Activity report on the project "*MIRROR: a Microplastic Raman Optical Rover to Understand Microplastics Variability Along Beaches of Matagorda Peninsula*"

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During the period from April to June 2025, the project focused on: (1) direct observation of the morphology and characteristics of the beach area along the Matagorda Peninsula, including the collection of UAV (unmanned aerial vehicle) photos; (2) collection of sediment samples along the beach; and (3) processing the UAV images collected from the beach area. Direct observation of beach morphology, the distribution of macroplastics along the beach, sediment characteristics, and microplastics in sediments is essential before deploying the MIRROR rover for in-situ plastic mesurements.

The MIRROR project aims to develop a compact and robust method for recognizing microplastics in field environments using a rover equipped with a near-infrared (NIR) spectrometer. This method will be tested on beach sediments from the Matagorda Peninsula in Texas. While previous work primarily focused on the development of the MIRROR rover, a work that will continue, this quarter marked the first time we collected field data along the Matagorda Peninsula beach.

The UAV was flown at different altitudes (4m, 15m, and 30 m) above the beach to compare image resolution and the ability to record/recognize plastic materials of various sizes. The photos captured during the flight were processed using Agisoft Metashape software to create a 3-D model of the beach surface with colored textures from the photos, which enables for the recognition of plastic materials. The UAV was flown at 4 m above the ground over a 50 m stretch of beach, at 15 m above the ground for about 1.28 km, and at 30 m above the ground for about 13.7 km (Figure 1). We will refer to the models as 4m-A-M, 15m-A-M, and 30m-A-M as abbreviations for the models created at 4, 15, and 30 meters, respectively.

Preliminary field observations suggest that UAV imagery from 30 m altitude is suitable for recognizing large plastic objects (macroplastics) around 10 cm (4 inches) in size or sometimes even smaller if the object is brightly colored. The UAV imagery from 30 m altitude (30m-A-M), covering 13.7 km, represents more than one-third of the entire Matagorda Peninsula length (Figure 1), which we plan to study.

The area covering approximately 50 meters southwest of the Colorado Canal (Figure 2) was used to test UAV flights at three different altitudes. The goal of collecting photos and building 3D models from different altitudes was to compare image resolutions and the ability to recognize plastic materials. Comparing the model resolutions for the same area shows that on the 4m-A-M model, plastics as small as 2 to 3 cm in dimension can be recognized if they are colored or have geometric/angular shapes. The type of plastic (e.g., bottle, rope, container, bottle cap, fragment, foil, shoe, spoon) can also be identified and was recorded.

On the model built from 15 m altitude (15m-A-M) for the same area as 4m-A-M, the same plastics can be recognized, despite the lower resolution of the images (Figure 3). Plastics that are 3 or 4 cm in size can still be recognized if they are bright colored. On the model built from 30 m altitude (30m-A-M) for the same area, 3 to 4 cm plastics are not easily distinguished (Figure 3). Therefore, the resolution for recognizing plastics at 30 m altitude is around 10 cm, and recognition of objects smaller than 10 cm depends on their color and shape but as seen on the comparing images on figure 3, a 4 cm red cap doesn't have recognizable characteristics.

Considering that the 30m-A-M model can identify plastics larger than 10 cm while also providing data on beach morphology and the location of organic flotsam (beach wrack), the largest area, approximately 13.7 km along the beach—, photographed from 30 m altitude.

