Preliminary Report on the Latimer Brook Project: NOx Concentrations and Stream Mixing

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NRWC

LB- and CMB data from Don Danila, Marvin Schutt *et al*.
NRWC

(November 2, 2012)

Outline

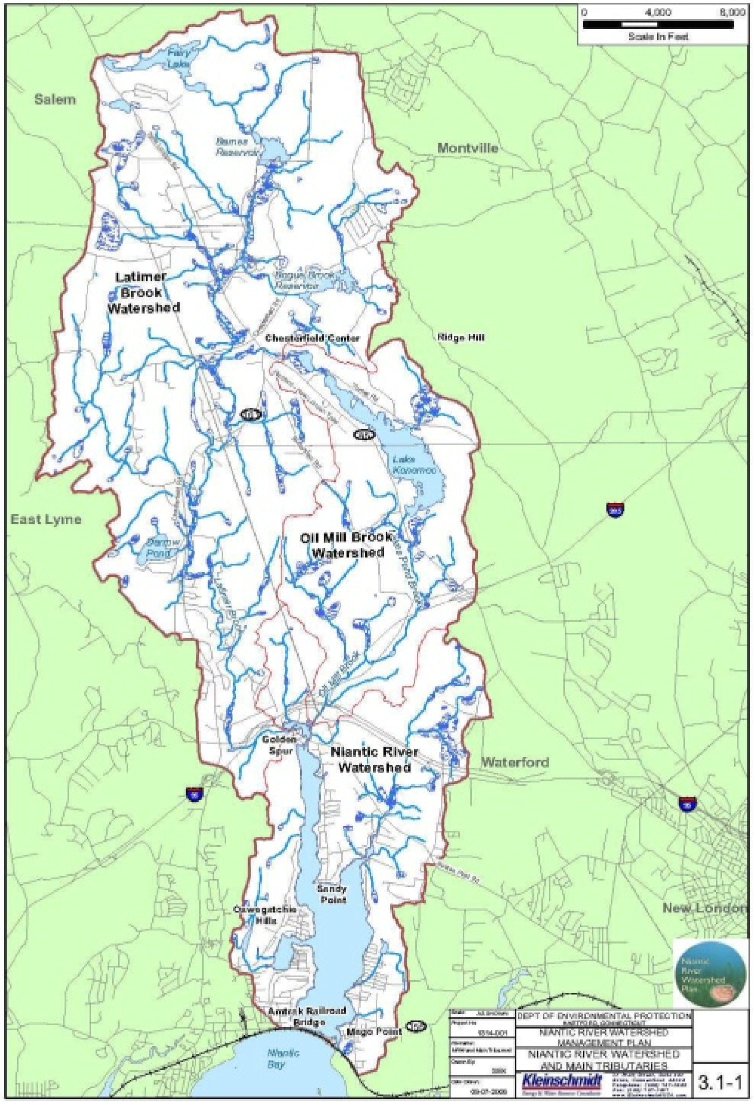
I. NOx Flux from LB to the Niantic R. Estuary.

II. Estuarine and riverine mixing models

- A. Background on mixing
- B. LB-CMB mixing lines.

III. Mode-shifting of the LB-CMB system?

I. NOx Flux from the LB to the Niantic River Estuary

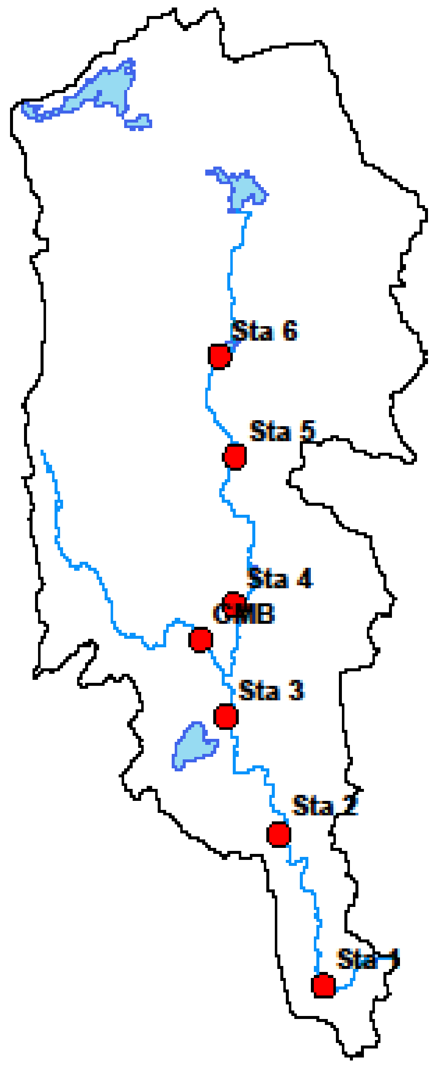


Niantic River Watershed and Niantic River Estuary

Three Main Tributaries:

- **Latimer Brook**
- **Oil Mill Brook**
- **Stony Brook**

Latimer Brook Watershed



Sampling Stations on Latimer Brook and Cranberry Meadow Brook.

Annual Nitrogen Influx to the Niantic River Estuary From Its Three Major Tributaries

	Nitrogen Flux (lbs /yr)	(% Total)
1. Latimer Brook	39,300	78
2. Oil Mill Brook	7,200	14
3. Stony Brook	3,750	8

(*Provisional data from J. Mullaney, USGS, 2012*)

Calculation of NO_X Flux

$$F_{NOx} = F_{water} * C_{NOx}$$

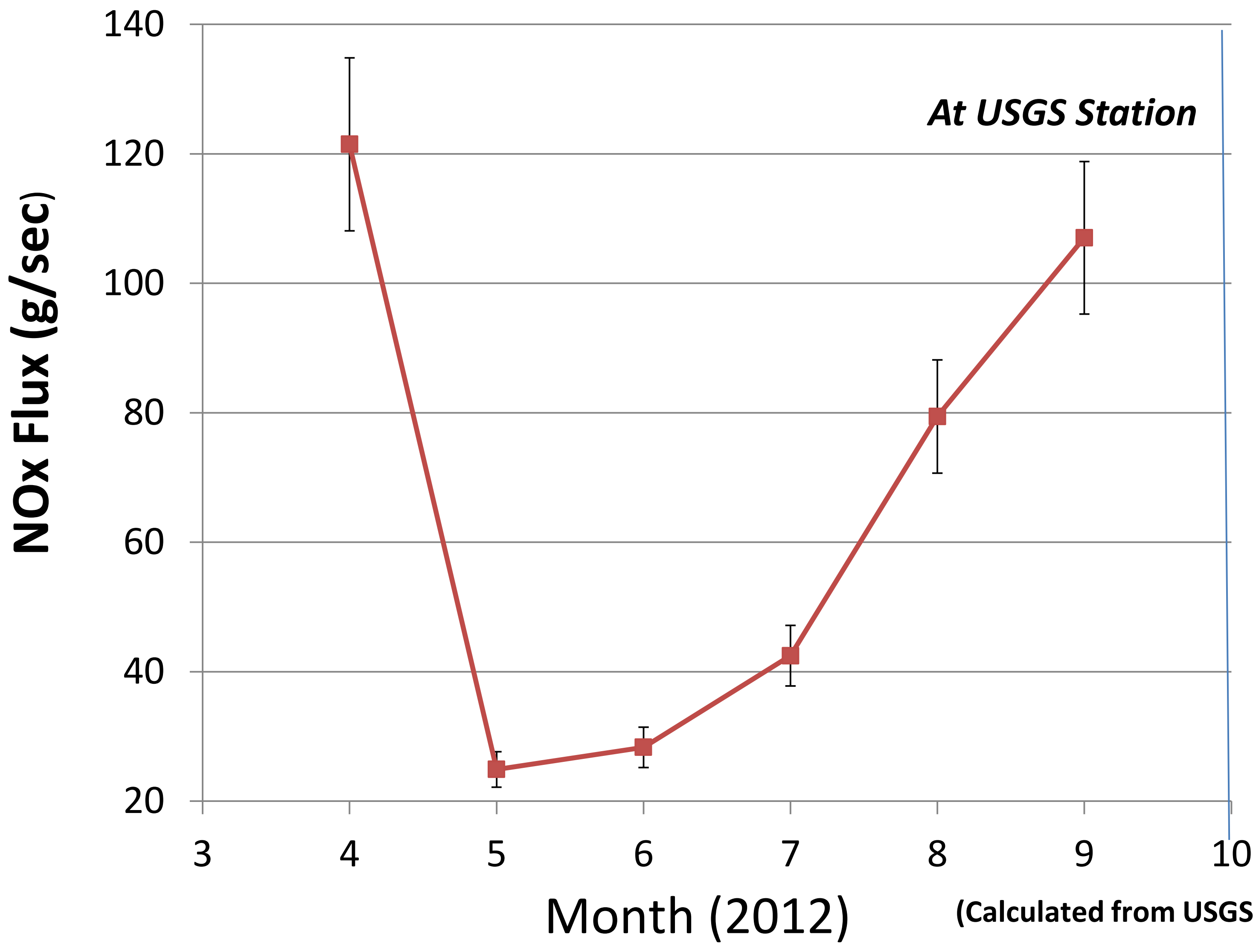
where,

F_{NOx} = Flux of Nitrogen (grams N/sec);
F_{H2O}= Flux of water (grams water/sec); and,
C_{NOx} = Concentration of N (grams N/sec).

