# Potential for sea bed munition transport due to turbulent prop wash

MR24-4560

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University of Delaware

In-Progress Review Meeting

1/15/2026

# Project Team: PI and co-PI

Specialty in experimental fluid mechanics---specifically underwater **propulsion** and **turbulence**.

**Tyler Van Buren**
*University of Delaware*
*Mechanical Engineering*

Specialty in coastal fluid mechanics--specifically **sediment transport** and **munitions mobility.**

**Jack Puleo**
*University of Delaware*
*Civil, Construction, and Environmental Engineering*

# Project Team: students

**Chinoye Agadi**

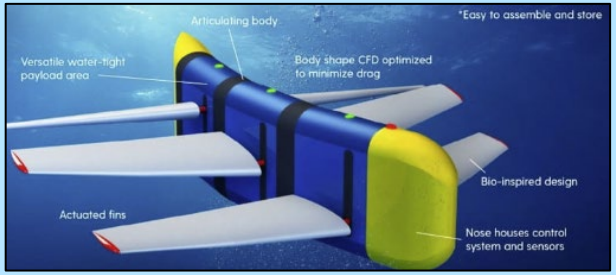
*Graduate (Ph.D.)*

Topher Swanson

M.C.E Student

# Project Team: lab background

## Bioinspired design




## Flow control









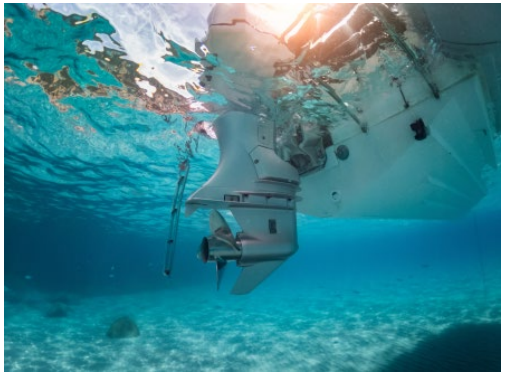

## Turbulence + stuff

# Bottom Line Up Front

- **What technology or methodology is being evaluated during this demonstration?**
  - We are studying the impact of the turbulent wakes of traditional propeller based propulsors with on the sediment bed in shallow water environments and the potential for munitions transport due to these processes.
- **What's been going well?**
  - All three study environments (laboratory water tunnel, small-scale sediment pool, full-scale field testing) of the project have been set up and studies are either underway or planned.
- **What's not working?**
  - Unexpected equipment delays led to subsequent project delays
- **What support do you need?**
  - I appreciate your patience as I learn more about SERDP-specific funding processes!

# Plain Language Summary

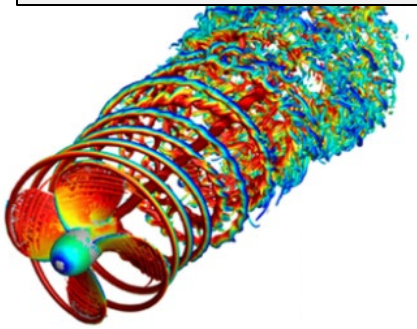
- Underwater unexploded ordnance (a.k.a., munitions) may exist in up to 450 sites across the US, many are ports and military vessel berthing sites.
- With small, mid, and full-scale testing we can better understand how propellers lead to munition mobility
- Outcomes include:
  - simplified model of propeller wakes for sediment suspension prediction;
  - guidelines for transport in shallow-water areas;
  - statistical likelihood of munition mobility

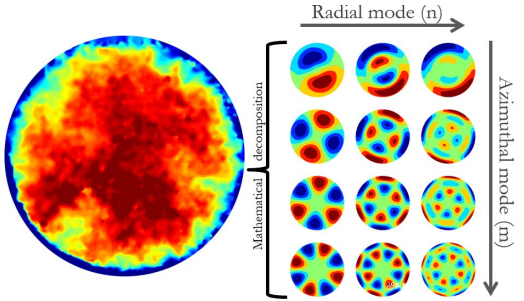


# Technical Objective

Our aim is to determine the impact that maneuvering propeller-driven vessels have on the transport of sediments and munitions resting on, or just underneath, a local sediment bed.

Understand turbulent propeller wake's sediment suspension mechanisms






Tie coherent wake structures to sediment suspension and munition mobility

Bench-top and mid-scale laboratory tests, with full-scale field tests, validate our models



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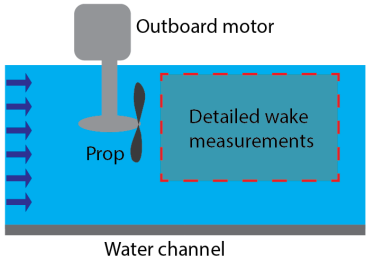
# Technical Approach

**Prep:** Purchase equipment; hire and train researcher; assemble new facilities; fabricate experimental models; build experiments; site planning visits.

