The influence of a dredge hole on tidal asymmetry and salinity structure in the Mullica River estuary.

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Introduction

Deepening an estuary's channel through dredging can affect salinity structure and tidal currents (Chant et al., 2019).

We compared velocity and salinity profiles within a dredge hole in the Mullica River estuary to investigate impacts on tidal flow and density stratification.

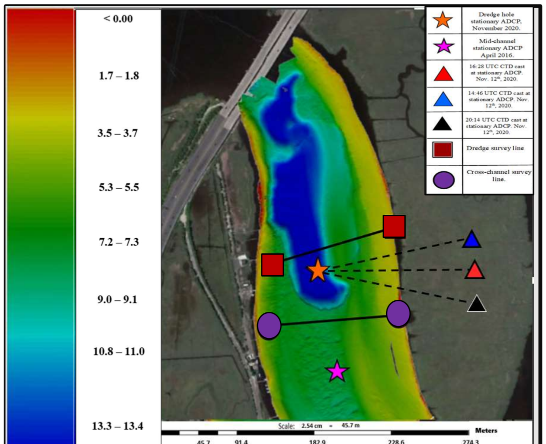

Figure 1: The dredge hole near Chestnut Neck is approximately 14-meters-deep. A vessel-mounted ADCP survey ran multiple transects over 6.5 hrs. within and adjacent to the hole. Supplemental data during the survey included three CTD casts (triangles) and a stationary ADCP within the hole (orange star). Velocity comparisons are made with previous survey data from a stationary ADCP downstream (pink star).

A vessel-mounted Acoustic Doppler Current Profiler (ADCP) quantified the spatial variability in velocity over cross-channel transects within and surrounding the dredge hole on November 12th, 2020.

In the hole, a stationary ADCP simultaneously measured velocity profiles for comparison to those from a downstream survey in April 2016.

Three Conductivity-Temperature Depth (CTD) casts in the dredge hole allowed vertical salinity gradient calculations:

$$\frac{\Delta S_H}{\Delta H} = \frac{S_{H2} - S_{H1}}{H_2 - H_1}.$$

Where H is water depth and S_H is salinity.

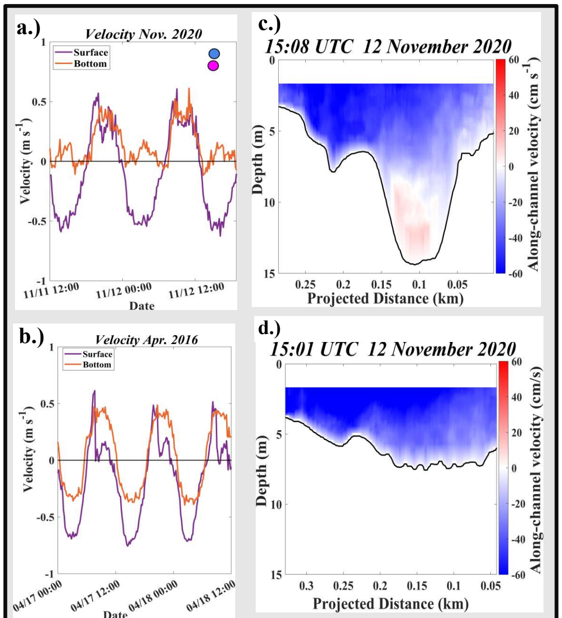

Figure 2: (a) Velocity near surface (purple) and near bottom (orange) in November 2020 within the dredge hole (orange star in Fig. 1). The two dots represent the time of November 2020 transects (Fig. 2c. & 2d.). (b) Velocity near surface and near bottom in April 2016 outside of the dredge hole (pink star in Fig. 1). (c) Velocity cross section over dredge hole (blue dot in Fig. 2a.) and (d) velocity cross section downstream of dredge hole (pink dot in Fig. 2a.) on November 12th during ebb tide.

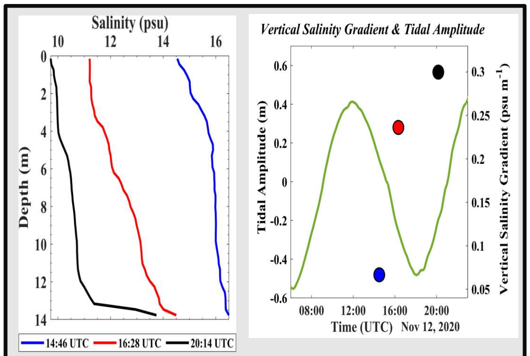

Figure 3: (a) Salinity profiles within the dredge hole on November 12th at three tidal stages (blue is early ebb; red is late ebb; black is slack tide) and (b) corresponding vertical salinity gradients (green line is water elevation). During ebb tide, the profiles show increased salinity at the bottom that persists as the tide changes and surface salinity decreases. This is confirmed by the increasing vertical salinity gradient.

Results

November 2020 stationary ADCP tidal analysis yielded a semidiurnal current amplitude of 0.5 m s^{-1} near-surface that weakened to 0.2 m s^{-1} near-bottom in the dredge hole.

In contrast, April 2016 had amplitudes of ~0.4 m s^{-1} for the whole water column.

November 12th maximum flood velocities were similar between the surface and bottom, 0.6 m s^{-1} and 0.5 m s^{-1} respectively.

The subsequent November 12th ebb tide has distinct asymmetry between surface and bottom flow. Surface reached a maximum ebb velocity of -0.6 m s^{-1}. Bottom flow was slightly positive at 0.1 m s^{-1}.

Vertical salinity profiles within the dredge hole show an increased gradient over ebb tide.

Conclusions

While tidal currents are roughly symmetric near the surface and downstream of the dredge hole, weak ebb tide velocities in the hole.

Survey transect comparisons and vertical salinity profiles confirm the that higher salinity water stays in the dredge hole during ebb tide.

This modification of the vertical salinity structure over the hole potentially alters flow patterns and impacts local benthic communities.

However, more detailed surveys over a full tide cycle with frequent CTD casts should be completed to confirm these results.

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