DOUBLE MAP SUPPLEMENT: THE WORLD

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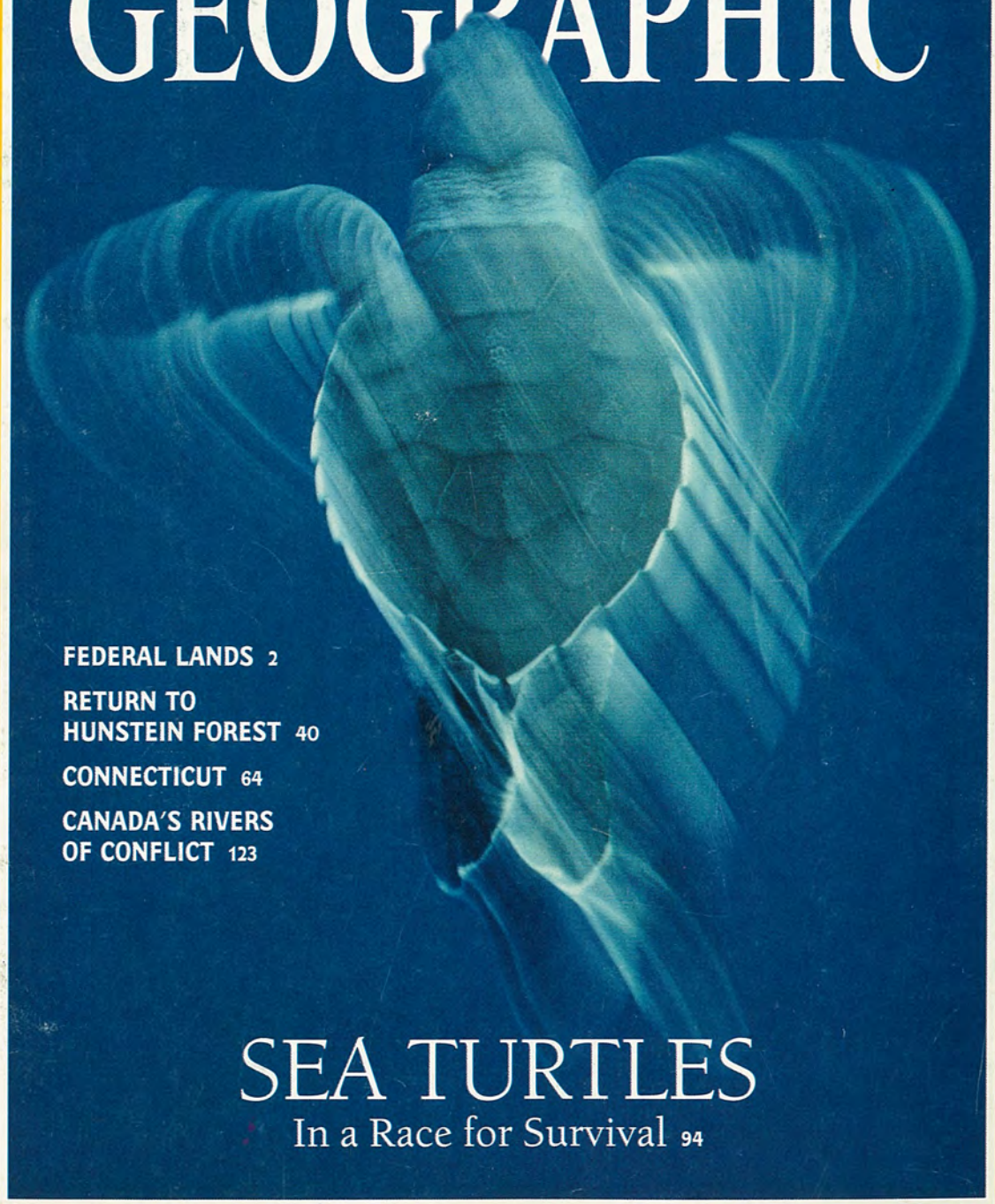




## SEA TURTLES

In a Race for Survival 94

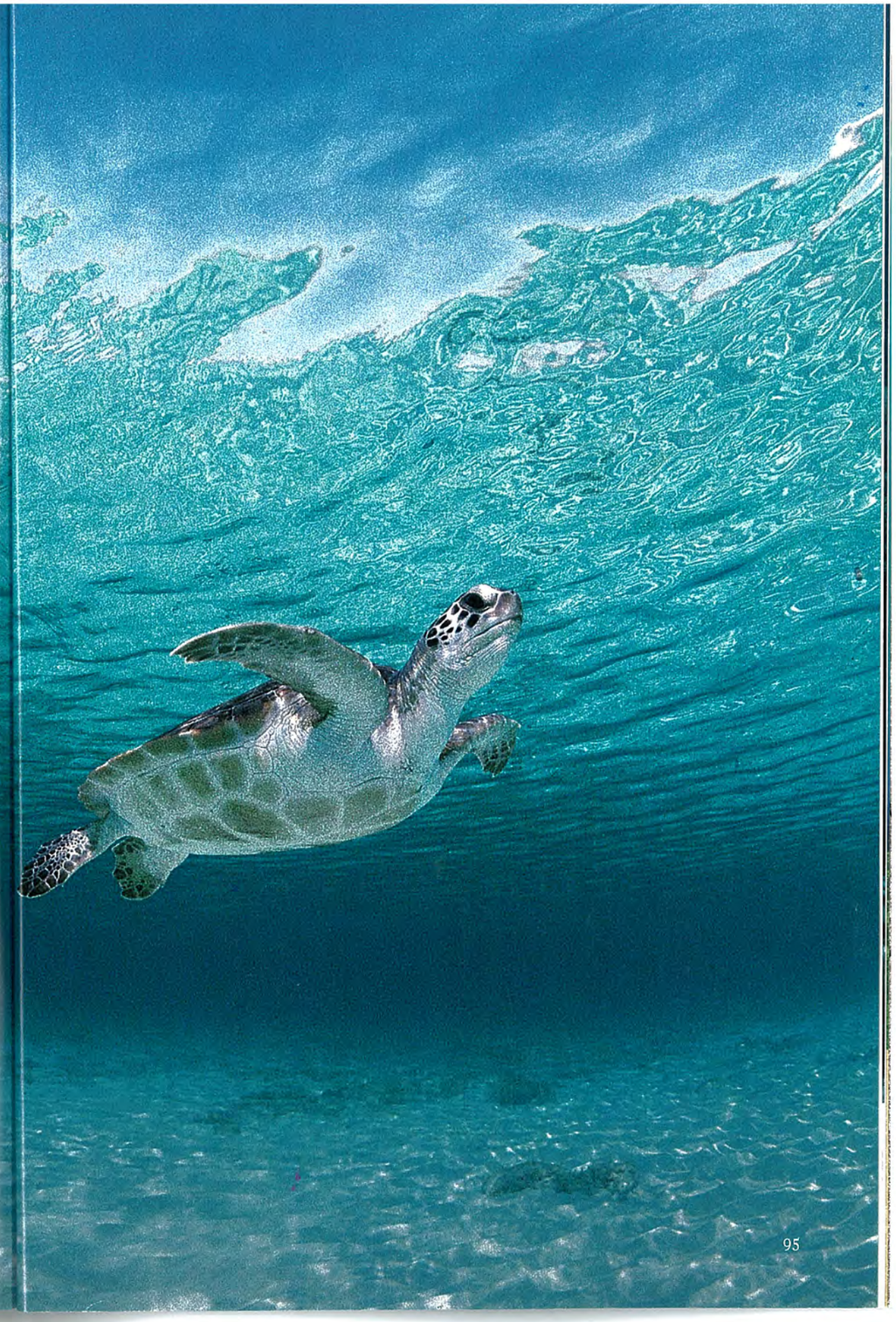
SEE "REFLECTIONS ON ELEPHANTS" WEDNESDAY, FEBRUARY 9, ON PBS TV

