Prepared by: John W. King,Professor of Oceanography, University of Rhode Island
Narragansett, RI 02882
jwking@uri.edu 4018746182

Phases of Our Plan:

Baseline Studies

Baseline studies are a key piece of understanding the sediment transport (and seaweed transport) processes within the Little Beach area and are needed to develop conceptual plan options, and for the permitting phase of a specific engineering plan. These studies should include:

(a) Produce topography and bathymetry maps
(b) Map offshore seagrass beds and bottom habitat types
(c) Do a wave height and circulation pattern study; and
(d) Develop a circulation and sediment transport model for the area.

Professor John King from Oceanography at URI has three decades of experience with a and b listed above, and has collaborated with Professor Reza Hashemi of Ocean Engineering and c and d during the last decade.

Topographic Mapping

Introduction

The goal of this study component is to characterize the end of summer conditions at Narragansett Town Beach that are typically associated with maximum sand volume of the annual storm beach cycle (Figure 1). We will use a boat mounted LiDAR system to characterize the topography of the beach and land-based structures adjacent to the beach. We will follow a similar approach to a monitoring program that we do for Narragansett Town Beach.

Methodology

Calibration and control sites

<u>Boresight Calibration and Control Sites</u>

A boresight calibration of the LiDAR and Inertial Measurement Unit (IMU) will be conducted just prior to the LiDAR survey. This particular calibration accounts for any angular misalignments between the LiDAR and IMU systems as they are mounted on a sensor frame. A ground control point survey will also be conducted at Little Beach prior to the LiDAR survey. A Trimble R10 RTK GPS system was used to collect position and elevation data along man-made structures on land within the Little Beach area. The purpose of establishing ground control points prior to a mobile LiDAR scanning survey is to have a set of fixed positions and elevations that the LiDAR data can be compared with, to assess the accuracy of the LiDAR survey. These points are used both for alignment and accuracy assessments in the LiDAR survey.

Survey

The following equipment was used to carry out LiDAR scans of Narragansett Town Beach (Figure 2):

- Teledyne-Optech ILRIS-3D motion compensated laser scanner system [Raw point and intensity data]
- Applanix POSMV IMU system [Positioning and orientation data]
- Trimble R10 RTK-enabled GNSS receiver [High-precision positioning]
- *R/V Shanna Rose* [42' survey vessel]

We will do an early spring survey and alate summer LiDAR survey with the goal of the spring survey to characterize the minimum beach volume, whereas the late summer survey willk characterize the end of summer beach volume maximum in the annual cycle (Figure 1) along Little Beach. The survey equipment will be setup on the *R/V Shanna Rose* at the URI Allen Harbor Facility in North **Kingstown**, RI the morning of the surveys. The optically-safe ILRIS laser scanner (LiDAR), IMU and RTK GNSS systems will be mounted on a sensor frame with known horizontal and vertical offsets. The sensor frame will be fixed to the *R/V Shanna Rose*, approximately 8 feet above the deck on the starboard side. The *R/V Shanna Rose* will then transit to Little Beach, with surveys beginning shortly thereafter. The surveys are planned to occur near the predicted low tide for Little Beach, to maximize the length of the exposed beach.

We will show examples from our work on Narragansett Beach to illustrate the approach and results. The survey date will be chosen based on the favorable forecasted weather and sea conditions, which can have a noticeable impact on data quality. In our example from Narragansett Town Beach, (Figure 3), seas were approximately 2 feet and winds were 5-10 kts from the South during the duration of the LiDAR scans. The calm seas and fair weather allowed the survey vessel to navigate as near to the beach as possible, allowing for the best possible data density. Some rolling waves approaching the beach occurred in short sets, producing short-lived unfavorable survey conditions.

Two shore-parallel, north-south scans were conducted along Narragansett Town Beach. Scans began at the north end of the beach near the Narrow River and ended near the Coast Guard House restaurant. LiDAR scan and navigation data were recorded to data acquisition laptops. The *R/V Shanna Rose* maintained survey speeds of 2-4 knots throughout each scan and generally followed the 10-foot isobath to ensure high data quality and safe navigation. Following the completion of LiDAR scans along Narragansett Town Beach, the boat was transited back towards Allen Harbor.

