Biodegradation of Emulsified MC252 Oil in Coastal Salt Marshes

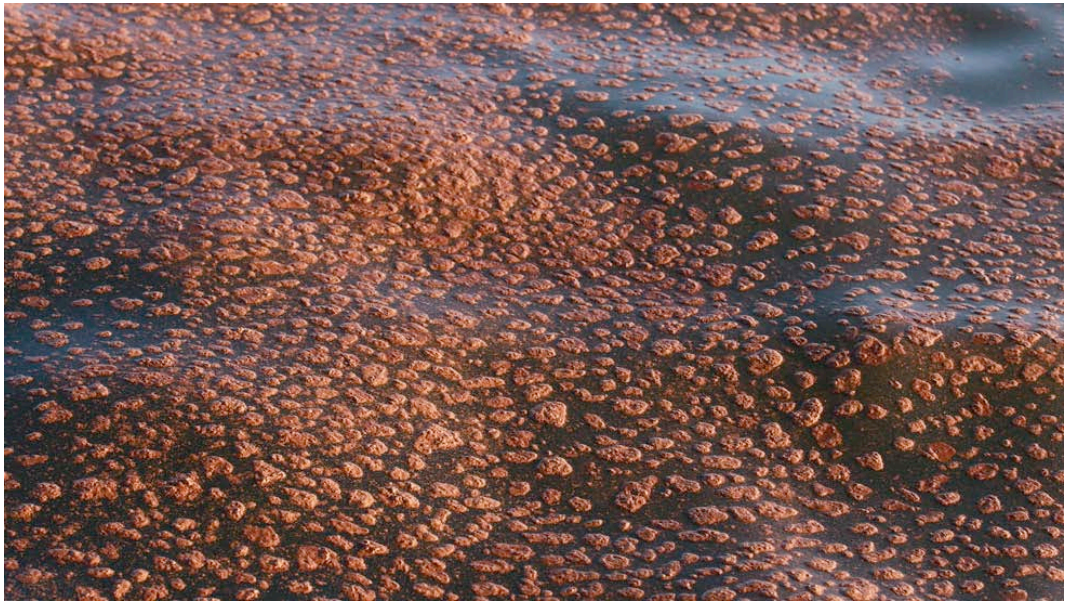
John H Pardue, Vijai Elango, Brooke R. McCoy,
Holly E. Samaha and John W. Bellone
Civil & Environmental Engineering, LSU

October 2011

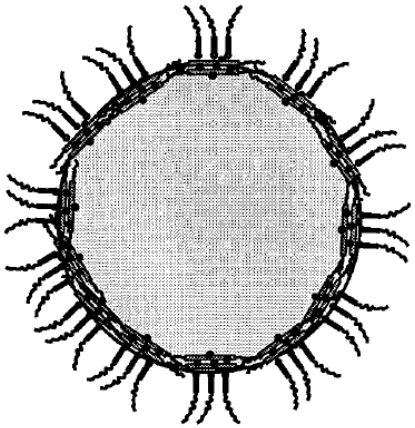
Outline

- Emulsified MC252 oil
- What we knew about biodegradation in salt marshes
- Initial salt marsh core studies using emulsified MC252

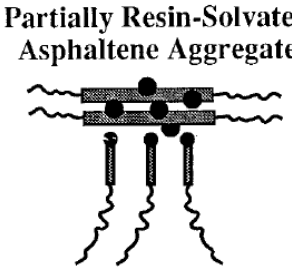
Emulsion or “mousse”- primary form of oil at coast



Stability of oil:water emulsions

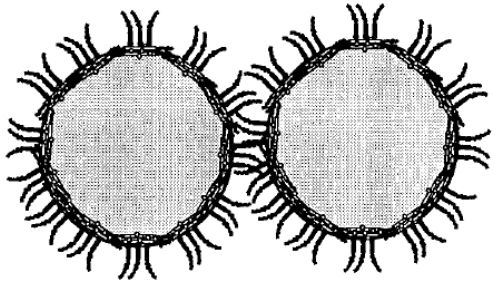


Asphaltene-Stabilized Water Droplet



Partially Resin-Solvated
Asphaltene Aggregate

Stable emulsions form due to surface-active components: asphaltenes and resins



Droplets Resist Fusion
Due to Steric Stabilization

From McLean and Kilpatrick, 1997

Outline

- Emulsified MC252 oil
- What we knew about biodegradation in salt marshes
- Initial salt marsh core studies using emulsified MC252