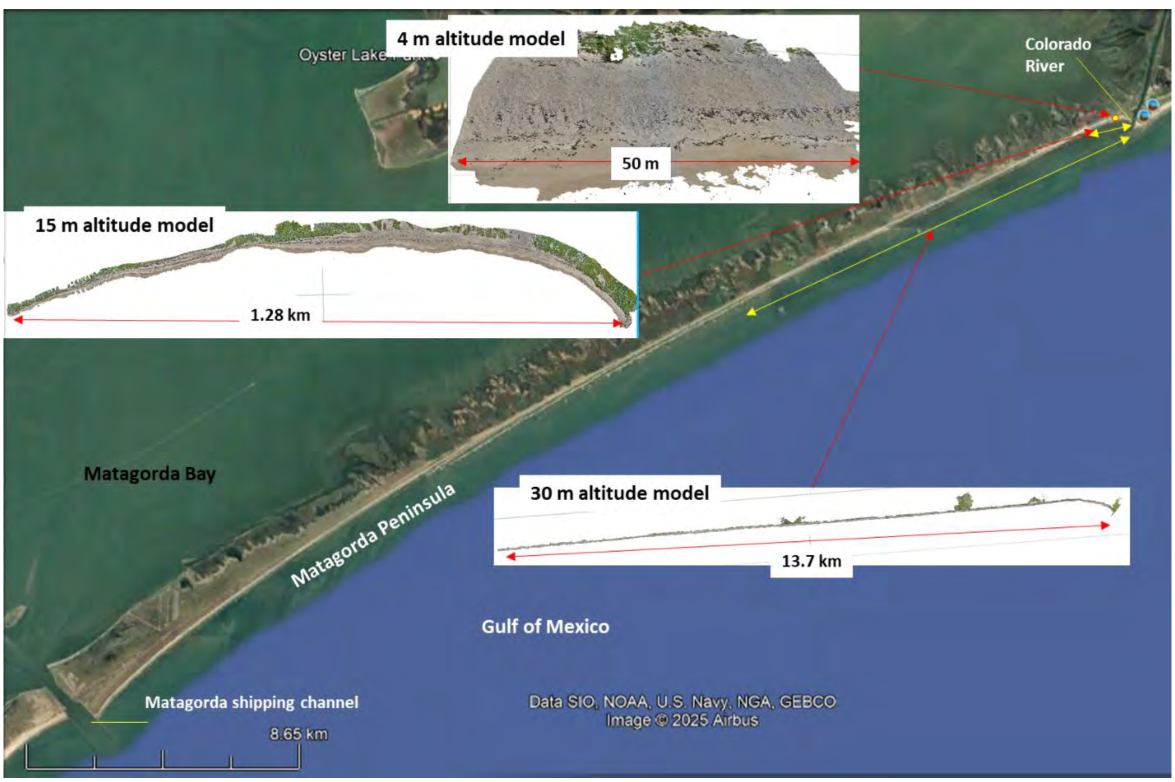

Figure 1. Map of the Matagorda Peninsula showing the area of UAV imagery collected at different altitudes for comparison.

