Environmental Studies Program: Ongoing Study

Title	Shallow-water Geophysical Mapping by Autonomous Underwater Vehicle(s): Feasibility Assessment, Field Techniques, and Best Practice (MM-21-01)
Administered by	Marine Minerals Program
BOEM Contact(s)	Shannon Cofield (shannon.cofield@boem.gov); Geoffrey Wikel, (geoffrey.wikel@boem.gov); Jeff Waldner (jeffrey.waldner@boem.gov)
Procurement Type(s)	Firm-fixed price contract under ID/IQ
Conducting Organization(s)	BOEM and Aptim
Total BOEM Cost	$125,345
Performance Period	FY 2021–2023
Final Report Due	February, 2023
Date Revised	August 25, 2021
PICOC Summary	
Problem	BOEM routinely funds shallow-water (order 10-30 m) geophysical mapping related to the identification and use of OCS sand and sediment resources in beach nourishment and coastal restoration projects. Traditional vessel-basedsurveying can be expensive and subject to scheduling and weather constraints, positional accuracy problems, and data quality issues. Recent advances in autonomous underwater vehicles (AUV) and geophysical sensor payloads can increase survey productivity, introduce cost savings, and minimize some environmental impacts. However, the technology, especially simultaneous deployment of multiple AUVs, has not been fully tested for scalability in shallow-water settings. This study will examine whether new AUV technology enables BOEM to accomplish its mission with increased productivity, faster response time, reduced cost, greater scale, equivalent or better data quality, and different environmental impact.
Intervention	This study proposes multiple phases of investigation to assess, test, and validate the viability of deploying commercially available AUVs for shallow-water geophysical mapping.
Comparison	The first phase proposes a desktop feasibility assessment and cost comparison of AUV deployment with traditional vessel-based surveying. Thesecond phase (if warranted) will compare data collected via AUV and traditional methods in the same study area using similar acquisition parameters.
Outcome	If successful, the study will address advantages and disadvantages (includingcost and productivity trade-offs) of geophysical mapping from single or multiple AUV deployment. The third phase of the study may result in a best practice protocol for AUV-based acquisition.
Context	Atlantic OCS. Potential implication for other OCS regions.

BOEM Information Need(s): AUV technology makes for an attractive proposition to improve the productivity and cost-effectiveness of recurrent reconnaissance-scale and design-level (or project-scale) geophysical surveys already being performed using vessels. Although the Marine Minerals Program and Environmental Studies Program have successfully deployed a passive, autonomous wave-glider to track acoustically-tagged animals in the Atlantic coastal ocean, there is less proof-of-concept for AUV geophysical mapping in shallow waters. AUV use in shallow water (order 10-30 m) is particularly challenging because of operating conditions and frequent downtime. Traditional towed-sensor surveying can be logistically challenging, can be susceptible to data quality problems from vessel noise and swell effects, and can contribute to different environmental impacts. BOEM needs to thoroughly assess trade-offs and feasibility of using AUVs for reconnaissance-scale geophysical surveys used to map sand resources, delineatehabitat, or otherwise characterize the environment that are funded by the government.

Background: Advanced AUVs can be outfitted with various electromechanical and other geophysical sensor payloads (e.g., high-frequency chirp sonar, multibeam sonar, side scan sonar, experimental magnetometer; high-definition video) critical to seafloor mapping applications (Wynn et al., 2014). AUVs have been deployed for the study of geologic framework (<100-200 m sub-seafloor), seafloor morphology and morphodynamics, benthic habitats, shipwrecks, and seafloor hazards, including unexploded ordnance and pipelines (e.g., Smale et al., 2012; Campbell et al., 2015; Trembanis et al., 2019).

AUV use in deep-water, beneath ice, and other extreme environments is routine and considered optimal since vehicles fly at a relatively low altitude over the seabed and collect data at improved resolution. However, use in shallow-water environments is more challenging because of dynamic conditions, such as vehicle draft, endurance (i.e., payload vs. power requirements), and navigation in the presence of surface waves and strong coastal currents, variable ensonification swath in varying water depths, and risk of collision and entanglement. Near real-time data recovery, data processing, and data quality control and management are also important factors to consider.