SEA TURTLES

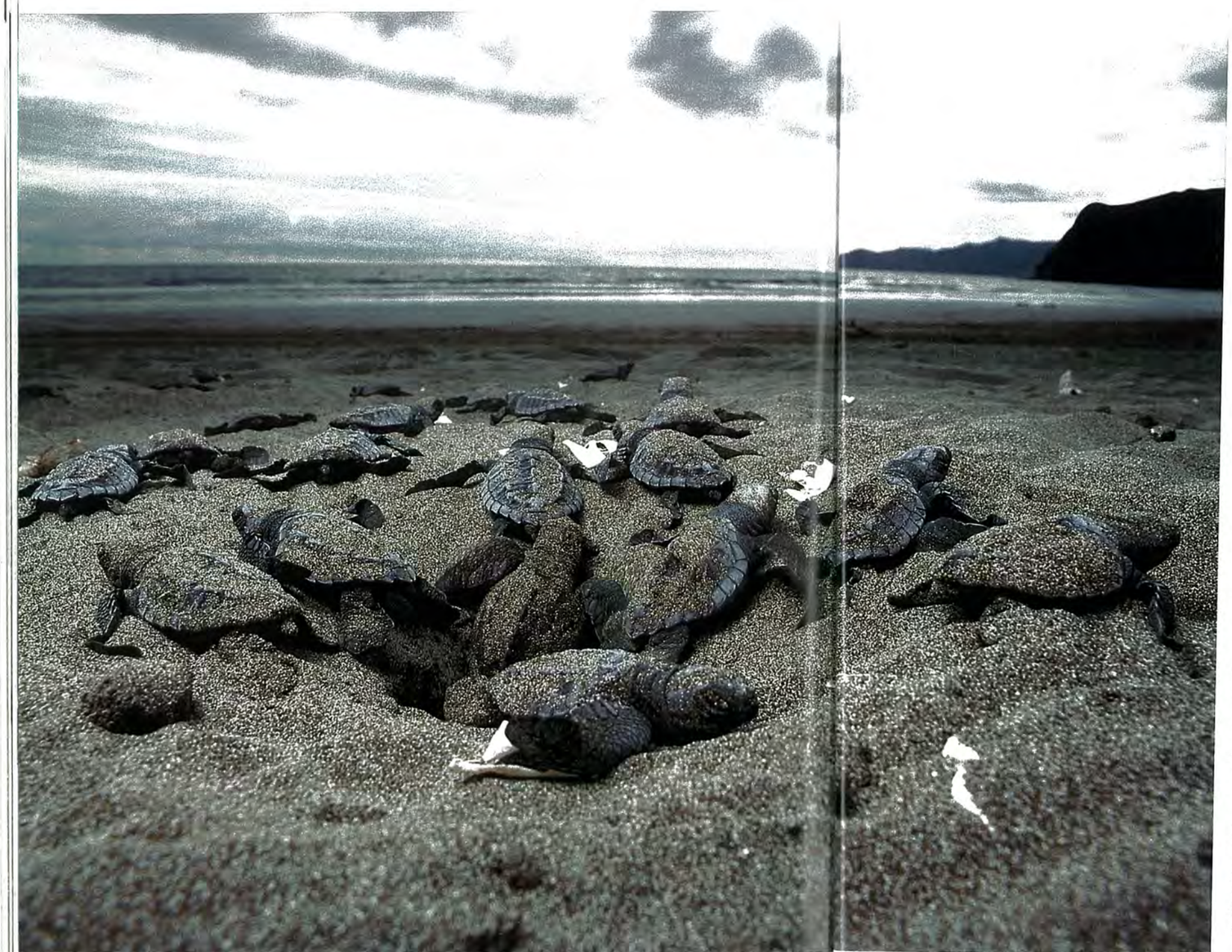
# IN A RACE FOR SURVIVAL

By Anne and Jack Rudloe

Photographs by Bill Curtsinger



Exposed and wary, a wild green sea turtle haunts a Caribbean shoal. Once abundant, all eight species of sea turtles are now threatened or endangered, pushed toward extinction by the hunting, development, and indifference of humankind.



Emerging at dawn on a remote beach in western Costa Rica, two-inch olive ridley hatchlings begin a dash to the sea—against dismal odds. Attacked in their nests by fungi and fly larvae, eaten ashore by birds, crabs, and small mammals, and caught at sea by groupers, sharks, and fishnets, sea turtles have less than a one percent chance of living to maturity. None from this nest even made it to the water.

TURTLES POURED OUT of the surf in wave after wave through the darkness. Heaving, huffing, gasping turtles plowed the coarse black sand with their noses, laboring onto shore. On this rain-soaked October night possibly 30,000 olive ridley sea turtles were converging on a half mile of Pacific beach at Ostional, Costa Rica, in a biological extravaganza called *la arribada*—the arrival.

