**Mapping NC's Estuarine Benthic Habitat with Unmanned Aerial Systems**

Business Process Innovations

North Carolina

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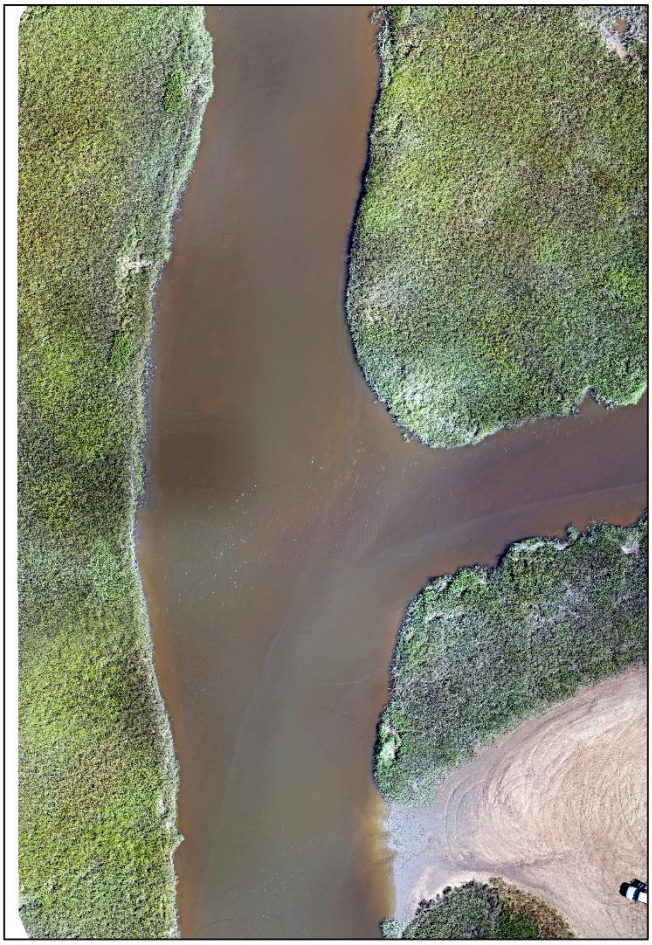


Mavic 2 Pro Drone Imagery - 0.43 In Resolution

2016 NAIP Imagery - 6 In Resolution

# EXECUTIVE SUMMARY

The North Carolina Department of Environmental Quality (DEQ) Division of Marine Fisheries (DMF), in conjunction with the Department of Information Technology (DIT), devised and is actively using an Unmanned Aerial Systems (UAS) drone program to completely revamp data collection and mapping processes. This program has allowed DMF to considerably improve their business processes, increasing productivity, saving staff time, and decreasing costs.

The UAS program's goal was to implement, where feasible, the use of drones for field data collection. Over the last five years, DEQ has made marked improvements in data collection with tablets and Geographic Information Systems (GIS) apps. The Environmental Systems Research Institute (ESRI) has recognized the state for these efforts. While the introduction of tablets and built-in GIS was a great improvement over pad and paper, it did not significantly change the work processes, nor the amount of time it took to collect the data. To make significant process improvements, the teams needed disruptive change. Thus, the introduction of drones.

