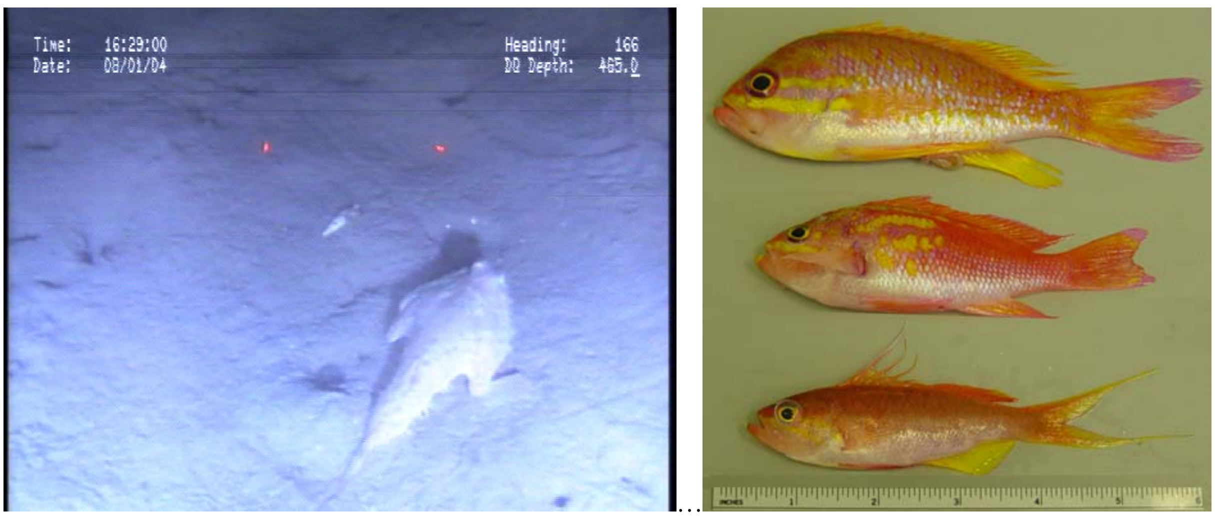
Anthiinae basses (Family: Serranidae) were the most abundant taxa observed in association with the wreck (Table 5.3; Figure 5.22-a). These deepwater reef fishes were observed hiding in coral thickets or in the ship's rigging, which made identifying species from video difficult. Individuals captured in traps or with the suction sampler included yellowfin bass (*Anthias nicholsi*), red barbier, (*Hemathias vivanus*), roughtongue bass (*Pronotogrammus martinicensis*), and a single longtail bass, (*Hemanthias leptus*) (Table 5.5 and 5.6). Observed members of the Serranidae subfamily Epinephelinae included Warsaw grouper (*Epinephelus nigritus*; Figure 5.22-b) and yellowedge grouper (*Epinephelus flavolimbatus*), both of which were captured in traps. Other reef-associated fishes seen or captured included vermilion snapper, greater amberjack (*Seriola dumerili*; Figure 5.23-a), blacktail moray, (*Gymnothorax kolpos*), red porgy (*Pagrus pagrus*), and deepwater scorpionfish, (*Setarches guenther*).

The fish most frequently observed on transects adjacent to the wreck was the greater amberjack. (Note: Amberjack were gregarious and appeared to follow the ROV, thus density estimates derived from their min counts were used in statistical analysis of community structure.) Many teleosts were observed next to the wreck that could not be identified due to poor visibility. Batfishes (*Ogcocephalus* sp.; Figure 5.23-b), were observed on transects both adjacent to and away from the wreck. Other fishes observed away from the wreck included flatfishes (Family: Bothidae) and a large king snake eel. Fishes caught in traps away from the wreck but not seen in video included spotted hake (*Urophycis regia*) and an American conger eel (*Conger oceanicus*). A single silvery John Dory (*Zenopsis conchifera*) was captured with the ROV suction sampler.



(a) (b)

Figure 5.22. (a) Amberjack, and (b) a large Warsaw grouper over or adjacent to *Halo*.



(a) (b)

Figure 5.23. (a) A batfish adjacent to *Halo*. Three species of Anthiinae basses captured with the ROV suction sampler are pictured in panel (b). From top to bottom are a yellowfin bass, roughtongue bass, and red barbier.

Diet and Trophic Structure

Stomachs were dissected from 39 fish sampled at the *Halo* site, but only 21 (54%) had food items present (Figure 5.24). Gut content analysis indicated fish dominated the diet of amberjack and conger eel, while invertebrate taxa composed the diets of blacktail moray and deepwater flounder (*Monolene sessilacauda*). The diets of Anthiinae basses (n = three species) were composed of invertebrate taxa but a large percentage of their diets could not be identified.

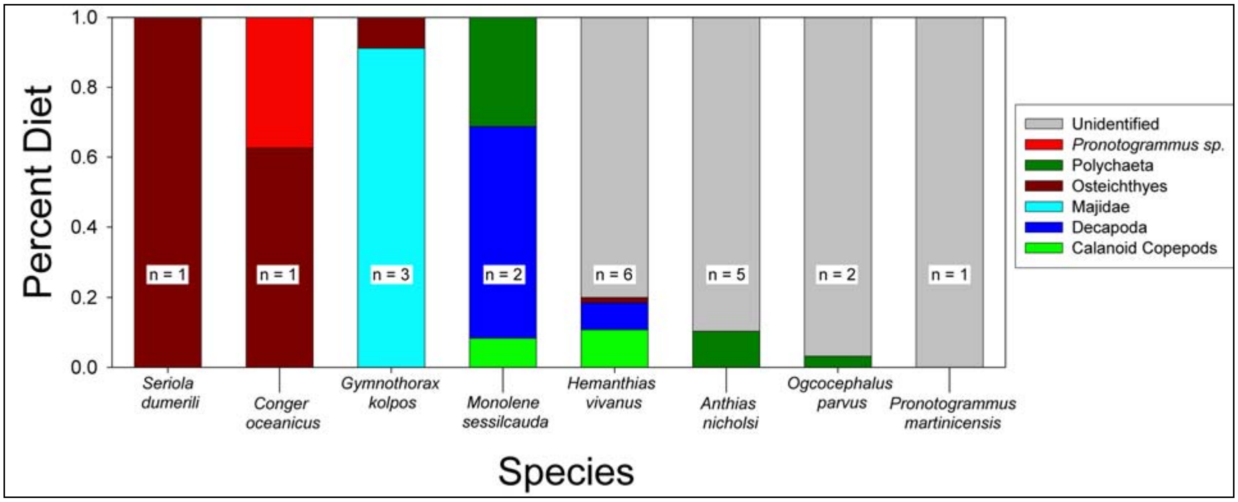


Figure 5.24. Prey taxa contribution to diets of fishes sampled at the *Halo*. Sample sizes are indicated for each species.

Stable isotopic composition of muscle samples was analyzed for several Anthiinae basses and Epinephelinae groupers captured over the ship (Figure 5.25). Tissue was analyzed from one red porgy and one amberjack associated with the wreck. Stable isotope values of Anthiinae basses were consistent with a zooplankton diet: $\delta^{13}C$ and $\delta^{15}N$ each were enriched approximately one trophic level above primary production and $\delta^{34}S$ values were consistent with pelagic production. The red porgy had values indicating a diet of benthic invertebrates. $\delta^{13}C$ and $\delta^{15}N$ values of amberjack and groupers indicated they fed at two full trophic levels higher than Anthiinae basses, but differences in $\delta^{34}S$ values among individuals indicated a range in benthic versus pelagic prey.

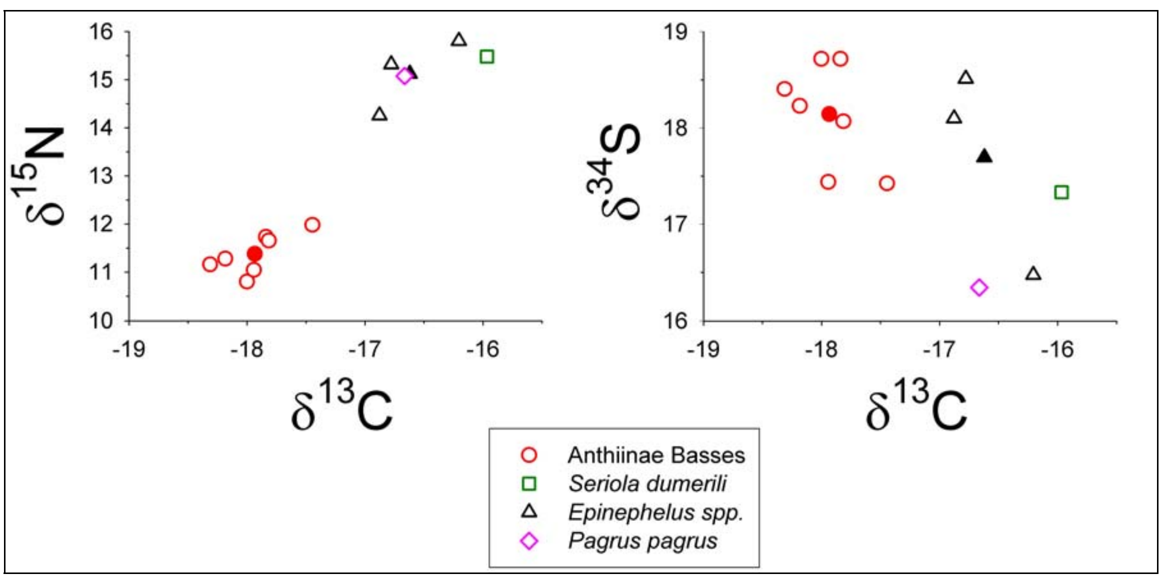


Figure 5.25. Stable isotope analysis of fish muscle samples collected during biological sampling at *Halo*. Filled symbols are species-specific mean values.

Tissue samples of several species captured away from *Halo* were analyzed (Figure 5.26). Batfish (*Ogcocephalus parvus*) fed at the lowest trophic level but their $\delta^{34}S$ values indicated a pelagic rather than benthic source of production despite the flounder's benthic existence. Only deepwater flounder (*Monolene sessilicauda*) had $\delta^{34}S$ indicating benthic production. Spotted hake, blacktail moray, and the American conger all fed at approximately one full trophic level above the deepwater flounder. Their $\delta^{34}S$ values also indicated pelagic sources of production. King snake eels fed at the highest trophic level among fishes sampled away from *Halo*. Their $\delta^{13}C$ and $\delta^{15}N$ values indicated feeding at approximately two trophic levels above the batfish, while their $\delta^{34}S$ values were intermediate between benthic and pelagic prey.

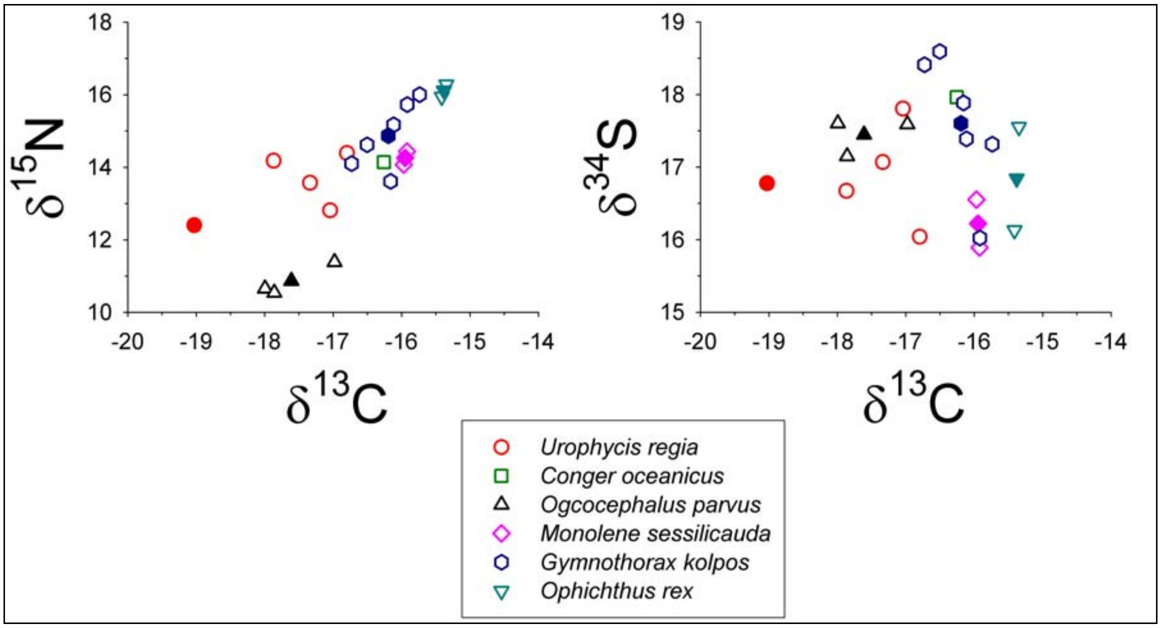


Figure 5.26. Results of stable isotope analysis of fish muscle samples collected during biological sampling away from *Halo*. Filled symbols are species-specific mean values.

Age Estimation

Opaque zones were counted in otolith sections prepared from 36 fish collected at *Halo*. Of the species sampled, opaque zones have been validated as annuli for amberjack (Thompson et al. 1999), yellowedge grouper (Manickchand-Heileman and Phillip 2000), Warsaw grouper (Manooch and Mason 1987), red porgy (Hood and Johnson 2000), Anthiinae basses (Thurman et al. 2004), and king snake eel (Clark 2000). Opaque zones in spotted hake have not been validated as annuli; however, validation has been performed for its congener *Urophycis cirrata*. Opaque zones also have not been validated as annuli in deepwater flounder, but otoliths of many other Bothid species on the outer shelf have been validated. Therefore, opaque zone counts were taken as age estimates for all species sampled at *Halo* (Figures 5.27-5.29).

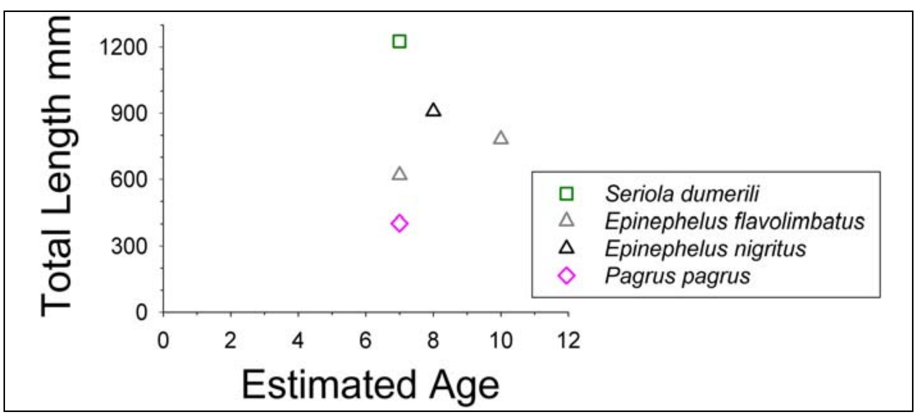


Figure 5.27. Size at age estimates for reef-associated fishes captured at *Halo*.

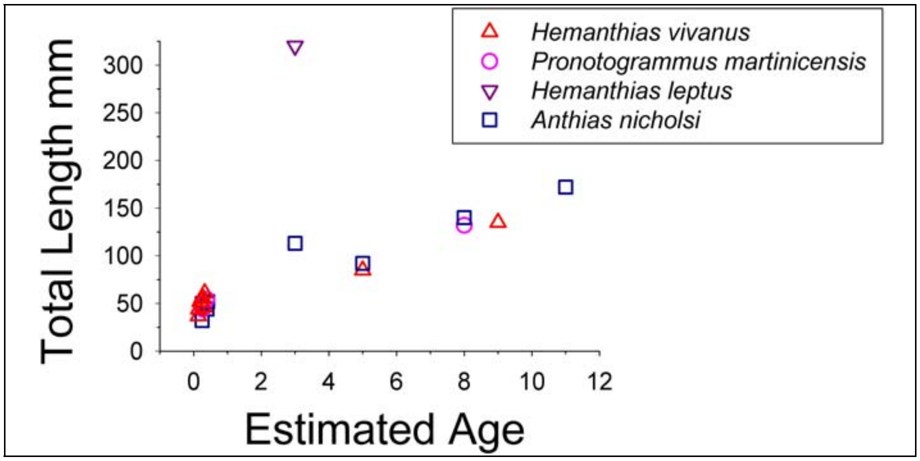


Figure 5.28. Size at age estimates for Anthiinae basses captured at *Halo*.

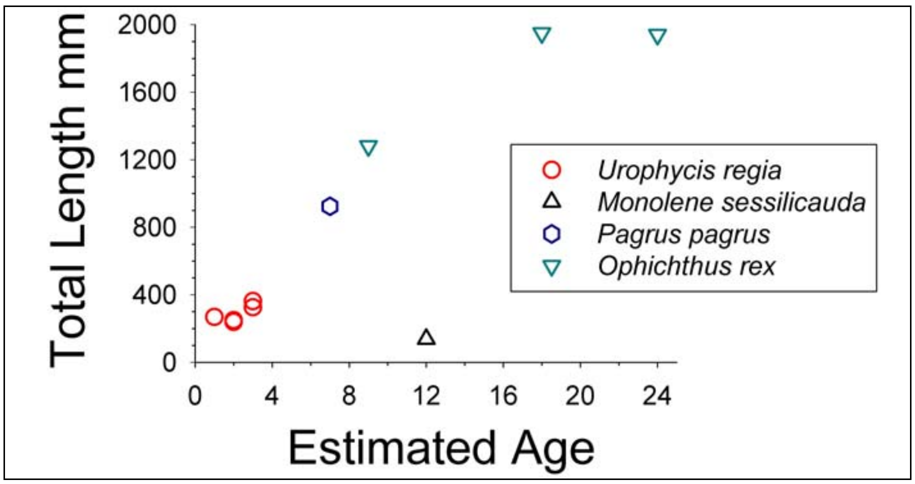


Figure 5.29. Size at age estimates for benthic and demersal fishes captured away from *Halo*.

5.6 Sediment Core Analysis

Four samples were taken at the designated distances from the ship. Each sample, after coming to the surface was removed from the sampling device and stored in a clean glass container at approximately 4° Celsius. *Halo*'s core samples did not indicate any visible differences. They all appeared to be smooth, gray/black sediment with a sour smell. The sour smell is indicative of the anaerobic biological activity (sulfate reduction) normally found within sediment samples. Samples were sent to a certified laboratory for organic chemistry analysis. The *Halo* site samples from each of the four cores indicated that the two closest core samples as well as the furthest sample tested positive for trace amounts of hydrocarbon in the C10-C14 carbon range. The positive samples were further analyzed using gas chromatography. Concentrations are as indicated in Table 5.11 below.

Table 5.11

Halo Core Analysis.

Site	Date	Sample Location	Concentration
Halo	August 3, 2004	Beside Ship	4.9 ug/g
		30 meters	5.3 ug/g
		152 meters	<1 ug/g
		305 meters	14 ug/g

6.0 *GULFPENN* SITE

6.1 Historical Background of the Tanker *Gulfpenn*

Figure 6.1. Tanker *Gulfpenn*, photograph taken by the United States Coast Guard (Courtesy of Mariner's Museum, Newport News, *Virginia*).

In 1916, the Sun Shipbuilding Company was formed in Chester, Pennsylvania, as an affiliate to the Sun Oil Company to bolster tanker construction, which was in great demand because of World War I. After the war, the Sun Shipbuilding Company continued constructing tankers, including *Agwihavre*, later renamed the *Gulfpenn* (Figures 6.1 and 6.2). *Agwihavre*'s keel was laid on April 2, 1920, and was launched June 16, 1921 (Kavanagh et al. 2001). She was built for the Atlantic, Gulf, and West Indies Steamship Line of New York. The vessel was a screw steamer powered by a quadruple expansion engine, located in the aft portion of the vessel. She had a length of 480.6 feet (146.5 meters), a beam of 65.6 feet (20 meters), a 36.7 feet (11.2-meter) depth of hold, and was 8,862 gross tons. The tanker had a plain stem with forecastle head, elliptical stern, and two masts. The Gulf Oil Corporation of Philadelphia, Pennsylvania acquired the vessel in 1942. Ownership of *Agwihavre* was transferred to the Gulf Oil Corporation of Philadelphia, Pennsylvania, and the vessel renamed *Gulfpenn*. On March 11, 1942, the *Gulfpenn* (Official Number 221244) was registered in the Port of Philadelphia, Pennsylvania under license to Arthur S. Hodges, as a coasting trade vessel (*Gulfpenn* 1921; and *Gulfpenn* 1942).

On February 28, 1942, *Gulfpenn* had its first exposure to U-boat activity when the crew received word that the unarmed oil tanker SS *Oregon* was attacked north of Cape Engano, Dominican Republic. *Oregon* was en route from Aruba to New York with a cargo of fuel oil when *U-156* (Hartenstein), which was out of torpedoes, caught and sank the tanker with its deck guns. *U-156* killed several of *Oregon*'s crew with machine-gun fire while they launched lifeboats. The following day, *Gulfpenn* rescued a group of survivors from *Oregon* (Hughes 2004; and Hocking 1969: 528).

On May 13, 1942, the unarmed *Gulfpenn* was transporting 90,000 barrels of gasoline from Port Arthur, Texas, to Philadelphia, Pennsylvania. *Gulfpenn* was steaming about eight kilometers ahead of another tanker, *Gulfprince*. At dawn *Gulfprince* was attacked by *U-507*. The first two torpedoes fired by *U-507* were spotted by *Gulfprince*'s lookouts and successfully evaded. The third glanced off the tanker's hull, but did not explode. The impact caused some damage, but both tankers escaped. *Gulfprince* sent a radio alert of the attack. Captain Harro Schacht of *U-507* stated in his logs that it was useless to pursue the tanker on the surface because his deck guns were secured, it was getting light, and the area had been alerted to his presence (Schacht 1942; and SeaWaves 2005).

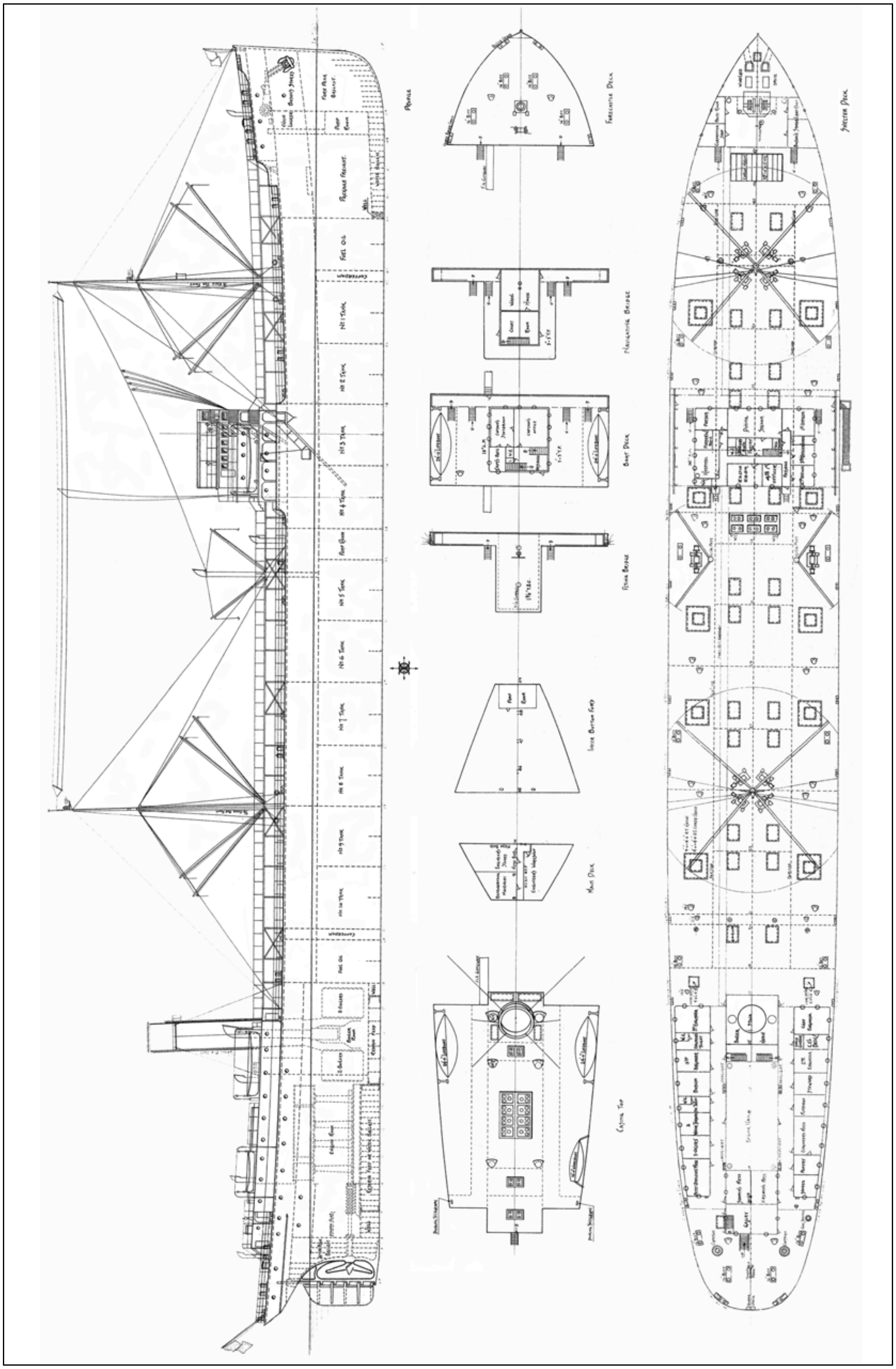


Figure 6.2. Architectural drawing of the tanker *Agwihavre* or "*Gulfpenn*," by the Sun Shipbuilding Company, July 8, 1920 (From the Independence Seaport Museum collection).

At 1450 hours (CT) on May 13th, *Gulfpenn*'s luck ran out when she crossed paths with *U-506*. The tanker had been traveling at 11 to 12 knots and zigzagging in irregular patterns. They were running radio-silent with four lookouts on duty, one on the forecastle, one on the bridge, and two on the aft deck. The weather was clear with moderate seas and light winds. Visibility was good and one other ship could be seen approximately 8.8 kilometers astern. The U-boat's torpedo struck the engine room, destroying that section of the ship, immediately stopping the engines, and killing all of the personnel in the engine room. The tanker sank stern first, taking only five minutes to slip beneath the waves. Out of the 38 crewmen, 26 made it into lifeboats. Of these 26, one man died in a lifeboat while the Honduran vessel *Telde* rescued the remaining 25 survivors less than three hours after the attack (Burch 1942a).

6.2 Previous Investigations

In 1994, the shipwreck, *Gulfpenn,* was discovered during a deepwater survey in Mississippi Canyon conducted for Shell International Exploration and Production Inc. John E. Chance and Associates using the TAMU (Texas A&M University), deep-tow system conducted the survey. The wreck was detected at the edge of the survey swath by side scan sonar, which was set at a range of 750 meters per channel (Figure 6.3). The large sonar target was within 13 kilometers of the historical location of *Gulfpenn*. Marine archaeologist Laura Landry conducted an archaeological assessment of the survey and tentatively identified the shipwreck as *Gulfpenn* (Landry 1994).

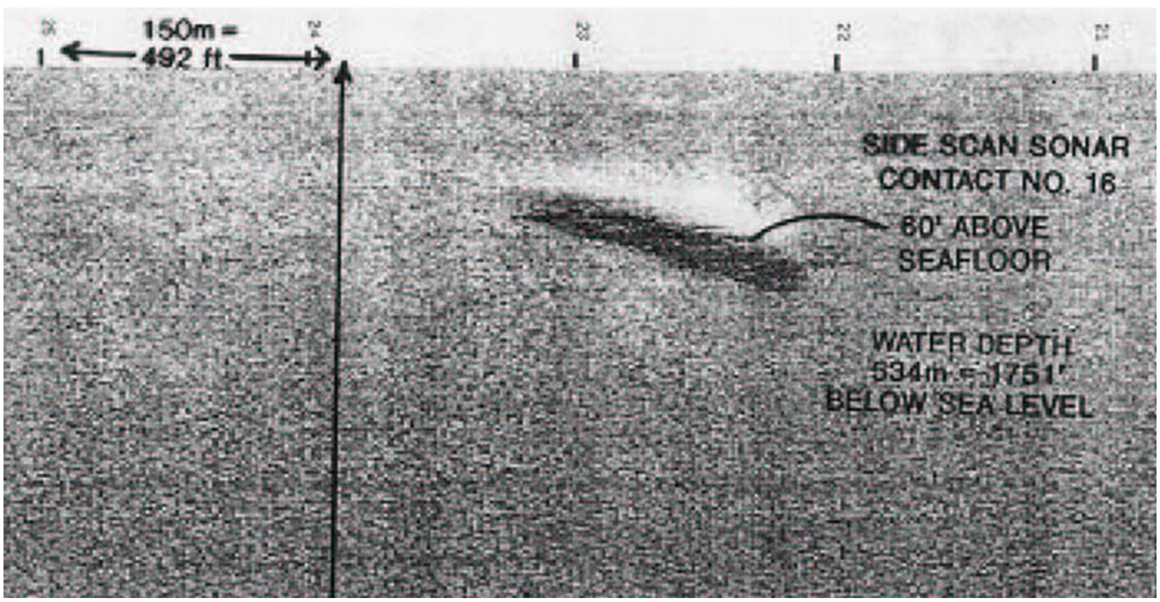


Figure 6.3. Side scan sonar image of *Gulfpenn* from the TAMU deep-tow system (Courtesy of Shell International Exploration and Production Inc.).

6.3 Geographical Setting

The *Gulfpenn* wreck site area is located in the central portion of the Mississippi Canyon Area of the northern Gulf of Mexico. The site is south of the mouth of the Mississippi River along the Upper Mississippi Fan's northern edge. The Mississippi Fan is a bow shaped fan made up of several fan-lobes and separated into three major regions: Upper, Middle, and Lower. The Mississippi Canyon is the conduit for the source material that comprises the Mississippi Fan (Bouma et al. 1985). The wreck site rests on the canyon's eastern slope and is likely influenced by the material flowing down the canyon. The seafloor in this area gently slopes at approximately three degrees toward the south with local variations in the seafloor slope. The seafloor trend at the wreck site is to the south-southwest (Figure 6.4). This area's sedimentation rate is relatively low in this area, approximately 2.13 millimeters per year.

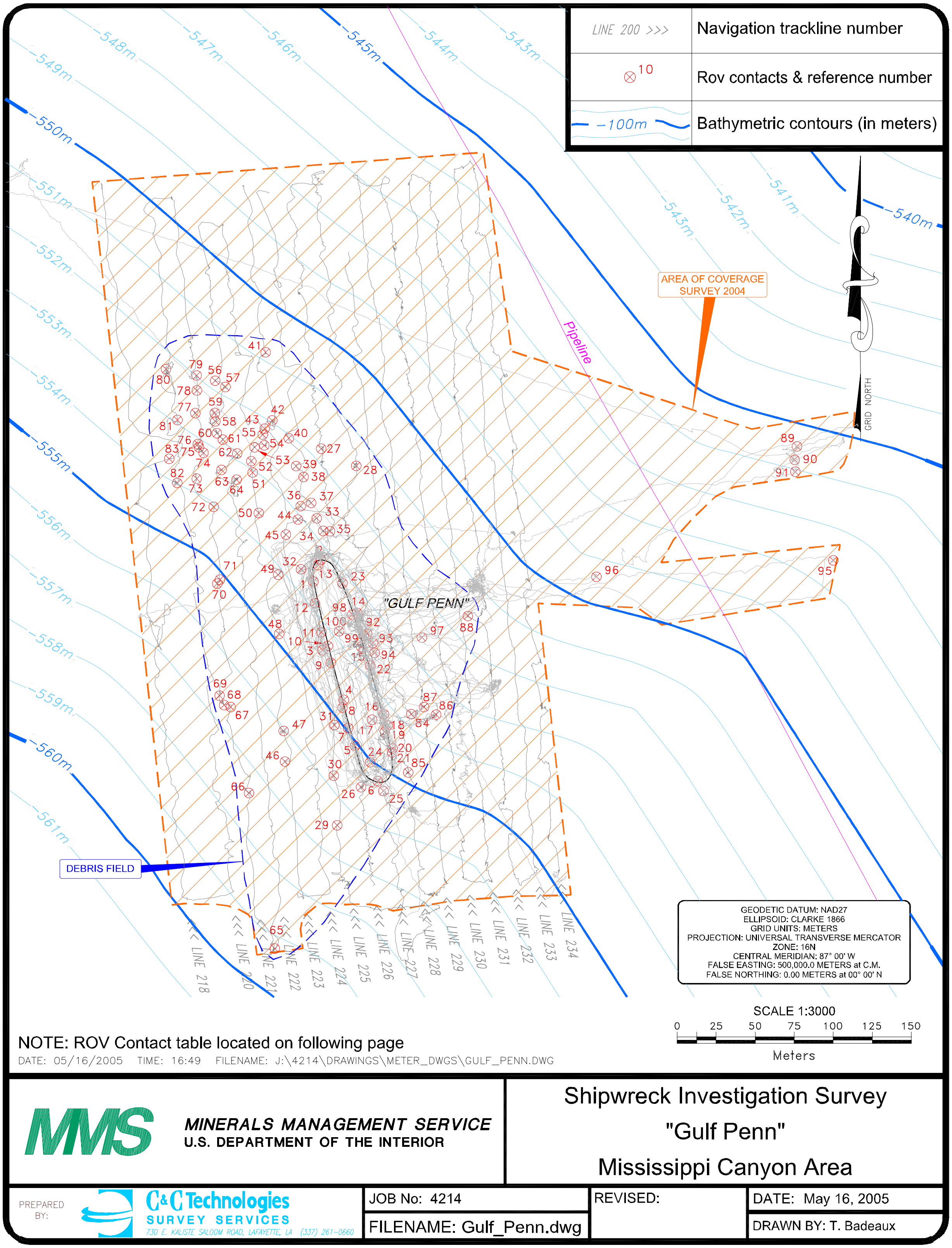


Figure 6.4. *Gulfpenn* site overview map.

Table 6.1

ROV Contacts from Figure 6.4.

No.	Description	Time		No.	Description	Time
1	Coral	0:17		51-52	UWD	8:17-18
2	Bow	0:24		53	Port hole	8:19
3	Pilot house, part of mast, & lines	0:34		54-55	UWD	8:20-22
4	Coral thicket	0:41		56	Ventilation cowl	8:45
5	Coral	0:46		57	Textile	8:48
6	Stern	1:02		58	Barrel	8:50
7	Scallops	1:13		59	Ventilation cowl	8:52
8	Rusticles	1:15		60	Bucket with handles	8:58
9	Rusticles	1:19		61	UWD	8:59
10	Leather or rubber, possible gasket	1:22		62	UWD	9:01
11	Pipe against hull	1:27		63	UWD	9:05
12	Rusticles	1:31		64	Life boat	9:09
13	Artifact 2 UWD	1:37		65	UWD	9:43
14	Wall of Coral	1:59		66	Metal tube	9:50
15	Standing mast	2:04		67	UWD metal	9:55
16	Hull buckle with cables	2:13		68	Metal rod	9:56
17	Stairs at engine room, experiment	2:18		69	UWD, metal	9:58
18	Coral	2:28		70	UWD	10:04
19	Obstacle	2:33		71	Ventilation cowl	10:05
20	Davit with coral	2:35		72	Round UWD	10:09
21	UWD metal pipes	2:47		73	Vent cowl & possible port hole	10:11
22	Rusticles on hull	2:52		74	UWD - pot/bowl shaped object	10:13
23	Rusticles	2:59		75	UWD - wood	10:15
24	Helm Wheel and Rusticles	3:40		76	UWD - Ferrous	10:17
25	UWD metal rectangular shape	3:55		77	UWD - metal	10:21
26	UWD and textile	4:18		78	UWD - metal	10:24
27	UWD	5:02		79	Ventilation cowl	10:25
28	Plastic crate and UWD	5:36		80	UWD	10:44
29	Possible ventilation cowl	6:29		81	Barrel	10:53
30	UWD	6:32		82	UWD - bowl shaped	11:00
31	UWD	6:34		83	UWD - metal rectangular shape	11:39
32	Metal pipe	6:43		84	Funnel	13:06
33	Metal pipes	6:45		85	Sack with Writing	13:17
34	Possible plate	6:46		86	Funnel with whistle & ladder	13:48
35	UWD, metal	6:49		87	Possible lettering	13:57
36	UWD	6:54		88	UWD - large letters	17:08
37	Metal and textile	6:55		89	UWD	7:14
38	UWD, possible port hole	6:57		90	Small trap set at 1000'	7:18
39	UWD	6:58		91	Lg fish trap set at 1000'	7:20
40	Ventilation cowl	7:01		92	Minnow trap set@1000'	8:00
41-43	UWD	7:35-40		93	Set lg trap near wreck	8:14
44	Ventilation cowl	7:44		94	Set crab trap near wreck	8:15
45	Possible stern	7:44		95	Set small trap near wreck	11:46
46	UWD	8:03		96	Core sample C	12:07
47	UWD	8:05		97	Core sample E	12:28
48	Ventilation cowl	8:09		98	Core sample A	12:42
49	UWD	8:12		99	Third Wall of Coral	15:33
50	UWD, possible port hole	8:15		100	Ship's telegraph	21:26

UWD = Unknown Wreck Debris

6.4 Discussion of Archaeological Finding

6.4.1 Physical Site

The following description of the wreck site is compiled from data collected during the 2004 field expedition. The wreck site investigation was conducted with the Triton XL11 ROV between August 4 and 5 and August 11 and 13, 2004. Visibility at the site was good, averaging approximately six meters.

The wreck is oriented with the bow pointing north-northwest and stern to south-southeast. Water depths range from approximately 553 meters at the bow to 555 meters at the stern. The vessel's bow extends into the water column more than the stern. The deck of the forecastle stands about 18 meters above the ambient seafloor as opposed to the aft deckhouse, which rises approximately 5.5 meters above the ambient seafloor.

The bow and forward section are relatively intact (Figure 6.5). The catwalk and piping are extant from the forecastle to the bridge structure. Coral covers the catwalk and railing, particularly along the starboard side of the vessel obscuring much of the structural detail. The foremast has separated from the deck and fallen forward. The foot of the mast lies on the deck and the mid-portion lies across the forecastle near the end of the catwalk. The mast's upper parts appear to have broken away and are gone. Figure 6.6 shows a site map of the shipwreck's main structure.

Figure 6.5. Bow of the *Gulfpenn*.

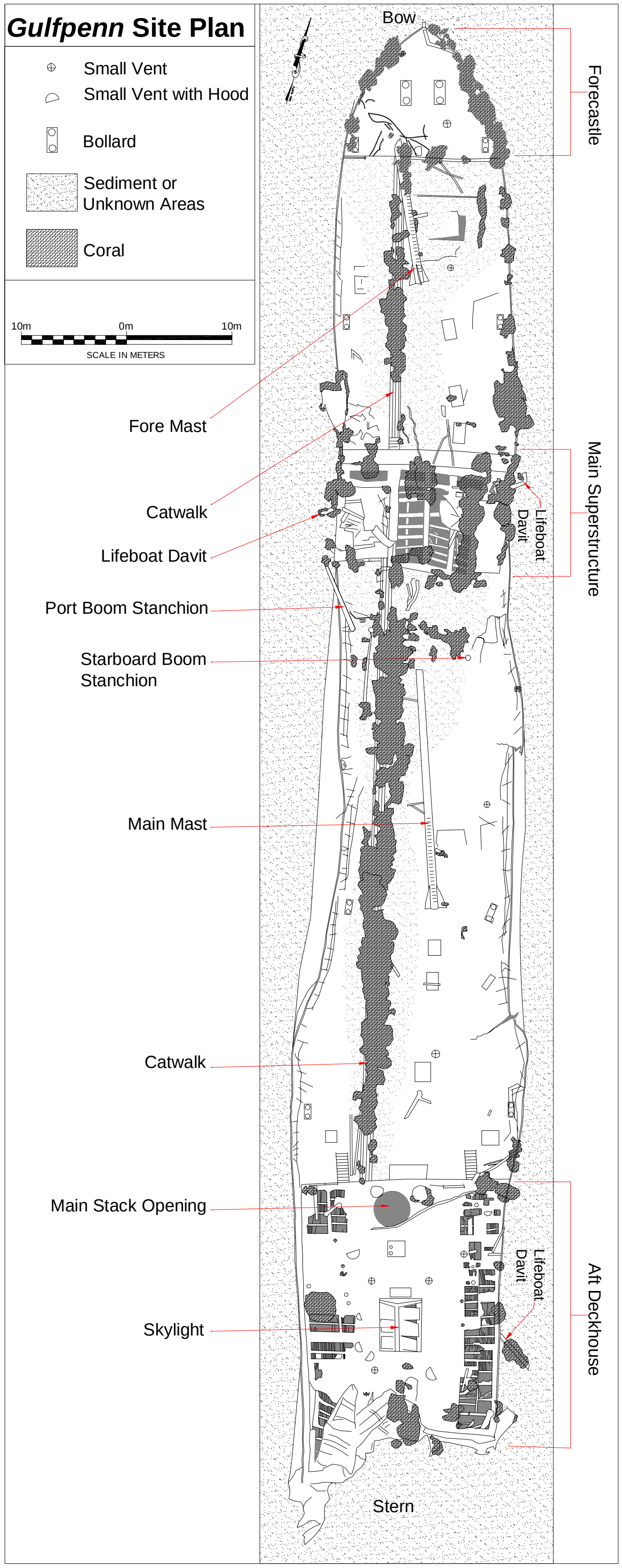


Figure 6.6. Site drawing of *Gulfpenn*'s main structure (Drawn by Robert A. Church).

The superstructure's upper works show a considerable deterioration. The pilothouse is gone and the bridge's deck is disintegrating. The remaining superstructure, mainly on the port side, is collapsing with sections of metal plating partially suspended from the vessel. The ship's telegraph has fallen over and spans part of the metal framework of the bridge (Figure 6.7). The superstructure's starboard side is almost entirely obscured by prolific coral formations.

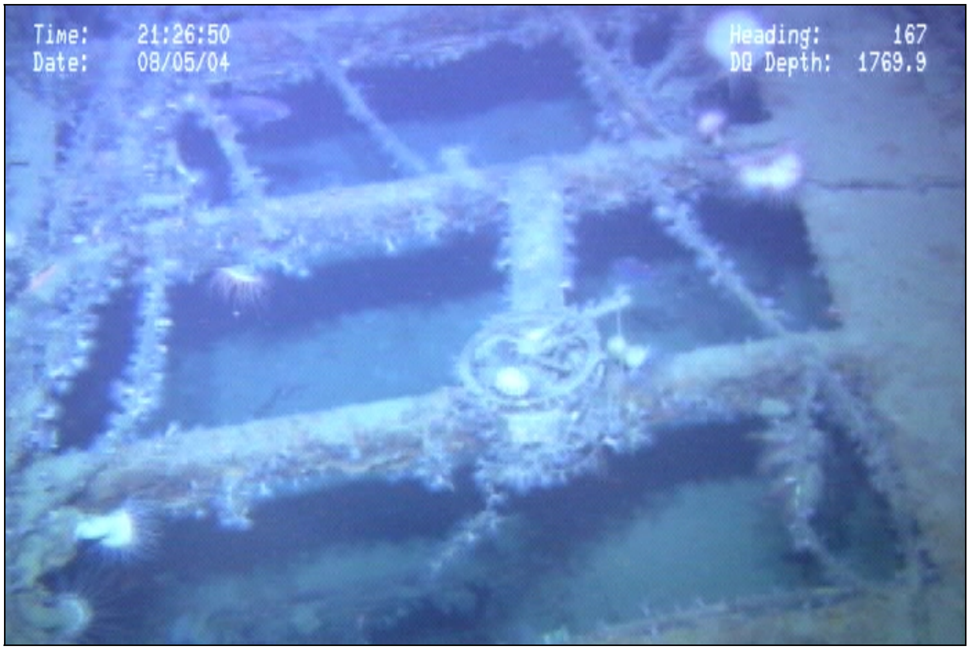


Figure 6.7. Top of *Gulfpenn*'s superstructure showing the bridge telegraph lying across the exposed deck frame supports.

Extensive damage is also present aft of the vessel's main superstructure. Although the catwalk and piping from the main structure to the aft deckhouse are intact, the hull amidships has partially collapsed. Sections of the railing and gunwales are lying nearly flat against the deck and the deck is buckled inward in places. There are two hull breaches on the starboard side. The first is approximately 16.7 meters aft of the main superstructure and the second is approximately 25.5 meters further aft than the first rupture (Figure 6.8). On deck, the starboard stanchion (small mast) remains upright approximately 8.3 meters aft of the main superstructure, but the port stanchion has fallen forward with the upper part extending beyond the side of the ship. The main mast has fallen forward and lies on the deck (Figure 6.9). Corals cover the catwalk along this section of the wreck.

Figure 6.8. Breach in the hull along the vessel's starboard side.

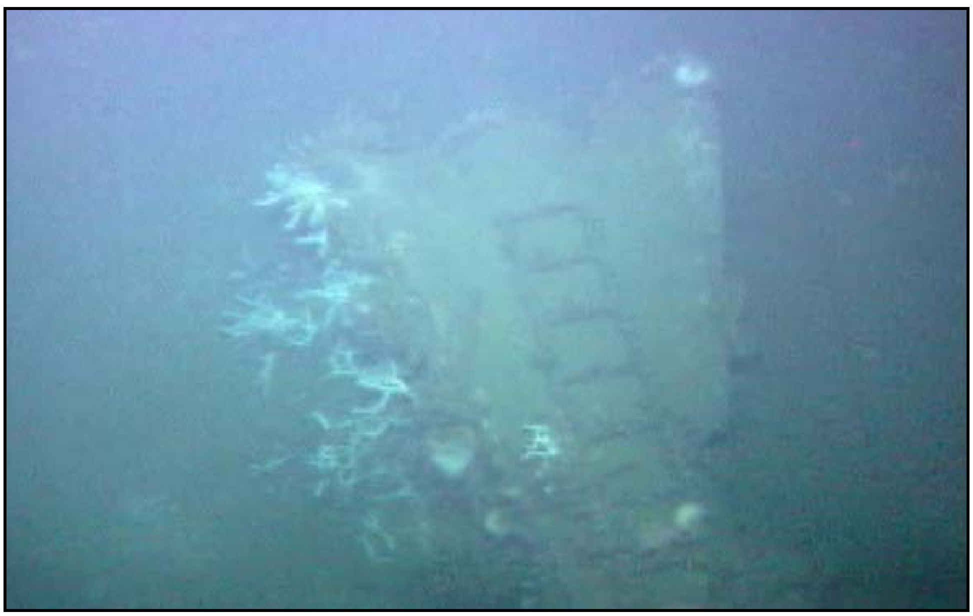


Figure 6.9. Foot of the main mast lying on the deck.

Gulfpenn's aft portion exhibits the most severe damage. The deck of the aft deckhouse is deteriorating and has partially collapsed inward exposing the interior. The main smokestack is gone, leaving behind a gaping hole where it once stood. Two vent pipes were originally located directly forward of the main stack. The starboard vent pipe still stands, albeit missing a vent hood. The port vent has been destroyed with only fragments visible where it should be. A skylight or air vent at the deckhouse's center is relatively intact. Roughly nine meters aft of the skylight the hull ends abruptly in a contortion of mangled metal plating. Almost 11 meters of the stern has been ripped away. Only partial remains of the aft helm controls, used for docking, are visible forward of this severely damaged area (Figure 6.10). Coral partly covers the wreck's aft section, and is more prevalent on the vessel's starboard side. Coral growth obscures much of the vessel's structural details on the starboard side, making them difficult to distinguish.

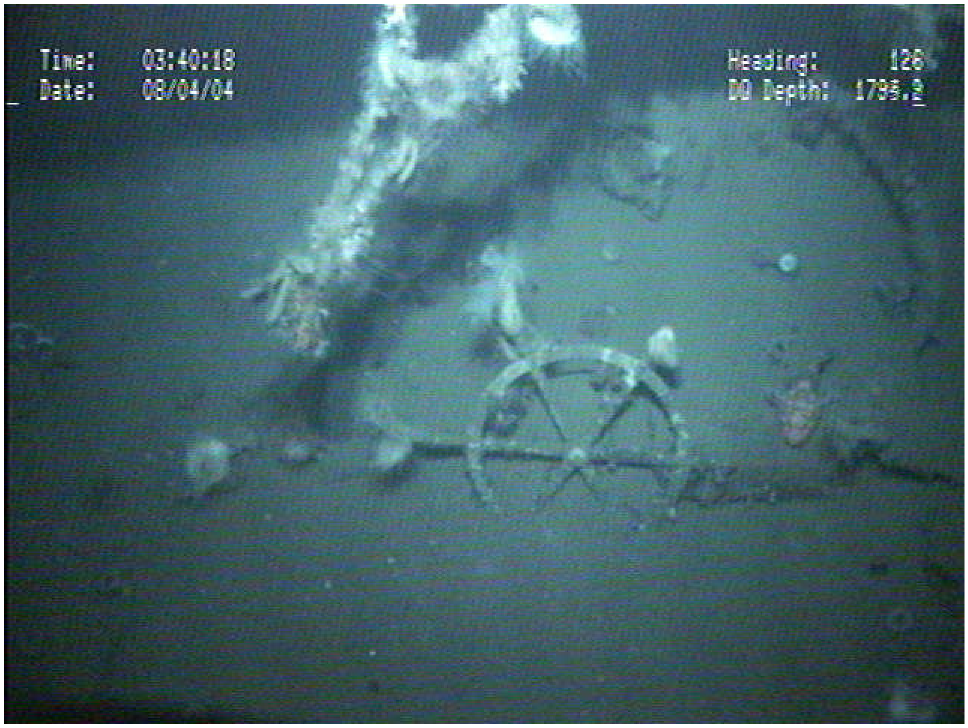
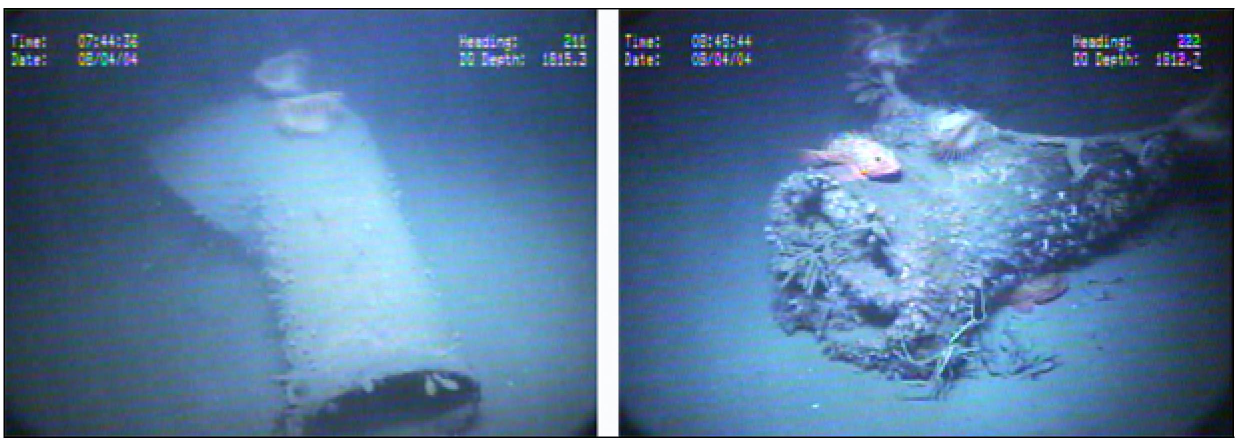


Figure 6.10. Remains of the docking helm control on the aft deckhouse.

An extensive artifact scatter surrounds the wreck site. The main debris zone extends nearly 161 meters northwest from the vessel. An area of light debris extends 130 meters southwest of the main hull. Smaller debris extends 65 meters to 70 meters east and west of the primary wreckage. A large section of the ship, that appears to be the stern's missing section (Figure 6.11), lies within the main debris field 27 meters northwest of the bow. Other material within this dense debris field includes vent hoods and pipe (Figure 6.12 a and b), railing, twisted metal, and a lifeboat (Figure 6.13). The vent shown in Figure 6.12a at ROV fix location No. 44 (See Figure 6.4) lies within a few meters of the suspected stern section. The vent hood shown in Figure 6.12b at ROV fix location No. 56 lies 133.6 meters northwest of the bow. The lifeboat shown in Figure 6.13 at ROV fix location No. 64 is 73 meters northwest of the bow. The missing stack lies 25 meters east of the aft deckhouse's starboard side, nearly perpendicular to its original deck location (Figure 6.14). The funnel is almost completely flattened with the top pointing away from the vessel. The ladder and steam whistle running up the stack's forward edge are still intact.

Figure 6.11. Possible section of the vessel's detached stern.



a) b)

Figure 6.12. a) Vent hood lying near the separated stern section. b) Vent hood lying near the northern extent of the debris field.

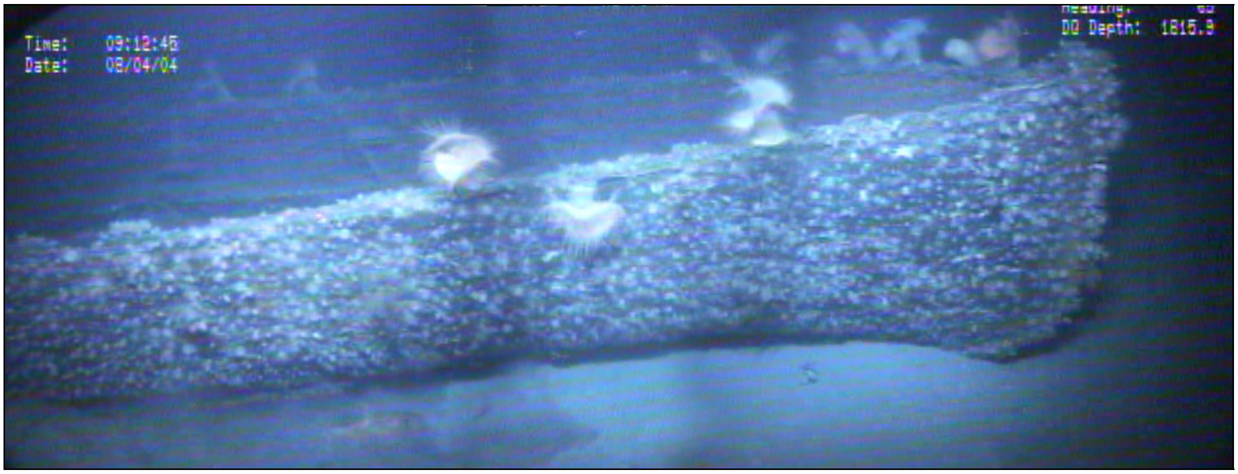


Figure 6.13. Lifeboat from *Gulfpenn* in the debris field (Photo mosaic).


Figure 6.14. *Gulfpenn*'s main stack, lying to the vessel's starboard side (Photo mosaic).

Gulfpenn's stern damage is consistent with the historical accounts of the U-boat attack. The evidence suggests the torpedo attack ripped the stern from the main hull. As the disarticulated stern plunged to the seafloor spilling debris, the remainder of *Gulfpenn*'s hull sank by the after most section. As the hull planed downward it crossed over the fragmented stern section and debris trail impacting the seafloor behind it. *Gulfpenn*'s main hull impacted the seafloor aft section first, collapsing the torpedo-damaged aft hull and leaving the bow extending proud off the seafloor. The masts' standing rigging possibly parted as a result of explosions during the attack. Drag encountered through the water column as the vessel sank likely caused forward stress on the masts before the ship impacted the seafloor. The fore and aft masts have both fallen forward, at a similar angle of four to nine degrees to port with their foot lying near the base, indicating they likely collapsed as a result of uniform stress experienced on impact. It is possible both masts fell before impact, but if the bolts holding the base had already given way, the masts would likely have slid aft on impact, which is not indicated from their present orientation.

6.4.2 Site Preservation

The wreck site is in a moderate state of preservation. Site deterioration is not as advanced as at the *Virginia* and *Halo* sites. The bow section is in good condition, but the aft section has considerable damage from the wrecking event. Some decking is still intact, but is rapidly deteriorating. The severe damage to the hull's aft section indicates the aft section likely will collapse before the bow and main superstructure.

6.5 Discussion of Biological Findings

6.5.1 Microbiology

Gulfpenn, at a depth of 538 meters exhibited very different growths than the other ships under investigation. Most significant of these differences was the abundance of microbial concretions (C4) that coated 30% of the ship's observable surface. All of these concretions appeared to be attached to form large branching whorls. These were found growing with a similar abundance over the decking, hull plates, railings and other ship structures. Sea anemones were also observed at an average density of 2 per m^2. Brown rusticles (C1) were more abundant in mass, but occupied only 15% of the area and many were of a larger size ranging up to 1.5 meters with widths ranging up to 500 millimeters. There was not such large mass of concretious dendritic growth (C3), but they occupied 60% of the area. Thickness ranged from 5 to 15 millimeters, and was commonly overlain with only thin coatings of slime (B1). This slime coated one third of the area occupied by the C3 type. One large integrated biocolloidal gel (also referred to as a "blob", B2) was identified on the starboard side above the mud line, coating approximately 20% of the starboard hull plates with a fine gel-like matrix that also embraced some of the C4 concretions. The "blob" was tracked along the starboard hull-mud line interface, it disintegrated and dispersed quickly and was not observed when the region was inspected again six hours later. For the bio-battery platform, electrical potentials (mV) were recorded (Figure 6.15) between only three of the coupons.

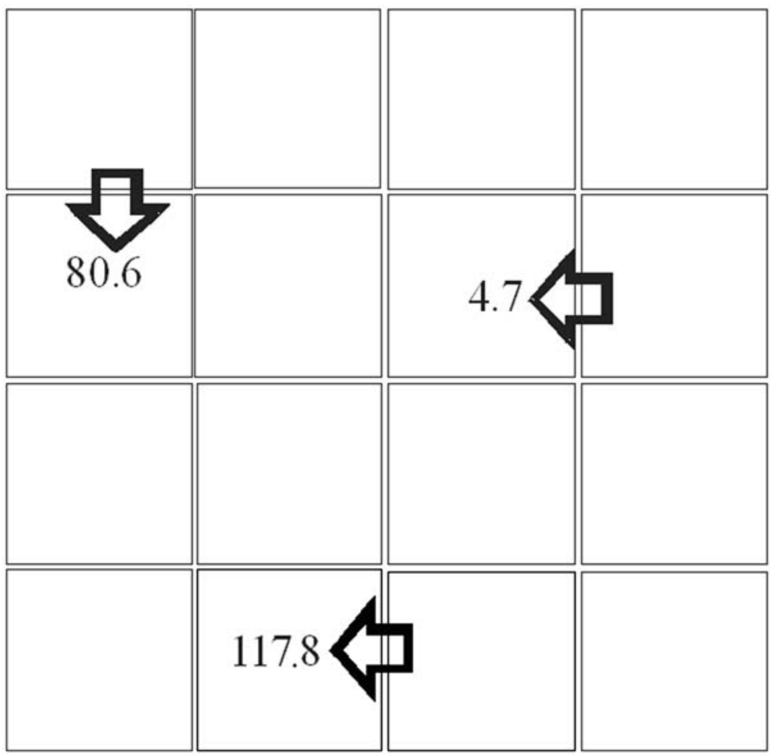


Figure 6.15. Voltages (millivolts) detected on bio-battery coupons deployed on *Gulfpenn*.

Gravimetric elemental analysis using ICP-AES of the rusticles recovered from the port and starboard sides of *Gulfpenn* are given in Table 6.3. Here it was found that the dominant three elements were iron (96%), sodium (2.5 – 2.7%), and magnesium (0.2 – 0.3%).

Table 6.2

Gravimetric Elemental Analysis of Brown Rusticles (C1) from *Gulfpenn*'s Port and Starboard Side

	Port	**Starboard**
Iron	96.3236%	96.8307%
Sodium	2.6978%	2.4549%
Magnesium	0.3440%	0.2387%
Potassium	01680%	0.1449%
Calcium	0.1322%	0.0784%
Phosphorus	0.1159%	0.1227%
Aluminum	0.0960%	0.0409%
Manganese	0.0670%	0.0392%
Molybdenum	0.0110%	0.0133%
Vanadium	0.0098%	0.0092%
Boron	0.0096%	0.0080%
Cadmium	0.0078%	0.0077%
Strontium	0.0053%	0.0031%
Lead	0.0045%	0.0038%
Barium	0.0027%	0.0011%
Titanium	0.0017%	0.0008%
Chromium	0.0007%	0.0007%
Zinc	0.0006%	0.0004%
Cobalt	0.0002%	0.0000%

6.5.2 Invertebrate Zoology

The *Gulfpenn* site had the highest species richness of all sites, and 99 voucher specimens belonging to 26 taxa were collected. This comparatively high abundance and diversity of fauna at 536 to 557 meters depth was perhaps a result of the low turbidity, resulting good visibility, and the intermediate oxygen content (> 4 mg l^{-1}); temperature was 7.4°C and salinity was approximately 35 ppt. Crustaceans were represented by the most species (17), followed by mollusks (5), echinoderms (2), and cnidarians and polychaets with one each. *Rochinia crassa* (inflated spiny crab) was abundant, and 26 specimens were collected. Galatheoid crabs (chirostylids and galatheids, sometimes called squat lobsters) and Venus flytrap anemones (*Actinoscyphia* sp.) were also common at this site.

Sediment composition was similar to that of the *Virginia* and *Halo* sites; the majority of the sediment was clay and silt, but some sediment was incorporated into pellets, increasing the water content and size of interstices. Nematodes were numerically predominant in the meiofauna, but their density was half of that recorded at *Halo* and 25% of the density found at *Virginia* (Table 6.5). Polychaets and harpacticoid copepods were less abundant and approximately equal. A few individuals of several other taxa were found sporatically. A single individual of the same species of caudofoveatan mollusk (*Scutopus* sp.) that was initially found at *Virginia* was found in core A. Ten tanaidaceans were found in core D. These chelate crustaceans were found at all deeper sites, and appeared to be the same species at all sites. Like many of the peracarid crustaceans, the tanaidaceans do not have planktonic larvae, but instead are brooded in a marsupium and released as juveniles. Our specimens appear to be juvenile *Gigantopseudes adactylus*, a species that grows to several centimeters in length as an adult and is largely restricted to the deep sea (Anderson et al. 2005).

Table 6.3

Density (Number Per 100 m^{-2}) of Invertebrates Observed on Transects Over, Adjacent and Distant (300 m) from the *Gulfpenn* Site.

	Transect Number								
	Far			**Adjacent**			**Near**		
GulfPenn	**200**	**201**	**202**	**222**	**223**	**224**	**225**	**226**	**227**
Crustaceans									
Chaceon quinquedens	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Munida sp.	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.2	0.0
Rochinia crassa	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.4	0.0
Hermit crab	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Shrimp	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Gooseneck barnacles	0.0	0.0	0.0	0.0	0.7	0.0	1.4	0.2	0.5
Echinoderms									
Holothurian	0.8	1.1	1.5	0.5	0.5	1.0	0.0	0.0	0.0
Mollusks									
Acesta sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Gaza superba	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Cnidarians									
Anemone	0.0	0.6	0.0	1.0	3.5	0.5	9.6	3.0	19.1

Table 6.4

Density of Meiofauna (numbers per 10 cm^2) From Sediment Cores Collected Adjacent to (Core A) and Progressively More Distant (Cores B And C) from *Gulfpenn*.

Wreck	***Gulfpenn***		
	Number per 10 cm^2		
Taxon	Core A	Core C	Core D
Harpacticoida	5.4	0.0	19.9
Tardigrada	0.0	1.8	0.0
Tanaidacea	0.0	0.0	18.1
Nematoda	273.8	250.2	359.0
Amphipoda	1.8	0.0	3.6
Gastrotricha	0.0	3.6	0.0
Kinorhyncha	0.0	0.0	1.8
Polychaeta	3.6	14.5	7.3
Aplocophoran	1.8	0.0	0.0
Unknown	1.8	0.0	0.0

Figure 6.16. *Eumunida picta* collected from *Gulfpenn* (Photo by Morgan Kilgour and Aaron Baldwin).

Many macrofaunal invertebrates, particularly chirostylid crabs and brittlestars, have been associated with deepwater corals and other bioherms (Buhl Mortensen et al. 1995; and Buhl Mortensen and Buhl Mortensen 2004). The galatheoid crab *Eumunida picta* is well known (Figure 6.16), but has commonly been associated with hydrothermal vents. We observed the species in association with the deepwater coral *Lophelia pertusa* and found the species only at the *Gulfpenn* site. *Eumunida picta* was observed in water depths from 533 to 556 meters. Although only 20% of the *Lopelia* had *E. picta*, 81% of the E. *picta* were observed in association with the deep-sea coral. *Eumunida picta* was usually within 1 m of the coral when it was not in direct contact with it. The coral may be providing an optimum feeding location for the crab, refuge from predation, or both. Interestingly, the crab was found only at this site, so the species may be bathymetrically constrained.

Rochinia crassa, the inflated spiny crab, was also abundant and conspicuous; 26 specimens were collected, with most (23) near *Gulfpenn*. The species is found on mud and sand substrates from 66 to 1,216 meters from Massachusetts to Texas, and from Colombia, and French Guiana (Williams 1984). The crab is a member of the family Majidae, and most members of the family have a terminal molt when they molt to maturity. That is, as the carapace reaches its adult morphology, the crab will not undergo another molt. This is particularly interesting in that none of the specimens in our photo documentation display evidence of lost limbs or earlier regeneration (Figure 13.3).

Table 6.5

Macroinvertebrate Species Collected at the *Gulfpenn* Site,
Including Number and Proximity to Wreck, Substrate, and Depth.

Gulfpenn					
Specimen ID	**Number Near Wreck (< 61 m)**	**Number far from wreck (>61 m)**	**Unknown collection location**	**Substrate**	**Depth (m)**
Pycnogonida					
Colossendeis bicincta	5			Wreck	551-555
Crustacea					
Bathynomous giganteus	3			Silt	554
Chaceon quinquedens	2	2		Silt	549-555
Eumunida picta	7			Wreck	538-549
Munida sp.	6			Wreck;Silt	545-556
Munidopsis glabra	3			Wreck	551-555
Parapagarus pilimanus	1	3		Silt	551-556
Phimochirus holthuisi	5			Silt	551-556
Podochela sp.			1	Unknown	
Rochinia crassa	23	*3*		Wreck; Silt	539-557
Trichopletarion nobile			1	Unknown	
Axiidae		2		Silt	548-553
Hippolytidae	4	1		Silt	553-556
Pandalidae	3			Wreck; Silt	551-557
Segestidae	1			Silt	555
Gooseneck barnacles (cf. *Scapellum*)	1			Wreck	549
Necrophagous isopods		1			547
Cnidarians					
Actinoscyphia sp. (Venus fly trap anemone)	1			Wreck	536
Polychaeta					
Onuphidae		2		Silt	557
Mollusca					
Acesta sp	4			Wreck	551-552
Gaza superba	4	2		Silt	554-557
Xenophora sp.			1	Unknown	
Buccinidae	*3*			Silt	553-556
Cephalopoda		1		Silt	546
Echinodermata					
Astropecten sp.		1		Silt	552-554
Holothuroidea		2		Silt	551-556

Several taxa encountered at this site exhibited giantism, a phenomenon in which species are unusually large in comparison to other members of the taxonomic group; giantism is more common in deeper and colder waters. The impressive giant sea spider, *Colossendeis bicinctata*, is one such example; the species has been found at depths to 3,058 meters in the Gulf of Panama (NMNH, 2006). Pycnogonida, or sea spiders, feed on the fluids of soft-bodied invertebrates, particularly hydroids and anemones. Their larvae are not planktonic and have slow dispersal; hence endemism (restricted spatial distribution of species) is relatively common within the pycnogonids. During the egg brooding period, males are relatively easy to identify, as they are incubating the fertilized eggs. The commonness of the giant sea spiders at this site may have been related to the commonness of anemones, soft corals, or other soft-bodied invertebrates at the site. The large isopod, *Bathynomus giganteus*, was another species displaying giantism, and three specimens were collected. This large scavenger is among the more common large predators at the sites and is widely distributed throughout the Gulf of Mexico, North Atlantic, and Caribbean Sea from relatively shallow depths of a few hundred meters to several thousand meters.

Scleractina, Antipatharia, and Gorgonacea

Good to very good visibility at this site resulted in a thorough examination and video documentation of the tanker *Gulfpenn*. Depth at the site is on the order of 554 meters BSL, and the hydrographic conditions measured during the survey were: temperature ~7.4º C; salinity ~34.9 psu; and dissolved oxygen ~4.2 mg l^{-1}. All depths reported in the following text are the uncorrected ROV readings displayed on the video recordings.

Two scleractinians, *Pourtalosmilia conferta* and the tuft coral *Lophelia pertusa*, were found on the *Gulfpenn* (Table 4.3). No antipatharians or gorgonians were observed or collected. *Pourtalosmilia conferta* was seen once on the video records. A solitary, medium size colony of this densely branched coral, or possibly a cluster of small colonies, was observed attached near the top of the standing portion of the mast on the aft deck at a water depth of 537 meters (Figure 6.17). Conversely, it is conservatively estimated that *L. pertusa* has colonized 12-15 percent of available exposed surfaces and structures throughout the wreck.

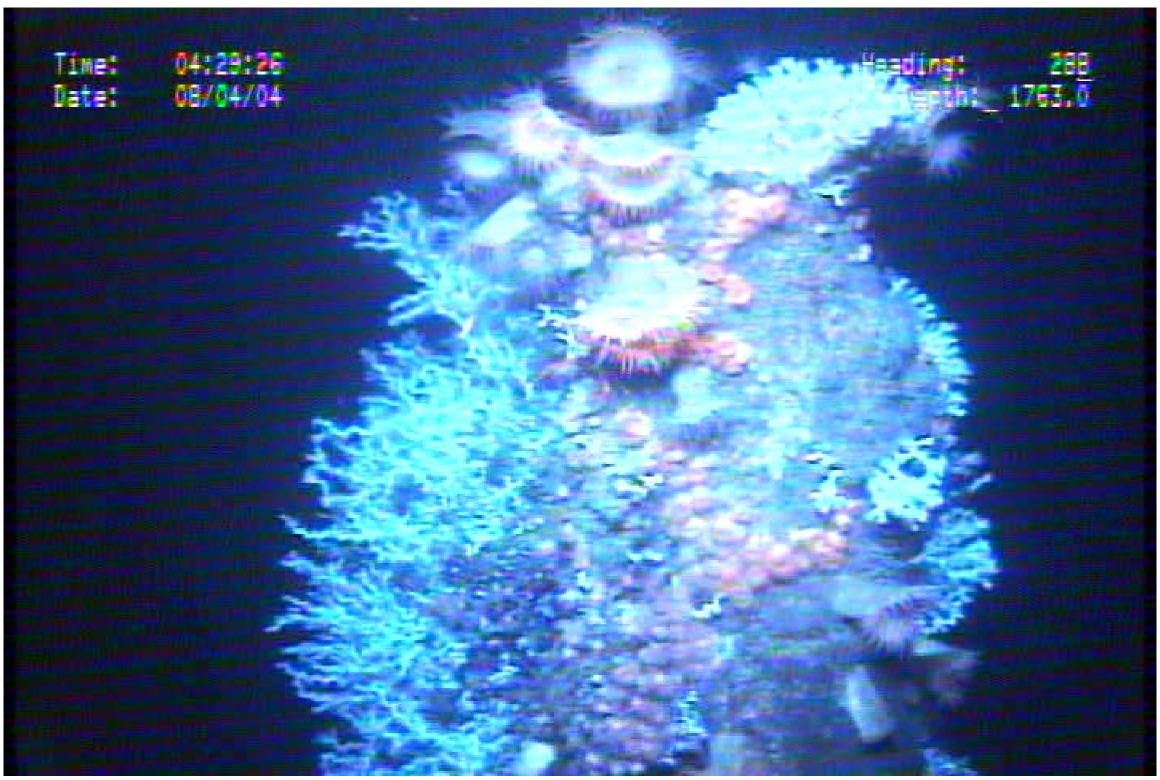


Figure 6.17. *Pourtalosmilia conferta* attached near the top of the extant mast. The specimen is located on the aft deck at a water depth of 537 meters.

Lophelia pertusa is known to exhibit a broad range in growth form and skeletal characteristics (Freiwald et al. 1997; Cairns 2000). Freiwald et al. (1997) describe three ecotypes based on the habit of the corallites and the budding type: tubular, stereome-thickened, and stout and crowded. Of these, the tubular is the dominant ecotype observed on the *Gulfpenn*. Two of the distinguishing characteristics that are most apparent are the trumpet-like shaped corallites and the open branched, out curved growth habit where each newly formed corallite grows in its own direction (Figure 6.18). *Lophelia pertusa* has been previously reported from numerous sites across the northern and eastern Gulf of Mexico (Schroeder et al. 2005).

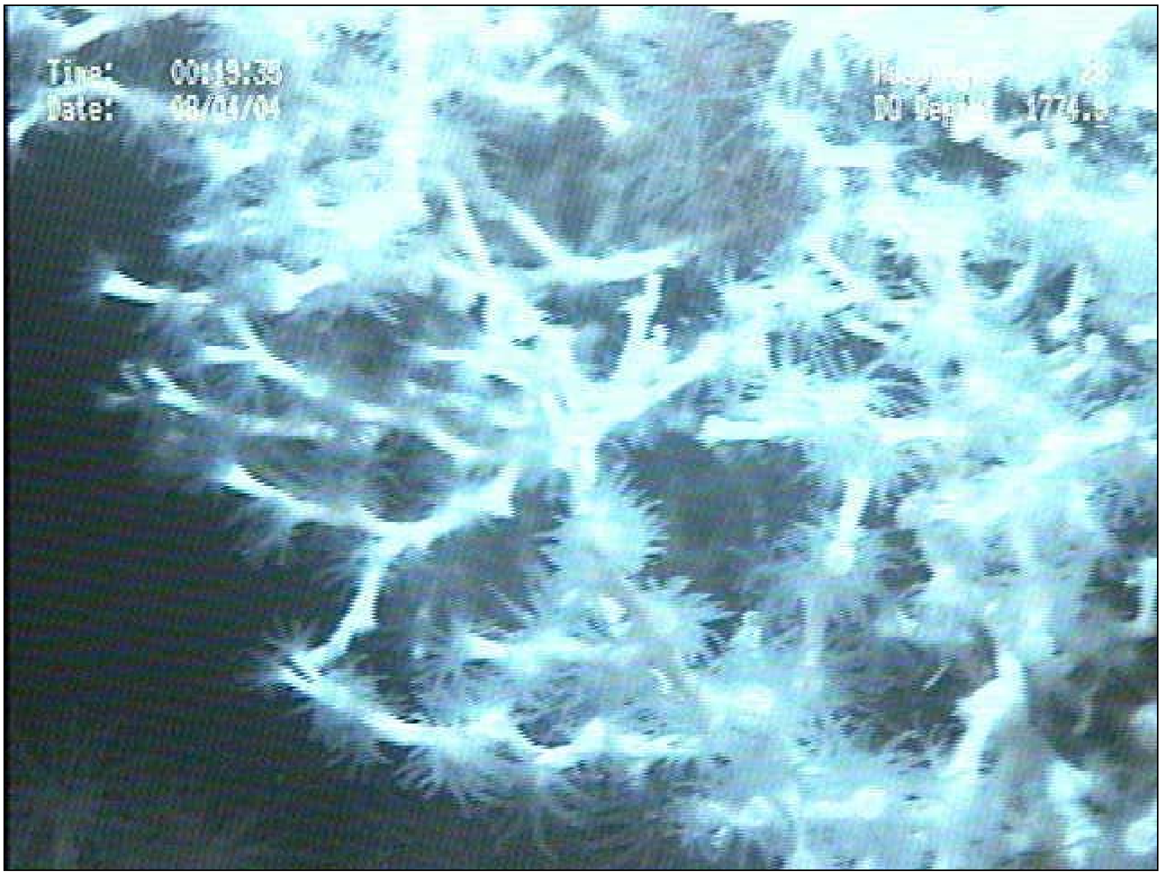
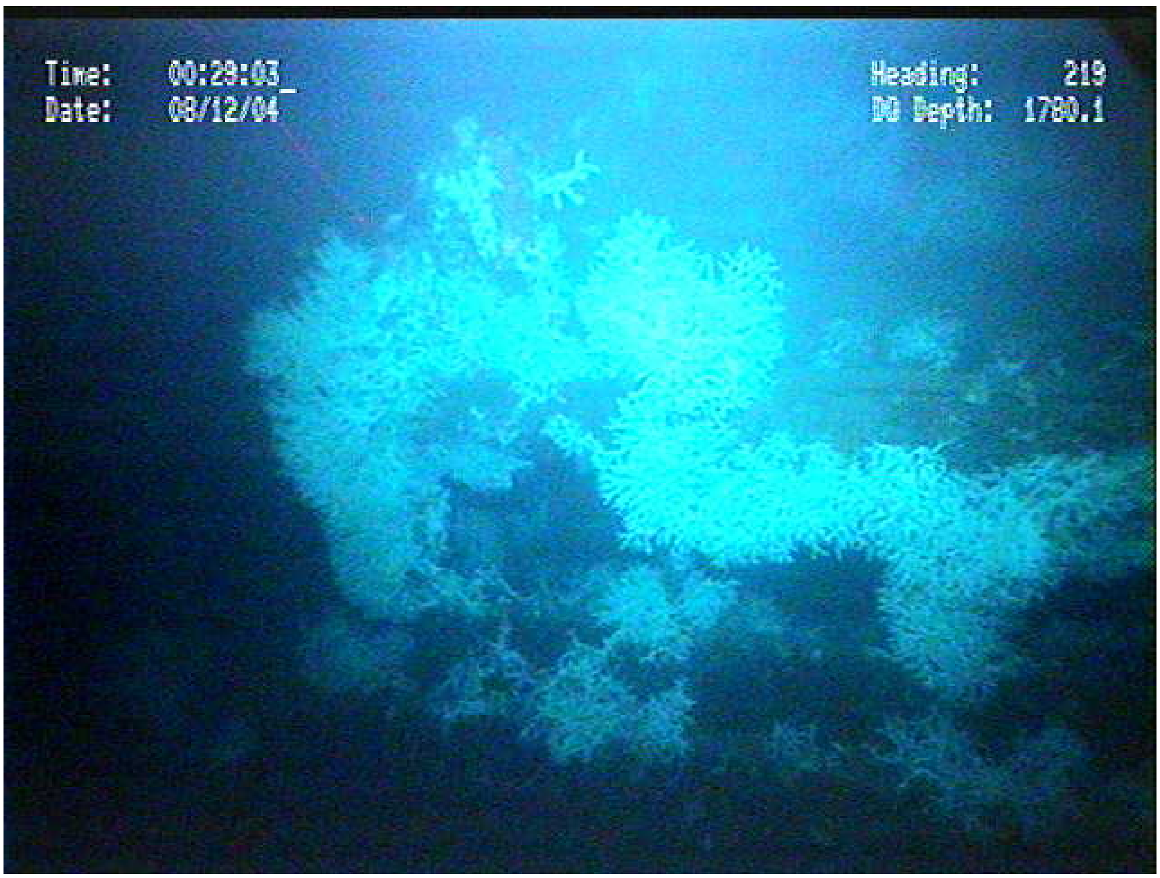


Figure 6.18. Tubular ecotype growth form of *Lophelia pertusa.* Trumpet-like shaped corallites and the open branched, out-curved growth habit where each newly formed corallite grows in its own direction.

Lophelia pertusa appears to have developed most successfully on surfaces or structures with vertical orientation (e.g., hull, bulwarks and the sides of superstructures) (Figures 6.19) or that have an upright (e.g., davits, masts, booms and stacks) (Figure 6.20), raised (e.g., catwalks and deck piping) (Figure 6.21), or open (e.g., railings and rigging) (Figure 6.22) construction or arrangement. Overall, the most extensive coral growth is on the starboard side, and on catwalks and deck piping along the portside of the aft and fore decks (Figure 6.6). At numerous locations clusters of adjacent colonies are coalescing in an initial phase of 'thicket' building (Figure 6.21) similar to that described by Squires (1964). In some cases aggregations have already formed thicket-like structures (Figure 6.22a). The largest development of coral is a 6 to 7 meters high by 3 to 3.5 meters wide aggregate of at least five or six coalescing colonies growing from the main deck/bulwarks level to above the pilot house on the forward starboard corner of the main superstructure (Figure 6.23). This vertical assemblage of colonies has formed an upright thicket. Generally, little or no colonization has occurred on most deck areas and other horizontal surfaces (Figure 6.24). One notable exception is the aft deck's forward area where colonies are growing on a deteriorating region of the deck beneath a coral-encrusted mast and boom (Figure 6.25). *Lophelia pertusa* also was found living on sediment adjacent to the hull (Figure 6.26) and colonizing wreckage in the debris field northwest and west of *Gulfpenn* (Figure 6.27).

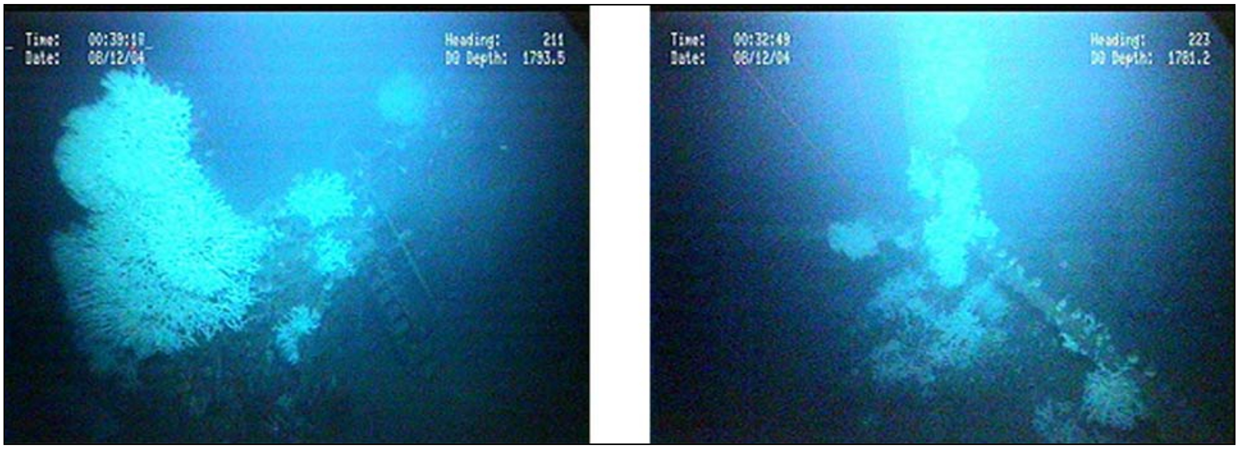
a).

b).



c).

Figure 6.19. *Lophelia pertusa* growing on (a) the starboard bower anchor, (b) the starboard hull below the main superstructure, and (c) the starboard aft side of the main superstructure from the second (lifeboat) deck down to the bulwarks.



a). b).

Figure 6.20. *Lophelia pertusa* growing on (a) a davit on top of forward starboard corner of the aft deckhouse and (b) a mast and booms on the aft deck.

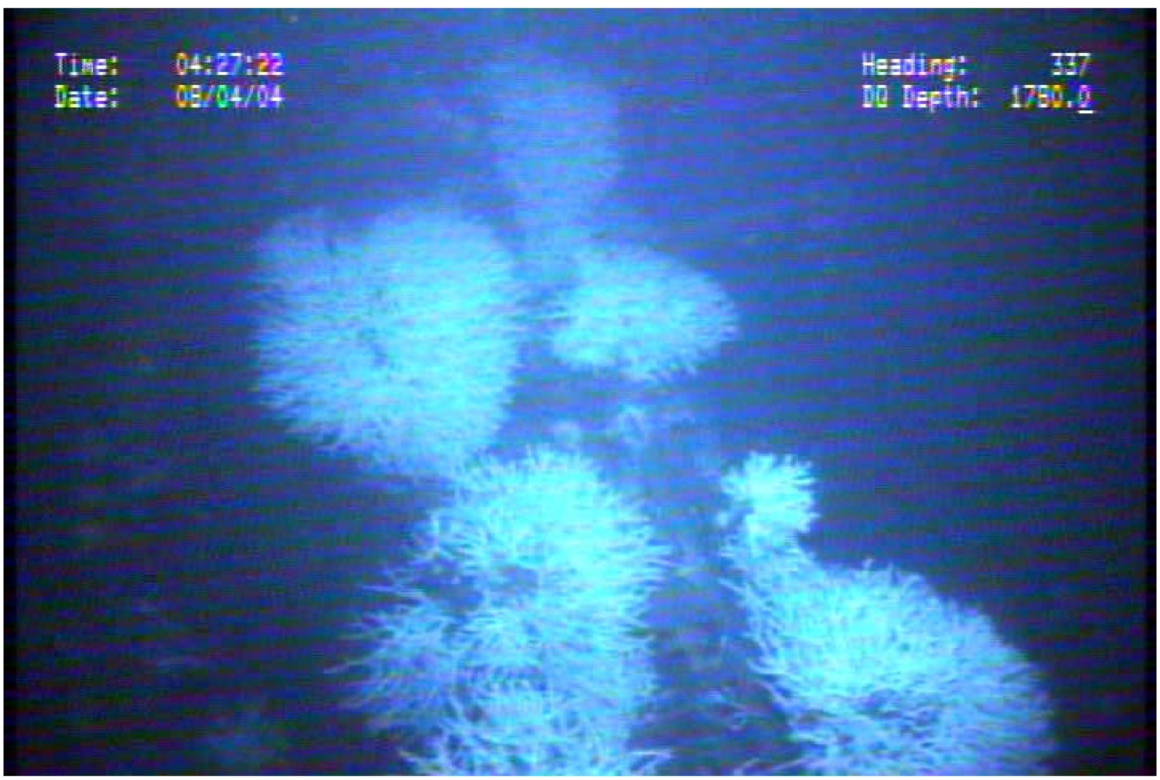
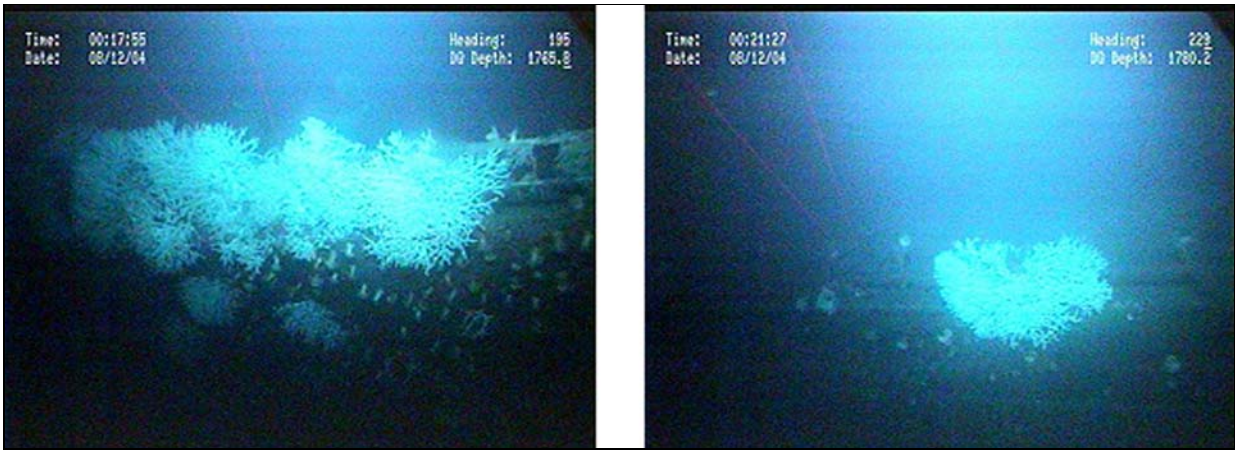


Figure 6.21. *Lophelia pertusa* colonizing deck piping and a catwalk on the port side of the aft deck.



a). b).

Figure 6.22. (a) Aggregating colonies of *Lophelia pertusa* on the railing and upper hull along the starboard foredeck. (b) Solitary *Lophelia pertusa* colony on railing along starboard aft deck.

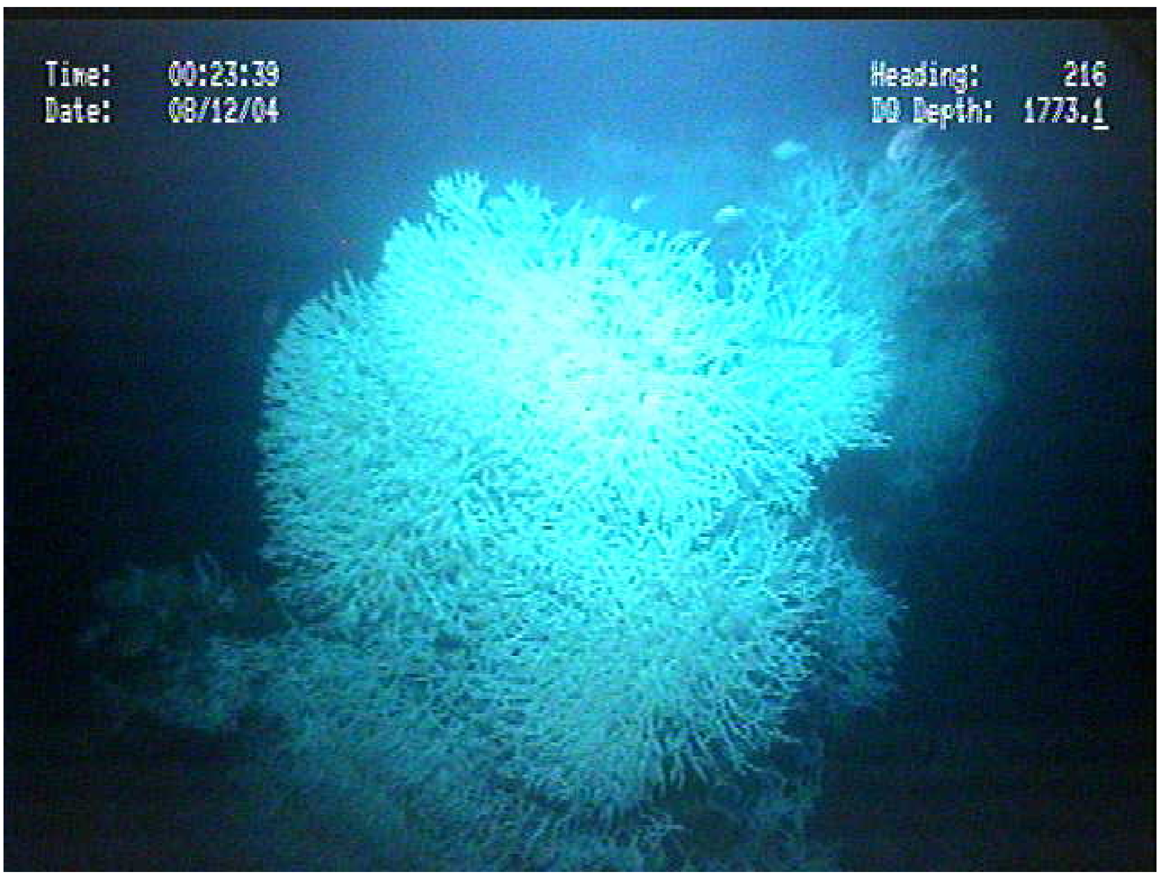
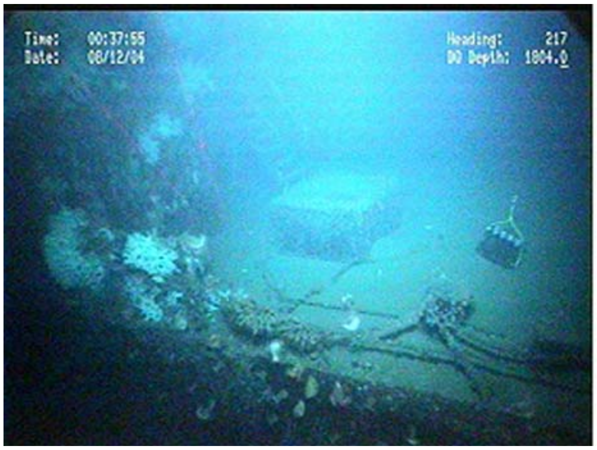
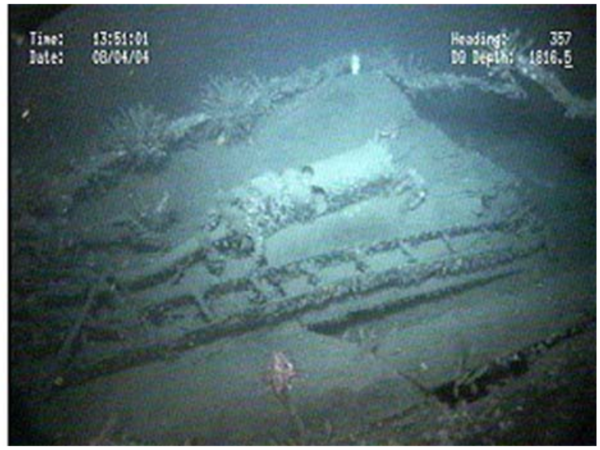


Figure 6.23. Looking down on the upper cluster of coalescing *Lophelia pertusa* colonies. These colonies are growing from the main deck to above the top of the pilothouse on the forward starboard corner of the main superstructure.



a).



b).

Figure 6.24. Examples of horizontal surfaces with no *Lophelia pertusa* colonization: (a) the stern end of the aft deck; and (b) the collapsed main stack.

Figure 6.25. *Lophelia pertusa* colonizing forward portion of the aft deck beneath a coral encrusted mast and boom.

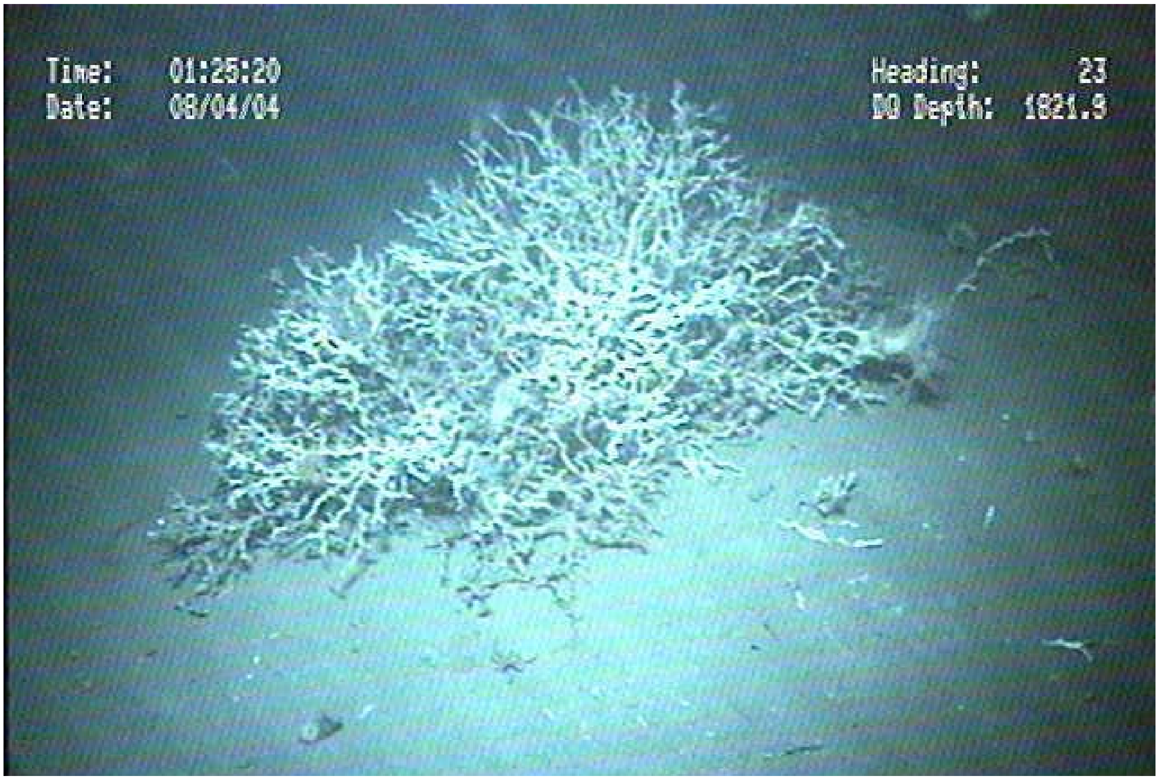
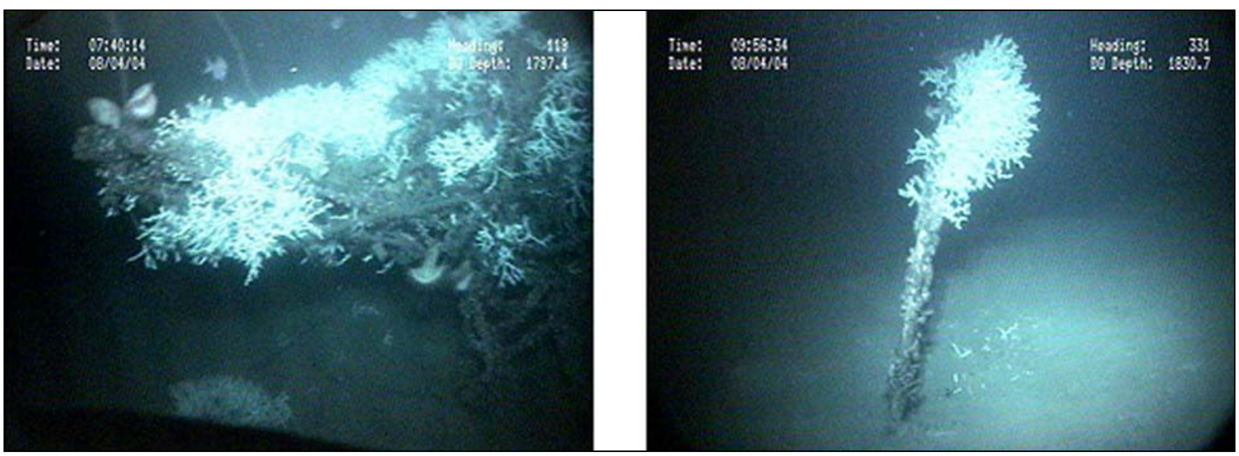


Figure 6.26. Large *Lophelia pertusa* colony growing on sediment adjacent to the hull.



a). b).

Figure 6.27. Small *Lophelia pertusa* colonies growing on (a) wreckage in the debris field 106 meters northwest of *Gulfpenn* and (b) an upright piece of metal rod in the debris field 70 meters west of *Gulfpenn*.

6.5.3 Vertebrate Zoology

Fish Community Structure

Visibility at *Gulfpenn* was significantly better than at *Virginia* or *Halo*. The mean width of transects was approximately 4.2 meters over the ship and 3.0 meters adjacent to and away from the wreck (Table 6.6). Mean dissolved oxygen concentration measured at this site during transect sampling (4.2 mg l^{-1}) was not as high as at *Virginia* but was not as hypoxic as at *Halo*.

Gulfpenn was the deepest wreck where reef fish taxa were observed. The fish community associated with the ship was dominated by the slimehead *Hoplostethus occidentalis* (Tables 6.6–6.8). Two scorpionfishes were abundant: the blackbelly rosefish (*Helicolenus dactylopterus*) and the Atlantic thornyhead (*Trachyscorpia cristulata*). Fishes captured in traps set next to the ship included the deepwater conger (*Bathycongrus dubius*) gulf hake (*Urophycis cirrata*) and gulf hagfish (*Eptatretus springeri*) (Tables 6.9 and 6.10).

Table 6.6

Abundance and Density Estimates for Fish Taxa Identified from ROV video During Biological Transect Over, Adjacent to, and 300 Meters Away from (Distant) *Gulfpenn*.

