Understanding microbes: a collaborative framework for understanding the fate and impacts of hydrocarbon spills

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What happened (happens) to the oil?

Some fates:

- collection
- volatilization
- photochemical degradation
- dispersion in the water column
  - suspensions, colloids, DOC
- deposition in sediments

- microbial biodegradation

- *Key point: bacteria represent the greatest living surface area in the oceans; though much is known, hydrocarbon impacts on the collective microbial biosurface remain a "black box"*

What did we know about biodegradation before the spill?

- genetics, physiology, and ecology of numerous alkane- and aromatic-degrading bacteria have been well documented
- distribution and diversity of some hydrocarbon-degrading functional groups have been documented for some hydrocarbon-contaminated coastal and terrestrial systems
- biodegradation rates for some groups of hydrocarbons have been documented for some contaminated water column, sediment and soil systems
- efficacy of nutrient and bacterial amendments are generally understood though continue to be debated

What did we know about biodegradation after the spill?

- Deep-sea bacterial communities respond rapidly to hydrocarbon inputs, especially LMW fractions, at low temperatures (Hazen, Valentine)
- Degradation rates for some hydrocarbon classes appear relatively rapid, even at low temperatures
- Hydrocarbon degraders include as yet unisolated taxa, but they appear similar to known strains and express readily identifiable genetic systems for biodegradation
- Low molecular weight alkanes, e.g., propane, may prime degradation of higher molecular weight alkanes

We also know:

- Pathogen “blooms” are not likely ✗
- Even massive spills do not necessarily deplete dissolved oxygen adversely ✗
- Permanent changes in microbial communities are not likely ✗

What do we need to know?

- Microbial community composition and genetic potential:
  - wetlands to deep-sea
  - temporal and spatial variability
  - * high-throughput sequencing and analysis collaboratories

- Controls of hydrocarbon-degrading bacteria:
  - distribution, activity, ecology
  - expression of biodegradation genes
  - * integrated observational-experimental teams from wetlands to the deep-sea

- hydrocarbon mediated changes in animal/plant-microbe interactions:
  - impacts of stress on pathogen susceptibility
  - trophic transfer of hydrocarbons
  - disturbance of biogeochemical cycles
  - * integrated observational-experimental teams from wetlands to the deep-sea

What are some achievable goals?

- Incorporate observations of microbial communities and activities into long-term observatories from wetlands to the deep-sea

- Develop bioindicators for hydrocarbon impacts deployed on moorings, AUVs, labs-on-chips

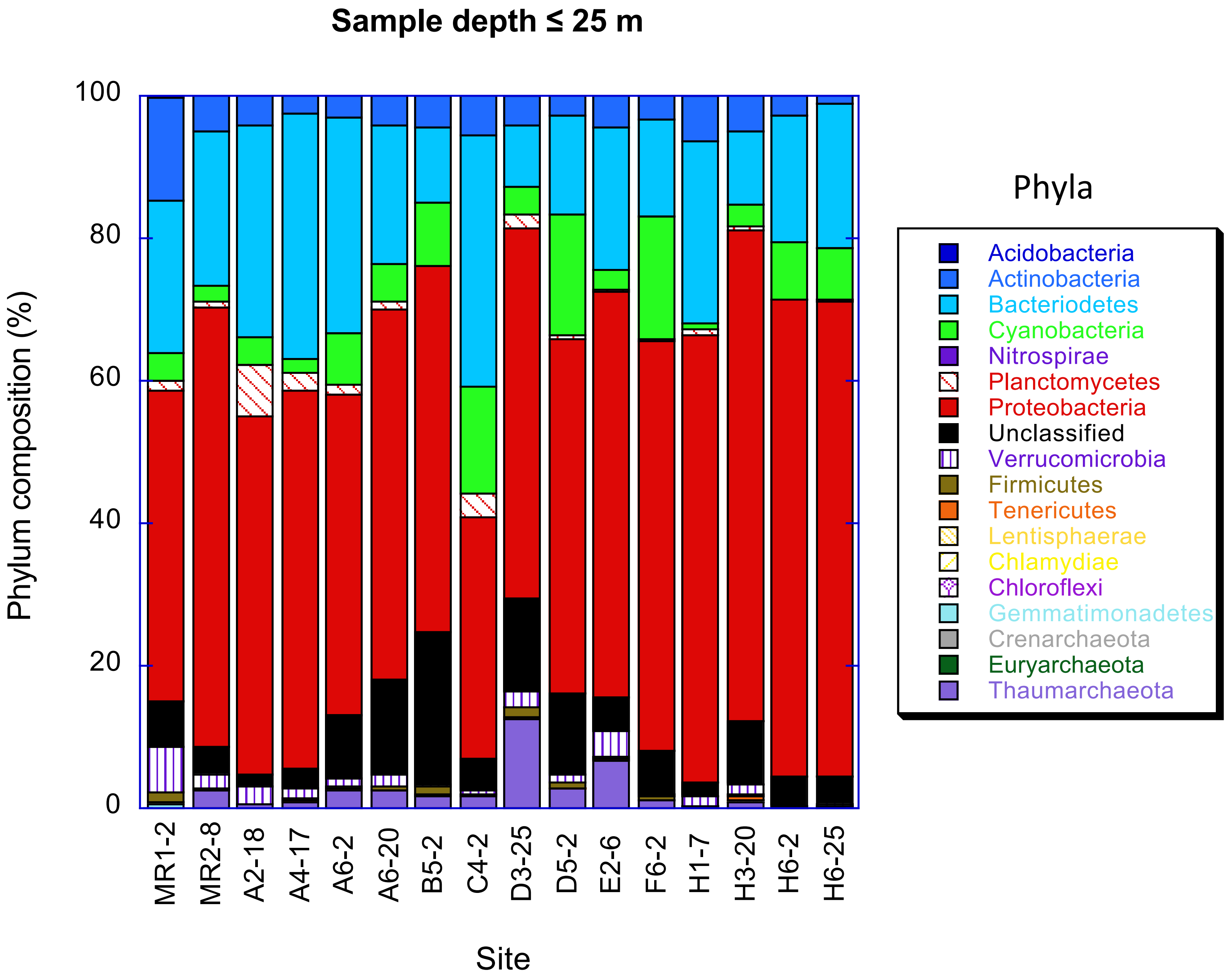
- Incorporate microbial community dynamics and activities into predictive numerical models for hydrocarbon distribution and fate

