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Chemical Measurements Confirm Estimate of Gulf Oil Spill Rate

By combining detailed chemical measurements in the deep ocean, in the oil slick, and in the air, a team of scientists including UC Santa Barbara's David Valentine has independently estimated how fast gases and oil were leaking during the Deepwater Horizon oil spill in the Gulf of Mexico in 2010.

The new chemistry-based estimate -- an average of 11,130 tons of gas and oil compounds per day -- is close to the official average leak rate estimate of about 11,350 tons of gas and oil per day (equal to 59,200 barrels of liquid oil).

"This study uses the available chemical data to give a better understanding of what went where, and why," said Thomas Ryerson, a research chemist at the National Oceanic and Atmospheric Administration (NOAA) and lead author of the study. "The surface and subsurface measurements and analysis provided by our university colleagues were key to this unprecedented approach to understanding an oil spill."

The NOAA-led team did not rely on any of the data used in the original estimates -- video flow analysis, for example, or pipe diameter and fluid flow calculations. "We analyzed a completely separate set of chemical measurements," Ryerson said, "which independently led us to a very similar leak estimate."

Valentine, a geochemist and professor of earth science at UCSB, and a co-author of the paper, added: "Not only does this chemical approach yield an independent

estimate of flow rate for the ruptured well, but it also helps to define the pathways traveled by the oil and gas after release to the ocean. These results represent another step in our quest to understand what went where, and what happened to it all."

The new study, "Chemical data quantify Deepwater Horizon hydrocarbon flow rate and environmental distribution," has been published online in the Proceedings of the National Academy of Sciences.

The analysis follows a series of studies, in which Ryerson, Valentine, and colleagues calculated Deepwater Horizon's leak rate based on individual methods. The new analysis combines these and other sources of data, including two days of airborne data; chemical makeup of the reservoir gas and oil, determined before the spill; subsurface and surface samples taken over six weeks during the spill; the post-spill respiration anomaly in the deep ocean; and a direct measure of the makeup of the gas and oil actually leaking into the Gulf.

The researchers found that the leaking gas and oil quickly separated into three major pools -- the well-known underwater plume about 3,300-4,300 feet below the surface, the visible surface slick, and an airborne plume. Each pool had a very different chemical composition.

The underwater plume was enhanced in gases known to dissolve readily in water, the team found. This includes essentially all of the lightweight methane (natural gas) and benzene (a known carcinogen) present in the spilling reservoir fluid.

The surface oil slick was dominated by the heaviest and stickiest components, which neither dissolved in seawater nor evaporated into the air. And the airborne plume of chemicals contained a wide mixture of intermediate-weight components of the spilled gas and oil.

The analysis further showed that a majority of the leaking gas and oil, by weight, was retained in the deep subsurface plume. The visible surface slick represented about 15 percent of the total leaked gas and oil; the airborne plume accounted for about 7 percent.

This information about the transport and fate of different components of the spilled gas and oil mixture could help resource managers and others to understand environmental exposure levels.

The chemical measurements made from mid-May through June 2010 showed that the composition of the atmospheric plume changed very little, suggesting little change in the makeup of the leaking gas and oil.

The team of researchers also used the detailed chemical measurements to calculate how much gas and oil -- in total -- was spilling from the breached reservoir deep underwater. The new chemistry-based estimate of about 11,130 tons per day (8,900 to 13,300 tons, including uncertainty) compares well with the official estimate of 11,350 tons per day (10,000 to 12,700 tons, including uncertainty).

Other co-authors of the study are Richard Camilli (Woods Hole Oceanographic Institution), John D. Kessler (Texas A&M University), Elizabeth B. Kujawinski and Christopher M. Reddy (Woods Hole Oceanographic Institution), Elliot L. Atlas (University of Miami), Donald R. Blake (UC Irvine), J.A. de Gouw (NOAA and Cooperative Institute for Research in Environmental Sciences, CIRES), Simone Meinardi (UC Irvine), David D. Parrish (NOAA), Jeff Peischl (NOAA and CIRES), Jeffrey S. Seewald (Woods Hole Oceanographic Institution), and Carsten Warneke (NOAA and CIRES).

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