# Update on Rutgers Program: Potentials for Methylation and Demethylation and Microbial Community Structure

South River Expert Panel Meeting
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Tamar Barkay, RiQing Yu
(Rutgers University, NJ)

Presented by Erin Mack
(DuPont, DE)

# Project Scope:

- Title: Factors controlling methylmercury production in the South River, VA: Substrate bioavailabilty and potentials for methylation and demethylation

- Pilot Program to testing:
  - Application of bioreporter to probe bioavailability of Hg in S. River
  - Determination of potential rates of mercury methylation and methylmercury demethylation in South River sediment samples.
  - Determination of microbial community structure

# Methods Used

- Mercury Methylation Potential (MP) =
  % added $^{203}Hg^{2+}$ → $Me^{203}Hg$
  Carried out May and August 2008 on 9 sites

***Potential Rate ≠ Rate in Nature***

- Methylmercury Demethylation Potential (DP) =
  % added $^{14}CH_3Hg+$ → $^{14}CO_2$ or $^{14}CH_4$
  Carried out May and August 2008 on 9 sites

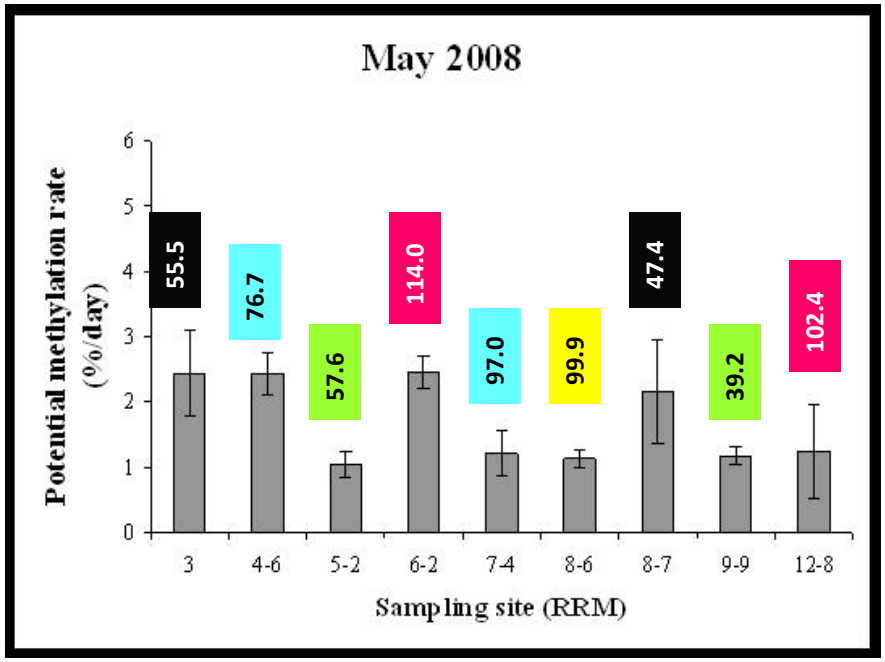
- Microbial Community = Determined by extracting and sequencing 16S Ribosomal RNA from samples.
  - Carried out on 4 samples with elevated MP
  - Ribosomal RNA is represents active community
  - 16S rRNA sequences identify groups of bacteria