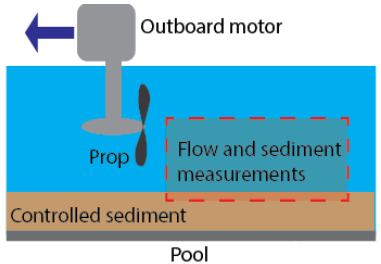
## Water channel experiments

1. Install motor and calibrate equipment.
2. SPIV experiments downstream of a propeller at various rotation speeds.
3. Data analysis and task inform



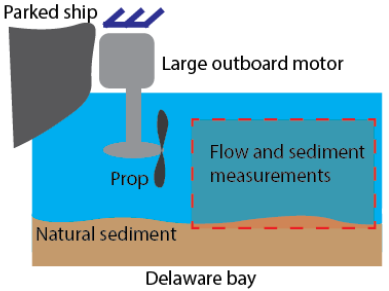

## Sediment pool experiments

1. Install motor and gantry.
2. Measure sediment deformation and munition transport after a passing propeller at various RPM and floor spacing.
3. Data analysis and task inform




## Field measurements

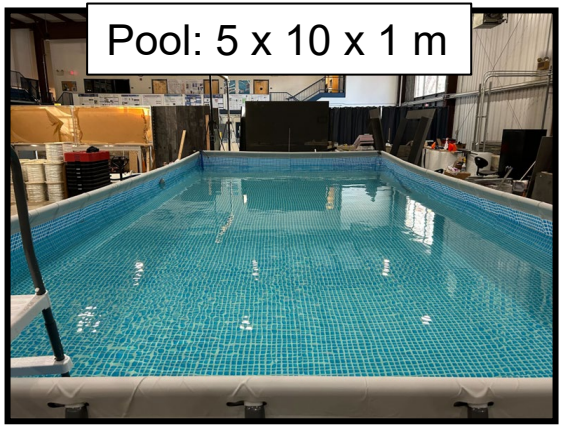
1. Install measurement equipment
2. Measure sediment deformation and munition transport after propeller at various RPM and time.
3. Data analysis and task inform



# Technical Approach: facilities and measurement devices

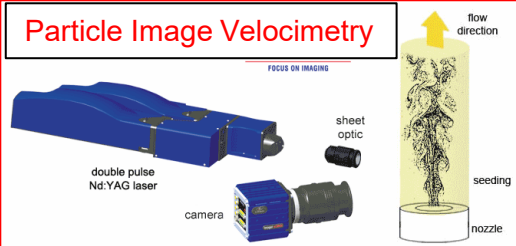
Water channel: 1x1x4 m

Pool: 5 x 10 x 1 m



Delaware bay inlet


Particle Image Velocimetry

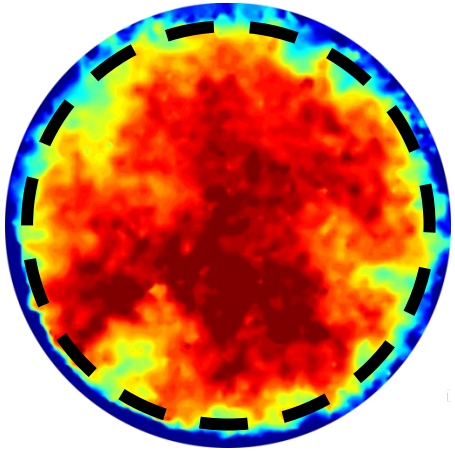



Turbidity sensors

Profiling sonar

# Results: decomposing axisymmetric turbulent flows

Instantaneous streamwise velocity



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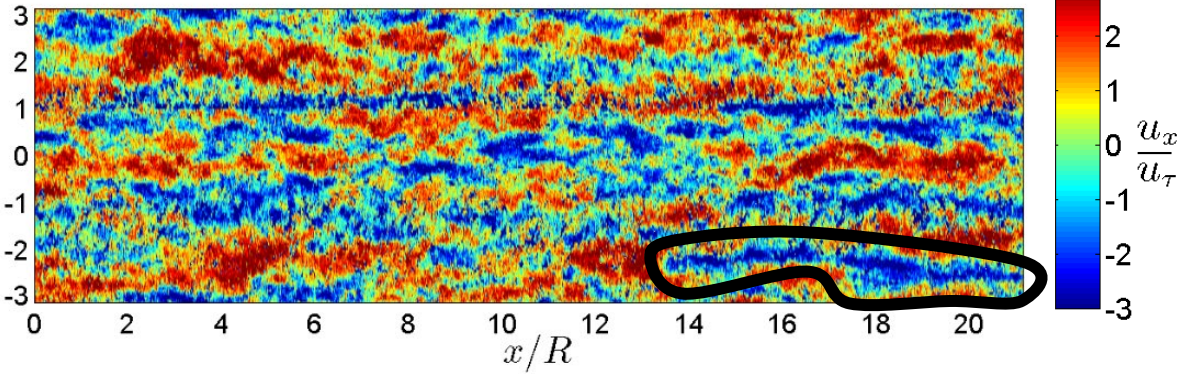
$\frac{s}{R}$

