# Biodegradation of Crude Oil and Corexit EC9500A in Arctic Seawater

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# Background

- Chemical dispersants are a widely used spill response strategy
  - Lower oil surface tension
  - Disperse slick to droplets
  - Potentially enhance biodegradation
- Increased shipping and drilling in Arctic has led to consideration of chemical dispersants

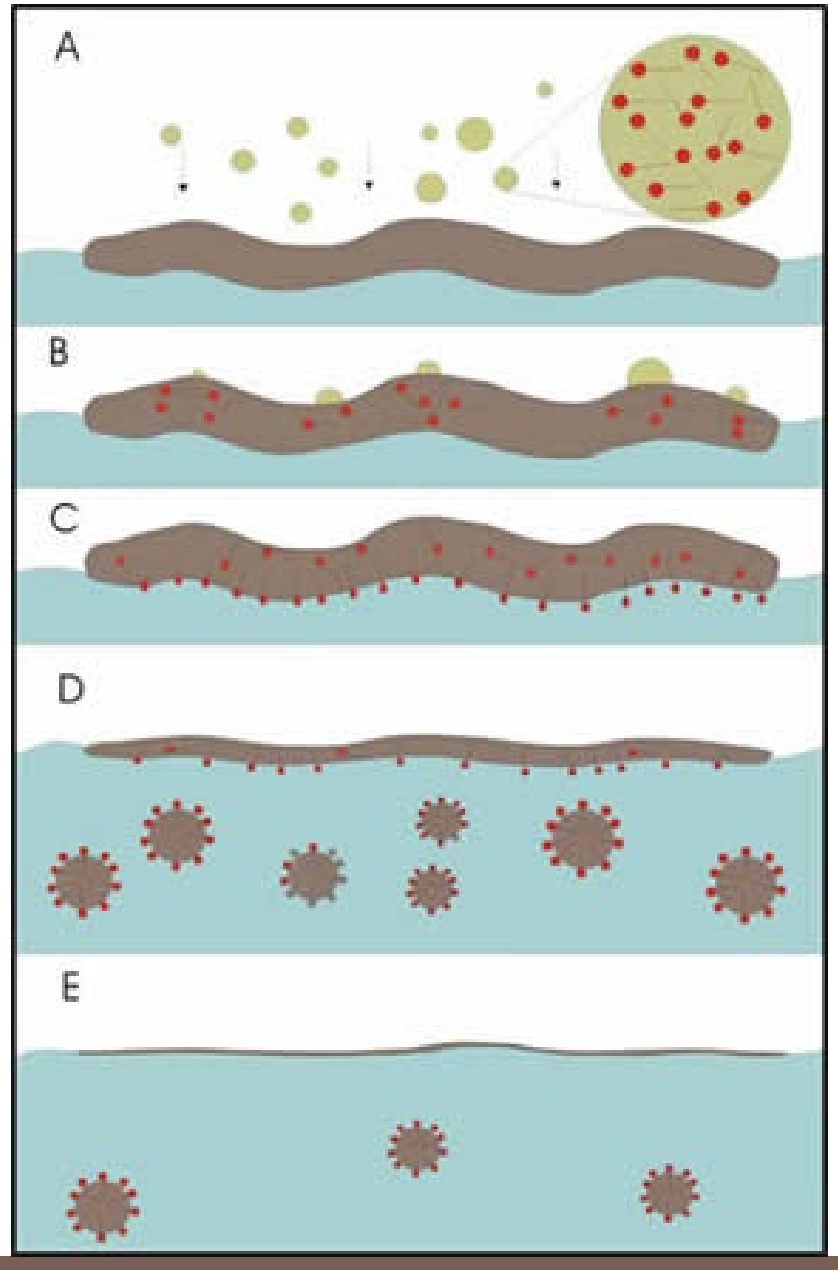
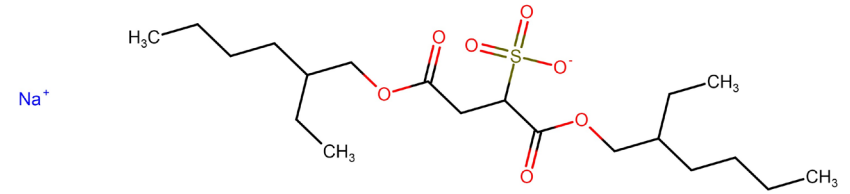


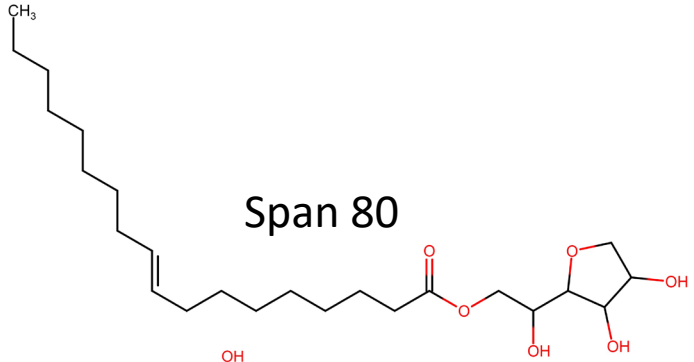

Photo credit: ITOPF

# Background

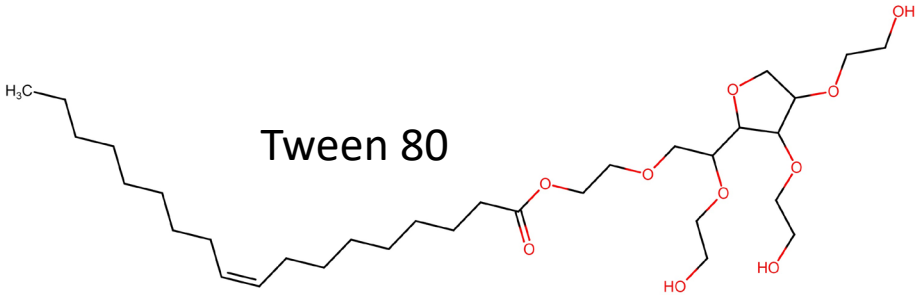
- Corexit 9500 is a widely used dispersant formulation
  - Anionic surfactants
    - Dioctyl sulfosuccinate (DOSS), 18%
  - Nonionic surfactants
    - Span 80, 4.4%
    - Tween 80, 18%
    - Tween 85, 4.6%
  - Solvents
    - Dipropylene glycol n-butyl ether (DGBE)
    - Petroleum distillates




DOSS

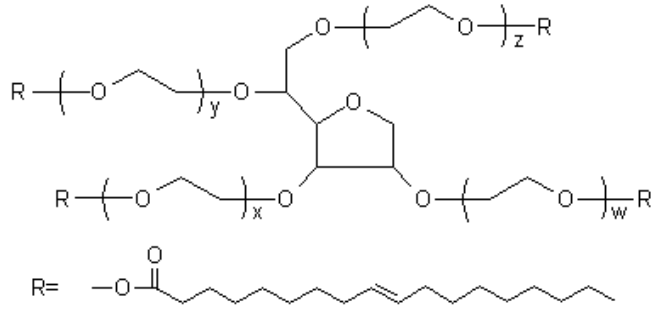


Span 80

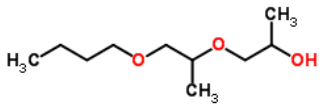


Tween 80

Tween 85



DGBE



# Experimental Aims

- Aim 1: Quantify biodegradation of crude oil and Corexit 9500 in Arctic seawater
  - Oil loss (GC/MS)
  - Dispersant loss (LC/MS/MS)
- Aim 2: Characterize microbial community changes and identify putative biodegradative organisms
  - 16S rRNA gene sequencing (Illumina MiSeq)

Photo credit: Mary Beth Leigh


Welcome to Barrow
Paġlagivsigiñ
Utqiaġvigmun
America's Northernmost City
Barrow
Arctic Ocean
Alaska
Prudhoe Bay
Top of the World!


