ASI Marine | SUMMARY REPORT

Submitted to:

Great Lakes Observing Station
4840 S State Road
Ann Arbor, MI 48108

Reference:

Acquisition of Underwater LiDAR Data Sample

Inspections Completed:
16-18 November 2020

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Table of Contents

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REPORT

Great Lakes Observing System

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1.0 INTRODUCTION

ASI Marine, a division of ASI Group Ltd. (ASI) was contracted by Great Lakes Observing System (GLOS) to acquire high resolution bathymetric data using an underwater laser scanner provided by 2G Robotics (2G) of Waterloo, Ontario, Canada.

GLOS intends to enhance their database of the Great Lakes with examples of high-density point cloud data for specific features of interest. Traditional multibeam sonar systems are used for larger area surveys whereas the 2G ULS-500 underwater laser is used to collect very high density point cloud data for localised items of interest such as shipwrecks, oilfield and marine structures.

ASI supported this goal by providing a remotely operated vehicle (ROV) with an inertial navigation system, a boat suitable for operations, technicians to operate the equipment and to collect and process the data.

The raw and processed data has been provided to GLOS for public distribution.

2.0 EQUIPMENT

2.1 Laser System

2G Robotics made a version of their ULS-500 available for this project (Figure 1). The unit is a large assembly consisting of a blue laser line projector and a receiving Dalsa HD ethernet camera angled to track the line. In addition, the model provided had a second camera and a LED lighting array for bottom imagery.

Figure 1: ULS-500 Micro Laser Scanner from 2G

The laser scanner has a swath of approximately 50 degrees and requires movment to scan along track. The data is streamed in a XYZ LAS format for collection and logging using a third party application. When combined with position, heading and attitude, a 3D point cloud is generated (Figure 2).

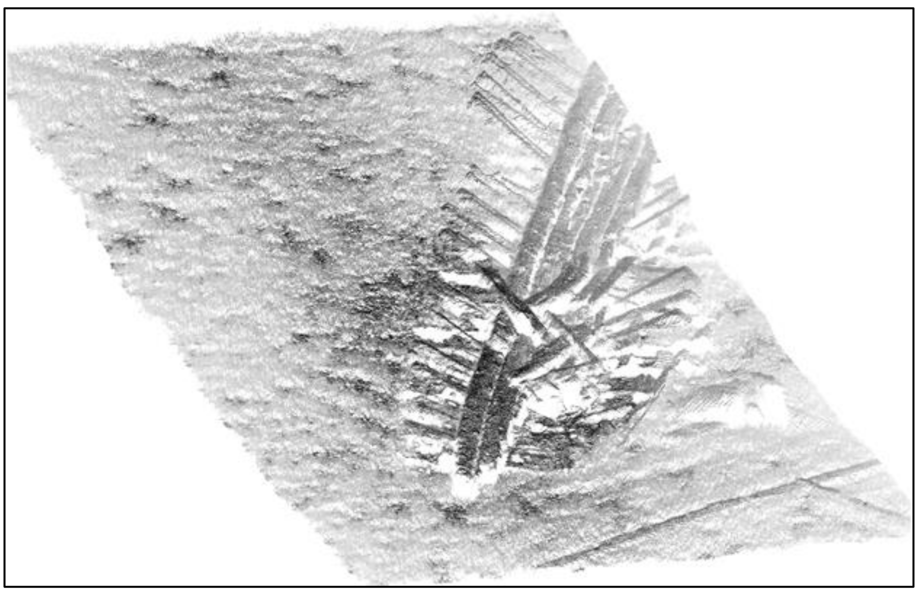

Figure 2: Example 3D shipwreck dataset provided by 2G

2.2 Inertial Navigation

To associate the points acquired by the laser system with position, ASI has added a Greensea Systems Inertial Navigation System, or INS (Figure 3) on the ROV. This system integrates a DVL (Doppler Velocity Log), IMU (Inertial Measurement Unit) a pressure and heading sensor. The INS measures the movement and orientation of the ROV independent of any external references.

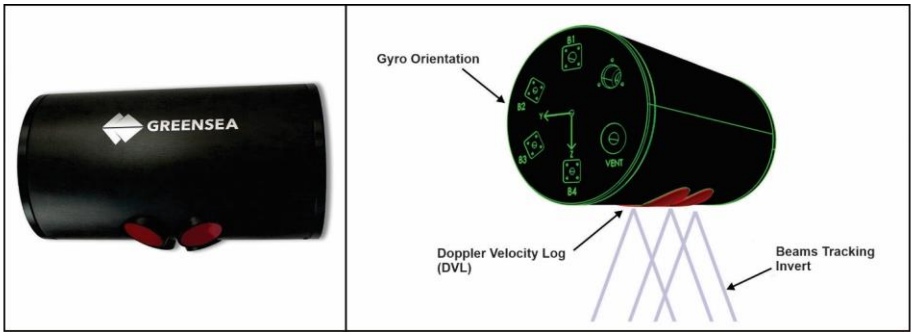

Figure 3: Greensea Systems Inertial Navigation System (INS)