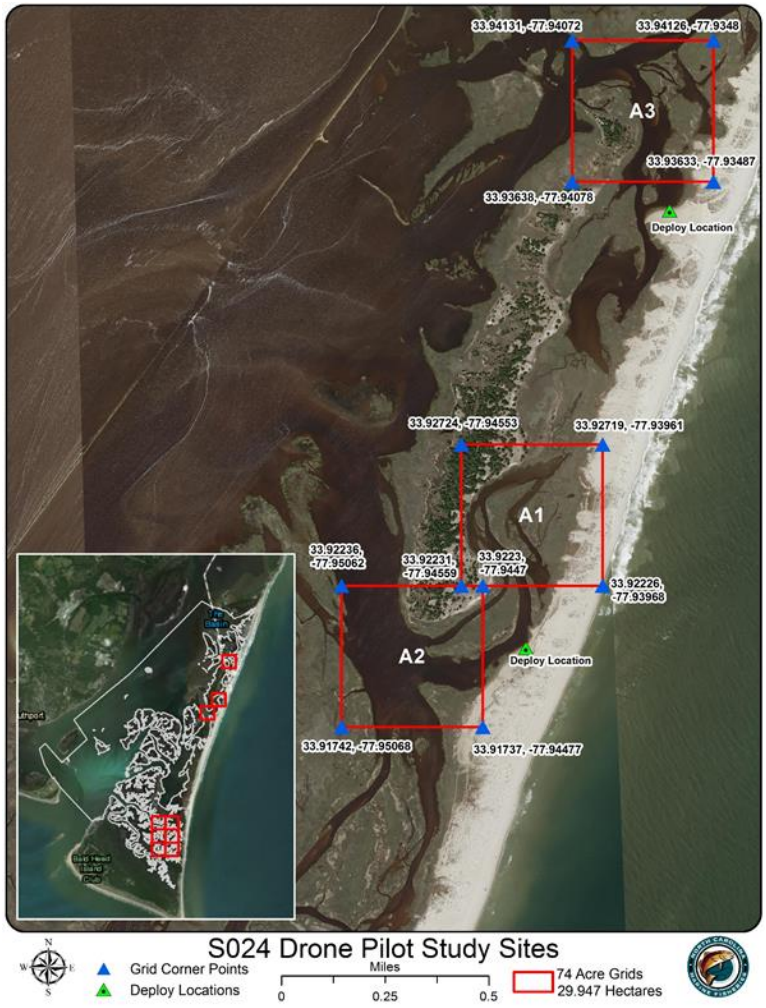
Initial case studies carried out in collaboration with the University of North Carolina Wilmington started in the spring and summer of 2018. These initial efforts produced compelling results and aided in buy-in from the state.

Initial flights and analysis efforts were predominately focused on the DMF Estuarine Benthic Habitat Mapping (EBHM) program. **Team members were astonished by the cost savings and accuracy gains realized when they began using a DJI Phantom 4 Pro drone. Acreage mapped in a day increased 5,900% for a two-=staff member team.** Traditional methods averaged 10 acres per day, while the UAS produced data for 600 acres per day. Estimated savings for the small portion (7,500 acres) of the EBHM study area projected to approximately $400,000. As this area is only a fraction for the EBHM area, the potential savings for this program alone are in the millions.

The possibilities for the UAS program within DEQ are endless. Improvements in data collection accuracy, efficiency, and cost have already begun to modernize the business processes within Marine Fisheries. All DEQ divisions are implementing UAS plans within their respective programs. The cost and time savings realized with this technology are allowing staff to focus time on other or new projects, enhancing DEQ's overall mission.

## CONCEPT

North Carolina has the largest and most productive estuarine system of any state on the east coast. Just behind the state's fragile strand of barrier islands lie shallow sounds where the land and sea gradually merge to form estuaries and brackish wetlands that support large populations of fish, shrimp, crabs and shellfish. In order to promote shellfish production and protect vital habitats, the Division of Marine Fisheries (DMF) maps and samples the benthic habitats of the coastal waters to determine habitat type, acreage and populations of oysters, clams, scallops and submerged aquatic vegetation (SAV).




Mapping the distribution of different bottom habitats is critical to effectively protect and manage estuarine resources. To facilitate shellfish harvest and aquaculture, DMF maps and samples the benthic habitats within areas known for shellfish growth. Estuarine benthic habitat types are delineated systematically using sounding poles and GPS coordinates along a map grid. The benthic habitat types are classified as soft, firm, or hard; vegetated or non-vegetated; and with or without shell. DMF workers sample benthic habitat types for the presence of shellfish and SAV using tongs, rakes, and meter squares. Sampling data include shellfish species counts, SAV species and density, and other environmental data. By collecting and utilizing the mapping and sampling data, DMF creates estuarine benthic habitat resource maps illustrating benthic habitat boundary types, SAV species habitat and productive shellfish habitat. To date, the division has mapped over 602,000 acres of the coastal estuarine waters from Little River in Brunswick County to the northern end of Roanoke and Croatan sounds in Dare County.