Transect Line	Relation to ship	Taxon	Min Count	Max Count	Min Density 100 m^{-2}	Max Density 100 m^{-2}
225	Over	*Helicolenus dactylopterus*	1	2	1.37	2.75
		Hoplostethus occidentalis	2	2	2.75	2.75
		Scorpaenidae	1	2	1.37	2.75
226	Over	*Helicolenus dactylopterus*	1	1	0.2	0.2
		Hoplostethus occidentalis	11	60	2.2	11.98
		Urophycis sp.	2	7	0.04	1.4
		Trachyscorpia cristulata	2	5	0.4	1
		Teleost	1	3	0.2	0.6
227	Over	*Hoplostethus occidentalis*	15	32	3.57	7.62
		Trachyscorpia cristulata	1	1	0.24	0.24
		Teleost	1	1	0.24	0.24
200	Adjacent	*Peristedion miniatum*	1	2	0.25	0.5
		Symphurus piger	2	3	0.5	0.76
		Macrouridae	1	5	0.25	1.26
		Teleost	1	9	0.25	2.27
201	Adjacent	*Symphurus piger*	1	4	0.29	1.15
		Macrouridae	2	4	0.57	1.15
		Teleost	1	2	0.29	0.57
202	Adjacent	*Symphurus piger*	1	2	0.29	1.15
		Macrouridae	1	3	0.57	1.15
		Teleost	1	2	0.29	0.57
222	Distant	*Symphurus piger*	1	4	0.17	0.7
		Teleost	1	6	0.17	1.04
223	Distant	*Symphurus piger*	1	2	0.23	0.46
		Trachyscorpia cristulata	2	3	0.46	0.69
		Teleost	1	7	0.23	1.62
224	Distant	Scorpaenidae	1	1	0.17	0.17
		Teleost	1	4	0.17	0.67

Table 6.7

Abundance of Fish Taxa Identified from Video Collected at the *Gulfpenn* on Other than Biological Transects. (Location indicates if video was collected over or away from the ship.)

Visit	Location	Taxon	Min Count	Max Count
Gulfpenn (1)	Over Ship	*Eptatretus springeri*	5	9
		Helicolenus dactylopterus	4	99
		Hoplostethus occidentalis	65	1,283
		Mustelus canis	1	2
		Symphurus piger	1	2
		Trachyscorpia cristulata	4	140
		Trichiurus lepturus	1	1
		Urophycis cirrata	1	6
		Ventrifossa macropogon	1	1
		Nezumia sp.	1	1
		Urophycis sp.	2	31
		Congridae	1	2
		Cynoglossidae	1	12
		Macrouridae	1	7
		Scorpaenidae	3	178
		Chlorophthalmidae	1	9
		Anguilliformes	2	11
		Gadiformes	1	12
		Osmeriformes	1	1
		Scorpaeniformes	1	3
		Teleostei	1	33
	Away From Ship	*Caranx crysos*	8	36
		Chlorophthalmus agassizi	1	1
		Etmopterus hillianus	1	1
		Peristedion minitum	1	15
		Symphurus piger	2	9
		Trichiurus lepturus	1	1
		Urophycis cirrata	1	5
		Ventrifossa macropogon	1	1
		Nezumia sp.	1	1
		Urophycis sp.	2	28
		Cynoglossidae	3	108
		Halosauridae	1	2
		Macrouridae	2	25
		Trichiuridae	1	1
		Anguilliformes	2	11
		Gadiformes	1	12
		Ophidiiformes	1	1
		Scorpaeniformes	1	3
		Teleostei	1	33

Visit	Location	Taxon	Min Count	Max Count
Gulfpenn (2)	Over Ship	*Eptatretus springeri*	1	3
		Etmopterus hillianus	1	1
		Helicolenus dactylopterus	1	15
		Hoplostethus occidentalis	25	507
		Monomitopus agassizii	1	1
		Nezumia aequalis	1	4
		Trachyscorpia cristulata	2	29
		Urophycis cirrata	1	9
		Urophycis sp.	1	17
		Cynoglossidae	1	7
		Halosauridae	1	1
		Scorpaenidae	3	17
		Squalidae	1	1
		Chlorophthalmidae	1	6
		Anguilliformes	1	2
		Gadiformes	1	10
		Teleostei	1	3
Gulfpenn (3)	Over Ship	*Helicolenus dactylopterus*	1	7
		Hoplostethus occidentalis	30	375
		Trachyscorpia cristulata	2	9
		Urophycis cirrata	2	5
		Urophycis sp.	1	2
		Carangidae	1	1
		Congridae	1	1
		Scorpaenidae	1	2
		Chlorophthalmidae	2	28
		Anguilliformes	1	4
		Gadiformes	1	1
		Teleostei	1	3
	Away From Ship	*Nezumia aequalis*	1	1
		Symphurus piger	1	4
		Urophycis cirrata	1	1
		Urophycis sp.	1	1
		Cynoglossidae	1	6
		Macrouridae	1	1
		Ophichthidae	1	1
		Teleostei	1	2

(*X*) Denotes the visit number for sites examine multiple times.

Table 6.8

Estimated Total Lengths of Fishes Observed on Video at the *Gulfpenn.*
(All individuals were captured on video with both ROV-mounted lasers striking them.)

Taxon	Number Measured	Mean TL mm	Standard Deviation	Range TL mm
Helicolenus dactylopterus	14	658	138.7	518-847
Hoplostethus occidentalis	6	249	66.1	148-346
Nezumia aequalis	1	219		
Trachyscorpia cristulata	9	706	174.9	359-940
Urophycis sp.	1	254		
Cynoglossidae	2	195	12.3	187-204
Macrouridae	1	404		
Scorpaenidae	1	404		

Table 6.9

Fish Taxa Caught in Chevron (large) and Baitfish (small) Fish Traps Deployed Adjacent to (ship) and 300 Meters Away From (distant) *Gulfpenn*.

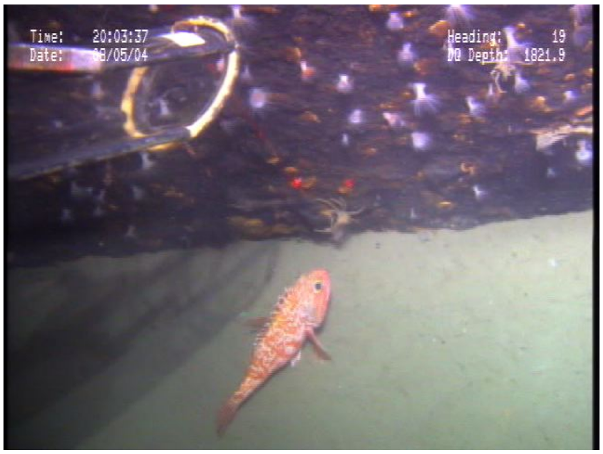
Trap Type	Location	Species	Number
Large	Distant	*Urophycis cirrata*	5
		Urophycis sp.	1
Large	Ship	*Argyropelecus sladeni*	1
		Bathycongrus dubius	1
Small	Distant	*Eptatretus springeri*	12
Small	Ship	*Bathycongrus dubius*	1
Small	Ship	*Eptatretus springeri*	21
Large	Ship	*Helicolenus dactylopterus*	1
		Symphurus piger	1
		Urophycis cirrata	1

Table 6.10

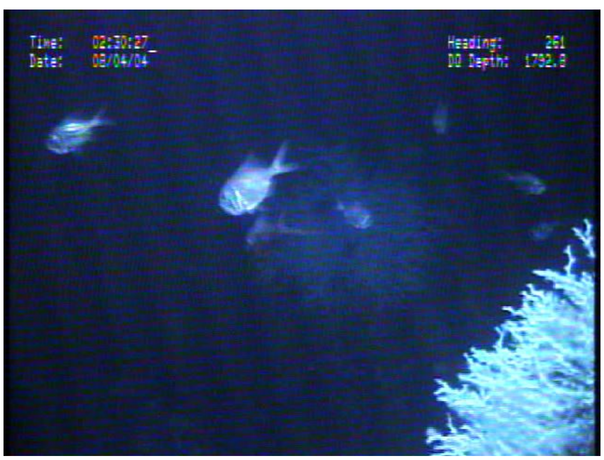
Fishes Caught with the ROV Suction Sampler at *Gulfpenn*.

Date	Species	Number
Aug 3 – Aug 5	*Etmopterus hillianus*	1
	Hoplostethus occidentalis	3
	Nezumia cyrano	3
	Peristedion miniatum	5
	Symphurus piger	4
	Ventrifossa macropogon	1
Aug 11 – Aug 12	*Merluccius albidus*	1
	Monomitopus agassizii	1
Aug 13	*Hoplostethus occidentalis*	5
	Monomitopus agassizii	1
	Nezumia aequalis	1
	Symphurus piger	3

Scorpionfishes were observed on transects flown immediately adjacent to the ship where they were associated with ship debris. Other fishes observed adjacent to and away from the wreck included grenadiers (Family: Macrouridae), deepwater tonguesole (*Symphurus piger*) and armored searobin, (*Peristedion miniatum*). Grenadiers were the most abundant fishes observed on video away from the wreck but species identification was not possible from video. From suction sampler collections, however, three species of grenadiers were identified: the longbeard grenadier (*Ventrifossa macropogon*) the common Atlantic grenadier (*Nezumia aequalis*), and (*Nezumia cyrano*). An offshore hake (*Merluccius albidus*), a cusk eel (*Monomitopus agassizii*), and a Caribbean lanternshark (*Etmopterus hillianus*) also were captured with the suction sampler.



a) b)



c) d)

Figure 6.28. (a) Blackbelly rosefish, (b) Atlantic thornyhead, (c) slimeheads, and (d) deepwater tonguesole over or adjacent to *Gulfpenn*.

Diet and Trophic Structure

Stomachs were dissected from 33 fish collected at *Halo*, but only 18 (54%) had food items present (Figure 6.29). Gut content analysis indicated fish dominated the diet of deepwater conger, while slimehead and deepwater tonguesole diet was composed of half fish and half crustaceans. Gut contents of the three gulf hake indicated their diet consisted solely of shrimp. Armored searobin diet also contained shrimp but other invertebrate taxa were present, including amphipods, which composed approximately half of identifiable prey items.

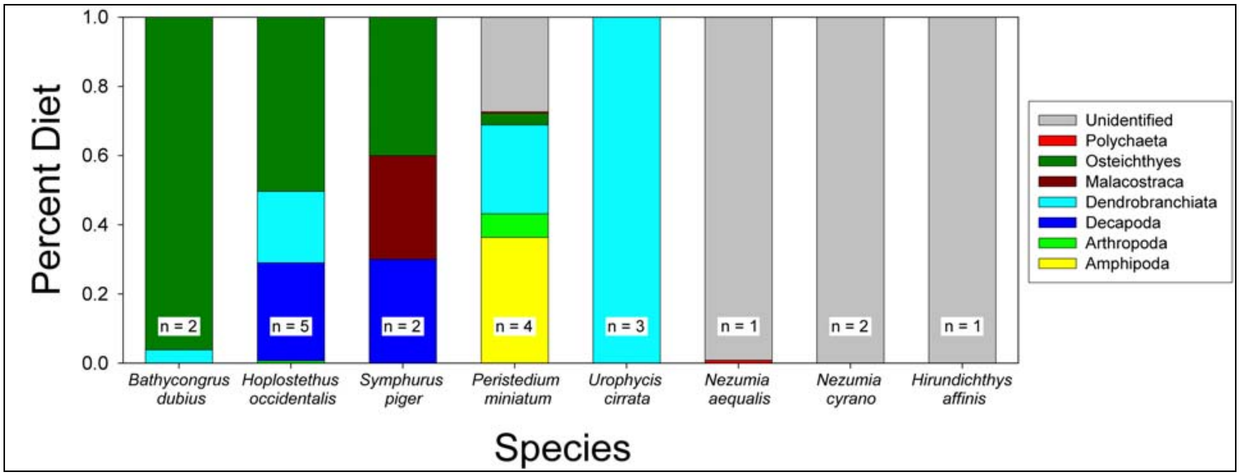


Figure 6.29. Prey taxa contribution to diets of fishes sampled at *Gulfpenn*. Sample sizes indicated for each species.

Stable isotope analysis of fishes associated with *Gulfpenn* indicated very similar trophic levels and sources of production for slimeheads, hakes, and the one blackbelly rosefish sampled (Figure 6.30). Their $\delta^{13}C$ and $\delta^{15}N$ values indicated feeding on macroinvertebrates and small fishes, with hakes feeding at a slightly higher trophic level than the other fishes. $\delta^{13}C$ and $\delta^{34}S$ values indicated a phytoplankton-based food web, thus providing evidence of the importance of phytoplankton production within the photic zone, perhaps exported as phytodetritus, to this slope environment. The range in $\delta^{34}S$ values also indicated these fishes feed on both pelagic and benthic prey items.

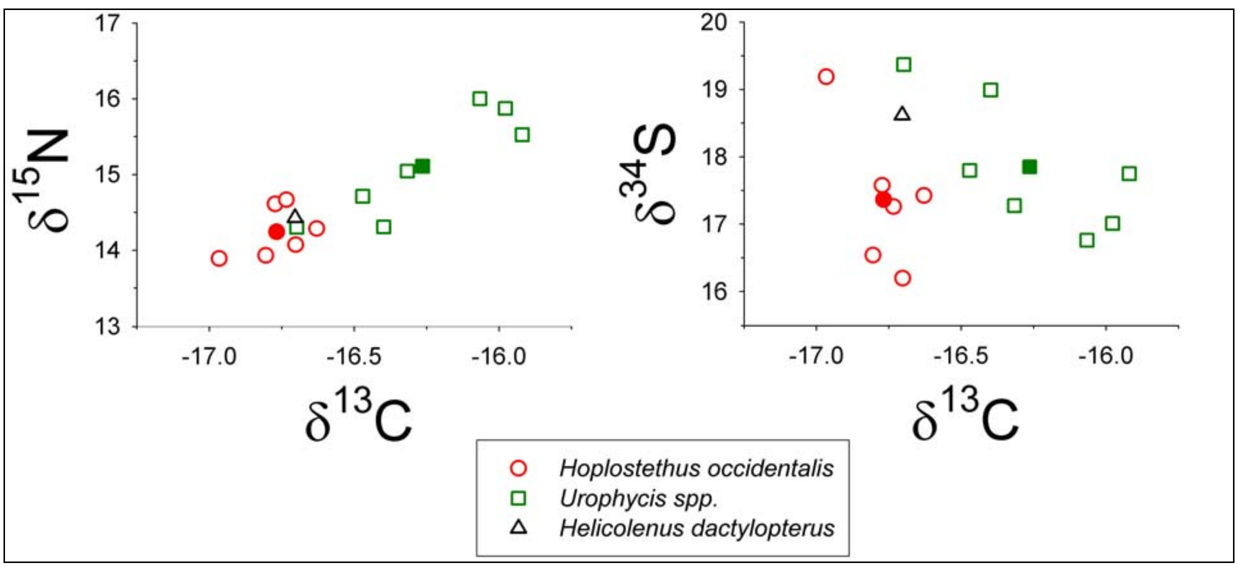


Figure 6.30. Results of stable isotope analysis of fish muscle samples collected during biological sampling from *Gulfpenn.* Filled symbols are species-specific mean values.

The one fish species that differed with respect to stable isotope values was the Gulf hagfish (Figure 6.31), which is a vagrant scavenger in the deep sea. Hagfish captured at *Gulfpenn* had $\delta^{15}N$ values indicating feeding at moderately high trophic levels. Thus, their depleted $\delta^{13}C$ values may indicate some component of their biomass was derived from chemosynthetic production (MacAvoy et al. 2002). Grenadiers had stable isotope values consistent with benthic feeding at a moderately high trophic level (macroinvertebrates to fishes). This result is important to understanding the trophic ecology of fishes at this site because there were no food items present in the stomachs of sampled grenadiers. Thus, stable isotope values provide the only insight into their feeding ecology.

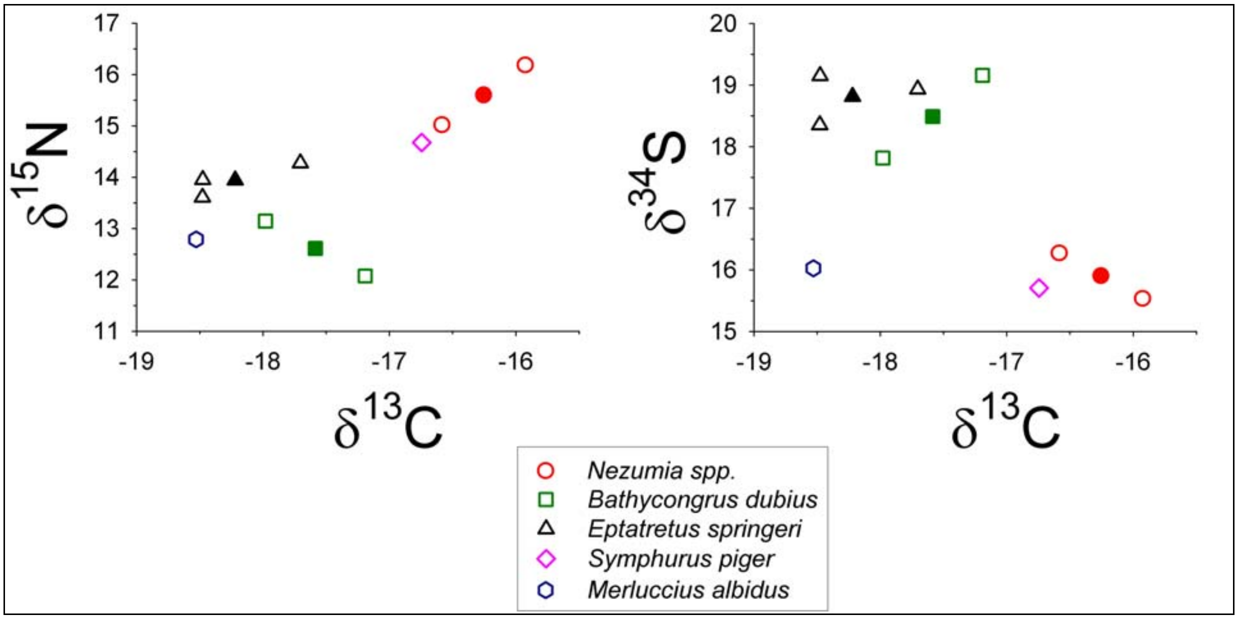


Figure 6.31. Results of stable isotope analysis of fish muscle samples collected during biological sampling away from *Gulfpenn.* Filled symbols are species-specific mean values.

Invertebrate tissue samples, collected at *Gulfpenn,* provide some insight into the trophic ecology of the rich invertebrate fauna sampled at this site (see Section 6.5.2 for details). Stable isotope values of the large scavenging isopod *Bathynomus giganteus* provides further evidence of chemosynthetic production as was seen in hagfish (Figure 6.32). Trends in $\delta^{15}N$ versus $\delta^{13}C$ values indicate an increase in two full trophic levels from the inflated spiny crab (*Rochinia crassa*) to the gastropod. There was no clear trend in $\delta^{34}S$ values among invertebrate taxa, but in general they conveyed a mix of pelagic and benthic food sources.

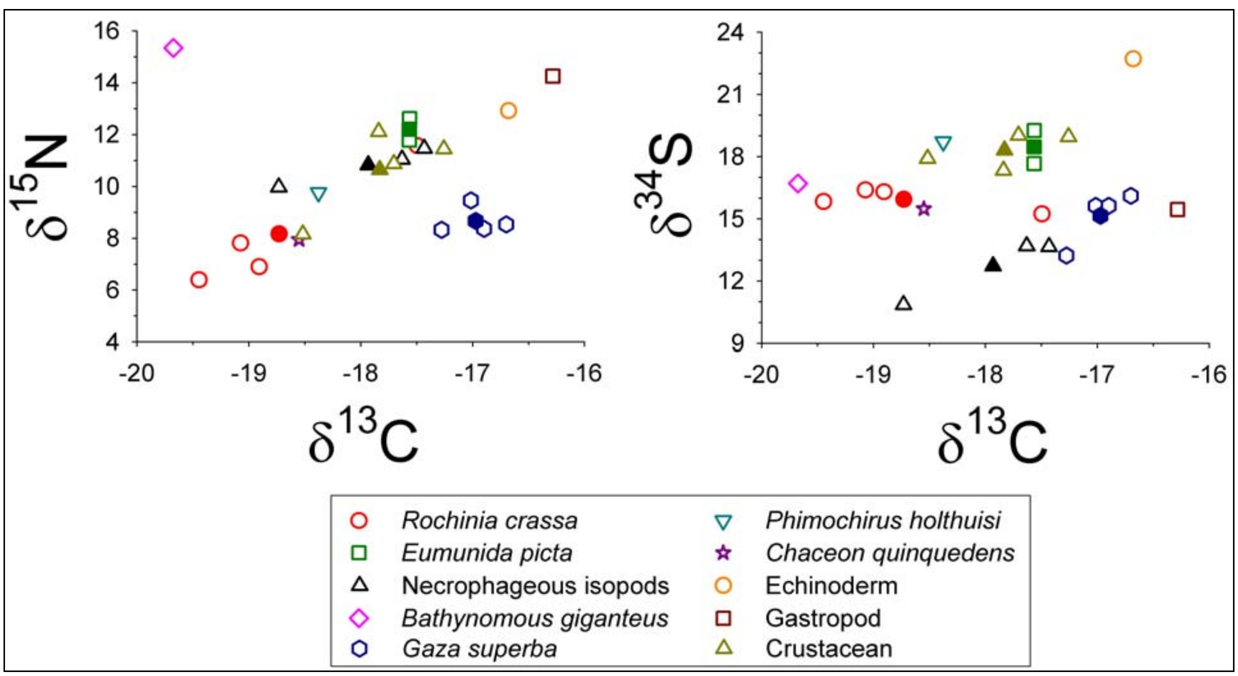


Figure 6.32. Results of stable isotope analysis of invertebrate tissue samples collected during biological sampling at *Gulfpenn.* Filled symbols are species-specific mean values.

Age Estimation

Opaque zones were counted in otolith sections prepared from 31 fish collected at *Gulfpenn* (Figures 6.33 and 6.34). Of the sampled species, opaque zones have only been validated as annuli for blackbelly rosefish (White et al. 1998) and Gulf hake (Martins and Haimovici 2000). Opaque zones have not been validated in the slimehead (*Hoplostethus occidentalis*), offshore hake, grenadier (*Nezumia cyrano*), deepwater tonguesole, armored searobin, or deepwater conger. Given the sampling depth, it is not unusual for otoliths of such a large number of species not to have been validated. Congeners of *Hoplostethus occidentalis* and *Nezumia cyrano* have had otolith opaque zones validated as annuli, and both genuses have members that are very long lived (Coggan et al. 1999, Tracy and Horn 1999). For the other species sampled, we assumed opaque zones were formed annually. While this is not a conservative approach, the preponderance of recent evidence suggests deep-sea fishes form annual opaque zones in their otoliths similar to shallow water species (reviewed in Calliet et al. 2001 and Morales-Nin and Panfili 2005)

As a group, fishes sampled at *Gulfpenn* were the oldest observed in this study, despite none of them being large in size. This finding is consistent with Caillet et al.'s (2001) hypothesis that deep-sea fishes are typified by slow growth and long lives resulting from physiological adaptations to living in high pressure environments with low dissolved oxygen and limited prey resources. For example, the oldest fish aged in this study was the blackbelly rosefish sampled at *Gulfpenn*. This individual was 450 millimeters TL and aged to be 50 years old. For comparison, an amberjack and a king snake eel captured at *Halo* were 1226 and 1940 millimeters TL and were estimated to be 7 and 24 years old, respectively (Figures 5.27 and 5.29).

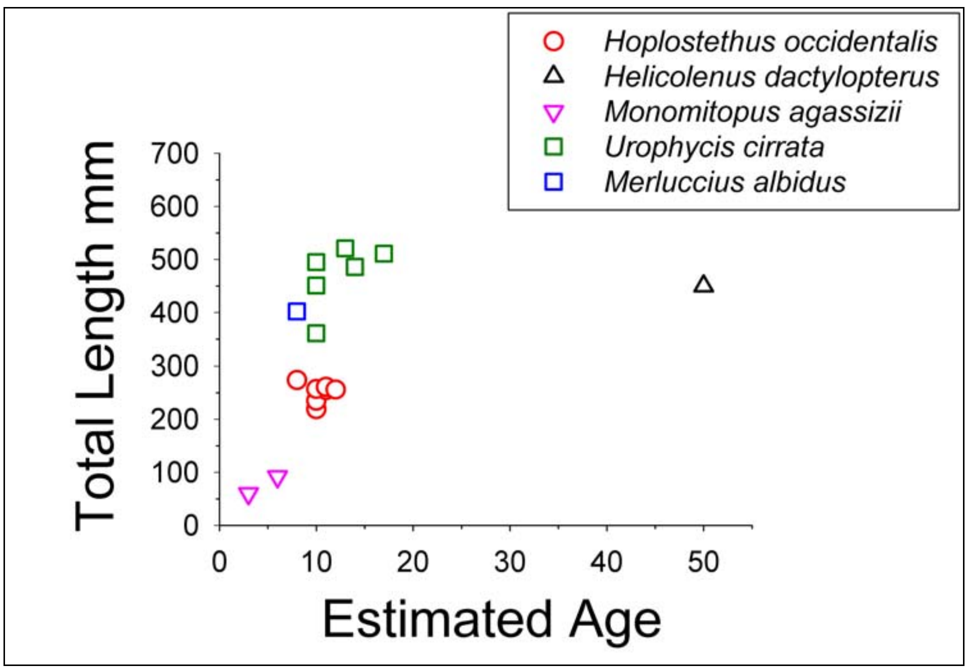


Figure 6.33. Size at age estimates for fishes captured over the *Gulfpenn*.

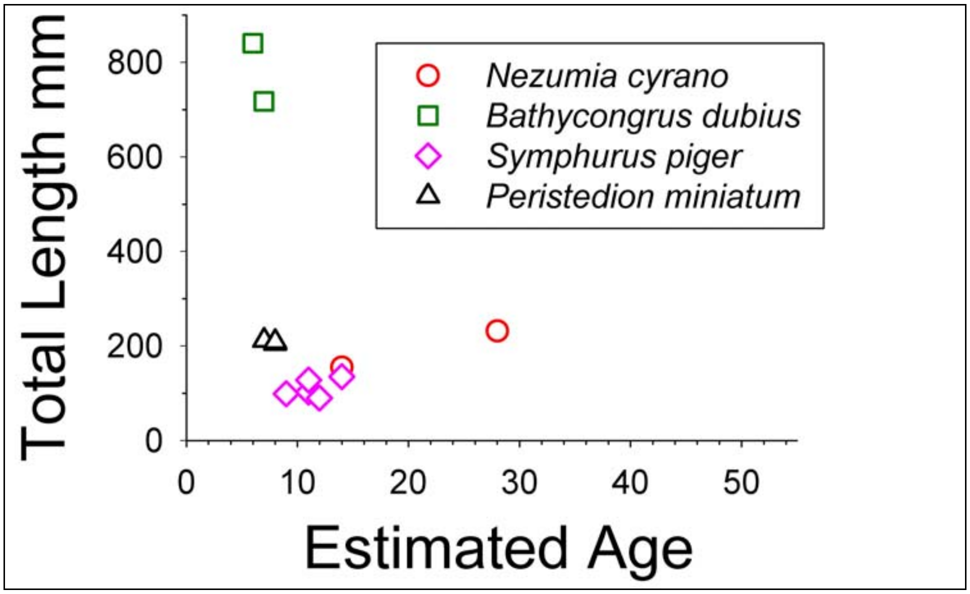


Figure 6.34. Size at age estimates for fishes captured away from the *Gulfpenn*.

6.6 Sediment Core Analysis

Four samples were taken at the designated distance from the ship structure. Each sample, after coming to the surface, was taken out of the sample device and stored in a clean glass container at approximately 4°C. *Gulfpenn*'s core samples did not indicate any visible differences. They all appeared to be smooth, gray/black sediment with a sour smell. The sour smell is indicative of the anaerobic biological activity (sulfate reduction) normally found within sediment samples. Samples were sent to a certified laboratory for organic chemistry analysis. The *Gulfpenn* site samples from each of the four cores all tested below detection levels for hydrocarbon C6-C36, as well as total petroleum hydrocarbons (Table 6.11).

Table 6.11

Gulfpenn Core Analysis.

Site	**Date**	**Sample Location**	**Concentration**
Gulfpenn	August 5, 2004	Beside Ship	<1 ug/g
		30 meters	<1 ug/g
		152 meters	<1 ug/g
		305 meters	<1 ug/g

7.0 DEUSTCHE KREIGSMARINE (DKM) *U-166* SITE

7.1 Historical Background of DKM *U-166*

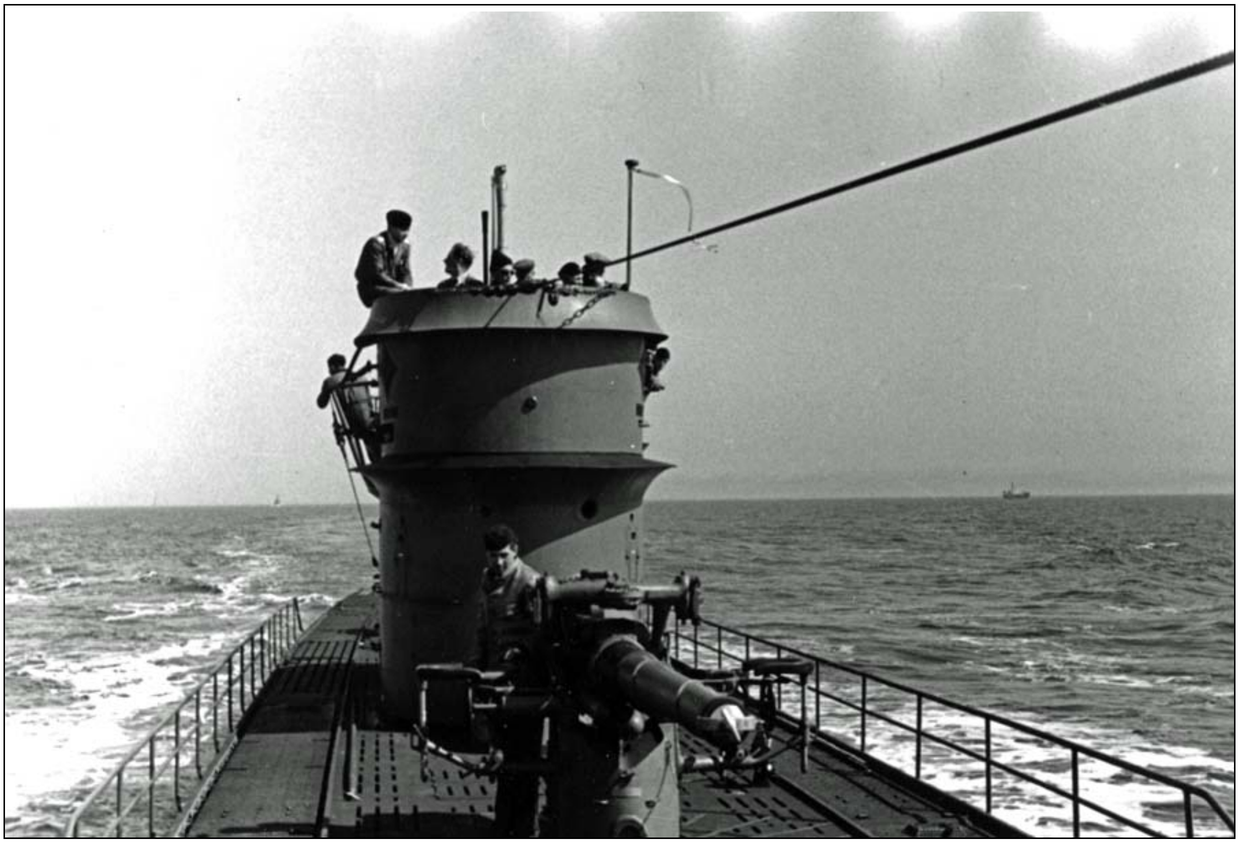


Figure 7.1. *U-166* at sea in early 1942 (Kuhlmann Collection courtesy of the PAST Foundation and the National D-Day Museum).

During the early months of 1942, the war seemed far away to most Americans, but in reality an ominous threat lurked in the waters off the Eastern and Gulf Coasts. America's entry into World War II, provided Hitler the opportunity to extend U-boat attacks to America's shores just as the Kaiser had in World War I. This time, however, Hitler's U-boats would not limit attacks to America's East Coast. They would strike deeply into America's backyard, the Gulf of Mexico. In just over a year's time, beginning in May 1942, twenty-four German U-boats entered the Gulf of Mexico. Seventeen of these U-boats, including *U-166*, sank fifty-six merchant ships and damaged several others (Wiggins, 1995).

U-166 (Figure 7.1 and 7.2) was built at the Seebeck Shipyard in Bremen, Germany between December 6, 1940 and March 23, 1942 (Morgan and Christ 2003). *U-166* was 76.8 meters long, had a beam of 6.8 meters, and a draft of 4.7 meters. It was one of 54 type IXC U-boats constructed by Germany during World War II. The IXCs were long-range fast-attack submarines. They were built to carry the war to foreign shores using two supercharged nine-cylinder MAN diesel engines that generated 2,200 horsepower each, and 208 tons of fuel. On the surface a IXCs could make 18.3 knots, and 7.3 knots submerged. Larger diesel bunkers than previous designs allowed the IXCs a surface range of 11,000 nautical miles at 12 knots, and a submerged range of 63 nautical miles at 4 knots. Like most type IXs, *U-166* had a full double hull with the outer hull extended nearly down to the keel (Miller 2000; and Rössler 2001). According to Rössler (2001), IXCs had a pressure hull composed of 10 sections with each section constructed of 4 to 6 steel plates welded on circular frames to form short cylinders. The plates had a thickness of 18.5 millimeters everywhere on the hull, except the conning tower where the plate thickness was increased to 22 millimeters (Rössler 2001). The deck was wide and flat leaving room for ten torpedoes stored in pressure tight containers. A IXC U-boat typically carried a complement of at least four officers and forty-four crew during wartime (Blair 2000; and Miller 2000). The class IXs were based on earlier Type IA U-boats but had substantial improvements to engines, fuel capacity, and armament. The Type IXs and its short-range counterpart, the Type VII, formed the backbone of the German U-boat fleet (Miller 2000).

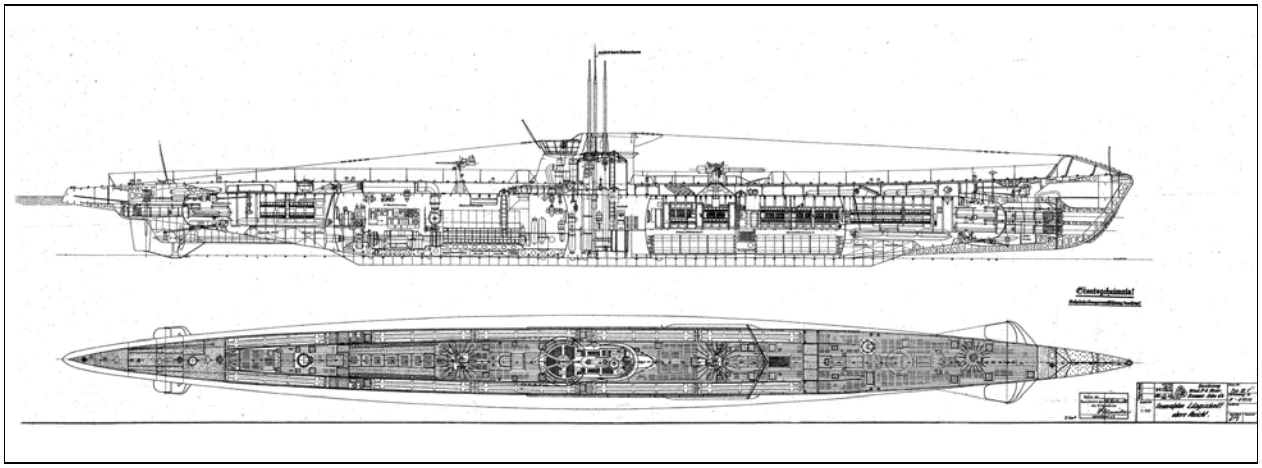


Figure 7.2. Schematic of a Type IXC U-boat (Courtesy of National Park Service and PAST Foundation).

U-166 was armed with twenty-two torpedoes that could be fired through four forward or two aft tubes. For surface actions, a 105-millimeter deck gun was mounted forward of the conning tower. Other armaments included a 20-millimeter machine-gun mounted on the single *wintergarten* and a 37-millimeter anti-aircraft gun on the aft deck for defense against aircraft or surface vessels. According to Miller (2000), later IXCs were constructed with an extended *wintergarten* for mounting additional anti-aircraft weaponry.

U-166 was constructed under the auspices of the man who eventually commanded her, Oberleutnant zur See Hans-Günther Kuhlmann (Figure 7.3). Kuhlmann, who was born in Cologne in 1913, served in the German Merchant Marine until joining the Kriegsmarine in January 1937. At the start of the war in 1939, he served as the No. 2 Torpedo Officer on the German heavy cruiser *Blücher* until January 1940 when he transferred to the U-boat arm. Kuhlmann was assigned to *U-37* as a third watch officer and over the next 13 months, he rose to the rank of first watch officer before leaving the boat for U-boat commander training. After successfully completing the commander's course Kuhlmann was assigned to the 24th U-boat Flotilla and in March 1941 was given command of the training boat, *U-7*. In July 1941, he took command of the *U-580*, remaining on that boat until it was lost off Norway during a training exercise. Kuhlmann survived and took command of *U*-166 in March 1942. He then took his new boat and crew for a sixty-nine day shakedown cruise (Busch and Röll 1999). It would be one of only two cruises made by the *U-166* (Morgan and Christ 2003).

Kuhlmann brought *U-166* back into port on May 31, 1942. Seventeen days later *U-166* left port on its first war cruise. The destination was the Gulf of Mexico. There Kuhlmann and his crew would mine enemy ports and attack allied shipping. Three days into the voyage the crew of the new U-boat barely escaped a night attack by allied aircraft. The remainder of the crossing was uneventful and *U-166* and her crew entered the Caribbean in mid-July. Kuhlmann and his crew did not claim a victory for several days after reaching the Caribbean. Then on July 13, 1942, they sank the 84-ton schooner *Carmen*. This success was followed in relatively quick succession by sinking of the 2,309-ton freighter *Oneida*, and the 16-ton trawler *Gertrude*. Finding only small vessels in this area, Kuhlmann continued towards the Gulf of Mexico and the area off the mouth of the Mississippi River (Morgan and Christ 2003).

Figure 7.3. Oberleutnant zur See Hans-Günther Kuhlmann (Kuhlmann Collection courtesy of the PAST Foundation and the National D-Day Museum).

U-166 entered the Gulf of Mexico in mid July 1942 and proceeded to lay mines off the southwest pass of the Mississippi River (Morgan and Christ 2003). On July 27, 1942, Kuhlmann radioed German Naval Command reporting completion of mine laying activities and that he was proceeding to hunt shipping (War Diary 1942: 36,53,92). It would be the final message from *U-166*.

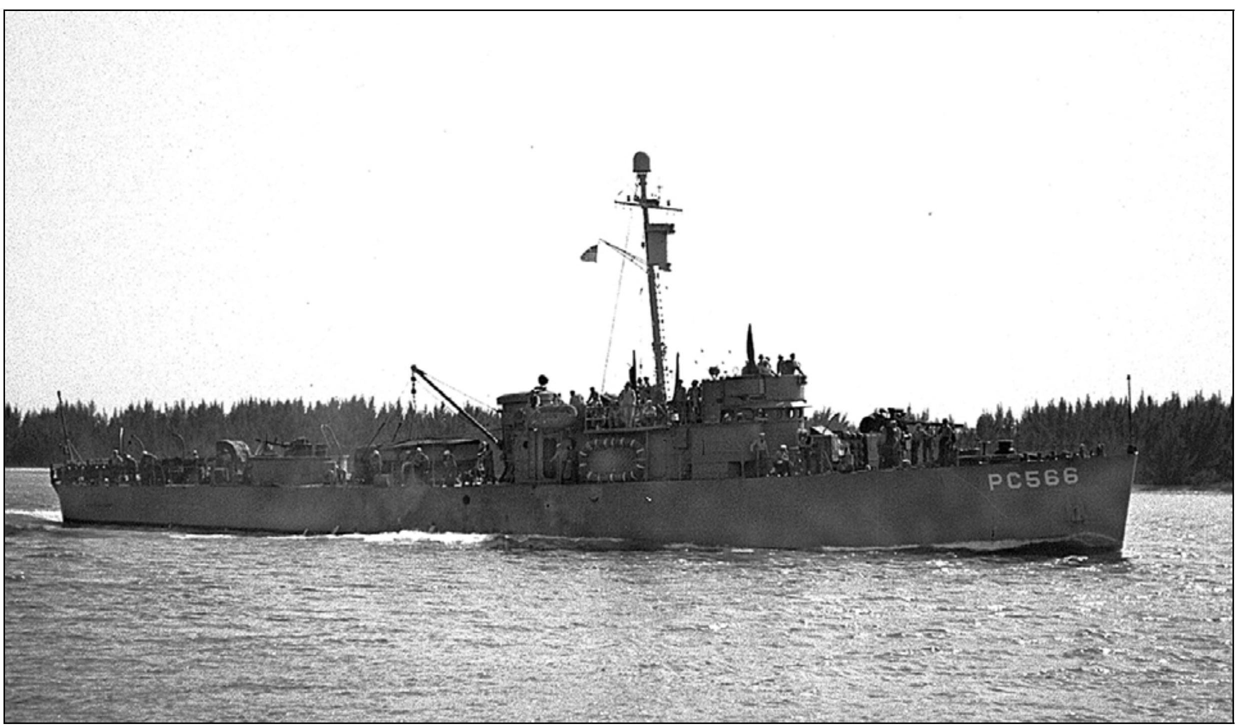


Figure 7.4. An undated photograph of *PC-566* (Courtesy of Mariner's Museum).

While *U-166* sailed to its assigned operation area, the passenger freighter *Robert E. Lee* left Port-of-Spain, Trinidad bound for New Orleans, Louisiana on July 20, 1942 carrying 270 passengers, six merchant marine officers, and 131 general crewmembers. *Robert E. Lee* transited the Caribbean with a heavily escorted convoy, but during the morning hours of July 29, it rendezvoused with United States Navy Patrol Craft *566* (Figure 7.4) near Key West, Florida.

Built in Houston, Texas, PC-*566* was a 461 class patrol craft. It was 178 feet (54.3 meters) long, had a 23-foot (7 meter) beam, and could cruise at 20 knots. Constructed to defeat the enemy submarine threat, PC-*566* was heavily armed with deck guns, rockets, and depth charges. Escorting *Robert E. Lee* was the naval vessel's first mission and Lt. Commander Herbert C. Claudius' first command. Under orders from the Commander of the Gulf Sea Frontier, PC-*566* was to escort *Robert E. Lee* to Tampa, Florida where the steamer would re-provision (Charlton 2003; Church et al. 2002; Henderson 1942; and USS PC-*566* 1942).

U-166 prowled shipping lanes near the Mississippi River mouth at the same time *Robert E. Lee* and PC-*566* arrived at Egmont Key Light, Tampa Bay, on July 29, 1942 around 2145 hrs. When no pilots were available the steamer used Morse code and signal lights to communicate with PC-*566*. *Robert E. Lee* stated they would proceed to New Orleans rather than wait. At 2325 hrs, PC-*566* broke radio silence to notify the Commander of the Gulf Sea Frontier that *Robert E. Lee* was continuing to New Orleans and request orders. PC-*566* was ordered to escort *Robert E. Lee* and the two vessels were immediately underway (Church et al 2002; Henderson 1942; and USS PC-*566* 1942).

Robert E. Lee and PC-*566* transited across the Gulf through the night and into the next day drawing closer to *U-166*. July 30 was a clear, calm day. PC-*566* was running half-mile ahead and to port of *Robert E. Lee*. The freighter and her naval escort were approximately 45 nautical miles southeast of the Southwest Pass of the Mississippi River when *U-166* spotted the freighter. At 1637 hrs, *U-166* fired a torpedo at the freighter's starboard side. Passengers and crew on *Robert E. Lee* noticed an elongated shape 150 meters to starboard (Henderson 1942). The single torpedo fired by *U-166* struck *Robert E. Lee*'s starboard side. The resulting explosion tore through C and B decks destroying the engines. Lookouts aboard PC-*566* spotted the U-boat's periscope and the patrol craft moved to attack.

PC-*566*'s radio operator had been transmitting their estimated arrival time to the Port Director of New Orleans when U-166 attacked. The transmission was cancelled and an SOS for *Robert E. Lee* sent instead. Six lifeboats and sixteen life rafts were launched from *Robert E. Lee* as passengers and crew frantically abandoned ship. *Robert E. Lee*'s bow rose out of the water until it reached a precariously steep angle, and the vessel suddenly plunged to the bottom. *Robert E. Lee* sank between six and ten minutes after the torpedo attack according to survivors and naval witnesses. The disaster resulted in the deaths of ten crewmembers, and 15 passengers (Church et al 2002; Henderson 1942; USS PC-*566* 1942; and Winnier 2003). As the freighter sank, Kuhlmann made a fatal error. Evidently not noticing the patrol craft, he kept *U-166* at periscope depth, and PC-*566* moved in for the kill.

U-166's first indication that they were under attack was probably when PC-*566*'s active sonar rang against the U-boat's hull from just 230 meters away. The U-boat immediately submerged, but PC-*566* maintained the contact for another 120 meters. Once PC-*566* lost contact, it returned to the point where *U-166* was last detected and a depth charge pattern of five charges was laid with settings for 76.2 meters (250 feet), 45.7 meters (150 feet), and 30.5 meters (100 feet). Following the first set of depth charges, PC-*566* reversed course for 1000 meters to re-establish sonar contact. At that time Captain Claudius noted *Robert E. Lee* was gone, and only lifeboats and rafts remained where the vessel had once been. PC-566 again detected *U-166* with sonar only 550 meters away. The contact was maintained as *PC-566* closed to within 350 meters, and dropped a second pattern of five depth charges. Soon the first airplane from New Orleans arrived on the scene and Claudius instructed the pilot to perform an aerial search for the U-boat. Commander Claudius circled the area cautiously, using *PC*-566's sonar to search for the U-boat. When the second plane arrived Claudius speculated the U-boat was either sunk or disabled and it was safe to begin rescue operations. While conducting the sonar search, PC-*566*'s crew noted a large oil sick on the surface. The brownish-gray slick was 60 meters in diameter, and smelled of diesel oil. No other debris floated to the surface, but Claudius believed the U-boat was either sunk by the attack, or was "so mortally wounded that she would never return to her base" (USS PC-566 1942).

Aside from the fatal torpedo that sank *Robert E. Lee*, the only evidence of *U-166*'s presence on July 30, 1942 was the periscope that had been spotted and the oil slick that appeared after PC-*566* dropped its second set of depth charges. The submarine, believed by Naval Command to be only slightly damaged by PC-*566* during its attack, would turn out to have been sunk during the battle, but the location of the only U-boat lost in the Gulf of Mexico during World War II would not be identified for half a century.

Two days after the attack on *Robert E. Lee* two U.S. Coast Guardsmen, Pilot Henry White and Radio Operator George Boggs, were patrolling in a J4F amphibious aircraft roughly 160 kilometers south of Houma, Louisiana, when they spotted a U-boat on the surface. As the U-boat crash-dived towards deeper water, White and Boggs attacked with their only weapon, a single depth charge. White and Boggs reported the depth charge exploded near the submarine and an oil slick appeared on the surface. When they returned to base they were informed the incident was classified. White and Boggs were later told they destroyed *U-166* and were decorated for their actions.

For the next 59 years history recorded *U-166* sank 160 kilometers south of Houma, Louisiana by two U.S. Coast Guard Aviators, Pilot Henry White and Radio Operator George Boggs on August 1, 1942. Despite numerous regional oil and gas surveys, and expeditions seeking *U-166*, the sub was not found until 1986. Then it remained incorrectly identified until 2001. *U-166*'s location near *Robert E. Lee* proves PC-*566* destroyed *U-166* on July 30, 1942. Historical records regarding U-boat actions in the Gulf of Mexico indicate White and Boggs attacked *U-171*. Although White and Boggs did not sink *U-171*, they did drive it from the coast and temporarily prevent it from sinking Allied vessels. Unfortunately, the commanding officer of *PC-566* H. G. Claudius died in 1981 before learning that his attack on the U-boat that day in July 1942 had succeeded. Most of the surviving members of *PC-566* have been informed of the discovery and history has been corrected.

7.2 Previous Investigations

Oil and Gas Exploration

In 1986, Shell Offshore, Inc. was exploring the deep waters of the Mississippi Canyon Area in the Gulf of Mexico for potential oil and gas prospects. Shell contracted John E. Chance and Associates to conduct a survey of the region using a 4075 EDO deep-tow system. During the survey they detected two shipwrecks. The only shipwrecks the MMS listed in the vicinity were two World War II casualties, *Robert E. Lee* and *Alcoa Puritan*. At the time, no archaeological assessments were required in deepwater lease blocks and it was not until 1994 that an archaeologist reviewed the data and prepared an assessment. Given the information at the time it was realistic to assume *Robert E. Lee* and *Alcoa Puritan* had been found. No further investigations were undertaken because of the time, and expense involved in conducting deep-tow surveys.

In January 2001, C & C Technologies, Inc. (C & C) conducted a survey for BP and Shell International in the Mississippi Canyon Area near *Robert E. Lee*'s reported location. C & C performed the survey utilizing *C-Surveyor I*, its new Autonomous Underwater Vehicle (AUV), a completely untethered survey platform. During this survey, a large wreck was detected near the edge of the survey swath. C & C marine archaeologists Robert Church and Daniel Warren verified with the MMS that this was *Robert E. Lee*. *Alcoa Puritan*'s reported proximity to *Robert E. Lee*, prompted BP and Shell to agree that additional survey investigation with the AUV be conducted to locate any wreckage in relation to the proposed pipeline route.

In March 2001, the additional survey work was completed. Archaeologists reviewed the data and noted *Robert E. Lee*'s wreckage and a new area of wreckage, less than a mile to the east, where the 1986 survey had placed the wreck of *Alcoa Puritan*. During analysis, it became apparent that the wreckage thought to be *Alcoa Puritan* was inconsistent with that size freighter. The wreckage, however, matched the dimensions of a Type IXC German U-boat (76.8 meters in length and 6.7 meters wide), the same class as *U-166*.

Church and Warren developed a new hypothesis to explain why *U-166* was 225.3 kilometers east of its recorded position. The hypothesis proposed *U-166* was destroyed on July 30, 1942, by Patrol Craft *566*'s depth charge attack, and Coast Guard aviators White and Boggs bombed a different submarine that escaped. An examination of *U-171*'s reconstructed logs, the only other U-boat in the area at the time, lends credence to this hypothesis. These logs stated that *U-171*, around early August 1942, while off the Louisiana coast, was bombed by a "flying boat" (a good description of an amphibious aircraft) but sustained no damage. The attack's exact date could not be determined since the original logbooks were lost when *U-171* was destroyed by a mine in the Bay of Biscay when returning from its Gulf of Mexico patrol.

The hypothesis that the second area of wreckage could be *U-166* led BP and Shell to sponsor site-specific investigations of the suspected *U-166* and *Robert E. Lee* sites using the *C-Surveyor I* AUV. The results of this data (Figure 7.5) provided additional support to the *U-166* hypothesis and stressed the need for verifying the wreck's identity through visual inspection.

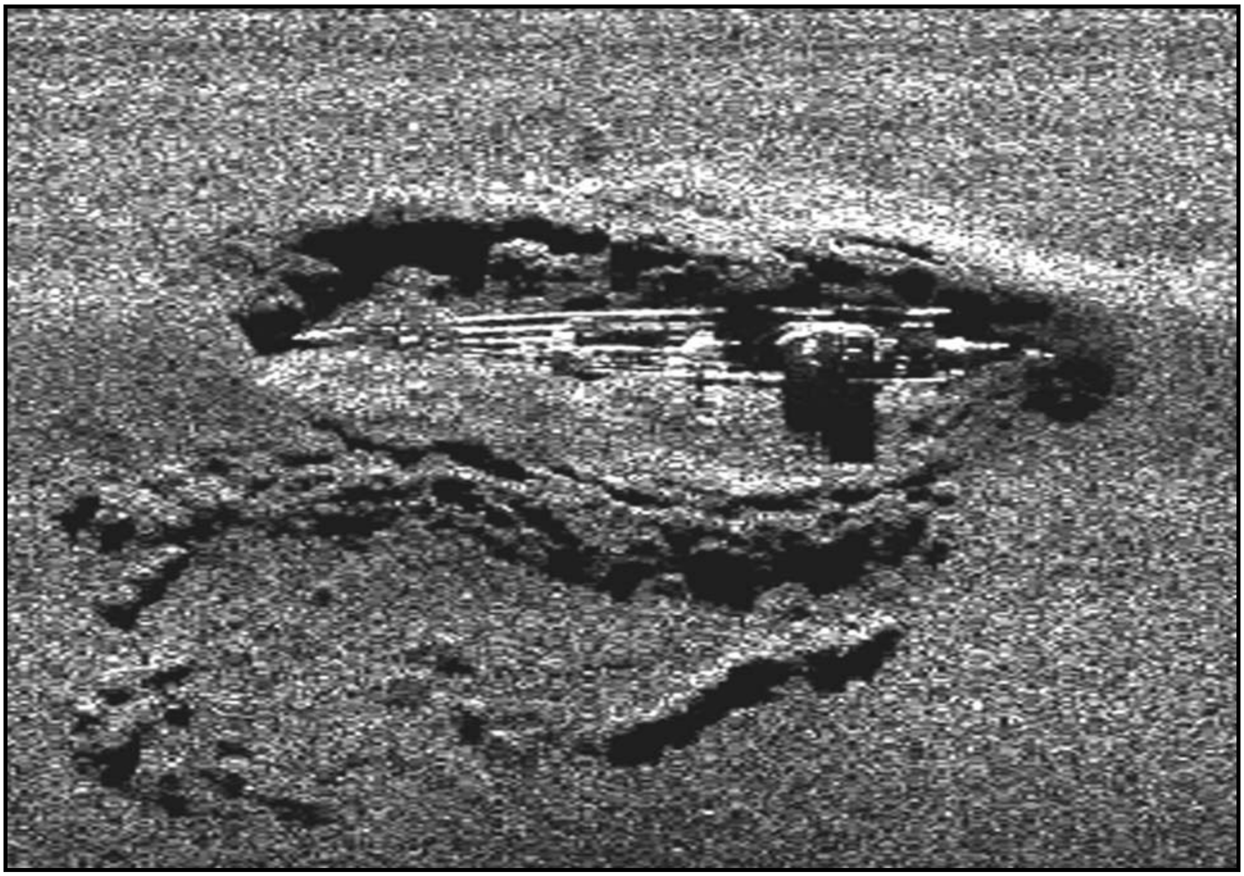


Figure 7.5. High-resolution side scan sonar image of *U-166*, 2001 (Courtesy of BP, Shell, and the National D-Day Museum).

Between May 31 and June 1, 2001, a research team comprised of representatives from BP, Shell, C & C, and the MMS traveled to the Mississippi Canyon Area to determine if the German U-boat, *U-166* had been located. The research team used *Gary Chouest*, an anchor-handling vessel under contract to Shell and equipped with an Oceaneering Millennium VI ROV.

The first glimpse of the vessel was the unmistakable conning tower of a German U-boat. The 105-mm deck gun, 37-mm, and 20-mm antiaircraft guns were clearly visible. Post field analysis and research revealed that each feature matched that of *U-166*.

Three distinct areas of wreckage were noted during the 2001 investigations of the *U-166* wreck site: the stern, the bow, and a debris field. The site is oriented roughly north to south (Figure 7.6). The stern remains are located near the site's eastern limits and consist of an approximately 55-meter hull section including the deck guns and conning tower. The bow remains are located near the site's western extent approximately 140 meters west of the stern section. The bow section consists of approximately a 20-meter hull section extending from the prow aft to just past the forward torpedo hatch. Debris is scattered throughout the site, but the main scatter is between the bow and stern sections. The debris consists of various materials dislodged or ripped from the U-boat as it plunged to the seafloor.

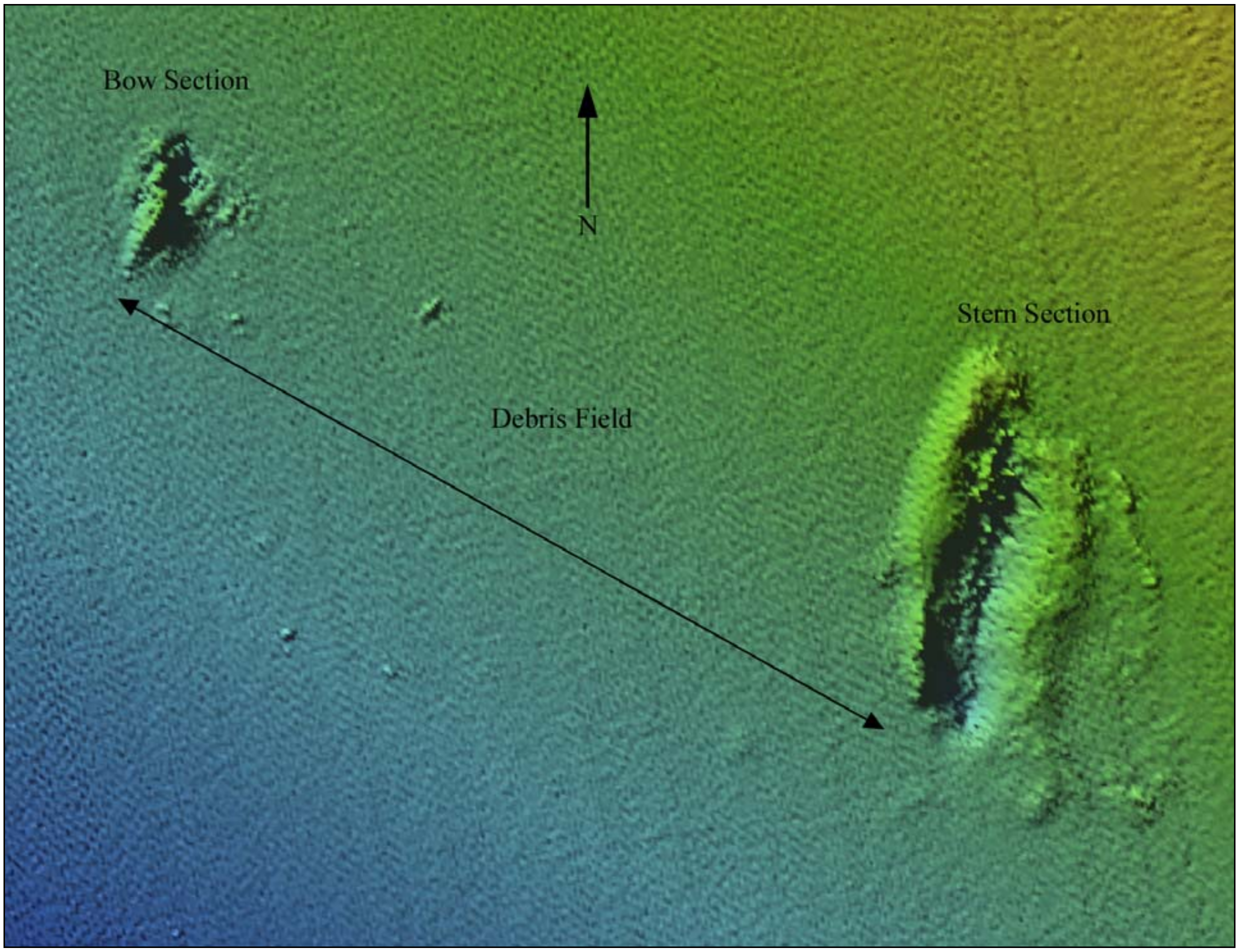


Figure 7.6. Bathymetric data collected in 2001 showing the *U-166* wreck site (Courtesy of BP, Shell, and the National D-Day Museum).

The investigation of the bow section provided a revealing look at a possible cause of the U-boat's demise. A large indentation in the deck may be the result of a depth charge explosion. Just aft of this feature the bow was torn from the rest of the hull and the serrated metal flares outward as if caused by an internal explosion. It is possible that a depth charge exploded very near the deck, ruptured the pressure hull, which in turn caused an internal explosion. It was speculated that salt water rushing into the battery room, which is located in this area of the U-boat, could have caused the batteries to explode.

The expedition successfully identified the long sought after U-boat and its last victim. Unfortunately, only cursory wreck site examinations were carried out because of the ROV's limited availability and capabilities. Time constraints with the ROV allowed only approximately 4 hours to investigate the wreck.

2003 C & C Technologies, Inc./NOAA OE Site Investigations

In October 2003, C & C Technologies, Inc., in conjunction with the NOAA Office of Ocean Exploration, Droycon Bioconcepts, Inc., and the PAST Foundation conducted a more thorough investigation of *U-166* (Warren et al. 2004; and Church et al. 2004). The project's purpose was to document in detail the *U-166* wreck site. Over five days in October 2003, archaeologists and other scientists successfully recorded *U-166*'s remains in one of the deepest archaeological mapping projects using long baseline positioning to date. The project's success was a result of the partnership of academic, private, and government entities coming together as a multi-disciplinary research team.

The 2003 field investigations of the *U-166* wreck site were carried out to fulfill the following six objectives:

Archaeological:
1. Determine the extent of the *U-166* wreck site
2. Collect high-definition video of the wreck sections and artifact field
3. Photo-document the visible wreck sections, artifacts, and relevant biological communities
4. Acoustically position visible wreck sections and artifacts

Microbiological:
5. Deploy long-term and short-term microbiological experiments
6. Collect biological samples (rusticles) from the wreck site for analysis

To conduct the fieldwork, scientists used Sonsub's Innovator Class ROV from NOAA's Research Vessel *Ronald H. Brown*. The ROV surveyed the wreck site following a pre-determined survey grid. The grid consisted of sixty-three lines oriented north-to-south and spaced 4.57 meters apart to provide overlapping coverage. During the survey, the ROV flew between 1.83 and 4.57 meters above the seafloor to minimize the chance of missing wreck pieces.

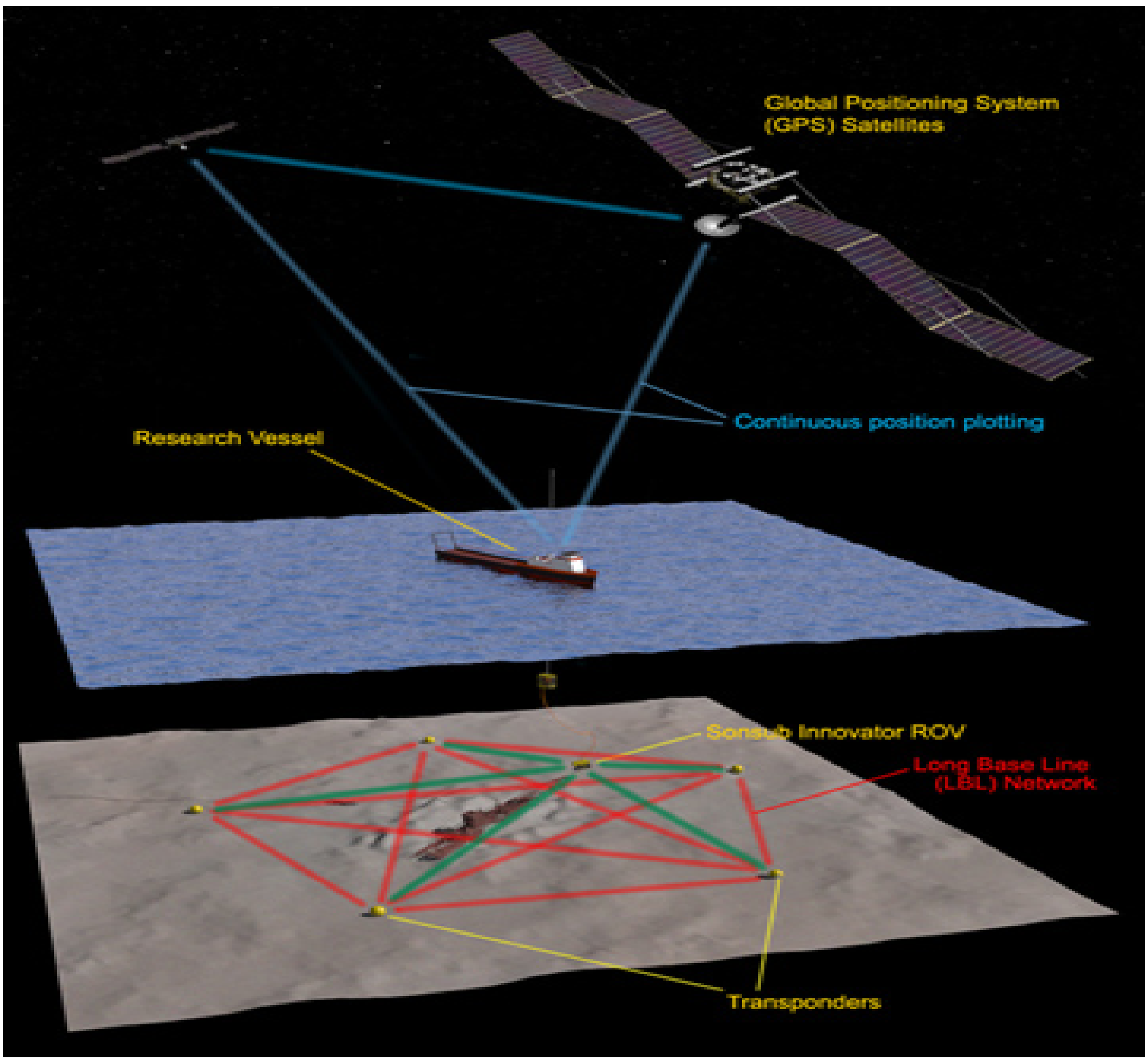


Figure 7.7. Artistic representation of how a Long BaseLine (LBL) positioning correlates with a Global Positioning System (GPS) (Courtesy of Andy Hall).

Survey positioning for the ROV was maintained by using a Sonardyne Fusion Long Baseline (LBL) or range-range acoustic measurement system (Figure 7.7). The system utilized transponders placed at known locations on the seafloor to calculate the position of the transceivers mounted on the ship and the ROV. The signals from the transponders and ROV were transmitted to the support vessel where they were calculated using positioning software, in this case Sonardyne's Pharos Navigation Software. During the *U-166* fieldwork, five medium frequency COMPATT transponder beacons were deployed in a 700-meter diameter array around the site in 1,480 meters of water. Once the beacons were calibrated, the navigation software calculated the ROV's position in real-world coordinates. Using the LBL system in conjunction with a corrected GPS, positions taken at the wreck site were accurate to within 30.48 centimeters.

During the 2003 mapping project, 307 artifacts, and/or groups of artifacts were documented at the *U-166* site (Table 7.1). Over 50 hours of high-resolution digital video and approximately 1,800 digital still images were taken. No artifact materials were recovered because of the wreck's status as an international war grave.

In addition to the archaeological investigations, the microbiological communities (rusticles) growing on *U-166* were documented. Assessment of the rusticles at the *U-166* site was accomplished with the placement of long and short-term experiments, and rusticle sampling from different wreck sections. Short-term experiments, called BARTS and etch tests, were placed on the wreck site at various locations and left in place for approximately 48 hours. The experiments helped biologists determine the types and level of bacterial activity present at the wreck site. The long-term experiments utilized test platforms containing a variety of materials such as wood, iron, and aluminum. These experiments assist biologists in determining the wreck site's biocorrosion rate. The experiments were left on the wreck and checked during the 2004 site visit (Figures 7.8 and 7.9).

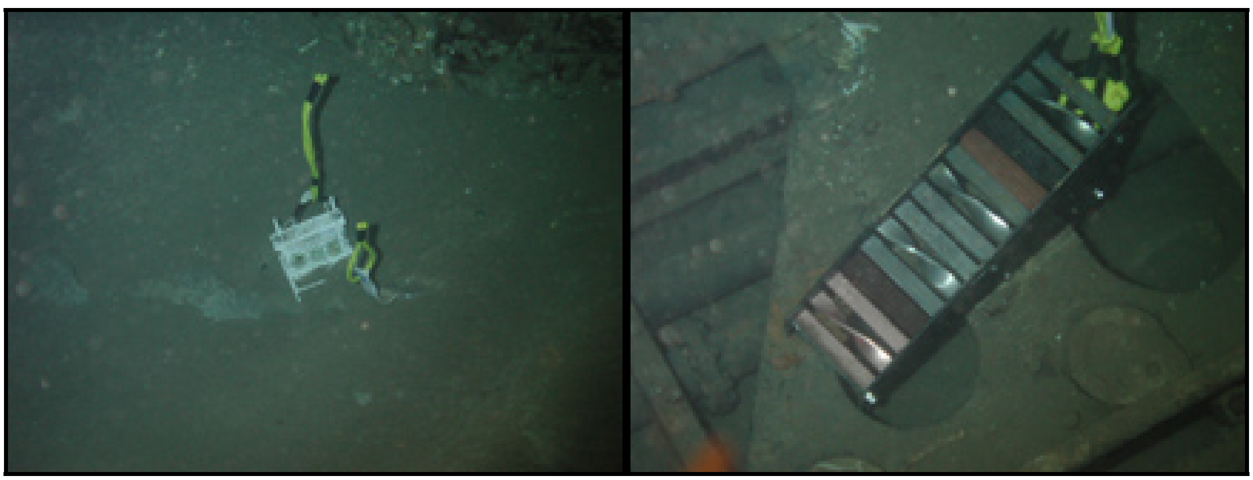


Figure 7.8. Microbiological experiments with BARTS and etch tests (left) and test platforms (right).

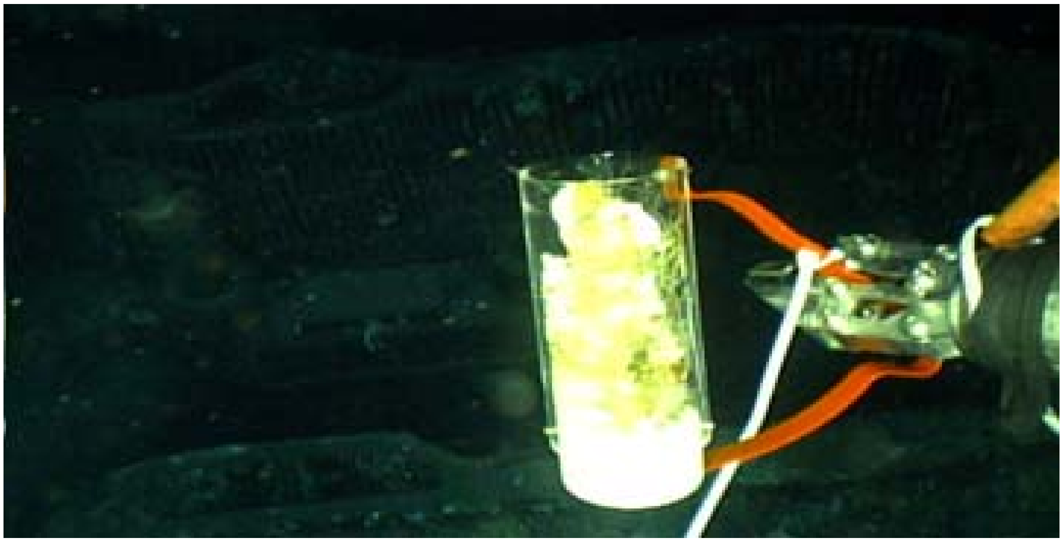


Figure 7.9. The "Lucas Stein" with rusticles from *U-166.*

Following the completion of the fieldwork, materials from the archaeological investigation were brought to the C & C offices in Lafayette, Louisiana. At C & C the digital data was copied and distributed to the groups involved in the project. The archaeological analysis consisted of reviewing the digital imagery in order to classify the vessel's remains. The wreckage was classified into five basic categories: Unidentified Wreckage, Crew-Personal Items/Equipment, Outer Hull/Deck Wreckage, Interior Hull Wreckage, and Intrusive Non-site Related Materials. Using these designations, a site map was developed from coordinates acquired during the wreck investigation. The microbiological experiments were taken to Droycon Bioconcepts, Inc. office in Regina Canada for further analysis.

During the *U-166*'s 2003 field investigations, archaeologists gained a better understanding of the site. The investigation confirmed the 2001 findings; the U-boat broke into two sections and that the sections are approximately 140 meters apart. Between the two sections is a debris field. The 2003 expedition determined the debris field was much denser than originally estimated based on the 2001 ROV survey. The remains are oriented north to south with the bow and stern sections demarcating the relative western and eastern edges of the site, respectively. Although the site's southern extent was not located during the 2003 investigation, it was estimated that the site covers an area of approximately 7.53 hectares or 0.75 square kilometers.

The 20-meter long section of the bow is partially imbedded in the seafloor and rests on its starboard side at a relatively acute angle. A substantial amount of sediment was displaced when it impacted the seafloor. The U-boat's forward portion was torn from the rest of the submarine near the forward torpedo loading hatch area. Approximately five meters of the starboard outer hull extends past the hatch. This aft five meters of the bow is a twisted heap of metal. The vessel's prow faces south with the damaged aft portion pointing north (Figure 7.10). The bow remains are covered with a thin corrosion product and silt layer. Substantial rusticle growth was noted near the bow's damaged portions.

The prow is exposed, but rests only a few centimeters above the seafloor. The hawsehole is still visible on the prow. Moving aft, the deck is relatively intact. A portion of the metal jump wire is still attached to its bow hook. The hull's drain holes are still visible. The wooden decking has disintegrated and the hatch covers are gone (many are in the debris field) revealing the U-boats internal bulwarks. In front of the forward torpedo hatch remains is a large indentation in the deck (as was noted in 2001) (Figure 7.11) corresponding to a crack on the hull's port side extending from the silt line to nearly deck level. Just behind this indentation (Figure 7.14) the metal is mangled with hull plates pushed and bent outward rather than crushed as would be suspected from an implosion. The forward torpedo winch's remains are visible in the wreckage. This winch was used to load torpedoes through the forward torpedo hatch.

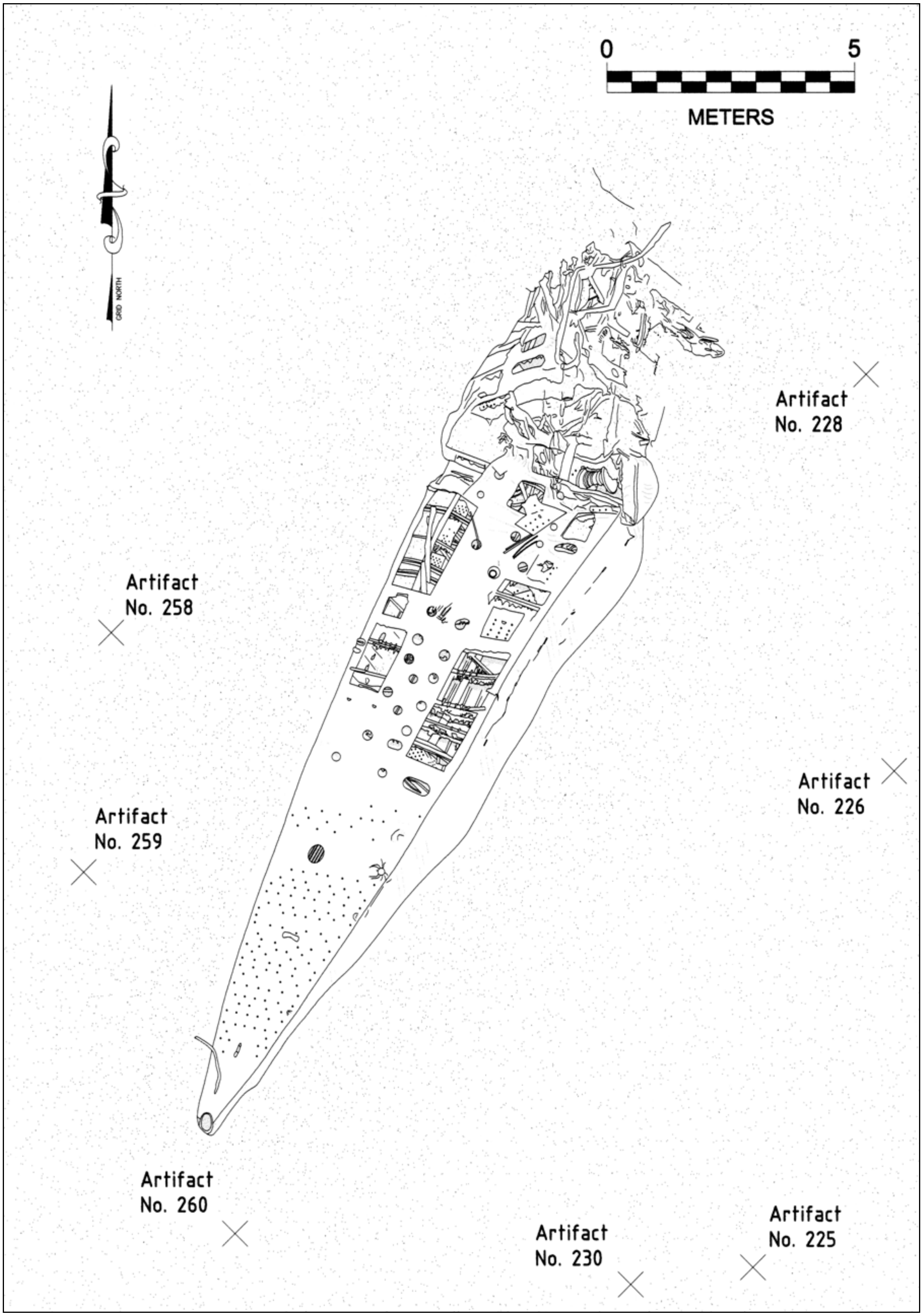


Figure 7.10. Site drawing of *U-166*'s bow (Drawn by Robert A. Church).

Figure 7.11. *U-166* images showing indentation (left) and damaged area near the forward torpedo-loading hatch (right).

Approximately 140 meters east of the bow section is *U-166*'s stern. The stern section lies behind a small berm of sediment located directly to its west. East of the stern is an area of low-relief sediment mounds. The stern wreckage is oriented north-to-south with the damaged foredeck toward the north. Other than the missing bow section, this portion of the hull is almost entirely intact, including the conning tower. The aft hull is buried in the seafloor up to the deck level. As with the bow section, all the wood decking is gone revealing the outer hull's open spaces. Conduits and piping are visible through these open areas. Most of the hatch and deck covers are also missing from this section of the wreck. The conning tower's exterior is heavily saturated with rusticle growth, with the exception of a small section on the starboard side forward of the conning tower hatch.

Moving down the stern section from forward to aft, most of the remaining forward deck is buried under sediment, the 105-millimeter deck gun is the first visible deck feature (Figure 7.12). The deck gun is intact and sits upright on the deck. The muzzle faces forward and the tampion is still in place. A portion of the forward jump wire is wrapped around the gun mount's base.

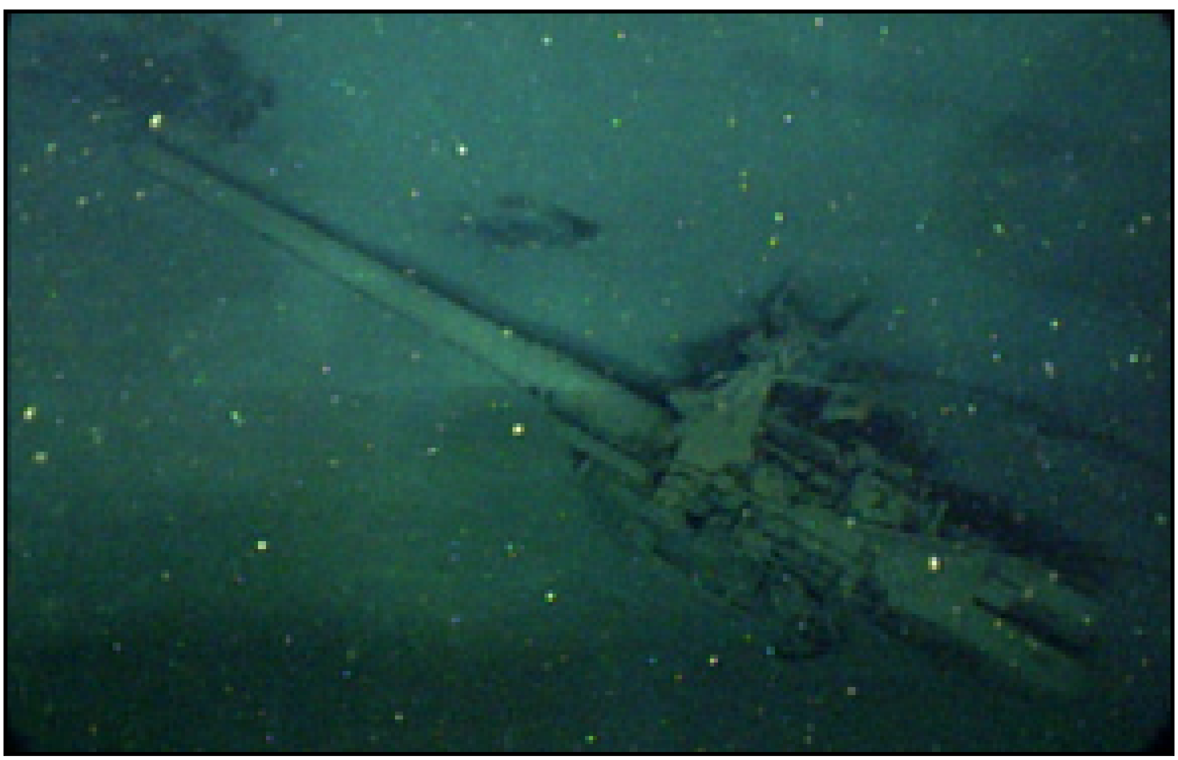


Figure 7.12. Overhead view of the 105-mm forward deck gun.

Continuing aft, the conning tower is encountered next. It is intact and in a good state of preservation. The splashguard on the front of the conning tower and the port and starboard running lights are still visible. At the top of the conning tower (Figure 7.13), the direction finding antenna is visible on the starboard side stowed in a recessed slot. Looking down on the conning tower, the conning tower hatch, bridge controls, and lookout stands are visible. Behind the conning tower hatch is the surface attack mounting for the *Uboot-Zieloptik* or U-boat Target Optical sight (UZO). The UZO was used to set up surface torpedo attacks. Aft of the UZO mount and conning tower hatch is the periscope console. Type IX U-boats used two periscopes, and both on the *U-166* were fully retracted. The compass mount is immediately behind the periscope console. The engine exhaust vents are to the rear of the bridge deck on each side of the conning tower. Near the port side vent, the short-wave radio antenna is partially extended and bent. Aft of the bridge area is the *wintergarten* containing the 20-mm machine-gun. The gun's barrel is pointed upwards and to port, with the shoulder supports resting on the *wintergarten* deck (Figure 7.14).

The ladder from the conning tower to the deck is still attached to the port side. The conning tower's starboard exterior door is ajar revealing the two interior hatches into the pressure hull (Figure 7.14). No visible symbols or markings, such as insignias or unit symbols, were noted on either side of the conning tower.

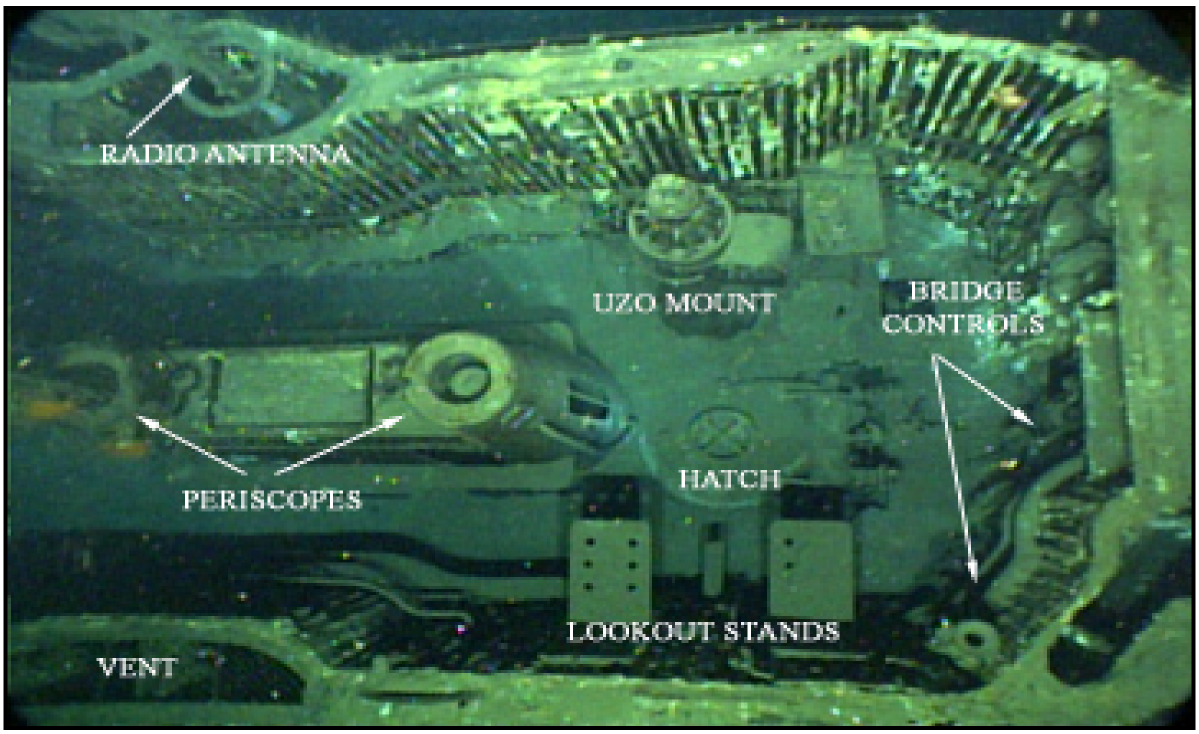


Figure 7.13. Overhead view of *U-166*'s conning tower bridge

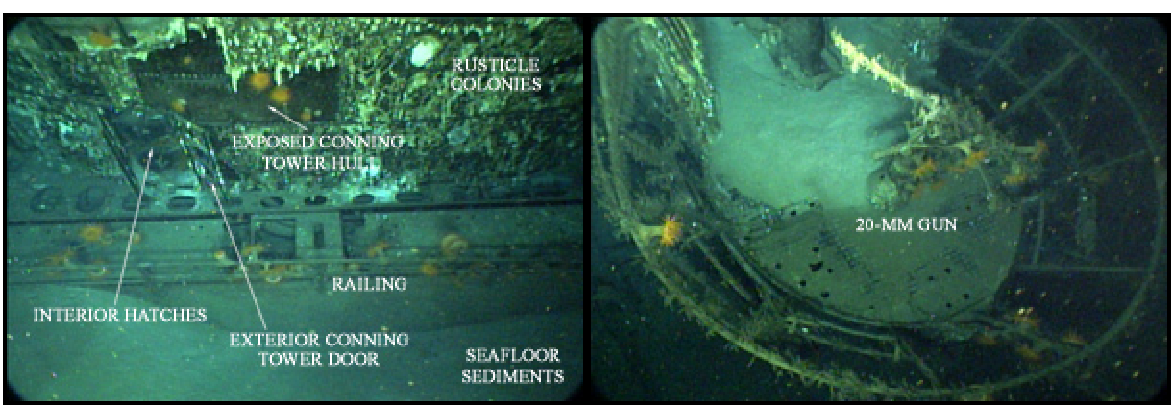


Figure 7.14. Starboard side of conning tower (left) and 20-mm deck gun on *Wintergarten* (right).

Continuing towards the stern, the railing is intact. A segment of the aft jump wire is strewn along the starboard deck, with the attached insulators lying near the conning tower. The 37-millimeter antiaircraft gun stands in the middle of the aft deck (Figure 7.15). Used primarily for defense against aircraft attacks, it is in a stowed position with the barrel parallel to the deck and pointing towards the conning tower. As with the 105-mm gun, the barrel tampion is in place. Moving aft from the 37-mm gun, the after torpedo-loading hatch is visible. The hatch's deck cover is missing, as is the hatch cover itself. The hinge remnants look as if the hatch was ripped or blown away (Figure 7.16). Continuing to the stern, silt has covered much of the hull, but both the stern running light and the end of the stern deck are visible.

Figure 7.15. *U-166*'s aft deck of showing the 37-mm gun and intact deck railing.

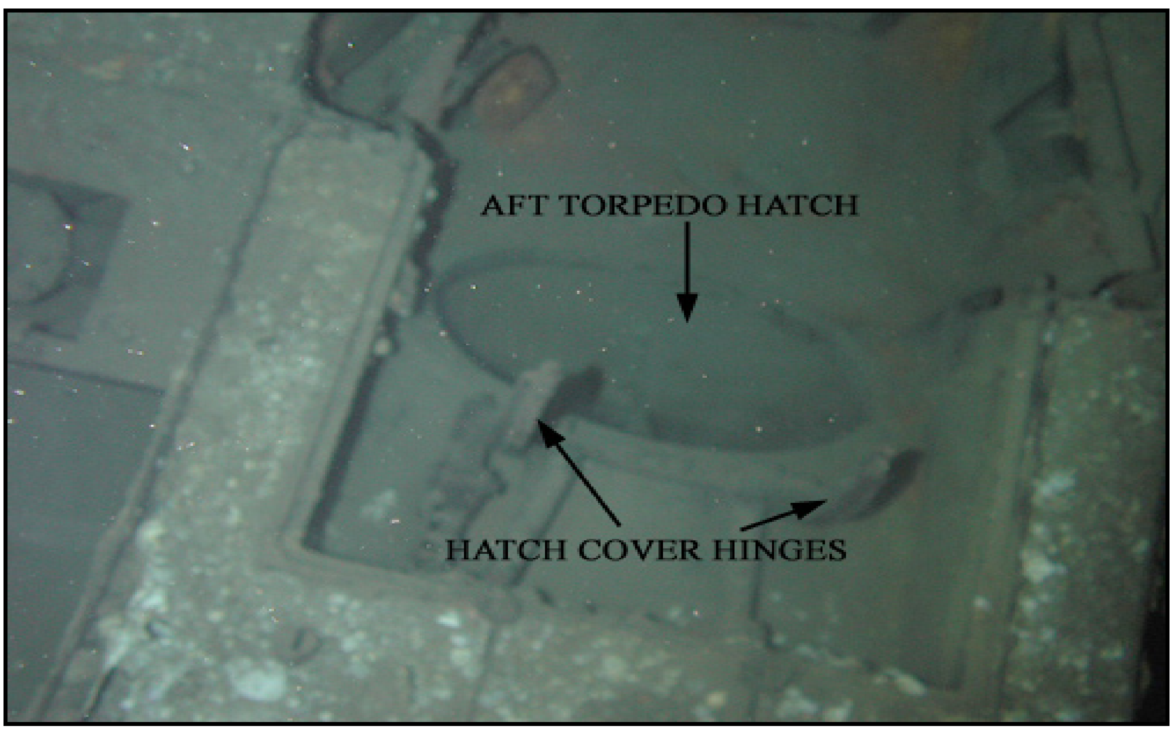


Figure 7.16. View showing aft torpedo hatch on stern wreckage.

Between the bow and the stern sections is a dense debris field. Near the stern section, artifacts are few and scattered. Proceeding west from the stern section, the debris density steadily increases towards the bow section where the heaviest scatter extends south. West and north of the bow, the artifact scatter abruptly stops except for one or two scattered objects.

A variety of objects make up the debris field. Hull fragments, personal materials, electrical equipment, survival gear, and hatch covers are strewn throughout the area. Intrusive materials such as aluminum soda cans and cardboard were also noted in the debris field.

The debris field contains many non-descript metal fragments that cannot be identified or associated with a particular part of the ship. Other pieces are barely visible because of silt build-up and could not be identified. No silt was removed in order to minimize site disturbance.

Identifiable hull components consisted of outer hull sections, bracing, and bulkhead fragments (Figure 7.17). These components range in size from small fragments to large pieces. Many of the materials have jagged edges as if they were torn from the hull. The debris field also contained numerous pieces of piping, similar to the conduits visible under the deck structures.

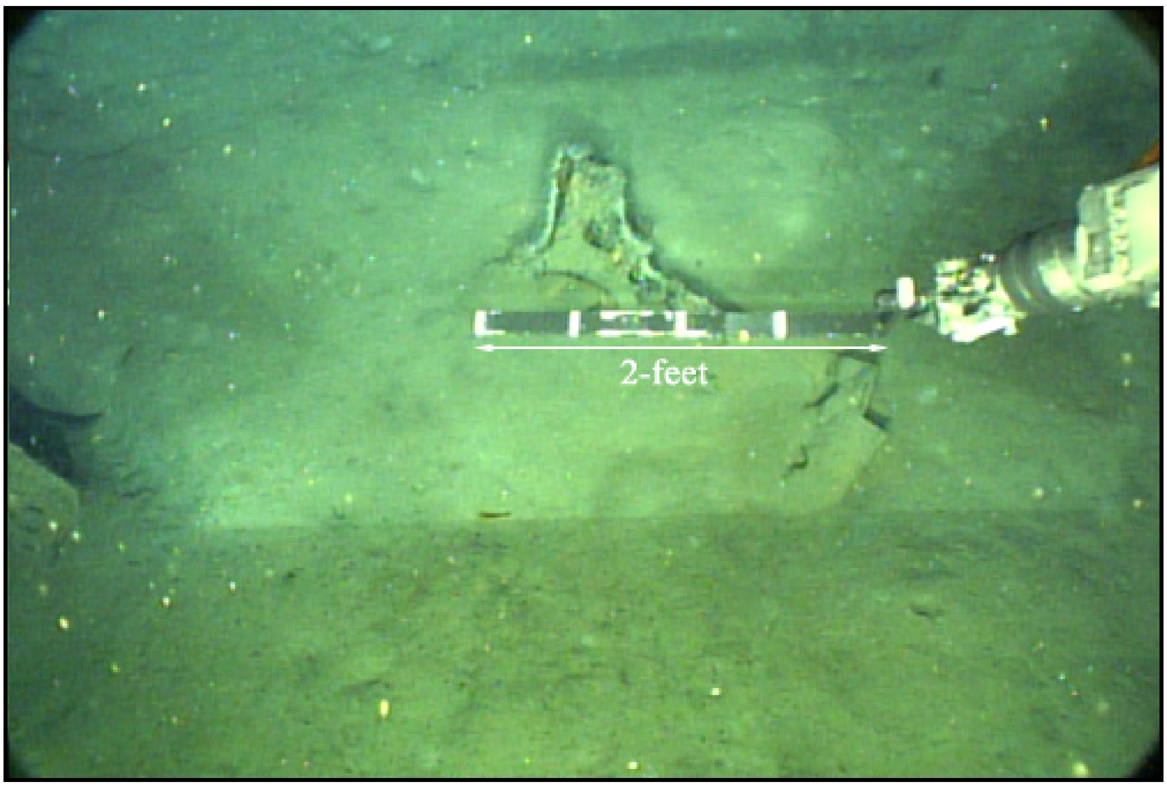


Figure 7.17. A 0.6-meter long section of *U-166*'s bulkhead found in the debris field (Artifact No. 60).

Several artifacts appear to be equipment from inside the pressure hull. These include hatch covers, electrical boxes, switches, electrical cable, and several pressurized cylinders (Figure 7.18). The cylinders are deeply buried in the seafloor, one up to the valve stem. The debris field also contains personal equipment and items from *U-166*'s crew. These materials are likely from the pressure hull's forward area where the crew was quartered and the hull breached. Observed items included shoes, leather foul weather gear, a dinner tray, and several Dräger Lung rescue devices (Figure 7.19). Dräger Lungs were intended for shallow water escapes from a disabled U-boat, but *U-166*'s crew never had the chance to use them.

