National UAS workshop 2015 Proposal

Rapid-response mapping of coastal change

The problem and the opportunity:

The Coastal and Marine Geology Program conducts research to monitor and assess coastal hazards and changes in landscape, land use, and ecosystems. This research includes mapping of offshore and coastal bathymetry, topography, geology, and habitat. Coastal hazards are assessed using these data with statistical and process-based models.

Coastal change is episodic. Significant changes in the beach and nearshore regions; erosion of dunes, bluffs, and cliffs; overwash; inlet formation; and changes in habitat occur in a matter of hours during storms. Major geomorphic changes occur with (at best) 24 to 48 hours advance notice, often after long periods of relatively slow change.

Prediction of storm impact in coastal regions requires accurate and up-to-date maps of coastal morphology on land (bluff or dune height, beach slope and width) and in the water (nearshore bars and shoals, offshore bathymetry). Evaluation of geomorphic response models requires accurate maps of the same features immediately after the events, before anthropogenic or natural fairweather processes modify the storm-related changes. Thus, the ability to map before and after infrequent but significant events is critically important.

Structure-from-motion (sfm) is a new but proven technique for making high-resolution maps from multiple photographic images. Unmanned aerial systems (UAS) provide the ability to acquire these images and map coastal features quickly, safely, and inexpensively, on short notice and with minimal impact. By contrast, lidar surveys of coastal regions are infrequent and costly: the most recent measurements on Cape Cod were obtained in 2011, and logistics prevented timely mapping after the series of winter storms that occurred in January and February 2015.

The advantages of sfm mapping with UAS provide a compelling case for its use by the USGS Coastal and Marine geology program. We propose to conduct a proof-of-concept survey of a segment of a dynamic and vulnerable coastline in that includes beaches, dunes, bluffs, and wetlands. This survey will provide the USGS and landowners with a high-resolution topographic digital elevation map, a digital surface model, and an orthophotomosaic to compare with previous maps and orthophotos and to serve as a baseline for comparison with future surveys. It will also provide an opportunity to test the mapping technology and evaluate its potential for assessing vegetation cover and habit, mapping details in wetlands such as small channels and mosquito ditches, and measuring the faces of steep bluffs.

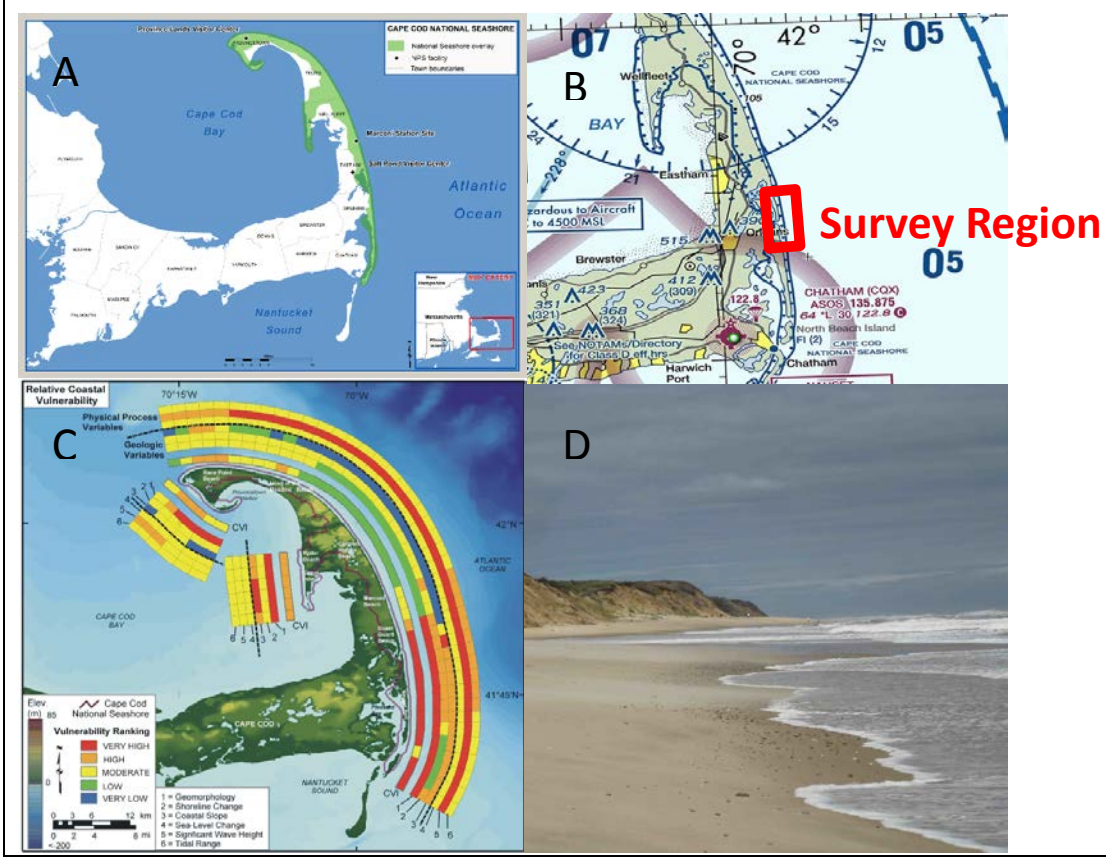
What kind of data do you need?

