Building a Salt Marsh Greenhouse Gas Budget: Lateral Fluxes

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photo: S. Baldwin

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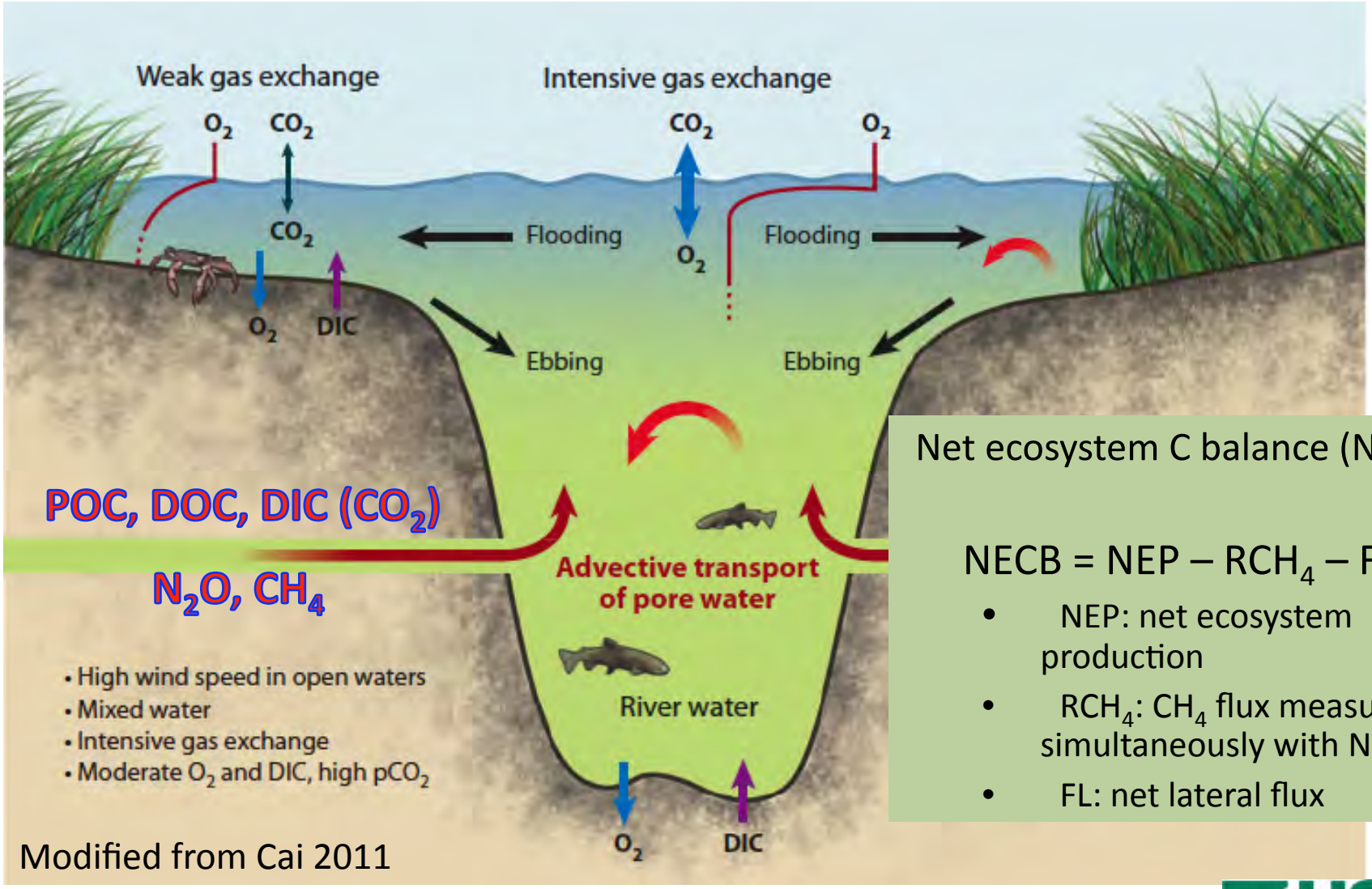
Lateral Fluxes = Tidal Exchanges of Carbon and Gases



Modified from Cai 2011

Net ecosystem C balance (NECB)

$NECB = NEP – RCH_4 – FL$

- NEP: net ecosystem production
- RCH_4: CH_4 flux measured simultaneously with NEP.
- FL: net lateral flux

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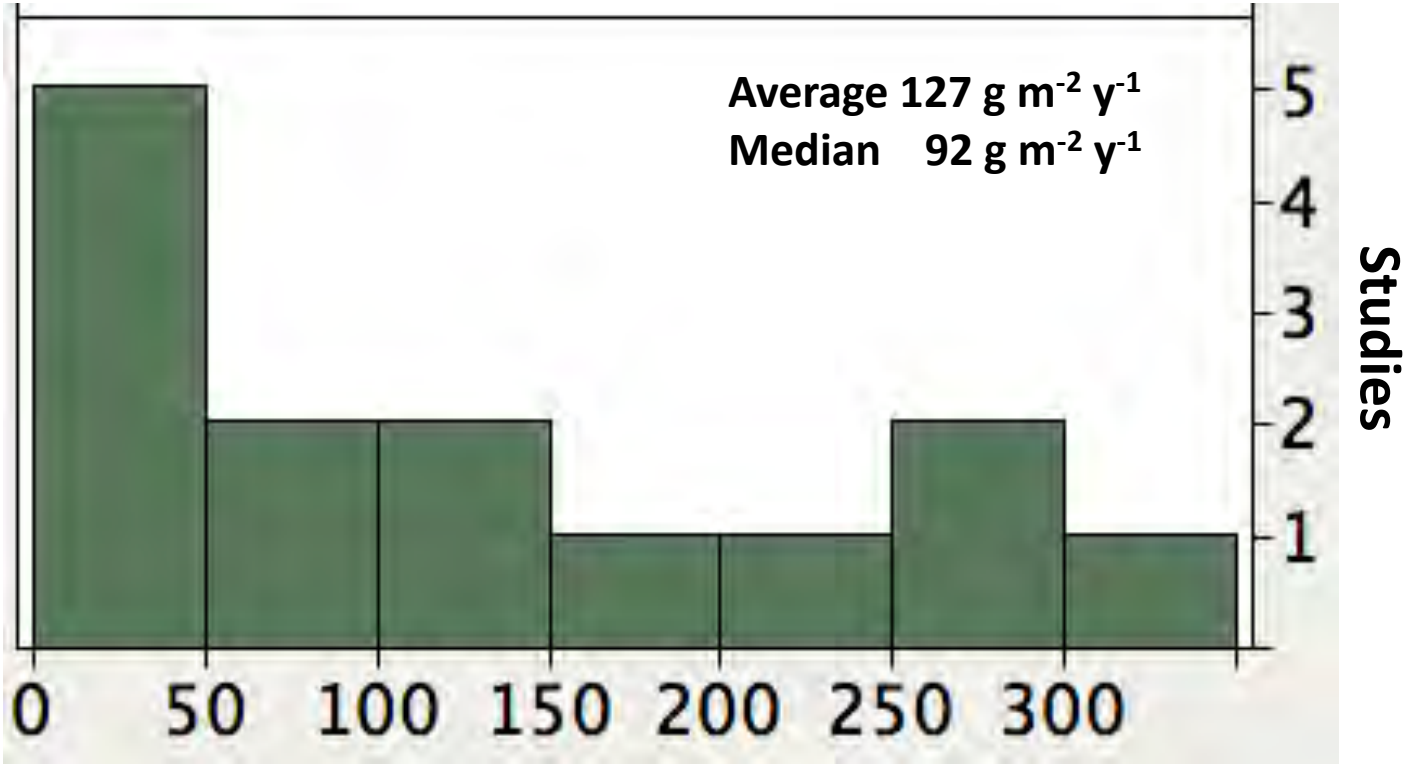
Published Rates of DOC Export on U.S. East Coast



Rate of C storage in soil

(Chmura et al. 2003, Loomis & Craft 2010, Duarte et al. 2005)

