

# NIUST AUV's study Shipwrecks in the Northern Gulf of Mexico

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**Abstract** - In October 2009 two autonomous underwater vehicles (AUV's), the explorer class Eagle Ray and the seabed class Mola Mola, were launched from the NOAA ship Nancy Foster to locate and retrieve information about sunken ships of historic interest, some of which had disappeared below the water surface of the northern Gulf of Mexico, almost 200 years ago. In a collaboration between the National Institute for Undersea Science and Technology (NIUST,) the US Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) and the US NOAA Office of Ocean Exploration and Research (OER), targets identified in side scan sonar images, were selected and investigated by the AUVs. Eagle Ray, due to its large size and design features, performed initial multibeam surveys of the target areas, producing high-resolution maps of the seafloor. These maps were used to determine safe working areas for the Mola Mola, which was subsequently launched to take a continuous series of photographs in close proximity to the seafloor, producing a photo-mosaic map of the target area. Operational procedures and results from these dives will be presented, showing the complementing features of these two very different AUVs in operation.

## I. INTRODUCTION

The use of autonomous underwater vehicles (AUVs) in the oceanographic research over the last decades has become more widely spread, ranging from gliders to fully maneuverable vehicles with advanced control mechanisms. These AUVs are platforms for advanced research, and development of new technologies is in association with these vehicles is cutting edge science and engineering. The National Institute for Undersea Science and Technology (NIUST), established in 2002 by the University of Southern Mississippi and the University of Mississippi in partnership with NOAA's Undersea Research Program (NURP), is made up of three divisions: the Ocean Biotechnology Center & Repository (OBCR), the Seabed Technology Research Center (STRC), and the Undersea Vehicles Technology Center (UVTC). These three divisions broadly encompass the fields of biotechnology (e.g., biomedical and agrochemical products) and engineered technologies (e.g., instrumentation development) in the marine environment.

NIUST's mission is to provide cutting edge technologies to NURP and their constituencies to further the nation's research capabilities in near shore, deep water, and extreme marine environments. Program objectives are focused on exploration, research, and advanced technology development. The explorer class Eagle Ray and the seabed class Mola Mola, NIUST's two AUVs [2,3], were launched from the NOAA ship Nancy Foster in October 2009, to locate and retrieve information about sunken ships of historic interest, some of which may have disappeared below the water surface of the northern Gulf of Mexico, almost 200 years ago. In collaboration between the National Institute

for Undersea Science and Technology (NIUST,) the US Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) and NOAA's Office of Ocean Exploration and Research (OER), targets identified in side scan sonar images, were selected and investigated by the AUVs.

## II. THE EAGLE RAY AUV

### a. Physical Description

The Eagle Ray AUV (Fig. 1) is a torpedo shaped, 5.1 m long, 0.69 m in diameter, which weighs 882 kg in air. The Aluminum pressure hull is rated to 2200 m depth comprising approximately half of the vehicle length. The extended bullet nose and tapered tail of the vehicle are fiberglass components designed to minimize hydrodynamic drag. These sections are flooded and used for payload instrumentation and mechanical systems. The forward flooded hull section houses a bottom avoidance sonar, a pop-off buoy and recovery line, depth sensor, inertial guidance system, Doppler velocity log, acoustic modem, multi-beam sonar receiver, and conductivity-temperature-depth (CTD) instrument [1]. Despite the number of components packed into this section, space and two bulkhead connectors are reserved for modular payloads required for special missions. The aft flooded hull section houses the thruster motor, cabling to the control surfaces, connections to the communications and positioning antennae in the mast and an emergency drop weight system. Lead ballast is located in both fore and aft hull sections. The multibeam sonar transmitter is surface mounted beneath the center hull section, the receiver is solidly attached to the Inertial Navigation System (INS)



Figure 1: Eagle Ray AUV.