- Develop predictive models of microbially mediated hydrocarbon impacts on plant and animal communities

and

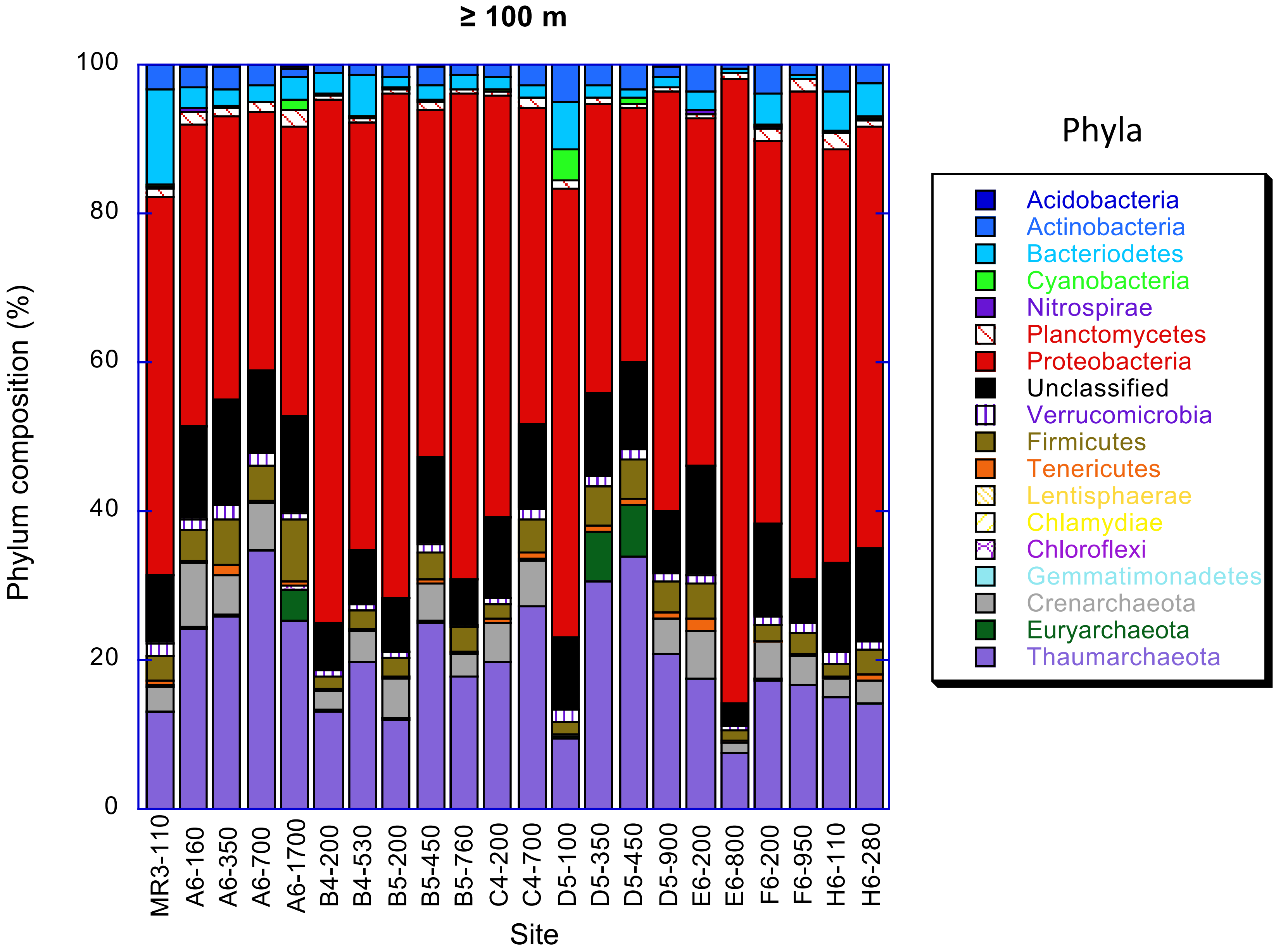
- Improve communication of risks and likely outcomes of spills to the public and policy-makers – (re)earn public trust