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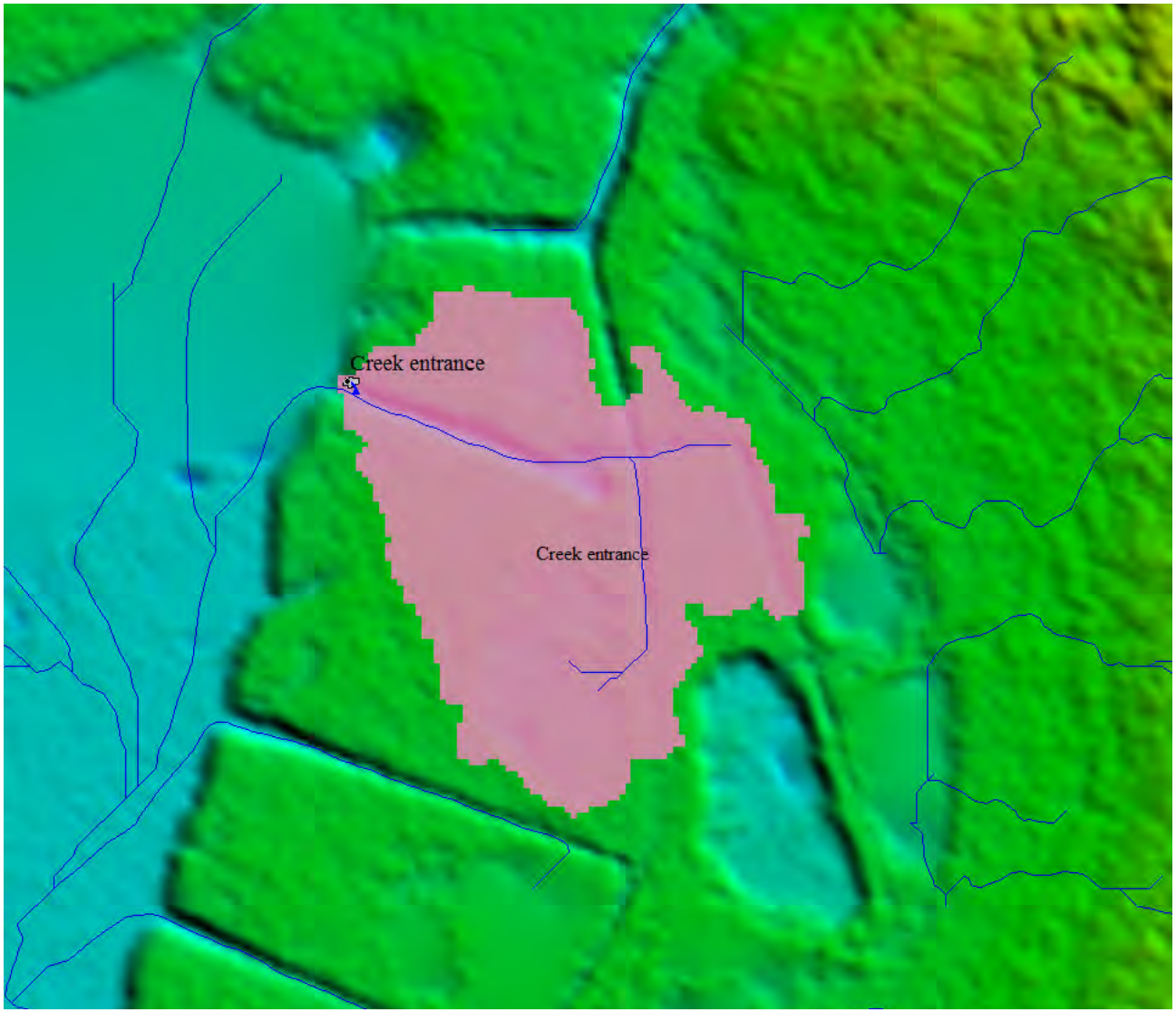
Experimental Design Strategy: Small, known basins and intensive collections during individual tidal cycles

Photo provided by J. Rassman (WBNERR)

Drainage Basin Based on 1 m Resolution LiDAR: 4,132 m^2



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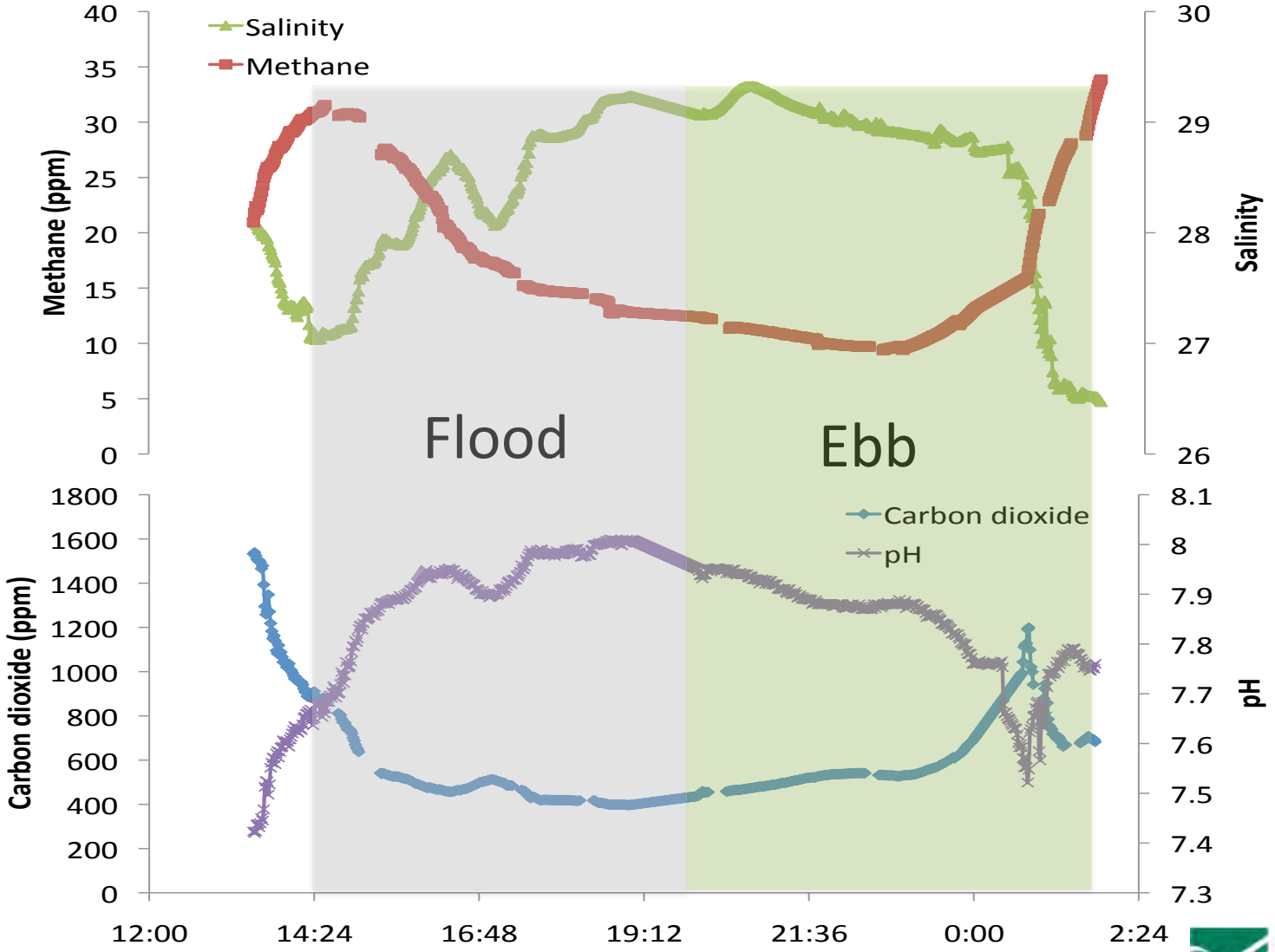
Station Set-up At Creek Mouth

Sample collections in cold weather…

...in beautiful weather...

…and after dark.

