Shallow water bathymetric and habitat mapping of coastal DoD sites using airborne hyperspectral and lidar imagery

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Jennifer Ayers[1], Leslie Bolick[1], Jessica Carilli[1], Donald Marx[1], Stephen Smith[1], Luc Lenain[2], Adam Young[2], David Miller[3], Jeffrey Bowles[3], Nick Statom[2], Ken Melville[2]

[1]Naval Information Warfare Center (NIWC) Pacific, [2]Scripps Institution of Oceanography (SIO), [3]Naval Research Lab (NRL) D.C.

I. Problem Statement

The DoD relies on strategic coastal sites for training and testing. To sustain these activities, they must comply with environmental regulations requiring monitoring and mitigation impacts on these sensitive ecosystems. Traditional, boots-on-the-ground methods of assessing environmental impacts are limited in scope and costly.

II. Objectives

Objective: To use integrated aerial remote sensing technologies to meet the DoD's monitoring and management challenges over broad areas, at high resolutions, and with reasonable costs.

This work will:

- Develop high-resolution land-to-sea digital elevation maps (DEMs) and shallow water benthic habitat maps for two sites using aerial LiDAR and hyperspectral data
- Illustrate use of these products to assess military training impacts (or lack thereof) in coastal areas.

III. Technology / Methodology

Primary technologies to be demonstrated:

1) The SIO Modular Aerial Remote Sensing System (MASS), which includes hyperspectral and bathymetric/topograhic LiDAR imaging systems.

2) The Coastal Waters Spectral Toolkit (CWST), a hyperspectral data processing methodology for benthic habitat classification in development at NRL.

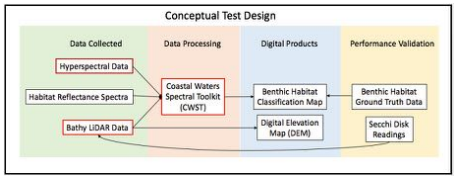


Figure 1: Conceptual Test Design.
Technologies to be demonstrated are outlined in red.

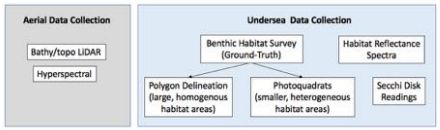


Figure 2. Field data sampling design.

Figure 3: We will incorporate measured bathymetry (LiDAR) into hyperspectral data processing workflow. Constraining the water depth is expected to improve habitat classification, as optical properties change significantly with depth.

IV. Field Data Collection: San Clemente Island

Aerial Data Collection

Test flights: April 2017. Aerial data collection: July 2017.

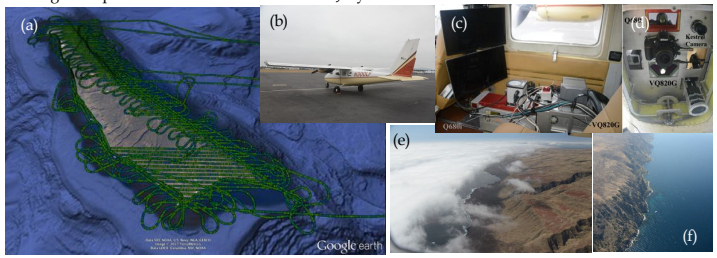


Figure 4. (a) Flight tracks; (b) Partenavia P68 aircraft with (c) modular aerial remote sensing system (MASS) installed; (d) view ports on bottom of plane; (e,f) flight conditions.

Underwater Ground Reference Data Collection

Undersea data collection: July 20-27, 2017.

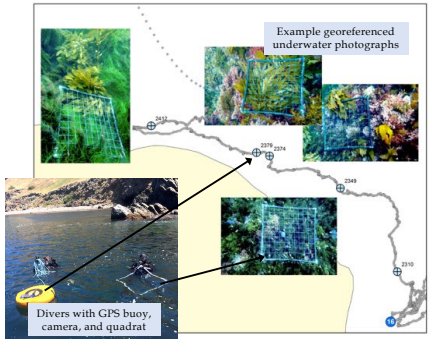


Figure 5 (left). Undersea validation data includes 300+ georeferenced digital photos of benthic habitat type, plus polygons delineating large, homogenous habitats around the island.

