



# Simultaneous Wind, Wave, and Current Measurements in Coastal Systems



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## Background and Objective

In coastal systems, the seabed and features along the seabed are affected and shaped by bottom currents driven by tides, wind and wave action, and longshore currents. Redbird Reef is an artificial reef located offshore of the mouth of Delaware Bay. To monitor the health and status of Redbird Reef and other coastal reef systems, there is a need to simultaneously collect data on local wind and waves conditions along with bottom currents. In this study, wind, water level, wave, and bottom current data collected at different locations near the U.S. Naval Academy (USNA) at the mouth of the Severn River estuary in January 2024 was compared to data collected by a Sofar Ocean Smart mooring deployed at the mouth of the Severn River in February 2026. Results will be used to evaluate the potential for the Sofar Ocean Smart mooring to be used as an all-in-one platform to collect simultaneous wind, wave, and current measurements at the Redbird Reef site in the future.

## Study Area and Methods

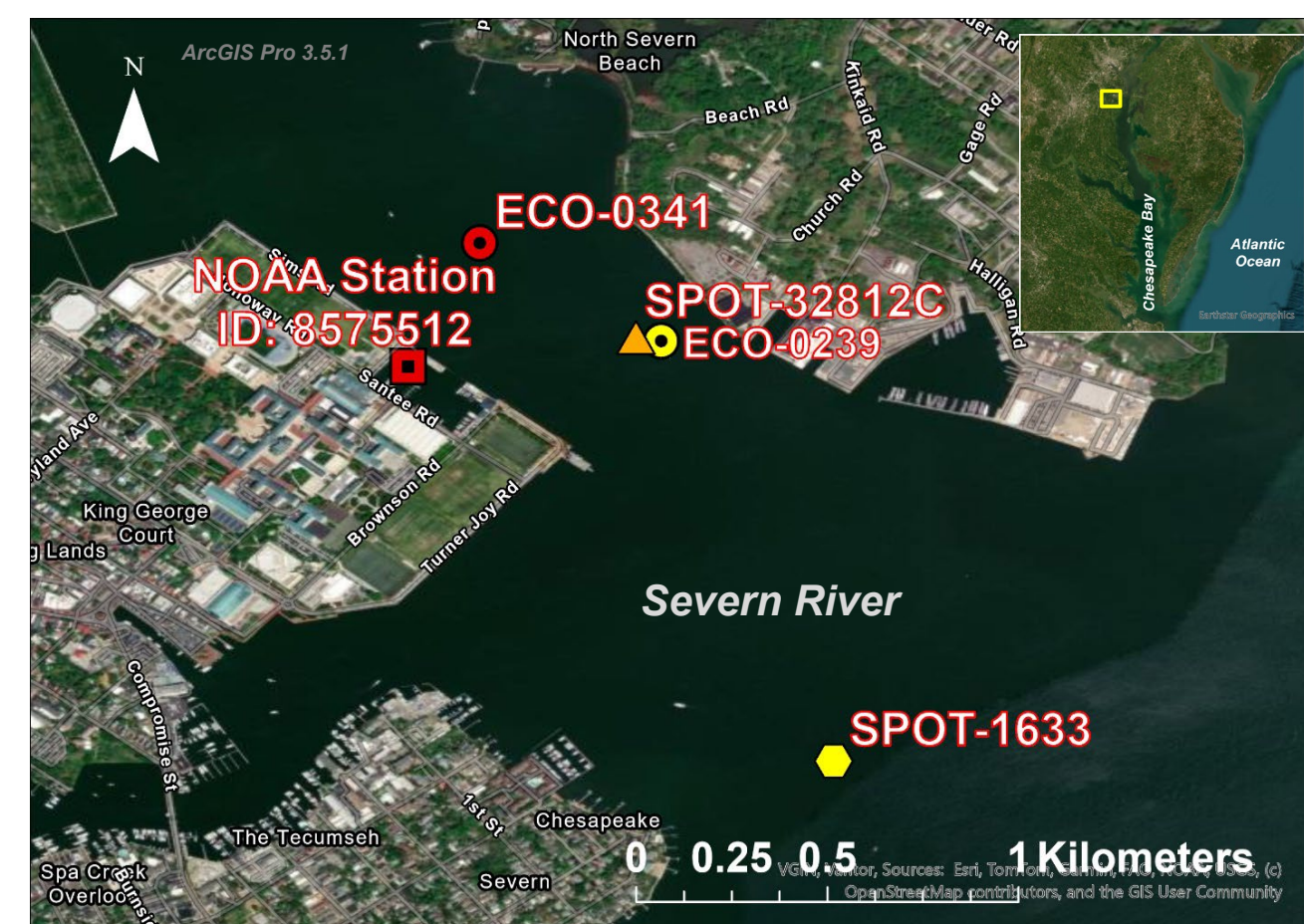


Figure 1. Mouth of the Severn River near USNA showing locations for a Nortek ECO Acoustic Doppler Current profiler (ADCP; ECO-0341) and Sofar Ocean Spotter wave buoy (SPOT-1633) deployed from 08-18 January 2024 and a Sofar Ocean Smart mooring with Spotter wave buoy and Aanderaa 4830 ZPulse® Doppler Current Sensor (DCS; SPOT-32812-C; <https://www.sofaroccean.com/products/spotter/sensors/current-meter>) deployed from 12-26 February 2026. A Nortek ECO ADCP (ECO-0239) was also deployed near the Sofar Spotter Smart mooring from 18-25 February 2026. Wind and water level data was obtained from the NOAA tidal gauging station, Annapolis, MD - Station ID: 8575512.

