The Role of Bacteria in Wetland Functionality and Sustainability

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Important issues in GSL Ecosystem

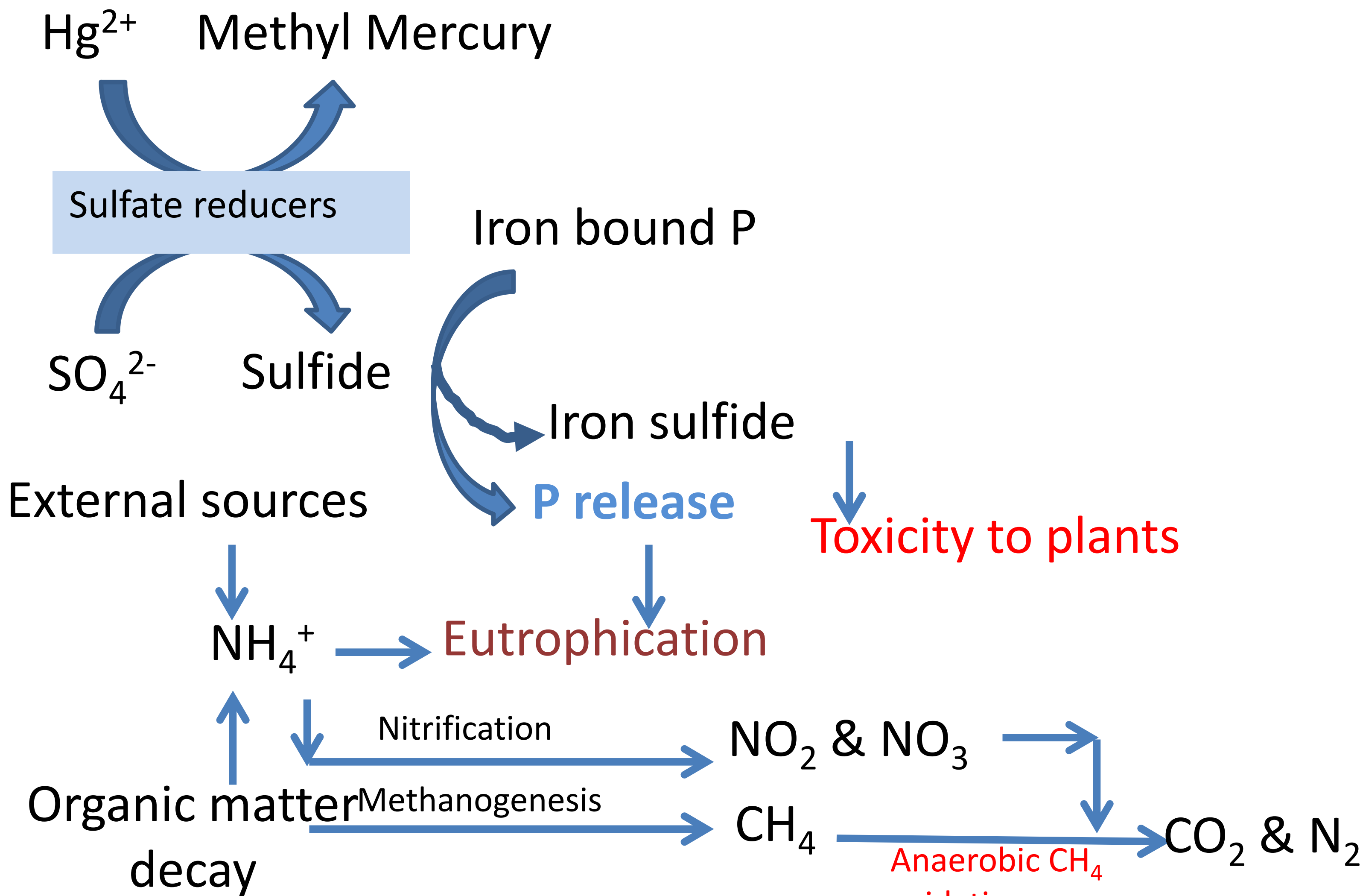
Nutrients

Mercury and Selenium

Salinity gradient

Cyanotoxins

Other heavy metals (??)



