Microbial variability of drill cuttings piles: thoughts on leaving *in situ*

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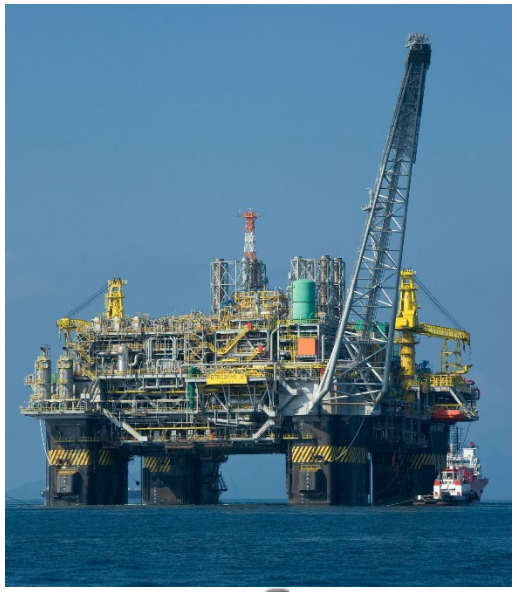
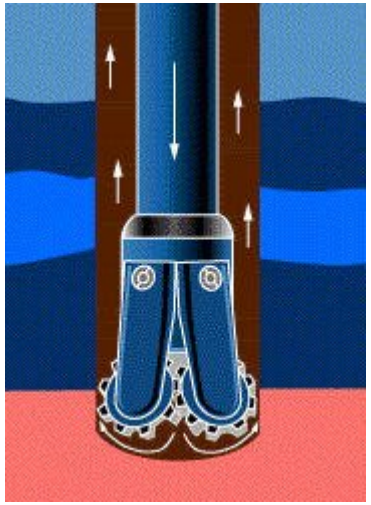
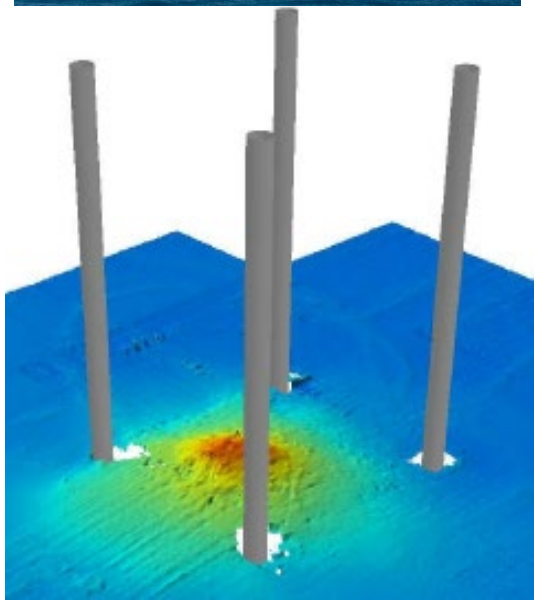
Background

Drill cuttings piles

- Drilling mud (DM) is used during drilling processes for lubrication, as a coolant and to transport rock debris (drill cuttings) to the surface.
- Drill cuttings (DC) were traditionally disposed of at sea; this resulted in the accumulation of cuttings at rig footings.
- Older (<1990s) styles of DM contained chemicals potentially harmful to marine wildlife.