Dimensional Analysis:

$$\frac{M(NOx)}{T} = \frac{M(W)}{T} * \frac{M(N0x)}{M(W)}$$

Monthly NO_X-Flux from LB to the Niantic River Estuary



NOx flux to the NRE is at a minimum in the warm months. What happens in the cold months?

(Calculated from USGS and NRWC data.)

II. Estuarine and Riverine Mixing

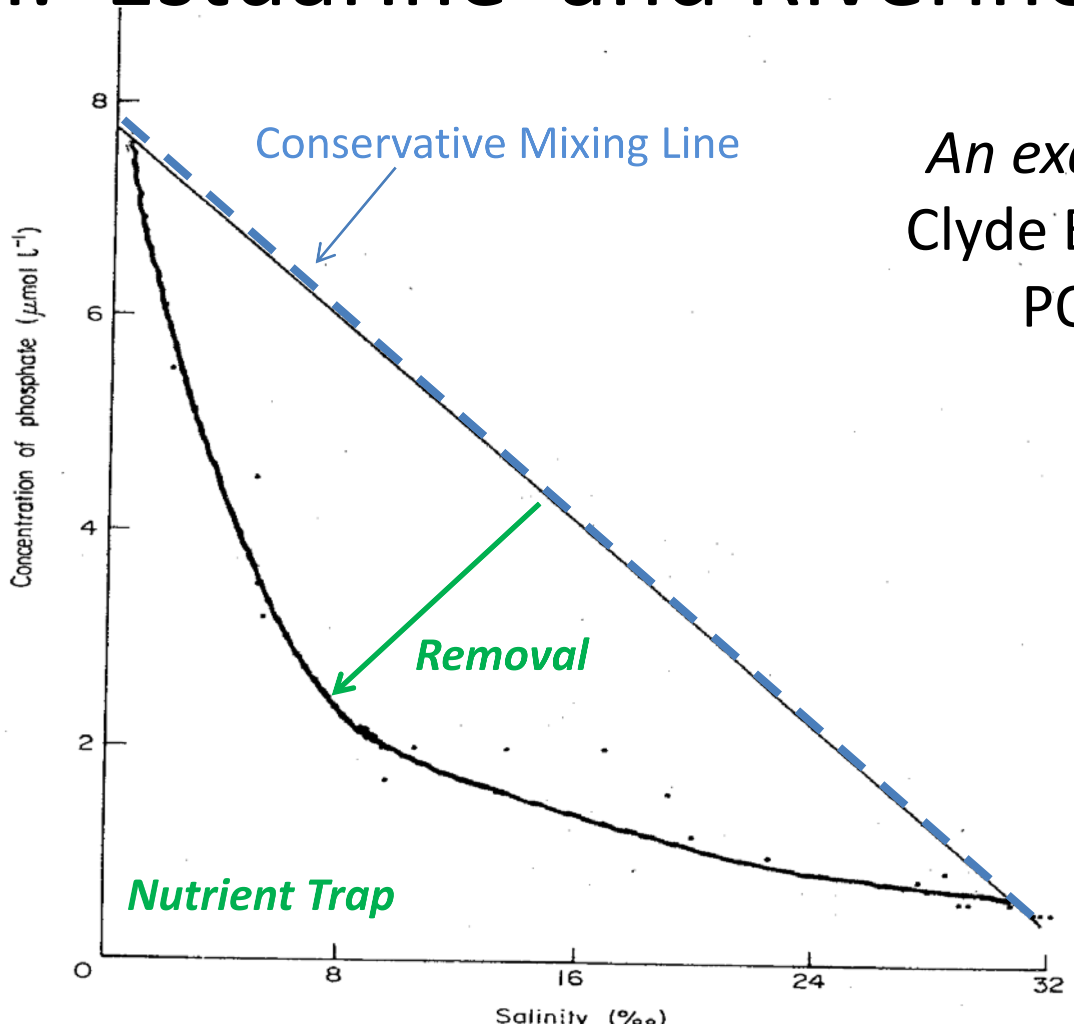


Fig. 9. Relationship between concentration of phosphate and salinity; survey of 12th April, 1973. The theoretical dilution line is shown.

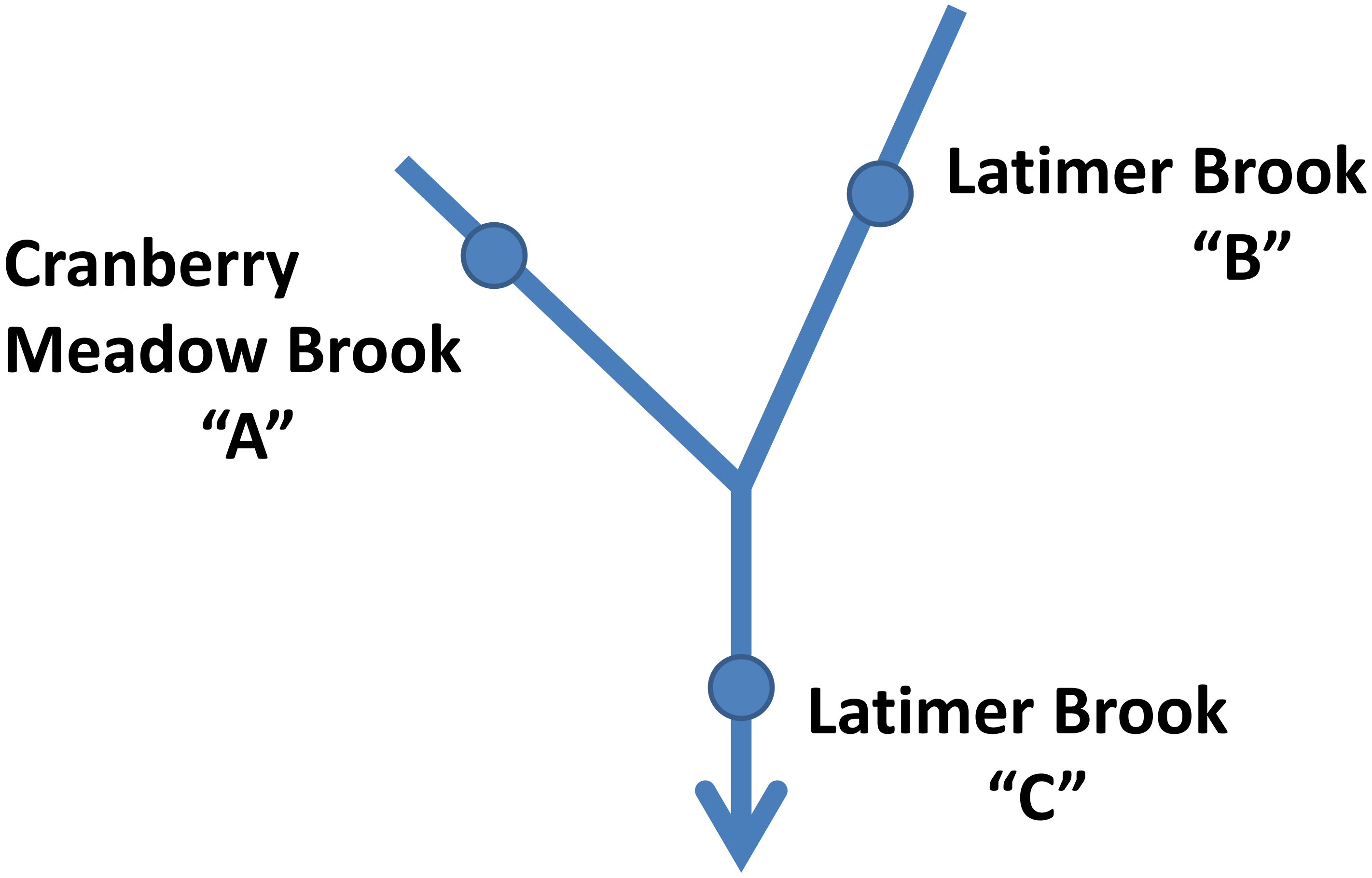
An example of mixing:

Clyde Estuary, Scotland:

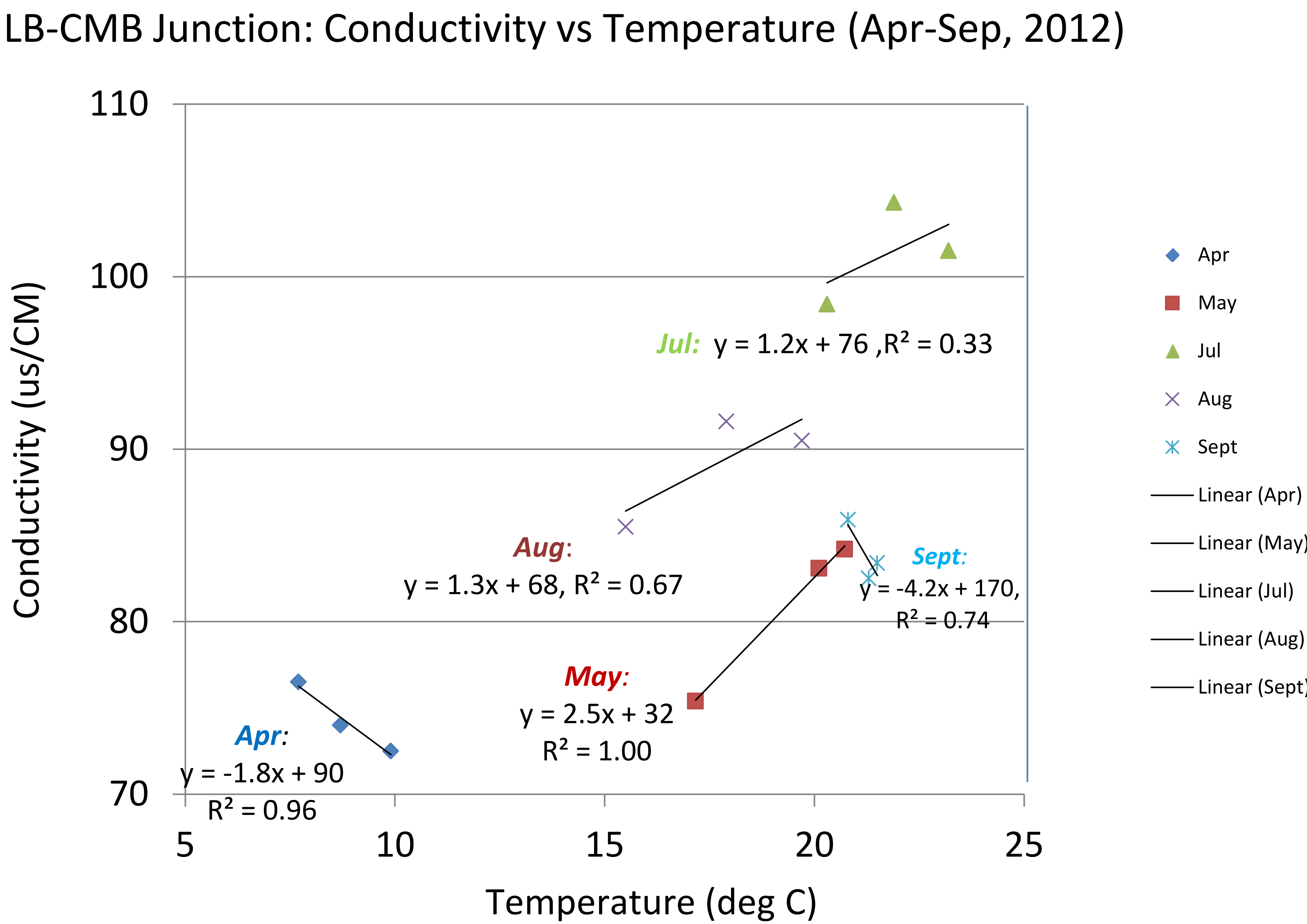
PO4 vs Salinity.

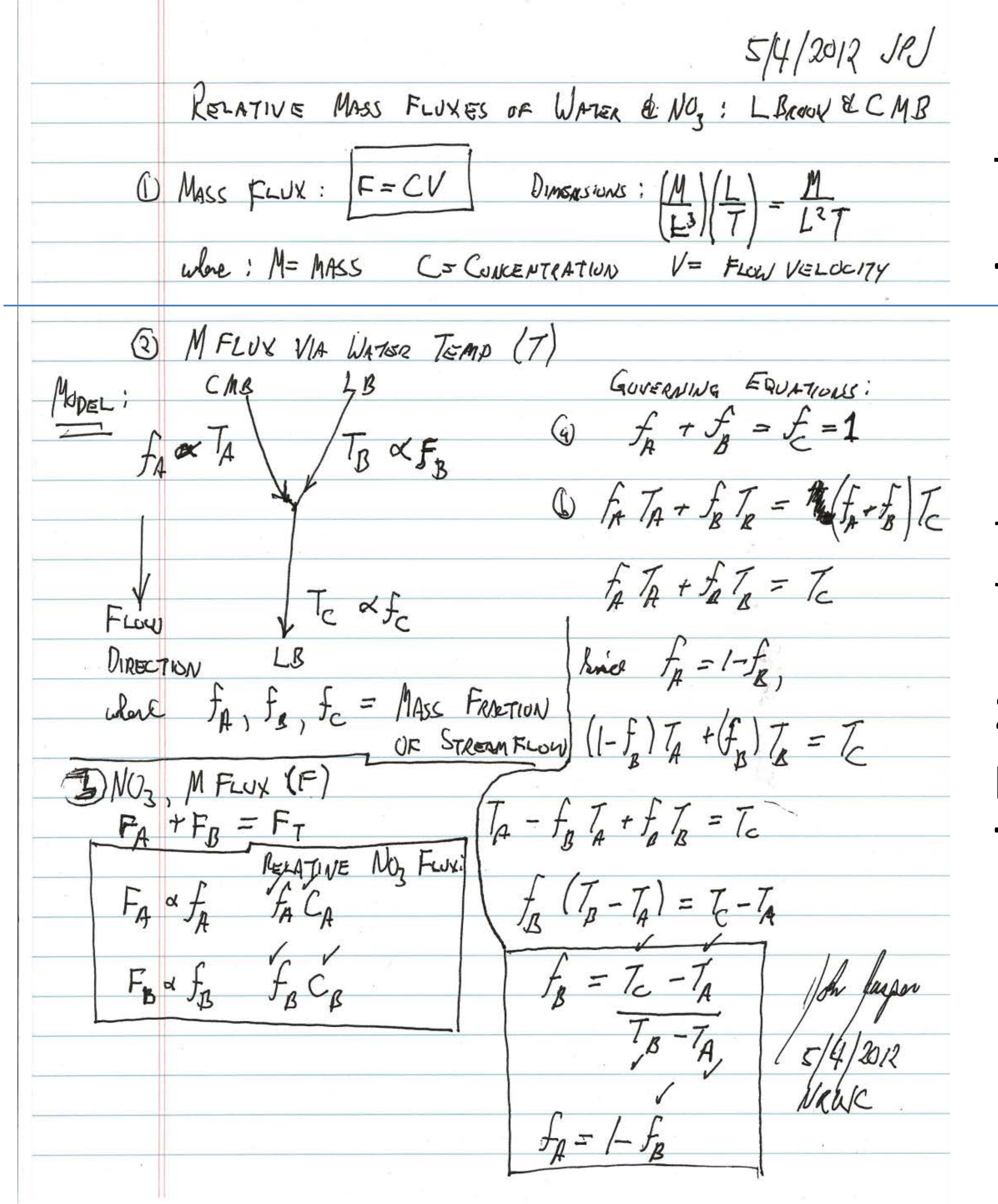
(Mackay & Leatherland, 1976)