After each LiDAR scan of Narragansett Town Beach, scan data were processed into a point cloud to determine if adequate resolution and data coverage along the beach were met. This method allows the surveyor to adjust LiDAR settings to maximize data quality.

Data Processing

<u>Generating georeferenced "xyz" point clouds</u>

The raw LiDAR scan data were parsed with the position and orientation data using Optech Parser software. The boresight calibration values and sensor offsets are also compensated in this software. The result is a 3-D point cloud XYZ file, where each point has a real-world projected position (x and y in meters) with respect to the WGS84 horizontal datum and an elevation (z in meters) value with respect to the WGS84 ellipsoid.

Datum transformations were then made in NOAA V-Datum software. Positions were re-projected in the NAD83 UTM Zone 19N projected coordinate system and elevations were projected with respect to the NAVD88 elevation datum. The units for all positions and elevations in the point cloud are meters.

<u>Data filtering and alignment</u>
Virtual Grid VRMesh and Cloud Compare software were used to filter out non-beach points and for fine-scale alignments. All LiDAR point clouds were merged into a single point cloud for maximum point density. A noise filter was applied to remove points in isolation, using a 5 m distance threshold. The resulting point cloud was then georegistered with ground control points, improving fine-scale alignment of the point cloud and allowing for an assessment of accuracy. A RMSE value of 46 cm was reported with georegistration.
Manual point removal was used to extract only points representing bare earth topography (in this case, points only representing elevations along the beach). The finalized point cloud was then rasterized into a 1x1 m grid, using an average value interpolation for elevation. This final beach elevation raster is referred to as a digital elevation model (DEM) and was exported in GeoTIFF format (Figure 4).

<u>Geoprocessing and analysis</u>
The DEM was then imported to ESRI ArcMap GIS software for additional geoprocessing and analysis. A polygon feature class representing the extent of the berm within the Narragansett Town Beach boundary was digitized. The DEM was then clipped to the extent of the berm polygon, removing identified dune features. Two-dimensional elevation transects were extracted from the DEM, following the same azimuth as beach profiles surveyed by traditional means.

Berm volume was calculated using the Functional Surface "Volume" tool (3D Analyst Geoprocessing toolbox) in ESRI ArcMap software. Two functional surfaces were generated, one setting a minimum elevation boundary plane at NAVD88 = 0 meter elevation, and the second setting a minimum elevation boundary plane at mean lower low water (MLLW) = -0.63 meters elevation. The vertical offset between NAVD88 and MLLW was computed using NOAA V-Datum software, where MLLW is 0.63 meters below NAVD88 at Narragansett Town Beach. Volumes of the DEM were then calculated using elevations above these planes.

Bathymetry, Bottom Habitat Type and Seagrass Mapping

Introduction
We have done many bathymetry, bottom habitat, and seagrass bed mapping projects over the last 20 years at URI. Most recently we have collected acoustic data using an EdgeTech 6205 MultiPhase Echo sounder system with sidescan. This system is capable of simultaneously acquiring co-located sidescan and bathymetry data and is optimized for shallow water surveying, allowing for increased survey efficiency. In addition, we use a grab sampler to collect surficial samples of the seafloor which are analyzed for sediment grain size composition, and organic content. The combination of these data types can be used to produce bathymetry, bottom habitat type, and seagrass bed location maps.

Methodology

A 28-foot pontoon survey vessel shown in Figure 5. This vessel can be fitted on the bow with a pole-mounted Edgetech 6205 Multi-Phase Echosounder (MPES) dual-frequency system will be used to collect co-located swath bathymetry and side-scan data. Vessel positioning and orientation data will be collected by an Applanix POSMV v4 system and integrated with the sonar data for motion corrections. Real-time positional accuracy is approximately 0.5 meters. Sonar data will be acquired using Ocean Imaging Consultants, Inc. (OIC) GeoDAS software. The total swath width of the Edgetech 6205 MPES system will be set to the 50 m range for the highest possible resolution. The survey will be conducted such that a shoreline trace will be collected at high tide and subsequent swaths are collected progressively offshore and roughly parallel to the shoreline. Each survey line will be spaced 10-25 meters apart to allow for full coverage swath bathymetry and side-scan sonar.