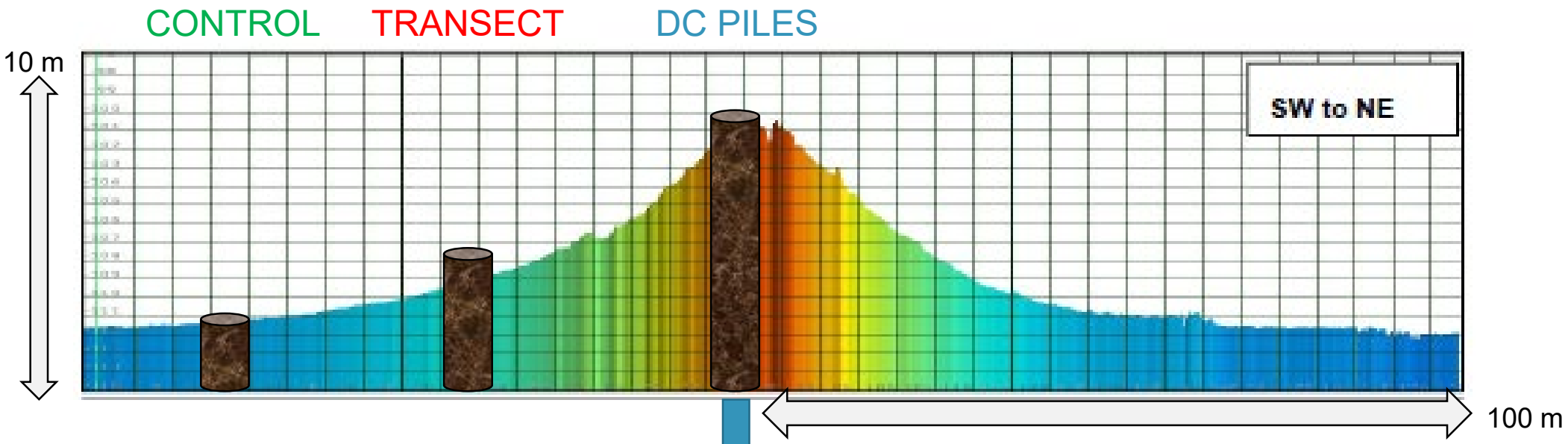






Installation decommissioning

Cuttings pile characterisation



Distance

Contaminant

Measurements:

- Hydrocarbons (HC)
- Metals
- etc

Within pile

Contaminant

Installation decommissioning

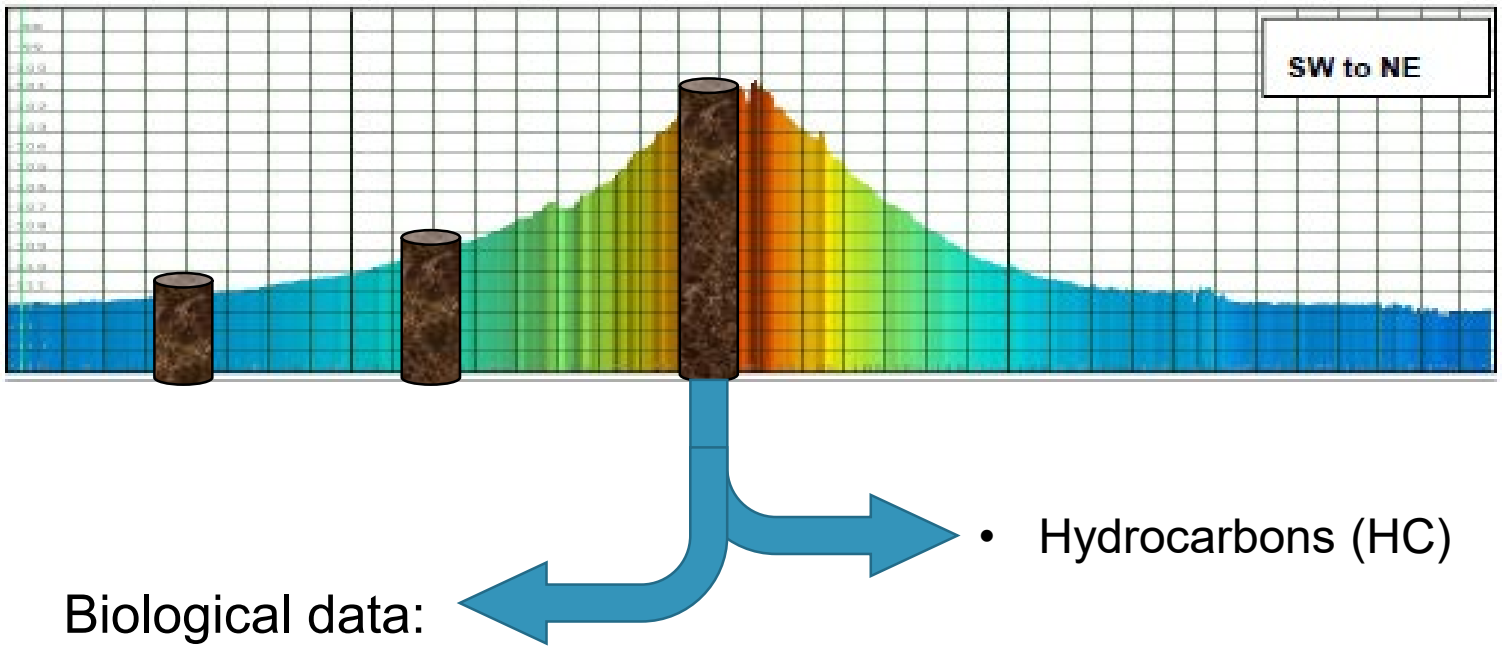
Cuttings pile microbial communities

Microbes

- Abundance
- Composition
- Diversity

Some microbes utilise hydrocarbons as an energy source

Hydrocarbon-degrading microbes



- Hydrocarbons (HC)

Biological data:

- Fauna
- Microbes

Distance +

Contaminant −

Microbes +

Considerations for leaving *in situ*

Leaching rate: 10 tonnes per year

Persistence: 500 km^2 year

(OSPAR 2006/5)

Options: Leave *in situ* / relocate on seabed / remove and treat

If they are left in place, is there a chance the hydrocarbons will degrade naturally?

Research objectives

General aims and objectives

Research items:

Assess microbial…

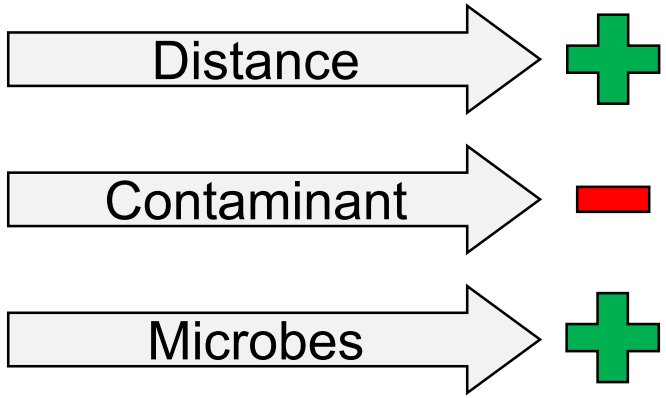
1. Abundance
2. Composition
3. Diversity

How different are bacteria within piles and between pile and control samples?

Research objectives

Predictions and expectations

1. Microbial abundance and diversity would increase with distance from DC piles due to lower concentration of hazardous materials.

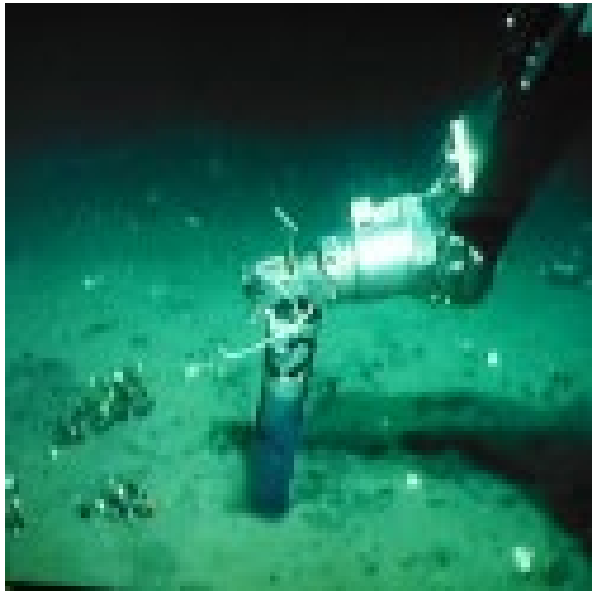


2. DC piles would be dominated by hydrocarbon-degrading bacteria.
3. Microbial community composition would be variable between and within DC piles due to small-scale variability of contaminants.

