



NATIONAL GEOGRAPHIC

THE GULF OIL SPILL

National Geographic Magazine

October 2010

Gone with the Water

Louisiana's wetlands are twice the size of Everglades National Park, funnel more oil into the United States than the Alaska pipeline, sustain one of the nation's largest fisheries, and provide vital hurricane protection for New Orleans. And they're disappearing under the Gulf of Mexico at the rate of 33 football fields a day.

By Joel K. Bourne, Jr. ASSISTANT EDITOR
Photographs by Robert Caputo and Tyrone Turner

Then and now: Awash in memories, Pete Vujnovich, Jr., holds a picture of what was once his grandparents' home near Empire, Louisiana.

TYRONE TURNER

An aerial photograph of a marsh at sunset. A long, straight pipeline canal, consisting of two parallel tracks, runs vertically through the center of the image. The canal is filled with water, which reflects the bright orange and yellow light of the setting sun. The surrounding marsh is a mix of dark, wet mudflats and lighter, drier areas. The overall scene is dramatic and highlights the impact of human infrastructure on a natural wetland environment.

**Louisiana is losing its protective
fringe of marshes and barrier islands
faster than any place in the U.S.**

HUMAN TRACKS

In the form of pipeline canals slice through the marsh near Leeville, an area suffering a high rate of wetland loss. More than 8,000 miles of canals crisscross the state's wetlands, fueling erosion and saltwater intrusion and altering the natural hydrology.

Texas state line, Louisiana is losing its protective fringe of marshes and barrier islands faster than any place in the U.S. Since the 1930s some 1,900 square miles of coastal wetlands—a swath nearly the size of Delaware or almost twice that of Luxembourg—have vanished beneath the Gulf of Mexico. Despite nearly half a billion dollars spent over the past decade to stem the tide, the state continues to lose about 25 square miles of land each year, roughly one acre every 33 minutes.

A cocktail of natural and human factors is putting the coast under. Delta soils naturally compact and sink over time, eventually giving way to open water unless fresh layers of sediment offset the subsidence. The Mississippi's spring floods once maintained that balance, but the annual deluges were often disastrous. After a devastating flood in 1927, levees were raised along the river and lined with concrete, effectively funneling the marsh-building sediments to the deep waters of the Gulf. Since the 1950s engineers have also cut more than 8,000 miles of canals through the marsh for petroleum exploration and ship traffic. These new ditches sliced the wetlands into a giant jigsaw puzzle, increasing erosion and allowing lethal doses of salt water to infiltrate brackish and freshwater marshes.

While such loss hits every bayou-loving Louisianan right in the heart, it also hits nearly every U.S. citizen right in the wallet. Louisiana has the hardest working wetlands in America, a watery world of bayous, marshes, and barrier

efforts to save the Everglades. But the Bush Administration balked at the price tag, supporting instead a plan to spend up to two billion dollars over the next ten years to fund the most promising projects. Either way, Congress must authorize the money before work can begin.

To glimpse the urgency of the problem afflicting Louisiana, one need only drive 40 minutes southeast of New Orleans to the tiny bayou village of Shell Beach. Here, for the past 70 years or so, a big, deeply tanned man with hands the size of baseball gloves has been catching fish, shooting ducks, and selling gas and bait to anyone who can find his end-of-the-road marina. Today Frank "Blackie" Campo's ramshackle place hangs



Even the Red Cross no longer opens hurricane shelters in New Orleans, claiming the risk to its workers is too great.

islands that either produces or transports more than a third of the nation's oil and a quarter of its natural gas, and ranks second only to Alaska in commercial fish landings. As wildlife habitat, it makes Florida's Everglades look like a petting zoo by comparison.

Such high stakes compelled a host of unlikely bedfellows—scientists, environmental groups, business leaders, and the U.S. Army Corps of Engineers—to forge a radical plan to protect what's left. Drafted by the Corps a year ago, the Louisiana Coastal Area (LCA) project was initially estimated to cost up to 14 billion dollars over 30 years, almost twice as much as current

off the end of new Shell Beach. The old Shell Beach, where Campo was born in 1918, sits a quarter mile away, five feet beneath the rippling waves. Once home to some 50 families and a naval air station during World War II, the little village is now "ga'an pecan," as Campo says in the local patois. Gone forever.

Life in old Shell Beach had always been a tenuous existence. Hurricanes twice razed the community, sending houses floating through the marsh. But it wasn't until the Corps of Engineers dredged a 500-foot-wide ship channel nearby in 1968 that its fate was sealed. The Mississippi River-Gulf Outlet, *(Continued on page 101)*



"WHEN I WAS A KID, you could walk through the swamp in summer in dress shoes," says 80-year-old Elward Stephens (above), wading through cypress knees near Morgan City. Today the swamp never dries out. Other changes are more dramatic: Thousands of acres of bald cypress (below) have been killed by saltwater flowing up canals, while once buried pipelines now lie exposed and must be regularly marked (left) to keep them from being struck by boats.



SPECIAL  EDITION

NATIONAL GEOGRAPHIC

Katrina

Why It Became a Man-made Disaster
Where It Could Happen Next



DISPLAY UNTIL
DECEMBER 20, 2005

PROFITS FROM THIS EDITION WILL BENEFIT HURRICANE VICTIMS



END OF THE ROAD

Local volunteers rescue the Taylor family from the roof of their car, stopped by rising waters along U.S. 90 in Bay St. Louis, Mississippi.

Ben Siler, Associated Press



THROUGH THE WALLS

Floodwaters drain out of New Orleans' Lower Ninth Ward through a breach in the Industrial Canal a day after the storm. Thousands of homes in this neighborhood, built over a cypress swamp, were destroyed when a series of waves from Lake Pontchartrain and Lake Borgne overran levee defenses.

Vincent Laforet, *New York Times*

How the defenses break down

Shelter from wind, run from water—that's the advice emergency managers have been giving coastal residents for years. The most lethal weapon in a hurricane's arsenal isn't howling winds, but rather the large dome of water it brings ashore known as a storm surge. For centuries, residents of low-lying Louisiana could count on a combination of natural and man-made barriers to at least slow down these tsunami-like waves, from fringing barrier islands to the once vast coastal marshes

to the levees that have been thrown up since the French settled the region in the early 1700s.

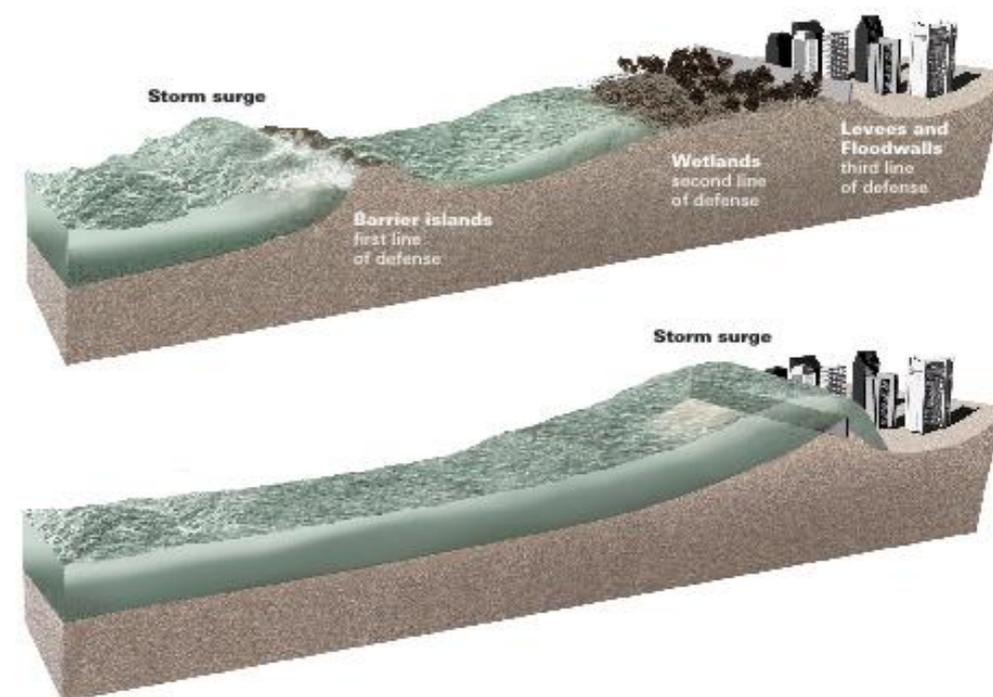
But over the last half-century, the natural defenses have been quietly melting away. Louisiana's barrier islands have some of the highest erosion rates in the country, with some islands losing more than 30 feet of shoreline every year. Sand and silt flowing down the Mississippi River once maintained the islands but are now dredged from ship channels and

dumped far offshore. During big hurricanes like Katrina, the low islands serve as little more than speed bumps and often get devastated in the process. Before the storm the Chandeleur Islands (below)—a thin crescent of barrier islands some 60 miles southeast of New Orleans—were intact; photos taken by the USGS after Katrina show the islands completely stripped of sand.