Sonar data will be processed using OIC Cleansweep software. Side-scan and bathymetry data will be bottom-tracked and trimmed to remove vessel turns. Angle-varying gains and histogram equalization signal processing will be applied to side-scan data to compensate for across-track signal attenuation and color balancing, respectively. Mount-angle corrections and ground-range filters will be applied to bathymetric data to compensate for pole angle and to remove non-quality pings, respectively. Processed side-scan swaths will then be mosaiced at 10-cm resolution and exported in geotiff file format. Processed bathymetric data will be mosaiced at 1-meter resolution and exported in geotiff file format. Side-scan backscatter intensity data will be scaled from 0 to 255 pixel values on reverse gold color scale, with bright pixels representing more reflective seafloor and darker pixels representing an acoustically more absorptive seafloor. Bathymetric data will be scaled for elevation from 0 to -35.0 meters with respect to the NAVD88 vertical datum. Warmer colors will represent shallower depth and cooler colors will represent deeper areas of the seafloor.

The side-scan sonar mosaic map will visually be subdivided into polygons of similar backscatter intensity (bottom type). Approximately 30-40 representative sites with be selected for collection of grab samples and Go-Pro video in order to ground truth the sonar map. A Smith-McIntyre grab sampler with a Go-Pro camera mount will be used to collect bottom samples and video from the URI 28' pontoon boat. These samples will be analyzed for sediment grain size composition, organic content, and seagrass abundance.

Habitat Map development

The sidescan sonar and bathymetry map production are described above. The bottom habitat and seagrass bed maps involve extra steps as follows. The new data will be interpreted and analyzed as needed to develop benthic habitat maps and seagrass maps. The first step of the process involves producing a full-coverage map of the geologic depositional environments, primarily accomplished through expert interpretation of the geologic facies visible in the sidescan sonar imagery. Geologic facies are spatially recognizable areas within the sidescan record due to their acoustic characteristics, such as backscatter intensity and texture. In addition, bathymetry, sediment grain size, and aerial imagery data will also be examined. These secondary datasets will be used to assist in the verification and interpretation of the geologic facies, particularly when there is a gradual transition zone, rather than a sharp boundary, between facies. These geologic depositional environments will form the basis for the habitat map units. One such unit is a seagrass bed.

Circulation Pattern Study and Circulation/Sediment Transport Model

Introduction

It is necessary to understand the circulation and sediment transport pattern within the Little Beach study area in order to propose potential engineering solutions to the beach erosion problems in the Little Beach study area. It is also necessary to have detailed knowledge of current speeds and directions and wave heights in the study area in order to develop a circulation/sediment transport model for the study area.

Methodology

This component of the study will include a field component. One aspect of the field component will be to analyze aerial photographs to determine areas of deposition/erosion around structures like breakwaters and groins to determine the direction of long shore currents. In addition, we plan to deploy two Teledyne-RDI bottom- mounted Acoustic Doppler Current meters in the study area. One near the south end and one near the north end of Little Beach. These devices can continuously record both wave height and current speed and direction. They will be deployed during the spring from our 42' research vessel and will be recovered after a 6-8 week-long deployment. The data will be analyzed using RDI software.

Using this data, we can use a nested version of the **Regional Ocean Modeling System** (ROMS). ROMS is an ocean model widely used by the scientific community for a diverse range of applications. One use will be to develop a circulation/sediment transport model for the Little Beach and adjacent areas of Narragansett Bay. Professor Hashemi has extensive experience in using this model.

Cost Estimate for Baseline Studies

Boat, equipment rentals, and supplies- $27,000
Personnel Costs (includes field work, data processing, and reporting)-$25,000
Total- $52,000

Develop and Evaluate Conceptual Alternative Engineering Solutions for the Study Area

Introduction

This phase of the study buses the information obtained in Phase 1 to evaluate engineering solutions for the study area. Our plan is to involve a group of senior Ocean Engineering student in a senior design course in order to use the data obtained in our baseline studies to come up with best practices for increasing coastal resiliency in the Little Beach area. A number of options will be considered including green shoreline options. We plan to do this work in collaboration with Save the Bay and CRMC.

