Blackened Mangrove, Smothered Reef

Years later, oil still sickens tropical coastal ecosystems

By ELIZABETH PENNISI

Though not a superstitious person, paleoecologist Jeremy Jackson knows that the mangrove forest east of where he sometimes works is haunted. The ghost that lurks among the vegetation along Bahiá Las Minas, on Panama's Atlantic coast, never howls at strangers or stalks unsuspecting fishermen. Instead, it shows up predictably each year, reenacting an accident that occurred in 1986.

That spring, an oil storage tank located at a refinery 12 kilometers northeast of Colón ruptured. Between 75,000 and 100,000 barrels of medium-weight crude rushed out. Only 60,000 gallons were recovered. Oil breached a retaining dike, flooded the refinery grounds, and overwhelmed a system designed to separate oil from water runoff. Winds kept the slick trapped in a small cove of Bahiá Las Minas for a week, then shifted, pushing much of the oil into the blue Caribbean. There, prevailing breezes caused it to linger at the shoreline and spread along an 85-km stretch of coast.

At low tide, the spill washed up against the edge of reefs. Then rising water floated the oil landward into the tangled, hanging roots of wading mangroves. Overall, the spill reached 16 square km of mangroves, killing 160 acres' worth and damaging another 1,100. Like a sponge, the root-bound sediments soaked up this black goo. There it remains — its degradation slowed by the sediments' anoxic environment — waiting to make its seasonal appearance.

The ghost of this oil spill still packs a toxic punch

"Every time the rainy season begins here in May, we have a new oil spill," says Jackson, who works at the Smithsonian Tropical Research Institute (STRI) in Balboa. "It's very dramatic: You can smell the oil and you can see it."

The ghost of this oil spill still packs a toxic punch, extending one incident into a recurring nightmare of contamination, according to former STRI researcher Brian D. Keller, who headed a 5-year follow-up study of the spill.

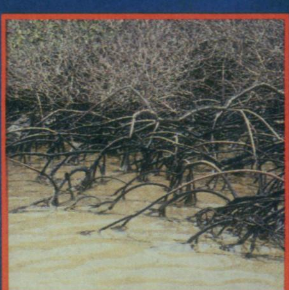
Furthermore, the 1986 accident "set off a process of destruction — not just of the organisms, but the structures they build," Jackson emphasizes. That, too, has long-term consequences. Along with the coral reefs just seaward, seagrass beds and mangroves calm waves and wind, dissipating potentially damaging energy. The plants also trap sediments that become the basis of ever more stable communities. Many residents of tropical shores thrive only because these biological structures create sturdy, protected spaces for them. They, in turn, become fodder for other species, including lobsters, shrimp, and commercially valuable fish, all of which prefer to spend their youth in these tranquil backwaters.

When the oil spill occurred, Jackson and his colleagues were carrying out research at the Punta Galeta reserve just a few miles away. In this shallow bay, algae, seagrass, and stationary invertebrates carpet a coralline slab. This slab, the product of coral and other calcareous material, has built up to become a reef flat, which is alternately exposed and submerged by changing tides. The flat provides the foundation for seagrass beds.

Jackson was investigating the effects of changing weather and sea conditions on life there. Other groups were studying the local seagrass, mangrove, and reef-flat communities. Jackson realized immediately that all this work would come in handy for evaluating the effects of the spill. He helped pull together those researchers and others in a 5-year, $4.5 million project funded by the U.S. Minerals Management Service, a branch of the Interior Department charged with minimizing damage from oil spills.

In November 1993, the scientists released their three-volume final report, a sobering statement about the vulnerability of these ecosystems to oil spills. "The answer was depressing," Jackson laments. "There was more erosion of shoreline than I thought there would be. The recovery time is clearly very slow."

The lesson: Keep oil away from tropical shores. Should spills occur, act quickly to try to preserve at least some original inhabitants, these researchers urge. Rather than automatically try to clean up all the oil, possibly at the expense of denizens that withstood the spill's initial onslaught, "it's important to maximize



Carl Hansen/Smithsonian

Oil-blackened mangrove prop roots (inset) and smothered reefs.

some survival," says John D. Cubit, a marine ecologist now with the National Oceanic and Atmospheric Administration Damage Assessment Center in Long Beach, Calif. Saving these local organisms is key to stemming an ensuing wave of disintegration.

Before the spill, the mangroves had provided a living fender along the land's edge, buffering it from wind- and water-caused erosion and slowing inland runoff from the many downpours. But like an insidious rust, the oil weakened and eventually led to the breakdown of parts of this natural barrier.

"That was the habitat that was affected most seriously," says Stephen D. Garrity, a marine ecologist at a small consulting firm, Coastal Zone Analysis, in Sopchoppy, Fla. At some sites, oil accumulated among mangrove roots, reaching concentrations of up to 1,000 times greater than in other areas.

Damaged trees lost their leaves, then their branches, and finally collapsed. Trees that survived put out fewer, shorter prop roots and had more dead root protuberances. The surface area of roots decreased by 33 percent along exposed coasts, by 38 percent in channels, and by as much as 74 percent farther inland, says Garrity. It seemed that the closer an area is to the cleansing action of tides, the faster the oil disappeared.

Populations of invertebrates living on roots also declined, initially smothered by the oil and later deprived of sufficient habitat. Working with Sally C. Levings, also with Coastal Zone Analysis, Garrity determined that their numbers dropped by 33 percent along open shores. The situation worsened the farther inland the researchers looked. About 65 percent of the edible oysters that dominated mangrove root communities in channels disappeared, as did almost 99 percent of the false mussels that populated mangrove fringes along streams. Garrity and Levings report these results in the April ESTUARINE, COASTAL & SHELF SCIENCE.

