

# Manatees

*These giant aquatic grazers outchewed their rivals in the New World. Now humans, their sole enemy, hold the key to their survival*

by Thomas J. O'Shea

Once upon a time, a young maiden was bathing by the banks of a river. Startled by the sight of approaching men, she jumped in, covering her bottom with a fan. Shyness then doomed her to a life in water: the maiden became a manatee, her fan metamorphosing into its distinctive spatulate tail.

So runs a legend from Mali in West Africa, echoing curiously the origins of manatees as mammals who left the land for a life in sea and river. Whereas myriad tales in native cultures from Africa to the Americas tell of manatees, only recently are the beasts yielding their secrets to scientific inquiry. Among their unique adaptations to life as marine herbivores are an unending supply of teeth—constantly replenishing worn ones—and an anomalously low metabolic rate that allows them to fast for up to seven months. Ponderous and slow, manatees have humans as their only enemy.

Manatees belong to the mammalian order Sirenia—so named because (at least to some eyes) they looked like sirens. The aquatic sirenians probably arose in the Old World; their antecedents were terrestrial mammals that

also gave rise to elephants, hyraxes and perhaps aardvarks. We do not know what forces of natural selection drove an ancient mammal to exploit the niche of a large marine herbivore. Yet the beginnings of such an ecological strategy can still be seen today. Domestic sheep on islands off Scotland forage for marine algae in the intertidal zone, even swimming between patches; pigs of the Tokelau Islands in the South Pacific habitually forage along coral reefs, wading with heads submerged.

Fossil evidence suggests that Old World sirenians reached an isolated South America in the Eocene or Oligocene era, more than 35 million years ago. The earliest known true manatee (who lacked, however, the dental technology of modern manatees) lived in the middle Miocene era, 13 to 16 million years ago. The sirenian order currently includes three species of manatees in the family Trichechidae, plus their older relative, the dugong, in the family Dugongidae. A second dugongid, the Steller's sea cow, was hunted to extinction within 25 years of its discovery in 1741.

Up to the late Miocene, dugongids exploiting sea-grass meadows colonized the marine waters of the western Atlantic and Caribbean. Manatees, though feeding on both freshwater and saltwater plants, were restricted to the rivers and estuaries of South America. Dugongs are now found only in the warm, shallow parts of the Indian Ocean and the western Pacific. The animals were evidently displaced about a million years ago by upstart New World manatees, which, as paleontologist Daryl P. Domning of Howard University convincingly argues, outchewed their older relatives.

The chewing prowess of manatees derives from the fact that they never run out of teeth. Manatees possess only premolars and molars (one row on either side of the jaw), but these are continuously replaced by new teeth sprouting

