Microplastics, Benthic Microbes & Nutrient Cycling: Implications for our Bay?

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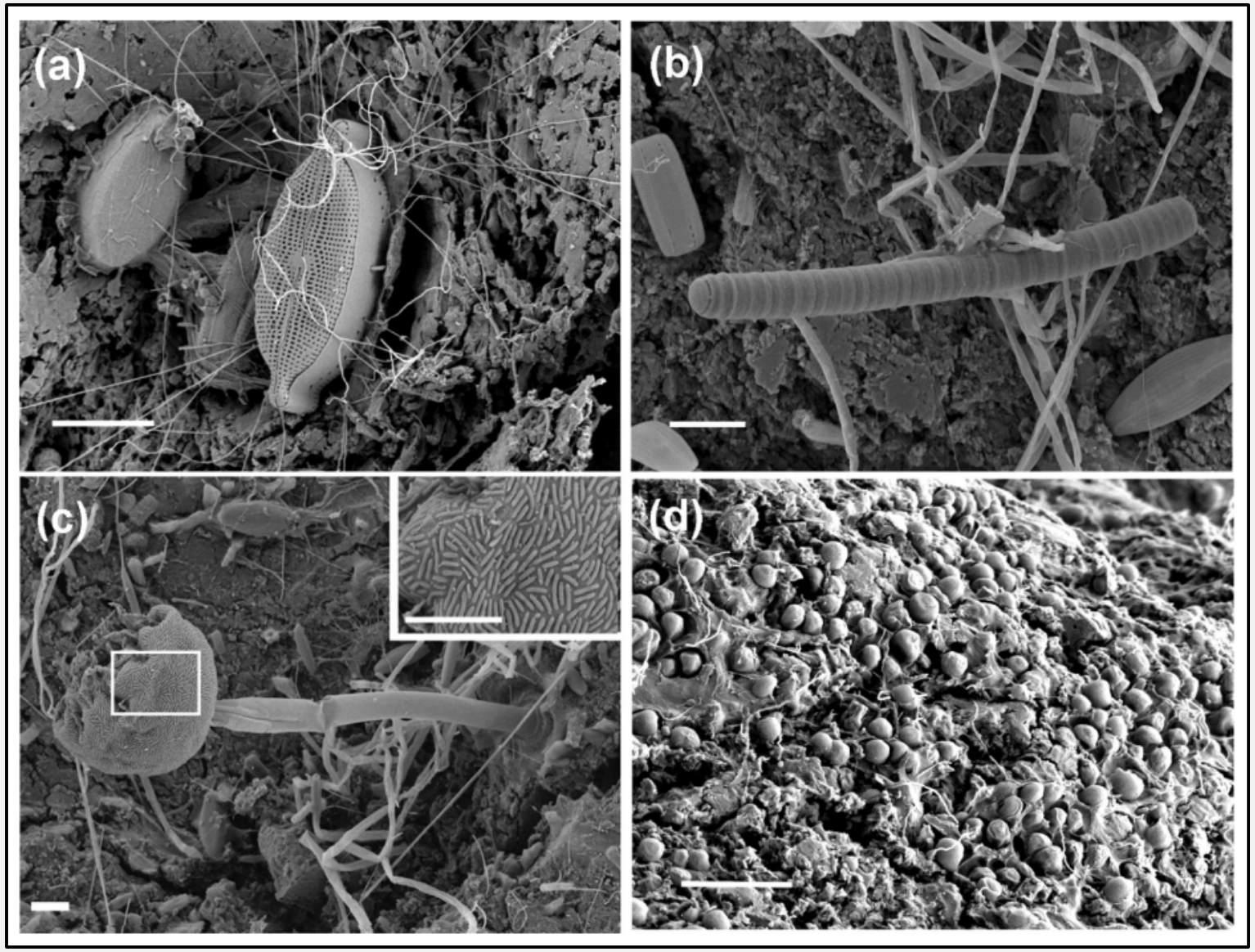
MICROPLASTICS & MICROBIAL COMMUNITIES



Zettler et al. 2013 *Env Sci & Tech*

Microplastics → microhabitat

- ✓ Diatoms
- ✓ Filamentous Cyanobacteria
- ✓ Predatory suctorian cilliates
- ✓ Ectosymbiotic Bacteria
- ✓ Microbial cells with surface pitting

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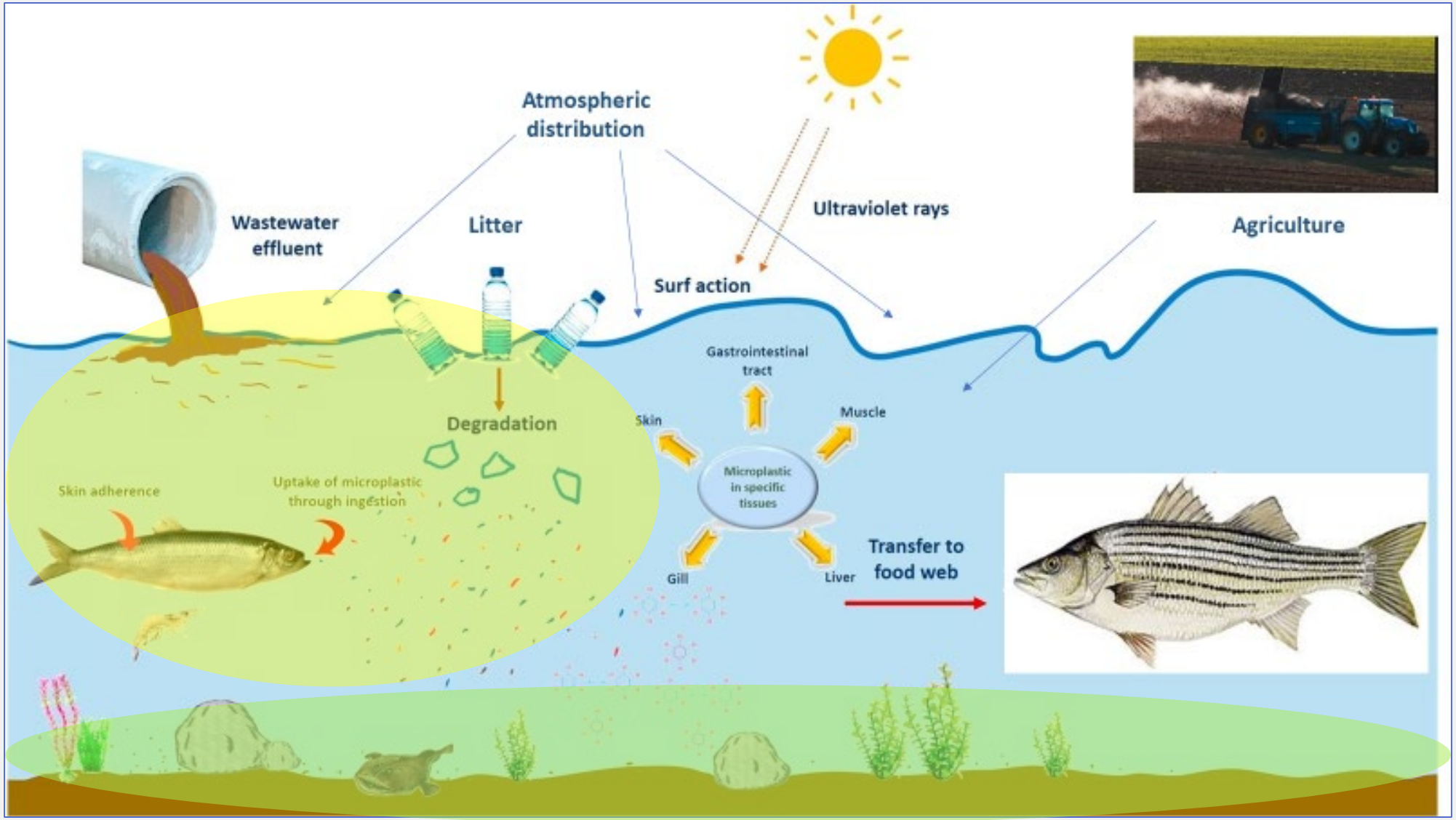
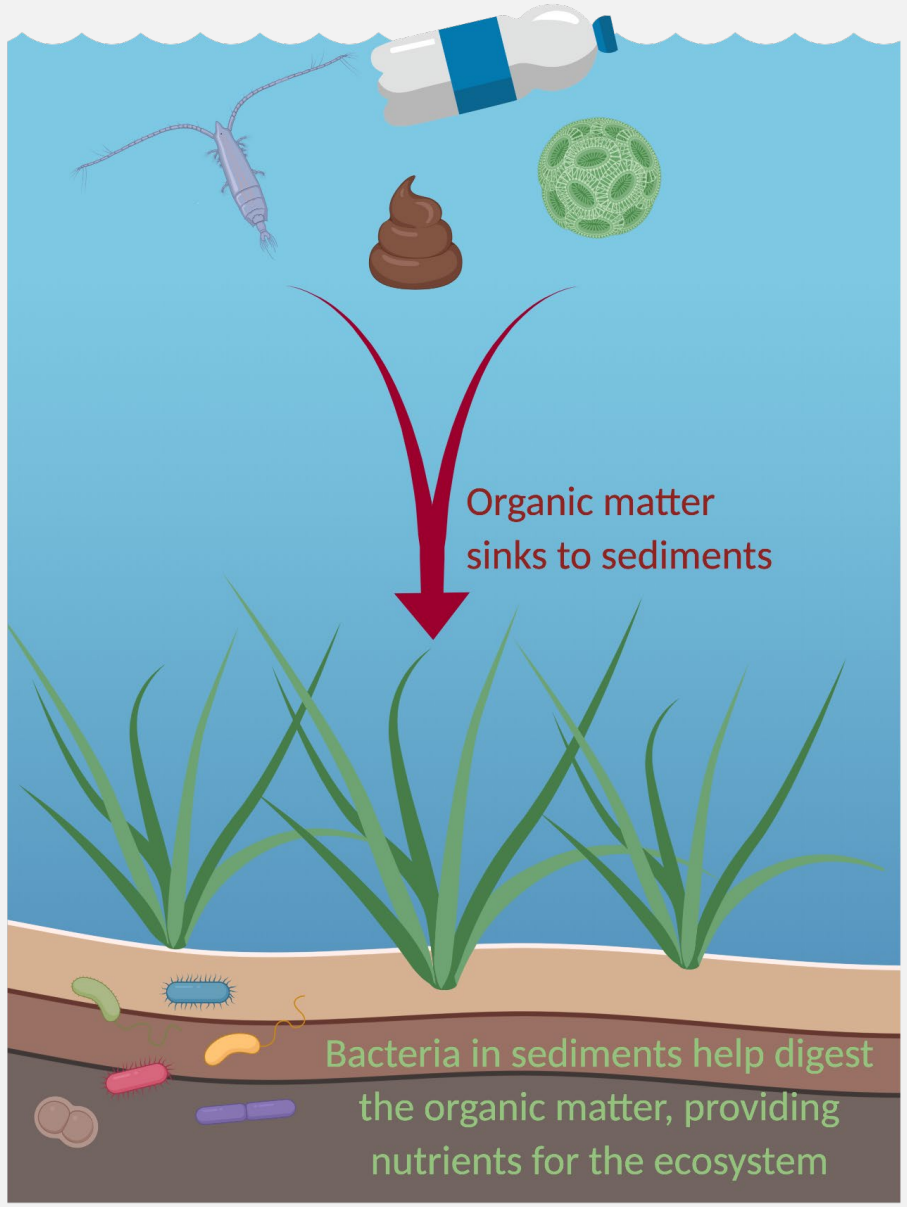


