A push from the Mississippi kept Deepwater Horizon oil slick off shore, research shows

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When the Deepwater Horizon drilling rig exploded April 20, 2010, residents feared that their Gulf of Mexico shores would be inundated with oil. And while many wetland habitats and wildlife were oiled during the three-month leak, the environmental damage to coastal Louisiana was less than many expected, in part because much of the crude never made it to the coast.

Research by a trio of geoscientists, including the University of Pennsylvania's Douglas Jerolmack, now offers an explanation for why some of the oil stayed out at sea. Using publicly available datasets, their study reveals that the force of the Mississippi River emptying into the Gulf of Mexico created mounds of freshwater which pushed the oil slick off shore.

"The idea is that, if the water surface is tilting a little bit, then maybe the oil will move downhill, sort of like a ball on a plate. If you tilt the plate, the ball will roll one way and then another," Jerolmack said. "Surprisingly no one had really investigated the effect that the tilting of the water surface can have on the migration of oil."

The finding, published in the journal PLoS ONE, could help make better predictions about where oil will make landfall in future oil spills, helping to direct efforts to spare fragile coastlines and wildlife.

Jerolmack, an assistant professor in Penn's Department of Earth and Environmental Science, collaborated on the study with lead author

Federico Falcini, a postdoctoral investigator in Jerolmack's lab at the time. Bruno Buongiorno Nardelli of Italy's Consiglio Nazionale delle Richerche also contributed to the work.

As the Deepwater Horizon disaster unfolded two years ago, the National Oceanic and Atmospheric Administration used information from satellite data and helicopter flights over the Gulf to produce aerial images of the shifting coat of oil. NOAA also issued daily forecasts of where the oil slick might travel, using computer models based on ocean currents.

"We noticed that there was a big disconnect between the forecasts of where the oil was going to be the next day and where the oil actually was the next day," Jerolmack said. "That maybe shouldn't be a surprise, because these computer models were not generated to forecast the movement of oil, they were generated to forecast the movement of water."

Clearly some force beyond the ocean's current was acting to direct the oil's movement. So the researchers turned their attention to the ocean's topography.

They accessed interpreted data from the Colorado Center for Astrodynamics Research that provides real-time information about sea-surface levels. These measurements, gathered from radar bounced off the surface of the ocean from the Jason2 satellite, were considered unreliable near shore, where land could confuse the signals.

The researchers performed their own analyses on the Jason2's raw data to separate out this confounding effect and glean sea-surface-level information within a few kilometers of shore. Their results confirmed the existence of several mounds and troughs in the Gulf. One mound in particular drew their attention.

"We recognized that there was a very persistent mound, a bump or a bulge, in the elevation of the sea surface in the vicinity of the Mississippi Delta," Jerolmack said.

The reason was that the oil spill coincided with the typical spring flood on the Mississippi, creating a larger-than-normal flow of water into the Delta. This powerful discharge of fresh water mounded on top of the denser salt water of the Gulf. The resulting bulge, which was approximately 10 centimeters higher than the surrounding ocean and 50-100 kilometers in diameter, was positioned so that oil from the Deepwater Horizon drilling rig ran "downhill" and away from the coast.

A mathematical model representing a two-layer fluid — comprised of oil on top and fresh water underneath — confirmed that the slope of the mound was sufficient to direct the oil's movement.

"The model was able to predict the speed at which the oil moved away from this fresh-water mound and how long it took for the oil to move away from the mound," Jerolmack said.

Despite this correlation, mound formation was just one of many competing forces driving the drift of the Gulf oil slick, Jerolmack noted.

"A mound can only form if the river discharge is relatively high and the ocean is relatively calm."

Indeed, as the Mississippi flood waters subsided and the river's discharge lessened, the bulge disappeared and the oil slick moved back toward shore. The winds of Hurricane Alex, which formed in late June 2010, also resulted in a decline in mound formation and the oil slick being pushed toward land.

Still, factoring in mound formation will help produce more accurate forecasts of oil spills around the Mississippi Delta — and perhaps predict other dispersion events as well.

"This feature is likely important not only for the oil spill, but also for the dispersal of nutrients, sediments and pollution into the Gulf," Jerolmack said.

Provided by University of Pennsylvania