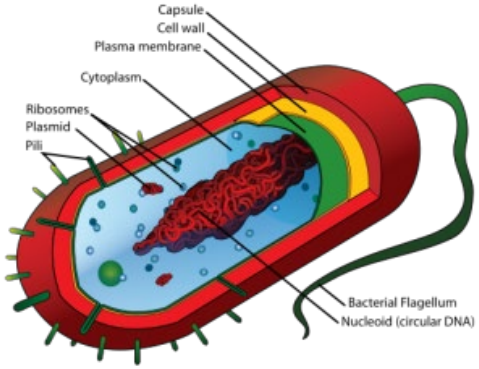
Experimental Design

DNA extraction and microbial characterisation

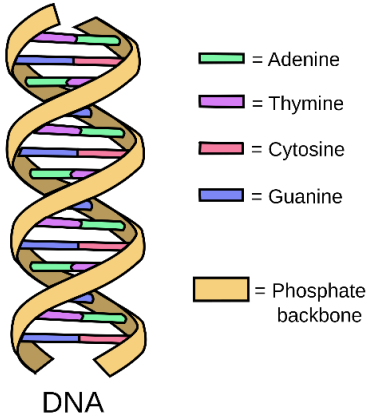
Sampling



DNA extraction



Microbial ID

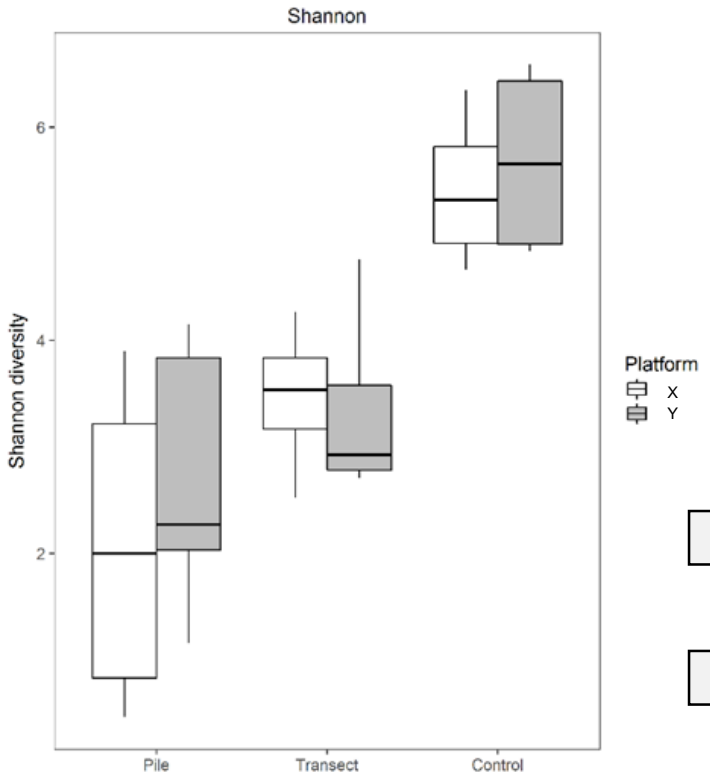


A) ACGAACGTTCTAATG
B) GCAAATGTTGCAAGT
C) TCTCATGCCAAGTTCC

Results

