



# Evaluation of Physiochemical Contours in the Lower Severn River Developed from Measurements by an EcoMapper Autonomous Underwater Vehicle (AUV)



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## Abstract

Physiochemical contour (temperature, salinity, dissolved oxygen (DO), and pH) plots in the lower Severn River, MD were developed using data collected by an EcoMapper Autonomous Underwater Vehicle (AUV) running different survey mission plans. Contour plots created from data collected during these surveys were compared to those created from discrete station profile data collected concurrently using a hand-held water quality monitoring probe deployed from a small boat. Results will be used to evaluate the strengths and limitations of different AUV survey mission plans in developing high-resolution, parameter-specific water quality contours and to assess the utility of using the EcoMapper AUV as a platform for water quality data collection in the Severn River and other estuarine systems.

## Study Area and Methods



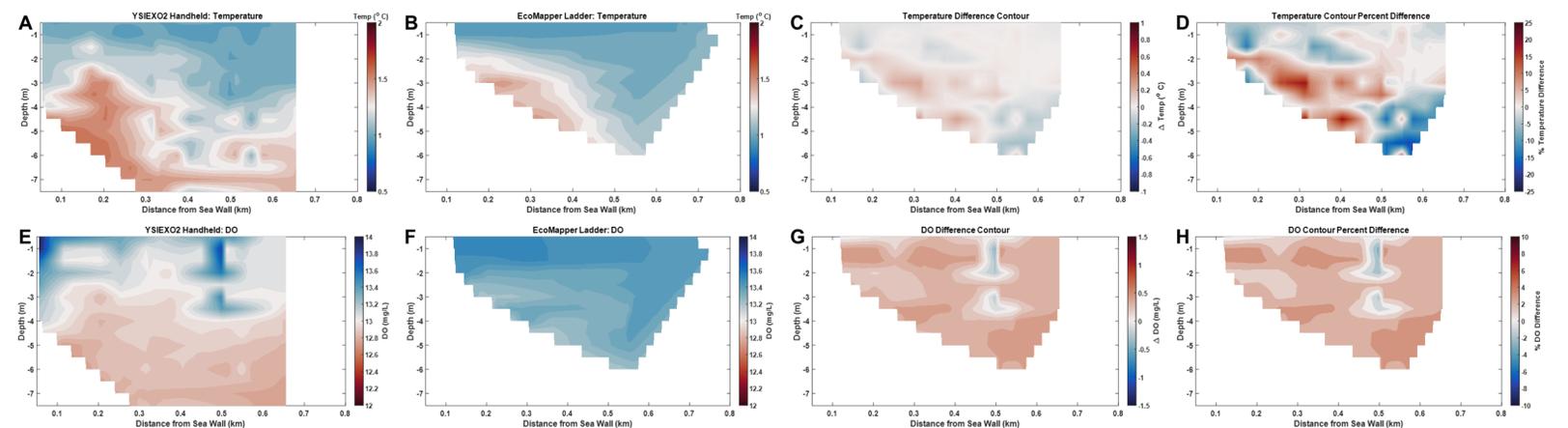
**Figure 1.** Map of lower Severn River, Chesapeake Bay near the U.S. Naval Academy (USNA) showing area for EcoMapper AUV surveys on 06 and 20 February 2018. Red dots indicate approximate locations for 8 YSI EXO2 water quality sonde profile casts (only 7 casts on 06 February) performed concurrently with EcoMapper AUV missions. Also shown are mission plans for the depth-specific ladder survey mission run on 06 February and the "tow-yo" ladder survey mission run on 20 February 2018.

Water quality data was collected from the lower Severn River on 06 and 20 February 2018 with an EcoMapper AUV using different survey mission plans (**Fig. 1**). The EcoMapper is an IVER-3 AUV (L3 OceanServer; **Fig. 2**) modified to include a YSI EXO1 multi-parameter water quality sonde which, for this study, was configured to measure temperature, conductivity (salinity), DO, and pH. On 06 February, the EcoMapper AUV survey was conducted using a ladder mission plan run at constant depths. On 20 February, the EcoMapper AUV survey was run using a ladder mission plan where the platform "tow-yo'd" between depths during each ladder leg. Concurrent with each AUV mission, water column profile data was collected from fixed sampling stations using a hand-held YSI EXO2 water quality monitoring sonde deployed from a small boat.