A Sofar Ocean Spotter buoy and a Nortek ECO Acoustic Doppler Current Profiler (ADCP) were deployed at the mouth of the Severn River (Fig. 1) from 08-18 January 2026. The Sofar Spotter (Fig. 2a; [www.sofaroccean.com/products/spotter](http://www.sofaroccean.com/products/spotter)) is a compact wave buoy system that uses differential GPS to calculate wave parameters along with derived wind speed and direction (Raghukumar et al., 2019). The Nortek ECO ADCP is a 1 MHz, 3-beam ADCP with an integrated pressure sensor (Fig. 2b; [www.nortekgroup.com/products/eco](http://www.nortekgroup.com/products/eco)) that collects 3-averaged depth layers of current speeds and directions (upper, middle, lower) at set intervals (4-6 minutes in this study). Six-minute wind and water level during January 2024 and February 2026 deployment was downloaded from the National Oceanic and Atmospheric Administration (NOAA), Tides and Currents, gauging station, Annapolis, MD - Station ID: 8575512 (Fig. 2c; [www.tidesandcurrents.noaa.gov/stationhome.html?id=8575512#info](http://www.tidesandcurrents.noaa.gov/stationhome.html?id=8575512#info)). A Sofar Ocean Smart mooring with Spotter wave buoy and Aanderaa 4830 ZPulse® Doppler Current Sensor (DCS) was deployed at the mouth of the Severn River from 12-26 February 2026 (Fig. 2d and 3a&b). All data were referenced to UTC and averaged to an hourly time step using MATLAB R2025b.