Example of full tidal cycle with greenhouse gas measurements



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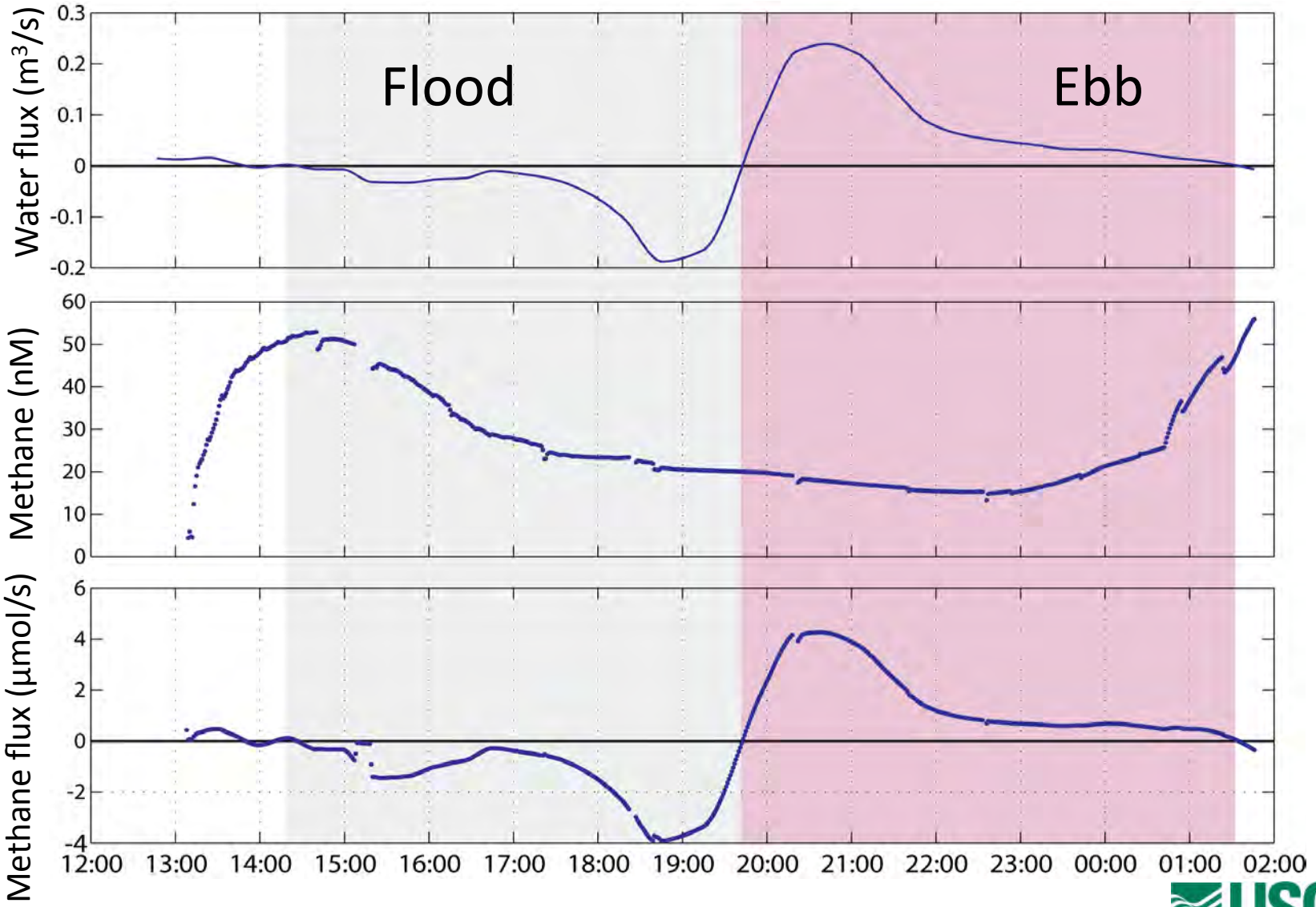
Subtle Features of Sub-Tidal Cycle Flux Rates



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Interpretations and Comments on Methods

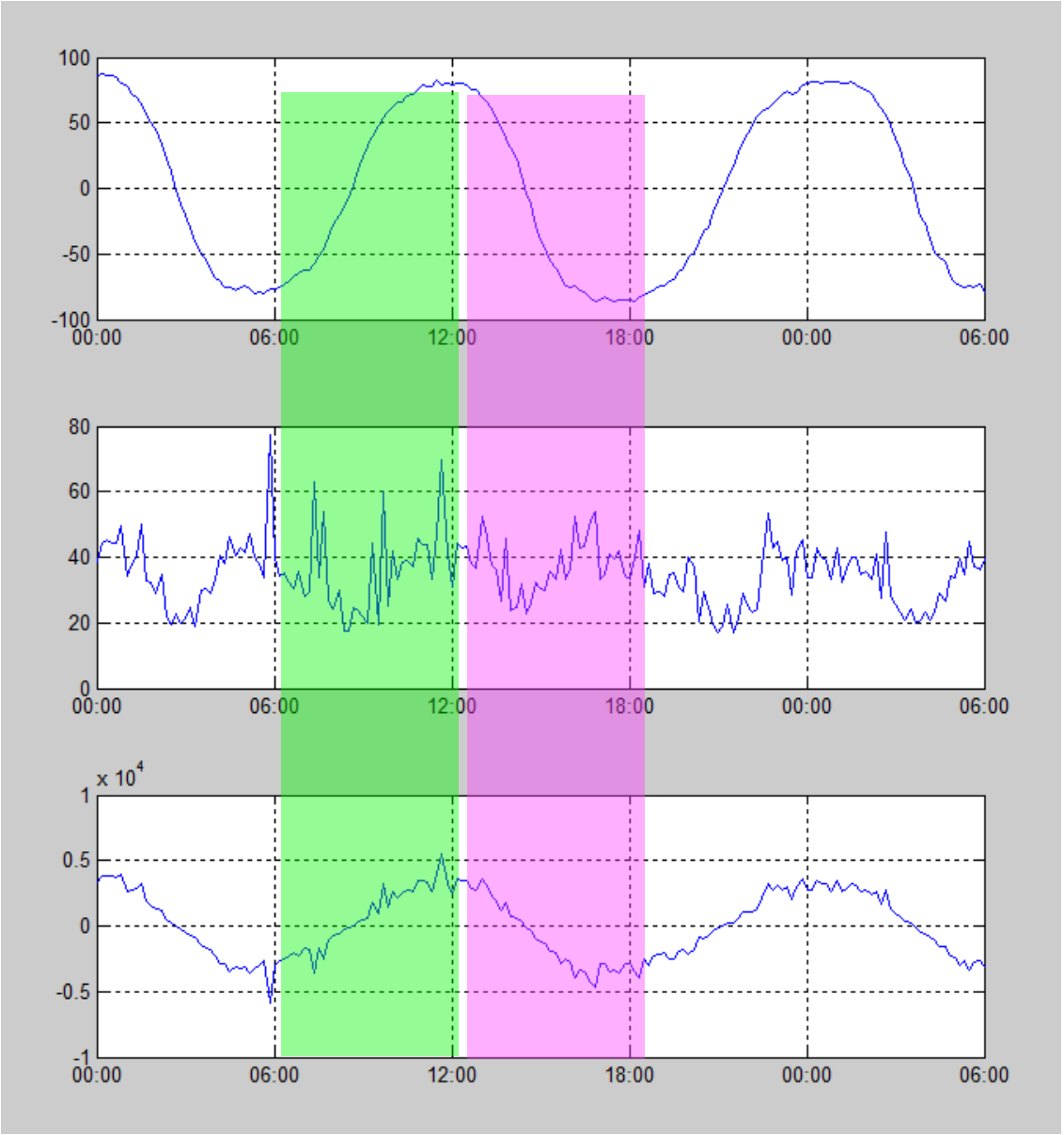
- Reduced salinity (groundwater-influenced) porewater seems to be the major source for high CH_4 concentrations at low tide.
- Wetland porewater seems to be the major source for CO_2.
- High sensitivity of flux calculations to small differences in concentration at times of major water flux is a critical feature and limitation: Insufficient frequency of measurements or insufficient accuracy could contribute to the lack of consensus in the literature about the role of coastal wetlands as exporters or importers of carbon.
- Continuous data appears to be necessary, given the high degree of variability on daily timescales and sensitivity of calculations to small differences in concentration between flood and ebb tide.

