Prediction models help determine best oil spill response

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Credit: Texas A&M University

Oil spills can be catastrophic, impacting health, the ecosystem and the economy. The severity of an oil spill's impact depends on the amount and source of oil, what courses of action responders choose and the physical properties of the oil. Research at Texas A&M University has resulted in stronger prediction models that will play a critical role in assessing the pros and cons of tactics used in future spills.

The presence of oil in the ocean affects surface and subsurface organisms and resources linked in a complex way, including humans. Damages include that which we see directly impacting wildlife, such as coating birds or mammals with a layer of oil, and the toxicity of the oil itself, which may be poisonous at high enough concentrations.

Oil spill research at Texas A&M seeks to mitigate the effects of future spills, predict the hazard conditions under future spill scenarios, and help with decision support in future spills for the response effort. It takes into consideration the solubility of oil, something previously ignored in past models, which allows for different predictions of impact on the ecosystem.

"With the Texas A&M Oilspill Calculator, TAMOC, we are able to demonstrate the best choices for a blowout model and help to improve model prediction," said Dr. Scott Socolofsky, professor in the Zachry Department of Civil Engineering. "Better predictions will save resources during the next major subsea blowout by helping to direct the response."

A blowout occurs any time an operator loses control of the flow rate in an oil well pipeline. Blowouts are most likely to occur during drilling of a new oil well since less is known at that time about the characteristics of the oil reservoir. Only in extreme cases do blowouts result in oil spills, as occurred during the Deepwater Horizon accident.

Droplet size is one of the most important parameters to consider when viewing spill magnitude, as droplets are transported differently through the vertical plume and encounter the layered density structure of the ocean.

Smaller oil droplets are affected by inner ocean turbulence and can become trapped in an intrusion layer and degraded by bacteria in the water column. Larger oil droplets rise to the sea surface because the internal ocean turbulence is not strong enough to keep them in an intrusion layer.

"To truly understand the transport, it is necessary to study the characteristics of the turbulence," said Chris Lai, Ph.D. student. "I measured these velocities and used equations of fluid mechanics to study them. The outcome is a better understanding of the transport mechanisms."

While it didn't set out to prove one way or the other, the model confirmed that subsea dispersant use is likely to be an effective mitigation strategy during the phase of the spill before the blowout is contained. The study relies on an assumption about how the dispersant will act, which is based on laboratory experiments in another paper (Brandvik et al., 2013). The conclusions are based on the predictions from several mainstream models. Hence, if dispersants are effective as they were in the Brandvik laboratory experiments, then mainstream models predict that subsea dispersant injection is an effective mitigation strategy during the early phase of a blowout, while containment equipment is being mobilized and installed.

Dispersant is a surfactant and acts a lot like soap. It helps the oil to "stick" to the water, allowing it to break up into smaller droplets, which are more easily dispersed in the environment. It is pumped directly into the oil and gas flow at the blowout source, ideally about 6 to 12 feet down-hole in the pipeline. It should be applied as soon as a leak to the water column is detected. Some new wells are likely being constructed with the capability to inject dispersant built into the well. When that is not the case, a remotely operated vehicle must be used to inject the dispersant from a pipeline from a supply ship.

When considering trade-offs, one has to remember that an oil spill is already a bad event for the environment. The choice to use dispersants is made whenever they will reduce exposure of toxic oil compounds to people. People usually encounter oil through fumes in the air, oil on the coast or oil on the sea surface. Subsea dispersant injection reduces oil residue in the air, coast and surface.

"The EPA's first line of decision making is to protect human health," said Socolofsky. "Dispersant injection did do that during the Deepwater Horizon accident and would still be selected today if human health would be protected. An unfortunate trade-off is that the oil still enters the environment, and in the case of subsea dispersant injecting, impacts more of the ocean water column and seafloor than if dispersants were not used."

The group conducted the model intercomparison study, built the model, conducted extensive laboratory experiments and participated in two major field experiments to study natural seeps. Each of these aspects has been published in different papers.

The TAMOC model is being used by the U.S. National Oceanographic and Atmospheric Administration (NOAA) in its oil spill model GNOME (General NOAA Operational Modeling Environment). The team is also working with NOAA to predict what might happen for an accidental blowout in the Arctic.

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