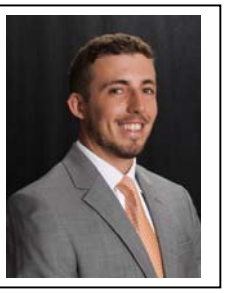
Geotechnical Investigation of Bivalve-Sediment Interaction with Regard to Bivalve Farms as a Self-Sustained Scour Mitigation Method



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Sponsor: National Science Foundation (NSF)

Start/Completion Dates: July 2018 / July 2020

Project Background

Scour around underwater foundations is a major concern for bridge failures. Traditional scour mitigation designs often significantly over-predict erosion and make scour the controlling factor for embedment depths or scour mitigation actions, which can substantially increase construction costs. Bivalves (oysters, mussels, etc.) can withstand high flow events such as floods without dislodgement and may represent a viable means to decrease sediment erodibility in scour-prone areas. Since bivalve colonies can adapt to changing local flow regimes, they provide a self-sustainable scour protection.

Project Objectives

The focus of this research is on the geotechnical aspects of bivalve-sediment interactions as it relates to sediment strength and erodibility. More specifically, the following objectives are pursued:

1. Characterize the morphology of existing bivalve colonies through both remote sensing surveying techniques and direct field measurements. This includes assessments of observed sediment erosion and/or deposition patterns in the vicinity of studied bivalve colonies.
2. Compare traditional scour protection measures to bio-engineered mitigation methods for simulated scour events based on realistic flow regimes.
3. Use geotechnical laboratory testing to quantify the change in shear strength and erodibility of representative material with and without the presence of bivalve adhesive protein mixed in with the sediment.
4. Investigate the conditions required to dislodge bivalve individuals and colonies from the soil(s).

Research Plan and Progress

This research consists of three broad phases. Each phase is described in detail below. Work completed to date is listed in italics following the description of each task in the phase.

<u>Phase 1: Field Observations</u>

- Perform field surveys of known oyster colonies in the Piankatank River. (This river feeds into the Chesapeake Bay on the east cost of Virginia.) Use remote sensing techniques such as the rotary side scan sonar and chirp sonar (a sub-bottom profiler) to image the riverbed in the vicinity of bivalve colonies and characterize their backscatter intensity signatures. Collect grab samples of the nearby surface level riverbed sediments for laboratory testing. Supplement the strength testing of the grab samples by deploying a portable free fall penetrometer (PFFP) onsite. *One field survey completed. Future field surveys in the same area are planned.*

- Carry out field surveys in the Northwest Arm of Sydney Harbor in Nova Scotia, Canada before and after the placement of shale and shell fragments meant to help re-establish scallop populations. Deploy the PFFP in strategic areas and obtain hand-pushed core samples (via diving) of the clayey harbor bed material. *One field survey completed. Future field surveys in the same area are planned.*
- Conduct field surveys at the Rachel Carson Reserve near Beaufort, North Carolina. Use instrumentation similar to that used in the Piankatank River. Characterize erodibility of soils in areas with and without the presence of bivalve colonies by performing in-situ jet erosion tests with a large-scale JET device. *The project collaborators visited the Reserve for a site reconnaissance and begin the permitting process needed to perform the intended field survey.*

Phase 2: Laboratory Testing and Data Processing

- Perform particle size distribution testing of collected samples. *In progress.*
- Determine the shear strength of sediments containing mussel adhesive protein (MAP), a synthetic replica of natural bivalve adhesive proteins, by performing triaxial shear, shear box, and direct shear testing on samples with and without MAP coatings. *To be performed.*
- Utilize the small-scale jet erosion device to quantify the impact of MAP on in-situ sediment shear behavior and erodibility. *To be performed.*
- Process sonar data and underwater camera footage from field surveys to reconstruct observed bivalve morphologies and flow environment. *In progress.*
- Reduce PFFP data to establish spatial strength variabilities for the areas studied and determine the sediment's ability to withstand loads. *In progress.*

Phase 3: Numerical Simulations and Preparation of Publication

- Following field surveys, data processing, and laboratory testing, create numerical models and simulations of a self-sustaining scour protection system using bivalves. Incorporate bivalve dislodgement characteristic findings from the large-scale JET device into the numerical models.

This research project is being conducted with collaborators at the Virginia Institute of Marine Science (VIMS), North Carolina State University (NCSU), and the Technical University of Darmstadt (TUD) in Germany.