Using a known location for the launch and recovery of the vehicle, an INS applies changes in movement in a cumulative manner to continuously calculate where the vehicle is. Since this is a cumulative process, small errors will add up and some post-processing is needed to adjust and correct the final plot of the vehicle. Having known features or landmarks helps to adjust and correct that data and improve its accuracy. The benefit of this device is that the true location of the vehicle is determined in real-time. Data from distance measurement sensors (sonar or laser) can be correlated so that all data is geo-referenced in X/Y/Z, be it latitude/longitude/elevation, UTM or the client's own unique system.

2.3 Seaeye Falcon DR

ASI chose the Seaeye Falcon DR ROV to conduct this inspection based on its capabilities and size. The ROV uses five electric thrusters to propel itself through the water; four horizontal vectored thrusters for forward, reverse, and lateral travel, with one vertical thruster to move the ROV vertically through the water column. The vehicle was equipped with two variable intensity 2520 lumen LED lights to illuminate the area of inspection for the high-resolution colour video camera.

Figure 4: Seaeye Falcon DR ROV (left) and underside equipped with ULS-500 and INS (right)

The system utilized a neutrally buoyant, highly visible umbilical 300 m (990 ft) in length. The umbilical housed both signal and power conductors (fiber optic and copper respectively), along with a Kevlar strength member in a protective jacket. The umbilical was neutrally buoyant in fresh water to reduce the drag and allow for enhanced vehicle handling. The ROV pilot controlled the vehicle's movement, lighting, camera position and tooling from the surface by the use of a hand-held control console.

The video signal was routed to the surface digitally through the fiber optic cable in the umbilical. The fiber optic signal was converted in the system console to an analogue video signal which was then fed into a high-resolution monitor for the pilot to view. The video signal was also recorded in real-time onto a digital video recorder (DVR) in digital format. The fibre conductors were also used to interface with the ULS-500 for control and data relay to the topside computer.

After integrating the laser unit and INS, the vehicle was ballasted to be neutrally buoyant in fresh water.

2.4 Multi-beam Imaging Sonar

A two-dimensional (2D) imaging sonar was integrated onto the tilt tray of the ROV. This type of sonar and mounting configuration provides real-time plan view information directly ahead of the ROV, making it a highly effective navigation and obstacle-avoidance tool. The sonar also provides valuable feature detection capabilities for inspection.

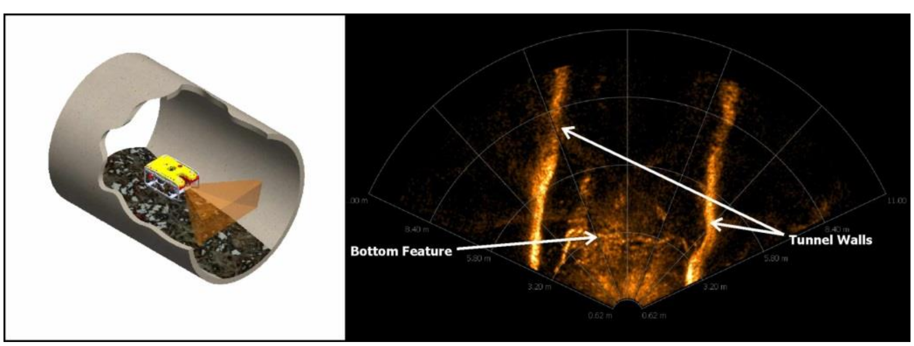

Figure 5: 2D multi-beam imaging sonar on ROV (representative image only)

2.5 Vessel

ASI used its dedicated survey vessel, the ASI Echocat, to complete all the survey field work (Figure 6). The Echocat is a custom-built Armstrong Marine aluminum catamaran survey vessel. The vessel is 7.9 m long, powered with twin Yamaha 150HP outboard engines, and equipped with a fully enclosed, climate-controlled cabin.

Figure 6: ASI Echocat survey vessel

2.6 Vessel Positioning

Positioning for the sensor suite aboard the survey vessel was provided by a Global Navigation Satellite System (GNSS) receiver coupled to an Inertial Motion Unit (gyroscope), providing an inertially-aided positioning source to operate in areas with poor satellite constellation coverage.

For this survey, the GNSS system operated in Real-time Kinematic (RTK) mode, utilizing the Michigan RTN network corrections service. Corrections from the base station support real-time positioning to typical accuracies of 1 cm. All raw data is recorded by the vessel-mounted inertial/GNSS system and can be post-processed to improve accuracies at a later date.

