How does Neuse Bottom-Water Hypoxia Affect Dissolved Oxygen Distributions in its Tributaries?

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1. INTRODUCTION

The Neuse River Estuary (NRE), like many estuaries on the US east coast, experiences bottom water hypoxia during summer. Hypoxia can occur when an estuary becomes strongly density stratified, which limits vertical mixing. During the summer, when biological activity in the bottom sediments is high, dissolved oxygen (DO) levels in the lower water column drop and conditions can become hypoxic/anoxic. Such conditions have been linked to extensive fish kills in the upper NRE. The tributaries of the Neuse serve as critical nursery areas for finfish and shellfish, but little is known about processes controlling their DO levels. We are using field measurements to better understand the influence of wind-driven processes in the main channel of the Neuse on DO distributions in its tributaries.

2. FIELD MEASUREMENTS

We made continuous measurements at a single position in the main part of the Neuse for a 1-month period in August 2013. These were accompanied by measurements along a transect across the Neuse and up Hancock Creek, a tributary to the south (Fig. 1).

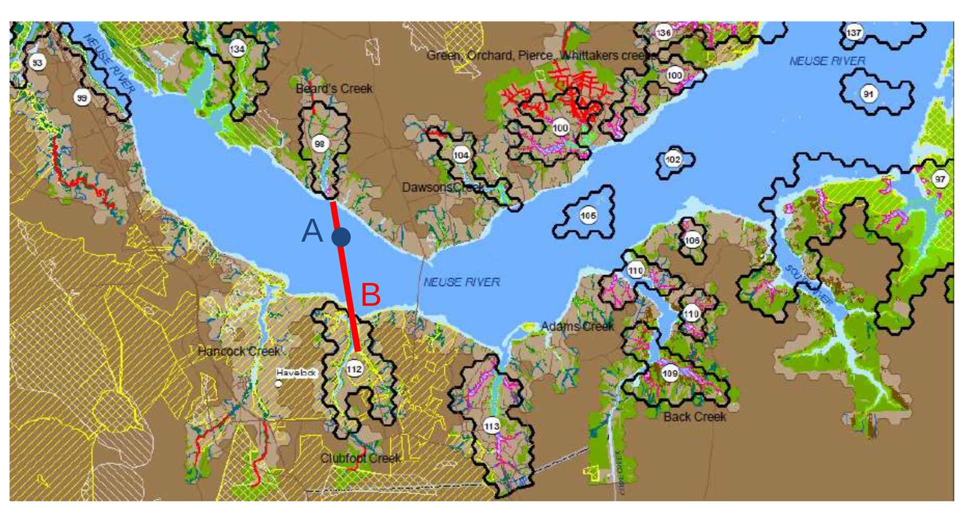
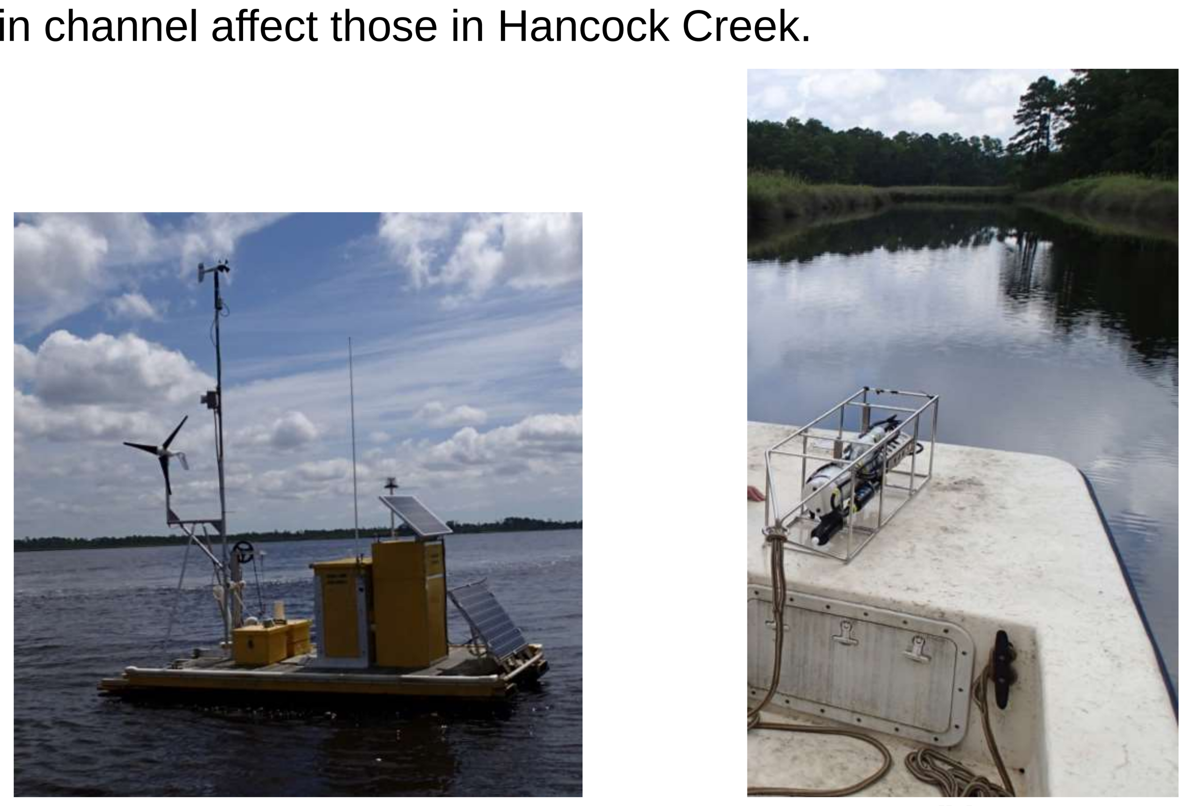


