OLEO SPONGE FIELD TEST – PHASE 1 REPORT

prepared for the Anthropocene Institute

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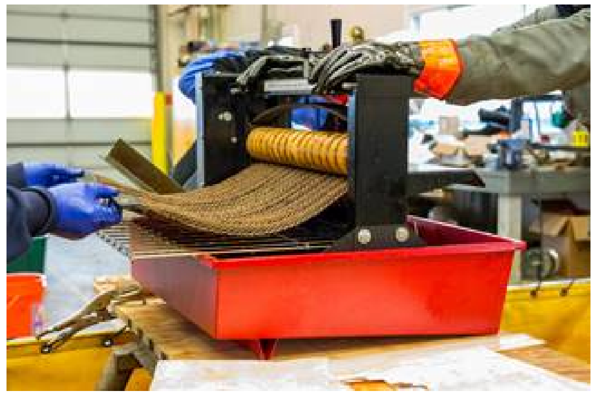
BACKGROUND AND **SIGNIFICANCE**



Argonne National Laboratory researchers have invented a technology for recovering oil and other petroleum products from bodies of water that surpasses similar technologies that are currently on the market in several key aspects:

- The technology is the first and only option to effectively and efficiently adsorb oil and other petroleum products below the water surface. Current industry-standard technologies only address the surface.
- Oleo Sponge is reusable (you simply wring the reclaimed oil into a holding tank). This dramatically reduces waste resulting from the clean-up process and enables a small amount of adsorbent to mitigate enormous spills. Current sorbent technologies soak up oil in a single use, and the oil-saturated materials must then be disposed of.
- Oleo Sponge is environmentally friendly – doing no harm to sea life, animals or the larger environment – a key advantage when compared with chemical dispersants or burning techniques that are used today. Previously captured oil will not shed from the sponge, even when it is dragged through the water.
- Oleo Sponge demonstrates unparalleled sorption performance.
- The oil and other petroleum products that are recovered by Oleo Sponge can be salvaged for future use.

Following substantial media coverage of Oleo Sponge technology (CNN, *Wall Street Journal*, *Business Insider*, etc.), Argonne has received approximately 500 serious commercial inquiries from a broad range of sectors. The largest response has been from the oil and gas industry, including potential applications beyond oil spill mitigation, but there has also been interest from the cosmetics, medical, and other industries.

Our goal for the Phase I field test funded by the Anthropocene Institute was to validate Oleo Sponge in a setting analogous to that presented by real-world oil spill scenarios. The focus of the test was to validate the technology for surface slick mitigation. Together, we aim for these results to catalyze the technology into an initial market.

PROJECT SUMMARY

Through work funded by the U.S. Coast Guard and Bureau of Safety and Environmental Enforcement, the oil sorption performance of Oleo Sponge has been demonstrated both in the laboratory and at scale at the Ohmsett facility in subsurface crude oil and diesel fuel sorption from within the water column. As a critical next phase in moving this technology from the laboratory to real-world use in oil spill mitigation, performance must be demonstrated in an environment closer to an operational setting. Issues associated with deployment from a vessel, collection on deck, and presence of marine obstacles are important to explore. Natural oil seeps, such as those off the coast of southern California, offer such an environment.

The Coal Oil Point seep field is located in the Santa Barbara Channel offshore from Goleta, California. The seeps, located in water depths of 20–80 meters, have been active for at least 500,000 years. Combined, seeps in the field release approximately 40 tons of methane, 19 tons of other organic gases, and more than 100 barrels of liquid petroleum each day.

In Phase 1, the Oleo Sponge was tested for the first time in a real-world setting. This phase, funded by the Anthropocene Institute, was particularly focused on testing sorption performance for surface slick mitigation. As may occur during environmental remediation, the Oleo Sponge was tested in a manual vessel-borne deployment at Coal Oil Point. This method of deployment provided a base platform from which more advanced configurations can be explored. Such Phase 2 explorations may explore mitigation in the water column at an oil seep location and include the implementation of a belt and wringer apparatus. A further goal of such field tests is to identify strengths and weaknesses of various potential form factors of the sorbent suitable for deployment.