Strategy for high frequency measurements over extended time

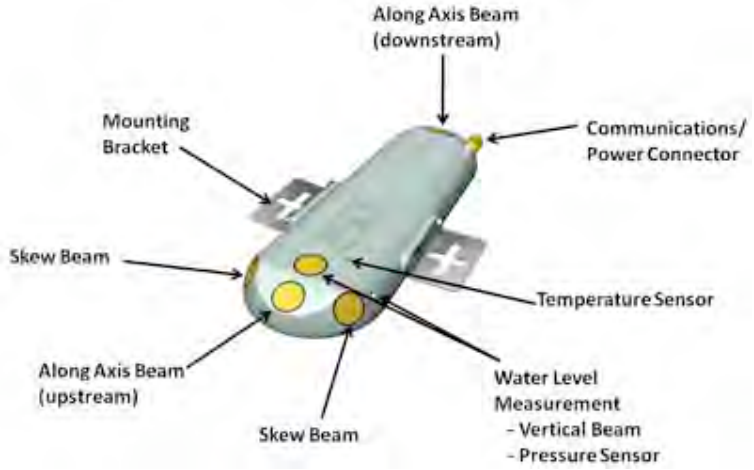
Water flux:
Liters per second

Concentration:
grams per liter
Measuring: Forms of carbon, nitrogen and greenhouse gases

Total flux:
Liters/Second x Grams/Liter
= Grams per second



Instruments deployed: Chemistry, Flow & Proxies for C Species



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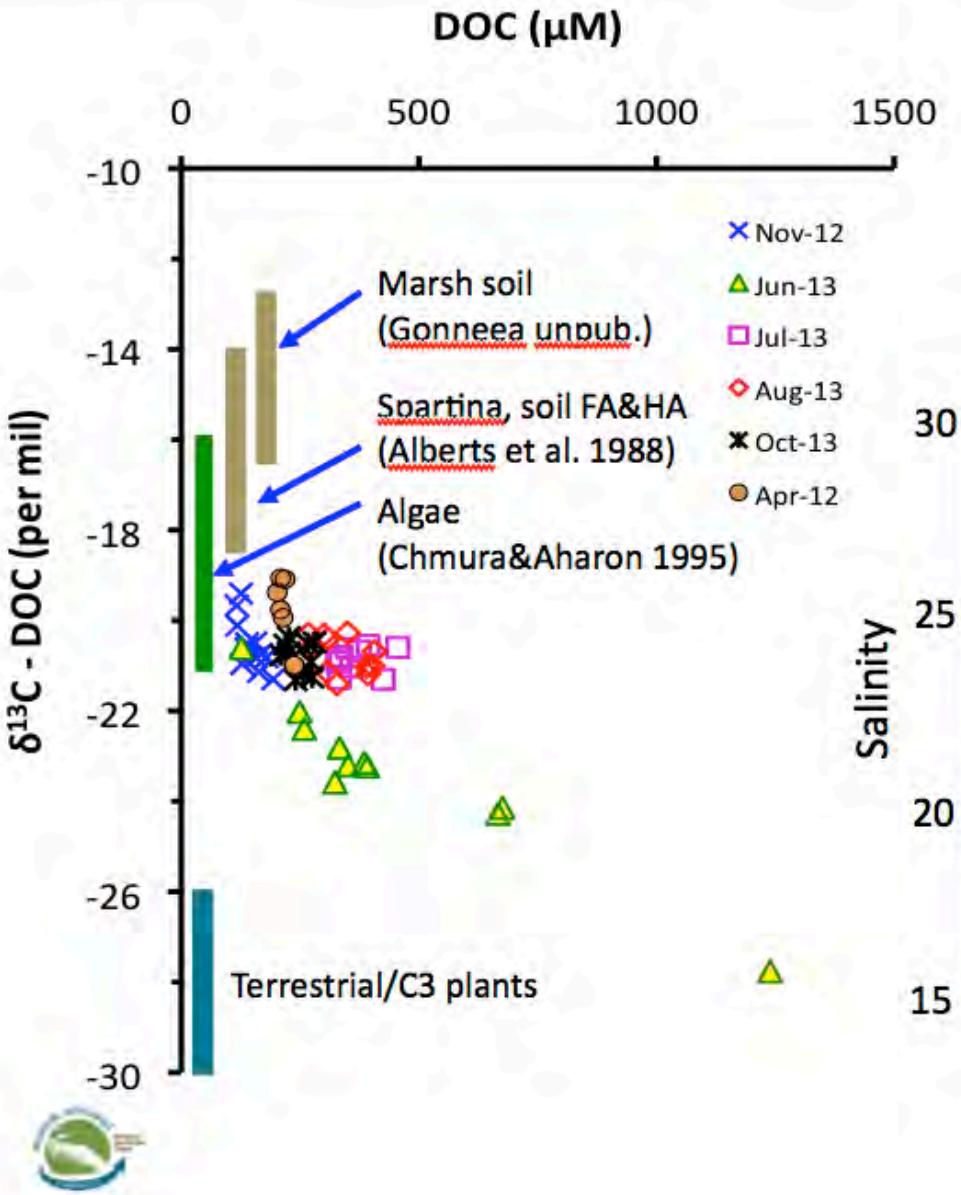
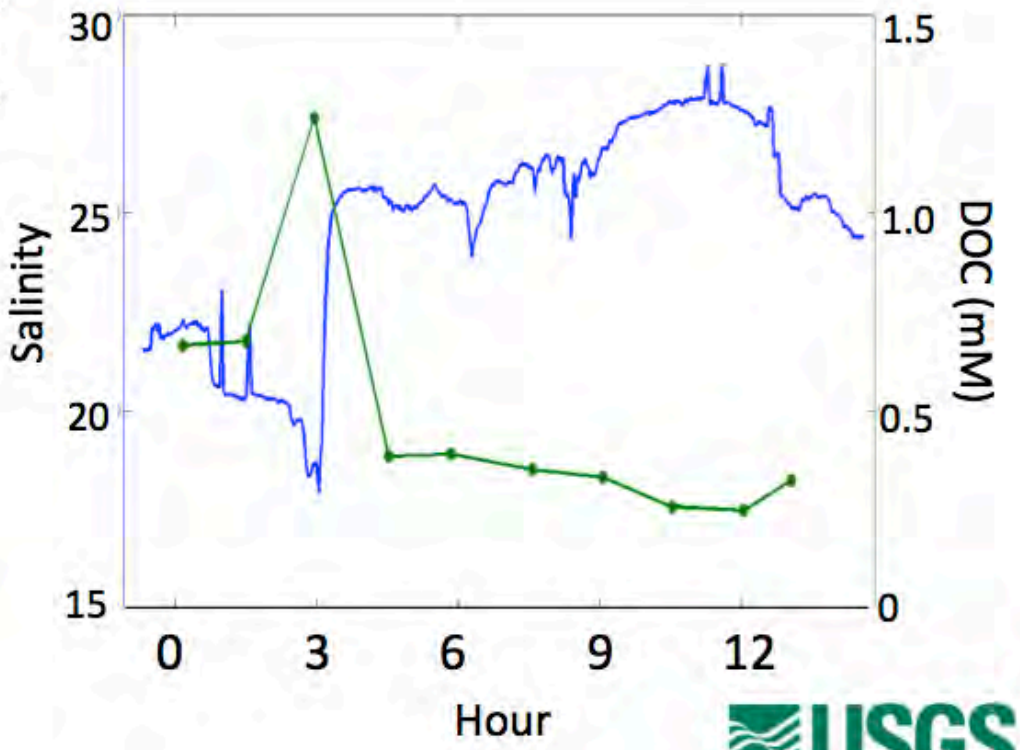
Sensor data as context for results of discrete sample analyses