Figure 1. Map of the Neuse River Estuary. Continuous measurements were made at A in the main channel and along transect B that extended 5 km upstream into Hancock Creek. Black polygons indicate areas designated as Strategic Habitat by NC DEENR and include many tributaries.

- Salinity (S), temperature (T), and DO profiles were measured using a CTD (Fig. 2b) along transect B on a day with calm winds (Aug 8th) and shortly after the onset of southwest winds (Aug 10th).
- An Autonomous Vertical Profiler (AVP) measured vertical profiles of T, S, and DO, as well as wind speed and direction in 30 minute intervals at a point on the centerline of the main channel (Fig. 2a). The data were transmitted in real-time over the internet.
- An ADCP was deployed near the AVP to measure current speed and direction in the main channel
- We are combining the measurements from the AVP and ADCP with those from the CTD transects to understand how conditions in the main channel affect those in Hancock Creek.



(a) (b)

Figure 2. Photographs of (a) the Autonomous Vertical Profiler and (b) the CTD used for the cross-channel transects.

3. RESULTS

Hancock Creek Transects

The main channel of the Neuse was strongly stratified with bottom salinities around 20 ppt in the lower water column, a sharp salinity gradient between 2.5 and 3 m below surface, and surface salinities of 6-8 ppt (Figs. 3, 4). The sharp halocline corresponded with a strong gradient in dissolved oxygen concentrations between saturated (~8 mg/L) in the upper water column and anoxic (<1 mg/L) in the lower water column.

Surface water in the tributary was generally warmer, fresher, and had lower oxygen levels than the main part of the Neuse. The first transect was during a calm period immediately following a period of northeast winds (Fig. 5). On this day, salinity increased monotonically from south to north and the most saline bottom water was on the north side of the channel (Fig. 3). The second transect was shortly after the onset of southwest winds. On this day, some fresh surface water was pushed to the north side of the main channel and saline low DO bottom water was forced up into the mouth of the tributary (Fig. 4).