Instantaneous streamwise velocity fluctuations



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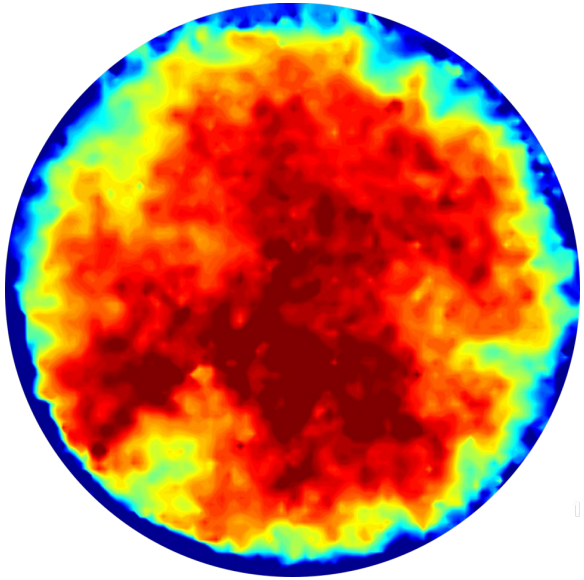
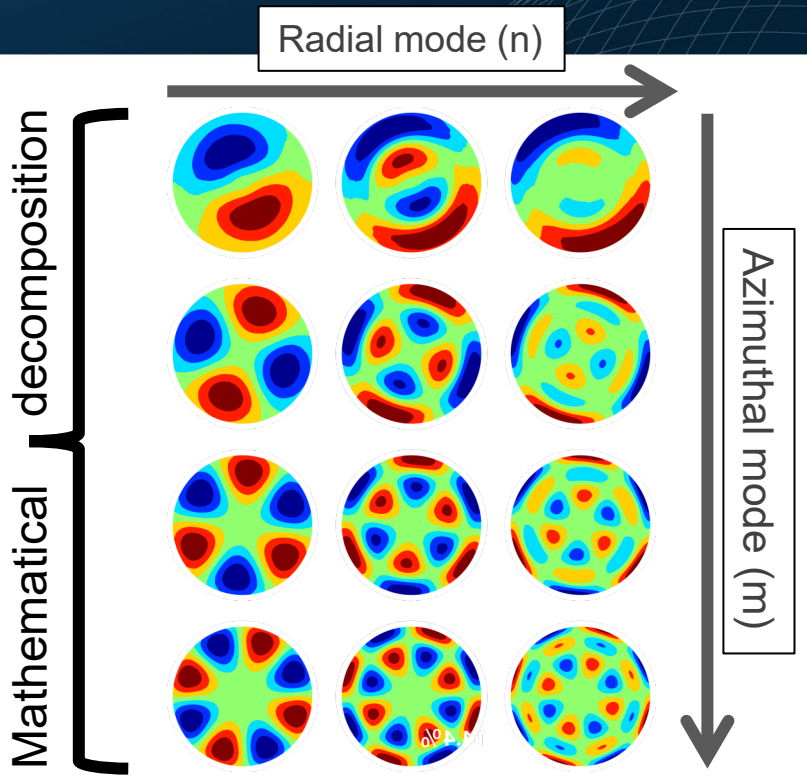
# Results: decomposing axisymmetric turbulent flows

Instantaneous streamwise velocity





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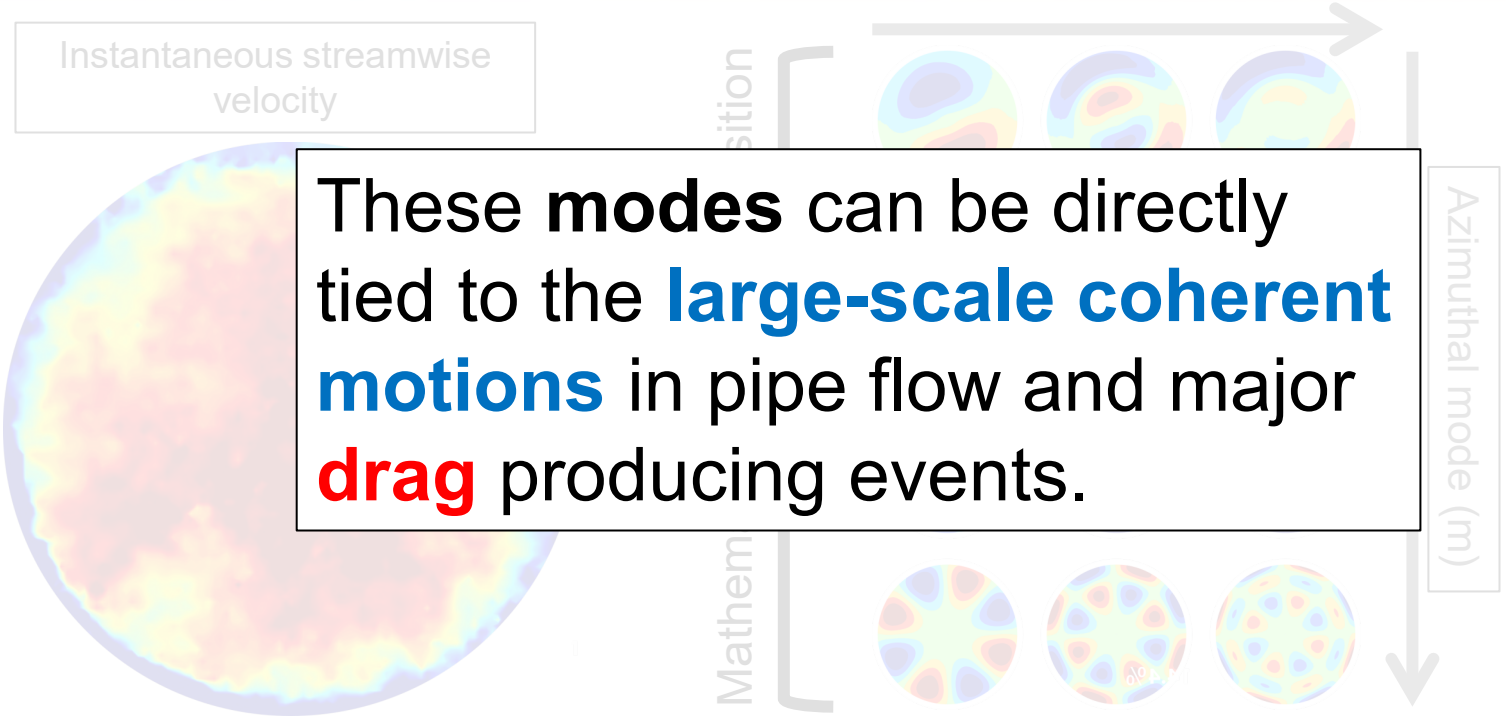
# Results: decomposing axisymmetric turbulent flows




