EVALUATING THE HYBRID MOBILE SURVEY METHOD (HMS) FOR TIDAL ENERGY RESOURCE ASSESSMENTS

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Sandia National Laboratories

Georgia Tech
Ocean Science & Engineering

umerc + OREC 2025

Today's Roadmap

Who I Am

Georgia Tech PhD student working on tidal energy

Why HMS?

Background & Motivation

Why traditional tidal resource assessment methods fall short for most small projects.

Field Deployment & Instrumentation

40-day fixed instruments (FI) + 3-day mobile vessel (MV) surveying

Quality Control & Data Processing

Cleaning, calibrating, and analyzing instrument data with MATLAB

Results: Velocity Structure & Trends

Flood vs ebb, shear, and key flow patterns

Next Steps

Linear Regression

Modeling & Applications

Background

IEC TS 62600-201 (1st Edition)

Direct measurement

- Minimum 90 days of in-situ velocity data at each Tidal Energy Converter (TEC) location
- Harmonic analysis: generate long-term velocity distributions

Hydrodynamic modeling

- 1-year minimum simulation & calibrated with real-world data

Focus: **Estimate Annual Energy Production (AEP) with acceptable uncertainty.**

Limitations

- Large commercial scale OR pilot projects

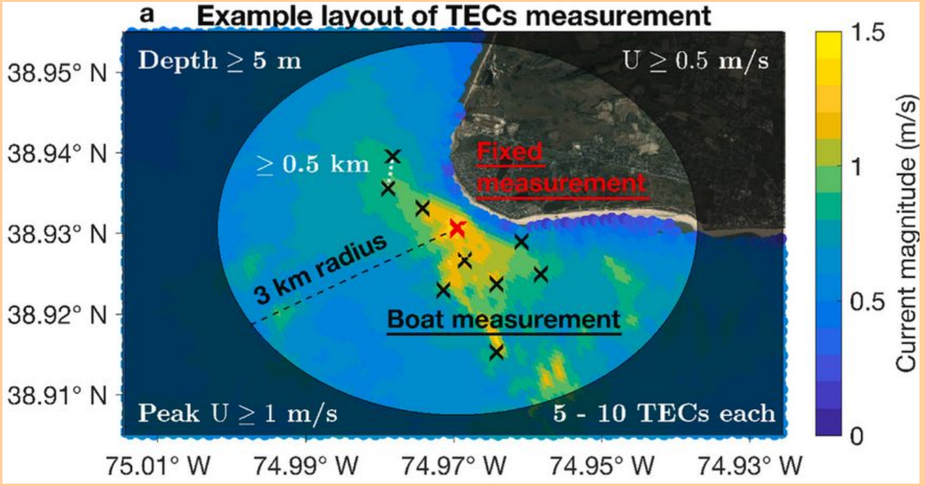
Xu et al. (2023)

Evaluated synthetic tidal records (14-196 days) over a 100-year span across multiple locations

- Direct AEP estimates from short periods
- Indirect methods: regression from fixed and mobile vessel measurements

Results:

- Essential to fully resolve multiple spring/neap cycles
- Hybrid method using FI and MV measurements
- **Short vessel-based surveys (HMS) can be effective if calibrated properly**



Xu et al. (2023)

Objective

Perform a field test of the Hybrid Mobile Survey method to be included in the forthcoming 2nd edition TS