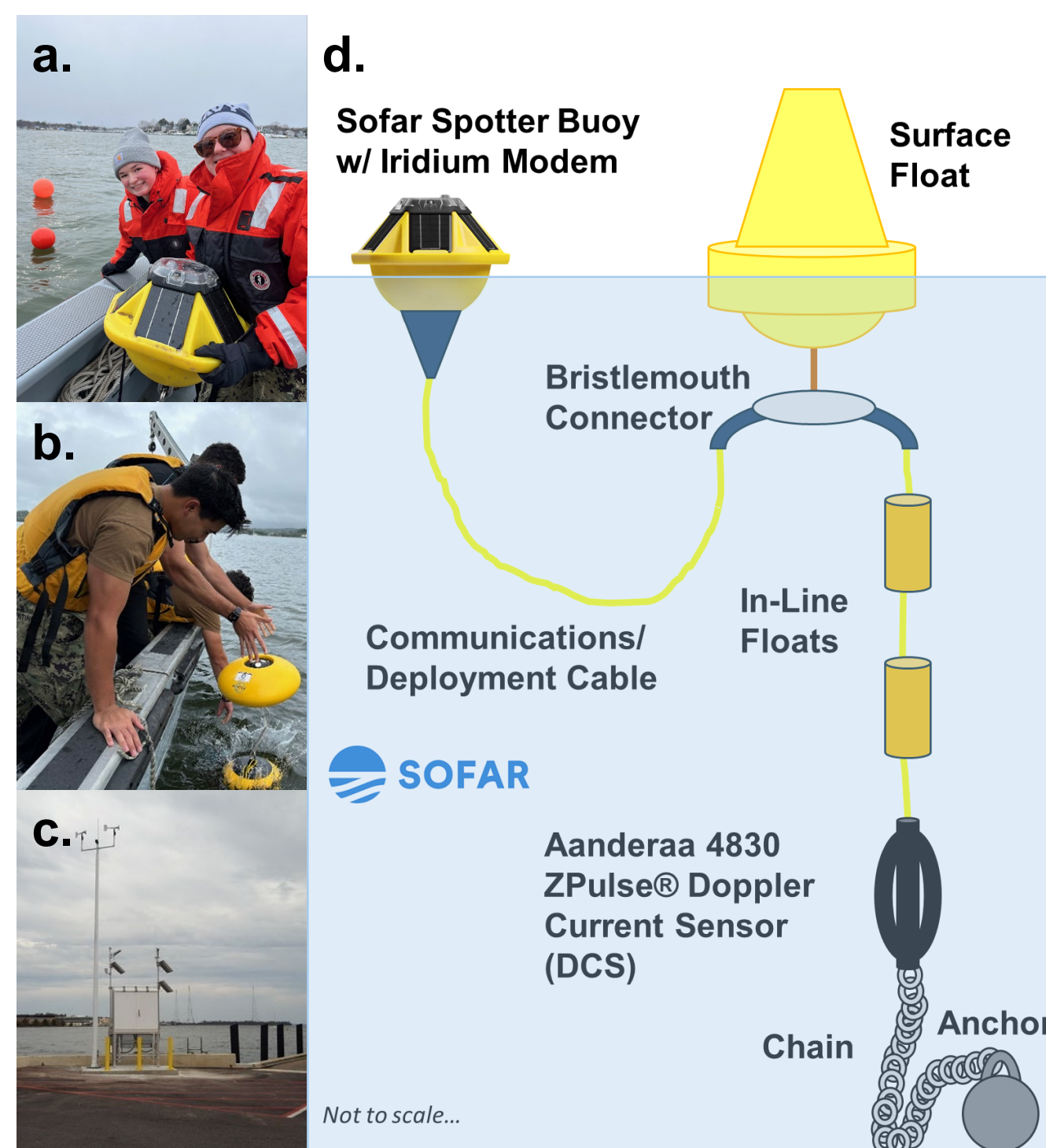


Figure 2. The (a) Sofar Ocean Spotter Wave Buoy (Perry and Stout, 2025); (b) Nortek ECO ADCP; (c) NOAA tidal gauging station, Annapolis, MD - Station ID: 8575512; and (d) diagram of the Sofar Ocean Spotter Smart mooring with Aanderaa DCS showing setup, instrumentation and connectivity. The Sofar systems upload data via iridium to an online dashboard every 30 minutes.