Utqiagvik
Fairbanks
East Siberian Sea
Bering Sea
Sea of Okhotsk
Sea of Japan
South Korea
Japan
North Pacific Ocean
Canada
United States
Mexico
Gulf of Mexico
Hudson Bay
Northwestern Passages
Cuba
Guatemala
Nicaragua
AK
YT
NT
NU
AB
BC
SK
MB
ON
QC
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
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SD
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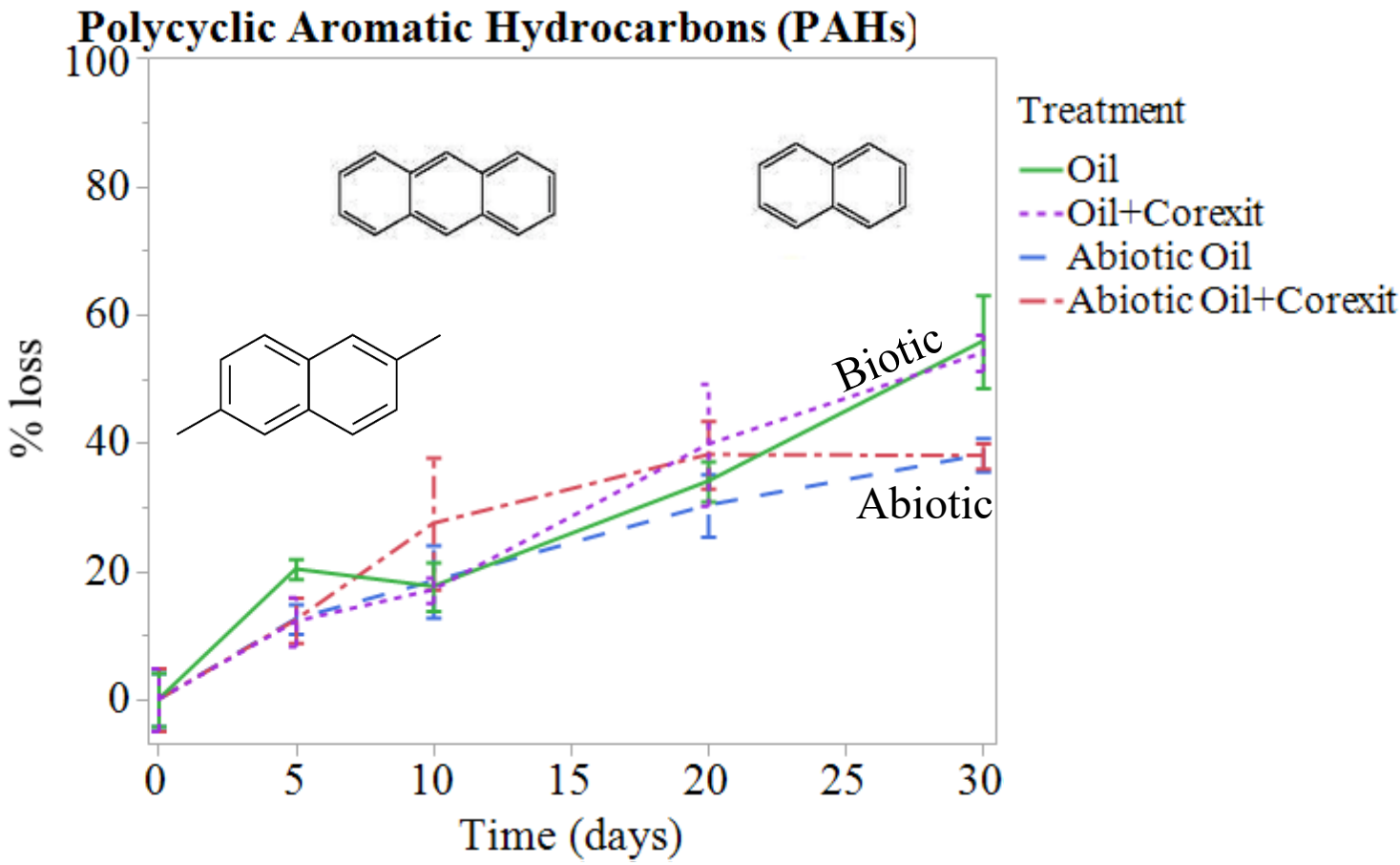
# Corexit 9500 Marine Incubation

- Arctic seawater microcosms, 4°C
- 16 ppm Bushnell-Haas
- Treatments:
  - Alaska North Slope crude oil, 50 ppm
  - Corexit 9500, 1:10 DOR
  - Both
  - No substrate (microbial controls)
  - Abiotic controls (autoclaved)
- Destructively harvested: 0, 5, 10, 20, 30 days
- Additional subsampled mesocosms


CATOWN
CAFE & ADOPTION

# Oil degradation in Arctic seawater

- Considerable abiotic loss observed
- n-Alkanes and branched alkanes readily degraded
- PAHs and unresolved complex mixture more recalcitrant
- No inhibition of oil degradation with Corexit



# TPH loss rates are similar to those previously reported in Arctic

- Biodegradation occurs in the Arctic, but more slowly than other regions
- While not observed here, some studies have observed increased TPH loss with addition of Corexit
  - Difficult to determine ex situ to compare surface slick vs. chemical dispersion

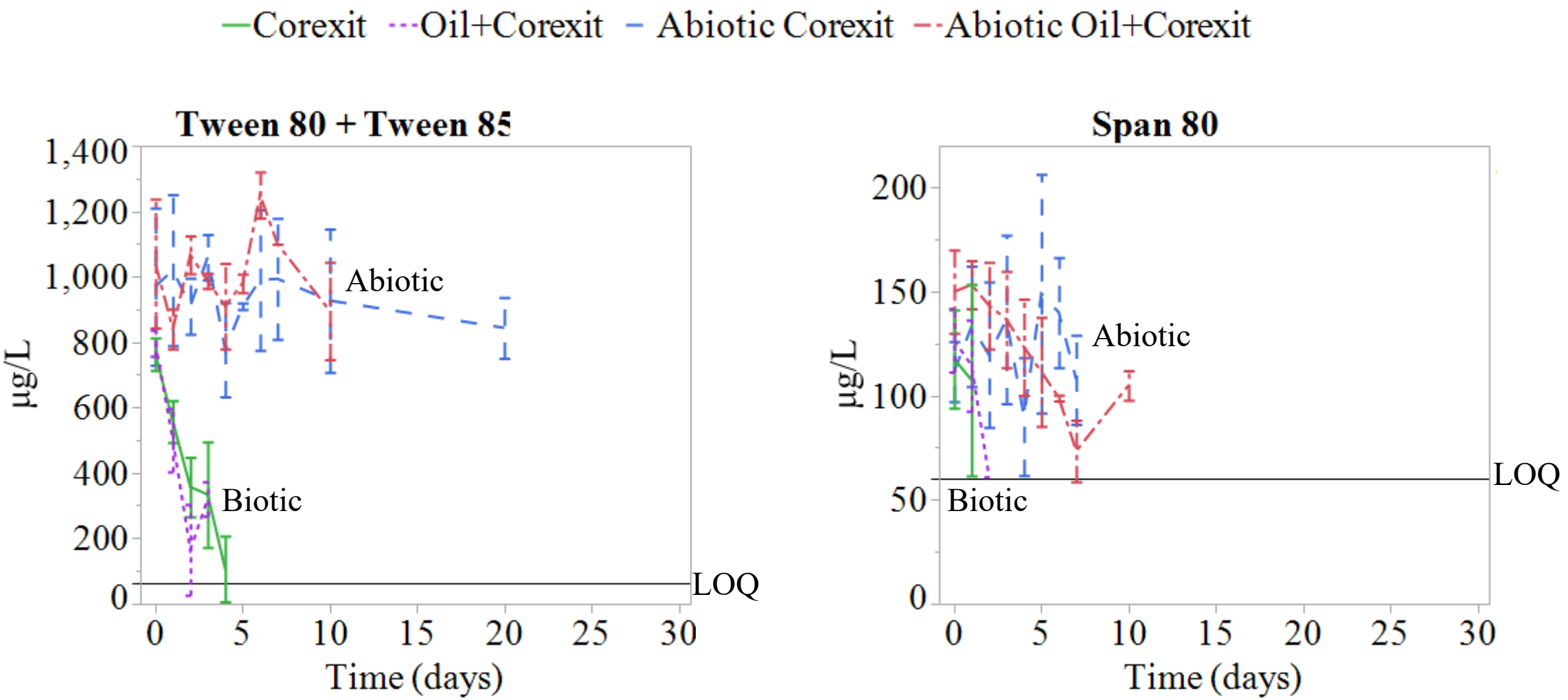
| Reference | Location | Treatment | TPH % loss at 30 days |
|---|---|---|---|
| This study | Utqiagvik, Alaska | Oil | 26 |
| | | Oil+Corexit | 32 |
| McFarlin et al. 2014 | Utqiagvik, Alaska | Oil | 45 * |
| | | Oil+Corexit | 54 * |
| McFarlin et al. 2018 | Burger lease area, Alaska (September) | Oil | 36 |
| McFarlin et al. 2018 | Burger lease area, Alaska (October) | Oil | 41 |
| Prince et al. 2013 | New Jersey | Oil | 69 * |
| | | Oil+Corexit | 77 * |