TetraTech, Phase 1 ERA Conceptual Model

BENTHIC MICROBIAL COMMUNITIES



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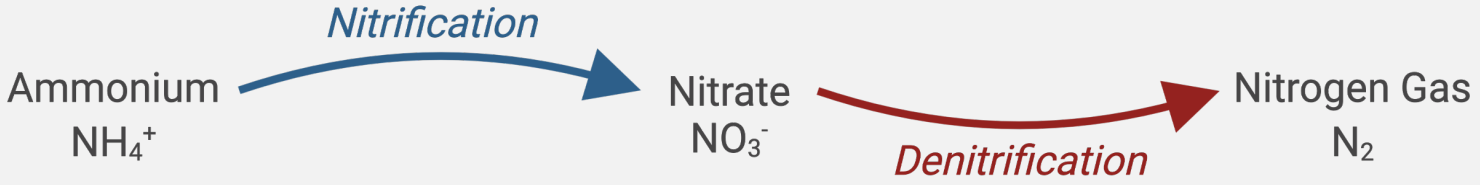
Coastal marshes

- Rapid accretion of sediment and organic matter
- Organic matter → critical nutrient cycling

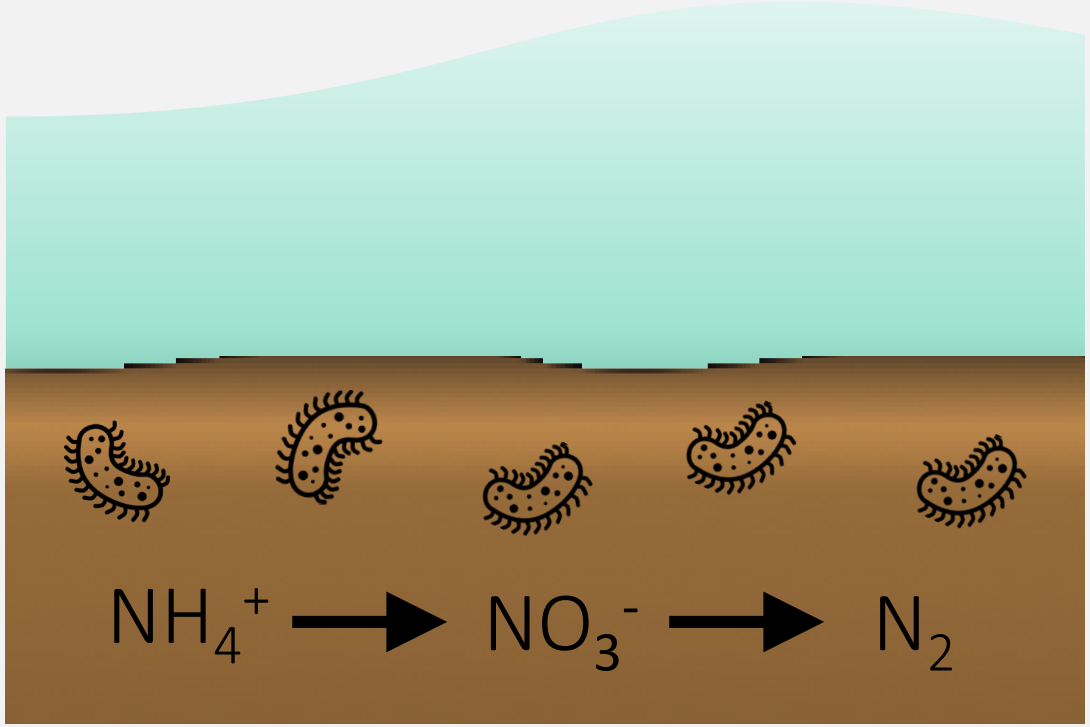
Nitrogen cycle

- Mediated by sedimentary microbes
- Increases nutrient availability from OM
- Prevents excess nutrients → eutrophication



MICROPLASTICS & BENTHIC MICROBIAL COMMUNITIES

Q: How do marsh sediment communities respond to microplastic burdens?



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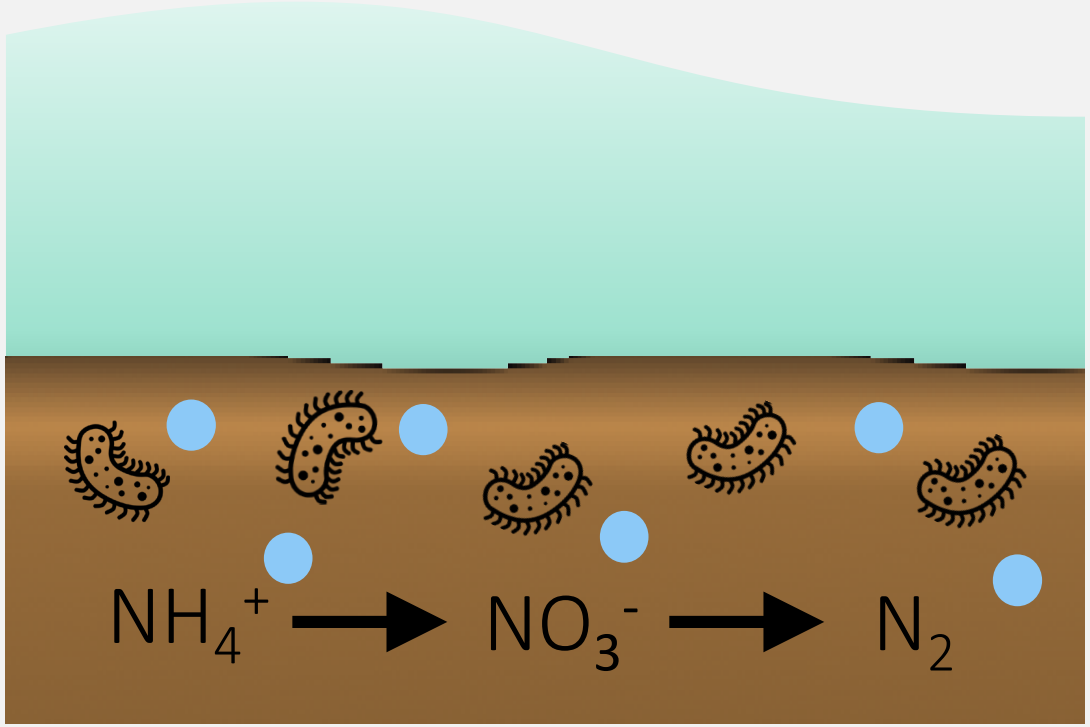

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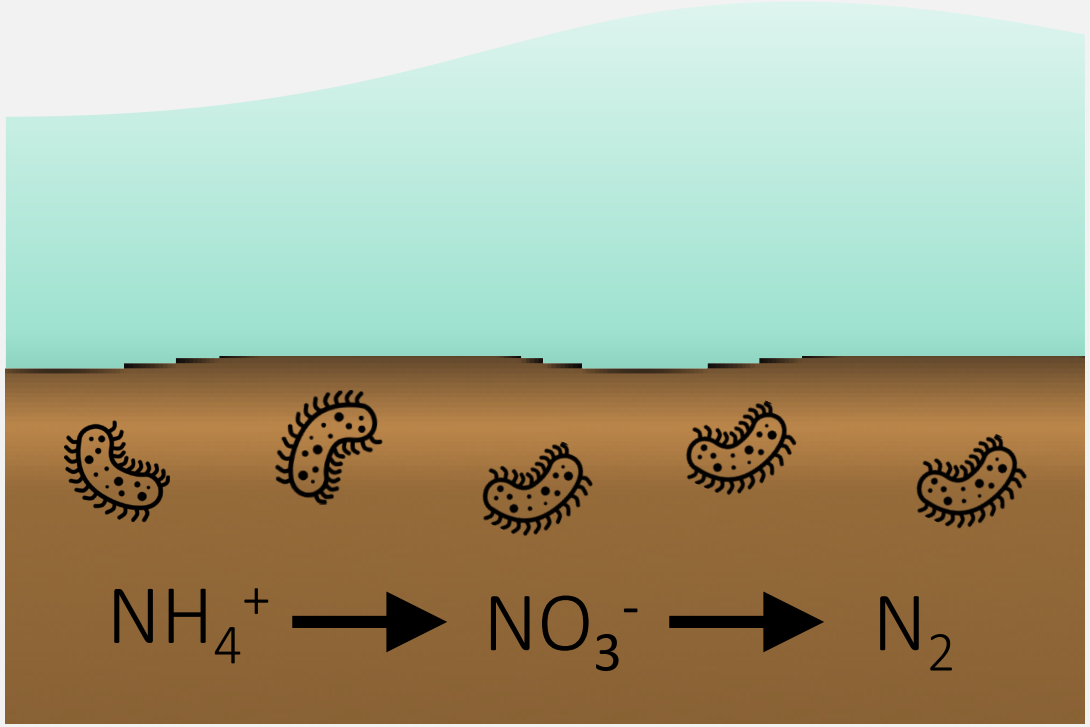