Stations for LB-CMB Mixing



LB-CMB Mixing Relationships




5/4/2012 JPJ

RELATIVE MASS FLUXES OF WATER & NO_3 : L BROOK & CMB

① MASS FLUX : $F = CV$ DIMENSIONS : $\left(\frac{M}{L^3}\right)\left(\frac{L}{T}\right) = \frac{M}{L^2 T}$

where : M = MASS   C = CONCENTRATION   V = FLOW VELOCITY

② M FLUX VIA WATER TEMP (T)

where f_A, f_B, f_C = MASS FRACTION OF STREAMFLOW

GOVERNING EQUATIONS:

(a) $f_A + f_B = f_C = 1$

(b) $f_A T_A + f_B T_B = (f_A + f_B) T_C$

$f_A T_A + f_B T_B = T_C$

since $f_A = 1 - f_B$,

$(1 - f_B) T_A + (f_B) T_B = T_C$

$T_A - f_B T_A + f_B T_B = T_C$

$f_B (T_B - T_A) = T_C - T_A$

$$f_B = \frac{T_C - T_A}{T_B - T_A}$$

$$f_A = 1 - f_B$$

③ NO_3, M FLUX (F)

$F_A + F_B = F_T$

RELATIVE NO_3 FLUX:

$F_A \propto f_A$ $f_A C_A$

$F_B \propto f_B$ $f_B C_B$

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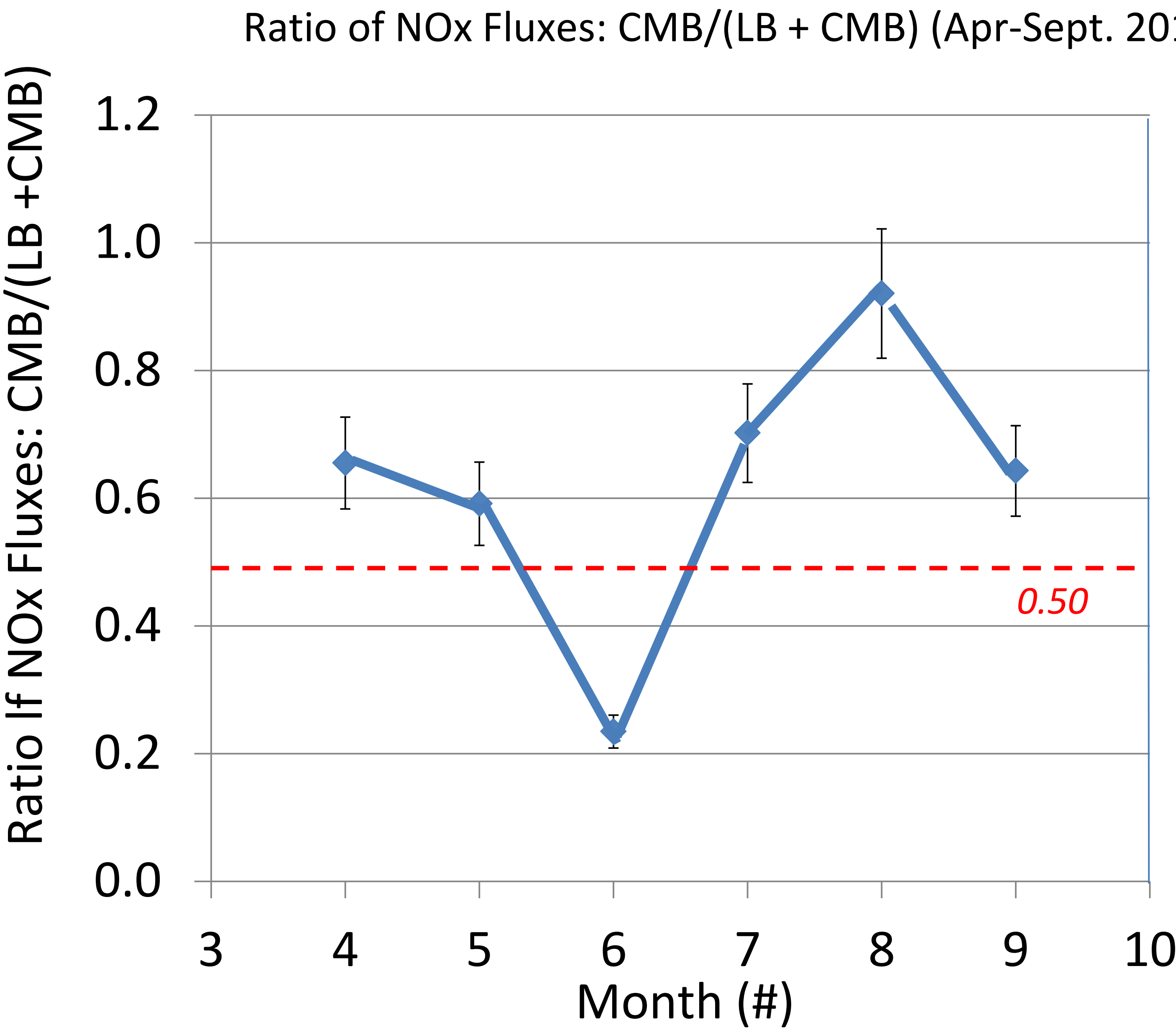
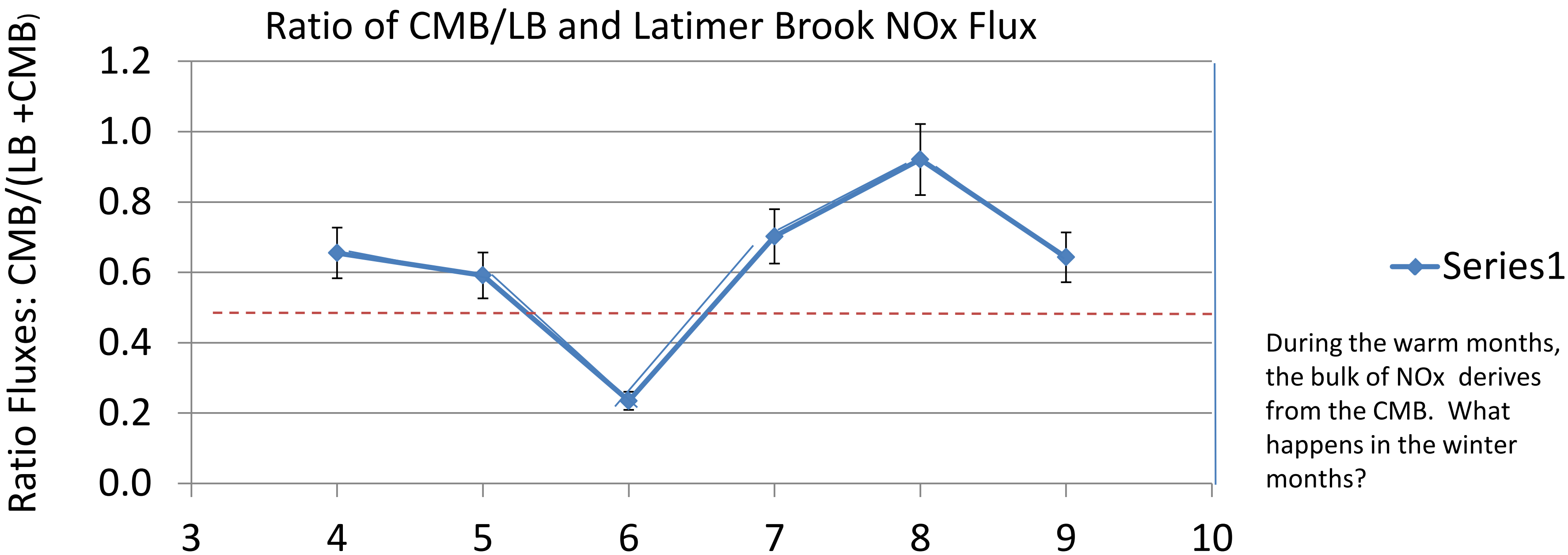
<u>Relative NOx Fluxes:</u>
From the upper LB + the Cranberry M'dow B → the lower LB.