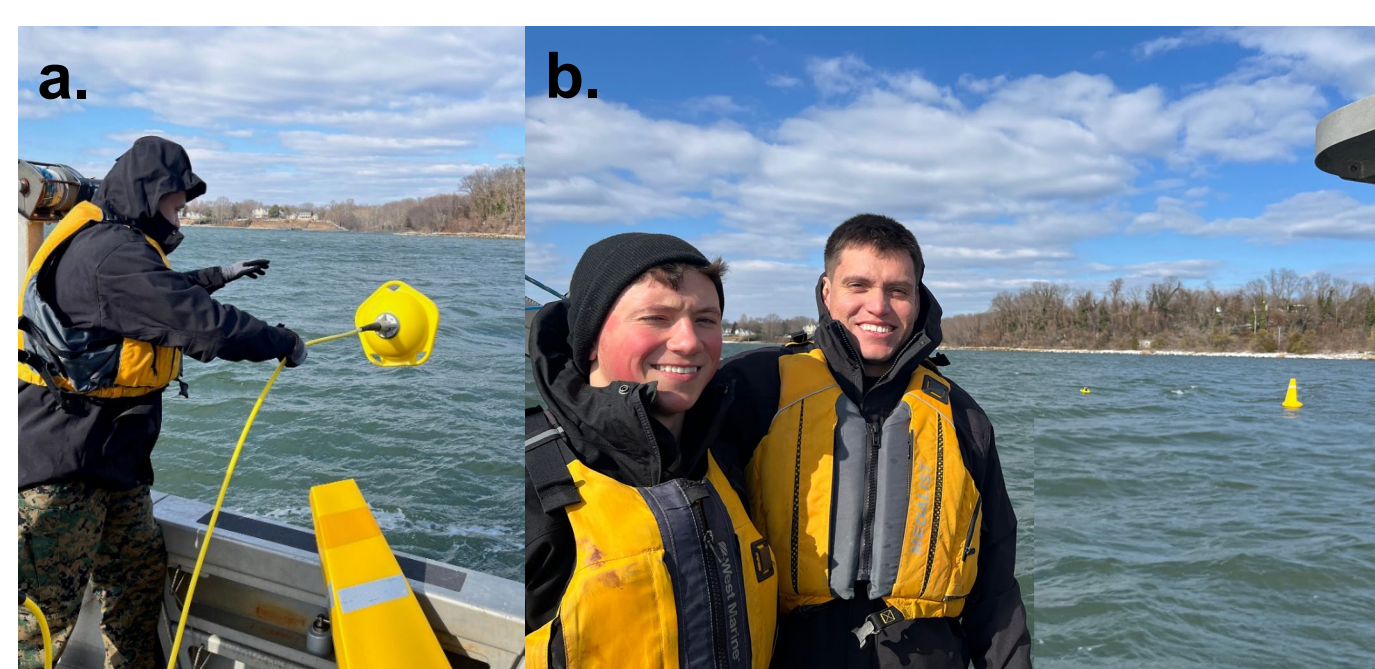


Figure 3. (a) Midshipman 1/C Chris Cangas and Midshipman 1/C Lucas Siudut deploying the Sofar Ocean Spotter Smart mooring on 12 February 2026 and (b) the Sofar Ocean Spotter Smart mooring up and transmitting data at the mouth of the Severn River.