Hg^{2+}
Methyl Mercury
Sulfate reducers
SO_4^{2-}
Sulfide
Iron bound P
Iron sulfide
P release
External sources
Toxicity to plants
NH_4^+
Eutrophication
Nitrification
NO_2 & NO_3
Organic matter decay
Methanogenesis
CH_4
CO_2 & N_2
Anaerobic CH_4 oxidation

Microbial transformations of nutrients and iron dictate vegetation composition in wetlands

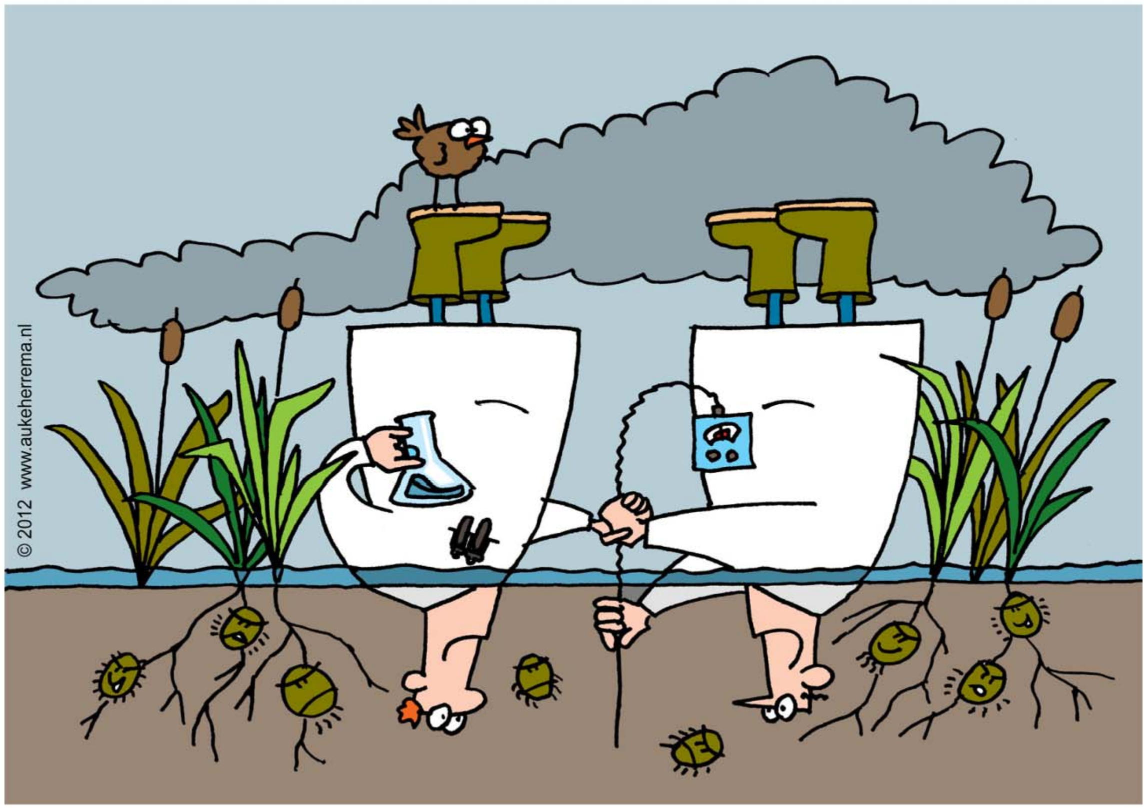


FIGURE showing Below-ground scientific collaboration in wetlands: microbiology meets plant ecology. (Taken from Lamers et al., 2012)

Specific Projects

- Cyanotoxins in Farmington Bay- Central Davis Sewer District
- Mercury and its methylation in GSL- UDWQ
- Nutrient fate flux and fate in Willard Spur Wetlands- UDWQ
- Nutrient fate and dynamics in Farmington Bay Wetlands- USEPA

Should Cyanotoxins be of concern to us?

Algal bloom in Farmington Bay (2008)

- Algal blooms (eutrophication?)
- Cyanobacteria (Blue-green algae) can release Cyanotoxins

But not all the algal blooms Correspond to Cyanobacteria

What are Cyanotoxins?

Cyanotoxins

Hepetotoxins

(affect liver)

Strains of

Microcystis, Nodularia, etc.

Microcystins, Nodularin, etc.

