"All of the studies in my lab are based on understanding on how the marine ecosystem recovers from oil spills naturally and how we can speed that process up."

(Photo: Greg Trauthwein)

Dr. Lee in front of BIO's Wave Tank Facility.

Dr. Kenneth Lee is the Spill Stopper

Dr. Kenneth Lee is a world-renowned authority on the use of chemical dispersants in the clean-up of oil spills. A pivotal player in some of the world's biggest oil spill clean-up events over the last 30 years, Dr. Lee and his team are dedicated to continually learn about and work in harmony with Mother Nature to help restore affected habitats as quickly and environmentally sound as possible.

By Greg Trauthwein, Editor & Associate Publisher

An oil spill is much like a snowflake, in that no two are alike and both are ever-changing. Different water temperature and environmental conditions, differing types of oil and response capability, and the sensitivity of the habitat in the area of concern and its living resources are just a few of the factors that conspire to make each oil spill event unique.

While the nature of oil spills may differ, the approach by Dr. Lee – a Research Scientist and Executive Director of COOGER, the Center for Offshore Oil, Gas and Energy Research for Fisheries Oceans Canada – is unwavering. While he is an expert on the use of chemical dispersants in remediation of oil spills – having taken up the study in the early 1980s – the central theme to the work of Dr. Lee and his team at COOGER in Halifax is working with Mother Nature to restore the affected area as quickly, and least intrusively, as possible. "What we want to do is understand natural recovery, because natural recovery is much stronger than people think," said Dr. Lee. "There are natural oil seeps around the world; petroleum hydrocarbons are not new to the environment," Lee said. "Natural bacterial populations have adapted to its presence and break it down as a food source. If it wasn't for natural biodegradation of oil, we'd be knee-deep in oil right now." In the case of large, concentrated spill, Dr. Lee said nature simply is not equipped to metabolize the oil fast enough. "The question is this: how can we enhance that rate of natural recovery?"

While there are dozens of factors that make the treatment of oil spills tricky, adding cold, icy waters to the equation quickly escalates the difficulty of operation. Lee, who is co-chair an International Maritime Organization (IMO) Working Group to establish Guidelines for the use of dispersants in the treatment of marine oil spills, finds his time increasingly devoted to studying protocol in the handling a major oil spill in cold waters and harsh environments including the Arctic.

Challenges in Ice

When it comes to marine and subsea activities in the Arctic, the stakes become much higher. The risk of oil spills in this region is ever-increasing due to increased marine traffic associated with community growth, the growth of the ecotourism industry, the recent lengthening of the ice-free period, and the growth of industries such as mining and offshore oil and gas. Indeed, as the world's onshore oil and gas reserves increasingly deplete on land, the world turns to offshore sources, more and more to frontier areas such as the Arctic where technology allows oil companies to discover and recover resources in ever more remote and deep portions of the planet.

Setting up shop and producing oil and gas in hostile environments is one thing; preparing for and enacting an oil spill response plan in the event of disaster is entirely another. "There's concern that an oil spill will occur in the Arctic, and the question is 'do we have the countermeasures in place to protect the environment and its resources," said Dr. Lee. "When you're talking about battling an oil spill in the Arctic the big challenge is working in the Arctic environment itself," said Dr. Lee. "Besides the weather, you have the major problem of logistics, as you're not able to get people or resources to a certain spot as quickly, and where do you deposit the waste from clean-up operations?"

In addition, there is the problem of how oil interacts with ice, which is significantly different than how it interacts with water. "What do you do when you have broken or solid ice; what would you do if you have a subsea blowout during the winter seasons?," asked Dr. Lee, "Unfortunately, most of the current equipment for physical recovery of oil has been designed and tested for use in ice-free waters."

Dr. Lee and his colleague maintain a busy pace today evaluating new techniques and technologies being devised to deal with such an occurrence. "There are a lot of environmental challenges: extreme cold temperatures, limited daylight hours, and also the fate, behavior and biological effects of oil in a cold water harsh environment."

Dispersants

"I support the use of chemical oil dispersants under the right conditions. Our research team has been conducting ongoing studies to see the long-term effect of dispersants in the water column. It is always important to remember that low toxicity does not mean no toxicity," Dr. Lee said. "But there is something people forget when you talk about oil dispersant use. Would I add chemical oil dispersants to a pristine environment? Of course not. But what you have to understand is that when you have an oil spill, you have a contaminated environment that you need to remediate, or bring back to where it was. We are treating a contaminated site, and we're trying to reduce the detrimental effects. Before we use dispersants, we always conduct a Net Benefit Analysis. And in some instances, we simply decide the best measure is to let nature takes its course."