## Mouth of the Severn River, January 2024

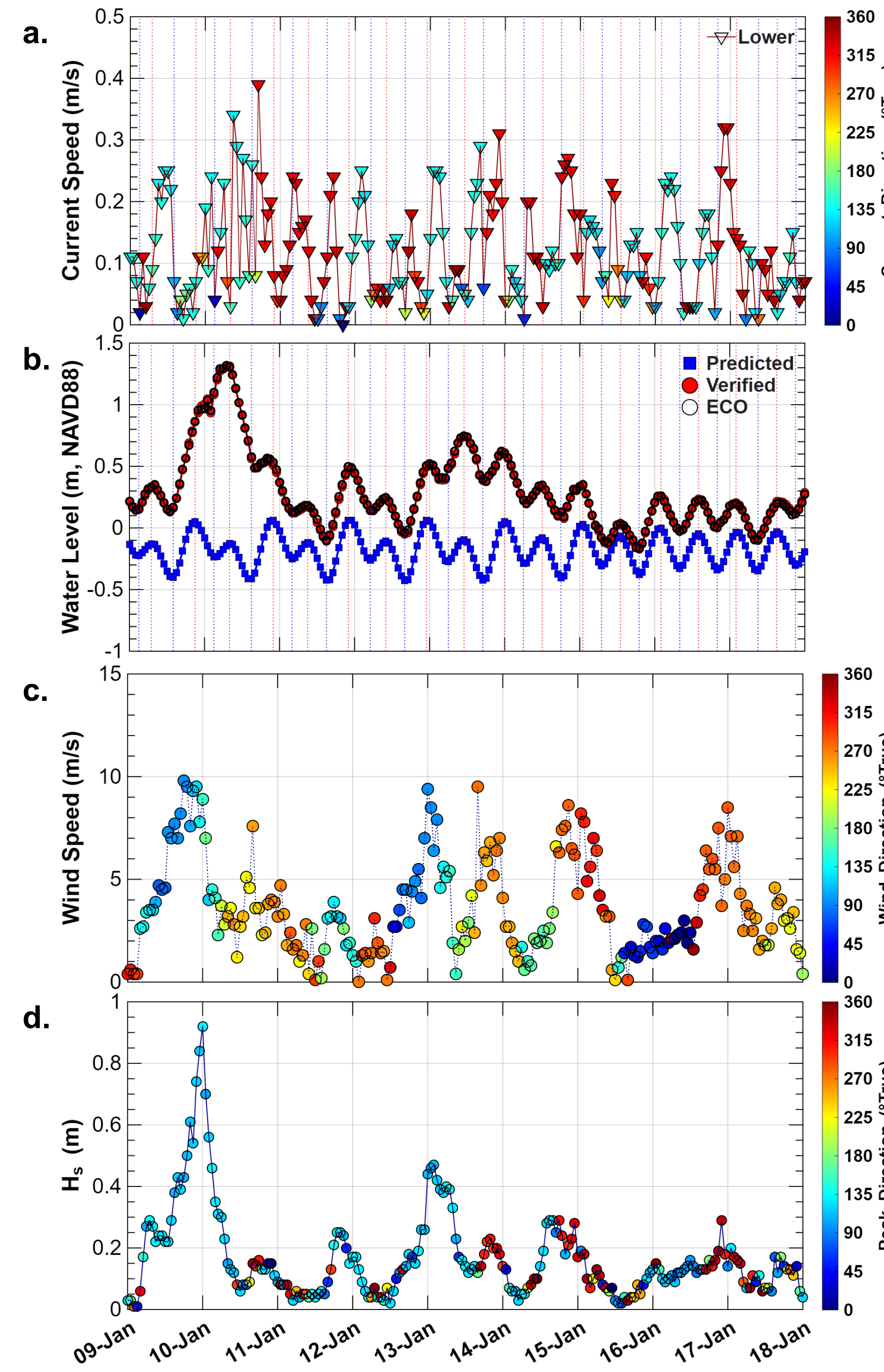


Figure 4. Hourly matched and averaged data at the mouth of the Severn River (Fig. 1) from 09-18 January 2024 (UTC) showing: (a) Nortek ECO ADCP lower water column (6.7 - 7.9 m) current speed (m/s) and direction (contoured "true, towards"); (b) NOAA predicted and verified (observed) water levels referenced to NAVD88 with barometric pressure corrected water levels from the Nortek ECO ADCP; (c) NOAA wind speed (m/s) and direction (contoured "true, from"); and (d) Sofar Spotter derived significant wave height ( $H_s$ , m) and peak wave direction (contoured "true, from"). The red and blue dashed lines on (a) and (b) indicate predicted high and low tide, respectively.