Beyond providing positioning, the system also provided heading and attitude information for the vessel. The combination of dual-antennae can compute heading by utilizing the GNSS signals, and the tactical grade gyroscope also provides heading. A solution of the gyroscopic and accelerometer measurements contributes the pitch and roll information for the vessel at a high rate in real time.

2.7 Multi-beam Echosounder

For bathymetric data collection, ASI utilized the R2Sonic 2024 Multi-beam Echosounder (MBES) system (Figure 7), which is a survey-grade system for bathymetric mapping. This system is characterized by high mapping productivity in combination with exceptionally high-sounding accuracy and a dense pattern of soundings to cover the seafloor, which reveals all details on the bottom.

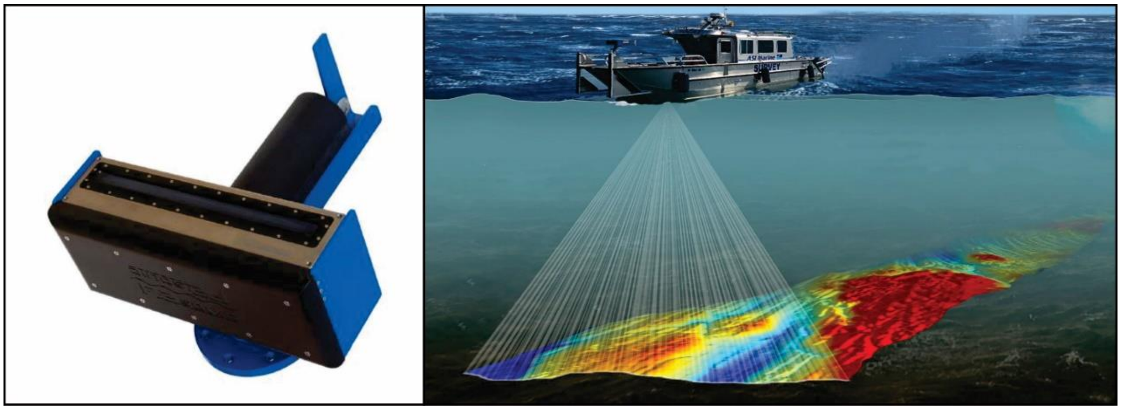

Figure 7: R2Sonic 2024 Multi-beam Sonar (left), depicting beam swath from vessel (right)

The system allows swaths to be surveyed with a single pass of the survey vessel. Since there are multiple beams pointed downward in a swath across the survey's track, three-dimensional (3D) bathymetric data is collected below the vessel and out to each side. Survey line spacing is selected to ensure the data coverage overlaps by half with the adjacent survey line, resulting in 200% coverage; this verifies all soundings.

By using this standard method of acquiring high resolution bathymetric data, the product from the ULS-500 could be compared with the more conventional techniques.

3.0 SURVEY PROCESS

3.1 Shop Preparation and Mobilization

Prior to each inspection, ASI personnel assembled the equipment packages and ancillary tools at ASI's shop. The 2G laser along with sonars and inspection equipment were integrated onto the ROV in a dry bench shop setting and all systems were function tested. After passing dry tests, the ROV was wet tested in ASI's test tank to ensure all components of the package functioned appropriately. Upon confirmation, the ROV was trimmed to be neutrally buoyant in fresh water. The equipment was loaded into ASI's truck for transport to site.

Four ASI personnel were assigned to field operations. One boat operator, one ROV pilot, one tender and one person for data collection. Personnel arrived at the docks of LaSalle Marina on November 16, 2020 to launch the vessel in the Detroit River.

3.2 Site Operations

The vessel left the docks at 08:25 to locate the "fish haven" feature of interest to collect multi-beam data to pinpoint a target to further investigate with the ROV and laser. After collecting 3D multi-beam of the area, the vessel travelled to McKee Marina to setup and launch the ROV.

The ROV and laser were tested at the marina prior to travelling back out into the Detroit River. The flows in the river were too strong to maintain control of the ROV and it immediately was swept downstream. The vessel returned to McKee Marina to recover the ROV and discuss options. At the same location, tests were conducted with the laser and the river turbidity was found to be too high to allow for data collection. An initial water sample was collected. The decision was made to travel south the following day into Lake Erie to find a location with less flow and high visibility.

ASI personnel departed at 07:00 on November 17, 2020 and stopped at Amherstville to view conditions. The yacht club with a boat launch was closed. Personnel then travelled to Colchester Harbour where conditions were rough and visibility was poor. Personnel travelled further east along the Lake Erie shoreline to Cedar Island Beach. Conditions were calm and the decision was made to launch the vessel and attempt to locate features with the multi-beam imaging sonar.

A water sample was collected once in open water and was found to be more opaque that that of the one taken in the Detroit River. No features of interest were noted on the 3D multi-beam and the vessel was recovered once again. Upon discussion with ASI project managers, the crew travelled to Sarnia, ON to attempt to locate features within the St. Clair River.