Table 7.1

Artifact Table from 2003 Survey

Artifact No.	Description		Artifact No.	Description		Artifact No.	Description
1	Stern		33	Metal grating		65	UWD
2	Bow		34	Metal fragment		66	Metal fragment
*3	Aluminum can		35	Compressed gas cylinder		67	Copper tubing
4	UWD		36	Metal pipe		68	Copper tubing
5	UWD		37	Copper tubing		69	UWD
6	Wire		38	Metal fragment		70	UWD
7	Wire		39	Compressed gas cylinder		71	UWD
8	Wire		40	Copper tubing		72	Metal fragments
9	Metal tubing and wire		41	Metal fragment		73	Metal fragment
10	UWD		42	Deck grating		74	UWD
11	UWD		43	Metal fragment		75	UWD
12	Metal gasket		44	Metal fragment		76	Metal fragment
13	Metal pipe		45	Metal pipe		77	Metal fragment
14	Copper tubing		46	Copper tubing		78	Metal fragment
15	Decking or hatch cover		47	Compressed gas cylinder		79	UWD
16	Metal fragment		48	Deck grating		80	UWD
*17	Chip bag		49	Metal fragment		81	UWD
18	Metal fragments		50	Metal fragment		82	UWD
19	Metal fragment		51	Metal fragment		83	Metal fragment
*20	Cardboard		52	Metal fragment		84	UWD
21	UWD		53	Compressed gas cylinder top		85	UWD
22	Copper tubing		54	UWD		86	UWD
23	Metal fragment		55	Copper tubing		87	Metal fragment
24	Metal fragment		56	Metal fragment		88	Metal fragment
*25	Plastic bag		57	UWD		89	Metal fragment
26	Instrument/electric box		58	Electrical switch/gauge		90	Electrical box and wiring
27	Metal fragment		59	Deck grating		91	Copper tubing
28	Glass bottle		60	Metal fragment		92	Metal fragment
29	UWD		61	Metal fragment		93	Metal fragment
30	Metal pipe		62	Metal pipe		94	Copper tubing
31	Metal fragment		63	Metal pipe		95	Metal coils
32	Metal Fragment		64	Metal fragment		96	Electrical box and wiring

(Continued)

Table 7.1

Artifact Table (2003)

Artifact No.	**Description**	**Artifact No.**	**Description**	**Artifact No.**	**Description**
97	UWD	130	Metal fragments	163	Metal fragment
98	UWD	131	UWD	164	UWD
99	UWD	132	UWD	165	Metal fragment
100	UWD	133	Glass bottle neck	166	UWD
101	UWD	134	Metal fragment	167	Metal fragment
102	Hatch cover latch	135	UWD	168	Metal fragment
103	Copper coils and tubing	136	Drager Lung	169	Metal fragment and tubing
104	Metal fragments	137	Tubing/electrical wiring	170	UWD
105	UWD	138	UWD	171	UWD
106	Metal fragment	139	Metal fragment	172	Metal fragment
107	Metal fragment	140	Metal fragment	173	Metal pipe
108	UWD	141	UWD	174	Metal fragment
109	Compressed gas cylinder	142	Deck hatch cover	175	UWD
110	UWD	143	Deck hatch cover	176	Drager Lung
111	UWD	144	Metal fragments	177	Metal fragments
112	UWD	145	UWD	178	Metal fragment
113	Deck grating	146	UWD	179	UWD
114	Deck grating	147	Deck covering	180	UWD
115	UWD	148	Deck covering	181	UWD
116	Metal fragments	149	Deck covering	182	Metal fragment
117	UWD	150	UWD	183	UWD
118	Metal fragments	151	UWD	184	Electrical wiring
119	UWD	152	UWD	185	UWD
120	Hatch cover	153	Metal fragment	186	UWD
121	Metal fragment	154	UWD	187	Compressed gas cylinder
122	UWD	155	Metal fragment	188	UWD
123	Metal fragment g	156	UWD	189	UWD
124	Switch w/wiring	157	Metal fragment	190	UWD
125	Metal fragments	158	UWD	191	Metal fragment
126	UWD	159	UWD	192	UWD
127	Drager Lung	160	UWD	193	UWD
128	Tubing/electrical wiring	161	UWD	194	Instrument/electrical box
129	Metal fragment	162	Metal pipe	195	Outer hull fragment

(Continued)

Table 7.1

Artifact Table (2003)

Artifact No.	Description		Artifact No.	Description		Artifact No.	Description
196	UWD		229	Metal fragment		262	UWD
197	Compressed gas cylinder		230	Internal hull debris		263	UWD
198	UWD		231	UWD		264	UWD
199	UWD		232	UWD		265	Metal fragment
200	Metal pipe or tubing		233	UWD		266	Copper tubing
201	Metal fragment		234	UWD		267	UWD
202	UWD		235	UWD		268	UWD
203	UWD		236	UWD		269	UWD
204	UWD		237	UWD		270	UWD
205	UWD		238	UWD		271	Metal bar
206	Metal fragment		239	Metal band		272	Metal fragment
207	Metal tray or basin		240	Deck grating		273	UWD
208	Metal fragment		241	UWD		274	UWD
209	Deck covering		242	Metal fragment		275	Glass bottle
210	Metal fragment		243	UWD		276	UWD
211	Deck covering		244	Leather shoe/boot		277	Leather jacket/coat
212	UWD		245	UWD		278	Metal fragment
213	UWD		246	Leather shoe/boot		279	UWD
214	UWD		247	UWD		280	Metal pipe
215	Metal pipe or tubing		248	UWD		281	Deck hatch cover
216	UWD		249	UWD		282	Leather jacket/coat
217	Metal fragment		250	UWD		283	UWD
218	Metal pipe or tubing		251	Metal fragment		284	UWD
219	UWD		252	UWD		285	UWD
220	UWD		253	Metal fragments		286	UWD
221	UWD		254	Metal pipe or tubing		287	UWD
222	UWD		255	UWD		288	UWD
223	UWD		256	Metal fragment		289	Metal Hull debris
224	UWD		257	Metal fragment		290	UWD
225	UWD		258	Dropwire insulator		291	UWD
226	Electrical wiring		259	UWD		292	UWD
227	Hull/bulkhead debris		260	UWD		293	UWD
228	UWD		261	UWD		294	UWD

(Continued)

Table 7.1

Artifact Table (2003)

Artifact No.	**Description**	**Artifact No.**	**Description**	**Artifact No.**	**Description**
295	Electrical wiring	300	UWD	305	UWD
296	Metal fragment	301	UWD	306	Metal fragment
297	UWD	302	UWD	307	Metal fragments.
298	UWD	303	UWD		
299	Instrusive Aluminum Can	304	Metal fragment		

UWD = Unidentified Wreck Debris
* = Intrusive Material

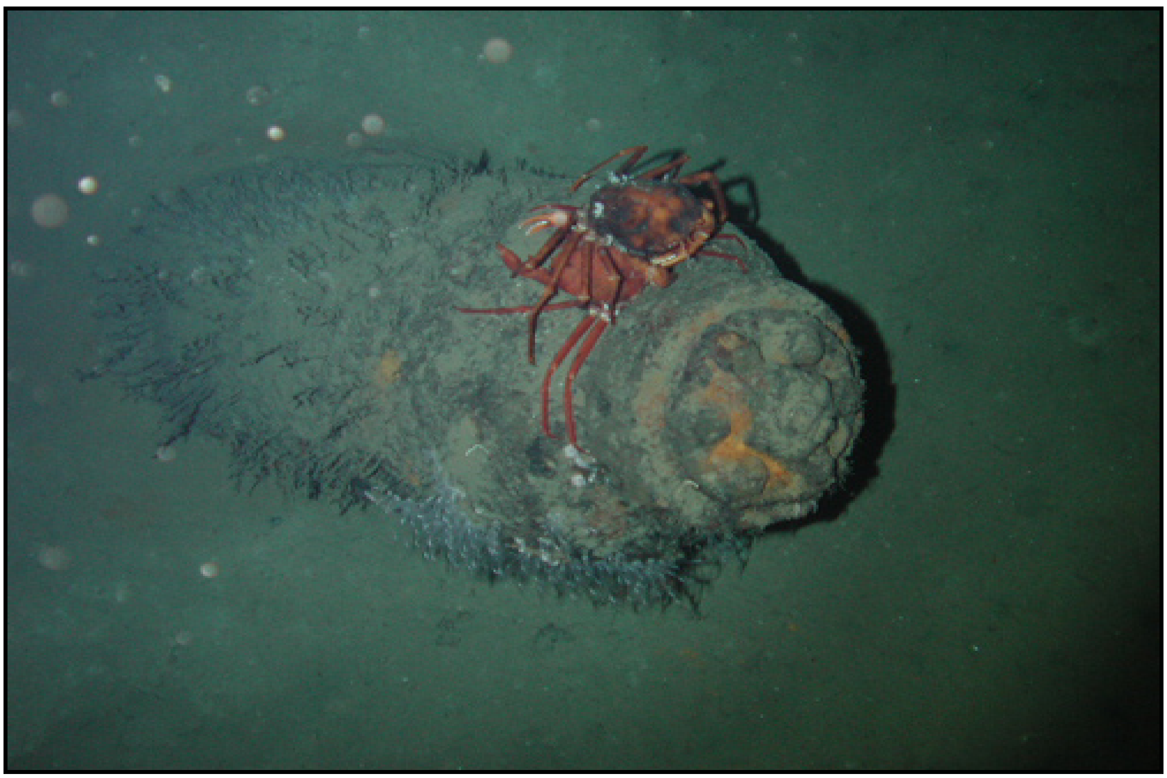


Figure 7.18. Pressurized cylinder from *U-166* (Artifact No. 47).

Analysis of the 2003 data provided a better understanding of the wreck site and of the site formation processes that shaped and continue to shape the site. Artifact distribution patterns suggest the northern and westernmost site boundaries are just beyond the bow section. The eastern boundary is 37 meters east of the stern and conning tower. The debris field extends south from the bow beyond the 2003 survey's limits. The debris density decreased near the survey's southern limit. This suggests the site does not extend much farther south. Using this information, it was estimated that the site covers a roughly 7.52 hectare area.

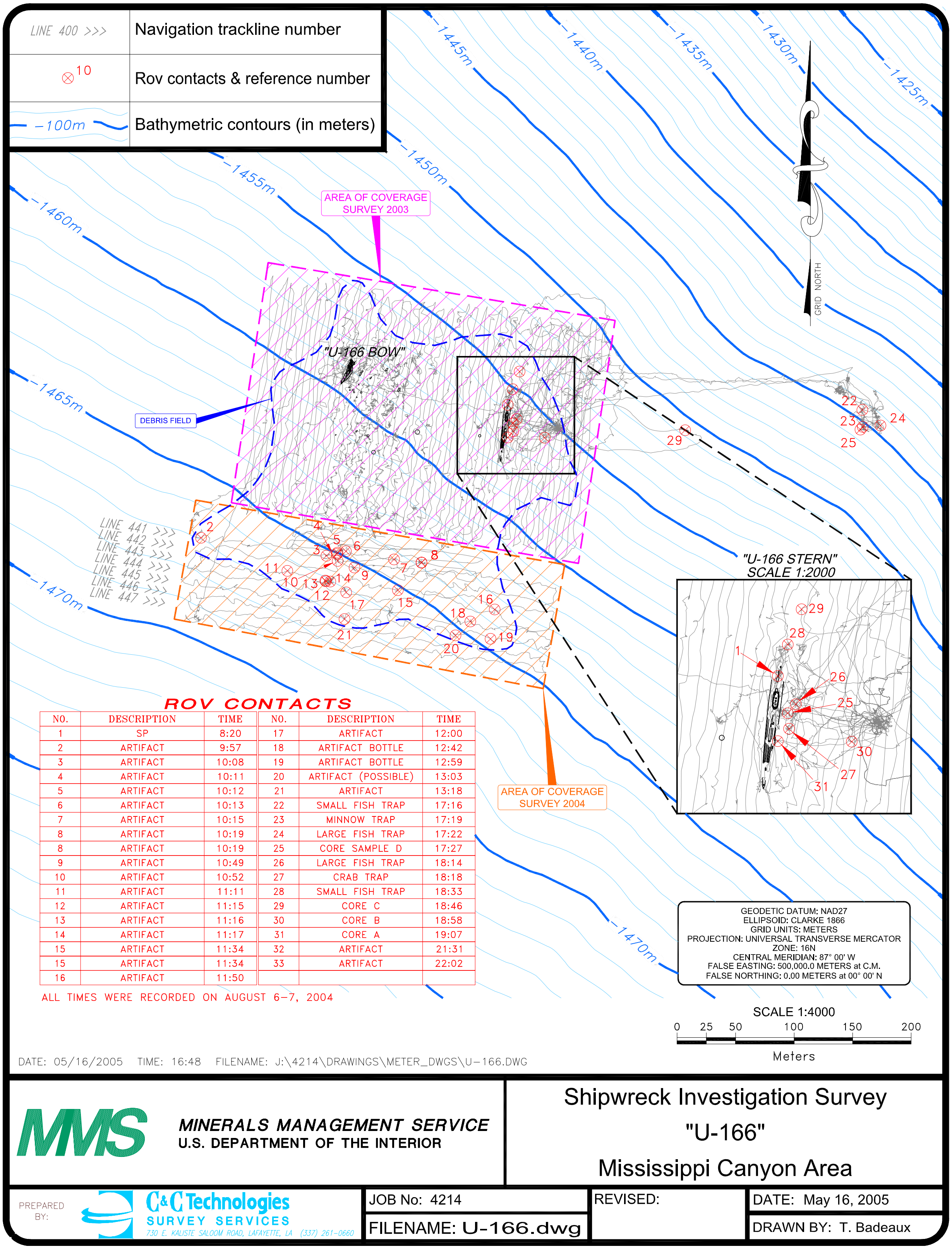
Figure 7.19. A Dräger Lung from the *U-166* (Artifact No. 127).

The debris field's heaviest artifacts concentration is located in the site's western area near the bow. The evidence suggests the hull broke just south of the current position and the separate hull sections impacted the seafloor with most the artifacts strewn from the bow section as it sank. The 2003 data supports the hypothesis that a depth charge from *PC-566* ruptured the pressure hull and a secondary internal explosion of unknown origin then occurred. This secondary explosion resulted in the eventual separation of the bow from the rest of the vessel.

The microbiological study from the 2003 investigations gathered rusticles from both *U-166* and *Robert E. Lee*. This analysis determined that the microbial activity at the *U-166* site was high, and that rusticle formations from *U-166* and *Robert E. Lee* were significantly different. High levels of strontium in the *U-166* and *Robert E. Lee* rusticles have raised more questions about the sites.

7.3 Geographical Setting

The site area is located in the eastern portion of the Mississippi Canyon Area of the northern Gulf of Mexico. The site is southeast of the Mississippi River's mouth and south of an area dominated by diapiric salt uplifts. The regional seafloor gently slopes at approximately 5° toward the south and may vary locally from southeast to southwest. The seafloor trend at the wreck site is to the southwest (Figure 7.20). There is a low sedimentation rate in this area of approximately 1.52 millimeters per year.



ROV CONTACTS

NO.	DESCRIPTION	TIME	NO.	DESCRIPTION	TIME
1	SP	8:20	17	ARTIFACT	12:00
2	ARTIFACT	9:57	18	ARTIFACT BOTTLE	12:42
3	ARTIFACT	10:08	19	ARTIFACT BOTTLE	12:59
4	ARTIFACT	10:11	20	ARTIFACT (POSSIBLE)	13:03
5	ARTIFACT	10:12	21	ARTIFACT	13:18
6	ARTIFACT	10:13	22	SMALL FISH TRAP	17:16
7	ARTIFACT	10:15	23	MINNOW TRAP	17:19
8	ARTIFACT	10:19	24	LARGE FISH TRAP	17:22
8	ARTIFACT	10:19	25	CORE SAMPLE D	17:27
9	ARTIFACT	10:49	26	LARGE FISH TRAP	18:14
10	ARTIFACT	10:52	27	CRAB TRAP	18:18
11	ARTIFACT	11:11	28	SMALL FISH TRAP	18:33
12	ARTIFACT	11:15	29	CORE C	18:46
13	ARTIFACT	11:16	30	CORE B	18:58
14	ARTIFACT	11:17	31	CORE A	19:07
15	ARTIFACT	11:34	32	ARTIFACT	21:31
15	ARTIFACT	11:34	33	ARTIFACT	22:02
16	ARTIFACT	11:50			

Figure 7.20. *U-166* site overview map.

Table 7.2

ROV Navigation Fix Points at *U-166*

No.	Description	Time
1	105 mm Deck Gun	8:20
2	Bottle	9:58
3	UWD - metal	10:09
4	UWD - metal	10:12
5	Boot	10:13
6	UWD - Substructure	10:14
7	Leather	10:17
8	Aluminum can	10:19
8	UWD	10:19
9	Metal plating	10:50
10	UWD	10:53
11	UWD - White	11:12
12	Textile and soda can	11:16
13	Stick	11:18
14	Jacket, possible leather and a pair of boots	11:19
15A	UWD	11:36
15B	UWD	11:34
16	Bottle	11:43
17	Metal decking	12:01
18	Artifact-bottle	12:43
19	Artifact-bottle	13:01
20	Biological	13:04
21	Textile or leather	13:20
22	Small fish trap	17:18
22	Minnow trap	17:21
24	Large fish trap	17:23
25	Core sample D	17:30
26	Large fish trap	18:15
27	Crab trap	18:19
28	Small fish trap	18:33
29	Core C	18:47
30	Core B	18:15
31	Core A	12:09
32	Textile or leather and metal debris	21:32
33	Hatch cover	22:03

UWD = Unidentified Wreck Debris

7.4 Discussion of Archaeological Findings

7.4.1 Physical Site

The 2004 archaeological investigations undertaken at *U-166* continued the 2003 fieldwork. The site's southern extent was not established during 2003, and the 2004 work focused on locating this boundary. During the 2004 project, the science team surveyed seven additional lines south of where the 2003 investigations ended. The lines were approximately 330 meters long, spaced 20 meters apart, and covered an area approximately 100 meters wide. The survey was terminated when the investigation of two successive lines found no further artifacts.

The seafloor covered by the 2004 survey is relatively flat and composed of the same sediment found throughout the *U-166* wreck site. The 2004 investigations located twenty-three additional artifacts associated with the wreck site. These were mainly hull fragments (Figure 7.21), most with more extensive impact craters than those to the north. Other artifacts documented during this field season included possible clothing (Figure 7.22).

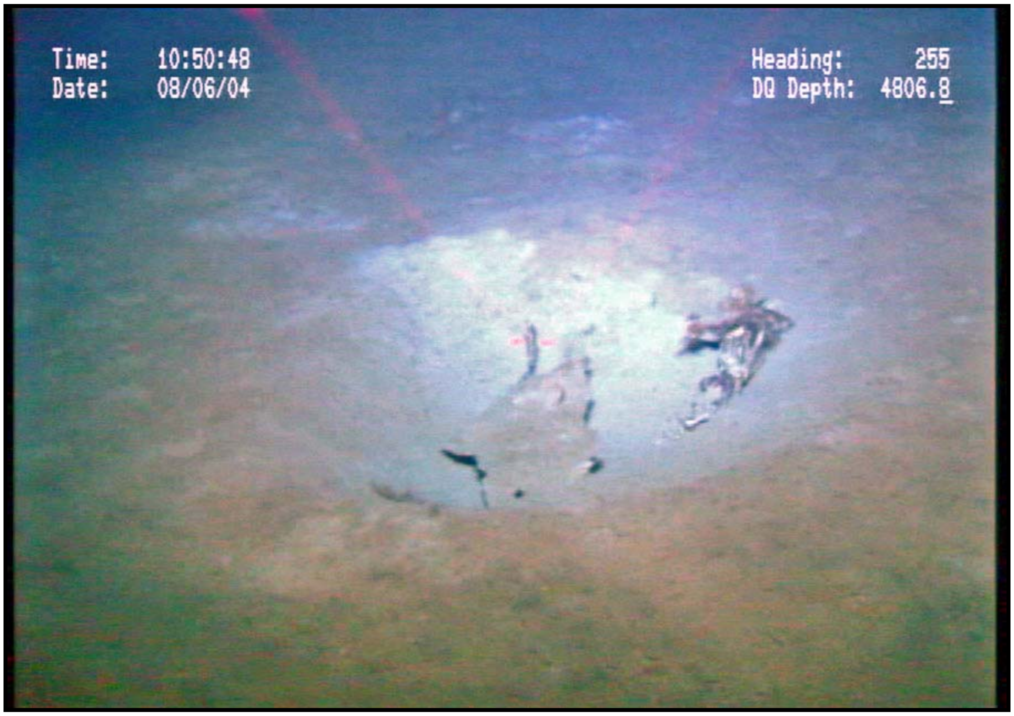


Figure 7.21. Hull remains in large crater located during 2004 investigations.

Figure 7.22. Remains of a uniform from *U-166* site

ROV transects were run over *U-166*'s bow and stern. A photo mosaic was produced from the video data of the bow (Figure 7.23). LBL position information collected in 2003 was used to correct the 2004 imagery while processing the mosaic.

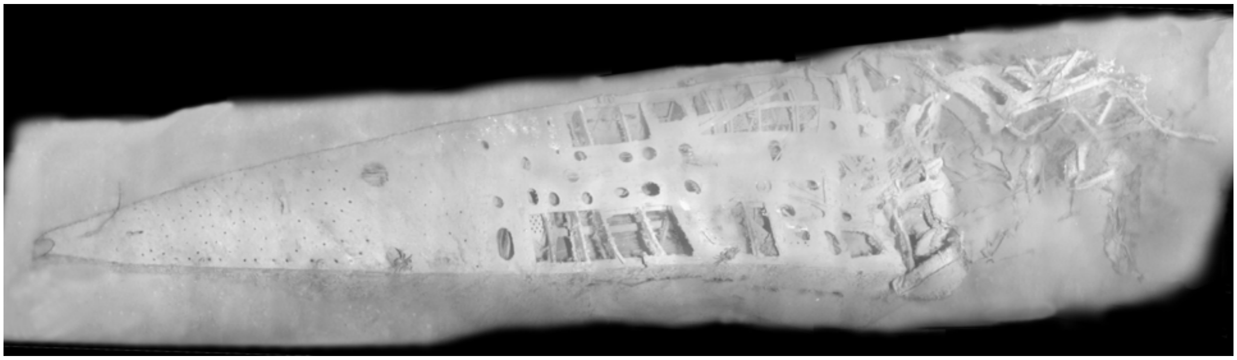


Figure 7.23. Photo mosaic of *U-166*'s bow.

7.4.2 Site Preservation

U-166 is in a good state of preservation. The splashguard, often among the first components to be lost, is showing the signs of deterioration, but is otherwise mostly intact. The wood decking along the vessel's exposed areas is gone. The damaged area of the stern is buried and could not be examined. The bow area that ripped away from the main hull is partially visible and shows considerable damage. The bow section forward of the damaged area is well preserved. Rusticle growth is most profuse on the conning tower and near the bow's exposed damaged sections.

7.5 Discussion of Biological Findings

7.5.1 Microbiology

Mark IB steel test platforms were deployed on *U-166* in 2003. These platforms included a mixture of metal and wood coupons. The metal coupons included three low carbon steel, high carbon steel, and aluminum, with coupons of mahogany and oak. For the metal coupons, one coupon was a control, a second was twisted longitudinally through 180 degrees, and the third coupon was subjected to hammering at 3,000 psi. One platform was placed in the bow just forward of the explosion point that sank the submarine. The second platform was placed in front of the conning tower on the submarine's aft deck members. The Mark IA platforms were set vertically on various other shipwrecks, which caused stability problems. Therefore the Mark IB platforms were laid down laterally so that the coupons formed a more stabile shallow staircase. Both platforms were examined *in-situ* in 2004 and both showed similar trends summarized in Table 7.3

Extensive rusticle growths were observed on both the low and high carbon steels with the surfaces appearing evenly coated, but with an overlay of floc material (floc may be defined as visible, irregular suspended particles held in the water). Generally, the twisted and hammered coupons had more growth and floc formation than the controls. Comparing microbial activity at the submarine's bow and stern, there were distinctly greater amounts of growth on the bow coupons than the stern coupons. Coupon five in particular exhibited concretion growth and peeling at the steel's midpoint on the twisted edge.

All six aluminum coupons were bright and reflective indicating the aluminum had not yet corroded or been visibly altered through microbial means. The aluminum coupons did, however, have loose beige floc-like growths. The stern platform's coupons had randomly positioned floc growths, while the bow platform coupons had congregated floc growths at the edges.

The oak, mahogany and copper coupons exhibited no differences between the bow and stern platforms. Unlike the control oak coupons, which had little fungal activity, the blackened oak coupons (deliberately burnt) showed heavy fungal growth. The copper coupons showed signs of oxidation with more floc attached to the bow coupons than the stern coupons.

In summary, the Mark IB platform bow coupons showed more growth than the stern platform coupons. The growth was typified by a greater amount of floc material on the coupon and a greater tendency for floc to grow between the coupons. If the platforms were recovered in 2005 then it could be expected that the steel coupons would have already lost a significant amount of iron. In comparison, platforms recovered from *RMS Titanic* lost the equivalent of 0.03 grams of iron per square centimeter per year (or 3 grams of iron from each coupon).

Table 7.3

Status of Bio-Deterioration of the Coupons on Platforms IA, *U-166*

Coupon #	**Material**	**Bow platform**	**Stern platform**
1	Low Carbon steel - control	Rusticle encrustation entire, depth 2 mm, 30% floc	Rusticle encrustation entire, depth 2 mm
2	Low Carbon Steel - twisted	Rusticle encrustation entire at depth 2 mm with 50% of floc formation connecting to coupon 3	Rusticle encrustation entire at depth 2 mm with 10% of twisted edge showing floc formation
3	Low Carbon Steel - hammered	Rusticle encrustation entire with depth 2 mm with 50% floc formation	Rusticle encrustation over 80% at 2 mm with 30% coupon edge still visible
4	Oak - burnt	Blackened with surface fungal growth over 70% as distinct raised areas	Blackened with surface fungal growth over 30% as distinct raised areas
5	Oak - control	Surface covered with beige encrustations with signs of wood deterioration at edges	80% surface covered with beige encrustations with signs of wood deterioration at edges
6	High Carbon steel - control	Rusticle encrustation entire, depth 2 mm with 80% floc	Rusticle encrustation entire, depth 2 mm with 10% floc
5	High Carbon Steel - twisted	Rusticle encrustation entire at depth 3 mm with detaching floc formation peeling of the twists	Rusticle encrustation entire at depth 2 mm with 20% of twisted edge showing floc formation
7	High Carbon Steel - hammered	Rusticle encrustation entire at depth 2 mm with 80% floc in large growths	Rusticle encrustation entire at depth 2 mm with 20% floc in large growths
8	Aluminum-control	Metal still bright with loose orange floc covering 40% surfaces at one end	Metal still bright with loose orange floc covering 30% surfaces
10	Aluminum – twisted	Metal still bright with loose orange floc over 40% of the surfaces at one end	Metal still bright with loose orange floc over 15% of the surfaces
11	Aluminum-hammered	Metal still bright with dark floc over 40% of the surfaces at one end	Metal still bright with dark orange and white floc over 40% of the surfaces
12	Mahogany – control	Darkened mauve-gray surfaces with about 40% of the surface coated in beige growths about 2 mm deep	Darkened mauve-gray surfaces with about 40% of the surface coated in beige growths about 2 mm deep
13	Copper – control	Surface (but not edges) coated in copper oxides. Beige floc on the edges and 10% across surfaces	Surface (but not edges) coated in copper oxides. Beige floc on the edges and 10% across surfaces
14	Copper – twisted	Coated in blue copper oxides including edges. Beige floc coating 30% of the surfaces	Coated in blue copper oxides including edges. Beige floc coating 30% of the surfaces
15	Copper-hammered	Coated in blue copper oxides with 40% of surfaces covered in loose beige floc	Coated in blue copper oxides with 40% of surfaces covered in loose beige floc

Gravimetric elemental analysis using ICP-AES of the rusticles recovered from *U-166*'s port and starboard sides are given in Table 7.4. Here it was found that the dominant four elements were aluminum (91%), sodium (5.1%), zinc (1.6%), calcium (0.7%), and magnesium (0.6 %). These rusticles had a very low iron content (0.3%) which was replaced by aluminum and a relatively high zinc content compared to the other sites.

Table 7.4

Gravimetric Elemental Analysis of a White Rusticle (C2) from *U-166*

Aluminum	90.724%		Lead	0.058%
Sodium	5.137%		Strontium	0.046%
Zinc	1.553%		Barium	0.041%
Calcium	0.737%		Titanium	0.031%
Magnesium	0.580%		Vanadium	0.012%
Potassium	0.381%		Copper	0.009%
Phosphorus	0.286%		Manganese	0.006%
Iron	0.236%		Molybdenum	0.005%
Chromium	0.083%		Zirconium	0.003%
Boron	0.070%		Cadmium	0.001%

A white rusticle was recovered from *U-166*. These rusticles are rarely observed. When analyzed, the rusticle was predominately aluminum rather than iron. *U-166* differed from the other ships in that the C2 white rusticles dominated with 20% coverage of the outside surfaces of the stern section, and the conning tower in particular. Brown rusticles were observed covering 3% of the viable surfaces. Dendritic concretious (C3) growths tended to be thin (one to five millimeters) and coated 40% of the surfaces. Commonly these C3 growths were overlain with a translucent slime (B1) that was two to five millimeters thick. Like *Robert E Lee*, *U-166* supported a significant sea anemone population (four organisms per m^2). No blobs were observed during the investigation.

7.5.2 Invertebrate Zoology

Collections at *U-166* were made between 1,451 meters and 1,470 meters BSL; water clarity increased with depth, and the visibility at the *U-166* was higher than at any of the shallower sites. The red deep-sea crab (*Chaceon quinquedens*) was conspicuously abundant at the *U-166* site. A number of specimens were observed molting (Figure 7.18) or engaged in premating or mating embraces (Figure 7.24). In most brachyuran crabs (true crabs), mating occurs only between hard-shell males and newly molted females. Males are attracted to females that are in a premolting stage, but in some species, females seek out large males. The larger males carry the females under their abdomen until the female molts, after which mating occurs. After mating, the male remains with the female until her carapace begins to harden before he departs. Our observations of molting and mating activities provide evidence of the seasonality of the event in deep-sea red crabs. The deep-sea red crab (*Chaceon quinquedens*) was found at our four deepest sites. The species supports a commercial fishery on the continental slope of the United States in New England and is distributed from 100 to 2,800 meters depth. The crabs are generally thought to move into shallower depths with increasing age and size, and females are found shallower than males. Females were only at our three deepest sites, while males were found at all four deeper sites. The smallest specimens were found at the shallowest sites, in contrast to published information, with our largest crabs at intermediate depths. We found no evidence of segregation with either sex or size. Our specimens largely were collected in fish traps and pot bias (e.g., small crabs may be less likely to enter a pot with large crabs) may have affected both the size and sex ratio of the collected specimens. In the video transects (Table 7.5) more red deep-sea crabs were observed near *U-166* than distant from it, however collections of specimens in traps was relatively similar both near and away from *U-166*.

Other than anemones, the most abundant organisms observed on the video transects were squat lobsters (*Munidopsis* sp.). *Munidopis* is an extremely speciose genus, with 24 species recorded. Identifying species from video is difficult. The anemones observed on the transects appeared to belong to several species, but the Venus flytrap (*Actinoscyphia* sp.) was the only anemone that could be readily identified.

Table 7.5

Density (number per 100 m$^{-2)}$ of Invertebrates Observed on Transects Over, Adjacent, and Distant (300 m) from the *U-166* Site.

	Transect Number					
	Over			**Distant**		
U-166	**1**	**2**	**3**	**446**	**447**	**448**
Crustaceans						
Chaceon quinquedens	1.8	0.9	0.0	0.0	0.0	0.0
Munidopsis sp.	0.0	6.5	0.0	0.7	0.0	0.0
Shrimp	1.3	0.0	0.1	3.4	4.0	2.2
Echinoderms						
Sea star	0.0	0.0	0.0	0.7	1.7	0.0
Cnidarians						
Anemones	9.2	33.3	0.3	0.0	0.0	0.0

Sediment remained primarily clay and silt in the cores collected for meiofauna. Meiofauna community composition at *U-166* was similar to that found at the *Gulfpenn*, with nematodes being most abundant, followed by harpacticoid copepods and polychaets (Table 7.6). The densities of nematodes are unusually low for marine sediments. Two tanaidaceans were found in core B; these appeared to be juveniles of the same species (*Gigantapseudes adactylus*) found at shallower sites.

Table 7.6

Density of Meiofauna (numbers per 10 cm^2) from Sediment Cores Collected Adjacent to and Away from *U-166.*

U-166		
	Number per 10 cam^2	
Taxon	Core B	Core C
Harpacticoida	16.3	1.8
Tanaidacea	3.6	0.0
Nematoda	335.4	63.5
Polychaeta	9.1	7.3

Figure 7.24. Two red deep-sea crabs (*Chaceon quinquedens)* found at the U-166 site. The male is carrying the female in a premating embrace. The red dots in the image are the parallel laser scale (12.7 cm scale)

Twenty-four specimens belonging to 10 taxa were collected at the *U-166* site, with equal numbers near and away from the site (Table 7.7). The similarity in diversity near and away from the site probably reflects the lack of collecting directly from the wreck. The *Plesionika* sp. observed on the transects differ from most pandalid (Family Pandalidae) shrimp in that they are found in deeper waters and do not change sex (Bauer 2004). Most pandalids are higher latitude, cold-water species that are commercially harvested, and are protandrous hermaphrodites (initially male, but changing to female after two-three years of age). *Plesionika longicauda* (horizontal rostrum; 53-412 meters depth) and *P. edwardsii* (soldier striped shrimp, recurved rostrum; 183-421 meters depth) are congeners within the family Pandalidae that are commonly collected in deeper waters of the Gulf of Mexico. The *Glyphocrangon* sp. (armored shrimp), which we collected, are commonly found in deep waters associated with muddy sediments (Bauer 2004). The genus is very speciose, with at least 46 species described, and 12 of those reported in U.S. waters. The U.S. Museum of Natural History has a large collection of the goniasterid seastar *Nymphaster arenatus* from the northern Gulf of Mexico, and also a few specimens from the Bahamas and off Rio de Janeiro, at depths of 415 meters to 2,160 meters. Interestingly, the most recent specimen in the museum was collected more than a century ago (1887). The seastar *Apollonaster yucatanensis* was named for its type location, the Yucatan Channel, where it was collected from 1,098 to 1,175 meters depth. Our specimen from an unknown location near *U-166* was in slightly shallower depth at 1,451-1,470 meters. The seastar *Diplasiaster productus* has been previously collected at the exact same depth (1,456 meters) as our specimen, near Grand Bahamas Island.

Table 7.7

Macroinvertebrate Species Collected at the *U-166* Site,
Including Number and Proximity to Wreck, Substrate, and Depth.

U-166					
Specimen ID	**Number Near Wreck (< 61 m)**	**Number far from wreck (>61 m)**	**Unknown collection location**	**Substrate**	**Depth (m)**
Crustacea					
Bathynomous giganteus			1		1451-1470
Chaceon quinquedens	8			Silt	1454-1457
Munidopsis sp.		1		Silt	1464
Plesionika sp.	2	1		Silt	1451-1455
Glyphocrangon sp.	3	1		Silt	1452-1465
Echinodermata					
Apollonaster yucatanensis			1		1451-1470
Diplasiaster productus	1			Silt	1456
Nymphaster arenatus		1		Silt	1465
Asteroidea	1			Silt	1453
Porifera					
Hexactinellida		1		Silt	1467

Scleractina, Antipatharia, and Gorgonacea

None observed at this site.

7.5.3 Vertebrate Zoology

Fish Community Structure

Visibility at *U-166* was much greater than at the three shallower sites. The mean transect width was approximately 4.8 meters over the ship and 2.6 meters adjacent to and away from the wreck (Table 7.8). The difference in these two figures was caused by the ROV maintaining a greater distance from the ship than the seafloor during transects.

Ichthyofaunal diversity was low at *U-166* and species composition was similar over and away from the wreck. Observed fishes included cuskeels (Order: Ophidiiformes), Halosaurs (Family: Halosauridae), eels (Order: Anguilliformes), and grenadiers (Family: Macrouridae) (Tables 7.8-7.12). Most individuals could not be identified below order or family from video, the exception being the cutthroat eel (*Synaphobranchus brevidorsalis*). This species also was captured in traps. The two species captured with the suction sampler were a halosaur (*Aldrovandia gracilis*) and Mexican grenadier (*Coryphaenoides mexicanus*).

Table 7.8

Abundance and Density Estimates for Fish Taxa Identified from ROV Video During Biological Sampling Over, Adjacent to, and 300 Meters Away from (Distant) *U-166.*

Transect Line	**Relation to Ship**	**Taxon**	**Min Count**	**Max Count**	**Min Density 100 m^{-2}**	**Max Density 100 m^{-2}**
1	Over	*Synaphobranchus brevidorsalis*	1	1	0.44	0.44
		Halosauridae	1	1	0.44	0.44
		Anguilliformes	1	1	0.44	0.44
		Teleost	1	2	0.44	0.88
2	Over	Anguilliformes	1	2	0.46	0.92
		Ophidiiformes	1	4	0.46	1.85
		Teleost	1	2	0.46	0.92
3	Over	Ophidiiformes	1	5	5.27	26.37
446	Distant	*Synaphobranchus brevidorsalis*	1	2	0.68	1.37
		Halosauridae	1	2	0.68	1.37
		Macrouridae	1	1	0.68	0.68
		Teleost	1	5	0.68	3.42
447	Distant	Teleost	1	2	0.57	1.14
448	Distant	Halosauridae	1	1	0.73	0.73
		Teleost	1	1	0.73	0.73

Table 7.9

Abundance of Fish Taxa Identified from Video Collected at *U-166* on Other than Biological Transects. (Location indicates if video was collected over or away from the ship.)

Location	Taxon	Min Count	Max Count
Over ship	*Hexanchus griseus*	1	1
	Synaphobranchus brevidorsalis	2	7
	Synaphobranchus sp.	8	146
	Halosauridae	1	2
	Macrouridae	1	2
	Anguilliformes	1	3
	Ophidiiformes	1	4
	Teleost	1	7
Away from ship	*Aldrovandia gracilis*	1	3
	Coryphaenoides mexicanus	1	1
	Dicrolene sp.	1	1
	Synaphobranchus brevidorsalis	1	3
	Synaphobranchus sp.	2	14
	Alepocephalidae	1	3
	Halosauridae	1	41
	Ipnopidae	1	12
	Macrouridae	1	3
	Synaphobranchidae	1	3
	Anguilliformes	1	5
	Ophidiiformes	1	3
	Teleost	1	15

Table 7.10

Estimated Total Lengths of Fishes Observed on Video at *U-166.* (All individuals were captured on video with both ROV-mounted lasers scale striking them.)

Taxon	**Number Measured**	**Mean TL mm**	**Standard Deviation**	**Range TL mm**
Aldrovandia gracilis	1	691		
Coryphaenoides mexicanus	1	552		
Hexanchus griseus	1	6,350		
Synaphobranchus brevidorsalis	3	850	154.7	710-1,016
Synaphobranchus sp.	6	817	280.6	535-1,191
Alepocephalidae	2	162	21.7	147-178
Halosauridae	5	423	159.9	247-624
Ipnopidae	1	269	67.3	229-346
Macrouridae	1	826		
Ophidiiformes	1	454		

Table 7.11

Fish Taxa Caught in Chevron (Large) and Baitfish (Small) Fish Traps Deployed Adjacent to (Ship) and 300 Meters Away from (Distant) *U-166*.

Trap Type	**Location**	**Species**	**Number**
Large	Distant	*Synaphobranchus brevidorsalis*	2
Small	Ship	*Synaphobranchus brevidorsalis*	1
Small	Distant	*Synaphobranchus brevidorsalis*	1

Table 7.12

Fishes Caught with the ROV Suction Sampler at *U-166*.

Date	**Species**	**Number**
8/6 - 8/7	*Aldrovandia gracilis*	1
	Coryphaenoides mexicanus	1

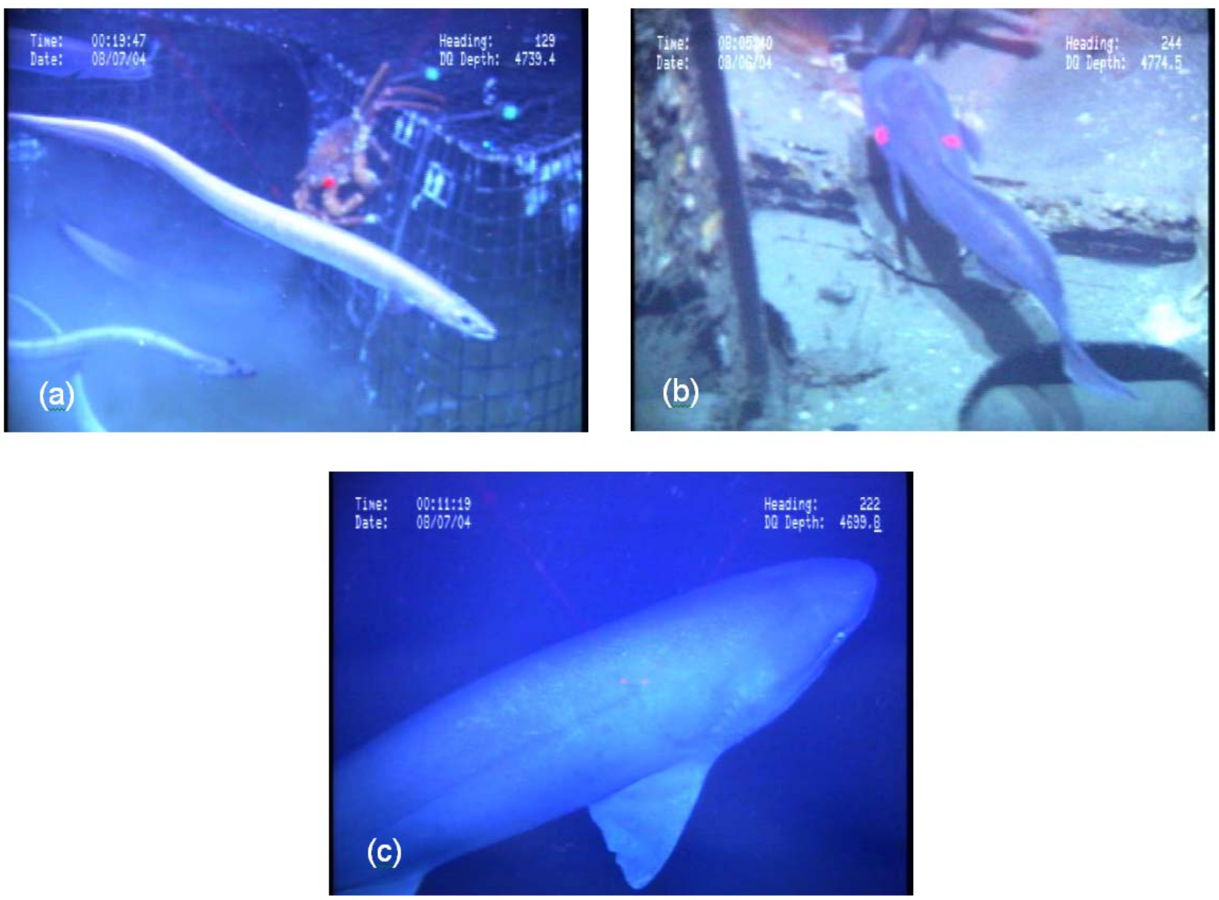


Figure 7.25. (a) Cutthroat eels around a chevron fish trap, (b) a large unknown Ophidiiform fish over the ship, and (c) a six-gill shark near a chevron fish trap at *U166*.

Diet and Trophic Structure

Stomachs were dissected from six fish sampled at *U-166*. Four fish (66%), had food items present (Fig. 7.26). Cutthroat eels had mostly fish, but they also had some unidentifiable prey items in their guts. A halosaur had invertebrate taxa remains present and none of the prey items in the Mexican grenadier's gut contents were identifiable.

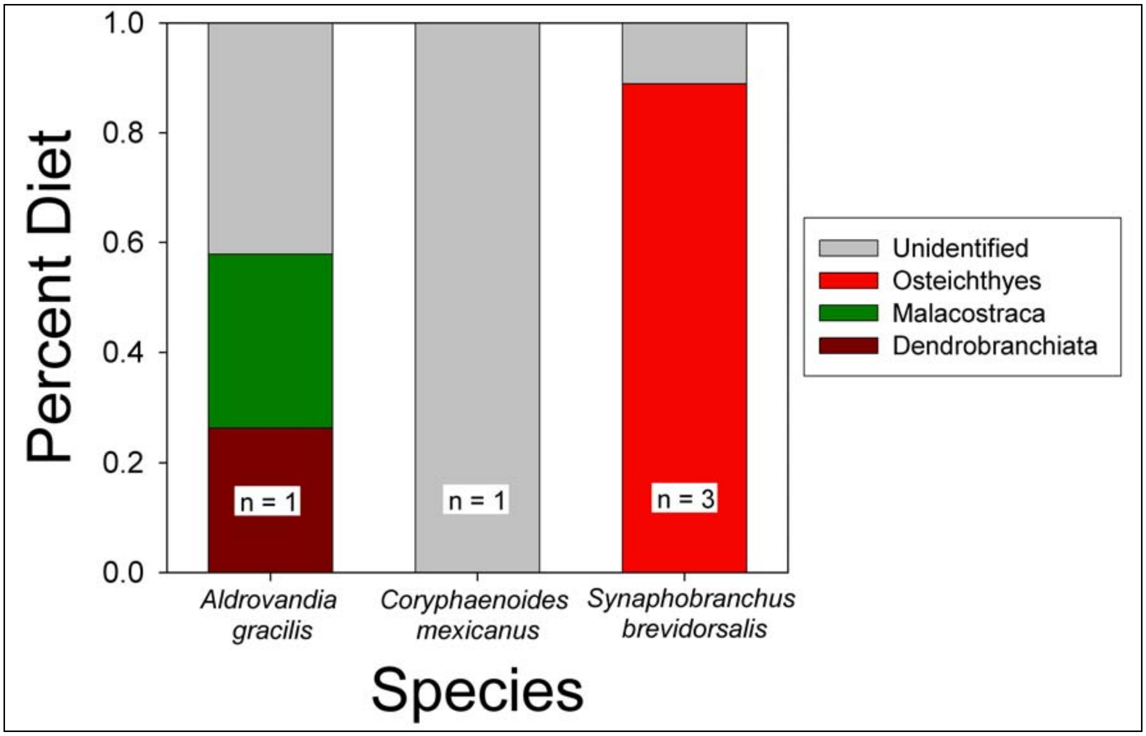


Figure 7.26. Prey taxa contribution to diets of fishes sampled at *U-166*. Sample sizes are indicated for each species.

Few fish and invertebrate samples from *U166* and *Robert E. Lee* were available for stable isotope analysis. No samples were available from *Alcoa Puritan*. Thus, data from all the samples collected at the *U-166* and *Robert E. Lee* sites were plotted together (Figure 7.27 and 7.28). Digitate cuskeels, (*Dicrolene introniger*), and a Mexican grenadier had $\delta^{13}C$ and $\delta^{15}N$ values indicating feeding at middle trophic levels. Their $\delta^{34}S$ values also indicated pelagic rather than benthic foraging. Cutthroat eels, (*Synaphobranchus brevidorsalis*), showed much greater variability in $\delta^{13}C$ than did *D. introniger* individuals. The depleted $\delta^{13}C$ value of a single cutthroat eel collected at a methane seep site near *Robert E. Lee* suggests some component of its biomass may have been derived from chemosynthetic production. Stable isotope values of the two other eels plotted in Figure 7.27 also may indicate some component of their diet was derived from chemosynthetic production. The stable isotope values of the single deepwater shrimp (*Notostomus gibbosus*) also indicate some component of its diet likely was derived from chemosynthetic production (Figure 7.28). Stable isotope values of the red deep-sea crab (*Chaceon quinquedens*) were consistent with a benthic scavenger.

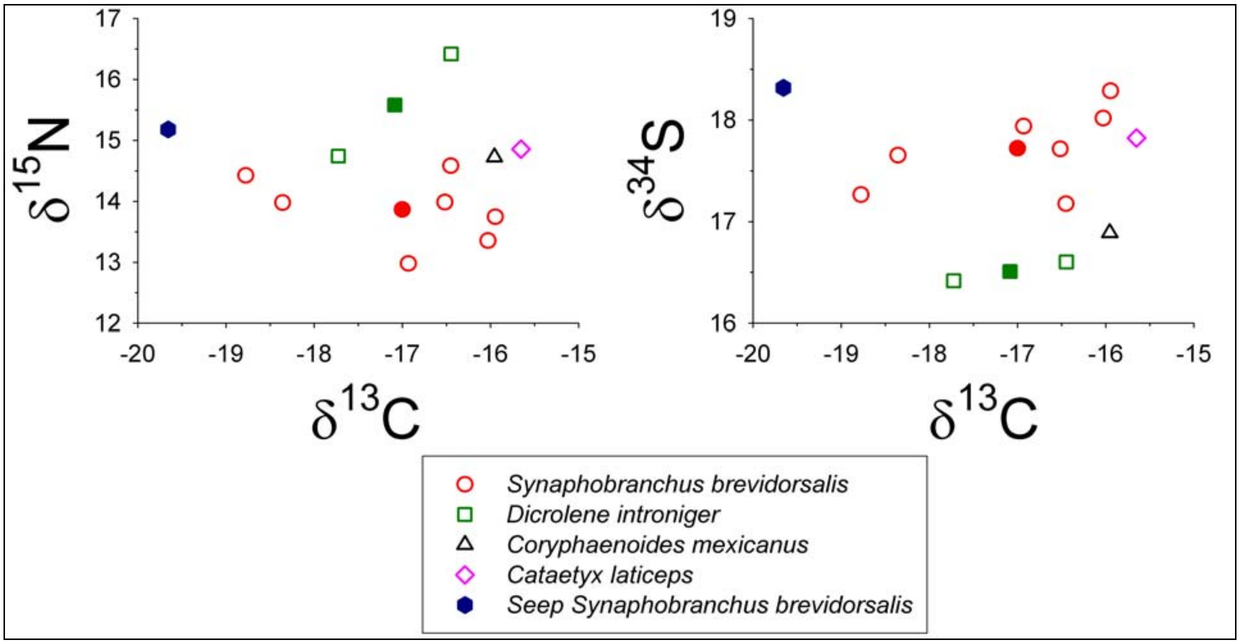


Figure 7.27. Results of stable isotope analysis of fish muscle samples collected during biological sampling at the deep wreck sites of *U-166* and *Robert E. Lee*. Filled symbols are species-specific mean values.

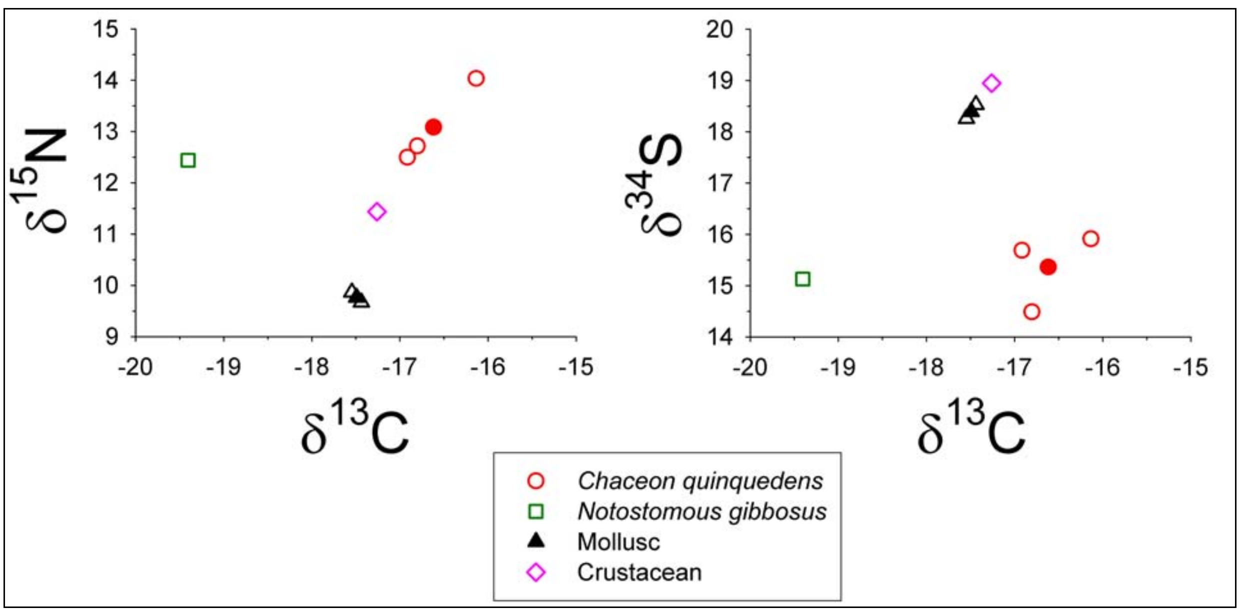


Figure 7.28. Results of stable isotope analysis of invertebrate tissue samples collected during biological sampling at *U-166* and *Robert E. Lee*. Filled symbols are species-specific mean values.

Age Estimation

Otolith samples were available from few fishes and invertebrates collected at *U-166* and *Robert E. Lee* for age estimation and no samples were available from *Alcoa Puritan*. Thus, data from all samples collected at *U-166* and *Robert E. Lee* were plotted together (Figure 7.29). Annual opaque zone formation has been validated for none of the fishes collected at the *U-166* and *Robert E. Lee* sites. Otoliths of the Pacific grenadier (*Corphaenoides acrolepis*) were validated radiometrically by Andrews et al. (1999), but, to our knowledge, annual opaque zone formation has not been validated for congeners of any other species collected at our deep sites. Following the logic presented in Section 6.5.3, however, we assumed annual opaque zone formation for all species sampled.

Similar to the *Gulfpenn* site, several long-lived individuals were sampled at *U-166* and *Robert E. Lee*. Andrews et al. (1999) estimated longevity in the Pacific grenadier to be over 70 years and Burton (1999) estimated the giant grenadier (*Albatrossia pectoralis*) could live approximately 60 years. Thus, the old ages of fishes we report is within the range for other deep-sea species, some of which are closely related to the grenadiers we sampled.

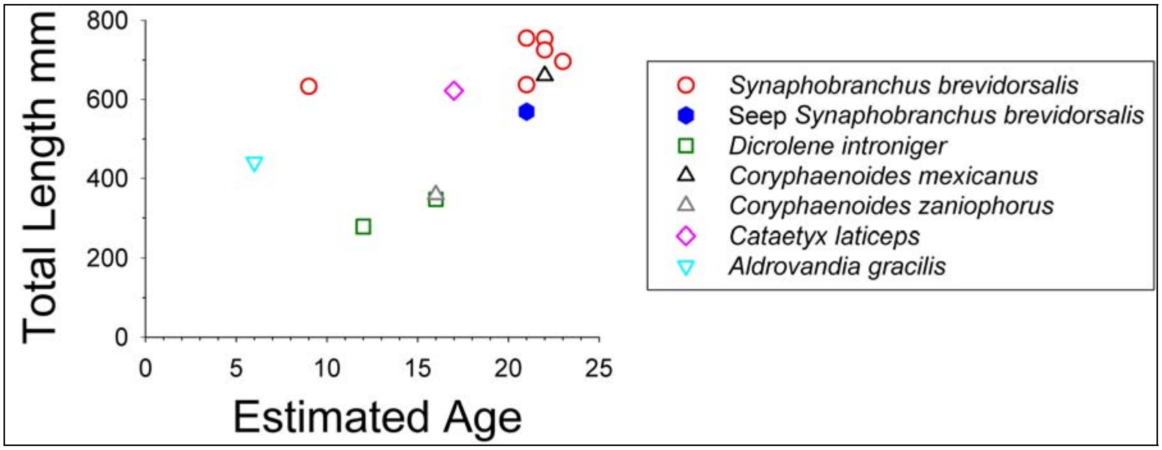


Figure 7.29. Size at age estimates for fishes captured at *U166* and *Robert E. Lee* sites.

7.6 Sediment Core Analysis

Four sediment core samples were taken at the designated distances from the wreck (Table 7.13). Each sample, after be brought to the surface was taken out of the sampling device and stored in a clean glass container at approximately 4° Celsius. *U-166* core samples did not indicate any visible differences. They all appeared to be smooth, gray/black sediment with a sour smell. The sour smell is indicative of the anaerobic biological activity (sulfate reduction) normally found within sediment samples. The core sample's lower portion did have small rocks mixed within the sediment. The rock samples were approximately 2-3 centimeters in diameter. Samples were sent to a certified laboratory for organic chemistry analysis. The *U-166* site samples from each of the four cores all tested below detection levels for hydrocarbon C6-C36, as well as total petroleum hydrocarbons.

Table 7.13

U-166 Core Analysis.

Site	Date	Sample Location	Concentration
U-166	August 6, 2005	Beside Ship	<1 ug/g
		30 meters	<1 ug/g
		152 meters	<1 ug/g
		305 meters	<1 ug/g

8.0 *ROBERT E. LEE* SITE

8.1 Historical Background of the Freighter *Robert E. Lee*

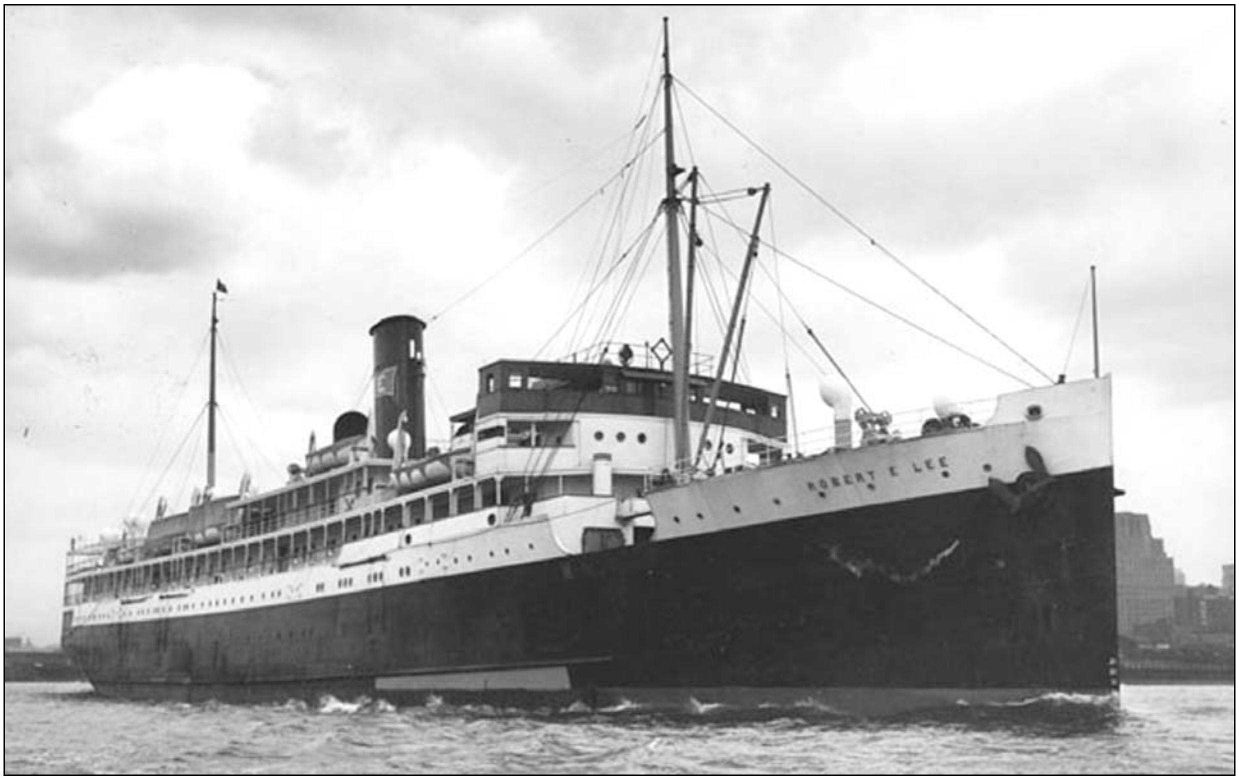


Figure 8.1. *Robert E. Lee* while in service to the Old Dominion Line (photograph courtesy of the Mariner's Museum, Newport News, *Virginia*).

The passenger and freight steamer *Robert E. Lee* (Official Number 224339) was built in 1925 at Newport News, *Virginia* (Figure 8.1). The vessel was commissioned and owned by Eastern Steamship Lines, Inc. of Boston, Massachusetts. *Robert E. Lee*'s sister ship, *George Washington*, was constructed in 1924, and the two vessels were practically identical. Each ship was 373.4 feet (113.8 meters) long, 53.8 feet (16.4 meters) wide, and had a 17-foot (5.2 meters) draft. Both vessels had a single propeller powered by two steam turbines. *George Washington* and *Robert E. Lee* were constructed to serve the Old Dominion Line, which was a smaller subdivision of Eastern Steamship Lines. The vessels primarily ferried passengers and cargo between Norfolk, Virginia and New York City (Figure 8.2). The two ships were popular with people taking weekend cruises or traveling during the tourist season (ACVC 1945; Browning 1996; Land et al. 1942; Talbot-Booth and Sargent 1942).

Robert E. Lee was in the Old Dominion Line's regular service until the early 1940s. In 1941, following America's entrance into World War II, the Alcoa Steamship Company contacted Eastern Steamship Lines and requested use of *Robert E. Lee* for transporting Alcoa personnel and cargo from New York to Bermuda and other eastern Caribbean ports. The Alcoa Steamship Company needed additional transport ships to replace the two vessels, *Acadia* and *Evangeline* that were under military contract. A.B. Sharp, president of Eastern Steamship Lines, agreed that because of the war, *Robert E. Lee* should be chartered to the Alcoa Steamship Company (Figure 8.3). Alcoa Steamship Company officially chartered *Robert E. Lee* on February 11, 1942, and an agreement was made with Eastern Steamship Lines whereby the Alcoa Company could retain the vessel until November 30, 1942 (Robson 1942; Stevenson 1942).

[6] EASTERN STEAMSHIP LINES — New York-Norfolk Service
"Old Dominion Line"

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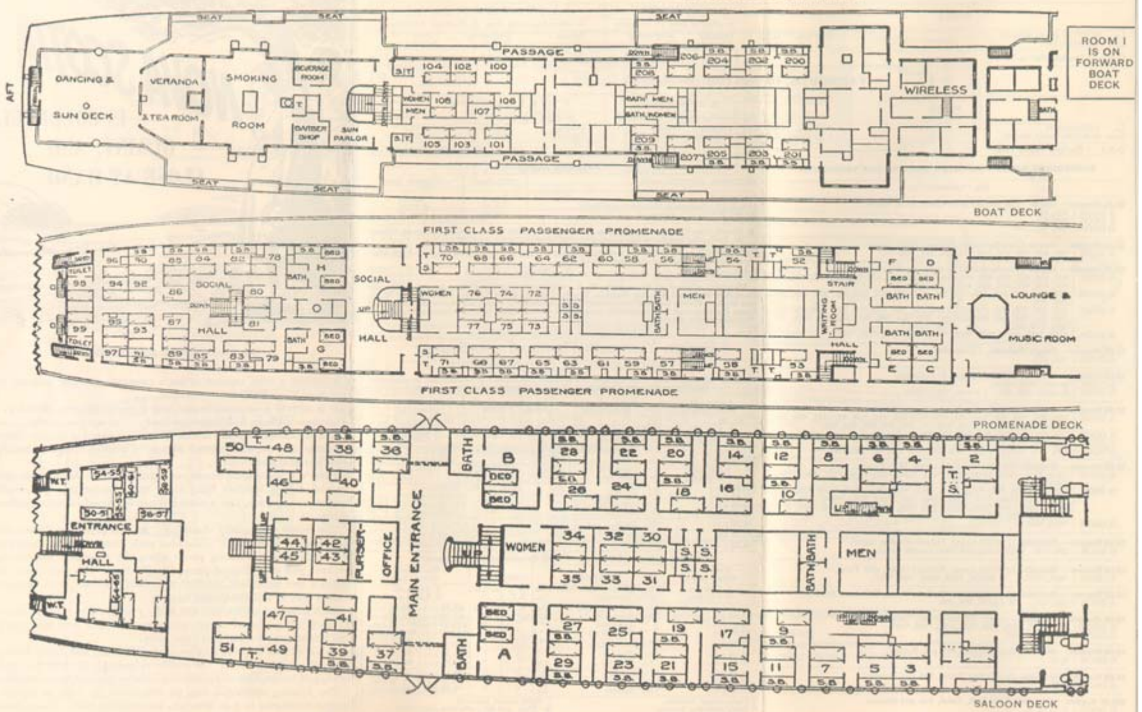
STATEROOM PLAN — S.S. GEORGE WASHINGTON and S.S. ROBERT E. LEE



General dimensions of the steel, oil burning, turbine-driven, new express steamships "GEORGE WASHINGTON" and "ROBERT E. LEE"
Length overall . . . . . . 389 ft., 9 in. Beam, moulded . . 53 ft., 9 in. Gross tonnage 5184

NEW YORK—NORFOLK SERVICE Summer 1941 [7]

THE SHORT SEA LINK BETWEEN NEW YORK AND NORFOLK, OLD POINT COMFORT, RICHMOND; ALSO POINTS IN VIRGINIA, WEST VIRGINIA, NORTH CAROLINA, SOUTH CAROLINA, GEORGIA, FLORIDA, ALABAMA, MISSISSIPPI, KENTUCKY, TENNESSEE, OHIO, INDIANA, ILLINOIS, IOWA, MISSOURI, ARKANSAS, LOUISIANA, TEXAS, ETC.

S.S. GEORGE WASHINGTON and S.S. ROBERT E. LEE

NEW YORK TO NORFOLK (Southbound)

	TIME		"Washington"	"Lee"	"Washington"	"Lee"
Lv. NEW YORK, Pier 25, N. R. (Foot of Franklin Street)	11.00 a.m.	E.S.T.	Tuesday	Wednesday	Friday	Saturday
Due NORFOLK, Pier B (Foot of Boissevain Ave.)	7.00 a.m.	E.S.T.	Wednesday	Thursday	Saturday	Sunday

E.S.T. Eastern Standard Time.

NORFOLK TO NEW YORK (Northbound)

	TIME		"Lee"	"Washington"	"Lee"	"Washington"
Lv. NORFOLK, Pier B (Foot of Boissevain Ave.)	7.30 p.m.	E.S.T.	Monday	Wednesday	Thursday	Saturday
Due NEW YORK, Pier 25, N. R. (Foot of Franklin Street)	3.00 p.m.	E.S.T.	Tuesday	Thursday	Friday	Sunday

Six Round Trip Freight Sailings per Week, Daily except Sunday in each direction.

STATEROOM RATES

S. S. "George Washington", S. S. "Robert E. Lee"

Minimum Rooms — With 1 Upper, 1 Lower. Berth Free with First-Class Ticket.

BOAT DECK	106, 107, 108.	INSIDE
PROMENADE DECK	72, 73, 74, 75, 76, 77, 80, 81, 86, 87, 92, 93, 94, 95.	INSIDE
SALOON DECK	30, 31, 32, 33, 34, 35, 42, 43, 44, 45.	INSIDE
PROMENADE DECK	96, 97, Outside.	

Special Minimum Room — Outside — With 3 Uppers, 3 Lowers (Free with First-Class Tickets - Minimum of 4 passengers).
BOAT DECK | Special Stateroom.

$2.00 Rooms — Outside (Two Berths) 75 cents Upper, $1.25 Lower.

BOAT DECK	100, 101, 102, 103, 206, 207.
PROMENADE DECK	60, 61, 78, 79.
SALOON DECK	16, 17, 24, 25, 40, 41, 46, 47, 50, 51.

$2.50 Rooms — Outside (Two Berths) $1.00 Upper, $1.50 Lower.

BOAT DECK	200, 201, 202, 203, 204, 205, 208, 209.	Contain Sofa Requiring Additional Ticket for Third Party
PROMENADE DECK	56, 57, 58, 59, 62, 63, 64, 65, 66, 67, 68, 69, 82, 83, 84, 85, 88, 89, 90, 91.	
SALOON DECK	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 18, 19, 20, 21, 22, 23, 26, 27, 28, 29, 36, 37, 38, 39.	

$3.50 Rooms — Outside, WITH TOILET (Two Berths) $1.50 Upper, $2.00 Lower.

PROMENADE DECK	52, 53, 54, 55, 98,99.
SALOON DECK	48,49.

$4.50 Rooms — Outside (Two Berths) $2.00 Upper, $2.50 Lower.
WITH TOILET AND SHOWER

BOAT DECK	104, 105.
PROMENADE DECK	70, 71.
SALOON DECK	2.

$5.50 Room — Outside (Two Berths) Upper and Lower.
WITH TOILET AND SHOWER
BOAT DECK | 1 (Minimum of 2 passengers or $10.50 single occupancy.)

$6.00 Rooms — Double Bed, Toilet and Tub.
PROMENADE DECK | C, D, E, F, Outside.

$8.00 Rooms — Twin Beds, Toilet and Tub.

PROMENADE DECK	G, H, Outside.
SALOON DECK	A, B, Outside.

Staterooms 1, 2, 52, 53, 54, 55, 70, 71, G and H each contain a Sofa and require an additional ticket for third party.

Connecting Rooms 16 and 18, 17 and 19, 24 and 26, 25 and 27, 40 and 46, 41 and 47, 58 and 60, 59 and 61, 62 and 64, 63 and 65.

EXCLUSIVE OCCUPANCY OF STATEROOMS

Staterooms when occupied by one person for exclusive use require the payment of Five ($5.00) Dollars additional plus regular room charges applying on such room.

All-Expense Tours are on sale from New York to Virginia Beach, Old Point Comfort, Williamsburg and other historic Virginia points, also to Smoky Mountain National Park, giving over 600 miles of sea-cruising on modern liners of the Old Dominion Line, New York to Norfolk and return and are briefly outlined in special announcement on page 14 of this folder.

PASSAGE FARES

BETWEEN NEW YORK and NORFOLK	ONE WAY	ROUND TRIP		
	1st Class	15 Day Exc.	6 Months	All Year
Including Minimum Stateroom Berth and Meals	$12.00	(See Note) $16.50	$18.00	$24.00

CHILDREN — 5 years of age and under 12 are charged half fare; under 5 years when accompanied by adult passengers are carried free. Between New York and Norfolk, Va., a charge of $2.00 will be made for meals furnished children between ages of 2 and 5 years, special meal ticket being purchased from the Purser.

Tourist Cabin Fare between New York and Norfolk, $5.00. (Including dormitory berth; meals 50 cents each extra.) Through cabin fares from New York to points in Southern, Eastern, Central and Western States quoted upon application.

NOTE: When purchased in connection with round trip transportation of private passenger automobile, round trip tickets sold at $16.50 fare are good to return within 6 months from date of sale.

Rental of Steamer Deck Chairs, 50 cents; Rugs, 25 cents.

For fares from New York to points south and west of Norfolk, via steamer to Norfolk, thence rail beyond, also round trip Circle Tour Fares from NEW YORK to Washington, D. C., Baltimore, Md., Richmond, Va., Natural Bridge, Va., see page 8.

THE SEASHORE—with a Southern Accent!

Bathing at Virginia Beach is marvelously good and there are literally miles of it. Day after day the clean surf breaks apple-green on the white sand. From the Old Dominion steamer one drives to Virginia Beach through aromatic pine woods growing almost down to the edge of the ocean.

Virginia Beach has everything you could expect of a seashore resort and more. Sparkling breakers, blue boating lagoons, tennis courts, golf courses, bridle and hiking trails.

Guests at its various Beach Clubs swim in the morning and lie browning on the clean sands afterward. Maybe crawl beneath a beach umbrella and sleep.

The people with nearby cottages belong to the Beach Clubs, and are a gay, congenial and hospitable group.

MOTOR COACH AND TAXI TRANSFER AT NORFOLK, VA.
Details of arrangements and charges for transfer service at Norfolk, are shown on next page.

S.S. GEORGE WASHINGTON
The "George Washington" and "Robert E. Lee" are Twin Ships

Figure 8.2. Page 6 and 7 of the Eastern Steamship Line Brochure, May 24, 1941. Page 6 shows the deck layout and page 7 shows the schedules and fares for SS *George Washington* and SS *Robert E. Lee*.

Figure 8.3. *Robert E. Lee*, early 1942 (photograph courtesy of the Mariner's Museum).

Soon after the Alcoa Steamship Company contracted *Robert E. Lee*, the War Shipping Administration (WSA) expressed interest in becoming the sole charterer of the vessel and requisitioned it from Eastern Steamship Lines. The WSA agreed that even though they would be the sole charter, the Alcoa Steamship Company would maintain the vessel for WSA. Eastern Steamship Lines agreed to the conditions, and a formal bareboat charter contract was signed on March 11, 1942 (official contract number WSA-1650). The contract stated the Eastern Steamship Lines would deliver *Robert E. Lee* to the War Shipping Administration on June 6, 1942, at New Orleans, Louisiana, and the Administration could utilize the ship for at least one year. To prepare *Robert E. Lee* for delivery, the Alcoa Steamship Company had the vessel dry-docked in New York City where the steamer was degaussed and armed between April 6 and May 2, 1942. One of the most noticeable changes made to the ship during this time was the addition of a stern mounted gun. *Robert E. Lee* was officially delivered to the War Shipping Administration at 8:00 a.m. on the aforementioned date, and preparations were made for departure on July 4 for Port-of-Spain, Trinidad (Browning 1996; Land et al. 1942; Sharp 1942; Sharp 1946).

Robert E. Lee, commanded by William C. Heath, was scheduled to depart New Orleans at midnight on July 4, but the ship was delayed for one hour and ten minutes because of difficulties finding qualified crew for the journey. The war caused a shortage of qualified merchant marine throughout the entire Gulf region. The most significant staff shortage on *Robert E. Lee* was in the steward's department. The steamer left port without a third radio operator, a junior third mate, and a junior third assistant engineer (AMMII 1942; Browning 1996).

After arriving in Port-of-Spain, Trinidad, freight cargo was unloaded from *Robert E. Lee*, and a group of American construction workers disembarked. The ship picked up approximately 270 passengers, most of whom were construction workers, their families, and victims of U-boat attacks in the Caribbean. Six Merchant Marine officers and 131 general crewmembers were aboard *Robert E. Lee* when the vessel left port on July 20 for the return trip to New Orleans. Throughout the voyage, the Merchant Marine officers kept rotating watches to look for enemy activities. *Robert E. Lee* crossed the Caribbean as part of a convoy, but on the morning of July 29 it broke from the group to rendezvous with the United States Navy Patrol Craft *566* near Key West, Florida. *PC-566*, commanded by Herbert C. Claudius, was designed for anti-submarine warfare. Escorting *Robert E. Lee* was the vessel's first mission and Lt. Commander Herbert C. Claudius' first naval command. Under orders from the Commander of the Gulf Sea Frontier, *PC-566* was to escort *Robert E. Lee* to Tampa, Florida, where the steamer would take on provisions (Charlton 2003; Church et al. 2002; Henderson 1942; USS *PC-566* 1942).

Around 9:45 p.m. on July 29, *Robert E. Lee* and *PC-566* arrived at Edgemont Key Light near Tampa Bay. *Robert E. Lee*'s captain attempted to secure a pilot to enter the harbor. He was informed that no pilots were available and the harbor was closed for the night. The steamer then communicated with PC-*566* using Morse code and blinker lights to state its intention to proceed to New Orleans. At 11:25 p.m., *PC-566* radioed the Gulf Sea Frontier Command that *Robert E. Lee* was continuing to New Orleans and requested orders regarding escort duties. *PC-566* received orders to escort *Robert E. Lee* to New Orleans (Church et al. 2002; Henderson 1942; USS *PC-566* 1942).

Robert E. Lee and the patrol craft transited the Gulf of Mexico on July 30 without incident until the vessels were 72 kilometers southeast of the Mississippi River's Southwest Pass. It was a clear day with calm glassy seas. *Robert E. Lee*'s speed was 16 knots, and a lookout was stationed on the bridge, on the forecastle head, in the wireless shack, and on the stern gun stand. At 4:40 pm, *PC-566* initiated a radio call to the Port Director of New Orleans. Suddenly, passengers and crew on *Robert E. Lee* noticed an elongated shape about 200 meters off the starboard side of the ship. The object, appeared to be 6 meters long, approached from *Robert E. Lee*'s stern starboard side running parallel to the steamer. The passengers who noticed the object argued that it was either a shark or a dolphin. The shape in the water reportedly turned sharply towards *Robert E. Lee*, and the passengers realized the object was a torpedo. The torpedo struck *Robert E. Lee*'s starboard side aft of the engine room. The resulting explosion extended up through the "C" and "B" decks and stopped the engines. Lookouts aboard *PC-566*, a half mile ahead and to *Robert E. Lee*'s port side, observed a periscope off the steamer's starboard side. *PC-566* changed course and headed towards the submarine. The steamer settled fast by the stern while *PC-566* moved to attack the U-boat. Six lifeboats and 16 life rafts were launched as the passengers and crew frantically abandoned the ship. The more desperate passengers jumped or fell climbing down ladders draped over the vessel's side. Those already in a boat or raft, swiftly retrieved the passengers in the water. *Robert E. Lee*'s bow rose out of the water until it reached a precariously steep angle, and the vessel plunged to the bottom of the Gulf (Church et al. 2002; Henderson 1942; USS *PC-566* 1942; Winnier 2003 and 2004).

Robert E. Lee sank within ten minutes following the torpedo attack. The disaster resulted in the deaths of ten crewmembers and fifteen passengers. While the freighter was sinking, *PC-566* crossed the submarine's suspected location twice and dropped five depth charges during each run. The depth charges were close enough to *Robert E. Lee*'s lifeboats and rafts that the survivor's felt the shockwaves from the explosions. The only evidence of the submarine's presence aside from the torpedo was an oil slick, which appeared after the depth charges were dropped. The submarine, finally identified as *U-166*, was indeed destroyed by *PC-566's* depth charges. After attacking the submarine, *PC-566* began rescuing *Robert E. Lee*'s survivors. Naval vessel *SC-519* and the tug *Underwriter* arrived to help with the rescue. Survivors were brought ashore at Venice, Louisiana, and then transferred by bus to New Orleans, where the injured were hospitalized and others were lodged at the Jung and Palace Hotels (Charlton 2003; Henderson 1942; USS *PC-566* 1942; Winnier 2003 and 2004).

8.2 Previous Investigations

In 1986, Shell Offshore, Inc., hired John E. Chance and Associates to conduct a geophysical survey in the Mississippi Canyon Area in the Gulf of Mexico using a EDO 4075 deep-tow system operating at 120 kHz. During the survey they found two shipwrecks in approximately 1,500 meters of water. The only shipwrecks the MMS listed in the vicinity were two World War II casualties, *Robert E. Lee* (Figure 8.4) and *Alcoa Puritan* (Prior et al. 1988). No further investigation of the shipwrecks was undertaken because of the expense and time involved in conducting deeptow surveys. *Robert E. Lee* was correctly identified, but the vessel believed to be *Alcoa Puritan* in 1986 was actually *U-166*. The U-boat's true identity was not discovered until additional survey work in 2001 with new survey technology and stricter MMS archaeological guidelines (Church et al. 2003).

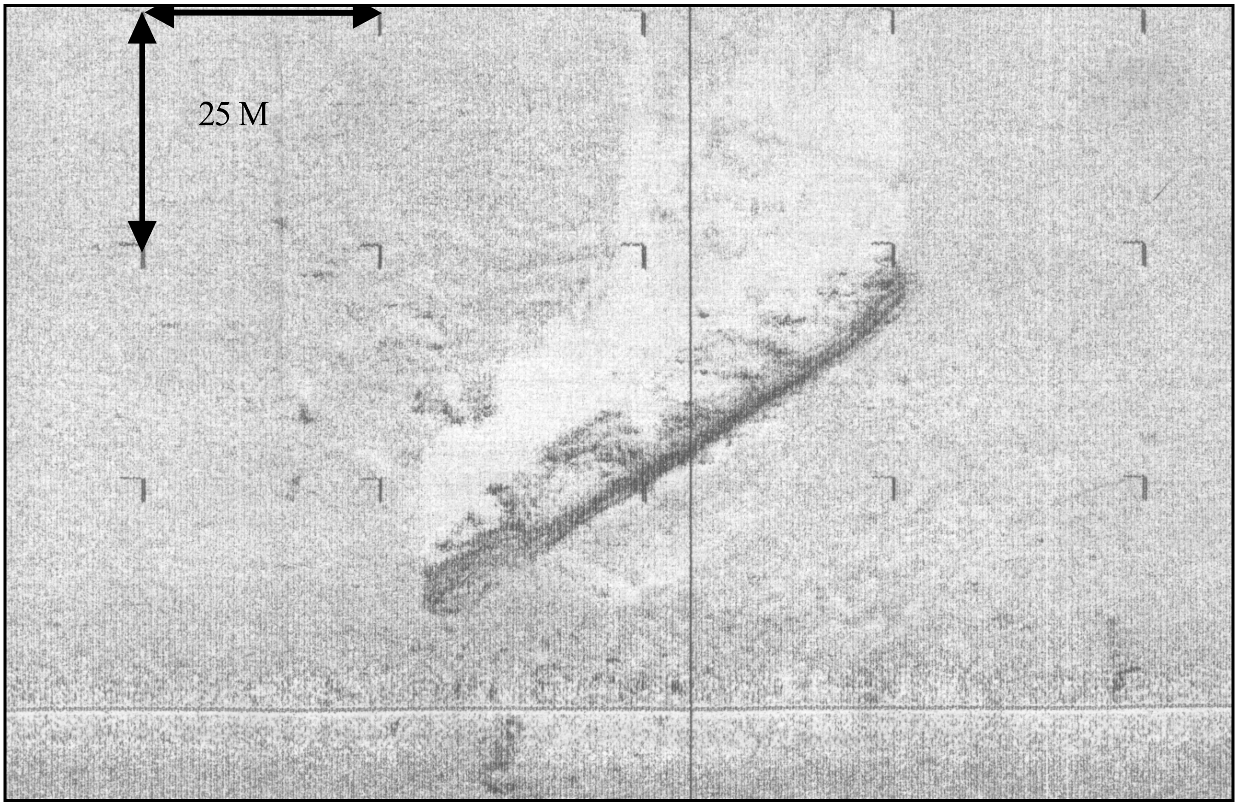


Figure 8.4. *Robert E. Lee,* Deep-tow side scan sonar image, 1986 (Courtesy of Shell Exploration and Production).

In January 2001, C & C Technologies conducted a deepwater pipeline survey in the Mississippi Canyon Area for BP Exploration and Production Inc., and Shell International Exploration and Production Inc., using C & C's *C-Surveyor I* AUV. The survey passed near *Robert E. Lee*'s location and the shipwreck was imaged on a wing line of the pipeline survey corridor. C & C's Marine Archaeologists requested additional survey of *Robert E. Lee* and of the reported *Alcoa Puritan*. In March, the oil companies directed C & C to conduct an area survey encompassing *Robert E. Lee* and *Alcoa Puritan*'s reported locations (Figure 8.5). C & C archaeologists informed the oil companies that the suspected *Alcoa Puritan* wreck was possibly *U-166* based on the survey data and historical evidence. The oil companies then notified the MMS of the potential discovery. In May 2001, BP and Shell contracted C & C to conduct a site-specific survey of *Robert E. Lee* and the alleged U-boat site. The site specific surveys were conducted at a tighter line spacing of 20 meters and utilized the AUV's high-resolution 410 kHz side scan sonar (Figure 8.6) (Church et al. 2002).

On May 31, 2001, C & C marine archaeologists Robert Church and Daniel Warren, with MMS archaeologists Jack Irion and Richard Anuskiewicz joined BP and Shell representatives to lead an ROV investigation of *Robert E. Lee* and the suspected *U-166* site. The research team used M/V *Gary Chouest*, which was equipped with Oceaneering's Millennium VI ROV (Church et al. 2003). The investigation helped confirm both site's identities and allowed a preliminary assessments of each wreck's condition. Although *Robert E. Lee* is mostly intact, parts of the vessel's superstructure are heavily damaged and the bridge is missing. Part of the bridge was found approximately 80 meters off the vessel's port side with the ship's telegraph standing upright on the seafloor as if it was still on *Robert E. Lee*'s bridge (Figure 8.7).

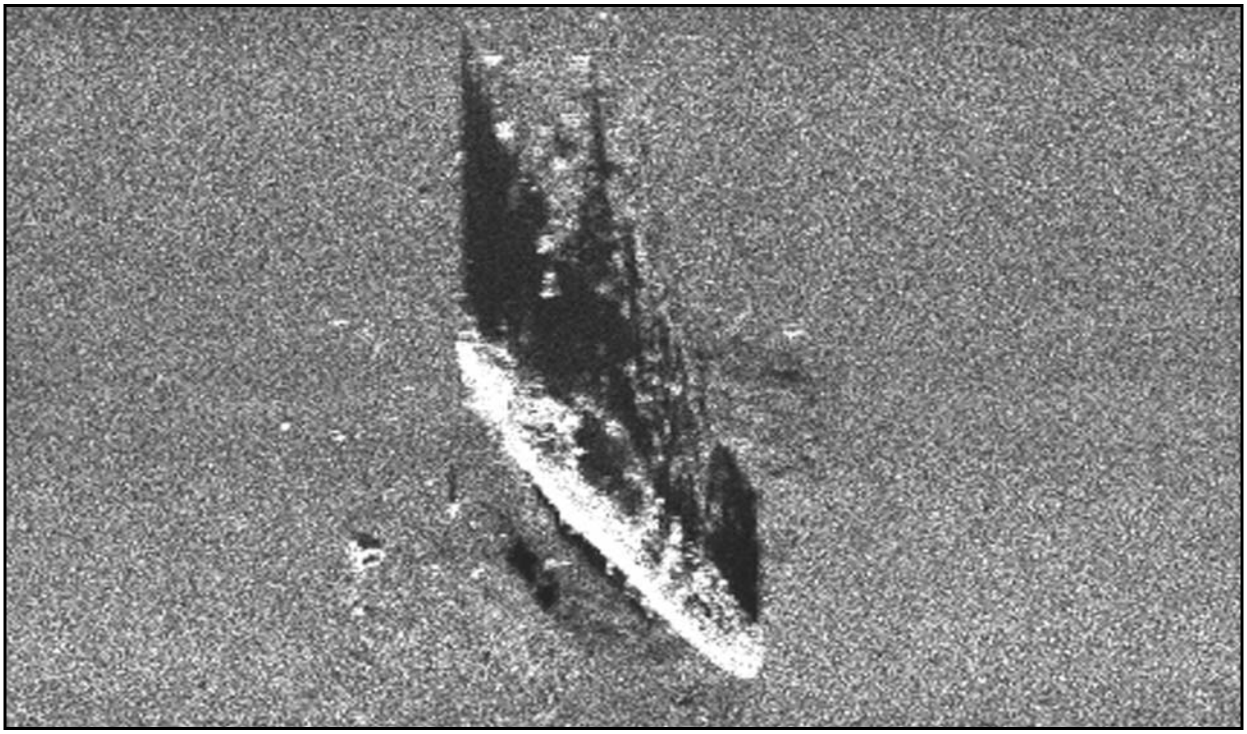


Figure 8.5. 120 kHz side scan sonar image of *Robert E Lee*, from the 2001 "grid survey" with *C- Surveyor I* AUV (Courtesy of BP, Shell, and the National D-Day Museum, New Orleans, Louisiana).

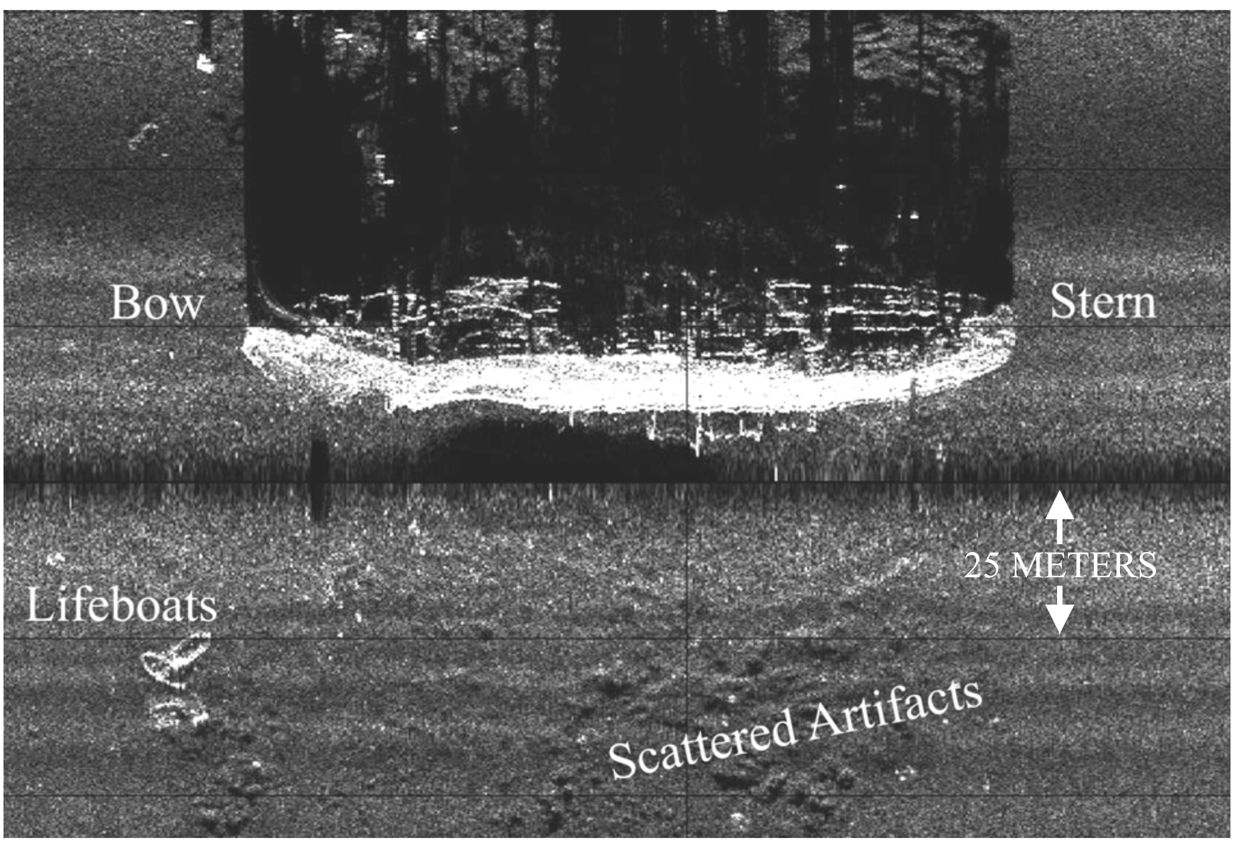


Figure 8.6. 410 kHz side scan sonar image of *Robert E Lee*, from the 2001 "site specific survey" with *C-Surveyor I* AUV (Courtesy of BP, Shell, and the National D-Day Museum, New Orleans, Louisiana).

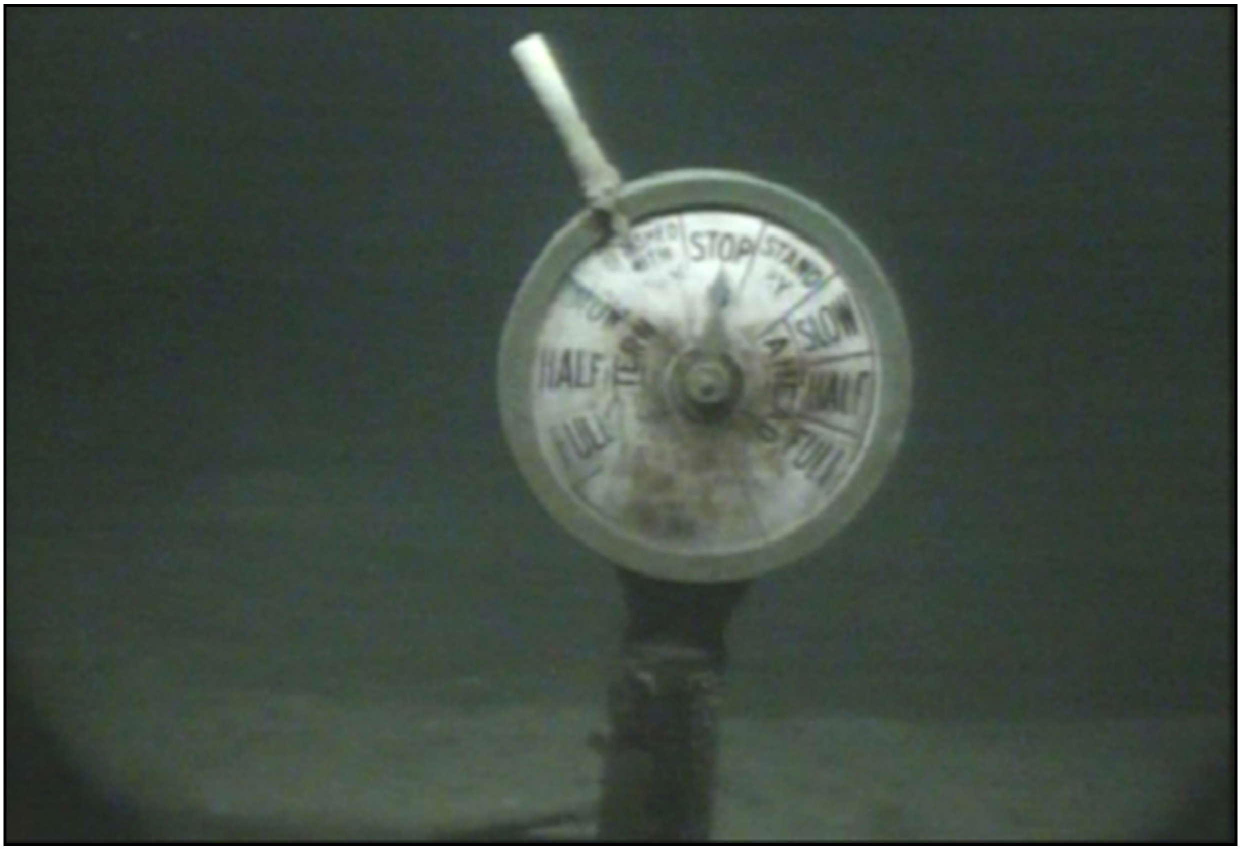


Figure 8.7. The telegraph from the bridge of the *Robert E. Lee* as found in 2001 (Courtesy of BP, Shell, and the National D-Day Museum, New Orleans, Louisiana).

2003 ROV and AUV Investigation

In October 2003, C & C Technologies conducted an archaeological and microbiological project focused on *U-166*. The project was conducted under a NOAA Office of Ocean Exploration grant and in partnership with Droycon Bioconcepts and the PAST Foundation. The work was conducted from the NOAA R/V *Ronald H. Brown* utilizing a Sonsub Innovator ROV (See description in Section 7.2, *U-166* Site, Previous Investigation). During the 2003 project, limited archaeological inspection and microbiological collection was conducted at the *Robert E. Lee* site. Targets near the wreck as well as those away from *Robert E. Lee* were investigated, but the debris field to the north was not examined. A large sonar target recorded during the 2001 AUV survey approximately 250 meters from the wreck was investigated and found to be a wall section from the freighter's superstructure. This debris is near the southern edge of the *Robert E. Lee*'s debris field. In addition, two unidentified targets documented by the AUV survey approximately 700 meters away from the *Robert E. Lee* wreck site were investigated and identified as two lifeboats (Figure 8.8). Their extreme distance from the wreck site suggests these boats were possibly abandoned after the survivors in them were rescued.

Figure 8.8. Lifeboat from *Robert E. Lee*, documented during the 2003 ROV Investigation (Courtesy of C & C Technologies Inc.).

8.3 Geographical Setting

The site area is located in the eastern portion of the Mississippi Canyon Area of the northern Gulf of Mexico. The site is southeast of the Mississippi River's mouth, on the northern edge of the Upper Mississippi Fan, and south of an area dominated by diapiric salt uplifts. The seafloor in this region gently slopes at approximately 4° toward the south (Figure 8.9). There is a low sedimentation rate in this area of approximately 1.52 millimeters per year.

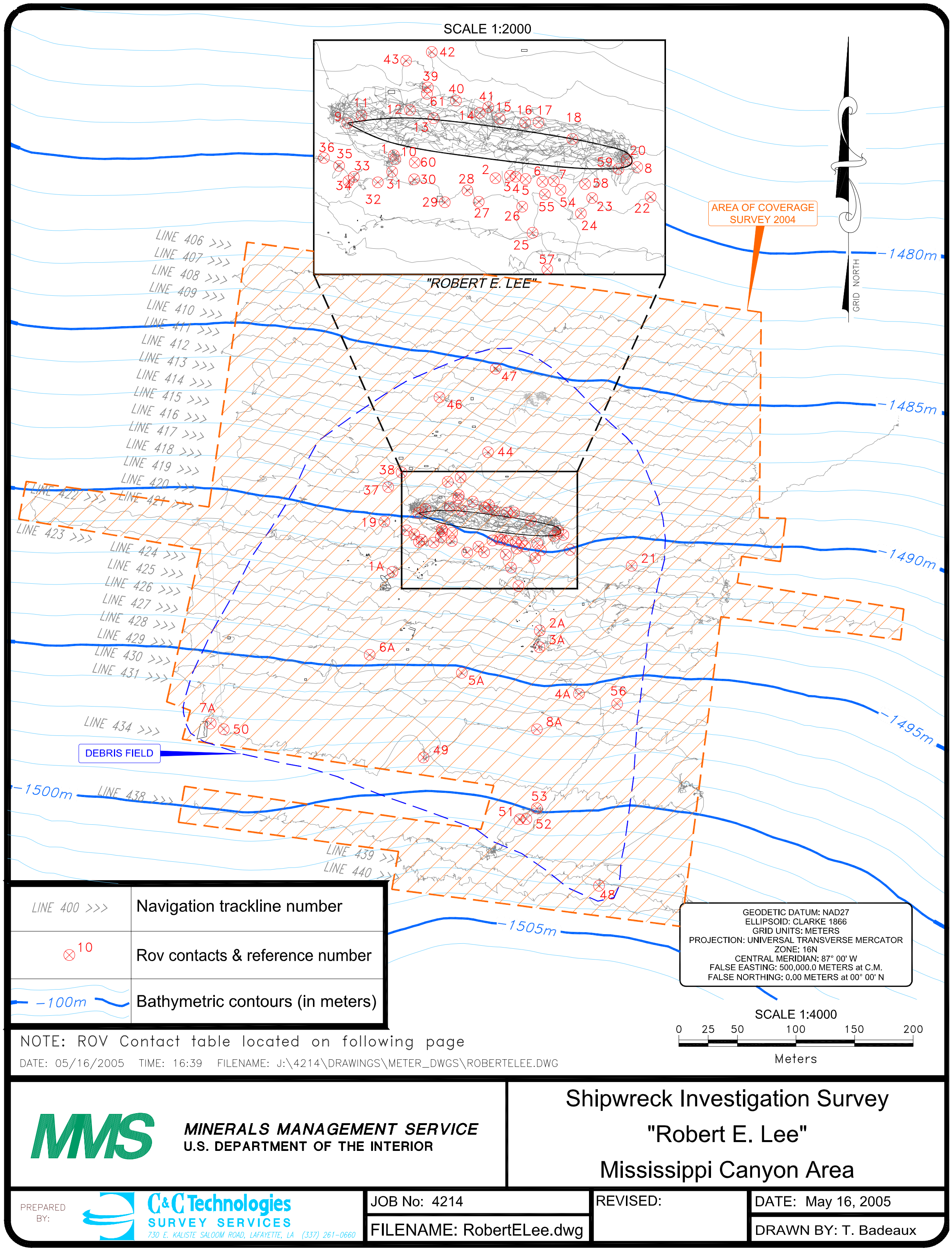


Figure 8.9. *Robert E. Lee* site overview map.

Table 8.1

ROV Navigation Fix Points at *Robert E. Lee*

No.	Description	Time		No.	Description	Time
1	Loading docks	3:34		32	Bathroom shack with toilet	8:31
2	Davit cable	3:42		33	Possible Signal Light	8:43
3	Davit cable	3:45		34	Sink	8:44
4	Davit cable	3:46		35	UWD - metal pipe	8:46
5	Davit cable	3:49		36	Ventilation cowl	8:51
6	Davit cable	3:51		37	UWD - metal	9:29
7	Grating, winch, wires, gallery doors, and davit	3:52		38	Possible portion of deckhouse pipes, decking, and machinery	9:31
8	Stern	4:33		39	UWD - metal beams	9:37
9	BOW	5:15		40	Window and door	9:47
10	Experiment	5:32		41	China plates	9:53
11	Experiment 2	5:46		42	UWD - metal	11:06
12	Obstruction	5:57		43	Bathroom stalls	11:11
13	Obstruction	5:59		44	Shoes and piece of textile	12:11
14	Obstruction	6:01		45	Cable and grating	13:49
15	Obstruction	6:03		46	Restart location	14:23
16	Obstruction	6:03		47	UWD - round	19:51
17	Obstruction	6:05		48	Copper/brass rod	1:26
18	Obstruction	6:09		49	Rope	2:52
19	Ventilation cowl	7:08		50	Pipes, light, ornate metal	3:13
20	Stern fix 2	7:23		51	Large fish trap	12:05
21	Textile	7:54		52	Small fish trap	12:13
22	UWD - pipe or rail	8:01		53	Core D	12:30
23	Possible refrigerator	8:04		54	Small trap	13:23
24	UWD - pipe or rail	8:06		55	Big trap	13:36
25	UWD - hull piece?	8:11		56	Core B	16:34
26	UWD	8:13		57	Core C	16:44
27	UWD	8:17		58	Core A	16:54
28	UWD - metal pipes	8:19		59	Stern 3	16:57
29	UWD - metal pipes	8:22		60	Core E	17:14
30	UWD	8:24		61	Telegraph	19:21
31	UWD	8:29				

UWD = Unidentified Wreck Debris

8.4 Discussion of Findings – Archaeology

8.4.1 Physical Site

The following analysis is based on the 2004 expeditions findings at the *Robert E. Lee* wreck site. The survey was conducted with Sonsub's Triton X11 ROV on August 7, 8, 9, and 12, 2004. Currents at the wreck site were negligible, and the visibility was clear. Sediments disturbed by the ROV, however, remained suspended in the water column for an extended time drastically decreasing visibility.

Robert E. Lee's wreckage lies 1,481 meters BSL and is oriented with the bow pointing west and the stern east. Upon initial inspection, the vessel appears to lie evenly on the sea floor, but at the bow the ship rises 10.9 meters above the ambient seafloor while at the stern it stands only 7.6 meters above the sediment. Considering the stern is buried deeper than the bow, it is likely that *Robert E. Lee* impacted the seafloor stern first.

The ROV survey of the hull indicated it is largely intact, but there is severe damage to the upper superstructure. A light layer of sediment covers the wreck, and is likely from the initial impact plume paired with 62 years of sediment deposition. Torpedo damaged areas were buried below the sediment and could not be assessed.

The ship's bower anchors are in their original stowed position (Figure 8.10), and the windlass and chains are clearly visible on the forecastle. The foremast has buckled near its base and fallen forward. The cargo booms to each side of the mast have also collapsed. *Robert E. Lee*'s funnel has fallen to the port side, crushing and covering that section of the boat deck. The most extensive damage is between the funnel and the forward portion boat deck. The entire bridge and boat deck superstructures, as well as, the underlying promenade deck's ceiling in this region are missing (Figure 8.11). The superstructures may have been destroyed by the shockwaves of *PC-566*'s depth charges.