Neurotoxins

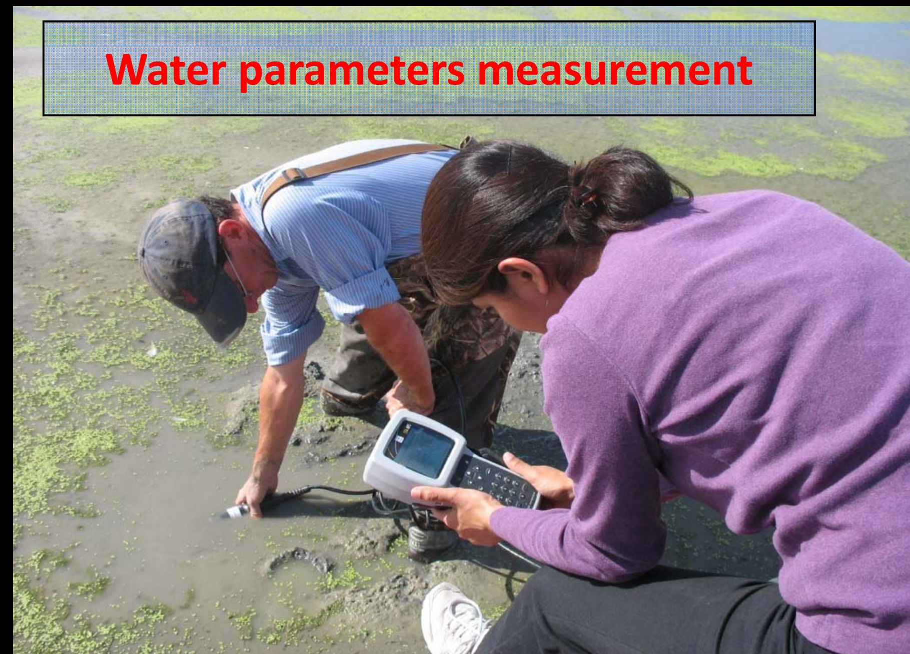
(affect nerve system)

Strains of

Aphanizonmenon, Oscilatoria, etc.

Anatoxins, Saxitoxin, etc.

Sample collection



Nodularin concentrations in monthly samples

2008: June, August, September, and November.

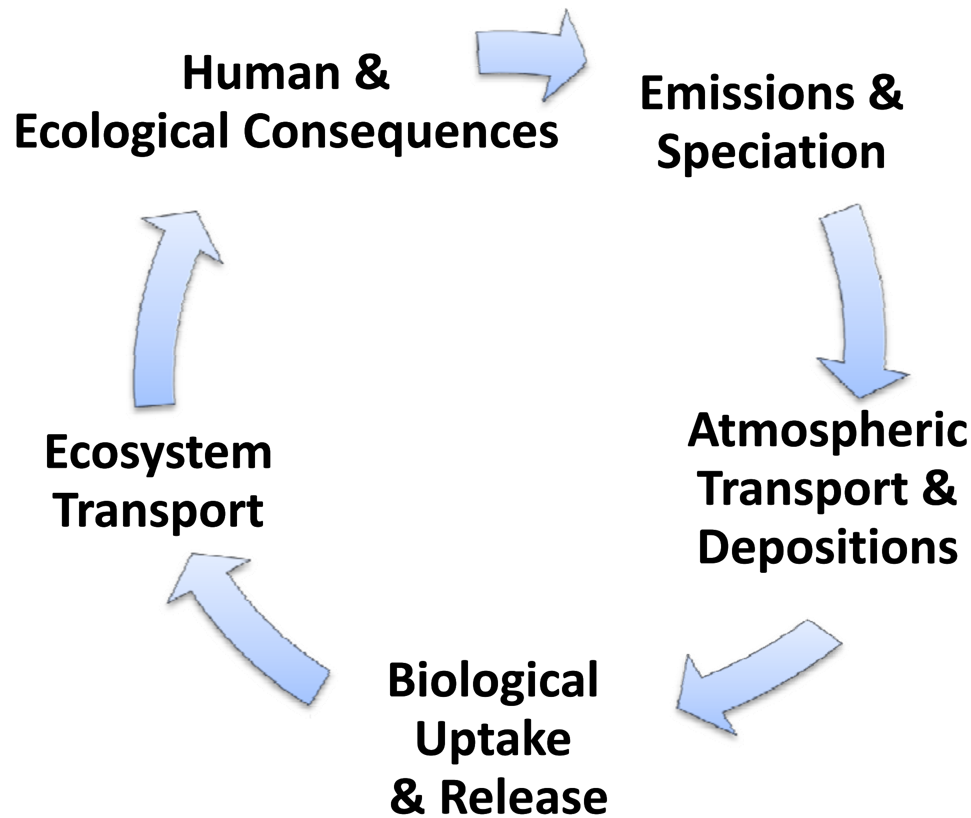
Table 1. Sampling sites gave positive Nodularin concentrations