* Denotes $p<0.05$

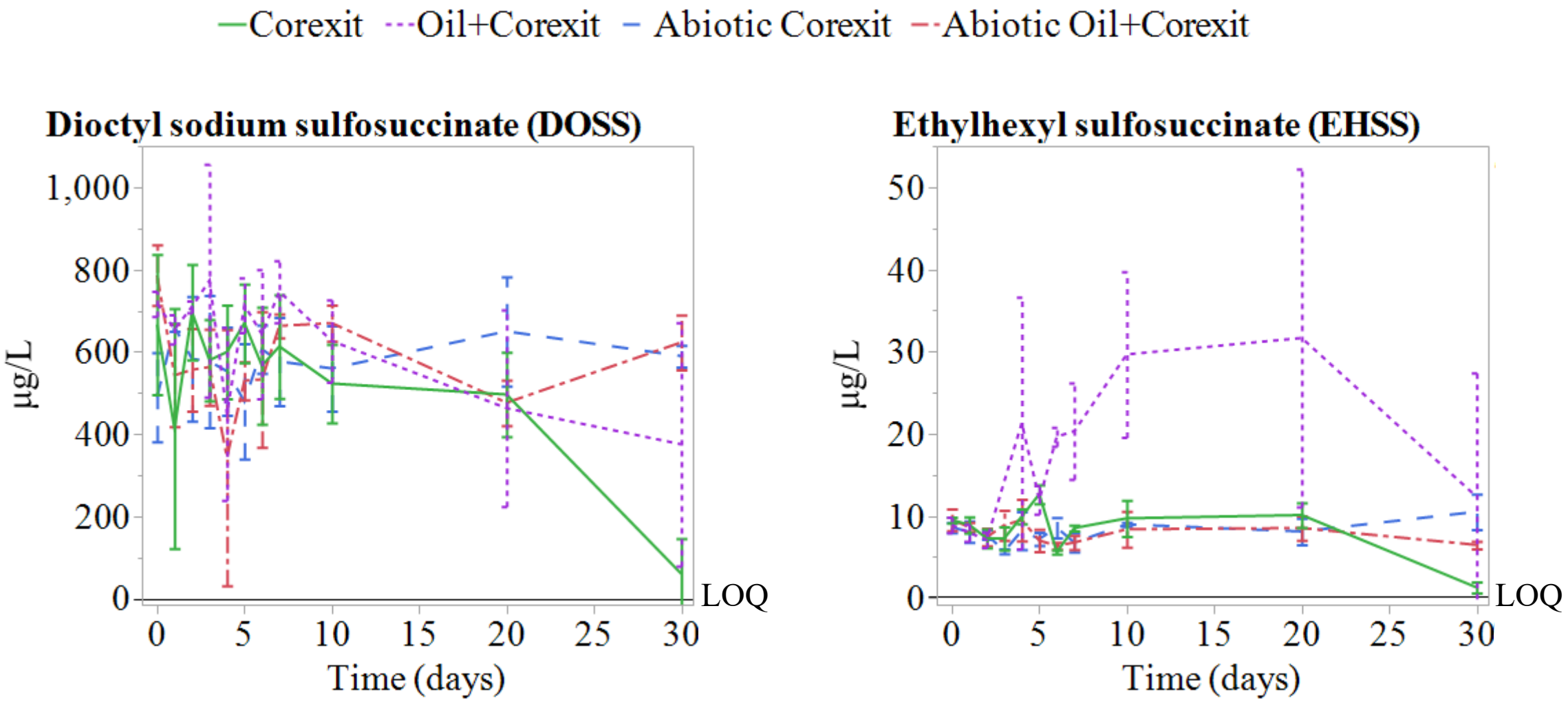
# Dispersant degradation in Arctic seawater

- Performed by LC/MS/MS
- Whole bottle and subsampled incubations are comparable
- Analytes:
  - Dioctyl sulfosuccinate (DOSS)
  - Ethylhexylsulfosuccinate (EHSS)
  - Span 80
  - Tween 80+85

# Non-ionic surfactants rapidly degraded in Arctic seawater



# DOSS degradation is slow in Arctic seawater



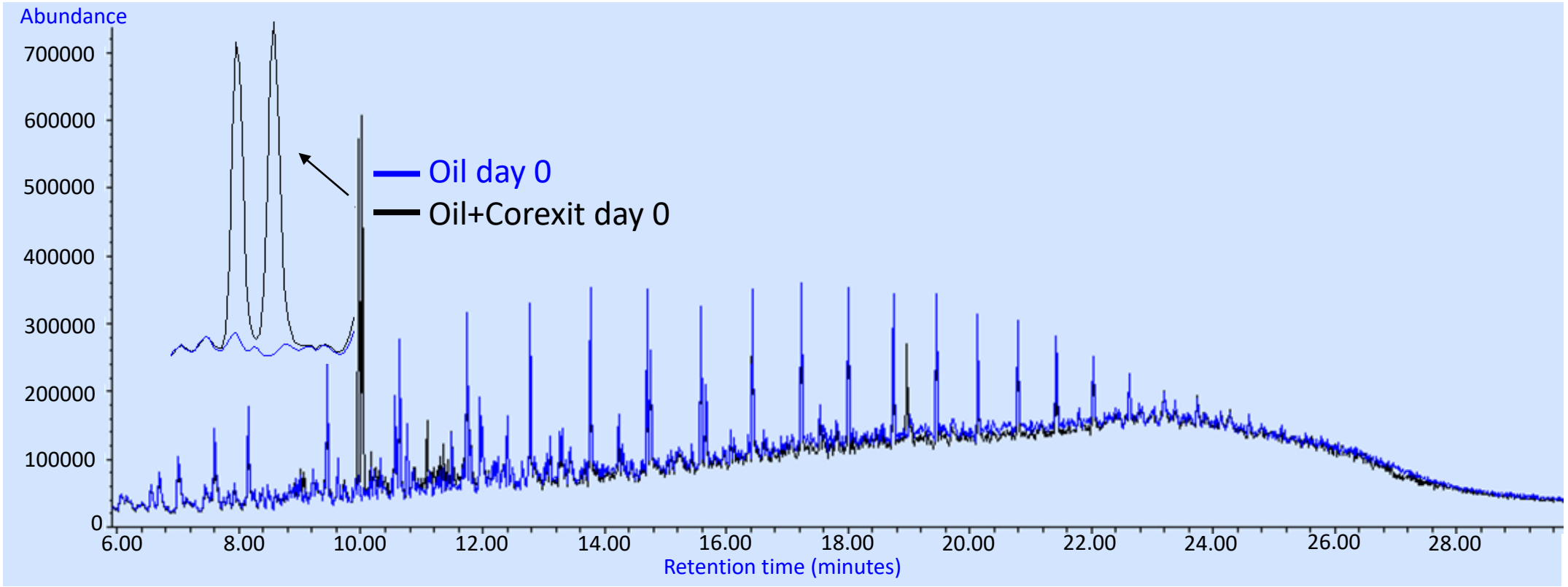
# Similar dispersant degradation previously reported in Arctic and Gulf of Mexico

- Near-complete degradation of non-ionics previously observed in Arctic
- Variable extents of DOSS degradation reported
  - Difficult to measure
  - Likely dependent on environmental parameters
- GoM enrichment cultures rapidly degraded DOSS at 25°C but not at 5°C (Campo et al. & Techmann et al.)