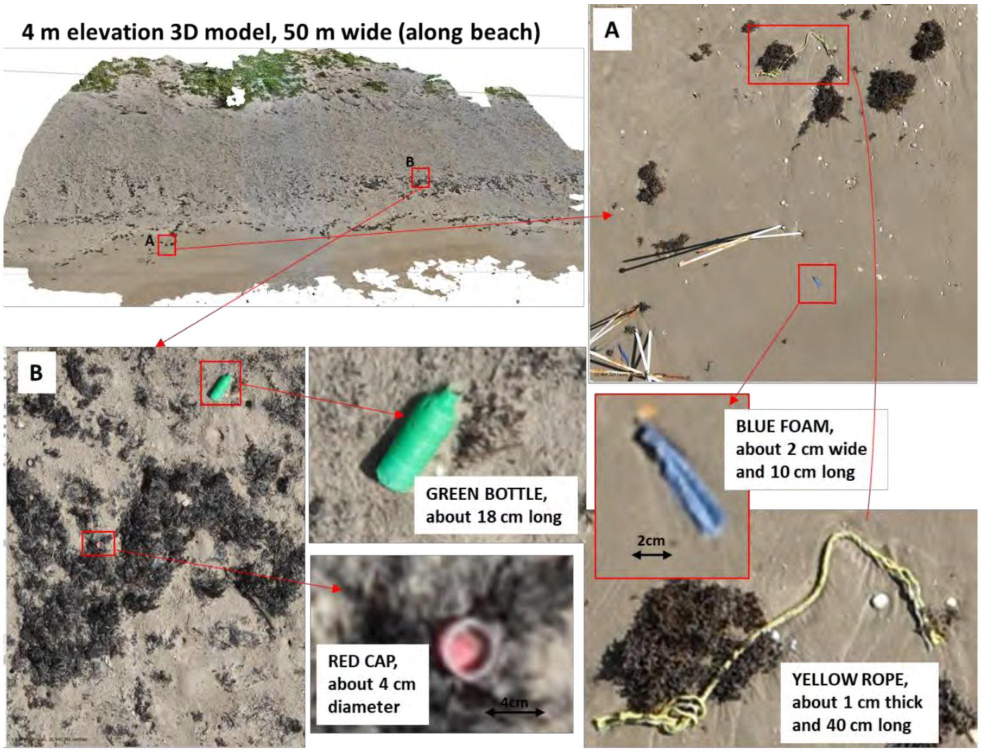

Figure 2. Map of the Matagorda Peninsula showing the area of UAV imagery collected from 4 m altitude for characterizing beach morphology and identifying large plastic materials.

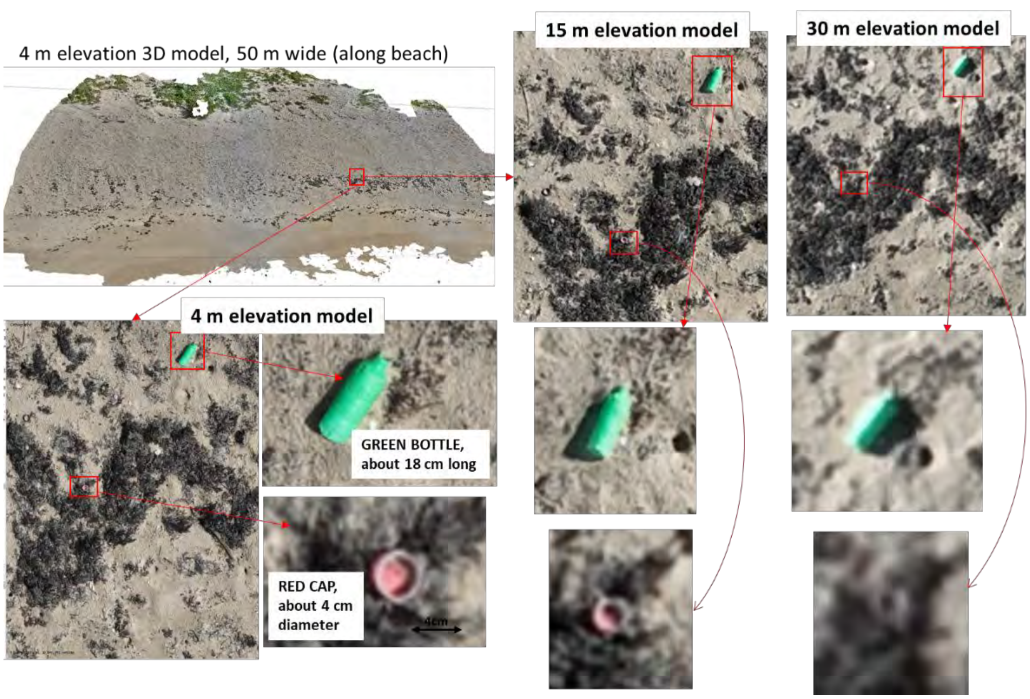

Figure 3. Comparison of image resolution from UAV flights at different altitudes (4 m, 15 m, and 30 m). Top left is the 4m-A-M with location of the detail images lower photos compare images form the 3 different altitude 3D models.

We began identifying and mapping plastics on the 4m-A-M model and found 115 plastic objects across 50 m of beach sand (Figure 4). The plastics varied widely in size, from 2 cm to over 60 cm, and included many different types of plastic objects, with plastic bottles and caps being the most common. A preliminary observation is that plastics appear to be trapped or mixed in with flotsam (vegetation accumulation washed up along the beach) (see the lower right area on the Figure 4). However, this observation requires further quantification.