These **modes** can be directly tied to the **large-scale coherent motions** in pipe flow and major **drag** producing events.



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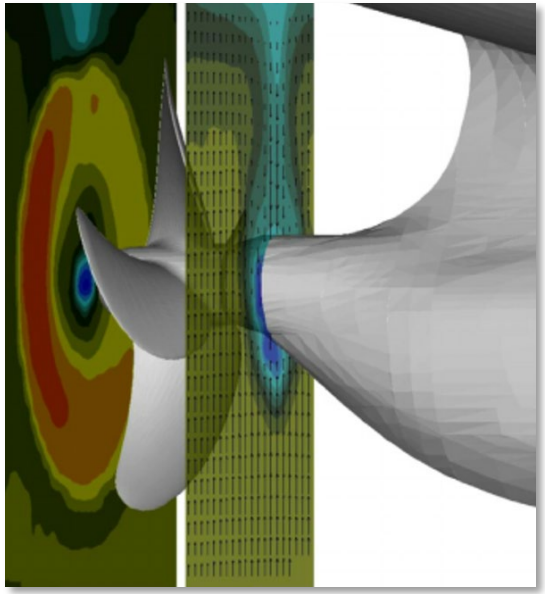
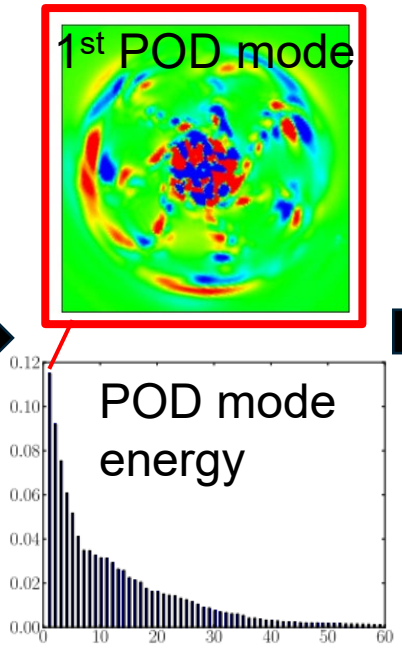
Can we do the same with **propeller wakes**--- correlate simple **mode** structures to **sediment suspension** and **munition mobility**?