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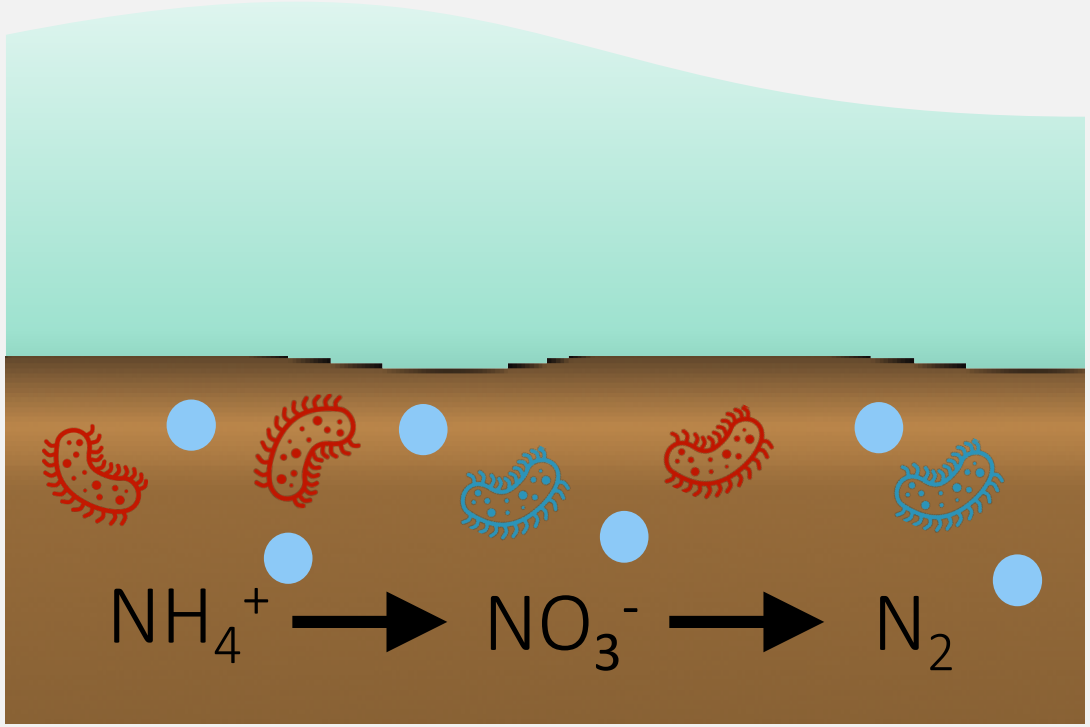

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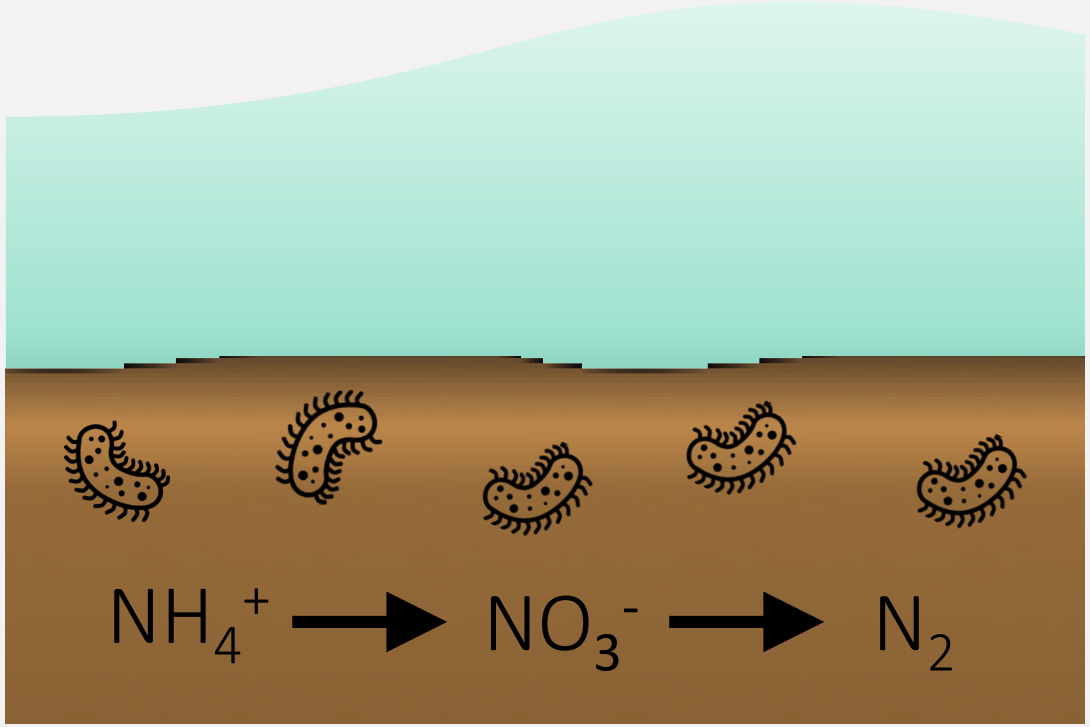
Microbial Community?

Nitrification and Denitrification?



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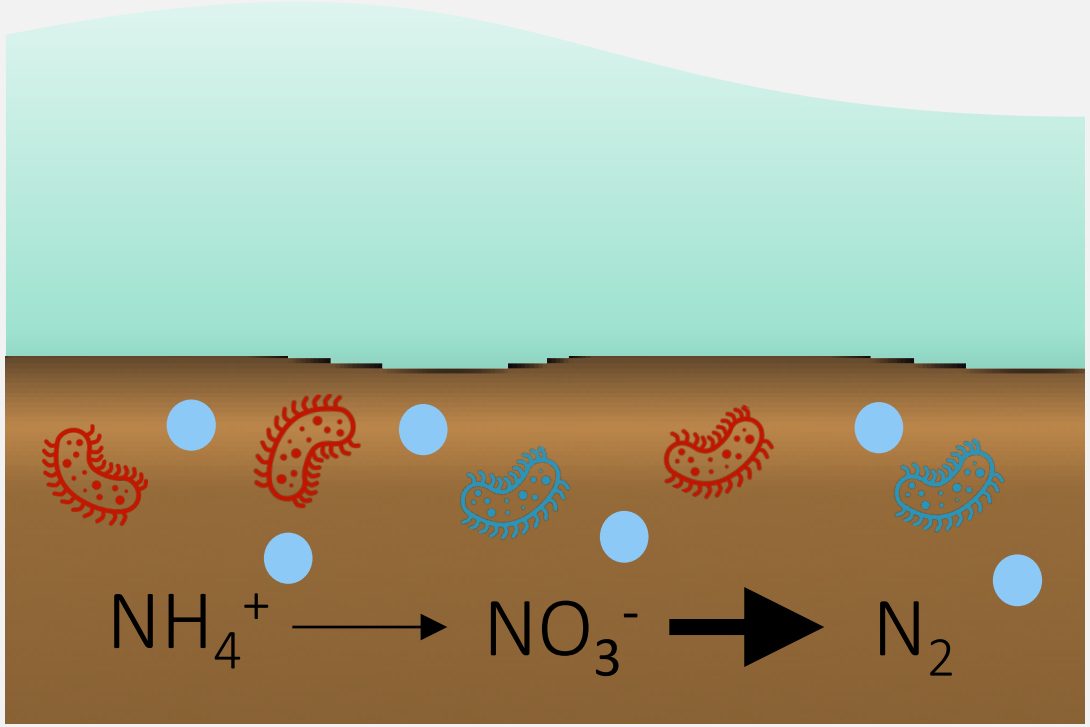
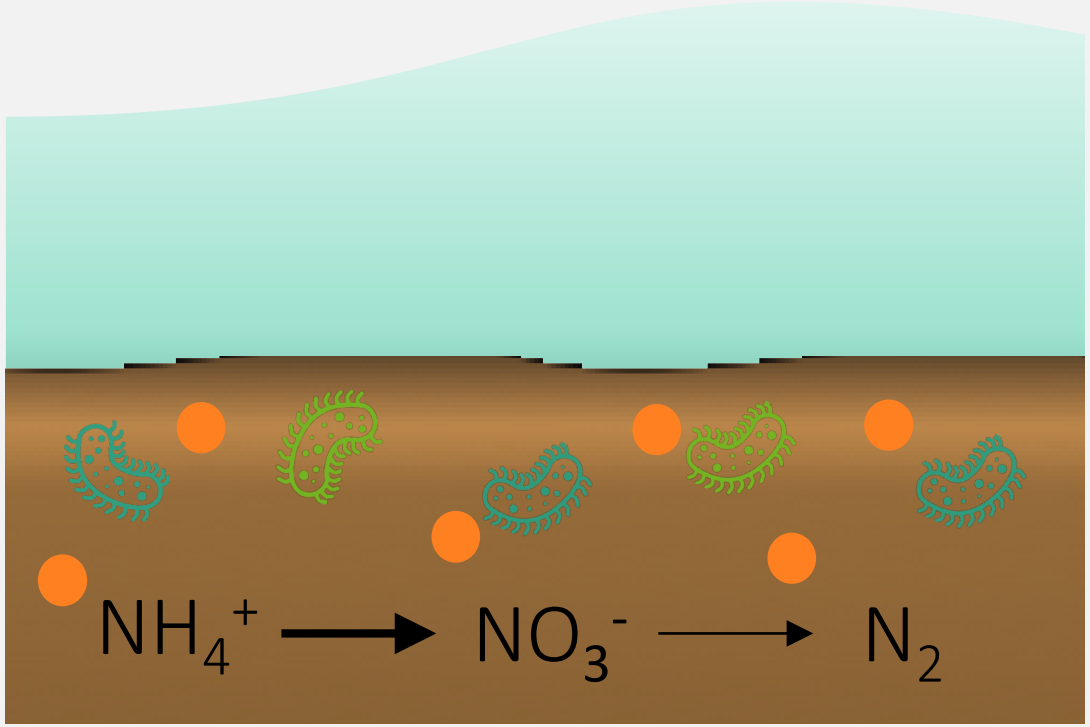


MICROPLASTICS & BENTHIC MICROBIAL COMMUNITIES

Q: How do marsh sediment communities respond to microplastic burdens?