The crew arrived at the boat launch in Sarnia at 14:30 to launch the vessel. Various targets were located in the harbour and within the St. Clair River using the charts and 3D multi-beam. The vessel returned to the harbour at sunset for recovery.

The vessel was launched at 07:15 on November 18, 2020. The ROV and laser were tested at the docks prior to leaving. Visibility was much better than in the Detroit River and Lake Erie. Initial tests in the harbour were unsuccessful due to the amount of light penetrating the water.

Figure 8: Launching the Falcon ROV with the ULS off the side of the vessel.

Flows in the river were too strong to operate the ROV for data. The crew travelled out onto Lake Huron where targets were identified using navigation charts. Initially, the crew located a large intake crib off the shore of Lexington, MI. The ROV and laser were not launched at this location due to it being an active intake.

A second target was located that appeared to be a large cargo shipwreck. The City of Genoa was a grain freighter that sunk in 1911. The basic structure of the wreck remains on the bed of Lake Huron and is heavily deteriorated. The ROV was launched at the site and successfully collected laser data of the wreck. Ambient light in the water limited the usable range of the laser, so passes were collected over only a portion of the wreck.

The ASI crew returned to the dock to recover the vessel, finally demobilizing to the ASI shop in Stoney Creek, ON.

3.3 Reporting

A review of the data collected during the inspections was completed in the ASI office. The 3D files were converted to point clouds and erroneous noise was removed. The LiDAR files were adjusted in position to best fit the sonar data that was collected of the wreck. The assembly of this report was then completed. The report includes documentation methodology, equipment descriptions, observations, observation images, and 3D dataset.

Data files are provided of the various areas survey by MBES in meters located in UTM zone 17 as collected and in elevation referenced to NAVD88 and adjusted using Geoid 2018-CONUS. The laser data is provided in LAS format as collected as well as in cleaned XYZ files that have been best-fit positioned to match the MBES data.

4.0 INSPECTION OBSERVATIONS

Four areas of multi-beam data were collected in preparation for the laser scanner collection. These different locations are identified with the final area having some success in laser data collection.

4.1 Fish Haven

This first area investigated was the fish haven area of interest initially requested by GLOS. This location was in the full flow of the Detroit River along the west embankment. The vessel-mounted MBES was utilized to locate the area and provide some mapping coverage.

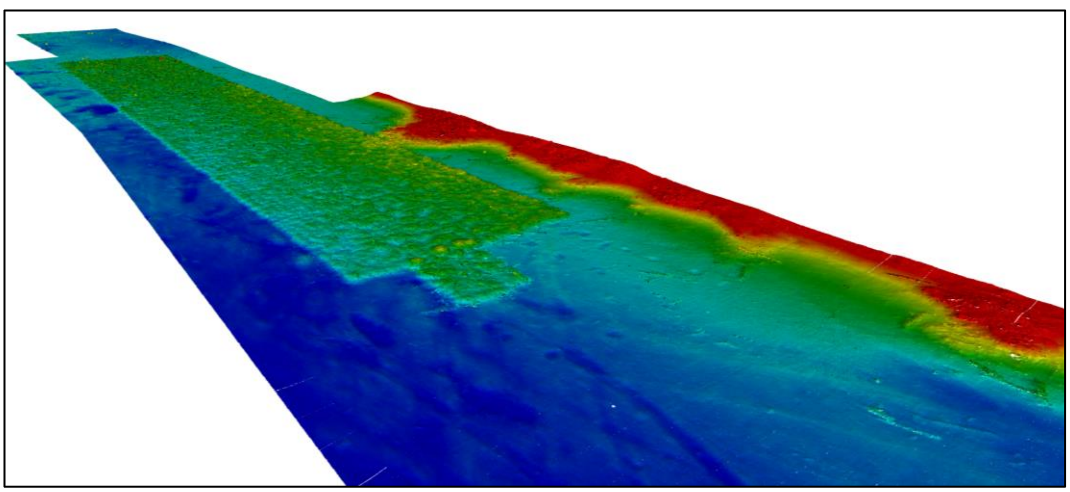

Figure 9: Fish Haven MBES survey area viewed looking downstream

The region was mapped in several passes focusing on collection of the entirety of the rock covered bottom which sits above the riverbed in elevation with a rectangular shape.

The area surveyed by MBES was 800 m long and 100 m wide. Water level was 174.5 m with an average bottom elevation at 162.5 m. Centre of survey area 327279 m E, 4684637 m N in UTM zone 17N.