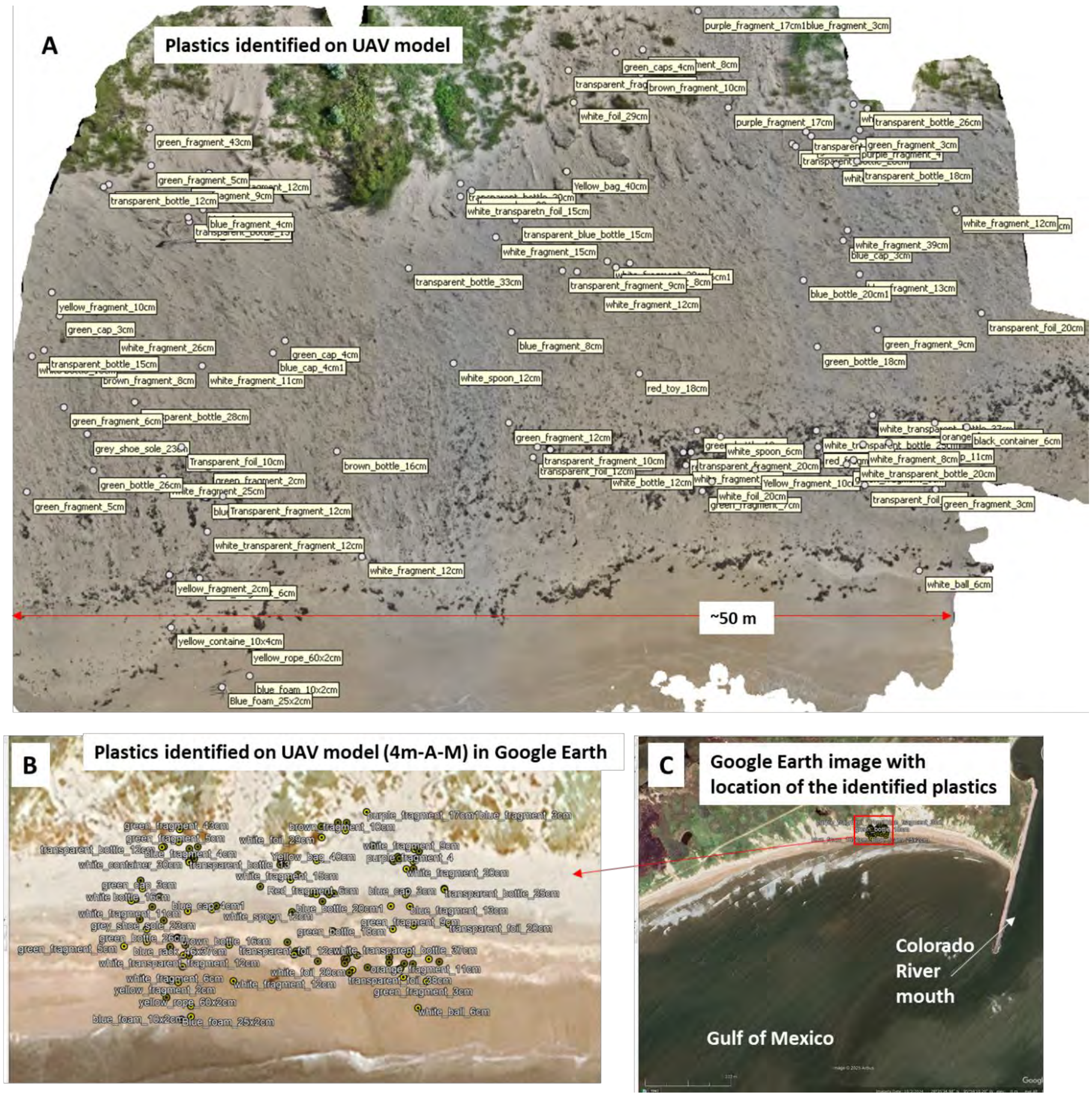

Figure 4. Mapping and identifying plastics on the UAV image model. A – Identification of the plastics' color, type, and size on the 4m-A-M. B – Identified plastic locations on Google Earth software, close-up view. C – Area of plastics mapped/identified on the beach south of the Colorado River mouth (on Google Earth software).