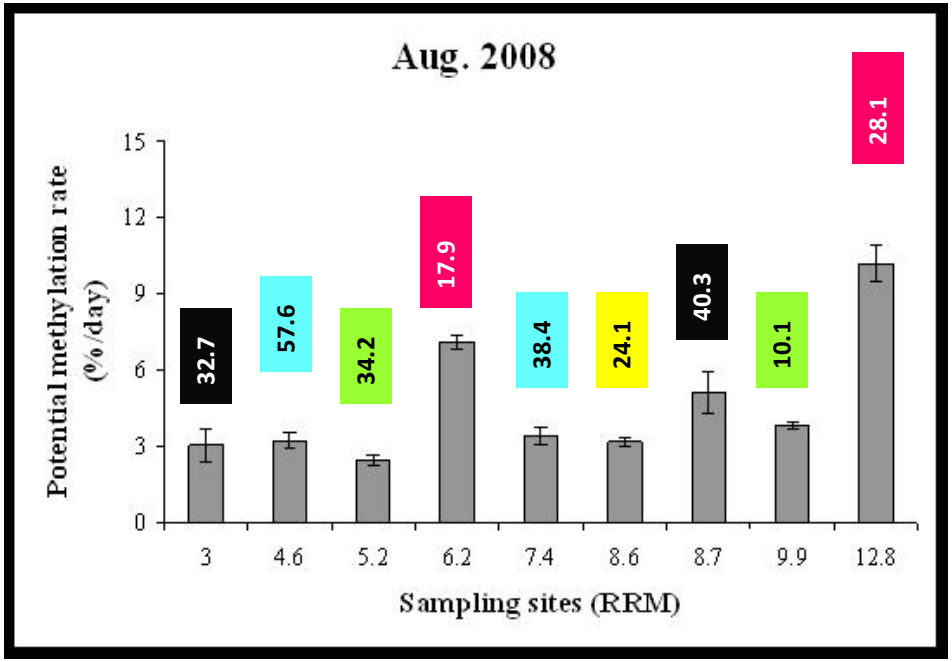
Thanks to JR Flanders and URS team in selecting and collecting samples

# Mercury Methylation Potentials (MP)

**Table 1:** Habitat types and samples that were included in the study

| Habitat type | Sampling sites |
|---|---|
| Baseline monitoring stations in toe of river pool | RRM 3.0 and RRM 8.7 |
| River pools | RRM 4.6 and RRM 7.4 |
| Fine grained sediment deposit along river pool edge | RRM 6.4 and RRM 12.7 |
| Island or mill race side channel pool | RRM 5.2 and RRM 9.9 |
| Floodplain wetland | RRM 1.6 and RRM 8.6 |



