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THE COVER: A spectacular array of birds feeds in a quiet freshwater lagoon a few miles inland from the Venezuelan coast. Beyond a mixed company of snowy egrets, great egrets, scarlet ibis, Louisiana herons, and black-necked stilts is a rank of greater flamingos. The photograph is by David O. Johnson, who used a Leicaflex SL, 400mm Telyt lens, and an exposure of 1/500 second at f:8 on Ektachrome 200.

Ixtoc's Oil Has a Silver Lining

There is no end in sight to the biggest oil spill in history; but government agencies finally have learned how to avoid the chaotic response that followed earlier disasters

GLADWIN HILL

The Accident

It was bound to happen. But most people expected the source would be a supertanker, colliding with another vessel or foundering on the coast. Instead, the biggest oil spill in history erupted June 3rd from an offshore well far out in the Gulf of Mexico—a quite different set of circumstances from the other big oil spills of the last dozen years.

Petroleos Mexicanos, the government-owned enterprise, was drilling the well, dubbed Ixtoc I, in 150 feet of water in the Bay of Campeche, 48 miles off Ciudad del Carmen, at the base of the Yucatán Peninsula. A gusher broke loose. Shutoff valving failed to work, and strenuous efforts in ensuing days to plug the well were unsuccessful. Finally it was decided that the only recourse was the protracted task of slant-drilling two "relief wells" down into the original shaft to intercept the flow below the rupture.

Tarry black crude streamed from the well at a rate of more than a million gallons a day, and was still pouring out months later. In just a few days the leakage exceeded the epochal 1969 spill at Santa Barbara, California, and soon it topped the other classic spills of recent

years—the 29 million gallons of the tanker *Torrey Canyon* off England in 1967; the 7.7 million gallons of the *Argo Merchant* off Nantucket Island in 1976. By mid-July it had exceeded the 55 million gallons of the *Amoco Cadiz* off France in 1978 to become an item for the record books.

The Gulf of Mexico is vast, covering some 700,000 square miles. The nearest United States soil, at Brownsville, Texas, is 500 miles away from Ixtoc I. For several weeks, wind and water currents carried the escaping oil generally out into the Gulf, away from land. It was not evident that it would impinge on the United States, and it was not until July 22nd that the Mexicans were moved to invite in as consultants some United States specialists experienced in oil spills.

But just off Mexico's east coast, north of the oil spill, is a gyre, a far-flung, slow-moving whorl of ocean currents, revolving in a clockwise direction. This tended to spin vagrant portions of the oil slick northward, just offshore. Prevailing seasonal winds from the southeast tended to push the drifting slick toward the Texas coast. In the early days of August, it became evident that oil might hit the shoreline anytime.

The Hazards

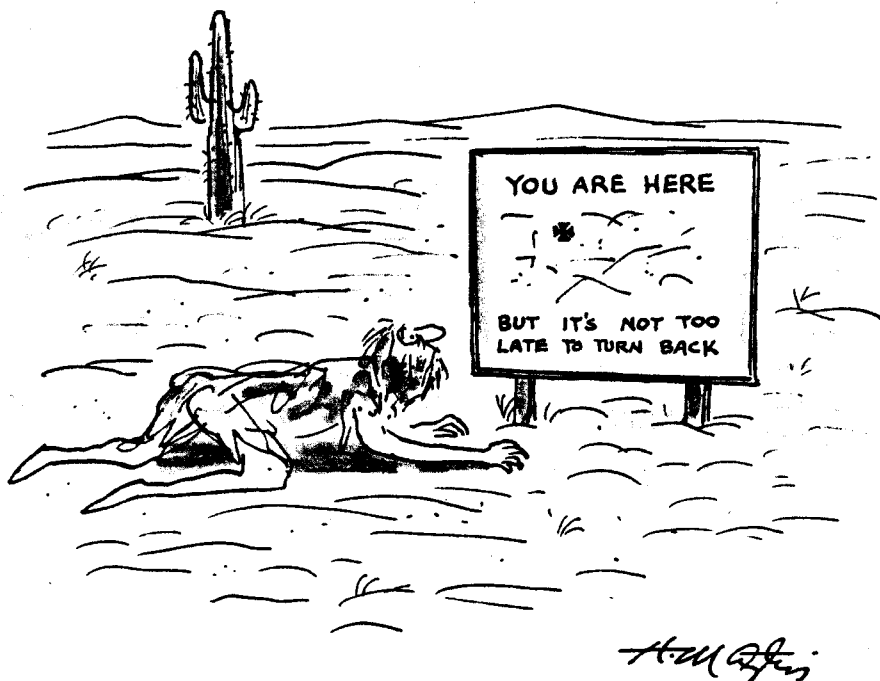
This possibility held some fearful implications. Although not as famed among laymen as, say, Florida's Everglades, the Texas coast is known to naturalists as one of the most remarkable sections of the continent—a combined aviary, zoo, aquarium, and arboretum stretching for 350 miles and immensely more variegated than any man-made preserves.