For microplastics analysis, sediment samples were collected along five profiles across the 13.7 km long segment (Figure 5) surveyed with UAV imagery. Four samples were collected from each profile: one from the swash zone, one from the berm, one from the back-berm area, and one from the seaside of the eolian dunes. A total of 20 samples were collected, with about 2 pounds (1kg) of sand collected at each location and stored in aluminum foil-lined bags. The sand samples will be analyzed in the lab using the density separation method.

The UAV imagery data collected in the field, along with the 3D models, plastic material analyses, and sand analyses for microplastics, will provide valuable data for better understanding the distribution of microplastics on Matagorda Peninsula and for the efficient deployment of the MIRROR rover.

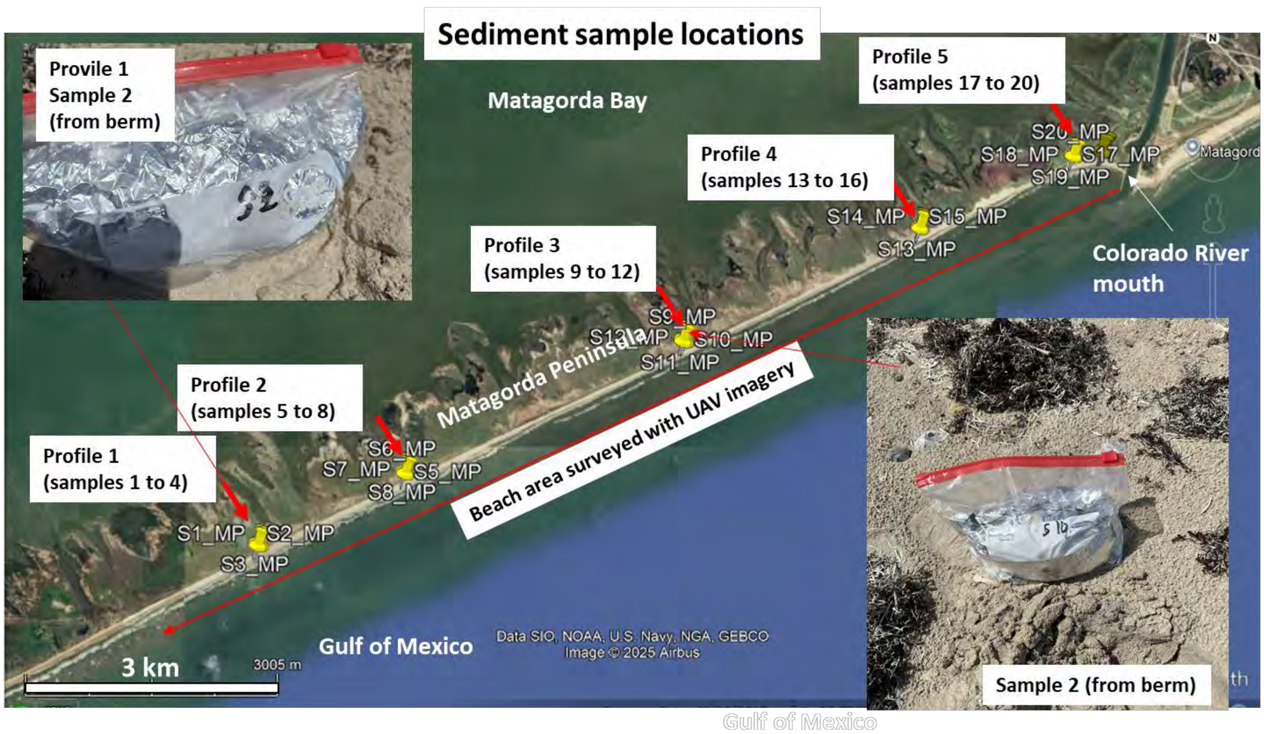

Figure 5. Location of the sediment samples collected for microplastics analysis along five profiles on Matagorda Peninsula beach. The inset shows examples of the sample bags collected at the berm location.