Initiated in the 1980s, the Estuarine Benthic Habitat Mapping (EHBM) program is vital in identifying habitat as well as mapping shellfish and submerged aquatic vegetation (SAV). Habitat data collected are used in Coastal Habitat Protection Plans, Fishery Management Plans, shellfish lease authorizations, and rulemaking. Historically, EBHM data collection was done with hand-drawn paper maps in the field, which were then scanned and digitized in the office. More recently, the program transitioned to an iPad Pro system in the field to create more accurate maps with Bluetooth GPS devices. This improved

efficiency, but still required immense field time. On average, a team of three following this process could map between 10 and 20 acres in a day.

**Using drones to map North Carolina's Estuarine Benthic Habitats**

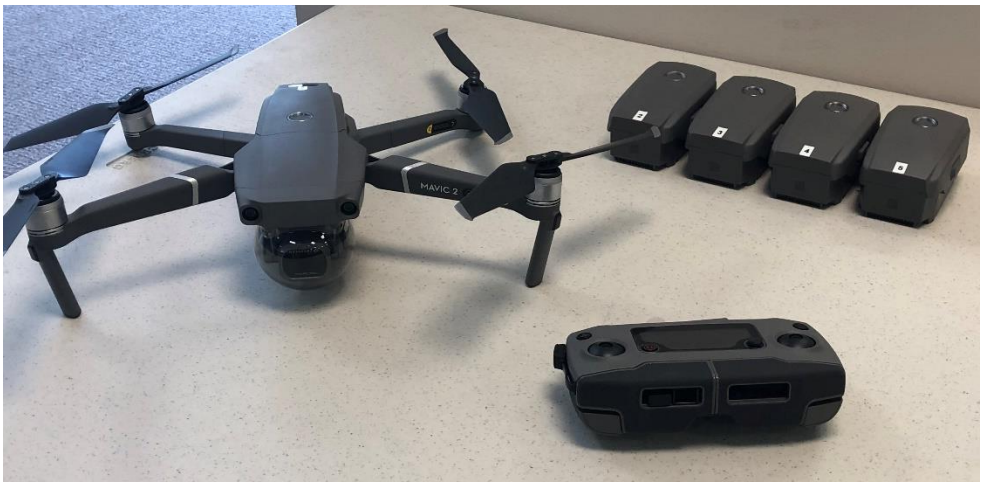
In February 2018, DMF partnered with faculty at UNC-Wilmington to test the use of Unmanned Aerial Systems (UAS) to map estuarine benthic habitats. DMF had one 7,500-acre zone of habitat left to map to complete documentation of North Carolina's estuarine benthic habitats.

Implementation of the UAS program began in March 2018 with the drafting of a policy for appropriate use of UAS. Initial case studies were carried out in collaboration with UNC-Wilmington through summer 2018. These initial efforts produced compelling results and aided in the buy-in from the state.

The UAS program utilizes numerous technologies. First and foremost are the airframes used for collection. DIT and DEQ choose to utilize DJI copter solutions as the exclusive airframe option. The DJI Phantom 4 Pro was used for the initial case study. Subsequent flights within the program incorporated the DJI Mavic 2 Pro with Hasselblad Sensor. Additionally, GPS receivers, ground control targets, and the Environmental Systems Research Institute's (ESRI) mapping platform, which includes Drone2Map, have been incorporated.

The initial goal of the program was to create high resolution orthomosaics in an efficient cost-effective manner. The EBHM program within DMF was chosen as the initial case study to explore the feasibility/usefulness of drones for environmental data collection.

The pilot study for the UAS program selected three 74-acre study areas in the Cape Fear River estuary. DJI's Phantom 4 Pro, with a one-inch CMOS 20-megapixel gimbaled sensor, was utilized in the study. Study area grids were programed to fly using Pix4D Capture mobile application. This software allows the user to easily program the flight, selecting altitude, image overlap, camera angle, and speed. The flight




was conducted at the FAA limit of 400 feet. At this altitude and chosen speed, each grid took approximately 17 minutes to fly. All images were stored locally to the drone's SD card. Ground control points were established in the field using Bad Elf GPS receivers and incorporated in the post-processing orthomosaic creation. ERDAS IMAGINE photogrammetry software performed the post-processing analysis to create one seamless orthomosaic of the survey. After completion of the orthomosaic, unsupervised classification of the image was performed to automatically identify varying benthic habitats. Imagery was then moved to ESRI's ArcMap 10.6 for supervised polygon creation of the numerous benthic habitat strata. These polygon files are the final product of the benthic habitat mapping.