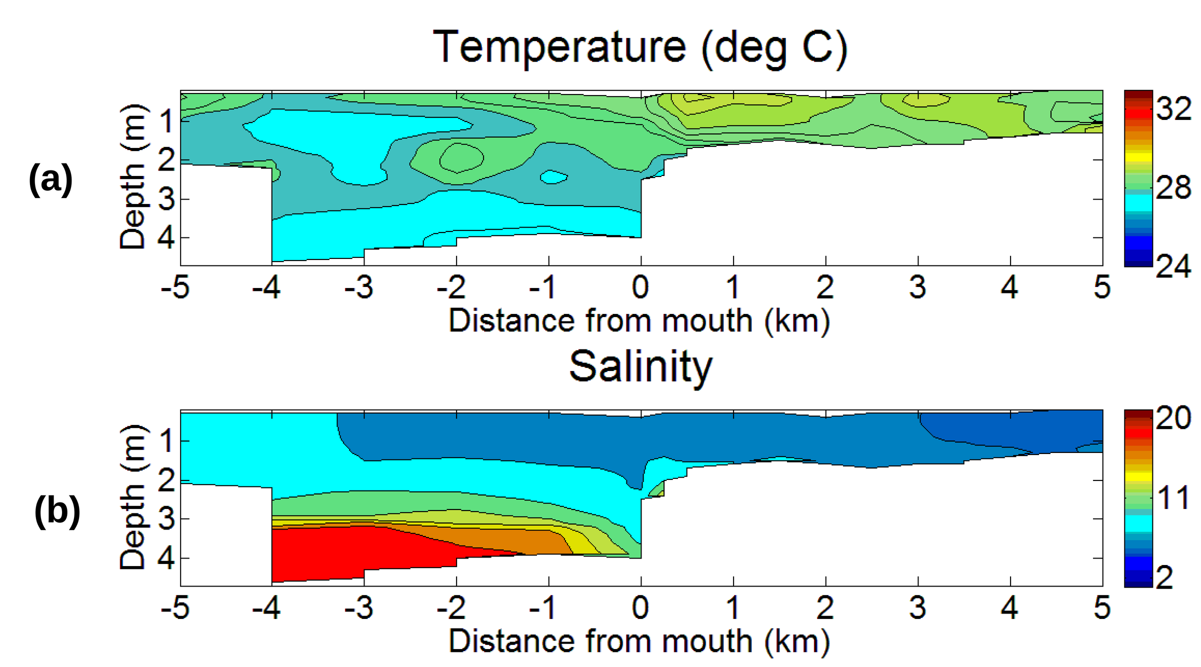


Figure 3. Contours of (a) temperature and (b) salinity along a transect from the main channel of the NRE to 5 km into Hancock Creek. Transect was done during calm conditions on Aug 8. South end of transect is on right side plots.