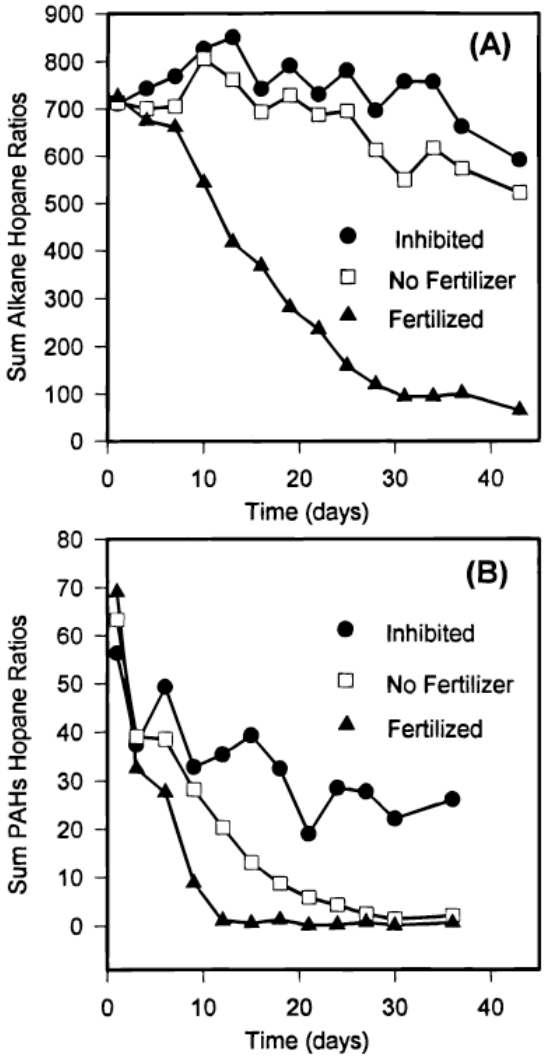
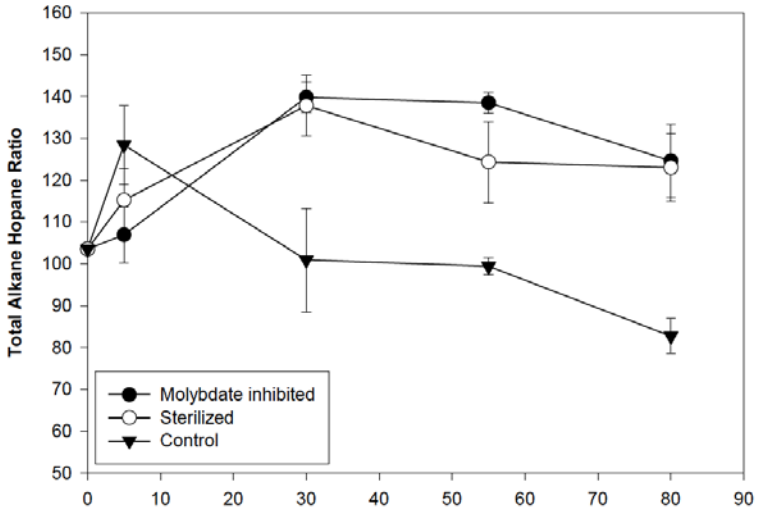


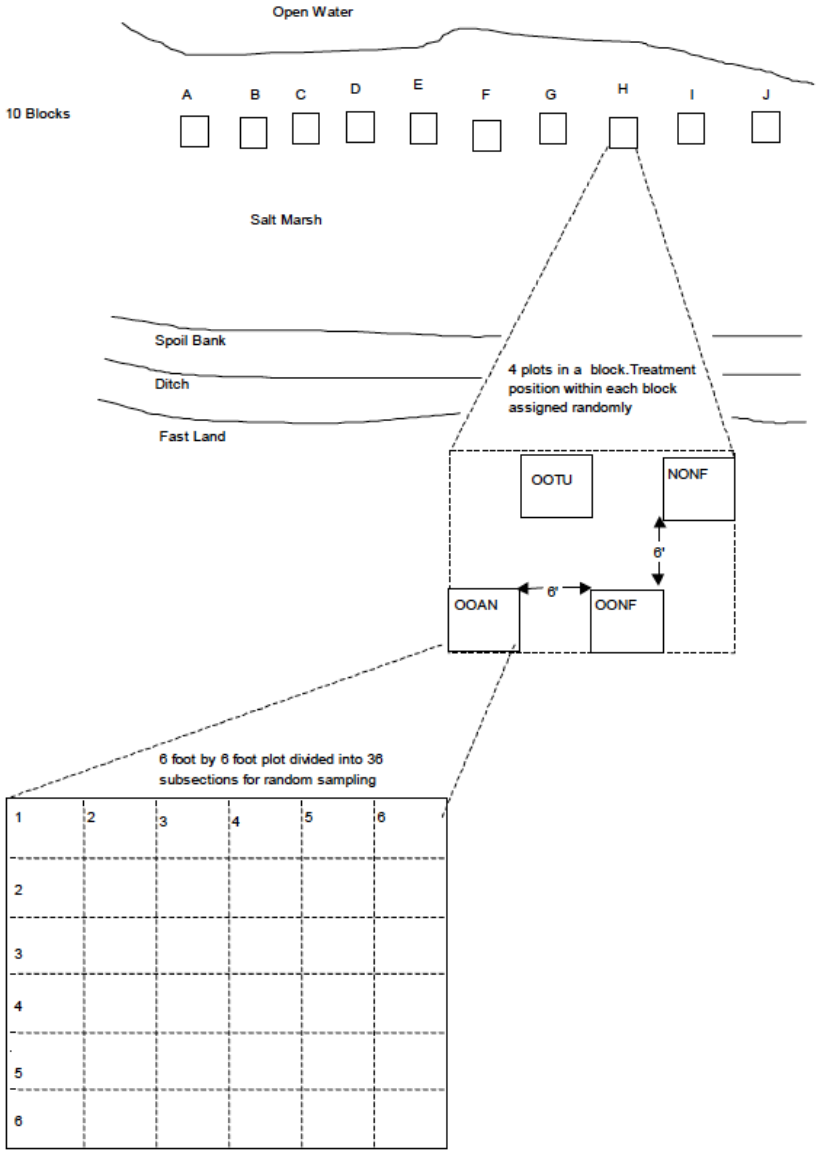
FIGURE 1. (A) Total (C15—C44) alkane hopane ratio versus time in aerated microcosms. (B) Total PAH (phenanthrene, C1—C2; naphthalene, C1—C2) hopane ratio versus time.