Examining Organic Carbon Sources



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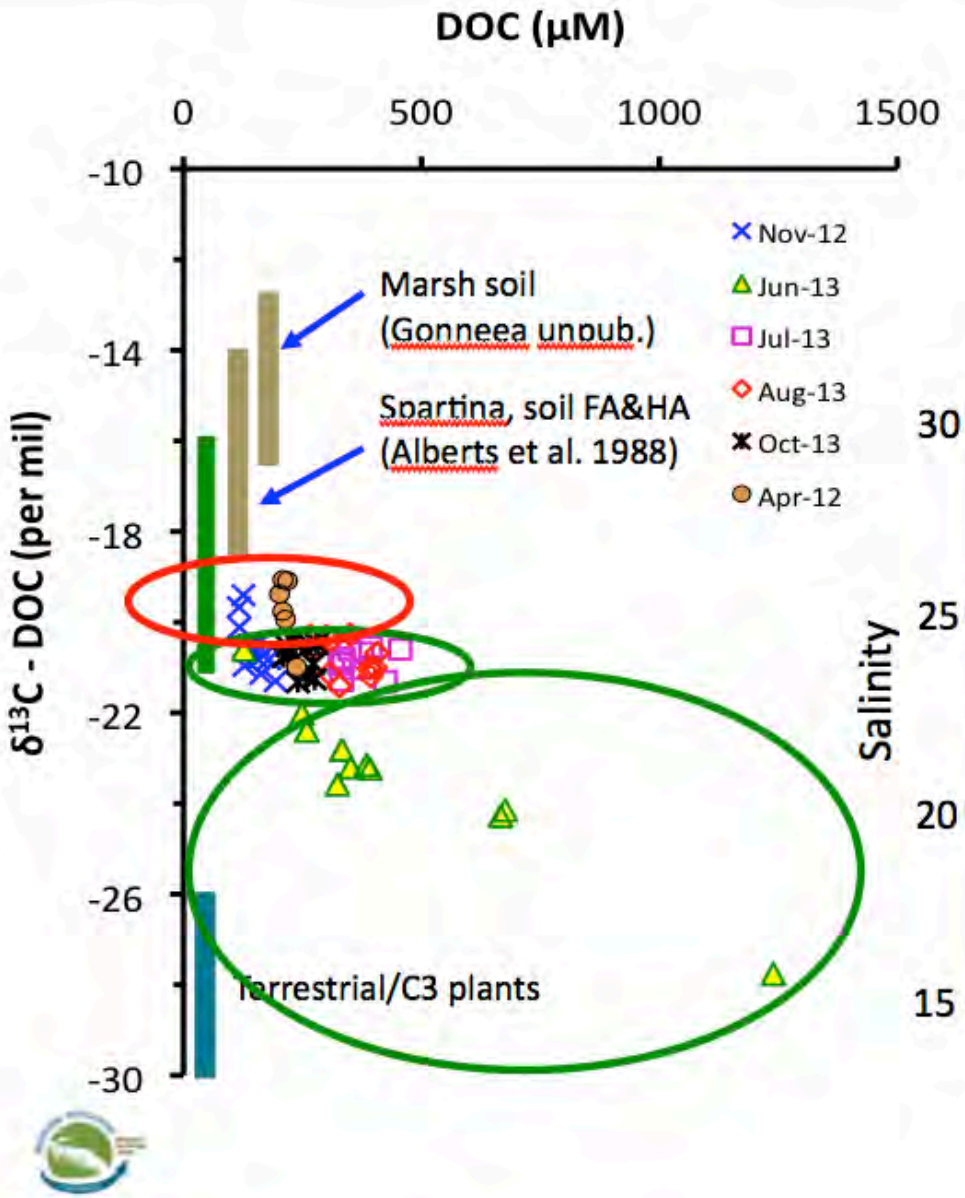

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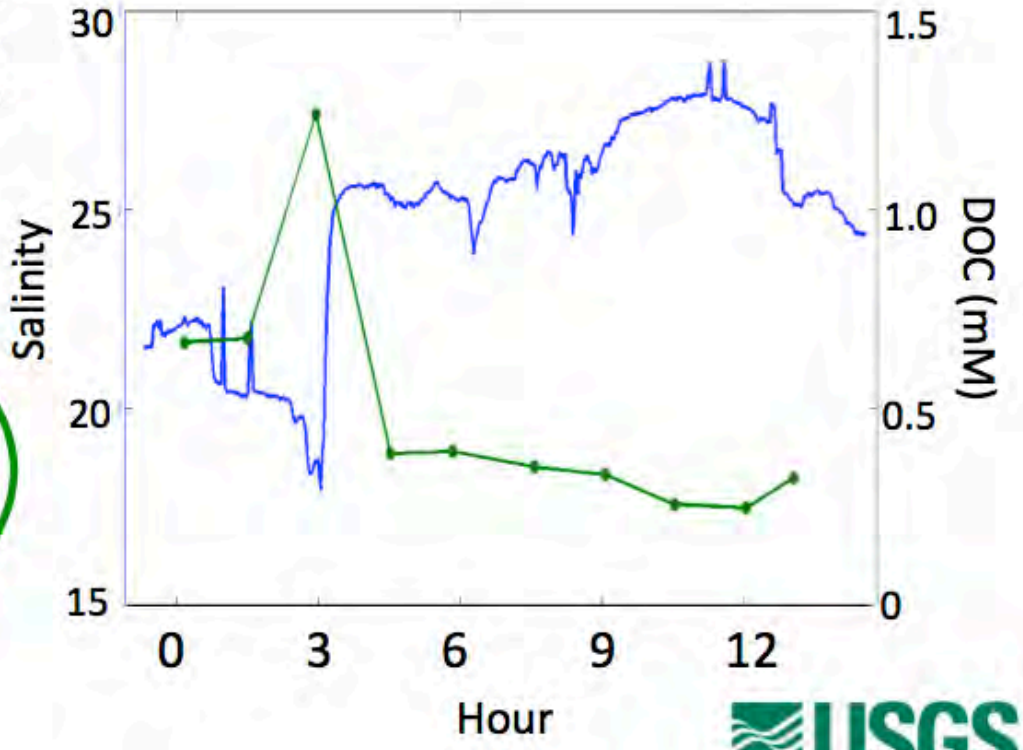

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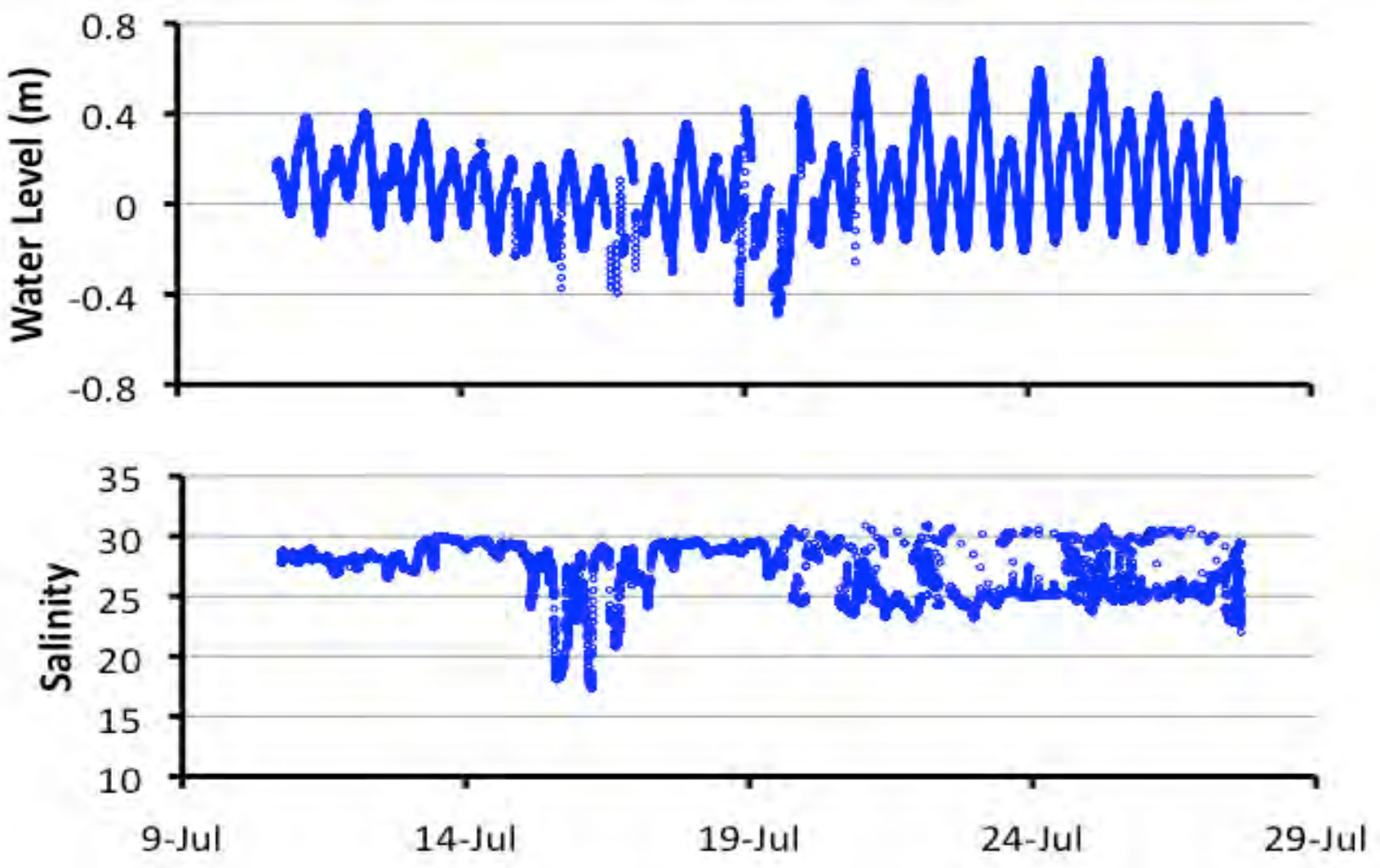
Sensor data to quantify groundwater contribution: 17 m^3/d