*Di Felice, 2004*



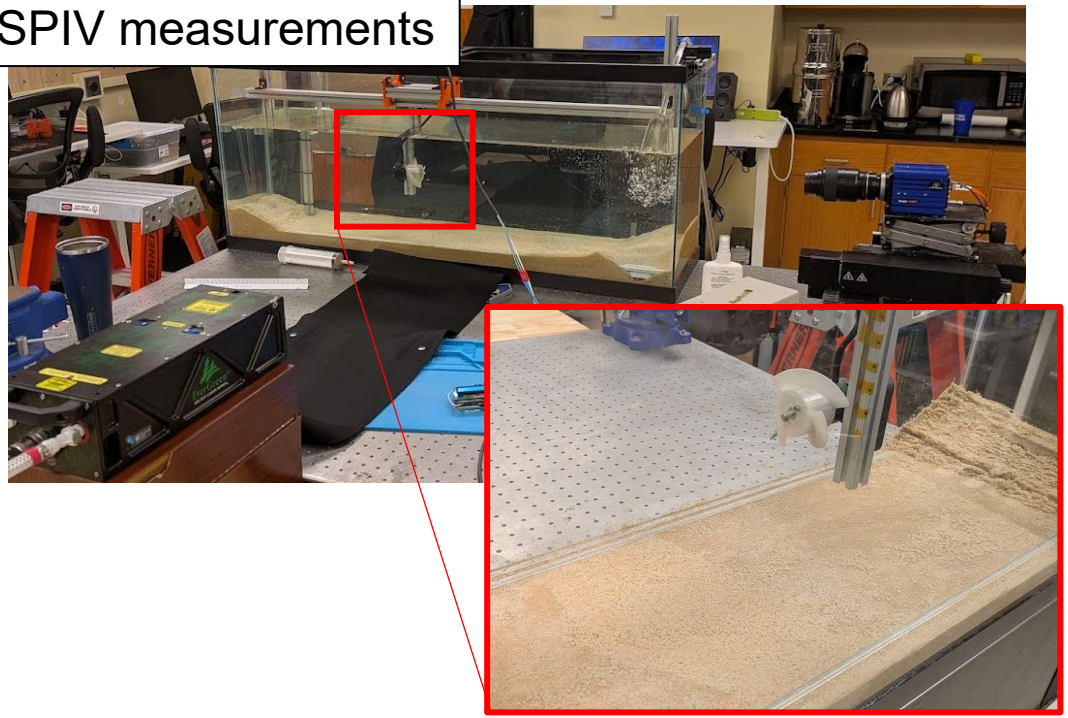

*Liefvendahl et al., 2010*

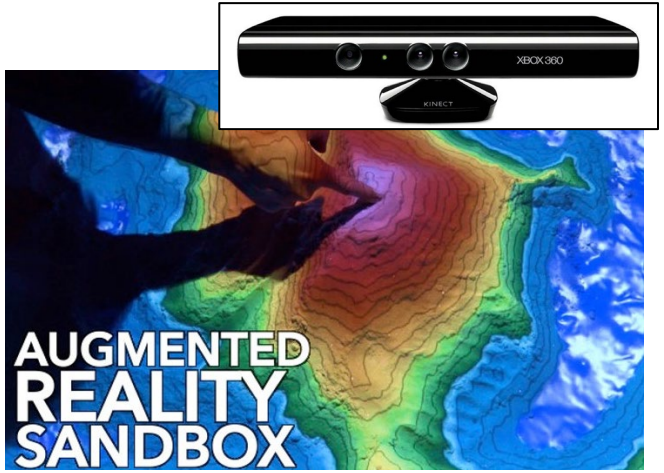
*Titanic, the movie*

(towards)

# Results: benchtop testing

SPIV measurements






Sediment deformation



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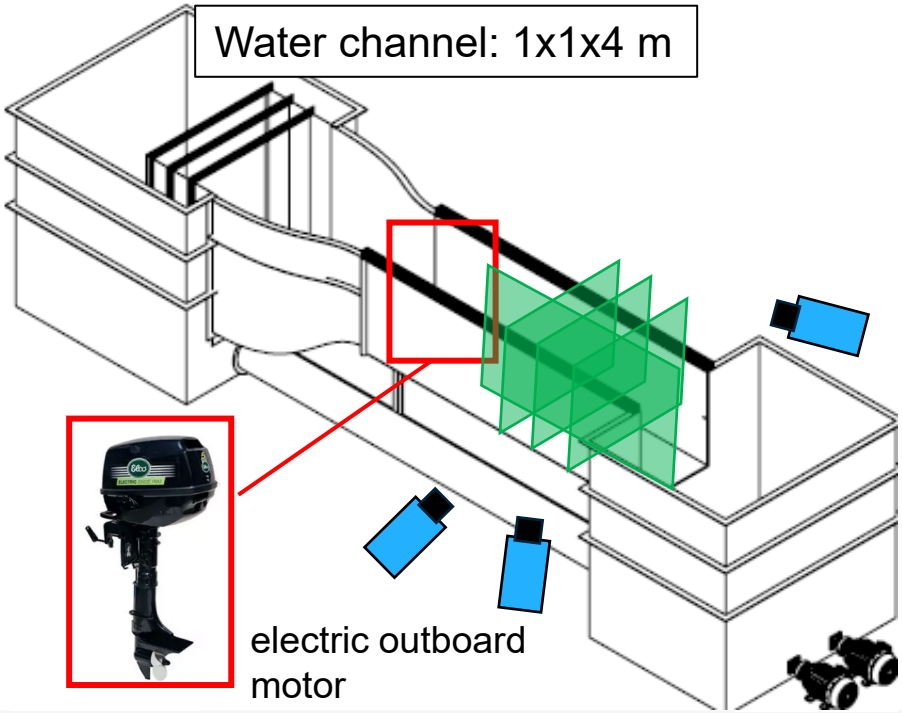
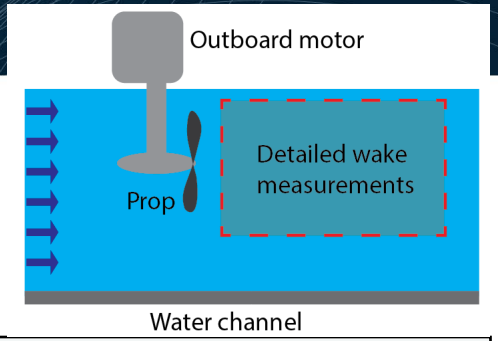
# Results: water channel experiments




- Varying motor strength and flow velocity.
- Measure wake downstream using SPIV, specific decomposition analysis.
- Informs sediment bed tests (what characteristics of the prop lead to sediment and munitions transport.



