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Background and Objectives
Oyster reefs provide important environmental services including water filtration and purification, protection of seagrass beds and saltmarshes from wave action, forage for some invertebrates and finfish, wading birds, and habitat for numerous marine organisms including commercially and recreationally important finfish. Mapping the physical extent and conditions of these reefs provides scientists and managers with data on the current status of oyster populations and hard bottom habitat within an estuary as well as information needed for ongoing oyster conservation and restoration efforts. Mapping intertidal shallow reefs are usually impeded by the inability to use traditional subtidal side scan sonar and survey methods. This ongoing research project aims to apply side-scanning sonar system (subtidal water depth 0.9-1.5 meters) combined with drone (also known as Unmanned Aerial Vehicle, UAV) photography (for shallow water where water depth < 0.9 meters) together with digital image processing techniques to map selected intertidal oyster reefs and shell bottom.

Study Sites
The following criteria were considered when selecting our two primary sites (Fig 1) for conducting this research: 1) sufficient water depth to allow easy and safe navigation of a small boat equipped with side scanning sonar system to the site; 2) high potential for aerial exposure of the reef sites due to low tides or wind driven winter storm systems; and 3) sites that are distant from airports to comply with FAA to gain future flight approval. Site 2 is scheduled to be surveyed; and Site 3 is considered for survey subject to FAA approval.

Methods and Initial Results

Side-scanning sonar: Transect routes were established to capture scan images that were partially overlapped to ensure no gaps existed in the final products as well as videos for comparison purpose. Side scan images were captured using a Humminbird Model 1197c with a XHS 9 HDSI 180 T Transducer attached to a small draft aluminum boat or kayak (Fig 2 & 3). Data collection was conducted during calm wind and at approximately high tide time to ensure proper functioning of survey equipment in shallow water. Post processing was conducted using SonarTRX and ArcGIS (Example is shown in Fig 4).

Drone Photography
The low-cost low altitude (200–300ft) photography using a Quest UAV (Aqua) with a photogrammetric system was used to acquire high-resolution images for mapping intertidal reefs at a reasonable cost (Fig 1). The collected images were digitally processed using Pix4D software to produce an ortho-image using a workflow that includes establishing the orientation of images, key points, image matching, and point cloud densification. The final product (Fig 8 & 9) was a 2.2 cm spatial resolution image where the reef extent can be clearly identified and mapped. The investigation of reef composition is underway using both visual interpretation and digital image processing that includes hard and soft classification using the ArcGIS and IDRISI platforms. Training data collected using 20 random quadrats (1m×1m) within 10m×10m area (Fig 5 & 10) was used. In addition, the composition within 1m×1m quadrats at additional sites in different locations on the reefs were used for validation purposes.

Conclusions and Further Analysis
1. Drone photography can be used in mapping the extent of intertidal reefs during extreme low water levels during full/partial exposure of reefs.
2. The spatial distribution and shapes of reefs must be considered during the planning process of UAV flights as sufficient key points must exist in each aerial image in order to conduct successful digital image processing of the collected data.
3. The side-scanning sonar system is useful for mapping the extent of shallow reefs. The sonar images may overlap with the images collected by drones.
4. Analyzing the composition of oyster reefs is a challenging process in digital image processing as submerged and exposed reefs produce different signatures. Further analysis in this regard combined with visual image interpretation in still underway.
5. The logistics for acquiring aerial images using drones can be challenging over shallow waters. Using the right operational platform (e.g. air boat) for water transport is essential.
6. Although acquiring FAA permits to operate UAVs is time consuming, the return value of this technology can be significant.

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