Aerobic biodegradation

1. Both aerobic and anaerobic microbial processes involved in crude oil biodegradation in salt marshes



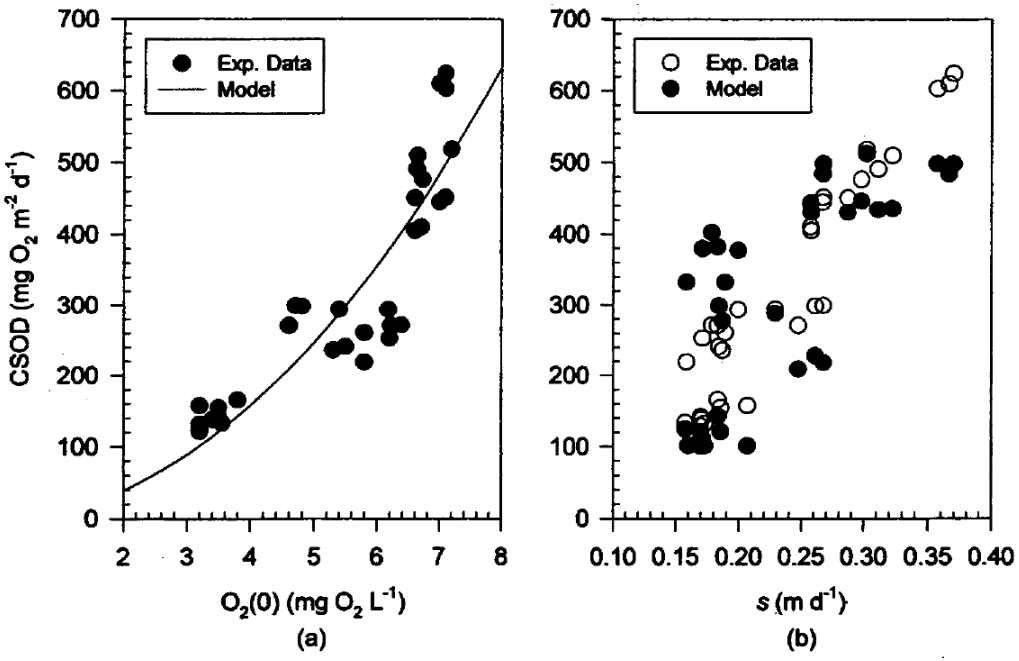
Anaerobic biodegradation

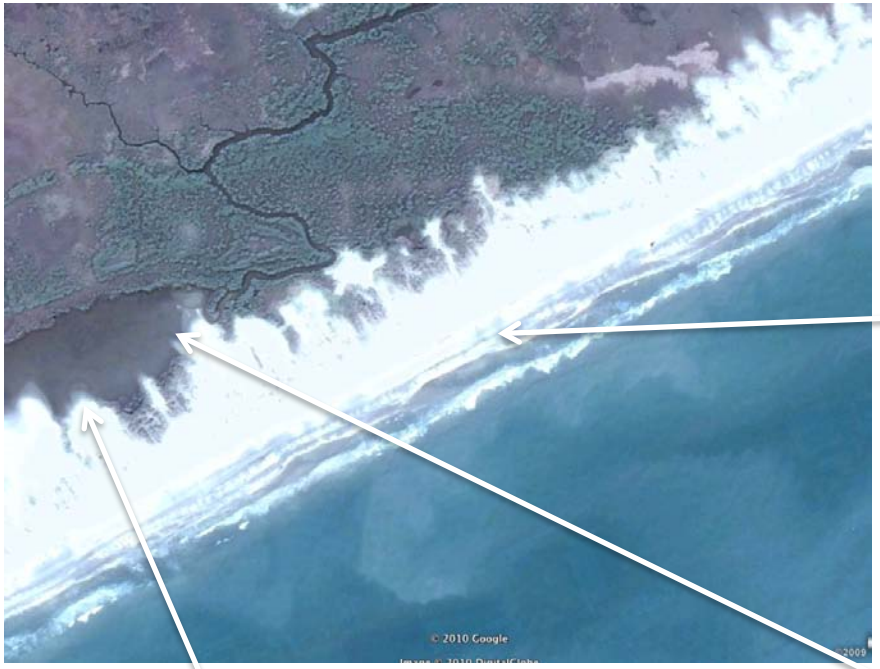


2. Mixed results for fertilization impacts on acceleration of crude oil components in marshes

	Sum of Alkanes
OONF	0.0054 ± 0.0027
OOAN	0.0059 ± 0.0025
OOTU	0.0058 ± 0.0009

3. Oil limits oxygen flux by creating a physical barrier but also increases O_2 demand from 3-5x through increased aerobic and sulfate reduction (sulfide oxidation)




© 2010 Google

Outline

- Emulsified MC252 oil
- What we knew about biodegradation in salt marshes
- Initial salt marsh core studies using emulsified MC252

Study Details

- Salt marsh cores (Lafourche Parish, LA) 6” dia × 36” long and incubated inside a greenhouse.
- Emulsified oil (100 g) added to core surface
- Replicate cores used to evaluate three treatment conditions; (i) natural attenuation with existing nutrient concentrations, (ii) nitrogen amendment and (iii) nitrogen + sulfate amendment.


1
control
3
control


3
control
1
control

Study Details

- **Short-term biodegradation** (0-3 months). For each treatment condition, cores were sacrificed for oil analysis every ~30 days. The cores were cut into 2 cm sections from the top and oil was extracted and analyzed from the soil sections 0-2 cm, 2-4 cm and 8-10 cm (GC-MS of PAHs, denaturing gradient gel electrophoresis, nutrients)
- **Longer-term** (320 days)-replicate cores sacrificed after ~10 months

MC252 PAH Compounds

(mg PAH/kg soil after 100 mL of emulsion)