1. Mass fraction of water to the lower LB is estimated via temperature-mixing model.

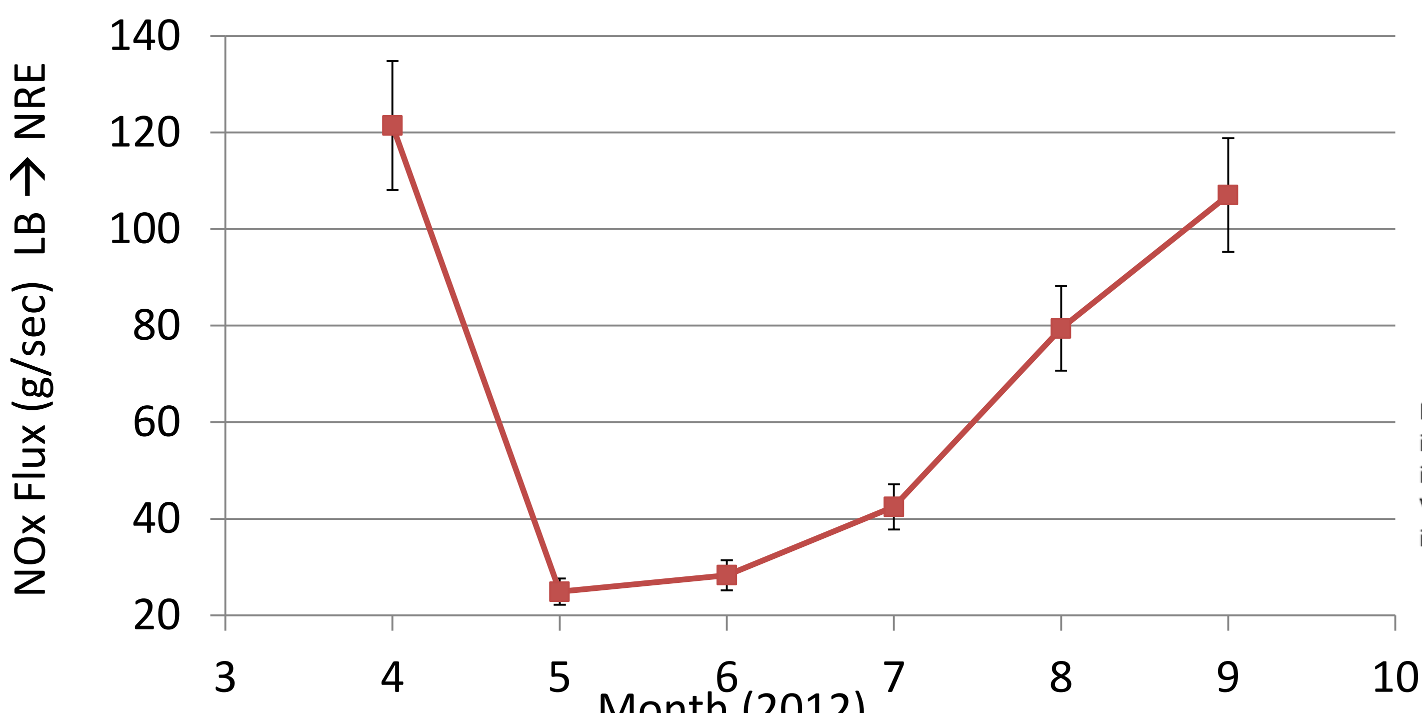
2. Allows estimation of proportions of NOx from the CMB and the upper LB.



During the warm months, the bulk of NOx comes from the CMB. What happens in the winter months?

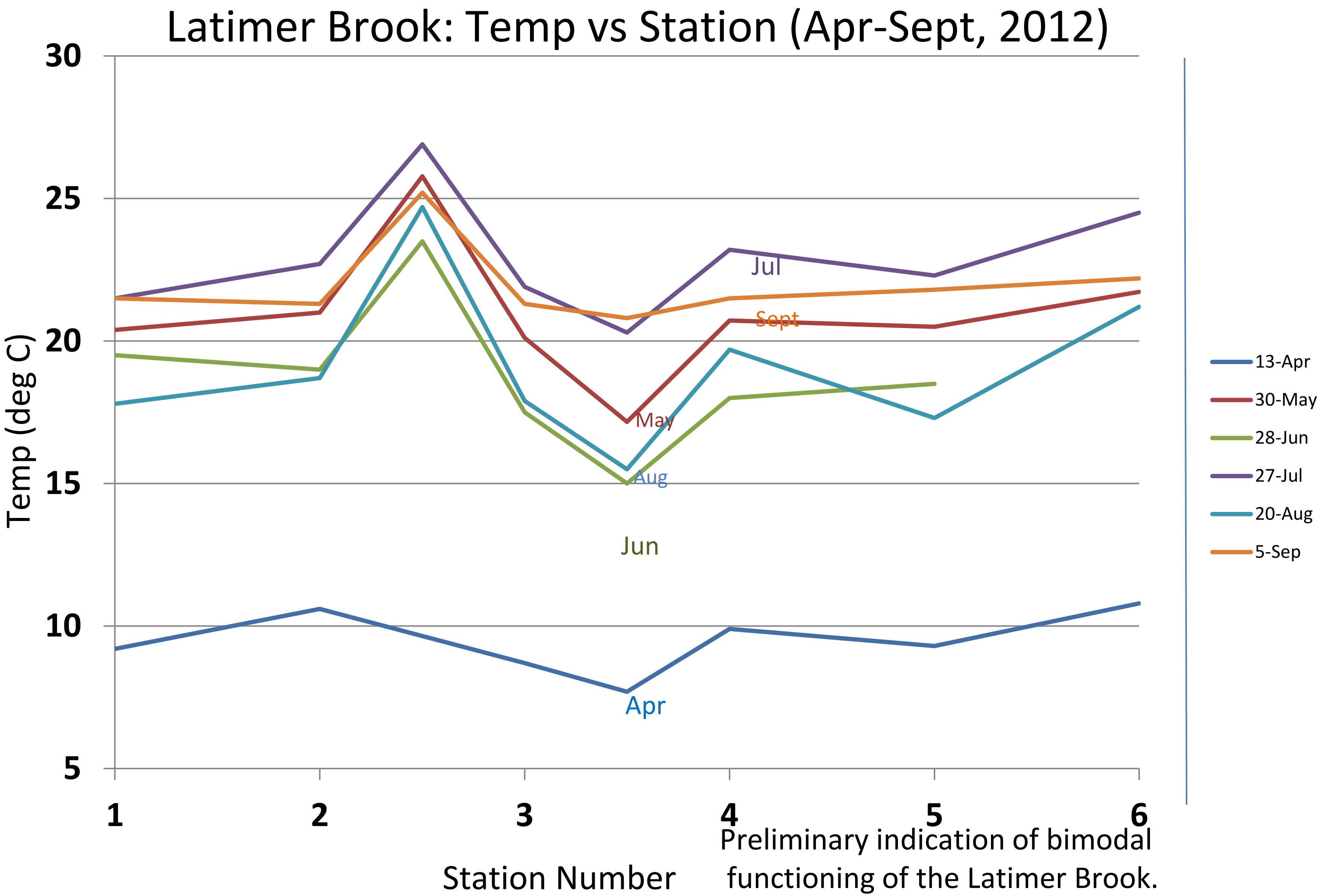


During the warm months, the bulk of NOx derives from the CMB. What happens in the winter months?