Louisiana's once dense coastal wetlands, which act like a sponge on a storm surge, have been vanishing as well at the rate of 25 square miles a year. Research after Hurricane Andrew showed that every linear mile of wetland cut the height of the surge by three inches. Some researchers believe that if

Louisiana's original marsh had been intact, it might have kept the city dry. Others say it would have made little difference against the possible 20-foot-high surge generated by Katrina.

Levees—big earthen mounds sometimes topped by floodwalls—are the last line of defense. Researchers have long known that the Lake Pontchartrain levees, which are about ten feet lower than the river levees near the French Quarter, were the city's Achilles' heel—particularly since the levees, like much of the city, are slowly sinking. Katrina poured an estimated six feet of surge into the lake. When the water rose above the floodwalls along three of the city's main drainage canals, the last defenses were breached.



When natural barriers vanish

Louisiana's beleaguered barrier islands pull double duty as the first line of defense against a surge, while protecting the second line of defense—coastal wetlands—from the day-to-day erosive power of the open Gulf. Wetlands act like a sponge, soaking up water and creating friction that can knock down a surge one foot for every four miles of wetlands it crosses. Without these natural barriers New Orleans would need massive dikes to keep out storm surges, like those the Netherlands uses to keep out the North Sea. "That's the future of New Orleans," says USGS oceanographer Jeff List. "If you're going to have a city below sea level, you'd better have levees high enough to protect it."

GOING, GOING, GONE—DAUPHIN ISLAND

Even 90 miles from where Katrina made landfall, the storm annihilated a section of Dauphin Island, Alabama. The top mosaic shows the barrier island still intact in 2001, three years before it was ripped apart by Ivan, a Category Three hurricane, center. Katrina washed out nearly two miles of Dauphin, leaving the Alabama coast even more vulnerable to storms. "The scale of this is something we've just never seen before," says Hilary Stockdon of the USGS.

July 17, 2001



September 17, 2004
After Hurricane Ivan



August 31, 2005
After Hurricane Katrina





CELEBRATING JANE

Goodall's 50 years with chimps

GIANTS DOWN UNDER

Animals that once ruled Australia

NGM.COM OCTOBER 2010

FREE MAP
*How the
Gulf Works*

NATIONAL GEOGRAPHIC

SPECIAL REPORT

THE SPILL

**Photos You Haven't Seen
Stories You Haven't Heard**

PLUS

*The Future of
Deepwater Drilling*

*Geography
of Offshore Oil*

MISSION BLUE

Our Call to Protect Marine Wildlife



*Brown Pelican,
Fort Jackson Bird
Rehabilitation Center*



THE GULF OF OIL

Smoke rises from surface oil being burned by cleanup crews near the Deepwater Horizon blowout. The well spewed nearly five million barrels, making it the world's largest accidental marine oil spill.

JOEL SARTORE

UNFLAGGING DEMAND
FOR OIL PROPELLED THE
INDUSTRY INTO DEEP WATER.
BUT THE BLOWOUT IN THE
GULF FORCES THE QUESTION:

IS IT WORTH THE RISK?



"You could see the life draining out of it," says parish official P. J. Halm, who impulsively rescued this severely oiled brown pelican on Queen Bess Island, La. The bird lived.

JILL SARTORS/GETTY

A shrimp the size of a staple swims amid dark brown globules of oil. The effect of the spill on the eggs and larvae of shrimps, crabs, and fish, all key to the local economy, remains unknown.

DAVID LITTSCHWAGER





Bottlenose dolphins slip through oiled waters in Chandeleur Sound, La. An adult dolphin can weigh up to 600 pounds. Because of their size, only a few were rescued and relocated to clean waters.

AP/WIDEWORLD



Their waters closed by the spill, fishermen in St. Bernard Parish, La., attended a May 1 BP training for cleanup crews—and bowed heads for an archbishop's impromptu prayer.

PHOTO: JEFFREY M. HARRIS

THE DEEP DILEMMA

The largest U.S. oil discoveries in decades lie in the depths of the Gulf of Mexico—one of the most dangerous places to drill on the planet.

BY JOEL K. BOURNE, JR.

ON A BLISTERING JUNE DAY in Houma, Louisiana, the local offices of BP—now the *Deepwater Horizon* Incident Command Center—were swarming with serious men and women in brightly colored vests. Top BP managers and their consultants wore white, the logistics team wore orange, federal and state environmental officials wore blue. Reporters wore purple vests so their handlers could keep track of them. On the walls of the largest “war room,” huge video screens flashed spill maps and response-vessel locations. Now and then one screen showed a World Cup soccer match.

Mark Ploen, the silver-haired deputy incident commander, wore a white vest. A 30-year veteran of oil spill wars, Ploen, a consultant, has helped clean up disasters around the world, from Alaska to the Niger Delta. He now found himself surrounded by men he’d worked with on the *Exxon Valdez* spill in Alaska two decades earlier. “It’s like a high school reunion,” he quipped.

Fifty miles offshore, a mile underwater on the seafloor, BP’s Macondo well was spewing something like an *Exxon Valdez* every four days. In late April an explosive blowout of the well had turned the *Deepwater Horizon*, one of the world’s most advanced drill rigs, into a pile of charred and twisted metal at the bottom of the sea. The

Joel Bourne is a contributing writer. His article about California’s water supply appeared in April.



The \$560-million Deepwater Horizon drilling rig burns after the April 20 well blowout. Eleven workers died in the explosion and flames that followed. On April 22 the rig sank.

WORLD HERBERT, AP IMAGES

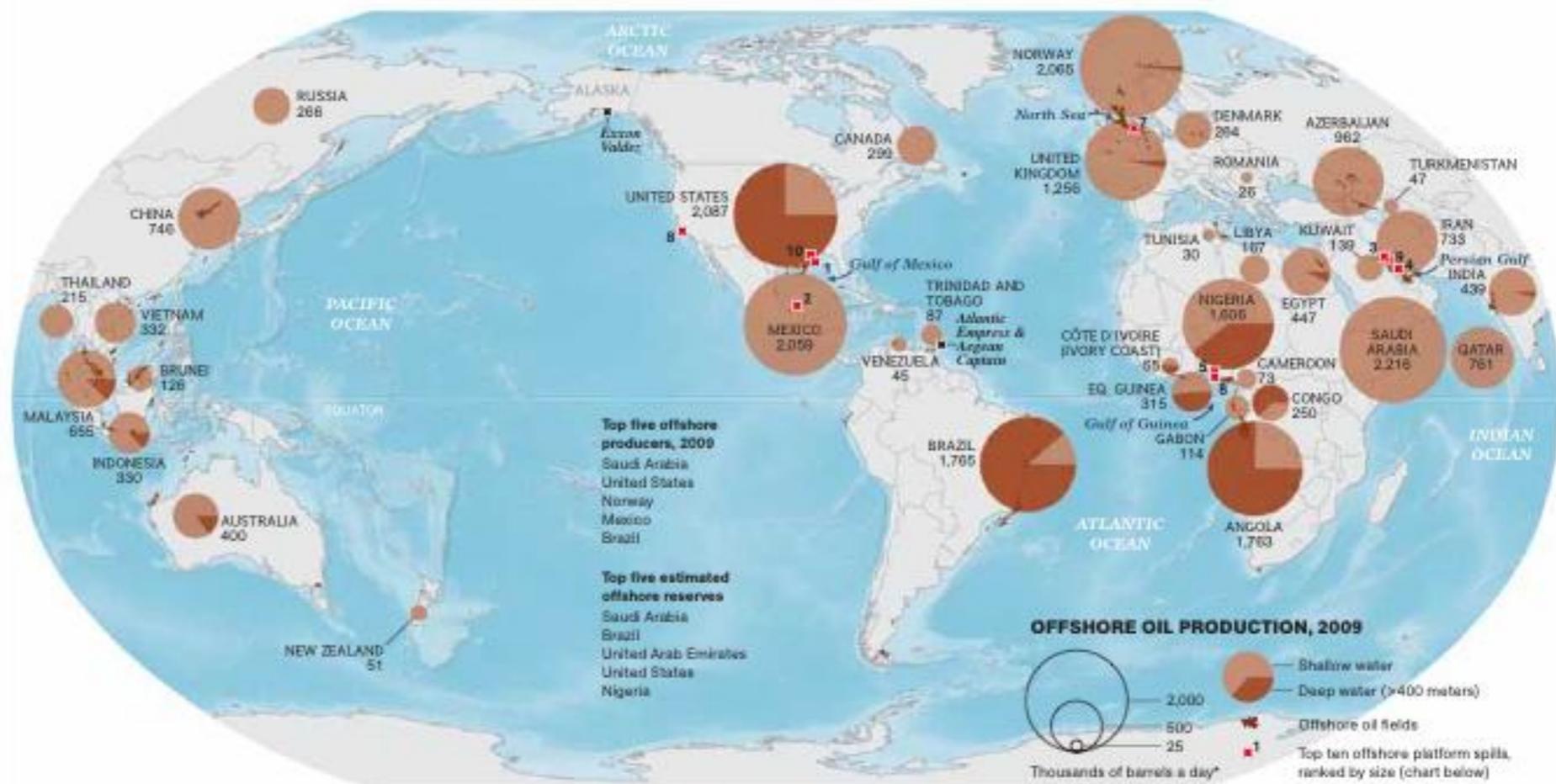
industry had acted as if such a catastrophe would never occur. So had its regulators. Nothing like it had happened in the Gulf of Mexico since 1979, when a Mexican well called Ixtoc 1 blew out in the shallow waters of the Bay of Campeche. Drilling technology had become so good since then, and the demand for oil so irresistible, that oil companies had sailed right off the continental shelf into ever deeper waters.