Microbial Community?
Nitrification and Denitrification?
Different plastics, different effects?



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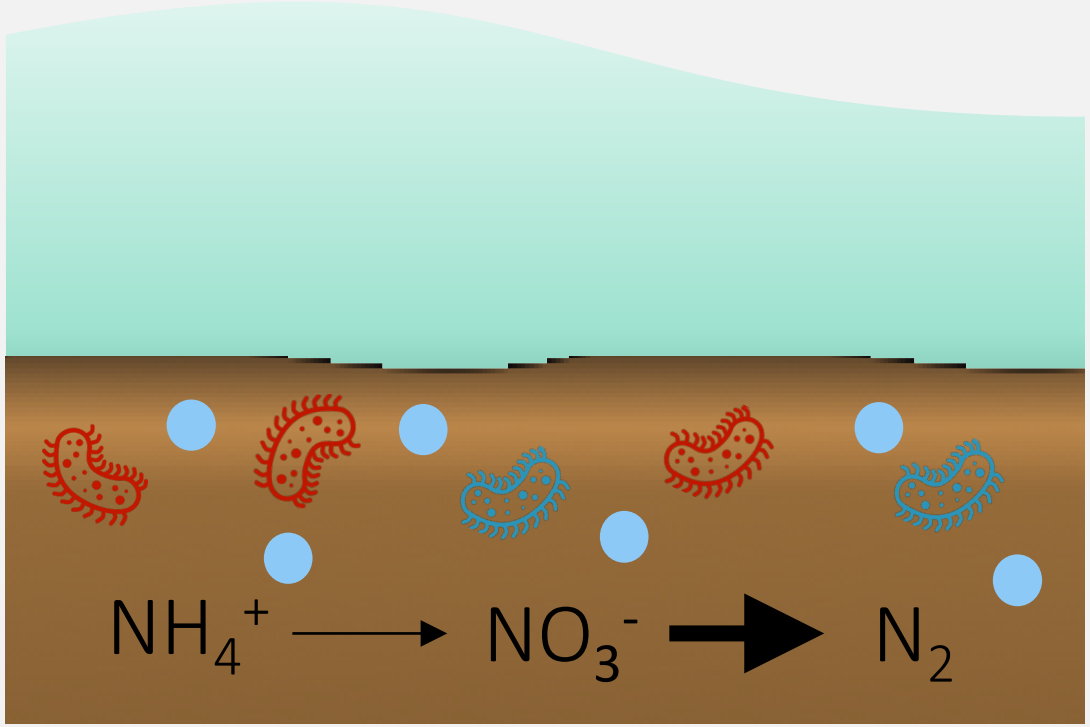


EXPERIMENTAL DESIGN

Test four diverse plastics:

POLYETHYLENE (PE)

- Petroleum-based
- $[C_2H_2\text{-}C_2H_2]_n$
- #1 most produced
- Many Applications

POLYVINYL CHLORIDE (PVC)

- Petroleum-based
- $[C_2H_2\text{-}C_2HCl]_n$
- High Density
- Industrial applications

POLYURETHANE FOAM (PUF)

- Petroleum-based
- $C_3H_8N_2O$
- Low Density
- High Additive conc.

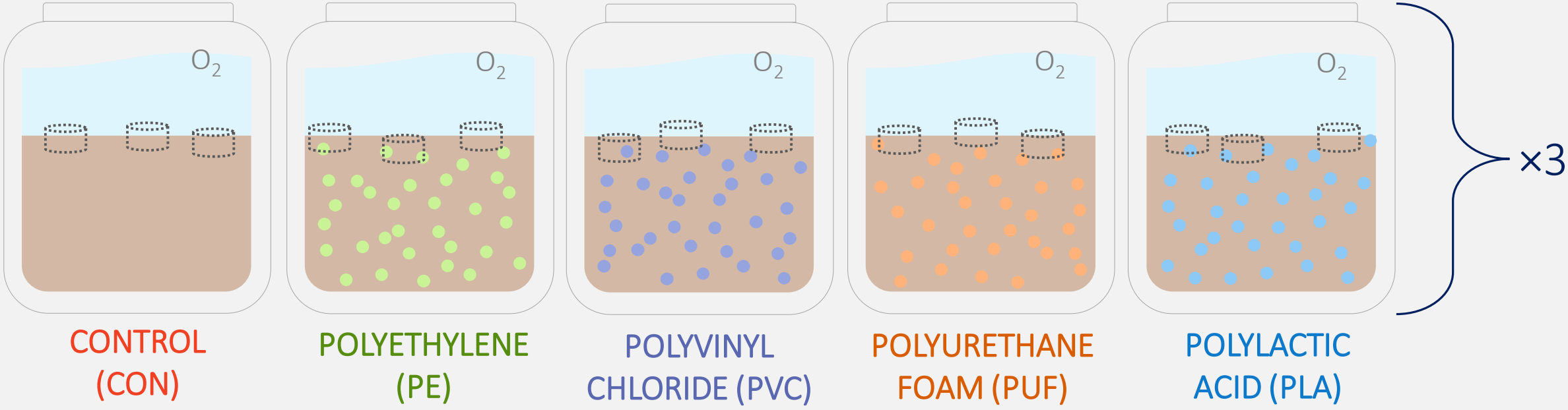
POLYLACTIC ACID (PLA)

- Bioplastic
- $[C_3H_4O_2]_n$
- Used in emerging applications

EXPERIMENTAL DESIGN

Microcosm incubation:

- Add microplastics (53-300 µm) to surface marsh sediment to 0.5% w/w
- Filtered marsh water (38 µm) added to each microcosm and aerated