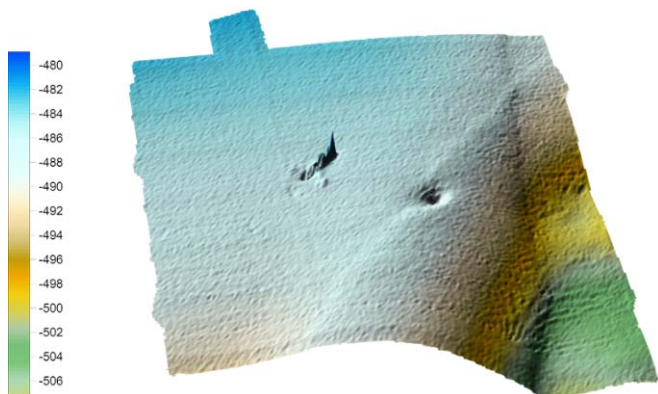
Propulsion is provided through a two-bladed aluminum propeller, driven through a 3:1 reduction gearbox. Vehicle attitude is controlled through the integrated action of six control planes, two forward and four aft. Maximum forward speed is  $2.5 \text{ ms}^{-1}$ ; normal survey speed is  $1.75 \text{ ms}^{-1}$ . Within the main pressure hull are located 18 lithium-ion rechargeable battery modules, the vehicle control computer and interfaces, the multibeam sonar computer, and various power and logic control devices. Space is left in this section to accommodate internal payload components as well. Vehicle telemetry and real-time pilot control communications utilize hardwired or radio Ethernet while on the surface. Underwater, communication can be maintained through proprietary acoustic channels if necessary. Vehicle control and feedback are naturally much more restricted when using the acoustic modem.

#### b. Dive Operations

Each dive of the Eagle Ray AUV begins with a conceptual layout of the dive path, using whatever bathymetric charts or other data are available. This concept is transposed into an electronic chart using the FleetManager program from ACSA (Meyreuil, France). FleetManager facilitates the layout of routine surveys using a basic “lawnmower pattern” defined within user selected boundaries, line spacing, run-in distances, turning rates, etc. This “lawnmower” pattern can be easily modified to fit the necessary boundaries of the target. The output of FleetManager is a text file containing all of the requisite waypoints in a format compatible with the AUV. This file is then manually inserted into a preexisting *mission template* developed by the operations team which contains standard initialization and mission completion actions. In addition to providing a uniform structure to all missions, this method assures that certain standard operating procedures and emergency maneuvers, procedures, and entry points are included in the final mission file.

During underwater operations FleetManager provides simultaneous display of:

- Position, speed, and heading of the surface vessel,
- AUV position based on acoustic telemetry from the AUV’s inertial navigation system



**Figure 2: Multibeam map acquired with Eagle Ray AUV at 30m above the seafloor, showing a wreck, a pock mark and two fault lines.**

- AUV position from USBL tracking
- Predicted AUV position from simulator software.
- Estimated position of the target on the sea floor.

During ER dive operations, the FleetManager display is repeated on the ship’s bridge and the ship’s position relative to the AUV is monitored by the AUV pilot and maneuvering requests are radioed to the bridge.

### III. THE MOLA MOLA AUV

#### a. Physical Description

In late May 2009 NIUST took delivery of the Mola Mola (Fig. 2), a SeaBED class AUV. The Mola Mola is capable of working off of small coastal vessels or other ships of opportunity. The 200 kg AUV is constructed of an upper and lower hull connected by vertical struts. Each hull is composed of individual pressure housings attached to an aluminum frame, which is then encased by a plastic cover. Positive buoyancy is achieved by syntactic foam pieces integrated into the vehicle. The vehicle was modified from its original configuration [4], and now has three main pressure housings, one for batteries, one for the Inertial Navigation System (INS), and another that contains the control computer and electronics. The batteries, the INS including the Doppler Velocity Log (DVL), digital still camera and the payload sensors are located in the bottom hull, while the top hull contains the electronics housing, antennae for communication and location and syntactic foam. This layout places most of the buoyancy in the upper hull, and most of the weight in the lower hull for pitch and roll stability. Wet cabling routed through the vertical struts provides power and communication within the vehicle. Final buoyancy adjustments of the vehicle are achieved by placing small lead weights and syntactic foam pieces into the vehicle to properly ballast and adjust its attitude while submerged.

#### b. Dive Operations

Mola Mola is designed to precisely navigate survey tracks at altitudes as low as 2.5 m above the sea floor. During normal operations, these survey tracks are planned based on the target and objective of the mission. Line spacing at a flight altitude of 3 m above the bottom is designed to allow adequate overlap of the images to produce large high resolution mosaics after the completion of the dive.