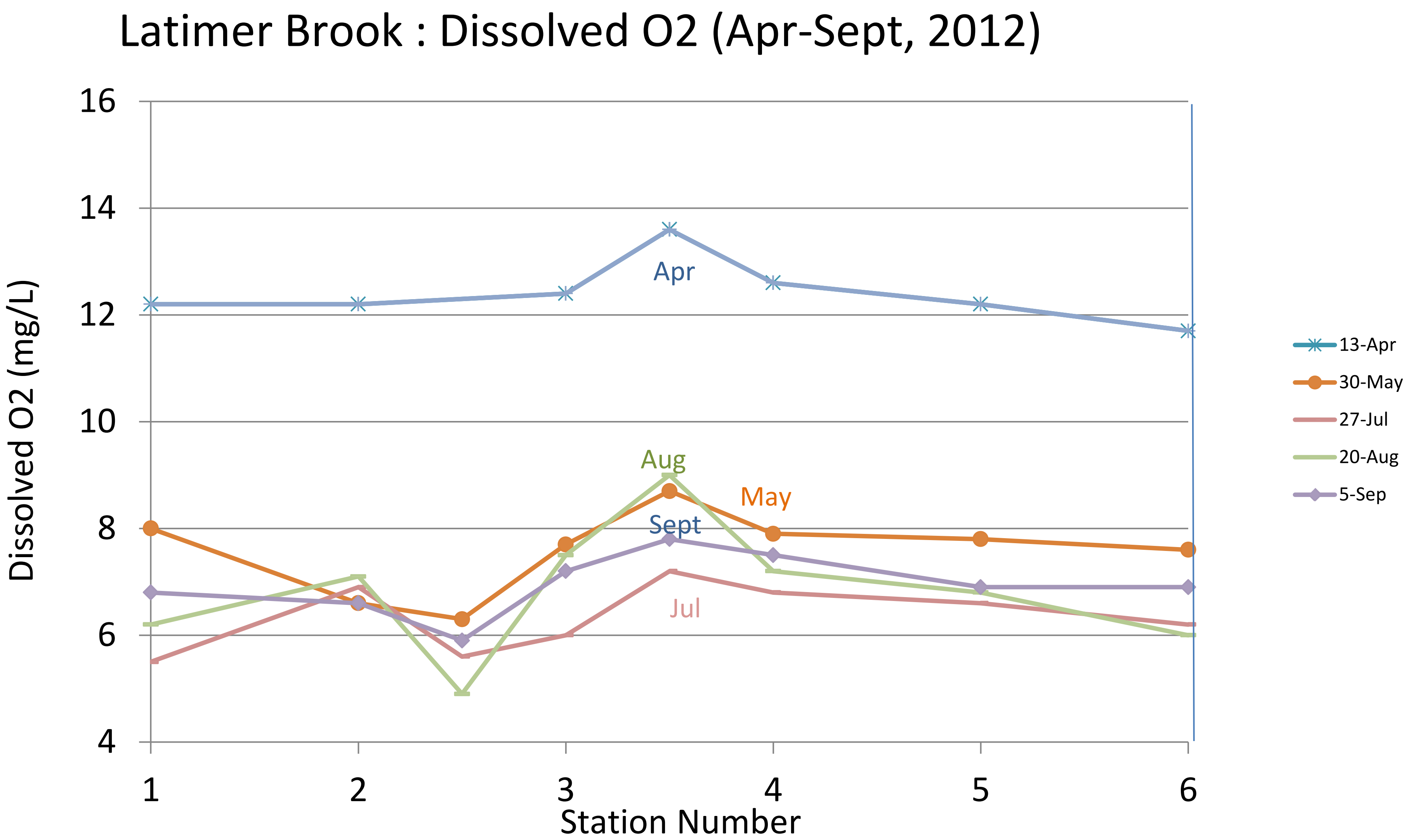


NOx flux to the NRE is at a minimum in the warm months. What happens in the cold months?

III. Preliminary Indication of Bimodal /Sinusoidal Regime



Preliminary indication of bimodal functioning of the Latimer Brook. Change of seasons &/or, stream dominance?



Latimer Brook : Dissolved O2 (Apr-Sept, 2012)
Dissolved O2 (mg/L)
16
14
12
10
8
6
4
1
2
3
4
5
6
Station Number
Apr
Aug
May
Sept
Jul
13-Apr
30-May
27-Jul
20-Aug
5-Sep

Summary

1. Latimer Brook- and CMB waters appear to linearly mix via the Temp-Conductivity relationship.
2. The NOx flux from the Latimer Brook to the Niantic River Estuary is *generally lowest* in the warmer months. (*What happens in the cooler months*?)
3. The *proportion* of NOx entering the lower LB is *generally highest* in the warmer months.
4. Times-series records of Temp and NOx-flux-ratio indi-cate either bimodal *or other* behavior in the lower LB. [Anecdotal observations support groundwater dominance in warm months (low water) -- and surface water in cool months (higher water).]

From: John Jasper [mailto:JPJasper@NaturesFingerprint.com]
Sent: Sunday, November 18, 2012 1:22 PM
To: 'Tobias, Craig'
Subject: A preliminary review of the Latimer Brook study (Apr-Sept, 2012)

Craig,

FYI, I am sending my six-month preliminary review of the Latimer Brook study. My initial impression is that the relative mass flux of NOx (CMB/LB) to the Niantic River Estuary (NRE) is seasonally bimodal with a maximum NOX relative mass flux in the warm months (Apr-Sept) and – *yet to be seen* – a minimum relative mass flux in the cold months (Oct – Mar). **So, my initial impression is the small C M Brook has a large effect on the total NOX entering into the NRE. It seems that the proper implementation work in a small area (CMB) could have large impacts on the NRE.**

Happy Thanksgiving,
John

Calculation of *Relative* NOx Fluxes:

NOx Fluxes from the Cranberry Meadow Brook + upper Latimer Brook → the lower Latimer Brook.

1. Mass fractions of water to the lower Latimer Brook is estimated by the temperature-mixing model.

2. Allows estimation of proportions of NOx from the CMB and the *upper* LB and relative NOx to the lower LB and the Niantic River Estuary.

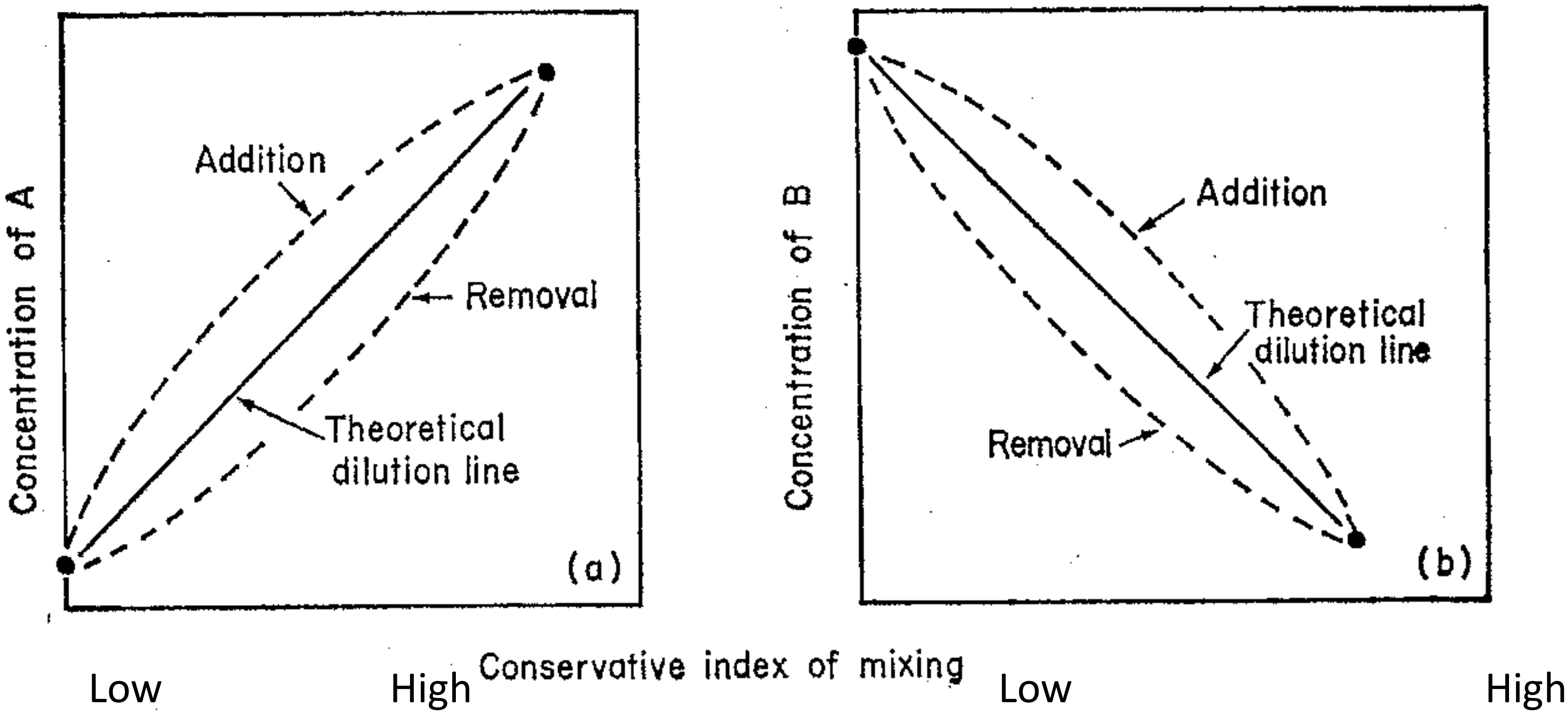
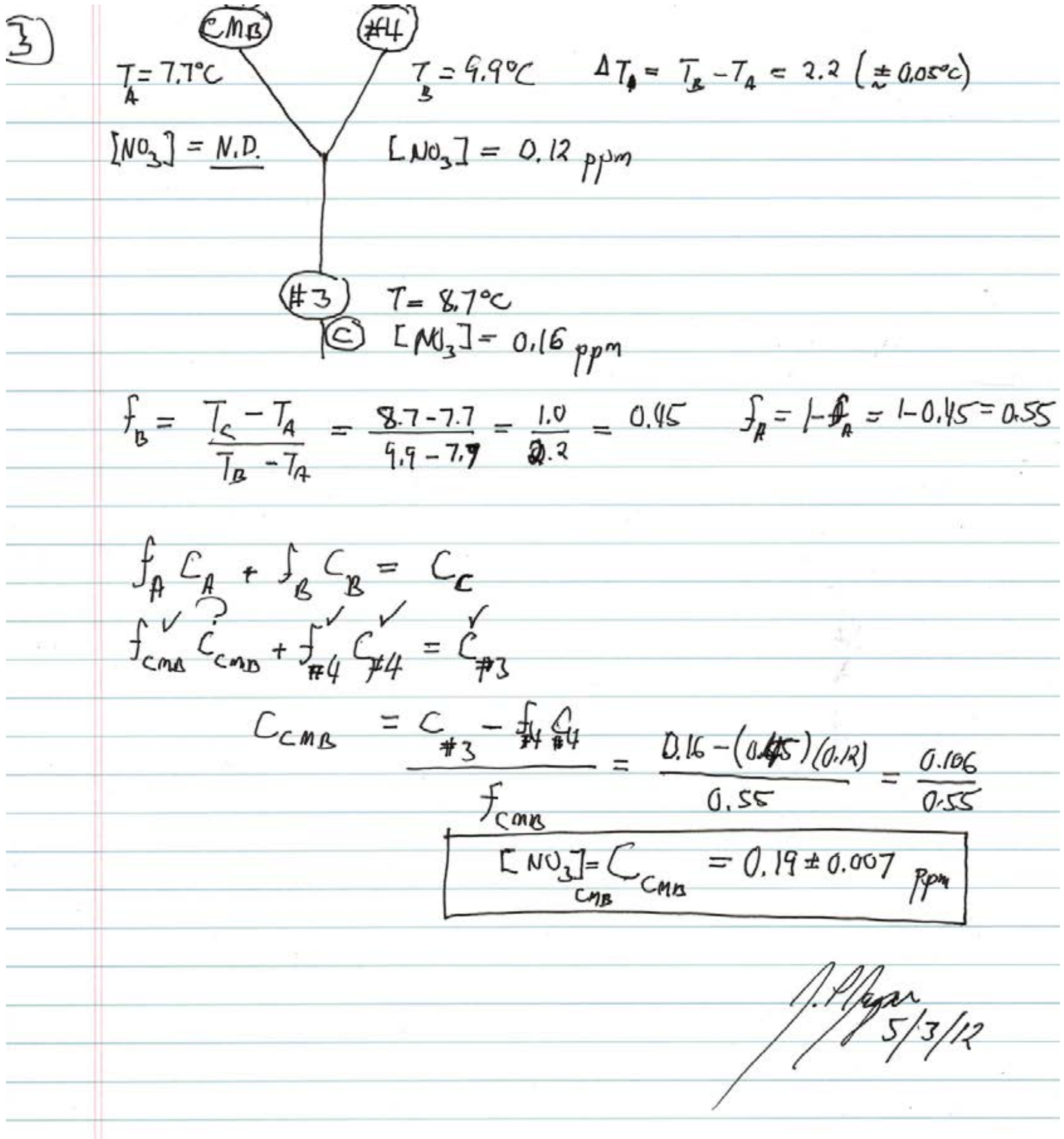