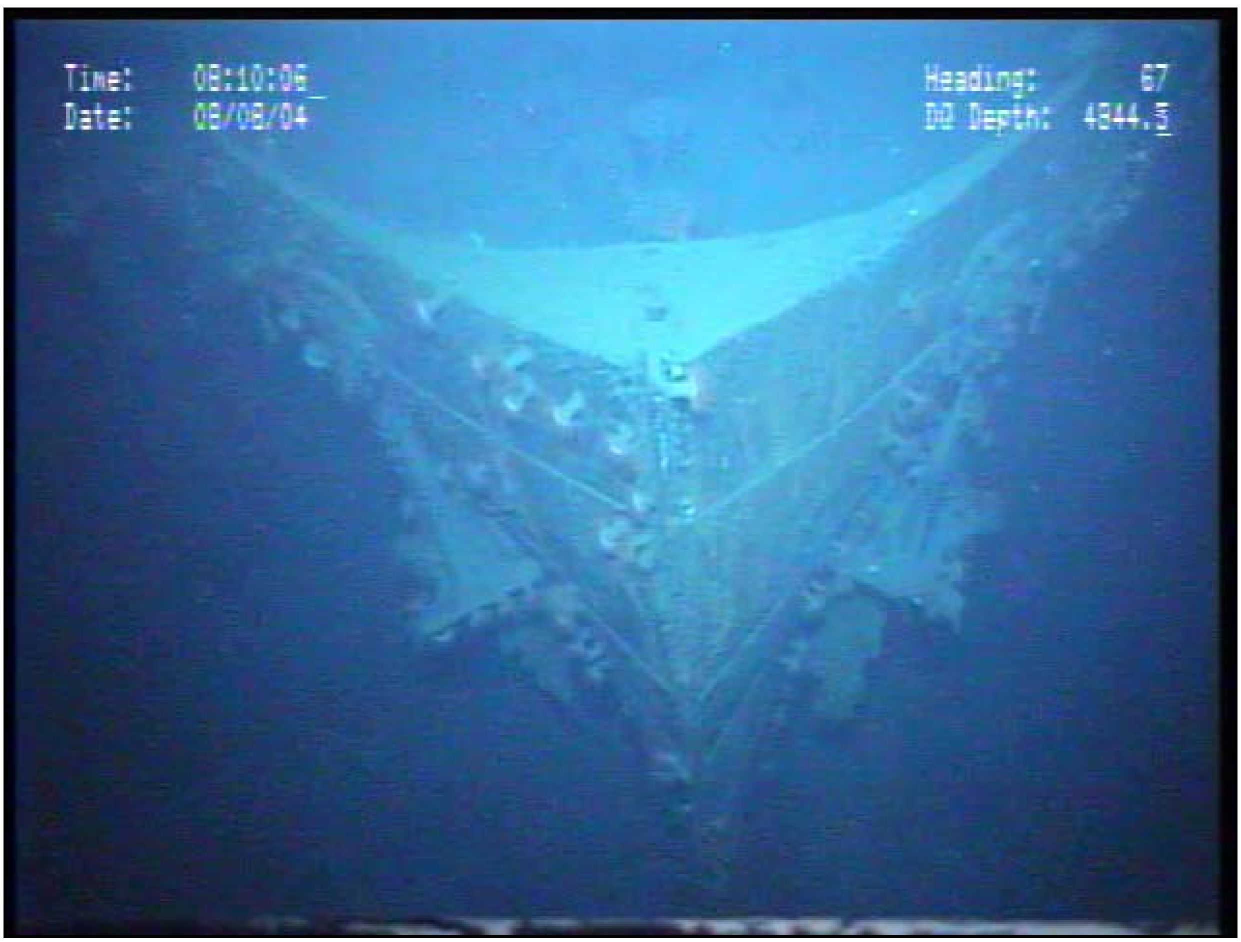


Figure 8.10. *Robert E. Lee*'s bow and both bower anchors.

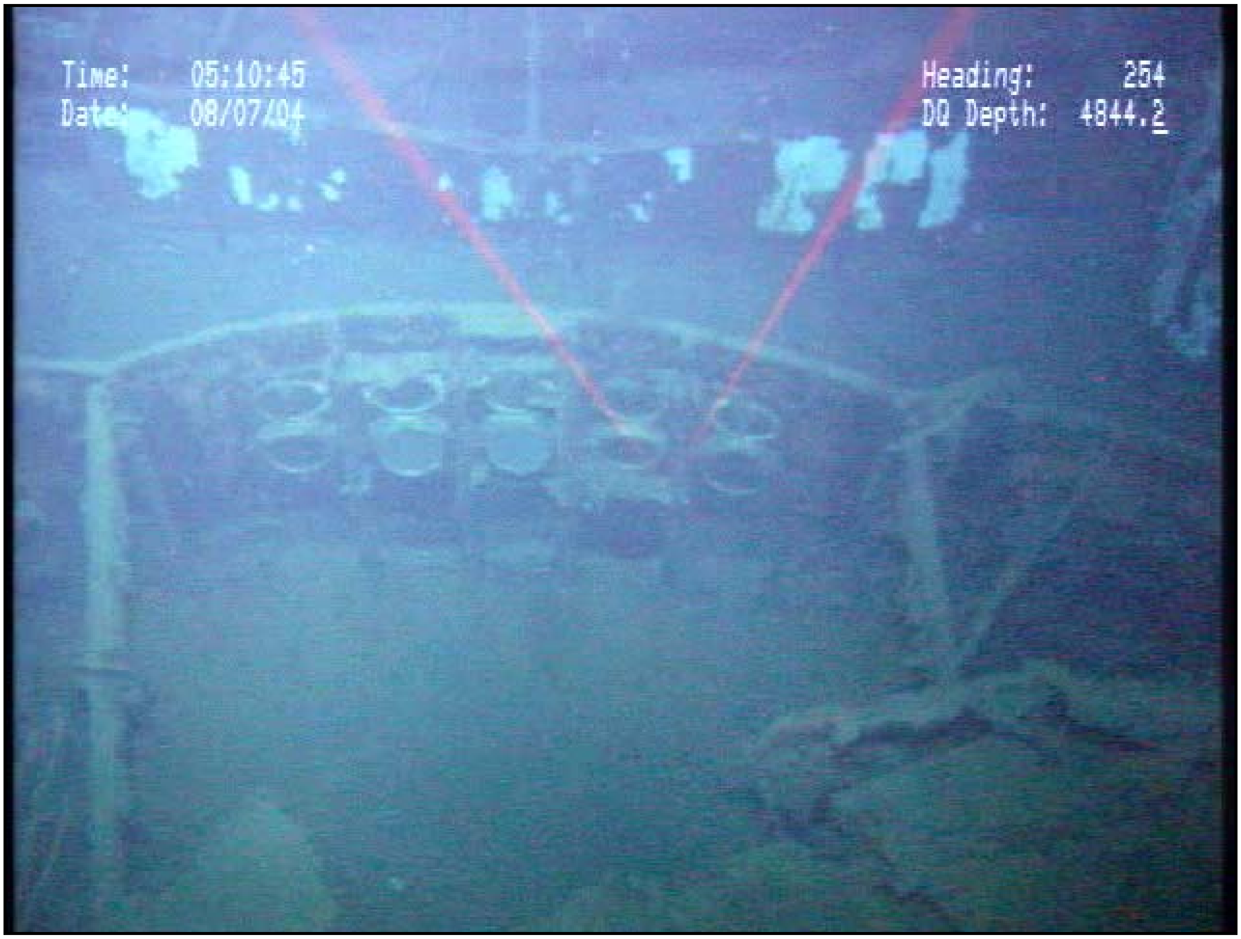


Figure 8.11. Looking down on the remaining forward structure of the promenade deck. The ship's bridge and underlying boat deck structures would have been in this location.

The boat deck's superstructure is intact between the vessel’s funnel and stern, although much of its top is gone or is in the process of collapsing. Many electrical wires and pipes, which would have run along the ceiling, now lie along the deck. The ceiling over the aft passenger staircase is gone, allowing a view into the wreck’s upper three decks. The aft mast has fallen forward and to the starboard side. The bottom portion of the mast's ladder has broken away and fallen into the stair well. On each side of the boat deck near the aft staircase, sections of an outer wooden wall still remain. The wall section is located between two large vents, which may have protected this area.

There is no significant damage at the *Robert E. Lee*’s stern. The most prominent structure in this area is a 4-inch gun mounted on the top deck of the fantail (Figure 8.12). The gun points aft and is covered with biological growth. The stern light fixture and flagpole bracket are also intact.

The geophysical survey indicated a large debris field surrounds the wreck site. Following the initial reconnaissance, two ROV survey lines were run east-west crossing the hull. Fourteen east-west lines were then run to the north of the main hull and three lines were run south of the main hull. The survey extended approximately 182 meters north and 46 meters south of the main hull. All the survey lines were at least 430 meters long. Three additional survey lines were run at the debris field’s extreme southern edge, approximately 300 meters away from the hull. One line was 364 meters long while the other two were 182 meters long.

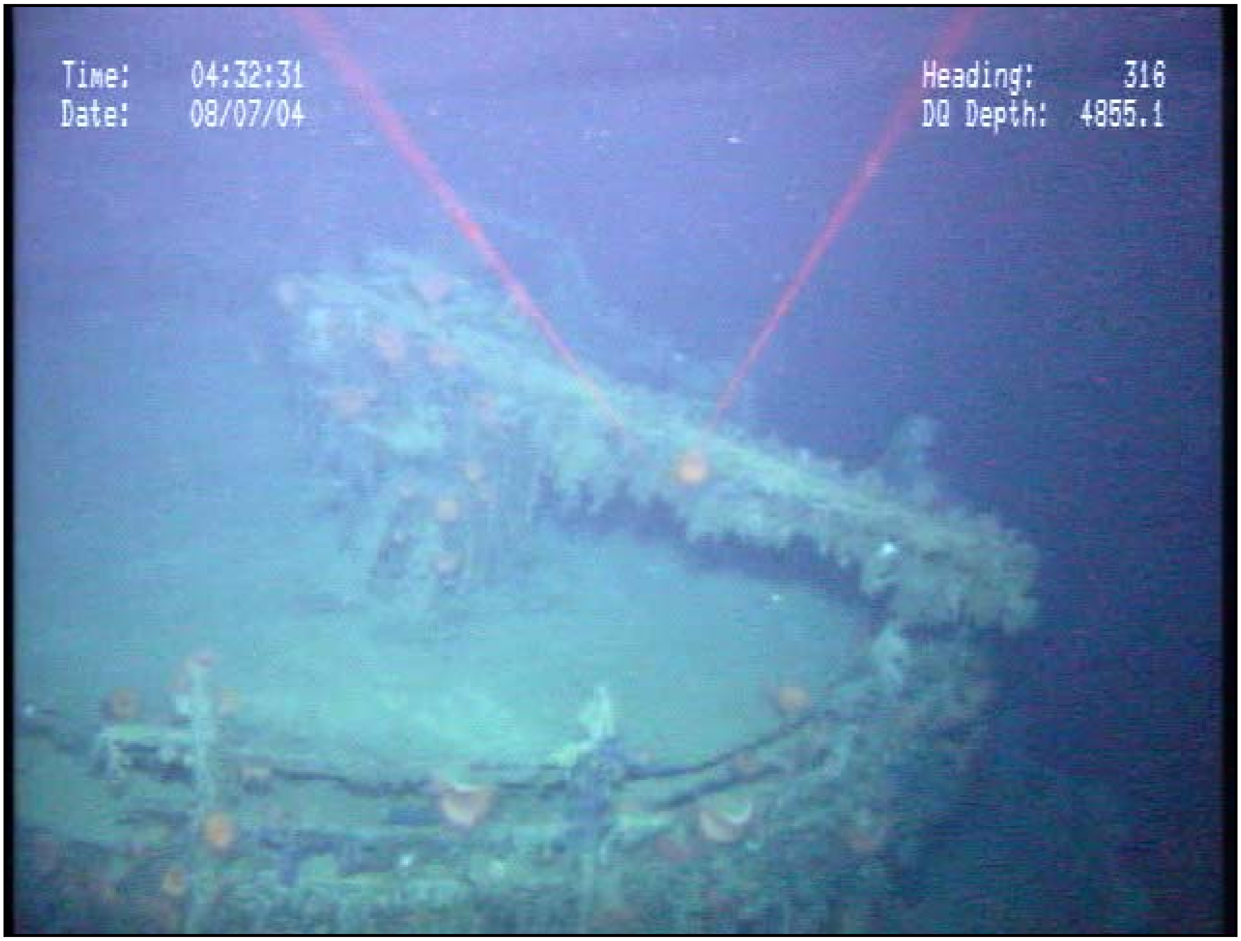


Figure 8.12. The gun mounted on *Robert E. Lee*'s stern.

The survey of the debris field focused on the northern area because of the lack of data from previous investigations. The artifact scatter extends 150 meters north of the hull's center. Artifacts within the northern debris field include various items from the ship as well as personal items from the crew and passengers. Two pairs of shoes along with other textile remains are located 52.7 meters north of the hull (Figure 8.13; Navigation Fix No. 44). The shoes appear to have been packed in a suitcase or bag that has all but disintegrated. Stacks of dishes are 8.2 meters north of the hull amidships (Figure 8.14; Navigation Fix No. 41). Bathroom stalls from the vessel's interior were discovered 24.4 meters off the starboard bow (Figure 8.15; Navigation Fix No. 43).

Figure 8.13. Shoes and Other Textiles in the Northern Debris Field.

Figure 8.14. Dishes off the Starboard Side of the Vessel.

Figure 8.15. Bathroom Stalls found in the Northern Debris Field.

Lying 11 meters off the vessel's starboard side is a tangled heap of metal, wire, and miscellaneous debris. A signal bell, rudder controls, and an engine order telegraph indicate this is part of the ship's bridge that fell to the starboard side of the wreck (Figures 8.16 and 8.17). The remainder of the bridge section was found on an earlier expedition 88 meters to port side of the ship.


Figure 8.16. Section of Bridge debris located to the starboard side of the vessel.

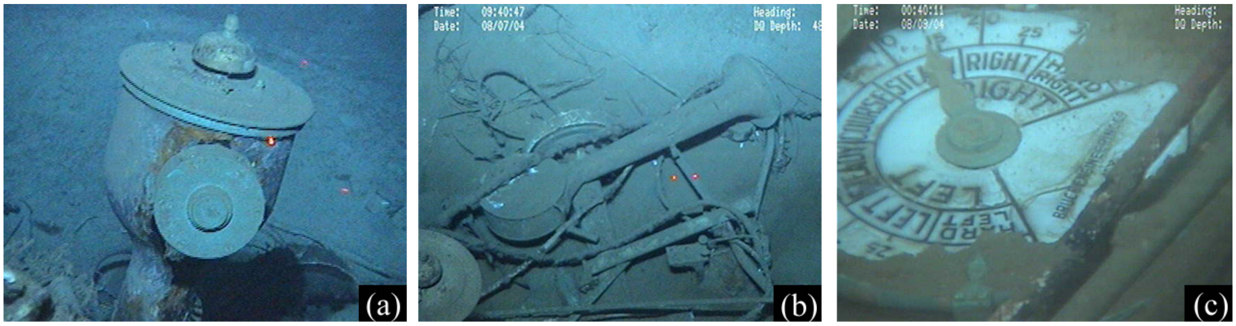


Figure 8.17. (a) Bridge signal bell, (b) Engine Order Telegraph lying across the Base of the Rudder Controls, and (c) Close-up of the Rudder Controls' Face.

Only the edges of the southern debris fields and areas near the hull were surveyed during the initial site investigation. Tropical Storm Bonny, however, forced the team back to the west later in the expedition, presenting an opportunity to return to the *Robert E. Lee* site to conduct additional work. During this time a more systematic examination of the area south of the main hull was undertaken. Eleven additional lines were surveyed to cover the area. Two of these lines, the first of which was run 12.1 meters away from the vessel, were extended to approximately 760 meters, while the remaining lines were shortened to 364 meters. The southern debris field stretches approximately 338 meters south-southeast from the ship's center.

The overall dimensions of the debris field are 478 meters north-south by 389 meters east-west. The debris field is wider at the southern end than at the northern. The greatest debris concentration is between 12 to 18 meters off either side of the main hull. The artifact scatter consists of a variety of smaller materials including metal beams, portholes, lifeboat davits, railings, and vent hoods (Figure 8.18). The proximity of these objects to the ship's hull suggests they were dislodged when the hull impacted the seafloor.

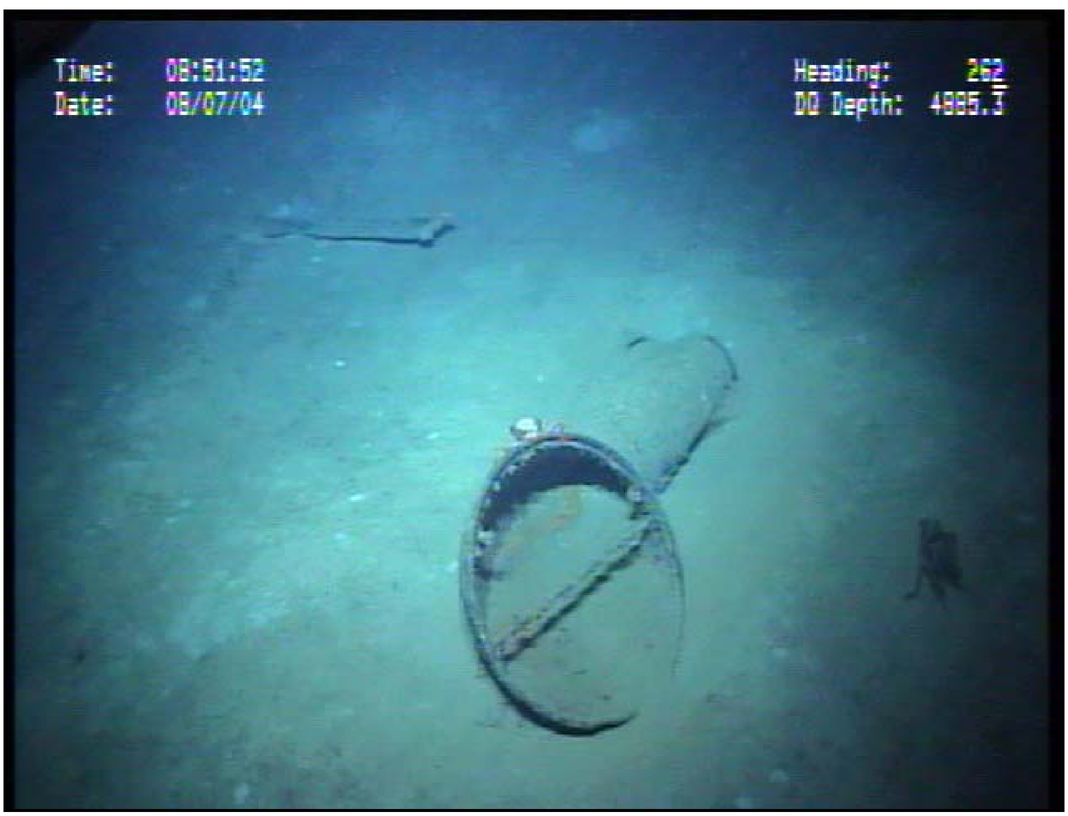


Figure 8.18. One of many vent hoods found within the debris field.

One of the most spectacular finds in the southern debris field was two ship's engine order telegraphs. They are attached to a dislodged piece of bridge decking about 85 meters south of the ship's stern. One of the telegraphs, documented on earlier expeditions, is standing upright, but the other is laying face down. The upright telegraph's face is visible and the controls are set to "Finished with Engines" (Figures 8.7 and 8.19). The telegraph lying down is 14 meters north of the upright telegraph, but was not documented on previous visits to the site (Figures 8.20).

Figure 8.19. Engine Order Telegraph stands upright south of *Robert E. Lee*.

Figure 8.20. The second of two telegraphs found on a deck section in the southern debris field.

Large objects including wall sections, refrigerators, the bathroom stalls previously discussed, and the deck section with the telegraphs is found farther away from the ship within the debris fields. The distance these objects are from the main hull indicates the vessel's superstructure began breaking apart soon after the ship sank. Two lifeboats were found 56 meters off the ship's port bow. The lines were still attached to these two lifeboats, which were lying with a section of railing. They may have never been launched, but rather ripped away from the ship as it sank, supporting accounts that crewmembers were unable to launch all the boats after Robert *E. Lee* was torpedoed (Figure 8.21).

Figure 8.21. Two lifeboats in the southern debris field.

8.4.2 Site Preservation

Other than the severe damage done to *Robert E. Lee*'s superstructure along the boat deck, the wreck site is in a good state of preservation. Portions of the wooden planking on the forecastle and the remaining boat deck are in the process of collapsing. Rusticle coverage is relatively light along the vessel's hull, and most of the wreck is covered with anemones and small branching polyps.

8.5 Discussion of Biological Findings

8.5.1 Microbiology

Gravimetric elemental analysis using ICP-AES of the rusticles recovered from *Robert E Lee*'s port and starboard sides are given in Table 8.2. It was found that the dominant three elements were iron (97%), sodium (1.7%), and magnesium (0.2 %).

Table 8.2

Gravimetric Elemental Analysis of a Brown Rusticle (C1) from Robert E Lee

Iron	97.446%		Manganese	0.026%
Sodium	1.772%		Vanadium	0.012%
Magnesium	0.221%		Molybdenum	0.011%
Phosphorus	0.145%		Boron	0.011%
Calcium	0.140%		Cadmium	0.008%
Potassium	0.109%		Strontium	0.006%
Zinc	0.055%		Lead	0.005%
Aluminum	0.031%		Barium	0.002%

Robert E Lee rests at the northern edge of the Upper Mississippi Fan at a depth of 1,490 meters. The most obvious difference with the biota on this ship was the population density of the sea anemones that had an average population of 8 anemones per square meters of visible surface. The high population meant these organisms dominated the activity occurring on the ship. Brown hanging rusticles (C1) were numerous occupying 20% of the visible areas and were generally at sites away from sea anemone colonies. Brown rusticles ranged in sizes up to two meters with widths ranging up to 250 millimeters. In addition to the C1 rusticles there were also C2 white rusticles but they only occupied 5% of the surface areas occupied by the C1 rusticles. Seventy percent of the ship's surface was coated in a dendritic concretion that was thick (15 – 25 millimeters) and partially coated (less than half) by a slime (B1), which was one to five millimeters thick. Concretions (C4) were observed occurring in a few dense patches that amounted to 15 percent of the viewable surface area. Where these patches occurred, they were very intense with the branches forming tight whorls. No blobs were observed. Moderate electrical potentials were created on the bio-battery (Figure 8.22).

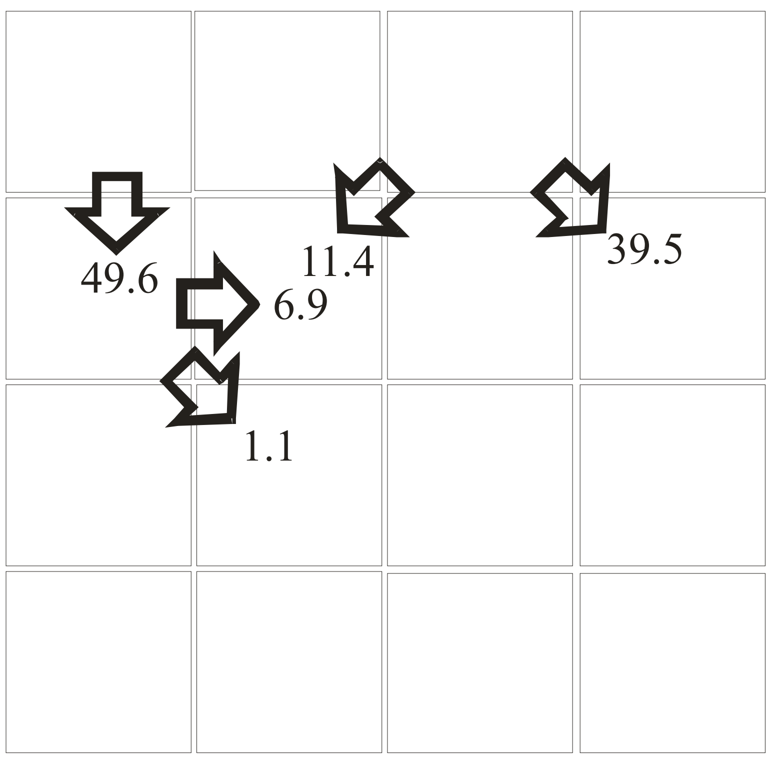


Figure 8.22. Voltages (millivolts) detected on bio-battery coupons deployed on *Robert E. Lee*.

8.5.2 Invertebrate Zoology

Invertebrates observed in the seven transects over, adjacent to, and distant from *Robert E. Lee* largely reflect the collections from fish traps and by the ROV. The deep-sea red crab (*Chaceon quinquedens)* was again the predominant or numerically conspicuous species, with specimens observed on all transects adjacent to the wreck site but not over the site or on distant transects (Table 8.3). Large numbers, however, were collected both adjacent and distant from *Robert E. Lee* in collections away from the original transect lines. Squat lobsters belonging to the genus *Munidopsis* were observed on four of the seven transects. Anemones were abundantly attached to the hard substrate provided by *Robert E. Lee*, and only a single specimen was observed on the six transects adjacent to and distant from the wreck.

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Table 8.3

Density (number per 100 m$^{-2)}$ of Invertebrates Observed on Transects Over, Adjacent and Distant (300 m) from the *Robert E. Lee* Site.

	Transect Number						
	Adjacent			**Over**	**Distant**		
Robert E. Lee	**415**	**416**	**417**	**420**	**438**	**439**	**440**
Crustaceans							
Chaceon quinquedens	1.3	0.7	0.5	0.0	0.0	0.0	0.0
Munidopsis sp.	0.2	1.5	0.4	0.4	0.0	0.0	0.0
Shrimp	0.6	0.0	0.0	0.0	0.4	0.2	0.7
Echinoderms							
Sea star	0.0	0.1	0.0	0.0	0.1	0.2	0.2
Cnidarians							
Anemone	0.0	0.0	0.4	28.0	0.0	0.0	0.0

Sediment in the meiofauna cores was mainly clay and silt, with some portion in the form of biogenic pellets created by deposit feeding macrofauna such as polychaets. Nematodes were numerically most abundant, followed by harpacticoid copepods and polychaets (Table 8.4). A single individual of the caudofoveatan *Scutopus* sp. was found in each core.

Table 8.4

Density of Meiofauna (numbers per 10 cm^2) from Sediment Cores Collected Adjacent to and Away from *Robert E. Lee.*

Wreck	***Robert E Lee***	
	Number per 10 cm^2	
Taxon	Core A	Core C
Harpacticoida	5.4	0.0
Nematoda	81.6	139.6
Polychaeta	0.0	3.6
Mollusca – *Scutopus* sp.	1.8	1.8

Seventy-seven voucher specimens belonging to 11 taxa were collected (Table 8.5). Three species were collected near the wreck, seven away from the wreck and two from unknown locations in the water column. Forty-six specimens of the red deep-sea crab *(Chaceon quinquedens*) were collected. Squat lobster (*Munidopsis* sp.) were common and 12 specimens were collected, as were two *Munida* sp. Squat lobsters (family Galatheidae) and pinch bugs (family Chirostylidae) of the super family Galatheoidea become increasingly conspicuous with increasing depth. Four species of shrimp (*Notostomus gibbosus, Notostomus* sp. *Plesionika* sp., *Glyphocrangon* sp.) were collected; all of the shrimp were collected away from the main hull, which might be expected since most are known to be associated with soft sediments.

Table 8.5

Macroinvertebrate Species Collected at the *Robert E. Lee* Site,
Including Number and Proximity to Wreck, Substrate, and Depth.

Robert E. Lee					
Specimen ID	**Number Near Wreck (< 61 m)**	**Number far from wreck (>61 m)**	**Unknown collection location**	**Substrate**	**Depth (m)**
Crustacea					
Bathynomous giganteus		3		Traps; basket	
Chaceon quinquedens	27	19		Silt; traps	1488-1491
Munida sp.	2			Silt	1491
Munidopsis sp.	12			Wreck; silt near wreck	1485-1491
Notostomus gibbosus			6	Water column	
Notostomus sp.			2	Water column	
Plesionika sp.		1		Silt	1494-1499
Glyphocrangon sp.		2		Silt	1490-1498
Amphipoda		1		Far fish trap	
Echinodermata					
Goniasteridae		1		Silt	1499
Ophiuroidea		1		Silt	1492-1499

Scleractina, Antipatharia, and Gorgonacea

None observed at this site.

8.5.3 Vertebrate Zoology

Fish Community Structure

Visibility at *Robert E. Lee* was good. The mean width of the single transect over the ship was approximately 8.9 meters (Table 8.6). Transects flown adjacent to and away from the wreck averaged 5.7 meters wide. The difference in these two figures was because the ROV maintained a greater distance from the wreck than the seafloor when flying transects.

Ichthyofaunal diversity was low at *Robert E. Lee* and species composition was similar over and away from the wreck. Fishes observed included cuskeels (Order: Ophidiiformes), Halosaurs (Family: Halosauridae), eels (Order: Anguilliformes), and grenadiers (Family: Macrouridae). Most individuals could not be identified below order or family from video, the exceptions being the cutthroat eel (*Synaphobranchus brevidorsalis*) and the Halosaur, (*Aldrovandia gracilis*). Both species were captured in traps and/or with the suction sampler. Other species captured with traps or the suction sampler included the distate cuskeel (*Dicrolene intronigra*), the brotula (*Cataetyx laticeps*), and the thickbeard grenadier, (*Coryphaenoides zaniophorus*).

Table 8.6

Abundance and Density Estimates for Fish Taxa Identified from ROV Video Over, Adjacent to, and 300 Meters Away from *Robert E. Lee*.

Transect Line	Relation to Ship	Taxon	Min Count	Max Count	Min Density 100 m^{-2}	Max Density 100 m^{-2}
420	Over	Ophidiiformes	1	1	0.10	0.10
416	Adjacent	Synaphobranchidae	1	1	0.14	0.14
		Teleost	1	1	0.14	0.14
438	Distant	Halosauridae	2	7	0.18	0.62
		Teleost	1	1	0.09	0.09
439	Distant	*Aldrovandia gracilis*	1	3	0.06	0.18
		Synaphobranchus brevidorsalis	1	1	0.06	0.06
		Halosauridae	1	2	0.06	0.12
		Nettastomatidae	1	3	0.06	0.18
		Teleost	1	1	0.06	0.06
440	Distant	*Aldrovandia gracilis*	2	8	0.18	0.72
		Synaphobranchus brevidorsalis	1	2	0.09	0.09
		Halosauridae	1	2	0.09	0.18
		Macrouridae	1	1	0.09	0.09
		Teleost	1	4	0.09	0.36

Table 8.7

Abundance of Fish Taxa Identified from Video Collected at *Robert E. Lee* on Other than Biological Transects. (Location Indicates if Video was Collected Over or Away from the Ship.)

Location	Taxon	Min Count	Max Count
Over Ship	*Cataetyx laticeps*	1	3
	Synaphobranchus sp.	2	4
	Alepocephalidae	1	1
	Halosauridae	1	3
	Macrouridae	1	3
	Anguilliformes	1	1
	Ophidiiformes	2	10
	Teleost	1	2
Away From Ship	*Aldrovandia gracilis*	1	4
	Cataetyx laticeps	1	1
	Coryphaenoides sp.	1	1
	Dicrolene intronigra	1	5
	Rajella purpuriventralis	1	1
	Synaphobranchus sp.	1	1
	Alepocephalidae	1	4
	Halosauridae	2	45

	Macrouridae	1	12
	Ophididae	1	1
	Anguilliformes	1	2
	Ophidiiformes	1	9
	Teleost	1	22

Table 8.8

Estimated Total Fish Lengths Observed on Video at *Robert E. Lee.*
(All individuals were captured on video with both ROV-mounted lasers striking them.)

Taxon	Number Measured	Mean TL mm	Standard Deviation	Range TL mm
Aldrovandia gracilis	5	498	115.3	381-656
Cataetyx laticeps	4	729	266.8	406-1,048
Dicrolene introniger	3	409	27.9	381-437
Synaphobranchus brevidorsalis	3	883	158.5	780-1,066
Coryphaenoides sp.	1	762		
Halosauridae	6	667	244.2	363-953
Macrouridae	1	318		
Nettastomatidae	2	1,424	81.0	1,367-1,482
Anguilliformes	1	529		
Ophidiiformes	2	484	483.1	142-826

Table 8.9

Fish Taxa Caught in Chevron (Large) and Baitfish (Small) Fish Traps Deployed Adjacent to (Ship) and 300 meters Away from (Distant) *Robert E. Lee*.

Trap Type	Location	Species	Number
Small	Distant	*Synaphobranchus brevidorsalis*	1

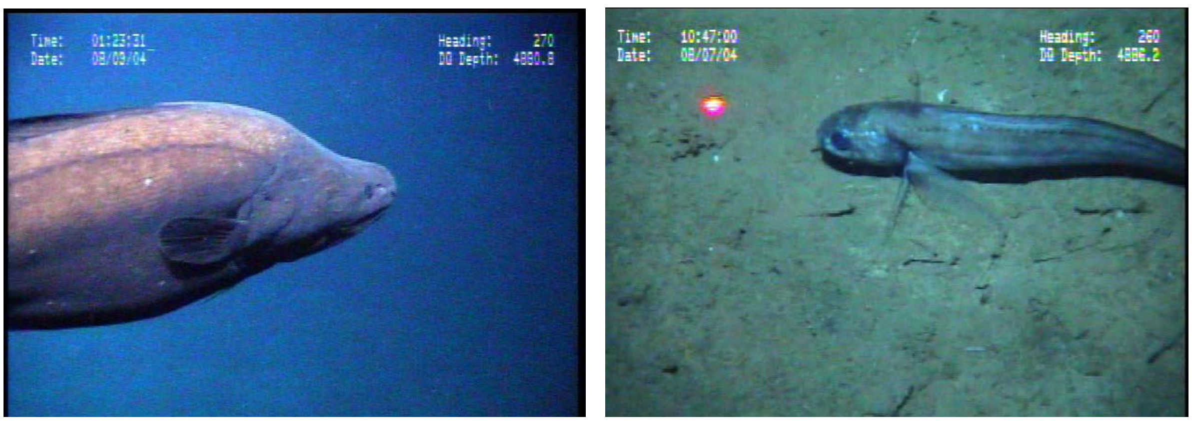
Table 8.10

Fishes Caught with the ROV Suction Sampler at *Robert E. Lee*.

Date	Species	Number
Aug 7 - Aug 9	*Cataetyx laticeps*	1
	Coryphaenoides zaniophorus	1
	Synaphobranchus brevidorsalis	1
Aug 12	*Aldrovandia gracilis*	1
	Dicrolene intronigra	2
	Synaphobranchus brevidorsalis	1

a) b)

Figure 8.23. (a) A purple belly skate, (b) a thickbeard grenadier.



a) b)

Figure 8.24. (a) Brotula (*Cataetyx laticeps*), and (b) distate cuskeel from video captured adjacent to *Robert E. Lee*.

Diet and Trophic Structure

Stomachs were dissected from eight fish collected at *Robert E. Lee* and five (63%) had food items present (Fig. 8.25). Gut content analysis indicated fish dominated the diet of cutthroat eels captured at *Robert E. Lee*. The sole halosaur analyzed had invertebrates present in its gut, but almost half the prey items present were unidentifiable. No prey items found in the Mexican grenadier's gut were identifiable. Stable isotope values for fishes captured at *Robert E. Lee* are reported in Section 7.5.3.

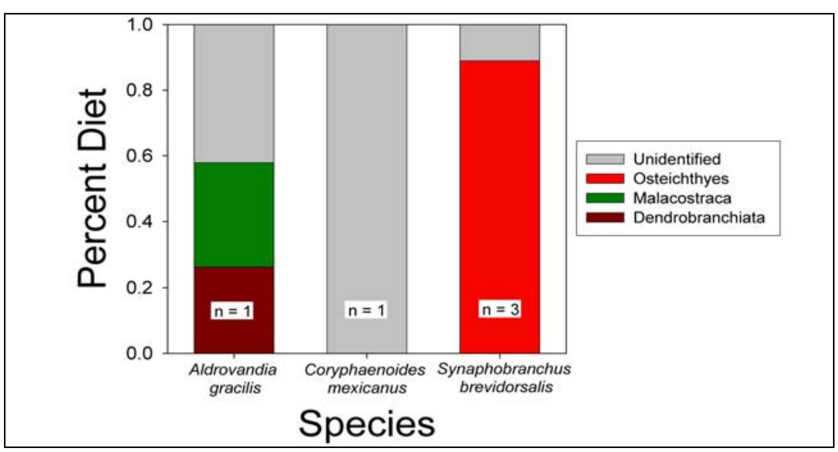


Figure 8.25. Prey taxa contribution to diets of fishes sampled at the *Robert E. Lee*. Sample sizes are indicated for each species.

Age Estimation

Size at age estimates for fishes collected at the Robert E. Lee are presented in Section 7.5.3

8.6 Sediment Core Analysis

Four samples were taken at the designated distance from the ship structure. Each sample, after coming to the surface was taken out of the sampling device and stored in a clean glass container at approximately 4° Celsius. The *Robert E. Lee* core samples did not indicate any visible differences. They all appeared to be smooth, gray/black sediment with a sour smell. The sour smell is indicative of the anaerobic biological activity normally (sulfate reduction) found within sediment samples. The lower portion of the core sample did have small rocks mixed within the sediment. The rock samples were approximately two to three centimeters in diameter. Samples were sent to a certified laboratory for organic chemistry analysis. The *Robert E. Lee* site samples from the four cores all tested below detection levels for hydrocarbon C6-C36, as well as total petroleum hydrocarbons (Table 8.11).

Table 8.11

Robert E. Lee Core Analysis.

Site	**Date**	**Sample Location**	**Concentration**
Robert E. Lee	August 9, 2005	Beside Ship	<1 ug/g
		30 meters	<1 ug/g
		152 meters	<1 ug/g
		305 meters	<1 ug/g

9.0 *ALCOA PURITAN* SITE

9.1 Historical Background of the Freighter *Alcoa Puritan*

Figure 9.1. *Alcoa Puritan*, United States Coast Guard Photograph, November 11, 1941 (Courtesy of the Steamship Historical Society of America, University of Baltimore).

Alcoa Puritan was a 6,795-ton cargo steamship built by the Bethlehem Steel Company in San Francisco, in 1941. She was one of fifteen C-1 B type cargo ships built by Bethlehem Steel. *Alcoa Puritan* was owned and operated by the Alcoa Steam Ship Company at the time of her loss. The vessel's length between the perpendiculars was 395 feet (120.4 meters) with an overall length of approximately 417.9 feet (127.4 meters). The ship was 60 feet (18.3 meters) wide at the beam, had a depth of hold of 37.4 feet (11.4 meters) from the main deck, and drew 27.5 feet (8.4 meters) of water when fully loaded. Like *Alcoa Pathfinder*, a sister ship, she had three forward cargo holds and two aft cargo holds. Three of the cargo hold openings measured 31.5 feet by 19.6 feet (9.6 meters by 6 meters) and the other two cargo hold openings measured 27.5 feet by 19.6 feet (8.4 meters by 6 meters). The holds were fitted with 'tweendecks' including traditional wood hatch covers and steel weather-deck hatch covers. There were two masts forward and one aft. Sixteen booms (derricks) served the holds, four booms at the holds amidship, and the traditional two booms at the aft and forward holds. The cranes utilized Westinghouse electric motors instead of traditional steam driven windlasses (*Marine* 1941: 106; and Conwell 1986: 55).

Alcoa Puritan could carry a typical compliment of 10 officers and 33 crew with berths for 8 to 10 passengers. On her last voyage she carried 41 officers and crew with seven passengers. At least six passengers were survivors of the tanker *T.C. McCobb,* which had been torpedoed off Brazil. (*Marine* 1941: 106; Conwell 1986: 55 and 65; and Browning 1996: 96).

The vessel accommodations were of a high standard utilizing many of the latest innovations. All quarters and living areas were supplied with forced air ventilation. Propulsion for *Alcoa Puritan* was provided by Bethlehem cross-compound steam turbines, which drove a single four-blade propeller. Typically the vessel carried approximately 879 tons of fuel oil, and could travel 16,093.4 kilometers at a speed of 14 knots fully loaded (Conwell 1986: 55; and *Marine* 1941: 147).

As America geared up for World War II, aluminum was in great demand and production by ALCOA (Aluminum Company of America) increased by 600 percent. ALCOA had steamships such as *Alcoa Puritan* built to transport the raw bauxite ore from mines in South America to their American plants (Alcoa 2002). ALCOA's principle sources of bauxite were in Dutch and British Guiana. The *Alcoa Puritan*'s typical operation for loading the ore consisted of traveling up the Suriname River to Paranam. At high tide water depth at the river's entrance was 5.5 meters. *Alcoa Puritan* could load only half her cargo capacity at Paranam because of the shallow sand bars at the mouth of the river. It then transited to Trinidad to take on the balance of her cargo. The Alcoa Steamship Company used lighters to ferry the remaining ore to Port of Spain, Trinidad. After a freighter was fully loaded it headed for Portland, Maine or Mobile, Alabama (Conwell 1986: 59-66).

In 1941, Trinidad was a busy island. With World War II well underway in Europe, Trinidad was a staging area for Atlantic convoys. On December 7, 1941, America entered the war following the attack on Pearl Harbor. *Alcoa Puritan*'s crew learned of the attack from a U.S. destroyer berthed along side and they wasted no time preparing the ship for wartime conditions. They painted the ship gray from the mast truck to the waterline. They operated in black out conditions while underway hoping that U-boats would not spot them. Some vessels were armed with deck guns and a navy gun crew, but not *Alcoa Puritan* (Conwell 1986: 59-66).

In May 1942, *Alcoa Puritan* was en route from Port of Spain, Trinidad to Mobile, Alabama, with a cargo of 10,000 tons of bauxite. The vessel, under Captain Yngvar Axelstien Krantz's command, plied the Gulf of Mexico's relatively unprotected waters when she crossed paths with the German U-boat *U-507* (Moore, 1993: 10). It was a clear day with fine weather. There was no wind and the sea was calm, like glass (Conwell 1986: 67). The third mate David M. Conwell relates the following account of the attack:

> …a torpedo passed astern of the ship. The wake of the torpedo was sighted by one of our survivor-passengers who was idling on the boat deck; in a few seconds the loud clanging of our general alarm bell was heard throughout the ship. Our position was about forty-three miles south-southeast of the entrance to the Mississippi River at Southwest Pass; we were steaming at fourteen knots on a course approximately north-by-east….(Conwell 1986: 66)

The torpedo reportedly missed *Alcoa Puritan*'s stern by 4.5 meters. It was 11:55 am, visibility was good, and no other ships were in sight (Powers 1942a).

Mr. Conwell continues:

> While we discussed the possibility of the torpedo's being merely a porpoise, a submarine surfaced at what appeared to be an initial range of two miles directly astern. Immediately he broke water he fired a single warning shell which passed overhead and landed in the water ahead of the ship. This was at 1205. Captain Krantz telephoned chief engineer Brewster in the engine room, and Brewster opened up the ship's engines to what was probably a speed of 17 knots. The captain hoped that at this speed we could out-distance our attacker.
>
> About a minute later the U boat (sic) fired a second shot which splashed close enough to send a tremor through the ship. I then found a place between the captain and the junior third mate who were lying flat on the grating abaft the steering wheel. The ship was on 'automatic', and so she made her courses without a helmsman. Captain Krantz steered by reaching up and adjusting the steering apparatus from time to time. The first two misses were followed by a hit about twenty seconds later, and there followed about 75 shells, of which probably 70 were hits on the PURITAN. These were at a rate of three a minute for twenty-five minutes. Apart from terrifying us all, the shelling laid open the ship's superstructure, perforated the funnel, broke all the windows and instrument faces, set fire to parts of the interior, shot away our anchors and chain, and, finally, disabled the steering machinery at the stern….
>
> I mentioned above that the captain changed course from time to time. First Assistant engineer J. W. Thomas, who had been with us on the deck of the wheelhouse, took up a position in the port wing of the bridge from where he could look aft at the submarine. As the submarine would gain on us, first on one side and then the other, Thomas would shout into the wheelhouse, "he's coming up on the port side", or "now he's coming up to starboard." With this guidance from Thomas, Krantz was able to change the PURITAN's course to the extent necessary to keep the submarine directly astern. Mr. Thomas, an older man, proved himself a person of uncommon courage.
>
> Our radio operator was, of course, on the air immediately to call for assistance. By the time our antenna was shot away he had communicated with naval authorities ashore on the Gulf coast, and they had acknowledged his messages.
>
> At about 1230 when the submarine was at point-blank range the ship started to turn in circles. Captain Krantz had no choice but to order us to abandon. Krantz rang the engines to 'full astern', and Brewster stayed by the engineroom (sic) throttle until the signal came down to 'stop engines.…

> Hurrying next to my station, which was the ship's No. 2 lifeboat on the port side, I threw my briefcase over the gunwale and into the boat and then undertook to launch it…. When we were ready to lower the boat I looked under it to ensure that all was clear. What I discovered was that the bottom of the boat had been torn open and perforated by gunfire. The boat was useless.
>
> I was turning with the others to seek some other avenue of escape when a shell struck the ship close to where we were standing. We were peppered with fragments, and Dewy Hart was badly hit in the neck. By then our ship was dead in water; the submarine was close aboard on our port side, parallel to the PURITAN at about 150 yards….
>
> I then ran aft along the port side of the main deck, now covered with heaps of bauxite from our holds, and jumped over the taffrail into the water. The rafts lay about two hundred yards astern, and it was easy to swim to them, clad as I was in a lifebelt.
>
> Captain Krantz was at this time launching the other lifeboat on the starboard side. Despite its being perforated by shrapnel fragments, as was he, he got it clear and rowed it to where the crew clung to the rafts. He was assisted by five crew members who pulled the oars. His own face and eyes were covered with blood, and I don't think he could see.
>
> By the time the captain's boat reached us the submarine fired a second torpedo, which struck the ship in the engineroom (sic) on the port side. The PURITAN started to list heavily to port and within a minute she sank below the surface. There was no bubble and very little flotsam came up (Conwell 1986: 66-70).

After being torpedoed the freighter sank in approximately eight minutes and reportedly went down stern first. All the passengers and crew survived the encounter, some with minor injuries, but two crewmembers were later hospitalized for shrapnel wounds. The U-boat approached the survivors before leaving the area, allowing them a close look at the U-boat and its commanding officer (Powers 1942a).

> The submarine then seemed to turn in her length and headed back toward the rafts on which we were sitting…. The sea-green colored submarine was about 300 feet in length. A number of men on deck were picking up empty shell cases from their two deck guns and throwing them down a hatch. One man took pictures of us with a motion-picture camera while a second crew-member held a machine gun. It was about 1245….
>
> As he passed close aboard us the boat's captain shouted across the water that he was sorry and that he hoped we "make it in all right." He then gave a parting wave, followed his crew down a scuttle, and submerged… (Conwell 1986: 69-70).

After the survivors were in the water about an hour, a U.S. Navy patrol plane arrived. At approximately 1605, after being adrift for four hours, the U.S. Cost Guard Cutter *Boutwell* arrived and picked up the survivors. They were landed at the Burrwood base and then taken to New Orleans (Powers 1942a; and Conwell 1986: 70).

9.2 Previous Investigations

In 1986, Shell Offshore, Inc., was exploring oil and gas prospects in the Mississippi Canyon Area of the Gulf of Mexico. During the Kepler field deep-tow survey, two shipwrecks were discovered and one thought to be *Alcoa Puritan*. Not until 2001 was it revealed that the wreck site was really *U-166* and *Alcoa Puritan*'s true location was discovered 23 kilometers away. Between March and June 2001, about the same time as *U-166*'s discovery, Shell International Exploration and Production contracted Fugro GeoServices, Inc. (FGSI) to conduct a deep-tow survey for the Nakika Pipeline Project. The survey took place aboard M/V *Geodetic Surveyor* using the FGSI DeepTow II system, equipped with 120 kHz side scan sonar and subbottom profiler, and a multibeam bathymetry system (Church et al. 2003).

During the survey, a large shipwreck was discovered in 1,965 meters of water 23 kilometers southeast of the *Robert E. Lee* and *U-166* sites. Marine archaeologist Laura Landry conducted the archaeological assessment for the survey. Based on survey data and historical information, Landry identified the wreck as *Alcoa Puritan* (USDI MMS 2002).

The shipwreck was imaged on only one wing line of the survey and the tow-fish crossed the vessel near mid-ships. Although much of the vessel is obscured by the side scan sonar's nadir, the bow and three forward cargo hatches are discernable (Figure 9.2). The multibeam data clearly shows the vessel's entire structure and a wide depression is apparent at the freighter's stern (Figure 9.3).

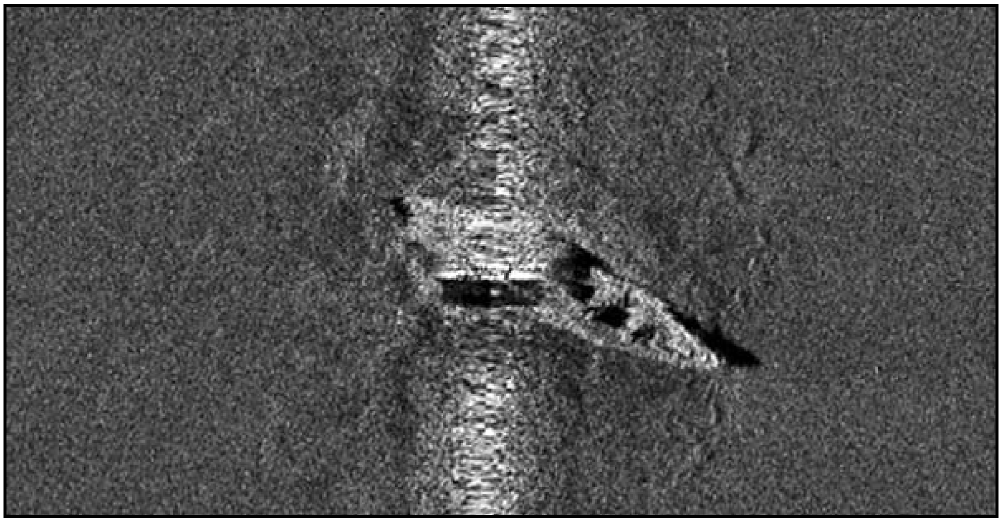


Figure 9.2. Side scan sonar image of *Alcoa Puritan* from the FGSI DeepTow II system (Courtesy of Shell International Exploration and Production Inc.)

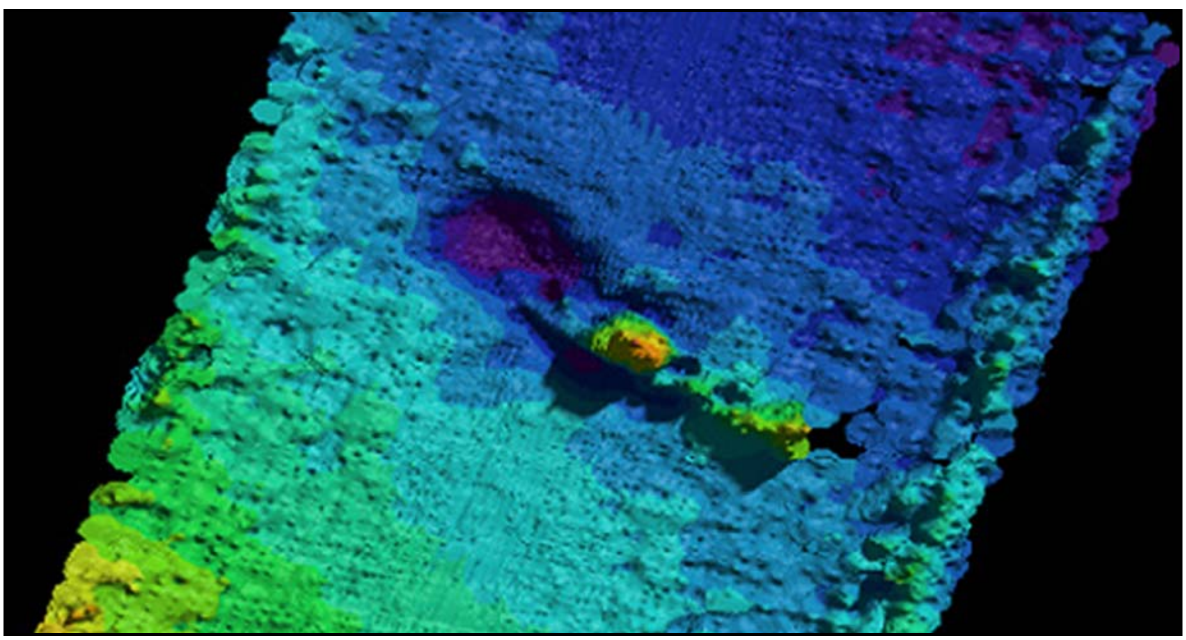


Figure 9.3. Multibeam image of *Alcoa Puritan* from FGSI DeepTow II system (Courtesy of Shell International Exploration and Production Inc.).

Following the vessel's initial identification, Shell asked C & C if they would conduct further investigations of the wreck site with their AUV (C-Surveyor I). In February 2002, C & C surveyed the wreck site while conducting AUV tests after mobilizing C-Surveyor I on a new support vessel, R/V *Rig Supporter*. Survey lines were run around the site from three directions to box in the vessel. Several parallel survey lines were run in each direction. Each set of parallel survey lines were at a 30-degree angle to the other two sets of lines, creating a "star pattern" survey grid. This provided a 202,500 square meter area of overlapping survey coverage and required less than 1 1/2 hours to complete (Church et al. 2003).

The swath bathymetry and dual frequency sonar (120 kHz and 410 kHz) images left little doubt that the site was *Alcoa Puritan*. The sonar images (Figures 9.4 and 9.5) clearly showed the mid-ship superstructure with its central stack, the crane bases, and five cargo hatches. The vessel's dimensions exactly match *Alcoa Puritan*. The vessel is oriented with the stern to the northwest and the bow to the southeast. The bow is slightly more elevated than the stern and the seafloor depression is deeper at the stern. It appears the ship's stern impacted the seafloor first, which is consistent with the historical account of the vessel sinking stern first (Church et al. 2003).

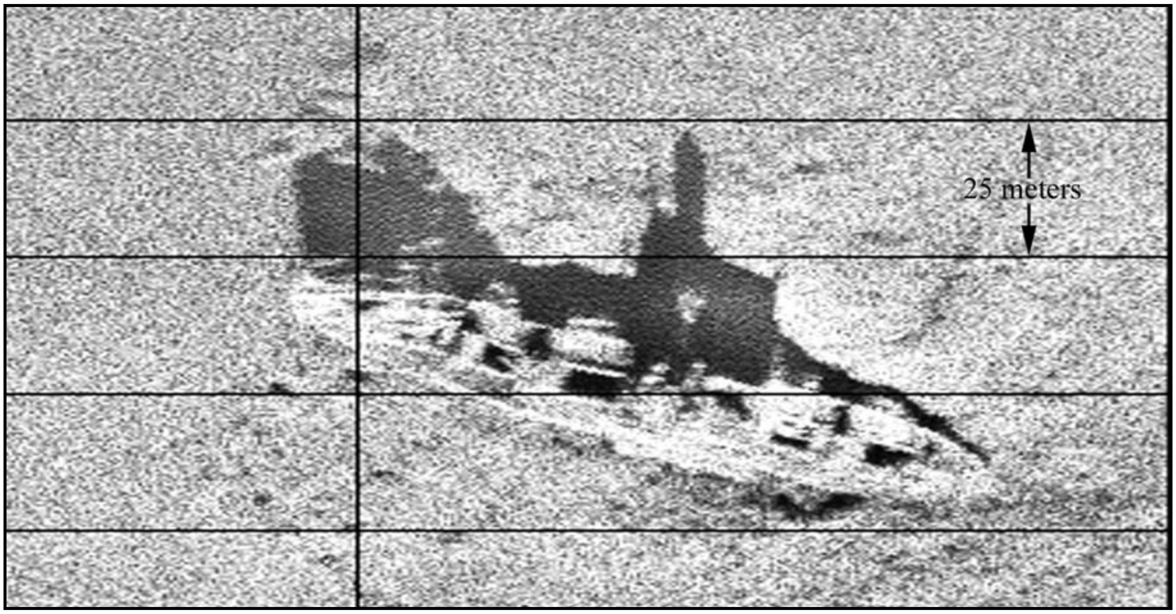


Figure 9.4. 120 kHz side scan sonar image of *Alcoa Puritan* from the *C-Surveyor I* AUV (Courtesy of C & C Technologies, Inc.).

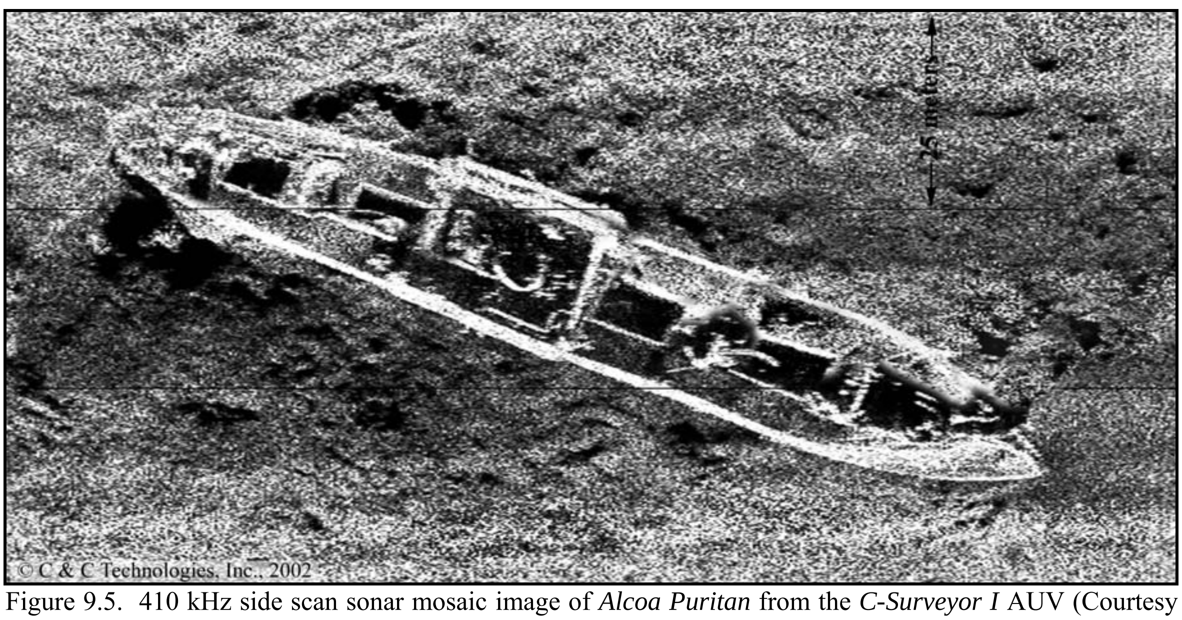
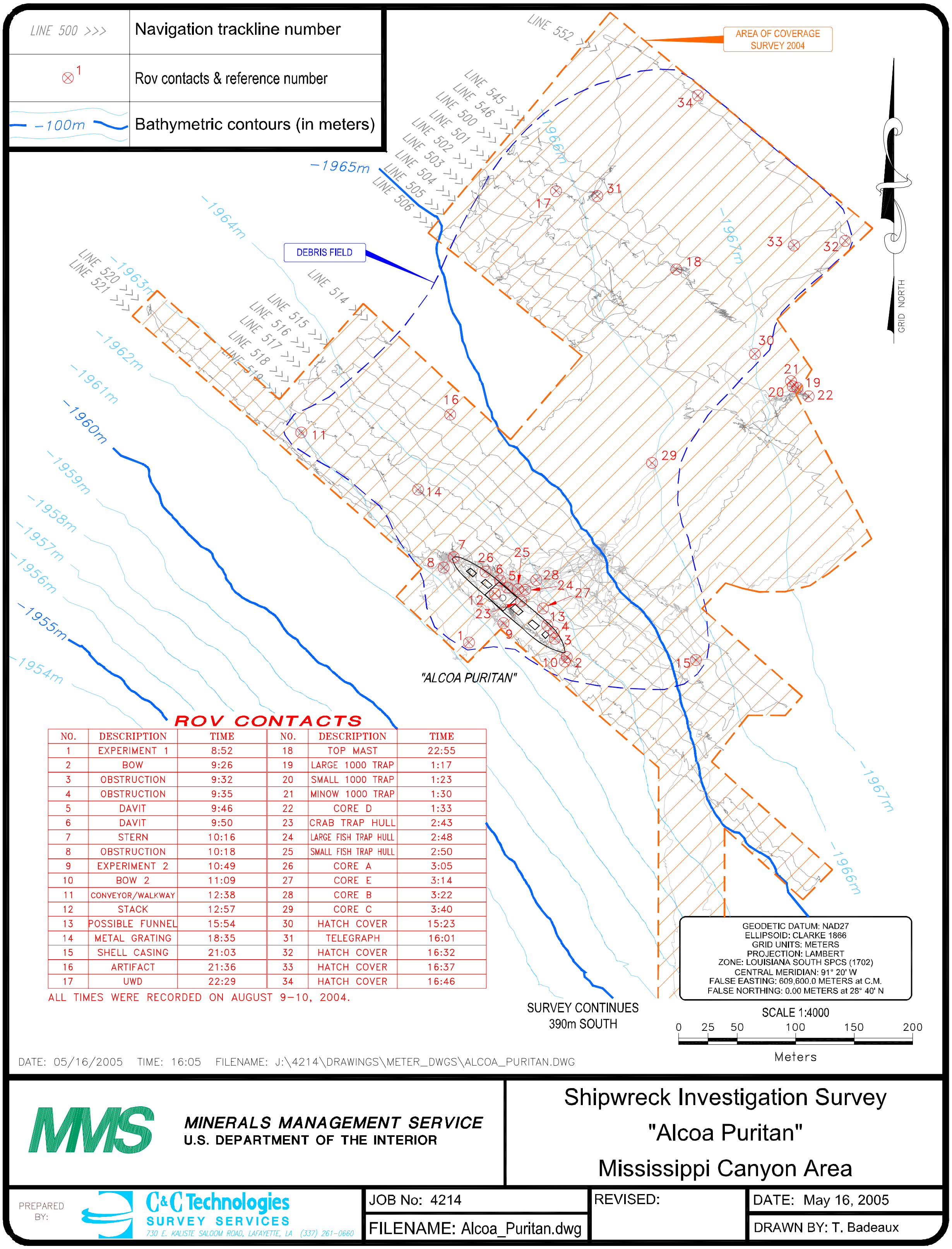


Figure 9.5. 410 kHz side scan sonar mosaic image of *Alcoa Puritan* from the *C-Surveyor I* AUV (Courtesy of C & C Technologies, Inc.).

Shell International and Production Inc. conducted the first ROV investigation of the wreck site on July 3, 2002. The visual inspection was conducted with Sonsub's ROV vessel HOS *Dominator* while in the area as a support vessel for the Nakika pipeline's construction. The ROV investigation confirmed the site's identity and provided valuable data for researchers (Church et al. 2003). The geophysical survey data and ROV investigation footage discussed above was used to plan the 2004 site investigations.



NO.	DESCRIPTION	TIME	NO.	DESCRIPTION	TIME
1	EXPERIMENT 1	8:52	18	TOP MAST	22:55
2	BOW	9:26	19	LARGE 1000 TRAP	1:17
3	OBSTRUCTION	9:32	20	SMALL 1000 TRAP	1:23
4	OBSTRUCTION	9:35	21	MINOW 1000 TRAP	1:30
5	DAVIT	9:46	22	CORE D	1:33
6	DAVIT	9:50	23	CRAB TRAP HULL	2:43
7	STERN	10:16	24	LARGE FISH TRAP HULL	2:48
8	OBSTRUCTION	10:18	25	SMALL FISH TRAP HULL	2:50
9	EXPERIMENT 2	10:49	26	CORE A	3:05
10	BOW 2	11:09	27	CORE E	3:14
11	CONVEYOR/WALKWAY	12:38	28	CORE B	3:22
12	STACK	12:57	29	CORE C	3:40
13	POSSIBLE FUNNEL	15:54	30	HATCH COVER	15:23
14	METAL GRATING	18:35	31	TELEGRAPH	16:01
15	SHELL CASING	21:03	32	HATCH COVER	16:32
16	ARTIFACT	21:36	33	HATCH COVER	16:37
17	UWD	22:29	34	HATCH COVER	16:46

Figure 9.6. *Alcoa Puritan* site overview map.

Table 9.1

ROV Navigation Fix Points at *Alcoa Puritan*

No.	Description	Time
1	Experiment 1	8:54
2	Bow	9:01
3	Wire Obstruction	9:33
4	Wire Obstruction	9:36
5	Davit	9:48
6	Davit	9:48
7	Stern	10:16
8	Wire and Rail Obstructions	10:20
9	Experiment 2	10:49
10	Bow 2	11:09
11	Remnants of a Conveyor or Walkway	12:39
12	POSSIBLE FUNNEL	12:58
13	METAL PIPES	15:54
14	METAL GRATING	18:36
15	SHELL CASING	21:04
16	UWD	21:37
17	METAL FRAME	22:28
18	TOP OF MAST	22:57
19	LARGE 1000' TRAP	1:19
20	SMALL 1000' TRAP	1:25
21	MINNOW 1000' TRAP	1:31
22	CORE D	1:34
23	CRAB TRAP HULL	2:44
24	LARGE FISH TRAP HULL	2:49
25	SMALL FISH TRAP HULL	2:51
26	CORE A	3:07
27	CORE E	3:15
28	CORE B	3:23
29	CORE C	3:41
30	HATCH COVER	15:23
31	TELEGRAPH	16:01
32	HATCH COVER	16:34
33	HATCH COVER	16:38
34	HATCH COVER	16:47

UWD = Unidentified Wreck Debris

9.3 Geographical Setting

The site area is located in the Mississippi Canyon's eastern portion in the northern Gulf of Mexico. The site is southeast of the mouth of the Mississippi River and south of an area dominated by diapiric salt uplifts. The seafloor in this region slopes gently at approximately 2° to the southwest at the wreck site (Figure 9.6). There is a low sedimentation rate in this area of approximately 1.52 millimeters per year.

9.4 Discussion of Archaeological Findings

9.4.1 Physical Site

The following wreck site description is from the 2004 expedition. The investigation was conducted with the Triton X11 ROV on August 9 and 10, 2004. The survey time at this site was limited because of Tropical Storm Bonnie's approach. There was no measurable current at the site and any silt that was disturbed during the investigation remained in the water column for a prolonged period of time.

The wreck is oriented with the bow pointing southeast and stern northwest. The vessel lies in 1,964 meters of water. The bow stands 4.3 meters proud of the ambient seafloor and is elevated higher than the stern. There is a seafloor depression around the stern measuring approximately 50 meters across and 4 meters deep. The stern is approximately 1.2 meters lower than the ambient seafloor outside the depression.

ROV reconnaissance of the main structure revealed the hull is mostly intact with moderate superstructure damage. Numerous shell holes are visible along the hull. The larger shell holes, probably from *U-507*'s 105-mm deck gun, measure between 43 and 88 centimeters across (Figure 9.7). The smaller shell holes are likely from *U-507*'s 37-mm or 20-mm guns. There is moderate damage on the vessel's starboard side, but the most extensive damage is to the port side. On this side near the mud line, below the superstructure's aft portion there is a large hull breach caused by a torpedo (Figure 9.8). The tear measures 11.4 meters across and extends 2.5 meters above the mud line. Physical deterioration is substantial in this area; part of the aft bridge roof has collapsed exposing the interior of the bridge. One of the ship's bridge telegraphs, lying on its side, is visible through the opening.

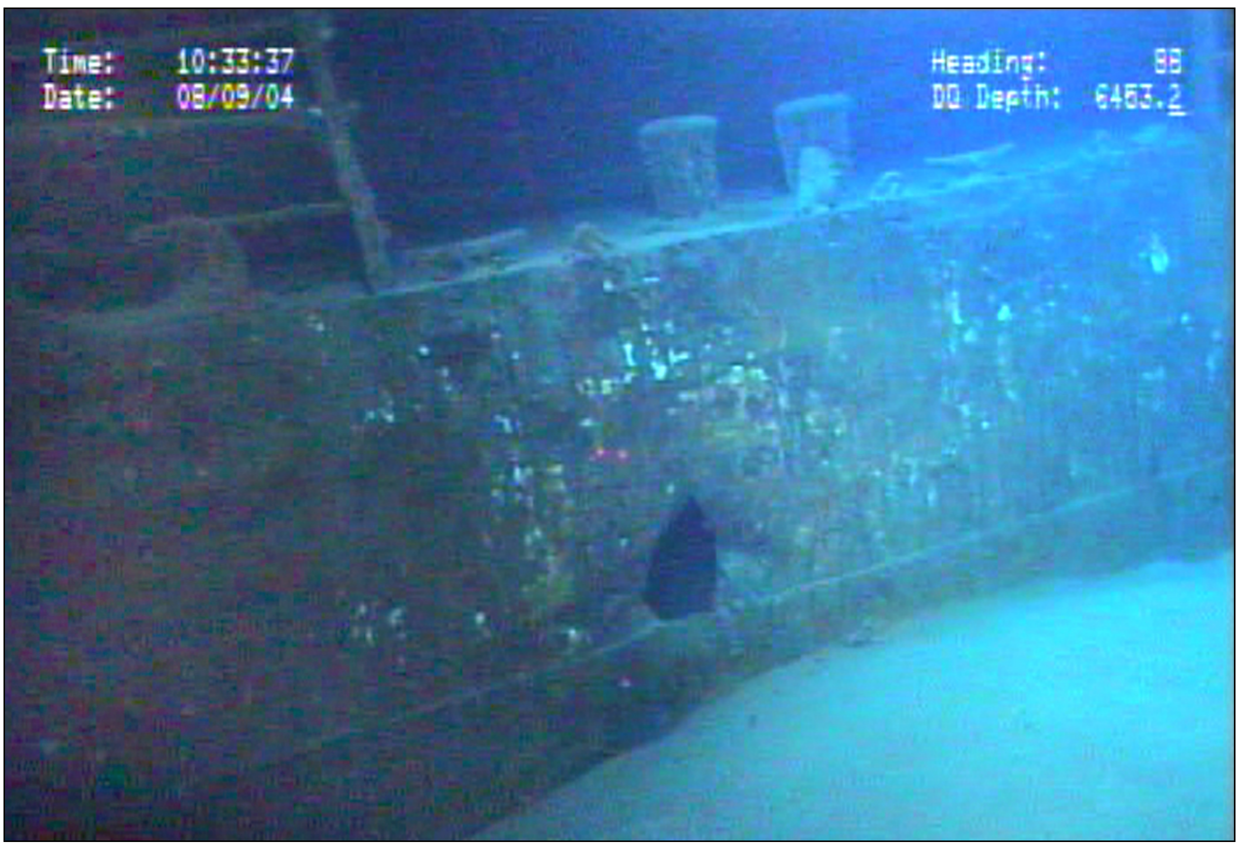


Figure 9.7. 105-mm shell damage on *Alcoa Puritan*'s starboard side. The breach is approximately 47 centimeters across.

Figure 9.8. Mosaic of the vessel's port side torpedo damage just below the superstructure's aft section.

The anchor windlass and chain are in place on the forecastle (Figure 9.9). Although the historical account states the ships anchors were shot away, both anchors are intact (Conwell 1986: 67). Just below the anchors, the bow is buckled (Figure 9.10). The buckling of the hull most likely occurred when the bow impacted the seafloor.

Figure 9.9. Two views of the ship's windlass: the view from starboard (left image), and the view from the bow looking aft (right image).

Figure 9.10. Starboard views of the buckling at *Alcoa Puritan*'s bow.

No masts remain standing on *Alcoa Puritan*'s forward deck, but the square mast steps are intact. The top of the forward mast lies directly over the No. 1 hold's hatch, obscuring the view into that hold (Figure 9.11). According to the third officer's journal, an automobile was loaded into the No. 1 hold before the ship left Trinidad (Conwell 1986:

66). The automobile is not visible in the footage. The Nos. 2 and 3 holds are unobstructed. Nothing notable was observed in these holds except thick silt. There are boom and rigging remnants scattered around the deck, and the electric motors that serviced the booms are present at each cargo hatch. The deck is otherwise relatively free of debris, but a thick silt layer covers the wreck's surface. The sediment rate is relatively low (1.52 millimeters per year), suggesting the sediment covering the site are from the sediment plume created when the vessel impacted the seafloor.

Figure 9.11. The top of the foremast laying over the No. 1 hold (looking aft).

On the aft deck, the view into the Nos. 4 and 5 holds are unobstructed. In the No. 4 hold, directly aft of the bridge, there is a bulky material, possibly bauxite, covered with silt that is built up higher than in any of the other holds. The mizzen (aft) mast is absent, leaving only one of the three masts present on the vessel's deck.

There is a slight, but noticeable twist in the hull between the superstructure and stern along the port side. The ship's name "*ALCOA PURITAN*" and homeport "NEW YORK" are visible embossed across the stern.

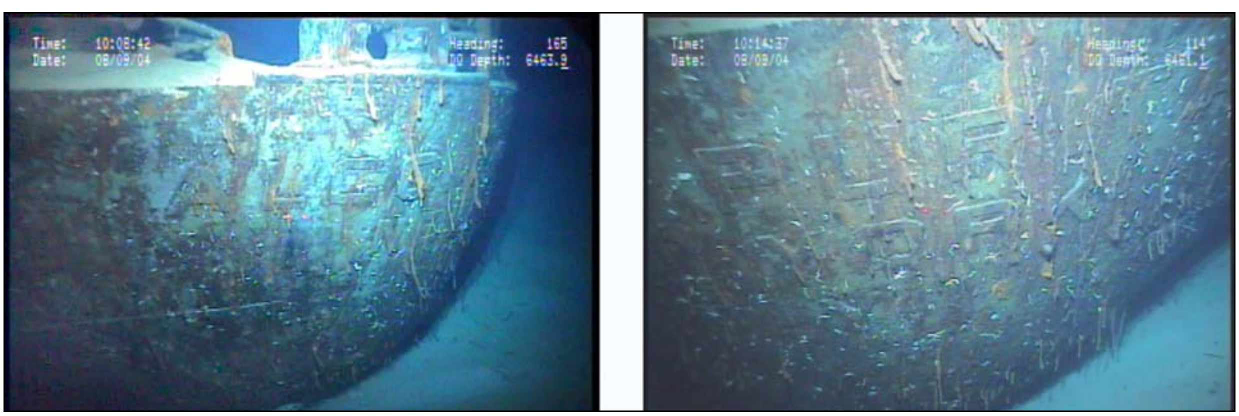


Figure 9.12. On the port stern quarter the word "ALCOA" is visible with the word "NEW" beneath (left), and on the starboard stern quarter the word "PURITAN" is visible with the word "YORK" beneath (right)

The geophysical survey data did not indicate an extensive debris field surrounding the wreck site. The ROV survey lines were run parallel to the vessel. Two survey lines were run the entire planned length of 760 meters. One line ran directly over the vessel and the other ran to the southwest or starboard side of the vessel. These lines extended at least 300 meters past either end of the vessel. Six survey lines were run to the northeast or starboard side of the vessel, providing coverage out to 80 meters. These six survey lines extended 150 meters past either end of the vessel. The observed debris was limited, as expected, and only four scattered artifacts were recorded during this portion of the survey. The most notable artifact was one of *U-507*'s 105-mm shell casings located approximately 112 meters east of *Alcoa Puritan*'s bow (Figure 9.13). Archaeologists recovered the shell casing after the survey and sent it to Texas A & M University for conservation. The casing is now displayed at the National D-Day Museum in New Orleans, Louisiana.

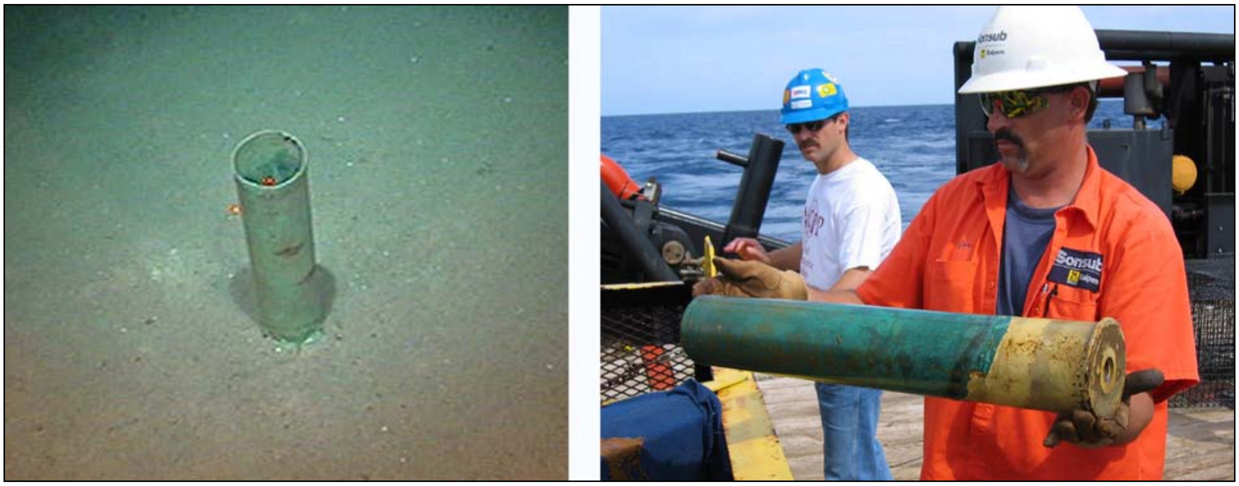


Figure 9.13. 105-mm shell casing found near *Alcoa Puritan* wreck site. Shell casing standing upright on the seafloor (left), ROV Superintendent Joey Lecovick holds the shell casing with Chief Scientist Robert Church looking on after recovery (right).

Two survey lines were run approximately 675 meters to the south in an attempt to locate any additional shell casings or debris. No other shell casings were found during the survey despite historical accounts that *U-507* expended approximately 75 rounds at *Alcoa Puritan*. After *Alcoa Puritan* sank and the survivors were in lifeboats and rafts, the freighter's third mate reported seeing the U-boat's crew throw the used shell casings down a hatch into the U-boat (Conwell 1986: 70). This may explain why more shells were not found.

Three transect survey lines were run 300 meters north of the vessel location. A large debris field was discovered on these transects. Additional survey lines were ran to document this debris zone. Investigations indicated the debris field covers a 213 meter by 213 meter area and contains large sections of wreckage, including a ship's mast and telegraph (Figures 9.14 and 9.15). The mast in the debris zone stands proud of the seafloor at a 45-degree angle. Only its top is visible as the lower portion is deeply embedded in the seabed. It is impossible to discern how much of the mast is intact, but there is a sufficient amount in the seafloor to allow the mast's heavy top section to remain upright. The observed artifacts included twisted sheet metal, pipe, and railing. Some items such as chair remains and several heavily constructed panels (probably hatch covers) were also noted (Figures 9.16 and 9.17). The steel panels measure 2 meters by 12 meters and appeared to be upside down.

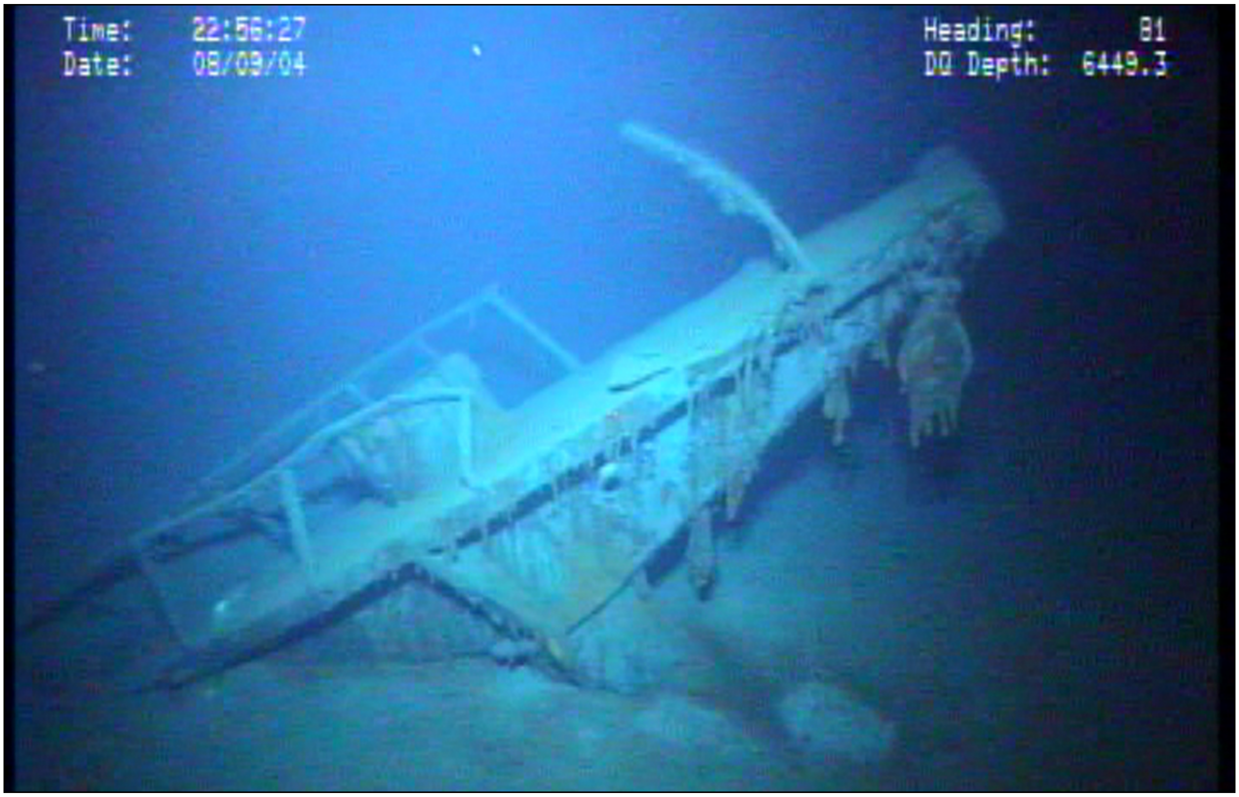


Figure 9.14. Top of one of the masts from *Alcoa Puritan* found embedded in the seafloor in the wreck's northern debris field.

Figure 9.15. Bridge telegraph or rudder control from *Alcoa Puritan* within the northern debris field.

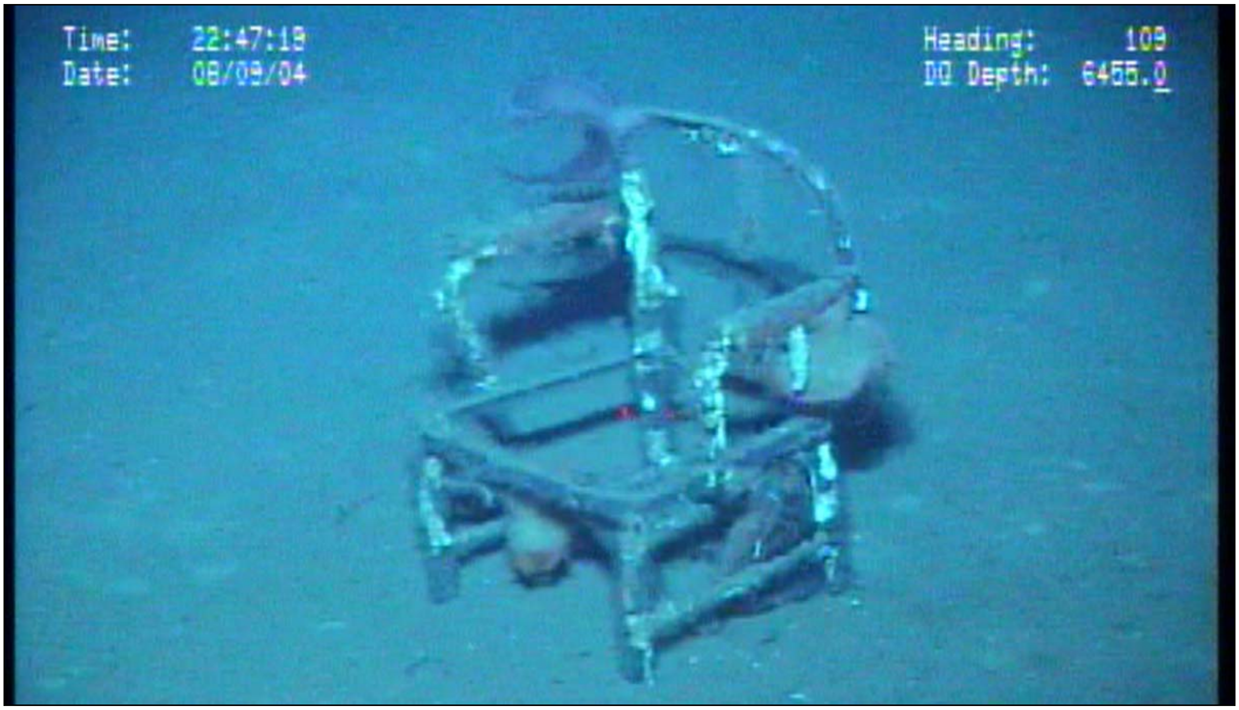


Figure 9.16. Chair found lying on the seafloor within the northern debris field.

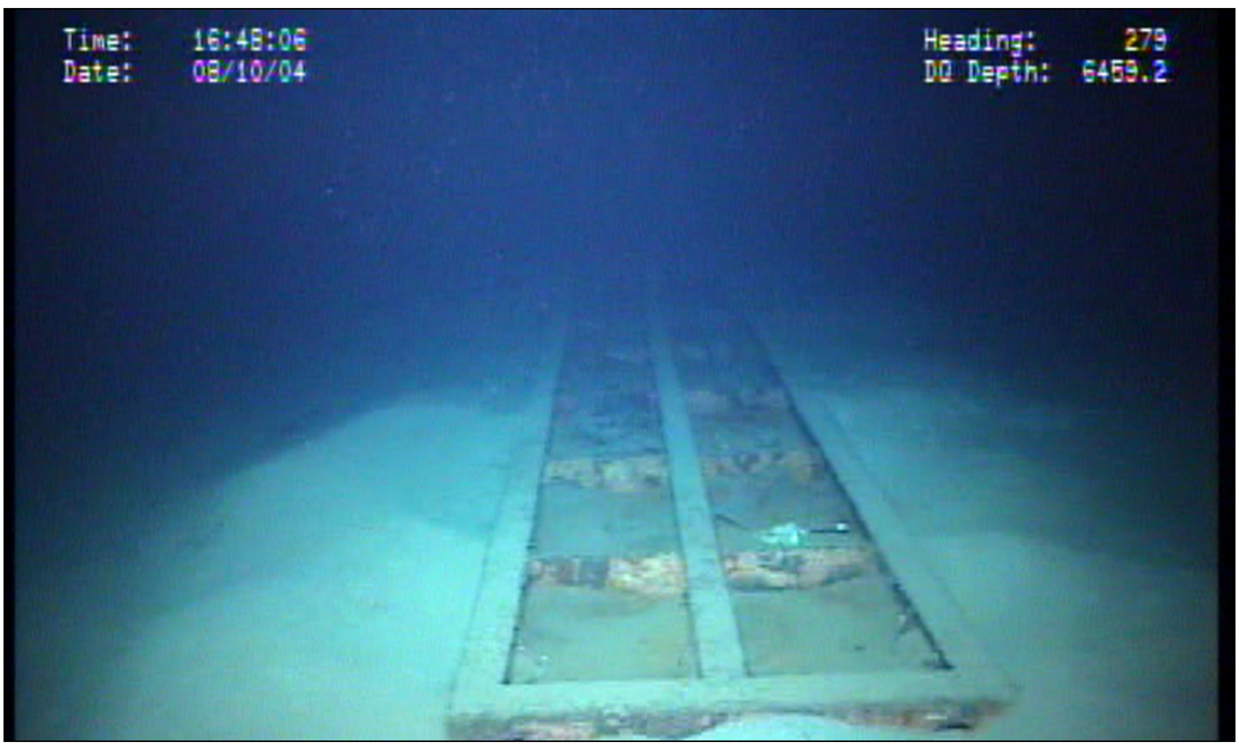


Figure 9.17. Hatch cover section found lying on the seafloor north of the wreck site.

The distribution of materials at the site supports the historical accounts regarding *U-507's* attack on *Alcoa Puritan*. *U-507* chased *Alcoa Puritan* from the south, finally crippling the freighter with a shot from its deck gun. The U-boat then torpedoed the freighter to finish it off near the location of the large debris field. The debris is distributed widely, as is to be expected of debris falling from the surface 1,966 meters to the seafloor below. The vessel reportedly sank quickly, but appears to have landed some distance south of where it was torpedoed.

9.4.2 Site Preservation

The wreck site is in a relatively good state of preservation. There is heavy damage to the vessel's port (northeast) and upslope side. Rusticle formations are considerably more extensive on this side of the vessel. For a detailed analysis of the bacteria activity and rate of deterioration of the site see the following microbiology analysis.

9.5 Discussion of Biological Findings

9.5.1 Microbiology

Gravimetric elemental analysis using ICP-AES of the rusticles recovered from the port and starboard sides of *Alcoa Puritan* are given in Table 9.2. The three dominant elements were iron (96%), sodium (3.7%), and magnesium (0.4 %). At 1,964 meters BSL, *Alcoa Puritan* was the deepest shipwreck investigated. The wreckage had the greatest density of brown rusticles in the study with 35% of the observable surfaces infested with brown rusticles (C1). These rusticles tended to be the narrower (less than 100 millimeters) and longer (up to five meters) and mostly clung to the hull rather than hanging down from it. In many ways this rusticle form may be similar to what occurred on *RMS Titanic* in 1974 after she too had been submerged for 62 years (Cullimore et al. 2001). While *RMS Titanic* has been the subject of many scientific investigations, with dives by submersibles or remotely operated vehicles in 1996, 1998, 2001, 2003, 2004 and 2005, (Cullimore and Johnston 2005) The natural iron extraction from the steels is still the subject of an ongoing investigation (Garzke et al. 1997). Four steel test platforms (one Mark I, two Mark II and one Mark III) have been deployed since 1998, and three have since been recovered for analysis (Cullimore and Johnston 2000). Based on available data, microbiologists developed a model projecting the Titanic's rate of the deterioration (Ballard 2004). From these parallel investigations of rusticle impact on vessel deterioration, further analysis can be made on the rusticle growths at *Alcoa Puritan* (Cullimore and Johnston 2005). It could be considered that *Alcoa Puritan* is generating similar types and intensities of rusticle infestations to those currently being observed at *RMS Titanic*. Given that *Titanic* sank in 1912 and *Alcoa Puritan* sank in 1942, the rusticle growth appears to be following a similar progression. This indicates that structural deteriorations of the steel superstructures will be apparent by the 2020's for *Alcoa Puritan* if the trends continue.

Dendritic concretions (C3) were observed over 65% of the observable surface area but they were generally thin (three to eight millimeters) and thin slimes (B1, one to two millimeters) were present on 15% of the surfaces. Sea anemones were rarely observed on the shipwreck and had a density of only 0.1 organisms per square meter. Significant electrical activity was detected on the bio-battery platforms (Figure 9.18)

Table 9.2

Gravimetric Elemental Analysis of a Brown Rusticle (C1) from *Alcoa Puritan*

Iron	95.636%		Vanadium	0.014%
Sodium	3.277%		Molybdenum	0.010%
Magnesium	0.376%		Strontium	0.009%
Calcium	0.247%		Cadmium	0.007%
Potassium	0.197%		Barium	0.005%
Phosphorus	0.140%		Lead	0.005%
Manganese	0.034%		Zirconium	0.001%
Aluminum	0.023%		Chromium	0.001%
Boron	0.016%			

An opportunity arose to test a 6" x 6" coupon of mild steel coated with "Royal Copper" (a mixture of copper flakes in an epoxy binder). Royal Copper is a hard non-leaching and abrasion resistant coating. This coating is widely used on surface ships to prevent fouling of the exterior hull and between double hulls. Given the extreme nature of the deep-sea environment at *Alcoa Puritan*, it was decided to include a Royal Copper coupon when the bio-battery platform was deployed. Site exposure time was two days before the coupon and bio-battery were recovered. Sixty-seven pitted areas were recognizable on the coupon where copper particles had been lost from the epoxy binder. All of these pitted sites were easily recognizable due to the discoloration of the brilliant copper colored surface to a dull matt gray. In all cases the edges of these pitted regions were very irregular, but generally had an ellipsoid or circular form. Average diameters ranged from one to 13 millimeters with the average size being approximately eight millimeters. Fourteen percent or 33.7 square centimeters of the total 234 square centimeter surface area had already been compromised by the copper particle loss. If this were a linear rate of loss all of the copper would be stripped from the epoxy binder in fourteen days. Clearly the test was in an environment far harsher than would be experienced on, or inside, a surface ship's steel hull, but it demonstrates the potential value of using deep ocean environments for corrosion testing of novel materials, coatings, and composites.

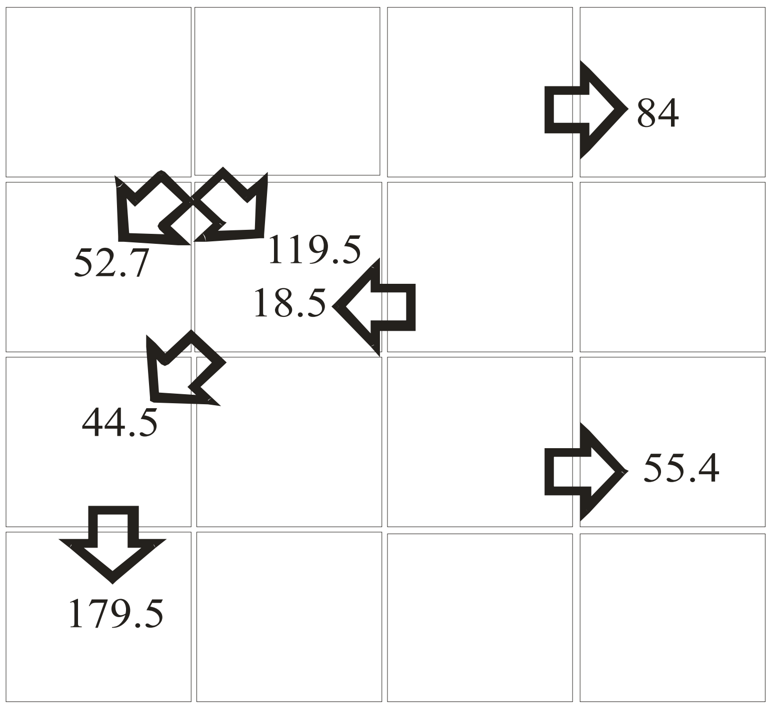


Figure 9.18. Voltages (millivolts) detected on bio-battery coupons deployed on *Alcoa Puritan*.

9.5.2 Invertebrate Zoology

Many of the deepwater invertebrate species are widely distributed or cosmopolitan. A bright red carid shrimp, *Notostomus* sp., a member of the deepsea shrimp family Oplophoroidea, was observed in low numbers on four of the six transects (Table 9.3). The shrimp observed in the videos resembled *N. gibbosus*, which has been reported from the western Atlantic Ocean, and also around Hawaii and in deepwaters on the east coast of Australia. The genus, however, has at least 11 congeners, which are widely distributed. Squat lobsters belonging to the genus *Munidopsis* are extremely speciose, and 23 species of the genus have been reported from Cuba. Squat lobsters were observed in four of the nine transects conducted at the *Alcoa Puritan* site; all appeared to be of the same species, but this could not be confirmed without collections. Elaspodid sea cucumbers were observed on seven of the nine transects. These swimming cucumbers are deposit feeders, settling to the benthos to feed on organics in the sediment, and become more common with increasing depth. These delicate cucumbers generally are torn during collection and transit to the surface.

Table 9.3

Density (number per 100 $m^{-2)}$ of Invertebrates Observed on Transects Over, Adjacent, and Distant (300 m) from the *Alcoa Puritan* site.

	Transect Number								
	Distant			Adjacent			Over		
Alcoa Puritan	**500**	**501**	**502**	**516**	**517**	**518**	**519**	**520**	**521**
Crustaceans									
Munidopsis sp.	0.4	0.0	0.2	0.0	0.2	0.0	0.0	0.0	12.2
Shrimp (cf. *Notostomus gibbosus*)	0.2	0.2	0.6	0.0	1.0	0.7	0.0	0.0	0.0
Unidentified crustacean	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Echinoderms									
Elasopodid cucumber	1.2	0.7	0.8	0.7	0.7	0.0	0.0	0.2	12.2
Holothurian	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sea star	0.0	0.3	0.6	0.1	0.0	0.0	0.0	0.0	0.0
Cnidarians									
Anemone	0.2	0.4	0.3	0.0	0.0	0.0	2.5	0.1	0.0

Sediment at *Alcoa Puritan* and all deeper sites, although still predominantly clay and silt, had fewer biogenically derived pellets. Nematodes were the most abundant meiofauna taxon in samples at *Alcoa Puritan*, followed by harpacticoids and polychaets (Table 9.4). Densities of all taxa were unusually low in comparison to those found in the shallower sites, as expected for a deeper site. The order of magnitude difference in abundance of specimens in the two cores is probably the result of the spillage of Core B during processing.

Table 9.4

Density of Meiofauna (numbers per 10 cm^2) from Sediment Cores Collected Adjacent to and Away from *Alcoa Puritan*.

Wreck	***Alcoa Puritan***	
	Number per 10 cm^2	
Taxon	Core A	Core B*
Harpacticoida	3.6	0.0
Isopoda	0.0	1.8
Nematoda	257.5	30.8
Polychaeta	1.8	1.8
Unknown	3.6	0.0

*Spilled sample while sieving, may have affected total counts.

Sixty-three specimens belonging to eight taxa were collected, mainly from fish traps and the suction sampler. The red deep-sea crab (*Chaceon quinquedens*) was the predominant species and 48 specimens were collected, but a hermit crab of the genus *Parapagurus* was also collected. Although not observed in the transects, *Munidopsis* sp. and *Bathynomous giganteus* were also collected in the traps. A number of sea cucumbers and a single echinoid were collected. The largest of the three articulate brachiopods (lamp shells) collected was only nine millimeters in diameter; all were of the same species, perhaps belonging to the genus *Terebratulina*.

Table 9.5

Macroinvertebrate Species Collected at the *Aloca Puritan* site, Including Number and Proximity to Wreck, Substrate, and Depth.

Alcoa puritan					
Specimen ID	**Number Near Wreck (< 61 m)**	**Number far from wreck (>61 m)**	**Unknown collection location**	**Substrate**	**Depth (m)**
Crustacea					
Bathynomous giganteus		2		Silt, Water Column	1968
Chaceon quinquedens	48			Silt; Traps	1966
Munidopsis sp.		3		Debris; Water Column	1965-1969
Parapagarus sp		1		Silt	1968
Polychaeta					
Sepulidae	1			Wreck	1960-1968
Brachiopoda – cf. *Terebratulina*	3			Wreck	1960-1968
Echinodermata					
Holothuroidea		4		Silt; Water Column	1966-1969
Echinoidea		1		Silt	1965-1970

Scleractina, Antipatharia, and Gorgonacea

None observed at this site.

9.5.3 Vertebrate Zoology

Fish Community Structure

Visibility at *Alcoa Puritan* was good. The mean transect width over the ship was approximately 7.1 meters (Table 9.6). Transects flown adjacent to and away from the wreck averaged 5.3 meters wide. The difference in mean width was due to the ROV maintaining a greater distance from the wreck than the seafloor when flying transects.

Ichthyofaunal diversity was low at *Alcoa Puritan* (Tables 9.6-9.8). As was true of *U-166* and *Robert E. Lee*, the fish community observed over the wreck was similar to that observed away from it. Fishes observed included cuskeels (Order: Ophidiiformes), Halosaurs (Family: Halosauridae), grenadiers (Family: Macrouridae), and a tripod fish (Family: Ipnopidae). Individuals could not be identified below order or family from video and no fishes were captured in traps or with the suction sampler at *Alcoa Puritan*. Thus, no samples were available for gut content, stable isotope, or age and growth analyses.

Table 9.6

Abundance and Density Estimates for Fish Taxa Identified from ROV Video During Biological Sampling Over, Adjacent to, and 300 Meters Away (distant) from *Alcoa Puritan*.