Date	Site	Nodularin concentration (µg/L)
Aug.,08	4	0. 384
	6	0. 207
Sept.,08	4	0.331
	5	0.25

Conclusion: Nodularin was either completely absent or present in very low concentrations in the Farmington Bay well below 1µg/L

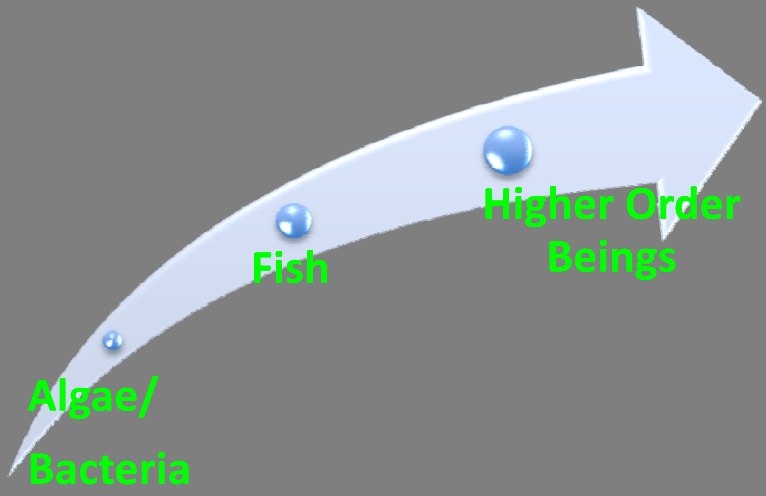
Mercury and its methylation

The Mercury Cycle



Concerns & Consequences

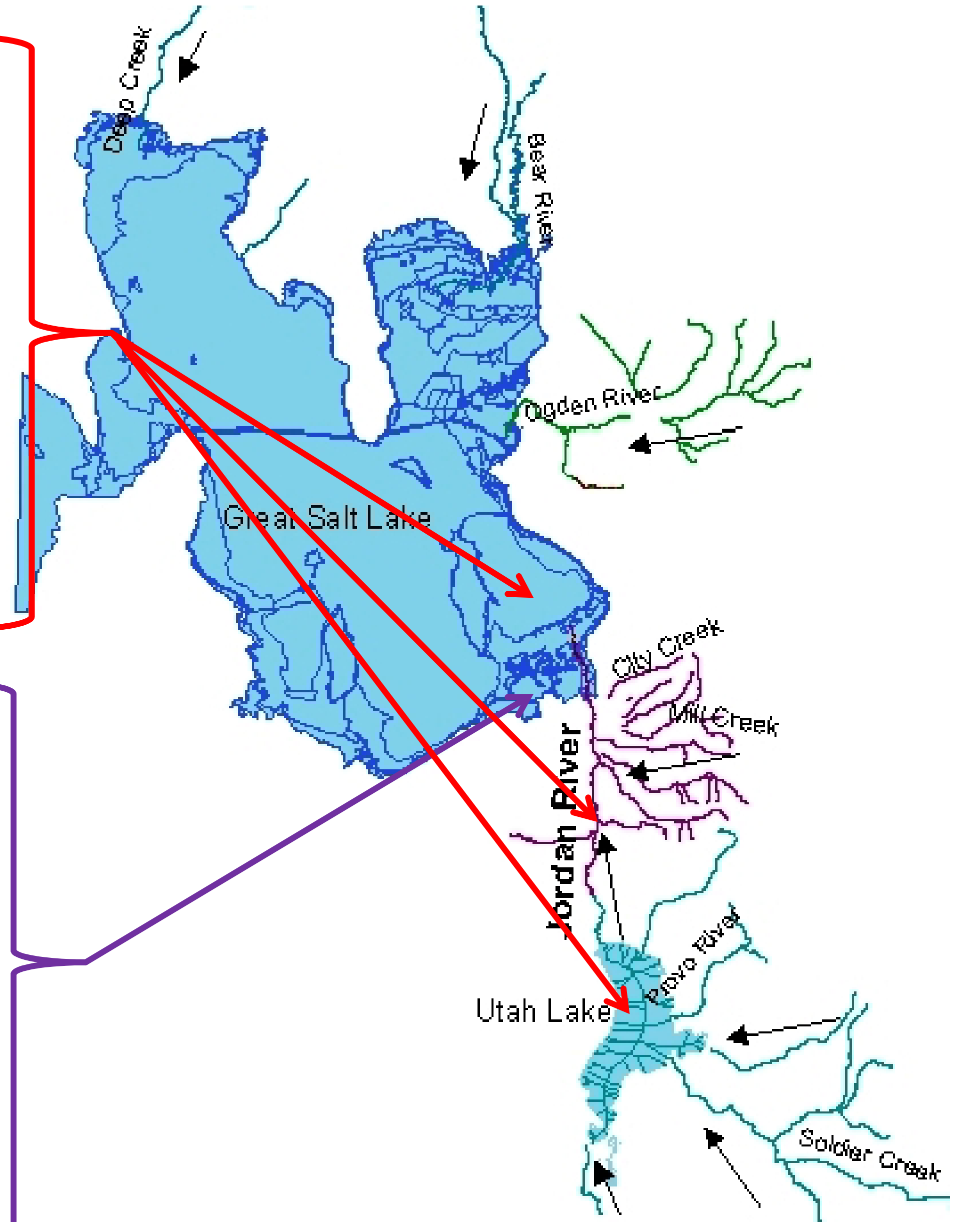
- Persistent Bioaccumulative Toxin (PBT)
- Ecological effects
  - Bioaccumulation & magnification



