Biogas emissions at the Estuarine Turbidity Maximum in the Hudson River

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Introduction

More than 12 million people in New York and New Jersey inhabit the Hudson River Estuary (HRE) [1] and depend on its health to sustain their quality of life. Dissolved oxygen (DO) depletion in estuaries causes ecosystem collapse [2] and results from rapid expansion of microbial communities. Nutrient enrichment of estuaries or eutrophication, precipitates this process [3]. The total economic cost of eutrophication to the communities near an estuary can reach hundreds of millions of dollars [4]. Engineering systems for eutrophication control in the HRE is dependent on understanding the cycling of carbon and nitrogen in the system because these elements are essential for microbial growth.

The influence of carbon and nitrogen on eutrophication is illustrated in (Fig. 1-4), which display a climatology computed from data collected by the New York Harbor Survey 2000-2008 (NYCHS). Figure 1 shows a peak in primary productivity during the summer months and (Fig. 2) shows that the DO reaches its low point during the same period. Figures 3 and 4 illustrate that both the Dissolved Organic Carbon (DOC) and Dissolved Organic Nitrogen (DON) are sustained at relatively high levels during the same period.

Microbial processing of carbon and nitrogen is affected by the Estuarine Turbidity Maximum (ETM) just south of the George Washington Bridge, where the relative strength of oceanic tides and the river's current are equal. The resulting turbulence stirs up the sediment to create suspended particle levels 10 to 100 times the amount in the rest of the estuary [2].

N_2 emissions from this zone were estimated based on measurements of the N_2/Ar ratio at 125st pier in Manhattan during late July 2010. The results were used with measurements of CO_2 and CH_4 emissions from 2007, N_2O model [5] estimates using ammonia data from the NYCHS, and data on all aqueous carbon and nitrogen compounds, collected by the NYCHS to construct a box model (Fig. 5) that accounts for the total nitrogen and carbon flowing through this section of the HRE in order to estimate the impact of the ETM on biogeochemical processes.

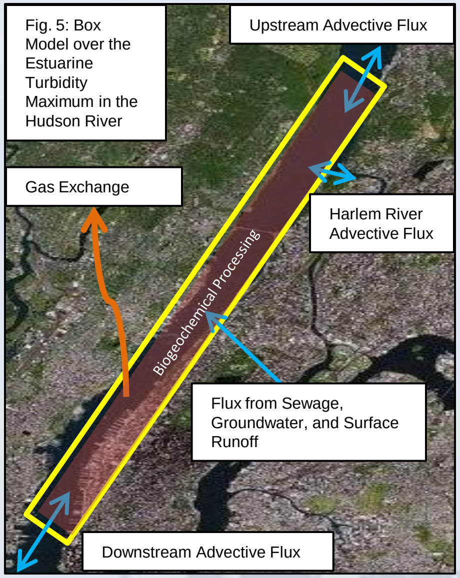
Fig. 5: Box Model over the Estuarine Turbidity Maximum in the Hudson River

This model includes all of the major processes that impact the fluxes of nutrients and carbon in a defined section of the HRE. These fluxes can be linked by the material balance:

$$\text{Local Change} = A_U - A_D + I_{WW} + G + I_{GW} + I_{SR} + B + H$$

Terms	Name	Term Classification	Definition	Calculation Method
A_U	Upstream Advective Flux	Advection	Movement of dissolved non-particulate material	diffusitivty * gradient
A_D	Downstream Advective Flux	Advection	Movement of dissolved non-particulate material	diffusitivty * gradient
I_s	Sewage Input		Effluent from North River WWTP	Concentration*Flow Rate
G	Gas Exchange	Gas Exchange	gas evasion/absorption	McGillis et al.
I_{GW}	Groundwater Input	Advection	-	-
I_{SR}	Surface Runoff	Advection	-	-
B	Biogeochemical Processing	Biogeochemical change from dissolved and particulate pools	Net fluxes finto and out of dissolved and organic pools	Difference between the two pools
H	Harlem River Exchange	Advection	Movement of dissolved non-particulate material	diffusitivty * gradient