For eons, the Rio Grande and a score of lesser rivers have flowed southward into the Gulf carrying silt and sand which, upon encountering landward ocean currents, have piled up in sandbars to form an almost continuous chain of barrier islands from Brownsville to the Louisiana swamps.

Between these islands and the mainland is a string of narrow, sheltered lagoons, along the mainland side of which is a phenomenal series of bays, inlets, estuaries, and marshes, the prized wetland interface of terrestrial and marine ecologies, where life itself is believed to have emerged from the deep.

Here the interaction of salt and fresh waters and the unusual deposition and propagation of nutrients have created an extraordinarily rich habitat for plants, animals, birds, fish, and insects. Vegetation ranges from algae and grasses to mangroves and hardwood forests. This is the great way station for birds migrating between the Americas, a prime bedding area for shellfish, and a breeding ground for ocean fish. It also is a big tourist and sport fishing center. Commercial shrimping out of Corpus Christi alone is a \$200-million-a-year business.

Along the Texas coast are no fewer than seven national wildlife refuges—Anahuac, Aransas, Laguna Atascosa, Brazoria, Moody, San Bernard, and Santa Ana. Altogether they cover 280 square miles. The dimension hardly hints at the scope of the ecological complex. National Audubon Society owns and manages a dozen sanctuaries along the Texas coast from the Rio Grande to the Louisiana line—Sabal Palm Grove, Three Islands, Green Island, South Bird Island, Lydia Ann and Harbor Islands, Long Reef and Deadman's Island, Ma-



tagorda Island, Second Chain of Islands, West Bay Bird Island, North Deer Island, Vingt-et-un Islands, and Sidney Island—which are as diverse in habitat and as rich in wildlife and natural values as the federal refuges.

The Santa Ana refuge, a few miles up the Rio Grande, is concentrated in less than four square miles. Yet in that small expanse have been identified over 450 species of plants, 30 species of animals and reptiles, and 326 species of birds. The 140-square-mile Aransas refuge near Corpus Christi is famed as a seasonal residence of the rare whooping crane; that is only one of 350 bird species regularly seen there. The birdlife includes four endangered species besides the whooping crane: bald eagles, brown pelicans, peregrine falcons, and Attwater's prairie chickens.

The major barrier strand is Padre Island, which extends 100 miles from Brownsville to Corpus Christi. East of it, Mustang, San José, Matagorda, and Galveston islands carry the barrier chain almost to the Louisiana border. Padre Island is almost entirely a unit of the National Park System, the biggest national seashore, with an area of more than 200 square miles. Most of the island is uninhabited and roadless; at the north end are federal and county camping areas; at the southern tip, a cluster of hotels and stores.

Oil is one of the most destructive substances that can strike an aquatic ecosystem. Its impacts begin with harm to zooplankton and phytoplankton, tiny organisms that are the primary building blocks in the marine food chain. An elementary fact not always considered is that many sorts of shellfish, from scallops to barnacles, have little or no mobility; they subsist by straining seawater and have no choice about ingesting oil if it comes their way. When ingested by shellfish and finfish, oil may lodge in fatty tissues and stay there indefinitely, causing reproductive and genetic disruptions. Some constituents of crude oil quickly induce cancer in marine creatures.