On launch, the vehicle



**Figure 3: Mola Mola AUV in its original configuration.**

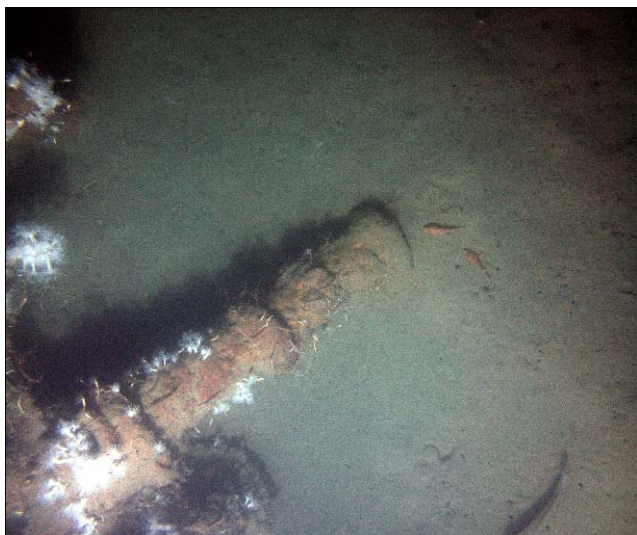
propels itself vertically downward until its navigation system locks onto the seabed at 30-m altitude and it can begin its programmed survey. Thrusters oriented in two different planes allow the AUV to maintain course and altitude while avoiding obstacles. Mola Mola can currently acquire digital color photographs and high-resolution swath topography data. In its present configuration, the AUV can remain submerged for as long as 8 hours and acquire 1,200 photographs per hour, with varying degrees of overlap as determined by the vehicle speed ( $0.125\text{-}1\text{ ms}^{-1}$ ). Images obtained can be post-processed into larger, color corrected mosaics revealing stunning views of the sea floor.

#### IV. WRECK SURVEYS

NOAA's Office of Ocean Exploration and Research collaborating with the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE formerly MMS) identified a number of potential shipwrecks in side scan sonar data acquired from energy company surveys. A few targets were selected for detailed investigation by the two AUVs. Ultimately, these shipwrecks were identified as vessels from the 19<sup>th</sup> and 20<sup>th</sup> Centuries.

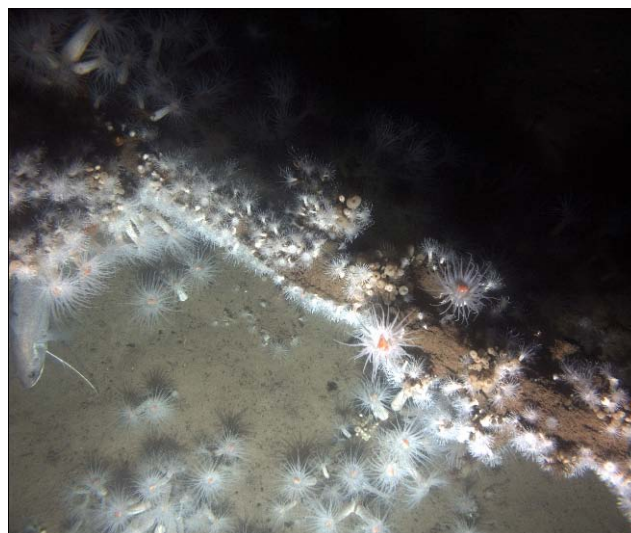
Eagle Ray's large size and design features, dictate a conservative operation procedure to investigate sunken shipwrecks. The AUV performs initial multibeam surveys of the target area between 30 and 50m above the bottom. Results are high-resolution bathymetric maps of the seafloor, showing potential shipwrecks and any other features on the seafloor which happen to be in the swath of the multibeam sonar on the AUV's flight path.

Upon receiving the mission goal to investigate a certain sunken ship wreck, Eagle Ray, due to its large size and design features, performs initial multibeam surveys of the target area. Initial



**Figure 4: Digital image of wooden hull wreck section, acquired with Mola Mola AUV, showing metal artifact, likely part of a windlass, with sea anemones. Image area is approximately 2.6m x 3.2m.**

dives of ER between 30 and 50m above the bottom, will produce high-resolution bathymetric maps of the seafloor, a potential shipwreck and any other features on the seafloor which happen to be in the swath of the multibeam sonar on the AUV's flight path (Fig. 3). After the first dive at 50 m above bottom, resulting in



