An Investigation of the Composition and Reactivity of Material Eroded from Chesapeake Bay Marshes

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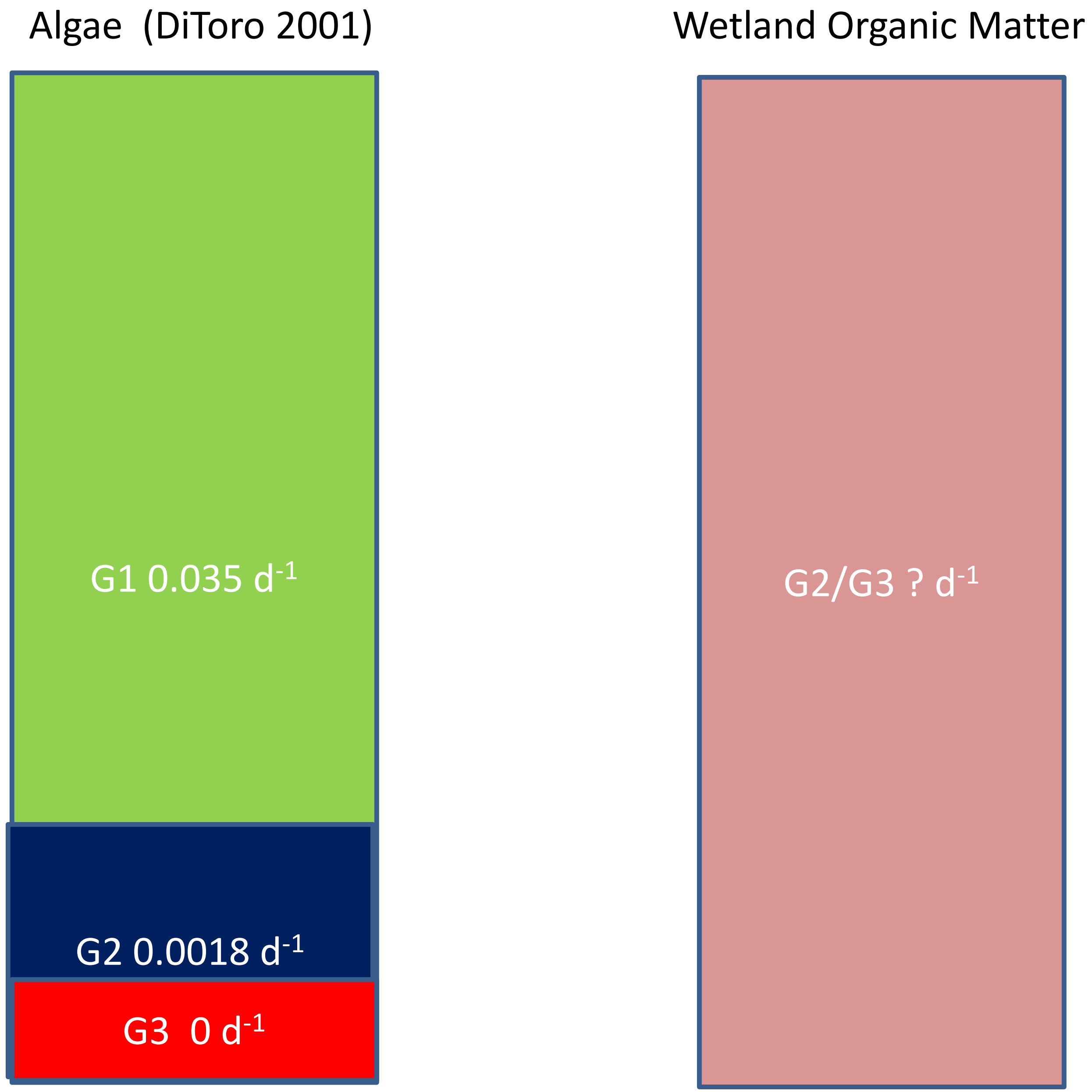
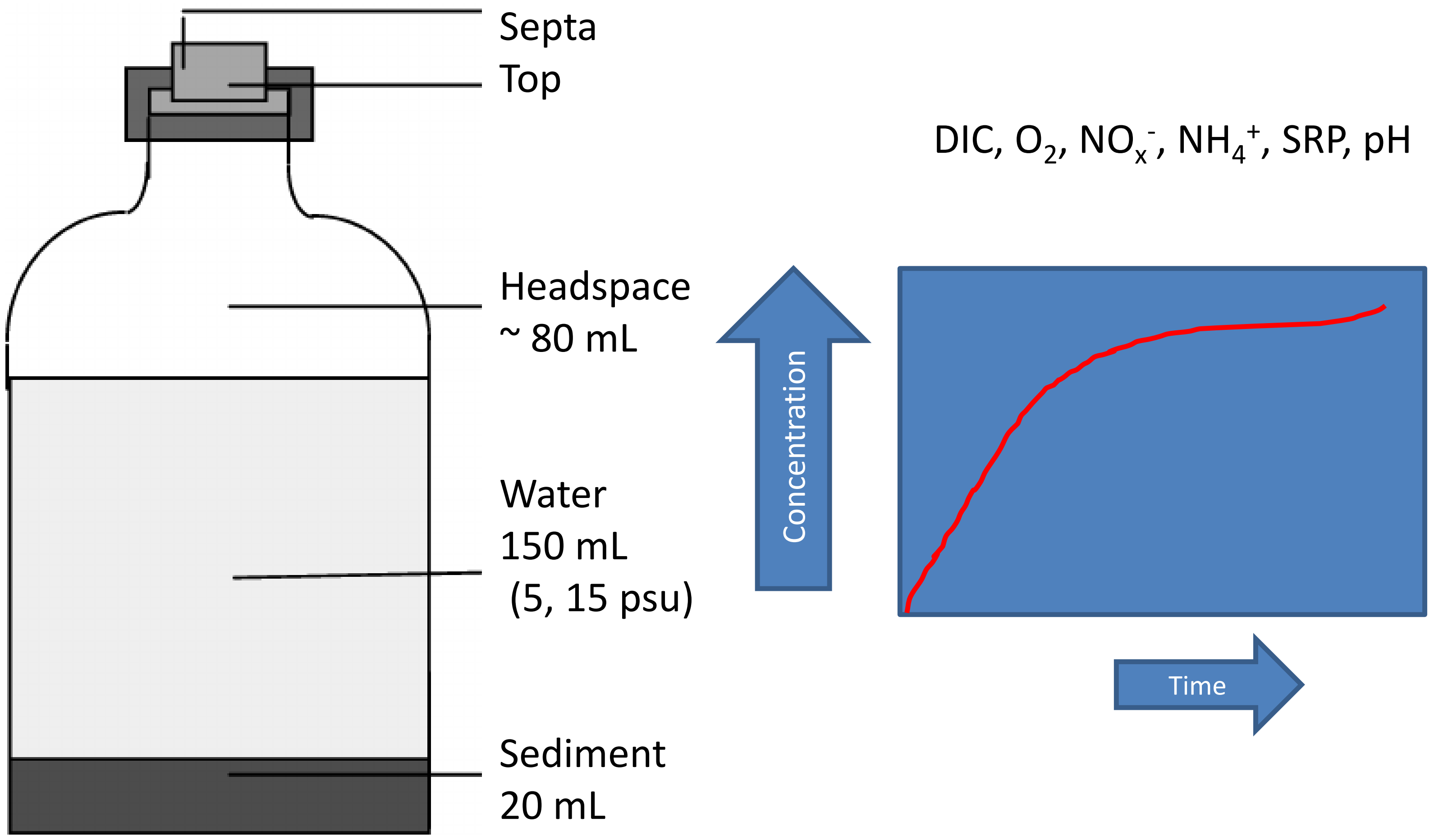
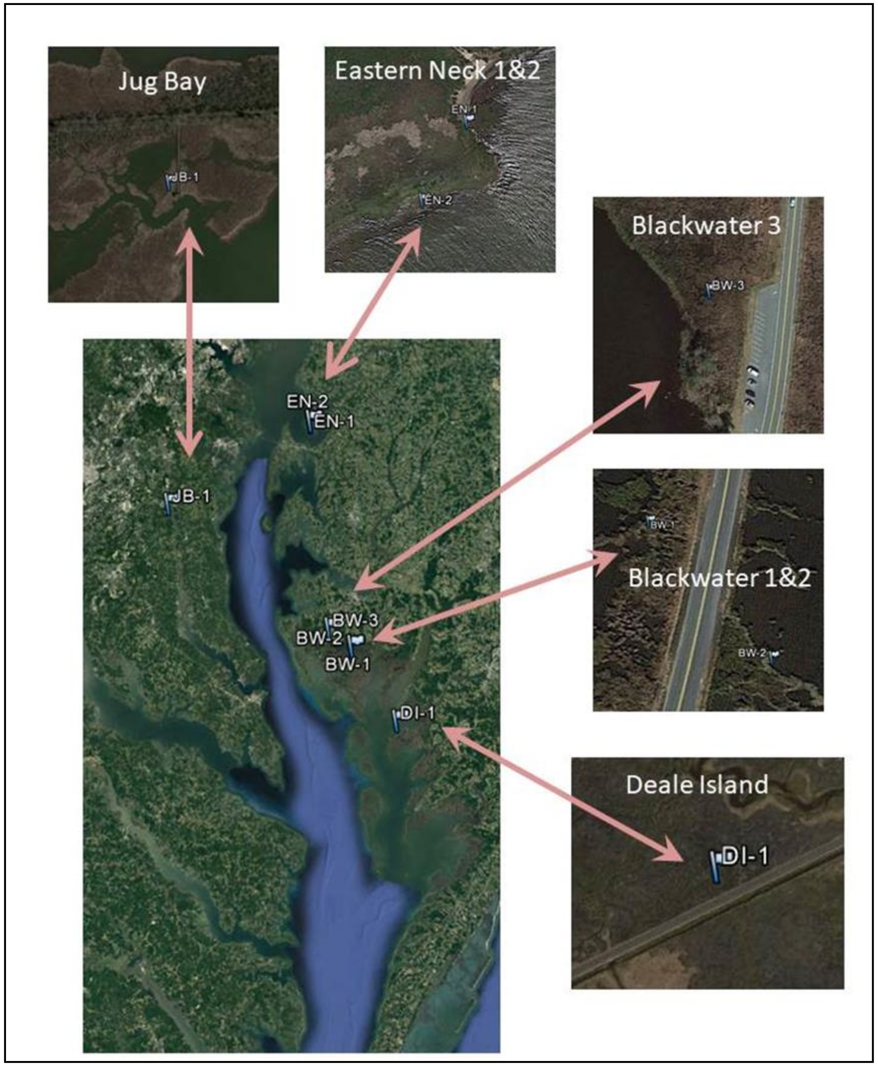
Project Goals