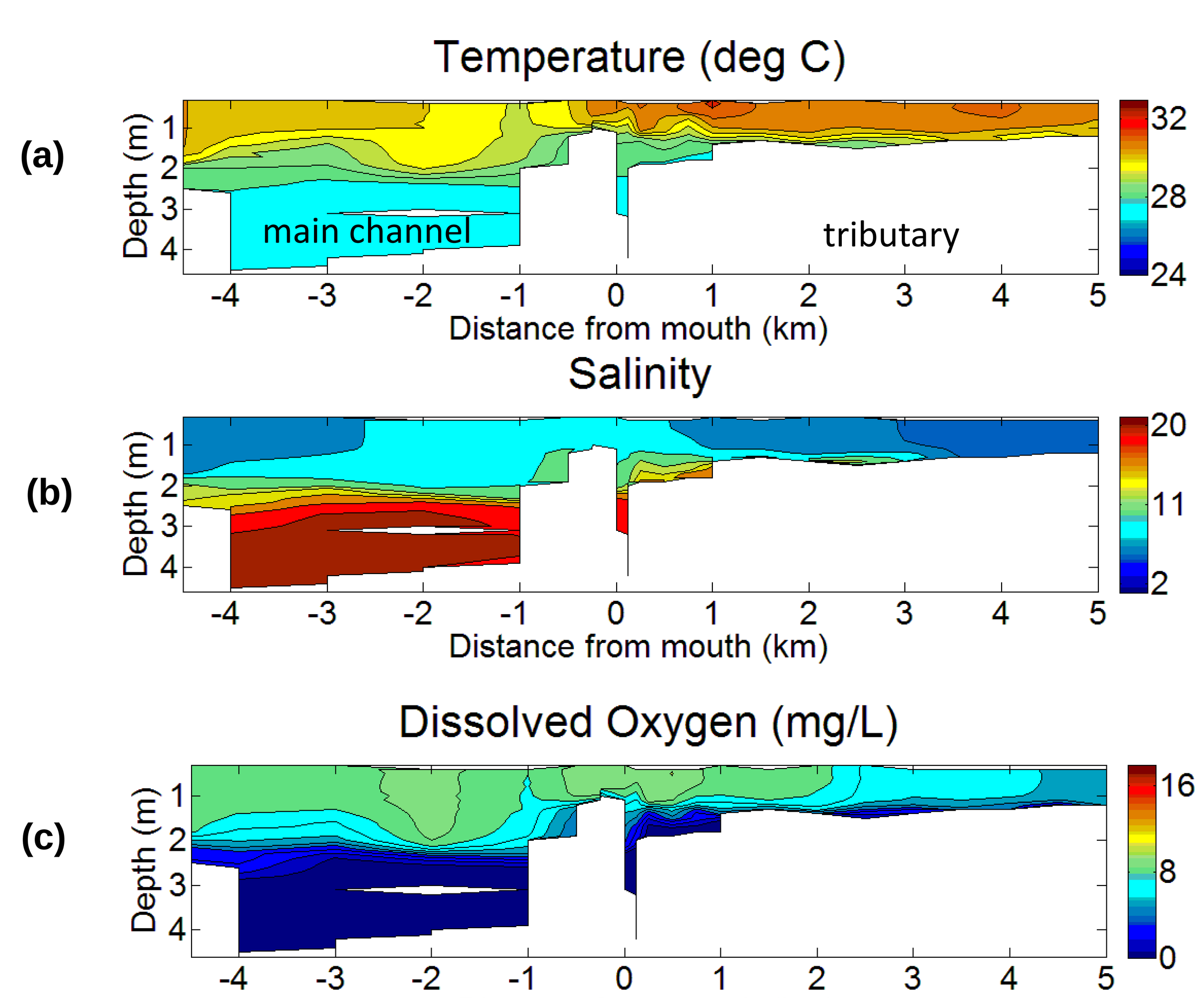


Figure 4. Contour plots of (a) temperature, (b) salinity, and (c) dissolved oxygen along a transect from the main channel of the Neuse to 5 km into Hancock Creek. Transect was done on Aug 10, shortly after the onset of winds from the southwest.

Main Channel Vertical Profiles

Bottom salinity in the main channel co-varied with the wind. Southwest winds drove surface water toward Pamlico Sound, forcing saline, low DO bottom water upstream to the AVP location (Figs. 5, 6).