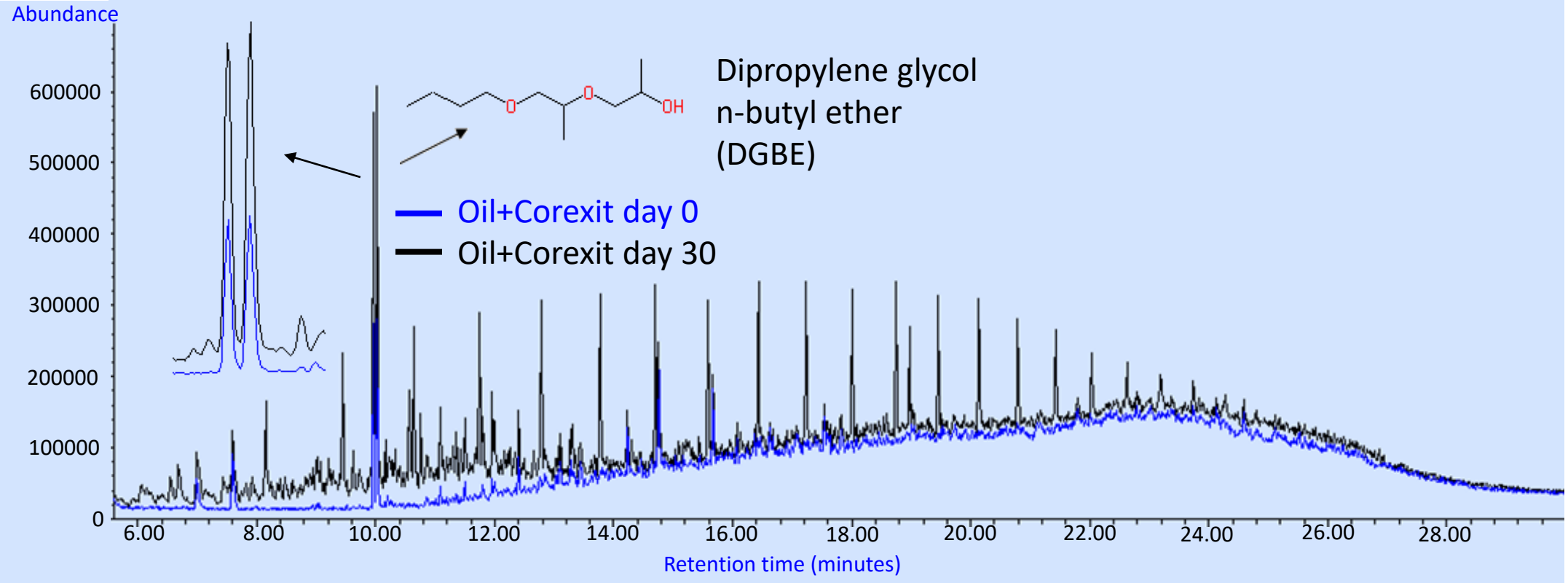
Percent loss after 30 days

| Reference | Location | Tweens 80+85 | Span 80 | DOSS |
|---|---|---|---|---|
| This study | Utqiagvik, Alaska | >93 | >53 | 48-91 |
| Kleindienst et al. 2015 | Gulf of Mexico | ~99.7 | ~87 | 8-30 |
| McFarlin et al. 2018 | Burger lease area, Alaska | >99 | >97 | 35-98 |

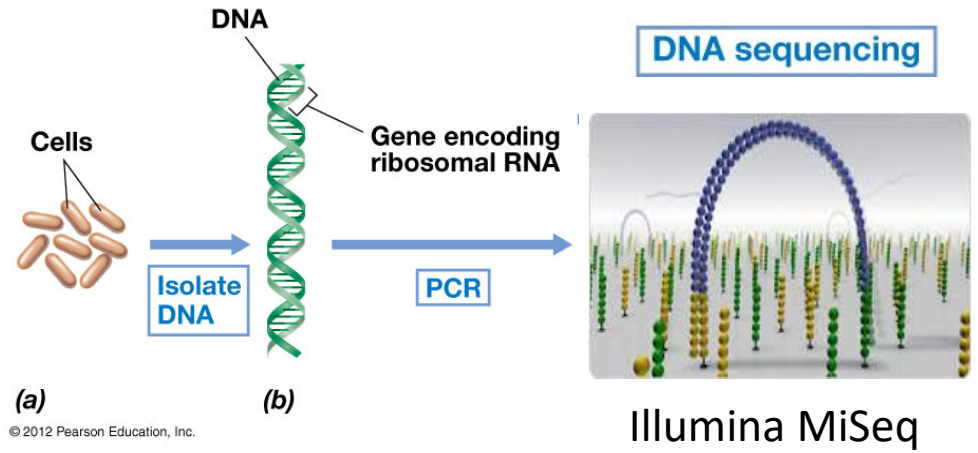
# Unexpected GC/MS peak detected in oil+Corexit treatments



# Unexpected peak persisted after 30 days



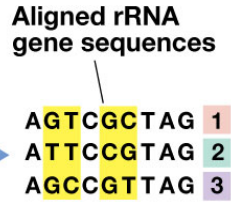
# Microbial community analysis using 16S rRNA Gene Sequencing