Location: Savannah River, Georgia

FI 40-day deployment

- ADCP & Aquadopp (Adopp)
- October 21, 2024

MV Surveying

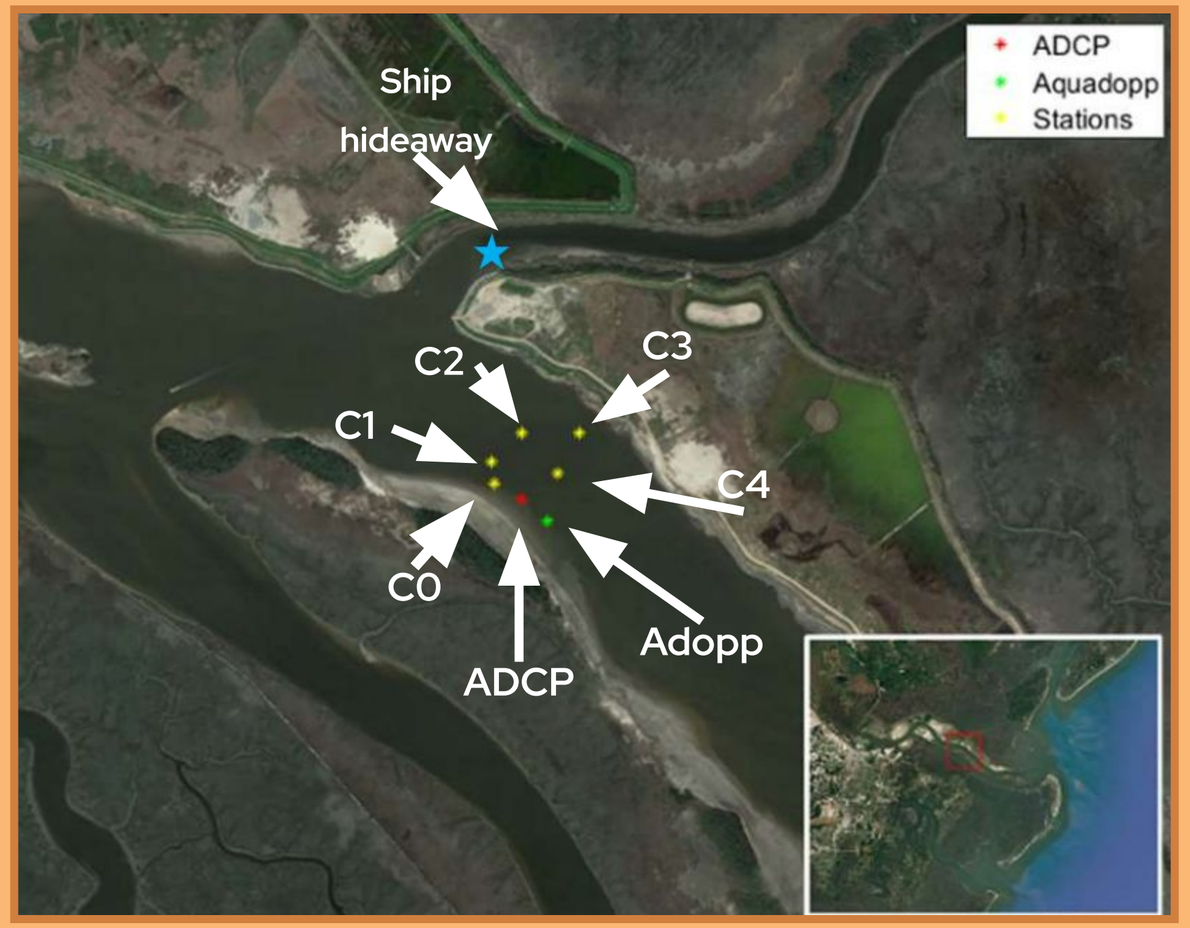
- 3-day ADCP
- October 22-24, 2024

6 TEC locations

- 5 locations chosen across river channel
- 1 marked location at Adopp

Cycles to each TEC location

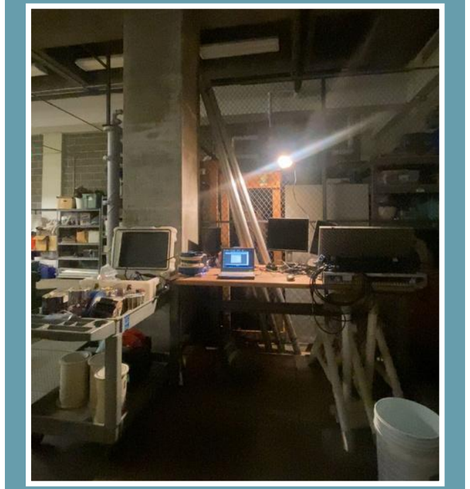
- 3-5 minutes of data recording
- Stay within 20m of TEC location
- Full TEC rotation: ~40-60 minutes