## Discussion

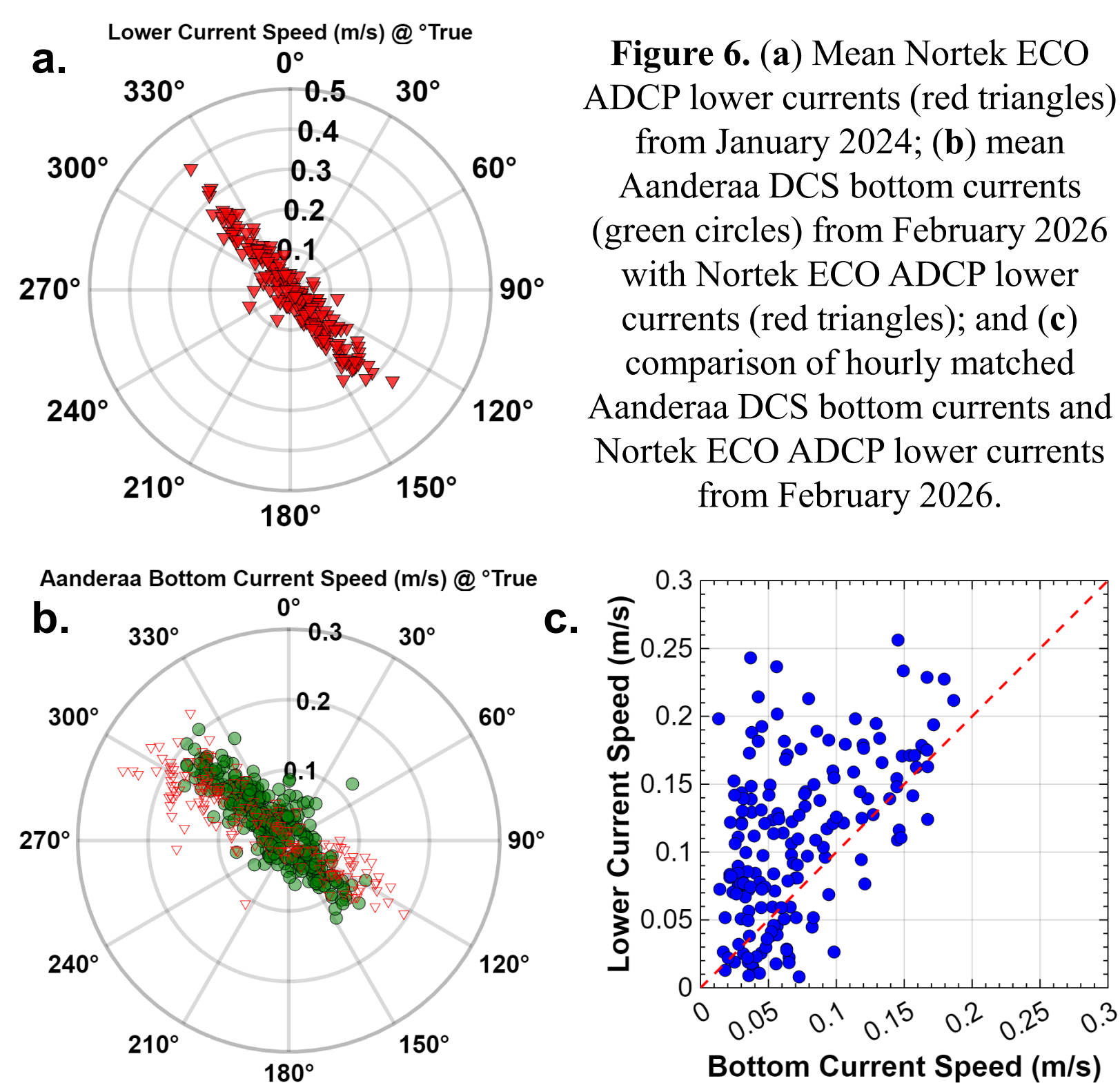


Figure 6. (a) Mean Nortek ECO ADCP lower currents (red triangles) from January 2024; (b) mean Aanderaa DCS bottom currents (green circles) from February 2026 with Nortek ECO ADCP lower currents (red triangles); and (c) comparison of hourly matched Aanderaa DCS bottom currents and Nortek ECO ADCP lower currents from February 2026.

References: Perry and Stout (2025). USNA Capstone; Davies et al. (2022). Earth Interactions; 26; Raghukumar et al. (2019). J. Atm. Oc. Tech.; 36; Beckman and Long (2022). Frontiers in Marine Science; 9.