The Anthropocene Institute's support for the partnership with Argonne and IGM Technologies (IGMT) enabled the Phase I test, which included direct oil collection on a vessel chosen by local fishermen with experience supporting similar projects with IGMT staff, proper disposal, and decontamination of the vessel and overboard gear.

Together this partnership aimed to:

- Manufacture a set of Oleo Sponge pads
- Examine the deployability of Oleo Sponge from a vessel in open water
- Determine the feasibility of using Oleo Sponge to recover crude oil from seawater
- Evaluate fluid recovery performance

RESULTS

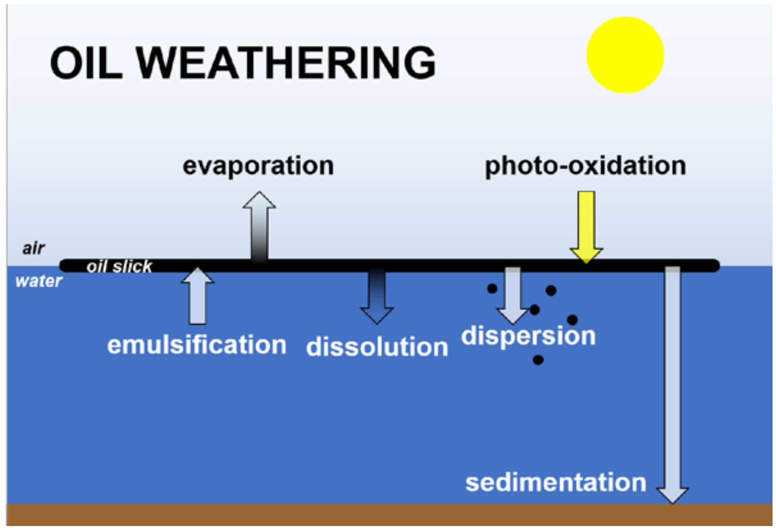
Preparation

Over the course of several months, our team optimized the design for sorbent pads and then manufactured a set of approximately 2’ × 2’ pads, each containing one of three different sorbent materials: commercial polypropylene, untreated polyurethane foam, or Oleo Sponge. The Oleo Sponge were manufactured using the same procedure as that used to create the materials used for testing at Ohmsett in 2016. These pads were brought by team members to the test site. Our industrial wringer was shipped to a holding location and retrieved upon the team’s arrival in Santa Barbara. The Argonne team met with Gordon Cota, who was the local logistics coordinator for this project, and discussed the plan for the following two days of testing on the water.

The vessel selected by our partners was the *Double Bogey* (pictured here), a small fishing boat with a fully open stern, enabling easy access to the water, and captained by an individual with extensive experience operating in the oil seep area. After inspecting the layout on the deck, the Argonne team devised a plan for installing the wringer in such a way that it would be secure during operation under ocean swell or choppy conditions.

The wringer was mounted on a sturdy piece of plywood with a hole drilled and aligned beneath the drain for the wringer’s collection basin. The plywood was secured on one side to the boat’s gunnel with screws and on the other side to a crab crate using zip ties. Wood pieces were installed on two sides of the wringer to prevent motion starboard or portside, and clamps were attached to prevent motion toward the bow or stern. A customized funnel with a threaded spout was affixed to the underside of the plywood, such that bottles could be screwed onto the bottom for collection of fluids without spillage.

Environmental conditions and oil weathering



Crude oil is a blend of dozens or even hundreds of different chemicals. Each of these constituent chemicals has unique behavior in the environment. When oil enters the ocean, these chemicals interact with the local physical and (bio)chemical environment. These interactions control the ultimate fate of the oil. Some components of crude oil are highly volatile and evaporate rapidly. Sunlight also contributes to various chemical transformations of some components. As evaporation and reactions take place, the properties of the oil (viscosity, density, etc.) evolve. The oil that has just entered the environment is called "fresh," and its evolution is called "weathering" (see figure).