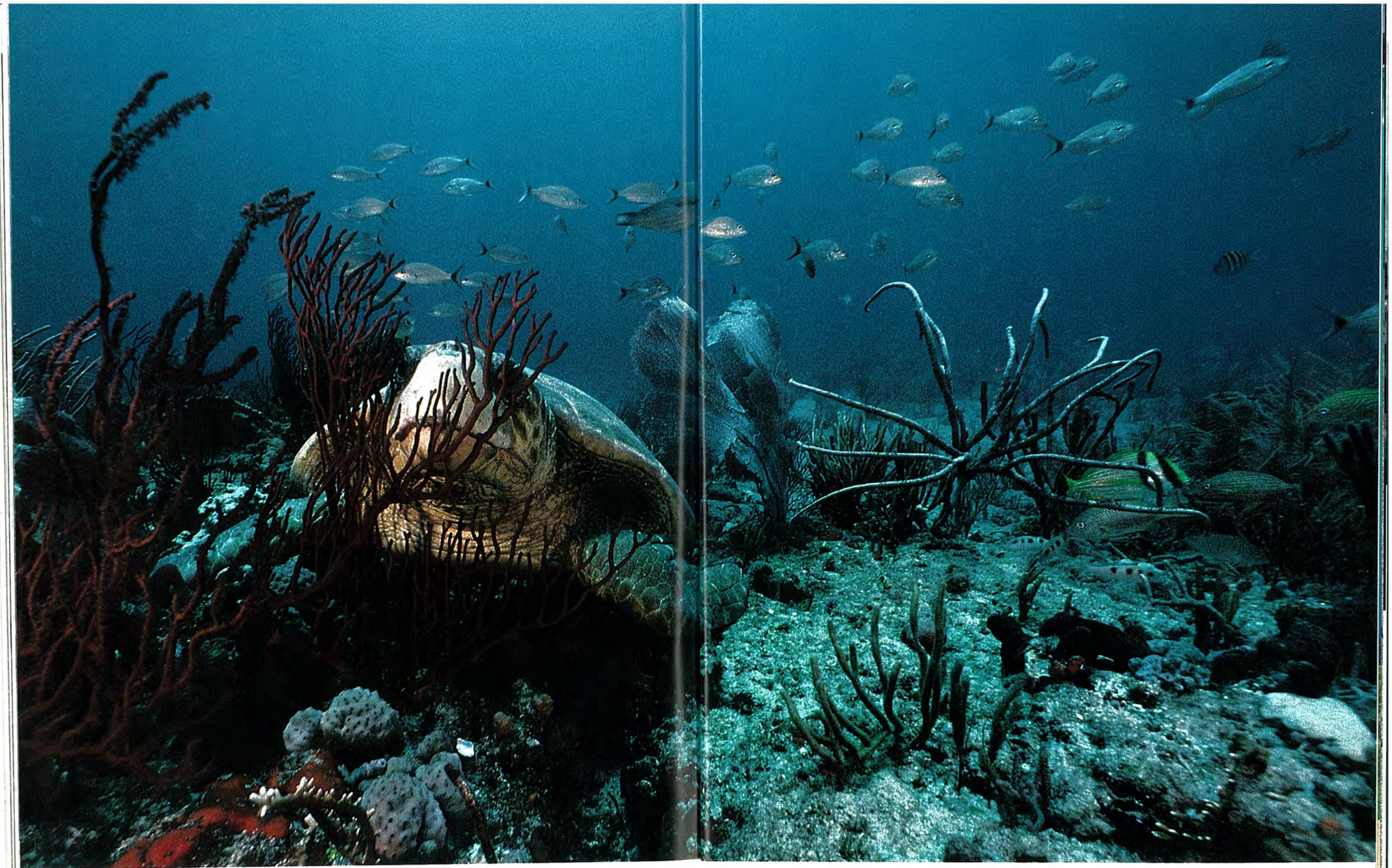
Following instincts that scientists have not begun to understand, the turtles had gathered offshore for mating, and now hordes of females were swimming to this particular beach to lay eggs. By 2 a.m. the beach looked like a cobblestone street where the cobblestones had come to life. And still more turtles were coming. All night they advanced and retreated. They collided and piled up in jams. They filled the air with the soft sound of flippers hollowing nests in the sand and a rhythmic *thump thump thump* as turtles that had finished laying rocked their 80-pound bodies to pack sand over their eggs. The turtles wheezed and shed tears, bathing their eyes from the flying grit they kicked up.

It was dawn when stragglers plowed the last trails back to sea. Thousands of other females still laden with eggs were swimming beyond the breakers, waiting for next evening's high tide when they would begin the assault anew.

All sea turtles come to shore to lay eggs, but for most it is a relatively solitary affair. Only the olive ridley and its Atlantic cousin, Kemp's ridley, stage arribadas. Watching those legions of olive ridleys break from the night surf, it was hard to remember that sea turtles are in serious trouble.

All eight species are endangered or threatened. They are killed for meat and leather;

Previous GEOGRAPHIC contributions by ANNE and JACK RUDLOE include articles on the Atchafalaya swamp in September 1979 and horseshoe crabs in April 1981. BILL CURTSINGER's photographs appear frequently in the magazine, most recently in "Bikini's Nuclear Graveyard," in June 1992.



In a bed of gorgonian coral off Florida's east coast, a gravid loggerhead awaits nightfall. After dark she'll lumber ashore, excavate a nest, drop and bury about 110 glistening eggs, then retreat to the waves. Prime nesting ground, Florida receives some 16,000 loggerheads a year. Each nests about four times during the April to October season, then migrates hundreds of miles to feed.

their eggs are taken for food and aphrodisiacs. Their nesting sites go for development. They are ground up by dredges, run over by pleasure boats, poisoned by pollution, strangled by trash, and drowned by fishline and net.

And we hardly know them. It was only in 1954 that the father of sea turtle research, a visionary herpetologist, the late Archie Carr, set up camp on the beach at Tortuguero, Costa Rica, the largest green turtle rookery in the Caribbean. Green turtle populations had plummeted, and Carr wanted to learn how to protect them. Today one man on a beach has grown into an international army of biologists and volunteers trying to understand the ways of sea turtles and save them from extinction.

We joined those ranks in the early 1960s. Through our business—collecting live marine specimens such as squid and sea urchins in the northern Gulf of Mexico for university studies—we had become fascinated by encounters with sea turtles. Hearing of the work of Archie Carr, who was then at the University of Florida, we went to him for information. "They're a mystery," he told us, "but you can help," and he recruited us to tag Gulf turtles for migration studies. We have been following these elusive creatures all the years since.

Despite the explosion of sea turtle research, scientists are frustrated. "I don't know any branch of science where we have applied so much effort and learned so little," said Richard Byles of the U. S. Fish and Wildlife Service. "We don't know where each species grows to maturity, or how long it takes them to grow up, or what the survival rates are."

But there are signs of progress. New conservation programs aim to help turtles by also helping the people who depend on turtles for food and income. New technologies of DNA mapping and satellite tracking are beginning to answer questions about behavior and migration. "This is almost a golden age of sea turtle research," said Alan Bolten, a biologist with the University of Florida.

Though the U. S. and 115 other countries have banned import or export of sea turtle products, the pressures on sea turtles are not abating. We could be at the turning point of saving these ancient beasts—or of losing them.

SO PONDEROUS ON LAND, sea turtles swim with grace and speed in the waters off every continent except Antarctica. All begin life as tiny hatchlings dashing for the surf. Those that are not eaten by swooping birds and marine predators seem to spend at least a year drifting on the high seas, eating pelagic crustaceans, jellyfish, algae, and insects blown from shore. As juveniles, each species takes up its own niche in the environment.

The olive ridley continues to ply the high seas in the tropics of the Pacific, Atlantic, and Indian Oceans. The Kemp's ridley takes to the shallows of the Gulf of Mexico and North American Atlantic. The behemoth leatherback adapts to both Arctic and tropical waters while making the longest seasonal migration of any sea turtle. The loggerhead populates the world's subtropics, and coral reefs attract the hawksbill. The green turtle grazes sea grasses in the tropics. The east Pacific black turtle, perhaps a subspecies of the green, ranges from Baja California to the Galápagos. Only the Australian flatback is not found in the Western Hemisphere, where we chose to focus our research for this article.

Based on the number of females nesting annually—the best way to estimate the size of sea turtle populations—the olive ridley is the most abundant. *Lepidochelys olivacea* is also one of the smallest, with a shell length of 30 inches or less. Seabirds perch on its back as it rides the waves, feeding on crustaceans hundreds of miles from shore.