Microbial Diversity

Diversity is significantly lower in piles and transects than controls

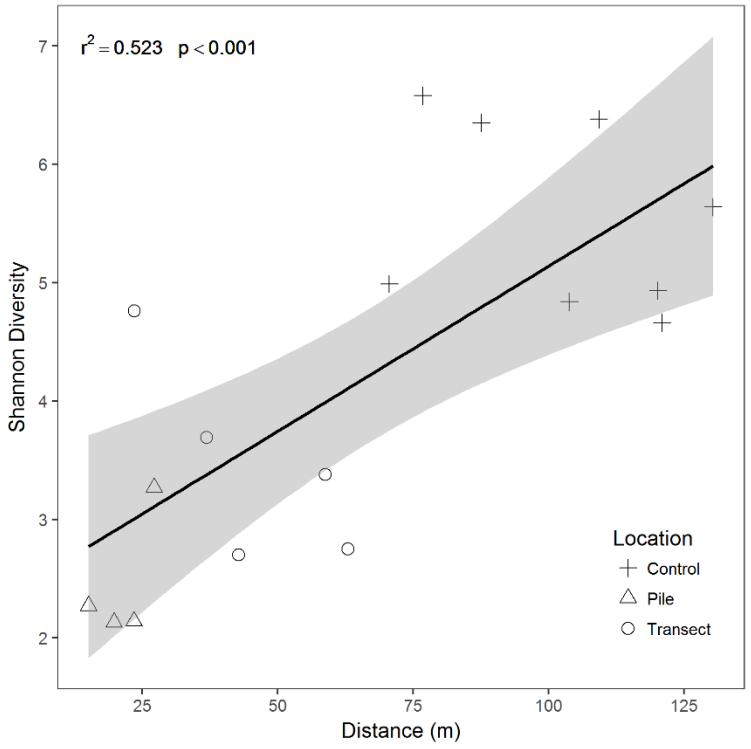


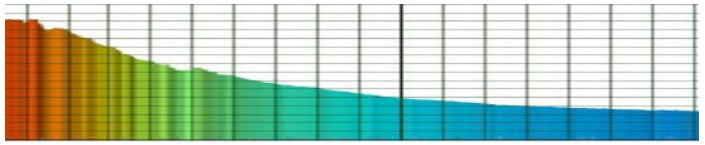
Distance

Contaminant

Microbes

As expected surface diversity increases with distance





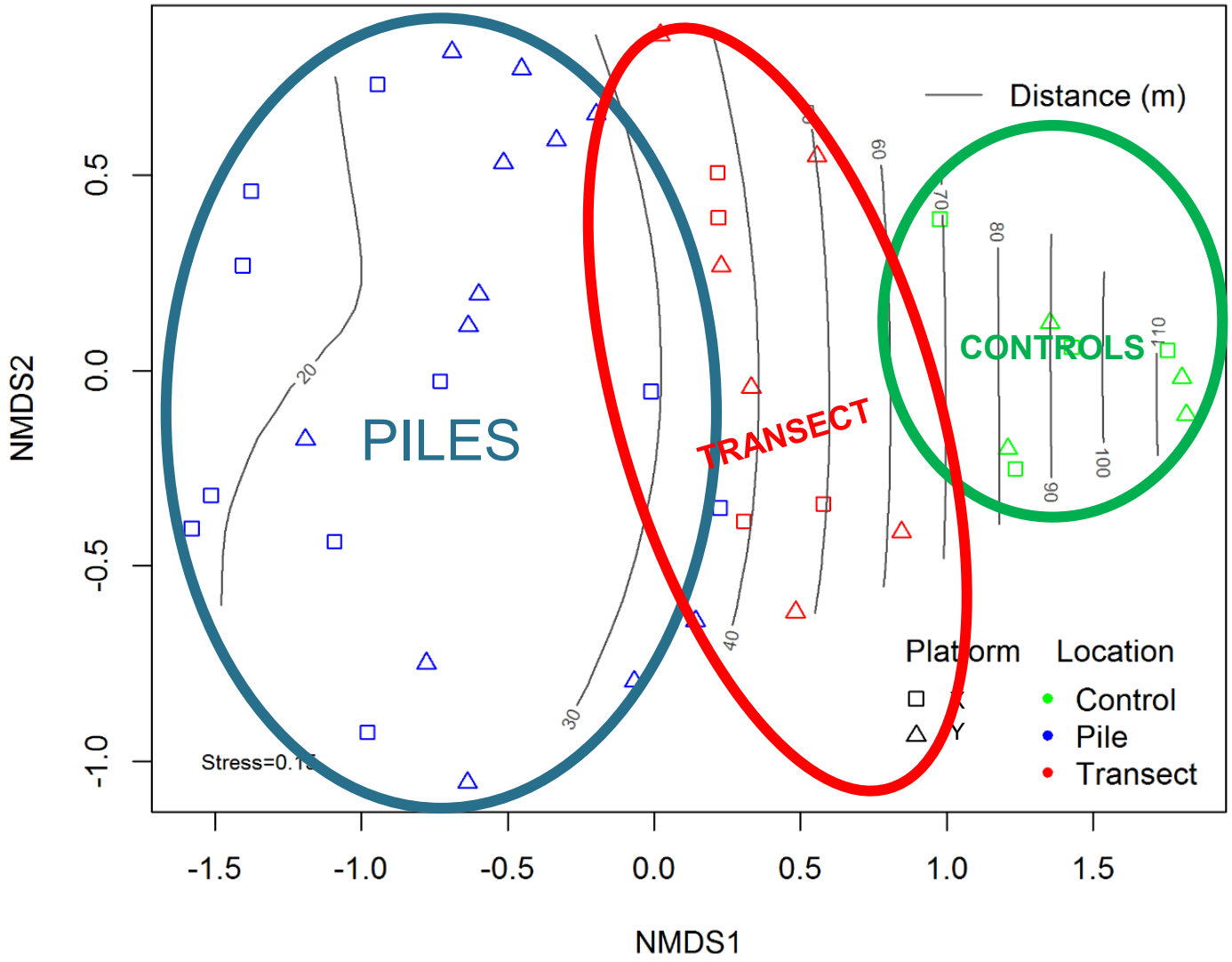