Our goal is to collect color digital photo imagery and ancillary data sufficient to create orthophotomosaics with resolutions of ~0.1 m and digital surface models (DSMs) and digital elevation maps (DEMs) with accuracy comparable to terrestrial lidar surveys (horizontal accuracy of 0.1 m and vertical accuracy of about 0.1 to 0.3 m). Ancillary data includes GPS coordinates and orientation of the camera and GPS fixes for ground-control points. Imagery will be collected during daylight hours during good weather.

Flight levels will be limited to <400 feet above ground levels. Target regions to be mapped are sandy beach environments with sparse vegetation. Portions of flights will be over water.

Area of interest (AOI):

The area of interest is the dynamic coastline in the southern portion of the Cape Cod National Seashore, the Towns of Chatham, Orleans, and Eastham, and the Monomoy National Wildlife Refuge. It includes sandy beach environments with sparse vegetation, dunes with grass and scrub, marshes, open water, and steep bluffs. Some of the broad area of interest lies within a five-mile radius of Chatham airport (CQX). Cape Cod National Seashore appears in green in Figure 1A, and Monomoy NWR extends south from the outer Cape. We are interested in establishing a rapid response program for this broad area of interest, but for the proof-of-concept study, we propose mapping four miles of coastline extending north 0.5 miles and south 3.5 miles from Coast Guard Beach (41.843163°, -69.945296°), outlined in red on the aviation charts (Fig. 1B). This AOI is about 4 km^2 and can be accessed by road at the north and south ends. As indicated on the Coastal Vulnerability Map (Fig. 1C), most of this coast is highly vulnerable. We proposes mapping in Autumn, when there are fewer visitors to the National Seashore, temperatures typically range from 40 to 60°F, winds are often light.



Personnel:

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Center name and location: USGS Woods Hole Coastal and Marine Science Center, Woods Hole, MA
Center Director: Walter Barnhardt, wbarnhardt@usgs.gov
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USGS collaborators: Rob Thieler, rthieler@usgs.gov (co-principal investigator)
Tommy O'Brien, Sawyer Stippa, Jon Borden, Sandra Brosnahan, Bill Danforth: USGS WHCMSC field and mapping technicians.

Support: The WHCMSC has can fully support field efforts in both marine and terrestrial coastal environments. The Center has several vessels including the jetyak and support equipment including trailers, a fleet of vehicles including a box truck that can double as a field office, a marine operations facility with electronics labs and machine and carpentry shops, and trained technicians. In addition, the Center has a full range of GIS, data management, and numerical modeling capabilities.

The Center can provide temporary office and work space for visiting UAS office personnel, transportation to field sites, and deployment of a GPS base station and ground-control stations.

Partners:

Technology Partner: Peter A. Traykovski, Associate Scientist w/ Tenure, Woods Hole Oceanographic Institution, Applied Ocean Physics & Engineering, 266 Woods Hole Rd, MS# 12, Woods Hole, MA 02543-1050, Office Phone: +1 508 289 2638, Fax: +1 508 457 2194, ptraykovski@whoi.edu
Support: Dr. Traykovski is a coastal and marine geologist with scientific experience in sediment transport and geomorphic evolution in shelf, estuarine, and nearshore environments, and technical expertise in acoustics and autonomous survey vessels (jetyak). He is also a UAS hobbyist with experience in flying rotary wing UAS and generating maps and mosaics using SfM software. He will collaborate scientifically and provide technical advice.

Landowners: Cape Cod National Seashore (CACO), Monomoy National Wildlife Refuge (MNWR), Towns of Chatham, Eastham, and Orleans. CACO and MNWR are open to requests for UAS research operations and gave us permission to submit this proposal. Research permits will be required prior to mapping, and we are working with NPS and FWS to obtain the necessary permits. The towns of Orleans and Chatham have informally approved this proposal, and we will obtain written permission from any towns in the AOI before mapping.

USSG Mission Area alignments

Our proposal results would contribute towards the goals of the following Mission Areas (check applicable):
☒ Climate and Land Use Change ☐ Core Science Systems ☒ Ecosystems
☐ Energy and Minerals, and Environmental Health ☒ Natural Hazards ☐ Water
(Natural Hazards is primary mission area)
May we share your proposal with the Associate Directors for the Mission Areas you checked above?
☐ No ☒ Yes