New advances in on-board, artificial intelligence have the potential to substantially improve the range, reliability, and flexibility of AUVs or ASVs for shallow-water application. That is especially true if multiple AUVs/ASVs can be deployed in concert on pre-programmed courses and potentially recovered every 24 hours of deployment in the case of high-endurance vehicles. Promising technology is also coming online for high-bandwidth transmission of data directly from AUVs/ASVs to mothership, and from mothership to shore-based facilities; that combination allows for near real-time data review and survey optimization.

Objectives:

1. Through a market assessment, address the feasibility of single and multiple AUV/ASV geophysical mapping in the shallow-water environment and evaluate trade-offs with existing vessel-based methods.
2. Provide a technology overview to include current technology availability, capabilities, and proper applications for shallow-water geophysical surveys.
3. Based on market research and technology, identify parameters that need to be addressed in a field acquisition plan, and develop a sample field acquisition plan.
4. Compare AUV/ ASV instrument performance with traditional vessel-based instrument performance.

Methods: The study would be pursued in three phases; each successive phase would depend and build on the results of the prior one. The first phase involves a desktop study, including an assessment of the availability and reliability of AUV technology, costs, and acquisition protocols,including environmental impact considerations. Provided promising results from the desktop assessment, the second phase would involve a field campaign in the Atlantic OCS. That phase would involve the deployment and testing of a single AUV and/or multiple AUVs with the geophysical payload of interest, as well as acquisition of vessel-based geophysics in the same footprint using similar operating parameters. Data quality and survey requirements, duration, and costs would be compared. Depending on available budget, the second phase may include sound source monitoring to improve our understanding of potential environmental impacts, including transmission loss of ultra-short baseline (USBL) acoustic communication systems. Thethird phase would be pursued if the results of the second phase demonstrated technical and economic viability. The third phase would develop a best practice guide for planning and conducting AUV geophysical surveys in shallow water environments, a guidance similar in nature to Fugro (2017).

Specific Research Question(s):

1. Are advanced AUV surveying capabilities a technical and economic alternative to traditional vessel-based surveying methods in shallow water environments?
2. Does specialized AUV equipment or protocols need to be developed, or can commercial-off-the-shelf equipment work?
3. What are the data quality and cost implications of this methodology?

Publications Completed: None

Current Status: AUV/ ASV study was recently issued as Task Order 2 under the ID/IQ to Aptim in August 2021.

Affiliated WWW Sites: None

References:

Journal article:

Campbell, K., Kinnear, S., and Thame, A. 2015. AUV technology for seabed characterization andgeohazards assessment. *The Leading Edge*, 34(2), 170-177.

Smale, D., Kendrick, G., Harvey, E., Langlois, T., Hovery, R., Van Niel, K., Waddington, K., Bellchambers, L., Pember, M., Babcock, R., Vanderklift, M., Thomson, D., Jakuba, M., Pizarro, O., and Williams, S., 2012. Regional-scale benthic monitoring for ecosystem- based fisheries management using an autonomous underwater vehicle. *ICES Journal of Marine Science, 69(6), 1108-1118.*

Trembanis, A., Abla, A., Haulsee, K., and DuVal, C., 2019. Benthic habitat morphodynamics – using remote sensing to quantify storm-induced changes in nearshore bathymetry and surface sediment texture at Assateague National Seashore. *Journal of Marine Science and Engineering*, 7(10), 1-30.

Wynn, R., Huvenne, V., Le Bas, T., Murton, B., Connelly, D., Bett, B., Ruhl, H., Morris, K., Peakall,J., Parsons, D., Sumner, E., Darby, S., Dorrell, R., and Hunt, J., 2014. Autonomous Underwater Vehicles (AUVs): their past, present, and future contributions to the advancement of marine geoscience. *Marine Geology*, 352, 451-468.

Technical report:

Fugro Marine GeoServices, Inc., 2017. Geophysical and geotechnical investigation methodology assessment for siting renewable energy facilities on the Atlantic OCS. U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Sterling, VA. OCS Study BOEM 2017-049.