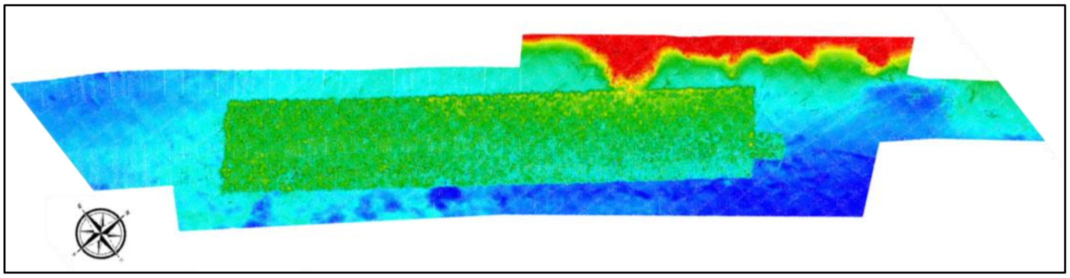

Figure 10: Plan view of Fish Haven survey area

The ROV was launched in the river near this area of interest, but flows would not allow the ROV to descend to the riverbed while holding position with the vessel. Visibility was also too low for use of the laser scanner.

4.2 Sarnia Harbour

In an effort to locate features that could be scanned by the laser, surveys were completed in the Sarnia harbour where flows are very low and visibility was good. Some known targets were identified on the navigation charts, and these were investigated by utilizing the MBES on the vessel. A large area was surveyed, but findings were narrowed to areas with good targets.

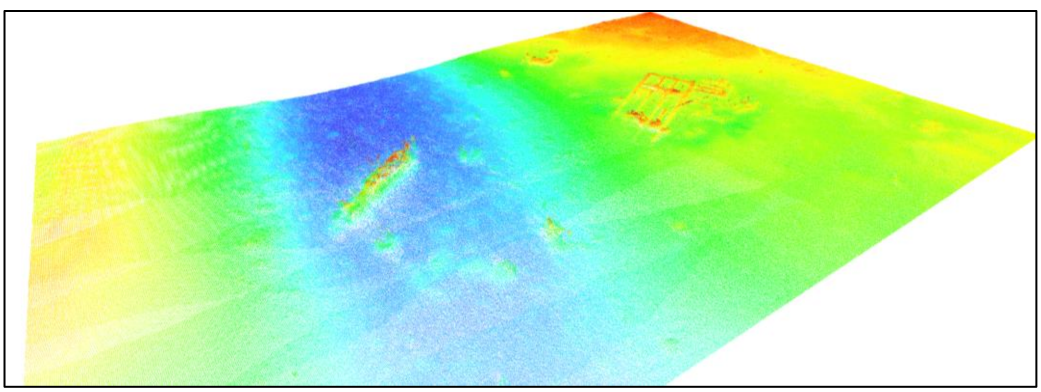

Figure 11: Sarnia Harbour targets of interest

Two more prominent features were evident in the survey which appeared suitable for laser scanning. However, the daylight reaching the bottom of the 6 m water depth saturated the laser line from the camera providing no usable data.

Location of targets was 385080 m E, 4759275 m N in UTM zone 17N. Average bottom elevation was 171.0 m with the waterline at 177.0 m.

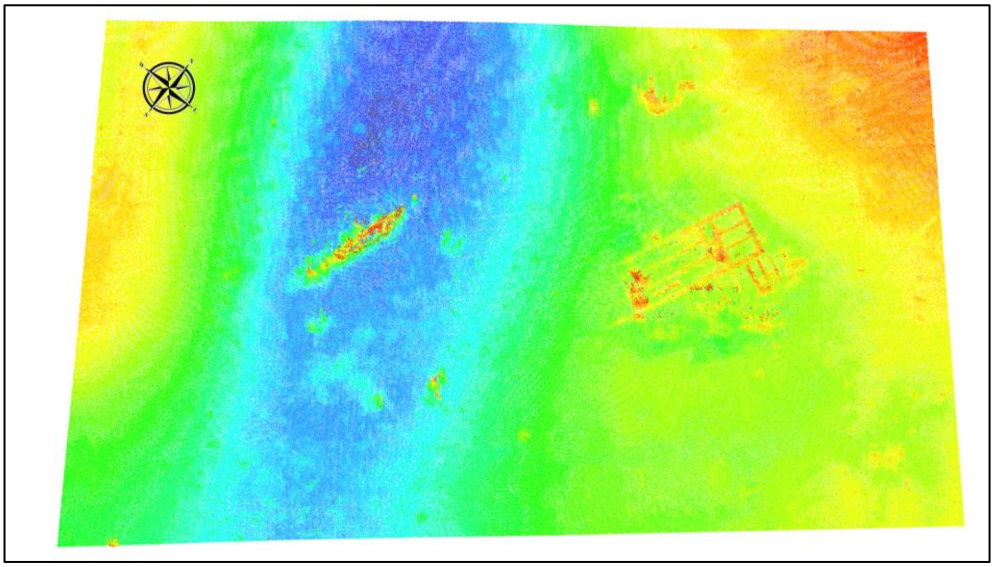

Figure 12: Map of features in Sarnia Harbour

4.3 Detroit Intake

In an effort to reach deeper and darker clear water, the vessel transited out into Lake Huron. Features marked on the navigation charts were investigated. First, a water intake crib was located. This is understood to be for the City of Detroit municipal supply.