To many people in industry and government, spills from tankers like the *Exxon Valdez* seemed a much larger threat. The Minerals Management Service (MMS), the federal agency that regulated offshore drilling, had claimed that the chances of a blowout were less than one percent, and that even if one did happen, it wouldn't release much oil. Big spills had become a rarity, said Ploen. "Until this one."

In the Houma building, more than a thousand people were trying to organize a cleanup unlike any the world had seen. Tens of thousands more were outside, walking beaches in white Tyvek suits, scanning the waters from planes and helicopters, and fighting the expanding slick with skimmers, repurposed fishing boats, and a deluge of chemical dispersants. Around the spot Ploen called simply "the source," a small armada bobbed in a sea of oil. A deafening roar came from the drill ship *Discoverer Enterprise* as it flared off methane gas captured from the runaway well. Flames also shot from another rig, the *Q4000*, which was burning oil and gas collected from a separate line attached to the busted blowout preventer. Nearby, two shrimp boats pulling fire boom were burning oil skimmed from the surface, creating a curving wall of flame and a towering plume of greasy, black smoke. Billions of dollars had already been spent. But millions of barrels of light, sweet crude were still snaking toward the barrier islands, marshes, and beaches of the Gulf of Mexico.

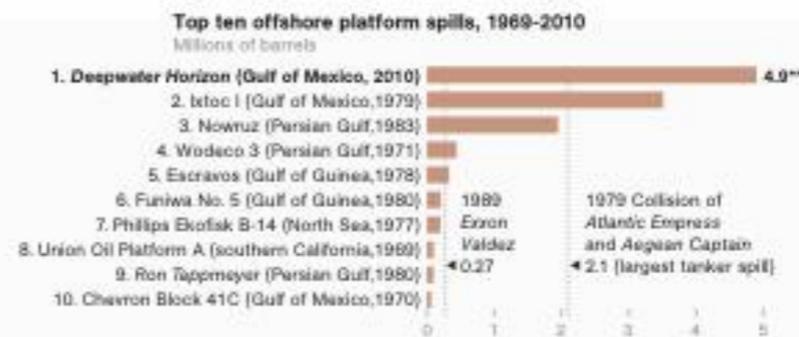
THE WATERS of the Gulf below a thousand feet are a relatively new frontier for oilmen—and one of the toughest places on the planet to drill. The seafloor falls off the gently sloping continental shelf into jumbled

basin-and-range-like terrain, with deep canyons, ocean ridges, and active mud volcanoes 500 feet high. More than 2,000 barrels of oil a day seep from scattered natural vents. But the commercial deposits lie deeply buried, often beneath layers of shifting salt that are prone to undersea earthquakes. Temperatures at the seafloor are near freezing, while the oil reservoirs can hit 400 degrees Fahrenheit; they're like hot, shaken soda



DRILLING FOR OFFSHORE OIL

Undersea oil provides an increasing amount of the global supply, as exploration heads ever deeper in search of new "plays." In 2020 wells more than 400 meters below the sea surface will likely provide 10 percent of the world's oil. But going deep poses technical challenges and safety risks.



*Only countries producing at least 25,000 barrels a day are shown (one barrel = 42 U.S. gallons). For legibility, some pie charts are shown inland or outside their country boundaries.

**August 2, 2010, estimate; of this total, 805,000 barrels of oil were captured by BP at the well.

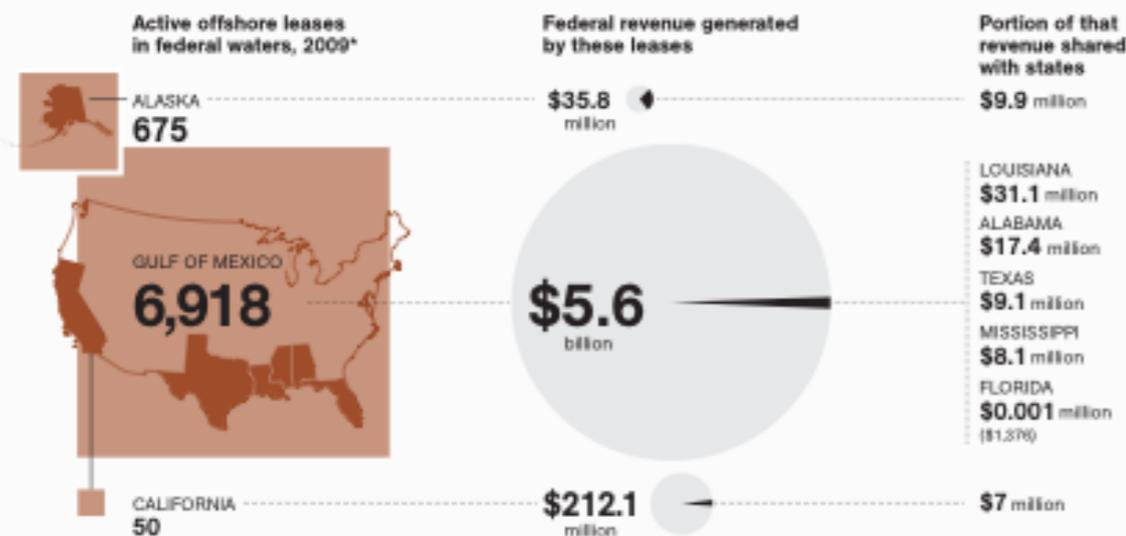
bottles just waiting for someone to pop the top. Pockets of explosive methane gas and methane hydrates, frozen but unstable, lurk in the sediment, increasing the risk of a blowout.

For decades the exorbitant costs of drilling deep kept commercial rigs close to shore. But shrinking reserves, spiking oil prices, and spectacular offshore discoveries ignited a global rush into deep water. Recent finds in Brazil's Tupi and

Guará fields could make that country one of the largest oil producers in the world. Similarly promising deepwater leases off Angola have excited bidding frenzies involving more than 20 companies.

In the Gulf of Mexico, the U.S. Congress encouraged companies to go deep as early as 1995. That year it passed a law forgiving royalties on deepwater oil fields leased between 1996 and