- Microbial community composition varies markedly in surface waters across the northern Gulf of Mexico

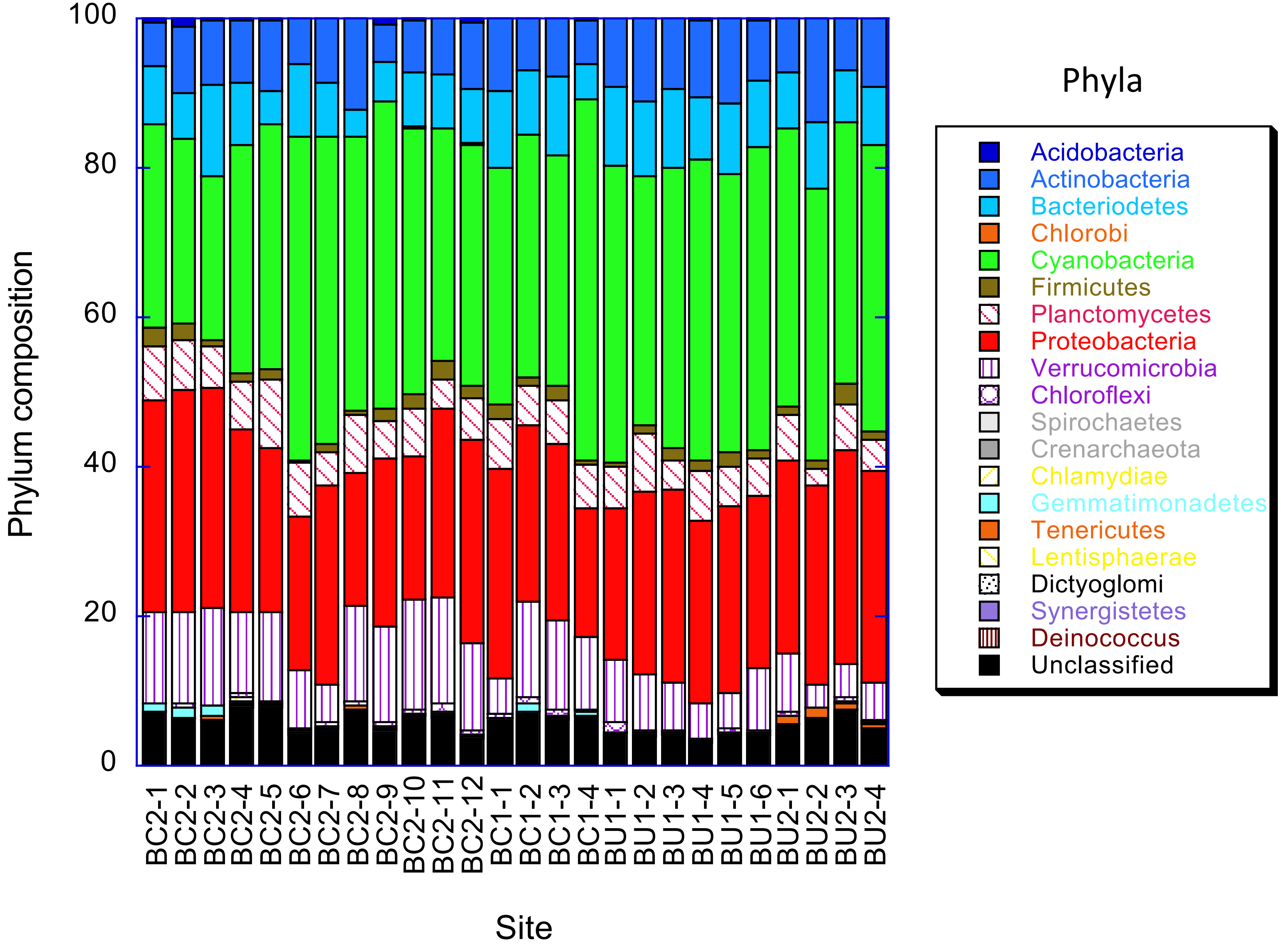


Sample depth ≤ 25 m

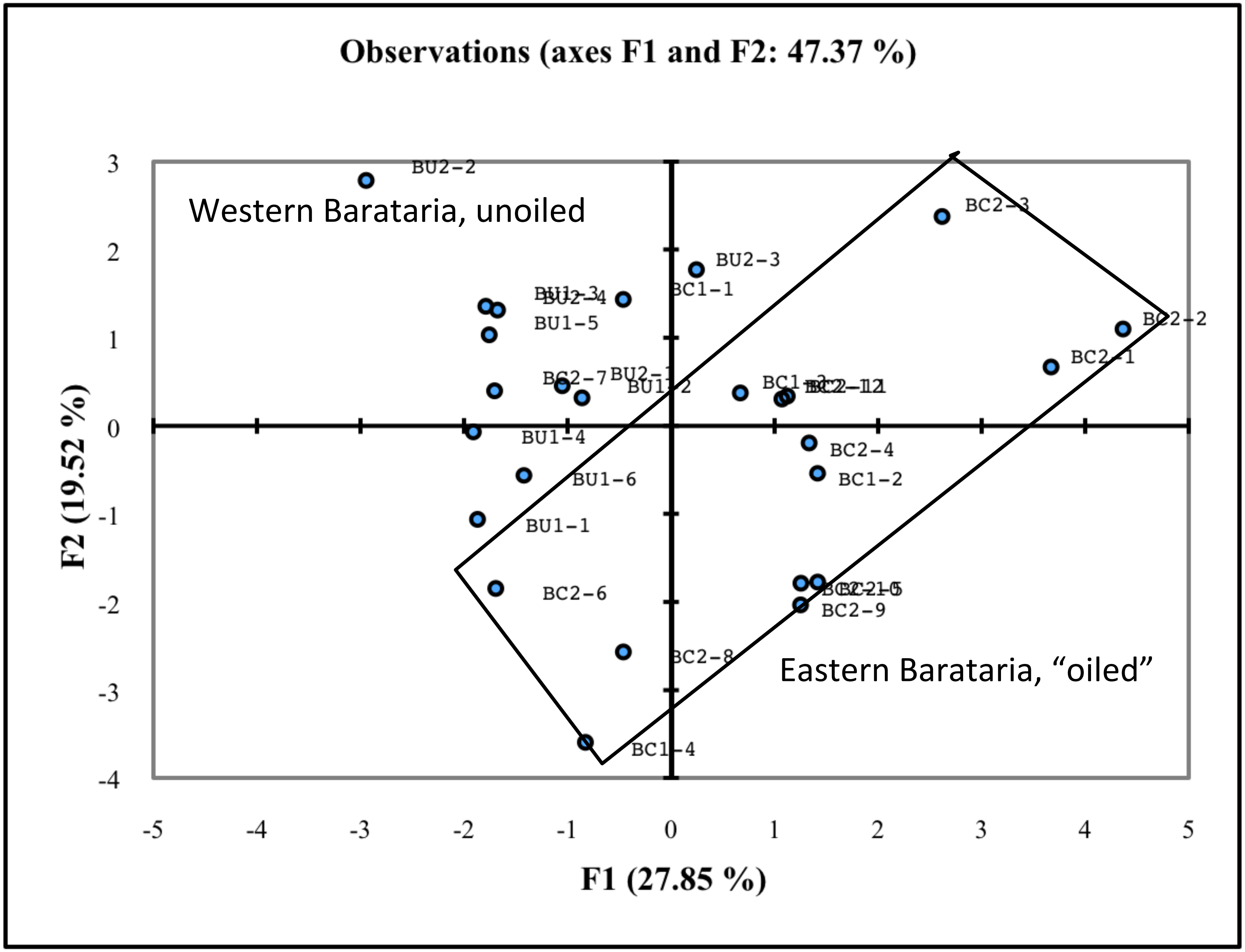
- Microbial communities vary dramatically from surface to deep waters in the northern Gulf of Mexico; increased archaeal abundance is notable



- Microbial community composition in Barataria Bay differs dramatically from nearshore-offshore communities, and shows small-scale spatial structure



- Microbial community composition varies spatially across Barataria Bay… responsive to hydrocarbons?



Western Barataria, unoiled

Eastern Barataria, “oiled”

- Oyster microbial communities differ dramatically from water column, among habitats and from stomach to gut