- Determine rates of organic matter decomposition
- Inform models of N/P release, O_2 uptake
- Determine if N/P release is fast/slow, important…..

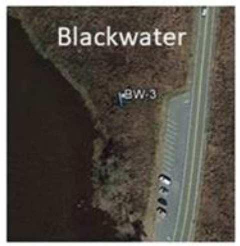

Algae (DiToro 2001)
Wetland Organic Matter
G1 0.035 d-1
G2 0.0018 d-1
G3 0 d-1
G2/G3 ? d-1


Septa
Top
Headspace
~ 80 mL
Water
150 mL
(5, 15 psu)
Sediment
20 mL
DIC, O_2, NO_x^-, NH_4^+, SRP, pH
Concentration
Time

Locations



Location	Core ID	Section ID	Depth Range (cm)	Latitude N	Longitude W	Collection Date
Blackwater NWR	1	BW-1A	0-30	38°29.490′	76°03.983′	10/25/2016
		BW-1B	30-56			
		BW-1C	56-79			
	2	BW-2A	0-28	38°29.470′	76°03.965′	
		BW-2B	28-65			
		BW-2C	65-80			
	3	BW-3A	0-12	38°26.396′	76°08.722′	
		BW-3B	12-19			
		BW-3C	19-39			
Eastern Neck NWR	1	EN-1A	10-30	39°00.539′	76°12.604′	11/15/2016
		EN-1B	30-55			
	2	EN-2A	0-13	39°00.522′	76°12.620′	
		EN-2B	13-38			
		EN-2A	38-47			
Jug Bay	1	JB-1A	0-17	38°46.850′	76°42.491′	11/15/2016
		JB-1B	43-61			
		JB-1C	61-78			
Deale Island	1	DI-1A	0-20	38°11.195′	76°54.647′	3/9/2017
		DI-1B	20-40			
		DI-1C	40-80			