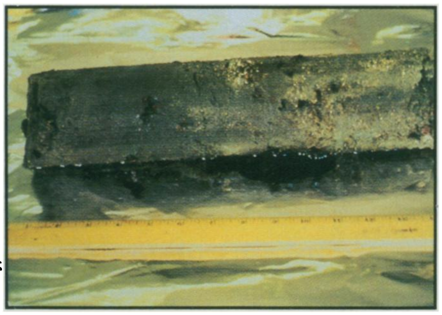
Along exposed coastline, the problem seems self-perpetuating. Waves pound these shores and clobber seedlings with floating tree trunks. "You get a bulldozing effect," says Keller.

Efforts to aid reforestation by planting young mangroves, first directly into the soil and later using seedlings still contained in rich potting soil, have not helped much. Instead, cleanup and restoration activities in these areas appear only to have slowed natural recovery, he notes.

Oil's continued presence further bogs down revegetation. "A lot of these streams had really soft sediment, so they [soaked] up a lot of oil," says Garrity. "There are pools of oil still in the soil; it's like a time bomb being released slowly."

Chemical data confirm this. Oil, actually a generic term for a mixture of petroleum compounds, has widely varying numbers of carbon and hydrogen atoms. Often, scientists can identify the source of a particular oil by its composition (SN: 5/8/93, p.294). That composition changes as the oil degrades, and with degradation, the oil's toxicity changes. To understand this spill's chemical effects, Kathryn A. Burns, now at the Australian Institute of Marine Science in Townsville, Queensland, and her colleagues analyzed sediment cores and tissues of sea creatures living in oiled and unoiled sites.

Oysters and mussels contained the same composition of hydrocarbon components as did the oil-soaked soil, which indicates that contamination did come from the spilled oil. In some places, the toxic components disappeared within 5 years, although residual compounds with sublethal effects still linger. Elsewhere, the results were less encouraging: "Five and 6 years later, the oil was virtually undegraded [at one site]," says Garrity. "It's a mess."



Garrity/Smithsonian

Soil sample still oozes oil after 3 years.

Researchers from STRI also looked at 12 sites along coral reefs, 6 of them heavily oiled, 2 moderately oiled, and 4 clean. Just a year earlier, they had surveyed organisms at some of those sites and so had a good basis for comparison, says Jackson. At the lowest tides, a coral reef presents a seawall to incoming waves, while the reef flat landward sits above water. The oil spill hit at low tide, so it piled up against the reef, smothering the living veneer there and leaving a band of bare carbonate rock when it finally washed away. "Places above that [band] weren't affected very much, and areas beneath there were only partially affected," says NOAA's Cubit.

Some species rebounded quickly; others have yet to resettle these bare zones. Success is determined in part by typical life history. For example, physical stresses often wear the fleshy red algae *Laurencia papillosa* down to mere stubs. These seaweeds grew back quickly after being damaged by the oil spill. But stony corals did not fare as well. New coral sprang up only when coral fragments subsequently washed in from deeper water that hadn't been affected by the spill, Cubit reports.

Cubit realized, too, that a critical difference exists between temperate and tropical communities. When disaster strikes colder coastlines, larval or adult forms of barnacles, mussels, algae, and other biota "walk or wash in," immigrating to these opened spaces, says Cubit. But in Panama, it was primarily up to the survivors to recolonize damaged areas.

Although in terms of its biomass this coast seems almost as productive now as before the spill, the success of the fleshy red algae could spell trouble in the future. These seaweeds have formed a tangled, almost impenetrable shag along the bared surfaces, effectively blocking the reestablishment of calcareous algae, corals, and other organisms whose carbonate production contributes to the reef's expansion. Without them, erosion from waves or from organisms that burrow into the reef can wear down this natural seawall. "If you take away the living coral, then the loss can exceed the gain of material, and you can have a net loss," says Keller. If the reef decays, it can take with it the reef flats, seagrass beds, and mangroves – and the productive communities associated with them.

The loss of mangroves and seagrass beds has freed sediments normally trapped by roots. As these sediments wash over the coral, they cut down on the sunlight reaching the reef and on the reef's productivity. The coral must devote more energy to removing debris and less to laying down new reef.

All in all, this 5-year project stands out as the longest follow-up to date of a tropical oil spill. Cubit and Garrity point out that what happened in Bahiá Las Minas is unique, because each oil accident involves different oils, weather and sea conditions, and cleanup responses. Nevertheless, Jackson and Keller think some generalizations are warranted. Do everything possible to ensure that oil doesn't reach reefs or mangroves, they conclude.

"If one wanted to be alarmist, which I don't, [the results] would raise concerns about places like the Everglades," says Jackson. "From what we've seen here, [an oil spill there] would be catastrophic."

He also cautions against generalizing from spill research done in laboratory or even field experiments. "The assumption that recovery will occur may be violated because the scale [of destruction] was too large [in real life]," he warns.

Their study now concluded, the nine scientists involved have moved on to different projects. Keller closed up his office in February and headed to Washington, D.C., to head the Ecological Society of America. Jackson has almost forsaken these shores, focusing his attention instead on the fossil record preserved in Panamanian sediments.

As for the ghost of this oil spill past, it lies beneath the mangroves, waiting for the next rainy season. □