- Human health concerns
  - Potent neurotoxin
  - RfD for MeHg: 0.1 µg/kg-day
  - Acute LD_{50} (Body weight of 70-kg human)
    - Inorganic: 14-57 mg/kg
    - Organic: 20-60 mg/kg (MeHg)

Research Objectives

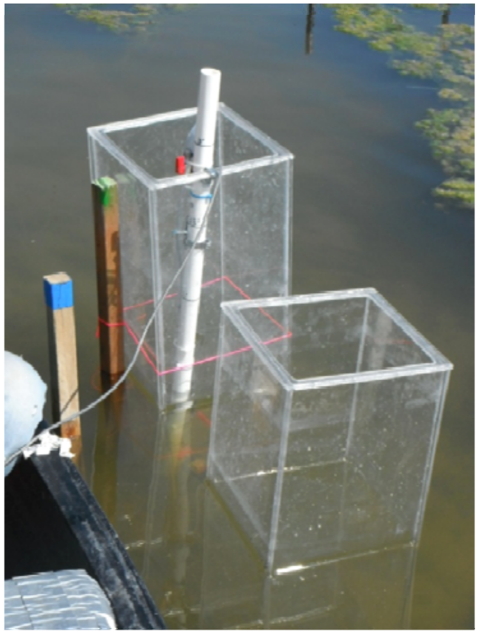
- Synoptic sampling & analysis of mercury, in water column & sediments from Farmington Bay (FB), Utah Lake and Jordan River
- Analyze the fate of mercury entering municipal waste water treatment plants (WWTP), emptying into Jordan River
- To evaluate the rate of mercury methylation in the sediments from the Turpin unit of FB
- And, to investigate the ecology of sulfate reducers possibly participating in mercury methylation of the sediments