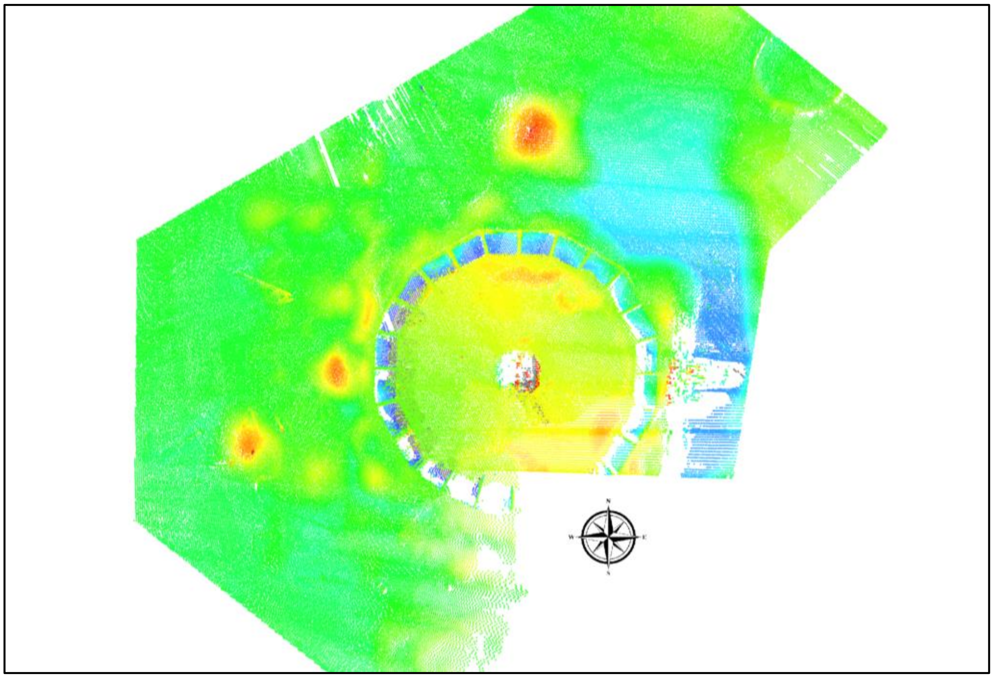

Figure 13: Water intake

The intake was quite large at 45 m in diameter and at location: 386822 m E, 4775751 m N in UTM zone 17N. Depth was 15.7 m at the intake. This location was deemed unsuitable for ROV deployment due to risk of flow at the live intake.

4.4 Genoa Wreck

This target was located using navigation charts and surveyed using the MBES mounted on the vessel. This site ultimately provided better conditions for the ROV deployed laser scanning.