Cost Estimate for Development/Evaluation of Engineering Solutions

Personnel costs for King and Hashemi- $15,000

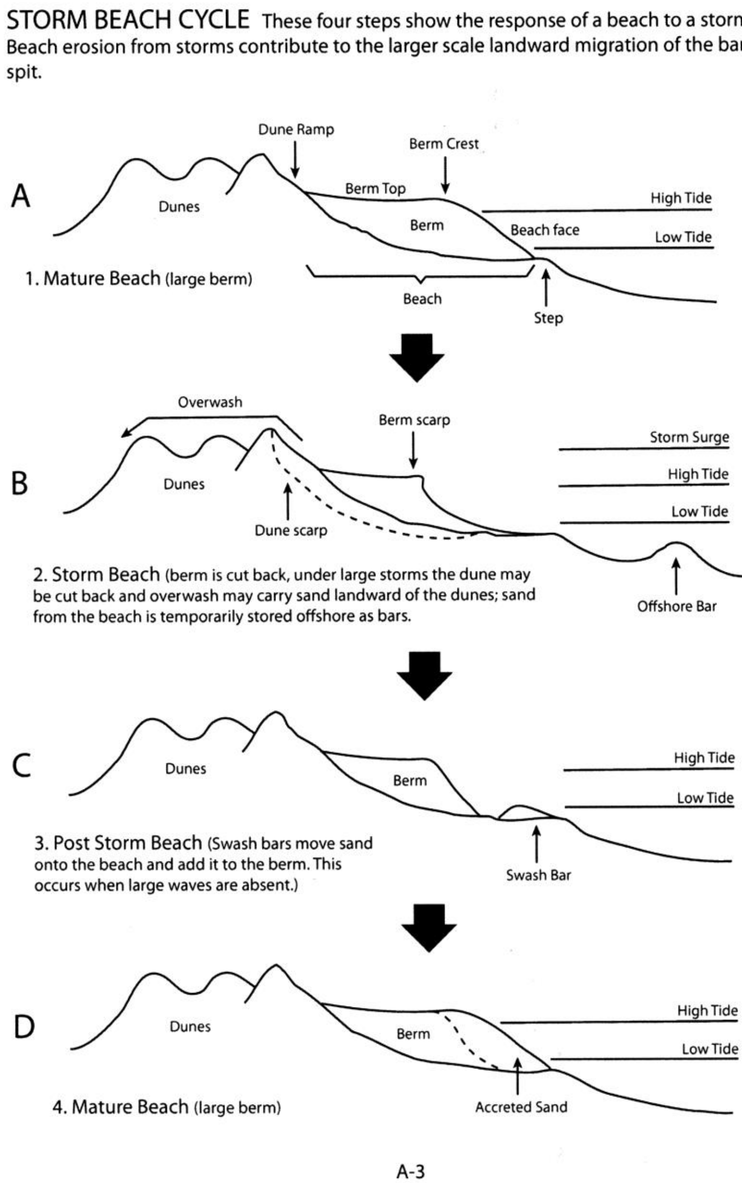

Figure 1. Storm Beach Cycle.

The typical phases of the storm beach cycle, beginning at a mature beach (A), typically seen in summer months in Rhode Island. The storm beach phase (B) occurs after large waves and storm surge erode the berm and dunes and are common in the Fall and Winter months. The post storm beach phase (C) occurs under low wave energy conditions, naturally replenishing the berm volume.