U.S. OFFSHORE LEASES



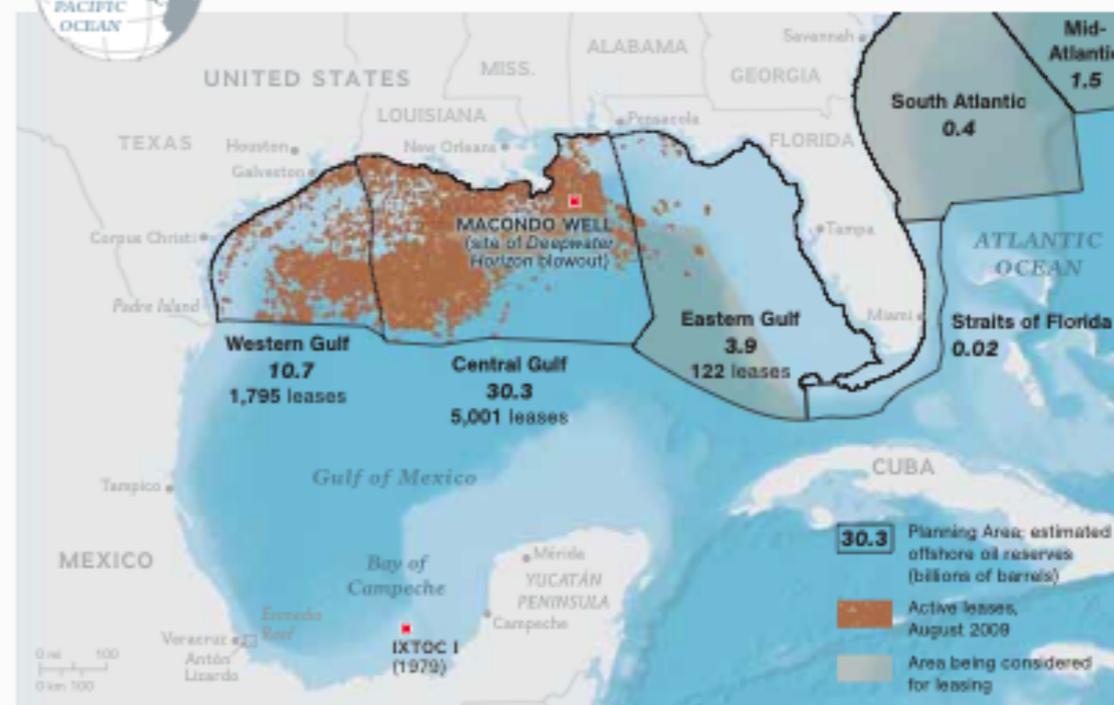
2000. A fleet of new rigs was soon punching holes all over the Gulf at a cost of up to a million dollars a day each. The number of leases sold in waters half a mile deep or more shot up from around 50 in 1994 to 1,100 in 1997.

It wasn't long before the industry hit pay dirt. New fields with names like Atlantis, Thunder Horse, and Great White came just in time to offset a long-term decline in shallow-water oil production. The Gulf of Mexico now accounts for 30 percent of U.S. production, with half of that coming from deep water (1,000 to 4,999 feet), a third from ultra-deep water (5,000 feet or more), and the rest from shallow water. BP's Macondo well, in about 5,000 feet of water and reaching another 13,000 feet beneath the seafloor, wasn't particularly deep. The industry has drilled in 10,000 feet of water and to total depths of 35,050 feet—the latter a world record set just last year by the *Deepwater Horizon* in another BP field in the Gulf. The U.S. government estimates that the deep Gulf might hold 45 billion barrels of crude. "We're in deep water because

that's where the resources are," says Larry Reed, an operations consultant in Houston who has worked with many of the major oil companies. Deepwater wells tend to be highly productive, he adds, like wells in the Middle East.

As technology was taking drillers deeper, however, the methods for preventing blowouts and cleaning up spills did not keep pace. Since the early 2000s, reports from industry and academia warned of the increasing risk of deepwater blowouts, the fallibility of blowout preventers, and the difficulty of stopping a deepwater spill after it started—a special concern given that deepwater wells, because they're under such high pressure, can spout as much as 100,000 barrels a day.

The Minerals Management Service routinely downplayed such concerns. A 2007 agency study found that from 1992 to 2006, only 39 blowouts occurred during the drilling of more than 15,000 oil and gas wells in the Gulf. Few of them released much oil; only one resulted in a death. Most of the blowouts were stopped within a week,



typically by pumping the wells full of heavy drilling mud or by shutting them down mechanically and diverting the gas bubble that had produced the dangerous "kick" in the first place.

Though blowouts were relatively rare, the MMS report did find a significant increase in the number associated with cementing, the process of pumping cement around the steel well casing (which surrounds the drill pipe) to fill the space between it and the wall of the borehole. In retrospect, that note of caution was ominous.

SOME DEEPWATER WELLS go in relatively easy. The Macondo well did not. BP hired Transocean, a Switzerland-based company, to drill the well. Transocean's first drill rig was knocked out of commission by Hurricane Ida after just a month. The *Deepwater Horizon* began its ill-fated effort in February 2010 and ran into problems almost from the start. In early March the drill pipe got stuck in the borehole, as did a tool sent down to find the stuck section; the drillers had to back out and drill around the

obstruction. A BP email later released by Congress mentioned that the drillers were having "well-control" problems. Another email, from a consultant, stated, "We have flipped design parameters around to the point that I got nervous." A week before the explosion, a BP drilling engineer wrote, "This has been [a] nightmare well."

By April 20 the *Deepwater Horizon* was six weeks behind schedule, according to MMS documents, and the delay was costing BP more than half a million dollars a day. BP had chosen to drill the fastest possible way—using a well design known as a "long string" because it places strings of casing pipe between the oil reservoir and the wellhead. A long string generally has two barriers between the oil and the blowout preventer on the seafloor: a cement plug at the bottom of the well, and a metal seal, known as a lockdown sleeve, placed right at the wellhead. The lockdown sleeve had not been installed when the Macondo well blew out.

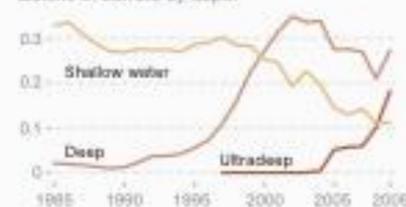
In addition, congressional investigators and industry experts contend that BP cut corners on

DRILLING DEEPER

As oil and gas reserves close to shore have been pumped dry, prospectors are plumbing a new frontier: the depths of the Gulf of Mexico. In 2009 Gulf oil production jumped 34 percent—largely from waters deeper than 5,000 feet. New technologies have made it possible to drill more than 35,000 feet down through water and rock.

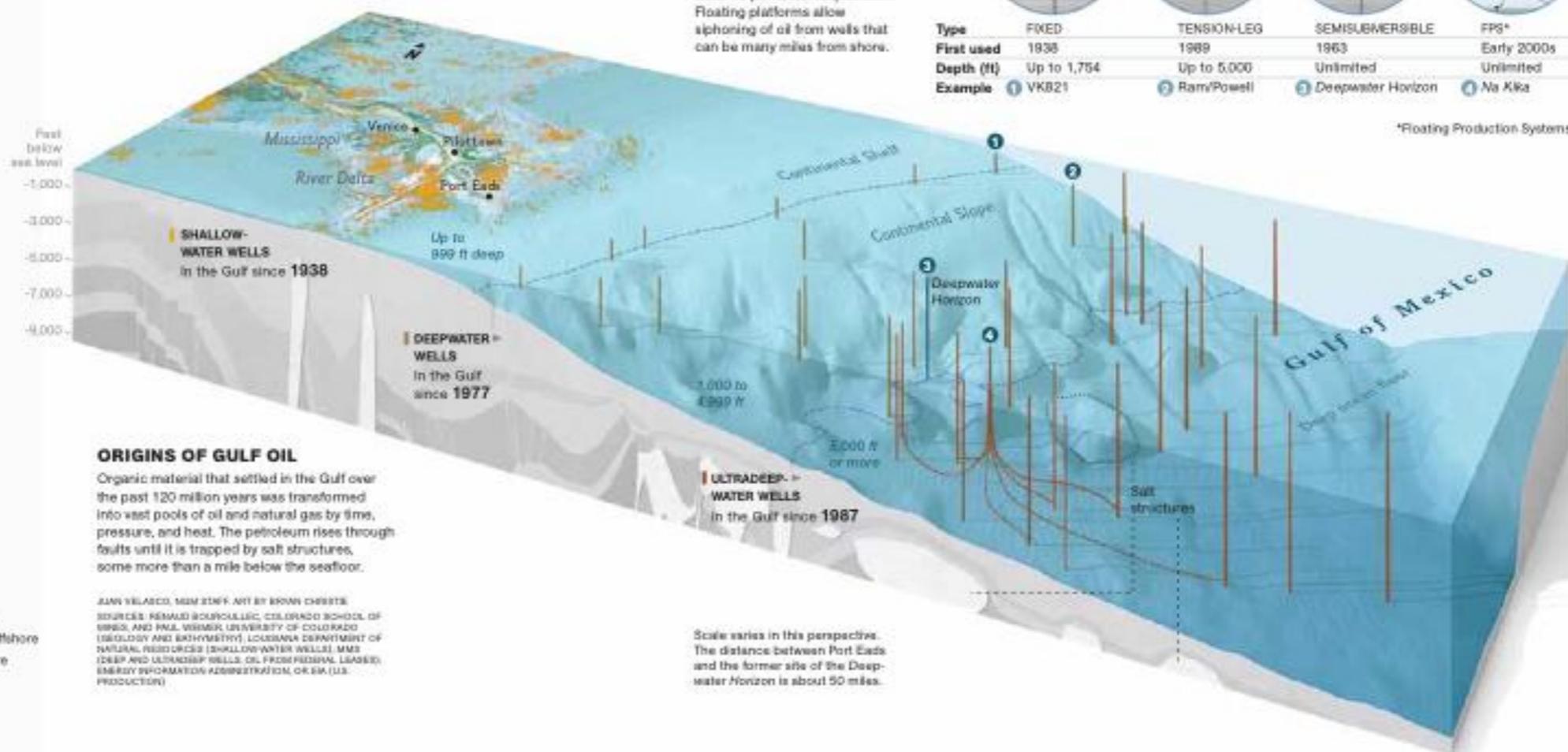
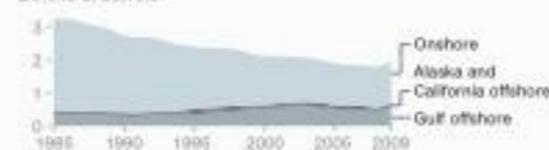
U.S. Gulf oil from federal leases, 1995-2009