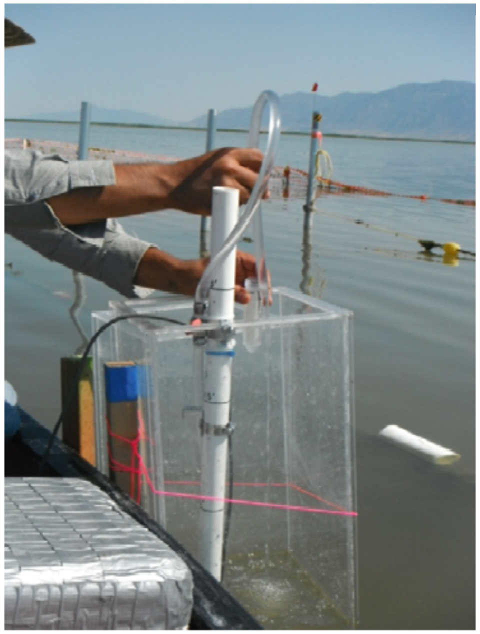


Summary of Analysis Results

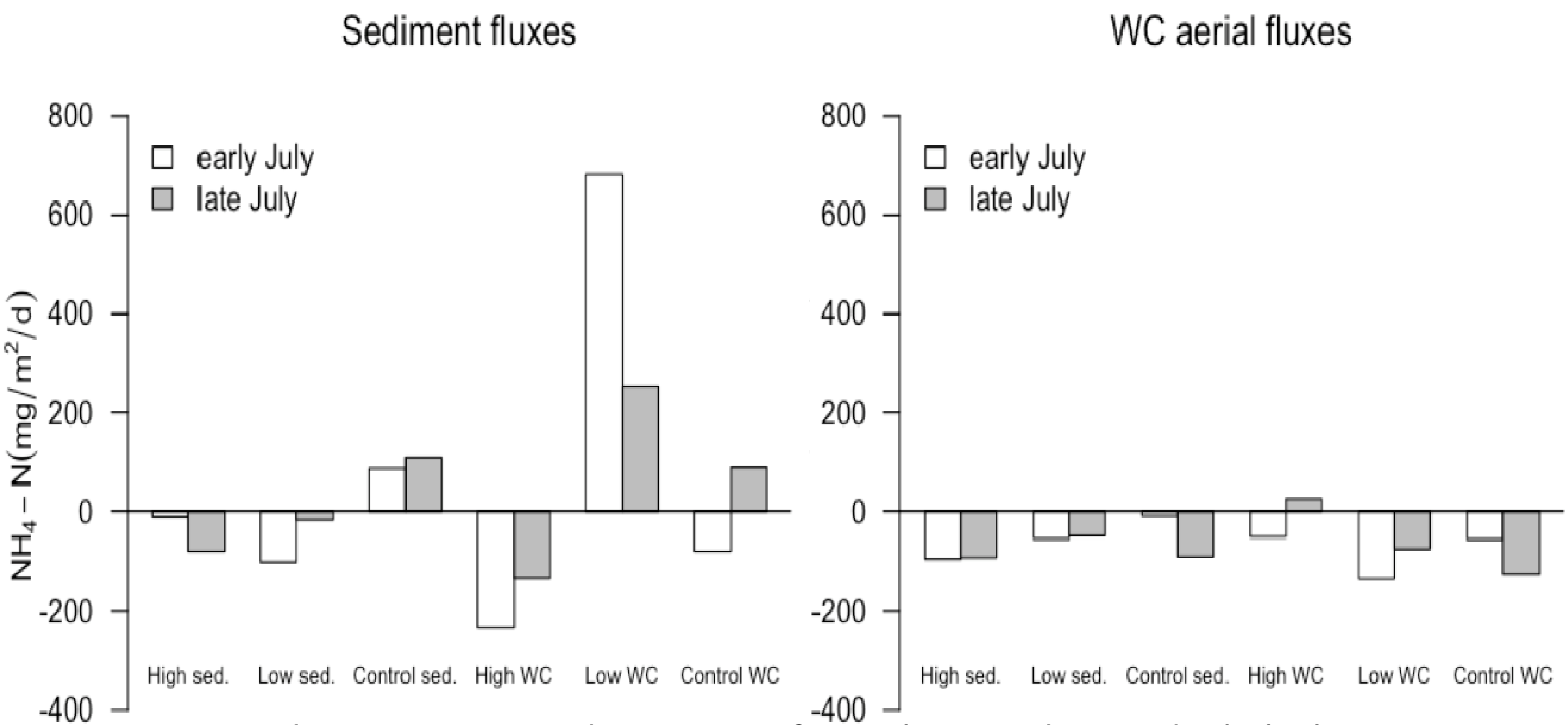
Site	Matrix		Total Mercury	Methyl Mercury
FB	Water Column(ng/L)	Range	6.92-25.32	0.602-3.12
		Average	19.05	1.49
FB	Sediments (µg/Kg)	Range	34.01-83.1	0.06-1.51
		Average	60.47	0.35
Utah Lake	Water Column(ng/L)	Range	1.23-4.26	0.0055-0.7813
		Average	2.74	0.0536
Utah Lake	Sediments(µg/Kg)	Range	18-49	0.012-0.34
		Average	27.13	0.0717
Jordan River	Water Column(ng/L)	Range	19.17-26.33	0.10-0.0712
	Upper	Average	19.95	0.18
	Lower	Average	26.9	0.64
Jordan River	Sediments (µg/Kg)	Range	18-110	0.021-0.170
	Upper	Average	18.50	0.021
	Lower	Average	79.05	0.147

