Technology

Janet Raloff reports from Tampa, Fla., at the 1993 Oil Spill Conference

Scouting for oil spills under ice

Oil spilled in the Arctic may become trapped under ice, well out of sight. But Canadian researchers have developed a simple optical system that they now report can identify oil lurking under as much as 1 meter of snow-free ice. This depth limitation should not preclude use of the technique in probing for oil beneath river and lake ice, they report, or first-year ice in the Beaufort Sea and Gulf of St. Lawrence.

When excited by ultraviolet light, electrons in some of oil's ring-shaped aromatic compounds — such as benzene and especially anthracene — respond by fluorescing, emitting a photon of longer-wavelength light. Though various researchers over the past 20 years have attempted to harness this principle for detecting ice-covered oil, the lasers they employed to deliver the ultraviolet light were never rugged and inexpensive enough to make the concept practical for field use, says Michael E. Moir of Esso Resources Canada Ltd., in Calgary, Alberta.

His team has opted for a simpler system, one that instead irradiates ice with a 10-megawatt flash lamp. By filtering its broadband spectral emissions, they can deliver a microsecond pulse of ultraviolet light that penetrates even cloudy ice.

In lab tests, a photodiode successfully detected the telltale fluorescence from crude oil under ice made from freshwater and synthetic seawater. But when they field tested the technique a month ago in a test basin capped by 16 inches of ice, Moir's team found they could dispense with the photodiode altogether. Even wearing goggles to protect against the lamp's intense flash, their eyes easily picked up the fluorescence from plastic bags of oil inserted below the "pretty opaque-looking ice."

Of course, Moir says, having this technology begs the question, "What do you do if you find oil?" After all, he points out, it's still buried, its quantity is unknown, and it might be near-impossible to retrieve.

Lasers map slicks from the air . . .

Determining which ecosystems an oil slick will threaten and when hinges upon mapping any floating oil. A group of Italian researchers has integrated a pair of remote-sensing techniques to acquire this information through aerial reconnaissance.

Because thermal anomalies reveal surface pollution, the team fitted a helicopter with a flir (forward-looking infrared) system to passively map sea-surface temperatures. The presence of anomalies, however, tells nothing about the type of pollution, notes project leader Alberto L. Geraci of the University of Catania in Sicily. For that, his team scans anomalous-temperature zones using a lidar (light detection and ranging) system, which irradiates the surface with an ultraviolet-light-emitting laser. A computer analyzes the returning light signature of the sampled zone against a library of known spectra to identify the polluting agent. By correlating these data with maps or positioning signals from satellites, spill-response teams can map oil slicks and project their spread.

Crews field tested the experimental system off Sicily last year at speeds of up to 20 kilometers per hour. Geraci says the region, whose coastal waters are extensively polluted, contains industrial plants, refineries, and offshore oil wells.

The flir/lidar system is especially effective when measurements are taken at a height of about 15 meters, and it not only can detect petroleum, but also can identify its type and roughly gauge how much is present, Geraci reports. Moreover, he adds, the system can distinguish a host of other pollutants as well — from residues of waste sewage to sulfonate of lignin, a highly polluting by-product of woodworking.

Geraci says his team is already at work on the prototype for a commercial flir/lidar system.

. . . and estimate their thickness

Though aerial photos can determine the surface dimensions of an oil slick at sea, they lack information about depth that is needed to estimate the volume of oil present. Marc Choquet of the National Research Council of Canada in Boucherville, Quebec, now reports progress on a new remote-sensing tool to gauge a slick's thickness from instruments aboard a low-flying aircraft.

The technique — borrowed from industrial quality-control experts who conduct nondestructive inspections of materials — involves directing a short pulse of laser light at the top of the slick to generate ultrasonic waves in the oil. A second laser, coupled to an optical interferometer, analyzes the return signal to measure those ultrasonic waves. If one knows the acoustic properties of the sampled oil, then the time it takes for an ultrasound wave to reflect between the top of the slick and the oil-water interface will provide a "direct and unambiguous determination of the oil layer's thickness," Choquet says.

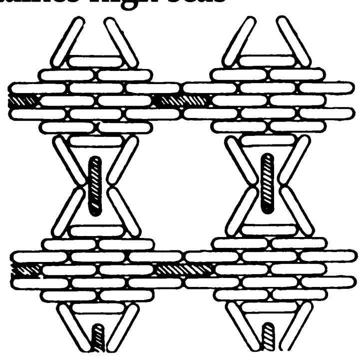
The two-laser technique proved adequate for measuring oil atop a motionless pool of water — not a condition typical of slicks at sea. To deal with waves, his team added a third laser. It monitors the tilt of the water-borne slick's surface. Only when the angle of a wave or ripple under the first laser is likely to result in a useful return signal will this third laser activate the two-laser ultrasound probe.

Choquet reports that waves do not reduce the system's accuracy for slicks between 200 microns and 15 centimeters thick, only the rate at which individual sampling measurements can be made. Preliminary airborne tests showed that height also reduces sampling rate — from a maximum of three times per second under quiet seas at 91 meters to perhaps only once every 10 seconds or more at sampling heights of 150 meters.

Choquet says a test of the complete system on board a DC-3 aircraft is scheduled for the first week in May.

Retiring approach tames high seas

On calm seas, vacuum cleaners can skim petroleum off of floating slicks for disposal or recycling. Unfortunately, waves complicate things, because present-day oil skimmers are ineffective in waves over four feet, according to ocean engineer Tadeusz Kowalski of the University of Rhode Island in Kingston. But one or more rows of floating breakwaters — each assembled from bundles of used auto tires — might reduce rough seas to manageable waves, he says. Lab and field tests of such tire breakwaters reduced the height of waves by 50 to 70 percent, he reports. This application might also be another productive way to recycle some of the 285 million tires discarded in the United States each year (SN: 3/7/92, p.155).



Kowalski

Four linked modules, from above. Shaded tires join modules.

Kowalski envisions deploying individual, 20-tire modules — each weighing 450 pounds — to the windward side of a leaking ship or floating slick, using tugs, hovercraft, or helicopters. At the site, scuba divers would assemble them into four-module squares (see diagram) and link the squares into chains of the desired length. Kowalski links tires within each module using four-inch-wide industrial conveyor belts, bolted into a band. "A new and better way of holding them together [might be] to glue them with an epoxy-based [compound]" recently developed by a tire retreading company, he notes.