Billions of barrels, by depth



U.S. domestic oil production, 1985-2009

Billions of barrels



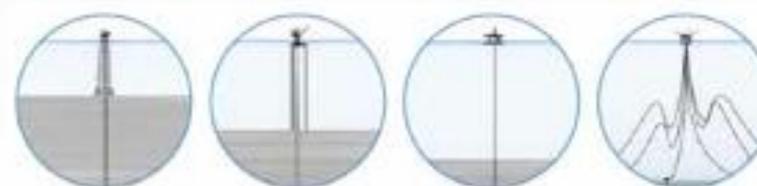
ORIGINS OF GULF OIL

Organic material that settled in the Gulf over the past 120 million years was transformed into vast pools of oil and natural gas by time, pressure, and heat. The petroleum rises through faults until it is trapped by salt structures, some more than a mile below the seafloor.

JUAN VELAZCO, MDM STAFF ART BY BROWN CHRISTIE
 SOURCES: FÉLIX BOURQUILLIC, COLORADO SCHOOL OF MINES; AND PAUL WERNER, UNIVERSITY OF COLORADO (GEOLOGY AND STRATIGRAPHY); LOUISIANA DEPARTMENT OF NATURAL RESOURCES (SHALLOW-WATER WELLS); MMS (DEEP AND ULTRADEEP WELLS); OIL FROM FEDERAL LEASES; ENERGY INFORMATION ADMINISTRATION, OR EIA (U.S. PRODUCTION)

SEAFARING RIGS

Floating rigs, first developed in the 1960s, have opened deep water to petroleum exploration. Floating platforms allow siphoning of oil from wells that can be many miles from shore.



| Type | FIXED | TENSION-LEG | SEMISUBMERSIBLE | FPSO* |
|------------|-------------|--------------|---------------------|-------------|
| First used | 1938 | 1989 | 1963 | Early 2000s |
| Depth (ft) | Up to 1,754 | Up to 5,000 | Unlimited | Unlimited |
| Example | 1 VKB21 | 2 Ram/Powell | 3 Deepwater Horizon | 4 Na Kika |

*Floating Production Systems

Scale varies in this perspective. The distance between Port Eads and the former site of the Deepwater Horizon is about 50 miles.

its cement job. It failed to circulate heavy drilling mud outside the casing before cementing, a practice that helps the cement cure properly. It didn't put in enough centralizers—devices that ensure that the cement forms a complete seal around the casing. And it failed to run a test to see if the cement had bonded properly. Finally, just before the accident, BP replaced the heavy drilling mud in the well with much lighter seawater, as it prepared to finish and disconnect the rig from the well. BP declined to comment on these matters, citing the ongoing investigation.

All these decisions may have been perfectly legal, and they surely saved BP time and money—yet each increased the risk of a blowout. On the night of April 20, investigators suspect, a large gas bubble somehow infiltrated the

casing, perhaps through gaps in the cement, and shot straight up. The blowout preventer should have stopped that powerful kick at the seafloor; its heavy hydraulic rams were supposed to shear the drill pipe like a soda straw, blocking the upward surge and protecting the rig above. But that fail-safe device had itself been beset by leaks and maintenance problems. When a geyser of drilling mud erupted onto the rig, all attempts to activate the blowout preventer failed.

The way BP drilled the Macondo well surprised Magne Ognedal, director general of the Petroleum Safety Authority Norway (PSA). The Norwegians have drilled high-temperature, high-pressure wells on their shallow continental shelf for decades, he said in a telephone interview, and haven't had a catastrophic blowout

since 1985. After that incident, the PSA and the industry instituted a number of best practices for drilling exploration wells. These include riserless drilling from stations on the seafloor, which prevents oil and gas from flowing directly to a rig; starting a well with a small pilot hole through the sediment, which makes it easier to handle gas kicks; having a remote-controlled backup system for activating the blowout preventers; and most important, never allowing fewer than two barriers between the reservoir and the seafloor.

"The decisions [BP] made when they had indications that the well was not stable, the decision to have one long pipe, the decision to have only six centralizers instead of 21 to create the best possible cement job—some of these things

were very surprising to us here," says Ognedal.

The roots of those decisions lie in BP's corporate history, says Robert Bea, a University of California, Berkeley expert in both technological disasters and offshore engineering. BP hired Bea in 2001 for advice on problems it faced after it took over the U.S. oil companies Amoco and ARCO. One problem, Bea says, was a loss of core competence: After the merger BP forced thousands of older, experienced oil field workers into early retirement. That decision, which made the company more dependent on contractors for engineering expertise, was a key ingredient in BP's "recipe for disaster," Bea says. Only a few of the 126 crew members on the *Deepwater Horizon* worked directly for BP.

The drilling operation itself was regulated by



"Mix two parts sugar white sand with one part crystal blue water," reads a tourism slogan for Orange Beach, Ala. In early June Deepwater Horizon oil was added to the recipe.

TYRONN TURPIN

BP's spill-response plan for the Gulf mentioned walrus and sea otters. It had been cut and pasted from plans for the Arctic.

the MMS (which, in the wake of the accident, was reorganized and renamed the Bureau of Ocean Energy Management, Regulation, and Enforcement). In 2009 the MMS had been excoriated by the U.S. General Accounting Office for its lax oversight of offshore leases. That same year, under the new Obama Administration, the MMS rubber-stamped BP's initial drilling plan for the Macondo well. Using an MMS formula, BP calculated that the worst-case spill from the well would be 162,000 barrels a day—nearly three times the flow rate that actually occurred. In a separate spill-response plan for the whole Gulf, the company claimed that it could recover nearly 500,000 barrels a day using standard technology, so that even a worst-case spill would do minimal harm to the Gulf's fisheries and wildlife—including walrus, sea otters, and sea lions.

There are no walrus, sea otters, or sea lions

in the Gulf. BP's plan also listed as an emergency responder a marine biologist who had been dead for years, and it gave the Web address of an entertainment site in Japan as an emergency source of spill-response equipment. The widely reported gaffes had appeared in other oil companies' spill-response plans as well. They had simply been cut and pasted from older plans prepared for the Arctic.

When the spill occurred, BP's response fell well short of its claims. Scientists on a federal task force said in early August that the blowout well had disgorged as much as 62,000 barrels a day at the outset—an enormous flow rate, but far below BP's worst-case scenario. Mark Ploen estimated in June that on a good day his response teams, using skimmers brought in from around the world, were picking up 15,000 barrels. Simply burning the oil, a practice that had been used with the *Exxon Valdez* spill,

had proved more effective. BP's burn fleet of 23 vessels included local shrimp boats that worked in pairs, corralling surface oil with long fire boom and then igniting it with homemade napalm. In one "monster burn" the team incinerated 16,000 barrels of oil in just over three hours.

"Shrimpers are naturals at doing this," said Neré Mabile, science and technology adviser for the burn team in Houma. "They know how to pull nets. They're seeing that every barrel we burn is a barrel that doesn't get to shore, doesn't affect the environment, doesn't affect people. And where's the safest place to burn this stuff? The middle of the Gulf of Mexico."

In June the *Discoverer Enterprise* and the *Q4000* began collecting oil directly at the busted blowout preventer, and by mid-July they had ramped up to 25,000 barrels a day—still far less, even when the efforts of the skimmers and the burn team were added, than the nearly 500,000

barrels a day BP had claimed it could remove. At that point the company finally succeeded in placing a tight cap on the well, halting the gusher after 12 weeks.