Transect Line	**Relation to Ship**	**Taxon**	**Min Count**	**Max Count**	**Min Density 100 m^{-2}**	Max Density 100 m^{-2}
521	Over	Halosauridae	1	3	12.23	36.68
516	Adjacent	Teleost	1	1	0.15	0.15
517	Adjacent	Halosauridae	1	1	0.24	0.24
518	Adjacent	Halosauridae	1	3	0.18	0.53
		Teleost	1	2	0.18	0.35
500	Distant	Halosauridae	1	2	0.19	0.29
		Ipnopidae	1	1	0.10	0.10
		Macrouridae	1	1	0.10	0.10
		Ophidiiformes	1	1	0.10	0.10
		Teleost	1	2	0.10	0.20
501	Distant	Halosauridae	2	3	0.19	0.29
		Teleost	1	1	0.10	0.10
502	Distant	Teleost	1	2	0.11	0.23

Table 9.7

Abundance of Fish Taxa Identified from Video Collected at Alcoa *Puritan* on Other Than Biological Transects. (Location indicates if video was collected over or away from the ship.)

Location	**Taxon**	**Min Count**	**Max Count**
Over Ship	*Aldrovandia gracilis*	1	1
	Cataetyx laticeps	1	1
	Rajella purpuriventralis	1	1
	Halosauridae	2	26
	Ipnopidae	1	2
	Ophididae	1	1
	Ophidiiformes	1	2
	Teleost	1	13
Away from Ship	*Aldrovandia gracilis*	2	8
	Dicrolene kanazawai	1	1
	Halosauridae	2	96
	Ipnopidae	1	5
	Macrouridae	1	1
	Ophidiidae	1	5
	Anguilliformes	1	2
	Ophidiiformes	1	10
	Teleost	2	52

Table 9.8

Estimated Total Fish Lengths Observed on Video at *Alcoa Puritan.*
(All individuals were captured on video with both ROV-mounted lasers striking them.)

Taxon	Number Measured	Mean TL mm	Standard Deviation	Range TL mm
Aldrovandia gracilis	3	619	230.4	370-826
Cataetyx laticeps	1	914		
Dicrolene kanazawai	1	640		
Halosauridae	21	433	167.4	265-847
Ipnopidae	3	235	150.9	131-408
Ophidiidae	4	190	33.0	149-227
Anguilliformes	1	154		
Ophidiiformes	3	393	314.1	206-756

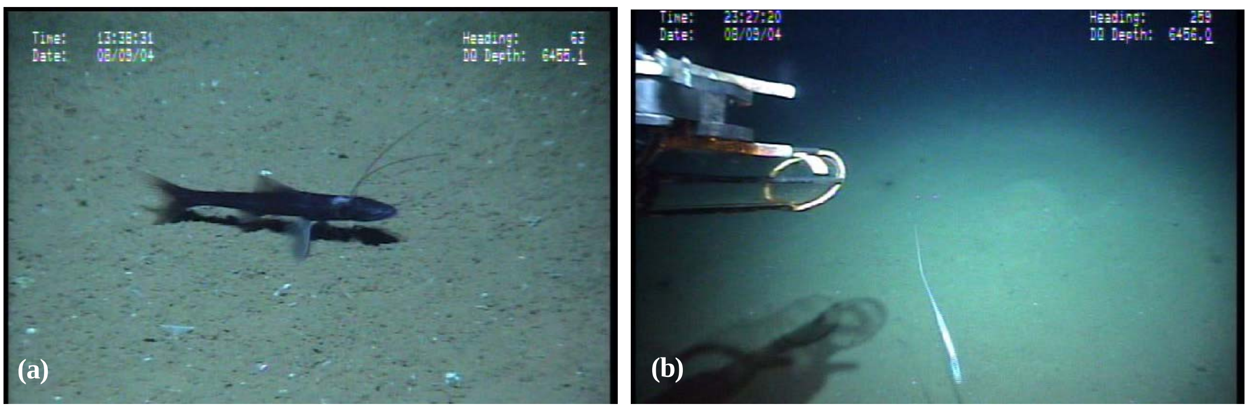


Figure 9.19. (a) a tripod fish and (b) a halosaur captured during video sampling at *Alcoa Puritan*.

9.6 Sediment Core Analysis

Four samples were taken at the designated distance from the ship. Each sample, after be brought to the surface was removed from the sampling device and stored in a clean glass container at approximately 4° Celsius. *Alcoa Puritan* core samples did not indicate any visible differences. They all appeared to be smooth, gray/black sediment with a sour smell. The sour smell is indicative of the anaerobic biological activity (sulfate reduction) normally found within sediment samples. The core sample's lower portion did have small rocks mixed within the sediment. The rock samples were approximately two to three centimeters in diameter. Samples were sent to a certified laboratory for organic chemistry analysis (Table 9.9). The *Alcoa Puritan* site samples from the four cores indicated that the core sample closest to the ship was positive for the hydrocarbons in the C6-C10 range, indicating that gasoline-type hydrocarbons are present. The sample taken from the furthest point also tested positive for trace amounts of hydrocarbon in the C10-C14 carbon range. The positive samples were then analyzed using gas chromatography. Concentrations are as indicated:

Table 9.9

Alcoa Puritan Core Analysis

Site	**Date**	**Sample Location**	**Concentration**
Alcoa Puritan	August 10, 2004	Beside Ship	<1 ug/g
		30 meters	<1 ug/g
		152 meters	<1 ug/g
		305 meters	16 ug/g

10.0 *ANONA* SITE

10.1 Historical Background of the Steam Yacht *Anona*

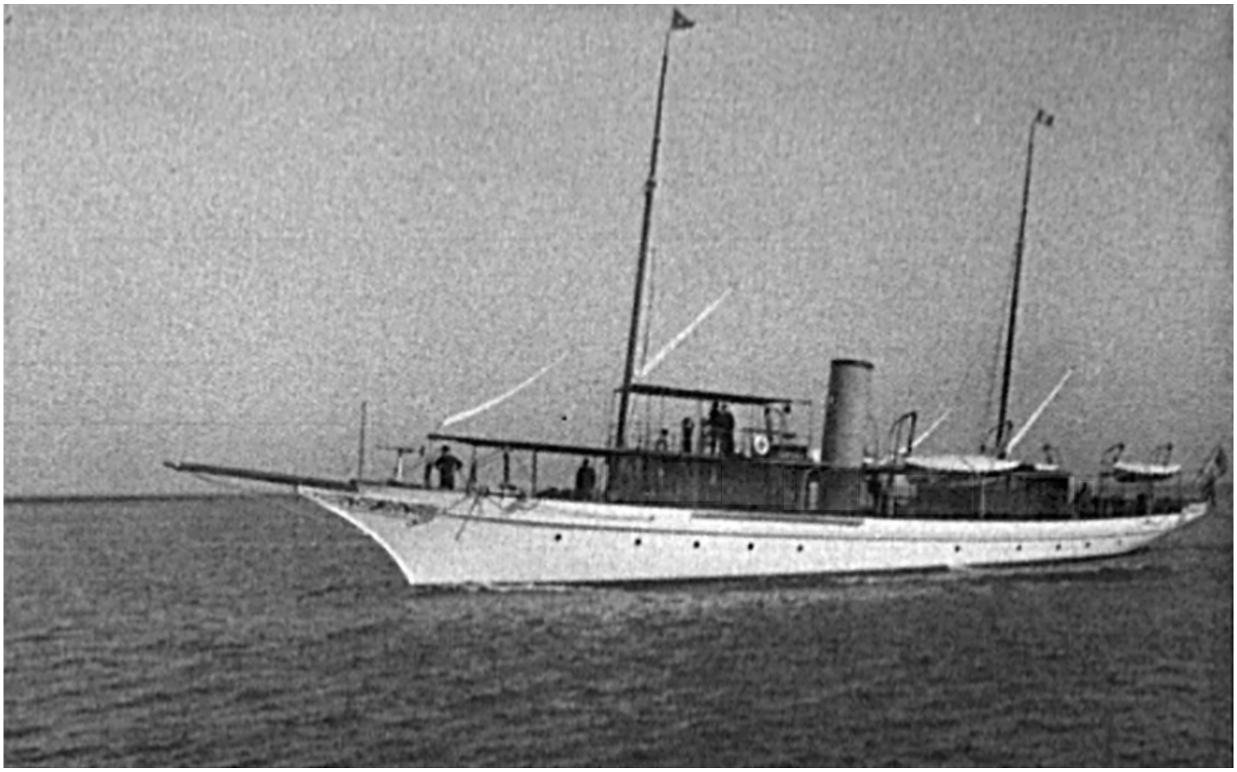


Figure 10.1. Steam Yacht *Anona* circa 1906-1915 (Courtesy Library of Congress Detroit Publishing Company Collection).

Anona (Figure 10.1) was a steam yacht commissioned by Theodore DeLong Buhl, a wealthy Detroit Industrialist in 1904 from the master yacht builders George Lawley and Son, Boston, Massachusetts. *Anona* was built during the heyday of steam yacht construction for the owner of Buhl Sons Company, Detroit for use on the Great Lakes. She was built and designed by a yard that had already produced two America's Cup winners, *Puritan*, and *Mayflower* (MacTaggart 2001:67). *Anona* displaced 146 gross tons. Her steel hull was 136 feet (length over all), 110 feet at the waterline, a 17 feet 5 inch beam, and drew only 7 feet 6 inches of water. She had two masts, a propeller, an elliptical stern, and graceful swept bow (Figure 10.2 and 10.3). A three-cylinder Lawley engine gave *Anona* a cruising speed of 12 knots and a maximum speed of 13.5 knots. A generator provided power for electrical lighting. According to the yacht journal, *The Rudder*, *Anona* was well adapted for coastal and Great Lake's use, and her beautiful accommodations included four staterooms, a piano, two full service heads, a saloon and a pantry, all finished in mahogany and teak (*Rudder* 1908). In 1907, while registered in the Port of Detroit, it was under the control of the Detroit Trust Company, the firm that was administrating Theodore Buhl's estate following his death in April 1907 (Whittington 2002). In 1908, ownership of *Anona* was transferred to Mrs. J. Elizabeth Buhl, Theodore Buhl's wife and the daughter of Canadian Club Whiskey Distillery founder Hiram Walker. The yacht remained in the Buhl family until it was transferred to Alfred E. Mathers in 1924.

Mathers changed the registry from American to Canadian shortly after taking possession of the yacht. He retained ownership of *Anona* until 1926 when, possibly because of Mathers' death, it came under the ownership of the Canadian Trust Company of London, Ontario. *Anona* remained under the control of this Trust until at least 1931, but disappeared from the registries until 1936. The owner at that point was John Wigle of Windsor, Ontario. Wigle retained ownership until 1937 when the yacht was sold to the Ye Olde Towne Hotel located in Toronto, Ontario. A year later, *Anona* was sold to Karl A. Eyre of Timmons, Ontario who owned the yacht until 1943 when it came under control of the Pan-American Banana Producers Association of Montreal, Quebec (Milwaukee Public Library

1989). Under the Pan-American Banana Producers Association *Anona* was no longer used as a recreational yacht, but instead hauled freight between the West Indies and North America. In June 1944, *Anona* was bound for the British West Indies with a load of potatoes when the lower steel hull plates buckled and *Anona* sank in the Gulf of Mexico. After two days adrift all nine crew were rescued by American PBY aircraft and returned to shore (Time-Picayune 1944).

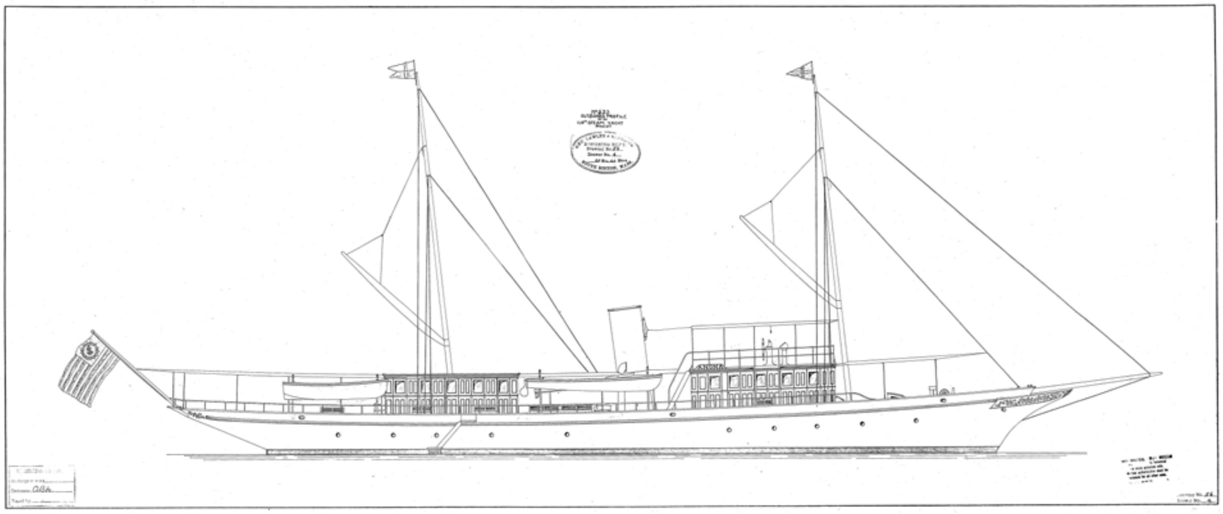


Figure 10.2. Out board profile of the steam yacht *Anona*, drawn by the George Lawley and Sons Corporation, April 20, 1904 (from the Haffenreffer-Herresheff collection, Nautical MIT Museum).

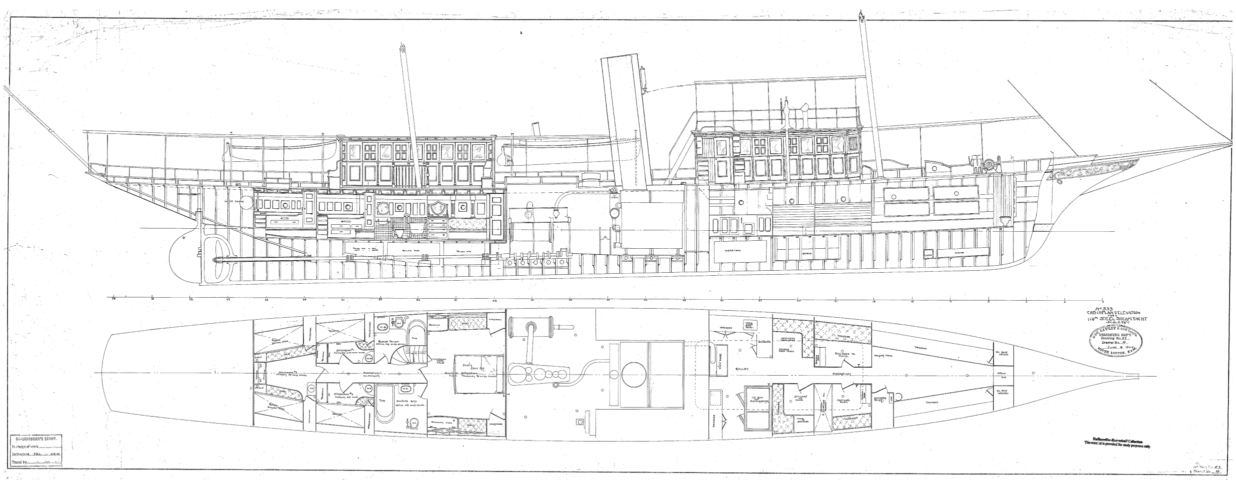


Figure 10.3. Cabin plan and elevation drawing of the steam yacht *Anona*, by the George Lawley and Sons Corporation, June 8, 1904 (from the Haffenreffer-Herresheff collection, Nautical MIT Museum).

10.2 Previous Investigations

Oil And Gas Exploration

In 1995, an oil and gas survey by Fugro, Inc., detected an unknown shipwreck in the Viosca Knoll Area. The survey was performed with a deep-tow side scan sonar, which depicted a wreck in approximately 1,219 meters of water. The vessel was identified as a probable crew boat based on the sonar image and the presence of linear debris, interpreted as pipe, in the wreck's vicinity (Warren 2002).

During May 2002, BP Exploration (BP) contracted C & C Technologies, Inc. (C & C) to perform a site-specific archaeological study over the shipwreck site as part of a larger block study. This site-specific survey was carried out on May 9, 2002 using the *C-Surveyor I* AUV.

The project's survey grid provided overlapping wreck site coverage. Nine lines were run northwest to southeast, parallel to the wreck site and a possible debris field north of the wreck site. One line was run over the wreck site to obtain multibeam bathymetry data, the first two wing lines were run at 25 meter spacing from the wreck site, and the remaining six wing lines were run at 50 meter spacing from the wreck site. Eight tie lines were run northeast to southwest over the shipwreck area and the possible debris field to the north to provide additional coverage. The site specific survey lines were run utilizing a 410 kHz side scan system and EM 2000 multibeam system.

Sonar data showed the partially buried remains of an unknown vessel at the wreck's reported location (Figure 10.4). Approximately 42.67-meters long and 5.18-meters wide at the beam, the vessel seemed relatively intact. The data indicated the ship is oriented with the bow to the southeast on a seafloor slope. The vessel is upright on the seafloor but listing slightly to starboard. Water depth at the wreck location is approximately 1,258 meters BSL. A moderate debris field was observed around the wreck. Sonar imagery indicated the ship has a sweeping bow and a squared stern with the widest point amidships. Near the vessel's center is an area of debris that reaches 0.61 to 2.13 meters above the deck. Thirteen unidentified sonar contacts were noted during the site-specific survey. The majority of these contacts were located north of the wreck site and it was hypothesized that they represented debris that was dislodged from the vessel as it sank. The debris distribution suggested the vessel was lost north of its current position.

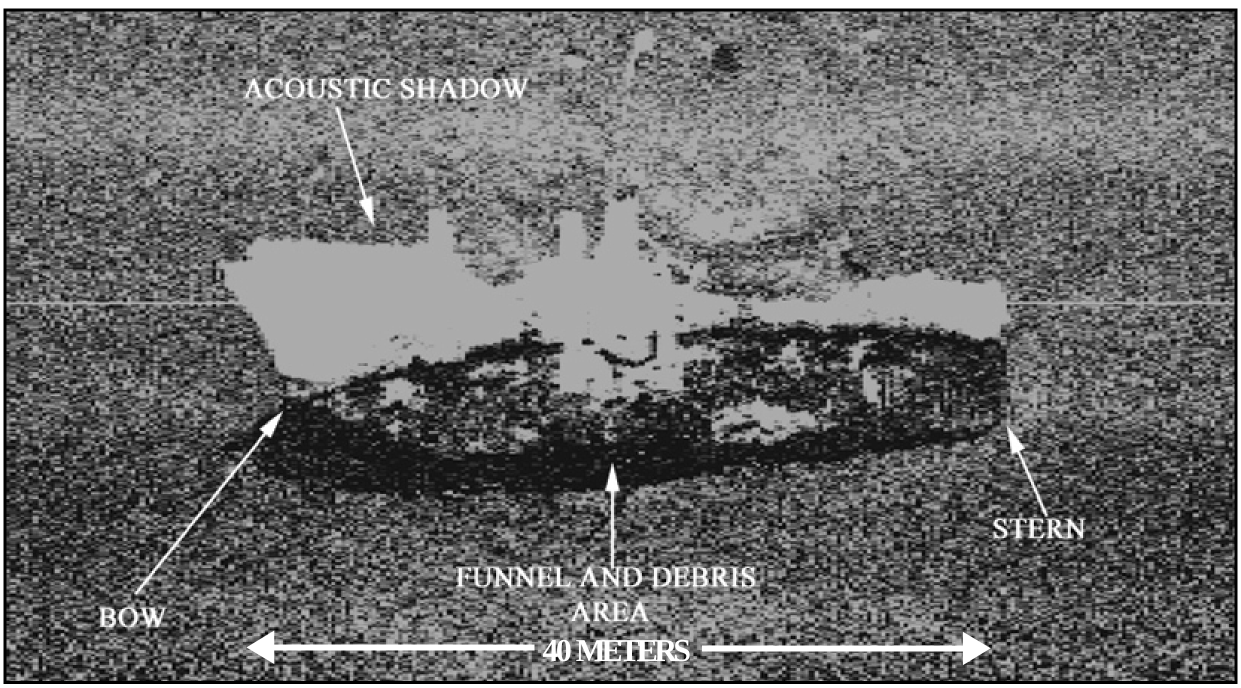


Figure 10.4. High-resolution side scan image of *Anona* (Courtesy of BP Exploration).

Multibeam bathymetry data collected during the site-specific survey was processed and displayed in Fledermaus, a three-dimensional visualization program. The multibeam imagery verified the sonar data interpretation. Dimensions of the area of relief amidships noted on the sonar images were confirmed from the multibeam data. The debris area was found to be approximately 9.14-meters in length, 4.27-meters wide, and at the highest point protrudes 2.13-meters above the rest of the vessel. A plan of the wreck produced in Fledermaus shows the area of debris amidships (Figure 10.5).

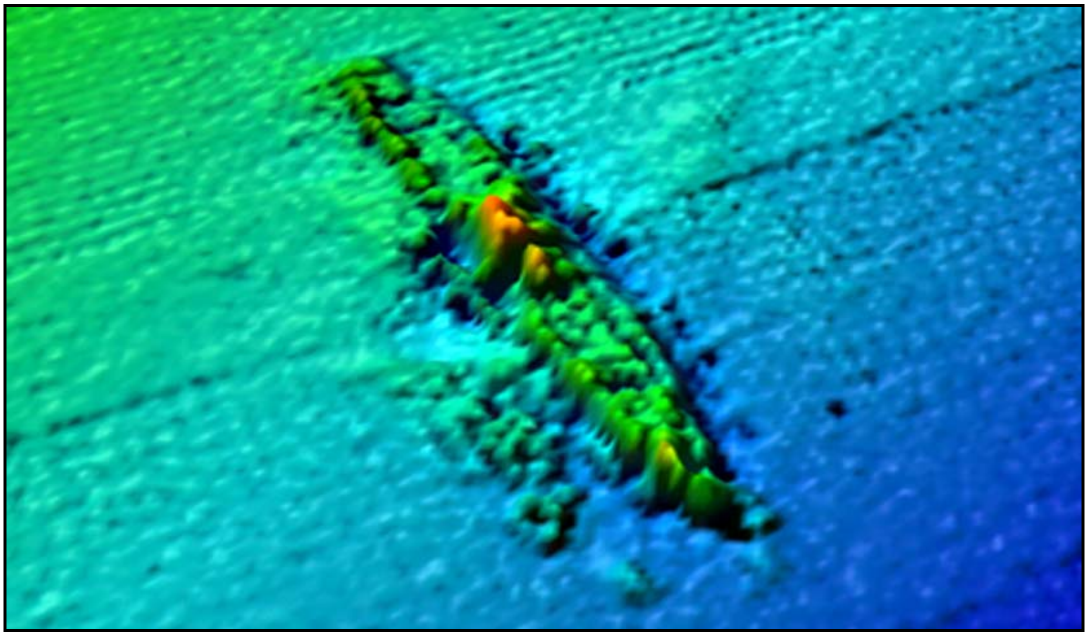


Figure 10.5. Fledermaus multibeam image of *Anona* wreck site (Courtesy of BP Exploration).

In June 2002 BP contracted Oceaneering International to undertake a ROV investigation of the wreck. Imagery from the survey showed a single deck vessel sitting upright on the seafloor but listing slightly to starboard as indicated in the side scan sonar and bathymetry data. The hull appeared to be carvel constructed of iron plate riveted to iron framing. The portion of the hull above the mud line appeared intact and in a good state of preservation, albeit covered with a variety of biological growth.

The video images confirmed the bow's sharp cutwater seen on the side scan sonar data. A bowsprit support extended out from the stem, but the bowsprit is gone. The trail board on both sides of the bow displays ornate metal work representing an intricate botanical pattern (Figure 10.6). No lettering indicating a vessel name was seen in this area although it may be covered by biological growth (Figure 10.7).

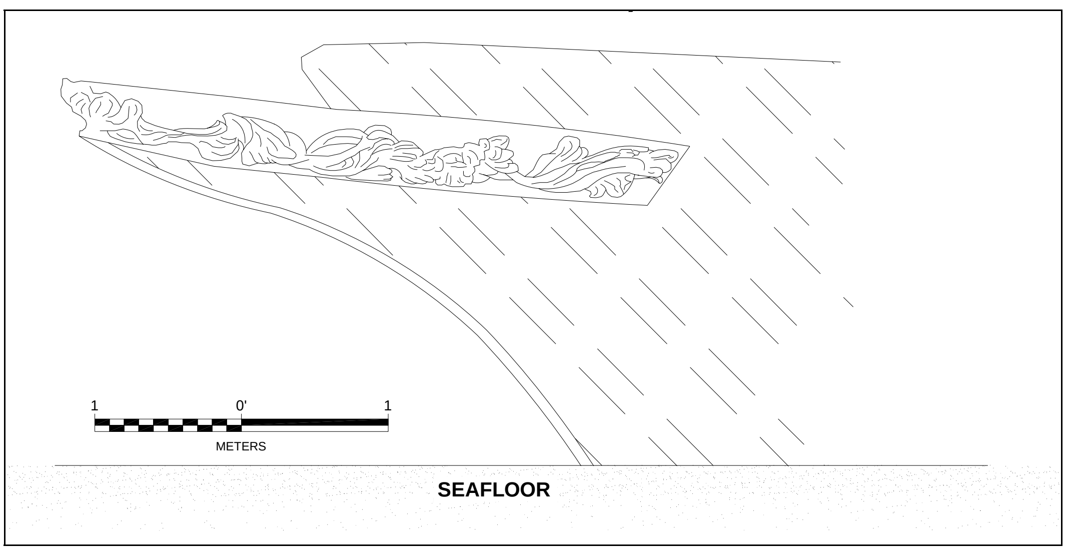


Figure 10.6. Profile drawing of trail board on *Anona*'s bow (Drawing by Robert A. Church).

In the forecastle area, a steam powered windlass sits aft of the bowsprit deck bracket. On either side of the windlass, near the gunwales, are single davits that may have acted as catheads to assist in securing the anchors. Two anchors are visible on either side of the bow adjacent to the windlass. They are at or near the locations where they would have been secured during transit. At least one appears to be a variant of the fisherman's anchor known as a close-stowing anchor. In the area of the forecastle deck aft of the windlass, the decking appears partially intact. A collapsed hatch combing is visible in this part of the deck. The entire forecastle area is littered with extensive amounts of debris including exhaust and vent pipes, electrical wire, wire rigging, and what appears to be a fire extinguisher among other items. Through an open portion of the forecastle deck a series of interconnected tubes are visible (Figure 10.8).

Figure 10.7. Detailed floral scrollwork depicting a plant on *Anona*'s bow (Courtesy of BP Exploration).

Figure 10.8. Extant decking and exposed piping on *Anona*'s forecastle (Courtesy of BP Exploration).

The area of relief visible on the side scan sonar data near the wreck's mid-section was identified as a single smokestack and possibly a piece of engine-related machinery. The stack and machinery indicate the vessel was probably steam-powered and utilized screw propulsion. The stack and machinery are resting on an area of deck reinforced with iron beams. Aft of the stack remains, the deck is strewn with more debris, including what appears to be a possible heat exchanger for a condenser or small engine (Figure 10.9).

Figure 10.9. Debris on *Anona*'s deck; the rectangular object in the upper right may be a condenser or small engine (Courtesy BP Exploration).

ROV imagery indicated several radial lifeboat davits were in their original positions and another had fallen across the vessel's aft deck. A gangway opening is clearly visible near the starboard stern area. Another hatch combing appears to have fallen between the iron frames in the after deck area. At the vessel's stern the deck planking has disintegrated exposing the internal framing and steerage mechanism (Figure 10.10). The propeller and rudder are not visible because of the silt deposits around the stern. The stern appears to be elliptical but no name was distinguishable.

Figure 10.10. Filtered image of *Anona*'s steering mechanism and internal framing (Courtesy of BP Exploration).

Based on data acquired during the 2002 AUV and ROV surveys, it was determined that the 1995 assessment of the wreck as a modern crew boat was incorrect. Using the side scan sonar and ROV imagery the wreck was determined to be a steam/sail powered vessel from the late 19^{th} to early 20^{th} Centuries. Part of this research focused on the bow's intricate botanical design (Figure 10.6 and 10.7). Three historic shipwrecks are reported lost in the area. One of the vessels, named *Anona*, was reported lost 14.4 kilometers north of the wreck site. Historical research focusing on *Anona* turned up two photographs and construction information indicating it was a steam yacht. After careful comparison of the Viosca Knoll wreck's physical remains and *Anona*'s photographic record this vessel was identified as *Anona*. The vessel's architectural drawings were found through archival research focusing on *Anona*. Figures 10.11 and 10.12 are artistic 3-D modeling representations of *Anona* based on the extensive architectural drawings.

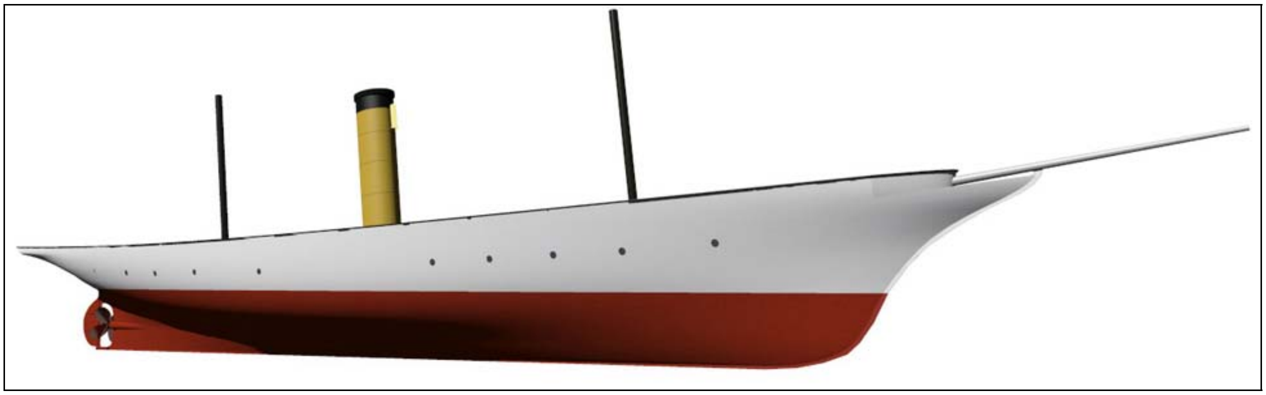


Figure 10.11. Hull profile of Steam Yacht *Anona* (Illustration by Andy Hall and the PAST Foundation).

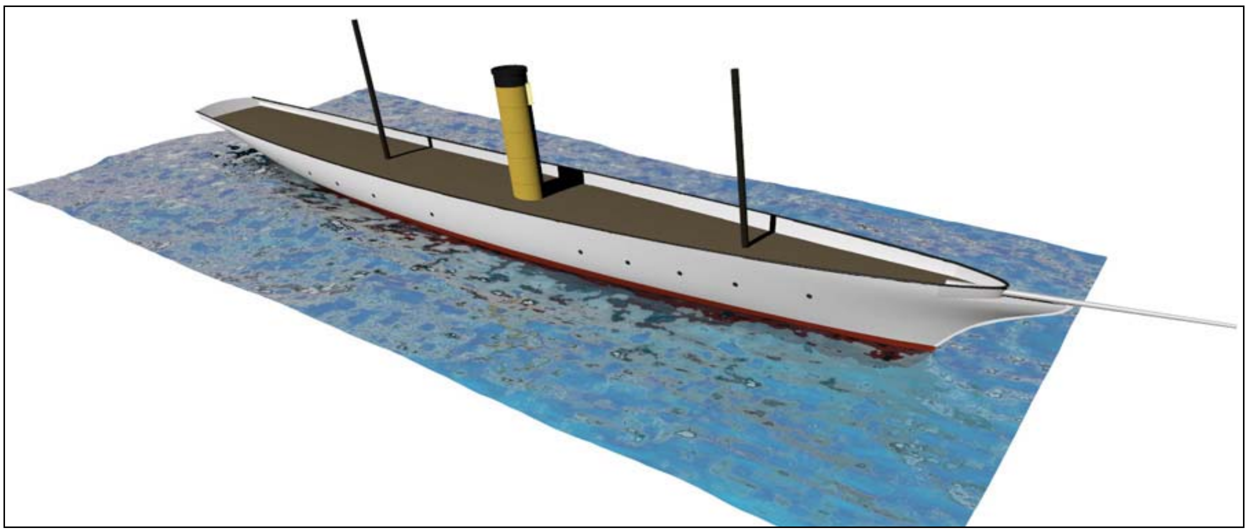


Figure 10.12. Waterline view of Steam Yacht *Anona* (Illustration by Andy Hall and the PAST Foundation).

10.3 Geographical Setting

The survey area is located in the southeastern corner of the Viosca Knoll Area of the Gulf of Mexico. The regional geology in this area is part of the northeastern Mississippi fan (upper fan), which is defined as a channel-levee-overbank system (Bouma et. al. 1985). The Mississippi fan is a submarine fan in the northeastern deep Gulf of Mexico. During Middle Miocene, a pronounced eastward migration of ancestral Mississippi River depocenter occurred and progradational sediments were deposited east of the present-day Mississippi River delta. Submarine fan deposition was extended into South Pass and the Viosca Knoll Areas during this epoch. The last progradational sediment across the Viosca Knoll Area occurred in Upper Pliocene when the depocenter migrated basinward and westward and submarine fan facies expanded into deep water across a wide area from Garden Banks to Viosca Knoll Areas (Hunt and Burgess 1995; and Lee and George 2002).

10.4 Discussion of Findings – Archaeology and Biology

Before the project team could investigate the *Anona* wreck site, Tropical Storm Bonnie developed in the central Gulf of Mexico. Bonnie's path carried it almost directly over *Anona*'s location preventing archaeological or biological investigations of the site during the 2004 project season.

11.0 SHIPWRECK DEBRIS DISTRIBUTION MODEL

Three primary debris distribution patterns were observed during this study (Figure 11.1-3). The first pattern is centralized debris scatter (Figure 11.1). In this pattern debris is densely distributed near the wreck's main section(s) and widely dispersed at distances away from it. The debris is usually distributed unevenly over the wreck site. This pattern is best illustrated by the *Robert E. Lee* site, but was also observed to a lesser degree at the *Halo* site. This pattern may result from debris separating from the vessel as it sinks nearly straight to the seafloor or by debris spreading out from the shipwreck upon impact. Debris may also be dispersed in this manner as a result of man-made or environmental impacts to the site.

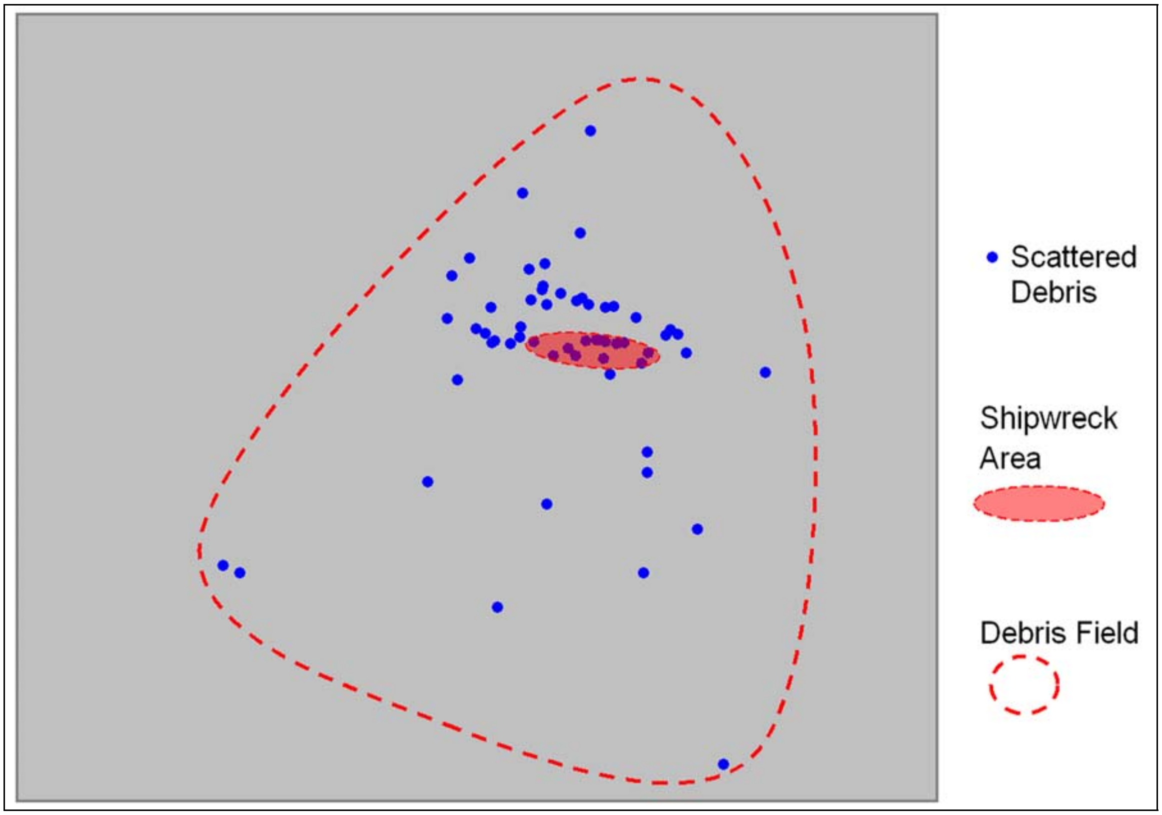


Figure 11.1. Debris field scattered out from a wreck site. Based on *Robert E. Lee's* debris field.

The second debris pattern is a scattered debris trail (Figure 11.2). This pattern consists of a trail of debris leading to the main wreck sections. This pattern is best illustrated by the *Gulfpenn* site. This pattern may occur as debris falls away from a ship moving horizontally through the water column while falling to the seafloor. As a result, the debris trail is often denser nearer to the main wreckage. A debris trail may also result if materials are dispersed from the wreck by man-made or environmental intrusions after the sinking event. Debris trailing away from the shipwreck would be expected on shallow water sites impacted by currents or trawling activities.

The third debris pattern is a separated debris field (Figure 11.3). In this pattern a dense debris zone is located away from the main hull with little or no materials observed around the main wreckage or between the two locations. This pattern is best illustrated by the *Alcoa Puritan* site. This pattern may occur when a ship loses a substantial component before or during the sinking event then drifts away coming to rest on the seafloor some distance from the initial wreckage with only limited additional debris dislodged from the main hull.

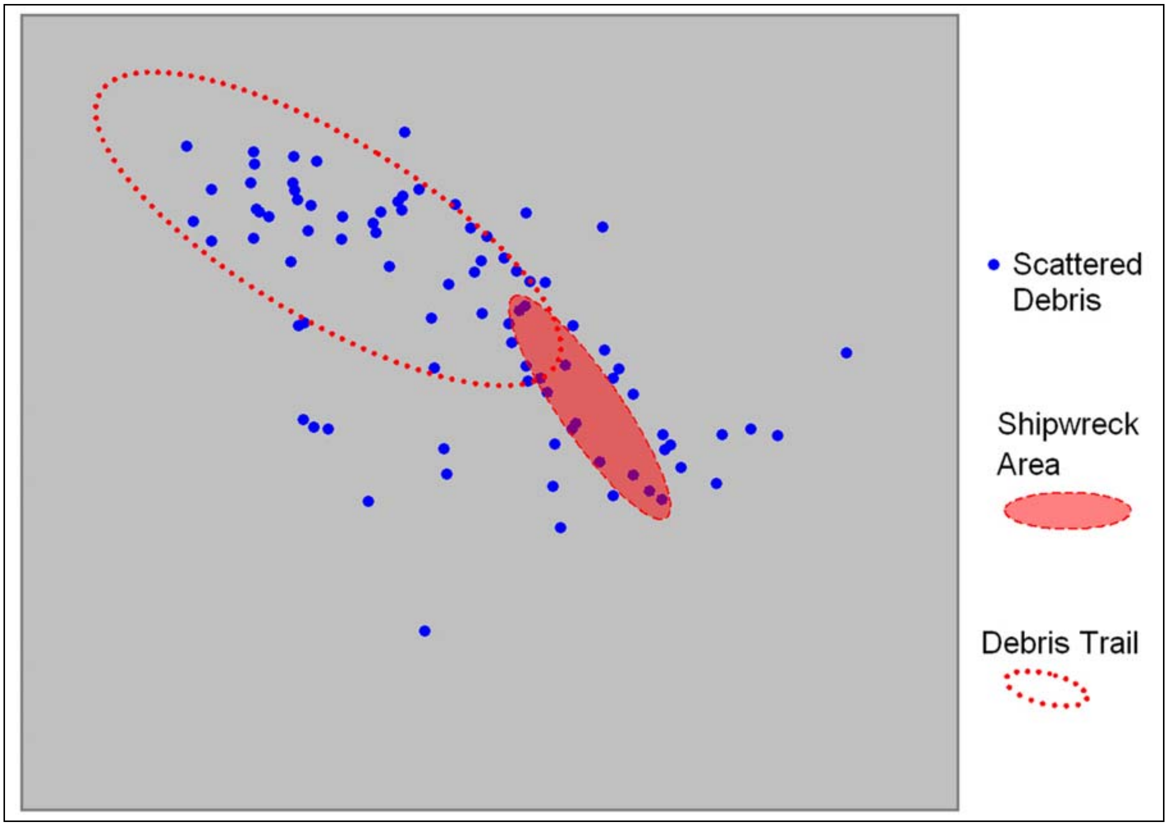


Figure 11.2. Scattered debris trail leading to the wreck site. Based on *Gulfpenn*'s debris field.

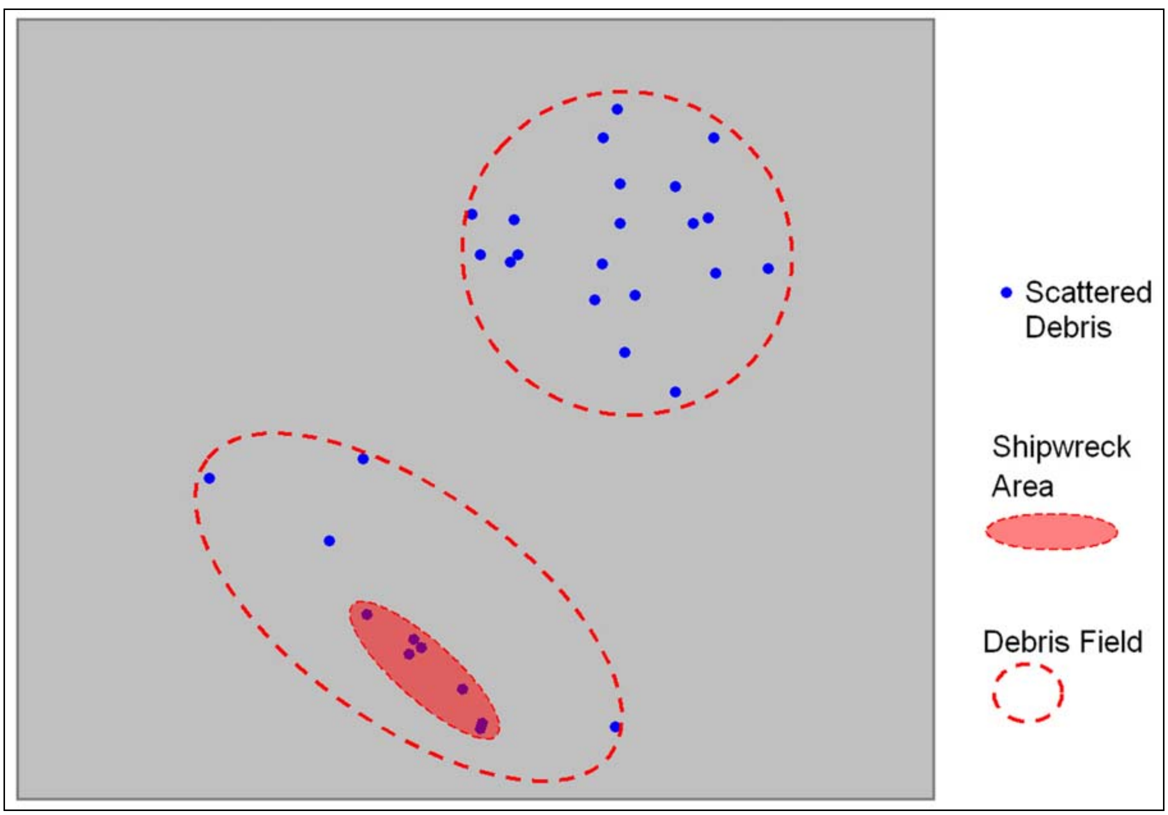


Figure 11.3. Dense debris field way from the wreck site. Based on *Alcoa Puritan*'s debris field.

Most deepwater shipwreck debris fields fit into one of these patterns or a combination of them. For example, the debris pattern of *U-166* is a combination of the centralized and trailing pattern (Figure 11.4). *U-166* broke into two main sections, one accounting for approximately 84 percent of the vessel (approximately 61-meter section including the stern and bridge) and the other for approximately 16 percent of the vessel (approximately 16-meter section of the bow). As the two sections separated, debris trailed from both sections with the densest debris leading to the bow section. Additionally a large amount of debris is dispersed out from the main concentration towards the south. This debris becomes increasingly sparse as distance from the main wreckage increases. Interestingly, the debris fields of *U-166* and *Robert E. Lee* both extend south-southwest, which may be an indicator of the mid-water current direction at the time these vessels sank on July 30, 1942.

One of the study's primary objectives was to document the debris fields associated with each shipwreck site and determine site boundaries. Establishment of site boundaries is crucial to deepwater cultural resources management. Well-defined site limits are essential for developing adequate avoidance criteria for existing deepwater wreck sites and those yet to be discovered. Additionally, data related to site formation processes in deep water will significantly aid in the development of better research designs for future site investigations.

An examination of debris distribution data from this study revealed the trend that site size increases proportionately with depth. This is illustrated with the graph in Figure 11.5. The maximum distance to the edge of the site boundaries from the shipwreck location forms a uniform curve with respect to water depth closely following the mean distribution average between boundary distance and water depth.

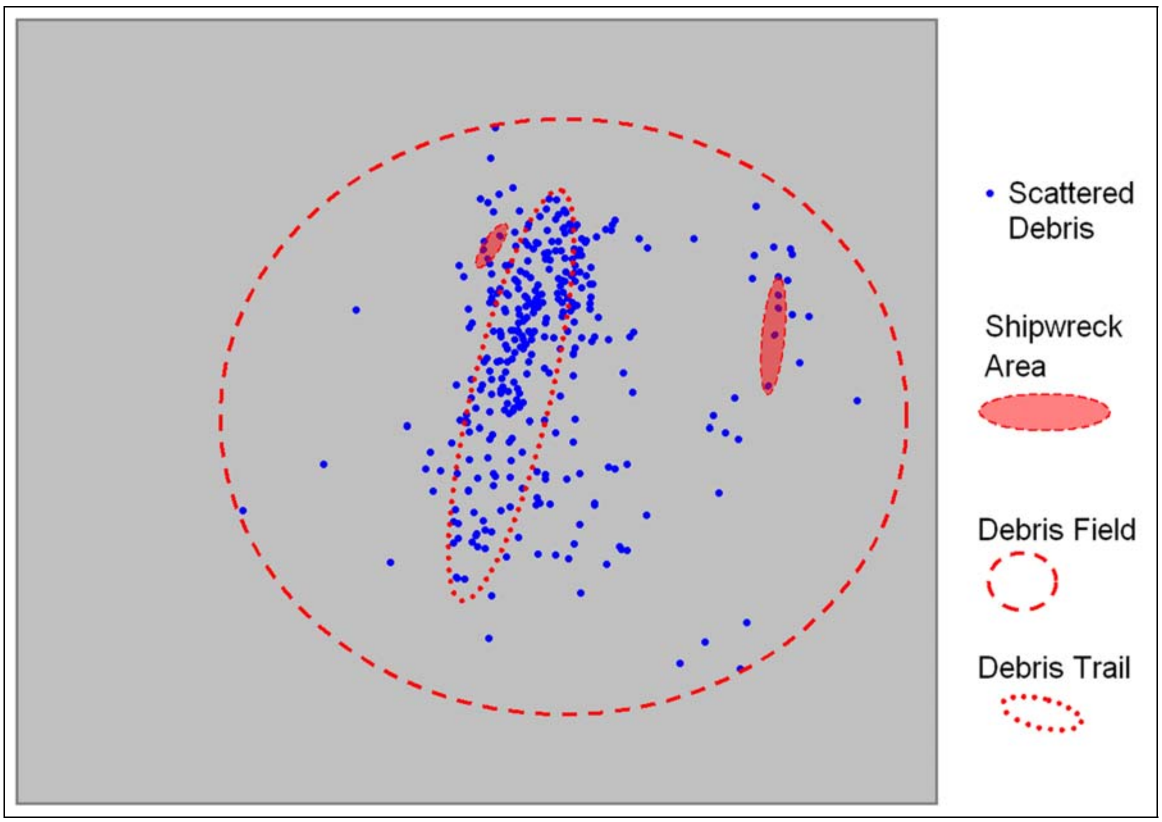


Figure 11.4. Debris field distribution at the *U-166* site.

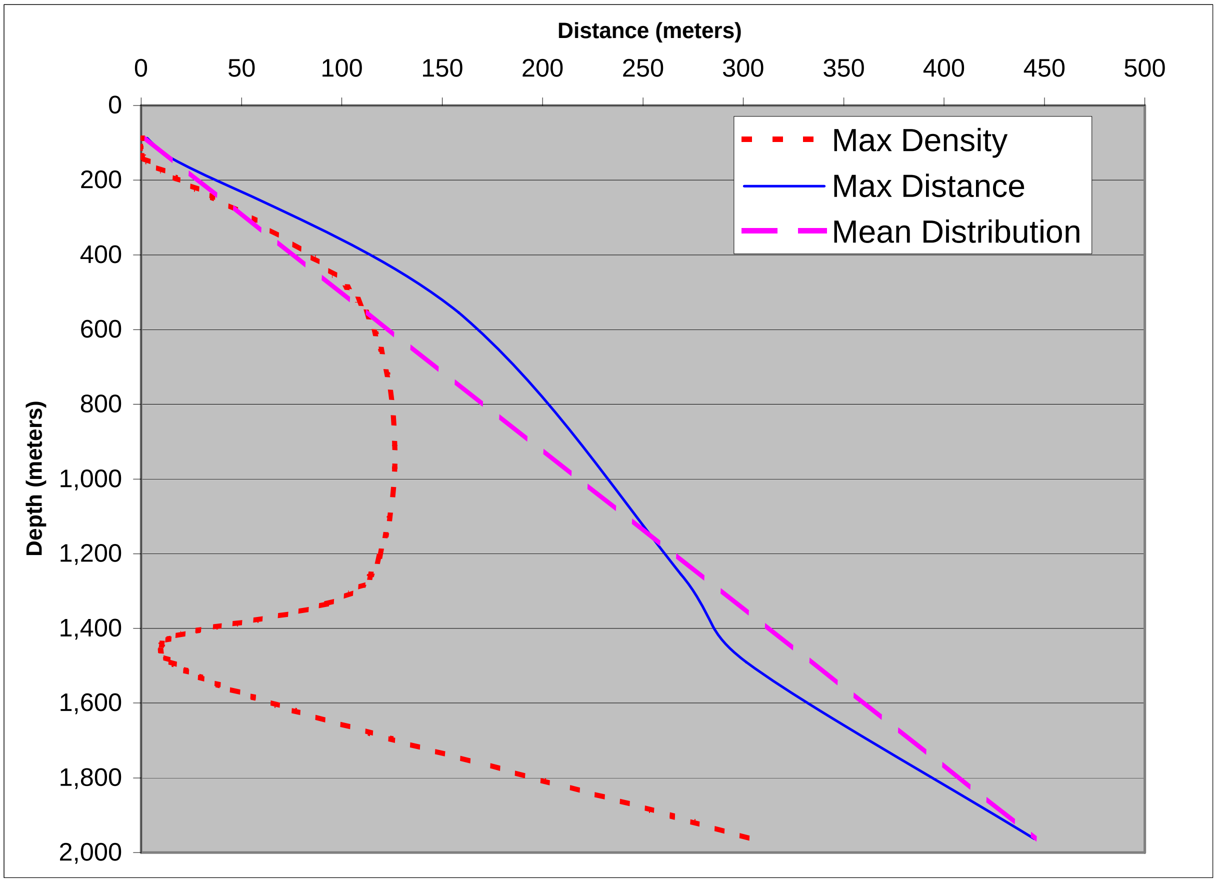


Figure 11.5. Debris distribution graph.

The data used to generate the graph is presented in Table 11.1. This table shows the maximum distance at which debris was documented from each wreck site (Column 5), the distance from the shipwreck to the densest area of the debris field (Column 3), and displays these distances as a function of the percentage of water depth (Columns 4 and 6). All the shipwrecks included in this study, with the exception of *Anona* (which is not included in this data set) and *U-166*, were torpedoed, and began breaking up at the surface. *U-166* was submerged when it was depth charged and broke up underwater. The depth entered for *U-166* was adjusted to account for its depth relative to the seafloor at the time it was lost by subtracting its crush depth from the site's water depth.

Table 11.1

Shipwreck Debris Distribution

Site Name	Average Depth (m)	Max Debris Density (m)	% of water depth Max Density	Max Debris Distance (m)	% of water depth Max Distance
Virginia	87.17	0.61	0.70%	3.05	3.50%
Halo	142.65	1.52	1.07%	15.54	10.90%
Gulfpenn	554.27	112.17	20.24%	158.19	28.54%
**U-166*	1,255.78	114.60	9.13%	269.14	21.43%
Robert E. Lee	1,489.86	14.94	1.00%	301.45	20.23%
Alcoa Puritan	1,963.52	303.58	15.46%	445.01	22.66%

*Water depth adjusted –220 meters to account for the U-boat being submerged

Using the current study's data the following formula was developed to estimate a radius slightly larger than the boundary size of a given shipwreck site:

$$(.20wd + vl \geq \text{site boundary})$$

wd=water depth
vl=vessel length

The formula takes into account a set percentage of water depth and the suspected shipwreck's estimated length. Table 11.2 shows the formula's result calculated using 20 and 25 percent of water depth compared with the actual measured extent of the study wreck sites.

Table 11.2

Avoidance Criteria Estimates

Tentative working avoidance formula = 20% to 25% plus vessel length						
Site Name		**At 20%**	**At 25%**	**Boundary from center of wreck (m)**	**Depth (m)**	**Length (m)**
Virginia	Avoidance area =	170.14	174.50	79.40	87.17	152.70
Halo	Avoidance area =	161.12	168.25	81.84	142.65	132.59
Gulfpenn	Avoidance area =	257.16	284.87	231.34	554.27	146.30
U-166	Avoidance area =	368.20	441.05	307.55	1,456.94	76.81
Robert E. Lee	Avoidance area =	412.27	486.77	358.60	1,489.86	114.30
Alcoa Puritan	Avoidance area =	514.62	612.80	505.97	1,963.52	121.92

It is cautioned that the data presented here is based on steel-hulled vessels that sank under catastrophic conditions. This formula does not take into account wooden shipwrecks or smaller iron vessels (such as *Anona)* that foundered. The above Estimated Shipwreck Avoidance Formula is provided solely as a working model for future research to build upon.

12.0 MICROBIOLOGY

All the ships investigated were heavily coated in various types of biological growth (summarized in Table 12.1). From this investigation it can be seen that considerable differences existed in the types of attached growths on the various ships. The shallowest shipwreck investigated was *Virginia* at 87 meters in the South Pass Area. This ship was dominated by surface concretions overlain with biofilms with a few brown rusticles growing through these intense growths. *Halo*, resting at a depth of 143 meters in Grand Isle exhibited similar growths to *Virginia*. *Halo*, however, exhibited emerging microbial concretion and brown rusticle growths. Next in depth was *Gulfpenn* lying at 538 meters at the edge of the Mississippi Canyon. This ship showed greater growth type divergence with dendritic concretions and microbial concretions dominating although there was also significant presence of brown rusticles, biofilms and even the brief observation of a large "slime blob" attached on the hull's starboard side. Sea anemones were commonly observed as active at this site. At a depth of 1,463 meters, *U-166* showed intense sea anemone clusters as the dominant growth form. Other attached growths were less significant including white and a very few brown rusticles, and some dendritic concretions and biofilms. Only slightly deeper at 1,490 meters was *Robert E Lee*. This ship was also heavily coated with sea anemones and a wide diversity of attached growths dominated by dendritic concretions. *Alcoa Puritan* was the deepest site investigated at 1,964 meters. Here brown rusticles and dendritic concretions dominated. Other attached growths observed included a low density of sea anemones and the presence of biofilms.

Table 12.1

Semi-Quantitative Dominance of Attached Organisms on the Project Shipwrecks

	Type	***Virginia***	***Halo***	***Gulfpenn***	***Robert E Lee***	***U-166***	***Alcoa Puritan***
C1	Brown rusticle						
C2	White rusticle						
C3	Dendritic concretion						
C4	Microbial Concretions						
B1	Biofilm						
B2	Blob						
	Sea anemones						

Note: This table summarizes the intensity of the various attached biological growths observed on the shipwrecks' exterior surfaces during the 2004 expedition. The six columns to the right indicate each ships investigated and the rows represent the different recognizable growth forms. For each cell the observed growth level is shown by the shading in which a black fill indicates dominant growths and a barred pattern indicated the growths were observed frequently. A clear cell indicates that the growths were frequently observed or absent from that site.

For the rusticles recovered and analyzed from all of the ships, one major factor was the ability of these organisms to bio-accumulate oxidized forms of iron. From parallel work being conducted on RMS *Titanic* it is evident that iron is being extracted from steel coupons deployed for six years at rates equivalent to 0.03 grams of iron per square centimeter per year. From the rusticle data gathered in 2004 it appears that the brown rusticles had an average iron content of 96.3±1.04%, placing the rusticles in the same category of iron content as pig iron. By comparison, the rusticles infesting the steel coupons on the platforms had iron contents of 97.8±0.78%.

Three other elements were also considered significant based on anomalies in the accumulated levels from ship to ship. These were lead, strontium, and phosphorus. Selection of these elements is based on the fact that hydrocarbon based fuels once employed lead as a principal anti-knock (biocide) agent. Lead was as also used in antifouling paints. Strontium is a common ingredient in explosives. While phosphorus is also used in explosives, and is a major nutrient and energy storage driver for all organisms.

Lead was recovered from rusticles on all of the ships with a gravimetric percentile concentration of 0.012±0.02%. Comparison of the concentrations for each of the ships revealed that *Virginia* was 38% below this average, *Halo* was 66% below, *Gulfpenn* was 60% below, *Robert E Lee* was 52% below and *Alcoa Puritan* was also 52% below but *U-166* was 453% above indicating that the rusticles on this ship had bioaccumulated significantly greater amounts of lead. This much higher lead level may be the result of the degradation and releases of diesel fuel containing lead biocides during and after the sinking. While some of the lead may come from anti-fouling paints this would have been a universal event for all of the ships being studies.

Strontium, commonly employed in explosives and flares, is commonly found in rusticles. The 2003 survey found higher levels of strontium at *U-166* than from any other rusticles that had been investigated up to that time. In 2004, the average strontium percentile concentration was 0.014±0.015%. Comparison of the concentrations for each ship revealed *Virginia* was 36% below this average, *Halo* was 80% below, *Gulfpenn* was 89% below, *Robert E Lee* was 84% below and *Alcoa Puritan* was also 76% below but *U-166* was 23% above, indicating that the rusticles on this ship had bioaccumulated significantly greater amounts of strontium than rusticles from the other ships. In comparison with 2003, it was found that the strontium concentration at the time was much higher at 0.21% for *U-166* (0.046%, 2004) and *Robert E Lee* at 0.12% (0.006%, 2004). This raises the possibility that rusticles growing in regions where there are releases of strontium from degrading munitions and flares are likely to accumulate much greater concentrations of strontium. Such information may have considerable forensic value in the determination of the role of munitions and their explosions or releases in the sinking of a ship. If such forensic work were to be conducted, then the precise location of the rusticles being analyzed would be a key factor in determining the location of the strontium releases.

Phosphorus is a major nutrient for living organisms and plays a major role in the storage of energy within the cell. Direct links have been established between environmental phosphorus levels and the scale of growth and function observed at a site. Generally, microorganisms accumulate phosphorus as polyphosphate within the cell as reserves against future starvation. Some forms of phosphorus (red, white, and amorphous) also have played roles in the production of explosives, munitions, and flares. For the rusticles on the ships in the cluster examined in 2004, anomalies were noted in the phosphorus concentrations determined in the rusticles. In 2004, the average percentile concentration of phosphorus was 0.138±0.0.071%. Comparison of the concentrations for each of the ships revealed *Virginia* was 69% below this average, *Halo* was 47% below, *Gulfpenn* was 40% below, *Robert E Lee* was 25% below and *Alcoa Puritan* was also 27% below but *U-166* was 49% above indicating that the rusticles on this ship had bioaccumulated significantly greater amounts of phosphorus than the rusticles from the other ships.

Given that *U-166* rusticles proved to have significantly higher levels of lead, strontium, and phosphorus, the following conclusions may be drawn: (1) the lead probably came from the biocides placed in the diesel fuel to prevent fouling while the other ships were fired by bunker oils that did not need such an additive to assure efficient use; and (2) the higher strontium and the phosphorus levels in *U-166*'s rusticles probably comes from degrading munitions and flares stored on the submarine at the time of the sinking.

There is clear evidence that the investigated ships are deteriorating as a result of biological activity extracting iron from the ship's steel hulls. At this time it can be seen that the microbiological challenges differs from ship to ship. For *Virginia* and *Halo*, both were dominated by concretious growths over most of the hull and so the major iron losses on these ships would be dependent upon the rates at which iron moves out through the concretions into the oceanic environment. Some rusticle activity was evident on *Halo* and this may mean increases in the rate of iron loss from the steel. *Gulfpenn* had the greatest diversity of biological activity with the greatest presence of microbial concretions. No chemical or biological analyses have yet been undertaken on the coral, but the color (shades of white) would suggest low iron contents at least in the walls and possibly a low ability to extract iron. Perhaps most unusual of the events was the observation of a large blob to *Gulfpenn*'s starboard side that dissipated during the investigation. These types of activities are not likely to materially increase the rates of steel compromise through the removal of iron. *Robert E. Lee* also supported a very diverse group of organisms with a very dense number of sea anemones. Sea anemones appeared to dominate parts of the ship and acted as limiters to the amount of concretions and rusticles observed. However, inside the ship veritable "forests" of rusticles could be seen (through open doors, windows, port holes and torn walls) meaning that in these cases deterioration will probably be from the inside out. Without a small ROV that could enter the ship, it is difficult to project the level of deterioration and evaluation would have to wait until secondary impacts on the outer ships structures and hull occurs.

While *U-166* lies in close proximity to *Robert E Lee*, there are significant differences in the growths observed on the two ships except sea anemones, which were dominant on both ships. Dendritic concretions (C3) were dominant of on *Robert E Lee* but only abundant on *U-166*. Brown rusticles (C1) and microbial concretions (C4) were also abundant on *Robert E Lee* but were insignificant on *U-166*. For *U-166* it was also noted that sections of the ship's stern appear to be relatively free from infestations. This submarine (*U-166*) does appear to generate rusticles with higher lead (due to the diesel fuel), strontium, and phosphorus (due to the stored munitions and flares that would have been carried on the submarine). It may be that these higher concentrations of strontium and lead are inhibiting the growth rate of the attached organisms. Inboard of the stern, the region appears virtually sealed, which would have the effect of: (1) creating a very reductive condition due to the lack of oxygen; and (2) changes the nature of the challenges to the steel to those created by electrolytic corrosion commonly involving sulphate reducing bacteria and acidulysis caused by the creation of an acidic environment by the acid producing bacteria. Such a closeted reductive environment in the stern section is likely to cause lateral embrittlement and perforation of the steel. The rate at which this will occur is very dependent upon organic loading and the levels of inorganic forms of sulphur. The outcome of such corrosive activities is likely to cause hull perforation, entry of oxygen, and a subsequent increase in biological activity.

Alcoa Puritan appears to be subjected to a different set of biological challenges and at present appears dominated by brown rusticles (C1), dendritic concretions (C3) and biofilms (B1) but with very sparse numbers of sea anemones. The manner in which the rusticles grow appears to follow the same trends as have already been experienced by RMS *Titanic*. Here, therefore, the ship's deterioration is likely the function of rusticles extracting iron from the ship steel.

From this investigation, the primary observations are that all the ships have become heavily infested with attached biological activity that varies from ship to ship. Depth may be a factor since the ships sit along a transect line from 87 meters to 1,964 meters. Depth cannot be the only influencing factor since the ships also sit within influence of the Mississippi River's discharges. Clearly the two shallow ships, *Virginia* and *Halo*, being closer to these discharges already exhibit the effects of the more eutrophic environment causing thicker attached growths and a greater density of fish populations. The deeper ships all show some differences with the deepest ship *Alcoa Puritan* standing out as the most different with brown rusticles dominating.

There was a considerable disparity in the voltage levels (in millivolts) generated between individual coupons (shown as arrows). The upper left quadrant (C12L14, Brass HR, Flat Bar, and ZA12) generally showed more electrical activity than the remaining coupons on the bio-battery platform. In terms of the levels of EMF detected, it was found (Table 12.2) that the most electrical activity was recorded on *Halo,* while the greatest intensity was observed on *Alcoa Puritan*.

Table 12.2

Average Millivolts Recovered from Bio-battery Coupons

Ship	**Number of EMF readings**	**Average millivoltage generated**
Halo	8	28.6
Alcoa Puritan	6	35.7
Robert E Lee	5	7.2
Gulfpenn	3	13.5

This comparison may reflect the ability of microorganisms to occupy narrow gaps between individual coupons and generate an EMF potential. For the two ships that generated higher voltages (29 and 36 millivolts average) there was evidence that the ships supported very aggressive microbial populations. *Alcoa Puritan* was dominated by rusticles that would be attracted to the dissimilarly charged coupons. *Halo*, on the other hand, was shallow at 143 meters and set in an environment with a very diverse range of microbial activities, some of which could also be attracted to the electrically dissimilar coupon surfaces. *Gulfpenn* and *Robert E Lee* tended to support a diverse range of attached growths including sea anemones, corals, or hydrozoans that deterred dominance by some microbial growths. On these two ships, fewer coupons generated charges, which were much weaker (on average only a third to a half of those recorded for the other two ships).

While it appears that the short term deployment of bio-battery platforms on a ship may give some evidence of the ability of the indigenous microbial flora to bridge electrically dissimilar metal coupons and generate a charge, the outcome of these experiments is twofold: (1) there appears to be the potential to relate the data gathered to the amount of aggressive microbial biofouling occurring at the site; and (2) the experiments were too brief in length to achieve sustained electrical activity. These experiments proved dissimilar metals in a deep ocean environment could develop determinable EMF measurable in the millivoltage range. Additionally there appears to be a potential to determine microbial activity levels through the rates of EMF generated after the metal coupons were selectively infested. Ongoing research is now being conducted at the DBI research facility and greater EMF is being generated through longer termed exposures with 0.5 volts DC having been obtained. In future expeditions it is proposed to include the bio-battery platforms in a modified form that would, with greater exposure times, deliver a significant sustainable voltage.

For the investigation's microbiological component, the main focus was the observable form and level of microbial activities (through imaging) and detected using three different methodologies. At-site, experiments were deployed to examine the rates at which ship steels are compromised by microbial activities and the functional ability of indigenous microbes to manipulate and impress electrical charges through biofouling. These experiments used both the steel tests platforms (Table 12.3) and bio-battery platforms with each deployed on four ships (*Halo*, *Gulfpenn*, *Robert E Lee*, and *Alcoa Puritan*). Recovered concretion and rusticle samples were later subjected to laboratory investigations to determine microbial loadings and chemical composition. Additionally, laboratory investigations were conducted to determine differences related to depth and potential nutrient loading at the shipwreck sites. This report includes an interpretation of the at-site observations and the subsequent laboratory investigations. Of prime interest is that there were significant differences between the ships in the form of attached microbiological growths from dendritic concretions (shallower depths), to very mixed growths including aggressive sea anemone populations (deeper), to a virtual dominance of rusticles and concretious growths on the deepest ship (*Alcoa Puritan*) lying at 1,964 meters.

Table 12.3

Deployment of Mark II Steel Test Platforms in Ship Cluster, 2004

Platform #	**Ship**	**Position (on Superstructure)**
A	*Gulfpenn*	Aft, amidship, port
B	*Alcoa Puritan*	Portside towards stern
C	*Robert E Lee*	Port, amidship
D	*Halo*	Port, amidship

13.0 INVERTEBRATE ZOOLOGY

Identification of invertebrate species from video transects could be made with certainty only for a few distinctive, macrofaunal species, including some decapod crustaceans, the giant isopod, the giant pycnogonid, a few sea stars, two species of sea urchins, and the venus flytrap anemone. The problem was exacerbated by turbidity at the shallower sites. Most specimens from the video transects were identified to higher taxa only.

The metazoan meiofauna, or meiobenthos, are defined as those organisms which pass through a 0.500 millimeter mesh sieve and are retained on a 0.063 millimeter or 0.045 millimeter mesh sieve; the upper and lower size limits of the group vary among specialists and with bathymetric depth. Often smaller size limits are used for both the upper and lower size criteria in the deep sea. We used the accepted standard, >0.500 millimeter and <0.063 millimeter for all samples from the wreck sites (Higgins and Thiel 1988; Giere 1993). Meiofauna can be found in or on almost any substrate (e.g., soft sediments, macroalgae, or as epibionts on macrofauna), but the group is perhaps most closely associated with sediments. Most marine taxa have representatives in the meiofauna, however many of these are only temporary members (meromeiofauna), and as they metamorphose from larval stages or increase in size, they join the macrofauna. Although metazoan meiofauna lack any taxonomic distinctiveness separating them from non-meiofaunal taxa, a characteristic that all members of the true meiofauna (holomeiofauna) share is that they lack pelagic larvae or have abbreviated development. A few taxa are more common in the meiofauna (such as the harpacticoid copepods and nematodes, and thus are always treated as meiofauna even if they do not fit the size criteria,

In our samples, nematodes predominated the meiofauna community, comprising more than 90% of the fauna numerically, with densities ranging from 81 to 1,117 per 10 cm^2. Our values in our shallow sites are slightly higher than the average values reported from 34 stations sampled off the south Texas continental shelf, but fall within the reported ranges of minimum and maximum values (Flint and Rabalais 1981). Nematodes numerically predominate in terms of numbers and biomass in most marine sediments at depths below 1 centimeter into the sediment at stations in the northern Gulf of Mexico (Fleeger et al. 1995). Although many nematode species are aerobic, most are facultative or obligate anaerobes (Giere 1993). Although we did not measure the depth of the RPD (redox discontinuity profile) in our cores, it often is within the upper centimeters of sediment in the northern Gulf of Mexico (Fleeger et al. 1995). Nematode densities generally decrease with bathymetric depth and distance from shore, and often are correlated with organic content of sediment. Nematode densities in our samples followed this trend, and densities were lower at the deeper sites. The densities of nematodes at the deeper sites decreased by almost an order of magnitude between the shallowest and deepest sites and hence a pronounced relationship with depth was evident (Figure 13.1).

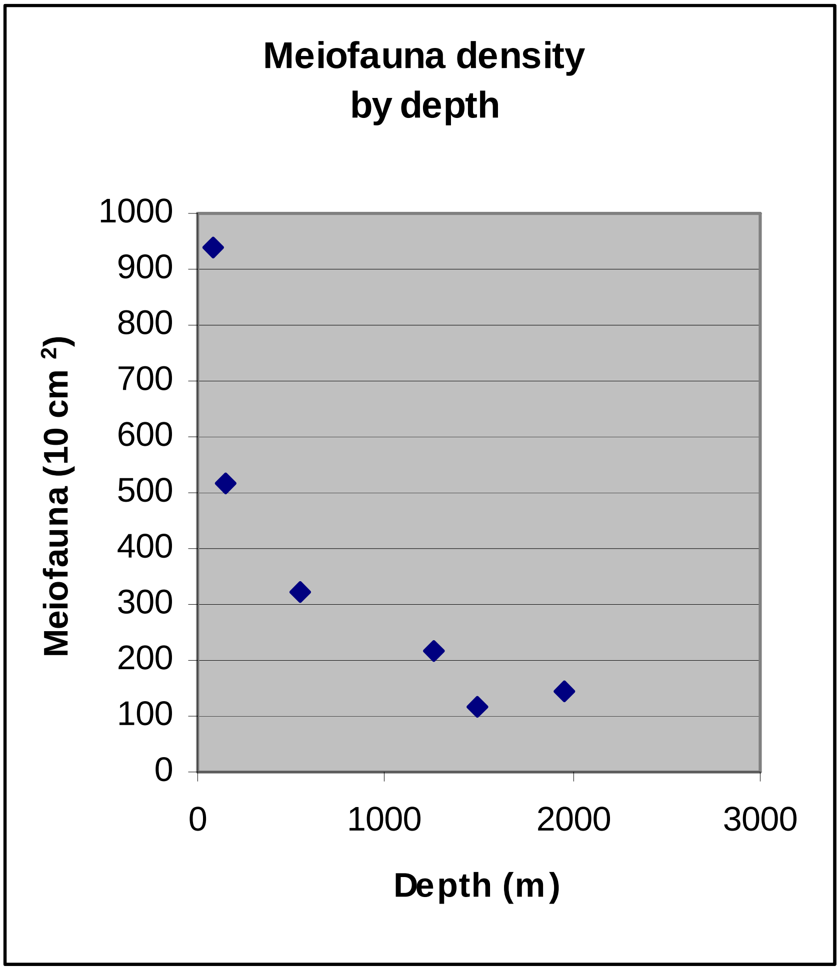


Figure 13.1. Changes in average meiofauna density (number per 10 cm^2) with bathymetric depth.

Mechanisms maintaining the diversity of macrofauna and meiofaunal communities often differ, as meiofaunal live on smaller spatial and temporal scales than macrofauna (Thistle 2003). Diversity of surficial dwelling meiofaunal species such as harpacticoid copepods was inversely related to flux of particulate organic matter (POM) in the northern Gulf of Mexico (Baguley et al. 2006). Generally, deep sea communities depend upon surface derived production, but the sedimenting organic material may have to pass through a microbial loop before they become available to harpacticoid copepods (Fleeger and Shirley, 1990). Conversely, species richness of harpacticoid copepods declined linearly with increasing depth and was maximal at approximately 1200 meters (Baguley et al. 2006). At sites, harpacticoids were always a minor component of the total meiofaunal community. In general, meiofaunal abundance decreases with bathymetric depth.

A total of 301 voucher specimens of macroinvertebrates, conservatively belonging to 79 taxa, were collected. Crustaceans were the most abundant higher taxon, with 47 species, followed by echinoderms (14 species), mollusks (13 species), polychaets (3 species) and brachiopods and sponges (1 species each). Many more specimens were collected near (<61 meters) wreck sites (209 individuals) than away from (>61 meters) wreck sites (72 individuals), with 20 specimens being recovered from sediment or water samples from unknown locations.

Several sampling biases resulted in more extensive collections at some sites, e.g., the *Gulfpenn* site was visited three times, and the *Halo* and *Robert E. Lee* sites were visited twice. In sharp contrast, no collections could be made directly from *U-166*, and visibility was extremely limited at the *Virginia* site, decreasing collection efficiency. The specimens collected at each site are voucher specimens, and are not necessarily representative of the abundance of species within each site, the differences in abundance of species between sites, or even of species richness (the number of species present). These voucher specimens, however, allowed identification of some specimens viewed on video imagery, and allowed more accurate quantification of species assemblages from analysis. Many voucher specimens could not be identified to species because of their ontogenetic size (immature individuals), sex (description of some species requires a particular sex), or condition (many were damaged during collection; others are incomplete). Other specimens will require scrutiny by taxonomic specialists. Undoubtedly more species will be added to the catalogue. A number of specimens appear to represent undescribed species, particularly several galatheoid crabs. With these caveats noted, species richness varied greatly among the sites: *Gulfpenn* (26), *Halo* (18), *Virginia* (12), *Robert E. Lee* (11), *U-166* (10), and the *Alcoa Puritan* (8). The differences in species richness between sites suggested by the voucher collections may be indicative of the species richness values, even with the noted caveats.

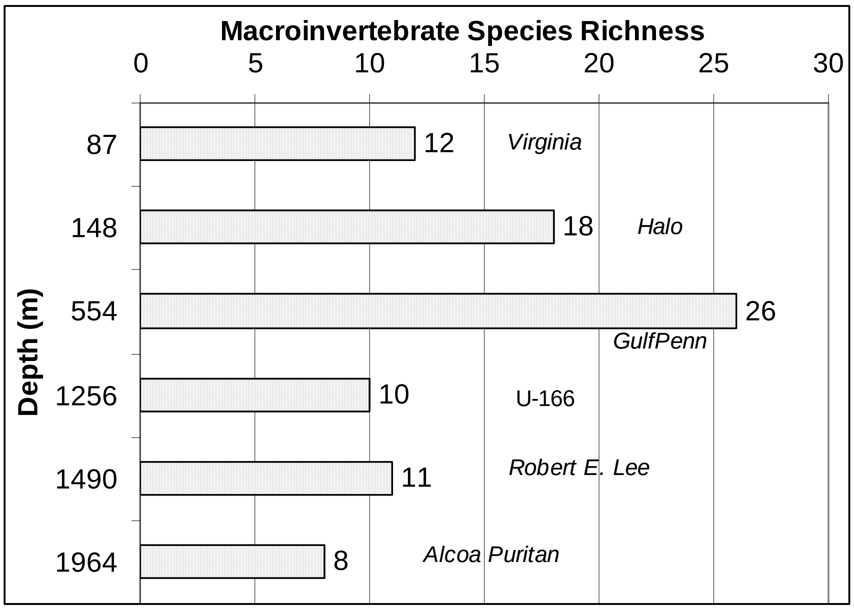


Figure 13.2. Changes in species richness with depth (meter) among the wreck sites.

A strong bathymetric component was evident in the distribution of crustacean species. For example, *Bathynomous giganteus* (giant isopod), *Chaceon quinquedens* (red deep-sea crab) and *Munidopsis* sp. (squat lobsters) were present at the four deeper wreck sites, but not at the two shallowest sites. *Rochinia crassa* (inflated spiny crab) was abundant at the intermediate depths (538-557 meters) of the *Gulfpenn* site, but was not collected at other sites (Figure 13.3).

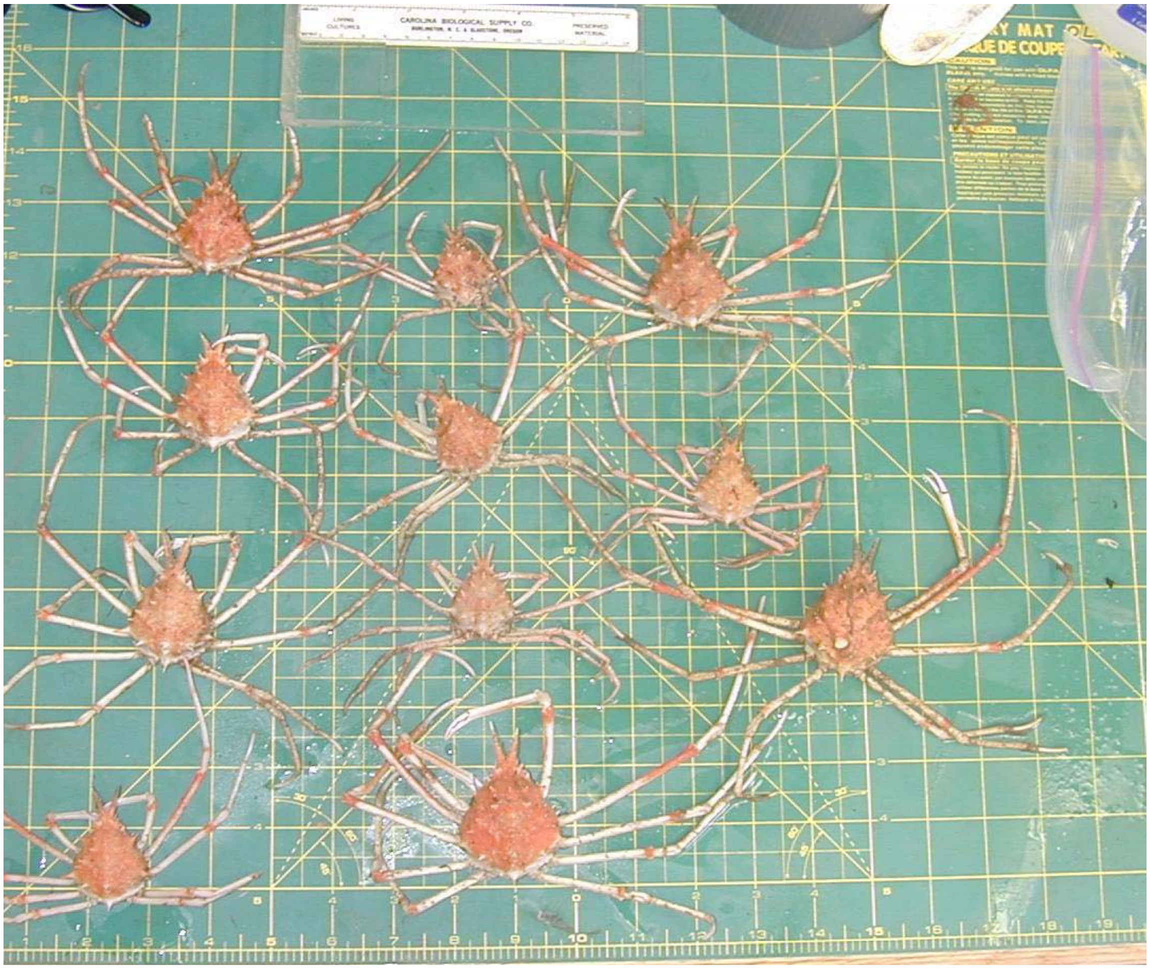


Figure 13.3. The spider crab *Rochinia crassa* was abundant at the *Gulfpenn* site (Photo by Morgan Kilgour and Aaron Baldwin).

The deep-sea red crab (*Chaceon quinquedens*) was found at the four deepest sites. It supports a commercial fishery on the continental slope of the United States in New England and is distributed from 100 to 2800 meters depth. The species is generally thought to move into shallower depths with increasing age and size, and females are found shallower than males. Females were only at the three deepest sites, while males were found at all four deeper sites. The smallest specimens were found at the shallowest sites, in direct contradiction to published information (Lockhart et al., 1990; Lindberg and Lockhart 1993), with the largest crabs at intermediate depths. We found no segregation with either sex or size. Our specimens largely were collected in fish traps and pot bias (e.g., small crabs may be less likely to enter a pot with large crabs; larger males may out compete smaller ones or females for pot access) may have affected both the size and sex ratio of the collected specimens.

Many macrofaunal invertebrates have been associated with deepwater corals and other bioherms (Buhl Mortensen et al. 1995; and Buhl Mortensen and Buhl Mortensen 2004), The galatheoid crab *Eumunida picta* has commonly been associated with hydrothermal vents, however we observed the species in association with the deep water coral *Lophelia pertusa* at the *Gulfpenn* site. *Eumunida picta* was observed on only 1 of the 6 wrecks, from 533 meters to 556 meters in depth. Although only 20% of the corals harbored *E. picta*, 81% of the E. *picta* were observed in association with the deep-sea coral *Lophelia pertusa*. *E. picta* was usually within 1 m of the coral when it was not in direct contact with it. The coral may be providing an optimum feeding location for the crab, refuge from predation, or some combination.

In contrast, echinoderms did not appear to have an obvious bathymetric component in voucher specimen collections. Pencil urchins were collected only at the *Halo* site, while several asteroid species (*Apollonaster yucatanensis*, *Diplasiaster productus* and *Nymphaster arentaus*) were collected only at the *U-166* site.

A number of micromolluscan specimens belonging to the classes Gastropoda and Bivalvia were qualitatively collected from sediments or as epibionts on other macrofauna at four of the collection sites (*Halo*, *Gulfpenn*, *Robert E. Lee,* and *U-166*). Dr. Emilio Garcia (University of Louisiana Lafayette) graciously identified the specimens. The microhabitat of most of the species is unknown within each shipwreck site. Many of the specimens represent adult mollusks, while others represent juveniles of macromollusks. The inequality of sampling availability and sorting effort among the sites decreases the utility of the impressive species list for ecological analysis, but several deductions are readily obvious. Of the 73 species (Table 13.1) identified, no species was collected at more than a single site; 38 unique families and 64 genera were collected. Species distribution among the sites was extremely skewed: 61 species were from *Halo*, the shallowest site, with only four species from *Gulfpenn*, five from *Robert E. Lee*, and three from *U-166*. Most species were without congeners; that is, they were the sole representatives of their genus within our collections. Similarly, most of the 38 unique families identified represented a single genus and species. The gastropod family Turridae is extremely speciose and widely distributed globally; it was collected at four shipwreck sites and was represented by 17 genera and 17 species. Only four other families were found at more than one site. Other families with a large number of genera were the gastropod families Cavoliniidae (six species), and Columbellidae (four species; dove shells). A few of these species are far outside their reported geographic ranges (e.g. *Seguenzia* cf. *formosa* f. *lin* is reported from off northeastern Brazil), while many are from much deeper depths or different habitats than previously reported. Perhaps the most impressive aspect of the collections is the high species richness and taxonomic diversity. High diversity is common in the deep sea, however most of these specimens were from *Halo* shipwreck, at only 146 meters depth. Species richness of micromollusks, particularly gastropods, decreased abruptly with depth; although this pattern might be partially explained by the qualitative nature of our sampling, the sharp bathymetric zonation of gastropod diversity is widely accepted (Rex et al., 1990) and supported by our observations.

Table 13.1

List of Micromollusks Identified from Four Shipwreck Sites.

VESSEL	FAMILY	GENUS	SPECIES	AUTHOR & DATE
Halo	Acteonidae	Rictaxis	punctostriatus	(C. B. Adams, 1840)
	Architectonicidae	Heliacus	bisulcatus	(d'Orbigny, 1842)
	Arcidae	Barbatia	candida	(Helbling, 1779)
	Atlantidae	Atlanta	peronii	Lesueur, 1817
	Buccinidae	Antillophos	elegans	(Guppy, 1866)
	Cardiidae	Nemocardium	tinctum	(Dall, 1881)
	Carditidae	Pleuromeris	armilla	(Dall, 1903)
	Carditidae	Pleuromeris	tridentata	(Say, 1826)
	Cavoliniidae	Cavolinia	tridentata	(Niebuhr, 1775)
	Cavoliniidae	Diacavolinia	deblainvillei	van der Spoel, Bleker, Kobayashi, 1993
	Cavoliniidae	Cavolinia	uncinata	(Rang, 1829)
	Cavoliniidae	Clio	pyramidata	Linnaeus, 1767
	Cavoliniidae	Creseis	acicula	(Rang, 1828)
	Cavoliniidae	Diacria	trispinosa	(Blainville, 1821)
	Columbellidae	Costoanachis	lafresnayi	Fischer & Bernardi, 1858
	Columbellidae	Astyris	lunata	Say, 1826)
	Columbellidae	Cosmioconcha	calliglypta	(Dall & Simpson, 1901)
	Columbellidae	Nassarina	Glypta	(Bush, 1885)
	Coralliophilidae	Babelomurex	cf. dalli	(Emerson and D'Attilio, 1963)
	Coralliophilidae	Coralliophila	cf. profundicola	(Haas)

VESSEL	FAMILY	GENUS	SPECIES	AUTHOR & DATE
	Cylichnidae	Scaphander	watsoni	Dall, 1881
	Eulimidae	Niso	aeglees	Bush, 1855
	Galeommatiidae	Cymatioa	bibsae	(Novelle-Usticke, 1969)
	Muricidae	Pteropurpura	bequaerti	(Clench & Pérez-Farfante, 1
	Muricidae	Siratus	beauii	(Fischer & Bernardi, 1857)
	Nassariidae	Nassarius	species 17	(of Lee) Undescribed
	Nuculanidae	Nuculana	acuta	(Conrad, 1831)
	Nuculanidae	Nuculana	carpenteri	(Dall, 1881)
	Olividae	Olivella	mutica	(Say, 1822)
	Ostreidae	Ostrea	equestris	Say, 1834
	Poromyidae	Poromya	rostrata	Rehder, 1943
	Pteriidae	Pinctada	imbricata	Röding, 1798
	Pyramidellidae	Eulimella	cf. smithi	(A. E. Verrill, 1880)
	Pyramidellidae	Turbonilla	species A	
	Pyramidellidae	Turbonilla	species B	
	Retusidae	Volvulella	recta	(Mörch, 1875)
	Ringiculidae	Ringicula	semistriata	d'Orbigny, 1842
	Rissoidae	Benthonellania	xanthias	(Watson, 1886)
	Rissoidae	Rissoina	sagraiana	(d'Orbigny, 1842)
	Semelidae	Abra	aequalis	(Say, 1822)
	Sequenziidae	Carenzia	cf. carinata	(Jeffreys, 1877)
	Gadilidae	Polyschides	greenlawi	Henderson, 1920
	Tellinidae	Macoma	tenta	(Say, 1834)
	Terebridae	Terebra	doellojuradoi	Carcelles, 1953
	Tonnidae	Tonna	galea	(Linnaeus, 1758)
	Trochidae	Dentistyla	dentifera	(Dall, 1889)
	Turridae	Bactrocythara	cf. asarca	(Dall & Simpson, 1901)
	Turridae	Cochlespira	radiata	(Dall. 1889)
	Turridae	Kurtziella	citronella	(Dall, 1886)
	Turridae	Cryoturris	cerinella	(Dall, 1889)
	Turridae	Drillia	species A	
	Turridae	Drillia	species B	
	Turridae	Ithycythara	lanceolata	(C. B. Adams, 1850)
	Turridae	Leptadrillia	cookei	(E. A. Smith, 1888)
	Turridae	Lioglyphostoma	species 2	of García & Lee
	Turridae	Lioglyphostoma	species B	of Garcia
	Turridae	Microdrillia	comototropis	(Dall, 1881)
	Turridae	Polystira	species	(undescribed)
	Turridae	Stenodrillia	species A	
	Cornirostridae	Tomura	bicaudata	(Pilsbry & McGinty, 1946)
	Yoldiidae	Yoldia	solenoides	Dall, 1881

VESSEL	FAMILY	GENUS	SPECIES	AUTHOR & DATE
Gulfpenn	Buccinidae	Eosipho	canetae	(Clench & Aguayo, 1944)
	Volutidae	Scaphella	robusta	Dall, 1889
	Turridae	Inodrillia	aepynota	(Dall, 1889)
	Mytilidae	Amygdalum	politum	(Verrill & Smith, 1880)
U166	Siphonodentaliida	Platischides	pandionis	(Verrill & Smith, 1880)
	Turridae	Benthomangelia	cf. bandella	(Dall, 1881)
	Turridae	Pleurotomella	ipara	(Dall, 1881)
R. E. Lee	Arcidae	Bentharca	asperula	(Dall, 1881)
	Neritidae	Vittina	usnea	(Röding, 1798)
	Propeamusiidae	Propeamusium	dalli	E. A. Smith, 1886
	Seguenziidae	Seguenzia	cf. formosa f. lin	Watson, 1879
	Turridae	Pleurotomella	ipara	(Dall, 1881)

Scleractinia, Antipatharia, and Gorgonacea

Representatives of Scleractinia, Antipatharia, and Gorgonacea were collected from and/or observed on the three shallow wrecks: *Virginia* (87 meters depth) *Halo* (143 meters depth) and *Gulfpenn* (554 meters depth). Scleractinians were found on all three wrecks (Table 13.1). Four of the five scleractinians species occurred on *Virginia* (*Madracis myriaster*, *Oculina varicosa*, *Paracyathus pulchellus* and *Pourtalosmilia conferta*), two species on *Halo* (*Madracis myriaster* and *Pourtalosmilia conferta*), and two species on *Gulfpenn* (*Pourtalosmilia conferta* and *Lophelia pertusa*). *Pourtalosmilia conferta* was found on all three wrecks (but only once on *Gulfpenn* in the video records), *M. myriaster* was found on the two shallowest wrecks (*Virginia* and *Halo*), *O. varicose* and *P. pulchellus* occurred only on *Virginia* and *L. pertusa* occurred only on *Gulfpenn*. Gorgonians were collected from and/or observed on the two shallowest wrecks; *Virginia* and Halo (Table 4.3). A single, large colony of *Muricea pendula*, growing on the top of main superstructure, was all that was found on *Virginia*. On the other hand, *Halo* had a well-developed gorgonian fauna. Examples of four species, *Placogorgia rudis*, *Thesea sp.* cf. *T. grandiflora*, *Thesea sp.* cf. *T. rubra* and *Thesea sp.*, were collected from this wreck and one unidentified species was recorded on video. Just two species of antipatharians were collected, *Antipathes furcata* and *Stichopathes sp.* cf. *S. pourtalesi*, and both were only found on *Virginia* (Table 4.3).

Available surfaces on *Virginia* and *Halo* generally appeared to be either densely colonized with combinations of their epibenthic fauna or had little to no colonization of these fauna at all. On *Virginia* the dominant species, in terms of numbers and possibly biomass, was the black wire coral *S. sp.* cf. *S. pourtalesi*. Large field-like assemblages have developed on horizontal to near-horizontal surfaces; frequently attaining densities estimated at 400-500 colonies per square meter and occasionally extremely dense concentrations on the order of 80-100 colonies per 0.1 square meter. This configuration of colonies, which commonly includes clusters of the fan-shaped *A. furcata*, results in an open, loosely constructed vertical complex extending as much as 20-30 centimeters above the attachment surface. In addition, a partial canopy often forms when the top portions of the longer *S. sp.* cf. *S. pourtalesi* colonies lean over into a more horizontal plane. Colonies of two of the scleractinian corals, *M.* myriaster and *P. conferta*, also form structurally complex cover, albeit relatively low profile, on all types of structures and surfaces throughout *Virginia*. They occur as isolated colonies, small groups of aggregating colonies, and large clusters of both living and dead coral.

On *Halo*, structurally complex cover has been developed by both the scleractinians and the gorgonians. Generally, colonies of the gorgonians provide the most vertical or horizontal extension from their attachment surfaces but only as isolated individuals, in small groupings, or in widely spaced field-like assemblages of single or mixed species composition. In contrast, the two scleractinians, *M. myriaster* and *P. conferta*, form a mostly low profile structurally complex cover, similar to what occurs on *Virginia*, on surfaces throughout the entire wreck. The most complex habitat develops where the two corals co-occur in association with other encrusting epibenthic fauna. In addition, fragments of living *M. myriaster* that have fallen off the wreck are growing into new colonies that are providing additional habitat on the adjacent muddy sediment.

Lophelia pertusa is the dominant species, both in terms of numbers and biomass, on *Gulfpenn*. It is estimated that *L. pertusa* has colonized at least 12-15 percent of available exposed surfaces and structures throughout the wreck. The most successful development of coral is on the starboard side most often on surfaces or structures that have a vertical orientation or an upright, raised, or open construction or arrangement. Additionally, *L. pertusa* was also found living on the sediment adjacent to the hull and colonizing wreckage in *Gulfpenn's* debris field. The coral cover, which ranges from small patches of low-relief, newly formed colonies to solitary colonies up to 1.5 meters in height and breadth to a vertical assemblage of at least five or six coalescing colonies six to seven meters high by three to 3.5 meters wide, is responsible for the formation of a variety of extremely complex structural habitats.

14.0 VERTEBRATE ZOOLOGY

Fish Community Structure

Several factors that potentially affected fish community structure estimates derived from ROV transect sampling must be discussed briefly prior to offering a synthesis of those results. First, and most obviously, video sampling is sensitive to turbidity. *Halo* had the most diverse fish community, yet it is likely some small, cryptic taxa were overlooked. Clearly, the potential to miss taxa at *Virginia* was greatest among all sites given the very poor visibility encountered. Even when fishes were seen, identification to species often was not possible from video. In shallow environments, body form and coloration was used to distinguish species. In the deep sea, however, many taxa have similar morphometrics and coloration, even ones only distantly phylogenetically related. Individuals collected in traps or with the ROV suction sampler provided voucher specimens of taxa present at all sites, but it remains likely that species diversity at the deepest wrecks (*U-166*, *Robert E. Lee*, and *Alcoa Puritan*) was underestimated.

A total of 105 taxa were observed in video and/or collected in traps and with the ROV suction sampler among all sites. *Halo* had the greatest community richness with 54 taxa observed. This was followed by *Gulfpenn* (n = 38 taxa), *Robert E. Lee* (n = 21 taxa), *Virginia* (n = 17 taxa), *U-166* (n = 14 taxa), and *Alcoa Puritan* (n = 11 taxa). One potential source of bias occurred in that *Halo* was visited twice and *Gulfpenn* visited three times to collect biological samples. Thus, there was a greater probability of documenting ichthyofauna associated with those two sites than the other four. It should be noted, however, that if species observed on subsequent visits to those sites were removed from the sum of taxa documented, *Halo* and *Gulfpenn* still would rank first and second in ichthyofaunal diversity by a wide margin.

There was a significant difference in the fish community among wreck sites (ANOSIM; $p < 0.01$) and among transect locations nested within site (ANOSIM; $p < 0.01$). The three shallowest (*Virginia*, *Halo*, and *Gulfpenn*) sites had soft or azooxanthellae hard corals that fouled the ships and added structural complexity required by reef fishes. It is likely reef fishes would have recruited to a given wreck without the coral yet present, but the fact that corals and rich fouling communities exist at those depths is the precise reason reef fishes are found at them. Thus, depth-specific reef fish fauna and fouling communities typical of natural reef environments in the northern Gulf were associated with each of the three shallowest wrecks. The fish community documented at the deepest wrecks (*U-166*, *Robert E. Lee*, and *Alcoa Puritan*), on the other hand, was similar among transects over, adjacent to, and away from the ships. These communities were typical of abyssal environments of the northern Gulf (Powell et al. 2003; Thompson et al. 1999) and no artificial reef effect of those wrecks was apparent for fishes.

One of the most interesting finds of the study was the massive *Lophelia* thickets associated with *Gulfpenn*. *Lophelia* colonies in slope environments provide some of the deepest natural reefs in the northern Gulf (Reed 2002; Schroeder 2002). Thus, their discovery on *Gulfpenn* permited study of fishes that are among the deepest true reef fishes that occur in the Gulf.

The three deepest sites (*U-166*, *Robert E. Lee*, and *Alcoa Puritan*) had very similar fish communities. As was expected *a priori*, we found no true reef fishes in the deep sea. Some fishes on the deepest wrecks were associated with a given ship's rigging and superstructure, but individuals of the same or similar species also were found away from wrecks. As a result, the fish community at those sites did not differ among transects flown over, adjacent to, and away from the ships. There were some differences in the relative dominance of taxa present, but for the most part fishes seen at each of the deep sites were predominantly from only a few groups: orders Ophidiiformes (cuskeels) and Anguilliformes (eels), and families Halosauridae (Halosaurs) and Macrouridae (grenadiers), all of which are typical of the abyssal ichthyofauna of the northern Gulf.

Diet and Trophic Structure

Gut content analysis and analysis of muscle stable isotope ratios revealed much information about the trophic dynamics of fish population at and near shipwreck sites sampled in this study. By combing these two techniques, a wide variety of feeding ecologies was observed among fish communities at the three shallowest sites: *Virginia*, *Halo*, and *Gulfpenn.* At *Virginia*, vermilion snapper had stable isotope values consistent with feeding in the water column on invertebrates, yet gut contents of the four fish sampled were predominantly filled with fishes. Red snapper and rock sea bass had stable isotope values a full trophic level higher than vermilion snapper, with $\delta^{34}S$ values indicating both species feed predominantly on benthic prey.

A much greater diversity of species was sampled at *Halo* and a greater diversity in feeding ecologies also was observed. Although Anthiinae basses had mostly empty stomachs, stable isotope analysis of muscle samples revealed a planktonic diet. At the opposite end of the spectrum, top predators amberjack, blacktail moray, king snake eels, and *Epinephelus spp.* groupers had stable isotope values at least two trophic levels higher than Anthiinae basses. All the fishes collected over the wreck, except for a red porgy and one grouper, as well as the blacktail moray and king snake eels, had $\delta^{34}S$ values consistent with pelagic feeding. Amberjack followed the ROV closely and appeared to be targeting Anthiinae basses as potential prey, while one king snake eel captured away from the ship actually had an Anthiinae bass in its gut. Therefore, we infer Anthiinae basses may play an important roll in the transfer of carbon from plankton and invertebrates to fishes at higher trophic levels.