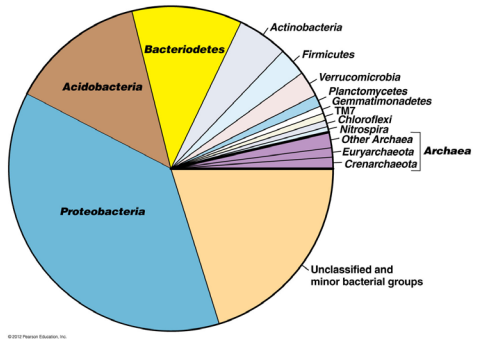


Illumina MiSeq



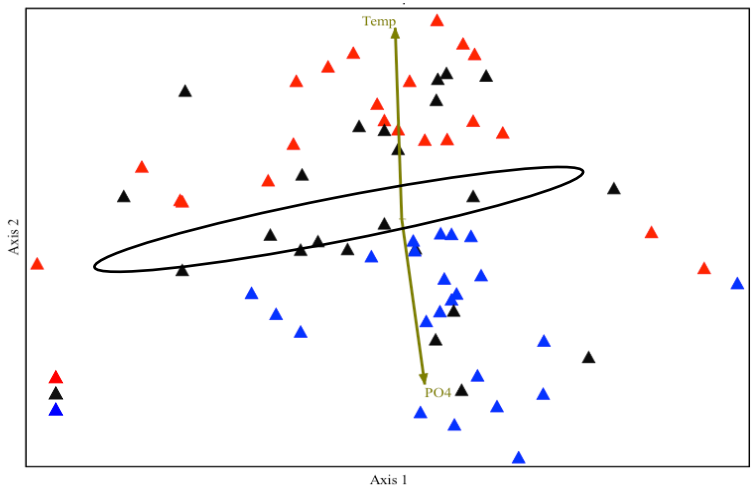

Compare to databases for phylogenetic identification

Group sequences by taxonomic affiliation




Count # reads per taxonomic group

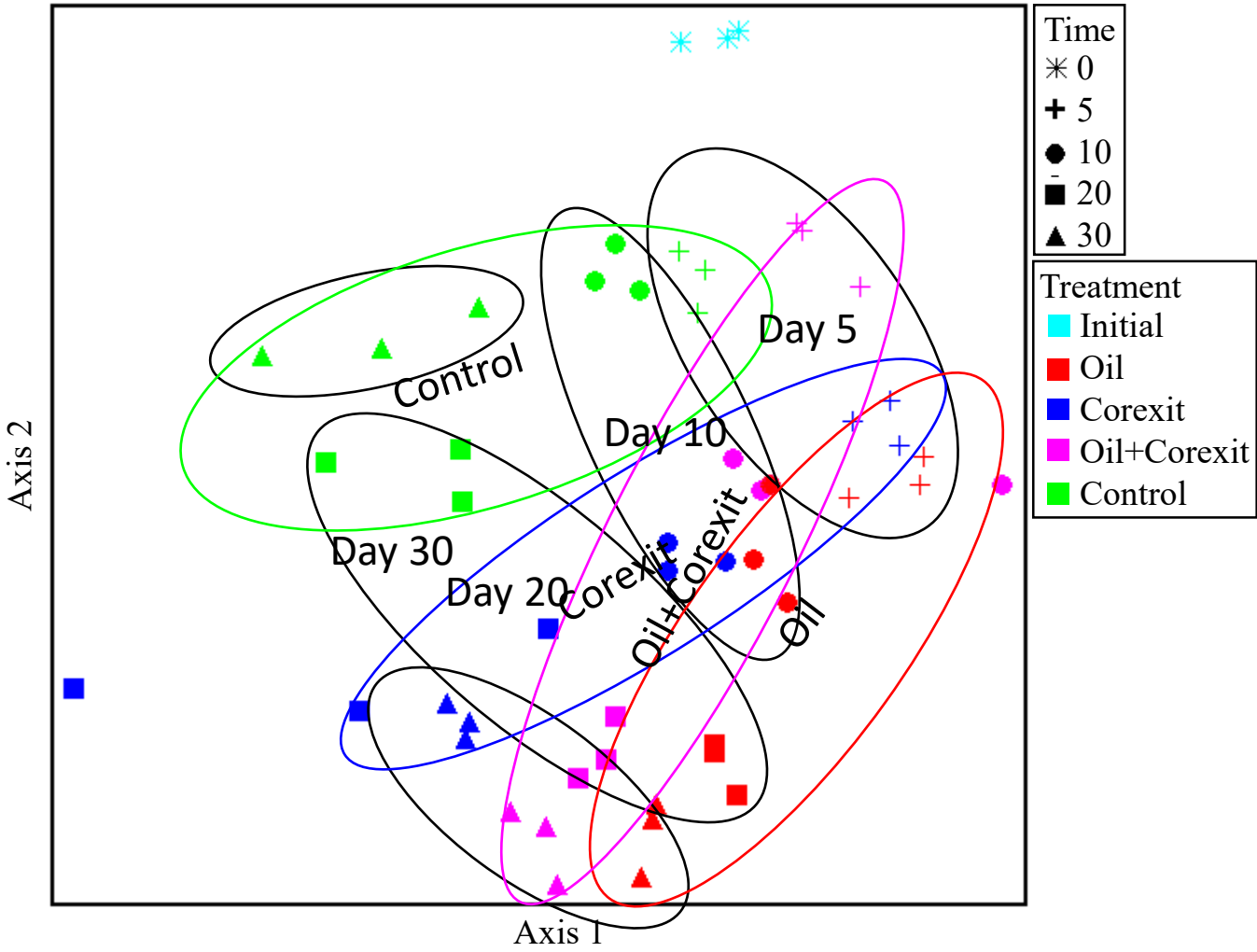
Community composition and structure

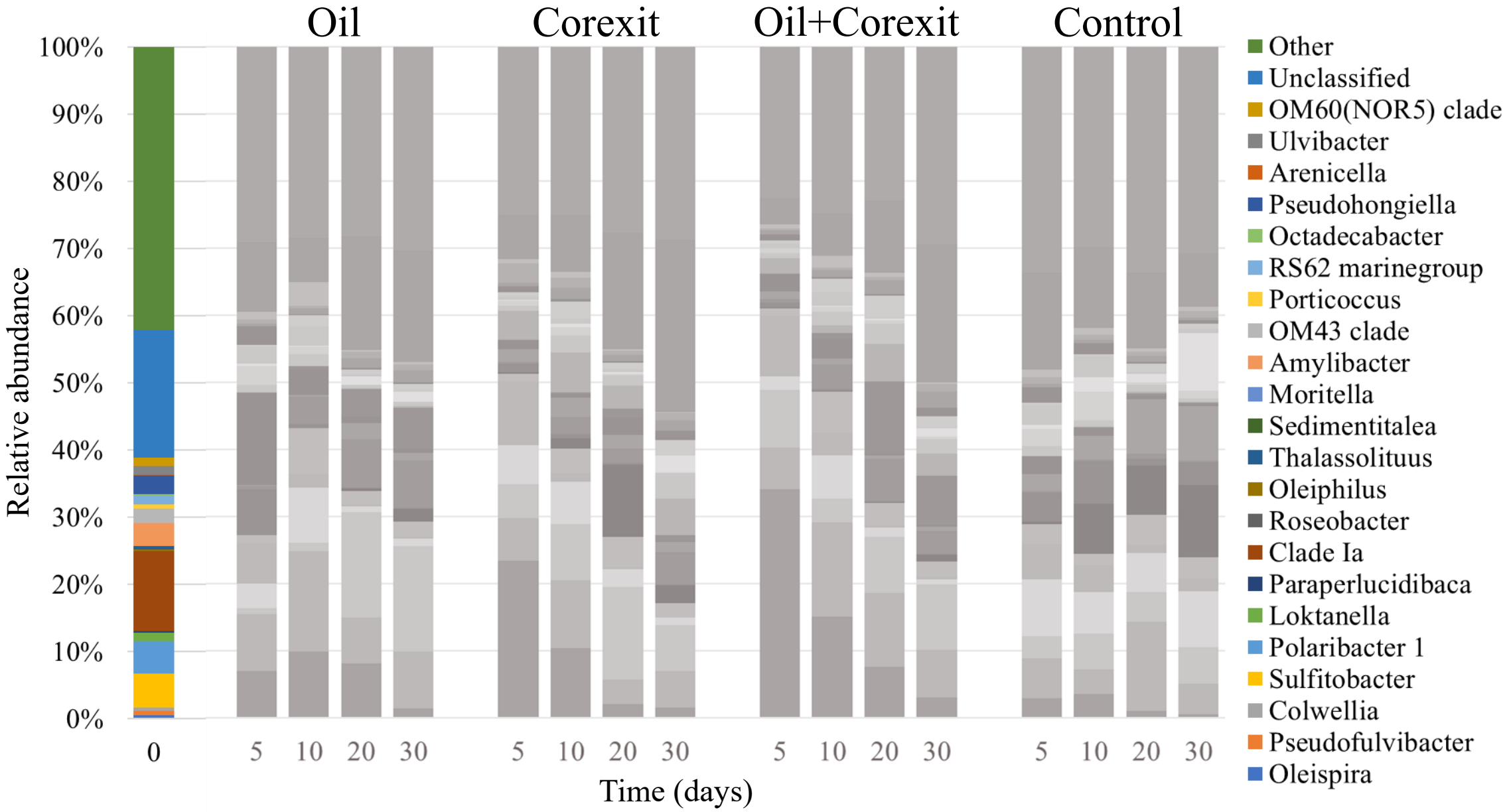



Ordination and multivariate statistics - compare community structure of different samples

# Microbial communities are influenced by treatment and time

- Significant effects of treatment, time, and interactions
- All treatments significantly different from each other except oil and oil+Corexit at t=10
- Oil+Corexit community succession: Corexit → Oil
- Community structure and individual taxa correlate with compound loss and nutrients concentrations