In 1990, after the *Exxon Valdez* spill, Congress's Office of Technology Assessment analyzed spill-response technologies and found them lacking. "Even the best national response system will have inherent practical limitations that will hinder spill-response efforts for catastrophic events—sometimes to a major extent," wrote OTA's director, John H. Gibbons. "For that reason it is important to pay at least equal attention to preventive measures as to response systems... The proverbial ounce of prevention is worth many, many pounds of cure."

Just weeks before the Macondo blowout, the Obama Administration had announced with some fanfare an expansion of offshore drilling. By summer the administration was struggling

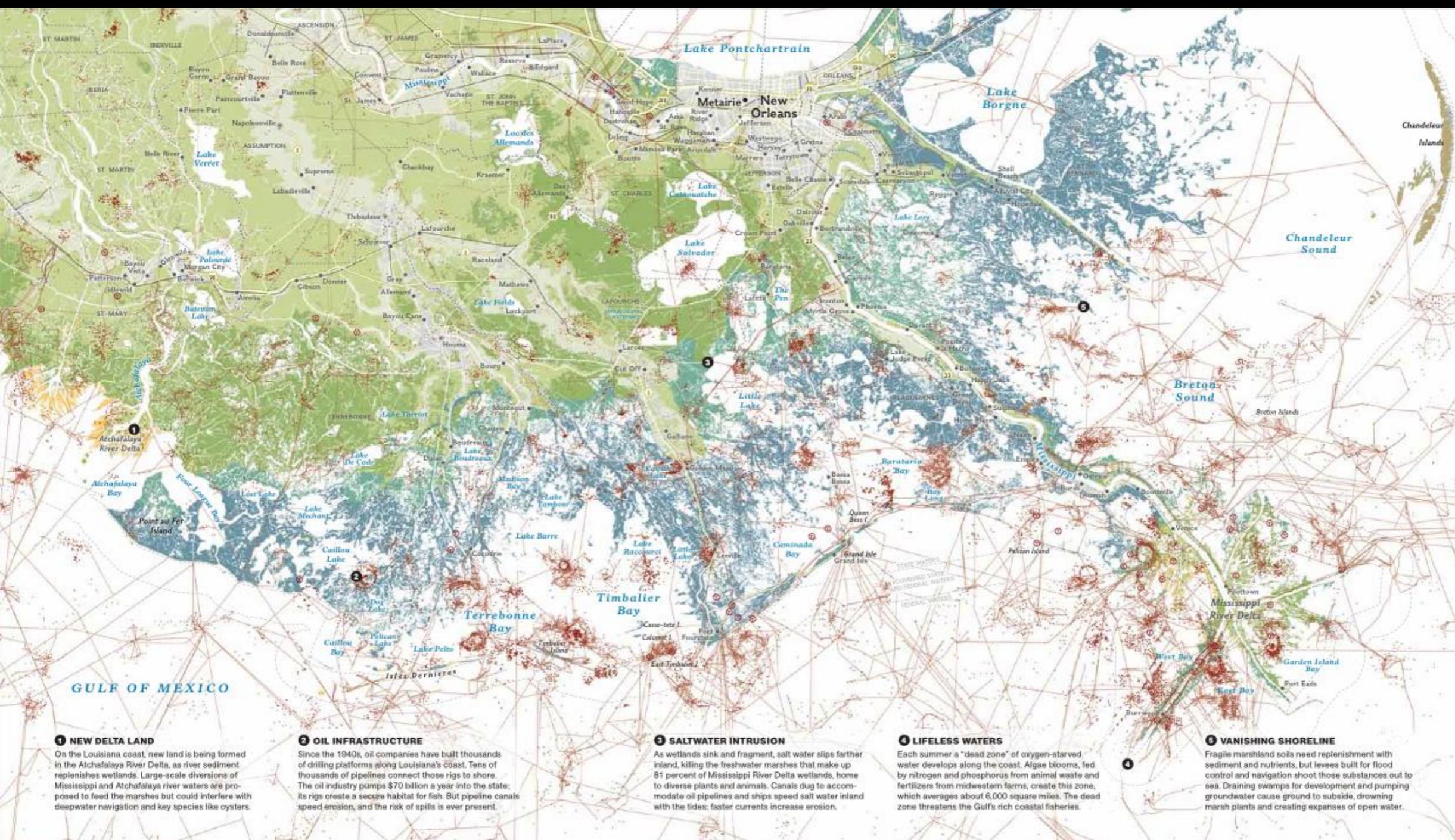


THE SPILL'S UNSEEN TOLL

Three formaldehyde-filled jars tell a tale of diminishing life in a water column about 90 miles north of the well. The May 4 sample (far left), collected by the Dauphin Island Sea Lab, Ala., shows a normal amount of plankton—minute plants and animals that are the foundation of the ocean's food chain. The June 2 jar holds only 40 percent of the first. The June 28 jar is down to 10 percent. Plankton cannot survive as waters become hypoxic—depleted of oxygen. The probable cause in this case: microbes digesting oil and methane gas from the spill.

Waters sampled about 35 feet deep on June 28 support a thriving population of tiny crustaceans called copepods (top right). Twenty feet farther below was a hypoxic layer almost devoid of life. Deep waters are more likely to remain hypoxic.

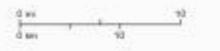




ENDANGERED WETLANDS

The Deepwater Horizon spill is just the latest threat to the Mississippi River Delta and its inhabitants. Both natural processes and human interference have submerged more than 2,300 square miles of coastal marshes. Nonetheless, the area is still one of the world's richest river deltas, home to shrimp and oyster fisheries, endangered sea turtles, millions of birds, a multibillion-dollar oil industry, and two million people. This map details the ongoing problems that confront the delta.

- Tidal flats and shoals
- Sea grass
- Saltwater marsh
- Intermediate marsh
- Freshwater marsh
- Other freshwater wetland
- Upland
- Urban area
- Oil or gas well
- ⊙ Crude oil or gas terminal
- ⊖ Oil refinery
- Oil or gas pipeline



1 NEW DELTA LAND

On the Louisiana coast, new land is being formed in the Atchafalaya River Delta, as river sediment replenishes wetlands. Large-scale diversions of Mississippi and Atchafalaya river waters are proposed to feed the marshes but could interfere with deepwater navigation and key species like oysters.

2 OIL INFRASTRUCTURE

Since the 1940s, oil companies have built thousands of drilling platforms along Louisiana's coast. Tens of thousands of pipelines connect those rigs to shore. The oil industry pumps \$70 billion a year into the state. Its rigs create a secure habitat for fish. But pipeline canals speed erosion, and the risk of spills is ever present.

3 SALTWATER INTRUSION

As wetlands sink and fragment, salt water slips farther inland, killing the freshwater marshes that make up 81 percent of Mississippi River Delta wetlands, home to diverse plants and animals. Canals dug to accommodate oil pipelines and ships speed salt water inland with the tides; faster currents increase erosion.

4 LIFELESS WATERS

Each summer a "dead zone" of oxygen-starved water develops along the coast. Algae blooms, fed by nitrogen and phosphorus from animal waste and fertilizers from midwestern farms, create this zone, which averages about 6,000 square miles. The dead zone threatens the Gulf's rich coastal fisheries.

5 VANISHING SHORELINE

Fragile marshland soils need replenishment with sediment and nutrients, but levees built for flood control and navigation shoot those substances out to sea. Draining swamps for development and pumping groundwater cause ground to subside, drowning marsh plants and creating expanses of open water.

WILLIAM MURPHY, NEAM STAFF; DEBBIE GIBSON AND SHARLEEN J. FLORAN FOR NEAM; THODORE A. BOKLEY
 SOURCES: NOAA AND THE NATURE CONSERVANCY (LAND COVER); USGS AND LOUISIANA DEPARTMENT OF NATURAL RESOURCES, OFFICE OF CONSERVATION AND OFFICE OF COASTAL MANAGEMENT (OIL AND GAS INFRASTRUCTURE); LANDSCAN 2016 (URBAN AREAS)

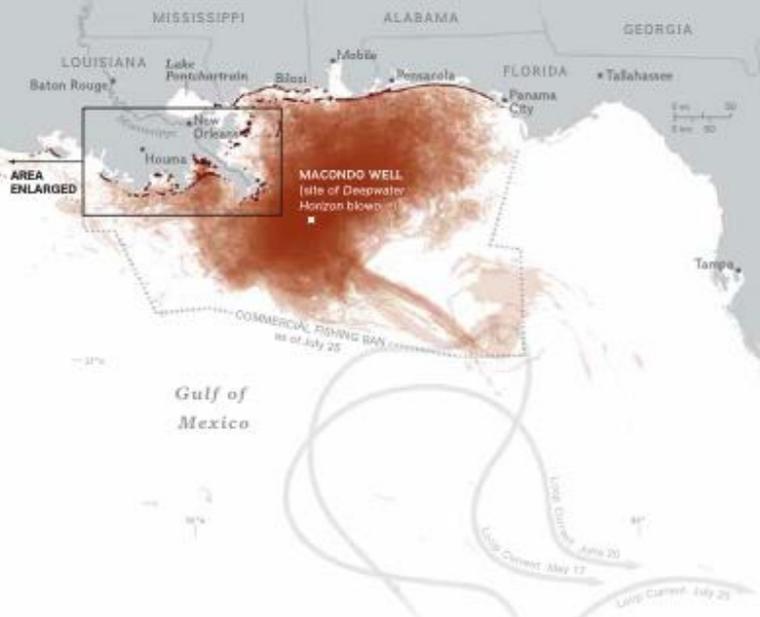
AN OILY STAIN

Winds and currents spread surface oil, contaminating more than 625 miles of coastline, most in Louisiana. The spill prompted a fishing ban in one-third of federal waters (partly rescinded in late July) and a massive and ongoing cleanup effort. Experts believe much of the oil never reached the surface and remains in voluminous and elusive underwater plumes.