Sampling: Triplicate sediment cores & water collected at 7 & 16 days

EXPERIMENTAL DESIGN

Microbial Composition

DNA Extraction from sediment collected at days 0, 7 & 16

16S rDNA Amplification

Sequencing – Illumina MiSeq

I. Microbial Community

II. Gene Abundance

Nitrogen Cycling

Water collected at days 0, 7 & 16

Nutrient Analysis

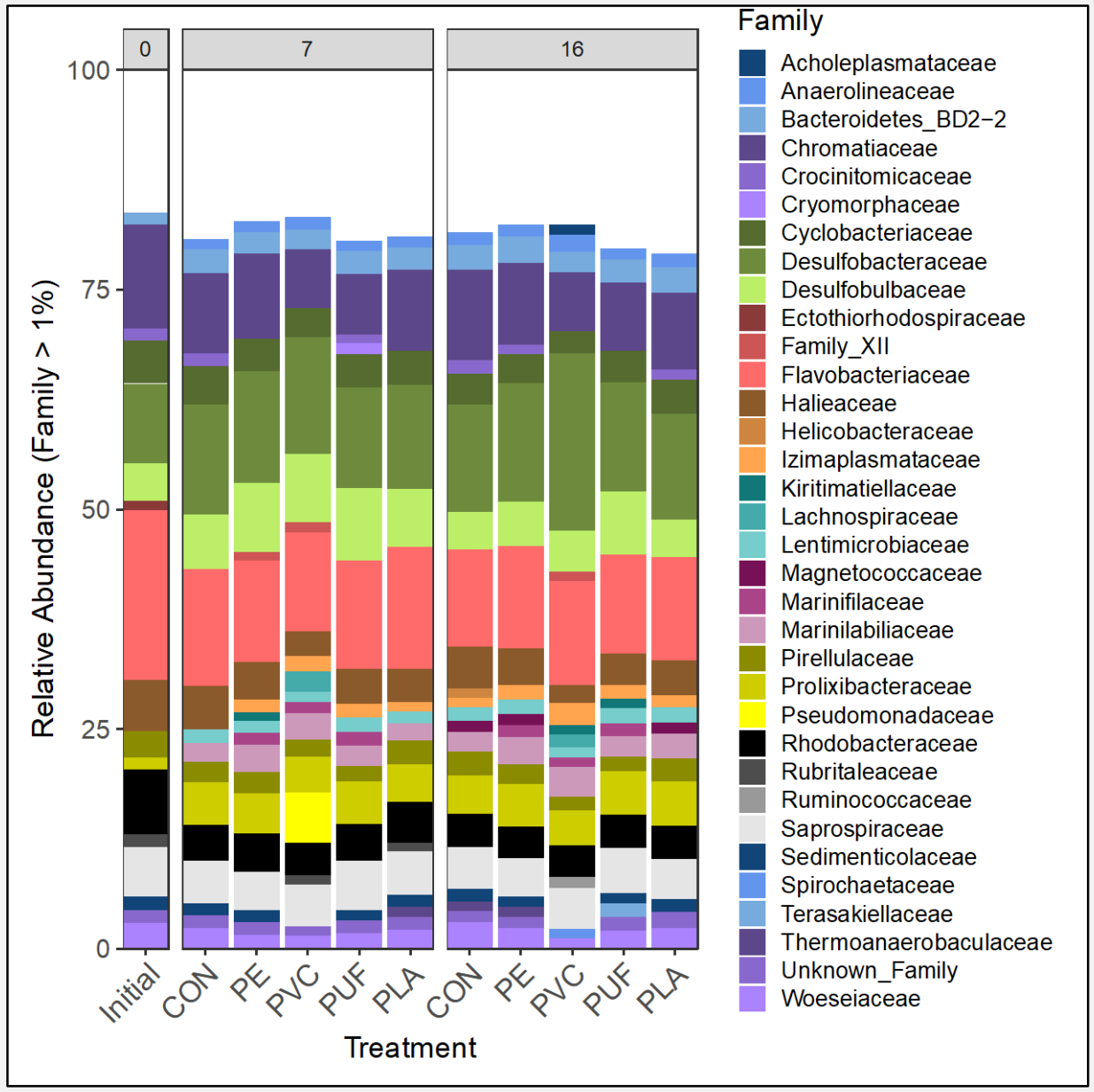
III. NO_3^-, NH_4^+ Concentration

Sediment collection post-incubation

Sediment Slurry with $^{15}NO_3^-$ tracer

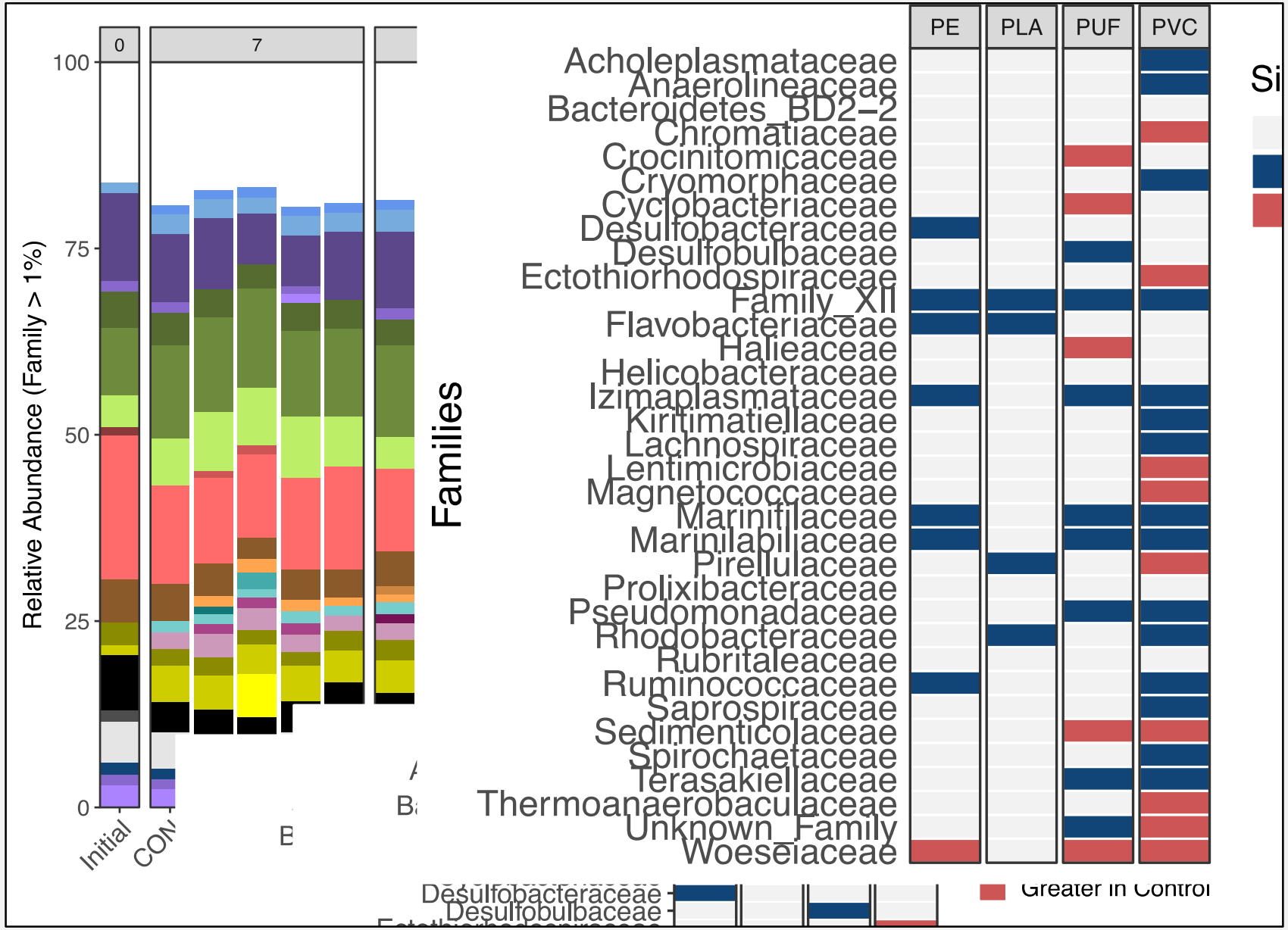
IV. Denitrification Activity Rate

RESULTS – MICROBIAL COMMUNITY



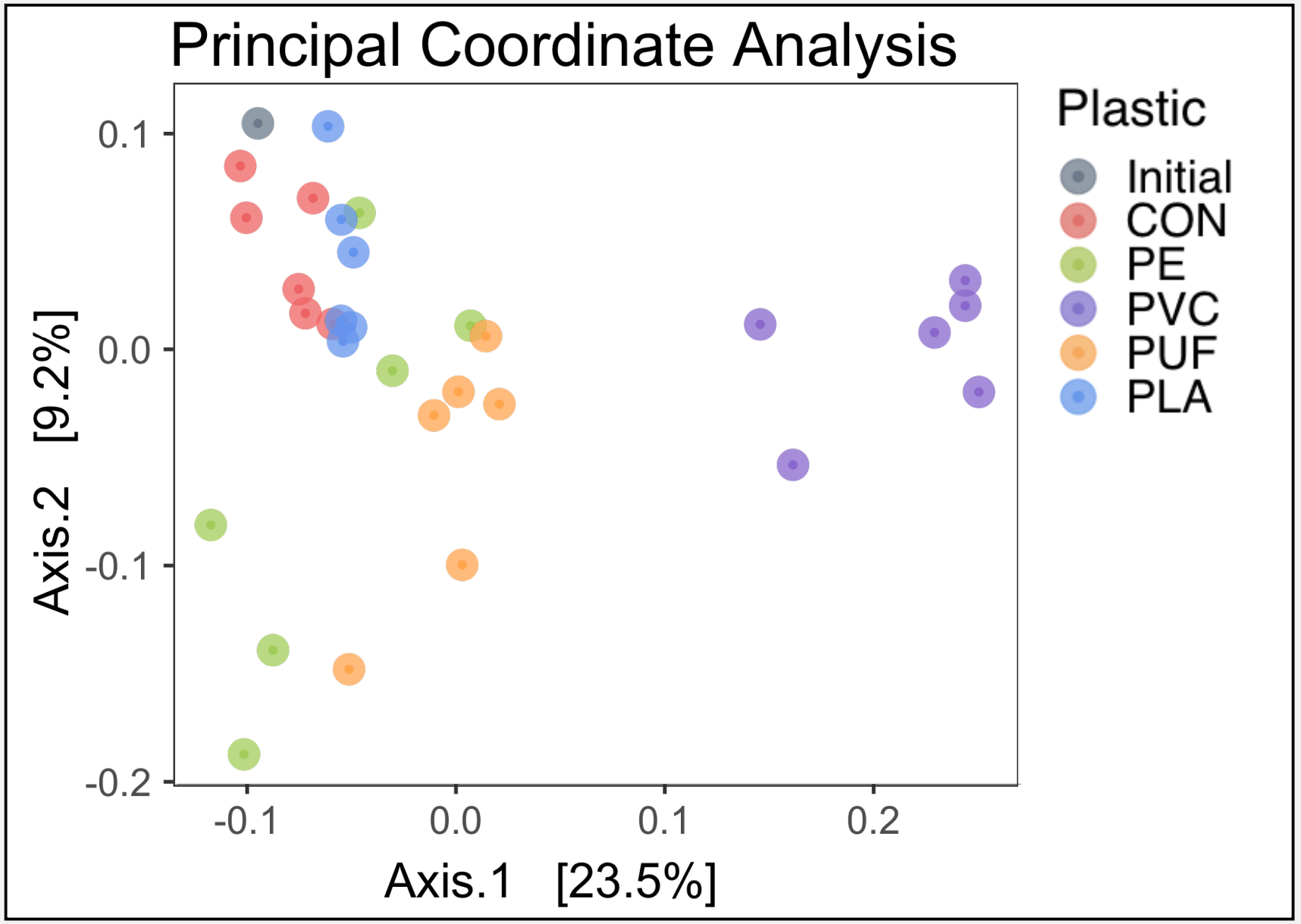
We know which taxa are present and how abundant, but are these different when plastics are added?

RESULTS – MICROBIAL COMMUNITY



Significant differences in abundances for certain families can be observed between plastic treatments and the control.