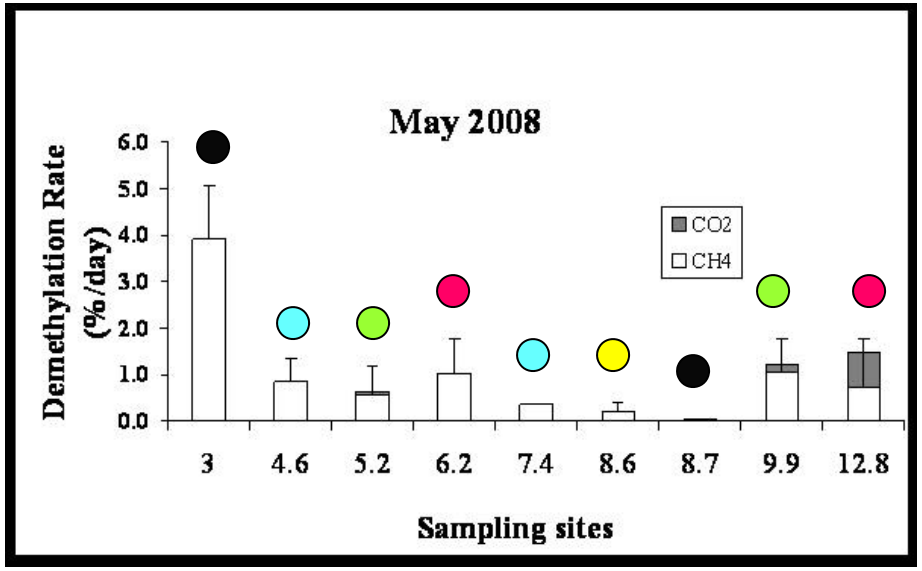



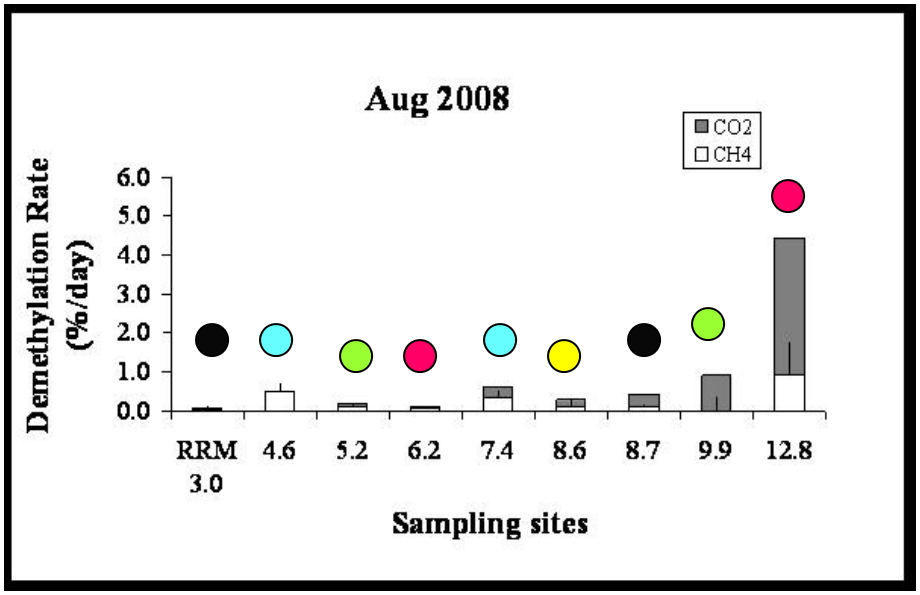

- **MP's Highest in August**
- **In August, the fine grained sediment deposits had elevated methylation potentials**

# Methylmercury Demethylation Potentials (DP)

**Table 1:** Habitat types and samples that were included in the study

| Habitat type | Sampling sites |
|---|---|
| Baseline monitoring stations in toe of river pool | RRM 3.0 and RRM 8.7 |
| River pools | RRM 4.6 and RRM 7.4 |
| Fine grained sediment deposit along river pool edge | RRM 6.4 and RRM 12.7 |
| Island or mill race side channel pool | RRM 5.2 and RRM 9.9 |
| Floodplain wetland | RRM 1.6 and RRM 8.6 |



