Measurements of oxygen flux over intertidal oyster reefs

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Introduction/Objectives

- The eastern oyster, Crassostrea virginica, is a filter feeding organism that can enhance fluxes of carbon, nitrogen, and phosphorus to the benthos.
- Oyster reefs can make a substantial contribution to total benthic oxygen uptake.
- Currently within the Virginia Coast Reserve (VCR), The Nature Conservancy (TNC) are conducting large-scale efforts to restore C. virginica reefs.
- We hope to identify key drivers of oyster metabolism and quantify restoration success through measurements of benthic oxygen flux via aquatic eddy covariance.

Methods

- Eddy Covariance measurements were made over three intertidal sites – natural reef, restored reef, and mudflat – at the Hillcrest Oyster Sanctuary at the VCR-LTER.
- These measurements were conducted June 17-24 (natural reef & mudflat), August 1-6 (natural & restored reef) and September 23-30 (natural & restored reef).
- The restored reef that was sampled was identified by TNC as their most successful restoration at the Hillcrest Sanctuary.

Site Description

A. The location of the Hillcrest Oyster Sanctuary at the VCR on the Delmarva Peninsula
B. Location of the different study sites within Hillcrest Sanctuary: natural reef (1), restored reef (2), and mudflat (3)

Eddy Covariance

- Natural reef: characterized by densely packed individuals cemented together with high vertical relief. Density = 350 oysters/m²
- Restored reef: slightly lower densities with less vertical relief and less cementation of the reef. Density = 295 oysters/m²
- Mudflat: intertidal plain with no oysters present

Results

- Mean nighttime flux at each site, along with standard errors. This represents the total oxygen demand of each system.
- Gross Primary Production (GPP)


Figure 1: Mean nighttime flux at each site, along with standard errors. This represents the total oxygen demand of each system.

Figure 2: Average Gross Primary Production (GPP) at each site, along with standard errors. Mean GPP was calculated in the difference between the average nighttime flux and average daytime flux.

Figure 3: Representative Eddy Covariance Data

- Graph of instantaneous velocities in the x, y, and z direction, as well as mean velocity averaged over 15 minute intervals
- Oxygen signals given by both a fast and a slow oxygen microsensor, as well as a slower but more stable oxygen-sensing optode used for calibration
- Cumulative oxygen flux averaged over 15 minute intervals
- Average August and Photosynthetically Active Radiation (PAR) over 15 minute intervals

Conclusions

- Average August/September values of nighttime O₂ flux were -318.0 mmol/m²d over the natural reef and -294.5 mmol/m²d over the restored reef. These results show that the restored oyster reef is close to functioning as a natural one and that this restoration appears to have been successful.
- Flow velocity, and probably PAR, are key controls on oyster reef metabolism.
- Benthic algae are very productive in this system, as shown by average August/September GPP values of 178.3 mmol/m²d at the natural reef and 139.2 mmol/m²d at the restored reef.
- Oyster metabolism and ideal productivity vary seasonally, as September values of oxygen uptake and GPP were both far lower than the June/August values.
- June O₂ fluxes were over eight times greater over the natural reef (-491.7 mmol/m²d) than over the mudflat (-65.7 mmol/m²d). These results suggest that oyster reefs have the potential to sequester large amounts of carbon as they grow and develop.

Future Research

- Sample more restored oyster reefs at Hillcrest to quantify their health and success.
- Measure other possible drivers of oyster metabolism (chlorophyll a, suspended sediment, etc.), and correlate these values to oyster reef metabolism.
- Conduct biodiversity and sediment sampling of Hillcrest mudflats to determine the edge effects (if any) imparted by the oyster reefs on the surrounding mudflats.
- Identify reason for apparent PAR/flow velocity relationship at restored reef.
- Conduct seasonal measurements of oyster reefs to study how metabolism varies annually.

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