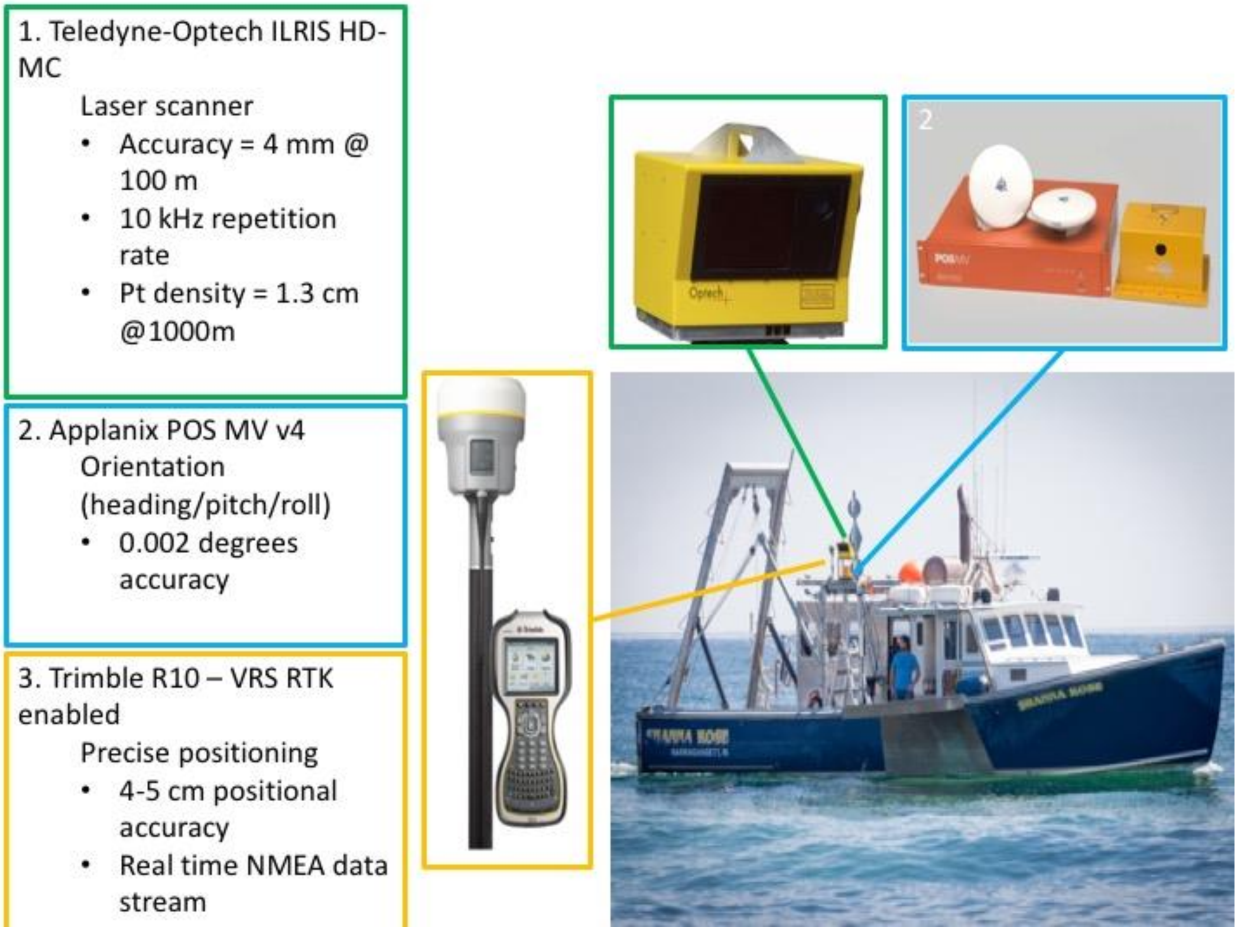

Figure 2. LiDAR survey components.

The LiDAR survey relies on integration of three primary components. The LiDAR system (1), the IMU (2) and an RTK enabled GPS (3). All components are mounted on a sensor frame aboard the *R/V Shanna Rose*.

Figure 3. Survey conditions.

Fair weather and a calm sea state enabled the *R/V Shanna Rose* to be navigated close to the shoreline, resulting in good data density. Surveying began near low tide when the beach is most exposed.