Blackwater
BW-3

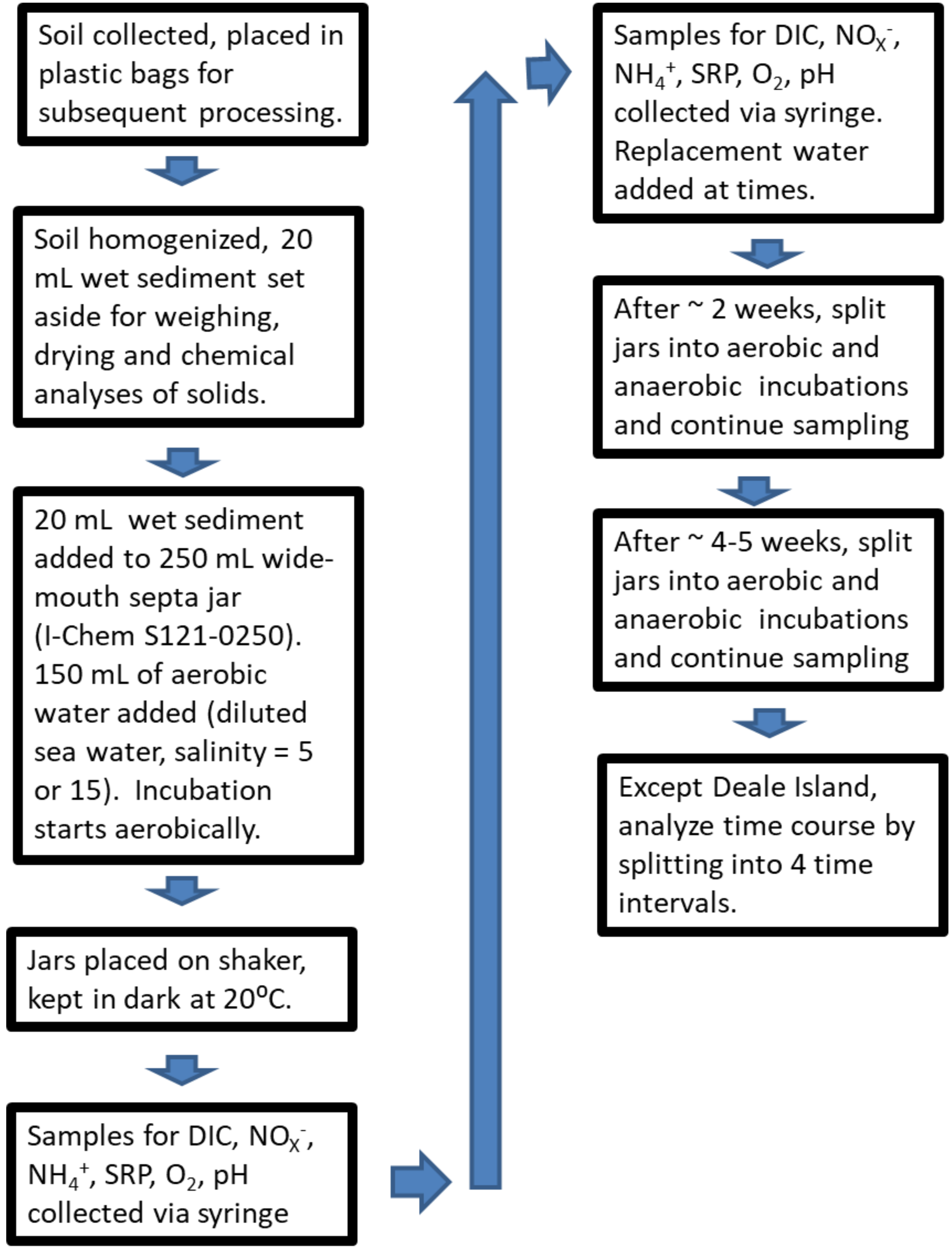
EN-1

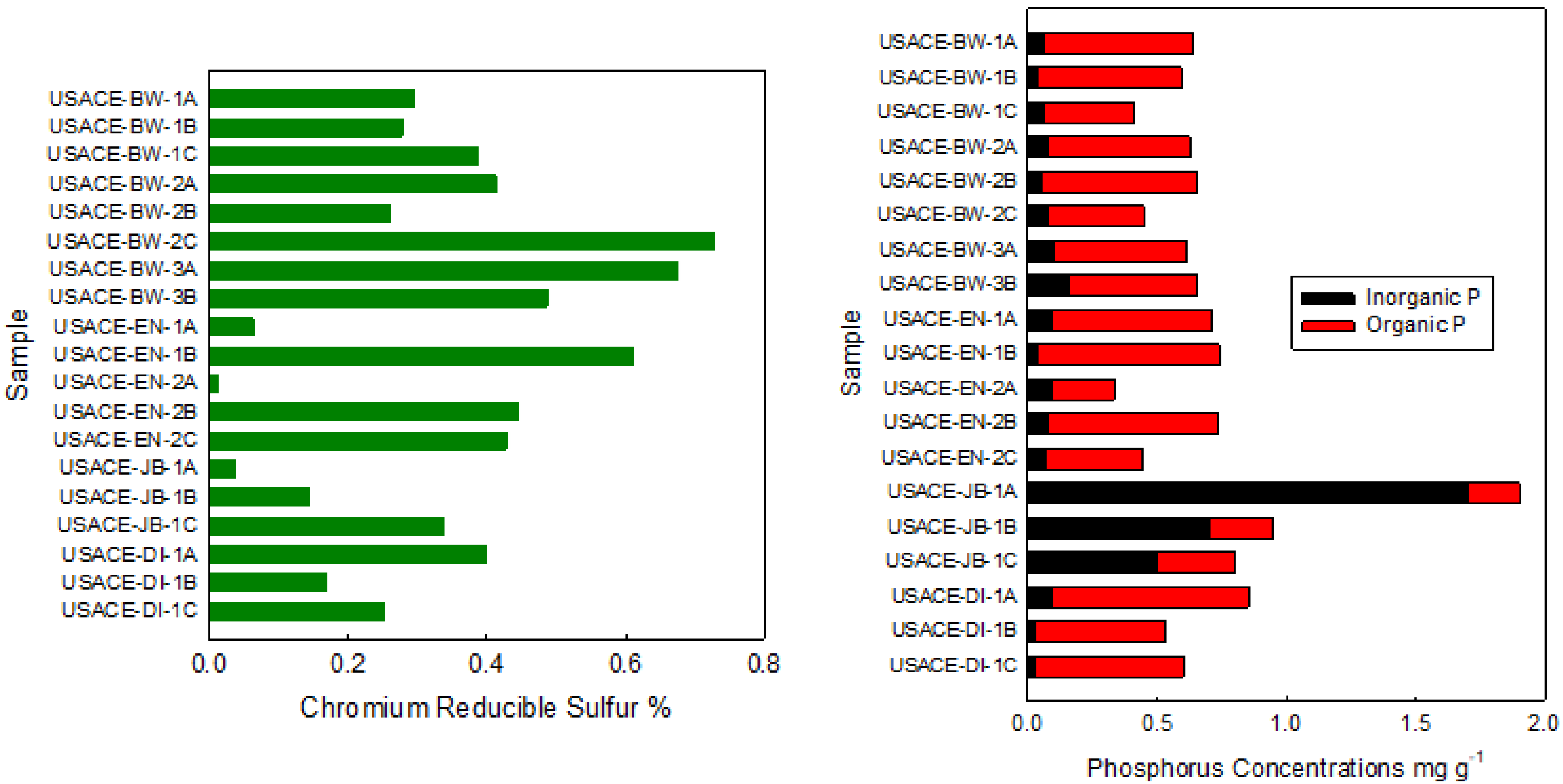
EN-2


Jug Bay

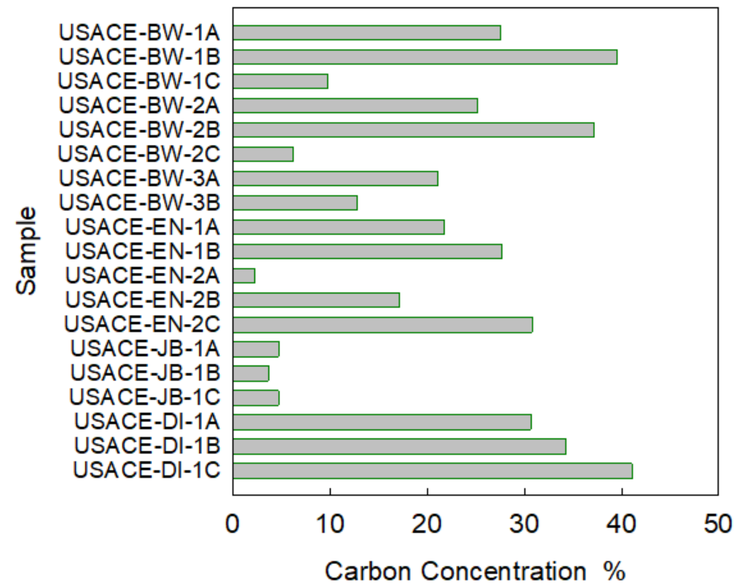

Deale Island
DI-1

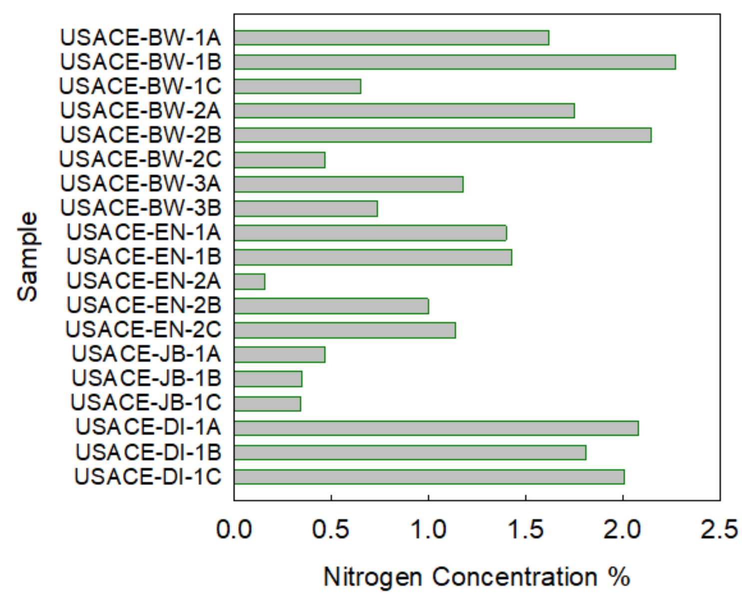
Sample Processing



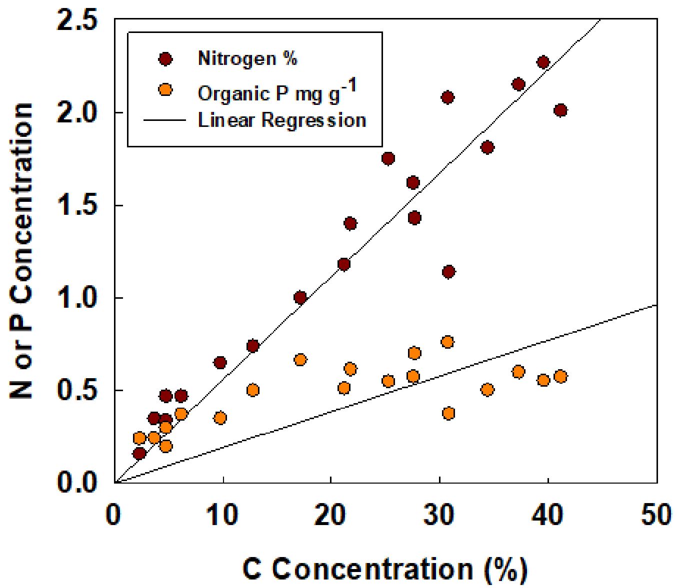


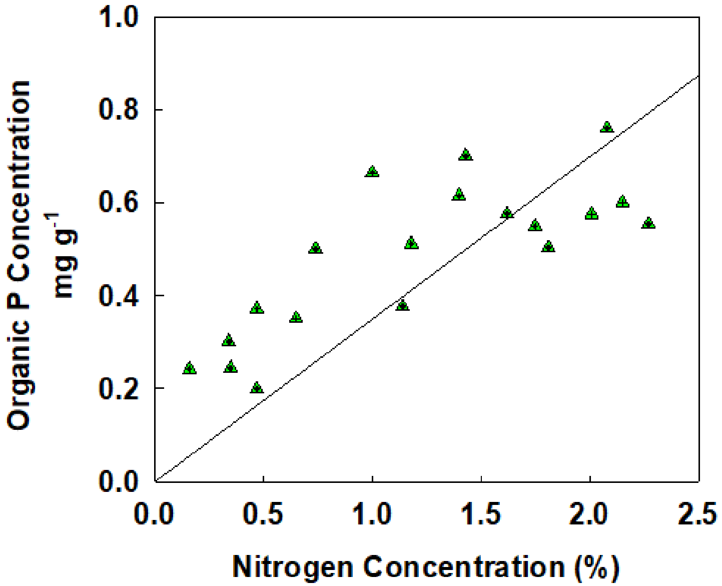
Sample
USACE-BW-1A
USACE-BW-1B
USACE-BW-1C
USACE-BW-2A
USACE-BW-2B
USACE-BW-2C
USACE-BW-3A
USACE-BW-3B
USACE-EN-1A
USACE-EN-1B
USACE-EN-2A
USACE-EN-2B
USACE-EN-2C
USACE-JB-1A
USACE-JB-1B
USACE-JB-1C
USACE-DI-1A
USACE-DI-1B
USACE-DI-1C
0.0
0.2
0.4
0.6
0.8
Chromium Reducible Sulfur %
Sample
Inorganic P
Organic P
0.0
0.5
1.0
1.5
2.0
Phosphorus Concentrations mg g-1