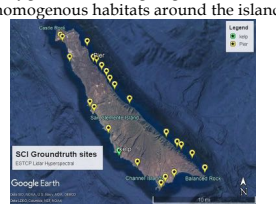


Figure 6 (above). Locations of diver-collected photo quadrat reference data.

V. Field Data Collection: Marine Corps Base Hawaii

Aerial Remote Sensing and Underwater Ground Reference Data Collection

April 2018.

Figure 7. Flight tracks covering the Marine Corps Base Hawaii peninsula.

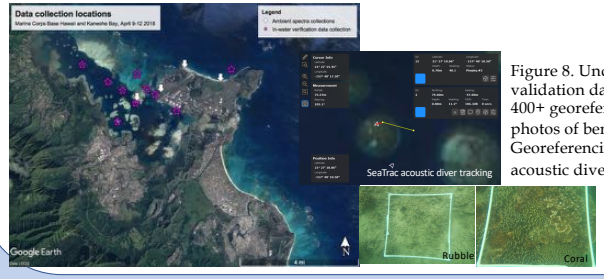


Figure 8. Undersea validation data includes 400+ georeferenced digital photos of benthic habitat. Georeferencing done via acoustic diver tracking.

VI. Results

Digital Elevation Model (DEM)

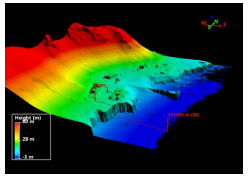


Figure 9. Lidar data are used to make a digital elevation model (DEM) of each demonstration site. Image shows a land-to-sea DEM of NOTS Pier area at San Clemente Island.

Benthic Habitat Map

Benthic habitat maps are made using NRL's Coastal Water Spectral Toolkit (CWST). The CWST:

- Generates a database of all probable combinations of bottom reflectance spectra (determined by benthic cover, water depth, and water column optical properties) using a radiative transfer model.
- Matches remotely-sensed pixel spectra with a library of in-situ habitat spectra to make its classification.

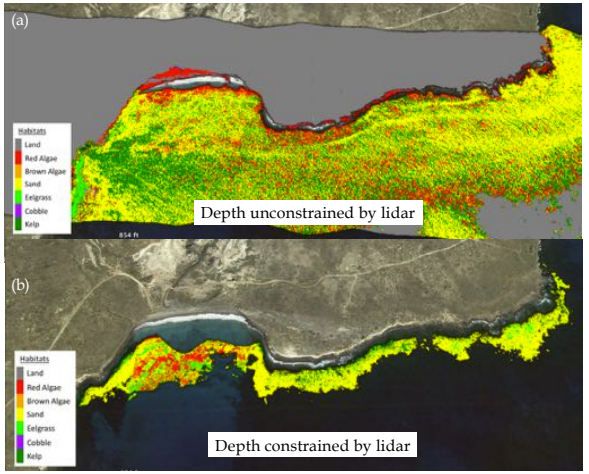
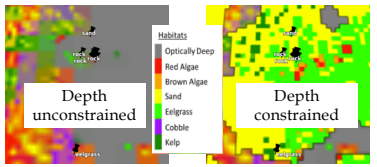


Figure 10. (a) Habitat classification with depth unconstrained, i.e. the CWST solves for depth on its own. (b) CWST classification with depth constrained by the lidar-sensed depth. Using known depths to constrain the benthic habitat classification is expected to significantly improve classification accuracy and is a key innovation in this approach.

Figure 11. Ground truth points (black pins) overlain on habitat classifications made with depth unconstrained (left) and depth constrained (right). Results improve.



Data uses for DoD environmental managers

- Primary need of DoD environmental managers: "knowing what is there"
- Direct training away from protected habitats/species
- Identify appropriate sites for compensatory environmental mitigation (e.g. MCBH is growing corals as compensatory mitigation, and also using their 500yd buffer zone to help re-establish native oysters in Kaneohe Bay).
- Monitor shoreline erosion (related to training, recreation, sea level rise)
- Monitor impacts of amphibious vehicles on shoreline

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