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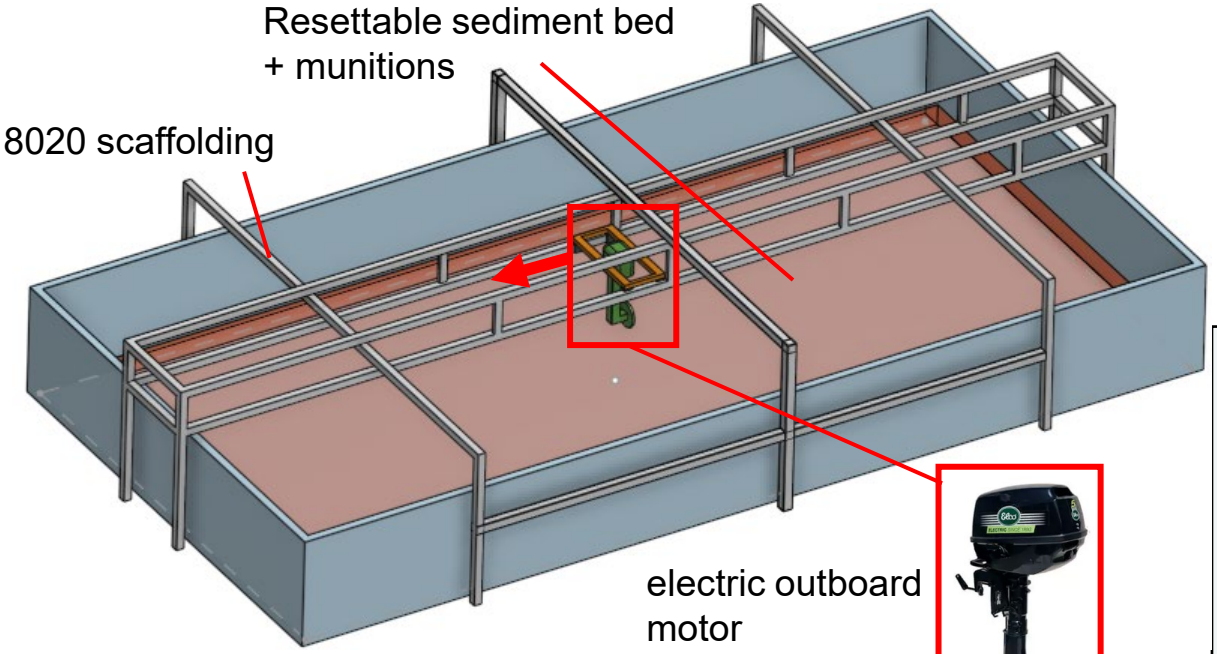
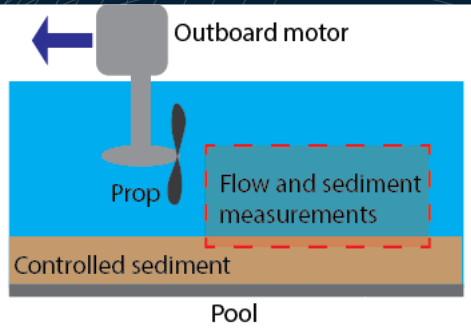
# Results: pool tests




Pool: 5 x 10 x 1 m




- Varying sediment type, layer height, motor strength, motor height, pass frequency.
- Measure turbidity, sediment deformation, munition mobility.
- Informed by water channel tests and inform field tests.