USACE-BW-1A
USACE-BW-1B
USACE-BW-1C
USACE-BW-2A
USACE-BW-2B
USACE-BW-2C
USACE-BW-3A
USACE-BW-3B
USACE-EN-1A
USACE-EN-1B
USACE-EN-2A
USACE-EN-2B
USACE-EN-2C
USACE-JB-1A
USACE-JB-1B
USACE-JB-1C
USACE-DI-1A
USACE-DI-1B
USACE-DI-1C
Sample
0
10
20
30
40
50
Carbon Concentration %


USACE-BW-1A
USACE-BW-1B
USACE-BW-1C
USACE-BW-2A
USACE-BW-2B
USACE-BW-2C
USACE-BW-3A
USACE-BW-3B
USACE-EN-1A
USACE-EN-1B
USACE-EN-2A
USACE-EN-2B
USACE-EN-2C
USACE-JB-1A
USACE-JB-1B
USACE-JB-1C
USACE-DI-1A
USACE-DI-1B
USACE-DI-1C
Sample
0.0
0.5
1.0
1.5
2.0
2.5
Nitrogen Concentration %

Organic P and N as a function of organic carbon concentration (top) and organic P as a function of nitrogen concentration (bottom). Linear regressions are forced through zero. These regressions yield molar ratios of carbon to nitrogen (20.9), carbon to organic phosphorus (1340) and nitrogen to organic phosphorus (63).



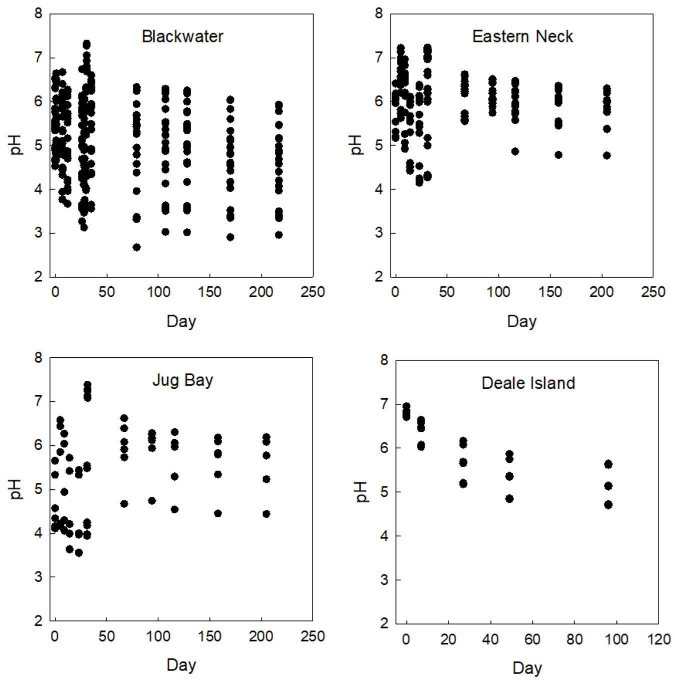


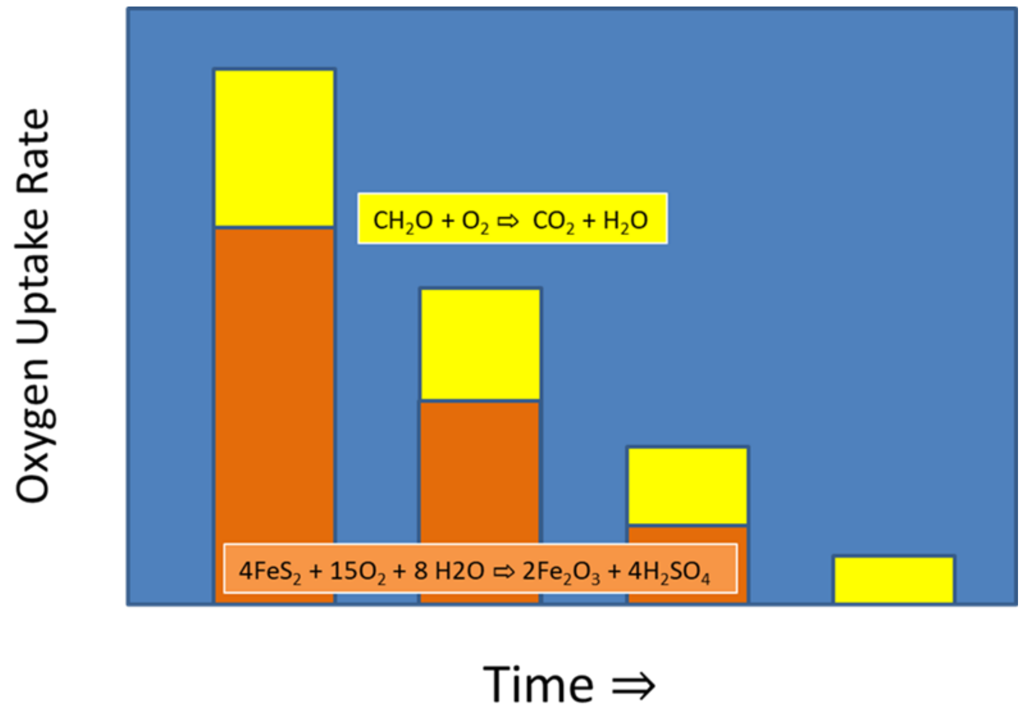
Forming Pyrite

$$15\ CH_2O + 8SO_4^{2-} + 4\ FeOOH + 16\ H^+ \rightarrow 4\ FeS_2 + 15\ CO_2 + 25\ H_2O$$

Oxidizing Pyrite

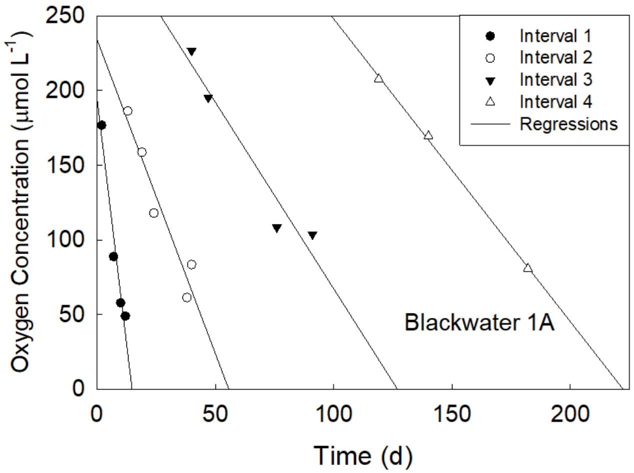
$$4FeS_2 + 15O_2 + 8H_2O \rightarrow 2Fe_2O_3 + 8\ H_2SO_4$$