Results & Discussion

N_2 emissions were estimated based on the N_2/Ar ratio measured with a mass spectrometer (Fig. 6). The transient decrease on the 27th and 28th coincided with a spring tide, when the entire water column was mixed with ocean waters. The nitrogen and carbon budgets (Fig. 7) show more material leaves the system as N_2 and CO_2 than is accounted for by advective inputs. The difference may be provided by the accumulation of particulate carbon and nitrogen that naturally occurs at the ETM. The maximum denitrification rate was measured to be 130 [umol-N/m^3-d], which is similar to the rate measured in Chesapeake Bay, MD.

Fig. 6: 125st Pier New York, Dissolved Nitrogen and Argon Ratio 7/25/10-7/30/10

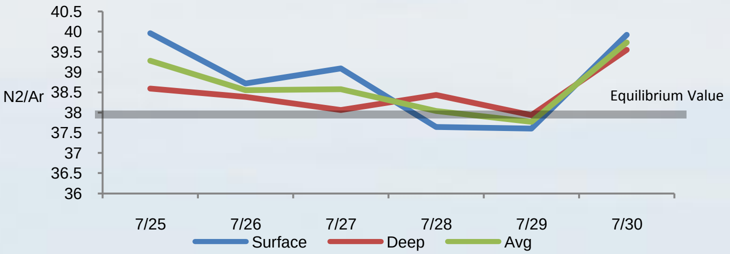

Fig. 7: Summer Nitrogen and Carbon Budget at the Estuarine Turbidity Maximum in the Hudson River

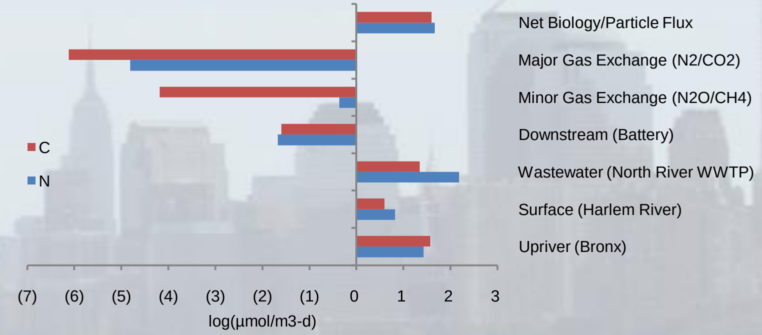

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Fig. 1: Chlorophyll a in Lower Hudson River Surface Waters New York Harbor Survey Climatology 2000-2008

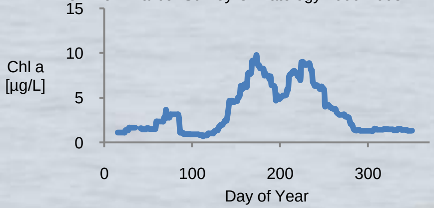

Fig. 2: Oxygen in Lower Hudson River Deep Waters New York Harbor Survey Climatology 2000-2008

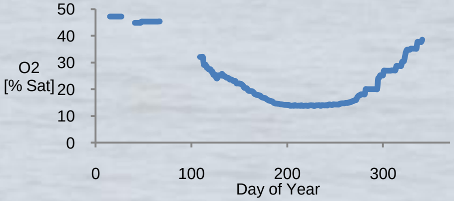

Fig. 3: Carbon in Lower Hudson River Surface Waters New York Harbor Survey Climatology 2000-2008

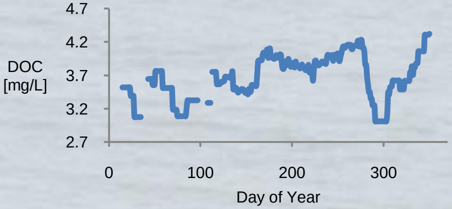

Fig. 4: Nitrogen in Lower Hudson River Surface Waters New York Harbor Survey Climatology 2000-2008