Field Overview & Timeline

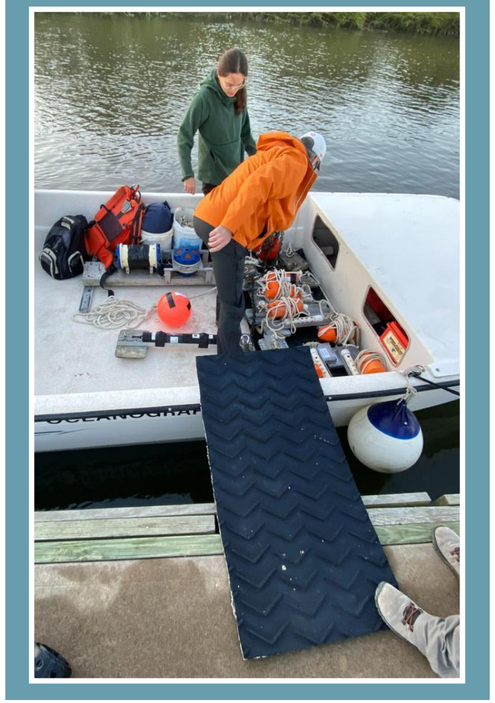
SEPTEMBER

Check and prepare instruments



OCTOBER

Deployment of 2 FI and 3-day MV surveying

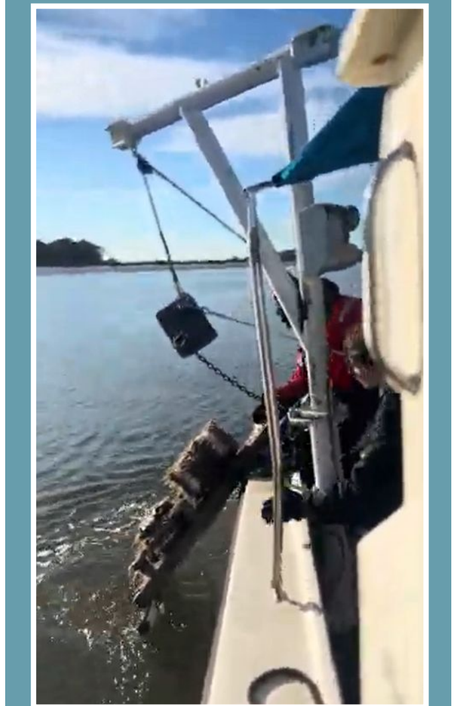


NOVEMBER

Sit patiently and hope the FI's are there in 40 days

DECEMBER

Retrieval of 2 FI's



Fixed Deployment & Instrumentation

October 21, 2024

FI Deployment Preparation

ADCP Workhorse

No divers permitted for deployment

Aquadopp

Testing HMS Method

3-Day Mobile Surveying - October 22-24, 2024

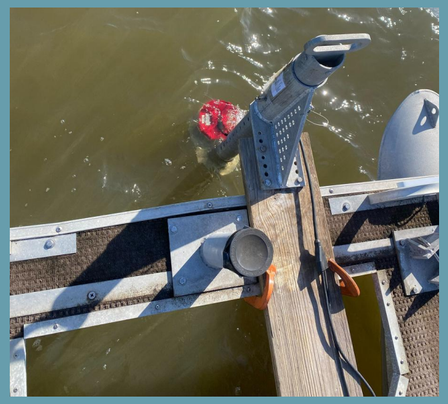
TEC Locations

- GPS tracking with Proflex 500
- TEC locations plugged into HUMMINBIRD
- Base station at Skidaway
- Vessel GPS Mapping (bow and stern)

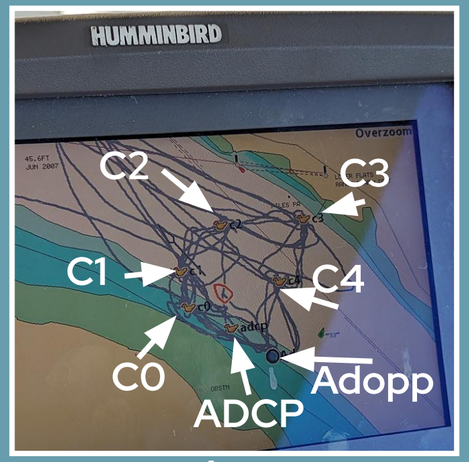
HMS Data Collection

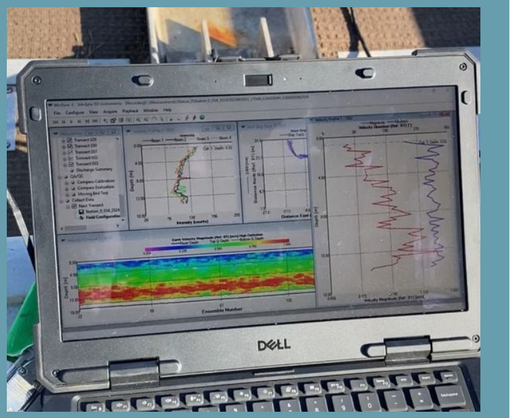
- 6 total Tidal Energy Converter (TEC) stations
  - 5 chosen across channel
  - 1 located at Adopp
- Get <= 20m of the TEC station
- Start vessel ADCP data collection
- Attempt to stay within 20m of station for 3-5 minutes
- Repeat