Willard Bay Nutrient Fluxes





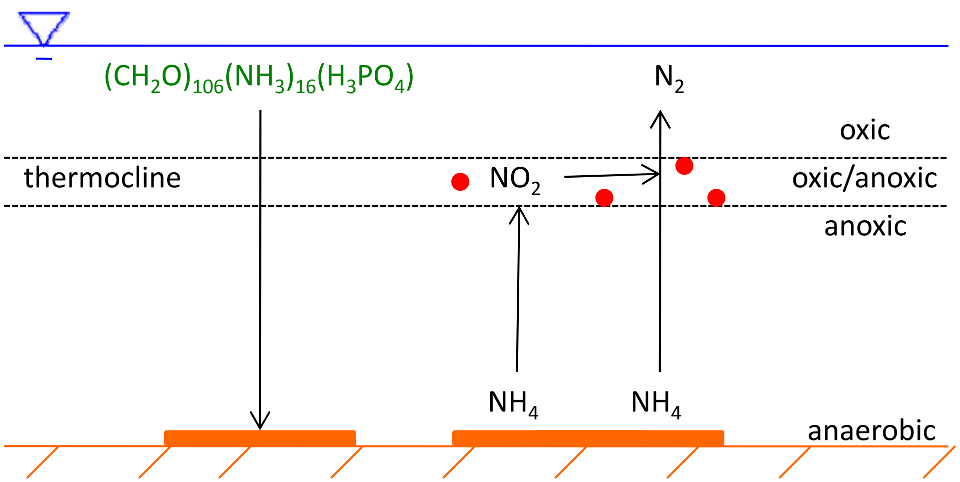
Sediment and WC fluxes- Ammonia

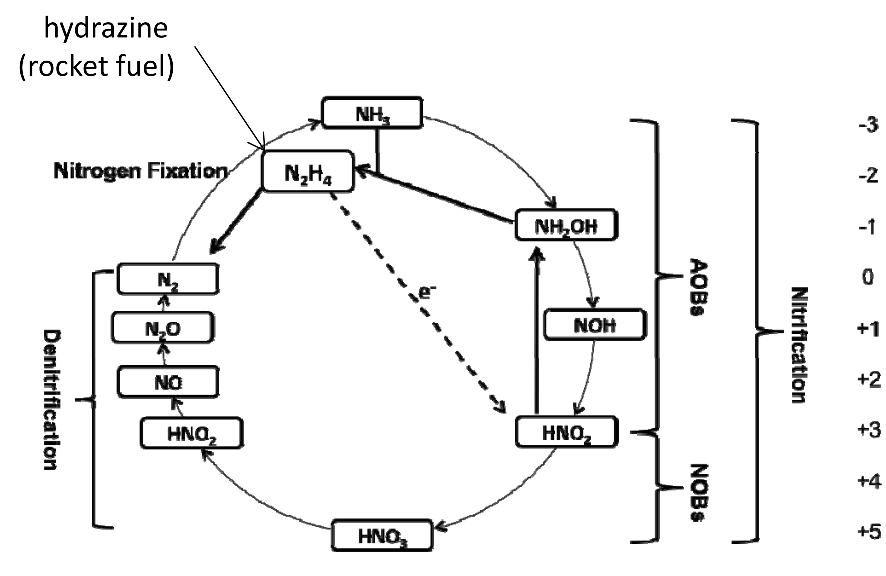


- Sediments removed ammonia from the WC during daylight hours
    - exceptions (Control Sediment & Low Water Column)
- WC removed ammonia during the daylight hours

Traditional Nitrogen Removal in Wetlands

- Oceanographers noticed ammonium deficits in anoxic waters (Richards, 1965)
  - postulated using thermodynamics with molar ratios of NO_2:NH_4 of 1:1 and 1.67:1 (Broda, 1977)
  - 50-70% of N_2 gas produced in ocean
    - 30% of every breath we take





[adapted from Ahn, 2006]

– Ammonia Oxidizing Bacteria (AOBs)

$$55NH_4^+ + 76O_2 + 109HCO_3^- \rightarrow C_5H_7O_2N + 54NO_2^- + 57H_2O + 104H_2CO_3$$

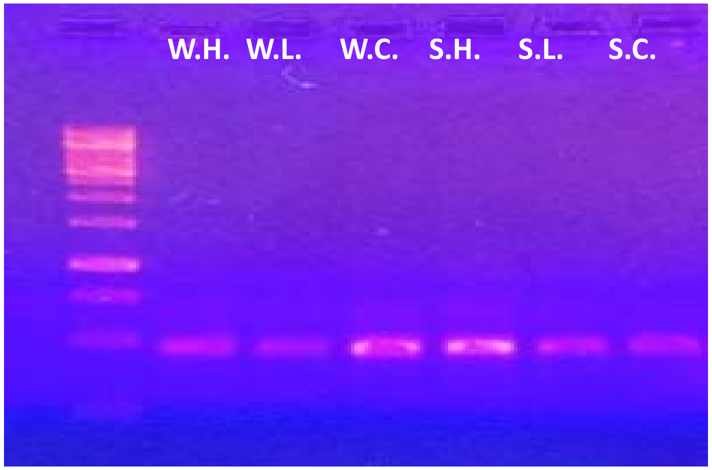
– Nitrite Oxidizing Bacteria (NOBs)

$$400NO_2^- + NH_4^+ + 4H_2CO_3 + HCO_3^- + 195O_2 \rightarrow C_5H_7O_2N + 3H_2O + 400NO_3^-$$