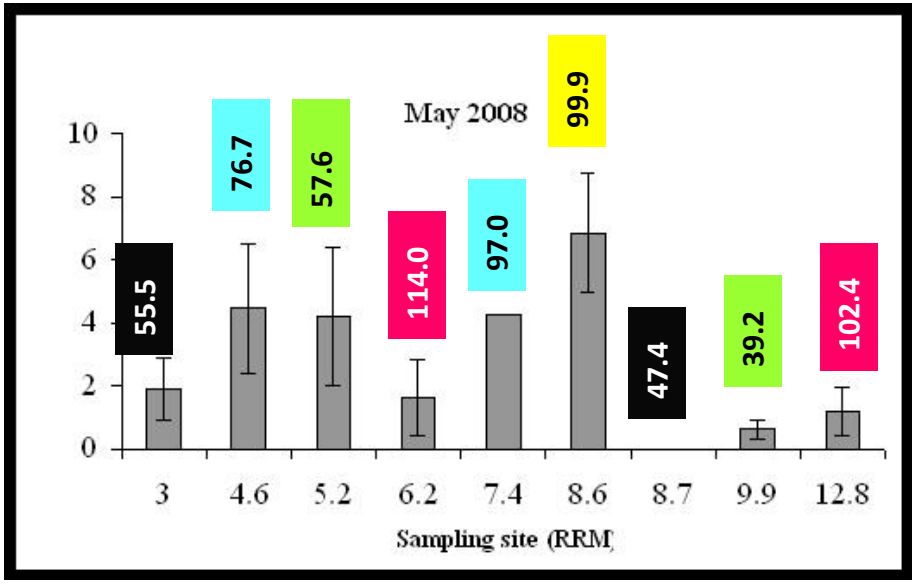



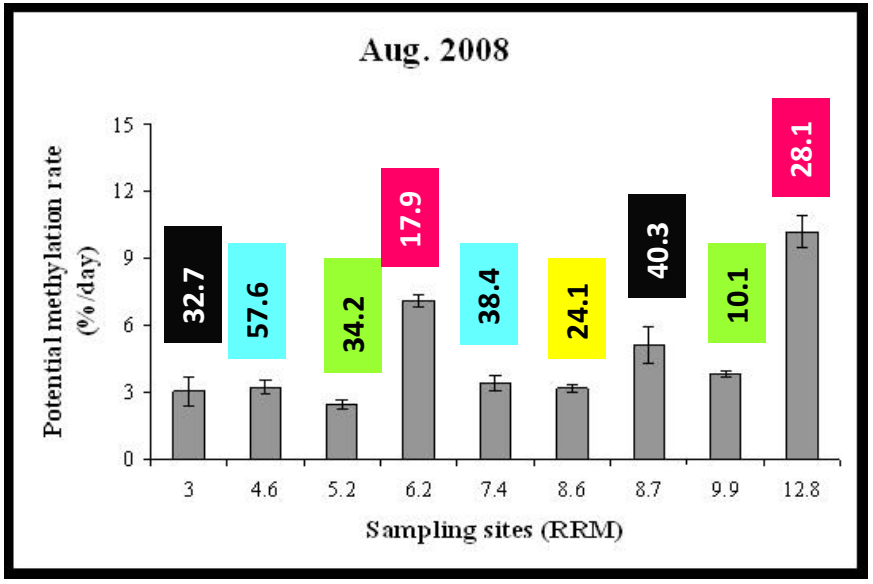

- **Highest DP was observed at RRM 12.8 in August**
- **The dominant pathway of MDP appears to differ between May and August**

# Methylation / Demethylation Ratios

**Table 1:** Habitat types and samples that were included in the study

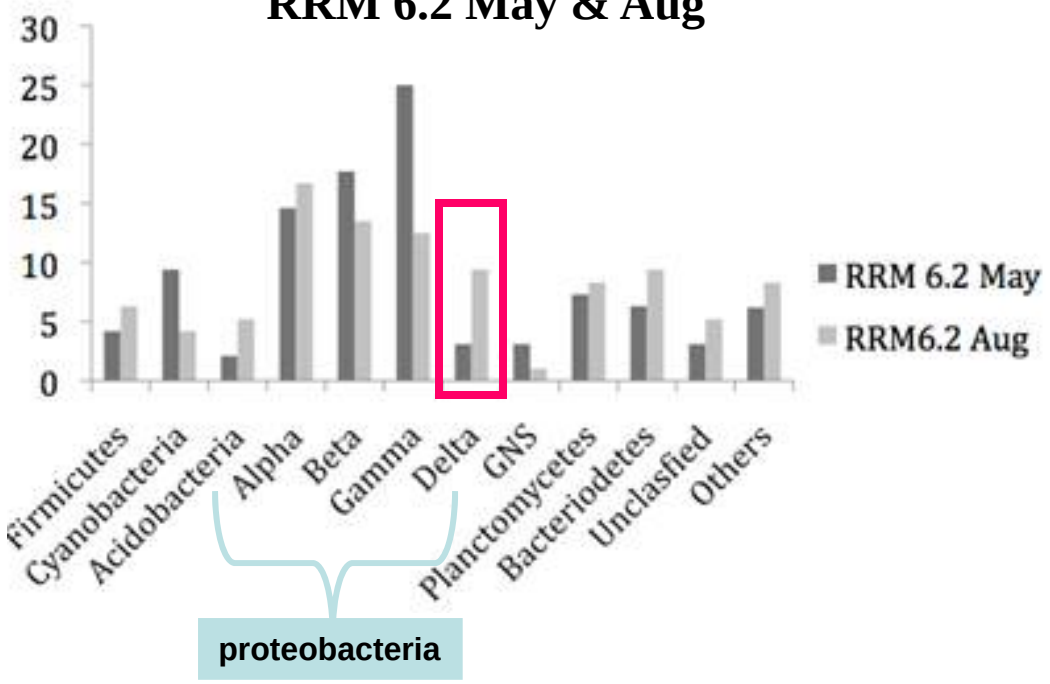
| Habitat type | Sampling sites |
|---|---|
| ● Baseline monitoring stations in toe of river pool | RRM 3.0 and RRM 8.7 |
| ○ River pools | RRM 4.6 and RRM 7.4 |
| ● Fine grained sediment deposit along river pool edge | RRM 6.4 and RRM 12.7 |
| ○ Island or mill race side channel pool | RRM 5.2 and RRM 9.9 |
| ○ Floodplain wetland | RRM 1.6 and RRM 8.6 |




- **All M/D ratios in August > 1**
- **Methylation / Demethylation ratios had a similar profile to River MeHg in May**