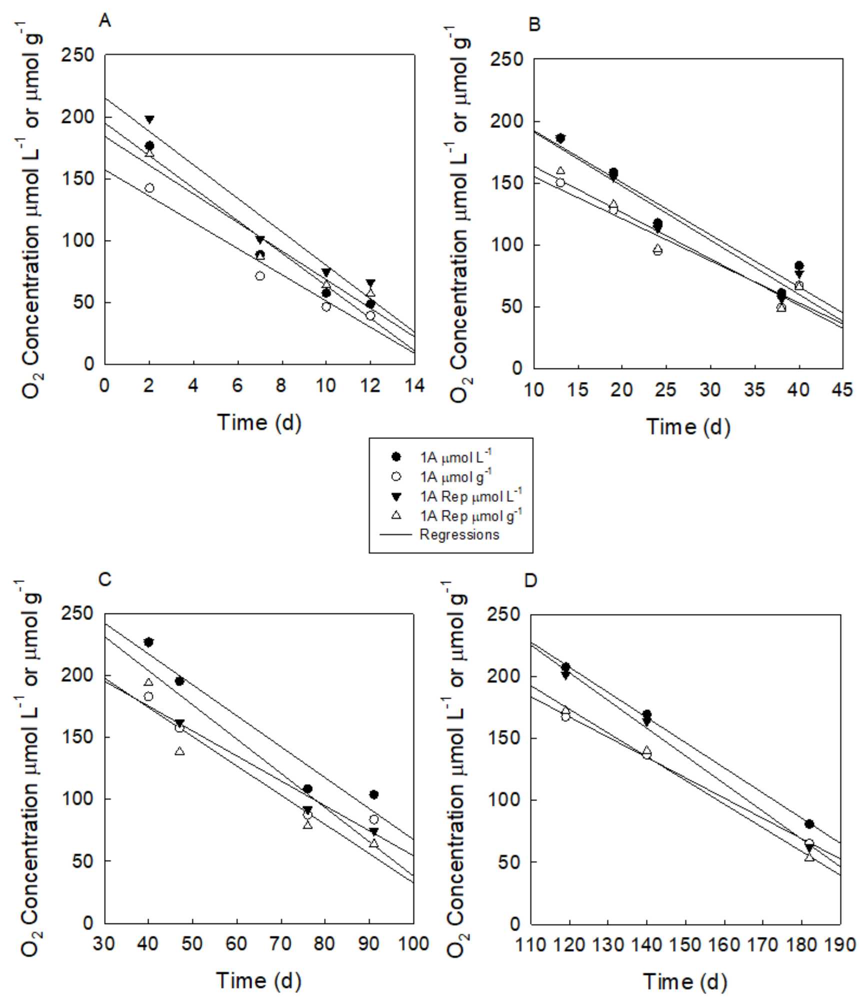


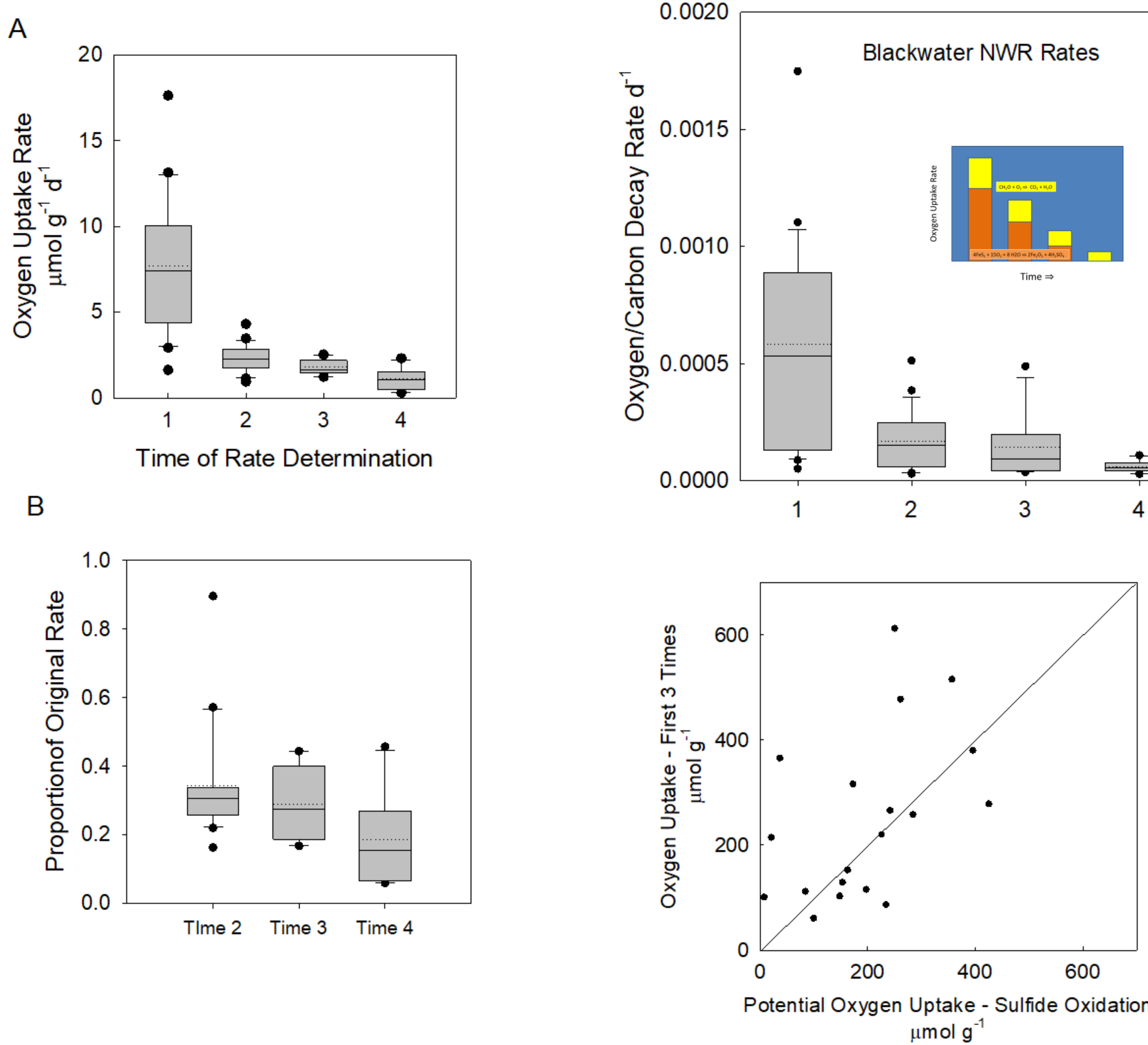


Oxygen Fluxes

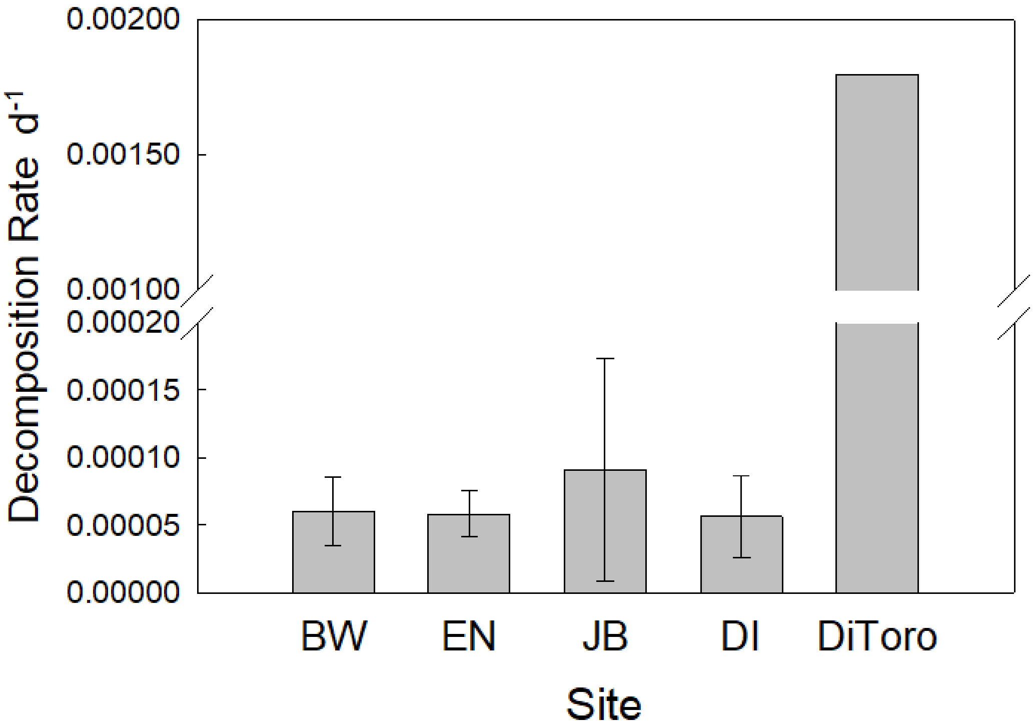
µmol L^{-1} µmol g^{-1}





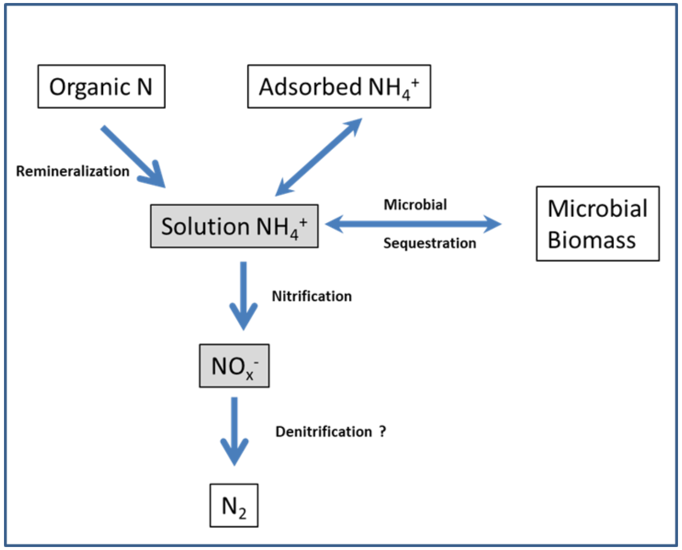


A
Oxygen Uptake Rate µmol g-1 d-1
Time of Rate Determination
Blackwater NWR Rates
Oxygen/Carbon Decay Rate d-1