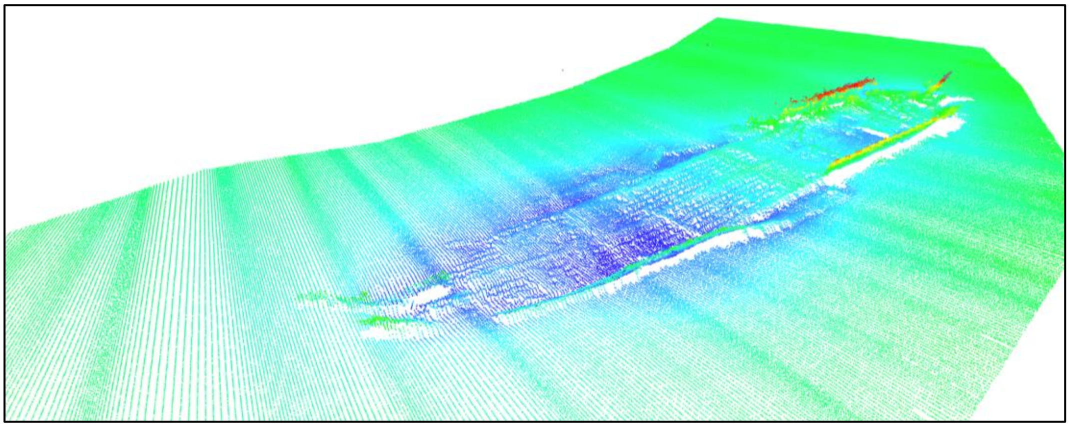

Figure 14: MBES perspective view of wreck site

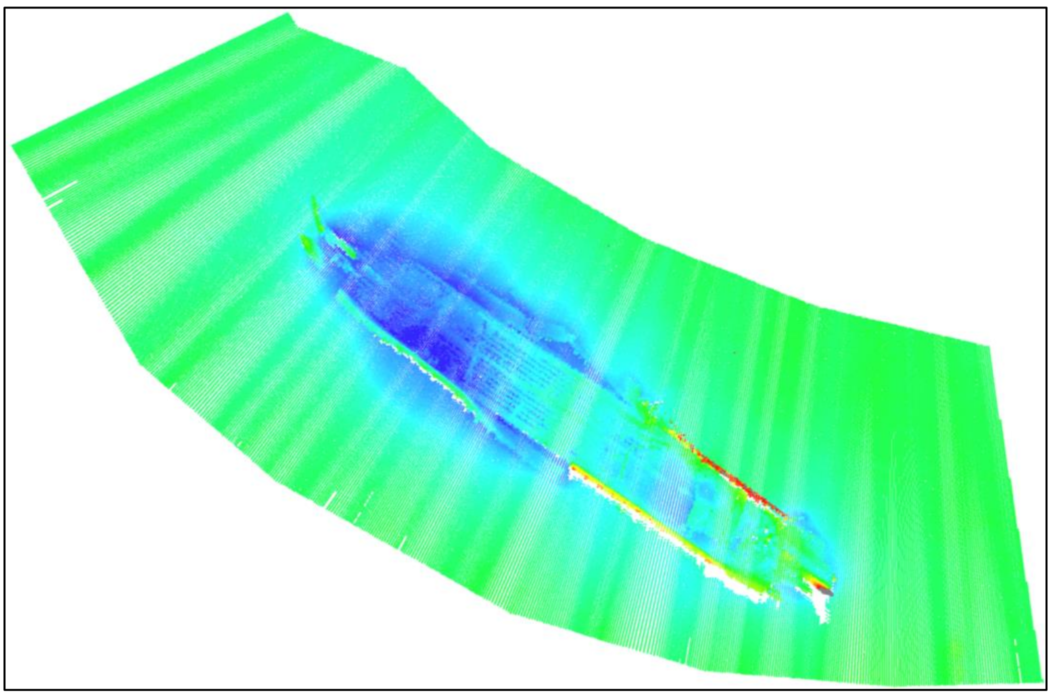

Figure 15: Plan view map of MBES over wreck site

The wreck was centred at 388400 m E, 4778032 m N UTM in zone 17N. Elevation of the bottom was 157.6 m, with waterline during the survey at 177.0 m. The wreck site was 100 m long and 15 m wide.

Following MBES data collection on the City of Genoa wreck site, the ROV was deployed with the laser scanner. The ROV was flown over the wreck site in attempts to collect data points. The ambient light reaching the wreck site was still influencing the laser scanner at 20 m water depth. As a result of this, the laser was required to operate within very close range of the bottom, less than 1 m. This low altitude resulted in a narrow swath width of data collected.

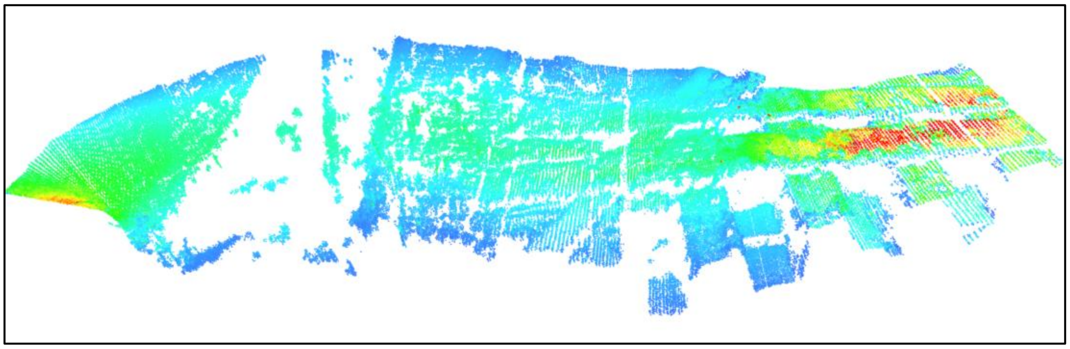

Figure 16: Perspective view of laser data

Areas with good characteristics were identified for the laser scanning and passes were attempted over these regions. The detail in the laser data was good, but the amount of noise was found to be excessive.