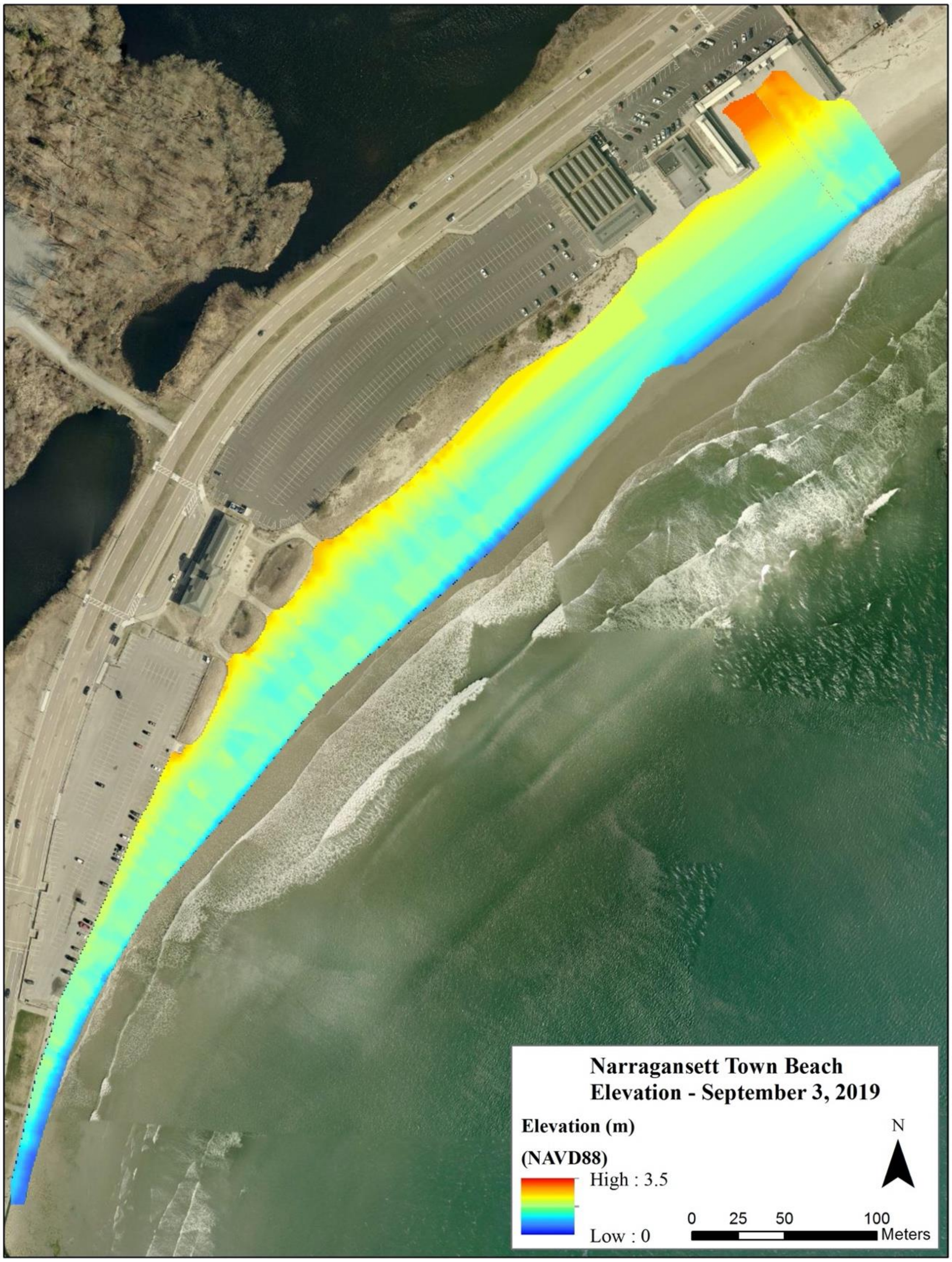

Figure 4. Interpolated DEM of Narragansett Town Beach berm.

Final DEM representing only beach elevations along the berm. All non-bare earth points were removed before producing the 1x1 meter gridded surface and data gaps were filled by an interpolation algorithm.

***Figure 5**: The 28' pontoon-type vessel that will be used for the surveying work.*