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Corexit
Oil+Corexit
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100%
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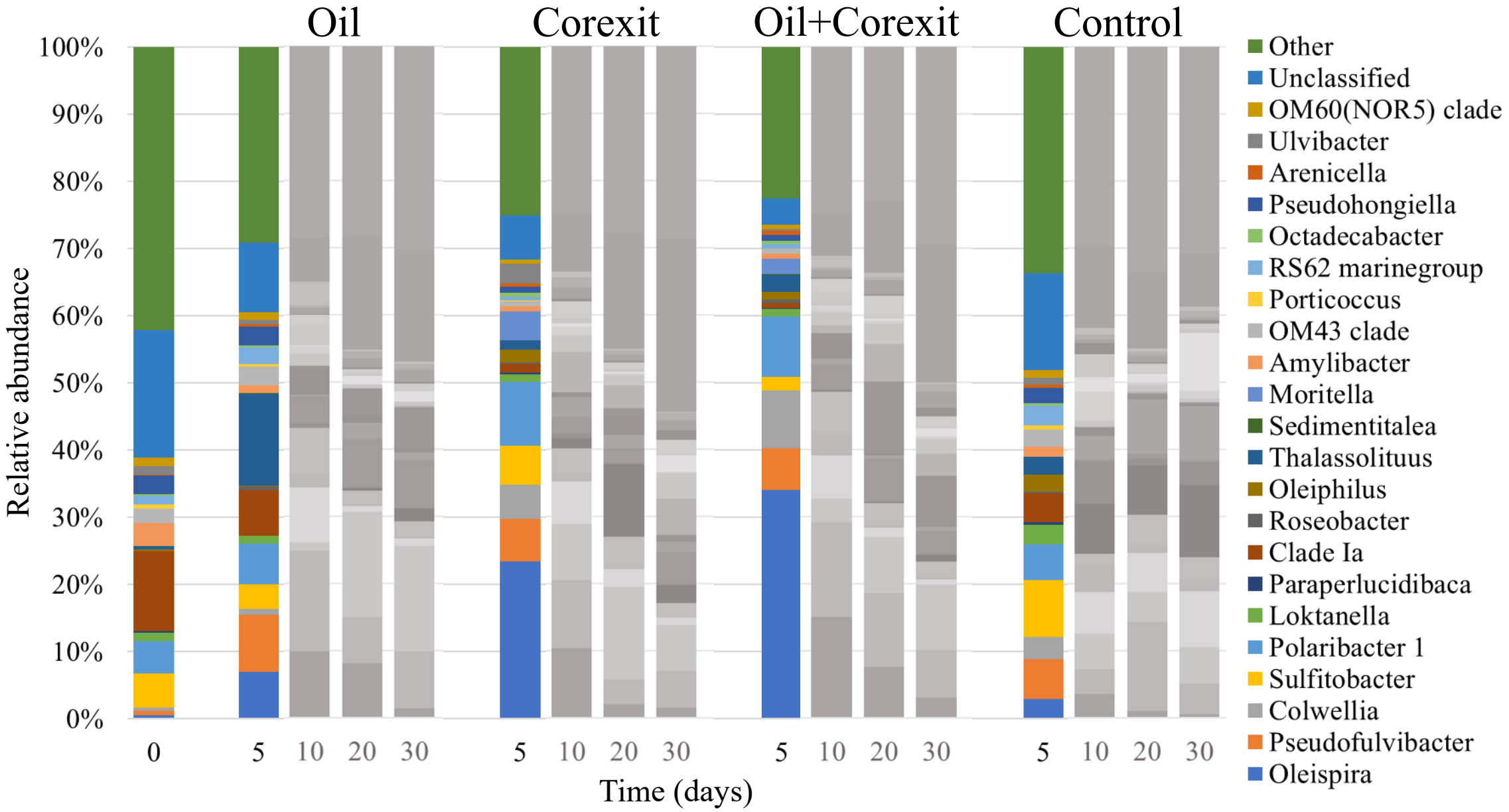
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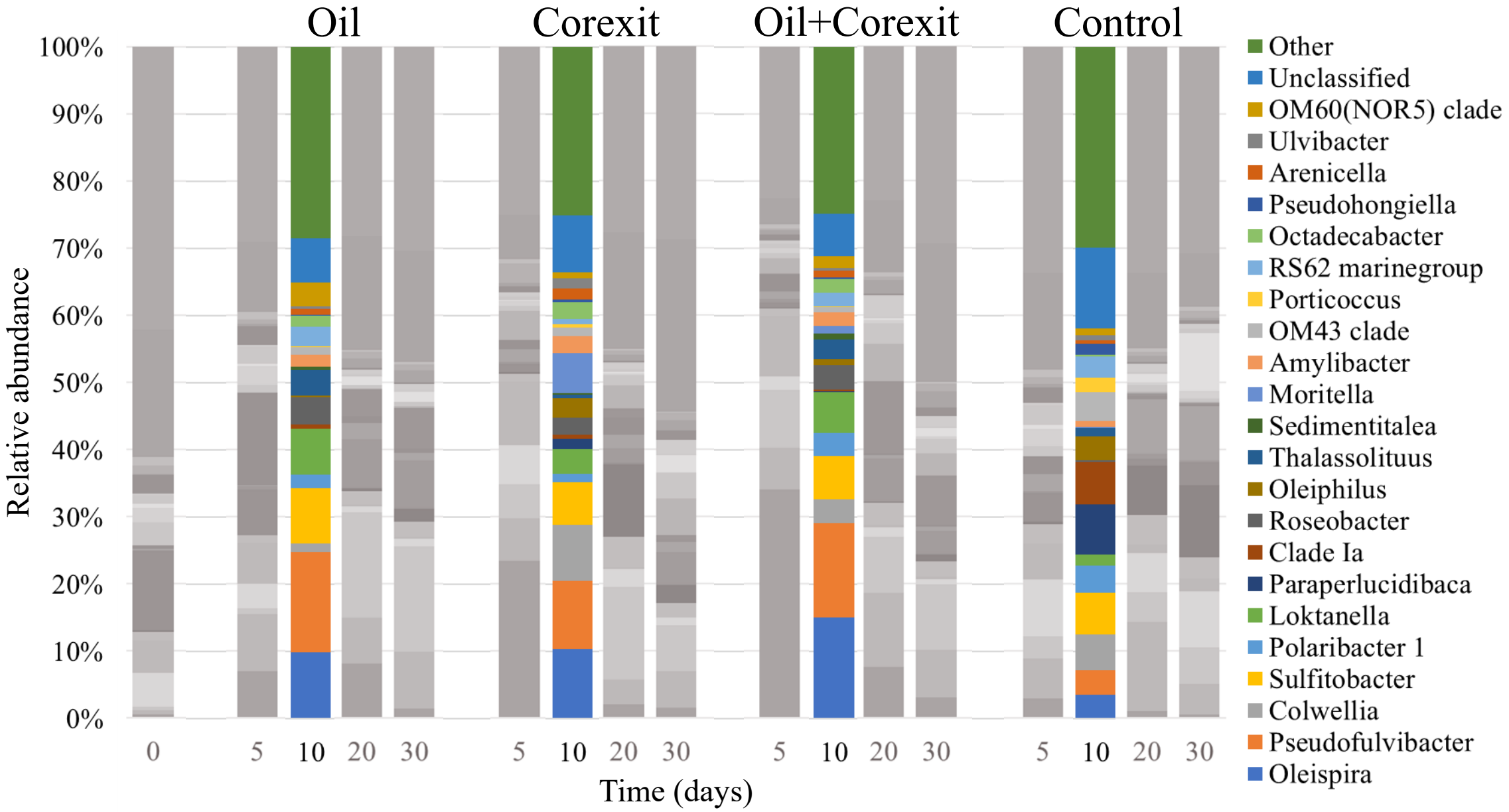
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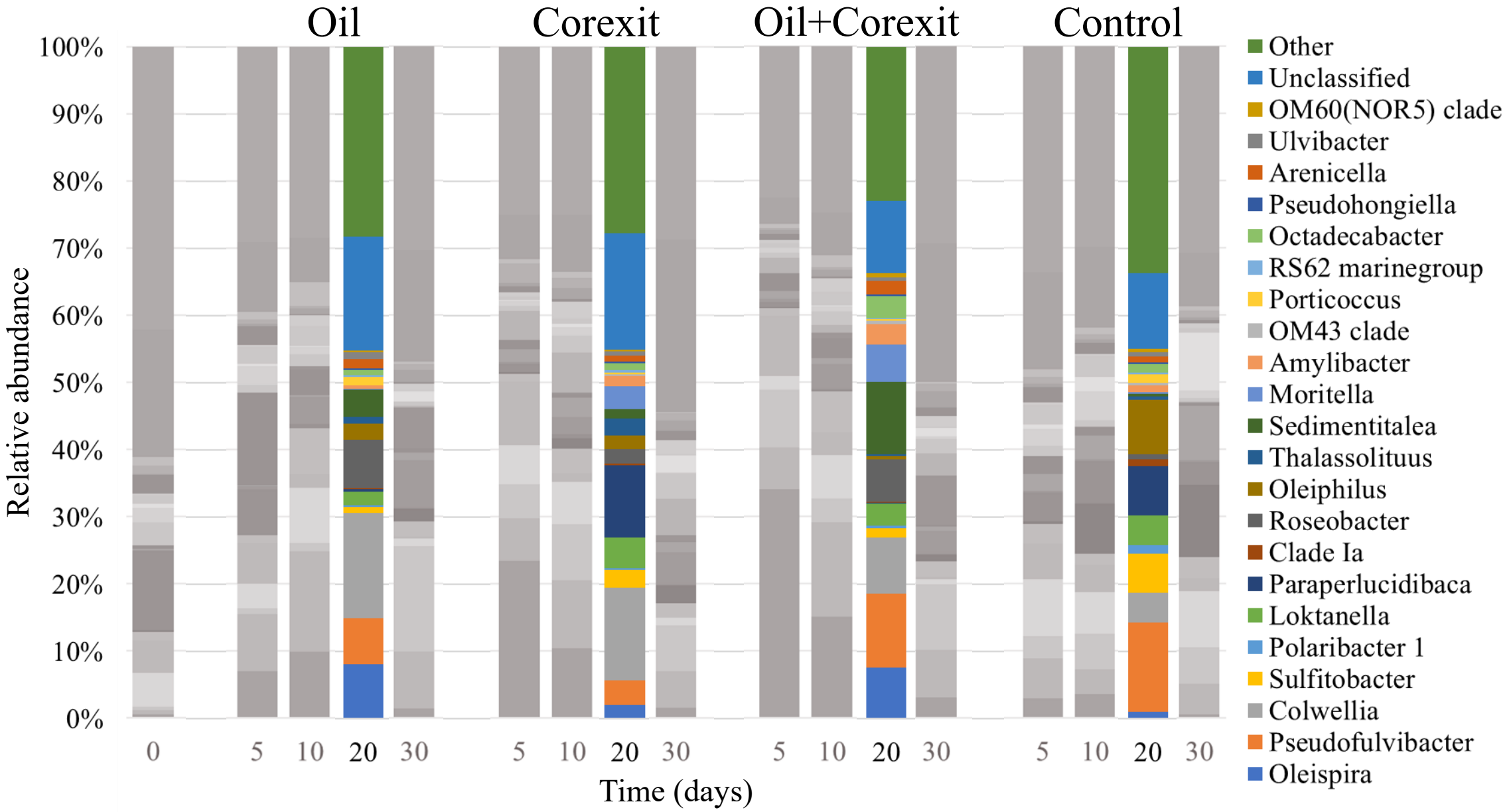