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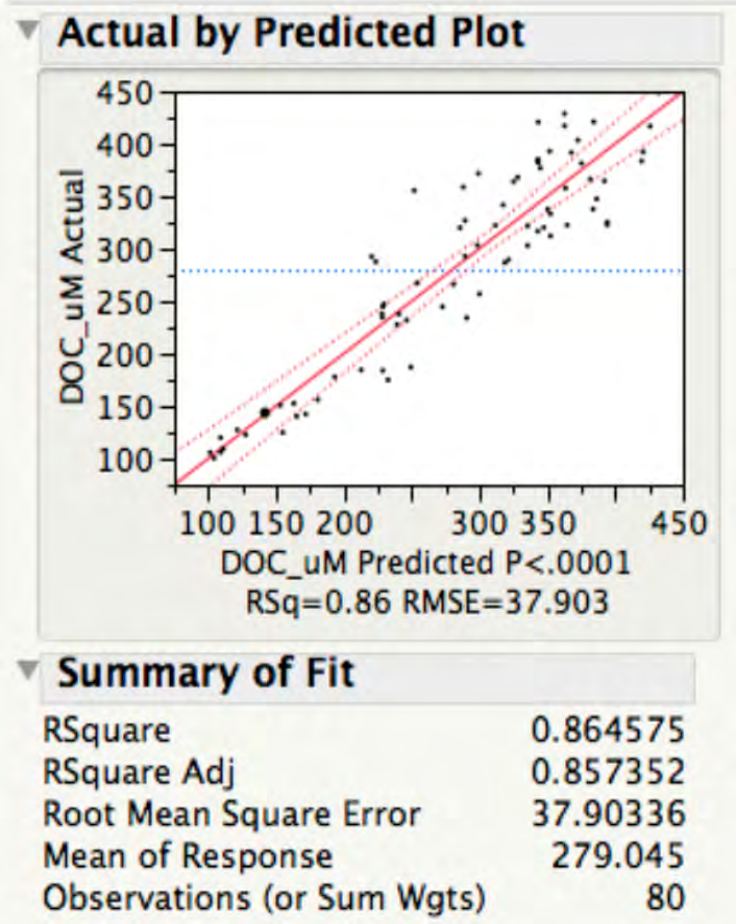
Sensor data as a C proxy: Multiple regression for DOC

DOC (µM) = 464.04 – 63.608*pH + 7.639*Temp + 2.576*FDOM + 4.006*Sal



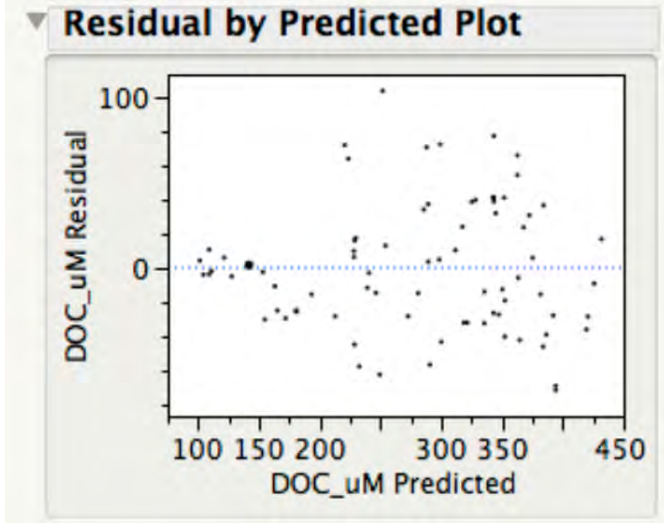
Summary of Fit

RSquare	0.864575
RSquare Adj	0.857352
Root Mean Square Error	37.90336
Mean of Response	279.045
Observations (or Sum Wgts)	80

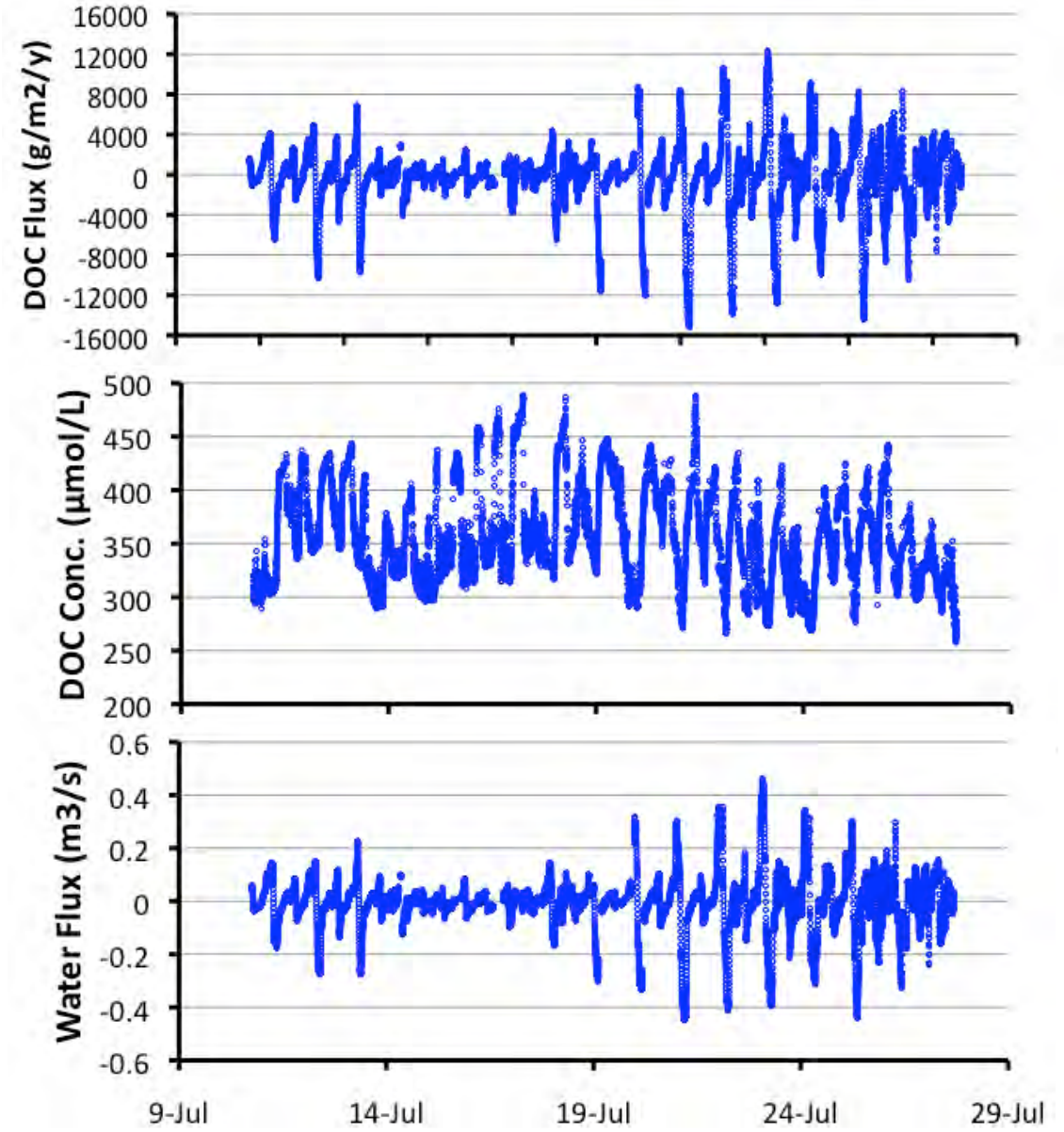
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	464.04427	124.2623	3.73	0.0004*
pH	-63.60782	14.67363	-4.33	<.0001*
Temp_C	7.638949	0.705161	10.83	<.0001*
FDOM_QSU	2.5764453	0.370786	6.95	<.0001*
Sal_ppt	4.0055984	0.907849	4.41	<.0001*