Results

Community composition

Microbial similarity plot

Samples close together have similar composition (type of microbe).

Contours indicate increasing distance from the pile (left to right).



Results

Community composition

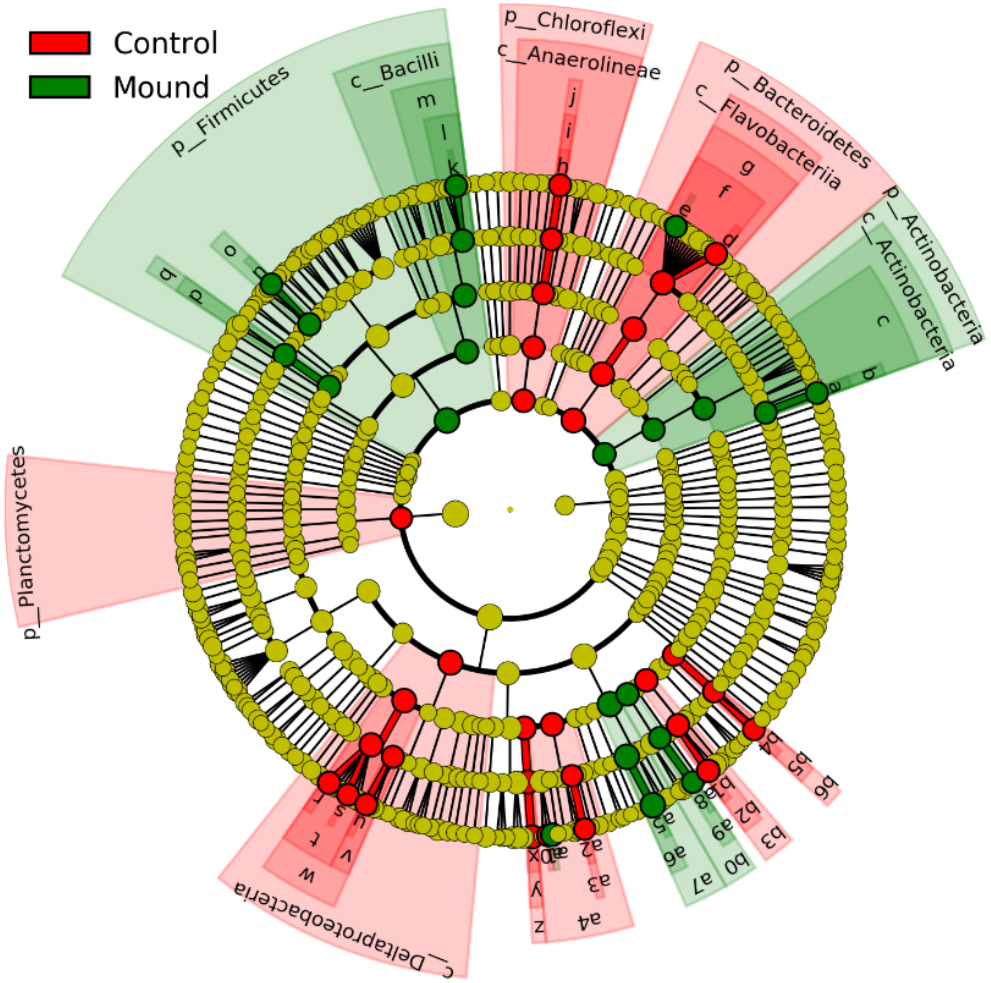
DC Pile & Transect (mound)