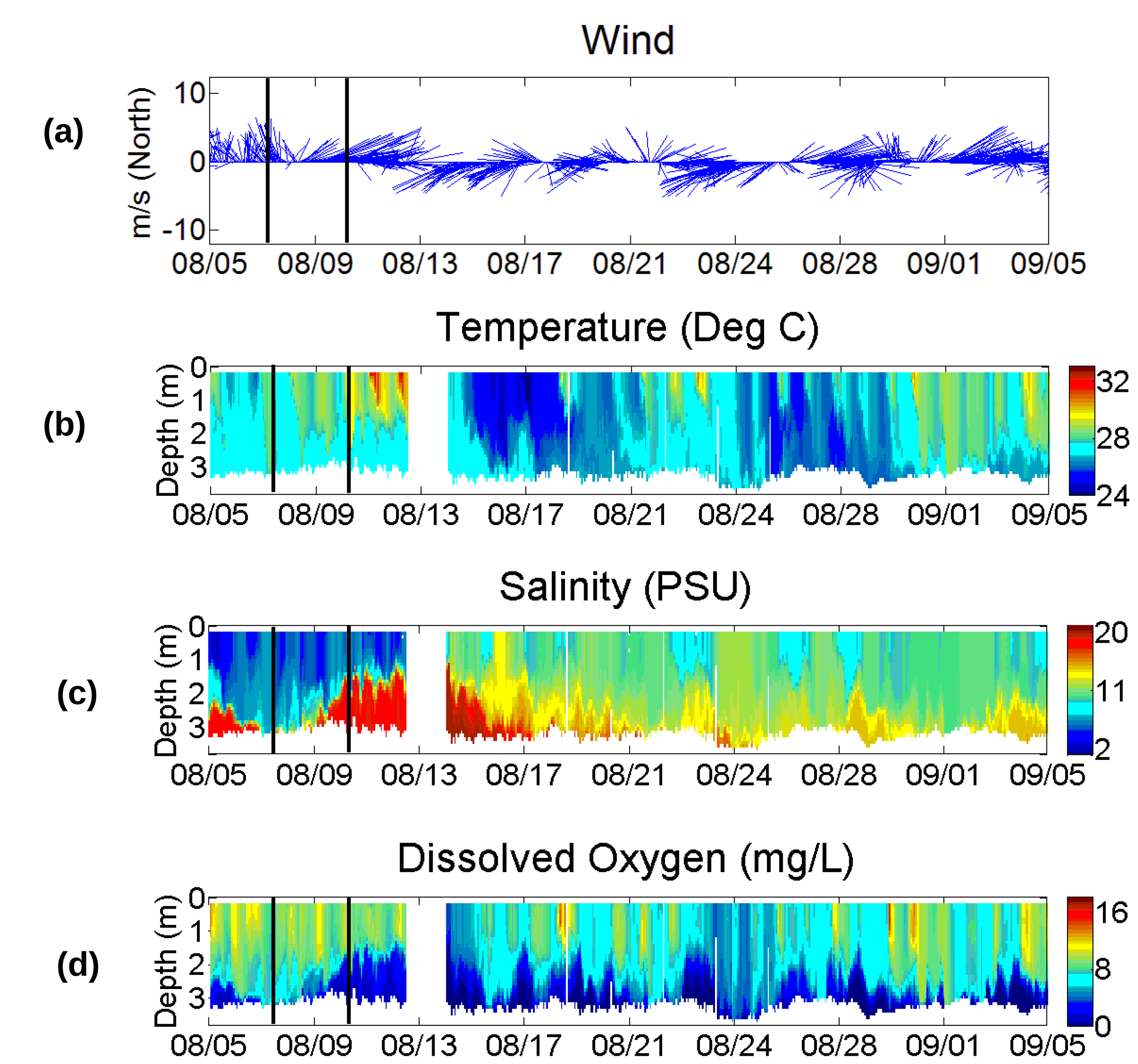


Figure 5. (a) Wind vectors and vertical profiles of (b) temperature, (c) salinity, and (d) dissolved oxygen measured by the AVP. Vertical black lines indicate the times of the two cross channel transects.

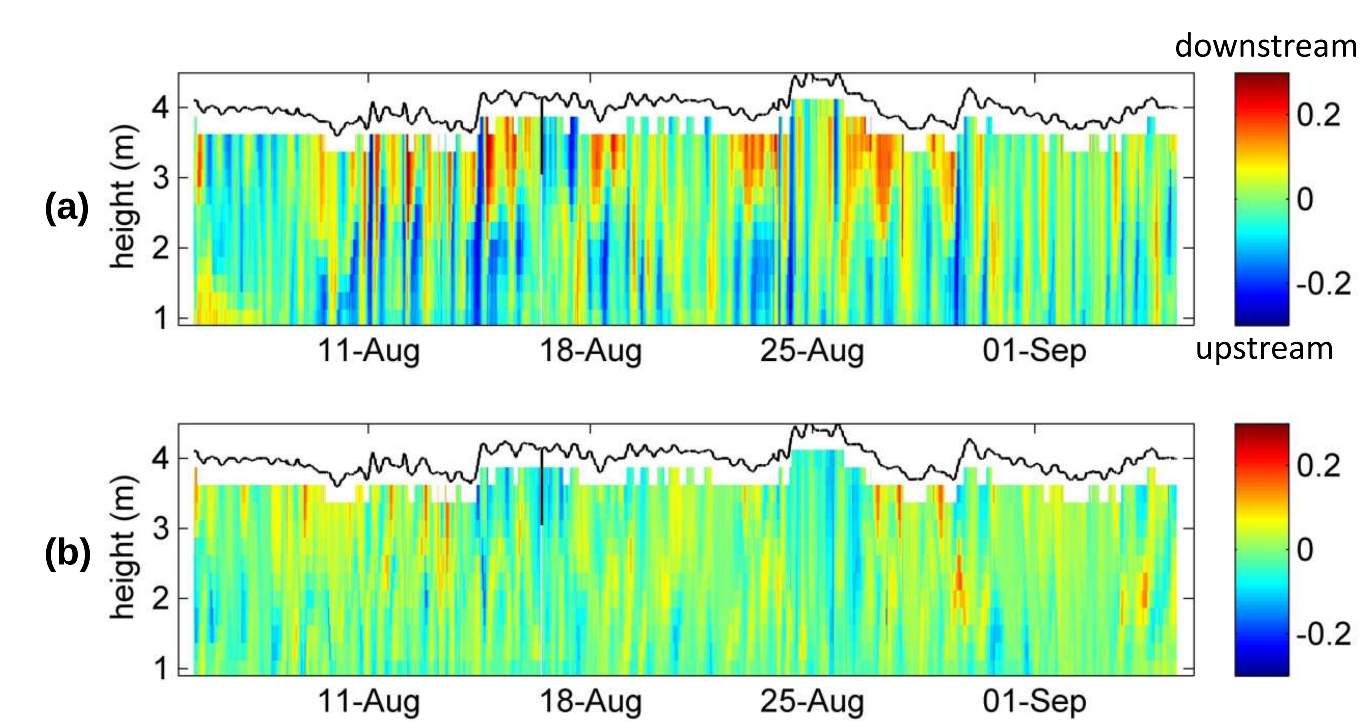


Figure 6. (a) Along-channel and (b) cross-channel current velocities (m/s) measured by the ADCP. Black line indicates water surface.

4. CONCLUSIONS AND FUTURE WORK

The main channel of the Neuse River Estuary was strongly density stratified and the lower water column was hypoxic during the experiment. The measurements in Hancock Creek indicate that wind-forced exchange processes between the main channel and tributaries may influence the salinity and dissolved oxygen distributions in the tributaries.

Future work will further examine the exchange processes between the main channel of the NRE and its tributaries. We plan to extend our investigation to include additional tributaries and investigate the relative influences of local processes within the tributary to external processes from the main channel on DO distributions and density stratification in the tributaries.

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