In the case of birds, oil clots feathers and inflicts many kinds of internal trauma on digestive, reproductive, and glandular systems, causing a range of problems from quick mortality to deficient eggs. Oil is a specific for killing aquatic insects, and this can be another disruption in the food cycle. Vegetation and mammals generally suffer from contact with oil.

The long-term impacts of specific oil spills are matters of intense scientific controversy, even in the case of spills that occurred years ago. Estimates of severity

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terminal set up in a bayfront motel room connected the Corpus Christi team to a master computer at NOAA's scientific headquarters at Boulder, Colorado, a thousand miles away.

The NOAA team had two immediate tasks: to predict where oil might come ashore, and to examine most of the Gulf Coast from Brownsville to New Orleans to rate the ecological vulnerability of the different coastal sites.

Daily reconnaissance flights were begun. A big Navy P-3 anti-submarine warfare plane loaded with sophisticated electronic equipment made sorties for thousands of miles out in the Gulf. A small DeHavilland Buffalo covered the coastline, supplemented by helicopters that could scrutinize the surface and land if necessary. In addition to visual observations, planes could spot oil, if it was thick enough, by radar; by infrared sensing, which measures temperature differentials; by ultraviolet light sensing; and by microwaves, which bounce off oil at a different rate from off water. The observations of these reconnaissance units were fed into the computer, along with weather data, and back from Boulder would come maps projecting conditions a day or two ahead.

There was oil all over the western half of the Gulf. Most of it was just a film, called sheen. One day's discharge from the runaway well could spread in twenty-four hours to cover thirty square miles. Amidst the sheen were occasional patches of "mousse," an oil-and-water emulsion, and spherical agglomerations of pure oil ranging from droplets to baseball size. Southeast winds were pushing the oil toward the coast at a rate of about ten miles a day.

Since big oil spills began occurring a few years ago, an immense amount of time, money, and technical expertise has been expended by the oil industry and by government on ways of handling them. But no panaceas have been found. Chemical detergents and dispersants often do more ecological harm than good, tending either to scatter the oil or to mat it into even less manageable forms. At the well, the Mexicans reported some helpful use of a compound called Corexit 9527, made by Exxon. But dispersants were eschewed at the Texas end of the migrating film of oil.

Drifting surface oil can be managed to a very limited extent by booms, strings of buoys supporting short fences or absorbent curtains that extend underwater a few feet. Some booms have suction apertures through which corralled oil can be pumped into barges. But if the sea gets rough, with waves more than a couple of



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erly, and could be expected to push the oil offshore. This year, as if to compensate for the area's bad fortune, the wind shift started early in September. On September 12th a response-team communiqué said that the oil for the moment "poses no threat to the Texas coastline."

The Damage

No one knows where all the oil from Ixtoc I has gone. In the *Amoco Cadiz* spill, which probably is the most comprehensively studied to date, it was estimated that approximately equal parts of the oil went ashore, evaporated, and stayed in the ocean, with one-third of the latter fraction going to the ocean bottom.

In the case of the Mexican spill, first-hand reports have been scanty, but aerial observations have indicated that a lot of the oil went onto the beaches along several hundred miles of sparsely populated coast between Yucatán and the United States border. Three months after the blowout, the Mexicans claimed to be recovering as much as half the daily leakage with the help of booms and a skimmer craft manned by a six-member Coast Guard assistance team.

Off central Texas, the continental shelf extends out for about 75 miles, with depths up to 600 feet. Beyond that the ocean floor drops off precipitously to depths of more than two miles. Oil that ends up in this great trench will not worry ecologists too much because at such depths, beyond the reach of sunlight, the biota is minimal.

The continental shelf is where marine life is concentrated. In the first month after the oil reached Texas, commercial fishermen reported no evident abnormalities in their fishing grounds, and federal and state food inspectors found no contaminated catches—probably because any oil residues that had drifted that far were too light to go to the bottom. Response-team experts estimate that about a third of the oil has ended up on beach surfaces, half is buried below beach surfaces, and the rest has remained in the ocean just offshore.