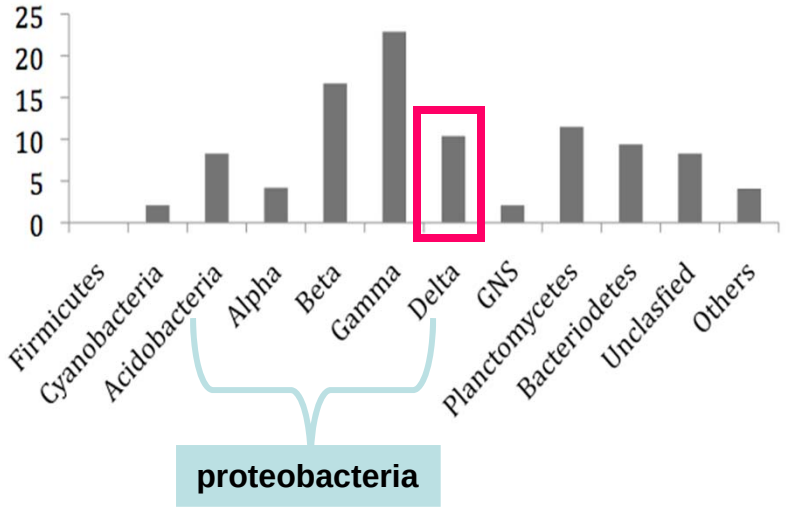
## RRM 6.2 May & Aug



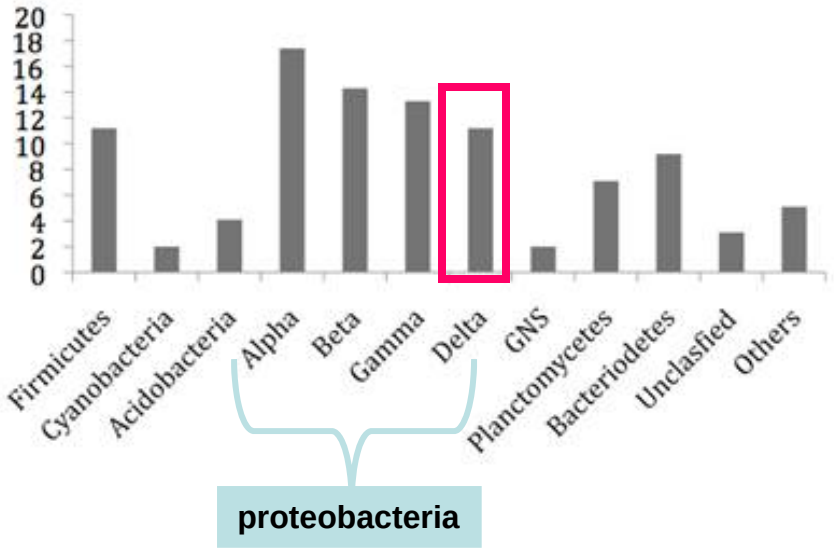

# Microbial Community Structure

- Active populations dominated by proteobacteria
- Δ Proteobacteria include strains known to methylate mercury - - Iron reducing bacteria and Sulfate reducing bacteria
- In RRM 6.2 Δ Proteobacteria increased in August (correlates w/increased MP for this time)

## RRM 8.7 May




## RRM 12.8 Aug



# Preliminary Results

- South River sediments methylate and demethylate mercury
- MP's and DP's change with site and season
- Measured MP's are not consistent with observations of MeHg in the river (i.e. highst MP measured in August)
- South River MP's comparable to those reported in the literature for other sites
- South River DP's lower than those reported in the literature and dominant mechanism of degradation may change with season
  - As a result, South River M/P ratios are relatively high
- Fine grain channel margin sediments may have elevated methylation potential relative to other sediments (August)
- Microbial community contains strains similar to known mercury methylating strains (iron reducers and sulfate reducers)