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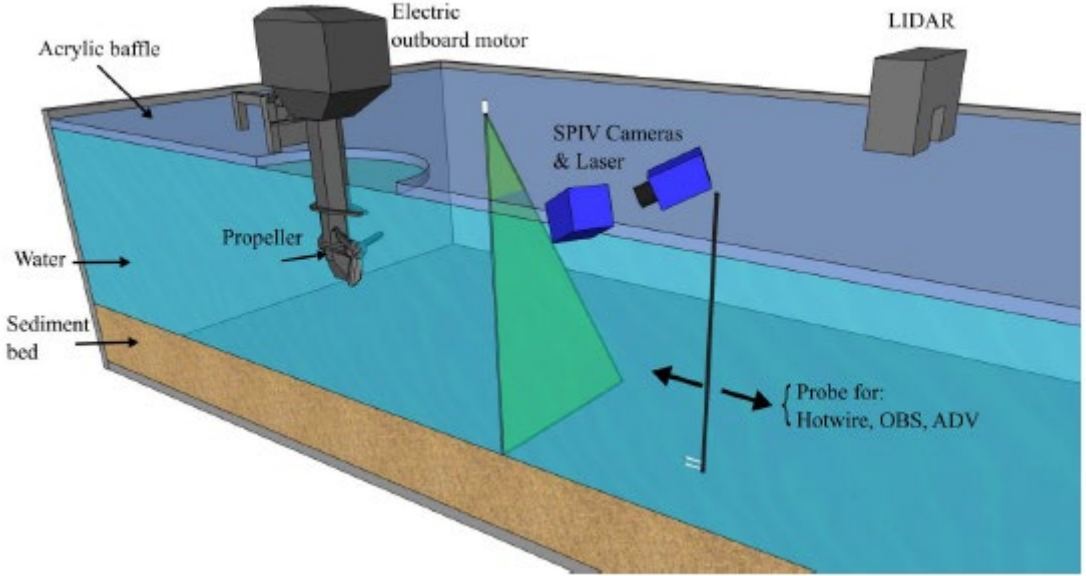
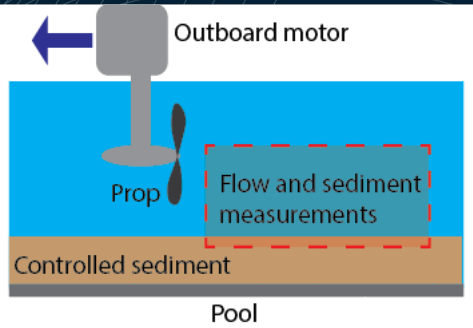
# Results: pool tests




- Varying sediment type, layer height, motor strength, motor height, pass frequency.
- Measure turbidity, sediment deformation, munition mobility.
- Informed by water channel tests and inform field tests.



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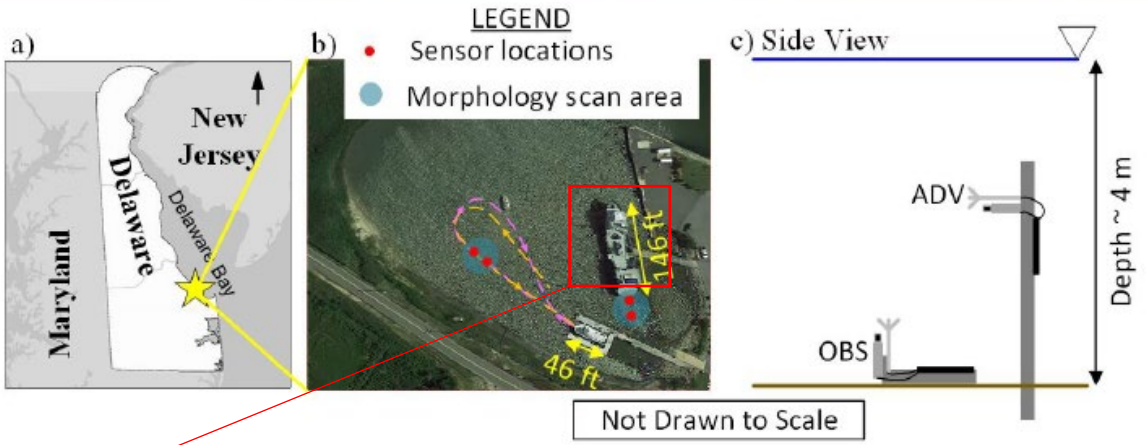
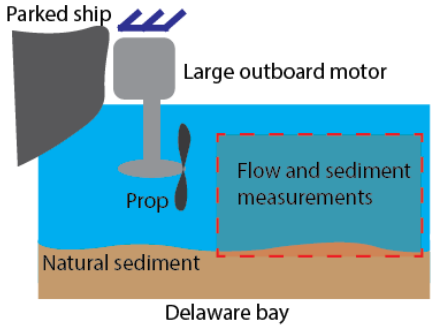
# Results: field tests




- Varying motor strength, thrust duration, water depth.
- Measure turbidity, sediment deformation, munition mobility.
- Informed by water channel and pool tests.



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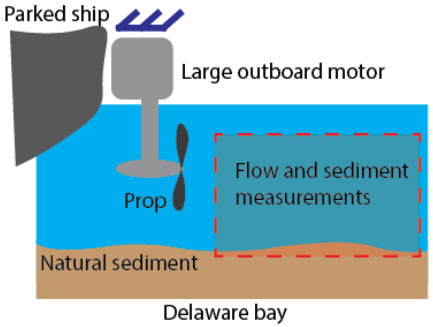
# Results: field tests


- Varying motor strength, thrust duration, water depth.
- Measure turbidity, sediment deformation, munition mobility.
- Informed by water channel and pool tests.