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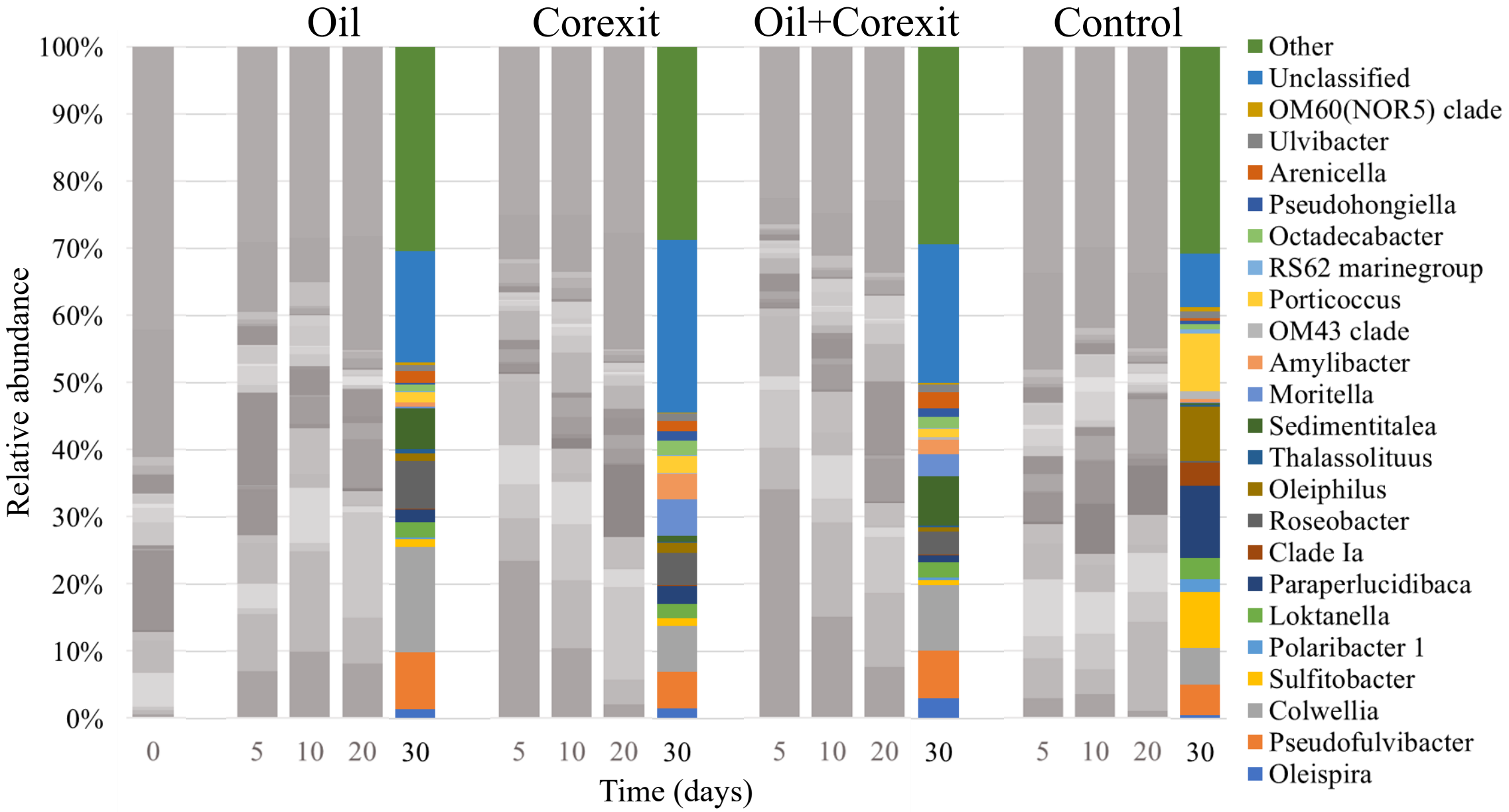
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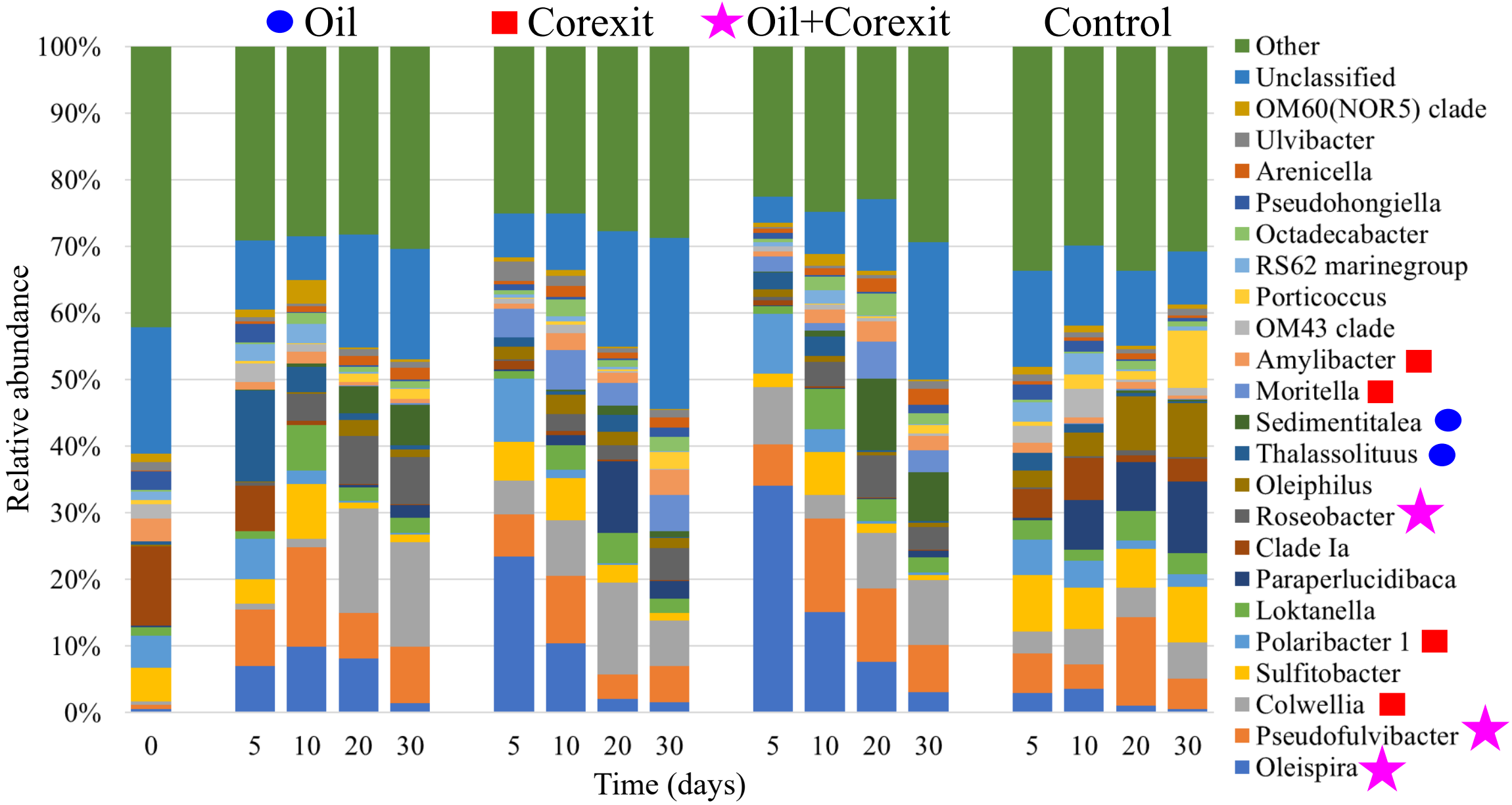
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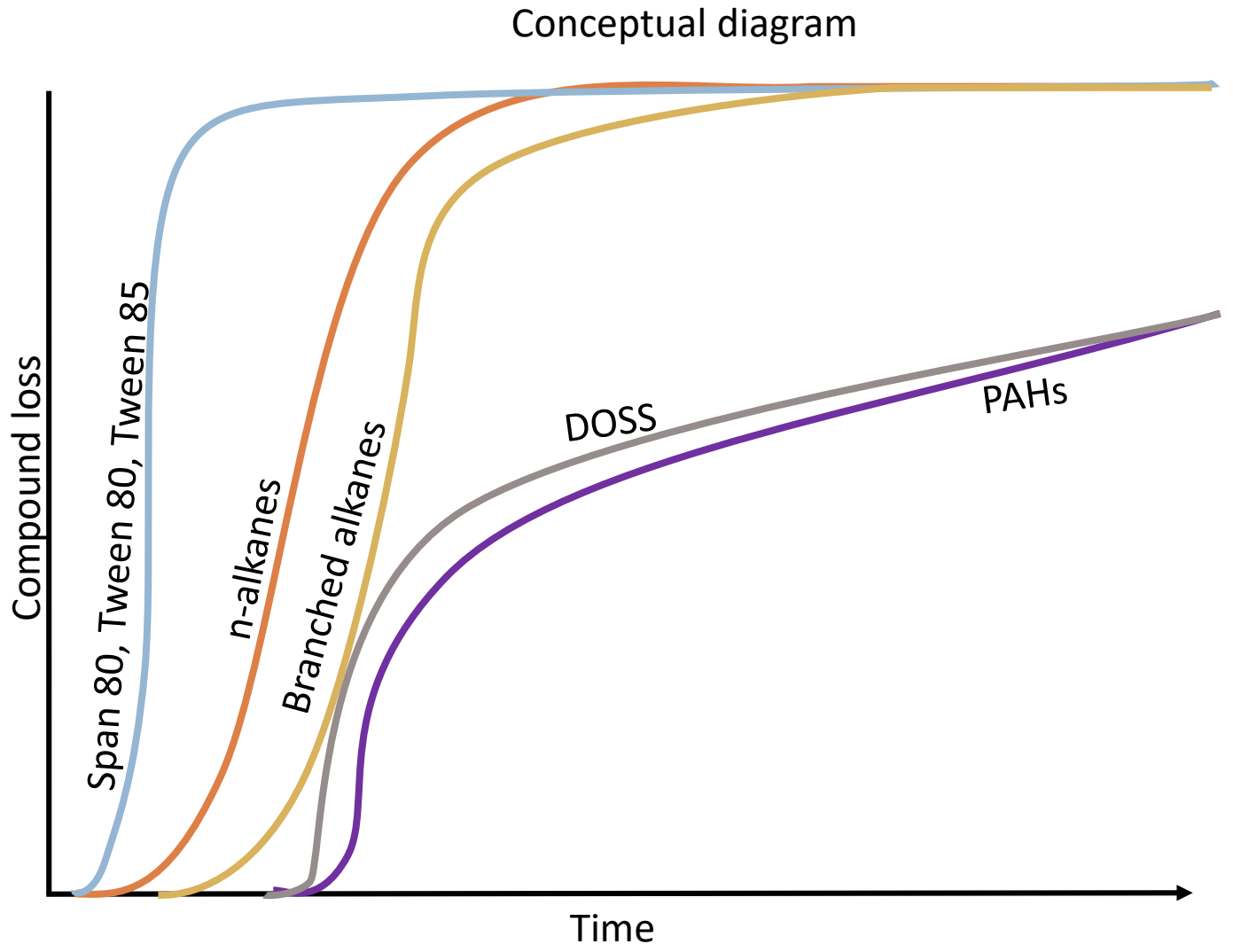
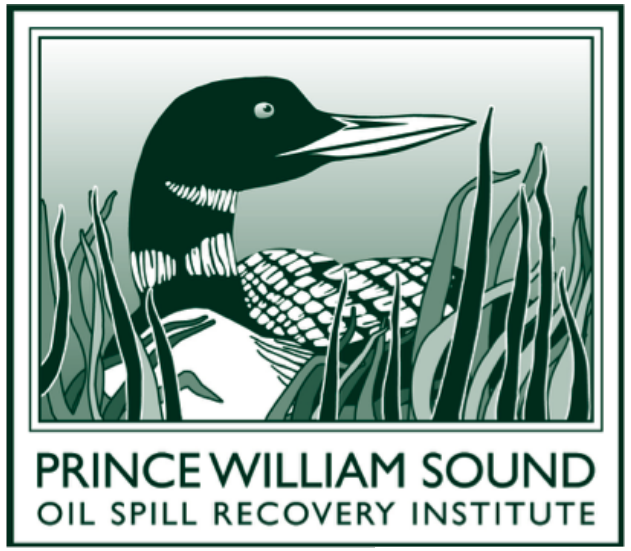
# Conclusions