Fig. 1. Idealized representation of the relationship between concentration of a dissolved component and a conservative index of mixing, for an estuary in which there are single sources of river and sea water: (a) for a component (A) whose concentration is greater in sea water than in river water and (b) for a component (B) whose concentration is greater in river water than in sea water.

(Liss, 1976; Estuarine Chemistry)

An Example of Mixing in the LB-CMB


3)

CMB　　#4

$T_A = 7.7°C$　　$T_B = 9.9°C$　　$\Delta T = T_B - T_A = 2.2\ (\pm 0.05°C)$

$[NO_3] = N.D.$　　$[NO_3] = 0.12\ ppm$

#3　$T = 8.7°C$

C　$[NO_3] = 0.16\ ppm$

$$f_B = \frac{T_C - T_A}{T_B - T_A} = \frac{8.7 - 7.7}{9.9 - 7.7} = \frac{1.0}{2.2} = 0.45 \qquad f_A = 1 - f_B = 1 - 0.45 = 0.55$$

$$f_A C_A + f_B C_B = C_C$$

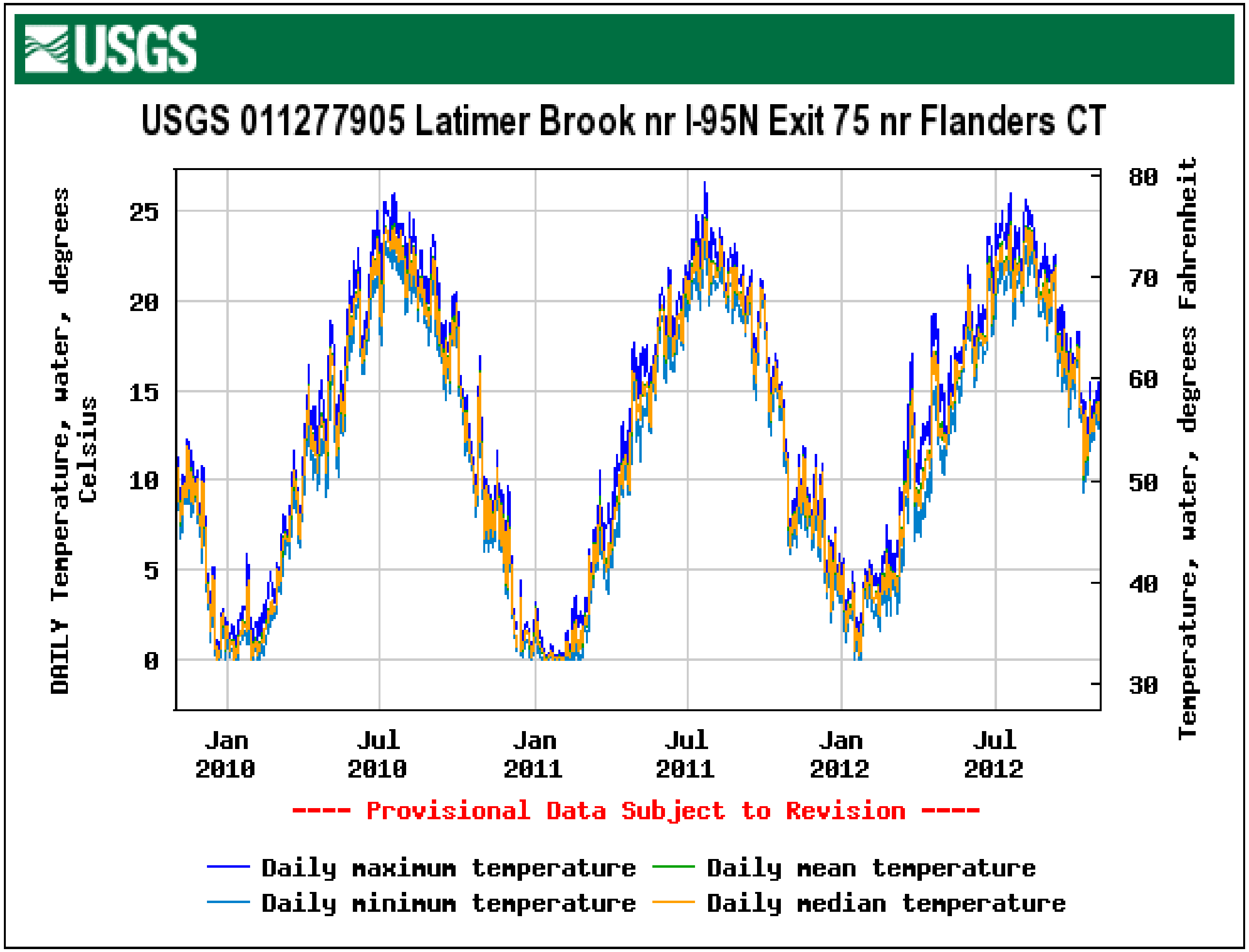
$$f_{CMB} C_{CMB} + f_{\#4} C_{\#4} = C_{\#3}$$

$$C_{CMB} = \frac{C_{\#3} - f_{\#4} C_{\#4}}{f_{CMB}} = \frac{0.16 - (0.45)(0.12)}{0.55} = \frac{0.106}{0.55}$$