But the ridleys' mass-nesting pattern makes them vulnerable. Mexico alone slaughtered nearly 75,000 annually, mainly for their leather, until the killing was banned by a presidential decree in 1990. Now the greatest threat to their survival seems to be the overharvesting of eggs.

Latin Americans prize sea turtle eggs as an aphrodisiac and energizing protein. Soft and as round as Ping-Pong balls, the eggs are sold as raw snacks in bars. It's hard to be angry at the egg collectors, called *hueveros*. Most have no other way to make so much money.

Costa Rica outlawed the taking of eggs in 1966, but harvesting remains widespread.

Gripping tightly during copulation—which can last for hours—a male black turtle off western Mexico hangs on even as the camera-shy female dives to 120 feet. Most males live entirely at sea, nearing shore only to mate.

**Green turtle**
*Chelonia mydas*
49 inches

Male

Female

**Leatherback**
*Dermochelys coriacea*
74 inches

**Hawksbill**
*Eretmochelys imbricata*
35 inches

**Australian flatback**
*Natator depressus*
39 inches

**Black turtle**
*Chelonia agassizi*
39 inches

**Olive ridley**
*Lepidochelys olivacea*
30 inches

**Kemp's ridley**
*Lepidochelys kempii*
30 inches

**Loggerhead**
*Caretta caretta*
47 inches

MEASUREMENTS ARE MAXIMUM CARAPACE LENGTH

# Ancient mariners

Sea turtles have roamed the oceans for at least 150 million years. Foraging for jellyfish, sponges, grasses, or crabs in all but the coldest waters, they nest on scattered tropical and temperate shores. Males are most easily distinguished by long tails (top left), which help grasp the females during mating. Biologists are still trying to learn where hatchlings (left) grow up, when they mature, and how they navigate. One certainty: All species are at risk.


PAINTING BY BRALDT BRALDS

Poaching eggs from a placid leatherback, a Costa Rican villager is one of legions who illegally take turtle eggs in Latin America; eggs can fetch two dollars a dozen. Believed to enhance the libido, raw turtle eggs are hot in bars. "They make you stronger," says Victor Cascante (left), who drinks eggs spiced with salsa to mask the taste.

The one exception to the ban is part of a bold conservation program: The villagers of Ostional are allowed to gather eggs laid during the first two nights of each arribada.

The morning after we watched that mass nesting, a rainbow arched overhead as a hundred villagers hiked onto the beach. The men jabbed their heels down in a sort of two-step dance. When they felt a soft spot in the sand, they marked the depression with a stick so the women would know where to dig.

"Everyone gathers eggs," said Gerardo Ordoñez, a leader of the Ostional Development Association. "Anyone in the village who doesn't work is suspended from the association and doesn't get a share of the proceeds."

The hueveros share about half their $95,000 annual revenues with the government and the Ostional turtle station, which is staffed by biologists from the University of Costa Rica. When the scientists first arrived, the villagers beat them. Now the legal egg harvest has brought Ostional a new school, a new clinic, and a new appreciation of the turtles.

In one nesting season 20 to 30 million eggs might be laid at Ostional. Even without human interference only 4 to 8 percent will hatch. Nests are so concentrated that females often destroy previous nests as they dig. Coyotes root for the eggs, and fungi also take a toll. Biologists calculated that a controlled harvest of three million eggs here would leave enough protected eggs to rejuvenate the population.

"And this project has the potential to stop the poaching of eggs on other beaches," explained turtle scholar Peter Pritchard. "It's a matter of economics. Poachers sell green and leatherback eggs for 25 colones [17 cents]. If legal Ostional eggs can get to market in good shape and sell for only 5 colones, this project can corner the market and relieve the pressure on other species."

After the harvest we drove a hundred bumpy miles to the capital, San José, where we went into cantinas with a licensed egg distributor. In one crowded saloon the bartender spiced an egg with hot sauce as a cocktail. "Aren't turtles endangered?" a local man demanded. These were legal Ostional eggs, the distributor explained. "Then you should have a brochure," the man said. "If someone brings the bartender eggs and they aren't from Ostional, he can report them to the police."

Suddenly we felt encouraged. If the plight of sea turtles was being discussed in bars, then the conservation ethic really was getting out.

IN THE GULF OF MEXICO the nesting grounds of Kemp's ridley were a mystery to scientists until 1961. Then a film taken by a Mexican engineer in 1947 surfaced. It captured an arribada of perhaps 40,000 *Lepidochelys kempii* striking the broad beach at Rancho Nuevo, about a

hundred miles south of the Texas border.

Those numbers have not been seen since. Kemp's ridley is now the most endangered sea turtle, decimated by egg harvesting, especially for the aphrodisiac market in Mexico City, and by accidental drowning in commercial fishing nets. In 1992 fewer than 500 females—nesting two or three times in their April to June arribada season—laid 1,242 clutches.

As Florida Gulf Coast residents, we have been especially watchful for this turtle, named in 1880 for Richard Kemp, a fisherman who shipped specimens from Key West to Harvard. In 30 years of tagging turtles we've met only 200 of them.

When that enormous arribada was filmed in 1947, perhaps 5,000 U. S. shrimping trawlers worked the Gulf of Mexico. There were 15,000 full-time and 40,000 part-time trawlers in 1989, when offshore shrimpers were required by federal law to fit their sock-shaped nets with turtle excluder devices (TEDs). A TED is a small net or metal grid inside the net that is supposed to allow shrimp to pass to the back while ejecting turtles (pages 112-113). Convinced that shrimp would escape too, shrimpers blockaded Texas and Louisiana ports in protest.

"It's taken some serious enforcement efforts, but compliance has improved. It's now more than 90 percent," said Chuck Oravetz of the National Marine Fisheries Service (NMFS). "Be it reluctantly, TEDs have increasingly been accepted as a way of life—and the shrimp industry has not crashed."

The number of nesters at Rancho Nuevo is slowly rising. Since 1978 Mexican and U. S. scientists have transferred the eggs to a local hatchery, so most of the hatchlings—30,000 to 80,000 a year—survive to enter the sea. When they might reach breeding age and return to nest is unknown. Biologists speculate that sea turtles take from 10 to 50 years to mature and reproduce. Statistics are hard to come by because no flipper tag will stay on a one-ounce hatchling that grows into a hundred-pound-plus adult.

For 15 years, 2,000 Rancho Nuevo eggs or hatchlings were flown annually to labs in Texas, to be raised in captivity for ten months until they were at least six inches long, to give them an edge in survival. These turtles were tagged, and some were fitted with internal magnetic tags that may last longer. None with tags intact have yet returned to nest, but they're out there. Six of the 33 Kemp's ridleys we caught in 1991 in our weekly netting and tagging efforts waved silver Texas tags.

The Texas experiment ended last year. "It's expensive, and it doesn't solve the problem of why the turtles are disappearing," said Earl Possardt of the U. S. Fish and Wildlife Service. The anti-TED lobby has argued that the government should raise more captive ridleys to boost the population. "But how can you bring things back to what they were," said Possardt, "if you haven't removed the threats that have gotten them where they are?"