Surface oil
Cumulative 1 day 10 304
daily survey

Oiled coast

May 17-July 25, 2010



THE BATTERED GULF COAST

Two centuries of efforts to tame the Mississippi River with levees, pumps, and channels have left its vast wetlands ecosystem dwindling and on the verge of collapse. "We know there was a crisis in the Gulf prior to what happened April 20," Tom Strickland, an assistant secretary of the interior, said after the Deepwater Horizon spill. Coastal-restoration plans have been authorized by Congress but are not yet under way. They include breaking open levees to restore the flow of rivers to marshlands. Environmentalists are lobbying to apply oil spill penalty funds to restoration.

MAP: PEPPE AND LISA R. REYER, NEMU STAFF
SOURCES: NOAA (SURFACE OIL); U.S. NAVAL RESEARCH LABORATORY (LOOP CURRENT); NOAA AND UNIFIED ANNA COMBINED (OILED COAST)



Canals carved through Golden Meadow, La., and elsewhere hold pipelines that deliver oil and gas from offshore wells. This chopping up of the wetlands is one of many forces contributing to the decline of the Mississippi Delta.

JILL SARTORE



A dead juvenile sea turtle lies marooned in oil in Barataria Bay, La. More than 500 sea turtles died in the spill area. As of August 2, eggs from 134 turtle nests had been moved to oil-free beaches, and 2,134 hatchlings released.

JOEL SANTOP

FORLORN IN THE BAYOU

Louisiana's wetlands are resilient and have bounced back before. But no one knows how long this recovery will take.

BY BRUCE BARCOTT

WHERE LAND MEETS THE SEA in the Mississippi River Delta, down at the bottom of the Louisiana boot, the term "coastline" doesn't really apply. There is no line. There are only the dashed pen strokes of the barrier islands, a dozen or so thin beachheads, and beyond, a porous system of open bays, canals, salt and brackish marshes, and freshwater swamps running inland for 25 to a hundred miles.

These are the Louisiana wetlands—12,355 square miles of one of the most productive ecosystems in North America. Mullet are so profuse they will literally jump into a fisherman's boat. Brown pelicans, tricolored herons, roseate spoonbills, great egrets, and blue-winged teal ducks call this place home.

One-third of the United States oyster and shrimp crop comes out of the waters along the Louisiana coast. And 98 percent of the fish, shrimps, crabs, and oysters harvested along that coast depend on habitat in and around the marshes of the Barataria-Terrebonne estuary, an area that encompasses some four million acres south and west of New Orleans. Without these

Environmental journalist Bruce Barcott lives on Bainbridge Island, Washington. This is his fourth feature for National Geographic.



Workers bag oil-collecting pom-poms near a bird rookery in Barataria Bay, La. Absorbent boom snakes at their feet. By the end of July, the cleanup had generated almost 40,000 tons of solid waste.

JOEL WATSON



In mid-May pools of oil moved into Louisiana's wetlands. BP boats laid yellow and orange boom to corral the oil for cleanup, white boom to soak it up. Oil covered the grass, but by mid-July new growth had sprouted.

TED JACKSON, TIMES-PICAYUNE

The federal government would not ride to the rescue. If Louisianans wanted the marshes protected, they would have to do it themselves.

that was heavily oiled two weeks ago," Kulp said. He showed me pictures of dark reddish-brown oil gunked on the shore at Devils Point. "It was pretty badly hit."

Kulp had recommended no radical cleaning. "We had them run some boom to suck oil from the water along the shoreline. I'm hoping the tidal action will slowly wash the oil out of the vegetation and into the boom." The material in the boom is hydrophobic (water repellent) and oleophilic (oil absorbent). So when oil touches it, the boom won't let it go.

Three hours later an airboat dropped us off on Devils Point. We sloshed ashore at high tide. Nearly the entire peninsula was under six inches of water. "What I want to know is if the oil is moving into the interior, or if it's staying on the fringe," Kulp said.

It took about five minutes to make our way across. The news was mostly good. Some mangrove leaves had gone black, and some areas of glasswort were still lightly oiled. But the tidal and wave action had worked like a washing machine agitator, lifting the oil off the plants and moving it onto the white boom, which was now black with oil.

Back at SCAT headquarters that evening, division leader Ed Owens brought his 45-member staff together for a half-hour debriefing. Owens, a bigger-than-life British man with a rakish eye patch, came up with the SCAT concept while working on the Exxon Valdez response. Each SCAT team reported on what it had found.

"Team two. Mark?"

Kulp nutshelled it. "We went back to Devils Point, where we're seeing progressive flushing with the tides. If we keep changing out the dirty boom, I think the high tides will continue doing us some good."

One of the other SCAT teams reported that the beach on East Grand Terre, a barrier island, was still full of pooled oil. "This is the poster child right now," the team leader said. "We need to get a cleanup team out there."

Owens sighed. In this complex cleanup operation, the assignment of cleanup crews was beyond his purview. He could recommend, but

he could not dispatch. That was the job of the operations division.

"We'll go to ops tonight and tell them they've got to get on this now," Owens said, clearly frustrated at the thought of yet another delay. As the meeting broke up, he turned to his deputy. "We're going to have to kick some ass on that Grand Terre situation." Whether that would result in any action, nobody could say.

Kulp stayed late filling out a report on Devils Point. It might get filed in the bureaucratic ether. Or somehow it might make a difference in the recovery of Timbalier Bay. On his computer screen he called up a photo of the oil from his original visit to Devils Point. "It certainly looks a lot less scary than when I saw it two weeks ago," he said. "With what we saw today, I do feel a sense of hope."

CLEANING OIL from the marshes is one thing. Cleaning the wildlife that lives in the marshes is another thing entirely. BP had hired dozens of wildlife professionals to collect oiled birds and turtles, but they were often overwhelmed by the workload. That led to frustration and sometimes improvisation.

Every morning in early June the Plaquemines Parish coastal director, P. J. Hahn, met a fishing guide named Dave Marino at 4:45 in the refinery town of Port Sulphur, and the two of them went oil scouting. Hahn needed to know where the oil was washing up. Marino, his business wrecked by oil, was happy to have the work.

On the morning of June 5 Hahn said to Marino, "We better take a look at Queen Bess."

A 97-acre clump of oyster grass and shell midden, Queen Bess Island is one of the fragile masterpieces of Barataria Bay. When Louisiana reintroduced the extirpated brown pelican in the late 1960s, Queen Bess became a primary nesting ground. In 1990 coastal-restoration advocates ringed the island with a rock barrier to keep it from sinking into the bay. Hundreds of brown pelicans, Forster's terns, and laughing gulls now flock there annually to nest.

Hahn glassed the shore as we approached the island. "It's getting worse over here," he said.



Workers wipe oil from marsh grass in St. Tammany Parish, La. It does look silly, a parish spokesman concedes, using diaper-like cloths to "wipe up seven billion blades of grass." But the task helped gauge the degree of marsh grass contamination, which turned out to be small, and provided oil samples for testing. Below, rust-colored crude oil coats a blue crab's face and claws at Grand Isle State Park, La.



We carried the pelican to the boat. The sopping, sun-heated bird felt as warm as fresh bread.

fingerlike breathing tubes that provide oxygen to the tree's underwater roots. "Even a light sheen can clog those tubes," St. Pé said as we scrutinized a number of empty pelican nests in the mangroves on Cat Island. Their oiled residents had been caught and taken to the rehab center the previous day.