Fishes captured away from *Halo* displayed an even greater diversity in feeding ecology than fishes captured over the wreck. Roughback batfish had $\delta^{13}C$ and $\delta^{15}N$ values indicating feeding at low trophic levels. Interestingly, they had $\delta^{34}S$ values consistent with pelagic feeding yet these fishes are truly benthic organisms. Other benthic fishes, such as deepwater flounder and spotted hake, fed at least one trophic level higher than batfish, but they most likely were feeding on benthic rather than pelagic prey resources.

Fishes sampled over *Gulfpenn* displayed greater breadth of diet than did fishes captured over *Halo*. Slimehead gut analysis indicated a diet split between fishes and macroinvertebrates. Stable isotope values of slimeheads, as well as hakes, were consistent with omnivorous diets derived from both pelagic and benthic prey. Some fishes sampled away from the wreck, such as grenadiers and the deepwater tonguesole, had intermediate $\delta^{13}C$ and $\delta^{15}N$ values, but clearly had benthic $\delta^{34}S$ values. Perhaps the most interesting fishes sampled at the Gulfpenn were hagfish, deepwater conger, and offshore hake that had depleted $\delta^{13}C$ values that may indicate some percentage of their biomass ultimately was derived from chemosynthetic production.

Few samples were available for analysis from the deep wrecks (*U166*, *Robert E. Lee*, and *Alcoa Puritan*), but interesting observations also were made about the food webs at those sites. A single cutthroat eel captured at a methane seep site near *Robert E. Lee* had stable isotope values clearly indicative of chemosynthetic production. Other cutthroat eels collected over wrecks also had somewhat depleted $\delta^{13}C$ values that may indicate chemosynthetic production. Overall, however, stable isotope values of the preponderance of samples from our deep sites indicated phytoplankton production was much more important to deep-sea fishes and invertebrates than chemosynthesis.

Age and Growth

Too few otolith samples were collected and processed to infer much about the age distributions of fishes at wreck sites, or to estimate growth rates. However, two general trends did emerge from the data. First, fishes on the three shallowest wreck sites tended to be larger at age than fishes on deep sites. Slower fish growth in the deep ocean is a function of limited carbon, extreme pressure, and low dissolved oxygen (Caillet et al. 2000), factors that also may explain the existence of many extremely long-lived deep-water fishes. The oldest fish sampled in this study was a 50-year-old blackbelly rosefish captured at *Gulfpenn*. While old, this fish was only a fraction of the size of much younger fishes in shallower waters, such as amberjack or various groupers sampled at *Halo*. Other old fishes (> 20 years) captured at the deepest sites included cutthroat eels and grenadiers, which again were much smaller at age than shallow water species of similar age, such as the king snake eels sampled at *Halo*.

Little can be inferred about age at recruitment to study wrecks based on the limited number of samples available. No fish was aged to be older than the wrecks, but the possibility exists some fishes at *Halo* approached the age of that wreck. Several Scorpaeniform fishes have been aged to reach 100 years or greater (reviewed in Caillet et al. 2000). As stated above, the only blackbelly rosefish we sampled was estimated to be 50 years old, and no Atlantic thornyheads were captured as none went in traps and all were too large for the ROV suction sampler.

Orange roughy (*Hoplostethus atlanticus*), a congener of the slimehead sampled in this study, has been estimated to have a maximum longevity greater than 120 years (Smith et al. 1995). None of the slimeheads we aged was significantly older than 10 years; however, the largest slimeheads on *Gulfpenn* were able to avoid the ROV suction sampler. Perhaps *H. occidentalis* does not live as long as *H. atlanticus*. Alternatively, *H. occidentalis* may be recent additions to *Gulfpenn* that began recruiting once *Lophelia* colonies reached some large size.

Anthiinae basses captured at *Halo* were the only fishes sampled as juveniles. Counts of daily-formed opaque zones in otoliths of small basses confirmed several were less the one year old. Thus, Anthiinae basses were the only fishes sampled which we infer settled directly on a wreck site. Perhaps other species also settled directly on wrecks, as opposed to recruiting to wrecks as post-settlement juveniles or adults, but no data were collected to support or reject direct settlement.

15.0 CONCLUSIONS

15.1 Archaeology

This study focused on seven shipwrecks lost during the mid-twentieth century. Historically, this group of shipwrecks represents two distinct periods in America's past. The historical significance of each wreck is related to the historical period it represents. The steam yacht *Anona*, for example, was once the pleasure vessel of a wealthy Detroit industrialist. Built in 1904, *Anona* represents America's golden era in the late nineteenth and early twentieth centuries when the United States was a developing industrial power and extravagance the trademark of wealth and privilege. *Anona* is also significant because the ship is the work of a master craftsman. She represents the culmination of iron construction and steam propulsion technology to emulate a ship type that in many ways was representative of the privileged class: the wooden sailing yacht.

The freighters *Alcoa Puritan*, *Robert E. Lee*, and the tankers *Gulfpenn, Halo,* and *Virginia* are reminders of a period when the world was embroiled in a conflict that changed the face of the globe, World War II. On a regional scale, these wrecks emphasize that the war came closer to the United States mainland than most Americans are aware. Additionally, these two freighters and three tankers are significant in that they represent the technological and industrial might of the United States, which played a significant role in turning the tide of the war.

U-166 also fits within the World War II framework. The wreck site is within fifty miles of the Louisiana coast and accentuates how successful the German U-boat campaign in the Gulf of Mexico was in bringing the war to America's shore. *U-166* is also significant as a form of warfare condemned during the First World War, but embraced and developed to deadly precision by the combatants of the Second World War.

Archaeologically, the seven wrecks provide details on deepwater wrecking processes over various depths. Site investigations were carried out in accordance with the project objectives to confirm site identity, determine site boundaries, assess preservation and environmental impacts, and evaluate potential eligibility for the National Register of Historic Places (NRHP).

Of the seven wrecks designated for this study, only four (*Alcoa Puritan*, *Anona*, *Robert E. Lee*, and *U-166*) were positively identified before the project. The remaining vessels (*Gulfpenn, Halo,* and *Virginia*) had only been tentatively identified based on geophysical surveys and limited video documentation. Water clarity at the *Gulfpenn* and *Halo* sites allowed relatively easy confirmation of the vessel's identity based on structural and hull characteristics. At the *Virginia* site, however, limited visibility and sedimentation made positive identification difficult. Close examination of the site's physical evidence and historical documentation confirmed the vessel is *Virginia*.

With the exception of *Virginia* and *Anona*, the extent of the debris fields (wreck site boundaries) were determined during the 2004 project. An investigation of the debris scatter at the *Virginia* site was not undertaken because of poor visibility and the geophysical data did not indicate substantial scatter debris at the site. Site investigations were also limited by a high sedimentation rate that may have buried debris as deep as 37 centimeters. Tropical storms near *Anona* prevented investigations of that site. *Anona*'s assessment as presented in this report is based on the 2002 investigations that were limited to the main hull wreckage. Investigations at the other wreck sites provided enough data, however, to indicate a relationship between water depth, ship size, and the extent of the debris scatter. Based on this information a preliminary model for determining the extent of deepwater wreck sites for this group of ships was developed. Future data acquisition and testing will be required to further refine the model.

The condition, state of preservation, and deterioration rate for each shipwreck, as well as potential environmental impact, was assessed. These results are discussed in detail in the Archaeological and Microbiological sections for each site, as is the impact of bio-fouling communities. In general there was a correlation between the wreck's state of preservation and depth in this area of the Gulf of Mexico. Sediment core samples taken at various locations at each wreck site indicated the wreck sites are not contaminating or adversely impacting the surrounding seafloor at this time.

Each wreck site was assessed for National Register of Historic Places (NRHP) eligibility. After reviewing the archaeological and historical data, it was decided that each site is potentially eligible for the NRHP under Criterion

"A" for their association with events that have made a significant contribution to the broad patterns of our history. It was also determined that all the sites are potentially eligible under Criterion "D" as archaeological sites. Additionally, *Anona* and *U-166* are deemed potentially eligible under Criterion "C" as representative examples of distinctive architecture, and in the case of *Anona* as representing the work of a master.

15.2 Biological

The northern Gulf of Mexico is one of the most productive coastal ecosystems in the world (Caddy and Bakun 1994; Turner and Rabalais 1994). The most significant source of nutrient inputs to the system is the outflow of the Mississippi River (Breed et al. 2004; Dagg and Breed 2003; Dinnell and Wiseman 1986; Hitchcock et al. 1997). Primary production fueled by the river's nutrient load in turn stimulates pelagic secondary production, with a significant amount of water column production raining down, or actively transported by vertical migrants, to the benthos (Dagg and Breed 2003; Turner and Rabalais 1994). Results from stable isotope analyses in this study confirm the importance of phytoplankton production to benthic environments, even those located at considerable depths on the continental slope and rise. Chemosynthetic sources of primary production may be important in the deep Gulf (Carney 1994; MacDonald et al. 2003; Sassen et al. 1998), but seep communities are patchily distributed and data presented herein indicate photic zone production is perhaps a greater source of carbon than chemosynthesis to the deep benthos.

Beyond the outer continental shelf, little natural hardbottom habitat is known to occur. Azooxanthellate corals associated with methane seeps are rare, and seeps themselves, with associated carbonate mounds, are patchily distributed (Reed 2002; Roberts and Aharon 1994). Therefore, as petroleum exploration and production expands into deeper Gulf waters, platforms potentially could add hard substrate for invertebrate and vertebrate taxa in the deep Gulf (Ponti et al. 2002; Roberts and Hirshfield 2003). For example, petroleum drilling and production platforms on the northern Gulf shelf and slope are known to provide substrate for attachment of sessile, suspension-feeding organisms, leading to complex communities in areas where naturally occurring hard substrates are rare. Platforms may also deflect or enhance currents, provide variation in light conditions, serve as attachment sites for algae, and otherwise enhance habitat complexity, attracting a diverse community of resident and nektonic fishes, and mobile invertebrates (Beaver et al. 2003; Ponti et al. 2002; Stanley and Wilson 1997, 2000). Whether platforms serve to increase fish and invertebrate production over broader geographic areas, or simply serve as aggregation sites, is still debated. Some argue that platforms attract and concentrate fishes, rendering them more vulnerable to fishing (Bohnsack 1989). Larger, more fecund individuals that might have been more dispersed in natural habitats may now be concentrated and more susceptible to harvest. Some concerns exist that the more than 4000 offshore platforms in the Gulf of Mexico act as a steel archipelago which may serve as stepping stones for more tropical or offshore species to increase their geographic range (Unpublished observations).

The contention that petroleum platforms serve as artificial reefs is unquestioned. Many studies conducted by a variety of funding agencies have investigated the effects of offshore platforms on marine communities. Fish densities have been reported to be 20 to 50 times higher in the vicinity of these platforms, and many invertebrate species common on the platforms are otherwise rare (Beaver et al. 2003; Roberts and Hirshfield 1999; Stanley and Wilson 1997, 2000). The platforms serve as popular fishing sites for both sport and commercial fishers, and are popular dive sites for scuba enthusiasts (Ditton et al. 2002a,b; Stanley and Wilson 1989). As a result, the Rigs-to-Reef program of MMS, in which obsolete offshore petroleum structures are converted to artificial reefs, has become increasingly popular (Kaiser and Pulsipher 2005; Kasprzak 1998; Stanley and Wilson 1997).

As drilling for oil and gas has progressed into deeper waters of the Gulf of Mexico, the morphology of platforms used in the exploration has changed. Large structures will remain on the seafloor at the drill site, but the upper water column portion of the drilling platform for most wells will exist only during the drilling phase. Should these structures be left on the seafloor as artificial reefs? Little research has been conducted at depths to examine whether these deep-water structures will also serve as artificial reefs, what the successional trends of the community will be, and if the structures will enhance the diversity or density of marine organisms over long time periods. What will the rates of degradation or dissolution be for the drilling structures? Can the rates of electrolysis of the steel structures be modified to advance or retard their dissolution into seawater?

In the current study, we examined the artificial reef effect of WWII shipwrecks, which may serve as surrogates to infer potential effects of deep-sea drilling structures on biological communities. All six of the shipwrecks originated from the same time period, from May to late July, 1942, and are aligned along a depth gradient from 87 to 1963 meters depth. Although we collected specimens by means of traps, suction devices and cores, and plates, most data were derived from video transects. Below, we generalize trends observed in microbiological, invertebrate, and vertebrate communities among shipwrecks studied, as well as differences between shipwrecks and nearby natural habitats at each site.

Microbiology

Major conclusions from this study include:

(1) Shallower sites of *Virginia* and *Halo* nearer the outflow of the Mississippi River were coated with thick layers of dendritic concretions and biofilms (slimes).

(2) Sea anemones were most abundant on *U-166* and particularly *Robert E. Lee*. The anemones appeared to compete for space with both the microbial concretions and concretious growths. Some of these differences in the community structures relate to the degree of impact from nutrients flowing from the Mississippi River into the Gulf of Mexico.

(3) *Alcoa Puritan* is estimated to be paralleling *RMS Titanic*'s (sunk thirty years earlier in 1912) rusticle growth pattern based on the *Titanic* deterioration model. *Alcoa Puritan* is likely following a similar pattern to the *Titanic* and now probably resembles what the *Titanic* looked like in 1974, eleven years before its actual discovery.

Marine Invertebrates

Major conclusions from this study include:

(1) Many rare or uncommon invertebrate species were encountered in this study.

(2) Species richness (the number of species) and abundance of organisms was higher near the shipwrecks in comparison to away from the shipwrecks. This generalization holds primarily for species that were associated with hard substrates. Our sampling methodology, primarily video transects, was biased against infaunal species, those that live within sediments.

- Scleractinia, Antipatharia, and Gorgonacea were only collected from and/or observed on the three shallow wrecks: *Virginia* [87 meters], *Halo* [143 meters], and *Gulfpenn* [554 meters] (Table 4.3).
- Scleractinians were found on all three shallow wrecks.
- Four of the five scleractinians species occurred on *Virginia*, two on *Halo* and two on *Gulfpenn*.
- One species was found on all three wrecks, one only on the two shallowest wrecks, two only on the *Virginia* and one only on *Gulfpenn*.
- Gorgonians were collected from and/or observed on the two shallowest wrecks.
- One individual of one species was found on *Virginia* while a well-developed gorgonian fauna comprised of five species was found on *Halo*.
- Two species of antipatharians were collected from *Virginia*.
- The dominant species on *Virginia* and *Halo* appear to be the antipatharian *Stichiopathes* sp. cf. *S. pourtalesi* and the scleractinian *Madracis myriaster*, respectively, while on *Gulfpenn* the scleractinian *Lophelia pertusa* was the predominant species.

(3) The shipwreck (*Gulfpenn*) at an intermediate depth had 50% more species than the next most speciose site; shallower sites may have been stressed because of increased turbidity, while resource limitations may explain decreased abundance at deeper sites.

- Surfaces on all three wrecks generally appeared either relatively densely colonized with these fauna or have little or no colonization at all.

(4) A strong bathymetric component was evident in the distribution of many taxa, particularly the crustaceans. Many species were restricted to particular depth ranges.

- Individuals and co-occurring species from Scleractinia, Antipatharia, and Gorgonacea have developed combinations of simple to structurally complex biological cover on all types of surfaces and structures.
- In addition, fragments of both living *Madracis myriaster* and *Lophelia pertusa* that have fallen off *Halo* and *Gulfpenn* respectively are growing into new colonies that are providing additional habitat on the muddy sediment adjacent to the hull.
- *Lophelia pertus*a has also successfully colonized wreckage in the debris field of the *Gulfpenn*.

(5) A comparison of within-site species richness, near (<61 meters) and away from (>61 meters) from the shipwrecks, supports the argument that the hard substrate afforded by the shipwrecks supported a higher

species richness, and increased abundance of organisms, at all sites. Again, sampling bias may be evident: epifaunal species are more visible than infaunal species.

(6) Comparison of species richness between sites may be complicated by collecting biases, e.g., decreased visibility because of increased turbidity and differential collecting effort. Alternately, shallower depths may be exposed to increased stress from surface phenomenon, such as increased wave action from storms, increased exposure to seasonal runoff that may cause seasonal variations in water temperature, salinity, and dissolved oxygen.

Marine Vertebrates

Major conclusions from this study include:

(1) Ichthyfaunal diversity generally decreased with depth. One departure from this trend was the shallowest wreck, *Virginia*, did not have the most diverse fish community. It was noted, however, that observed diversity at *Virginia* likely was much lower than true diversity given the poor visibility.

(2) Reef fishes were present at the three shallowest sites, where hard and soft corals were members of the fouling community colonizing the ships, but absent from the three deepest wrecks. This general trend was expected prior to the study. One deviation from expectation, however, was the observation of large numbers of structure-oriented slimeheads and scorpionfishes at *Gulfpenn* (depth = 554 meters). Finding reef-associated taxa on *Gulfpenn* was not anticipated but ichthyofauna documented there are characteristic of deepwater hard bottom areas, such as *Lophelia* reefs, located at similar depths in the north Atlantic.

(3) At the deepest wreck sites, community structure and fish density estimates were not significantly different over the ships versus away from the ships. Therefore, we infer the three deepest shipwrecks in this study conveyed little if any artificial reef effect to fishes found at those depths.

(4) The fish community differed over versus away from the three shallowest wreck sites, but no difference was observed among transect locations at the three deepest wreck sites.

(5) The fish community over the three shallowest wrecks (*Virginia*, *Halo*, and *Gulfpenn*) was dominated by depth-specific reef taxa (e.g., Lutjanids, Serranids, Sebastids, and Trachichthyids). The observed ichthyofauna was quite different away from the wrecks versus over the wrecks from each of those sites, as the community away from wrecks was dominated by benthic and demersal fishes typical of a given depth.

(6) No general trend was observed in the fish community over the wrecks versus away from the three deepest wreck sites (*U-166*, *Robert E. Lee*, and *Alcoa Puritan*). Typical deep-water demersal forms (e.g., Ophidiiforms, Anguilliforms, *Halo* saurids, and Macrourids) dominated the sites. Many families, genera, and species were similar among the deep sites.

A few generalizations can be distilled from the study of the biota (microbes, macro and meiofaunal invertebrates, and fishes) on and around World War II shipwrecks in the northern Gulf of Mexico. The influence of the shipwrecks was evident in the kinds and numbers of epifaunal invertebrates associated with hard substrate, as the abundance and species richness decreased with distance from the shipwrecks at all depths. The abundance of sedimentary meiofauna decreased dramatically with depth, most likely linked to decreases in particulate organic matter derived from surface water production (Rex, 1981; Levin et al., 1994). Species richness of micromollusks, particularly gastropods, decreased abruptly with depth. Many of the distinctive macroinvertebrates also had pronounced bathymetric distributional patterns, being found only at the deeper sites, and not necessarily associated with the shipwrecks. Venus flytrap anemones were conspicuous and abundant members of the epifaunal community on the wrecks. Azooxanthellate hard and soft corals (Scleractinia, Antipatharia, and Gorgonacea) were associated with shipwrecks, but only at the shallowest three shipwrecks. The dense *Lophelia* colonies associated with the *Gulfpenn* may have been among the more dramatic biocenoses in the study. The complex matrix of living and dead branches of corals increase habitat complexity; the absence of these corals in deeper depths undoubtedly resulted in a loss of habitat complexity and some associated macroinvertebrates, as has been noted in *Lophelia* reefs in the northeast Atlantic (Fossa et al., 2002; Mortensen et al., 2001). These deep coral habitats associated with the shipwrecks permitted one of the deeper studies of true reef fishes in the northern Gulf. Reef fish assemblages did not occur at the deeper wreck sites, and the composition of the fish communities were similar among the deeper shipwreck sites, both near and away from the wrecks.

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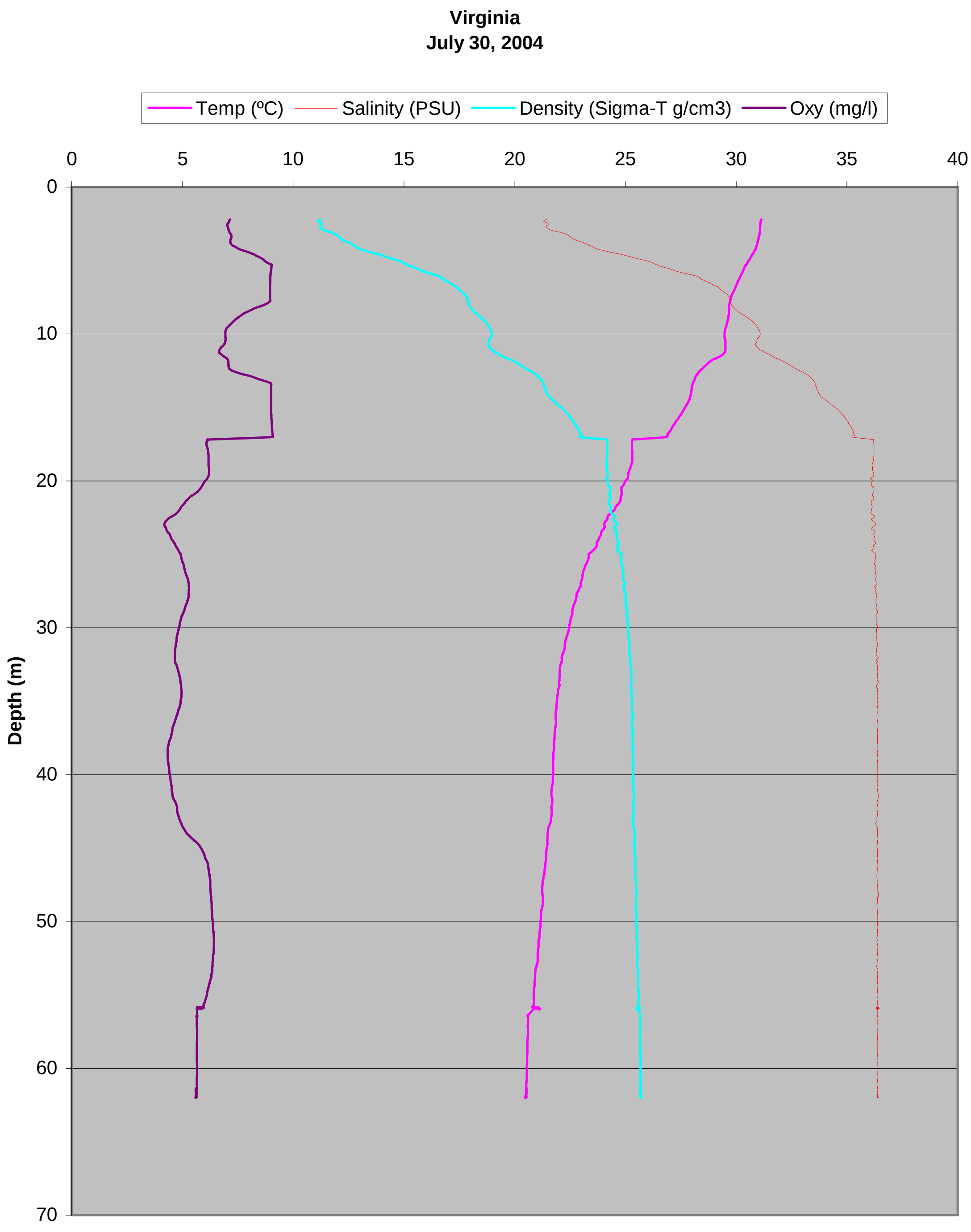
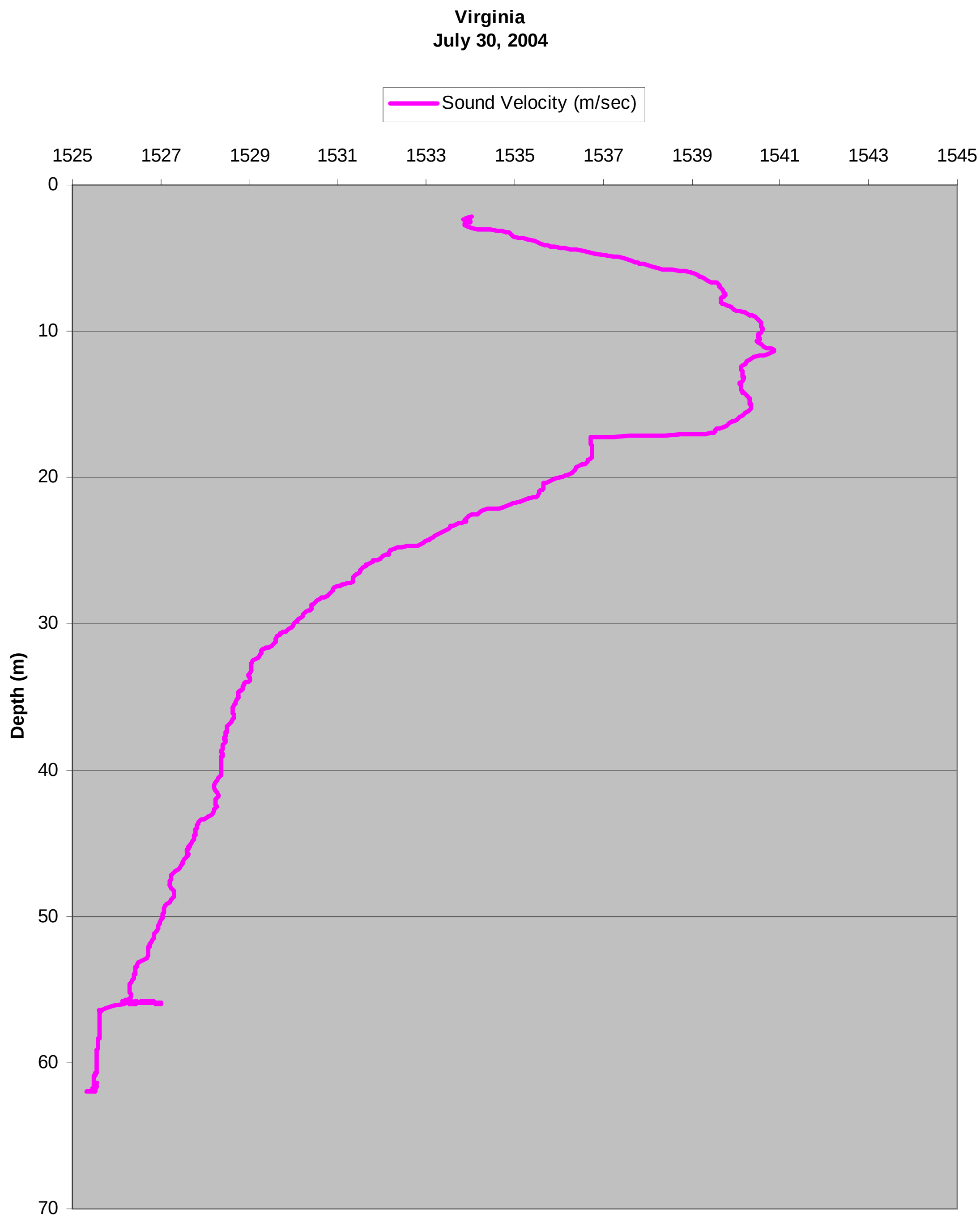
APPENDIX A

Temperature Profile
Salinity Profile
Density Profile
Dissolved Oxygen Profile
Sound Velocity Profile

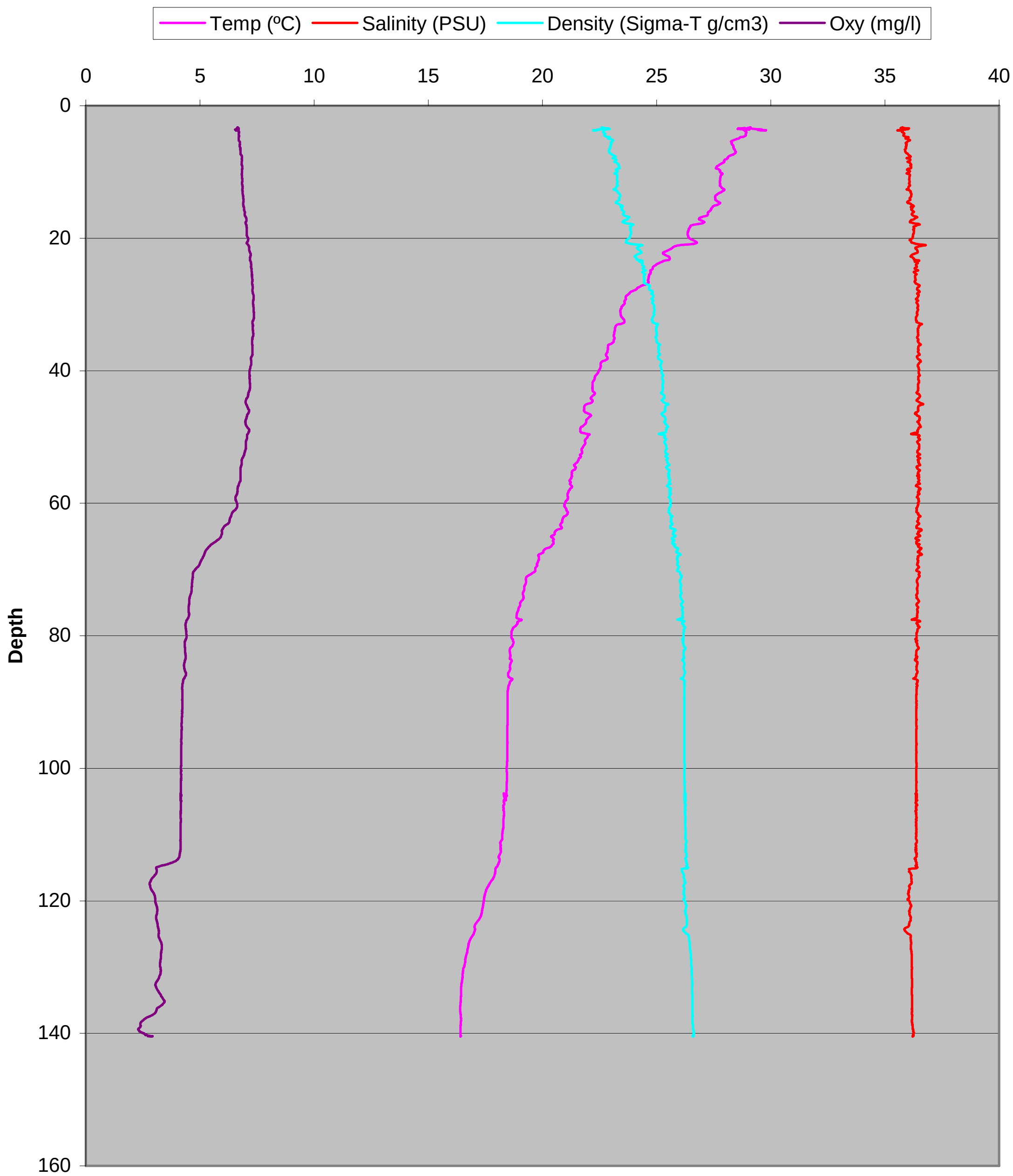


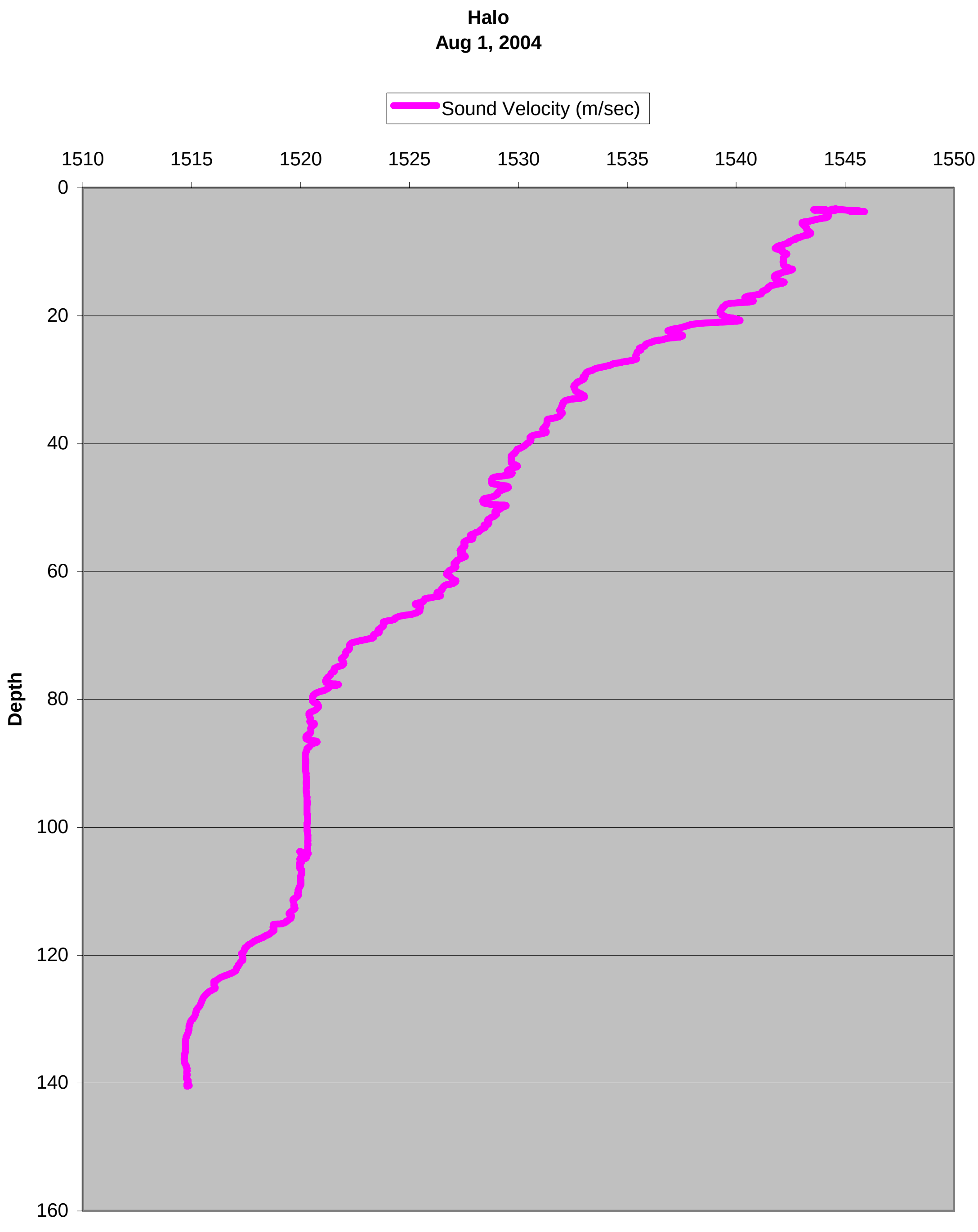
Virginia
July 30, 2004
Temp (ºC)
Salinity (PSU)
Density (Sigma-T g/cm3)
Oxy (mg/l)
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
70
Depth (m)

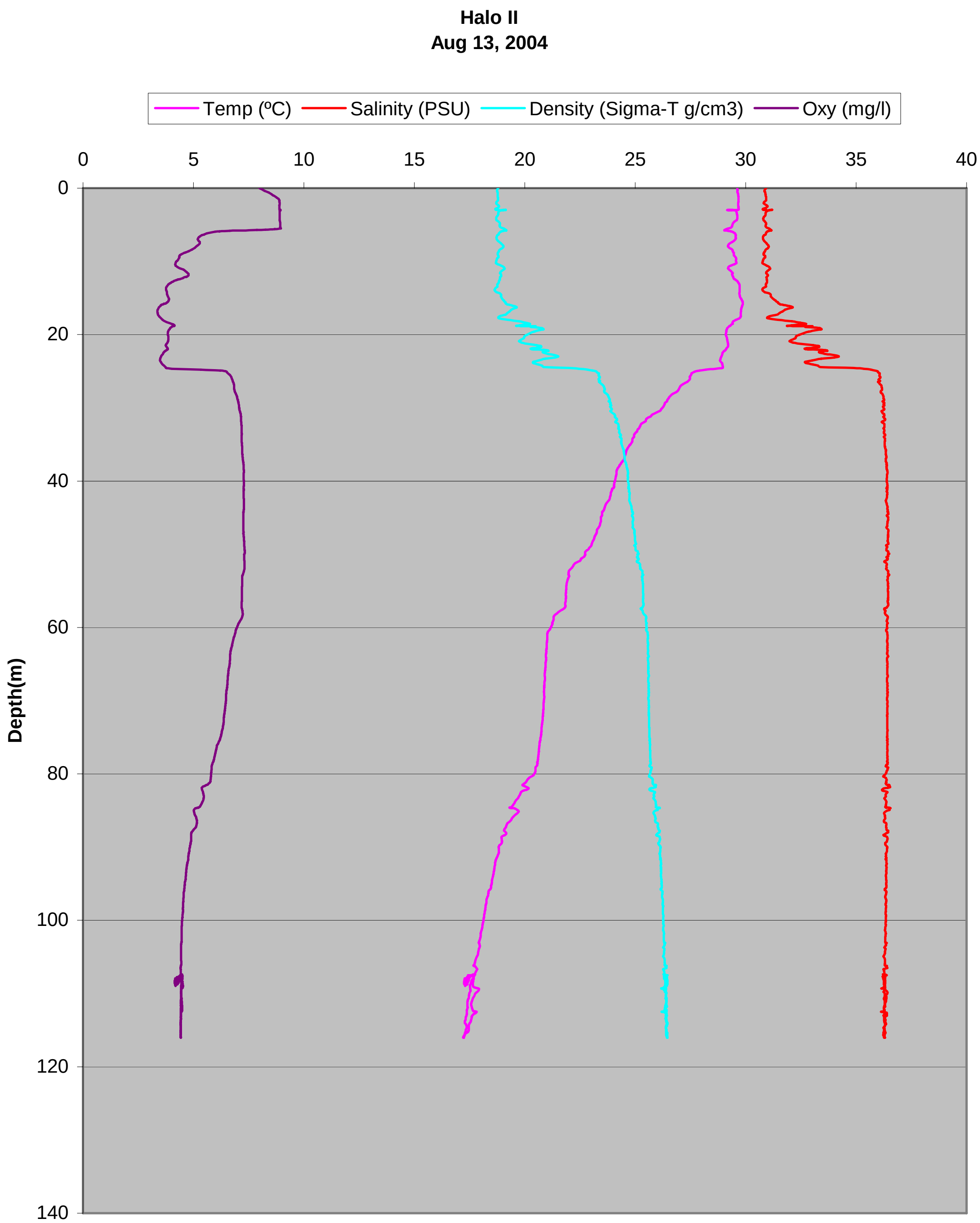


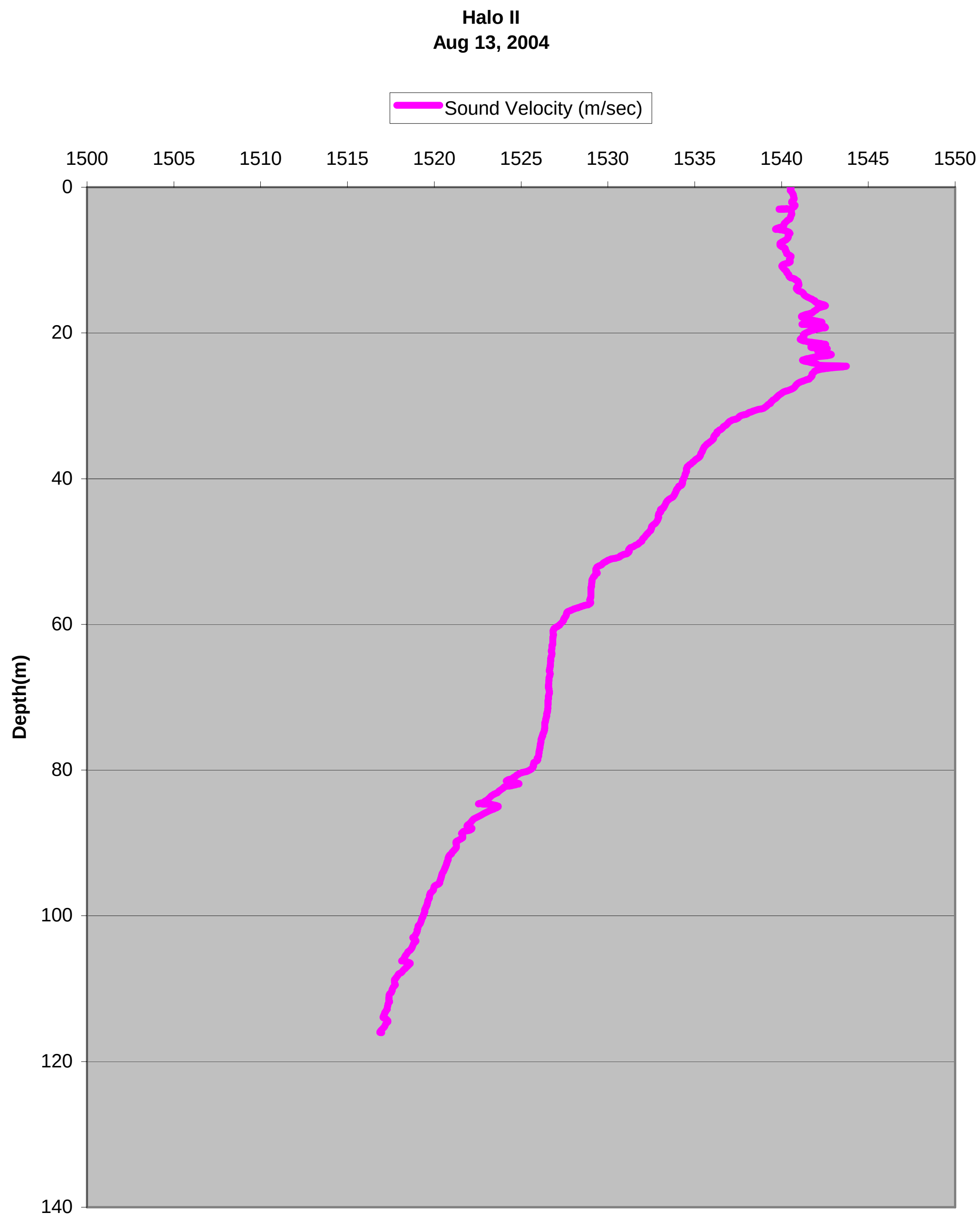
Virginia
July 30, 2004
Sound Velocity (m/sec)
1525
1527
1529
1531
1533
1535
1537
1539
1541
1543
1545
0
10
20
30
40
50
60
70
Depth (m)

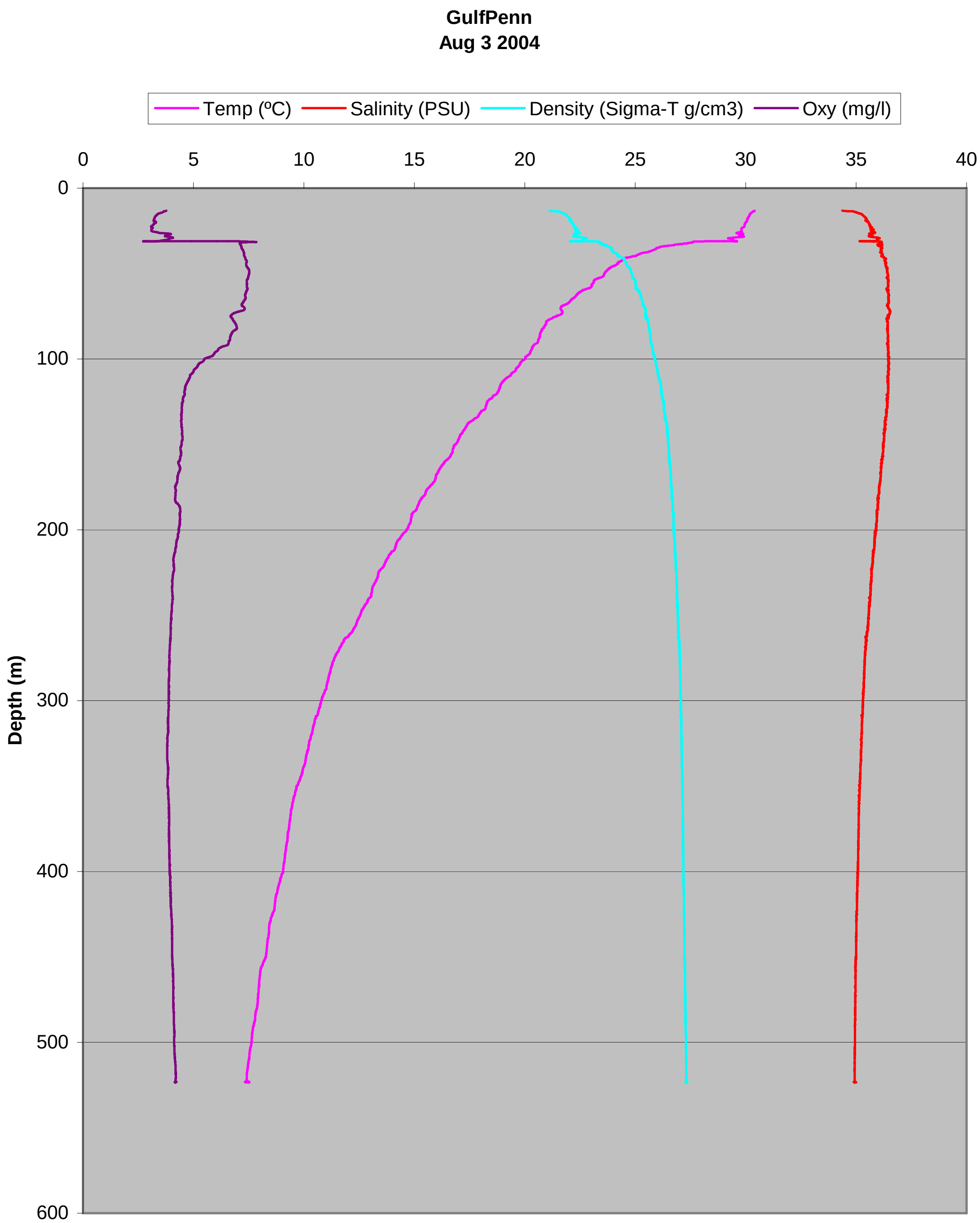
Halo
Aug 1, 2004

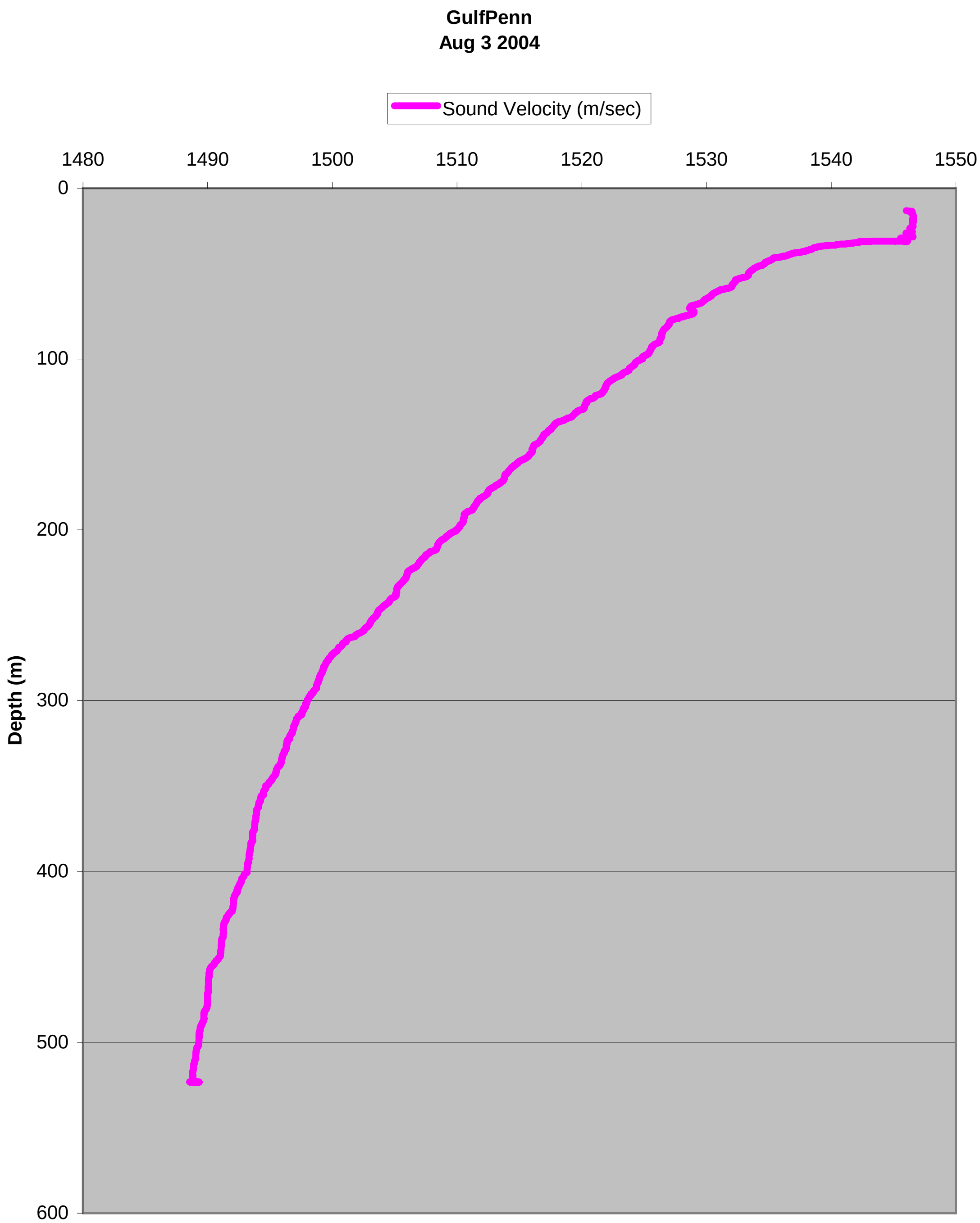


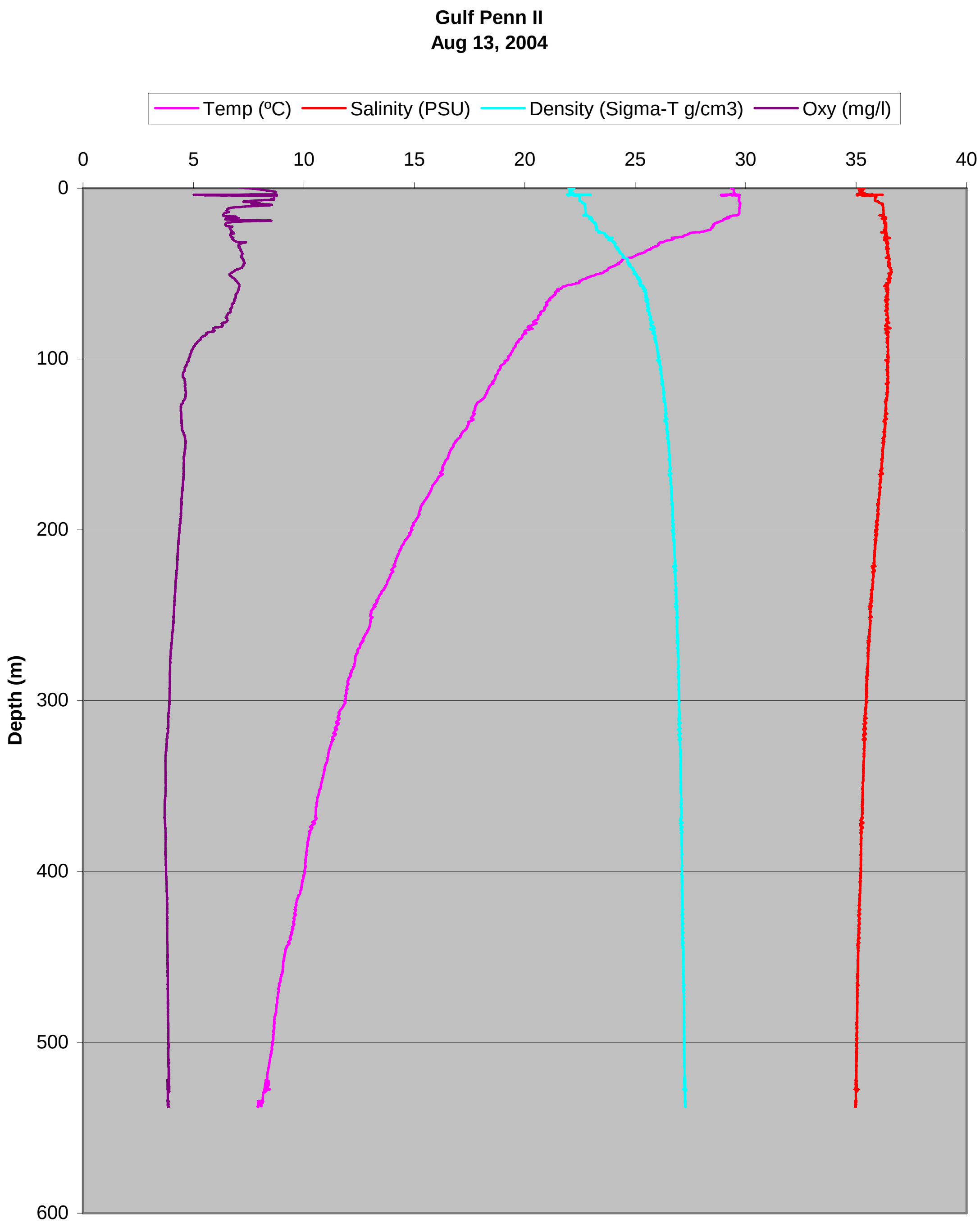

Halo
Aug 1, 2004
Sound Velocity (m/sec)
1510
1515
1520
1525
1530
1535
1540
1545
1550
0
20
40
60
80
100
120
140
160
Depth

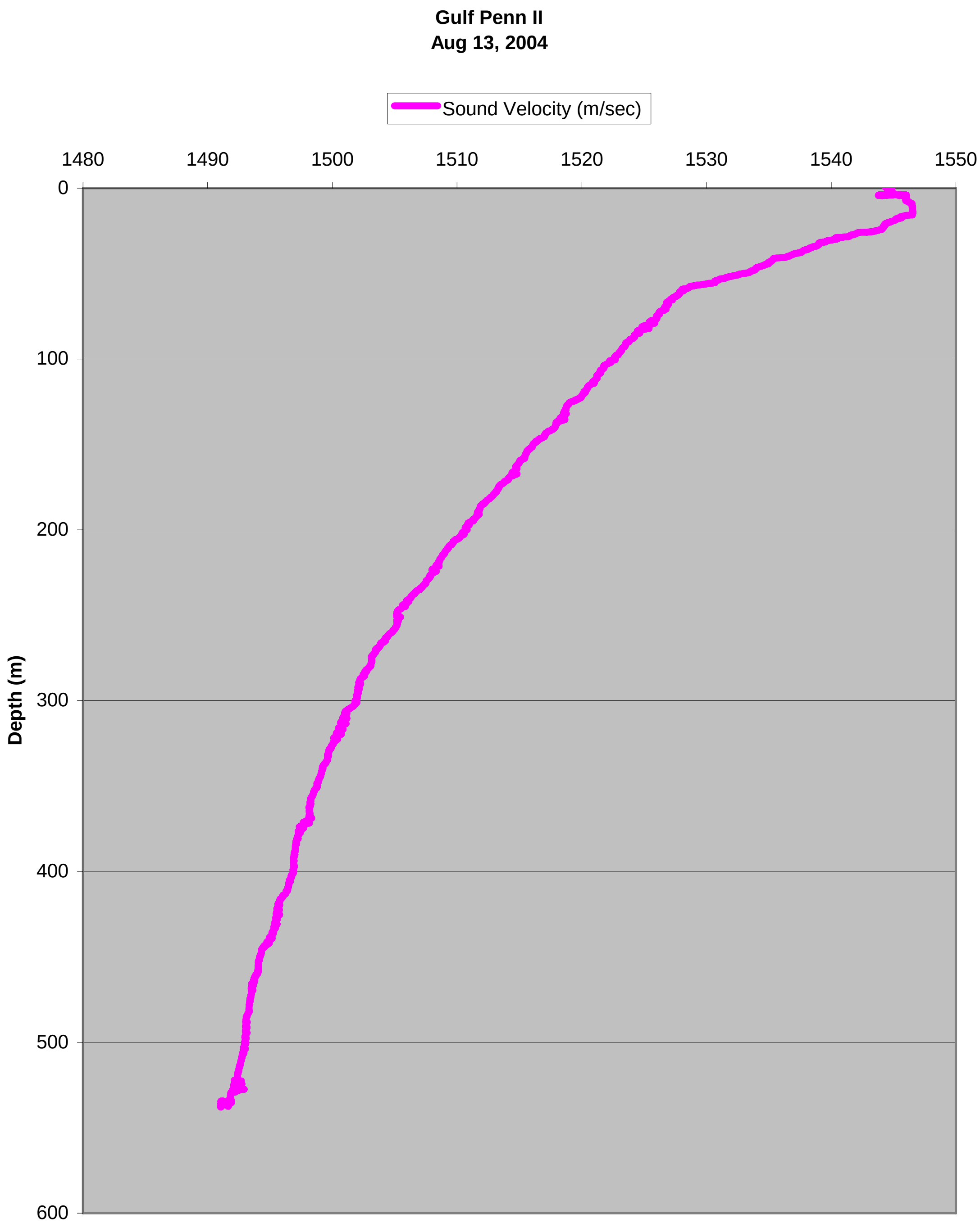

Halo II
Aug 13, 2004
Temp (ºC)
Salinity (PSU)
Density (Sigma-T g/cm3)
Oxy (mg/l)
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
120
140
Depth(m)


Halo II
Aug 13, 2004
Sound Velocity (m/sec)
1500
1505
1510
1515
1520
1525
1530
1535
1540
1545
1550
0
20
40
60
80
100
120
140
Depth(m)

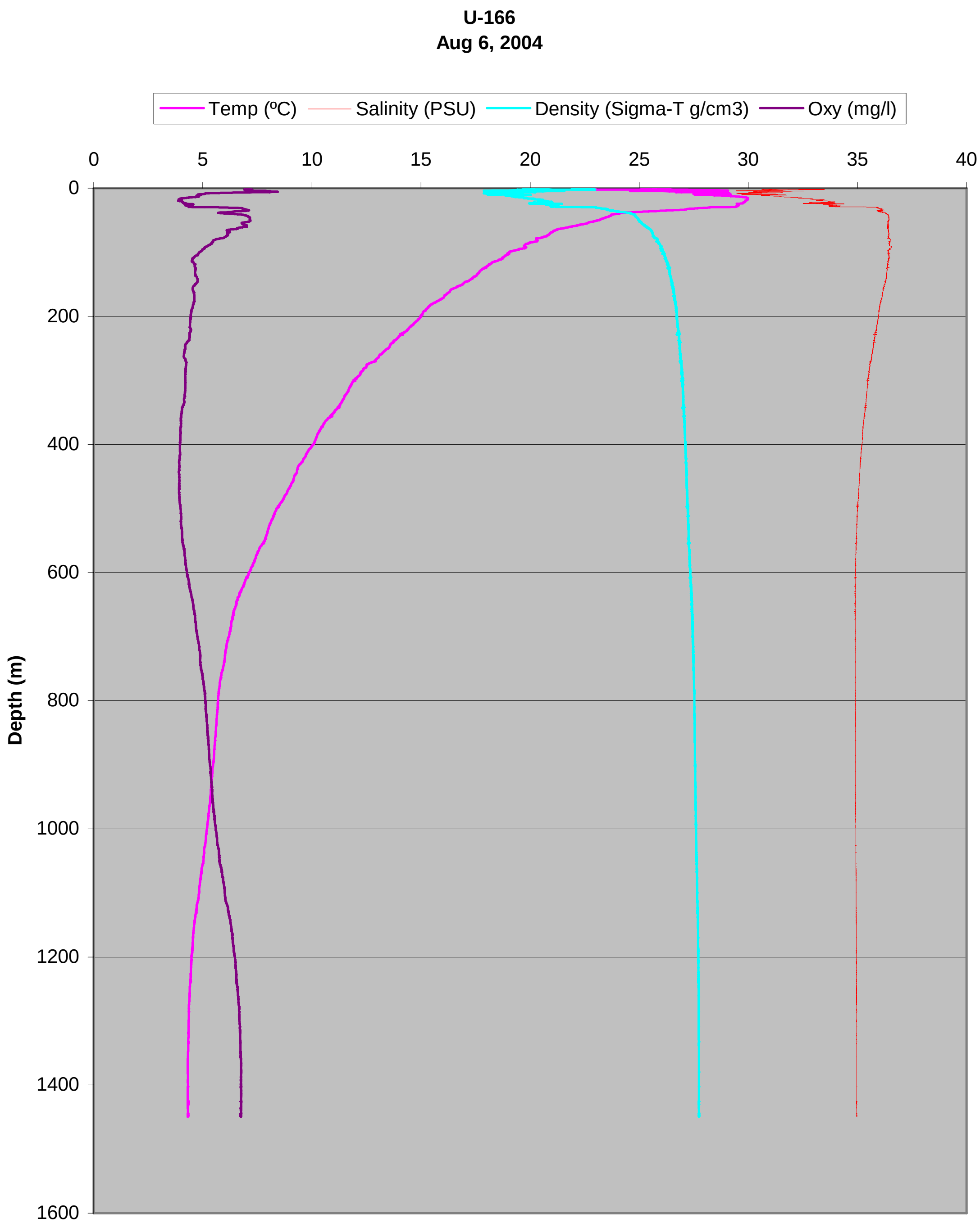

GulfPenn
Aug 3 2004
Temp (ºC)
Salinity (PSU)
Density (Sigma-T g/cm3)
Oxy (mg/l)
0
5
10
15
20
25
30
35
40
0
100
200
300
400
500
600
Depth (m)


GulfPenn
Aug 3 2004
Sound Velocity (m/sec)
1480
1490
1500
1510
1520
1530
1540
1550
0
100
200
300
400
500
600
Depth (m)

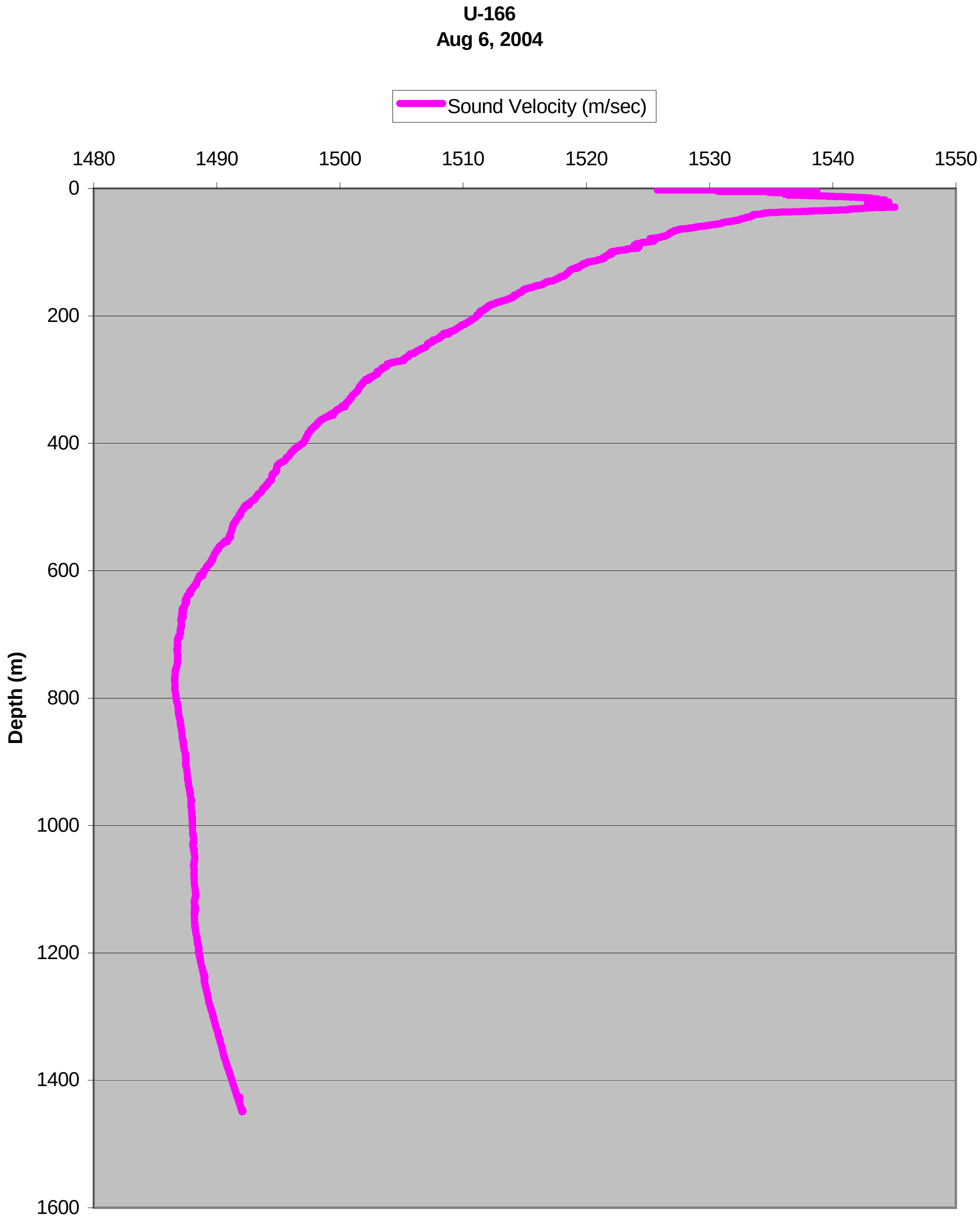

Gulf Penn II
Aug 13, 2004
Temp (ºC)
Salinity (PSU)
Density (Sigma-T g/cm3)
Oxy (mg/l)
0
5
10
15
20
25
30
35
40
0
100
200
300
400
500
600
Depth (m)

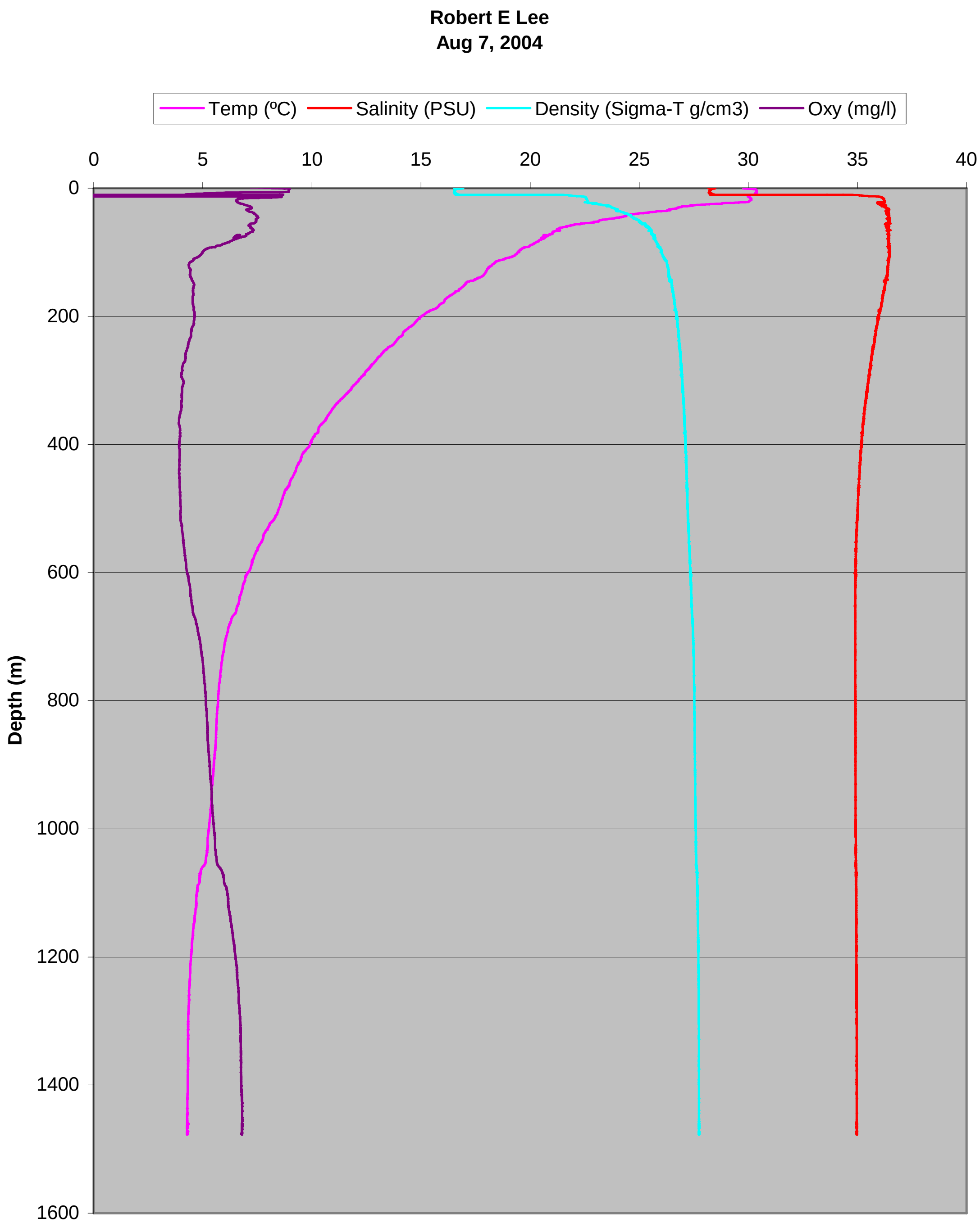


Gulf Penn II
Aug 13, 2004
Sound Velocity (m/sec)
1480
1490
1500
1510
1520
1530
1540
1550
0
100
200
300
400
500
600
Depth (m)

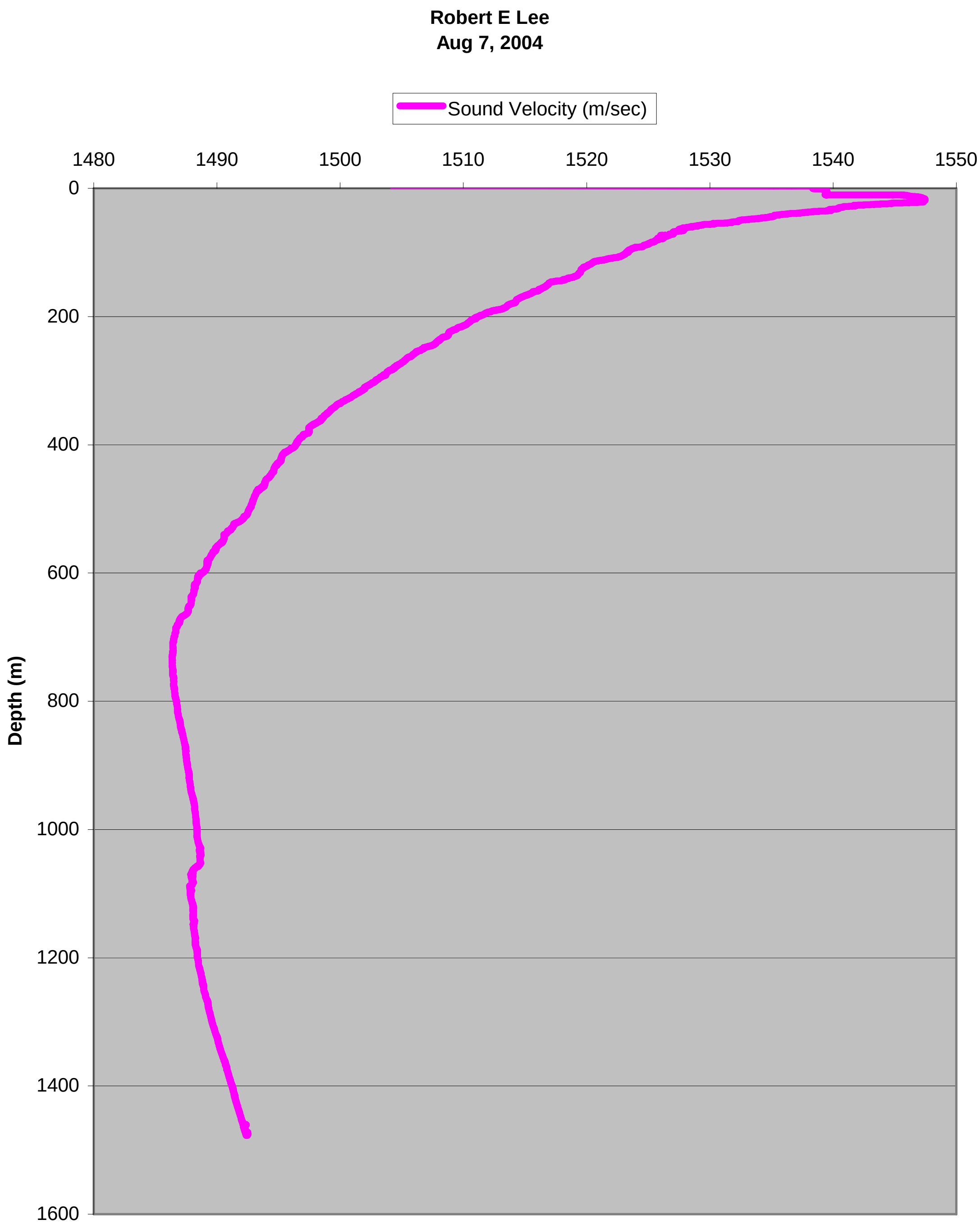


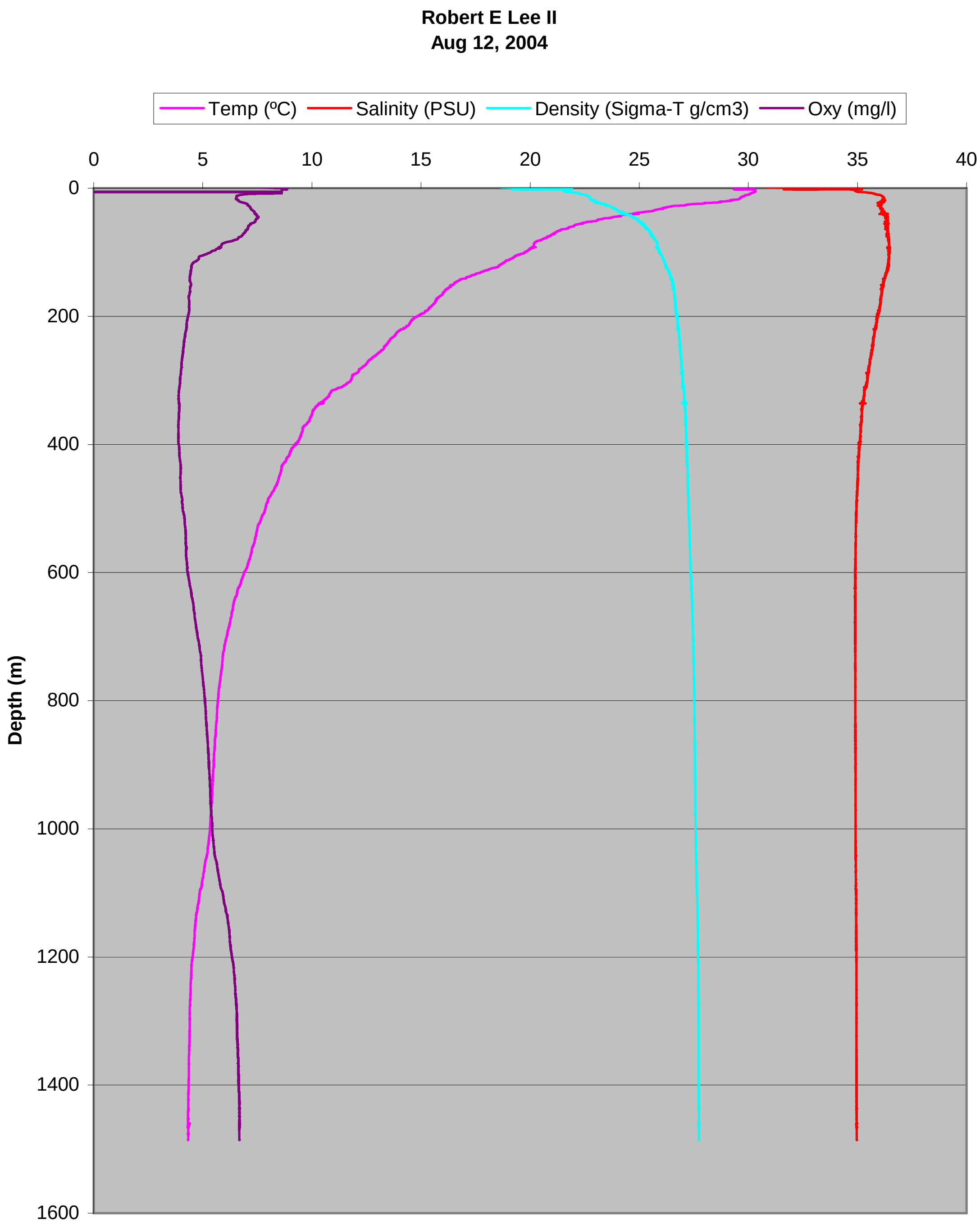
U-166
Aug 6, 2004
Temp (ºC)
Salinity (PSU)
Density (Sigma-T g/cm3)
Oxy (mg/l)
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
1200
1400
1600
Depth (m)


U-166
Aug 6, 2004
Sound Velocity (m/sec)
1480
1490
1500
1510
1520
1530
1540
1550
0
200
400
600
800
1000
1200
1400
1600
Depth (m)

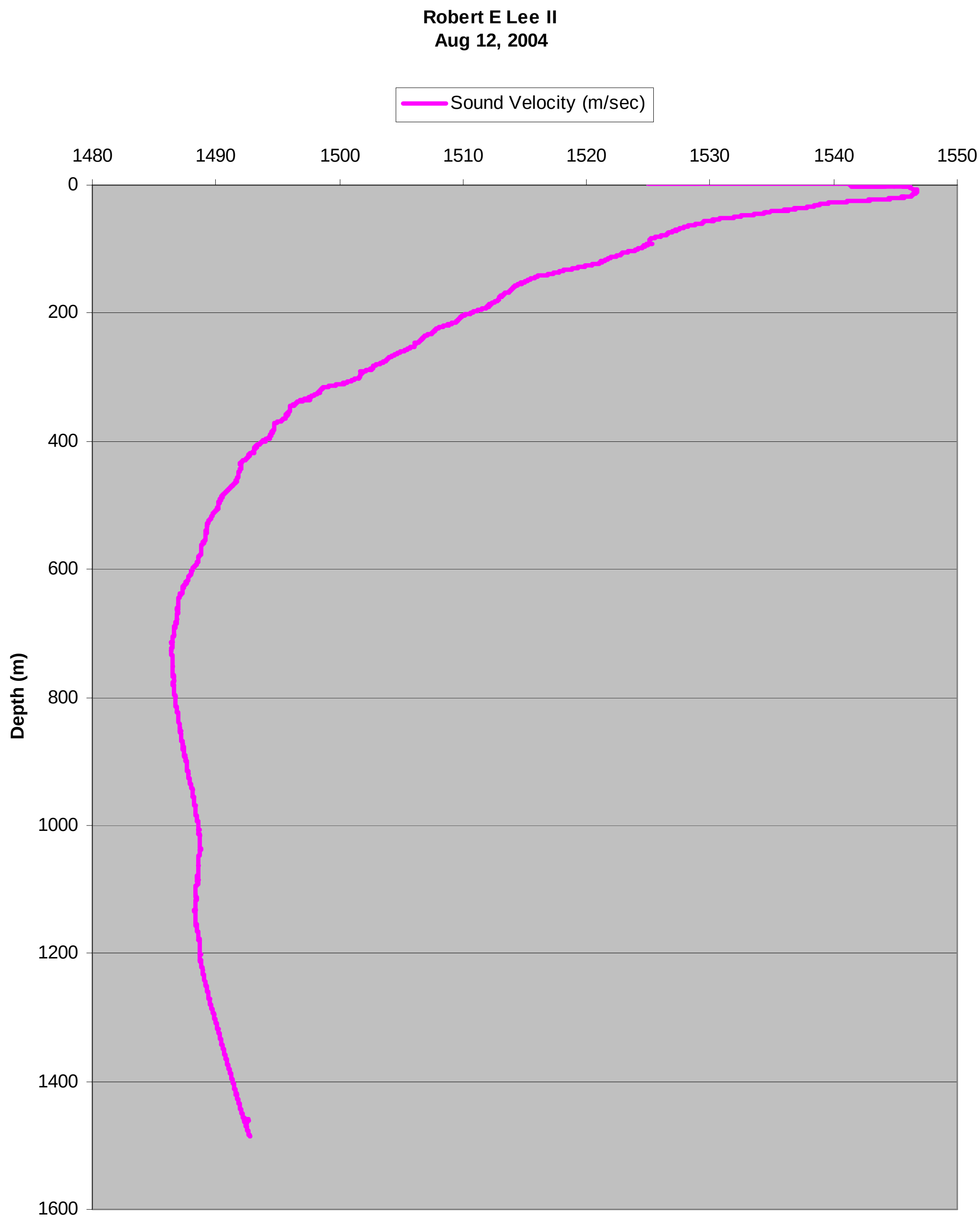


Robert E Lee
Aug 7, 2004
Temp (ºC)
Salinity (PSU)
Density (Sigma-T g/cm3)
Oxy (mg/l)
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
1200
1400
1600
Depth (m)

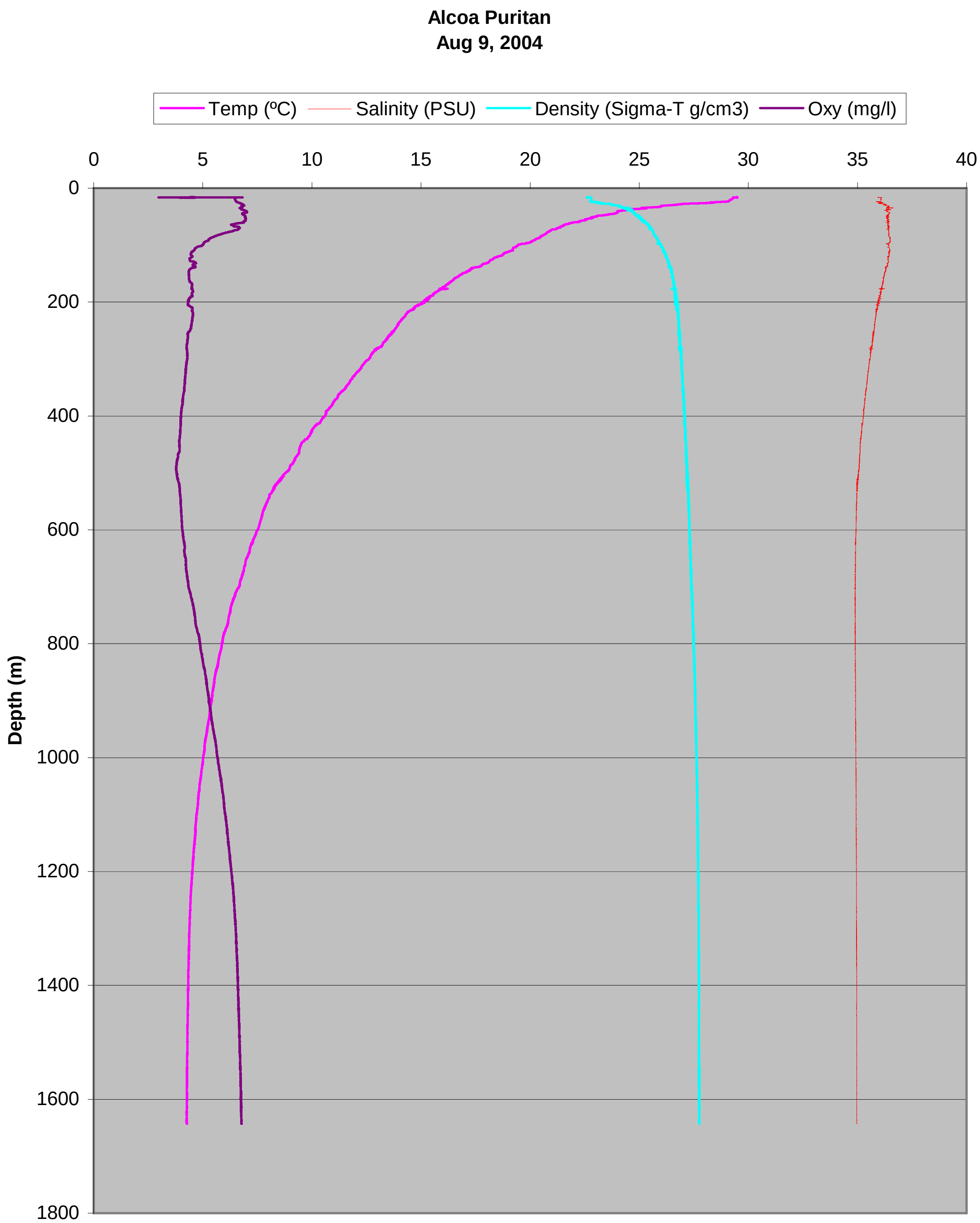

Robert E Lee
Aug 7, 2004
Sound Velocity (m/sec)
1480
1490
1500
1510
1520
1530
1540
1550
0
200
400
600
800
1000
1200
1400
1600
Depth (m)



Robert E Lee II
Aug 12, 2004
Temp (ºC)
Salinity (PSU)
Density (Sigma-T g/cm3)
Oxy (mg/l)
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
1200
1400
1600
Depth (m)

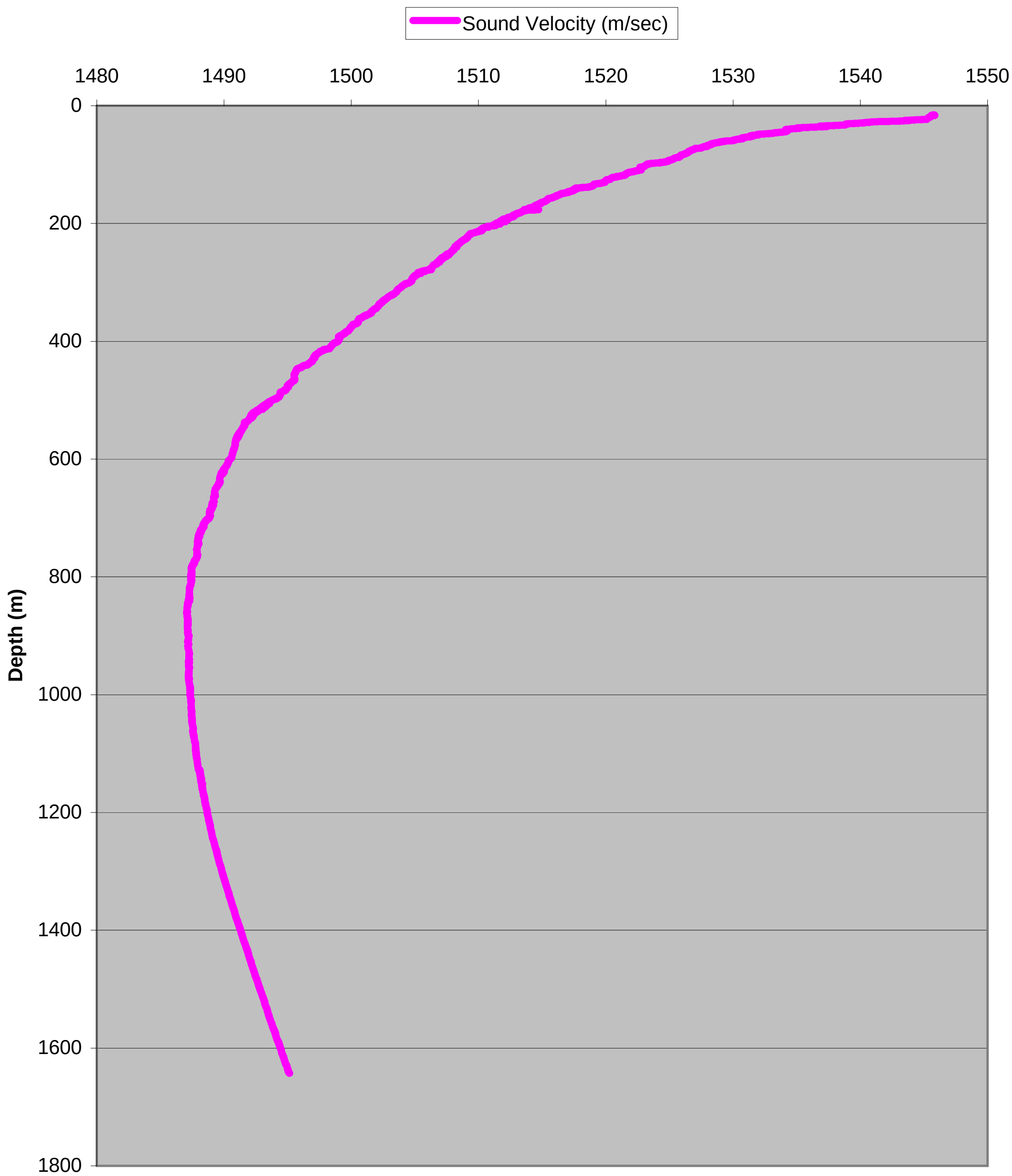


Robert E Lee II
Aug 12, 2004
Sound Velocity (m/sec)
1480
1490
1500
1510
1520
1530
1540
1550
0
200
400
600
800
1000
1200
1400
1600
Depth (m)



Alcoa Puritan
Aug 9, 2004
Temp (ºC)
Salinity (PSU)
Density (Sigma-T g/cm3)
Oxy (mg/l)
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
1200
1400
1600
1800
Depth (m)

Alcoa Puritan
Aug 9, 2004



APPENDIX B

Science Logs

Site ***Virginia***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
7/30/2004	21:33	VI 1	Sea Fan. Laser Distance is 4".	Bio	1-1	21:08:44	VI-1	2
			Test fix here for collection					
7/30/2004	-		Sea Fan. Laser Distance is 4". Test fix here for collection	Bio	1-2			2
7/30/2004	21:42		Sea Fan. Laser Distance is 4". Test fix here for collection	Bio	1-3			2
7/30/2004	21:47	Vi 2 [n/a]	Ship Telegraph [fix Vi 2 was taken at stern at 23:37]	arch	1-4			2
7/30/2004	21:49		Ship Telegraph	arch	1-5			2
7/30/2004	-		Ship Telegraph	arch	1-6	21:51:14	VI-2	2
7/30/2004	[23:37]	[Vi 2]	[Stern]			22:46:55	VI-3	2
7/30/2004						23:30:31	VI-4	2
7/30/2004	23:57		Test Pic for Floc. Matter (Flash Test)	-	1-7			2
7/30/2004	23:59		Test Pic for Floc. Matter (Flash Test)	-	1-8			2
7/31/2004	0:15	Vi 3	Remains of net	Trash	1-9	0:14:35	VI-5	2
7/31/2004	-		Remains of net	Trash	1-10			2
7/31/2004	0:19		Sea Fan (rusticles to right)	Bio	1-11			2
7/31/2004	0:23	Vi 4	Possible rivet holes [No rivets observed]	arch	1-12			2
7/31/2004	0:30	Vi 5	coral (look to right second type)	Bio	1-13			2
7/31/2004	0:34	Vi 6	Hatch	arch	1-14			2
7/31/2004	0:36		batfish (?)	Bio	1-15			2
7/31/2004	0:40	Vi 7	Coral	Bio	1-16			2
7/31/2004	0:57	Vi 8	Brittle/Basket Star	Bio	1-15	0:57:11	VI-6	2
7/31/2004	1:13	Vi 9	Sea Anemone	Bio	1-16			2
7/31/2004	1:24	Vi 10	[Bow Port] Corner (alleged)	arch	1-17			2
7/31/2004	1:31	VI 11	Coral	Bio	1-18	1:40:33	VI-7	2
7/31/2004	1:58	Vi 12	Possible Rust/Steel Sample @ mag hit, aft of stern	Bio				2
7/31/2004	2:00	Vi 13	Possible Rivet Hole [Not a rivet hole - biological origin]	Arch				2
7/31/2004	2:06	Vi 14	Vent Hole, No Pic	Arch				2
7/31/2004	2:14	Vi 15	Possible Bollard	Arch				2
7/31/2004	2:18	Vi 16	[Bow] Definite (lots sea whips)	Arch		2:23:45	VI-8	2

Site ***Virginia***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
7/31/2004						3:06:25	VI-9	2
7/31/2004						3:49:10	VI-10	2
7/31/2004						4:31:36	VI-11	2
7/31/2004						5:14:25	VI-12	2
7/31/2004						5:56:50	VI-13	2
7/31/2004						6:39:13	VI-14	2
7/31/2004	7:15		basket at bottom					2
7/31/2004	7:40		at basket			7:46:00	VI-15	2
7/31/2004	8:01		1st fish trap from basket, going to 1000 ft out.	Bio				2
7/31/2004	8:11	[Vi 17]	large basket at 1000 ft, fix taken	Bio				2
7/31/2004	8:22		Pulling trap away from basket	Bio				2
7/31/2004	8:32	Vi 17 [n/a]	End Time for Basket at 1000ft. Moving to Steel basket	Bio				2
7/31/2004	8:39		at Basket small fish trap back to 1000 ft.	Bio				2
7/31/2004	8:48	Vi 18	Small Fish trap Dropped	Bio				2
7/31/2004	8:56		at basket for core sample plunger "d"	Bio				2
7/31/2004	9:13	Vi 19	Core sampled "D", 1000 ft. LOST CORE	Bio		9:10:16	VI-16	2
7/31/2004	9:17		coming up to drop weights					2
7/31/2004	9:30		basket returned to surface					2
7/31/2004	10:22		ROV in the H2O					2
7/31/2004	10:41		ROV at basket			10:36:57	VI-17	3
7/31/2004	[10:52]	[Vi 20]	Fix on basket					3
7/31/2004	11:19		Disconnected cable from basket					3
7/31/2004	11:38		set large trap close to wreck	Bio		11:41:28	VI-18	3
7/31/2004	11:58	Vi 20	large trap	Bio				3
		[Vi 21]						
7/31/2004	12:52	Vi 21	crab/shrimp trap set	Bio				3
		[Vi 22]						
7/31/2004	12:58		ROV returns to Basket					3
7/31/2004	13:06		Small fish trap retrieved from basket	Bio		12:48:49	VI-19	3

Site ***Virginia***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
7/31/2004	13:13	Vi 22	small fish trap set	Bio				3
		[Vi 23]						
7/31/2004	13:20		ROV returns to Basket					3
7/31/2004	13:24		Core "A" taken from Basket	Bio				3
7/31/2004	13:30		ROV arrives at port side of wreck					3
7/31/2004	13:39	Vi "A"	Core sample "A" collected	Bio				3
		[Vi 27]						
7/31/2004	13:41		ROV leaves wreck					3
7/31/2004	13:51		Core tube "A" replaced in basket	Bio		End of Tape	VI-19	3
7/31/2004	14:02		Core tube "B" retrieved from basket	Bio		13:57:31	VI-20	3
7/31/2004	14:07	Vi "B"	Core sample "B" collected 100 ft. from wreck	Bio				3
		[Vi 28]						
7/31/2004	14:08		ROV leaves sampling site					3
7/31/2004	14:14		ROV returns to Basket					3
7/31/2004	14:17		core tube "b" returned to basket	Bio				3
7/31/2004	14:19		core tube "c" taken from basket	Bio				3
7/31/2004	14:33	Vi "C"	core sample "C" collected 500 ft from wreck	Bio				3
		[Vi 29]						
7/31/2004	14:34		ROV leaves sampling site					3
7/31/2004	14:41		ROV returns to Basket					3
7/31/2004	14:43		Core tube "c" returned to basket	Bio				3
7/31/2004	14:50		Core tube "d" taken from basket	Bio				3
7/31/2004	15:13	Vi "D"	Core "D" collected 1000ft from wreck	Bio		15:01:33	VI-21	3
		[Vi 30]						
7/31/2004	15:14		ROV leaves sampling site					3
7/31/2004	15:31		ROV returns to Basket					3
7/31/2004	15:36		Core tube "D" returned to basket	Bio				3
7/31/2004	15:37		ROV leaves basket to collect bio samples	Bio				3
7/31/2004	16:01		arrive at Vi1 fix; attempt to sample sea fan	Bio				3

Site ***Virginia***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
7/31/2004	16:05		soap fish observed at Vi 1	Bio		16:06:09	VI-22	3
7/31/2004	16:19		attempt to collect invert (nudi branch) at Vi1	Bio				3
7/31/2004	16:26		Invert collected (sea cucumber) seen in basket: suction	Bio				3
7/31/2004	16:29		Sea Whip suction - sampled	Bio				3
7/31/2004	16:42		Removed gregornian? From ship with claw	Bio				3
7/31/2004	16:43		attempt to suck gregornian into back; sea whip went	Bio				3
			past screen; gregornian not seen in basket					3
7/31/2004	16:52		Picked up another gregornian	Bio				3
7/31/2004	16:54		Sucked Gregornian into basket	Bio				3
7/31/2004	16:59	Vi [24]	invert cluster; took fix, survey said this was Vi 26	Bio				3
			but Sonsub and bio/arch log shows this as Vi 23					
7/31/2004	17:39		Sucked up possible invert	Bio		17:11:27	VI-23	3
7/31/2004	17:46		Branching coral (depth of 240 ft) is vaccumed into	Bio				3
			collection box; core was at Vi 23					
7/31/2004	18:16		Arrive back at Vi 1 to attempt to sample sea fan	Bio				3
7/31/2004	18:18		removed portion of sea fan	Bio				3
7/31/2004	18:20		sea fan sucked into hose	Bio		18:15:46	VI-24	3
7/31/2004	18:34		toadfish in view at Vi 9	Bio				3
7/31/2004	18:37		Leaving Vi 9; tried to locate anemone but no luck	Bio				3
7/31/2004	18:59		broke off and sucked up a sea whip at random spot	Bio				3
			near bow					
7/31/2004	19:09		new soft coral observed	Bio		End of Tape	VI-24	3
7/31/2004	19:14		small coral colony	Bio				3
7/31/2004	19:19		suction-sample small branching hard coral colony	Bio				3
7/31/2004	19:22		sampled branching coral; possibly black coral	Bio				3
7/31/2004	19:24		small fish observed	Bio				3
7/31/2004						19:22:31	VI-25	3
7/31/2004	20:06-20:14		rusticle gathering at Vi 12; small sample from overhang	Bio				3
			hull/decking?					