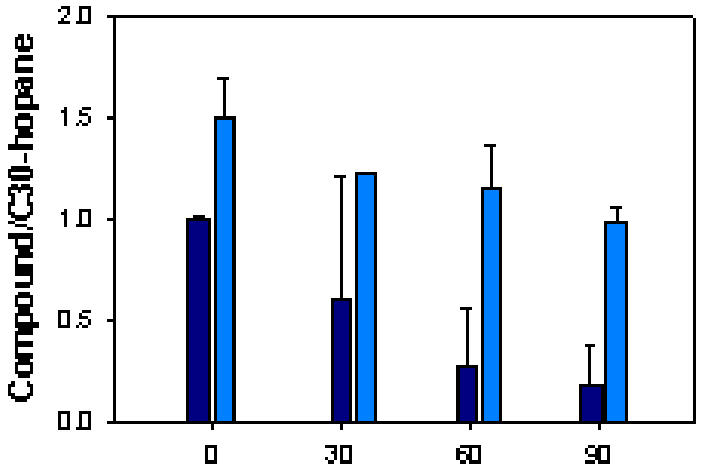
- Naphthalene (<0.1)
  - C1-NAP 0.51
  - C2-NAP <0.1
  - C3-NAP <0.1
  - C4-NAP <0.1
- **Phenanthrene (3.1)**
  - **C1-PHEN 15.2**
  - C2-PHEN <0.1
  - C3-PHEN <0.1
  - C4-PHEN 0.53
- Dibenzothiophene (<0.1)
  - C1-DBZ <0.1
  - **C2-DBZ 8.0**
  - **C3-DBZ 5.6**
- Chrysene (2.5)
  - C1-CHRYS 1.3
  - C2-CHRYS 1.2
  - C3-CHRYS 1.0