Unlike the olive ridley, Kemp's ridleys live in the coastal shallows, staying in depths of 150 feet or less. Many of the young are carried by currents up the Atlantic coast; some eventually reach New England.

"We've radiotracked 32 juveniles in Long

Relying on sea legs and sweat, Miskito Indians haul aboard a 250-plus-pound green turtle 30 miles off Nicaragua. Turtle meat is shared with other villagers, and surplus is sold in Puerto Cabezas markets (left). This fishery appears not to diminish the species.

Island Sound since 1986," said Steve Morreale of Cornell University. "The Northeast coast seems to be one of the places where young ridleys quit feeding on open ocean plankton. They have to learn how to forage along the bottom somewhere; we think these are learning grounds."

Kemp's ridleys seen in the north were once thought to be strays. The increase in sea turtle research shows them to be regular visitors, part of a great seasonal migration that takes Kemp's ridleys, loggerheads, greens, and leatherbacks up and down the Atlantic coast.

It's a gantlet. The dredges that maintain shipping channels crush them. Trawling nets still drown thousands a year. Recreational sportfishing and boating kill too: Turtles are mangled by propellers and get tangled in discarded monofilament line and drown.

ON A HOT JULY 4 last year, 75-year-old Joseph Mohr motored out to check for crabs in Jones Creek, which flows into the southern Chesapeake Bay on Maryland's Eastern Shore. "I saw something bobbing—I thought it was a body. Then it raised its head; it was as big as mine."

A leatherback sea turtle—five feet long and some 700 pounds—had wrapped 25 feet of crab-pot line a dozen times around each front flipper and tightly around its neck.

Mohr had never seen such a turtle. Instead of a shell it wore seven keels of rubbery black skin. He and a friend loosened and cut its rope manacles. "I was thinking it was hurting," he said. "It wasn't aggressive at all. We tried to point it toward the bay, but it wanted to swim south on the creek—a dead end."

By the noon high tide 20 neighbors had gathered and pushed and pulled the turtle onto shore. They kept it wet with a sprinkler and shaded by a beach umbrella. A crew from the Baltimore aquarium arrived after a five-hour drive. "When I learned it was called a leatherback, I could see why," said Mohr. "Its skin was soft."

At the aquarium it was clear the turtle had no chance of surviving and was put to sleep; loss of circulation had rendered its flippers dead flesh. An autopsy showed it to be a mature female.

An abundance of jellyfish probably drew the leatherback into the Chesapeake as she headed north on her marathon Atlantic migration. (By flipper tag, biologist Peter Pritchard logged one that traveled 2,700 miles from French Guiana to New Jersey.) Feeding almost exclusively on jellyfish, *Dermochelys coriacea* reaches 2,000 pounds and grows to six feet, the largest of all marine reptiles.

Beneath its tender skin a layer of oily tissue insulates the titan as it dives to frigid depths of 3,200 feet, seeking giant jellyfish. A leatherback feeding this deep may get the oxygen it needs from its muscles, which are saturated with oxygen before diving.

How does the leatherback, a cold-blooded reptile, regulate its body temperature for both cold and warm waters? A team led by Jim Spotila of Drexel University and Frank Paladino of Purdue University is finding answers on a Pacific beach near Tamarindo, Costa Rica.

At midnight, loaded with equipment, we took off along a path through the jungle that fringes the coast. When we found a leatherback, we waited in the starry darkness until she finished laying. Then the flashlights came on. Six people netted her flippers to immobilize her. Hoisted slightly, she tipped the block-and-tackle scale at 703 pounds.

It took all night to surgically attach temperature sensors to different muscles. Not once did she try to bite.

The temperature probes revealed that the turtle maintained a body heat of 88.2°F, while her skin and flippers were ten degrees cooler. Tests proved that she can regulate blood flow to her extremities.

"I got involved with leatherbacks to answer questions of biology, but then I got involved in the conservation of the species," said Jim Spotila, who helped create a national park here.

Once as many as 200 females came to this beach nightly during nesting season, some having traveled 600 miles north from the Galápagos. But years of steady egg harvesting has reduced the number of nesters to 70.

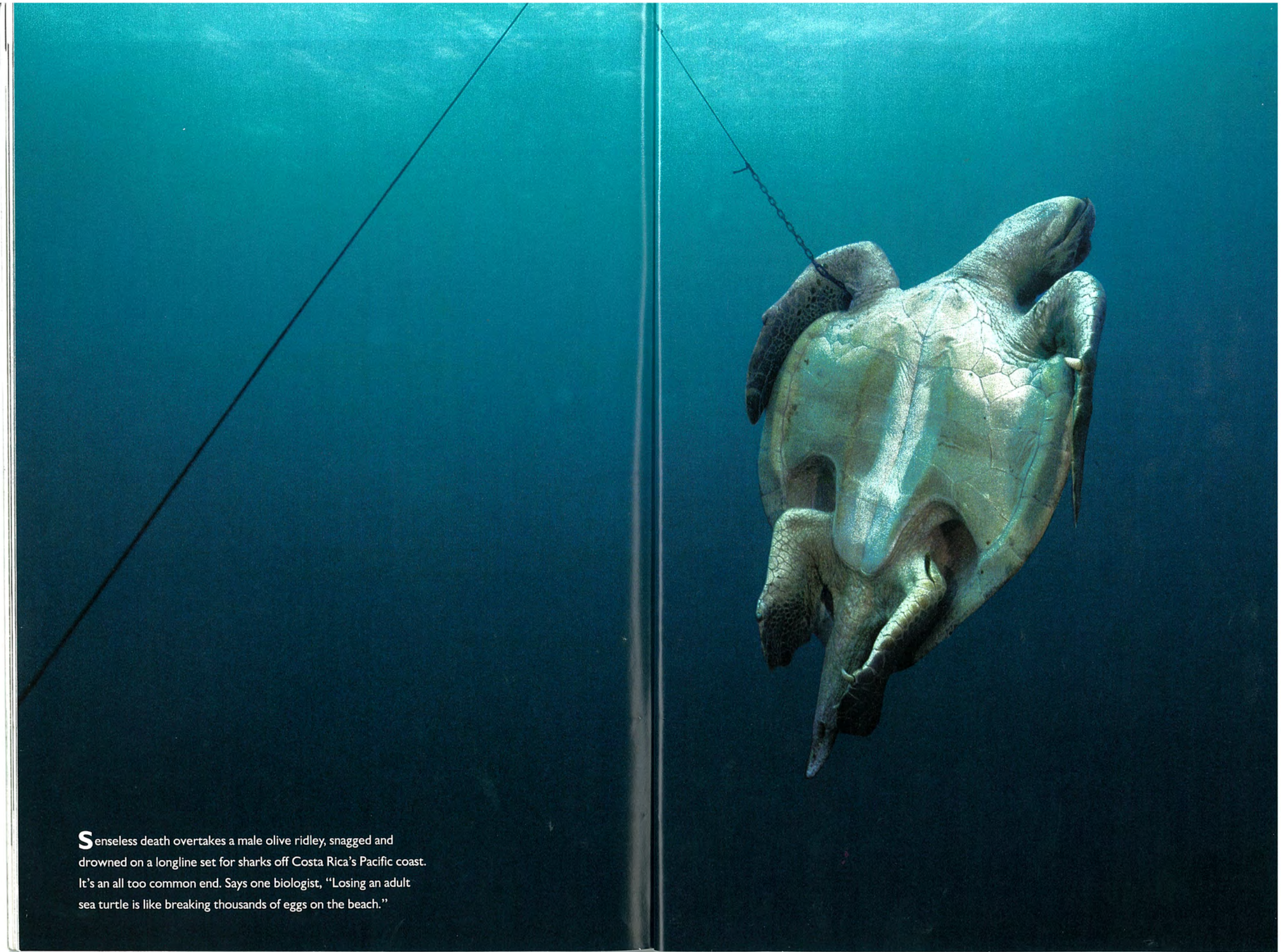
"I give leatherbacks a 50-50 chance of surviving, but I'm an optimist," said Jim. "The next 20 years are critical."