Site ***Virginia***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
7/31/2004	20:15		going to steel basket					3
7/31/2004	20:28		rusticle in bucket. Collect large and small traps	Bio		20:26:30	VI-26	3
			at 1000 ft					
7/31/2004	21:01		small fish trap recovered	Bio				3
7/31/2004	21:17		large trap recovered	Bio		21:30:44	VI-27	3
7/31/2004	[21:45]	[Vi 25]	[Quick Fix]			22:35:04	VI-28	3
7/31/2004	23:37		ROV put back in water to retrieve remaining traps	Bio		22:38:37	VI-29	4
7/31/2004	23:50		large fish trap retrieved	Bio				4
7/31/2004	23:55		test photo of fish in trap (no flash)	Bio	1-19			4
8/1/2004	0:01		Large fish trap placed in basket	Bio				4
	[0:08]	[Vi 26]	[Basket Location]					
8/1/2004	0:34		small fish trap recovered	Bio				4
8/1/2004	0:43		small fish trap placed in basket	Bio		0:42:47	VI-30	4
8/1/2004	0:58		crab trap recovered will bring up with ROV. Recovering ROV	Bio				4
8/1/2004						1:57:48	VI-31	5
8/1/2004						3:02:03	VI-32	5

Site **Investigative Survey South of *Virginia* (Possible Debris)**

Date	Time	Fix No.	**Description** [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	1:55		ROV down. Depth 284			1:57	VI-31	5
8/1/2004	2:01:31		SOL 347					
8/1/2004	2:29		Holo-square 22.9' across					
8/1/2004	2:42		Holo-Square 22' across					
8/1/2004	2:45		Scatter Test					
8/1/2004	2:58		Cont Survey			3:01	VI-32	5
8/1/2004	3:21		Hole- ~ 20' around magnetic anomaly	a				
8/1/2004	3:37		No more mag hits, pull up and change sites	a				

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	8:45		Dominator on site			9:43:08	HA-1	6
8/1/2004	9:24		ROV wet					6
8/1/2004	9:34		ROV sonar contact					6
8/1/2004	9:42		ROV video contact					6
8/1/2004	9:58	HA-1	coral next to stairs (port)	bio	HA 1-1			6
8/1/2004	10:25		Lori's experiment photo I	bio	HA1-2			6
8/1/2004	10:27	HA-2	Lori's experiment in place	bio				6
8/1/2004	10:30		Lori's experiment Photo II / coral	bio	HA2-1 (1-3)			6
8/1/2004	10:32		Lori's experiment Photo II / coral	bio	HA 2-2 (1-4)			6
8/1/2004	10:43		Stern-net	trash				6
8/1/2004	10:47	HA-3	stern fix	arch		10:47:11	HA-2	6
8/1/2004	10:54	HA-4	coral on port stern rail	bio				6
8/1/2004	11:11	HA-5	coral clump/ port side	bio	HA 1-5			6
8/1/2004	11:24	HA-6	red coral mark for urchin collection	bio	HA 1-6			6
8/1/2004	11:36	HA-7	davit port side midship superstructure	arch				6
8/1/2004	11:44	HA-8	forward davit port side midship superstructure	arch				6
8/1/2004	11:47	HA-9	forward end port side	arch		11:51:14	HA-3	6
8/1/2004	12:00	HA-10	anomoly (life boat?) corals	arch/bio				6
8/1/2004	12:12	HA-11	railway? Beside port superstructure in mud	arch				6
8/1/2004	12:19	HA-12	Bow of ship, pictures are out of sync	arch	HA 1-9			6
			missing log photos					
8/1/2004			(1-7) and (1-8)	arch				6
8/1/2004	12:25		Bow of ship	Arch				6
8/1/2004	12:30		hermit crab	bio	HA 1-10			6
8/1/2004	12:34		going down starboard side of vessel (wreck)	arch				6
8/1/2004	12:35		cucumber?	bio				6
8/1/2004	12:37		hermit crab	bio				6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	12:38		hermit crab	bio				6
8/1/2004	12:40		corals and crab	bio				6
8/1/2004	12:41		urchin, corals	bio	HA 1-11			6
8/1/2004	12:42		fish (amber jack)	bio				6
8/1/2004	12:43	HA-13	coral (fix sponge, sea anemone)	bio	HA 1-12			6
8/1/2004	12:45		hermit crab (near bow)	bio				6
8/1/2004	12:47		turned back to railing (changed					6
			direction same as before)					
8/1/2004	12:49		resume where left off					6
8/1/2004	12:50		hermit crab	bio				6
8/1/2004	12:51		fish, coral	bio				6
8/1/2004	12:52		fish, coral, hermit crab	bio		12:54:59	HA-4	6
8/1/2004	12:53	HA-14	basket star	bio	HA 1-13			6
8/1/2004	12:55		coral	bio				6
8/1/2004	12:57		more coral	bio				6
8/1/2004	12:58		coral, fish	bio				6
8/1/2004	13:01		same fish as before, closer picture	bio				6
8/1/2004	13:02		jacks	bio				6
8/1/2004	13:04		school of small fish	bio				6
8/1/2004	13:05		jacks	bio				6
8/1/2004	13:06		grouper? (small fish too)	bio				6
8/1/2004	13:07		coral, small fish	bio				6
8/1/2004	13:14		fish	bio				6
8/1/2004	13:15		coral (backside of superstructure), fish	bio				6
8/1/2004	13:16		ring of coral	bio				6
8/1/2004	13:18		school of fish	bio				6
8/1/2004	13:22		coral	bio				6
8/1/2004	13:22		bollard	arch				6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	13:24		mounting frames	arch				6
8/1/2004	13:26		coral	bio				6
8/1/2004	13:26		valve/ shutoff	arch				6
8/1/2004	13:28		coral on mast structure	arch/bio				6
8/1/2004	13:29		valve	arch				6
8/1/2004	13:31	HA-15	School of fish/coral	bio	HA 1-14			6
8/1/2004	13:33		coral on midship structure	arch/bio	HA1-15			6
8/1/2004	13:34		coral on midship structure	bio	HA 1-16			6
8/1/2004	13:34		school at fish around broken pipe	arch/bio	HA 1-17			6
8/1/2004	13:42		valve	arch				6
8/1/2004	13:45		damaged structure/hole	arch				6
8/1/2004	13:48		separated hull plates (picture) aft at hole	arch				6
8/1/2004	13:48	HA-16	stairs	arch	HA 1-18			6
8/1/2004	13:53		stock-small forward at main funnel	arch				6
8/1/2004	13:56		remains of smoke stack/ funnel	arch				6
8/1/2004	13:57	HA-17	funnel-fold in onself -> bow	arch	HA 1-19			6
8/1/2004	14:02		grouper	bio	HA 1-20	13:58:34	HA-5	6
8/1/2004	14:03		rusticle	arch				6
8/1/2004	14:10		nets on stern	trash				6
8/1/2004	14:11		davit on stern	arch				6
8/1/2004	14:23		floats from shrimp nets	trash				6
8/1/2004	14:27		bollard	arch				6
8/1/2004	14:28		winch/windless	arch				6
8/1/2004	14:37		gun shaped structure/ fire fighting?	arch				6
8/1/2004	14:45		*sub recovery from profile*					6
						15:02:42	HA-6	6
8/1/2004	15:33		scatter test ends					6
8/1/2004	15:52		SOL #120 @ 1kt/ bearing 212 degrees					6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	16:20	HA-18	anemones	bio		16:11:11	HA-7	6
8/1/2004	16:25		batfish observed	bio				6
8/1/2004	16:29		batfish observed	bio				6
8/1/2004	16:33	HA-19	unknown invert?	bio				6
8/1/2004	16:40		unknown invert? Callapa?	bio				6
8/1/2004	16:42		invert	bio				6
8/1/2004	16:45		invert	bio				6
8/1/2004	16:51		invert	bio	HA 1-21			6
8/1/2004	16:53		fish	bio				6
8/1/2004	16:55		shell	bio				6
8/1/2004	16:56		scorpion fish	bio				6
8/1/2004	16:57	HA-20	pipeline	a	HA 1-22			6
8/1/2004	17:00		crab p. 2	bio	HA 1-23			6
8/1/2004	17:01	HA-21	pipeline	a	HA1-24			6
8/1/2004	17:03		crab pic	bio	HA1-25			6
8/1/2004	17:04		invert	bio				6
8/1/2004	17:05		batfish pic	bio	HA1-26			6
8/1/2004	17:06	HA-22	pipeline	a	HA1-27			6
8/1/2004	17:17		flatfish pic	bio	HA1-28	17:15:10	HA-8	6
8/1/2004	17:19		burrow with unknown white invert	bio	HA1-29			6
8/1/2004	17:20		EOL #120					6
8/1/2004	17:23		SOL#121					6
8/1/2004	17:24		seabass? Pic	bio	HA1-30			6
8/1/2004	17:28		fish	bio				6
8/1/2004	17:30		crabs (purse crab)	bio				6
8/1/2004	17:34		invert	bio				6
8/1/2004	17:34	HA-23	pipeline	a				6
8/1/2004	17:35		small fishes	bio				6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	17:37	HA-24	pipeline	a				6
8/1/2004	17:38		batfish	bio				6
8/1/2004	17:39		fish	bio				6
8/1/2004	17:40		invert	bio				6
8/1/2004	17:40		invert	bio				6
8/1/2004	17:43		fish	bio				6
8/1/2004	17:45		fish	bio				6
8/1/2004	17:47		shrimp? Shells	bio				6
8/1/2004	17:48		fish	bio				6
8/1/2004	17:49		batfish	bio				6
8/1/2004	17:50		shell	bio				6
8/1/2004	17:51		fish	bio				6
8/1/2004	17:52		invert	bio				6
8/1/2004	17:55		fish, crab	bio				6
8/1/2004	17:56		fish	bio				6
8/1/2004	17:57		invert	bio				6
8/1/2004	17:58		?	bio				6
8/1/2004	17:59		invert	bio				6
8/1/2004	18:00		fish, shell	bio				6
8/1/2004	18:01		crab	bio				6
8/1/2004	18:02		invert	bio				6
8/1/2004	18:03		invert	bio				6
8/1/2004	18:04		invert	bio				6
8/1/2004	18:05		shell (2)	bio				6
8/1/2004	18:05		fish	bio				6
8/1/2004	18:06		invert	bio				6
8/1/2004	18:07		fish	bio				6
8/1/2004	18:08		invert	bio				6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	18:09		invert	bio				6
8/1/2004	18:09		crab? Shrimp?	bio				6
8/1/2004	18:11		shell (2)	bio				6
8/1/2004	18:12		crab?	bio				6
8/1/2004	18:14		hermit crab	bio				6
8/1/2004	18:15	HA-25	sea star	bio				6
8/1/2004	18:17		flatfish	bio				6
8/1/2004	18:18		batfish	bio		End of Tape	HA-8	6
8/1/2004	18:19		shell	bio				6
8/1/2004	18:21		invert	bio				6
8/1/2004	18:22		shell	bio				6
8/1/2004	18:25		shell	bio				6
8/1/2004	18:28		cucumber? Fireworm?	bio				6
8/1/2004	18:29		fish and crab	bio	HA1-31			6
8/1/2004	18:32		fish	bio	HA1-32			6
8/1/2004	18:34		windless	arch				6
8/1/2004	18:38		fish	bio		18:34:53	HA-9	6
8/1/2004	18:40		shrimp, fish and coral	bio				6
8/1/2004	18:41		shell	bio				6
8/1/2004	18:42		fish	bio				6
8/1/2004	18:43		fish	bio				6
8/1/2004	18:43		fish	bio				6
8/1/2004	18:44		fish	bio				6
8/1/2004	18:46		fish	bio				6
8/1/2004	18:47		fish (2:00 min), fish	bio				6
8/1/2004	18:48		branching coral	bio				6
8/1/2004	18:50		invert	bio				6
8/1/2004	18:51		fish	bio				6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	18:53		fish	bio				6
8/1/2004	18:54		fish	bio				6
8/1/2004	18:55		shell	bio				6
8/1/2004	18:56		sea star, shell	bio	HA1-33			6
8/1/2004	18:57		sea star	bio	HA1-34			6
8/1/2004	18:57		bat fish	bio				6
8/1/2004	18:58		invert	bio				6
8/1/2004	19:05		fish	bio				6
8/1/2004	19:06		hermit crabs	bio				6
8/1/2004	19:09		invertebrate-tubular	bio				6
8/1/2004	19:11		shell, empty?	bio				6
8/1/2004	19:11		invert	bio				6
8/1/2004	19:17		fish in hole	bio				6
8/1/2004	19:22		invert	bio				6
8/1/2004	19:24		fish, small on bottom	bio				6
8/1/2004	19:27		batfish	bio				6
8/1/2004	19:28		invert	bio				6
8/1/2004	19:30		invert, shell	bio				6
8/1/2004	19:35		anemones	bio				6
8/1/2004	19:36		anemones	bio				6
8/1/2004	19:37		shell (2)	bio				6
8/1/2004	19:38		shell	bio				6
8/1/2004	19:39		hermit crab	bio				6
8/1/2004	19:41		hermit crab	bio		19:39:17	HA-10	6
8/1/2004	19:42		shell	bio				6
8/1/2004	19:42		fish	bio				6
8/1/2004	19:43		shell	bio				6
8/1/2004	19:45		invert	bio				6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	19:46		binver	bio				6
8/1/2004	19:52		tile fish	bio				6
8/1/2004	19:54		fish, small	bio				6
8/1/2004	19:55		fish, small	bio				6
8/1/2004	19:57		shell	bio				6
8/1/2004	19:58		crab- dead? Upside down?	bio				6
8/1/2004	20:02		shell	bio				6
8/1/2004	20:04		shell (2)	bio				6
8/1/2004	20:05		fish	bio				6
8/1/2004	20:09		sponge? Probably echinoderm	bio				6
8/1/2004	20:11		shrimp in holes	bio				6
8/1/2004	20:16		echinoderm	bio				6
8/1/2004	20:18		shrimp?	bio				6
8/1/2004	20:21		shell	bio				6
8/1/2004	20:21		echinoderm	bio				6
8/1/2004	20:23		echinoderm	bio				6
8/1/2004	20:24		tube worms	bio				6
8/1/2004	20:30		sea heart	bio				6
8/1/2004	20:33		crab	bio				6
8/1/2004	20:36		squid	bio				6
8/1/2004	20:43		fish	bio				6
8/1/2004	20:49		scorpion fish	bio		20:45:17	HA-11	6
8/1/2004	20:51		SOL #119					6
8/1/2004	20:54		sea heart	bio				6
8/1/2004	20:56		lobsters	bio				6
8/1/2004	21:00		fish, sea robin?	bio				6
8/1/2004	21:03		invert	bio				6
8/1/2004	21:05		zoom on fish	bio				6

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	21:08		spider crab	bio				6
8/1/2004	21:09		small fish	bio				6
8/1/2004	21:10		eel zoom	bio				6
8/1/2004	21:12		invert	bio				6
8/1/2004	21:12		crab	bio				6
8/1/2004	21:14		lobster	bio				6
8/1/2004	21:15		invert	bio				6
8/1/2004	21:19		batfish	bio				6
8/1/2004	21:19		crab	bio				6
8/1/2004	21:20	HA-26	invert, soft coral?	bio				6
8/1/2004	21:24		invert	bio				6
8/1/2004	21:25		inverts	bio				6
8/1/2004	21:26		bryozoan, zoom?	bio				6
8/1/2004	21:28		invert	bio				6
8/1/2004	21:29		bryazoan?	bio				6
8/1/2004	21:34		invert	bio				6
8/1/2004	21:34		lobsters	bio				6
8/1/2004	21:35		scorpion fish	bio	HA 1-35			6
8/1/2004	21:37		invert	bio				6
8/1/2004	21:45		invert zoom	bio				6
8/1/2004	21:46		crab, wormtube, zoom	bio				6
8/1/2004	21:46		batfish	bio				6
8/1/2004	21:48		fish	bio				6
8/1/2004	21:49		fish pic	bio	HA 1-36			6
8/1/2004	21:50		super zoom fish	bio		21:49:34	HA-12	6
8/1/2004	21:52		crab and scorpion fish	bio	HA 1-37			6
8/1/2004	21:52		crab and scorpion fish	bio	HA 1-38			6
8/1/2004	21:53		zoom on scorpion fish	bio				6

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	21:54		amberjacks visit	bio				6
8/1/2004	22:00		after about 21:00 starting to mark fishon					6
			sonar also turbidity up					
8/1/2004	22:02		batfish	bio				6
8/1/2004	22:04		fish	bio				6
8/1/2004	22:06		seabass	bio				6
8/1/2004	22:06		eel zoom	bio				6
8/1/2004	22:09		fish	bio				6
8/1/2004	22:12		fish	bio				6
8/1/2004	22:14		starfish	bio				6
8/1/2004	22:15		suction eel seastar	bio				6
8/1/2004	22:22		coke can	trash				6
8/1/2004	22:28		hermit crab	bio				6
8/1/2004	22:29		debris	arch				6
8/1/2004	22:30		coral	bio				6
8/1/2004	22:31		large burrow	bio				6
8/1/2004	22:32		debris	arch				6
8/1/2004	22:37		fish sample collected	bio				6
8/1/2004	22:45		shiny metal object	trash				6
8/1/2004	22:46	HA-27	anemones	bio				6
8/1/2004	22:54		fish sample collected	bio				6
8/1/2004	23:07		burrowing invert	bio		22:53:48	HA-13	6
8/1/2004	23:17		grouper	bio	HA 1-39			6
8/1/2004	23:17		grouper	bio	HA 1-40			6
8/1/2004	23:23		grouper	bio	HA 1-41			6
8/1/2004	23:28		batfish	bio				6
8/1/2004	23:35		redfish	bio				6
8/1/2004	23:36		grouper	bio	HA 1-42			6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/1/2004	23:39		anemone?	bio				6
8/1/2004	23:52		hermit crab	bio				6
8/1/2004	23:55		pipeline					6
	-	-	shift change			23:57:48	HA-14	6
8/2/2004	0:16		eol #119					6
8/2/2004	0:18		SOL #118 (1000 ft long)					6
8/2/2004	0:23		pipeline					6
8/2/2004	0:24		pipeline					6
8/2/2004	0:41		flounder	bio				6
8/2/2004	0:59		batfish	bio				6
8/2/2004	1:00		sea cucumber	bio				6
8/2/2004	1:09		crab	bio		1:01:48	HA-15	6
8/2/2004	2:02		eol #118					6
8/2/2004	2:04		SOL #116					6
8/2/2004	2:18		starfish	bio		2:05:57	HA-16	6
8/2/2004	2:40	HA -28	survey hit					6
8/2/2004	2:59		EOL #116					6
8/2/2004	3:01		SOL #115					6
8/2/2004	3:14	HA-29	slurp gun, unknown object	bio		3:10:00	HA-17	6
8/2/2004	3:48		batfish	bio				6
8/2/2004	3:49		EOL #115					6
8/2/2004	3:50		SOL #114					6
8/2/2004	3:56		batfish	bio				6
8/2/2004	3:58		shrimp	bio				6
8/2/2004	4:02		batfish	bio				6
8/2/2004	4:05		EOL #114					6
8/2/2004	4:08		heading over to line 122					6
8/2/2004	4:19		sitting on seafloor lights off					6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/2/2004	4:39		lights back on- moving					6
8/2/2004	4:13		started line #122			4:14:03	HA-18	6
8/2/2004	4:46		stopped the ROV, moving TMS					6
8/2/2004	4:49		ROV started again (line 122)					6
8/2/2004	4:56		EOL #122					6
8/2/2004	4:57		started line #123					6
8/2/2004	5:00		batfish	bio				6
8/2/2004	5:03		shrimp	bio				6
8/2/2004	5:15		EOL #123					6
8/2/2004	5:16		SOL #124					6
8/2/2004	5:33		EOL #124			5:18:02	HA-19	6
8/2/2004	5:33		SOL #125					6
8/2/2004	5:44		randalia (crab from leucosiidae)	bio				6
8/2/2004	5:52		EOL #125					6
8/2/2004	5:52		SOL 126					6
8/2/2004	6:11		EOL #126					6
8/2/2004	6:31		cables, bow stern	arch	HA 1-43	6:22:03	HA-20	6
8/2/2004	6:32		writing? Before blowings	arch				6
8/2/2004	6:36		hand railing, starboard	arch				6
8/2/2004	6:39		winch, both stbd and port, portside	arch				6
			buried in mud (3/4) buried					
8/2/2004	6:43		rail and stack, beam of ship~63ft	arch				6
8/2/2004	6:44		bollards	arch				6
8/2/2004	6:45		drop down x 2	arch				6
8/2/2004	6:49		mast flattened	arch				6
8/2/2004	6:51		broken mast, end 52 ft from bow stern to	arch				6
8/2/2004	6:54		mast end portside hand rail	arch				6
8/2/2004	6:55		port winch below deck drops down shaft	arch				6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
			to mast (80 ft)					
8/2/2004	7:06		mast top (40 ft)	arch				6
8/2/2004	7:10		rope/wire from mast	arch				6
8/2/2004	7:13		top of mast moving down (forward to bow)	arch				6
8/2/2004	7:21		start mosaic top of bow winch 24 ft from bow	arch				6
			stem to winch.					
8/2/2004			First line is 3 degree heading and altitude					6
			is ~6ft					
8/2/2004	7:30		raise altitude to 10 ft	arch		7:26:20	HA-21	6
8/2/2004	7:30-7:50		stop line 1 portside bow	arch				6
8/2/2004	7:32		suck up rare crab	bio				6
8/2/2004	7:36		portside line 2, bow mosaic; headline 4	arch				6
			degrees, elevation at					
8/2/2004			start 10ft->4ft	arch				6
8/2/2004	7:43		EOL #2, back to bow	arch				6
8/2/2004	8:07		SOL #3, portside bow, 4 degrees,	arch				6
			altitude 6 ft					
8/2/2004	8:14		winch and cathead, EOL #3, back to bow	arch				6
8/2/2004	8:18		SOL #4, heading 4-6 degrees, 6ft	arch				6
8/2/2004	8:20		just passing cathead on port side	arch				6
8/2/2004	8:23		square box with stack on top of it, just	arch				6
			beside mast->					
8/2/2004			going further slightly past mast. Done line 4	arch		End of Tape	HA-21	6
8/2/2004	8:30		SOL #5, same elevation	arch				6
8/2/2004	8:32		rails and vent	arch				6
8/2/2004	8:34		end of drive shaft	arch				6
8/2/2004	8:35		rollar with pipe running perpendicular	arch				6
8/2/2004	8:35		EOL #5	arch		8:36:11	HA-22	6

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/2/2004	8:40		SOL #6	arch				6
8/2/2004	8:47		EOL #6, starboard moving	arch				6
8/2/2004	8:52		SOL # 7 starboard closest to center then	arch				6
			move outward					
8/2/2004	8:55		winch 1	arch				6
8/2/2004	8:58		starboard baby bollards just in front of winch	arch				6
8/2/2004	8:59		EOL #7	arch				6
8/2/2004	9:07		bow mosaic. Start of line 8, 2nd line of	arch				6
			starboard bow					
8/2/2004	9:09		winch	arch				6
8/2/2004	9:13		small bollard with piplines	arch				6
8/2/2004	9:14		EOL 8 (2nd line stbd)	arch				6
8/2/2004	9:19		SOL #9 (3rd line stbd)	arch				6
8/2/2004	9:20		chain to winch	arch				6
8/2/2004	9:21		vent holes in deck, wooden?	arch				6
8/2/2004	9:22		handrail, stairs (ladders) possible walkway	arch				6
			suspended					
8/2/2004	9:24		box with holes	arch				6
8/2/2004	9:25		EOL #9 (3rd line stbd)	arch				6
8/2/2004	9:29		starboard side at deck outside viewing	arch				6
			45 degrees to stern					
8/2/2004	9:31		moving down stbd side of hull	arch				6
8/2/2004	9:33		possible handrail posts	arch		9:31:20	HA-23	6
8/2/2004	9:34		raise of camphered edge	arch				6
8/2/2004	9:34		another camphered	arch				6
8/2/2004	9:35		edge, hole at 22 ft off bottom, back up	arch				6
			to edge					
8/2/2004	9:36		continuing on by edge	arch				6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/2/2004	9:37		davit up a deck	arch				6
8/2/2004	9:38		corner of pilot house moving aft to stern	arch				6
8/2/2004	9:39	HA-30	stbd side davit just after of pilot wheel house	arch				6
8/2/2004	9:42		aft corner of wheel house	arch				6
8/2/2004	9:43		drop down to decking	arch				6
8/2/2004	9:44		to camphered edge below is hole to confirm	arch				6
8/2/2004	9:52	HA-31	bow fix -> bow #2	arch				6
8/2/2004	9:56		long lines possible?	arch				6
8/2/2004	10:06		moving boat/rov to port side of stern	arch				6
8/2/2004	10:17		at portside stern	arch				6
8/2/2004	10:17		camphered edge port side, moving aft	arch				6
8/2/2004	10:19		1st porthole moving aft to stern	arch				6
8/2/2004	10:20		handrail sticking out? Can't count	arch				6
8/2/2004	10:21		move to stern portholes	arch				6
8/2/2004	10:28	HA-32	stern get fish as 2nd stern # 2nd bow/stern					6
8/2/2004	11:00		start 1st bioline			10:35:33	HA-24	6
8/2/2004	11:30		buried red and white fish, escaped, chased	bio				6
			away by conger eels					
8/2/2004	11:25		start 2nd biol line					6
8/2/2004	12:15		end 2nd bioline			11:39:39	HA-25	6
8/2/2004	12:18		start 3 bioline					6
8/2/2004	12:36		collection, flatfish	bio		12:44:33	HA-26	6
8/2/2004	12:38		collection	bio				6
8/2/2004	12:40		batfish collected	bio				6
8/2/2004	12:47		collected fish	bio				6
8/2/2004	12:49		collected invert	bio				6
8/2/2004	12:50		invert	bio				6
8/2/2004	12:51		collected invert	bio				6

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/2/2004	12:53		check for invert	bio				6
8/2/2004	12:54		collected invert	bio				6
8/2/2004	12:55		invert	bio				6
8/2/2004	12:56		collected invert	bio				6
8/2/2004	12:58		fish collected	bio				6
8/2/2004	13:00		fish collected	bio				6
8/2/2004	13:01		jack	bio				6
8/2/2004	13:04		end of bioline 3					6
8/2/2004	13:13		ROV brought back up to surface	bio		End of Tape	HA-26	6
8/2/2004	15:35		Basket in water	bio				
8/2/2004	16:43		ROV placed back in water	bio				7
8/2/2004	16:52		ROV reaches basket	bio		16:48:49	HA-27	7
8/2/2004	16:53		basket hits bottom	bio				7
8/2/2004	16:55		ROV picks up large fish trap	bio				7
8/2/2004	17:00	HA-33	large fish trap set 1000 ft from wreck	bio				7
8/2/2004	17:02		ROV arrives at basket	bio				7
8/2/2004	17:03		ROV picks up small fish trap	bio				7
8/2/2004	17:08	HA-34	small fish trap set ~30 south of large fish trap	bio				7
8/2/2004	17:09		ROV reaches basket	bio				7
8/2/2004	17:10		shrimp traps	bio				7
8/2/2004	17:14	HA-35	shrimp traps placed ~30 ft north of large	bio				7
			fish trap					
8/2/2004	17:16		ROV reaches basket	bio				7
8/2/2004	17:17		Core tube "D" retrieved	bio				7
8/2/2004	17:22	HA-D	Core sample "D" taken 1000 ft from wreck	bio				7
8/2/2004	17:29		Core tube "D" returned to basket	bio				7
8/2/2004	17:30		basket raised, begin moving to location	bio				7
			closer to wreck					

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/2/2004	18:06		basket placed in new location (200 ft east	bio		17:52:38	HA-28	7
			of wreck)					
8/2/2004	18:22		Large fish trap picked up	bio				7
8/2/2004	18:34		test picture taken- now using photo software	bio	test			7
8/2/2004	18:35	HA-36	large fish trap placed	bio				7
8/2/2004	18:43		shark	bio				7
8/2/2004	18:44		flipped trap (large fish trap) to correct	bio				7
			orientation					
8/2/2004			(weights on bottom)					7
8/2/2004	18:46		ROV reaches basket	bio				7
8/2/2004	18:51		ROV picks up small fish trap	bio		18:58:22	HA-29	7
8/2/2004	18:54		ROV reaches basket	bio				7
8/2/2004	18:55		ROV picks up crab trap	bio				7
8/2/2004	19:00	HA-37	crab trap placed	bio				7
8/2/2004	19:04	HA-38	small fish trap placed	bio				7
8/2/2004	19:08		Core "A" taken from basket	bio				7
8/2/2004	19:12	HA-A	sample "A"collected on core tube; sample	bio				7
			taken next to wreck					
8/2/2004	19:18		core tube "A" placed in basket	bio				7
8/2/2004	19:19		Core "B" taken from basket	bio				7
8/2/2004	19:21	HA-B	Core "B" sample collected 100 ft from wreck	bio				7
8/2/2004	19:24		Core "B" placed back in basket	bio				7
8/2/2004	19:28		Core "C" taken from basket	bio				7
8/2/2004	19:34	HA-C	Core "C" accidentally dropped before	bio				7
			reaching 500 ft mark					
8/2/2004			from the wreck; enough sediment has	bio				7
			been collected to keep					
8/2/2004			despite the accided.	bio				7

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/2/2004	19:40		too much sediment has fallen out of core	bio				7
			tube "C"; core tube "E"					
8/2/2004			will be used to take an alternate sample	bio				7
8/2/2004	19:43		Core tube "C" returned to basket	bio				7
8/2/2004	19:44		Core "E" taken from basket	bio				7
8/2/2004	19:51	HA-E	Core sample "E" collected 500 ft from wreck	bio				7
8/2/2004	20:02		core tube "E" placed in basket	bio		End of Tape	HA-29	7
8/2/2004	20:11		coral pic	bio	HA 1-44			7
8/2/2004	20:11		coral pic	bio	HA 1-45			7
8/2/2004	20:16		coral suction sample	bio				7
8/2/2004	20:17		coral sample	bio	HA 1-46	20:15:12	HA-30	7
8/2/2004	20:18		occulina sample	bio				7
8/2/2004	20:24		urchin sample	bio				7
8/2/2004	20:36		coral and fish sample	bio				7
8/2/2004	20:40		light sampling	bio				7
8/2/2004	20:44		fish/coral sampling	bio				7
8/2/2004	20:49		attempt fish sample	bio				7
8/2/2004	21:01		fish sample	bio				7
8/2/2004	21:05		fish sample	bio				7
8/2/2004	21:45		fish/coral sampling	bio		21:19:34	HA-31	7
8/2/2004	21:51		reef picture	bio	HA 1-47			7
8/2/2004	21:55		grouper picture	bio	HA 1-48			7
8/2/2004	21:56		grouper picture	bio	HA 1-49			7
8/2/2004	21:57		grouper picture	bio	HA 1-50			7
8/2/2004	21:58		grouper picture	bio	HA 1-51			7
8/2/2004	21:59		grouper picture	bio	HA 1-52			7
8/2/2004	22:00		grouper picture	bio	HA 1-53			7
8/2/2004	22:02		rusticle collection	bio				7

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/2/2004	22:13		grouper picture	bio	HA 1-54			7
8/2/2004	22:27		sample collected	bio		22:22:48	HA-32	7
8/2/2004	22:33		fish sample	bio				7
8/2/2004	22:43		grouper picture	bio	HA 1-55			7
8/2/2004	22:45		coral collected	bio				7
8/2/2004	22:47		yellow coral collected and crab	bio				7
8/2/2004	22:47	HA-39	rusticle	bio				7
8/2/2004	22:55		grouper picture	bio	HA 1-56			7
8/2/2004	22:55		grouper picture	bio	HA 1-57			7
8/2/2004	23:10		basket star collected	bio				7
8/2/2004	23:10		heading towards basket	bio				7
8/2/2004	23:26		basket star placed in yellow basket unknown	bio				7
			letter below k and heads back					
8/3/2004	0:00		fish; ROV returns to wreck	bio	HA 1-58	23:29:11	HA-33	7
8/3/2004	0:30		Dory	bio				7
8/3/2004	0:38		roughtongue seabass?	bio				7
8/3/2004	0:52		scaphella sp	bio		0:35:02	HA-34	7
8/3/2004	0:54		crab	bio				7
8/3/2004	1:03		crab	bio				7
8/3/2004	1:10		crab	bio				7
8/3/2004	1:19		fishes	bio				7
8/3/2004	2:02		coral	bio		1:39:00	HA-35	7
8/3/2004	2:35		heading down portside hunting for	bio				7
			rusticles… locked and loaded					
8/3/2004	3:04		possible rivet-based rusticle trying to	bio	HA 1-59	2:42:59	HA-36	7
			retrieve stein. Ok					
8/3/2004	3:17		nodule	bio	HA 1-60			7
8/3/2004	3:22		rusticles (2) maybe on railing covered in	bio	HA 1-61			7

Site ***Halo***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
			algae/coral					
8/3/2004	3:28		another rusticle on railing	bio	HA 1-62			7
8/3/2004	3:54		rusticle on hull	bio	HA 1-63	End of Tape	HA-36	7
8/3/2004	3:55		another rusticle on hull- did stein get it?	bio	HA 1-64	3:55:40	HA-37	7
8/3/2004			Knocked concretion off hull revealing original	bio	HA 1-65			7
			steel					
8/3/2004	4:26		recover small fish trap near hull	bio				7
8/3/2004	4:33		recover small crab trap near hull	bio				7
8/3/2004	4:34		one shrimp trap fell off crab trap	bio				7
8/3/2004	4:39		crab trap in basket (from hull)	bio				7
8/3/2004	4:42		fish trap in basket (from hull)	bio				7
8/3/2004	4:46		recover loose crab trap	bio				7
8/3/2004	4:50		recover large fish trap	bio				7
8/3/2004	4:55		large fish trap in basket	bio				7
8/3/2004	4:56		loose crab trap in basket	bio				7
8/3/2004	5:07		recover experiment from wreck (lori)	bio		4:59:45	HA-38	7
8/3/2004	5:11		experiment in basket	bio				7
8/3/2004	5:26		attached hook to basket	bio				7
8/3/2004	5:31		move ROV/ Basket 1000 ft	bio				7
8/3/2004	6:00		recovered small fish trap (white)	bio				7
8/3/2004	6:07		recovered large fish trap	bio		6:03:47	HA-39	7
8/3/2004	6:16		recovered minnow traps	bio				7
8/3/2004	6:15		Basket off bottom	bio				7
8/3/2004	6:20		Basket on Deck	bio				7
8/3/2004	6:27		ROV on Deck	bio				7

Site ***Gulfpenn***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/3/2004	23:30		ROV hit bottom					
8/4/2004	0:15		arrive on site ship (upright), bow			23:42:24	GP-1	9
8/4/2004	0:17	GP-1	bollard, handrails port side coral (large colony all	Arch/Bio				9
8/4/2004			along handrail, large number of colonies					9
8/4/2004	0:20		bow-tip port side anchor, large hole on port side	a				9
8/4/2004	0:24	GP-2	below anchor. Stem tip: large anemone, corals	Arch/Bio				9
			all along handrails					9
8/4/2004	0:25		4 large bollards	a				9
8/4/2004	0:27		start portside recon. (bow ~50ft off bottom)	a				9
8/4/2004	0:28		camphor? down, hand rails with anemones	Arch/Bio				9
8/4/2004	0:30		2 bollards, portside, between rails	a				9
8/4/2004	0:33		part of davits, passing	a				9
8/4/2004	0:34	GP-3	pilot house, part of mast, flat top and wires fallen	a				9
			over just beside pilot house					9
8/4/2004	0:36		hold- aft of pilot house, catwalk behind hold large	a				9
8/4/2004			buckle on portside; aft of pilot house					9
8/4/2004	0:39		pulley head?	a				9
8/4/2004	0:41	GP-4	large coral thickets	bio				9
8/4/2004	0:42		rivets and hull plating; chain and rails	arch				9
8/4/2004	0:43		straighten out, definite buckle	a		0:42:32	GP-2	9
8/4/2004	0:42		box, ladder to engine room, portholes	arch				9
8/4/2004	0:46	GP-5	large corals growing on davits	bio				9
8/4/2004	0:48		drop down, continue onto portside, portholes	arch				9
8/4/2004	0:49		hole in decking, deck, house fallen in?	a				9
8/4/2004	0:50		stern end, blown out, twisted debris,	arch				9
			moving around stern, keel clearly visible					
8/4/2004	0:52		winch visible, small corals and anemone	arch/bio				9
8/4/2004	0:54		rusticles on stern, eel, rivet line, hanging rusticle,	arch/bio				9

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
			fish, chain and twisted metal					
8/4/2004			hull, fish, rusticle rivet					9
8/4/2004	1:02	GP-6	galathaid crab, hanging rusticle	bio				9
8/4/2004	1:04		begin mud line survey, portside, fish picture	bio				9
8/4/2004	1:07		bow, does not appear to be scour around hull,	arch				9
			fish around base of keel					
8/4/2004	1:08		hawse hole?	arch				9
8/4/2004	1:09		sea slug, sea roach	bio				9
8/4/2004	1:10		fish, cucumber	bio				9
8/4/2004	1:11		large anemones	bio				9
8/4/2004	1:12		black tip shark	bio				9
8/4/2004	1:13	GP-7	scallops, attached to port hull	bio				9
8/4/2004	1:14		crab, large buckly (start)	bio				9
8/4/2004	1:15	GP-8	fish, hanging rusticle, nodules	bio				9
8/4/2004	1:17		more rust hanging	bio				9
8/4/2004	1:17		fish from side moving down to mid line	bio				9
8/4/2004	1:18		fish, venemous, dropped off from stern to	bio				9
			bow ~10 ft					
8/4/2004	1:19	GP-9	rusticles from hulll from both complete and broken	bio				9
			scouring					
8/4/2004	1:20		wireline coming down, elevation move up 2 ft.	arch				9
			rivet line					
8/4/2004	1:22	GP-10	artifact 1- leather or rubber gasket	arch				9
8/4/2004	1:23		chain with coral, anemone and fish, cucumber,	bio				9
			scallops and coral debris					
8/4/2004	1:25		coral debris with new growth and anemone	bio				9
8/4/2004	1:27	GP-11	pipe up against hull	arch				9
8/4/2004	1:29		crab and rusticle, hanging, scallops and fish	bio				9
8/4/2004	1:31	GP-12	hanging rusticle, very good samples with rust rivers	bio				9

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	1:35		hull, exagerated	arch				9
8/4/2004	1:37	GP-13	buckle, mud line shows crinkle buckles, fish,	arch				9
			anemones, artifact 2					
8/4/2004	1:38		tip stern, coral along mud line	bio				9
8/4/2004	1:40		anchor, port	arch				9
8/4/2004	1:42		possible gulf penn name on portside	arch				9
8/4/2004	1:48		tip of stern	arch		1:46:34	GP-3	9
8/4/2004	1:51		stbd coral on side. Large coral thicket, all on	bio				9
			handrails					
8/4/2004	1:56		ladder on deck, right at camphor down, ropes	arch				9
			and wires					
8/4/2004	1:57		hol in deck, linsting to stbd	arch				9
8/4/2004	1:59	GP-14	wall of coral, estimate~15 ft tall, 40-55ft off mud	bio				9
			line, ROV					
8/4/2004	2:02		davit with coral	arch/bio				9
8/4/2004	2:03		mast fallen across deck hand rails laying in	arch				9
8/4/2004	2:04	GP-15	large amound of fish around mast	bio				9
8/4/2004	2:05		wench, next to stand mast, wire from mast to	arch				9
			pilot house					
8/4/2004	2:07		large amount of coral up mast; more growth on N,	bio				9
			mast 60' from floor					
8/4/2004	2:09		continue on survey					9
8/4/2004	2:10		tear in plating? Or door (loading)	arch				9
8/4/2004	2:12		tear in deck-seam; biological unknown	arch/bio				9
8/4/2004	2:13	GP-16	hull buckle with cables; 15-18' from sea floor to	arch				9
			deck					
8/4/2004	2:16	GP-17	stairs, box, just in front of engine room;	arch				9
			experiment placement from					
8/4/2004			stbd (Platform F)					9

Site ***Gulfpenn***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	2:21-2:23		Placement of small experiment	bio				9
8/4/2004	2:28	GP-18	2nd wall of coral on engine room, fish 10' of coral	bio				9
			wall, fish vacuumed up					
8/4/2004	2:33	GP-19	back to recon ; move up aft along engine room	arch				9
			structure. Port hole with glass					
8/4/2004	2:35		anenome on wire with coral, hole in decking,	bio				9
			fish at coral					
8/4/2004	2:36		At end of engine room	arch				9
8/4/2004	2:36	GP-20	Davit with coral can see decking below	arch/bio				9
8/4/2004	2:37		twisted stern, hull plating twisted back;	arch/bio				9
			lots of fish located at stern					
8/4/2004			around break					9
8/4/2004	2:39		Moving forward on stbd to look for funnels	arch				9
8/4/2004	2:42		Decking gone, hole visible into ship structure	arch				9
8/4/2004	2:42		Vent visible, hatch	arch				9
8/4/2004	2:42		Funnel hole clearly visible	arch				9
8/4/2004	2:43		Large school of fish by coral (Fix GP-19 &18)	bio				9
8/4/2004	2:45		Mud line; stern rip on steel plates water tight	arch				9
8/4/2004			seam? Moving forward from stern to tip					9
8/4/2004	2:47	GP-21	Artifact 3- on floor; fish; corals	arch/bio				9
8/4/2004	2:48		buckle visible on mud line	arch				9
8/4/2004	2:52	GP-22	rusticles down hull plating, more plate like on hull;	bio		2:50:42	GP-4	9
8/4/2004			not necessary running down					9
8/4/2004	2:54		~194 ft on stbd side; 486 ft to stern					9
8/4/2004	2:55		Slime cloud; rusticle growth large on hull plates;	arch/bio				9
			slime cloud large: 2-3 ft off floor up to bow tip					
8/4/2004			covered throughout base with slime cloud					9
8/4/2004	2:59	GP-23	Large rusticles (pectorals) possible, layering visible	bio				9
8/4/2004	3:00		shrimp vacuum up	bio				9

Site ***Gulfpenn***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	3:04		Caved in around base (40' from bow), large	arch				9
8/4/2004	3:06		Rusticles hanging just in front of the caved in	bio				9
			section					
8/4/2004	3:07		Bow stem	arch				9
8/4/2004	3:15		Recon over center of bow to stern	arch				9
8/4/2004	3:40	GP-24	fix on rusticles and wheel (steeing wheel) helm	arch/bio				9
8/4/2004	3:44		fish in water column	bio				9
8/4/2004	3:44		stern/starboard side davit?	arch				9
8/4/2004	3:46		hole in stern	arch				9
8/4/2004	3:46		scorpion fish	bio				9
8/4/2004	3:47		fish at stern	bio				9
8/4/2004	3:49		skylights on stern	arch				9
8/4/2004	3:49		wheel possibly on a valve, took a picture,	arch				9
			same as wheel from Fix GP24					
8/4/2004	3:51		End Recon; start survey- Bio and Arch					9
			moving to lines					
8/4/2004	3:55	GP 25	Debris; artifact	arch		3:54:41	GP-5	9
8/4/2004	3:55		fish next to artifact Ophididae (2)	bio				9
8/4/2004	3:58		sea cucumber (2) on bottom	bio				9
8/4/2004	3:59		fish in water column	bio				9
8/4/2004	3:59		jellyfish; cucumber	bio				9
8/4/2004	4:01		pipeline?					9
8/4/2004	4:03		fish; attempted to catch	bio				9
8/4/2004	4:04		cucumber	bio				9
8/4/2004	4:04		depression in sand	arch/bio				9
8/4/2004	4:07		Start of line 226 (1500 ft)	ml541				9
8/4/2004	4:08		cucumber	bio				9
8/4/2004	4:11		cucumber	bio				9
8/4/2004	4:11		part of crab	bio				9

Site ***Gulfpenn***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	4:14		indention in sand-right of screen	arch				9
8/4/2004	4:16		cucumber	bio				9
8/4/2004	4:16		anenome	bio				9
8/4/2004	4:18	[GP 26]	anenome; [unidentified debris]	arch				9
8/4/2004	4:20		cucumber	bio				9
8/4/2004	4:22		At stern	bio				9
8/4/2004	4:25		corals	bio				9
8/4/2004	4:27		fish	bio				9
8/4/2004	4:28		fish	bio				9
8/4/2004	4:32		many possible slimeheads around mast (GP15)	bio				9
8/4/2004	4:39		shrimp in water column	bio				9
8/4/2004	4:47		crab collection	bio				9
8/4/2004	4:48		scorpion fish	bio				9
8/4/2004	4:49		Lots of coral	bio				9
8/4/2004	4:50		fish	bio				9
8/4/2004	4:56		cucumber	bio				9
8/4/2004	4:56		Fish along bottom	bio				9
8/4/2004	4:57		anenome	bio				9
8/4/2004	4:57		Jellyfish;	bio				9
8/4/2004	4:57		Anenome	bio				9
8/4/2004	4:58		Jellyfish	bio		4:58:42	GP-6	9
8/4/2004	4:59		Shrimp	bio				9
8/4/2004	5:01		cucumber	bio				9
8/4/2004	5:01		Anenome	bio				9
8/4/2004	5:02	GP27	Artifact 4	arch				9
8/4/2004	5:04		cucumber (2)	bio				9
8/4/2004	5:05		Cucumber	bio				9
8/4/2004	5:07		Cucumber, anenome	bio				9
8/4/2004	5:08		anenome	bio				9

Site ***Gulfpenn***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	5:10		cucumber	bio				9
8/4/2004	5:12		cucumber	bio				9
8/4/2004	5:13		fish; rattail?	bio				9
8/4/2004	5:14		fish collection	bio				9
8/4/2004	5:14		anenomes (2)	bio				9
8/4/2004	5:16		fish; cucumber (2)	bio				9
8/4/2004	5:19		fish on bottom	bio				9
8/4/2004	5:19		End of Line 226	bio				9
8/4/2004	5:20		fish on bottom (3)	bio				9
8/4/2004	5:21		Start of line 227 (Bio)	bio				9
8/4/2004	5:22		Crab?	bio				9
8/4/2004	5:24		Fish swimming left to right; fish on bottom	Bio				9
8/4/2004	5:25		octopus on bottom	bio				9
8/4/2004	5:25		Cucumber	bio				9
8/4/2004	5:26		Anenome	bio				9
8/4/2004	5:26		Cucumber collection	bio				9
8/4/2004	5:28		Fish	bio				9
8/4/2004	5:28		Cucumber (5)	bio				9
8/4/2004	5:30		Cucumber (2); fish; anenome	bio				9
8/4/2004	5:31		jellyfish	bio				9
8/4/2004	5:36	GP28	Plastic crate	arch				9
8/4/2004	5:49		Cable in soil on stbd side	arch				9
8/4/2004	5:50		On Stbd side of hull					9
8/4/2004	5:51		fish in water column	bio				9
8/4/2004	5:52		scorpion fish	bio				9
8/4/2004	5:53		fish in water column	bio				9
8/4/2004	5:54		Slimehead	bio				9
8/4/2004	5:56		Floating ring- falling	bio				9
8/4/2004	5:57		Slimeheads	bio				9

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	6:00		Lots of slimeheads close to stern	bio				9
8/4/2004	6:03		Starfish; fish (ribbonfish)?; cucumber	bio		6:02:44	GP-7	9
8/4/2004	6:04		jellyfish (2); cucumber	bio				9
8/4/2004	6:08		End of Line 227, but continued along for					9
			possible pipeline					
8/4/2004	6:10		Depression off of stern ~300-320 feet out	Arch				9
8/4/2004	6:20		Cucumber (2); crab	bio				9
8/4/2004	6:24		cucumber	bio				9
8/4/2004	6:25		jellyfish	bio				9
8/4/2004	6:28		Start line 225 for Bio					9
8/4/2004	6:29		Anenome	bio				9
8/4/2004	6:29	GP29	Circular object; barrels; Artifact 6; vents (circular)	arch				9
8/4/2004	6:29		2 scorpion fish inside vents; anenomes	bio				9
8/4/2004	6:31		Ophididae	bio				9
8/4/2004	6:32	GP30	Pan; artifact; Anenomes; crabs,	arch/bio				9
8/4/2004	6:33		Ophididae	bio				9
8/4/2004	6:34	GP31	Artifact	arch				9
8/4/2004	6:36		Anenomes (6)	bio				9
8/4/2004	6:37		Cucumbers (2); anenomes (8)	bio				9
8/4/2004	6:39		crab; scorpion fish	bio				9
8/4/2004	6:40		scorpion fish	bio				9
8/4/2004	6:41		corals	bio				9
8/4/2004	6:43		anenomes (3) on artifact	bio				9
8/4/2004	6:43	GP32	Artifact; handrail?	arch				9
8/4/2004	6:44		Anenomes; fish	bio				9
8/4/2004	6:45	GP33	Artifact; pipe? Handrail?	arch				9
8/4/2004	6:46		Sea roach; isopod	bio				9
8/4/2004	6:46	GP34	Plate,cup?; artifact	arch				9
8/4/2004	6:48		lobster under artifact	bio				9

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	6:49		Ophididae	bio				9
8/4/2004	6:49	GP35	Artifact	arch				9
8/4/2004	6:50		cucumber	bio				9
8/4/2004	6:54	GP36	crab; fish; artifact	arch/bio				9
8/4/2004	6:55	GP37	artifact; box?	arch				9
8/4/2004	6:57	GP38	artifact; porthole?; miller light can	arch				9
8/4/2004	6:58	GP39	Artifact; scorpion fish in artifact (4)	arch/bio				9
8/4/2004	6:59		scorpion fish next to artifact	bio				9
8/4/2004	7:01	GP40	Circular air vent; artifact (500 ft)	arch				9
8/4/2004	7:09		Fish	bio		7:06:50	GP-8	9
8/4/2004	7:10		Rattail collection	bio				9
8/4/2004	7:11		Jellyfish	bio				9
8/4/2004	7:13		End of Line 225					9
8/4/2004	7:14		Crab collection- let go because it was to large	bio				9
8/4/2004	7:16		Lights out for ~ 10 minutes					9
8/4/2004	7:20		Lights on- no sign of life; 224					9
8/4/2004	7:35	GP41	Artifact	arch				9
8/4/2004	7:38	GP42	Artifact	arch				9
8/4/2004	7:40	GP43	Artifact	arch				9
8/4/2004	7:44	GP44	Artifact	arch				9
8/4/2004	7:44	GP45	Artifact (possible stern)	arch				9
8/4/2004	8:03	GP46	Artifact	arch				9
8/4/2004	8:05	GP47	Artifact	arch				9
8/4/2004	8:09	GP48	Artifact (Air vent)	arch				9
8/4/2004	8:12	GP49	Artifact	arch		8:11:11	GP-9	9
8/4/2004	8:15	GP50	Artifact	arch				9
8/4/2004	8:17	GP51	Artifact	arch				9
8/4/2004	8:18	GP52	Artifact	arch				9
8/4/2004	8:19	GP53	Artifact (port hole)	arch				9

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	8:20	GP54	Artifact	arch				9
8/4/2004	8:22	GP55	Artifact (box inside maybe) Same as GP43	arch				9
8/4/2004	8:27		Artifact GP41	arch				9
8/4/2004	8:29		460ft from bow	arch				9
8/4/2004	8:36		Start Line 222	arch				9
8/4/2004	8:45	GP56	Artifact; vent artifact 32	arch				9
8/4/2004	8:48	GP57	Artifact 33	arch				9
8/4/2004	8:50	GP58	Artifact 34; possible telegraph	arch				9
8/4/2004	8:52	GP59	Artifact 35; back to barrel	arch				9
8/4/2004	8:58	GP60	Artifact 36; 2 pics	arch				9
8/4/2004	8:59	GP61	Artifact 37	arch				9
8/4/2004	9:01	GP62	Artifact 38; 2 pics	arch				9
8/4/2004	9:05	GP63	Artifact 39; 2 pics; drums crushed	arch				9
8/4/2004	9:10	GP64	Artifact life boat b,c,d; inside view and	arch/bio				9
			profile of lifeboat, small photo					
8/4/2004			mosaic of lifeboat interior, galatheid crab collection			9:14:37	GP-10	9
8/4/2004	9:43	GP65	Artifact 41	arch				9
8/4/2004	9:46		End line 222; start line 221	arch				9
8/4/2004	9:50	GP66	Artifact 42; tubular tank blown out	arch				9
8/4/2004	9:55	GP67	Artifact 43; twisted metal	arch				9
8/4/2004	9:56	GP68	Artifact 44; metal rods parallel ~20' apart, with coral	arch/bio				9
8/4/2004	9:58	GP69	Rod with frame; Artifact 45	arch				9
8/4/2004	10:04	GP70	Artifact 46; biological	arch/bio				9
8/4/2004	10:05	GP71	Artifact 47; lots of anenomes	bio				9
8/4/2004	10:09	GP72	Artifact 48; metal collar	arch				9
8/4/2004	10:11	GP73	Artifact 49; vent and porthole	arch				9
8/4/2004	10:13	GP74	Artifact 50; steel pot/bowl	arch				9
8/4/2004	10:15	GP75	Artifact 51; wood	arch				9
8/4/2004	10:17	GP76	Artifact 52;[unidentified ferrous material]	arch				9

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	10:21	GP77	Artifact 53; squished metal led???	arch		10:18:42	GP-11	9
8/4/2004	10:24	GP78	Artifact 54; squished barrel	arch				9
8/4/2004	10:25	GP79	Artifact 55; split air vent	arch				9
8/4/2004	10:31		fish collection	bio				9
8/4/2004	10:39		End Line 221; start 220					9
8/4/2004	10:44	GP80	Artifact 56; collared wire?	arch				9
8/4/2004	10:53	GP81	Artifact 57; barrel	arch				9
8/4/2004	10:54		Artifact small	arch				9
8/4/2004	10:55		Artifact small (2)	arch				9
8/4/2004	10:57		Artifact decking small	arch				9
8/4/2004	10:58		Artifact; twisted metal; large amount of small artifact	arch				9
8/4/2004	10:59		Artifact; porthole	arch				9
8/4/2004	11:00	GP82	Artifact 58; bowl shape like helmet	arch				9
8/4/2004	11:10		end Line 220					9
8/4/2004	11:16		Start Line 218; no hits					9
8/4/2004	11:37		Artifact; bucket	arch		11:22:45	GP-12	9
8/4/2004	11:38		Bent up tray/drawers	arch				9
8/4/2004	11:39	GP83	Artifact 59; [Box Shaped]	arch				9
8/4/2004	11:47		End Line 218					9
8/4/2004	11:48		move to Stbd side					9
8/4/2004	12:09		Surveying line 228	arch				9
8/4/2004	12:33		ROV sit on sea floor for 20 minutes with lights out			12:26:47	GP-13	9
8/4/2004	12:54		End of lights out survey; scorpion fish; fish	bio				9
			sitting in front of camera					
8/4/2004	12:57		Resume survey on line 228					9
8/4/2004	13:06		Photo taken of lifeboat	arch				9
8/4/2004	13:06	GP84	Flattened smokestack (Artifact 60)	arch				9
8/4/2004	13:17	GP85	Artifact 61; sack	arch				9
8/4/2004	13:27		End of survey line 228					9

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	13:30		Sea cucumber collected	bio				9
8/4/2004	13:32		fish collected	bio				9
8/4/2004	13:35		Begin survey of line 229					9
8/4/2004	13:48	GP86	Flattened smokestack with whistle and ladder	arch		13:31:05	GP-14	9
8/4/2004	13:48		Fish and anemone sighted	bio				9
8/4/2004	13:57	GP87	Artifact 62; possible letter G	arch				9
8/4/2004	14:02		Can and crab	trash/bio				9
8/4/2004	14:06		crab and shrimp	bio				9
8/4/2004	14:16		artifact	arch				9
8/4/2004	14:17		eel	bio		End of Tape	GP-14	9
8/4/2004	14:43		anenome	bio		14:48:16	GP-15	9
8/4/2004	14:45		anenome	bio				9
8/4/2004	14:48		lobster? Collected	bio				9
8/4/2004	14:49		eel collected	bio				9
8/4/2004	14:53		fish collected	bio				9
8/4/2004	14:58		fish, cucumber	bio				9
8/4/2004	15:03		fish collected	bio				9
8/4/2004	15:07		cucumber collected	bio				9
8/4/2004	15:09		anenome	bio				9
8/4/2004	15:10		cucumber	bio				9
8/4/2004	15:12		rattail	bio				9
8/4/2004	15:13		eel collected; lobster (not)	bio				9
8/4/2004	15:17		jellyfish	bio				9
8/4/2004	15:20		flatfish collected	bio				9
8/4/2004	15:21		anenome	bio				9
8/4/2004	15:22		anenome	bio				9
8/4/2004	15:23		Crab capture	bio				9
8/4/2004	15:24		invert	bio				9
8/4/2004	15:25		shrimp	bio				9

Site ***Gulf Penn***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	15:26		inverts	bio				9
8/4/2004	15:27		crab capture	bio				9
8/4/2004	15:29		Attempted crab capture	bio				9
8/4/2004	15:32		small fish capture	bio				9
8/4/2004	15:35		small fish capture	bio				9
8/4/2004	15:41		searobin capture	bio				9
8/4/2004	15:43		searobin capture	bio				9
8/4/2004	15:45		End of Line 230					9
8/4/2004	15:49		Start of Line 231					9
8/4/2004	15:51		Snail, tube capture	bio		15:54:57	GP-16	9
8/4/2004	15:54		small fish capture	bio				9
8/4/2004	16:01		plant detritus	bio				9
8/4/2004	16:03		Crab capture	bio				9
8/4/2004	16:11		lobster capture	bio				9
8/4/2004	16:18		invert capture	bio				9
8/4/2004	16:19		fish capture; escape	bio				9
8/4/2004	16:32		Aluminum can	trash				9
8/4/2004	16:34		octopus	bio				9
8/4/2004	16:35		octopus capture	bio				9
8/4/2004	16:35		End of line 231					9
8/4/2004	16:38		Start of line 232					9
8/4/2004	16:49		Crab capture	bio				9
8/4/2004	16:57		hermit crab capture	bio		End of Tape	GP-16	9
8/4/2004	17:00							9
8/4/2004	17:08	GP88	Debris	arch		17:04:47	GP-17	9
8/4/2004	17:20		fish	bio				9
8/4/2004	17:23		shark-collected	bio				9
8/4/2004	17:28		searobin fish	bio				9
8/4/2004	17:31		Start of line 233					9

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	17:41		flatfish	bio				9
8/4/2004	17:45		crab	bio				9
8/4/2004	17:47		scorpion fish	bio				9
8/4/2004	17:48		eel fish?	bio				9
8/4/2004	17:49		fish collected	bio				9
8/4/2004	17:51		fish; cucumber	bio				9
8/4/2004	17:52		cucumber	bio				9
8/4/2004	17:53		shrimp collected	bio				9
8/4/2004	17:58		fish	bio				9
8/4/2004	18:00		cucumber	bio				9
8/4/2004	18:01		fish	bio				9
8/4/2004	18:02		invert	bio				9
8/4/2004	18:03		invert collected	bio				9
8/4/2004	18:05		cucumber and fish	bio				9
8/4/2004	18:06		fish collected	bio				9
8/4/2004	18:06		fish	bio				9
8/4/2004	18:07		cucumber	bio		End of Tape	GP-17	9
8/4/2004	18:09		fish collected	bio				9
8/4/2004	18:13		end of line 233					9
8/4/2004	18:16		pipeline					9
8/4/2004	18:17		starfish collected	bio		18:12:44	GP-18	9
8/4/2004	18:18		Start of line 234					9
8/4/2004	18:28		burrow	bio				9
8/4/2004	18:31		fish collected	bio				9
8/4/2004	18:36		invert collected	bio				9
8/4/2004	18:56		shark egg (mermaid's purse)	bio				9
8/4/2004	18:59		shark egg picked up w/ ROV arm	bio				9
8/4/2004	19:00		shark egg collected	bio				9
8/4/2004	19:09		crab collected	bio				9

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/4/2004	19:12		end of line 234			End of Tape	GP-18	9
8/4/2004	19:19		Moving to wreck for coral sample	bio				9
8/4/2004	19:40		coral collected from stbd side of wreck	bio				9
8/4/2004	19:45		coral taken from base of wreck's hull	bio				9
8/4/2004	19:50		coral collection ends	bio				9
8/4/2004	19:51		ROV recovery begins					9
8/4/2004	20:15		ROV on Deck	bio				9
8/4/2004	21:40		Dive # 10 Start Camera Problems					10
8/4/2004	21:50		Dive # 10 End			22:42:30	GP-19	10
						23:46:32	GP-20	11
8/5/2004	0:34		Start of mosaic bow to stern; Start of center line	arch				11
8/5/2004	0:34		Mosaic- start at bow tip center beam	arch				11
			~67'. Portside first					
8/5/2004	0:38		bollards; steel box	arch				11
8/5/2004	0:40		broken decking; heading 169; 24ft centerline	arch				11
8/5/2004	0:42		large coral clumps on catwalk; possible fallen	arch				11
			mast ~16ft from deck;					
8/5/2004			visual reference o hatch (centerline)					11
8/5/2004	0:46		hatch, mast	arch				11
8/5/2004	0:48		Air vent; center of ship	arch				11
8/5/2004	0:49		center hatches; vent stack and engine room;	arch				11
			base and stern finished					
8/5/2004	0:50		first line; centerline end	arch				11
8/5/2004	0:52		jellyfish	bio		0:50:32	GP-21	11
8/5/2004	1:02		IP-> port side (B to S) survey line # I+ 11	arch				11
8/5/2004	1:14		End of 1 P (Bow to Stern)	arch				11
8/5/2004	1:28		Start 2P (B to S) survey line # I +22	arch				11
8/5/2004	1:39		End of 2P	arch				11
8/5/2004	1:49		Start 3P (B to S); survey line # I + 33	arch				11

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/5/2004	2:01		End of 3P	arch		1:54:28	GP-22	11
8/5/2004	2:13		Start 4P (B to S); survey line # I + 44	arch				11
8/5/2004	2:24		End of 4P	arch				11
8/5/2004	2:46		Survey line #: I-11	arch				11
8/5/2004	2:59		End of 1S (tbd)	arch		2:57:59	GP-23	11
8/5/2004	3:18		Start of 2S (B to S) Survey line # I -22	arch				11
8/5/2004	3:22		End of line 2S (stbd); Start of line 3S; Line # I-33	arch				11
8/5/2004	3:55		Port profile line 1 (PP1). At mudline; stern to bow;					11
8/5/2004	4:17		End of line PP1			4:01:18	GP-24	11
8/5/2004	4:26		Start of line PP2, stern to bow					11
8/5/2004	4:42		End of line PP2					11
8/5/2004			Start of line PP3, stern to bow					11
8/5/2004			End of line PP3			5:04	GP-25	11
8/5/2004	5:28		Start of line PP4 (port superstructure)					11
8/5/2004			End of line PP4					11
8/5/2004	5:40		Start of line					11
8/5/2004	5:51		End of line					11
8/5/2004	5:51		End of profile view					11
8/5/2004	6:30		Basket wet at surface	bio		6:19:35	GP-26	11
8/5/2004	6:46		Pipeline out from wreck 600 ft	arch				11
8/5/2004	6:51		Hovering above bottom at 1000 ft	bio				11
8/5/2004	6:52		Moving large trap to location (1000 ft)-black	bio				11
8/5/2004	6:55		Moving minnow trap to 1000ft location	bio				11
8/5/2004	7:03		Moving small trap to 1000ft location-white	bio				11
8/5/2004	7:14	GP89	Small trap set @ 1000 ft	bio				11
8/5/2004	7:18	GP90	Large trap set @ 1000 ft	bio				11
8/5/2004	7:20	GP91	Minnow trap set @ 1000 ft	bio				11
8/5/2004	7:22		Moving basket next to wreck	bio				11
8/5/2004	7:42		Basket on bottom near wreck	bio		7:23:39	GP-27	11

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/5/2004	7:44		Removed hook from basket	bio				11
8/5/2004	7:54		Moving large trap to location- white	bio				11
8/5/2004	8:06		Moving small trap to location-black	bio				11
8/5/2004	8:08		Moving crab trap to location	bio				11
8/5/2004	8:00	GP92	Set large trap near wreck	bio				11
8/5/2004	8:14	GP93	Set crab trap near wreck	bio				11
8/5/2004	8:15	GP94	Set small trap near wreck	bio				11
8/5/2004	8:23		Rusticle collection devise	bio				11
8/5/2004	8:33		Small minnow trap on basket	bio		8:26	GP-28	11
8/5/2004	8:43		Rusticle collection starboard	bio				11
8/5/2004	8:58		Port side GP-12; 3 rusticles	bio				11
8/5/2004	10:02		GP-8 portside rusticles	bio		9:31:51	GP-29	11
8/5/2004	10:35		ROV came up in water	bio				11
8/5/2004	10:40		ROV back in water	bio				11
8/5/2004	10:58		ROV at bottom	bio		10:58:39	GP-30	11
8/5/2004	11:02		Bio collection	bio				11
8/5/2004	11:10		Move bio collection to after core samples	bio				11
8/5/2004	11:35		Core tube D picked up to move to 1000 ft	bio				11
8/5/2004	11:46	GP D	Taking Core D sample	bio				11
8/5/2004	12:00		Sample D back in basket	bio				11
8/5/2004	12:03		Core tube C taken from basket	bio		12:02:40	GP-31	11
8/5/2004	12:07	GP C	Core sample C taken 500 ft from wreck	bio				11
8/5/2004	12:13		Core tube C returned to basket	bio				11
8/5/2004	12:16		Core tube B taken from basket; it appears to have	bio				11
8/5/2004			sediment in it, so it will be replaced with tube E					11
8/5/2004	12:21		Core tube B returned to basket	bio				11
8/5/2004	12:23		Core tube E taken from basket	bio				11
8/5/2004	12:28	GP E	Core sample E taken 100 ft from wreck	bio				11
8/5/2004	12:35		Core tube E placed in basket	bio				11

Site ***Gulfpenn***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/5/2004	12:37		Core tube A taken from basket; tube had sediment	bio				11
			in the bottom but quickly					
8/5/2004			fell out. Tube A will still be used					11
8/5/2004	12:42	GP A	Core sample A taken next to wreck	bio				11
8/5/2004	12:49		Core tube A placed in basket	bio				11
8/5/2004	13:00		Coral sampling	bio				11
8/5/2004	13:15		Coral sampling	bio		13:06:44	GP-32	11
8/5/2004	13:43		Crab capture	bio				11
8/5/2004	13:57		Slimehead capture	bio				11
8/5/2004	14:05		Eel?	bio				11
8/5/2004	14:27		Pick up basket hook	bio		14:13:13	GP-33	11
8/5/2004	14:30		Hooked basket	bio				11
8/5/2004	14:31		Basket returned to surface	bio				11
8/5/2004	14:32		ROV returns to sampling	bio				11
8/5/2004	14:40		Attempt scallop capture	bio				11
8/5/2004	14:48		Shrimp sample	bio				11
8/5/2004	14:50		Colonial invert	bio				11
8/5/2004	15:12		ROV at depth 1803 ft; 20 ft altitude	bio				11
8/5/2004	15:13		ROV at depth 1793 ft; 30 ft altitude; multiple	bio				11
			colonies of coral			End of Tape	GP-33	
8/5/2004	15:16		ROV at 1796.5 ft; coral is at its widest and	bio				11
			growing on corner of stbd.					
8/5/2004			side of aft house					11
8/5/2004	15:19		invert collected	bio				11
8/5/2004	15:25		crab and shrimp sample	bio				11
8/5/2004	15:26		crab sample	bio				11
8/5/2004	15:27		crab sample attempt	bio				11
8/5/2004	15:30		crab sample	bio				11
8/5/2004	15:36		1797', 28 ft off bottom. Wall of to 1786';	bio				11

Site *Gulfpenn*

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
			41 ft off bottom. Widest at 1792'					
8/5/2004	15:44		crab sampled	bio				11
8/5/2004	15:49		coral 1787',14' feet altitude to 1768', 55' alt	bio				11
			1785' widest					
8/5/2004	15:56		Slimehead capture	bio				11
8/5/2004	16:23		Crab capture	bio				11
8/5/2004	16:27		Shrimp sample	bio				11
8/5/2004	16:30		scallops sampled	bio				11
8/5/2004	16:33		Crab capture	bio				11
8/5/2004	16:39		Crab capture	bio				11
8/5/2004	16:41		Handle feel off slurpe gun coming to surface			16:40:26	GP-34	11
8/5/2004	17:05		ROV on Deck					11
8/5/2004	17:30		ROV back in water					12
8/5/2004	17:47		at 1790'	bio				12
8/5/2004	18:08		Sea spider capture	bio				12
8/5/2004	18:29		coral collection	bio		18:13:59	GP-35	12
8/5/2004	18:41		shark between ship and basket	bio				12
8/5/2004	19:10		small fish capture	bio				12
8/5/2004	19:12		Shrimp sample	bio				12
8/5/2004	19:13		flatfish	bio				12
8/5/2004	19:18		scorpion fish attempt	bio				12
8/5/2004	19:19		crab sample	bio				12
8/5/2004	19:21		scorpion fish attempt	bio				12
8/5/2004	19:25		Crab capture	bio				12
8/5/2004	19:26		hermit crab sample	bio				12
8/5/2004	19:26		invert collected	bio				12
8/5/2004	19:27		Shrimp sample	bio		19:18:02	GP-36	12
8/5/2004	19:27		Tongue sole	bio				12
8/5/2004	19:28		Fish?	bio				12

Site ***Gulfpenn***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/5/2004	19:29		hagfish?	bio				12
8/5/2004	19:33		Shrimp and crab sample	bio				12
8/5/2004	19:57		scallops sampled	bio				12
8/5/2004	20:12		Crab capture	bio				12
8/5/2004	20:23		invert collected	bio				12
8/5/2004	20:28		scorpion fish attempt	bio				12
8/5/2004	20:31		shrimp	bio		20:22:07	GP-37	12
8/5/2004	20:34		Fish	bio				12
8/5/2004	20:38		shell	bio				12
8/5/2004	20:40		Crab capture	bio				12
8/5/2004	20:42		Bathynomus	bio				12
8/5/2004	20:46		scorpion fish	bio				12
8/5/2004	20:50		scorpion fish	bio				12
8/5/2004	20:55		coral collection	bio				12
8/5/2004	21:18		panning over center of vessel; bow to stern	arch				12
8/5/2004	21:26	GP 100	ship's telegraph	arch		21:26:52	GP-38	12
8/5/2004	21:50		Lori's small test platform recovered	bio				12
8/5/2004	21:55		Small fish trap recovered- next to wreck	bio				12
8/5/2004	22:02		Small fish trap put in basket	bio				12
8/5/2004	22:03		Small test platform put in basket	bio				12
8/5/2004	22:13		Crab trap retrieved	bio				12
8/5/2004	22:16		Large trap retrieved	bio				12
8/5/2004	22:29		Large trap placed in basket	bio				12
8/5/2004	22:31		Crab trap placed in basket	bio				12
8/5/2004	22:41		Basket lifted; taken to traps 1000 ft from wreck	bio				12
						22:48:27	GP-39	12
8/5/2004	23:40		Minnow trap retrieved from 1000 ft	bio				12
8/5/2004	23:43		Small fish trap retrieved	bio				12
8/5/2004	23:45		Large fish trap tretieved	bio				12

Site ***Gulfpenn***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/5/2004	23:48		Large trap placed in basket	bio				12
8/5/2004	23:48		Small trap and crab trap placed in basket	bio				12
8/5/2004	23:50		Basket being brought to surface	bio				12
8/6/2004	0:01		Basket on Deck	bio				12
8/6/2004	0:15		ROV on Deck	bio				12

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/6/2004	5:50		ROV wet					13
8/6/2004	6:10		Return ROV to surface					13
8/6/2004	6:30		ROV wet again					13
8/6/2004	7:21		Sonar contact U 166 range 100'			7:18:56	U-1	13
8/6/2004	7:23		Portside recon	arch				13
8/6/2004	7:28		Experiment view	bio				13
8/6/2004	7:30		Aft torpedo loading hatch	arch				13
8/6/2004	7:33		Stern vent (port); Zoom handle on stern also 2 crabs	arch/bio				13
8/6/2004	7:40		Move from stern to bow stbd side	arch				13
8/6/2004	7:41		Stern light	arch				13
8/6/2004	7:45		Stern deck gun	arch				13
8/6/2004	7:46		Experiments--> detailed	bio				13
8/6/2004	7:57		White rusticle at 15" beside platform, coupon X 3 Cu & 5-7. All appear	bio				13
8/6/2004			to have some white rusticles (nodule like 8-10 & 13-15 rusticulate					13
8/6/2004			over surface)and appear to have small hanging rusticles behind the					13
8/6/2004			first 3 or 4 coupons					
8/6/2004	8:03		Portside conning tower	arch/bio				13
8/6/2004	8:08		Pan along port side conning tower	arch				13
8/6/2004	8:09		Bow side of conning tower; 2 rattails	arch/bio				13
8/6/2004	8:10		front of conning tower gun	arch				13
8/6/2004	8:11		deck gun plugged; sediment covering; hagfish	arch				13
8/6/2004	8:13		sediment debris?	arch				13
8/6/2004	8:15		defined depression	arch				13
8/6/2004	8:17		debris	arch				13
8/6/2004	8:20		run scatter plot, set over gun; forward of conning	arch				13
8/6/2004	8:25	U1	Fix anotation "U"	arch		8:22:29	U-2	13
8/6/2004	8:37		Bio-tree- 1st survey line from main hull to bow	arch				13
8/6/2004	8:53		End of line	arch				13
8/6/2004	8:54		Bow reconnaisance	arch				13

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/6/2004	9:26		End Bow recon	arch		End of Tape	U-2	13
8/6/2004	9:27		Headed to south survey lines	arch				13
8/6/2004	9:50		Start survey line 441 (West to east)			9:32:24	U-3	13
8/6/2004	9:52	U2	Bottle	arch				13
8/6/2004	10:10	U3	Textile	trash/arch				13
8/6/2004	10:12	U4	Artifact, round pot/helmet	arch				13
8/6/2004	10:13	U5	Boot/artifact	arch				13
8/6/2004	10:14	U6	Artifact; substructure	arch				13
8/6/2004	10:17	U7	leather artifact	arch				13
8/6/2004	10:20	U8	bud light/artifact	trash/arch				13
8/6/2004	10:30		End of line 441					13
8/6/2004	10:34		Start of line 442					13
8/6/2004	10:50	U9	Artifact- metal plating	arch		10:36:30	U-4	13
8/6/2004	10:53	U10	Artifact- plating	arch				13
8/6/2004	11:03		End of line 442					13
8/6/2004	11:05		Start of line 443					13
8/6/2004	11:12	U11	Artifact	arch				13
8/6/2004	11:16	U12	Artifact (textile?) soda can	trash/arch				13
8/6/2004	11:18	U13	Artifact; burnt wood	arch				13
8/6/2004	11:19	U14	artifact; jacket	arch				13
8/6/2004	11:36	U15	metal artifact	arch				13
8/6/2004	11:48		End of line 443			11:39:39	U-5	13
8/6/2004	11:50		Start of line 444					13
8/6/2004	11:51	U16	bottle	a				13
8/6/2004	12:01	U17	metal decking	a				13
8/6/2004	12:17		End of line 444	a				13
8/6/2004	12:19		Start of line 445					13
8/6/2004	12:24		red shrimp	bio				13
8/6/2004	12:42		invert and sea star collected	bio				13
8/6/2004	12:43	U18	bottle	a				13

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/6/2004	12:50		sea star collected	bio		12:43:39	U-6	13
8/6/2004	12:52		End of line 445					13
8/6/2004	12:54		red shrimp collected	bio				13
8/6/2004	12:54		Start of line 446					13
8/6/2004	12:55		small animal collected	bio				13
8/6/2004	12:59		shrimp collected	bio				13
8/6/2004	13:01	U19	bottle	a				13
8/6/2004	13:04	U20	possible artifact	a				13
8/6/2004	13:20	U21	artifact-textile	a				13
8/6/2004	13:36		End of line 446					13
8/6/2004	13:37		Start of line 447					13
8/6/2004	14:10		End of line 447			13:47:40	U-7	13
8/6/2004	14:13		Start of line 448					13
8/6/2004	14:28		glass sponge collected	bio				13
8/6/2004	14:43		End of line 448					13
8/6/2004	15:13		Mosaic-bow section, stbd side	a		15:14:13	U-8	13
8/6/2004	15:19		Mosaic- bow secion, center	a				13
8/6/2004	15:22		Mosaic-bow section, port side	a				13
8/6/2004	15:52		Mosaic- stern secion, center	a				13
8/6/2004	16:00		Mosaic-stern section, stbd side	a				13
8/6/2004	16:05		Mosaic-stern section, port side	a				13
8/6/2004	16:45		Basket in Water	bio		16:20:55	U-9	13
8/6/2004	17:02		Basket on Bottom	bio				13
8/6/2004	17:03		ROV reaches basket; large fish trap missing	bio				13
8/6/2004	17:13		Minnow trap picked up at 1000 ft	bio				13
8/6/2004	17:15		Small fish trap picked up	bio				13
8/6/2004	17:18	U22	Small fish trap set at 1000 ft	bio				13
8/6/2004	17:21	U23	Minnow trap set at 1000 ft	bio				13
8/6/2004	17:23	U24	Large fish trap set at 1000 ft	bio		17:25:23	U-10	13
8/6/2004	17:30	U25	Core D 1000'	bio				13

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/6/2004	17:37		Moving basket to wreck	bio				13
8/6/2004	18:03		basket is set near wreck	bio				13
8/6/2004	18:09		crab trap removed from basket	bio				13
8/6/2004	18:12		large trap removed from basket	bio				13
8/6/2004	18:15	U26	large trap set near wreck	bio				13
8/6/2004	18:19	U27	crab trap set near wreck	bio				13
8/6/2004	18:23		small fish trap removed from basket	bio				13
8/6/2004	18:33	U28	small fish trap set near wreck	bio		18:30:59	U-11	13
8/6/2004	18:40		Core tube C taken from basket	bio				13
8/6/2004	18:47	U29	Core sample C taken from 500' mark	bio				13
8/6/2004	18:53		Core tube C placed into basket	bio				13
8/6/2004	18:54		Core tube B taken from basket	bio				13
8/6/2004	18:59	U30	Core sample B taken from 100 ft from wreck	bio				13
8/6/2004	19:04		Core tube B put in basket	bio				13
8/6/2004	19:05		Core tube A taken from basket	bio				13
8/6/2004	19:09	U31	Core sample A taken collected at stern section	bio				13
			of the wreck					13
8/6/2004	19:14		Core tube A put in basket	bio				13
8/6/2004	19:20		crab sample	bio				13
8/6/2004	19:25		plant detritus	bio				13
8/6/2004	19:35		starfish	bio		End of Tape	U-11	13
8/6/2004	19:40		crab sample	bio		19:41:49	U-12	13
8/6/2004	19:52		Unknown invert sample	bio				13
8/6/2004	20:03		crab sample	bio				13
8/6/2004	20:11		invert capture	bio				13
8/6/2004	20:17		shrimp capture	bio				13
8/6/2004	20:18		shrimp capture	bio				13
8/6/2004	20:22		invert capture	bio				13
8/6/2004	20:28		shrimp	bio				13
8/6/2004	20:31		invert collected	bio				13

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/6/2004	20:36		invert collected	bio				13
8/6/2004	20:44		shrimp	bio				13
8/6/2004	20:47		2 shrimp	bio		20:46:02	U-13	13
8/6/2004	20:48		sea star (brittle?); collected at 20:50	bio				13
8/6/2004	20:52		eel	bio				13
8/6/2004	20:56		fish	bio				13
8/6/2004	21:32	U32	artifact	a				13
8/6/2004	21:39		crab collected	bio	Crab in trap			13
8/6/2004	21:42		eel	bio				13
8/6/2004	21:44		sediment collected	bio				13
8/6/2004	21:45		eel collected; fish	bio				13
8/6/2004	21:55		shrimp collected	bio		21:50:28	U-14	13
8/6/2004	21:57		fish	bio				13
8/6/2004	21:58		collected unknown	bio				13
8/6/2004	22:01		tripod fish	bio				13
8/6/2004	22:03	U33	artifact (steel plate)	a	Artifact U33			13
8/6/2004	22:07		sea star	bio				13
8/6/2004	22:14		shrimp collected	bio				13
8/6/2004	22:15		brittle star collected	bio				13
8/6/2004	22:16		shrimp collected	bio				13
8/6/2004	22:19		tripod fish	bio				13
8/6/2004	22:20		eel	bio				13
8/6/2004	22:23		Unknown	bio				13
8/6/2004	22:27		shrimp	bio				13
8/6/2004	22:28		sea star collection	bio				13
8/6/2004	22:32		unknown collected	bio				13
8/6/2004	22:38		sea star collected	bio				13
8/6/2004	22:49		crabs; 2 Geryon embracing	bio	crabs			13
8/6/2004	23:06		Located large/close fish trap (black)	bio		22:56:57	U-15	13
8/6/2004	23:17		Small fish trap (white) and crab trap returned	bio				13

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/6/2004	23:17		ROV moves away from basket	bio				13
8/6/2004	23:18		ROV reaches large fish trap	bio				13
8/6/2004	23:24		Large fish trap in basket	bio				13
8/6/2004	23:25		Basket is raised	bio				13
8/6/2004	23:55		ROV back to basket	bio				13
8/6/2004	23:57		Basket is down	bio				13
8/7/2004	0:03		Minnow trap picked up at 1000 ft	bio		0:01:00	U-16	13
8/7/2004	0:05		Shark	bio	6 pictures			13
8/7/2004	0:15		minnow trap put in basket	bio				13
8/7/2004	0:16		ROV goes to collect more traps	bio				13
8/7/2004	0:21		Large trap picked up	bio				13
8/7/2004	0:24		Large trap in basket (white)	bio				13
8/7/2004	0:35		Small trap to the basket (black)	bio				13
8/7/2004	0:37		Small trap in basket	bio				13
8/7/2004	0:39		Basket off bottom	bio				13
8/7/2004	1:00		Basket on Deck	bio				13
8/7/2004	1:45		ROV on Deck	bio				13

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	2:25		ROV Wet					14
8/7/2004	3:25		Sonar Contact			3:21:11	RL-1	14
8/7/2004	3:29		Visual Contact 4890'					14
8/7/2004	3:31		bow		RO-1			14
8/7/2004	3:32		Bow Port side		RO-2			14
8/7/2004	3:34		ships bell (davit)		RO-3			14
8/7/2004	3:36	RO-1	Loading docks		RO-4			14
8/7/2004	3:49	RO-5	davit with cables					14
8/7/2004	3:51	RO-6	davit with cables					14
8/7/2004	3:52	RO-7	grating winch, wires, gallery doors, davit					14
8/7/2004	3:59		moving forward, funnel hatches in background					14
			deck gone, handrails mast broken, laying					14
			over to stbd, funnel smashed					14
8/7/2004	4:03		portholes; (loading) latch open, left hand door					14
8/7/2004	4:12		stern, port deck gun					14
8/7/2004	4:30		close up of deck gun			4:25:11	RL-2	14
8/7/2004	4:33	RO-8	stern flag pole holder					14
8/7/2004	4:38		gun barrel					14
8/7/2004	4:41		fly over top from stern to bow					14
8/7/2004	4:52		winch down center, pipes					14
8/7/2004	4:55		hold through 3 decks, dorm, ladder					14
8/7/2004	4:56		main mast					14
8/7/2004	4:58		looking at back of hatches					14
8/7/2004	5:00		vents and hatch					14
8/7/2004	5:04		beam measurement 54"					14
8/7/2004	5:05		Toilet					14
8/7/2004	5:06		smoke stack					14
8/7/2004	5:10		portholes open vent, mast with ladder, vent,					14
			pilothouse					14

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	5:13		hatch to lower decks					14
8/7/2004	5:13		bell (ships)					14
8/7/2004	5:14		bow, with anchor chains					14
8/7/2004	5:17		bow tip					14
8/7/2004	5:26		move around portside place experiments					14
8/7/2004	5:38	RO-9	Experiment			5:30:38	RL-3	14
8/7/2004	5:41		portside anchor					14
8/7/2004	5:42		bow tip					14
8/7/2004	5:43		stbd anchor					14
8/7/2004	5:40		bow, experiment (bio-battery) Stbd					14
8/7/2004	5:57	RO-12	obstruction					14
8/7/2004	5:59	RO-13	obstruction					14
8/7/2004	6:01	RO-14	Obstruction, davit					14
8/7/2004	6:03	RO15-18	multiple davits on stbd side			End of Tape	RL-3	14
8/7/2004	6:30		end of stbd midline recon					14
8/7/2004	6:34		start toward survey line 420 off stbd side			6:34:40	RL-4	14
8/7/2004	6:53		SOL survey line 420					14
8/7/2004	7:08	RO-19	artifact 1 (exhaust tube opening?)	Arch				14
8/7/2004	7:11		invert picture taken	Bio				14
8/7/2004	7:12		port of bow wreck reached					14
8/7/2004	7:23	RO-20	stern with gun	Arch				14
8/7/2004	7:39		EOL 420			7:38	RL-5	14
8/7/2004	7:42		SOL 421					14
8/7/2004	7:54	RO-21	Artifact 2 (textile)	Arch				14
8/7/2004	8:01	RO-22	Artifact 3 (railing)	Arch				14
8/7/2004	8:04	RO-23	Refrigerator	Arch				14
8/7/2004	8:06	RO-24	Artifact 4	Arch				14
8/7/2004	8:07		Artifact 5	Arch				14
8/7/2004	8:09		Artifact 6	Arch				14
8/7/2004	8:11	RO-25	Hull Piece	Arch				14

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	8:13	RO-26	Artifact 7	Arch				14
8/7/2004	8:17	RO-27	Artifact 8 (wire?)	Arch				14
8/7/2004	8:19	RO-28	metal pipe	Arch				14
8/7/2004	8:22	RO-29	metal pipes	Arch				14
8/7/2004	8:24	RO-30	hull piece #2	Arch				14
8/7/2004	8:29	RO-31	exhaust tube	Arch				14
8/7/2004	8:30		Artifact 9 (picture only)	Arch				14
8/7/2004	8:31	RO-32	doorway	Arch				14
8/7/2004	8:43	RO-33	metal drum	Arch		8:43:02	RL-6	14
8/7/2004	8:44	RO-34	sink	Arch				14
8/7/2004	8:46	RO-35	artifact 10	Arch				14
8/7/2004	8:47		artifact 11 (395 ft to stern- artifact may be part	Arch				14
			of a flagpole)					14
8/7/2004	8:51	RO-36	top of exhaust vent	Arch				14
8/7/2004	8:53		artifact 12 (piece of steel with rivets)	Arch				14
8/7/2004	8:55		artifact 13	Arch				14
8/7/2004	9:12		EOL 421					14
8/7/2004	9:13		to line 419 (port side of hull)					14
8/7/2004	9:15		SOL 419					14
8/7/2004	9:29	RO-37	artifact 14, girder metal object					14
8/7/2004	9:31	RO-38	outerwall gerdens artifact 15					14
8/7/2004	9:32		ventcover? Metal round, artifact 16					14
8/7/2004	9:35		cable, insulating device metal scrape					14
8/7/2004	9:36		metal cables, porthole					14
8/7/2004	9:37	RO-39	metal beams, pipes, hull decking, steam					14
			whistle, artifact 18					14
8/7/2004	9:38		trash-cup	trash				14
8/7/2004	9:48		telegraph artifact 19	arch		9:46:22	RL-7	14
8/7/2004	9:42		possible bulkhead, cylinders deck railing	arch				14
8/7/2004	9:44		conduit, light, plate, decking	arch				14

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	9:45		davit	arch				14
8/7/2004	9:47	RO-40	twisted metal on stbd side of ship, windows, doors,	arch				14
8/7/2004			artifact 20, condensor fridge door					
8/7/2004	9:50		bag of chips	trash				14
8/7/2004	9:51		davit, anemone, crab	bio				14
8/7/2004	9:53	RO-41	china plates, artifact 22	Arch				14
8/7/2004	9:56		textiles, metal	Arch				14
8/7/2004	10:00		decking/wicker	Arch				14
8/7/2004	10:05		buckle up on stbd side, steal plate sheared off	Arch				14
8/7/2004	10:08		handrailing, stern deck promenade	Arch				14
8/7/2004	10:10		firehose attachment, lots of anemones	arch/bio				14
8/7/2004	10:11		large rusticles hanging, extensive fire damage					14
8/7/2004	10:13		crab, anemones	bio				14
8/7/2004	10:16		end of stern, stbd					14
8/7/2004	10:23		past stern					14
8/7/2004	10:34		artifact textile	arch				14
8/7/2004	10:38		EOL 419					14
8/7/2004	10:42		SOL 418					14
8/7/2004	10:48		ray/skate	bio				14
8/7/2004	11:00		vent cover art 25	arch				14
8/7/2004	11:03		vent art 26	arch		10:51:59	RL-8	14
8/7/2004	11:04		vent art 27	arch				14
8/7/2004	11:05		light/railing art 28	arch				14
8/7/2004	11:06	RO-42	box metal art 29	arch				14
8/7/2004	11:08		"junkyard pile"	arch				14
8/7/2004	11:10		bedpan/porcelin, fire damage?? Art 30	arch				14
8/7/2004	11:11	RO-43	bathroom stalls art 31	arch				14
8/7/2004	11:13		light fixture	arch				14
8/7/2004	11:14		gangway art 32	arch				14
8/7/2004	11:28		EOL 418					14

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	11:29		SOL 417					14
8/7/2004	11:34		textile	arch				14
8/7/2004	11:35		pipe (steel)	arch				14
8/7/2004	11:36		cable	arch				14
8/7/2004	11:37		pipe (steel)	arch				14
8/7/2004	11:41		vent bent over art 33	arch				14
8/7/2004	11:42		debris field	arch				14
8/7/2004	11:43		broken sink artifact 34	arch				14
8/7/2004	11:44		refrigerator unit	arch				14
8/7/2004	11:45		sink-> porcelin	arch				14
8/7/2004	11:46		rectangular box art 35	arch				14
8/7/2004	11:47		metal stairs	arch				14
8/7/2004	11:59		EOL 417			End of Tape	RL-8	14
8/7/2004	12:00		SOL 416					14
8/7/2004	12:07		artifact, shotgun? 36	arch		12:03:30	RL-9	14
8/7/2004	12:08		fish, crabs	bio				14
8/7/2004	12:08		artifact 37	arch				14
8/7/2004	12:11	RO-44	artifact 38, shoes	arch				14
8/7/2004	12:14		crab, invert	bio				14
8/7/2004	12:16		sink again	arch				14
8/7/2004	12:17		artifact 39	arch				14
8/7/2004	12:18		artifact 40	arch				14
8/7/2004	12:21		vent	arch				14
8/7/2004	12:23		art 41	arch				14
8/7/2004	12:24		box, artifact 42	arch				14
8/7/2004	12:25		crab	bio				14
8/7/2004	12:37		EOL 416					14
8/7/2004	12:39		SOL 415					14
8/7/2004	12:50		artifact 43 (wood?)	arch				14
8/7/2004	12:52		vent	arch				14

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	12:54		hull piece	arch				14
8/7/2004	12:56		art 44	arch				14
8/7/2004	12:57		vent	arch				14
8/7/2004	12:58		art 45	arch				14
8/7/2004	12:59		art 46	arch				14
8/7/2004	13:00		art 47	arch				14
8/7/2004	13:02		art 48	arch				14
8/7/2004	13:04		art 49	arch				14
8/7/2004	13:08		art 50 (metal frame)	arch		13:09:00	RL-10	14
8/7/2004	13:12		art 51 (textile)	arch				14
8/7/2004	13:23		sunkist can	trash				14
8/7/2004	13:23		EOL 415					14
8/7/2004	13:23		sea star	bio				14
8/7/2004	13:26		SOL 414					14
8/7/2004	13:29		fish	bio				14
8/7/2004	13:33		indentation in sediment					14
8/7/2004	13:38		clam opening and closing	bio				14
8/7/2004	13:39		clam	bio				14
8/7/2004	13:40		crab	bio				14
8/7/2004	13:40		shrimp	bio				14
8/7/2004	13:41		large crab	bio				14
8/7/2004	13:45		art 52	arch				14
8/7/2004	13:48		fish	bio				14
8/7/2004	13:49	RO-45	art 53	arch				14
8/7/2004	13:52		art 54 (brace?)	arch				14
8/7/2004	13:56		sea star	bio				14
8/7/2004	13:59		shrimp	bio				14
8/7/2004	14:01		fish	bio				14
8/7/2004	14:04		EOL 414					14
8/7/2004	14:04		crabs	bio				14

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	14:10		SOL 413					14
8/7/2004	14:12		old can	trash				14
8/7/2004	14:20		debris	arch		14:14:45	RL-11	14
8/7/2004	14:23	RO 46	stop to come up and fix camera					14
8/7/2004	14:27		ROV coming up					14
8/7/2004	15:24		ROV at surface					14
8/7/2004	15:26		ON deck					14
						17:53:29	RL-12	15
8/7/2004	18:34		moving ROV					15
8/7/2004	18:35		artifact 55					15
8/7/2004	18:36		wire	arch				15
8/7/2004	18:37		fish	bio				15
8/7/2004	18:38		urchin	bio				15
8/7/2004	18:39		shrimp	bio				15
8/7/2004	18:39		invert	bio				15
8/7/2004	18:40		fish, shrimp	bio				15
8/7/2004	18:43		invert	bio				15
8/7/2004	18:44		invert?	bio				15
8/7/2004	18:46		invert	bio				15
8/7/2004	18:48		brittle star - invert	bio				15
8/7/2004	18:49		shrimp	bio				15
8/7/2004	18:50		shrimp, fish, sea star	bio				15
8/7/2004	18:51		shrimp	bio				15
8/7/2004	18:53		sea star, crab	bio				15
8/7/2004	18:54		sea star	bio				15
8/7/2004	18:55		shrimp	bio				15
8/7/2004	18:56		EOL 413			End of Tape	Rl-12	15
8/7/2004	18:57		shrimp	bio				15
8/7/2004	18:57		SOL 412					15
8/7/2004	18:58		shrimp	bio				15

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	18:59		shrimp	bio				15
8/7/2004	18:59		sea star	bio				15
8/7/2004	19:00		shrimp, sea star (3)	bio				15
8/7/2004	19:02		fish	bio				15
8/7/2004	19:10		art 56	arch	art 56			15
8/7/2004	19:10		crab	bio				15
8/7/2004	19:12		sea star (brittle)	bio				15
8/7/2004	19:15		art 57	arch	art 57			15
8/7/2004	19:17		shrimp, cuc	bio				15
8/7/2004	19:17		art 58	arch	art 58			15
8/7/2004	19:18		invert	bio				15
8/7/2004	19:19		shrimp (red)	bio				15
8/7/2004	19:21		shrimp (red)	bio		19:20:21	RL-13	15
8/7/2004	19:22		sea star	bio				15
8/7/2004	19:23		shrimp (red)	bio				15
8/7/2004	19:24		shrimp (red)	bio				15
8/7/2004	19:25		shrimp (red)	bio				15
8/7/2004	19:26		sea star	bio				15
8/7/2004	19:29		sea star, white invert	bio				15
8/7/2004	19:30		EOL 412					15
8/7/2004	19:32		shrimp	bio				15
8/7/2004	19:33		SOL 411 (missed very beginning)					15
8/7/2004	19:37		shrimp	bio				15
8/7/2004	19:39		sea star	bio				15
8/7/2004	19:41		shrimp, shrimp,	bio				15
8/7/2004	19:42		crab	bio				15
8/7/2004	19:43		shrimp	bio				15
8/7/2004	19:47		crab (2)	bio				15
8/7/2004	19:49		shrimp	bio				15
8/7/2004	19:50		sea grass	bio				15

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	19:51	RO-47	art 59 (fire alarm)	arch	art 59, art 59-2			15
8/7/2004	19:54		switch cameras to one chip on 19:56					15
8/7/2004	19:57		art 60	arch				15
8/7/2004	19:58		shrimp	bio				15
8/7/2004	20:00		shrimp (red)	bio				15
8/7/2004	20:01		fish, rattail?	bio				15
8/7/2004	20:02		crab	bio				15
8/7/2004	20:05		shrimp	bio				15
8/7/2004	20:09		fish	bio				15
8/7/2004	20:10		shrimp (5)	bio				15
8/7/2004	20:11		tripod fish	bio				15
8/7/2004	20:12		sea star (2), shrimp (2)	bio				15
8/7/2004	20:13		EOL 411					15
8/7/2004	20:14		SOL 410					15
8/7/2004	20:15		fish, shrimp	bio				15
8/7/2004	20:16		fish (2)	bio				15
8/7/2004	20:18		shrimp	bio				15
8/7/2004	20:19		shrimp	bio				15
8/7/2004	20:21		fish	bio				15
8/7/2004	20:22		sea star	bio				15
8/7/2004	20:22		fish, sea star	bio		End of Tape	RL-13	15
8/7/2004	20:24		shrimp	bio				15
8/7/2004	20:24		invert, shrimp	bio				15
8/7/2004	20:25		fish, shrimp, cucumber	bio				15
8/7/2004	20:28		stick, shrimp	bio				15
8/7/2004	20:29		shrimp	bio				15
8/7/2004	20:30		invert	bio				15
8/7/2004	20:31		shrimp (2)	bio				15
8/7/2004	20:32		shrimp (3)	bio				15
8/7/2004	20:33		shrimp	bio				15

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	20:34		art 60	arch	art 60			15
8/7/2004	20:35		shrimp 2	bio		20:28:17	RL-14	15
8/7/2004	20:36		fish	bio				15
8/7/2004	20:37		crab, shrimp	bio				15
8/7/2004	20:38		sea star	bio				15
8/7/2004	20:39		fish, sea star	bio				15
8/7/2004	20:40		shrimp 2	bio				15
8/7/2004	20:41		sea star, shrimp, sea star	bio				15
8/7/2004	20:43		sea star, shrimp	bio				15
8/7/2004	20:44		shrimp 2	bio				15
8/7/2004	20:45		artifact 61	arch	art 61			15
8/7/2004	20:45		crab	bio				15
8/7/2004	20:46		fish, sea star	bio				15
8/7/2004	20:47		shrimp 2	bio				15
8/7/2004	20:48		sea star	bio				15
8/7/2004	20:48		EOL 410					15
8/7/2004	20:50		SOL 409					15
8/7/2004	20:51		shrimp	bio				15
8/7/2004	20:52		fish, shrimp	bio	fish			15
8/7/2004	20:54		shrimp	bio				15
8/7/2004	20:57		crab, shrimp	bio				15
8/7/2004	20:58		sea star, shrimp 2	bio				15
8/7/2004	21:01		shrimp 2, fish	bio				15
8/7/2004	21:03		hagfish, shrimp 2	bio				15
8/7/2004	21:04		shrimp, white shrimp	bio				15
8/7/2004	21:05		art 62	arch	art 62			15
8/7/2004	21:07		crab	bio				15
8/7/2004	21:19		glass sponge	bio				15
8/7/2004	21:23		shrimp	bio				15
8/7/2004	21:23		EOL 409					15

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	21:24		fish (eel?)	bio				15
8/7/2004	21:26		SOL 408					15
8/7/2004	21:26		fish	bio				15
8/7/2004	21:27		shrimp	bio				15
8/7/2004	21:27		fish	bio				15
8/7/2004	21:28		shrimp	bio				15
8/7/2004	21:30		invert	bio		End of Tape	RL-14	15
8/7/2004	21:31		brittle star	bio				15
8/7/2004	21:32		hermit crab	bio				15
8/7/2004	21:40		artifact 63 (beam?)	arch		21:37:28	RL-15	15
8/7/2004	21:42		crab and invert	bio				15
8/7/2004	21:44		crab	bio				15
8/7/2004	21:45		sea star	bio				15
8/7/2004	21:46		shrimp	bio				15
8/7/2004	21:49		invert	bio				15
8/7/2004	21:52		fish	bio				15
8/7/2004	21:54		shrimp	bio				15
8/7/2004	21:54		sea star	bio				15
8/7/2004	21:56		brittle star	bio				15
8/7/2004	21:58		EOL 408					15
8/7/2004	22:02		SOL 407					15
8/7/2004	22:04		hermit crab	bio				15
8/7/2004	22:06		sea star	bio				15
8/7/2004	22:09		sea star	bio				15
8/7/2004	22:13		crab	bio				15
8/7/2004	22:14		shrimp	bio				15
8/7/2004	22:14		fish	bio				15
8/7/2004	22:18		fish	bio				15
8/7/2004	22:19		sea star	bio				15
8/7/2004	22:20		shrimp	bio				15

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	22:22		shrimp; brittle star	bio				15
8/7/2004	22:23		shrimp; fish	bio				15
8/7/2004	22:24		shrimp	bio				15
8/7/2004	22:25		anemone	bio				15
8/7/2004	22:26		brittle star; shrimp (2)	bio				15
8/7/2004	22:28		crabs, male carrying female	bio				15
8/7/2004	22:29		shrimp	bio				15
8/7/2004	22:30		shrimp (2)	bio				15
8/7/2004	22:32		seastar, invert	bio				15
8/7/2004	22:33		shrimp	bio				15
8/7/2004	22:34		EOL 407					15
8/7/2004	22:36		sea star (2), brittle star	bio				15
8/7/2004	22:37		SOL 406					15
8/7/2004	22:37		scatter plot begins					15
8/7/2004	22:38		lights out			End of Tape	RL-15	15
8/7/2004	22:53		lights on			22:41:33	RL-16	15
8/7/2004	22:53		fish	bio				15
8/7/2004	22:56		brittle star	bio				15
8/7/2004	22:58		brittle star	bio				15
8/7/2004	22:59		shrimp	bio				15
8/7/2004	23:01		brittle star	bio				15
8/7/2004	23:02		shrimp	bio				15
8/7/2004	23:04		fish	bio				15
8/7/2004	23:06		fish	bio				15
8/7/2004	23:07		brittle star, shrimp	bio				15
8/7/2004	23:08		shrimp	bio				15
8/7/2004	23:09		crab	bio				15
8/7/2004	23:14		sea star; shrimp	bio				15
8/7/2004	23:15		shrimp; anemone	bio				15
8/7/2004	23:16		crab	bio				15