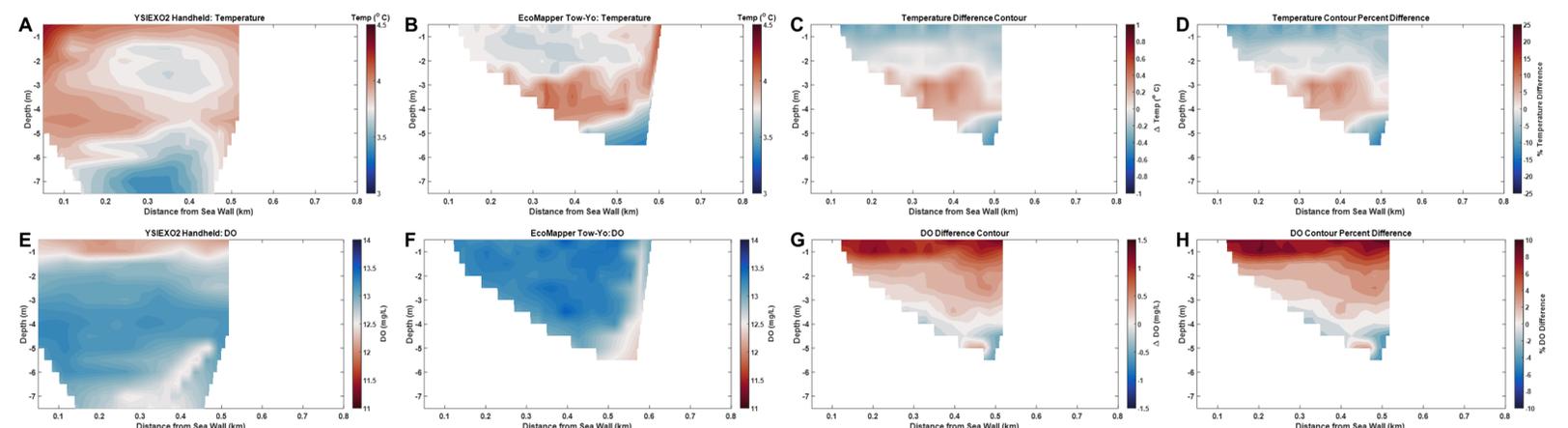


**Figure 2.** (A) MIDN 1/C Francis adding weights to the EcoMapper AUV before deployment on 20 February 2018. (B) 1/C Sharp cleaning the EcoMapper AUV after the deployment on 06 February 2018. Inset: YSI EXO2 Water Quality Sonde.

## Results and Discussion



**Figure 3.** Water-quality contour plots from data collected on 06 February 2018. (A-D) Temperature (°C): (A) station water column profile data using a hand-held YSI EXO2; (B) high-resolution EcoMapper AUV data collected using a depth-specific ladder mission; (C) difference in measured values between the two methods; (D) difference in measured values expressed as % of YSI EXO2 profile. (E-H) DO (mg/L): (E) station water column profile data using a hand-held YSI EXO2; (F) high-resolution EcoMapper AUV data collected using a depth-specific ladder mission; (G) difference in measured values between the two methods; (H) difference in measured values expressed as % of YSI EXO2 data.



**Figure 4.** Water-quality contour plots from data collected on 20 February 2018. (A-D) Temperature (°C): (A) station water column profile data using a hand-held YSI EXO2; (B) high-resolution EcoMapper AUV data collected using a "tow-yo" ladder mission; (C) difference in measured values between the two methods; (D) difference in measured values expressed as % of YSI EXO2 profile. (E-H) DO (mg/L): (E) station water column profile data using a hand-held YSI EXO2; (F) high-resolution EcoMapper AUV data collected using a "tow-yo" ladder mission; (G) difference in measured values between the two methods; (H) difference in measured values expressed as % of YSI EXO2 data.

**Figures 3 and 4** show comparative contour results for temperature (A-D) and DO (E-H) from data collected using a hand-held YSI EXO2 sonde and the EcoMapper AUV running a depth-specific ladder mission (**Fig. 3**; 06 February 2018) and a "tow-yo" ladder mission (**Fig. 4**; 20 February 2018). Results suggest strengths and potential limitations of collecting water quality data using the EcoMapper AUV. Using either mission profile, the difference between contoured temperature data is between -0.2 to +0.2 °C or at most 5-10% of the YSI EXO2 contoured results. Given the rapid response and sampling frequency of the temperature probe on the EcoMapper AUV it is reasonable to assume that the contoured AUV data represents a true higher resolution contour of water column temperatures in the Severn River at the time of data collection. There were significant differences in the DO contour plots developed from the YSI EXO2 profiles and the data from either AUV survey mission. There are some clear contouring (sampling) artifacts present that are likely a result of the profile sampling interval and/or a lower sampling frequency of the DO sensor or a failure to allow the sensor to reach equilibrium during data collection (**Fig. 3E** and **4E**). The sampling rate for a DO sensor is much slower and equilibration time much longer than that for a temperature sensor. This presents a challenge for data collection (both for going from high-to-low and from low-to-high). This likely complicated continuous DO data collection from the AUV and comparisons to profiles. The AUV did not capture any significant variation in bottom water DO concentrations during the AUV depth-specific ladder mission (**Fig. 3F**) as compared to the contoured profile data (**Fig. 3E**), and the "tow-yo" mission failed to capture lower DO concentrations in surface waters. Given the complexities of processing "tow-yo" data, no definitive conclusion as to which mission plan is better for collecting high-resolution DO data but results suggest that the depth-specific ladder mission might be preferred. Additional studies are required under conditions where variability in water quality parameters like DO are higher to allow for the development of data processing techniques and the performance of quantitative sensitivity analysis of data collection using different AUV mission profiles.

**Conclusions:** *The EcoMapper AUV can produce high-resolution contour maps of water column temperature but the low sampling rate and long equilibration time for the DO sensor limits resolution and complicates data processing. For developing water temperature contour plots, either a depth-specific ladder or a "tow-yo" mission may be used but results suggest there may be more advantages in collecting DO data using a depth-specific ladder mission. Follow-on research is required under conditions with high variability in water quality parameters like DO before any conclusions on the utility of using the EcoMapper AUV as a water quality data collection platform in the Severn River and other estuaries can be reached.*