## Mouth of the Severn River, February 2026

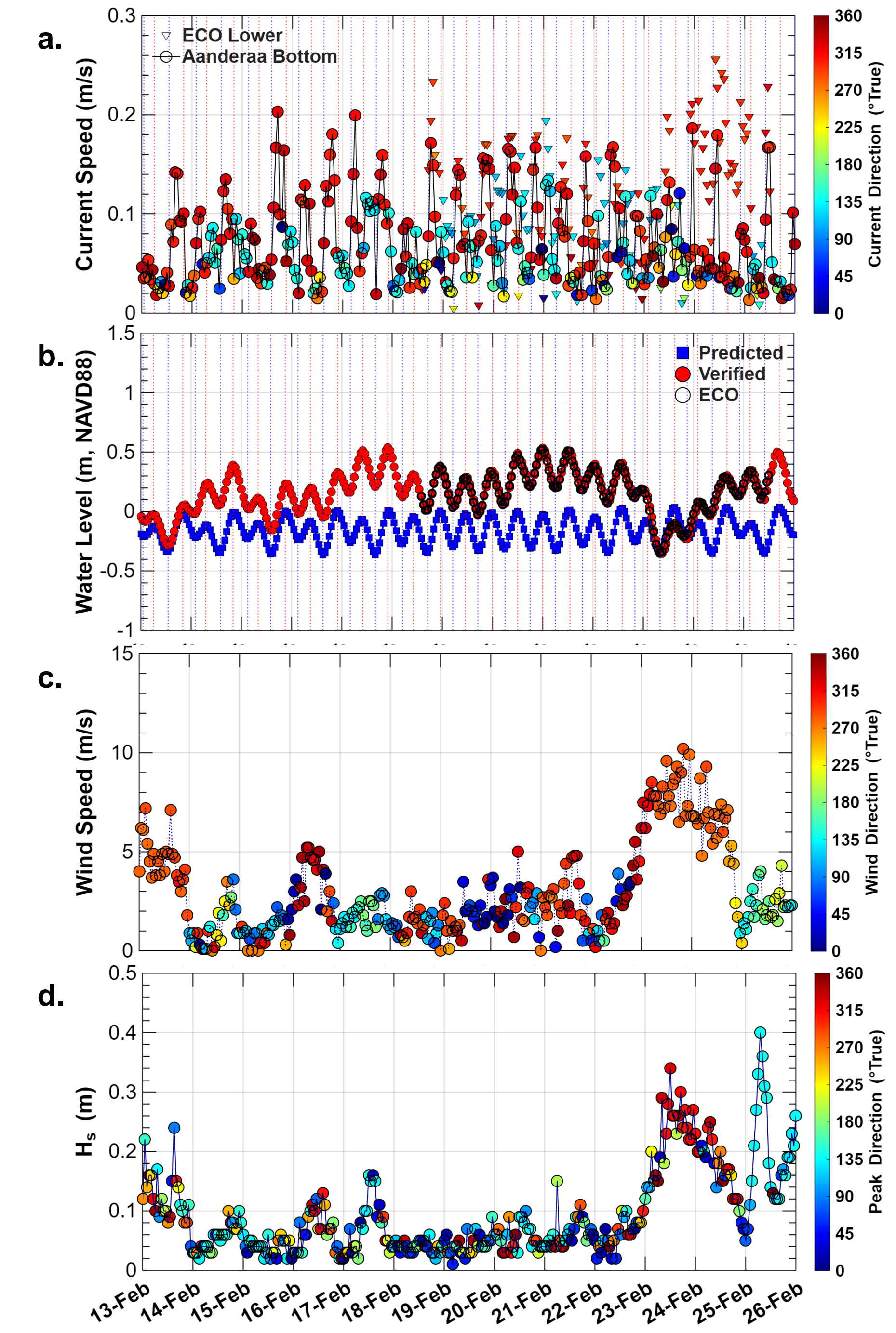


Figure 5. Hourly matched and averaged data at the mouth of the Severn River (Fig. 1) from 13-26 February 2026 (UTC) showing: (a) Aanderaa DCS bottom current speed (m/s at ~1 m from bottom) and direction (contoured "true, towards) with Nortek ECO ADCP lower water column (6.6 - 7.9 m) values from 18-26 February; (b) NOAA predicted and verified (observed) water levels referenced to NAVD88 with barometric pressure corrected water levels from the Nortek ECO ADCP; (c) NOAA wind speed (m/s) and direction (contoured "true, from); and (d) Sofar Spotter derived significant wave height ( $H_s$ , m) and peak wave direction (contoured "true, from). The red and blue dashed lines on (a) and (b) indicate predicted high and low tide, respectively.