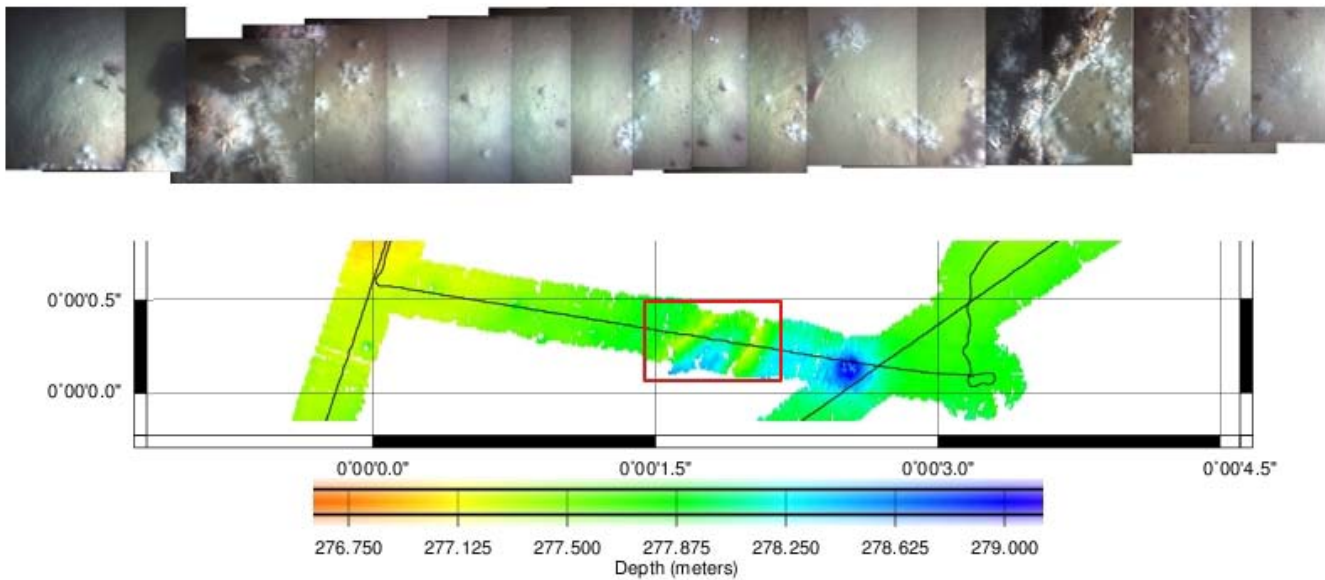
**Figure 5: Digital image of wooden hull wreck section, acquired with Mola Mola AUV, showing hull planking with sea anemones. Image area is approximately 2.6m x 3.2m.**

swath width of approximately 175m, the AUV comes to the surface and the multibeam data are being downloaded via Radio modem and an on-the-fly analysis of the individual swath lines is performed to establish the exact location of the wreck and to get a first glimpse on the type of vessel and the relief of the wreck above the seafloor. Once the target location has been established and the initial survey does not show any large objects protruding into the water column, ER is sent on a second mission, which in normal cases is flown at 30m above the bottom in a much smaller area right above the wreck to achieve an even higher pixel resolution multi beam map which serves as a guide as to whether Mola Mola can or cannot dive on that wreck due too much of a relief or other hazardous objects protruding from the wreck which would compromise the AUV's safety and return to the surface.

The Mola Mola, a much smaller and slower flying vehicle, is subsequently launched to take a continuous series of color photographs (Figs. 4 and 5) in close proximity to the seafloor along a pre-programmed path. The acquired images are geo-referenced and, using the attitude information from the AUV's Inertial Navigation System, and height of the camera above bottom, can be imported into a GIS package to produce high resolution color photo-mosaic maps of the target area (Fig. 6).

#### V. CONCLUSION

The Eagle Ray and Mola Mola represent two very different AUV designs. The features of these designs allow for an easy selection of the proper vehicle for a given task, and the availability of both at the same time will provide great versatility



**Figure 6: Wreck survey data from Moa Mola AUV, showing digital image mosaic and Multibeam bathymetry along the flight path of the AUV.**

in survey abilities. The vehicles proved to be great tools to investigate targets on the seafloor formerly only seen in side scan imagery. Both AUV's provided a significant part in the safe and non intrusive investigation of ship wrecks on the seafloor. The use of both AUV's in a team effort, provided not only a wealth of new information about the targets on the seafloor, but also supported the decision making process during the immediate dive planning and operations. Safe operations and an equal number of launches and recoveries of the AUV's are always the final goal for the teams operations.

#### ACKNOWLEDGMENT

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