Back up slide

**Table 3:** Physical and chemical characteristics of sediment samples collected in May 2008 (Mean ± STD)

| Study site (RRM) | Description | Moisture (%) | LOI (%) | AVS (μmol/g) | Total Solids (%) | Inorganic Hg (μg/g) | MeHg (ng/g) | Fe(II):Fe(III) |
|---|---|---|---|---|---|---|---|---|
| 1.6 | Floodplain wetland | 63.50±2.12 | 13.98±0.32 | <1.8 | 36.86±1.24 | 4.0 ±0.2 | 5.3±0.4 | 1.30±0.01 |
| 3.0 | Toe of pool (Bed sediment) | 65.75±0.92 | 10.33±0 | <1.9 | 34.74±0.01 | 20.4±0.05 | 55.5±2.8 | 1.00±0.02 |
| 4.6 | Embedded pool | 69.25±0.92 | 9.86±2.29 | <2.1 | 36.84±4.36 | 21.0±2.6 | 76.7±11.0 | 2.40±0.08 |
| 5.2 | Mill race | 44.50±2.83 | 6.46±1.58 | <1.2 | 43.90±13.93 | 45.2±11.5 | 57.6±5.0 | 2.00±0.03 |
| 6.2 | FGCM deposit | 75.90±1.27 | 15.29±0.11 | <2.6 | 23.23±1.95 | 18.9±2.2 | 114.0±9.0 | 3.00±0.36 |
| 7.4 | Embedded pool | 71.50±1.13 | 12.14±0.24 | <2.3 | 30.91±1.23 | 22.0±2.2 | 97.0±0.9 | 1.30±0.04 |
| 8.6 | Floodplain wetland | 74.50±1.13 | 11.23±0.58 | <2.5 | 31.04±0.42 | 17.8±1.9 | 99.9±3.2 | 1.70±0.10 |
| 8.7 | Toe of pool (Bed sediment) | 75.00±0.71 | 11.91±0.74 | <2.5 | 27.80±2.73 | 21.1±0.1 | 47.4±0.0 | 0.40±0.00 |
| 9.9 | Mill race | 79.20±2.26 | 36.73±25.75 | 6.1 (1.5) | 28.94±8.53 | 6.3±2.0 | 39.2±9.9 | 7.70±0.07 |
| 12.8 | FGCM deposit | 76.50±0.42 | 6.60±8.97 | 3.7 (0.8) | 25.23±9.81 | 22.6±6.0 | 102.4±21.7 | 4.30±0.26 |

Back up slide

**Table 4:** Physical and chemical characteristics of sediment samples collected in August 2008 (Mean ± STD)

| Study site (RRM) | Description | Moisture (%) | AVS (μmol/g) | Total Solids (%) | Total volatile solids (%) | Inorganic Hg (μg/g) | MeHg (ng/g) |
|---|---|---|---|---|---|---|---|
| 1.6 | Floodplain wetland | 64.0±0.6 | 1.8±0.1 | 48.2±0.6 | 12.4±0.3 | 4.2±1.0 | 5.7±0.0 |
| 3.0 | Toe of pool (Bed sediment) | 75.6±2.1 | 2.6±0.2 | 37.1±3.8 | 12.6±1.2 | 26.2±0.5 | 32.7±0.1 |
| 4.6 | Embedded pool | 68.2±3.0 | 2.0±0.1 | 31.4±3.5 | 21.0±3.6 | 23.4±5.9 | 57.6±1.3 |
| 5.2 | Mill race | 45.9±2.1 | 1.2±0.1 | 61.0±1.1 | 7.2±0.3 | 32.7±1.8 | 34.2±15.1 |
| 6.2 | FGCM deposit | 52.7±8.1 | 4.3±2.5 | 62.8±1.0 | 4.6±0.1 | 6.8±0.1 | 17.9±0.0 |
| 7.4 | Embedded pool | 75.0±0.7 | 2.6±0.1 | 33.4±2.3 | 12.9±0.1 | 23.7±0.4 | 38.4±1.6 |
| 8.6 | Floodplain wetland | 70.3±2.8 | 4.3±0.9 | 47.9±2.3 | 10.9±0.1 | 14.4±0.3 | 24.1±0.6 |
| 8.7 | Toe of pool (Bed sediment) | 77.4±0.8 | 2.8±0.1 | 36.9±5.3 | 12.2±0.5 | 21.0±0.3 | 40.3±3.9 |
| 9.9 | Mill race | 80.9±1.9 | 12.5±1.6 | 36.5±4.2 | 15.4±1.0 | 8.7±0.3 | 10.1±2.7 |
| 12.8 | FGCM deposit | 53.8±0.6 | 1.4±0.1 | 46.3±2.5 | 11.2±2.5 | 15.2±6.6 | 28.1±5.6 |