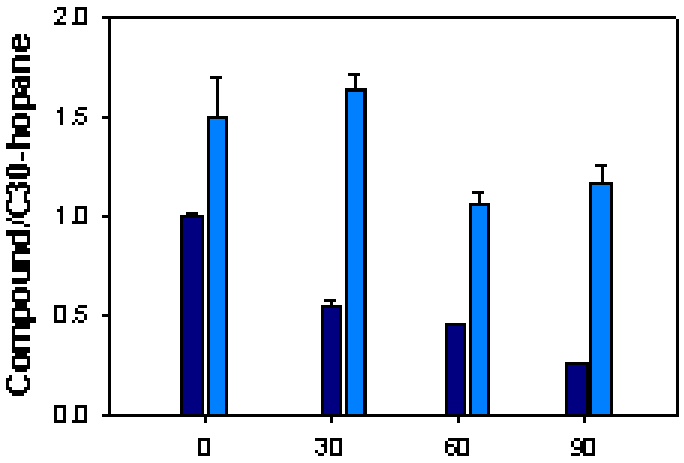
ΣPAHs = 50-70 mg/kg in 0-2 cm

SHORT-TERM

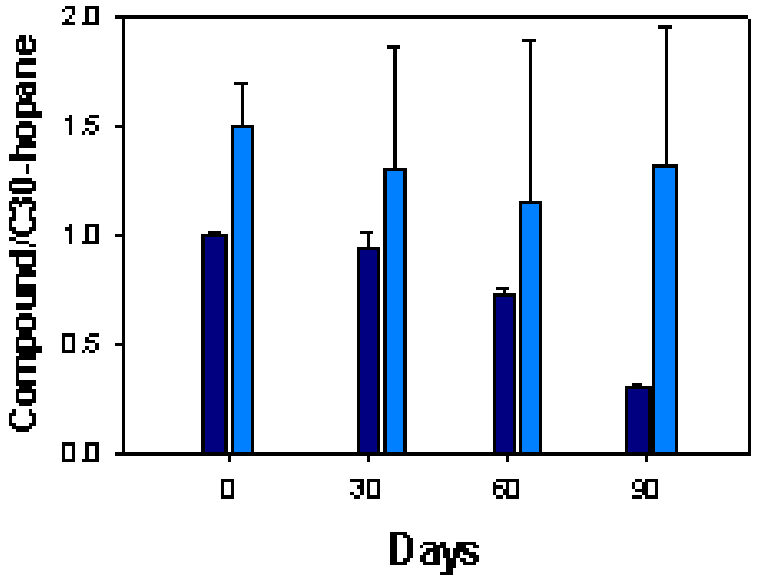
Phenanthrene and C1-phenanthrene

CTRL





N added

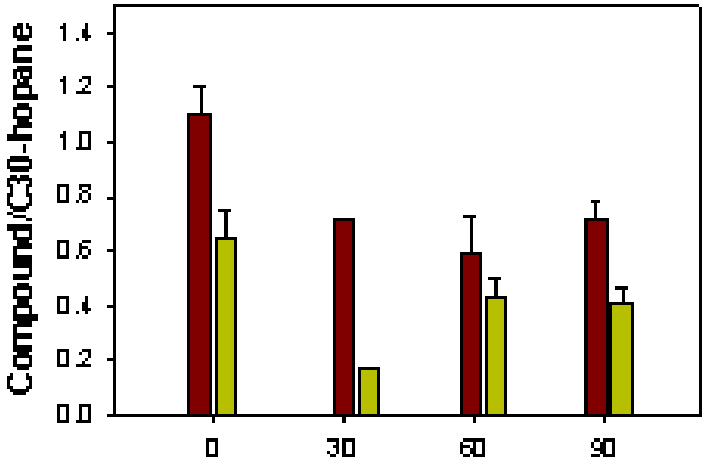


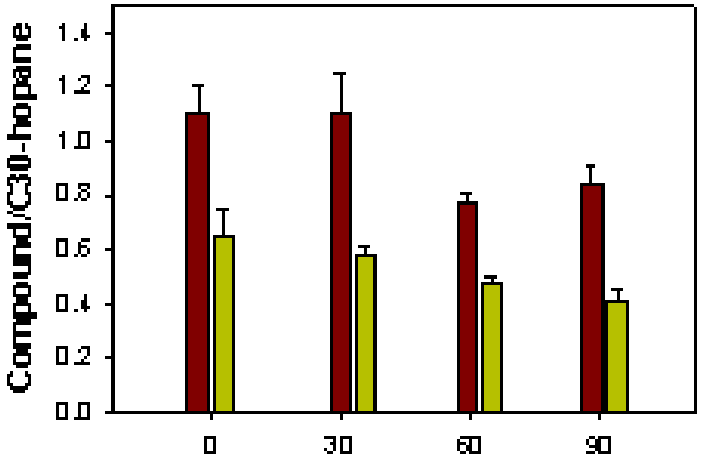
N+sulfate

SHORT-TERM

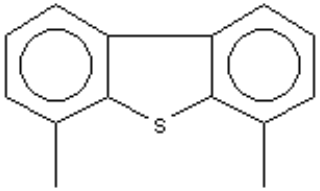
C2-dibenzothiophene C3-dibenzothiophene

