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ULTRA-VIOLET LIGHT AND CLIMATE-CHANGE STRESSORS INCREASE OIL TOXICITY AND MORTALITY IN ESTUARINE ORGANISMS

Understanding how salinity, temperature and UV light modify the toxicity of oil to estuarine species can help predict environmental damage and recovery following an oil spill.

The Deepwater Horizon oil spill that occurred in April 2010 is known as the nation's most detrimental offshore environmental disaster. Over the course of almost three months, approximately 134 million gallons of crude oil was released into the Gulf of Mexico. Tens of thousands of marine organisms, including dolphins, sea turtles, several bird species, and marine plants such as mangroves, whose roots hold together the eroding coasts of Louisiana and South Florida, were negatively affected by this calamity.

Estuarine organisms are particularly vulnerable and sensitive to oil pollution, especially during early life stages, given the stressful environmental conditions of their habitat. Estuaries experience daily tidal fluctuations in light penetration, temperature, and salinity; and the range of these factors is expected to increase with global climate change. These changes could also magnify the toxicity of chemicals in the water.

One environmental factor that can change the toxicity of oil is ultraviolet (UV) light from the sun. Crude oil is made up of polycyclic aromatic hydrocarbons (PAHs), which are formed from the incomplete burning of fossil fuels. When oil spills happen, UV light can change the PAH chemistry, making oil up to 100 times more toxic to marine organisms.

Cheldina Jean, an undergraduate student at American University and a summer intern with the College of Charleston (CofC) Fort Johnson REU program, is investigating the effects of UV light on the toxicity of oil on larval grass shrimp when paired with climate change factors such as salinity and temperature. "Toxicity assessments are usually conducted under ideal conditions of light, temperature, and salinity for the test organism. Unfortunately, those toxicity values may not be representative of environmental conditions, now or with future changes in climate. Every oil spill has different conditions so it important to examine how organisms respond to oil using a greater range of test conditions" (Marie DeLorenzo).

Grass shrimp are commonly found in estuarine waters of South Carolina and along the Gulf and Atlantic coastlines. Grass shrimp are detritivores, playing an important role in estuaries by recycling the nutrients of decaying matter back into the food chain. They are also an important prey species for commercially and recreationally important marine organisms, such as spotted sea trout and red drum.

Image of grass shrimp with eggs. Photo credit: Katy Chung

For this project, Jean and researchers with NOAA's National Centers for Coastal Ocean Science, collected adult grass shrimp with eggs from Leadenwah Creek, located on Wadmalaw Island, Charleston, SC. The oil Jean used in her tests was obtained through NOAA from the Deepwater Horizon oil spill. Jean collected the larvae once they hatched and exposed them to two types of oil exposures likely to occur after an oil spill, 1) High Energy Water Accommodated Fraction (HEWAF), which is dissolved oil in seawater, and 2) thin oil sheen, which is a thin layer of oil placed on the surface of the water.

Jean collecting grass shrimp with eggs at Leadenwah Creek. Photo: Katy Chung

Jean creating a HEWAF
Photo credit: Katy Chung

For both oil exposure scenarios (HEWAF and sheen) Jean set up larval shrimp under combinations of the different environmental conditions: UV or no UV (using UV light bulbs or cool-white fluorescent bulbs, respectively) temperatures of 32 °C (90 °F) and 25°C (25 °F), and salinities of 10 ppt, 20 ppt, and 30 ppt, which represent a range of Southeastern estuarine conditions. Every 24 hours, the amount of larvae that survived and the amount that died were recorded. Each test ran for 96 hours and on the 96th hour, Jean recorded water quality (temperature, dissolved oxygen, salinity and pH).

The results showed that UV light alone altered the chemical composition of the oil as both a HEWAF and sheen, leading to greater toxicity to the larvae in all of the tests. The lower salinity of 10 ppt and the higher temperature of 32 degrees Celsius were the most stressful climate conditions for larval grass shrimp in both the UV and non UV conditions. The high salinity of 30 ppt did not significantly alter oil toxicity. Combining UV light with high temperature and low salinity significantly altered the toxicity of oil and further increased the mortality of larval grass shrimp.

Although we cannot eliminate oil pollution in the ocean, the results of this research will help us characterize how multi-stressors and oil affect the early life stages of aquatic organisms. Understanding how salinity, temperature and UV light modify the toxicity of oil to estuarine species will help resource managers predict environmental damage and recovery following an oil spill.

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For more information on this project and the NSF REU program, please visit http://www.reu.cofc.edu/ and the CofC REU blog website: http://www.blogreu.wordpress.com/

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