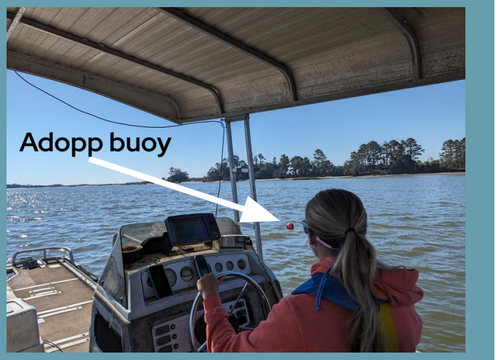
MV ADCP



Vessel ADCP Data Collection

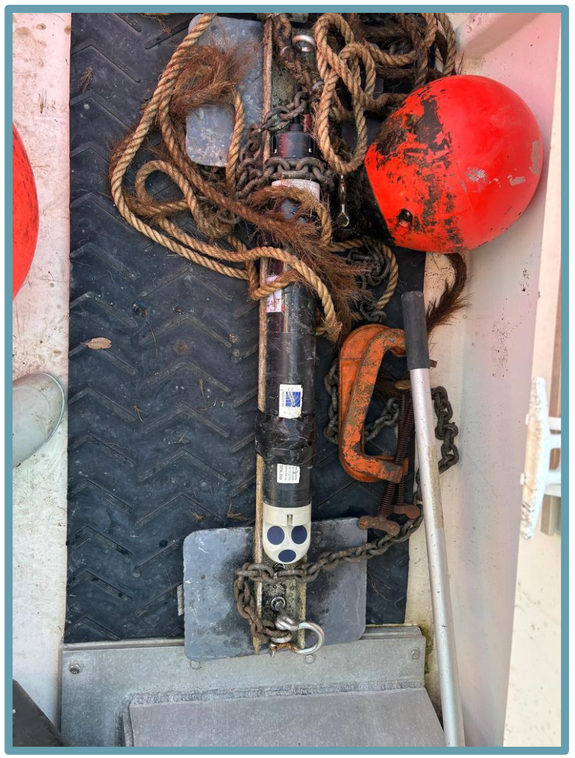






Instrument Retrieval

40-day deployment complete: December 2024



Raw Data Quality Control & Initial Observations

Data Recording & Organization

Bin Size

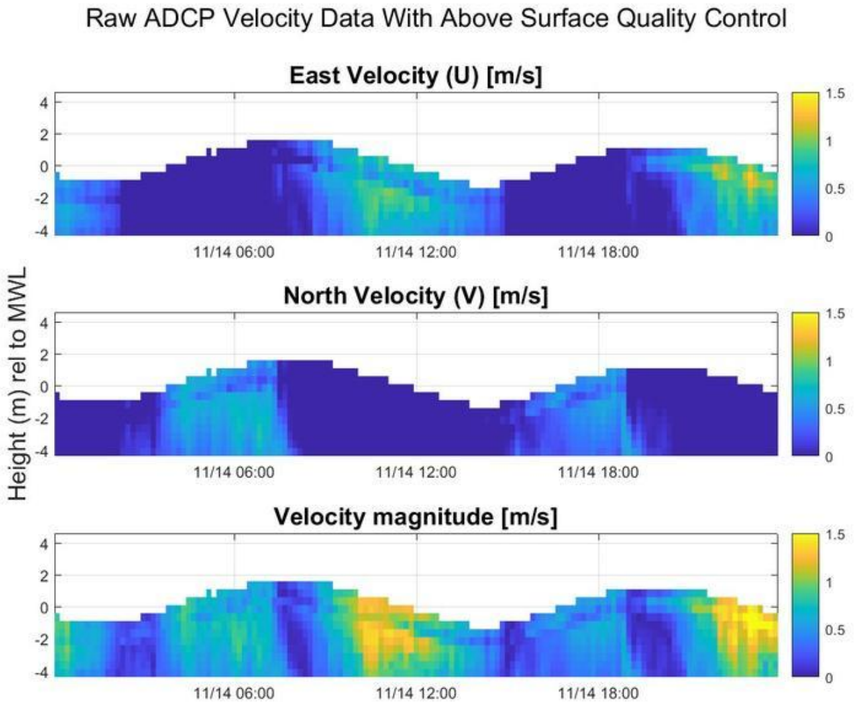
- Fixed: 0.5m (20 total)
- Vessel: 0.1m

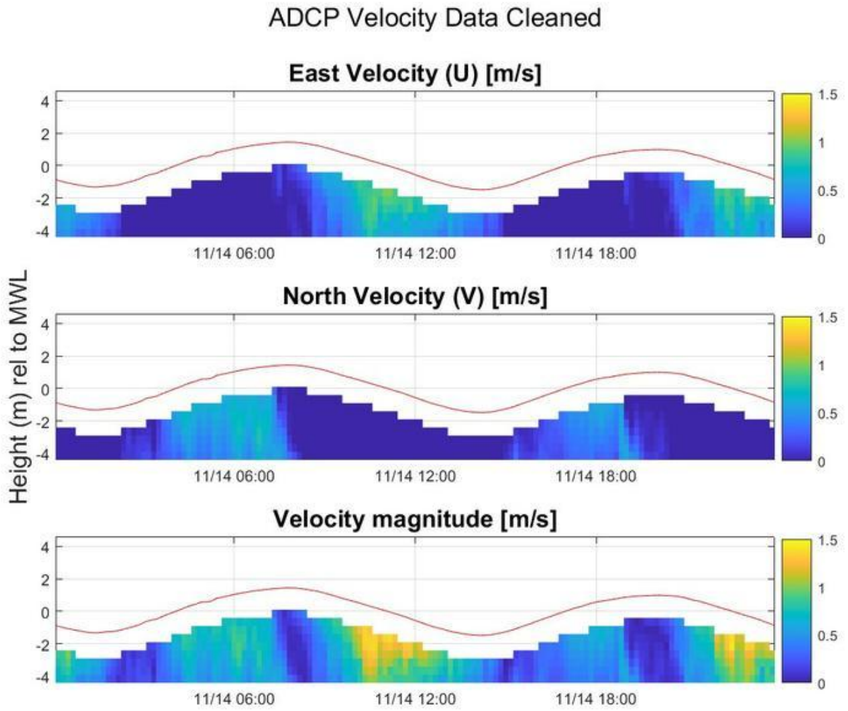
Sampling Rate

- Fixed
  - 3 min average; 10 min interval
- Vessel
  - 2 Hz; 3-7 minutes per TEC location

Quality Control

- Remove outliers and bad data bins
  - Interpolate removed data points
- Remove surface noise
- Remove sidelobe interference