IN MIDSUMMER we walked along the beach of Boca Raton, Florida. Concrete walls protected condominiums from the encroaching sea; at high tide this stretch of beach was little more than 50 feet wide, scant room for loggerheads to nest.

Eighty percent of loggerheads in the western Atlantic lay their eggs on a 200-mile stretch




Hunger lures a vulture to a Costa Rican beach for a ready meal. Florida's ocean views lure developers—equally deadly to sea turtles. On Palm Beach a sign that discourages human tampering with turtle nests (above) stands useless against high tides that can lap seawalls, drowning eggs. Urban lights can draw hatchlings inland, where thousands die from dehydration or in traffic each year.



Senseless death overtakes a male olive ridley, snagged and drowned on a longline set for sharks off Costa Rica's Pacific coast. It's an all too common end. Says one biologist, "Losing an adult sea turtle is like breaking thousands of eggs on the beach."

midway on Florida's populous east coast. Even this cramped shore in Boca Raton had not discouraged their drive to reproduce, and members of the local Gumbo Limbo Nature Center were trying to help them succeed.

The beach was covered with wire cages, set up to protect each nest from egg-hungry raccoons and human disturbances. Volunteers patrol the beach daily, looking for signs of emergence.

As we watched one nest known to be near hatching, dozens of little loggerheads erupted. In a furious flailing of tiny flippers they raced for the ocean. Some were thrown back by the first wave and lay stranded until the water reached them again. Suddenly all the turtles became water. When the next wave pulled back, they were gone.

Growing to 450 pounds, *Caretta caretta* feeds primarily in the subtropics in estuaries and along the continental shelf, using the jaw muscles that make up most of its oversize head to crush mollusks and crustaceans.

Crab and lobster fishermen curse them for mangling traps and eating their catch. Fishermen claiming lower catches of shrimp and flounder because of TEDs have argued that loggerhead declines are caused mainly by loss of nesting sites to condominiums and hotels. No scientist denies the impact of coastal development, but the turtles have put a twist on the dilemma. It seems they like high-rises.

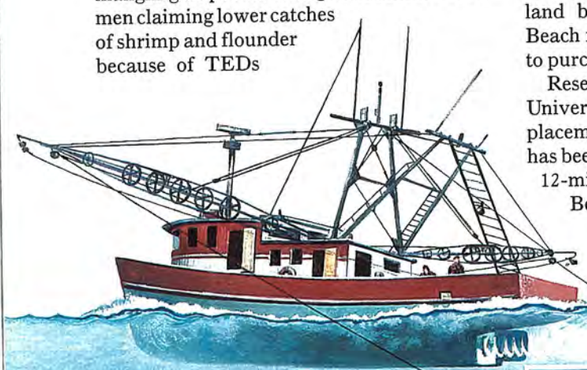
"Most residents are not there in summer when the turtles nest," explained biologist Mike Salmon of Florida Atlantic University. "At night the buildings are dark and look like a high row of trees."

The higher the building, the more nests Salmon finds in front of it. "Loggerheads are becoming urban turtles."

But later the location can disorient hatchlings. Street light can leak onto the beach from between buildings. If hatchlings run to the lights instead of the sea, they perish.

To keep some unspoiled shore for loggerheads, as well as for greens and a few leatherbacks that nest on Florida's east coast, the Archie Carr National Wildlife Refuge is being pieced together as funds become available. Named for the pioneering turtle researcher who died in 1987, nine miles of undeveloped land between Melbourne Beach and Vero Beach may cost as much as 90 million dollars to purchase.

Research by biologist Lew Ehrhart of the University of Central Florida guided the placement of the refuge. "Loggerhead nesting has been up the past four years," he said. On a 12-mile survey site between Melbourne Beach and Sebastian Inlet he now finds more than 10,000 nests in the April to October breeding season.



"I try to be gentle as possible," says Ernest Carlisle, cooling a soft-skinned leatherback found in a trap net off Rhode Island. Unlike shrimp trawls (below), traps let turtles rise for air. Carlisle cut an old hook from this 700-pounder and set her free.

When a loggerhead hatchling—or any hatchling—breaks through the sand after 50 to 70 days, how does it know where to go? It was once thought that it headed toward the sea only because the water is brighter than the shore. But experiments by Mike Salmon indicate that it is also crawling away from the land's higher horizon.

Salmon also discovered, along with Jeanette Wyneken of Florida Atlantic and Ken Lohmann of the University of North Carolina, that once in the water hatchlings orient themselves in the direction from which the waves are coming. They are also guided by another biological compass—an inborn sense of magnetic direction.*

From Florida beaches the hatchlings swim about 25 miles in 30 hours to take shelter and feed in sargassum, a bushy floating seaweed. Currents draw them farther out, where many are picked up by the Gulf Stream and carried across the Atlantic. The next time anybody sees these little loggerheads, they are at least four inches long and living near the Azores.

That internal compass and sense of wave direction presumably help the loggerheads find their way back across the Atlantic and guide the other species on their migrations as well. Folklore has held that turtles return to nest on the beach where they hatched. Now genetic evidence suggests that it is true.

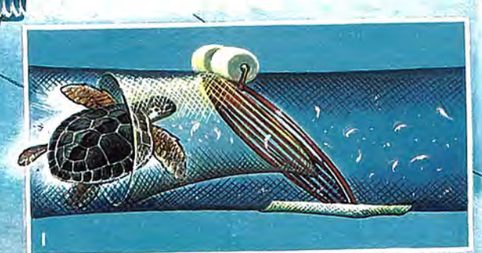
The DNA in a cell nucleus is from both

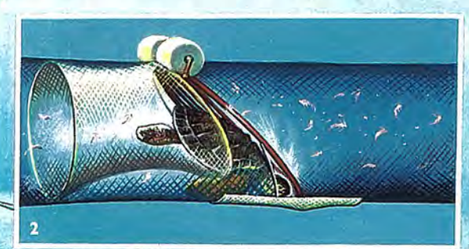
*See "Secrets of Animal Navigation," by Michael E. Long, NATIONAL GEOGRAPHIC, June 1991.