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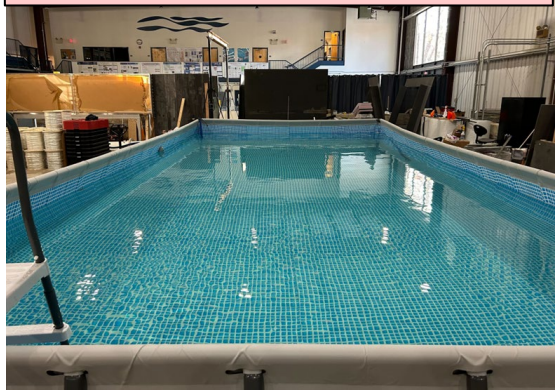
# Results: setbacks

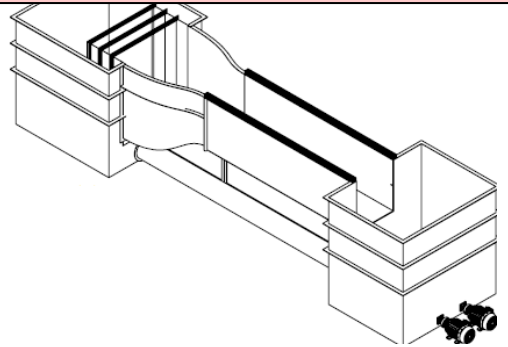
12 weeks added to lead time

Profiling sonar

Purchased, not delivered, repurchased



Test section alteration needed: limited availability



Resolutions: for all three, we altered the timeline to accommodate delays and still meet deliverables. Added personal to expedite data acquisition. Reserved back-up equipment/facilities.

# Future Research

- Over the next sixth months, we will...

**Water channel**

- Detailed wake measurements using SPIV
- POD data analysis
- Date range: March – May 2025

**Sediment pool**

- Finish construction
- Sediment transport and munition mobility tests
- Date range: January – February 2025

**Field tests**

- Three field test sessions
- Sediment deformation and munition mobility tests
- Date range: April-June 2025

- Approximate spend: 65% budget

# MR24-4560: Potential for sea bed munition transport due to turbulent prop wash

**Performers: Tyler Van Buren, Ph.D.; Jack Puleo, Ph.D.; University of Delaware**

## Technology Focus

- *Utilizing modern data decomposition techniques to model propeller wakes and their impact on sediment dynamics and potential for munition mobility.*

## Research Objectives

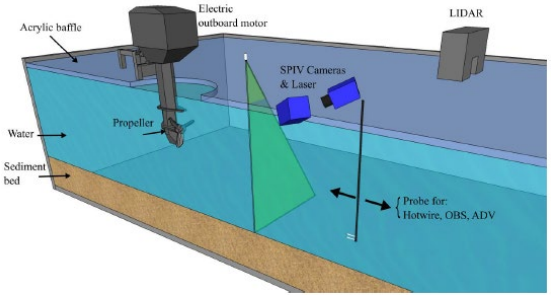
- *To better understand what features of propeller wakes lead to sediment suspension, and how this sediment suspension can result in munition dynamics in harbors. Includes a range of scales from benchtop, water channel, pool, and field testing.*

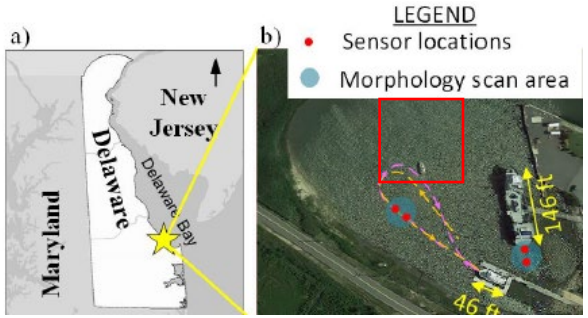
## Project Progress and Results

- *All the equipment for the project has been purchased and facilities are mostly constructed. Experiments are underway and students on the project are trained and performing. Despite setbacks of equipment delays, we are poised to obtain all the results within the project timeframe.*

## Technology Transition

- *Reduced order models will allow us to determine best pathing and operational conditions to limit munition mobility in application. May identify propeller features that deter sediment suspension and identify new propulsion technologies less prone to sediment suspension.*



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# Impact to DoD Mission

- What's the most impactful thing that's happened since the last time you presented your work to us?

  Constructed facilities for novel studies on the interaction of propeller wakes with sediment beds and munitions. Initiated a wide-range of experiments from benchtop, to mid-scale, to full-scale field tests.

- Why is this important?

  Underwater unexploded ordnance (a.k.a., munitions) may exist in up to 450 sites across the US, many are ports and military vessel berthing sites. Understanding their mobility due to sea traffic is imperative.

- How is your project advancing DoD capabilities?

  Developing reduced order models correlating propeller operation to sediment suspension and munition mobility. Identifying new technologies for shallow-water transport less impactful on munitions.

# Literature Cited


- Yu, Duo, et al. "Influence of Load Conditions on the Propeller Wake Evolution." *Journal of Marine Science and Engineering* 11.9 (2023): 1674.
- Guarnieri, A., et al. “Effects of marine traffic on sediment erosion and accumulation in ports: a new model-based methodology”, Ocean Sci., 17, 411–430.
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- Liefvendahl, M., M. Felli, and C. Troëng. "Investigation of wake dynamics of a submarine propeller." Proceedings of the 28th Symposium on Naval Hydrodynamics, Pasadena, CA, USA. 2010.
- Reed, Sarah E., et al. "Shaping watersheds exhibit: An interactive, augmented reality sandbox for advancing earth science education." AGU Fall Meeting Abstracts. Vol. 2014. 2014.

# Thanks! Questions?

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