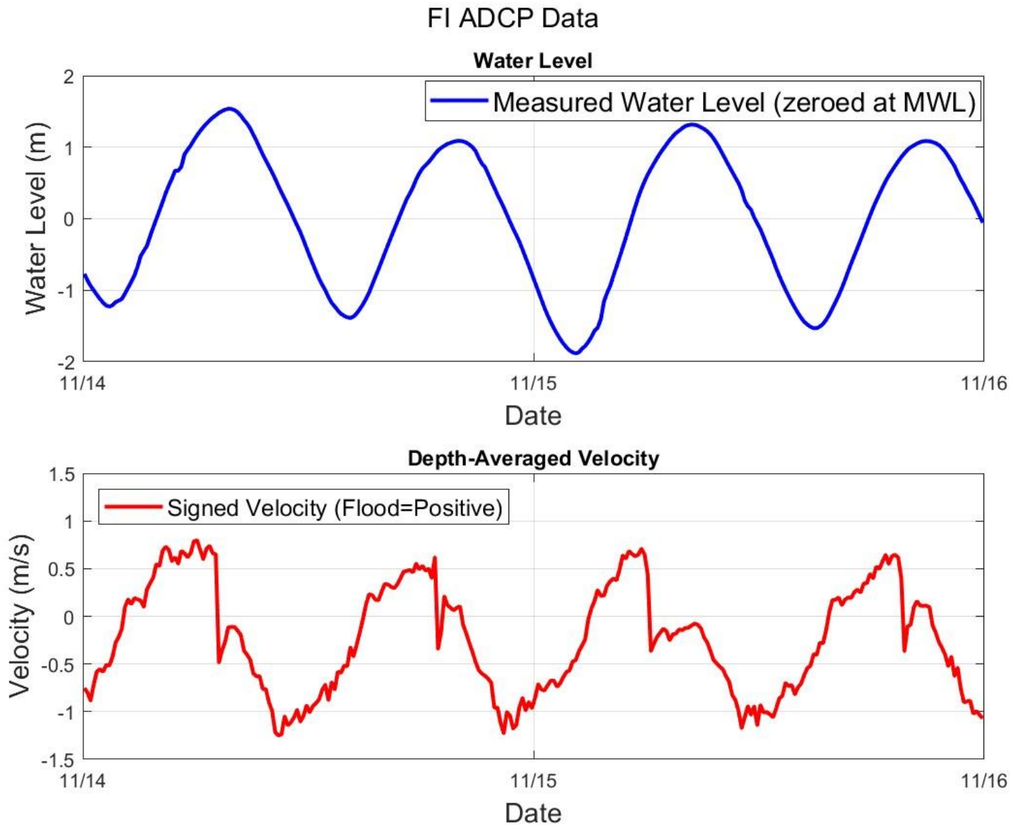


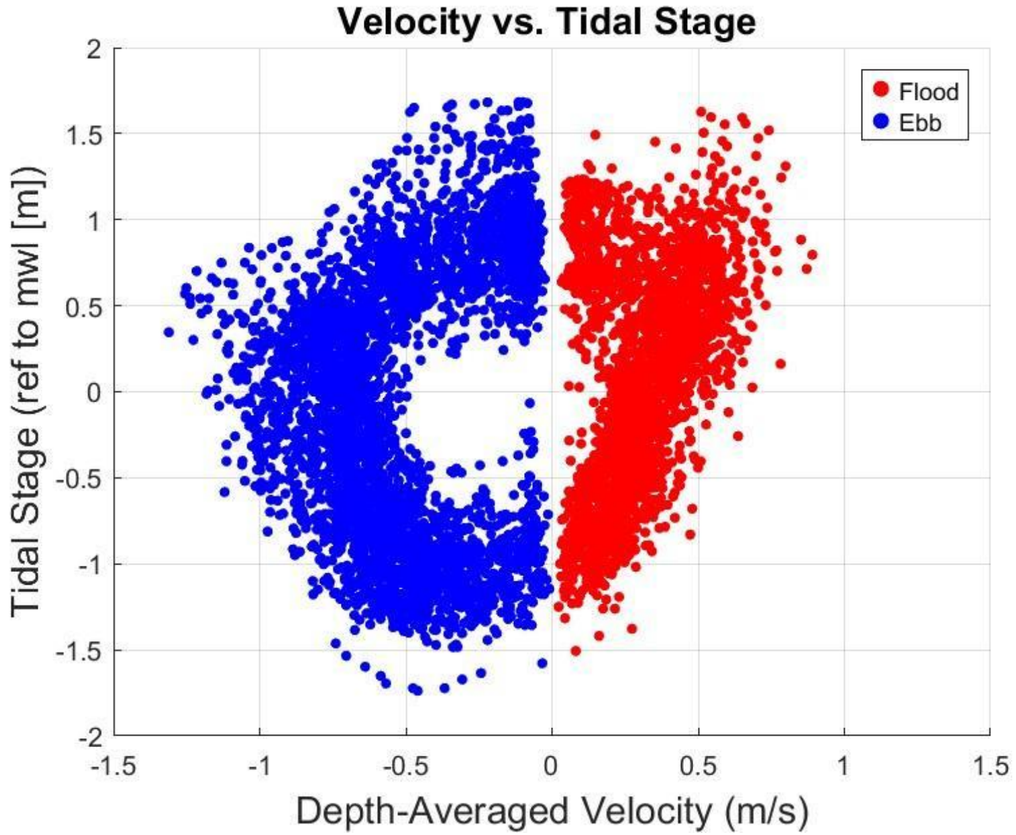


Sensitivity Analysis

- **Duration Averaging**
  - Converged to stable vertical profile at 3 minutes
- **Proximity to TEC location**
  - Consistent results within 20m of each TEC location

