Airborne chemistry measurements used to assess flow rate, fate of spilled gases and oil during Gulf oil spill

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An oil recovery vessel flares gases during the summer 2010 oil spill. NOAA researchers and colleagues used atmospheric measurements during the spill to derive independent estimates of the recovery rate, oil spill rate and the fate of the spilled gases and oil. Credit: With permission from David Valentine, University of California, Santa Barbara

NOAA scientists and academic partners have found a way to use air chemistry measurements taken hundreds of feet above last year's BP Deepwater Horizon oil spill to estimate how fast gases and oil were leaking from the reservoir thousands of feet underwater. The scientists also determined the fate of most of those gas and oil compounds using atmospheric chemistry data collected from the NOAA WP-3D research aircraft overflights in June. The study, accepted for publication in *Geophysical Research Letters*, a publication of the American Geophysical Union, is available online as a paper in press.

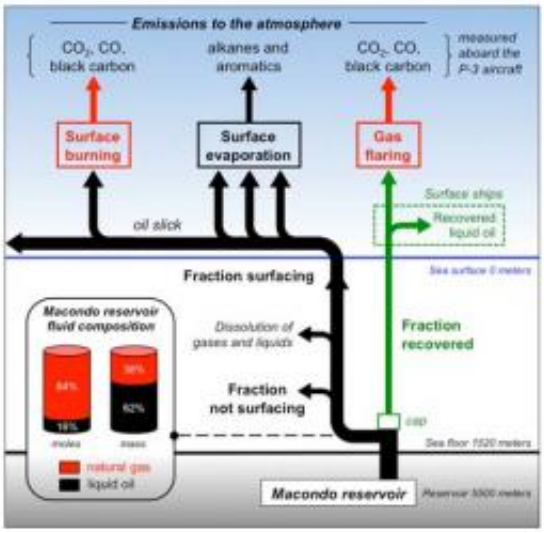
"We present a new method for understanding the fate of most of the spilled gases and oil," said Tom Ryerson, lead author of the report, from NOAA's Earth System Research Laboratory in Boulder, CO. "We found that the spilled gases and oil (spilled fluid) obeyed a simple rule: whether a compound can dissolve or evaporate determines where it goes in the marine environment. That simple rule, and the methods we lay out in this paper, could enable airborne evaluation of the magnitude of future spills."

Knowing where the spilled gas and oil mixture ended up could also help resource managers and others trying to understand environmental exposure levels.

Using the atmospheric measurements and information about the chemical makeup of the leaking reservoir fluid, Ryerson and his colleagues calculated that at least 32,600-47,700 barrels of liquid gases and oil poured out of the breached reservoir on June 10. This range, determined independently of previous estimates presents a lower limit.

"Although we accounted for gases that dissolved before reaching the surface, our atmospheric data are essentially blind to gases and oil that remain trapped deep underwater," Ryerson said. Comparison of the new result with official estimates is not possible because this airborne study

could not measure that trapped material.



Schematic of oil carbon and combustion product partitioning in the marine environment. Airborne in situ measurements quantify mass flux along each of the three atmospheric emissions pathways shown; drawing is not to scale. The fraction surfacing can be altered by dissolution in the water column, but has a significant surface expression. In contrast, the fraction not surfacing is that reservoir fluid (gas plus oil) presumably emitted in droplets with insufficient buoyancy to reach the surface, and thus has no surface expression. Credit: NOAA

Not including that trapped material, atmospheric measurements combined with reservoir composition information showed that about one-third (by mass) of the oil and gas dissolved into the water column on its way to the surface. The team found another 14 percent by mass (570,000 lbs per day) was lost quickly to the atmosphere within a few hours after surfacing, and an additional 10 percent was lost to the atmosphere over the course of the next 24 to 48 hours.

Among the study's other key findings:

• Some compounds evaporated essentially completely to the atmosphere, which allowed scientists to make an estimate of flow rate based solely on atmospheric measurements and reservoir composition information.

• Airborne instruments picked up no enhanced levels of methane, the lightest-weight hydrocarbon in the leaking reservoir fluid, showing that it dissolved essentially completely in the water column.

• Benzene — a known human carcinogen — and ethane were found in only slightly elevated concentrations in the air, meaning they dissolved nearly completely in the water.

• A number of slightly heavier carbon compounds ended up in both the air and water, with the precise fraction depending on the compound. Based on these data, the team inferred different exposure risks of mid- and shallow-water marine species to elevated levels of potentially toxic compounds.

A portion of oil and gas was "recovered" by response activities and piped from the leaking wellhead to the Discoverer Enterprise drill ship on the ocean surface. The research team calculated this recovered fraction by measuring emissions from natural gas flaring aboard the recovery ship. They calculated a recovery rate of 17,400 barrels of reservoir fluid (liquid gas and oil) for June 10, and which accounted for approximately one-third to one-half of the group's total estimate of 32,600-47,700 barrels of fluid per day.

Ryerson and his colleagues concluded that the technique they developed could be applied to future oil spills, whether in shallow or deep water. The Gulf research flights were possible only because a NOAA WP-3D research aircraft had already been outfitted with sensitive chemistry

equipment for deployment to California for an air quality and climate study and was redeployed to the Gulf. NOAA's Gulf flights were in support of the Unified Area Command's effort to observe and monitor the environmental effects of the spill.

Provided by NOAA