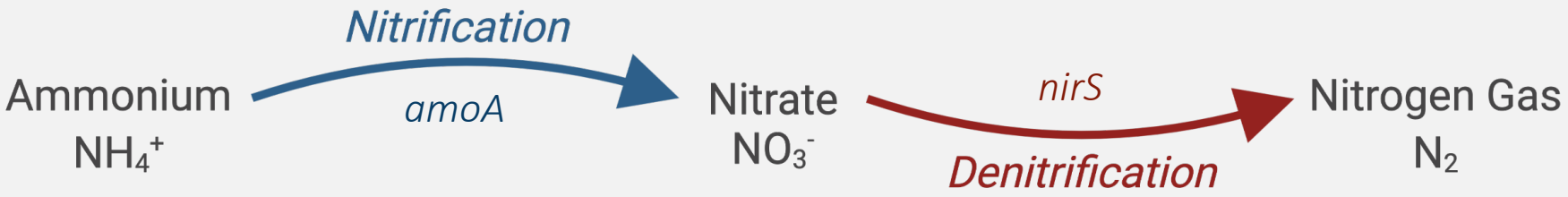
RESULTS – MICROBIAL COMMUNITY



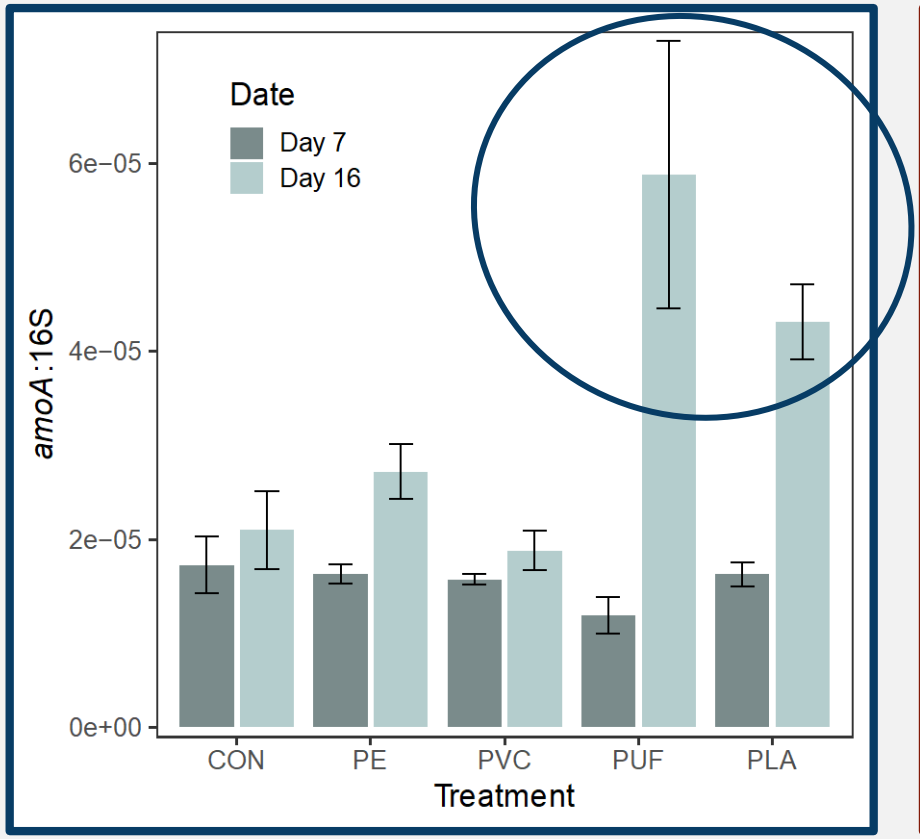
Sediment bacterial community is different with addition of plastics, and differs between plastic treatments.

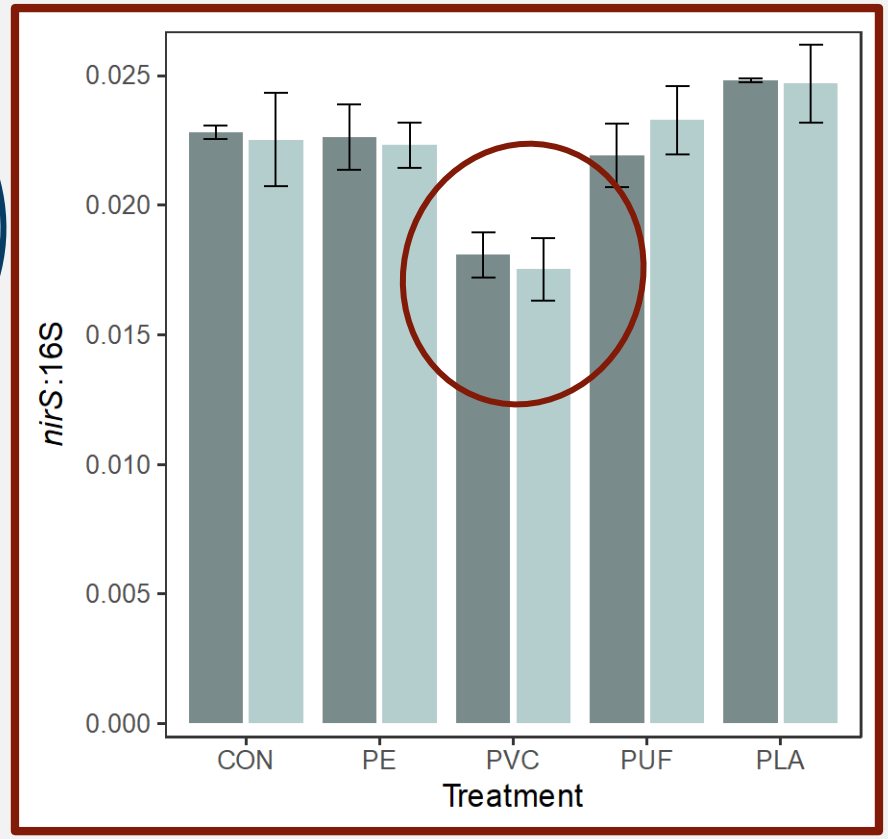
Do these structural changes → functional changes?

RESULTS – NITRIFIER/DENITRIFIER GENE ABUNDANCE



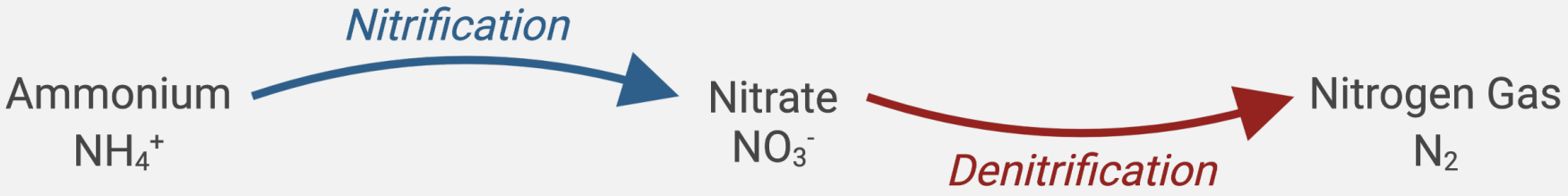
↑ *nitrifier abundance in PUF/PLA treatments*