Oxygen Uptake Rate
Time ⇒
B
Proportionof Original Rate
TIme 2
Time 3
Time 4
Oxygen Uptake - First 3 Times µmol g-1
Potential Oxygen Uptake - Sulfide Oxidation µmol g-1

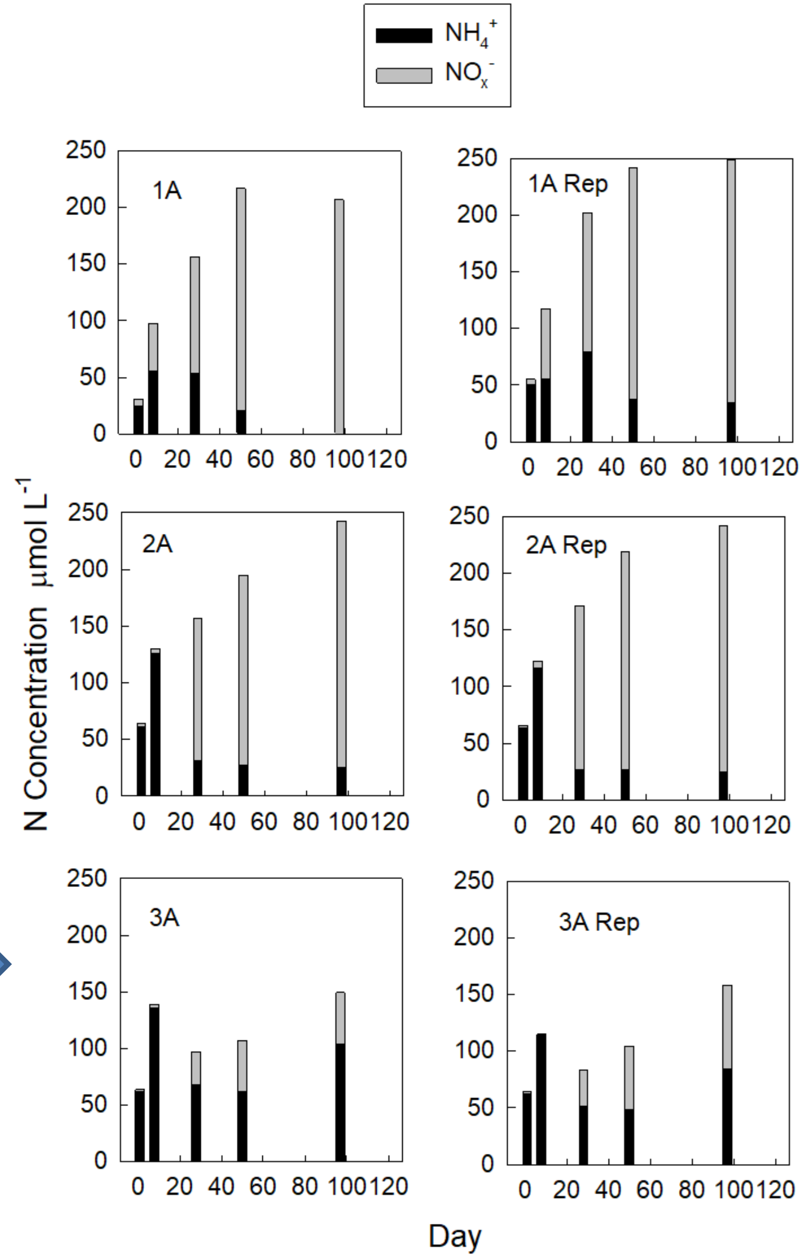


Decay rate of wetland organic matter at 4 sites compared to the algal G2 rate from Ditoro (2001)