Overall Flow Characteristics

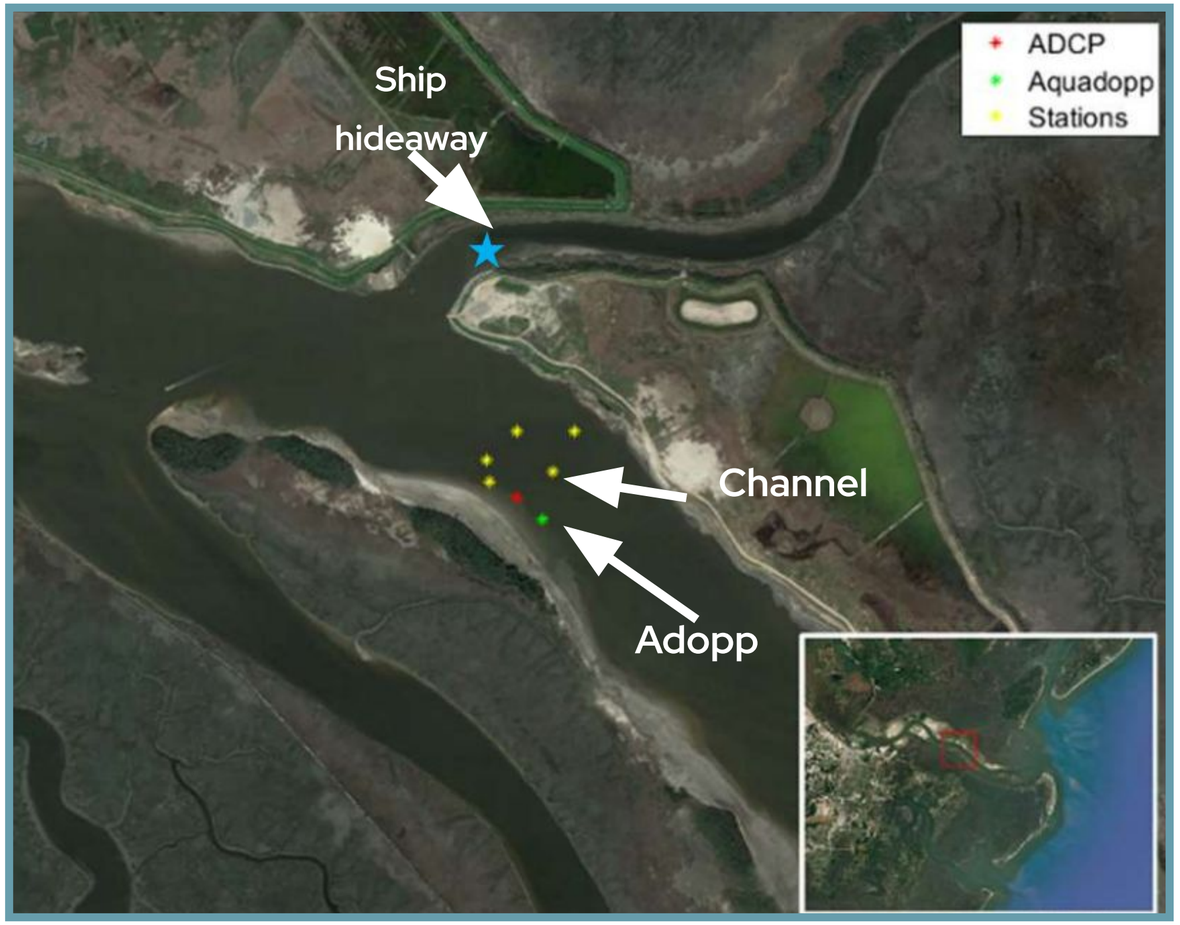




ADCP data

- Flood(+) Ebb(-)
- Ebb dominance
- Tidal elevation controls flow direction and magnitude

