SCOPE OF WORK:

Traditional biodegradation studies employ the bulk sampling of liters of seawater at discrete time intervals from marine locations or laboratory batch reactors. While these macroscale approaches are important for assessing the biogeochemical state of the environment, they are not designed to elucidate underlying physicochemical mechanisms that fundamentally control transport and biodegradation in marine waters. Our microscale approach addresses this shortcoming through the ability to systematically control the microenvironment with microfluidic devices while closely observing bacteria dynamics via microscopy. Insights regarding micro-scale processes of how bacteria physically attach to and colonize individual oil droplets are crucial towards (i) understanding the fate and transport of hydrocarbon pollutants in the ocean, and (ii) establishing a quantitative mechanistic framework that will improve environmental-scale contingency planning. Proposed experiments build upon preliminary results from the Juarez lab at Illinois that analyze the physical attachment of bacteria to stationary oil droplets through direct visualization using optical microscopy with novel microfluidic devices. By integrating direct observations in microfluidic devices with mechanistic models, this flexible toolset facilitates analysis of an array of environmentally relevant parameters such as droplet size distribution, crude oil composition, oil-degrading bacteria concentration, biofilm growth, and community composition. By doing so, this research over the next four years will:

- Provide the first direct visual description of microbial attachment and growth rates on the surface of oil droplets of varying sizes at unprecedented temporal resolution.
- Bridge lab results and field measurements by establishing a direct link between physical processes at the microscale and the oil transport observed in situ following oil spill events.

A long-term research goal of the Juarez Research Group is to counter the impact of marine oil spills on society and marine ecosystems by optimizing bioremediation strategies based on fundamentally understanding the remarkable natural ability of marine bacteria to degrade hydrocarbons. This multidisciplinary research proposal targets the underlying physicochemical mechanisms between bacteria and individual oil droplets. The objectives of our proposal are indeed resonant with that of the OSRI Research Program. By following through with our proposed project, we will gain a better understanding of the impact of bacterial growth on oil droplet size and morphology, which ultimately influence the fate and transport of dispersed oil in marine environments. Our research would also guide oil spill mitigation strategies by informing decision makers with fundamental and sound scientific results.