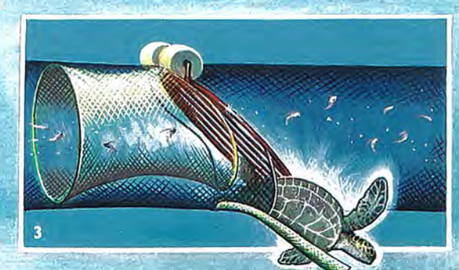
## Escape hatch: giving turtles a break

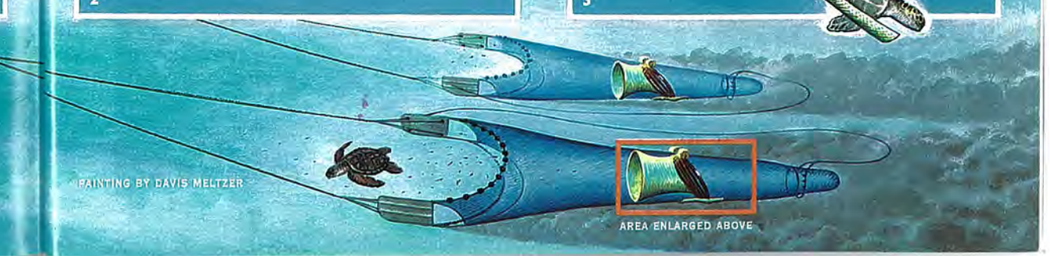
With a push from the law, shrimp fishermen have struck a truce with turtles. Until recently, as many as 55,000 sea turtles—mostly loggerheads and Kemp's ridleys—died from U. S. shrimp trawling each year. Caught in a net and unable to surface for air, turtles can drown in 40 minutes. To reduce the slaughter, offshore trawlers have been required to use turtle excluder devices, or TEDs, since 1989. All U. S. shrimpers must install the $300 devices by late 1994.

In most TED-equipped trawls, a webbed funnel quickens the flow of water—and catch—toward the back of the net. At the end of the funnel is a metal bar grid (1). Shrimp shoot through the bars into the net. But turtles slide down the bars and hit a webbed flap (2), which pops open allowing escape (3). Full compliance would mean a virtual end to trawl-related deaths of adult turtles in the U. S. Yet thousands still die. Young turtles can slip through the four-inch gaps in TED bars, and in other nations TED use is as rare as a ridley.




PAINTING BY DAVIS MELTZER

Corralled and guarded, Kemp's ridley hatchlings stampede in safety at Rancho Nuevo, Mexico—the chief nesting beach for this most endangered sea turtle. To help bolster the species, Mexican and U. S. biologists fly 2,000 of the young to a nursery in Texas (below). Since 1978 thousands have been tagged and released into the Gulf in the hope that when they mature, they will return to nest.

mother and father, but the DNA in a cell's mitochondria—the bodies that produce the cell's energy—is passed directly from female to offspring. If female turtles are returning to their natal beaches to nest, the turtles on each beach would have similar and distinctive mitochondrial DNA. For the most part, they do.

The turquoise and emerald shallows surrounding the small Bahamian island of Great Inagua are feeding grounds for juvenile green turtles. Here University of Florida biologists Karen Bjorndal and Alan Bolten are using DNA to match the turtles with their native beaches and learn their migration patterns.

"We know the mitochondrial DNA pattern of most of the major green turtle rookeries in the Atlantic," said Alan. "Now we'll be able to tell where these juveniles came from based on genetics. We won't have to tag 10,000 turtles and wait to catch one."

The Inagua study shows that greens born in Florida, Costa Rica, Suriname, and Venezuela's Isla Aves are coming here to feed. "We can do our best to save the nesting beaches," said Karen, "but if we don't protect turtles in their foraging grounds, we haven't accomplished anything."

Still there remains what Alan Bolten calls the "most exciting question in sea turtle biology." How, when it's time to nest, do these turtles know to go back to Florida or Costa Rica or Suriname or Venezuela? Did they imprint as hatchlings on the smell of the sand or local waters? The same question haunts scientists researching salmon migration. But no one knows for sure.

IT WAS BEAUTY that all but killed the hawksbill. Polished and carved, the intricate black-and-yellow plates on its back were long sought for tortoiseshell jewelry and combs. Now the hawksbill sits with Kemp's ridley on the edge of extinction.

A creature of the coral reef, *Eretmochelys imbricata* uses its sharp beak to nip sponges out of crevices. It grows, very slowly, to 250 pounds. On a private 300-acre Caribbean island called Jumby Bay, off Antigua, 20 to 40 hawksbills nest each year. On this haven of million-dollar lots, hawksbills have become the most pampered guests.

"When we bought Jumby Bay, we knew little about the turtles," said developer John Mariani. "We were told 2,000 units were feasible. That would have destroyed the beach. Instead we set the limit at 125 units."

The island's wealthy residents, mostly Americans, consulted Jim Richardson of the University of Georgia to learn how to live with their hawksbill neighbors. "They realize they have an absolute treasure on the island," Richardson told us.

The biologist told Jumby Bay: Do not rake and manicure the beach the hawksbills come to—they nest under scrubby bushes. Nothing can be built too close to the water; lighting must be subdued.

"The future for the hawksbill in the Caribbean is proper management of private beaches and resorts," said Richardson. "Rich people will be paying for the bulk of it—the governments can't. I'm getting calls from other resorts asking, 'How can we keep the turtles on our beaches for the guests to see?' "

A nesting hawksbill comes out of the water fast, at times lifting herself on her flippers and walking like an alligator. Barreling into the brush, she digs a nest and lays around 150 eggs. Her return to water is just as swift. "You do not want to intercept a hawksbill," said Zandy-Marie Hillis. "They're little tractors—they'll run you over."

Hillis, a U. S. National Park Service biologist, works at St. Croix's Buck Island Reef National Monument, where 25 to 30 hawksbills nest a year. One April night she and a crew of research assistants and volunteers staked out the island's rocky beach.

They set up rows of survey markers along the forest's edge, 15 inches apart. Even if they missed the moment when a hawksbill sprints from sea to brush (a rare observance), a break in the markers would show where the turtle went. "Then you listen for them crashing around," explained Hillis. "And you smell for them—it's the smell of disturbed soil."

By 3:30 a.m. the moon had set, and somewhere in the dark sea a hawksbill was scouting our beach. An hour earlier she had started to come up, but something wasn't quite right, and she left without laying. Now, heavy with eggs, she was watching, listening, waiting.

Then Hillis's radio crackled: "We have a hawksbill. We hear her in the bushes throwing sand around." We hiked up the beach and saw the nester wedged tightly under a sea grape bush. We crouched so she wouldn't see us.

Like all sea turtles, once she began dropping her eggs, she entered a hypnotic-like state in

Born to be wild, a male green turtle at the Grand Cayman turtle farm waits to be freed to breed in the mating lagoon. Several thousand captively bred young are raised here in tanks (above, drained for cleaning). Some are released; most are sold for stew and steaks.