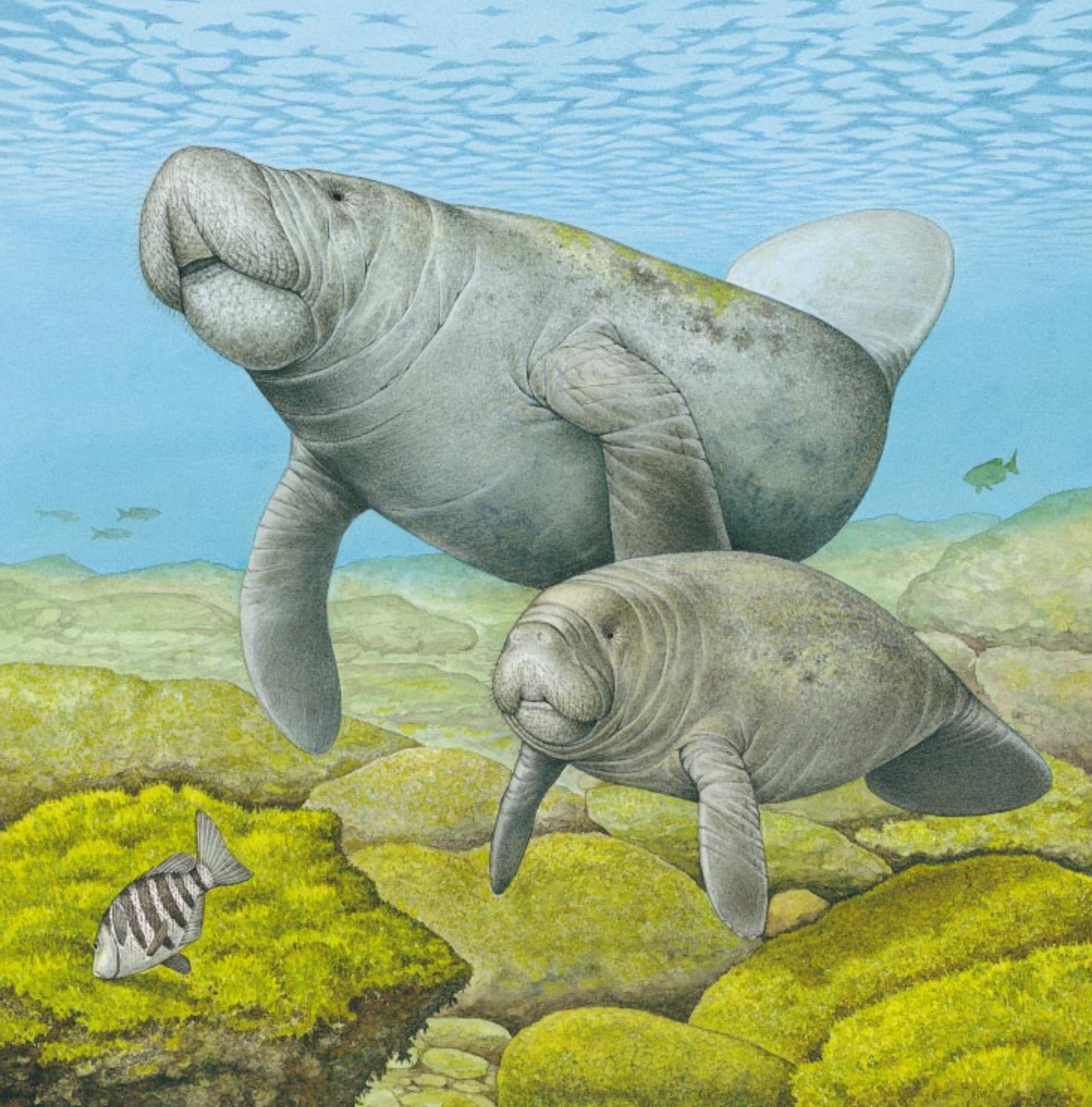
at the rear of the row—rather like wisdom teeth—and moving forward. The worn-down front teeth drop out, and the bony tissue separating the tooth sockets continuously breaks down and re-forms to allow the new teeth to move forward at roughly one or two millimeters per month. This process takes place throughout life: even the oldest specimens show new cheek teeth erupting at the rear of each tooth row.

Such an adaptation points to an increased abrasiveness of the manatee diet at some earlier time. Horses, for example, evolved high-crowned cheek teeth in response to the emergence of the true grasses, which have an elevated content of sandpapy silica. Currently true grasses are an important part of the diet of all three species of manatees; in contrast, the staple of the exclusively marine dugong is marine angiosperms (sea grasses). The ancient Caribbean dugongids probably also lived on this diet.

Domning notes that the newly abundant true grasses seem to have invaded South American ecosystems in the Miocene. Continental glaciation in the Pliocene and Pleistocene periods lowered the sea level and increased erosion and runoff of sand and soil. Sand deposition likely increased the amount of abrasive material ingested with the sea grasses. The more sand-tolerant trichechids invaded these habitats as well. By about a million years ago they had broadened their feeding niche to include sea grasses and replaced dugongids in the Atlantic and Caribbean.