Effect Tests



Extended sensor deployments thus allow high frequency flux calculations



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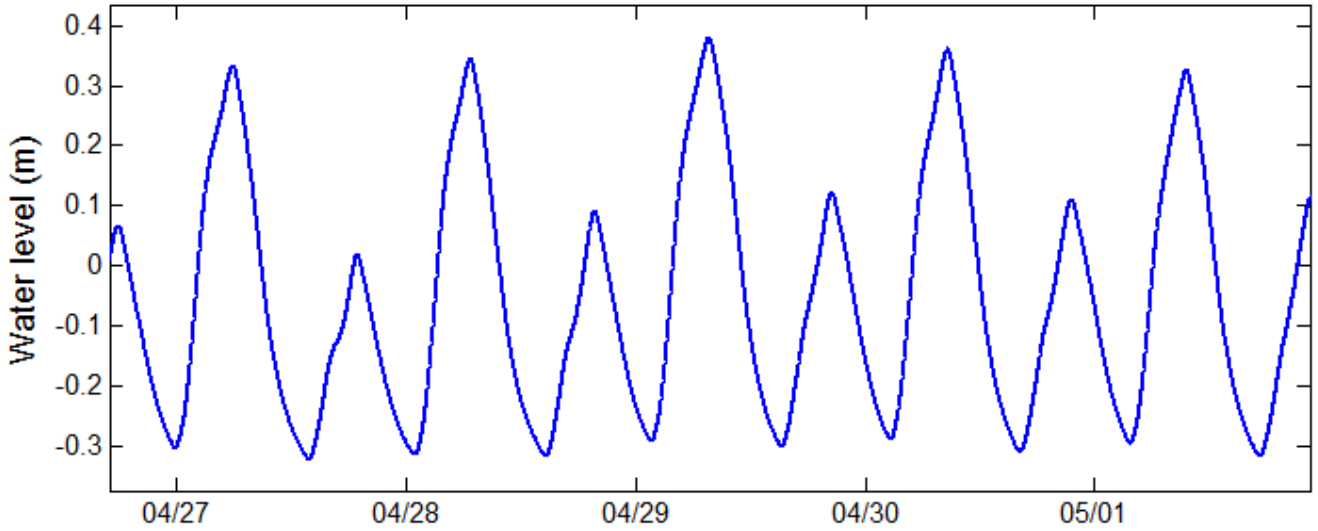
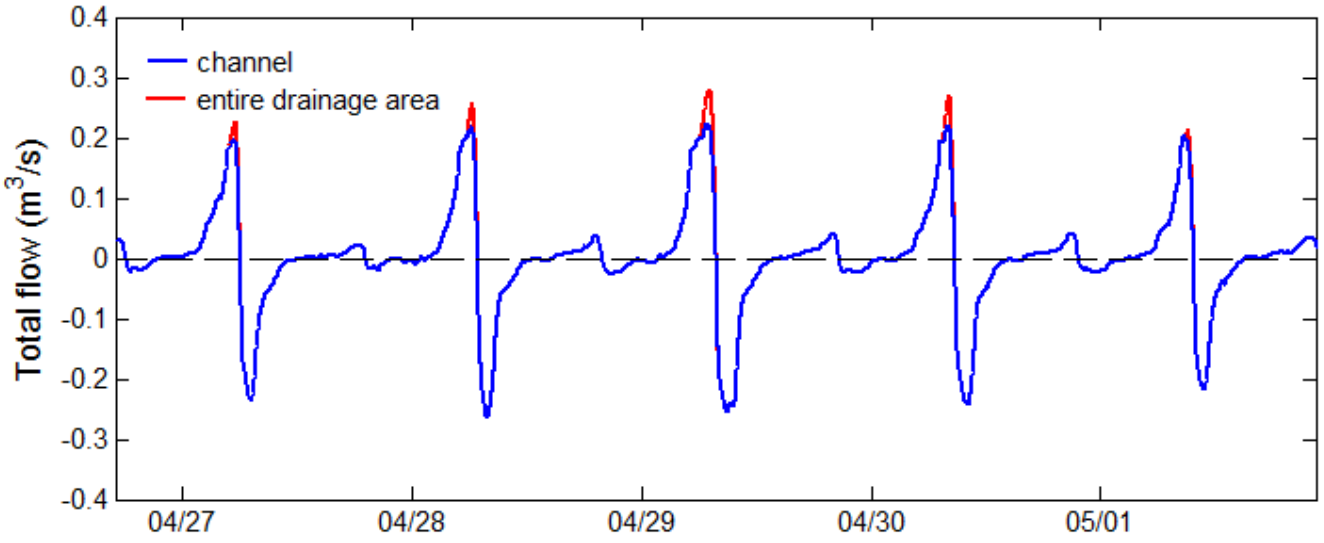
Correction to water flow for sheetflow outside of creek





Application of COAWST (J. Warner) and ROMS models showed that a greater fraction of total water flow occurred outside of the creek during flood tide than during ebb tide. Correction reduced estimate of net export of DOC by ~30%.