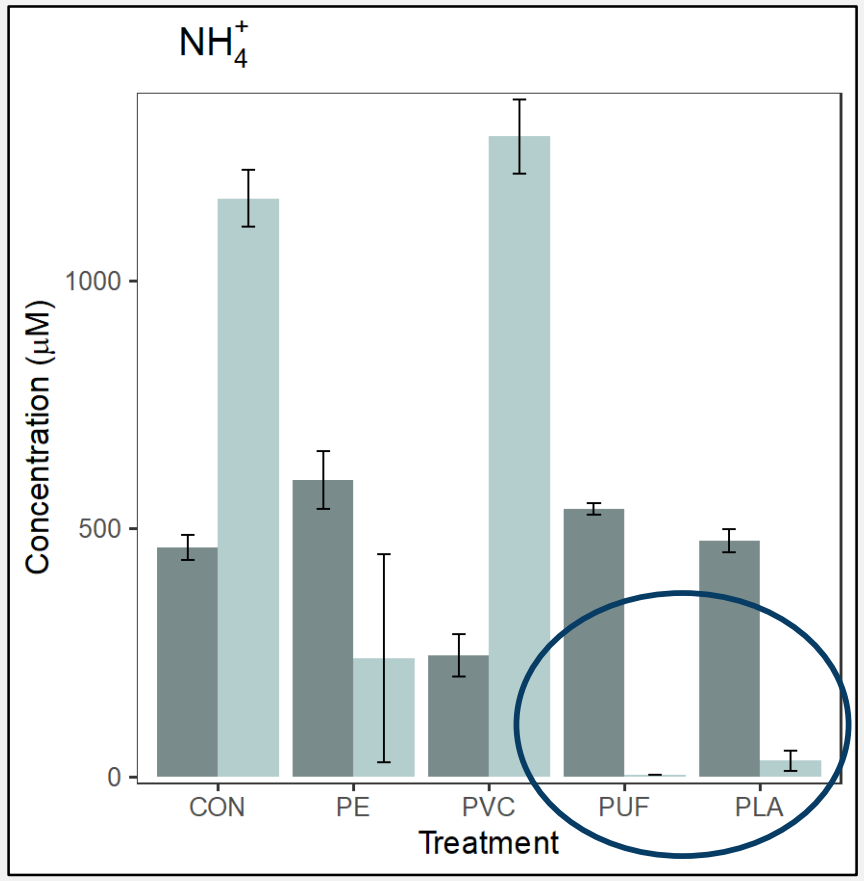


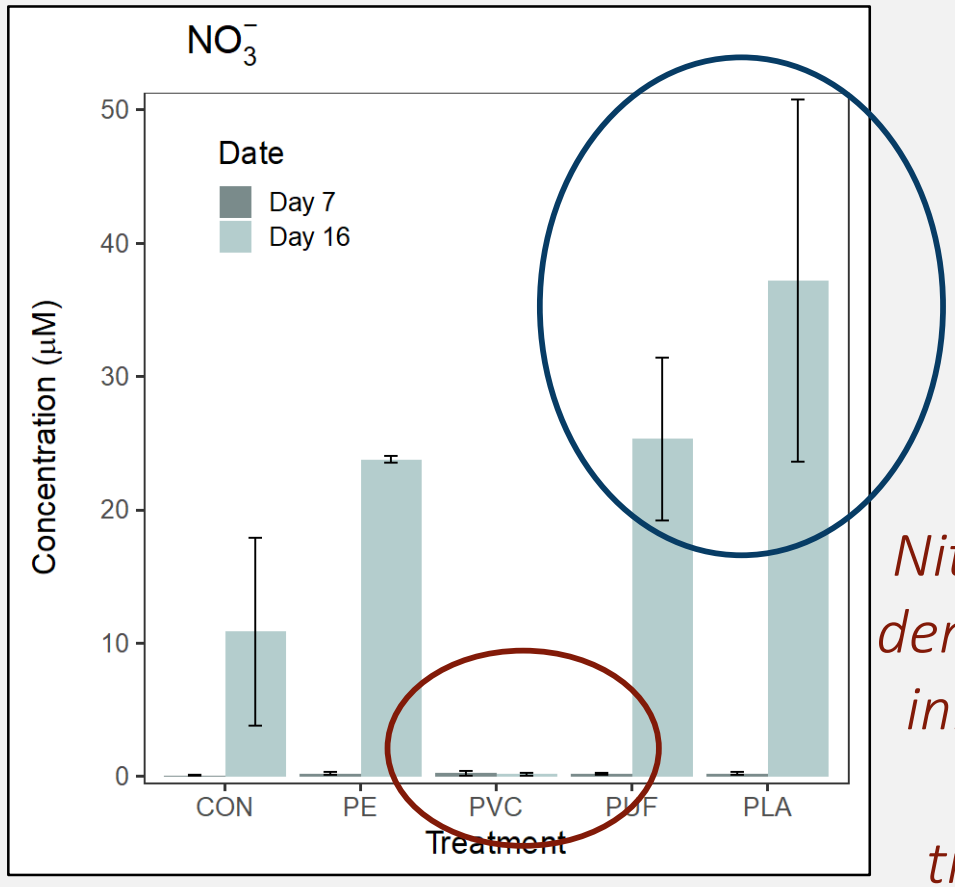
↓ *denitrifier abundance in PVC treatment*

RESULTS – DISSOLVED INOGANIC NITROGEN



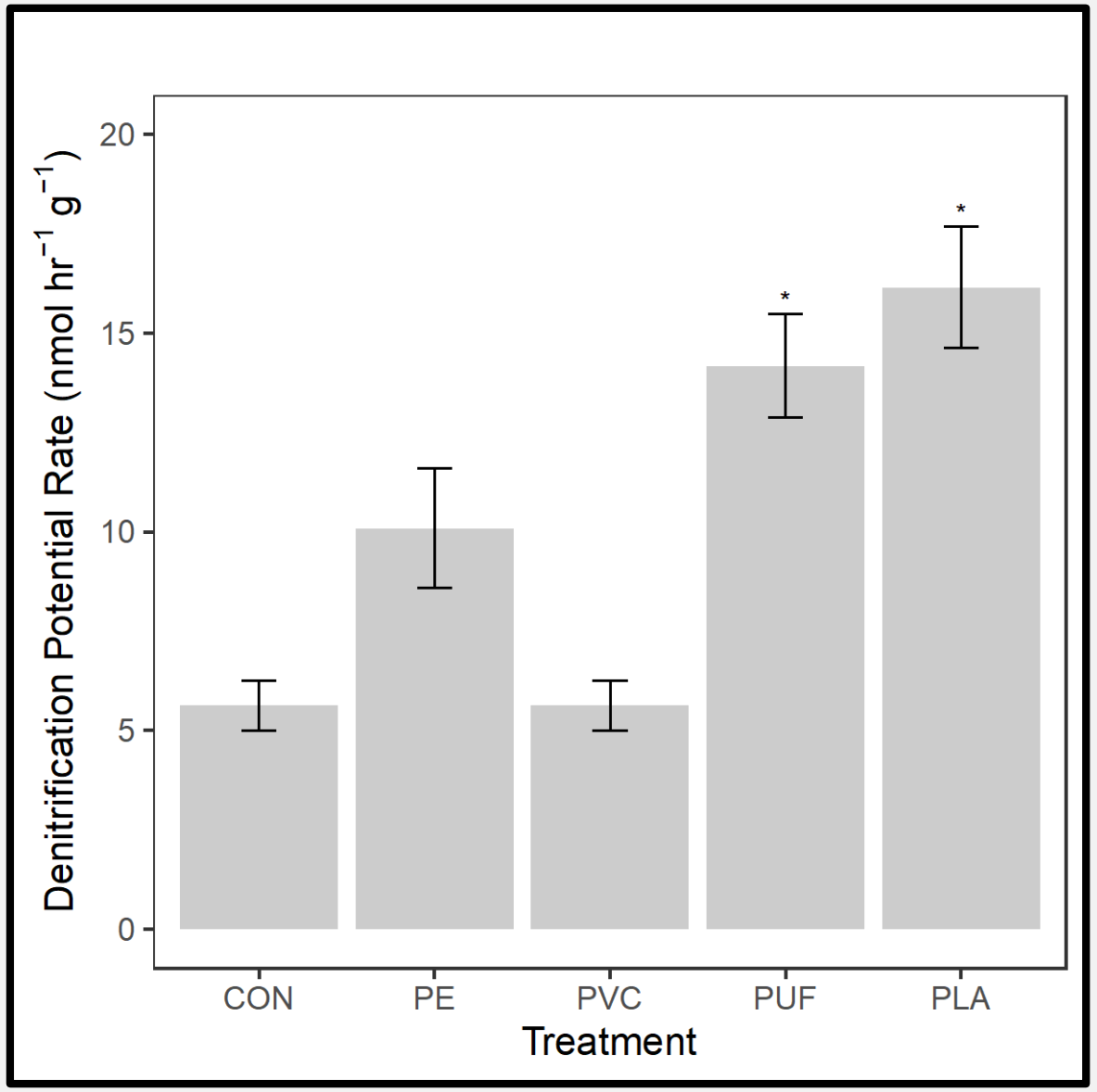
↑ *nitrification in PUF/PLA treatments*





Nitrification/ denitrification inhibition in PVC treatment

RESULTS – DENITRIFICATAION RATE POTENTIAL



Sediment slurry experiment:

- Measures the potential maximum rate of denitrification using a $^{15}NO_3^-$ tracer

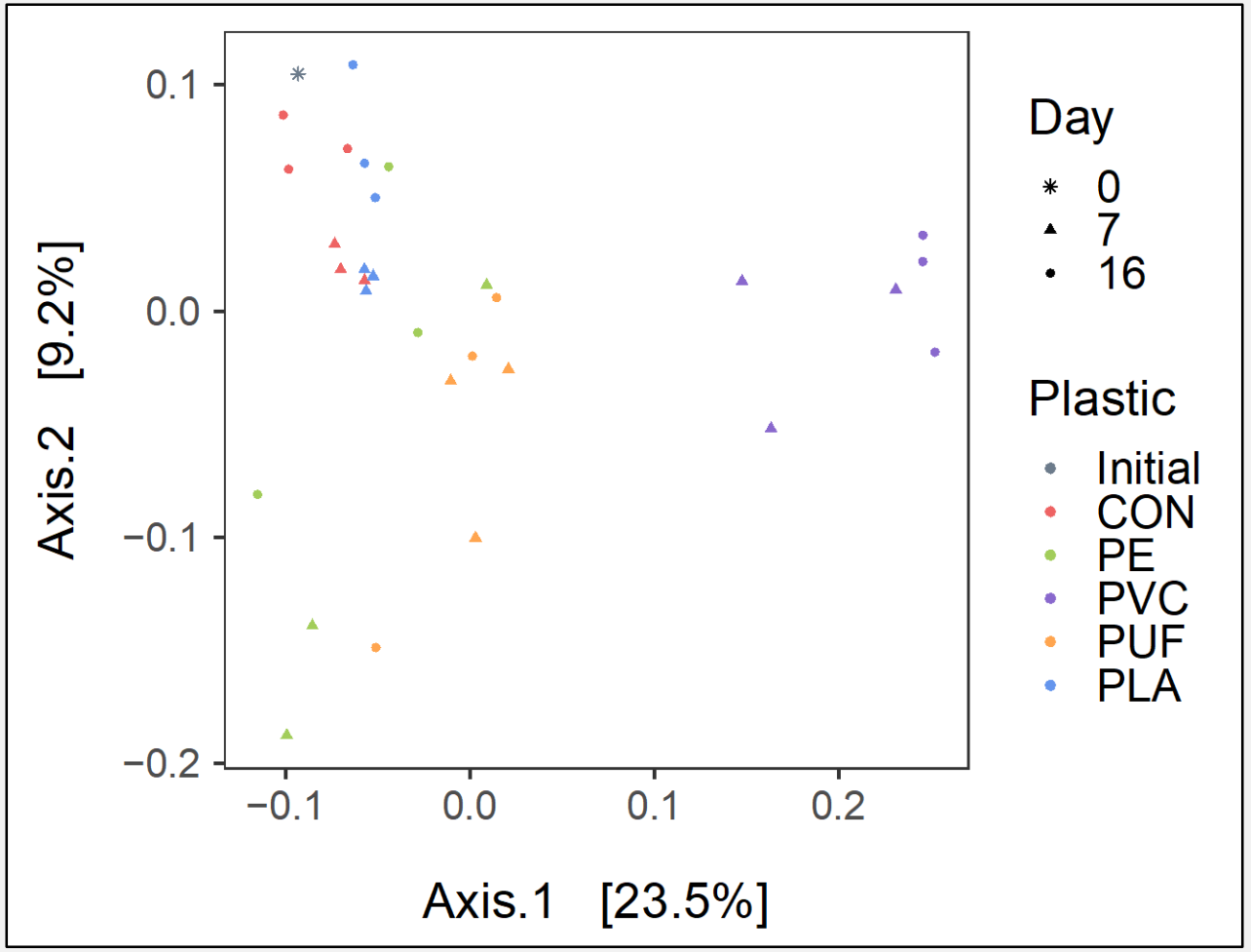
✓ Denitrification is significantly higher in PUF/PLA treatments

✓ Denitrification is inhibited in PVC treatment

✓ Denitrification is also low in unamended control → carbon limitation?