In the Amazon region, mountain building in the late Miocene era created a transient closed basin; trichechids isolated here became the Amazon manatee (*Trichechus inunguis*). The West Indian manatee (*T. manatus*) is apparently a little-changed descendant of coastal South American trichechids of the Pliocene-Pleistocene time; at present it can be distinguished into subspecies from Florida and the Antilles. A similar form also reached West Africa by way

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**FLORIDA MANATEE and her calf** laze in placid waters. Calves stay with their mothers for up to two years, communicating by faint squeaks and learning seasonal migration patterns. The two may recognize each other long after weaning.

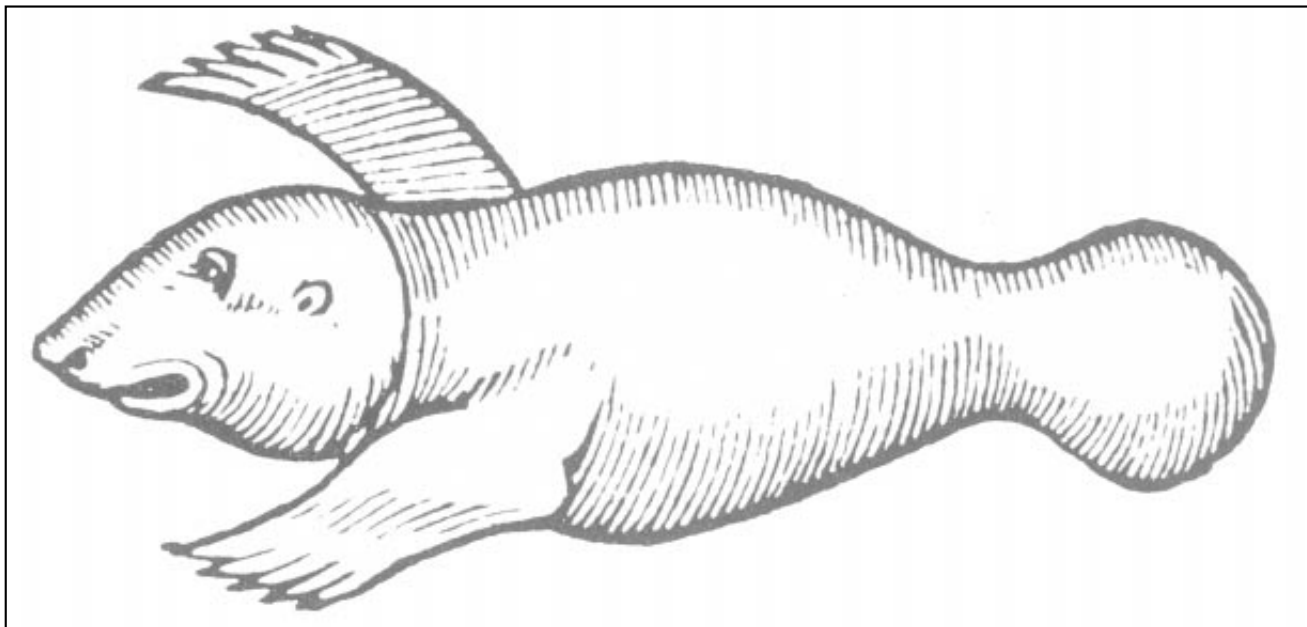
of transoceanic currents comparatively recently—perhaps since the late Pliocene—to give rise to the West African manatee, *T. senegalensis*.

Manatees have had a long and intimate relationship with humans, mostly as food. These large animals—my colleagues and I once weighed a Florida manatee at 3,650 pounds—have been

hunted and relished by members of coastal and riverine cultures throughout the tropical Atlantic. In West Africa, manatees are lured into box traps with cassava, speared from platforms on stilts, entangled in nets, shot by harpoons on baited triggers and trapped by fences on outgoing tides. South American Indians place logs across streams

to trap manatees in receding waters.