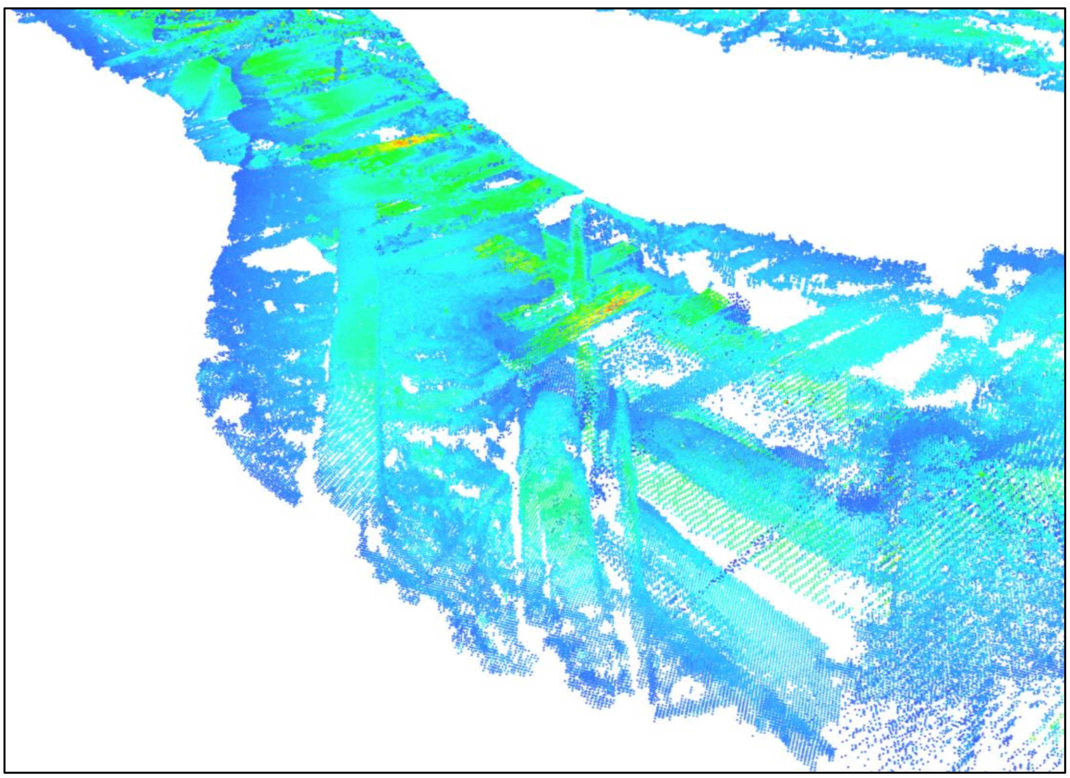

Figure 17: Further perspective view of laser data

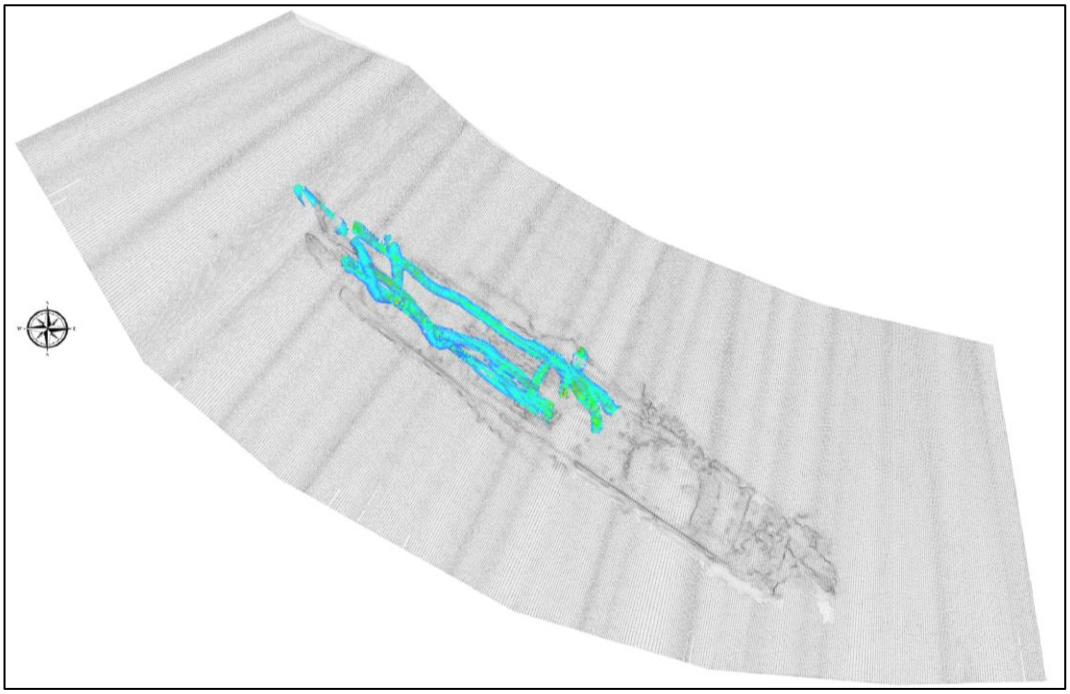

Figure 18: Laser scanner coverage shown in colour over the MBES data map in grey