Results from the UAS EBHM analysis provided 2.3-inch resolution, allowing users to zoom in tight on features without distortion. North Carolina has exceptional imagery services for the state; however, the resolution is limited to 6 inches. Further, the service is only flown every four years, and not typically at low tide. UAS solutions allow for more detailed analysis at varying times of day and tide conditions.

Mavic 2 Pro Drone Imagery - 0.43 In Resolution

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Through the pilot, a finished product for 74 acres of habitat was achieved in under three hours. Traditional methods only averaged 10 acres a day (with three staff members in the field), not including office processing time. **It took more than 30 years to map the first 90 percent of NC's estuaries. The improvement initiatives that DIT and DMF have implemented in the last year allowed DMF to map the last 10 percent in five days.**

## SIGNIFICANCE & IMPACT

The EBHM program is designed to map the estuarine benthic habitats for the entirety of the state – approximately 610,000 acres.

The savings and reduction in staff requirements for these programs allow North Carolina to initiate new projects in order to sustain and improve the environment, a core mission of DEQ.

Using the drone, DMF was able to map 80 acres in just 25 minutes - the equivalent of over 1,500 acres in a day. Three 80-acre blocks were mapped to test the methodology, and all 240 acres were mapped in just an hour and a half.

Initial EBHM case studies highlighted the savings that are and will be realized with future adaptations of UAS technology. For instance, the S024 (lower Cape Fear Estuary) area measures 7,500 acres. With traditional methods, that equates to 750 field days (assuming a team of three mapping 10 acres per day). Further tests of the UAS program proved it to be capable of 600 acres in a two-hour window around low tide. Low tide is required for either method to capture the estuarine benthos. At this rate, the UAS can complete the field work for the 7,500-acre area in 12.5 days. The estimated savings potential realized from S024 alone is about $400,000. Extrapolated coast-wide, the EBHM program savings are in the millions.

| | **Traditional Mapping** | **Drone Mapping** |
|---|---|---|
| Field personnel requirements | 3 | 1 |
| Acres mapped per field day | 10 | 600 |
| **Total field days required to map 7,500 acres** | **2,250** | **12.5** |

Using drones to map the 7,500 acre site, DMF was able to eliminate the need for three individuals to spend 750 days in the field manually collecting data. Instead, those employees were able to spend time analyzing the data collected.

DEQ has identified several other areas where drones will be used to significantly increase efficiencies while providing safety and environmental improvements.

The sky is truly the limit with this technology. When the initial groundwork was laid for this program, approximately ten programs were identified within DEQ that would benefit from this technology. That number is growing rapidly as every division within DEQ would like to implement the technology. Considering the savings possibilities realized by initial Marine Fisheries studies, this has the potential to save the state millions in data collection costs yearly.

Numerous plans are being discussed within DEQ, but those below are already in latter stages of development for UAS deployment:

- **Farmland inspections**. These inspections are currently performed manually by a three-person team. The use of drones would save over $400,000 per year in salary, gas, and supply costs.
- **Shellfish leasing.** Each application for shellfish leasing must be investigated for shellfish and Submerged Aquatic Vegetation (SAV). The drones would be able to perform these inspections more quickly, and without disturbing the habitat.
- **Harmful Algal Bloom (HAB) monitoring.** Drones can accurately map the extend of HABs without exposing staff to the harmful algae. The use of drones would improve safety, speed, and accuracy of reporting.

- **Rhodamine Dye Studies.** This would increase the accuracy of tracking the dispersion, timing, and extent of the dye. The drones would reduce internal costs of these studies by 50 percent.
- **Hurricane Response.** Drones can provide a useful tool for post-storm analysis to identify pollution sources, shoreline changes, and habitat destruction. Additionally, UAS would be a valuable tool for Marine Patrol for search and rescue.

Short-term gains have been realized in efficiency and accuracy. Long term, this technology will revolutionize the way North Carolina collects environmental data.