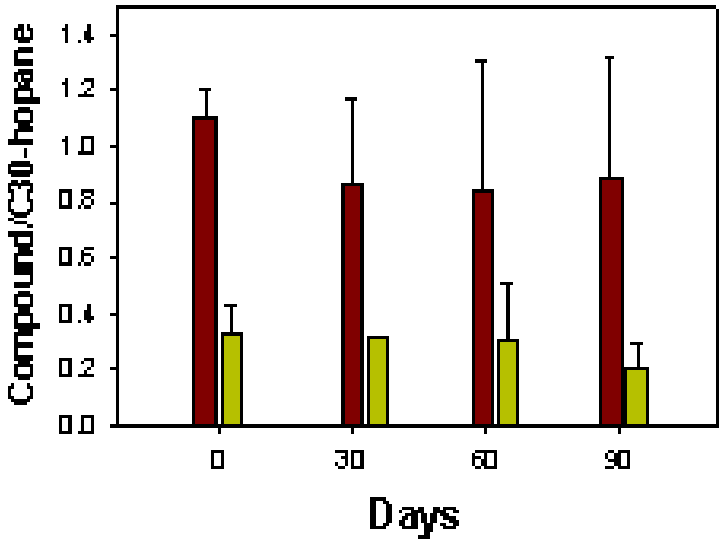
CTRL





N added

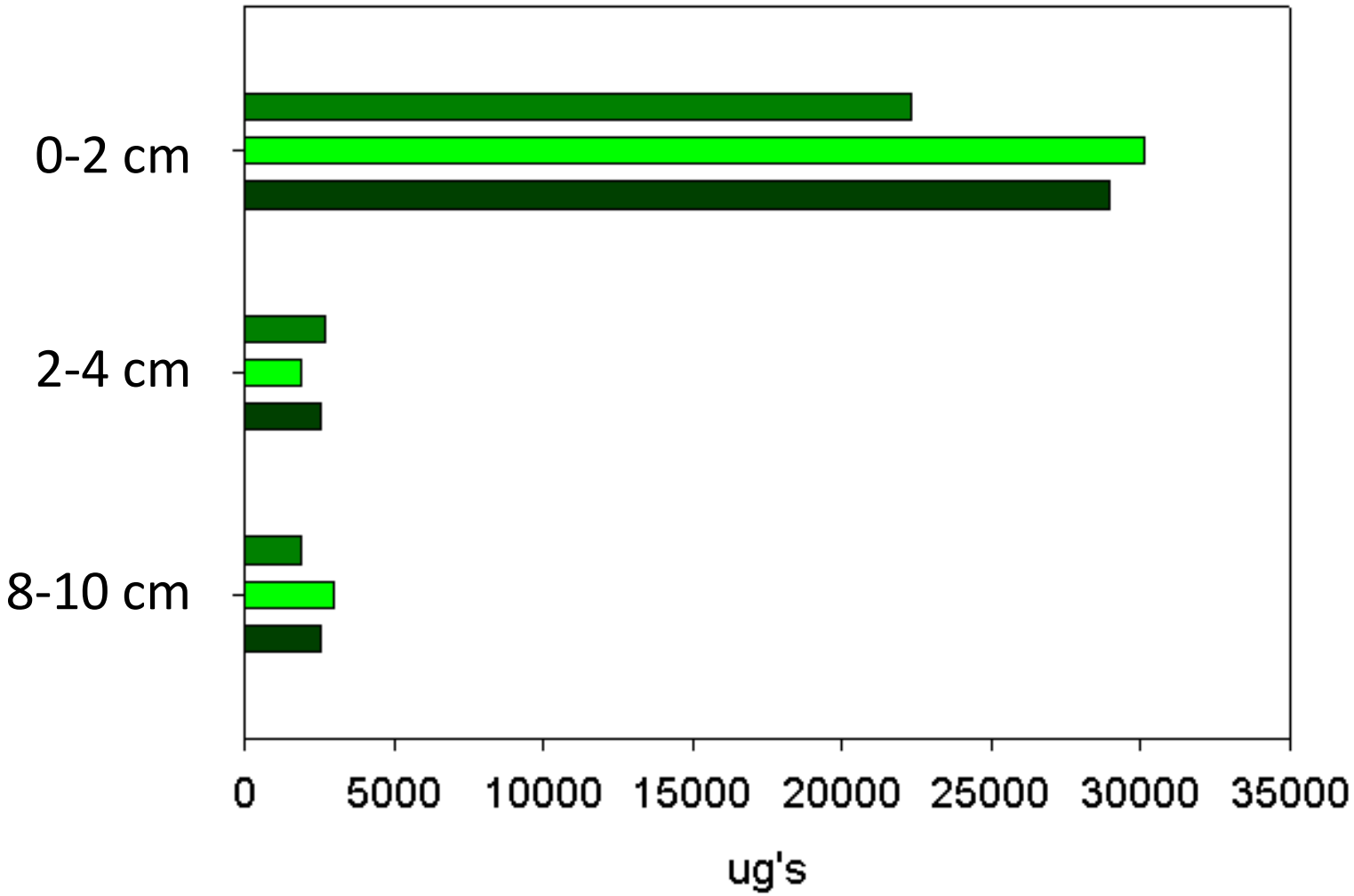




N+sulfate

SHORT-TERM

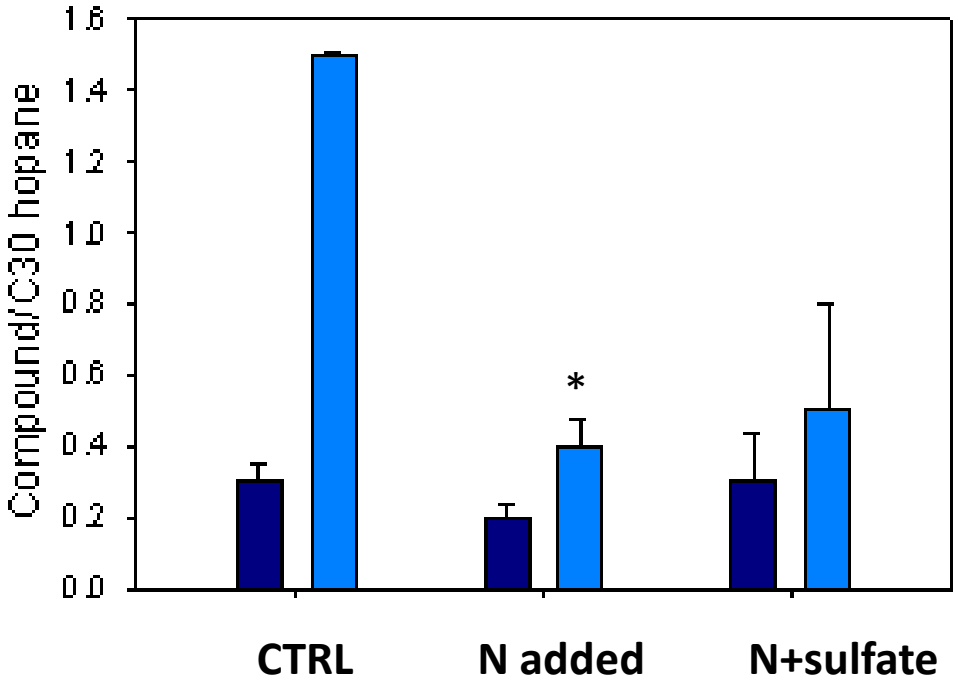
Distribution of ΣPAH's with depth




10
13
15

LONGER-TERM

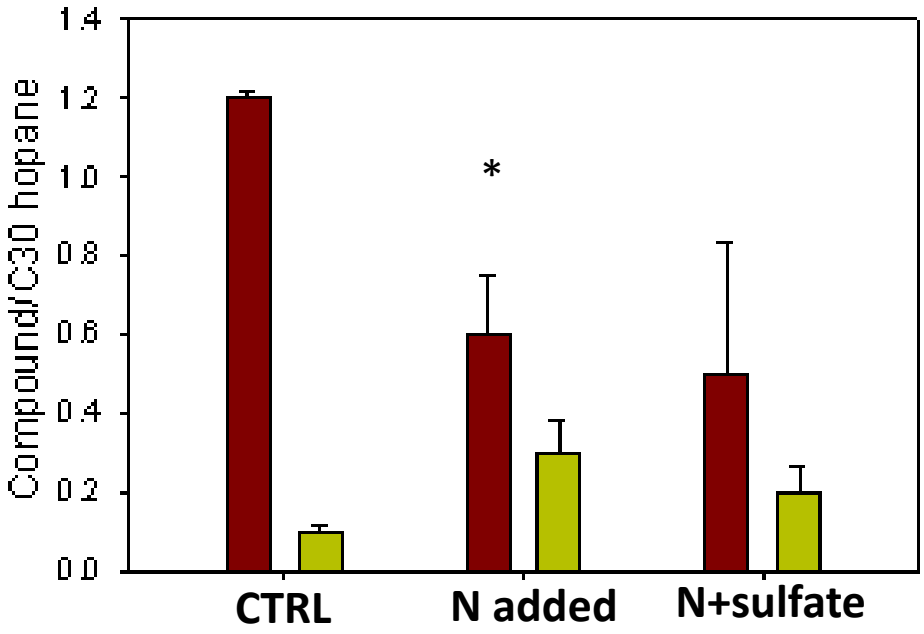
Phenanthrene and C1-phenanthrene



after 326 days

LONGER-TERM

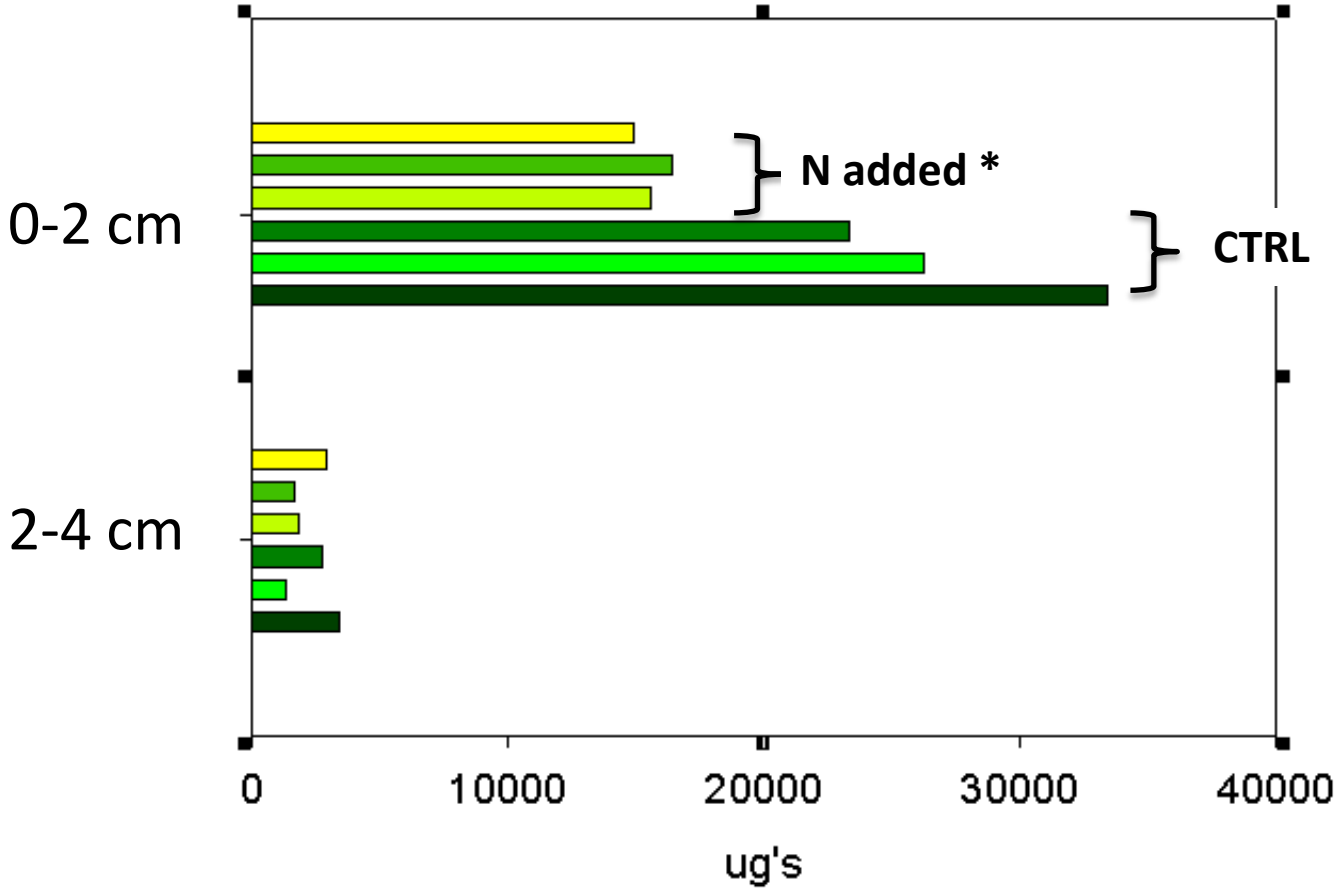