Courtesy of a diverse background, Dr. Lee started working on oil dispersant in the early 1980s. "I did a post-doctoral fellowship in chemical oceanography on the West Coast in the Institute of Ocean Sciences in British Columbia, and as it turned out because I had an interest in hydrocarbons and expertise in microbiology; I worked on oil dispersants."

Work today focuses on new formulations of dispersants that are more efficient in the break-up of heavier oils. "If you would have asked me 10 years ago would we use oil dispersants off the east coast of Canada I would have said 'no', because it was thought that the hydrocarbons off of Newfoundland – those waxy crude oils – were too viscous to use a dispersant," Dr. Lee said. "Of course now, with several major oil spills being heavier oils such as Prestige and Erika, there are new formulations and it turns out that they are effective for some of these heavier oils, so we started studying chemical oil dispersants again. In addition, we built a wave tank facility at Bedford Institute of Oceanography (BIO) specifically for that." As it turned out, this investment would prove beneficial in the Gulf of Mexico.

BIO's Wave Tank Facility

At Dr. Lee's base at BIO in Dartmouth, NS, he spearheaded the construction of a unique wave tank which allows scientists to closely study the interaction of oil and water in a raucous real-world wave environment. The wave tank was co-funded by the U.S. and Canada, and it was designed to generate wave energy similar to that in the environment, including breaking waves. The platform allows the team to test types of crude oil and dispersant combinations in the push to deliver guidelines for dispersant use. In addition, the open flow-through nature of the system (to mimic current flow) allows the team to conduct toxicity tests to determine the combination's effect on the water column under realistic exposure conditions.

Dr. Lee points to specific 'knowledge gaps,' gaps highlighted by a U.S. National Academy of Sciences report which reviewed the use of chemical oil dispersants, that BIO's wave tank helps to fill, including:

- Under what conditions do oil spill dispersants work? We know for them to work, we also need energy to break the oil into smaller droplets, Dr. Lee said.
- If they do work, how efficient are they? And how do you measure their efficiency?
- The role of Bacteria: Bacteria can only attack oil at the oil/water interface. If you can increase the surface area of the oil, ie. break the oil into smaller droplets, you can enhance and expedite the breakdown of oil.
- If the dispersants do work, what are their short and long-term biological effects?

When you use chemical oil dispersants, you are trying to break the oil into very small droplets, which are then diluted in the water column to concentrations below that that has biological effects, Dr. Lee said.

By virtue of Dr. Lee's career accomplishments, and the fact that his team already had collaborative project in place with techniques to monitor dispersant toxicity, he services following the massive Gulf of Mexico blowout and resulting spill was a natural.

According to Dr. Lee, there was a keen and immediate interest in using dispersants in the GOM spill for two main reasons:

- The Wetlands: There was the concern that the oil would breach sensitive ecological wetlands and kill the plants. If you kill the plants and lose the roots, massive erosion could effectively wipe out the wetlands.
- Human Safety: There was so much oil around the rig (and the rig drilling of the relief well) that there was a very high concentration of Volatile Organic Compounds (VOCs), making it unsafe for humans. To work they were forcing them to wear protective gear, slowing productivity to stop the leak.

Because of the volume of oil spilled, however, there was concern regarding the volume of dispersants entering the environment. This led to a world first: the direct injecting of the dispersant at the wellhead at a depth of 1500 meters. Taking this drastic step was deemed necessary, as "You knew that you were applying the dispersant directly to the oil. Also, as oil surfaces through the water, it becomes emulsified, and emulsified oil – which basically has the consistency of mayonnaise – is much harder to deal with."

In total his team spent four months in the region, not only advising on the use of dispersants but monitoring their effects on the environment, and even tracking the much reported sub-surface 'oil plume' through the Gulf.

While Dr. Lee's career and knowledge base is inextricably linked to the use of chemical dispersants, he is always quick to stress the overriding nature of his work: "All of the studies in my lab are based on understanding on how the marine ecosystem recovers from oil spills naturally and how we can speed that process up."