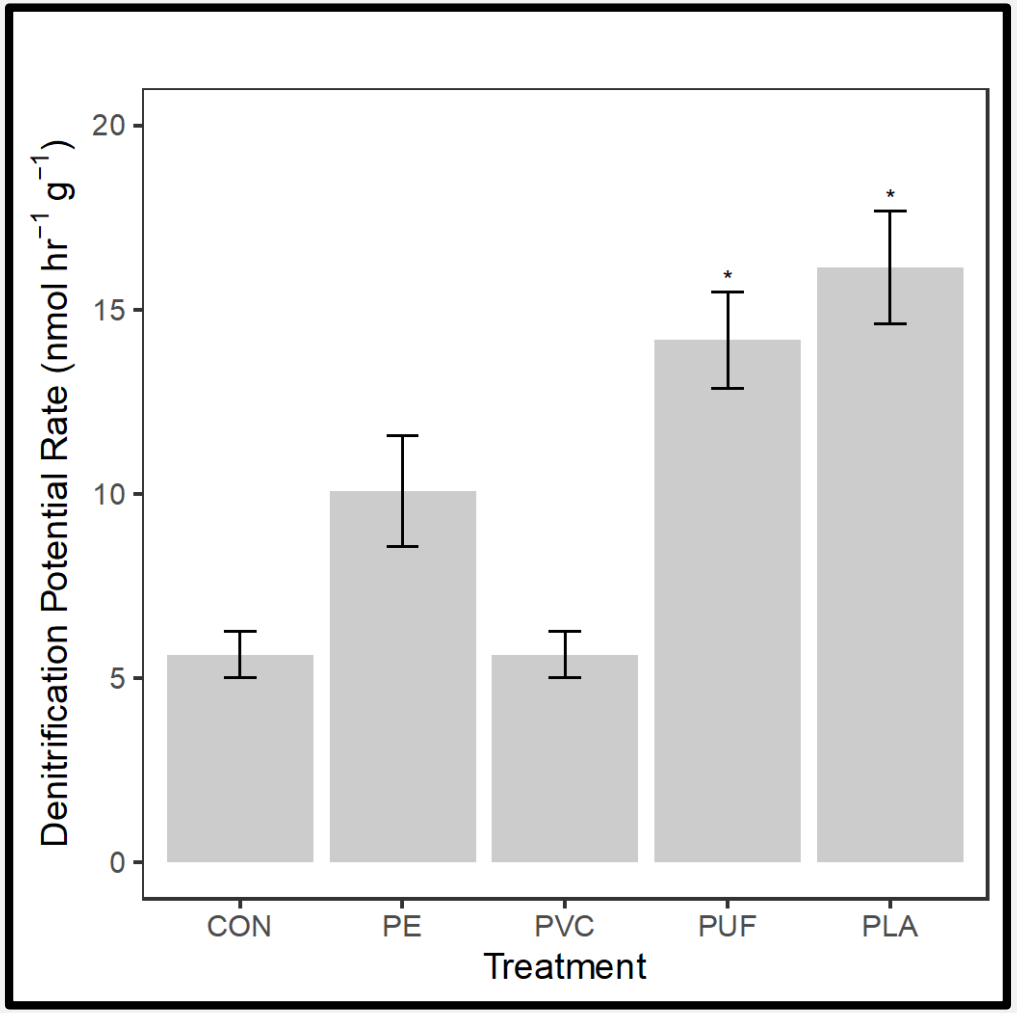
CONCLUSIONS

Sediment microplastic pollution *can* alter benthic microbial community structure!



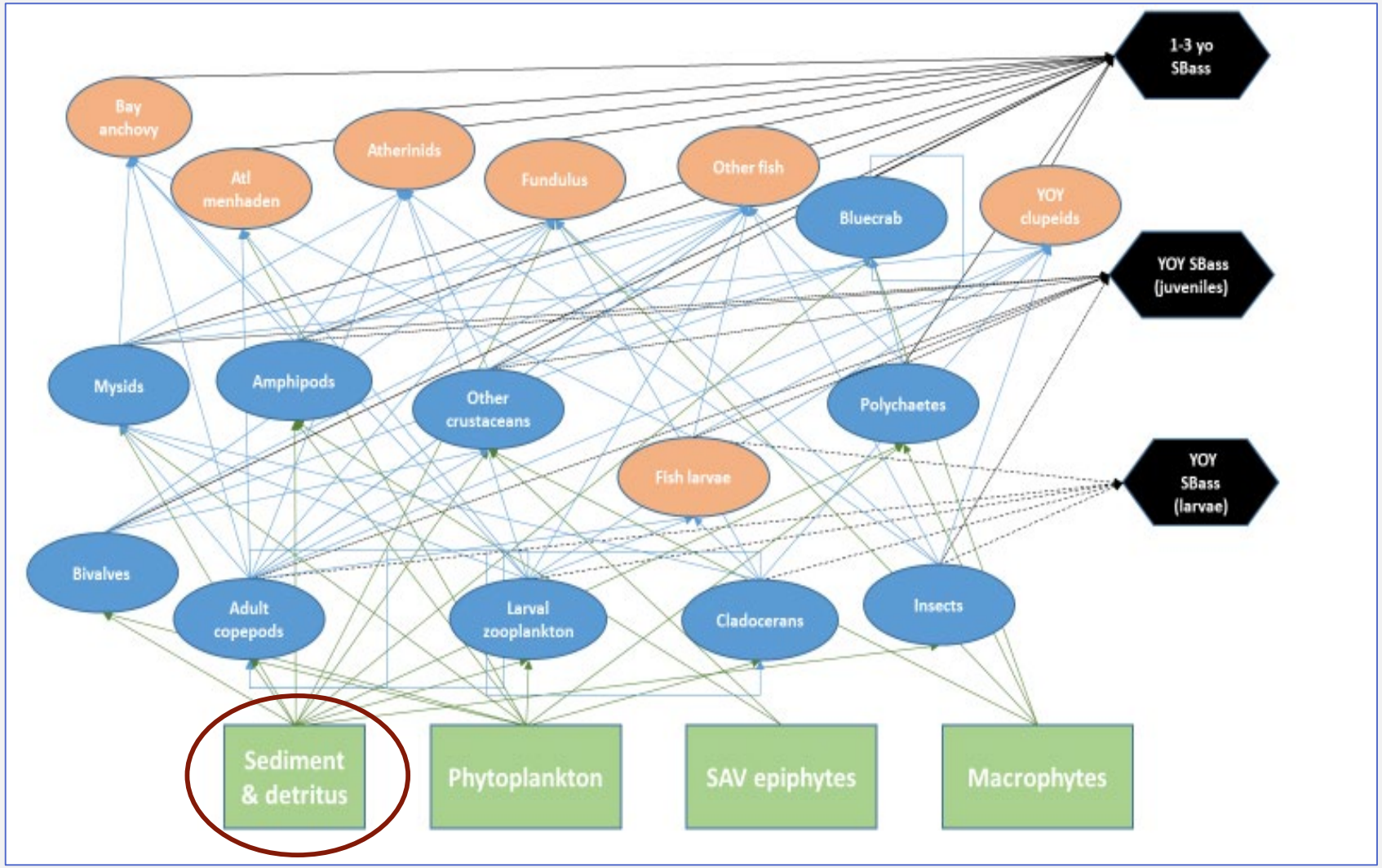
CONCLUSIONS

Sediment microplastic pollution *can* alter benthic microbial community function, affecting nutrient cycling!



MORE QUESTIONS REMAIN…

Can this affect the sea bass food web?



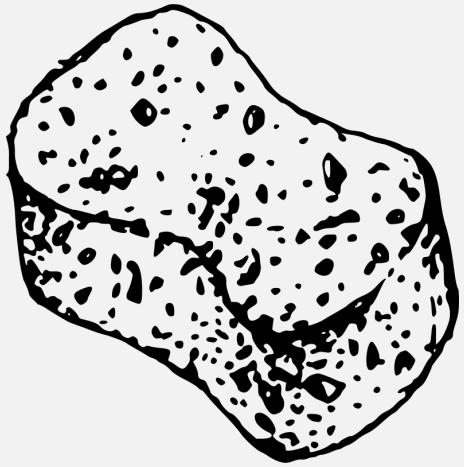
TetraTech, Phase 1 ERA Conceptual Model

MORE QUESTIONS REMAIN…

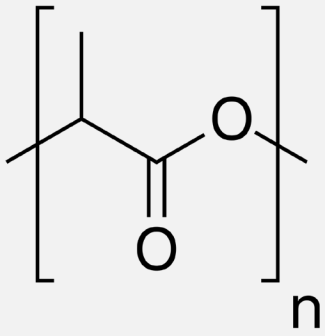
Can this affect the sea bass food web?

What causes these effects and differences between plastics?

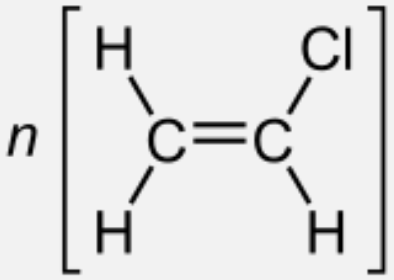
PHYSICAL EFFECTS



POLYMER EFFECTS



PLA



PVC

ADDITIVE EFFECTS

What areas of the Bay are, or will become, most vulnerable?

Thank you!

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Read the article!

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