C2-dibenzothiophene C3-dibenzothiophene

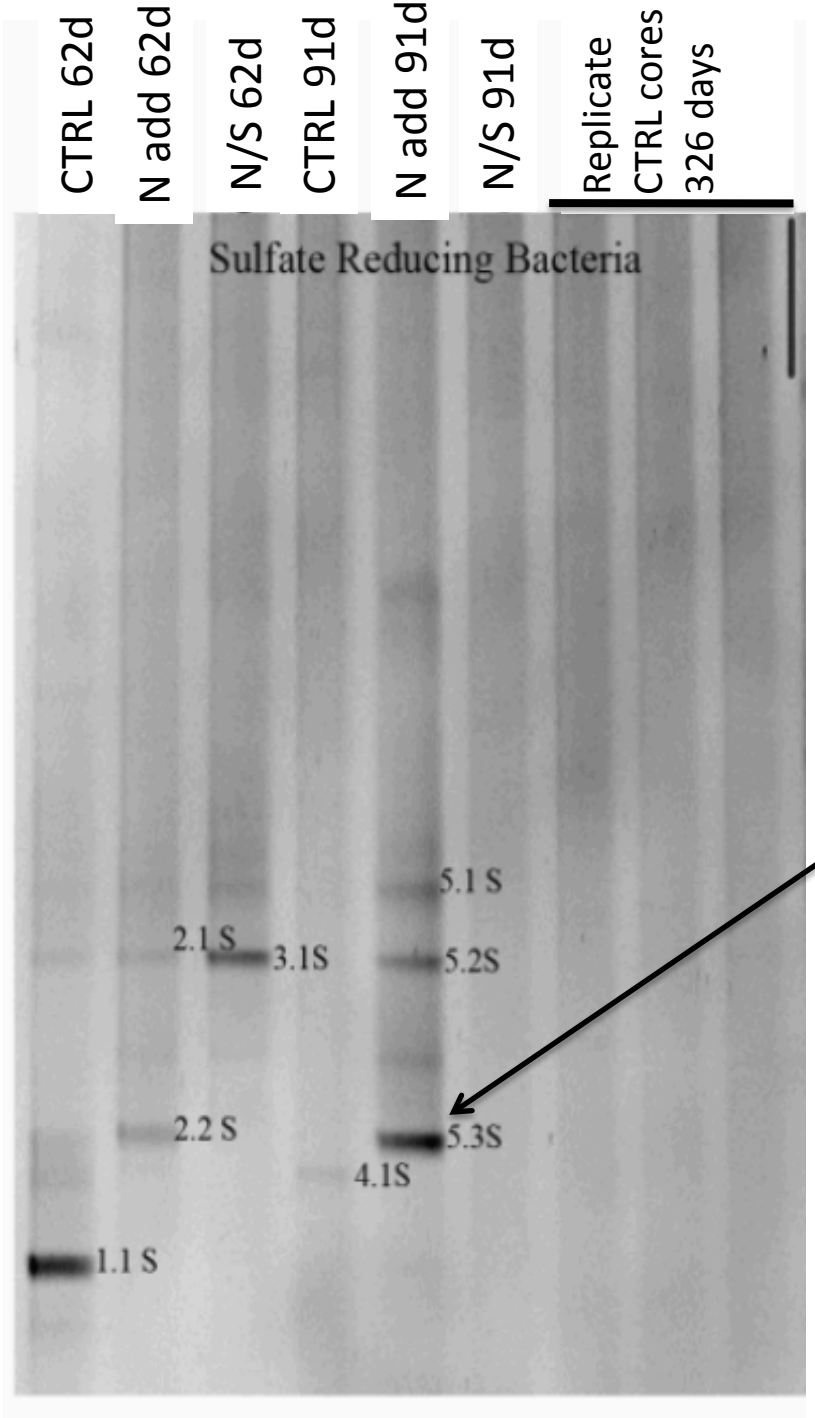


after 326 days

LONGER-TERM

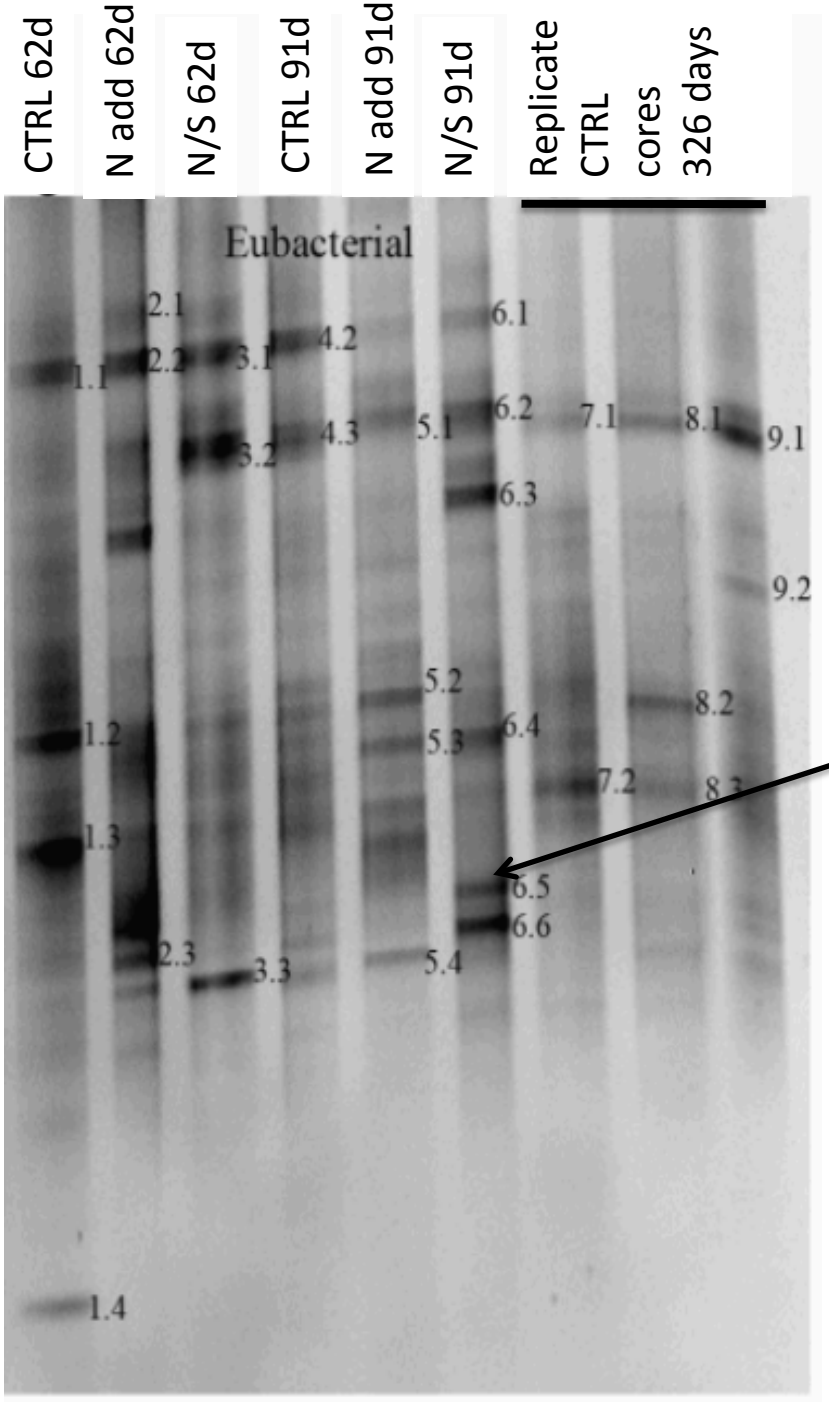
Distribution of ΣPAH's with depth





DGGE-SRB on 0-2 cm soil samples

All sequenced bands were identified as *Anaerolinea spp* (Chloriflexi)
Similarity indices ranging from 0.71-0.75

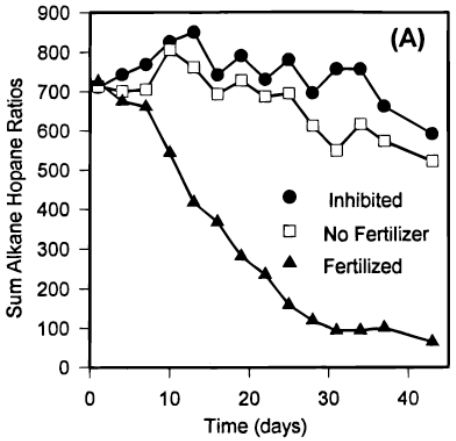


Eubacterial-DGGE on 0-2 cm soil samples

Diverse populations in all treatments

Bacteroidetes spp

Future directions



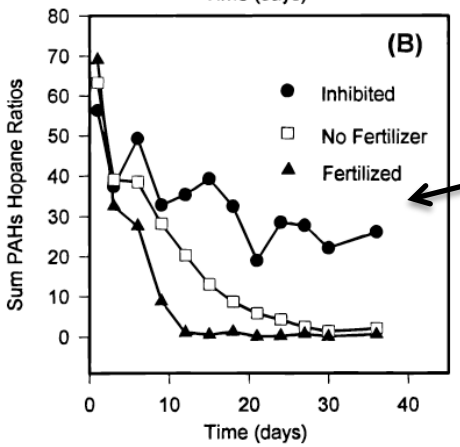


FIGURE 1. (A) Total (C15–C44) alkane hopane ratio versus time in aerated microcosms. (B) Total PAH (phenanthrene, C1–C2; naphthalene, C1–C2) hopane ratio versus time.

Resolve differences in PAH degradation studies in marshes