Gulls and other shorebirds on the ocean side of Padre Island had their own solution to the oil incursion: Like a number of tourists they decamped to cleaner surroundings. The U.S. Fish and Wildlife Service opened an oiled-bird rescue center on the island, but during a six-week period only a few patients were brought in.

In a continuing joint United States-Mexico project to protect the Atlantic ridley turtle, an endangered species that lays its eggs on a Mexican beach near the



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four basic international agreements on liability and compensation for oil spill damage. All, however, relate to tanker operators and cargo owners, not to offshore oil drilling. Several United States laws now cover liability and compensation for oil spills, including those from offshore drilling. But these necessarily govern only occurrences in U.S. waters.

Because the United States and Mexico had been engaged in rather tense negotiations over U.S. procurement of Mexican oil and gas, the U.S. Department of State was hesitant about broaching the question of remuneration for the expense to which the oil spill had put the United States, through no fault of its own. But a rising clamor of political voices in Texas, which had incurred indefinite losses in tourist trade, and other costs, finally sparked an international exchange.

On August 22nd, the State Department raised the question in a formal cable to Mexico City. But Mexico's Foreign Ministry said it was "not prepared" to begin conversations on the subject, adding, "There is no basis in international law to recognize the existence of a legal international responsibility on the part of the government of Mexico or Petroleos Mexicanos."

This point had already been explored by international lawyers in Washington who concluded there was some precedent for negotiation. In the 1920s a metal smelter in Trail, British Columbia, began bombarding farms in the State of Washington with fumes that inflicted heavy crop losses. Ultimately the United States and Canada put the matter before a special international arbitration panel, which awarded substantial damages. However, this resolution was reached only through mutual consent of the two nations. Whether Mexico will acknowledge that an international obligation exists remains to be seen.

Participants in the 1972 United Nations Conference on the Human Environment, including Mexico, endorsed the principle of national responsibility for international pollution. An outgrowth of that conference, the continuing Law of the Sea parley, has before it draft articles that say:

"States shall ensure that recourse is available in accordance with their legal systems for prompt and adequate compensation or other relief in respect of damage caused by pollution of the marine environment by persons, natural or juridical, under their jurisdiction. States shall cooperate in the development of international law relating to criteria and procedures for the determination of liability, the assessment of

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The smoothness of the operation obviously was due in some part to the fact that the source of the oil was hundreds of miles away, isolating the U.S. response teams from the clangor and complexities of the struggle to cap the well. But this circumstance set the stage for an opportunity that is unique in the annals of oil spills.

"For the first time," commented NOAA's John Robinson, "we weren't confronted with a *fait accompli*, where the damage was already done and there wasn't much to do but mop up and try to reconstruct what happened.

"Here it has been something like an 'instant replay,' with the problems unfolding in slow motion. We've had time to do extensive, if hurried, baseline research, do some prioritizing, and make some strategic choices.

"On the basis of this experience, as soon as we can get to it, we want to make surveys of all the country's key coastal areas, so we won't be in the position of having to do the work of rating vulnerabilities and ecological values when the oil is already coming in."

The problem of protecting coasts from oil spills is getting bigger all the time. Most of the world's oil is moved by sea, and the vessels, for economy's sake, are getting bigger and less manageable. When they come to grief the releases of oil become increasingly horrendous. In 1978, tanker accidents alone dumped some 78 million gallons of oil into the ocean. That total was nearly matched in the first five months of 1979.

The quest for offshore oil is expanding, with the chances for spills like the Ixtoc's increasing in direct proportion to the number of platforms in operation. The Interior Department has just published a stepped-up offshore leasing program calling for thirty auctions in the next five years. Each probably will involve tracts covering hundreds of square miles, with scores of platforms and hundreds of wells.

In a fortuitously gentle way, the Gulf spill has dramatized how elementary the technology is for controlling and cleaning up spilled oil. All known equipment and methods are still critically dependent on bland weather; strong winds and heavy seas can nullify both apparatus and efforts. And since this is the net result of more than a decade's unstinting work to develop new techniques, the chances of any big leap forward seem slim. As with every previous episode, the exertions in the Gulf have underscored the truth of the axiom: "The only really effective way to deal with oil spills is to prevent them." ☀

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