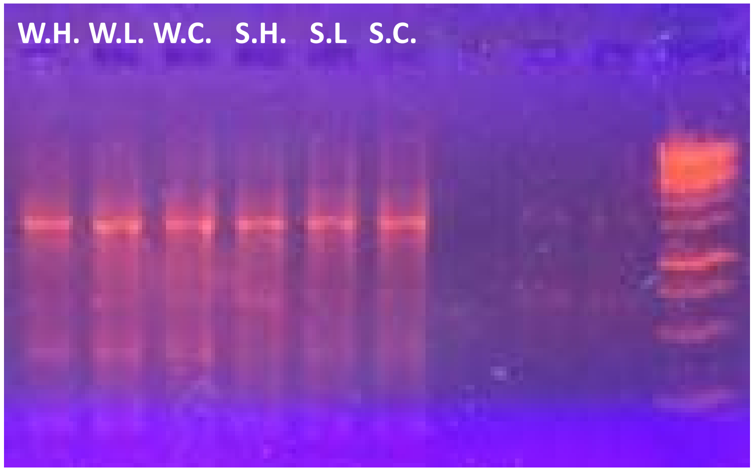
- $NH_4^+ + 1.32\ NO_2^- + 0.066\ HCO_3^- + 0.13\ H^+ \rightarrow 1.02\ N_2 + 0.26\ NO_3^- + 0.066\ CH_2O_{0.5}N_{0.15} + 2.03\ H_2O$

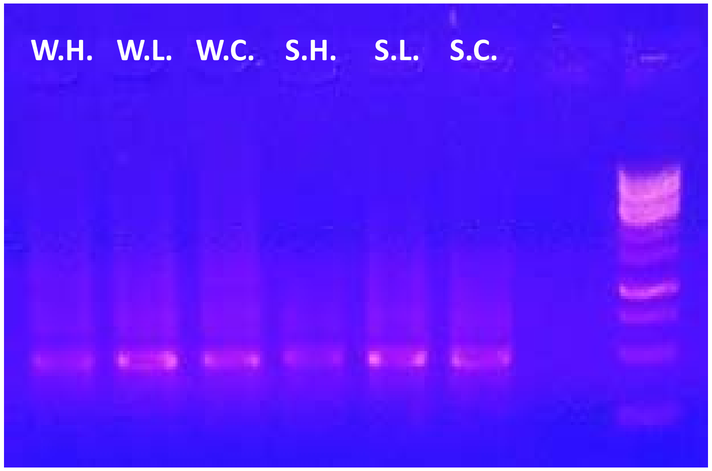
Molecular Tests

AOBs (amoA gene)
PCR (fragment size of **491** bp)

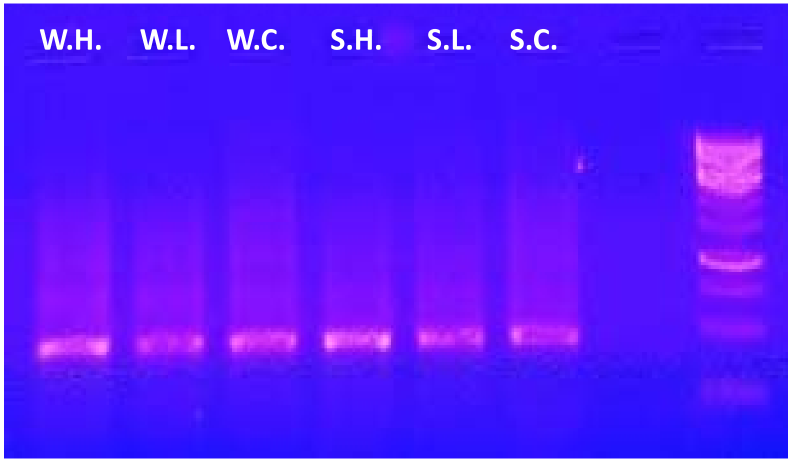


All Anammox (1484 bp)





Brocadia and/or kuenenia
(452 bp)



Scalindua (452 bp)

QUESTIONS