As we drifted along the shore of Cat Island, gobs of oil floated by, fraying at the edges in the 97-degree heat. "It's degrading pretty quickly," said St. Pé. "The hot Louisiana sun can induce a lot of photooxidation and evaporation," he said. "And oil-consuming bacteria will multiply quickly now, because there's lots of food."

For the marshes of the Barataria-Terrebonne estuary, the damage done by the oil spill didn't compare with the damage done by decades of canal cutting and sediment starvation, St. Pé said. "The ecological effects of this will gradually subside. But the socioeconomic impacts will be devastating. No oysters, at least in the near future. No crabbing. No fishing. No seafood to restaurants. Nobody buying ice or bait or marine supplies. Lost paychecks with the offshore-drilling moratorium. Those impacts will stay for a long time."

ONE EVENING in early June I drove down to the Grand Isle shore and watched coin-size gobs of oil wash up in the surf. The beach at Grand Isle has become famous for visits from President Barack Obama and clean-up crews scooping oil out of sand. But on this night it was deserted. The only sound was a light whoosh from the waves.

Then I spotted two birds flying low from the east along the tide line. It took me a moment to identify them. Oystercatchers? No. By their motion they revealed themselves. They were black skimmers, which catch small fish by dipping their lower bills into the top three inches of water as they fly. As they flew past, I watched them skim water pocked with oil. I wanted to wave them away, flash a warning sign, scare them off. But it was too late. They continued down the shore, skimming and skimming and skimming. □



A brown pelican rests at the Fort Jackson Bird Rehabilitation Center in Buras, La., after a cleaning. Only a tiny fraction of birds are retrieved and released. No one yet knows how oil and dispersants will affect reproduction.

JOEL SANTORA

COASTAL ECOSYSTEMS

The meeting of land and sea along more than 16,000 miles of coastline from Texas to Florida creates a wealth of ecosystems, from mangrove forests to coral reefs. The dynamic mixing of salt water and fresh water and the daily infusions of sediments from rivers nourish areas that provide habitat for wildlife and protection from pollution and storms.

SALTWATER MARSHES

Tough grasses, like cordgrass, thrive in the intertidal zone, with its high salinity levels. Marsh grasses filter pollutants in the water and trap sediment to help build up land.

MARSH PERIWINKLES, feeding on grasses, regulate the growth of healthy marshes and serve as food for turtles, crabs, and birds.

COASTAL PRAIRIES

An endangered ecosystem, coastal prairies in Texas and Louisiana, fringed by marsh, accommodate migrating waterfowl, shorebirds, and songbirds.

OYSTER BEDS

The Gulf's oyster beds are among the most productive in the world. Oysters filter water, and the reef structure provides habitat for many marine species.

SHORELINE FORESTS

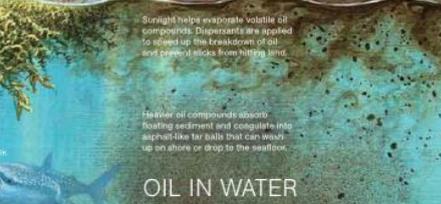
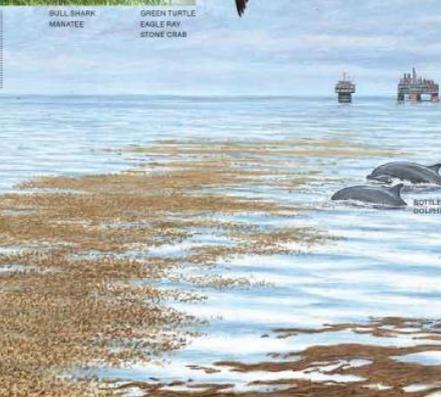
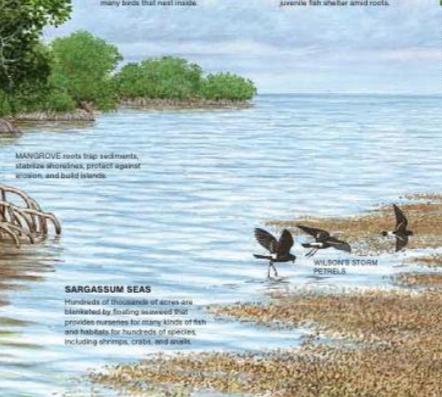
Coastal forests, including pine wetlands and banks of the oak, form buffers between shoreline and inland ecosystems and offer vital stopovers for migrating birds.

FRESHWATER RIVERS

Almost 60 percent of the U.S. watershed drains into the Gulf. River sediments have built up the Mississippi Delta, the largest coastal wetland in the lower 48 states.

TURTLES

The Gulf harbors one of the world's greatest concentrations of turtle species. Five threatened or endangered sea turtle species lay their eggs on Gulf beaches.



MARINE ECOSYSTEMS

Between its light-flooded surface and dark, barely explored depths, the Gulf's water world hosts an intricate web of life, from plankton to whales. Many inhabitants move between levels to feed. Others live on organic debris falling from above. Creatures composed mostly of water haunt the deep under crushing pressure, the darkness lit by bioluminescent hunters.

BRIGHT SURFACE

Plankton drifting in the sunlit epipelagic zone create a rich soup to start the marine food chain. Many plankton account for roughly half of Earth's photosynthesis, pulling energy from the atmosphere's oxygen. Many fish, crustaceans, and mammals, hiding in deep water by day, rise at night to feed.

TWILIGHT ZONE

As sunlight fades, plants can't survive, giving way in the mesopelagic zone to an animal realm of predators, scavengers, and filter feeders. Many of its inhabitants feed on organic matter falling from above. The huge sperm whale passes through this zone, descending 3,000 feet and deeper to hunt squid.

DARK AND TEEMING

In the bathypelagic zone, more than two miles deep at its outer limit, live animals that have adapted to extreme cold and pressure, including 20-foot-long eelworm squid, bioluminescent fish, and deep-sea jellyfish.

CORAL REEF

Perhaps the most endangered marine ecosystem, coral reefs can house hundreds of fish species and deflect high storm waves. The world's third largest barrier reef lies off the Florida Keys.

COLD-WATER CORAL

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.

COLD SEEP

Mussels and tube worms subsist on methane and hydrogen sulfide, chemicals seeping from the seafloor. Corals and sponges feed on organic matter drifting and swimming past.

SEA FAN

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.

SEA FAN

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.

SEA FAN

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.

SEA FAN

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.

SEA FAN

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.

SEA FAN

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.

SEA FAN

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.

SEA FAN

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.

SEA FAN

Deep-sea coral grows slowly on reefs built up over thousands of years. These structures anchor an ecosystem with more than 2,000 species, including crabs, sponges, fish, sea stars, and sponges.



THE GULF OF MEXICO Layers of Life

The rich habitats of the Gulf of Mexico help make it one of the most ecologically and economically productive bodies of water in the world. Its environments range from sandy, ever shifting barrier islands to muddy, tide-washed marshes, from frigid dark zones miles deep to immense islands of floating seaweed. Even before the *Deepwater Horizon* rig explosion on April 20, 2010, which spewed millions of barrels of oil into the water, the Gulf was battling serious problems, including overfishing, extensive wetlands loss, and a huge oxygen-starved "dead zone" at the mouth of the Mississippi River. The oil spill is affecting every habitat, testing the Gulf's resilience.



ILLUSTRATION BY NICHOLE GONZALEZ FOR NATIONAL GEOGRAPHIC, OCTOBER 2011
 ART DIRECTION AND DESIGN: JENNIFER HARRINGTON. ART: ALAN CHARLES. TREE: JAMES HARRIS. MOUNTAIN: TONY HARRIS. CANYON: JAMES HARRIS. RIVER: JAMES HARRIS. SEA: JAMES HARRIS. SKY: JAMES HARRIS. SUN: JAMES HARRIS. MOON: JAMES HARRIS. STARS: JAMES HARRIS. PLANETS: JAMES HARRIS. GALAXIES: JAMES HARRIS. UNIVERSE: JAMES HARRIS.

Straight helps evaporate volatile oil compounds. Dispersants are spotted to speed up the breakdown of oil and prevent it from hitting land.

Heavier oil compounds absorb floating sediment and coagulate into asphalt-like tar balls that can wash up on shore or deep to the seafloor.

OIL IN WATER

Crude oil contains hundreds of compounds that are toxic to marine life. To break up oil gushing from the Macondo well, BP has used large amounts of chemical dispersants at the surface and in the depths. The environmental impact of oil combined with dispersants in deep water is uncertain, and scientists worry that damage control will further imperil the food web.

Vast numbers of drifting fish eggs and larvae, food for larger creatures like whale sharks, are vulnerable to globules of oil and dispersants that envelop and kill microseans.



MACONDOS WELL DEPTH: APPROXIMATELY 6,000 FEET