- Non-ionic surfactants in Corexit rapidly biodegraded
  - DOSS and DGBE need more investigation
- Oil+Corexit degradation: Corexit non-ionics begin degradation first, then oil
- No evidence Corexit inhibits oil biodegradation
- Oil and Corexit can enrich different microbial communities
  - Enriched taxa may be putative degraders
  - Some taxa respond to both substrates – may be capable of degrading both



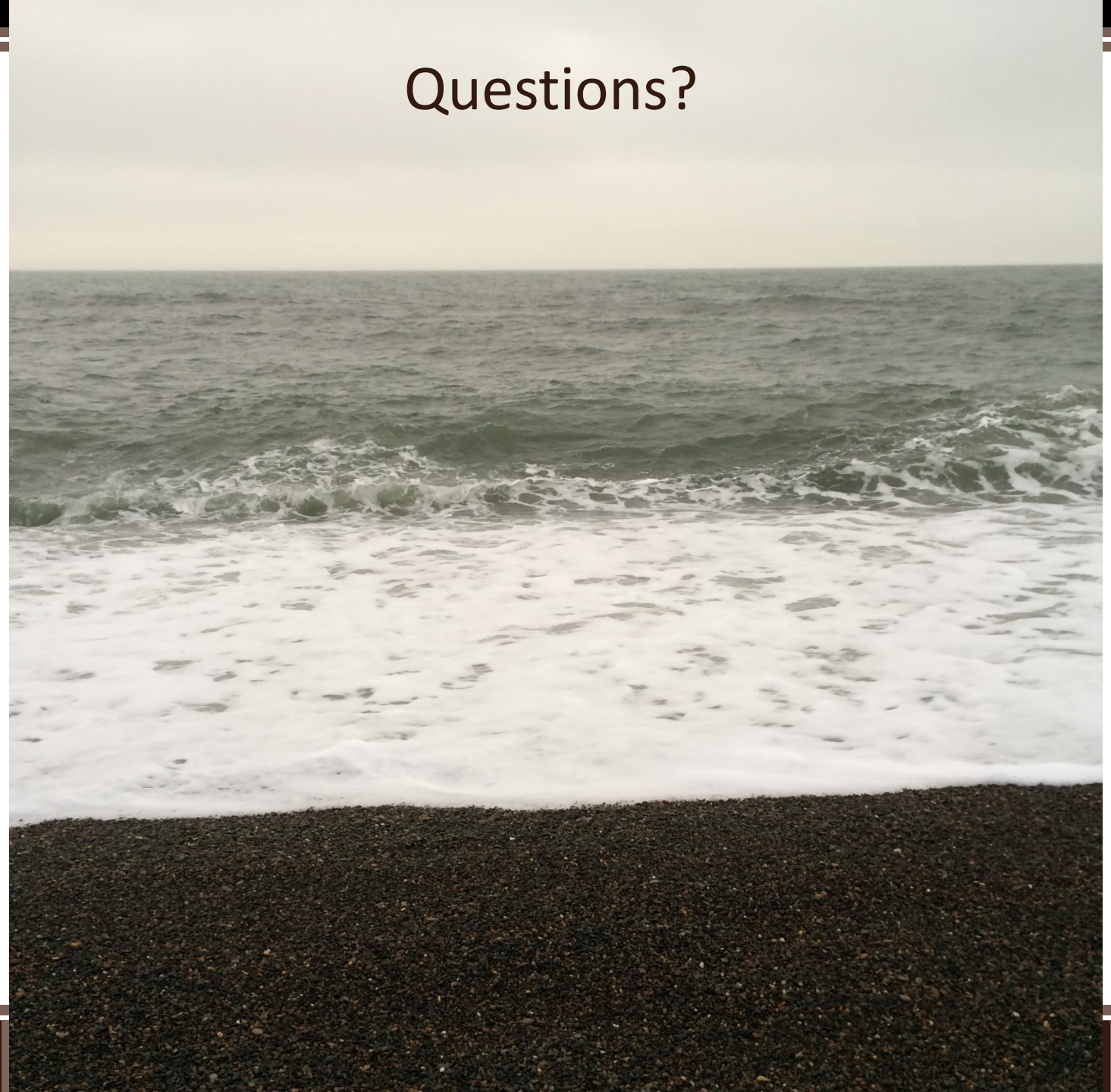
# Acknowledgments








# Questions?



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