Location/ID	Average	Standard Deviation
	d^{-1} (x 10^{-5})	
Blackwater	6.1	2.5
Eastern Neck	5.8	1.7
Jug Bay	9.1	8.2
Deale Island	5.7	3.0
DiToro G2	180	

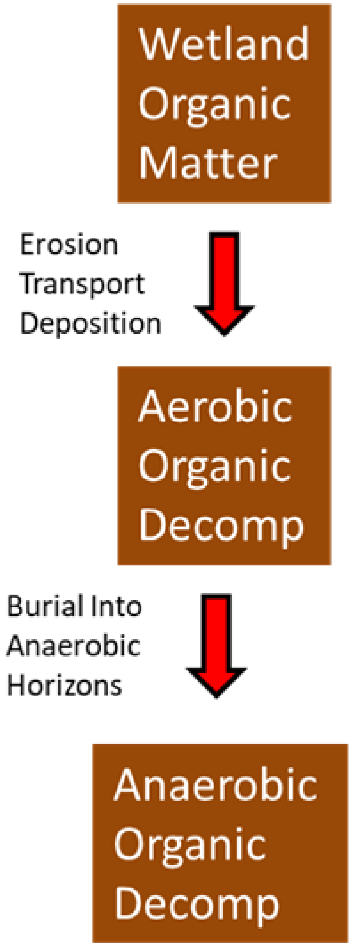


Stacked bar graph of the concentrations of NH_4^+ and NO_x^- from Deale Island sediments over the course of 97 days. Three depths in the core are shown, with duplicate aerobic incubation time courses.



Rate ~ 5 x 10^{-5} d^{-1}

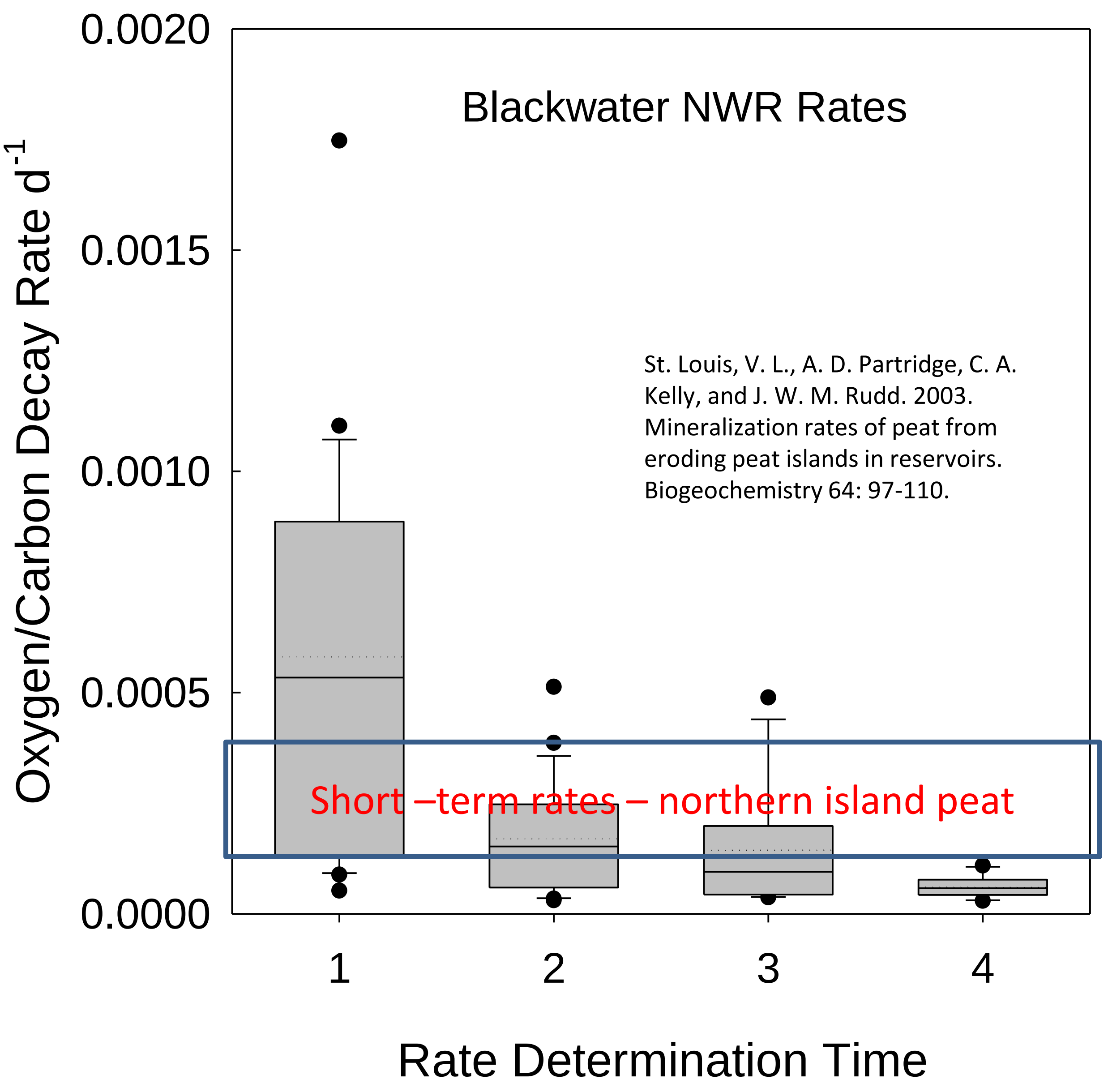
Processes/Notes



- Low lability in marsh sediments
- Sediment accretion needs to match sea-level rise
- Sediments are (mostly) anaerobic
- N and P are largely in organic forms*

- In the water column and sediment surface, aerobic conditions
- Eroded sediment particles are 0 to > 150 y old
- Reworking by animals, resuspension changes particle size
- Residence time under aerobic conditions highly variable

- After long-term anaerobic processing in marsh, starts again
- Lability likely negligible
- Transfer of “permanent” N and P burial to new site



At long-term rate, our rates = 2% y^{-1} degraded

Conclusions

- Aerobic rates are very low, but consistent with peat degradation rates in the literature. Rates are ~ 2% per year.
- Low N and P concentrations limit release.
- Burial into these organic forms makes N and P relatively recalcitrant, and likely to be “re-buried” into anaerobic sediments.
- Marsh N and P burial are likely true net losses to the system, with minimal return even with erosive losses from SLR.
- Fewer samples, more detail likely a more effective study approach.