Promoters claim that farming boosts turtle populations and safely supplies demand. Critics argue that it fuels appetites for endangered animals, making poaching more likely. Ironically, tourists pay half a million dollars a year to glimpse the farm's greens, once so plentiful in the Caymans that one of Columbus's crew said the sea "seemed to be full of little rocks."

which little would disturb her. We turned on our lights, quickly measured and tagged her, then waited in darkness for her to leave.

Before we realized she had moved a flipper, she was bolting for the water. She made 15 feet in five seconds and swam away.

Japan was the last large importer of hawksbill shells—reportedly 31,000 a year from around the world at about $375 dollars a shell. There is a centuries-old Japanese tradition of carving tortoiseshell into ceremonial bridal combs, though most of the recent output has been earrings and tie clips and bowls. Under U. S. pressure Japan agreed to halt imports in 1992.

Cuba had been selling some 3,500 shells a year to Japan. Cuban scientists argue that hawksbills do not migrate but stay in one place, so they can be managed as a fishery. U. S. researchers counter that there is no proof; studies of hawksbill migration are just beginning. "If animals protected elsewhere in the Caribbean are harvested in Cuba," said hawksbill specialist Anne Meylan, "their conservation would be undermined."

Meylan had just returned from a sea turtle conference in Japan, where shell dealers had been lobbying biologists to give their multimillion-dollar industry a break. "They seem to have no sense that the stuff comes off a turtle and that a turtle looks like this," she said, spreading her arms. "They think of tortoiseshell as swatches in a box."

ARCHIE CARR set up his green turtle research camp 40 years ago at Tortuguero, Costa Rica. But poachers still turned the beach into a virtual slaughterhouse. "It was white with bones," Carr told us when we visited him there in 1975. "Hardly a turtle came up that wasn't killed. A creature that tastes so good, is so easy to catch, and comes back to the same place over and over again could disappear before anyone knows it's gone."

The green turtle's meat is the most delicious of any sea turtle's, perhaps because it is a vegetarian, grazing pastures of sea grasses and algae to grow to an average of 300 pounds. Its common name comes from its popularity as food. Its heart-shaped shell is gray-brown; green is the color of its fat, which, boiled with cartilage called calipee, makes a fine soup.

The gourmet craze for green turtle soup contributed to the decline of *Chelonia mydas*. But it also prompted a group of philanthropists called the Brotherhood of the Green Turtle to back Archie Carr's efforts to save the species. They formed the Caribbean Conservation Corporation to finance research, preserve nesting beaches, and promote projects to help not only turtles but also the people who make their living from them.

Since 1975 Tortuguero's beach and the surrounding forest have been protected as a national park. The local economic base is no longer turtle harvest but ecotourism. Now that people make money showing turtles to more than 15,000 visitors a year, turtles are worth more alive than dead.

"A live animal benefits the community," said park director Eduardo Chamorro. "If you kill it, you have a meal. Alive, people come again and again to see it. We want to keep this habitat for wildlife, not cattle farmers. No one comes to Costa Rica to watch cows."

Tortuguero had once seemed to us the most remote place in the world. Today five new hotels are full during much of the July to October nesting season, and the village population has increased to 500. But getting there remains an adventure, and along the way we would see that the turtles were still in danger.

We traveled northwest from the port of Limón along 50 miles of inland canals in the canopied boat of Modesto Watson. A passionate guide, he pointed out sloths, toucans, and crocodiles as we motored through the rain forest. Then we came upon a bulldozer and log skidder clearing the land. "Each one of those machines is a cancer cell," said Modesto.

Costa Rica has one of the highest deforestation rates in the world, and banana plantations—pushing against the borders of the park—are a major factor. Some biologists fear that without the vast forest to draw up groundwater, the water table will rise under the beach and drown nests.

And ecotourism alone is not a conservation cure-all. On Costa Rica's Pacific coast a tourist development near Villarreal hired guards to keep hueveros off the beach, without offering villagers jobs to replace the income. "That kind of tourism leaves nothing for the people," a despairing woman told us. The following season the resort decided to save money by not hiring beach patrols. All the eggs were taken.

OF ALL THE RESEARCH and conservation projects we visited, the east Pacific black turtle project in the state of Michoacán, Mexico, seemed the most promising. The legal egg harvesting that works at Ostional is only possible with ridley arribadas. The upscale ecotourism of Tortuguero cannot be sustained at every beach. But here in the villages of Colola and Maruata, scientists have involved the residents in ways that can be repeated on turtle beaches around the world.

Twelve years ago when biologists from the

Fitted with a satellite transmitter in Costa Rica, an olive ridley begins an ancient odyssey. She was one of 7,000 females that came here in one night of an *arribada*—arrival—a mass nesting unique to ridleys. Telemetry may help reveal where turtles go and what reunites them for nesting. No. 79 swam 2,728 miles before her signal faded out.

University of Michoacán set up a camp in Colola, they had to request Mexican marines to stop the turtle killing and egg stealing.

Cut by rocky outcrops, the beach is one of the largest surviving nesting grounds for east Pacific black turtles, which range from the Gulf of California to Ecuador. Each nest is precious, for the black seldom lays more than 85 eggs to a clutch. Some scientists believe *Chelonia agassizi* is a subspecies of the green turtle (its heart-shaped outline resembles a green dipped in black ink); some say it is a species of its own. To the poor villagers, it was food and money.

"It became obvious that if we wanted to protect the turtles, we would have to do something about the situation of the people," said project director Javier Alvarado.

An iguana farm now aims to provide meat and cash income. An artisans' cooperative teaches crafts and sells pottery to tourists. People are paid to patrol for nesting turtles and bring the eggs to the project's hatcheries.

The scientists lobbied the government for a satellite dish for the Colola school, where they now teach courses. "We are finally entering into a sense of community," said Alvarado. "One biologist even plays in the local band."

It's a 45-minute hike up the hills above Maruata to the project's palm-roofed radio-telemetry tracking station, an open-sided shed speared by a 15-foot-high antenna.

We watched a biologist teach a 13-year-old village boy, Hugo Dominguez, how to read the chirps coming from a radio-tagged black turtle far at sea. He twisted the controls on the receiver and shared his dreams of doing this work himself someday. We hoped we were watching the future, and we dared to believe that there truly is a chance that attitudes will change and these ancient reptiles will survive.

A nearly full tropical moon was blazing when we saw our first black turtle. She was a solitary nester, far from the chaos of the arribada at Ostional. Here we could sit beside this momentary visitor to our shores, at her most vulnerable time, and marvel at her design and drive to reproduce, before she slipped back into her liquid world.

"We want our children to know the turtles," Maruata fisherman Herlindo Verduzco told us. "If there was no project, the turtles would be gone. We don't want to have to tell our children someday that the turtles were here once, but they were all killed." □



Frantic flight propels a newborn black turtle away from its natal beach in Michoacán, Mexico, one of the last major nesting areas for black turtles—which number only about 3,000 here. Concerned Michoacán citizens now ardently protect nests and promote turtle-watching, ecotourism, and food alternatives to replace the cash and protein that turtles once provided. Such programs may ensure that sea turtles will survive into the next century and beyond.