***Halomonas* (>95%)**

Dietzia

Pseudomonas

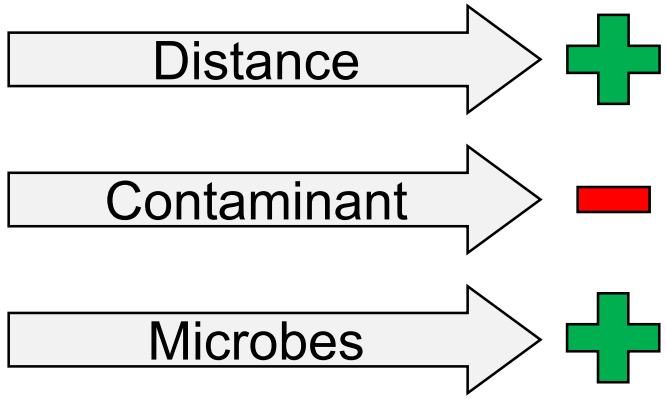
➢**Hydrocarbon-degraders**



a: g__Dietzia
b: f__Dietziaceae
c: o__Actinomycetales
d: f__Flavobacteriaceae_uncl
e: g__Salegentibacter
f: f__Flavobacteriaceae
g: o__Flavobacteriales
h: o__GCA004_unclassified
i: o__GCA004_unclassified
j: o__GCA004
k: g__Bacillus
l: f__Bacillaceae
m: o__Bacillales
n: g__Dethiosulfatibacter
o: f___Tissierellaceae_
p: f__Anaerobrancaceae
q: o__Natranaerobiales
r: f__Desulfobacteraceae_unc
s: g__Desulfococcus
t: f__Desulfobacteraceae
u: f__Desulfobulbaceae_uncl
v: f__Desulfobulbaceae
w: o__Desulfobacterales
x: c__Gammaproteobacteria_
y: c__Gammaproteobacteria_
z: c__Gammaproteobacteria_
a0: g__HB2_32_21
a1: g__Marinobacter
a2: g__Psychromonas
a3: f__Psychromonadaceae
a4: o__Alteromonadales
a5: g__Halomonas
a6: f__Halomonadaceae
a7: o__Oceanospirillales
a8: g__Pseudomonas
a9: f__Pseudomonadaceae
b0: o__Pseudomonadales

Conclusions

What does this mean?



The study confirmed many of our expectations…

- Low microbial diversity and abundance in piles.
- Different communities in piles compared to ‘control’ sites.

But also provided many novel findings…

- Strong dominance of known hydrocarbon-degraders – low abundance/biomass?
- High variability within and across piles – how does this impact predictions?

➢Increases confidence that hydrocarbons will be degraded – how long and consistent?

Future perspectives

Options for bioremediation

Knowing more about the microbes within piles will aid in development of bioremediation and monitoring strategies:

- Nutrient addition – biostimulation.
- Microbial culture addition – bioaugmentation.
- Degradation enhancement, oxygen provision with snorkels.

Genovese *et al* (2014) Effective bioremediation strategy for rapid in situ cleanup of anoxic marine sediments in mesocosm oil spill simulation.

- Biomonitoring tools – use of biomarkers such as genes or specific hydrocarbon-degraders for tracking bioremediation.

Mapelli *et al* (2017) Biotechnologies for Marine Oil Spill Cleanup: Indissoluble Ties with Microorganisms.

Thank you for listening.

Questions?

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