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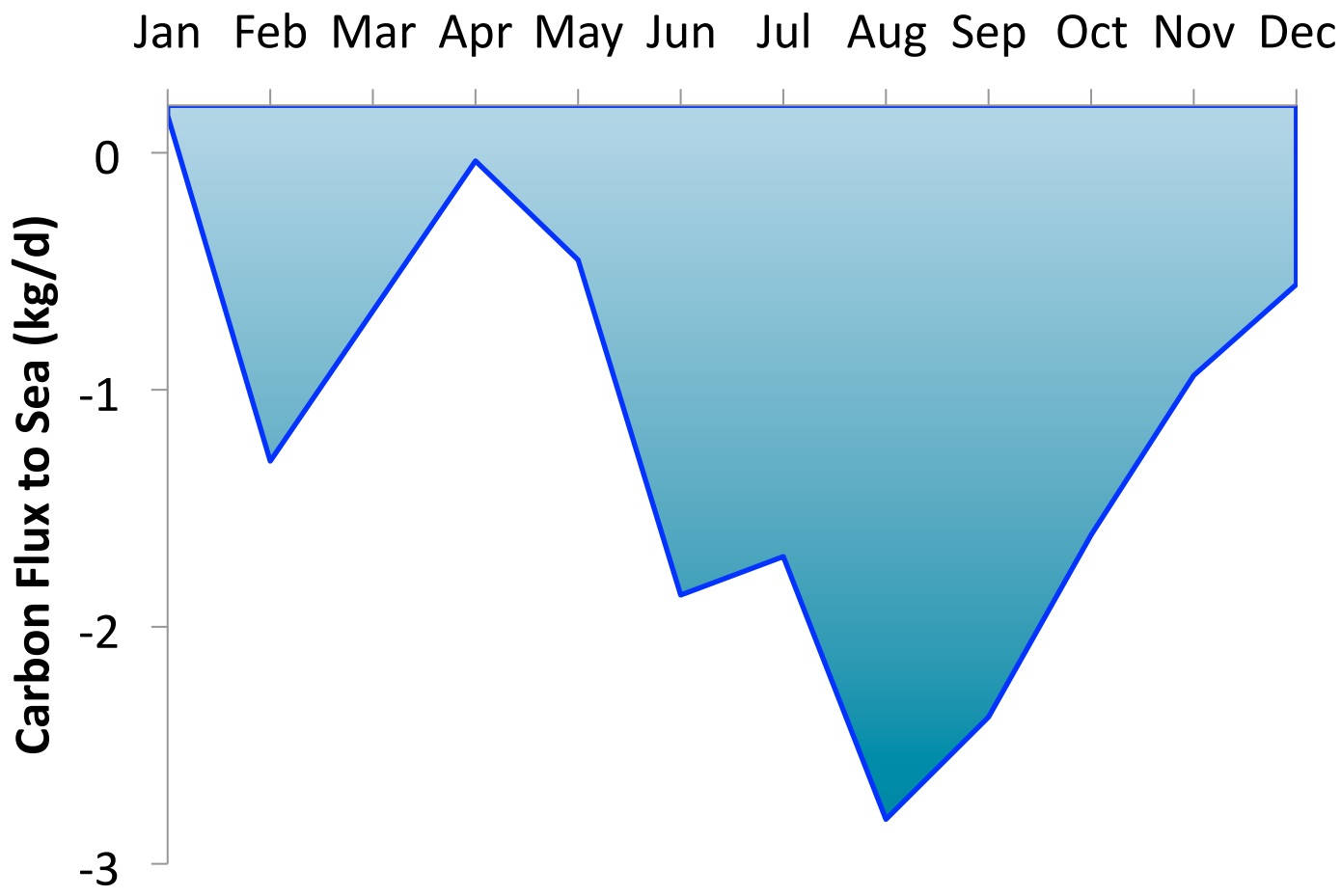
Seasonal Patterns in Carbon Flux



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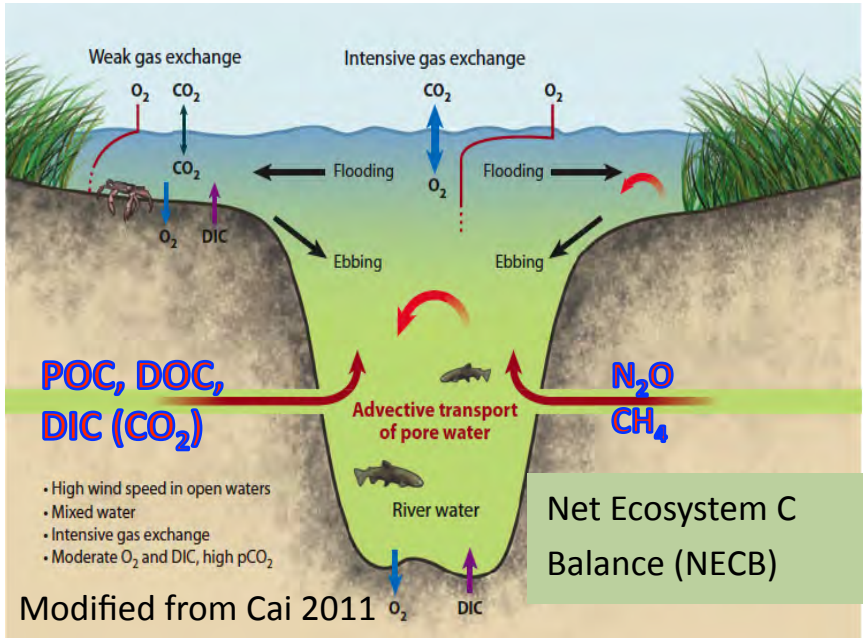
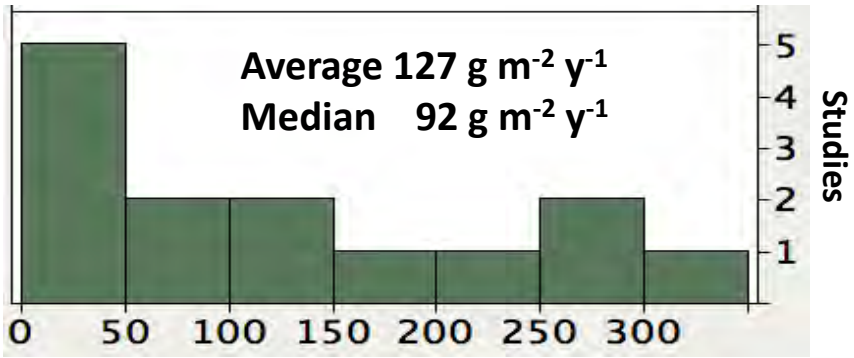
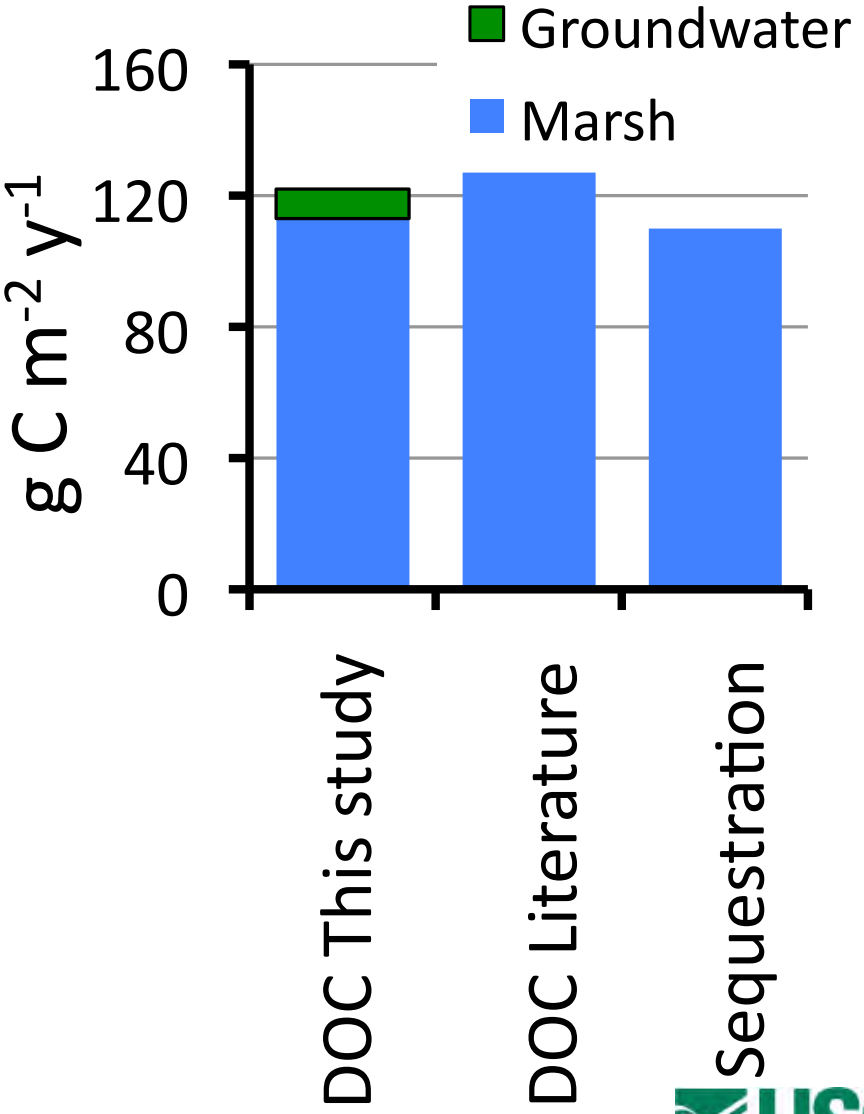
Carbon Fate: Annual Fluxes & Comparison to Literature







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Tidal Exchange:

1. Primary fate for carbon removed from the atmosphere and contributes to accretion through sediment supply
2. A new method to quantify a critical term in wetland C budgets
3. Isotopes and other tracers aid identification of C source

Comparison of Carbon Pools:
Dissolved inorganic > Dissolved organic >> Particulate