The weather conditions were similar for both days of testing, with temperatures around 70 °F, mostly clear skies, and little to no wind. As a result, as the oil from the seeps found its way to the ocean's surface, it spread out into an ultrathin sheen covering large areas. This sheen weathered rapidly, because nearly all of the material was exposed to air, water, and sunlight. Wind is necessary to collect the oil into localized areas and form well-defined, thick "streamers." The calm conditions we encountered meant that streamers formed slowly, at which point the oil was highly weathered, as in the photo shown here. This weathered oil had a viscous, tar-like consistency because most of the volatile components had evaporated, leaving behind long-chain hydrocarbons.

In the morning hours, before the sun had an opportunity to weather the oil, fresh sheens were found, which offered an opportunity for important experiments described below. With only oil sheen available (as opposed to fresh streamers), however, there was not enough oil on the surface in any given area to capture significant amounts and perform quantitative comparisons between the different sorbent pad materials. Despite this, we did use the opportunity to test usage of the wringer on deck, putting our pads through and collecting oily water captured from the ocean. The collection system worked perfectly (see photo), indicating that this method of fluid recovery is feasible under the operational conditions experienced in a small vessel on the open water. This information will be valuable for future studies and for potential deployment in oil spill response.

Mitigation of oil sheen

In accordance with Section 311(j)(1)(C) of the Clean Water Act as amended by the Oil Pollution Act of 1990, any spill that produces a visible sheen on the water must be reported to the federal government. A corollary is that, when a spill occurs, it is not considered clean until even the sheen is removed. Oil sheen cannot be mitigated using typical spill response techniques such as skimming or performing an in situ burn. Today, the most common strategies employed by spill responders for mitigating sheens are the use of gelation agents, which coalesce the sheen into a floating solid that can be recovered using a skimmer but also greatly increase the volume of waste, or single-use sorbents, which become hazardous waste themselves after collecting oil. Moreover, commercial sorbents are often slow to capture oil, consuming substantial time and effort. *A superoleophilic, reusable sorbent, such as Oleo Sponge, is a potential game-changer in this area—but only if it is capable of adsorbing oil sheen from the ocean. The conditions present at the oil seeps during our field test afforded a perfect opportunity to explore this aspect of oil spill remediation*.

Oleo Sponge pads were secured to long PVC pipe for deployment on the oil sheen and easy recovery (see photos). Numerous runs were performed, using both very fresh and somewhat weathered oil. In all cases, Oleo Sponge successfully lifted the sheen from the water, leaving behind no visible oil. Videos of this process, submitted to accompany this report, provide compelling evidence for the efficacy of this technology for oil sheen mitigation.

CONCLUSIONS

Oleo Sponge was put to the test for the first time in a real-world setting, taking advantage of natural oil seeps at Coal Oil Point near Santa Barbara, CA. Because of environmental conditions on the day of the test, the oil was only present in the form of a sheen, precluding quantitative investigation of sorption capacity or selectivity in this setting. However, this test represented several important landmarks for the Oleo Sponge technology, namely:

- **Successful deployment of Oleo Sponge in the open water**
- **Demonstrated ability to perform wringing and fluid collection on a vessel in the field**
- **Successful capture of oil sheen using a reusable sorbent and without the use of gelation agents**

FUTURE DIRECTIONS

The results described above serve to validate Oleo Sponge in the eyes of the oil spill response community and demonstrate the promise for the technology to be a potential game-changer. Our team aims to continue the validation of this technology through the following (Phase 2) explorations:

- To make quantitative comparisons in sorption performance between Oleo Sponge and commercial sorbents in the field.
- To determine the best options for water surface deployment. These may include booms and pads or even a coating on mechanical drum, disk, and belt skimmers; and a variable speed belt that might optimize the sorbent capacity by controlling contact time and thereby increasing recovery rate.
- To evaluate the ability of Oleo Sponge to mitigate oil in the water column in the field, and to determine the best deployment options for this subsurface oil mitigation. These might involve tactics utilizing booming and air curtains for concentrating suspended oil then attacking it at the surface, with recovery taking place down current, or integration with a net for capture below the surface.