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Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/7/2004	23:20		shrimp	bio				15
8/7/2004	23:21		shrimp	bio				15
8/7/2004	23:22		seastar?, shrimp 2	bio				15
8/7/2004	23:23		shrimp	bio	shrimp1			15
8/7/2004	23:28		shrimp (2)	bio				15
8/7/2004	23:29		shrimp	bio				15
8/7/2004	23:34		EOL 406; move loactions					15
8/8/2004	0:19		SOL 438, biosurvey and arch (debris)			23:45:37	RL-17	15
8/8/2004	0:19		starfish; fish	bio				15
8/8/2004	0:20		fish	bio				15
8/8/2004	0:21		fish- halosaur?					15
8/8/2004	0:22		tether is trapped on slurpgun					15
8/8/2004	0:27		tether out; starting again					15
8/8/2004	0:28		fish	bio				15
8/8/2004	0:30		water hyacinth; starfish	bio				15
8/8/2004	0:32		crab; shrimp (geryon)	bio				15
8/8/2004	0:33		fish; shrimp	bio				15
8/8/2004	0:42		fish	bio				15
8/8/2004	0:47		fish	bio				15
8/8/2004	0:49		fish	bio				15
8/8/2004	0:50		water hyacinth	bio	shrimp	0:49:29	RL-18	15
8/8/2004	0:51		shrimp	bio				15
8/8/2004	0:54		shrimp; fish	bio	halosaur			15
8/8/2004	0:56		shrimp	bio				15
8/8/2004	1:00		fish	bio				15
8/8/2004	1:02		shrimp; water hyacinth	bio				15
8/8/2004	1:04		fish	bio				15
8/8/2004	1:07		EOL 438					15
8/8/2004	1:07		shrimp	bio				15
8/8/2004	1:10		lights out for ten minutes					15

Site ***Robert E. Lee***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/8/2004	1:20		lights on					15
8/8/2004	1:20		SOL 439					15
8/8/2004	1:22		shrimp (2)	bio				15
8/8/2004	1:23		halosaur	bio				15
8/8/2004	1:24		water hyacinth; starfish	bio				15
8/8/2004	1:26	RO-48	artifact	arch	art 64			15
8/8/2004	1:28		shrimp; cutthroat eel	bio				15
8/8/2004	1:30		brittle star	bio	brittlestar			15
8/8/2004	1:31		halosaur	bio				15
8/8/2004	1:31		fish	bio	eel			15
8/8/2004	1:33		starfish	bio				15
8/8/2004	1:34		shrimp, fish	bio				15
8/8/2004	1:35		sardine can	bio				15
8/8/2004	1:35		shrimp	bio				15
8/8/2004	1:36		halosaurs (2)	bio				15
8/8/2004	1:37		water hyacinth	bio				15
8/8/2004	1:38		EOL 439 (600 ft)	bio				15
8/8/2004	1:39		halosaurs (2)	bio				15
8/8/2004	1:45		SOL 440	bio				15
8/8/2004	1:41		trash	bio				15
8/8/2004	1:42		rattail	bio				15
8/8/2004	1:45		fish (2)	bio				15
8/8/2004	1:49		fish, rattail	bio				15
8/8/2004	1:50		starfish	bio				15
8/8/2004	1:53		shrimp	bio		1:53:27	RL-19	15
8/8/2004	1:54		halosaurs, shrimp	bio				15
8/8/2004	1:55		shrimp, starfish, shrimp (glyphocranson)	bio				15
8/8/2004	1:57		3 shrimp, halosaurs- maybe four of them,	bio				15
			brittle star swimming					15
8/8/2004	1:58		halosaur; shrimp; cutthroat eel; halosaur;	bio				15

Site ***Robert E. Lee***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
			shrom on bottom (orange eyes)					15
8/8/2004	1:59		cutthroat eel; shrimp	bio				15
8/8/2004	2:00		line 440 ended					15
8/8/2004	2:03		moving to line 434					15
8/8/2004	2:18		tms- problems					15
8/8/2004	2:30		SOL 434					15
8/8/2004	2:31		unidentified artifact	arch				15
8/8/2004	2:40		Bathynomous isopod swimming	bio				15
8/8/2004	2:44		fish (rattail?)	bio				15
8/8/2004	2:50		fish	bio				15
8/8/2004	2:51		fish	bio				15
8/8/2004	2:52	RO-49	rope, at 2:52, metal object 2:53, artifact 64,	arch				15
			F#49					15
8/8/2004	2:56		fish (rattail) 2	bio				15
8/8/2004	3:09		artifact #65, metal object	arch		2:57	RL-20	15
8/8/2004	3:14	RO-50	artifact #66, RO50 assoc. features	arch				15
8/8/2004	3:18		EOL 434					15
8/8/2004	3:19		travel to line 422					15
8/8/2004	3:19		fish	bio				15
8/8/2004	3:47		shrimp	bio				15
8/8/2004	3:50		first artifact of line 422, artifact 67	arch				15
8/8/2004	3:52		2 objects	arch				15
8/8/2004	3:54		airvents	arch				15
8/8/2004	3:57		airvents					15
8/8/2004	4:00		metal piece					15
8/8/2004	4:05		finish line 422			4:01:28	RL-21	15
8/8/2004	4:21		SOL 423, close up shop due to weather					15
						6:24:39	RL-22	15
8/8/2004	7:06		start of mosaic of stern-center-line, first top to					15
			bottom then sides (stbd then port)					15

Site ***Robert E. Lee***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/8/2004	7:18		end of stern mosaic					15
8/8/2004	7:19		recon of stern for bio will s.					15
8/8/2004	7:37		plan view mosaic stern to bow			7:28:00	RL-23	15
8/8/2004	7:51		start of centerline (s->b)					15
8/8/2004	8:09		EOL					15
8/8/2004	8:23		start of stbd line 1					15
8/8/2004	8:50		start of stbd line 2			8:32:07	RL-24	15
8/8/2004	9:05		EOL					15
8/8/2004	9:32		start of 1 line port side (s->b)					15
8/8/2004	9:49		EOL			9:35:19	RL-25	15
8/8/2004	9:57		start of line 2 portside (s->b)					15
8/8/2004	10:15		EOL 2					15
8/8/2004	10:26		End of Mosaic (plan view) footage, basket at					15
			bottom					15
						10:38:31	RL-26	15
8/8/2004	12:05	RO-51	large trap set 1000 ft from wreck			11:42:32	RL-27	15
8/8/2004	12:07		shrimp trap taken from basket					15
8/8/2004	12:08		small trap taken from basket					15
8/8/2004	12:11		small trap set (no fix taken)					15
8/8/2004	12:13	RO-52	shrimp trap set					15
8/8/2004	12:29		core tube "D" taken from basket					15
8/8/2004	12:30	RO-53	core sample "D" collected; sample taken only					15
			800 ft from wreck					15
8/8/2004	12:33		core tube "D" returned to basket					15
8/8/2004	12:35		basket lifted from floor; will be taken to 150 ft					15
			SE of the stern of the wreck					15
8/8/2004	13:06		basket set on bottom			12:48:16	RL-28	15
8/8/2004	13:17		small trap taken from basket					15
8/8/2004	13:23	RO-54	small trap set near wreck					15
8/8/2004	13:28		crab trap taken from basket; trap appears					15

Site ***Robert E. Lee***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
			crushed and cannot be set					15
8/8/2004	13:30		large trap taken from basket					15
8/8/2004	13:36	RO-55	large trap set near wreck; ROV will now be					15
			brought to surface due to sonar malfunction;					15
			remaining core samples to be taken after					15
			repairs					15
						13:52:17	RL-29	15
8/8/2004	16:25		ROV back @ basket					15
8/8/2004	16:29		core tube "B" taken from basket					15
8/8/2004	16:32		crab	bio				15
8/8/2004	16:33		shrimp	bio				15
8/8/2004	16:34	RO-56	core sample "B" taken 500 ft from wreck					15
8/8/2004	16:39		Core "B" placed in basket			16:38:16	RL-30	16
8/8/2004	16:40		core "C" taken from basket					16
8/8/2004	16:44	RO-57	core "C" taken 100ft from wreck					16
8/8/2004	16:48		core tube "C" returned to basket					16
8/8/2004	16:49		core "A" taken from basket					16
8/8/2004	16:54	RO-58	sample "A" collected ~50 ft fore of stern (port					16
			side)					16
8/8/2004	16:57	RO-59	fix taken on stern	arch				16
8/8/2004	17:01		core tube "A" put in basket					16
8/8/2004	17:02		core tube "E" taken from basket, core sample					16
		RO-60	"E" taken near bridge					16
8/8/2004	17:14		area of port side of wreck					16
8/8/2004	17:25		core "E" returned to basket					16
8/8/2004	17:26		biological sampling begins					16
8/8/2004	17:29		shrimp					16
8/8/2004	17:31		crab					16
8/8/2004	17:39		white crab; sucked up #1					16
8/8/2004	17:42		another white crab- sucked up #2					16

Site ***Robert E. Lee***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/8/2004	17:44		still shot at two crabs - two_crabs.tiff		two_crabs	17:42:27	RL-31	16
8/8/2004	17:56		possible hydrozoan - sucked up					16
8/8/2004	17:56		white crab; sucked up #3		white_crab			16
8/8/2004	17:58		hydrozoan/ bryozoan- sucked up					16
8/8/2004	17:59		white crab #4- sucked up		white_crab2			16
8/8/2004	17:50		hydrozoan, sucke up (greenish)					16
8/8/2004	17:51		purple hydrozoan, sucked up		purple_hydrozoan			16
8/8/2004	17:53		bryozoan/ hydrozoan; sucked up					16
8/8/2004	17:55		sea anemone; brown		sea_anemone			16
8/8/2004	17:56		white crab #5		white_crab3			16
8/8/2004	17:59		white crab #6		white_crab4			16
8/8/2004	17:59		white crab #7		white_crab5			16
8/8/2004	18:00		bryozoan/ hydrozoan					16
8/8/2004	18:04		crab on sea floor next to wreck sucked up	bio				16
8/8/2004	18:07		white crab on floor	bio				16
8/8/2004	18:09		munidopsis x 3 sucked up	bio				16
8/8/2004	18:10		white crab #8	bio				16
8/8/2004	18:13		green crab - sucked up.	bio	green_crab.tiff			16
8/8/2004	18:15		fish - fish.tiff	bio	fish.tiff			16
8/8/2004	18:17		another feesh… sucked up	bio	fish2.tiff			16
8/8/2004	18:22		crab- green crab.tif	bio	green_crab.tiff			16
8/8/2004	18:46		fish- sucked up	bio	fish3.tif	End of Tape	RL-31	16
8/8/2004	18:57		invert	bio		18:50:56	RL-32	16
8/8/2004	18:59		shrimp, large	bio				16
8/8/2004	19:03		crab with missing leggs	bio	cripple_crab.tiff			16
8/8/2004	19:04		white crab? Sucked up	bio				16
8/8/2004	19:05		green_crab. Sucked up	bio	green_crab3.tif			16
8/8/2004	19:21	RO-61	fix on telegraph	arch				16
8/8/2004	19:53		head back to TMS. Electric comms need to					16
			be resealed.					16

Site ***Robert E. Lee***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/8/2004	19:55		Recovering ROV			19:55:23	RL-33	16
8/8/2004	22:23		ROV back on botttom			22:34:49	RL-34	17
8/8/2004	22:32		fish collected	B				17
8/8/2004	22:45		rusticle collection box taken from basket					17
8/8/2004	22:51		rusticle container ("gucci") taken from basket					17
8/8/2004	23:00		rusticle collected from stern					17
8/8/2004	23:02		rusticle collected from stern					17
8/8/2004	23:08		rusticle collected from stern					17
8/8/2004	23:11		rusticles dumped in"gucci" container					17
8/8/2004	23:26		rusticle taken from aft promenade					17
8/8/2004	23:32		rusticle, port stern. Rusticle_collected_from					17
8/8/2004			_stern4.jpg					17
8/8/2004	23:42		rusticle, port stern. Rusticle_collected_from					17
8/8/2004			_stern5.jpg					17
8/8/2004	23:51		rusticle, port stern. Rusticle_collected_from			23:38:45	RL-35	17
8/8/2004			_stern6.jpg					17
8/8/2004	23:52		rusticle, port stern. Rusticle_collected_from					17
8/8/2004			_stern7.jpg					17
8/8/2004	23:54		Rusticle collected from stern 8.jpg					17
8/9/2004	0:02		rusticle collected from stern 9.jpg					17
8/9/2004	0:09		Rusticle collected from stern 10.jpg					17
8/9/2004	0:15		rusticle collected from stern 10.jpg (the next two)					17
8/9/2004	0:18		Rusticle collected from stern 11.jpg					17
8/9/2004	0:19		rusticle collected from stern 12.jpg					17
8/9/2004	0:27		telegraph, lying down, telelgraph clean. Jpg	arch				17
8/9/2004	0:34		cleaning second telegraph	arch	possible_rudder_control.			17
8/9/2004	0:39		possible rudder control (2nd telegraph)	arch	Possible	0:37:30	RL-36	17
8/9/2004					Rudder control 2.jpg			17
8/9/2004	0:41		possible rudder control (2nd telegraph)	arch	possible_rudder_control3.			17
8/9/2004	0:42		possible rudder control (2nd telegraph)					17

Site ***Robert E. Lee***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/9/2004						1:41:34	RL-37	17
8/9/2004						2:45:58	RL-38	17
8/9/2004	3:28		large-white at 1000 ft, small white at 1000 ft,					17
8/9/2004			minnow trap at 1000 ft all back in basket					17
8/9/2004	3:39		basket off bottom					17

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
9-Aug-04	7:27		ROV hits water			7:27:14	AP-1	18
9-Aug-04	8:47		At depth 6370 ft			8:31:15	AP-2	18
9-Aug-04	8:54	AP1	Depth experiment	arch				18
9-Aug-04	8:56		Arrive at ship, stbd side ~1/2, railings, mast down;	arch				18
			going around bow					18
9-Aug-04	9:00		Stbd anchor, impact	arch				18
9-Aug-04	9:01	AP2	Site at bow; stbd anchor below	arch				18
9-Aug-04	9:04		Large rusticles; spent rusticles, windlass, anchor chains	a/b				18
								18
9-Aug-04	9:07		Vent wall, bollards	arch				18
9-Aug-04	9:08		Large buckle stbd side	arch				18
9-Aug-04	9:29		Port side rusticles	bio				18
9-Aug-04	9:32		Rusticulated mast?	a/b				18
9-Aug-04	9:33	AP3	Wire obstruction	arch		End of Tape	AP-2	18
9-Aug-04	9:34		Anenomes and crabs (2)	bio				18
9-Aug-04	9:36	AP4	Wire obstruction	arch				18
9-Aug-04	9:38		Hole from gun; mast bent over	arch				18
9-Aug-04	9:39		Cleat hause hole; hole from gun 37 mm & 105 mm hole	arch				18
9-Aug-04	9:41		Large hole, midship, mast?, wall of rusticles;	a/b				18
			move up mast					18
9-Aug-04	9:48	AP5	Davit; mid ship bridge	arch				18
9-Aug-04	9:49		Roof falling in quarters	arch				18
9-Aug-04	9:48	AP6	stack; davit	arch				18
9-Aug-04	9:54		torpedo hole	arch				18
9-Aug-04	9:57		hole above torpedo	arch				18
9-Aug-04	9:58		fish-rattail, spent rusticles below torpedo hole, rusticle	a/b				18
			river flowing					18
9-Aug-04	10:00		Exit wound? from torpedo, hand rails bent and twisted;	arch		9:49:19	AP-3	18
			moving aft					18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
9-Aug-04	10:02		white plastic with duct tape	arch				18
9-Aug-04	10:04		Deck split from hull; large anenome	a/b				18
9-Aug-04	10:05		On hand rail, lots of little white crabs	a/b				18
9-Aug-04	10:06		large buckle by stern mast, aft of winch, bollards, vents	arch				18
9-Aug-04	10:08		Porthole with glass and rusticle	arch				18
9-Aug-04	10:08		Name of stern ALCOA NEW; fish	a/b				18
9-Aug-04	10:08		plastic? canvas; stern at mud line	arch				18
9-Aug-04	10:12		Damage and plate split	arch				18
9-Aug-04	10:14		scan of name on stern, bollards with rusticles hanging off	arch				18
9-Aug-04	10:16	AP7	Stern; length from bow fix to stern: 423 ft	arch				18
9-Aug-04	10:20	AP8	wire and rail obstructions	arch				18
9-Aug-04	10:21		netting in mud; 6-8 ft off of sediment	arch				18
9-Aug-04	10:29		hole	arch				18
9-Aug-04	10:30		door, porthole, entry	arch				18
9-Aug-04	10:33		hole bullet	arch				18
9-Aug-04	10:34		ladder and bollards	arch				18
9-Aug-04	10:37		davit, mast	arch				18
9-Aug-04	10:38		davit, bridge door open, twisted hand rails; fallen in deck	arch				18
			roofing					18
9-Aug-04	10:42		telegraph in wheel house, flying port to stbd	arch		End of Tape	AP-3	18
9-Aug-04	10:44		entry way	arch				18
9-Aug-04	10:45	AP9	bullet hole below entry way; platform placement	arch				18
9-Aug-04	10:58		stbd side; forward of promenade deck beside winch	arch		10:53:19	AP-4	18
9-Aug-04	11:01		mast falling down	arch				18
9-Aug-04	11:03		dent	arch				18
9-Aug-04	11:04		flattened mast	arch				18
9-Aug-04	11:09	AP10	Bow; fly over from bow to stern	arch				18
9-Aug-04	11:19		forwardmost hold	arch				18
9-Aug-04	11:23		second hold	arch				18
9-Aug-04	11:24		pilot house rusticles	arch				18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
9-Aug-04	11:33		wood object on pilot house roof	arch				18
9-Aug-04	11:34		telegraph	arch				18
9-Aug-04	11:37		funnel	arch				18
9-Aug-04	11:46		Stern	arch				18
9-Aug-04	12:25		Start survey line 520	arch		11:57:23	AP-5	18
9-Aug-04	12:30		sea star	bio	Sea star			18
9-Aug-04	12:33		sea star	bio				18
9-Aug-04	12:37		sea star	bio				18
9-Aug-04	12:39	AP11	artifact 1; bracing for walkway	arch				18
9-Aug-04	12:46		sea star	bio				18
9-Aug-04	12:49		artifact 2; metal railing	arch				18
9-Aug-04	12:50		shrimp and crab	bio				18
9-Aug-04	12:51		burlap sack	arch				18
9-Aug-04	12:52		wire	arch				18
9-Aug-04	12:58	AP12	smoke stack	arch				18
9-Aug-04	13:09		sea cucumber	bio				18
9-Aug-04	13:10		wire	arch				18
9-Aug-04	13:16		cucumber	bio		13:01:25	AP-6	18
9-Aug-04	13:19		invert	bio				18
9-Aug-04	13:23		sea star	bio				18
9-Aug-04	13:26		sea star	bio				18
9-Aug-04	13:30		cucumber collected	bio				18
9-Aug-04	13:30		sea star	bio				18
9-Aug-04	13:31		fish	bio				18
9-Aug-04	13:32		sea star	bio				18
9-Aug-04	13:37		fish	bio				18
9-Aug-04	13:38		fish collected	bio				18
9-Aug-04	13:42		fish	bio				18
9-Aug-04	13:45		fish	bio				18
9-Aug-04	13:46		shrimp collected	bio				18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
9-Aug-04	13:54		End of line 520					18
9-Aug-04	13:55		Start of line 521					18
9-Aug-04	13:59		hermit crab	bio		End of Tape	AP-6	18
9-Aug-04	14:15		cucumber sampled	bio		14:08:30	AP-7	18
9-Aug-04	14:30		metal railing	arch				18
9-Aug-04	14:31		Door- artifact 3	arch				18
9-Aug-04	14:32		netting	arch				18
9-Aug-04	14:35		artifact 4	arch				18
9-Aug-04	14:38		invert collected	bio				18
9-Aug-04	14:53		End of line 521					18
9-Aug-04	14:56		Start of line 519					18
9-Aug-04	14:59		brittle star collected	bio				18
9-Aug-04	15:01		fish; anenome	bio				18
9-Aug-04	15:03		urchin?	bio				18
9-Aug-04	15:05		artifact 5	arch				18
9-Aug-04	15:06		anenome (2)	bio				18
9-Aug-04	15:07		brittle star	bio				18
9-Aug-04	15:09		shrimp	bio				18
9-Aug-04	15:11		onion sack	trash		End of Tape	AP-7	18
9-Aug-04	15:12		invert	bio				18
9-Aug-04	15:12		rag	trash				18
9-Aug-04	15:15		invert	bio				18
9-Aug-04	15:16		crab	bio				18
9-Aug-04	15:18		crab (2)	bio				18
9-Aug-04	15:19		crab (2)	bio				18
9-Aug-04	15:21		fish (2)	bio				18
9-Aug-04	15:56		milk box	trash		15:31:14	AP-8	18
9-Aug-04	16:10		shrimp; sea star	bio				18
9-Aug-04	16:17		End of line 519					18
9-Aug-04	16:21		lights out					18

Site *Alcoa Puritan*

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
9-Aug-04	16:59		shrimp, lights on	bio		16:35:28	AP-9	18
9-Aug-04	17:05		ROV heads to basket					18
9-Aug-04	17:08		ROV reaches basket					18
9-Aug-04	17:11		Basket brought to surface	bio				18
9-Aug-04	18:05		Start of line 218			17:39:25	AP-10	18
9-Aug-04	18:11		invert	bio				18
9-Aug-04	18:13		invert collected	bio				18
9-Aug-04	18:19		fish	bio				18
9-Aug-04	18:23		invert; fish	bio				18
9-Aug-04	18:25		crab	bio				18
9-Aug-04	18:27		fish	bio				18
9-Aug-04	18:27		Chaecon sp.	bio				18
9-Aug-04	18:28	AP13	artifact 6	arch	art 6			18
9-Aug-04	18:51		sea star	bio		18:43:38	AP-11	18
9-Aug-04	18:32		invert	bio				18
9-Aug-04	18:34		shrimp	bio				18
9-Aug-04	18:36		sea cucumber collected	bio				18
9-Aug-04	18:37	AP14	artifact 7	arch				18
9-Aug-04	18:42		bag?	t				18
9-Aug-04	18:43		shrimp, fish, sea star	bio				18
9-Aug-04	18:44		shrimp	bio				18
9-Aug-04	18:46		fish; invert	bio				18
9-Aug-04	18:48		sea star	bio				18
9-Aug-04	18:53		End of line 218					18
9-Aug-04	19:00		Start of line 217					18
9-Aug-04	19:06		invert	bio				18
9-Aug-04	19:07		brittle star	bio				18
9-Aug-04	19:11		invert collected	bio				18
9-Aug-04	19:14		sea star	bio				18
9-Aug-04	19:15		skate	bio				18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
9-Aug-04	19:23		artifact 8	a				18
9-Aug-04	19:26		shrimp	bio				18
9-Aug-04	19:30		cucumber collected	bio				18
9-Aug-04	19:31		artifact 9	a				18
9-Aug-04	19:32		shrimp	bio				18
9-Aug-04	19:33		fish	bio				18
9-Aug-04	19:34		fish?	bio				18
9-Aug-04	19:45		sea star	bio		End of Tape	AP-11	18
9-Aug-04	19:50		End of line 517					18
9-Aug-04	19:52		Start of line 516					18
9-Aug-04	19:52		fish	bio				18
9-Aug-04	19:56		excreting cucumber	bio		19:56:54	AP-12	18
9-Aug-04	20:03		invert	bio				18
9-Aug-04	20:01		orange fabric	ar/t	orange-fabric			18
9-Aug-04	20:14		invert; white-skeleton sea urchin	bio	invert2			18
9-Aug-04	20:23		sea star	bio				18
9-Aug-04	20:29		fish	bio	fish7			18
9-Aug-04	20:41		artifact; white crab	a/b	artifact10			18
9-Aug-04	20:44		fish	bio				18
9-Aug-04	20:45		sea star	bio				18
9-Aug-04	20:45		fish in sediment (sucked up?)	bio	fish8			18
9-Aug-04	20:51		garbage bag?	trash	garbage			18
9-Aug-04	20:52		plate- prob. modern	arch	modern_plate			18
9-Aug-04	20:53		white long thing- worm/eel?	bio	long_whitething			18
9-Aug-04	21:04	AP15	shell casing	arch	shell casing	21:02:34	AP-13	18
9-Aug-04	21:06	AP15	same casing, diff. view	arch	shell casing2			18
9-Aug-04	21:10		End of line 516					18
9-Aug-04	21:13		Start of line 514					18
9-Aug-04	21:22		chip packet	trash	chips			18
9-Aug-04	21:33		trash-unknown	trash				18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
9-Aug-04	21:35		artifact	arch	artifact11			18
9-Aug-04	21:37	AP16	artifact	arch	artifact12			18
9-Aug-04	21:41		sea star	bio				18
9-Aug-04	21:40		sea cucumber; sucked up	bio	cucumber3			18
9-Aug-04	21:48		End of line 514					18
9-Aug-04	21:53		Heading to 1000 ft line					18
9-Aug-04	22:18		Start of line 500					18
9-Aug-04	22:19		shrimp	bio		22:07:12	AP-14	18
9-Aug-04	22:23		invert collected	bio				18
9-Aug-04	22:26		shrimp	bio				18
9-Aug-04	22:26	AP17	artifact 13	arch	artifact13			18
9-Aug-04	22:33		invert (2) collected	bio				18
9-Aug-04	22:35		artifact 14	arch	artifact14			18
9-Aug-04	22:37		artifact 15	arch	artifact15			18
9-Aug-04	22:39		debris	arch				18
9-Aug-04	22:40		debris (artifact 16)	arch	artifact16			18
9-Aug-04	22:42		debris	arch				18
9-Aug-04	22:44		debris; gangway	arch	artifact17			18
9-Aug-04	22:46		chair	arch	chair			18
9-Aug-04	22:46		trash	trash				18
9-Aug-04	22:50		fish collected	bio				18
9-Aug-04	22:52		debris	arch				18
9-Aug-04	22:53		artifact18	arch	artifact18			18
9-Aug-04	22:56		barrel	arch	barrel			18
9-Aug-04	22:57	AP18	Top of mast	arch	Top of Mast			18
9-Aug-04	22:59		End of line 500					18
9-Aug-04	23:02		sea cucumber collected	bio				18
9-Aug-04	23:02		Start of line 501					18
9-Aug-04	23:04		debris	arch				18
9-Aug-04	23:07		shrimp	bio				18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
9-Aug-04	23:11		shrimp, brittle star	bio				18
9-Aug-04	23:12		sea star	bio				18
9-Aug-04	23:17		debris	arch		23:11:12	AP-15	18
9-Aug-04	23:16		debris	arch	wreckage			18
9-Aug-04	23:21		debris	arch				18
9-Aug-04	23:27		fish	bio				18
9-Aug-04	23:27		End of line 501					18
9-Aug-04	23:30		Start of line 502					18
9-Aug-04	23:31		fish collected	bio				18
9-Aug-04	23:34		shrimp	bio				18
9-Aug-04	23:38		debris	arch				18
9-Aug-04	23:38		shrimp NOT collected	bio				18
9-Aug-04	23:41		invert collected	bio				18
9-Aug-04	23:43		cargo netting, debris	arch				18
9-Aug-04	23:56		metal artifact	arch				18
9-Aug-04	23:59		fish? collection	bio				18
10-Aug-04	0:07		starfish collection; eel	bio				18
10-Aug-04	0:10		Basket in water	bio				18
10-Aug-04	0:36		shrimp collection	bio		0:17:42	AP-16	18
10-Aug-04	0:39		Tripod fish	bio				18
10-Aug-04	0:40		attempted fish collection	bio				18
10-Aug-04	0:41		attempted fish collection	bio				18
10-Aug-04	0:42		fish collected	bio				18
10-Aug-04	0:47		brittle star	bio				18
10-Aug-04	0:53		attempted fish collection; caught fish	bio				18
10-Aug-04	1:05		Basket at depth; moving to 1000 ft mark	bio				18
10-Aug-04	1:15		Basket on bottom	bio				18
10-Aug-04	1:17		Removing large trap (white) from basket	bio				18
10-Aug-04	1:19	AP19	Set large trap at 1000 ft	bio				18
10-Aug-04	1:21		Moving small trap from basket (white)	bio		1:21:45	AP-17	18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
10-Aug-04	1:25	AP20	Set small trap at 1000 ft	bio				18
10-Aug-04	1:28		Moving minnow trap from basket	bio				18
10-Aug-04	1:31	AP21	Set minnow trap at 1000 ft; core tube d taken from	bio				18
			basket					18
10-Aug-04	1:34	AP22	Core sample D taken from 1000 ft	bio				18
10-Aug-04	1:34		Core sample D back in basket	bio				18
10-Aug-04	1:38		Basket off bottom- moving to wreck	bio				18
10-Aug-04	2:12		Basket on bottom	bio				18
10-Aug-04	2:15		Hook removed from basket	bio				18
10-Aug-04	2:19		Moving large fish trap (black)	bio				18
10-Aug-04	2:23		Moving small trap from basket (black)	bio				18
10-Aug-04	2:30		Moving crab trap	bio		2:25:45	AP-18	18
10-Aug-04	2:44	AP23	Crap trap set near wreck	bio				18
10-Aug-04	2:49	AP24	Set large fish trap near wreck	bio				18
10-Aug-04	2:51	AP25	Set small fish trap near wreck	bio				18
10-Aug-04	3:02		Core tube A taken from basket; between stern and the	bio				18
			deckhouse					18
10-Aug-04	3:07	AP26	Core sample A taken	bio				18
10-Aug-04	3:11		Core tube A back in basket	bio				18
10-Aug-04	3:12		Core tube E taken from basket	bio				18
10-Aug-04	3:15	AP27	Core sample E taken by hull	bio				18
10-Aug-04	3:19		Core tube E back in the basket	bio				18
10-Aug-04	3:20		Core tube B taken from basket	bio				18
10-Aug-04	3:23	AP28	Core sample B taken from 100 ft from hull	bio				18
10-Aug-04	3:27		Core tube B back in the basket	bio				18
10-Aug-04	3:28		Core tube C taken from basket	bio				18
10-Aug-04	3:41	AP29	Core sample C taken from 500 ft from hull	bio		3:29:54	AP-19	18
10-Aug-04	3:48		Core tube C back in basket	bio				18
10-Aug-04	4:00		Basket for rusticle collection device	bio		End of Tape	AP-19	18
10-Aug-04	4:10		Large rusticle collected from portside midship	bio				18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
10-Aug-04	4:21		return to basket for small stern	bio				18
10-Aug-04	4:41		portside rusticles premenade	bio		4:33:59	AP-20	18
10-Aug-04	5:08		rustilces near stern	bio				18
10-Aug-04	5:59		pick up compression experiment	bio		5:38:00	AP-21	18
10-Aug-04	6:45		compression experiment, stein, and gucci in basket	bio		6:42:02	AP-22	18
10-Aug-04	6:53		hooked the basket	bio				18
10-Aug-04	6:54		Basket off bottom	bio				18
10-Aug-04	7:19		basket on deck	bio				18
10-Aug-04	7:15		fish	bio				18
10-Aug-04	7:15		Start of line 503					18
10-Aug-04	7:16		sea roach collection; fish	bio				18
10-Aug-04	7:17		fish, cucumber collection	bio				18
10-Aug-04	7:18		fish	bio				18
10-Aug-04	7:19		fish	bio				18
10-Aug-04	7:19		sea urchin collection	bio				18
10-Aug-04	7:20		shrimp; fish	bio				18
10-Aug-04	7:21		shrimp	bio				18
10-Aug-04	7:22		2 shrimp	bio				18
10-Aug-04	7:23		2 fish	bio				18
10-Aug-04	7:24		fish collected	bio				18
10-Aug-04	7:25		unknown invert collected	bio				18
10-Aug-04	7:25		shrimp	bio				18
10-Aug-04	7:27		shrimp	bio				18
10-Aug-04	7:28		fish collected	bio				18
10-Aug-04	7:28		fish collected	bio				18
10-Aug-04	7:29		cucumber	bio	blue cucumber			18
10-Aug-04	7:30		shrimp	bio				18
10-Aug-04	7:31		shrimp	bio				18
10-Aug-04	7:32		sea urchin collection	bio				18
10-Aug-04	7:34		water hyacinth collection	bio				18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
10-Aug-04	7:34		possible fish collection	bio				18
10-Aug-04	7:36		fish	bio				18
10-Aug-04	7:37		shrimp; 2 fish	bio				18
10-Aug-04	7:38		fish	bio				18
10-Aug-04	7:42		plastic	trash				18
10-Aug-04	7:43		fish; shrimp	bio				18
10-Aug-04	7:44		pepsi can	trash				18
10-Aug-04	7:44		sea urchin	bio		End of Tape	AP-22	18
10-Aug-04	7:45		unknown invert collected	bio				18
10-Aug-04	7:48		brittle star	bio				18
10-Aug-04	7:53		basket in water	bio				18
10-Aug-04	7:51		shrimp collection	bio				18
10-Aug-04	7:52		sea urchin collection	bio				18
10-Aug-04	7:54		artifact	arch	pic			18
10-Aug-04	7:55		crab	bio		7:55:11	AP-23	18
10-Aug-04	7:59		brotula	bio				18
10-Aug-04	8:00		sea roach collection	bio				18
10-Aug-04	8:00		brittle star	bio				18
10-Aug-04	8:03		artifact; white crab	a/b				18
10-Aug-04	8:05		fish	bio				18
10-Aug-04	8:07		artifact; white crab	a/b				18
10-Aug-04	8:09		2 cucumbers	bio				18
10-Aug-04	8:11		2 cucumbers	bio				18
10-Aug-04	8:11		artifact	arch	23			18
10-Aug-04	8:13		artifact	arch				18
10-Aug-04	8:14		artifact	arch				18
10-Aug-04	8:15		artifact 24	arch	pic			18
10-Aug-04	8:17		artifact;fish	a/b				18
10-Aug-04	8:18		2 anenomes	bio				18
10-Aug-04	8:19		artifact 25	arch	pic			18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
10-Aug-04	8:20		beach ball	trash	pic			18
10-Aug-04	8:20		white crabs	bio				18
10-Aug-04	8:22		2 crabs	bio				18
10-Aug-04	8:23		2 crabs collected	bio				18
10-Aug-04	8:24		fish	bio				18
10-Aug-04	8:25		artifact- chair 2	arch	pic			18
10-Aug-04	8:25		2 fish	bio				18
10-Aug-04	8:26		artifact	arch	pic			18
10-Aug-04	8:28		starfish	bio				18
10-Aug-04	8:30		End of line 503					18
10-Aug-04	8:23		Basket at depth					18
10-Aug-04	8:41		Start of line 504					18
10-Aug-04	8:42		fish	bio				18
10-Aug-04	8:44		artifact	arch				18
10-Aug-04	8:45		artifact	arch				18
10-Aug-04	8:48		starfish	bio				18
10-Aug-04	8:53		fish	bio				18
10-Aug-04	8:58		End of line 504					18
10-Aug-04	9:00		Start of line 505			8:59:13	AP-24	18
10-Aug-04	9:01		artifact 26; crab	a/b	pic			18
10-Aug-04	9:05		artifact	arch				18
10-Aug-04	9:09		fish collected	bio				18
10-Aug-04	9:10		shrimp	bio				18
10-Aug-04	9:14		shell-argonaut collected	bio				18
10-Aug-04	9:15		fish	bio				18
10-Aug-04	9:20		End of line 505					18
10-Aug-04	9:20		Start of line 506					18
10-Aug-04	9:23		artifact	arch				18
10-Aug-04	9:24		artifact (same as earlier)	arch				18
10-Aug-04	9:28		shrimp	bio				18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
10-Aug-04	9:35		End of line 506; go to wreck					18
10-Aug-04	10:08		Start mosaic- center line	arch		10:03:23	AP-25	18
10-Aug-04	10:30		finished center line	arch				18
10-Aug-04	10:38		Artifact pick up	arch				18
10-Aug-04	11:05		basket at bottom, pick up artifact	arch				18
10-Aug-04	11:13		pick up artifact 27	arch		11:07:26	AP-26	18
10-Aug-04	11:20		artifact in basket; set basket at 250 ft	arch				18
10-Aug-04	11:57		Start of line "shell casing"	arch				18
10-Aug-04	12:34		possible artifact detected	arch		12:11:48	AP-27	18
10-Aug-04	12:42		fish; 2 sea stars	bio				18
10-Aug-04	12:52		heading back to basket; will run a line 1000 ft west of	arch				18
			shell casing					18
			line back to basket			End of Tape	AP-27	18
10-Aug-04	13:18		possible artifact detected	arch				18
10-Aug-04	13:38		debris found	arch		13:21:12	AP-28	18
10-Aug-04	13:52		large trap near wreck	bio				18
10-Aug-04	13:57		large trap set in basket	bio				18
10-Aug-04	14:01		"raccoon" fish	bio				18
10-Aug-04	14:04		crab trap retrieved	bio				18
10-Aug-04	14:05		small trap retrieved	bio				18
10-Aug-04	14:12		traps placed in basket	bio				18
10-Aug-04	14:38		basket set 1000 ft from wreck	bio		14:25:25	AP-29	18
10-Aug-04	14:42		large trap received	bio				18
10-Aug-04	14:46		large trap put in basket	bio				18
10-Aug-04	14:50		shrimp trap retrieved	bio				18
10-Aug-04	14:53		shrimp trap put in basket	bio				18
10-Aug-04	15:01		small trap retrieved	bio				18
10-Aug-04	15:04		smal trap set in basket	bio				18
10-Aug-04	15:06		Basket brought to surface; running additional survey lines	bio				18
10-Aug-04	15:20		hatch cover?	arch				18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
10-Aug-04	15:26		long flat debris	arch				18
10-Aug-04	15:27		debris	arch				18
10-Aug-04	15:28		Start of line 546			End of Tape	AP-29	18
10-Aug-04	15:30		Debris	arch				18
10-Aug-04	15:46		debris	arch				18
10-Aug-04	15:48		debris (rail?)	arch				18
10-Aug-04	15:49		debris	arch				18
10-Aug-04	15:50		top of (AP18)	arch				18
10-Aug-04	15:51		fish	bio				18
10-Aug-04	15:57		debris (barrel?)	arch				18
10-Aug-04	15:58		debris	arch				18
10-Aug-04	15:59		debris	arch				18
10-Aug-04	16:01		debris	arch				18
10-Aug-04	16:02	AP31	telegraph	arch				18
10-Aug-04	16:04		debris	arch				18
10-Aug-04	16:06		plate	arch				18
10-Aug-04	16:09		end of line 546					18
10-Aug-04	16:10		start of line 545					18
10-Aug-04	16:14		debris	arch				18
10-Aug-04	16:15		debris	arch				18
10-Aug-04	16:17		debris in crater	arch				18
10-Aug-04	16:18		debris	arch				18
10-Aug-04	16:21		railing and bucket	arch				18
10-Aug-04	16:22		fish	bio				18
10-Aug-04	16:24		debris	arch				18
10-Aug-04	16:24		cucumber	bio				18
10-Aug-04	16:27		debris	arch				18
10-Aug-04	16:28		pipe with anenome	a/b				18
10-Aug-04	16:28		debris	arch				18
10-Aug-04	16:29		End of line 545					18

Site ***Alcoa Puritan***

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
10-Aug-04	16:31		barrel	arch				18
10-Aug-04	16:32		debris	arch				18
10-Aug-04	16:34	AP32	debris-hatch cover?	arch				18
10-Aug-04	16:38	AP33	debris hatch cover	arch				18
10-Aug-04	16:40		Start of line 552			16:40:31	AP-30	18
10-Aug-04	16:43		debris	arch				18
10-Aug-04	16:47	AP34	debris- hatch cover	arch				18
10-Aug-04	16:55		End of line 552-heading back to telegraph (AP31)	arch				18
10-Aug-04	17:02		telegraph (AP31) surveyed; face plate missing	arch				18
10-Aug-04	17:05		ROV being brought to surface	arch				18
10-Aug-04	17:09		ROV stopped	arch				18
10-Aug-04	17:48		Run test platforms collected from wreck	arch				18
10-Aug-04	17:49		ROV being brought to surface	arch		17:44:34	AP-31	18

Site **Gas Vent**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
						21:20	TV-1	19
						22:50	TV-2	19
8/10/2004	23:46		shrimp-sucked up	bio				19
8/10/2004	23:47		basket in water	bio				19
8/10/2004	23:48	GV2	tube worms- 2 shots	bio	worms1.jpg;			19
8/10/2004				bio	worms2.jpg			19
8/10/2004	23:52		fishie	bio	fishie1.jpg	23:52	TV-3	19
8/10/2004	23:57		dead clam	bio				19
8/10/2004	23:58		crab collected	bio				19
8/10/2004	23:58		crab collected	bio				19
8/10/2004	23:59		hydrate-	bio	hydrate1.jpg			19
8/11/2004	0:04		carbonate	bio	carbonate1.jpg			19
8/11/2004	0:07	GV3	mussels	bio	mussels.jpg			19
8/11/2004	0:21		crab collected	bio				19
8/11/2004	0:25		collected hunk of hydrate	bio				19
8/11/2004	0:38		basket at bottom	bio				19
8/11/2004	0:43	GV4	small black trap at fix GV 4 (near fix GV 2)	bio				19
8/11/2004	0:51	GV5	small white trap at fix GV5 (near fix GV 3)	bio		0:49	TV-4	19
8/11/2004	0:55		several crabs collected	bio				19
8/11/2004	1:24		mussels collected with stein (GV 3)	bio				19
8/11/2004	1:33		mussels in basket	bio				19
8/11/2004	1:43		collected tubeworms at GV 2	bio				19
8/11/2004	2:01		bacterial mat	bio	bac_mat;	1:52	TV-5	19
					bac_mat2;			19
8/11/2004				bio	bac_mat3			19
8/11/2004	2:06		fish collected	bio	fishie2.jpg			19
8/11/2004	2:19		core sample taken	bio	core1.jpg			19
8/11/2004	2:21		stein scraped across bac mat surface	bio	stein_scrape.jpg			19
8/11/2004	2:35		core sample placed in basket	bio				19

Site **Gas Vent**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/11/2004	2:43		crab collected	bio				19
8/11/2004	2:44		crab collected	bio				19
8/11/2004	2:49		attempted shrimp collection	bio				19
8/11/2004	2:50		shrimp collection	bio				19
8/11/2004	2:51		crabs white	bio				19
8/11/2004	2:54		crabs collected	bio				19
8/11/2004	2:55		crabs collected	bio				19
8/11/2004	3:01		crab collected	bio		2:56	TV-6	19
8/11/2004	3:03		small black trap removed	bio				19
8/11/2004	3:10		small white trap removed; both picked up	bio				19
			moving to basket					19
8/11/2004	3:20		basket off bottom	bio				19
8/11/2004	3:25		basket on deck	bio				19
8/11/2004			Going back to bottom to pick up d	bio				19
			ecompression exp.					19
8/11/2004	3:39		basket off bottom	bio				19
8/11/2004	3:45		ROV recovery; watching decompression exp.	bio				19
8/11/2004	4:50		ROVon deck			3:47	TV-7	19

Site ***Gulfpenn*** **(Visit II)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/11/2004	19:59		on stern			18:45	GP2-1	21
8/11/2004	20:04		coral	bio		20:00	GP2-2	21
8/11/2004	20:05		moving down starboard side (s->b)					21
8/11/2004	20:06		coral; slimehead	bio				21
8/11/2004	20:07		fish	bio				21
8/11/2004	20:11		coral	bio				21
8/11/2004	20:14		fish	bio				21
8/11/2004	20:16		bringing up ROV to fix suction					21
8/11/2004	20:38		ROV breaks surface					21
8/11/2004	21:15		ROV back in water					22
8/11/2004	21:31		on bottom			21:30	GP2-3	22
8/11/2004	21:37		fish	bio				22
8/11/2004	21:38		shrimp; crab collected	bio				22
8/11/2004	21:39		slimehead collected	bio				22
8/11/2004	21:41		eel	bio				22
8/11/2004	21:42		crab collected	bio				22
8/11/2004	21:44		fish not collected	bio				22
8/11/2004	21:49		fish	bio				22
8/11/2004	21:50		crab	bio				22
8/11/2004	21:52		slimehead collected	bio				22
8/11/2004	21:54		slimehead	bio				22
8/11/2004	21:55		slimehead	bio				22
8/11/2004	21:59		pycnogonid collected	bio				22
8/11/2004	22:08		slimehead	bio				22
8/11/2004	22:15		crabs (2) collected	bio				22
8/11/2004	22:17		crab collected	bio				22
8/11/2004	22:19		shrimp collected	bio				22
8/11/2004	22:20		shrimp	bio				22
8/11/2004	22:20		slimehead collected	bio				22

Site ***Gulfpenn* (Visit II)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/11/2004	22:24		scorpion fish collected	bio				22
8/11/2004	22:30		crab collected	bio				22
8/11/2004	22:33		fish	bio				22
8/11/2004	22:36		crabs collected	bio				22
8/11/2004	22:37		crabs collected	bio		22:37	GP2-4	22
8/11/2004	22:47		invert collected	bio				22
8/11/2004	22:58		crab collected	bio				22
8/11/2004	23:03		eel	bio				22
8/11/2004	23:05		slimehead	bio				22
8/11/2004	23:12		invert collected	bio				22
8/11/2004	23:17		fish	bio				22
8/11/2004	23:26		slimehead	bio				22
8/11/2004	23:28		scallop collected	bio				22
8/11/2004	23:34		slimehead collected	bio				22
8/11/2004	23:44		crab collected	bio		23:40	GP2-5	22
8/11/2004	23:48		slimehead collected	bio				22
8/12/2004	0:01		start bow to stern survey			0:33	GP2-6	22
8/12/2004	0:56		end survey					22
8/12/2004	1:06		scorpion fish	bio				22
8/12/2004	1:08		scorpion; cucumber	bio				22
8/12/2004	1:09		crabs (2) collected	bio				22
8/12/2004	1:13		fish and scorp	bio				22
8/12/2004	1:19		crab collected (2)	bio				22
8/12/2004	1:22		fish attempt	bio				22
8/12/2004	1:24		fish attempt	bio				22
8/12/2004	1:30		slimeheads	bio				22
8/12/2004	1:33		slimehead	bio				22
8/12/2004	1:38		scorp attempt	bio				22
8/12/2004	1:45		shrimp collected	bio				22
8/12/2004	1:50		slimeheads	bio				22

Site ***Gulfpenn* (Visit II)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/12/2004	1:58		bivalve	bio		1:54	GP2-7	22
8/12/2004	2:00		bivalve collection (half of body)	bio				22
8/12/2004	2:04		bivalve collection	bio				22
8/12/2004	2:08		bivalve collection	bio				22
8/12/2004	2:10		bivalve collection	bio				22
8/12/2004	2:11		crabs	bio				22
8/12/2004	2:22		unknown invert	bio				22
8/12/2004	2:23		unknown invert collection	bio				22
8/12/2004	2:25		scorp	bio				22
8/12/2004	2:28		scorp attempt	bio				22
8/12/2004	2:28		fish attempt	bio				22
8/12/2004	2:31		slimeheads	bio				22
8/12/2004	2:34		slimehead captured	bio				22
8/12/2004	2:35		fishes	bio				22
8/12/2004	2:35		slimehead captured	bio				22
8/12/2004	2:36		fish	bio				22
8/12/2004	2:39		crab collected	bio				22
8/12/2004	2:40		crab collected	bio				22
8/12/2004	2:40		crab collected	bio				22
8/12/2004	2:42		shrimp collected	bio				22
8/12/2004	2:43		sea roach collection	bio				22
8/12/2004	2:43		sea roach; scorpion	bio				22
8/12/2004	2:46		2 scorps	bio				22
8/12/2004	2:47		bivalves	bio				22
8/12/2004	2:48		attempted bivalve	bio				22
8/12/2004	2:49		2 bivalves collected	bio				22
8/12/2004	2:52		2 scorp attempts	bio				22
8/12/2004	3:02		scorp attempt	bio		2:57	GP2-8	22
8/12/2004	3:04		scorp attempt	bio				22
8/12/2004	3:05		shrimp collected	bio				22

Site **_Gulfpenn_ (Visit II)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/12/2004	3:07		crab collected	bio				22
8/12/2004	3:08		crab collected	bio				22
8/12/2004	3:10		Rochinia attempt	bio				22
8/12/2004	3:14		crab collected	bio				22
8/12/2004	3:16		fish attempted	bio				22
8/12/2004	3:17		cucumber	bio				22
8/12/2004	3:19		polychaete collected	bio				22
8/12/2004	3:20		cucumber (2)	bio				22
8/12/2004	3:22		crab collected	bio				22
8/12/2004	3:24		shrimp; cucumber	bio				22
8/12/2004	3:25		plant collected	bio				22
8/12/2004	3:25		snail	bio				22
8/12/2004	3:31		shrimp collected	bio				22
8/12/2004	3:41		cucumber	bio				22
8/12/2004	3:42		shrimp collected	bio				22
8/12/2004	3:43		shrimp collected	bio				22
8/12/2004	3:48		fish	bio				22
8/12/2004	3:54		snail collection	bio				22
8/12/2004	3:58		cucumber	bio				22
8/12/2004	3:58		crab collection	bio				22
8/12/2004	3:59		fish collection	bio				22
8/12/2004	4:01		fish collection (2)	bio		4:01	GP2-9	22
8/12/2004	4:01		shrimp	bio				22
8/12/2004	4:02		crab collection	bio				22
8/12/2004	4:02		snail collection	bio				22
8/12/2004	4:03		cucumber	bio				22
8/12/2004	4:04		hermit crab collection	bio				22
8/12/2004	4:04		cucumber	bio				22
8/12/2004	4:07		crab collection	bio				22
8/12/2004	4:08		cucumber (2)	bio				22

Site			***Gulfpenn* (Visit II)**					
Date	**Time**	**Fix No.**	**Description** [Note, Laser Distance is 5", not 4"]	**B/A/T**	**Photo No.**	**Tape Start Time**	**Tape No.**	**Dive No.**
8/12/2004	4:09		crab collected (2)	bio				22
8/12/2004	4:10		cucumber	bio				22
8/12/2004	4:11		cucumber	bio				22
8/12/2004	4:12		shrimp	bio				22
8/12/2004	4:12		snail collection	bio				22
8/12/2004	4:15		sea roach	bio				22
8/12/2004	4:17		shrimp collected	bio				22
8/12/2004	4:17		hermit crab collection	bio				22
8/12/2004	4:18		crab collected	bio				22
8/12/2004	4:19		2 crabs collected	bio				22
8/12/2004	4:20		crab collected	bio				22
8/12/2004	4:21		shrimp collected	bio				22
8/12/2004	4:22		crab collected	bio				22
8/12/2004	4:23		cucumber fish	bio				22
8/12/2004	4:27		shrimp collected; 2 crab collected	bio				22
8/12/2004	4:29		crabs (5) collected	bio				22
8/12/2004	4:31		snail collection	bio				22
8/12/2004	4:34		scorp	bio				22
8/12/2004	4:42		fish collected	bio				22
8/12/2004	4:43		snail collection	bio				22
8/12/2004	4:45		cucumber	bio				22
8/12/2004	4:47		possible snail collection	bio				22
8/12/2004	4:48		fish collected	bio				22
8/12/2004	4:52		fish collected	bio				22
8/12/2004	4:52		shrimp collected	bio				22
8/12/2004	4:52		snail collected	bio				22
8/12/2004	4:54		lobster collected	bio				22
8/12/2004	5:03		shrimp collected/ crab	bio				22
8/12/2004	5:12		fish collected	bio		5:05	GP2-10	22
8/12/2004	5:13		crab collected	bio				22

Site ***Gulfpenn* (Visit II)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/12/2004	5:14		crab collected	bio				22
8/12/2004	5:15		crab collected/ slimeheads	bio				22
8/12/2004	5:18		sea roach; scorpion	bio				22
8/12/2004	5:24		scorp	bio				22
8/12/2004	5:30		fish	bio				22
8/12/2004	5:30		fish collected	bio				22
8/12/2004	5:34		2 scorps	bio				22
8/12/2004	5:38		scorp	bio				22
8/12/2004	5:42		cucumber	bio				22
8/12/2004	5:45		fish	bio				22
8/12/2004	5:48		fish	bio				22
8/12/2004	6:00		trap pick up? Check video					22
8/12/2004	6:09		trap in basket					22
8/12/2004	6:10		crab in basket			6:10	GP2-11	22
8/12/2004	6:21		basket off bottom					22

Site ***Robert E. Lee*, (Visit II - South Debris Field)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/12/2004	12:44		ROV on sea floor			11:49	RL2-1	23
8/12/2004	12:46		SOL 422					23
8/12/2004	12:46		Isopod	bio				23
8/12/2004	12:54		fish	bio				23
8/12/2004	12:56		shrimp in water column	bio				23
8/12/2004	13:11		artifact 70	arch		13:05	RL2-2	23
8/12/2004	13:15		artifact 71	arch				23
8/12/2004	13:15		artifact 72- side paneling?	arch				23
8/12/2004	13:17		artifact 73	arch				23
8/12/2004	13:18		artifact 74- large vent	arch				23
8/12/2004	13:19		artifact 75- large vent	arch				23
8/12/2004	13:21		fish	bio				23
8/12/2004	13:21		artifact 76- porthole?	arch				23
8/12/2004	13:22		debris	arch				23
8/12/2004	13:23		fish	bio				23
8/12/2004	13:25		sea star	bio				23
8/12/2004	13:25		artifact 77	arch				23
8/12/2004	13:27		sea star and fish	bio				23
8/12/2004	13:29		sea star	bio				23
8/12/2004	13:34		crab	bio				23
8/12/2004	13:00		EOL 422					23
8/12/2004	13:45		SOL 423					23
8/12/2004	13:01		shrimp	bio				23
8/12/2004	13:52		fish	bio				23
8/12/2004	14:07		debris	arch				23
8/12/2004	14:08		artifact 78- pipe	arch		14:08	RL2-3	23
8/12/2004	14:09	RO2-1	lifeboat #1 (2 life boats together	arch				23
8/12/2004	14:11:00		lifeboat #2	arch				23
8/12/2004	14:13		pipes	arch				23

Site ***Robert E. Lee*, (Visit II - South Debris Field)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/12/2004	14:15		artifact 79	arch				23
8/12/2004	14:15		artifact 80	arch				23
8/12/2004	14:16		artifact 81- vent	arch				23
8/12/2004	14:18		artifact 82- rail	arch				23
8/12/2004	14:20		artifact 83	arch				23
8/12/2004	14:21		artifact 84	arch				23
8/12/2004	14:22		debris	arch				23
8/12/2004	14:25		artifact 85- porthole?	arch				23
8/12/2004	14:29		fish	bio				23
8/12/2004	14:28		debris in distance (ladder)	arch				23
8/12/2004	14:41		EOL 423					23
8/12/2004	14:43		SOL 424					23
8/12/2004	14:54		crab	bio				23
8/12/2004	14:57		debris	arch				23
8/12/2004	14:59		artifact 86	arch				23
8/12/2004	15:01		fish	bio				23
8/12/2004	15:03		artifact 87	arch				23
8/12/2004	15:03		vent	arch				23
8/12/2004	15:06		debris	arch				23
8/12/2004	15:07		debris	arch				23
8/12/2004	15:08		debris	arch		15:08	RL2-4	23
8/12/2004	15:09		debris	arch				23
8/12/2004	15:10		rail	arch				23
8/12/2004	15:13		debris and rail	arch				23
8/12/2004	15:13		fish	bio				23
8/12/2004	15:23		EOL 424					23
8/12/2004	15:25		SOL 425					23
8/12/2004	15:31		metal wire	arch				23
8/12/2004	15:32		shrimp	bio				23
8/12/2004	15:36		fish	bio				23

Site ***Robert E. Lee*****, (Visit II - South Debris Field)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/12/2004	15:39		artifact 88	arch				23
8/12/2004	15:40		wiring	arch				23
8/12/2004	15:41		debris	arch				23
8/12/2004	15:46		artifact 89 (buried hull section	arch				23
8/12/2004	15:47		artifact 90	arch				23
8/12/2004	15:50	RO2-2	telegraph on deck section	arch				23
8/12/2004	15:53		crab	bio				23
8/12/2004	15:55		fish	bio				23
8/12/2004	15:56		shrimp	bio				23
8/12/2004	16:05		EOL 425					23
8/12/2004	16:08		SOL 426					23
8/12/2004	16:15		debris	arch				23
8/12/2004	16:18		debris	arch				23
8/12/2004	16:20		pipe	arch		16:19	RL2-5	23
8/12/2004	16:21		vent; railing and telegraph (RO2-2); section of deck	arch				23
8/12/2004	16:23	RO2-3	2nd telegraph on deck section- called telegraph "b"	arch				23
8/12/2004	16:36		artifact 91	arch				23
8/12/2004	16:37		artifact 92- piece of hull?	arch				23
8/12/2004	16:39		vent; railing and telegraph (RO2-2); section of deck	arch				23
8/12/2004	16:40		fish	bio				23
8/12/2004	16:45		debris	arch				23
8/12/2004	16:46		shrimp collected	bio				23
8/12/2004	16:49		shrimp collected	bio				23
8/12/2004	16:51		brittlestar collected	bio				23
8/12/2004	16:51		sea star	bio				23
8/12/2004	16:55		shrimp collected	bio				23
8/12/2004	16:07		EOL 426					23
8/12/2004	16:59		SOL 427					23
8/12/2004	17:00		brittlestar collected	bio				23
8/12/2004	17:02		shrimp collected	bio				23

Site ***Robert E. Lee*****, (Visit II - South Debris Field)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/12/2004	17:03		sea star	bio				23
8/12/2004	17:04		shrimp and brittlestar collected	bio				23
8/12/2004	17:05		brittlestar collected	bio				23
8/12/2004	17:07		2 shrimp	bio				23
8/12/2004	17:08		shrimp	bio				23
8/12/2004	17:10		2 brittlestars collected	bio				23
8/12/2004	17:12		shrimp	bio				23
8/12/2004	17:14		possible debris	arch				23
8/12/2004	17:16		artifact 93	arch				23
8/12/2004	17:17		Metal beam	arch				23
8/12/2004	17:19		debris	arch		17:19	RL2-6	23
8/12/2004	17:21		pipes; metal debris	arch				23
8/12/2004	17:22		fish collected	bio				23
8/12/2004	17:23		shrimp collected	bio				23
8/12/2004	17:25		wiring	arch				23
8/12/2004	17:27		miller lite can	trash				23
8/12/2004	17:28		artifact 94	arch				23
8/12/2004	17:30		fish	bio				23
8/12/2004	17:32		fish	bio				23
8/12/2004	17:37		fish	bio				23
8/12/2004	17:39		artifact 95 and shrimp	arch/bio				23
8/12/2004	17:41		shrimp and crab captured	bio				23
8/12/2004	17:43		fish	bio				23
8/12/2004	17:44	RO2-4	artifact- porthole hatch	arch				23
8/12/2004	17:46		2 shrimp	bio				23
8/12/2004	17:47		shrimp captured	bio				23
8/12/2004	17:51		crab	bio				23
8/12/2004	17:52		fish collected	bio				23
8/12/2004	17:52		scallops collected	bio				23
8/12/2004	17:53		artifact 96	arch				23

Site **_Robert E. Lee_, (Visit II - South Debris Field)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/12/2004	17:54		artifact 97; crab and shrimp	arch/bio				23
8/12/2004	17:55	RO2-5	shoe (white)	arch	shoe sole			23
8/12/2004	17:56		artifact 98	arch				23
8/12/2004	17:58		artifact 99- vent	arch				23
8/12/2004	18:02	RO2-6	artifact 100- shoe and crab	arch/bio	shoe 2			23
8/12/2004	18:05		artifact 101- hose	arch	waterhose			23
8/12/2004	18:08		drag scar					23
8/12/2004	18:09		brittlestar	bio				23
8/12/2004	18:15		hydroid/ bryozoan	bio				23
8/12/2004	18:17		search for hit; none found					23
8/12/2004	18:20		fish	bio				23
8/12/2004	18:20		EOL 428					23
8/12/2004	18:23		SOL 429			18:23	RL2-7	23
8/12/2004	18:24		crab; brittlestar	bio				23
8/12/2004	18:26		brittlestar	bio				23
8/12/2004	18:32		crushed vent	arch				23
8/12/2004	18:33		brittlestar and worm collected	bio				23
8/12/2004	18:34		artifact 102	arch				23
8/12/2004	18:35		artifact 102-B	arch				23
8/12/2004	18:36		crab	bio				23
8/12/2004	18:39		fish	bio				23
8/12/2004	18:42		debris	arch				23
8/12/2004	18:44		debris	arch				23
8/12/2004	18:57		EOL 429					23
8/12/2004	18:59		SOL 430					23
8/12/2004	19:00		fish collected	bio				23
8/12/2004	19:06		cucumber	bio				23
8/12/2004	19:09		debris and small white crab	arch/bio				23
8/12/2004	19:13		shrimp collected	bio				23
8/12/2004	19:16		fish collected	bio				23

Site ***Robert E. Lee*, (Visit II - South Debris Field)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/12/2004	19:23		artifact 103	arch				23
8/12/2004	19:32		brittlestar collected	bio				23
8/12/2004	19:36		debris- pipe	arch		19:33	RL2-8	23
8/12/2004	19:37		cucumber	bio				23
8/12/2004	19:38		EOL 430					23
8/12/2004	19:41		SOL 431					23
8/12/2004	19:45		artifact 104-section of hull?	arch				23
8/12/2004	20:07		fish	bio				23
8/12/2004	20:08		debris	arch				23
8/12/2004	20:10		buried debris	arch				23
8/12/2004	20:23		fish	bio				23
8/12/2004	20:25		dish	arch				23
8/12/2004	20:29		fish	bio				23
8/12/2004	20:29		shrimp collected	bio				23
8/12/2004	20:30		shrimp collected	bio				23
8/12/2004	20:31		shrimp collected	bio				23
8/12/2004	20:32		shrimp collected	bio				23
8/12/2004	20:33		shrimp collected	bio				23
8/12/2004	20:34		sea star	bio				23
	20:37		EOL 431					23
	20:38		ROV being brought to surface					23

Site ***Gulfpenn* (Visit III)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/13/2004	6:13		Fish collected			5:58	GP3-1	24
8/13/2004	6:15		Crab collected					24
8/13/2004	6:17		Fish collected					24
8/13/2004	6:18		2 Fish attemps					24
8/13/2004	6:21		Scorp, Squat lobster					24
8/13/2004	6:22		Fish					24
8/13/2004	6:23		Slimhead					24
8/13/2004	6:27		Slimhead attempt					24
8/13/2004	6:29		2 scorps					24
8/13/2004	6:30		crab attempt					24
8/13/2004	6:31		Fish					24
8/13/2004	6:32		Slimheads					24
8/13/2004	6:37		Slimheads Collected					24
8/13/2004	6:40		Amphipod Hyperlid					24
8/13/2004	6:41		Slimheads					24
8/13/2004	6:42		Crab; Slimheads					24
8/13/2004	6:44		Crab collected					24
8/13/2004	6:47		Slimheads					24
8/13/2004	6:50		Scorp					24
8/13/2004	6:51		Fich					24
8/13/2004	6:55		Slimhead					24
8/13/2004	6:58		Siphonophore					24
8/13/2004	6:59		Slimheads					24
8/13/2004	7:03		Caught Eumunida Picta			7:02	GP3-2	24
8/13/2004	7:06		Caught Slimhead					24
8/13/2004	7:13		Caught Slimhead					24

Site ***Gulf Penn* (Visit III)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/13/2004	7:16		Caught Slimhead					24
8/13/2004	7:19		Caught Slimhead					24
8/13/2004	7:32		Caught Eumunida Picta					24
8/13/2004	7:33		Caught Anenume, maybe Slimhead					24
8/13/2004	7:37		Aenphoe					24
8/13/2004	7:38		2 Fish					24
8/13/2004	7:39		Fish					24
8/13/2004	7:40		Fish Collected					24
8/13/2004	7:41		Crab Collected					24
8/13/2004	7:43		Crab Collected					24
8/13/2004	7:45		Crab Collected					24
8/13/2004	7:48		Snail Collected					24
8/13/2004	7:50		Crab Collected					24
8/13/2004	8:02		Crab Collected/Hermit Crab also					24
8/13/2004	8:05		Crab Collected					24
8/13/2004	8:05		Shrimp Collected					24
8/13/2004	8:06		Shrimp Collected			8:06	GP3-3	24
8/13/2004	8:10		Rottail Collected					24
8/13/2004	8:11		Collected Flatfish					24
8/13/2004	8:14		Collected Fish					24
8/13/2004	8:14		Collected Shrimp					24
8/13/2004	8:15		Collected mud, maybe crabs					24
8/13/2004	8:17		Collected Shrimp (2)					24
8/13/2004	8:20		Collected Fish, Poss. Bivalre					24
8/13/2004	8:25		Collected Shrimp					24
8/13/2004	8:28		Collected Shrimp					24

Site *Gulfpenn* **(Visit III)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/13/2004	8:30		Collected Crabs and 2 shrimp					24
8/13/2004	8:32		Collected Snail (Gaza Superbo)					24
8/13/2004	8:32		Collected Flatfish					24
8/13/2004	8:35		Collected Crab (Poss. Bathynectes)					24
8/13/2004	8:36		Collected Crab					24
8/13/2004	8:37		Collected Fish (Goby?)					24
8/13/2004	8:38		Collected Shrimp and Shell					24
8/13/2004	8:40		Collected Brittlestar					24
8/13/2004	8:47		Collected Shrimp,snail,and fish					24
8/13/2004	8:49		Collected "Goby"					24
8/13/2004	8:56		Collected Snail (Gaza Superbo 2)					24
8/13/2004	9:08		Collected Crab (2)					24
8/13/2004	9:16		Snail Collected					24
8/13/2004	9:17		2 Crabs					24
8/13/2004	9:18		Hermit Crabs			9:18	GP3-4	24
8/13/2004	9:27		Slimheads					24
8/13/2004	9:32		Bivalve Collected					24
8/13/2004	9:34		Bivalve Collected					24
8/13/2004	9:39		Scorp					24
8/13/2004	9:41		Scorp, seaspider					24
8/13/2004	9:43		Seaspider collected					24
8/13/2004	9:50		Crab collected					24
8/13/2004	9:51		Seaspider					24
8/13/2004	9:53		Seaspider collected					24
8/13/2004	9:54		Slimheads					24
8/13/2004	10:06		Slimhead collected					24

Site **_Halo_ (Visit II)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/13/2004	23:15		ROV in Water			23:20	HA2-1	27
8/13/2004	23:43		basket on bottom					
8/13/2004	23:58		basket unhooked					
8/14/2004	0:02		large trap picked up					
8/14/2004	0:09		large trap at Halo, Stbd (stern)					
8/14/2004	0:17		large trap at Wht, Stbd(bow)					
8/14/2004	0:27		Bio platform set at Stbd bow behind Bollards			0:30	HA2-2	27
8/14/2004	1:29		ambarjack everywhere					
8/14/2004	1:33		at most (basses)					
8/14/2004	1:37		red barbier			1:34	HA2-3	27
8/14/2004	1:39		trying to vaccuum little fish in water column					
8/14/2004	1:46		lights off					
8/14/2004	1:54		light on					
8/14/2004	1:56		shrimp collected					
8/14/2004	1:59		unknown collection					
8/14/2004	2:02		unknown collection					
8/14/2004	2:07		lights out					
8/14/2004	2:17		unknown collection					
8/14/2004	2:20		unknown collection					
8/14/2004	3:18		ambarjack			2:39	HA2-4	27
8/14/2004	4:14		coral sample taken					
8/14/2004	4:20		seafan taken			3:58	HA2-5	28
8/14/2004	4:42		seafan in basket					
8/14/2004						5:02	HA2-6	28
8/14/2004	6:42		fish	B		6:33	HA2-7	29
8/14/2004	6:47		fish collected	B				
8/14/2004	7:18		fish collected	B				
8/14/2004	7:34		hermit crab collected					
8/14/2004	7:35		unknown invert					

Site ***Halo* (Visit II)**

Date	Time	Fix No.	Description [Note, Laser Distance is 5", not 4"]	B/A/T	Photo No.	Tape Start Time	Tape No.	Dive No.
8/14/2004	7:38		unknown invert collection			7:37	HA2-8	29
8/14/2004	7:45		fish collection					
8/14/2004	7:46		urchin collection					
8/14/2004	7:52		fish collected					
8/14/2004	7:57		unknown ? Collected					
8/14/2004	8:13		large trap removed-black					
8/14/2004	8:25		black large in basket					
8/14/2004	8:32		large white trap removed					
8/14/2004	8:35		large white trap in basket					
8/14/2004	8:48		basket off bottom			8:42	HA2-9	29

APPENDIX C

Sediment Core
Chemical Analysis Data

SRC Group: 2004-4541

SRC ANALYTICAL

422 Downey Road
Saskatoon, Saskatchewan S7N 4N1
(306) 933-6932 1-800-240-8808

Sep-21-2004

Date Samples Received: Sep-07-2004 Client P.O.:

SAMPLE	CLIENT DESCRIPTION
19050	8/1/2004 to 8/2/2004 VI A *SOLIDS*
19051	8/1/2004 to 8/2/2004 VI B *SOLIDS*
19052	8/1/2004 to 8/2/2004 VI C *SOLIDS*

ANALYTE	UNITS	19050	19051	19052
ORGANIC CHEMISTRY				
Benzene	ug/g	<0.01	<0.01	<0.01
Ethylbenzene	ug/g	<0.01	<0.01	<0.01
Toluene	ug/g	<0.01	<0.01	<0.01
Xylene	ug/g	<0.01	<0.01	<0.01
Hydrocarbons C06-C10, purge.	ug/g	<1	<1	<1
Hydrocarbons C11-C20, ext.	ug/g	<10	<10	<10
Hydrocarbons C21-C36, ext.	ug/g	<10	<10	<10
T. Petroleum Hydrocarbons	ug/g	<10	<10	<10

SAMPLE	CLIENT DESCRIPTION
19053	8/1/2004 to 8/2/2004 VI D *SOLIDS*
19054	8/3/2004 HA A *SOLIDS*
19055	8/3/2004 HA B *SOLIDS*

ANALYTE	UNITS	19053	19054	19055
ORGANIC CHEMISTRY				
Benzene	ug/g	<0.01	<0.01	<0.01
Ethylbenzene	ug/g	<0.01	<0.01	<0.01
Toluene	ug/g	<0.01	<0.01	<0.01
Xylene	ug/g	<0.01	<0.01	<0.01
Hydrocarbons C06-C10, purge.	ug/g	<1	<1	<1
Hydrocarbons C11-C20, ext.	ug/g	<10	<10	<10
Hydrocarbons C21-C36, ext.	ug/g	<10	<10	<10
T. Petroleum Hydrocarbons	ug/g	<10	<10	<10

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Sep-21-2004

SAMPLE	CLIENT DESCRIPTION
19056	8/3/2004 HA C *SOLIDS*
19057	8/3/2004 HA D *SOLIDS*
19058	8/9/2004 REL A *SOLIDS*

ANALYTE	UNITS	19056	19057	19058
ORGANIC CHEMISTRY				
Benzene	ug/g	<0.01	<0.01	<0.01
Ethylbenzene	ug/g	<0.01	<0.01	<0.01
Toluene	ug/g	<0.01	<0.01	<0.01
Xylene	ug/g	<0.01	<0.01	<0.01
Hydrocarbons C06-C10, purge.	ug/g	<1	<1	<1
Hydrocarbons C11-C20, ext.	ug/g	<10	<10	<10
Hydrocarbons C21-C36, ext.	ug/g	<10	<10	<10
T. Petroleum Hydrocarbons	ug/g	<10	<10	<10

SAMPLE	CLIENT DESCRIPTION
19059	8/9/2004 REL B *SOLIDS*
19060	8/9/2004 REL C *SOLIDS*
19061	8/9/2004 REL D *SOLIDS*

ANALYTE	UNITS	19059	19060	19061
ORGANIC CHEMISTRY				
Benzene	ug/g	<0.01	<0.01	<0.01
Ethylbenzene	ug/g	<0.01	<0.01	<0.01
Toluene	ug/g	<0.01	<0.01	<0.01
Xylene	ug/g	<0.01	<0.01	<0.01
Hydrocarbons C06-C10, purge.	ug/g	<1	<1	<1
Hydrocarbons C11-C20, ext.	ug/g	<10	<10	<10
Hydrocarbons C21-C36, ext.	ug/g	<10	<10	<10
T. Petroleum Hydrocarbons	ug/g	<10	<10	<10

SAMPLE	CLIENT DESCRIPTION
19062	8/9/2004 REL E *SOLIDS*
19063	8/5/2004 GULF PENN A *SOLIDS*
19064	8/5/2004 GULF PENN B *SOLIDS*

ANALYTE	UNITS	19062	19063	19064
ORGANIC CHEMISTRY				
Benzene	ug/g	<0.01	<0.01	<0.01
Ethylbenzene	ug/g	<0.01	<0.01	<0.01
Toluene	ug/g	<0.01	<0.01	<0.01
Xylene	ug/g	<0.01	<0.01	<0.01

SRC Group: 2004-4541

SRC ANALYTICAL

Sep-21-2004

SAMPLE	CLIENT DESCRIPTION
19062	8/9/2004 REL E *SOLIDS*
19063	8/5/2004 GULF PENN A *SOLIDS*
19064	8/5/2004 GULF PENN B *SOLIDS*

ANALYTE	UNITS	19062	19063	19064
Hydrocarbons C06-C10, purge.	ug/g	<1	<1	<1
Hydrocarbons C11-C20, ext.	ug/g	<10	<10	<10
Hydrocarbons C21-C36, ext.	ug/g	<10	<10	<10
T. Petroleum Hydrocarbons	ug/g	<10	<10	<10

SAMPLE	CLIENT DESCRIPTION
19065	8/5/2004 GULF PENN C *SOLIDS*
19066	8/5/2004 GULF PENN D *SOLIDS*
19067	8/6/2004 to 8/8/2004 U166 A *SOLIDS*

ANALYTE	UNITS	19065	19066	19067
ORGANIC CHEMISTRY				
Benzene	ug/g	<0.01	<0.01	<0.01
Ethylbenzene	ug/g	<0.01	<0.01	<0.01
Toluene	ug/g	<0.01	<0.01	<0.01
Xylene	ug/g	<0.01	<0.01	<0.01
Hydrocarbons C06-C10, purge.	ug/g	<1	<1	<1
Hydrocarbons C11-C20, ext.	ug/g	<10	<10	<10
Hydrocarbons C21-C36, ext.	ug/g	<10	<10	<10
T. Petroleum Hydrocarbons	ug/g	<10	<10	<10

SAMPLE	CLIENT DESCRIPTION
19068	8/6/2004 to 8/8/2004 U166 B *SOLIDS*
19069	8/6/2004 to 8/8/2004 U166 C *SOLIDS*
19070	8/6/2004 to 8/8/2004 U166 D *SOLIDS*

ANALYTE	UNITS	19068	19069	19070
ORGANIC CHEMISTRY				
Benzene	ug/g	<0.01	<0.01	<0.01
Ethylbenzene	ug/g	<0.01	<0.01	<0.01
Toluene	ug/g	<0.01	<0.01	<0.01
Xylene	ug/g	<0.01	<0.01	<0.01
Hydrocarbons C06-C10, purge.	ug/g	<1	<1	<1
Hydrocarbons C11-C20, ext.	ug/g	<10	<10	<10
Hydrocarbons C21-C36, ext.	ug/g	<10	<10	<10
T. Petroleum Hydrocarbons	ug/g	<10	<10	<10

SRC Group: 2004-4541

SRC ANALYTICAL

Sep-21-2004

SAMPLE		CLIENT DESCRIPTION	
19071	8/10/2004	ALCOA PURITAN A	*SOLIDS*
19072	8/10/2004	ALCOA PURITAN B	*SOLIDS*
19073	8/10/2004	ALCOA PURITAN C	*SOLIDS*

ANALYTE	UNITS	19071	19072	19073
ORGANIC CHEMISTRY				
Benzene	ug/g	<0.01	Not reported	<0.01
Ethylbenzene	ug/g	0.02	Not reported	<0.01
Toluene	ug/g	0.04	Not reported	<0.01
Xylene	ug/g	0.2	Not reported	<0.01
Hydrocarbons C06-C10, purge.	ug/g	7.7	Not reported	<1
Hydrocarbons C11-C20, ext.	ug/g	<10	Not reported	<10
Hydrocarbons C21-C36, ext.	ug/g	<10	Not reported	<10
T. Petroleum Hydrocarbons	ug/g	<10	Not reported	<10

Note for Sample # 19072

"Not Reported": No sample was received in the laboratory.

SAMPLE		CLIENT DESCRIPTION	
19074	8/10/2004	ALCOA PURITAN D	*SOLIDS*
19075	8/10/2004	ALCOA PURITAN E	*SOLIDS*

ANALYTE	UNITS	19074	19075
ORGANIC CHEMISTRY			
Benzene	ug/g	<0.01	<0.01
Ethylbenzene	ug/g	<0.01	<0.01
Toluene	ug/g	<0.01	<0.01
Xylene	ug/g	<0.01	<0.01
Hydrocarbons C06-C10, purge.	ug/g	<1	<1
Hydrocarbons C11-C20, ext.	ug/g	<10	<10
Hydrocarbons C21-C36, ext.	ug/g	<10	<10
T. Petroleum Hydrocarbons	ug/g	<10	<10

Results are reported on a dry basis.

Trace amount of Hydrocarbons (in C10-C14 carbon range) were detected in samples #19054, 19055, 19057 and 19075.Please see the GC/FID chromatograms. The concentrations are listed below:

#19054: 4.9ug/g

#19055: 5.3ug/g

SRC Group: 2004-4541

SRC ANALYTICAL

Sep-21-2004

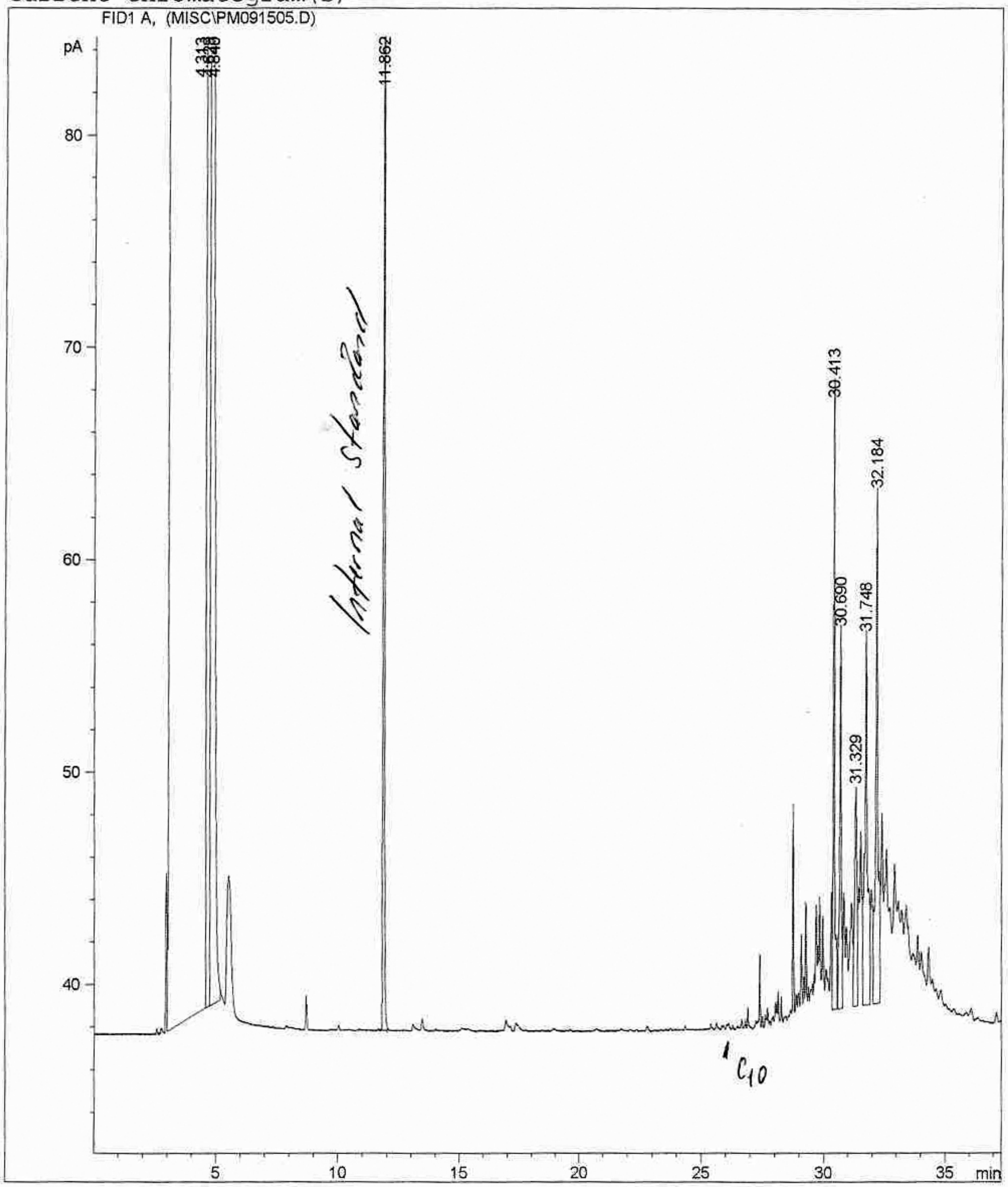
#19057: 14ug/g
#19075: 16ug/g

Hydrocarbons detected in sample #19071 are in Gasoline carbon range.

"<": not detected at level stated above

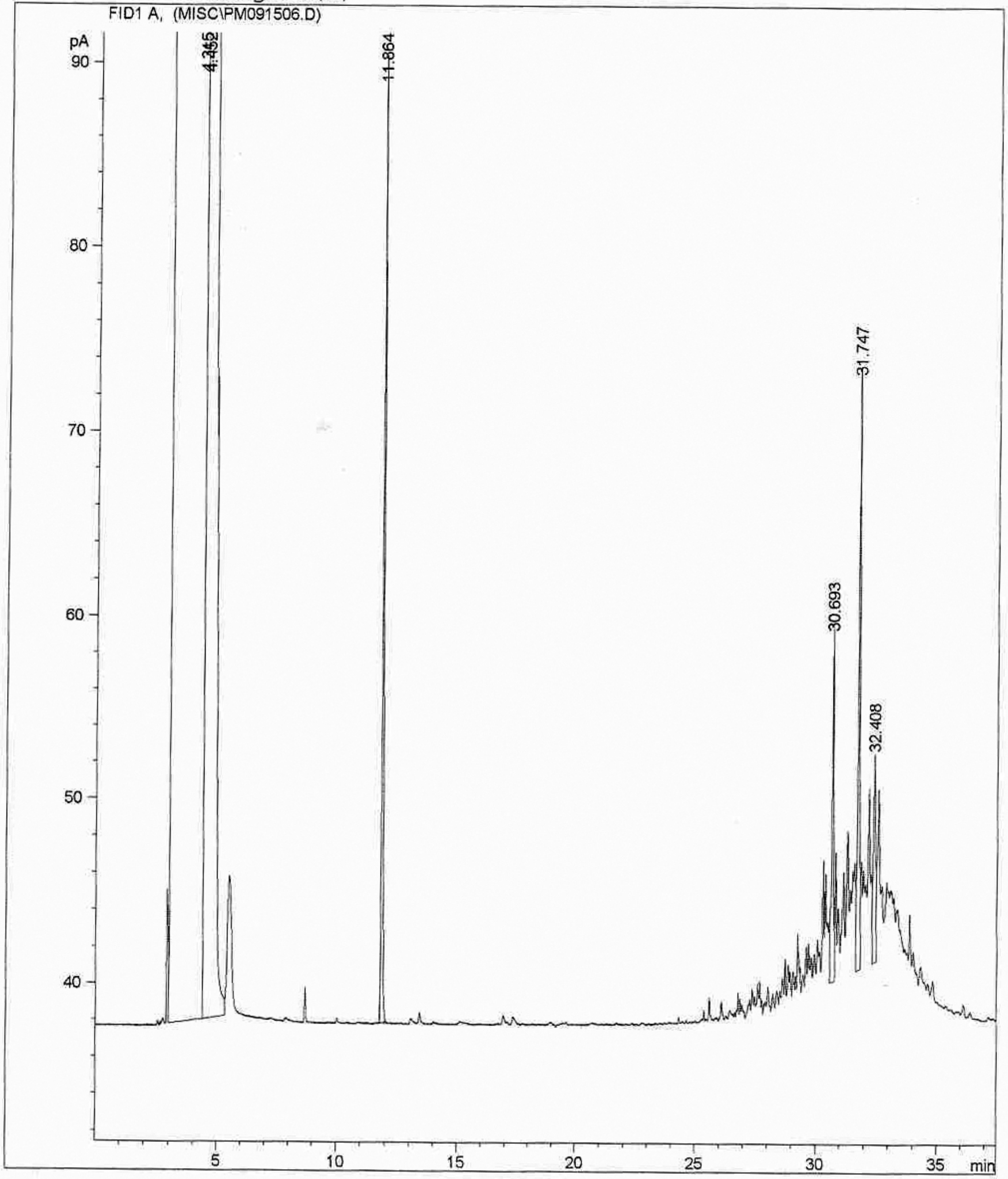
```
================================================================================
Injection Date  : 9/15/04 1:19:37 PM               Seq. Line :   5
Sample Name     : DB19054 (3mLs)                         Vial :   5
Acq. Operator   : Pat                                     Inj :   1
                                              Inj Volume : Manually
Acq. Method     : C:\HPCHEM\1\METHODS\CCME.M
Last changed    : 10/22/03 2:01:32 PM by cindy
Analysis Method : C:\HPCHEM\1\METHODS\STBY6890.M
Last changed    : 8/23/04 7:55:16 AM by Pat
Shutdown 6890
```

Current Chromatogram(s)



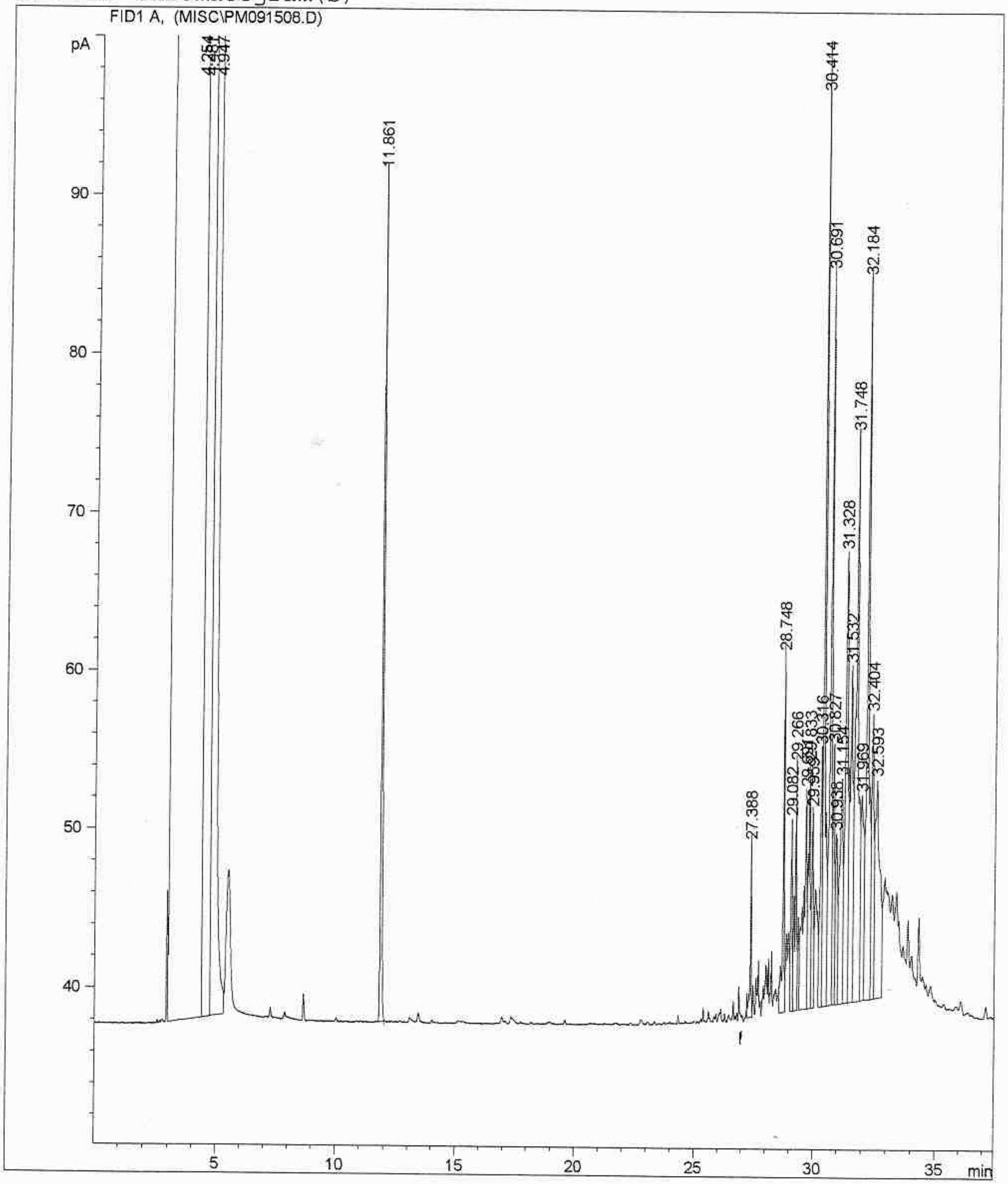
```
================================================================================
Injection Date   : 9/15/04 2:09:28 PM                  Seq. Line :    6
Sample Name      : DB19055 (3mLs)                           Vial :    6
Acq. Operator    : Pat                                       Inj :    1
                                                   Inj Volume : Manually
Acq. Method      : C:\HPCHEM\1\METHODS\CCME.M
Last changed     : 10/22/03 2:01:32 PM by cindy
Analysis Method  : C:\HPCHEM\1\METHODS\STBY6890.M
Last changed     : 8/23/04 7:55:16 AM by Pat
Shutdown 6890
```

Current Chromatogram(s)



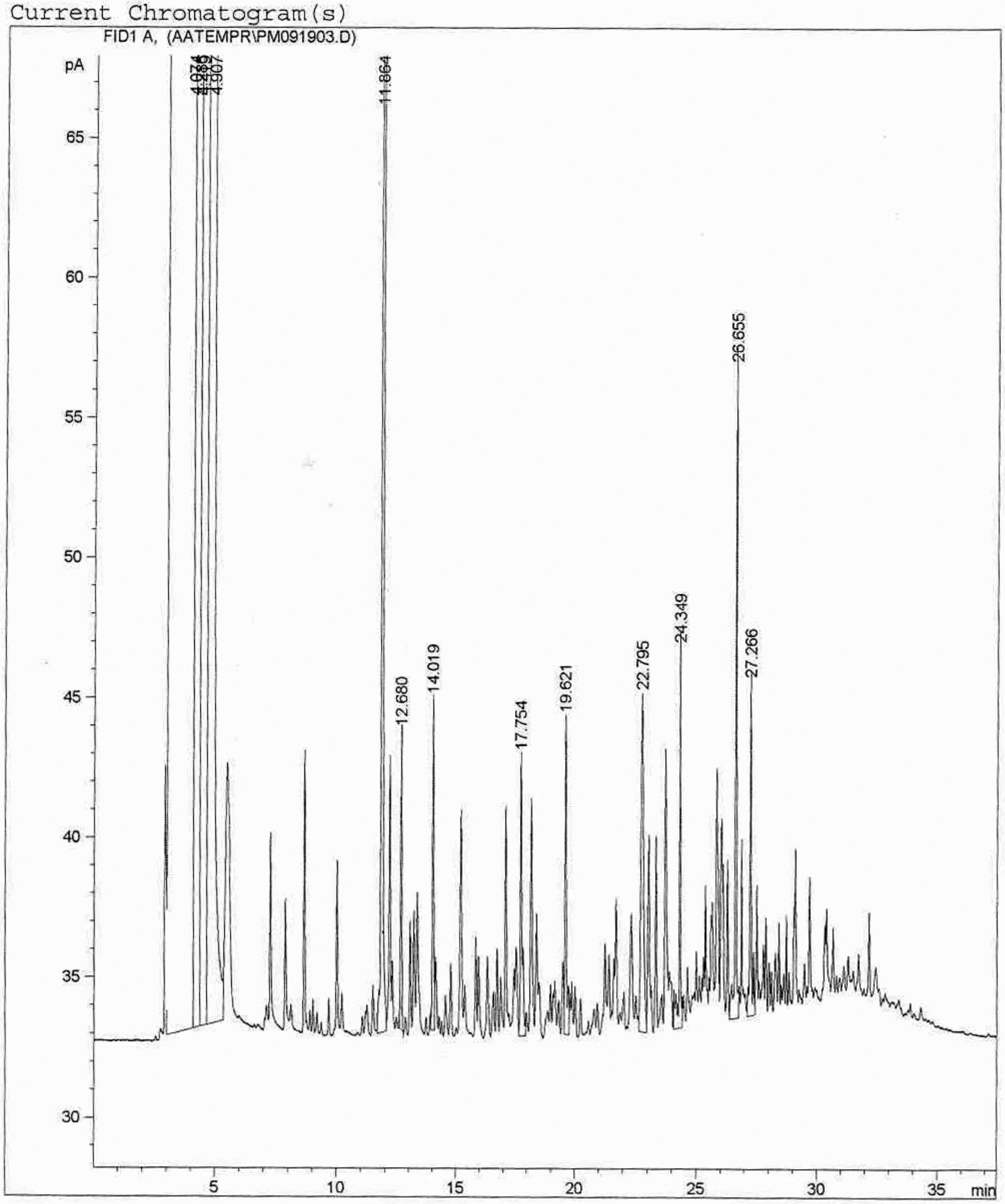
```
==============================================================================
Injection Date  : 9/15/04 3:49:45 PM                 Seq. Line :    8
Sample Name     : DB19057 (3mLs)                          Vial :    8
Acq. Operator   : Pat                                      Inj :    1
                                                    Inj Volume : Manually
Acq. Method     : C:\HPCHEM\1\METHODS\CCME.M
Last changed    : 10/22/03 2:01:32 PM by cindy
Analysis Method : C:\HPCHEM\1\METHODS\STBY6890.M
Last changed    : 8/23/04 7:55:16 AM by Pat
Shutdown 6890
```

Current Chromatogram(s)



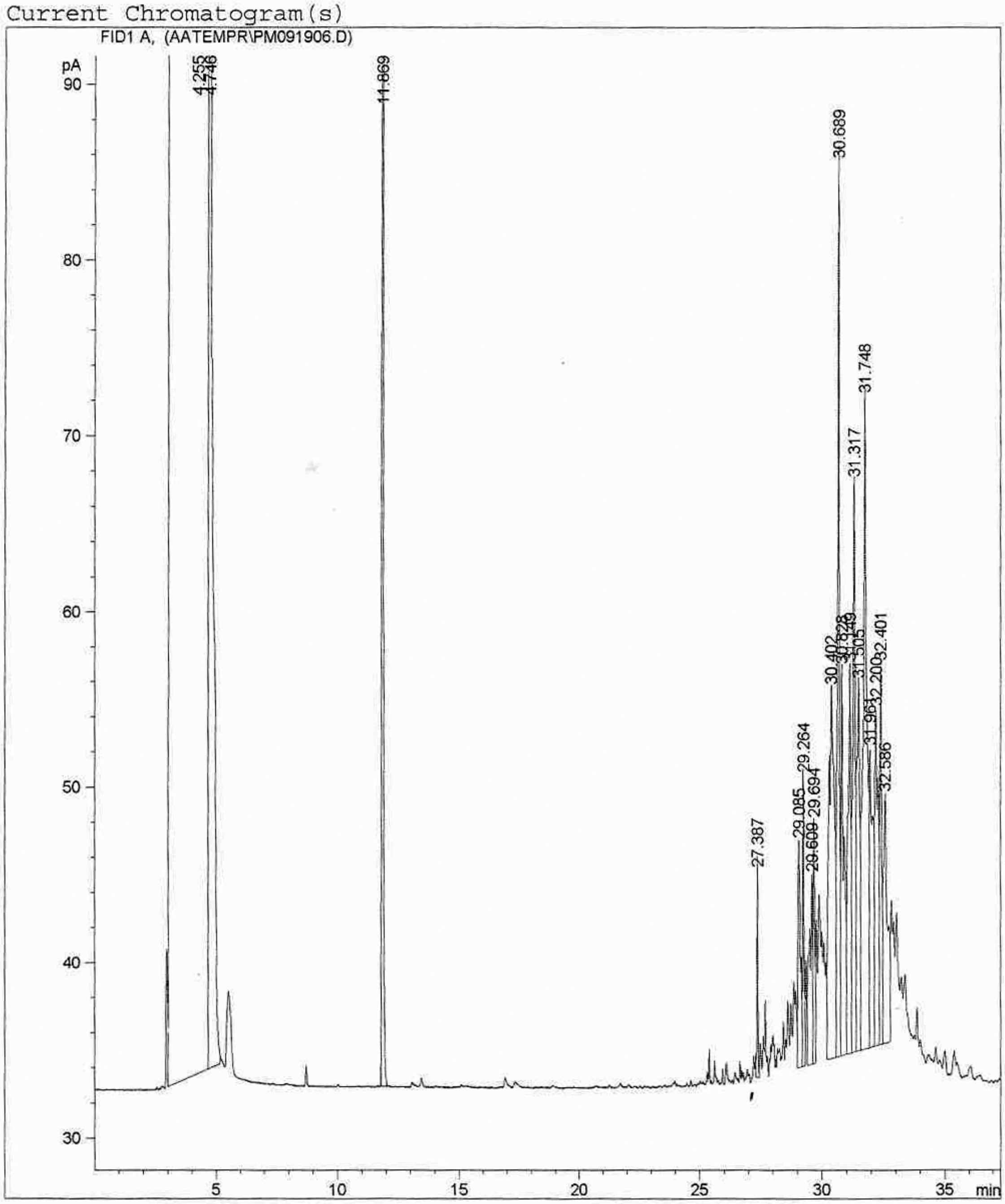
```
==================================================================
Injection Date  : 9/19/04 7:27:17 PM              Seq. Line :   3
Sample Name     : DB19071 (3mLs)                       Vial :   3
Acq. Operator   : Pat                                   Inj :   1
                                                Inj Volume : Manually
Acq. Method     : C:\HPCHEM\1\METHODS\CCME.M
Last changed    : 10/22/03 2:01:32 PM by cindy
Analysis Method : C:\HPCHEM\1\METHODS\STBY6890.M
Last changed    : 8/23/04 7:55:16 AM by Pat
Shutdown 6890
```

Current Chromatogram(s)



```
==========================================================================
Injection Date  : 9/19/04 9:52:10 PM               Seq. Line :    6
Sample Name     : DB19075 (3mLs)                        Vial :    6
Acq. Operator   : Pat                                    Inj :    1
                                                  Inj Volume : Manually
Acq. Method     : C:\HPCHEM\1\METHODS\CCME.M
Last changed    : 10/22/03 2:01:32 PM by cindy
Analysis Method : C:\HPCHEM\1\METHODS\STBY6890.M
Last changed    : 8/23/04 7:55:16 AM by Pat
Shutdown 6890
```

Current Chromatogram(s)



The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.