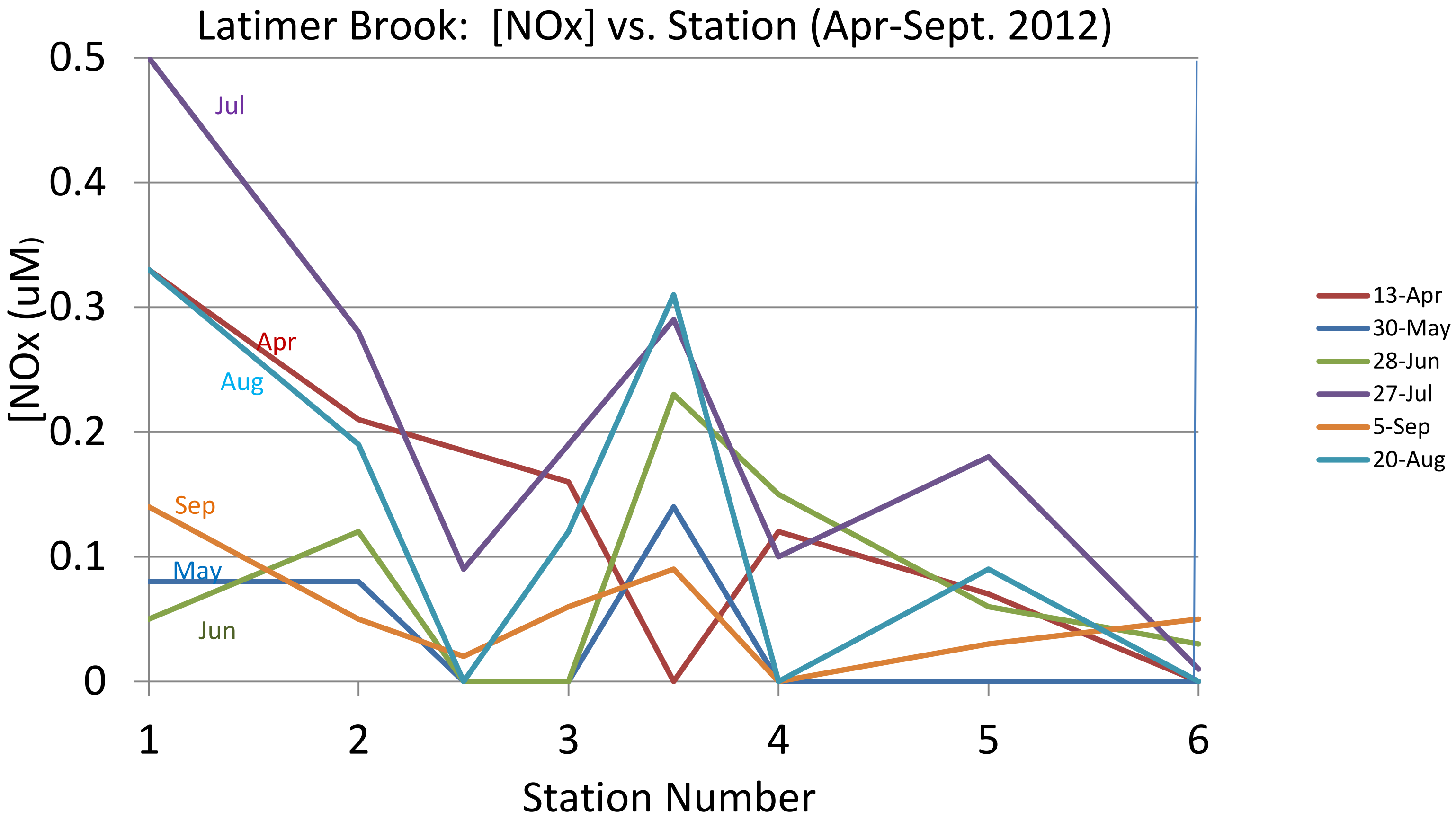
$$[NO_3]_{CMB} = C_{CMB} = 0.19 \pm 0.007\ ppm$$

5/3/12

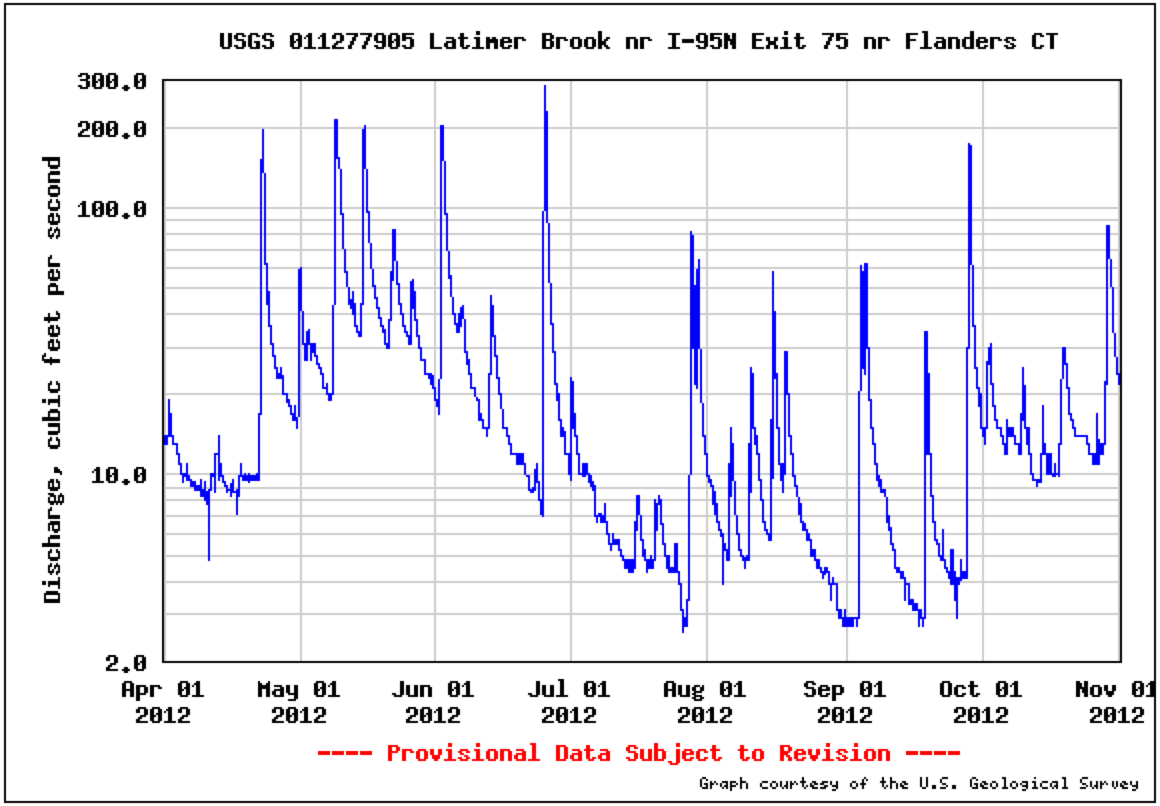
Major Driving Force in LB Chemistry: Temperature



- Seasonal T variation is straightforward.
- Is there seasonal variable forcing the relative – *LB & CMB* -- NOx flow? (Warm- vs. cold-season flows.)



Latimer Brook: [NOx] vs. Station (Apr-Sept. 2012)
[NOx (uM)
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
6
Station Number
Jul
Apr
Aug
Sep
May
Jun
13-Apr
30-May
28-Jun
27-Jul
5-Sep
20-Aug


USGS 011277905 Latimer Brook nr I-95N Exit 75 nr Flanders CT
Discharge, cubic feet per second
300.0
200.0
100.0
10.0
2.0
Apr 01 2012
May 01 2012
Jun 01 2012
Jul 01 2012
Aug 01 2012
Sep 01 2012
Oct 01 2012
Nov 01 2012
---- Provisional Data Subject to Revision ----
Graph courtesy of the U.S. Geological Survey

A Preliminary Biogeochemical Assessment of the Niantic River Estuary

John P. Jasper
Niantic River Watershed Organization
***And* Nature's Fingerprint® / MIT LLC**
Niantic, CT

Niantic River Data from Dr. Jamie Vaudrey and Prof. James Kremer
Department of Marine Sciences
University of Connecticut, Avery Point
Groton, CT

(February 19, 2010)