Evolution of MV Vertical Velocity Structure



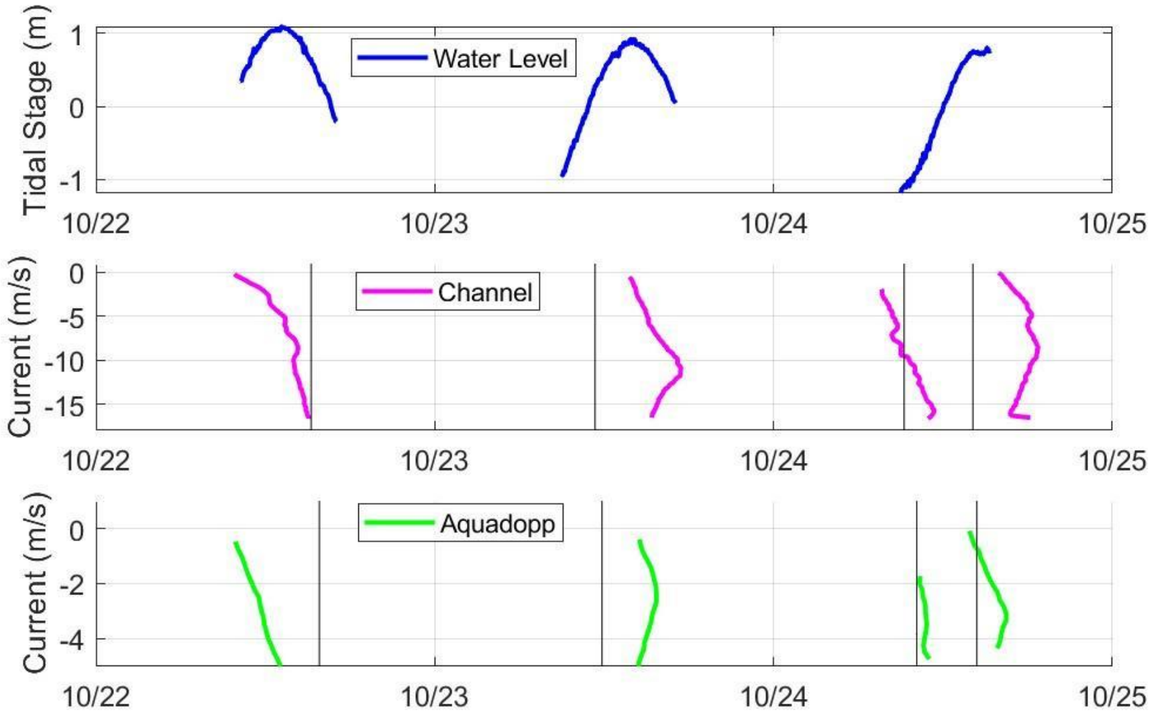
MV measurements

Slack tide: Flatter velocity profiles

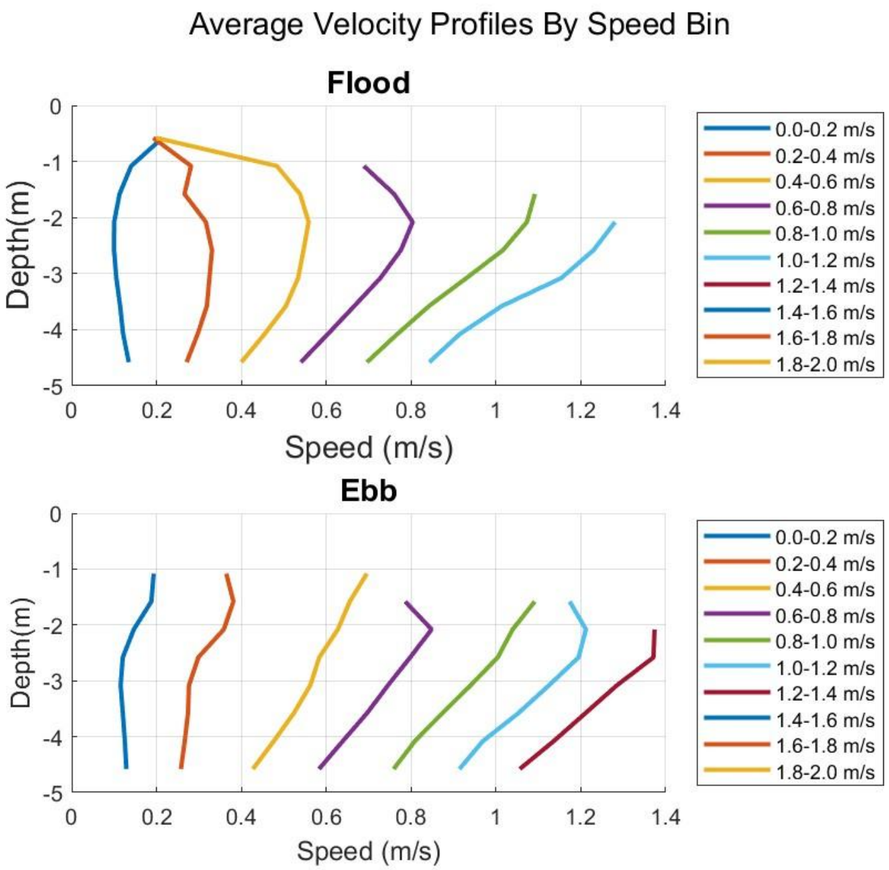
Peak ebb: Stronger & sheared profiles

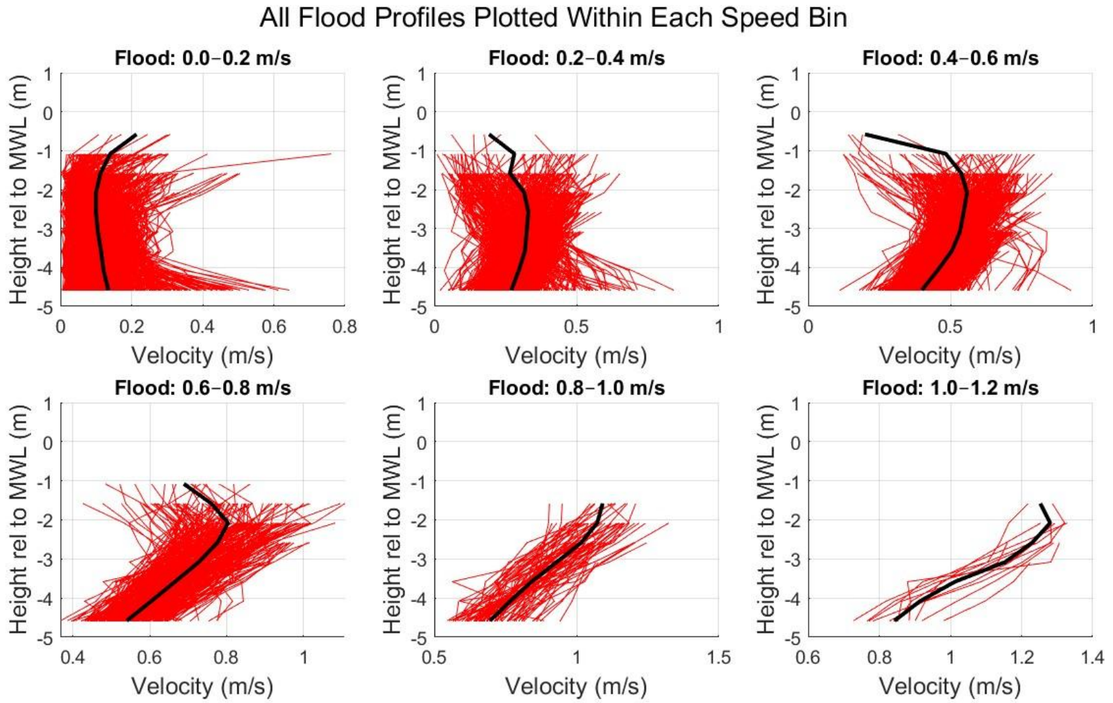
Peak flood: Lower peak, different shape

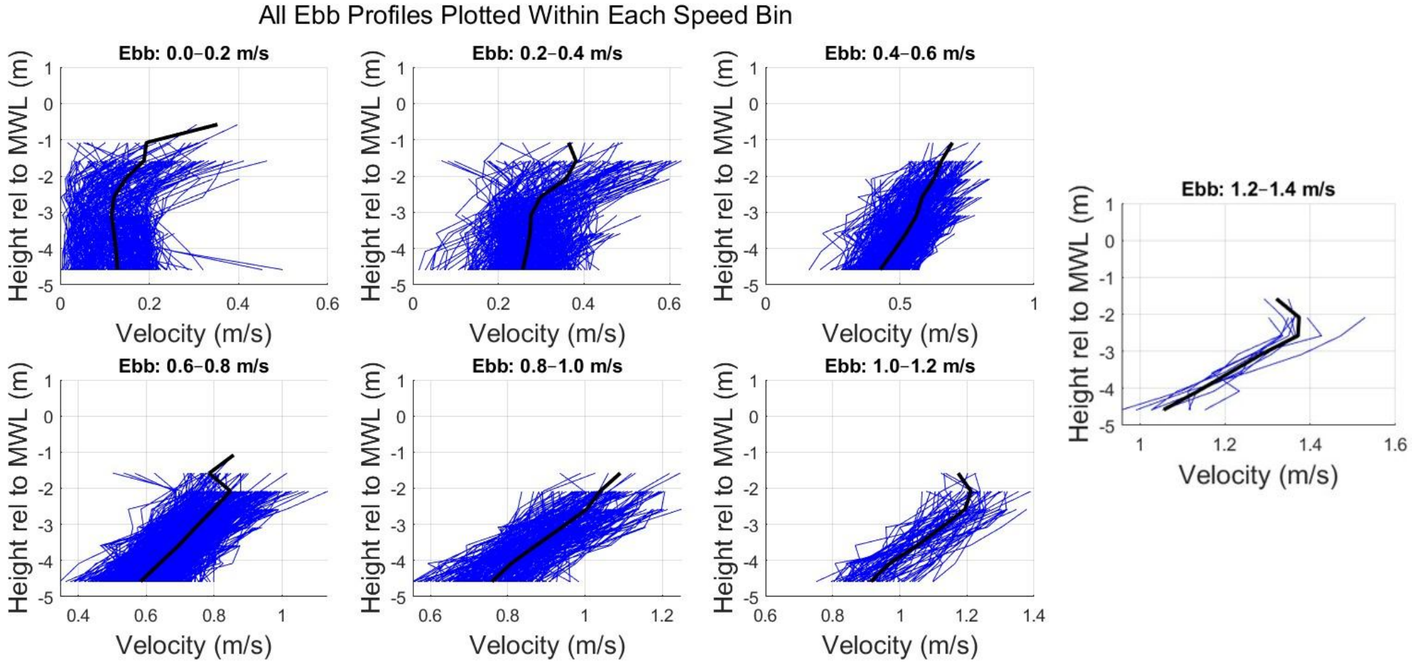
Importance of sampling across the full tidal range and throughout the water column



ADCP Vertical Velocity Structure







Speed bins

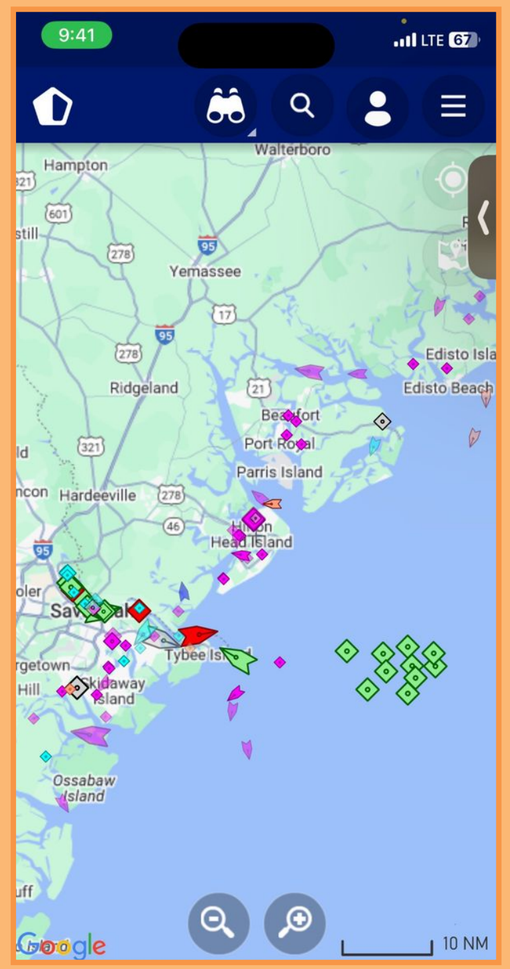
- Sorted into bins using depth-averaged speed
- Vertical variability in each bin

  <u>Higher speeds: strong vertical shear</u>

Wrapping Up

Conclusions

- **Field deployment worked**
  - Challenges: no divers to deploy frames - adjust frame structure and deployment method
- **HMS Overview**
  - 3-minute averaging & 20m proximity produced consistent results
  - Challenges: ship wake & wind vs pontoon boat
- **Observations**
  - Ebb dominant (tidal asymmetry)
  - Velocity profile asymmetry (ebb magnitude is stronger)
  - Strong velocity shear & variability in vertical profiles
- **FUTURE WORK**
  - Linear regression modeling
  - Use full-depth velocity profiles
  - Build regression model to predict velocity at the Energy Extraction Plane (EEP, eg. turbine height)
  - Why it matters
    - Applicable to anywhere with limited data
    - Reduces the need for FI measurements at every site
    - Keeps HMS cost-effective while still maintaining accuracy
  - Completed by September 2025



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