## Conclusions and Future Work

- The Sofar Ocean Spotter Smart mooring with Aanderaa DCS can provide simultaneous wave and current measurements in coastal systems like the Severn River and Redbird Reef
- At offshore sites like Redbird Reef (Fig. 7; planned deployment in summer 2026), the Sofar Ocean Spotter Smart mooring with Aanderaa DCS should also be able to provide simultaneous wind measurements since the known limitations of the system at lower wind speeds and underdeveloped sea in estuaries and bays will be less prevalent (Beckman and Long, 2022)

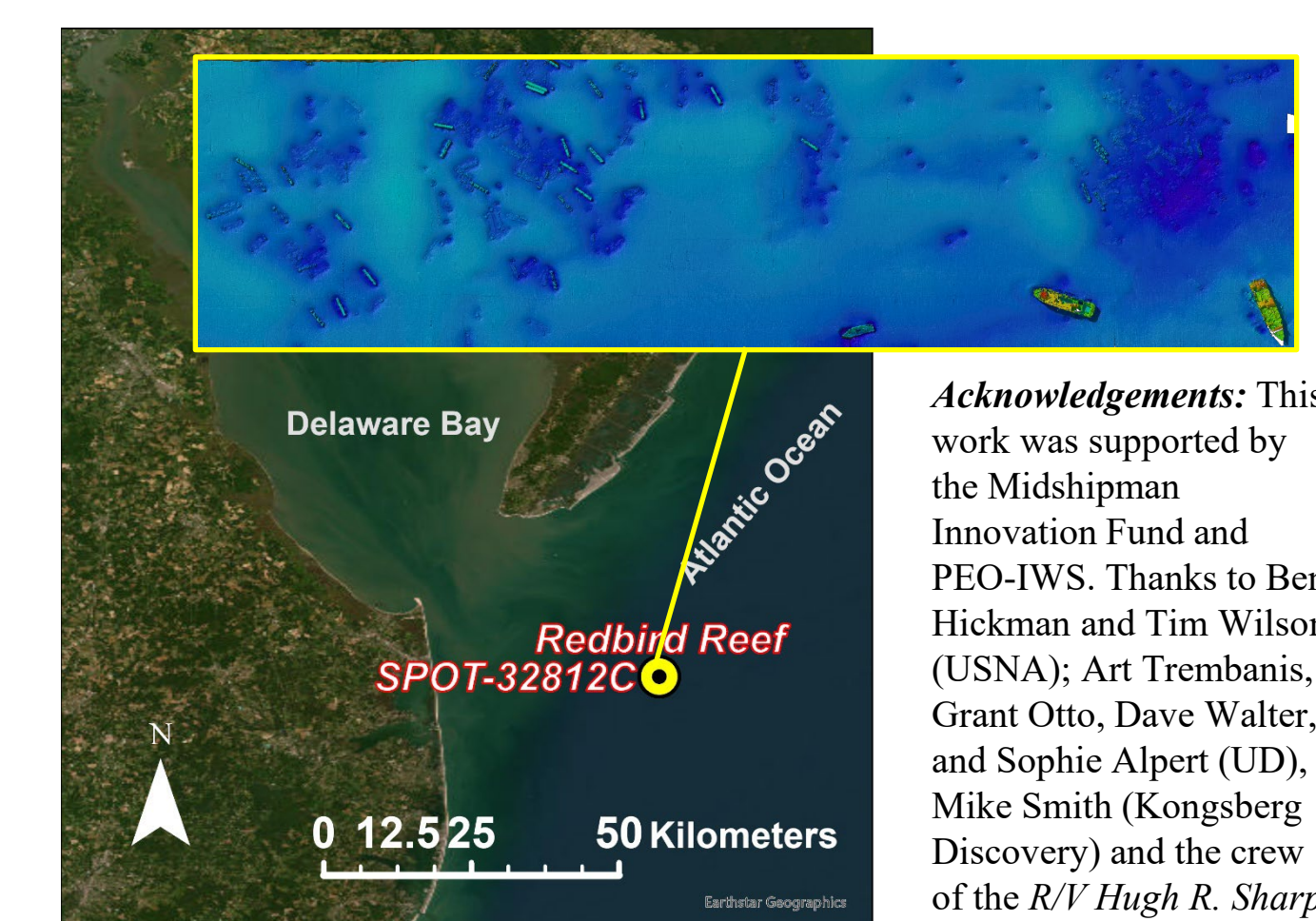


Figure 7. Planned Sofar Spotter Smart mooring deployment on Redbird Reef. Image courtesy of University of Delaware (UD).

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