The creatures also feature in numerous superstitions and legends in native cultures. In Mali, manatees in the river Niger are considered evil spirits; only a few tribesmen know the proper incantations to hunt and kill a manatee without dying or going mad. When a hunt is successful, cuts of meat are distributed



**EARLIEST KNOWN REPRESENTATION of a manatee, from Fernán­dez de Oviedo's 1535 *History of the Indies*, is based on Christopher Columbus's description of the creatures. His crew, the first Europeans to see manatees, took them to be mermaids.**

according to social status. Some other protocols must be followed, too. If a pregnant woman eats certain cuts, the unborn child is believed to be in danger of becoming an adult of low moral character. The oils and skin of the manatee are made into remedies for various ailments, and potions are made from its ribs.

Across the Atlantic, in the headwaters of the Amazon in Ecuador, a Siona Indian shaman told my fellow scientists and me a legend about the origin of the Amazon manatee. An ancient god was deceived and trapped by a tapir, who cruelly subjected the god to attack by piranhas. The god escaped and in revenge banished one of the tapir's daughters to live forever in the water—as a manatee.

Inhabitants of the coasts and rivers of Central America, the Caribbean and northeastern South America prize manatees as food and as a source of medicine. Great stealth and machismo are needed to harpoon manatees from dug-out canoes on the Orinoco River. Accordingly, the tiny middle-ear bones of manatees are worn as magical charms against evil and disease. The Piraoa Indians of Venezuela, however, have a taboo on hunting manatees and river dolphins. The Piraoa think they will die if they eat manatee meat; they believe the creatures to be bewitched humans who dwell in underwater cities at the bottom of the Orinoco.

In 1493 Christopher Columbus and his crew became the first Europeans to see manatees in the New World. They

reported the creatures as mermaids. In the decades that followed, Europeans acquired a closer acquaintance with manatees. Indians used manatee hides as shields against Spanish explorers armed with crossbows. In the late 1600s William Dampier, the English buccaneer, fed his crews with boatloads of manatee meat from Panama, supplied by Miskito Indians.

Later, manatees were exploited commercially, both as bush meat for laborers at South American frontier posts and in processed form for resale in distant markets. Shiploads were exported to the West Indies from Guyana, Suriname and Brazil in the 17th and 18th centuries. Exports ended with the close of the 19th century, when manatee populations had become greatly reduced. Legal trade in Amazon manatees continued in Brazil until 1973. Perhaps as many as 7,000 were killed in peak years of the late 1950s.

The end of commercial exploitation coincided with the rise of other threats to the survival of manatees. By the 1970s it became clear that increasing numbers were dying in accidents and in encounters with man-made artifacts. Inexpensive synthetic gill nets that became widespread in tropical fisheries incidentally entangled and suffocated manatees. Rivers and estuaries became polluted and turbid because of deforestation and erosion, blocking the light needed by aquatic plants. Manatee habitats became endangered, especially in areas where humans are plentiful. An estimated 800 to 1,000 people move to

Florida every day; many newcomers settle in coastal areas, where wetlands are drained and replaced by housing—complete with canals and boat docks. Water quality has dropped; in Tampa Bay, 80 percent of the sea-grass beds have vanished over recent decades. In Florida, boat propellers inflicted gruesome wounds. Deaths of manatees accidentally caused by humans doubled during the 1980s, as the number of registered boats plying the waters also grew dramatically.

**C**learly, the manatee needed protection, or else it would rapidly become legend alone. So little was known about its habits and habitat, however, that it was difficult to formulate plans to save the manatee. Then, in the 1970s, the Marine Mammal Protection Act and the Endangered Species Act initiated a spurt of research, concentrated in Florida.

Biologists began, for one thing, to dissect systematically carcasses cast on the beach. The dissections augmented earlier knowledge about the anatomy of manatees. In addition to replacing their teeth constantly, manatees have evolved other features helpful to their aquatic lifestyle.

A manatee's lungs have single lobes and lie above the abdominal cavity—along the back—enabling the creature to remain horizontal under water. Its gastrointestinal tract is long, and the animal digests food in the hindgut. There is also a "cardiac gland" in a pouch off the stomach. The gland con-

tains specialized secretory cells, and the pouch protects them from the abrasive diet.

The animal's heavy, dense bones lack marrow; they help to keep the manatee submerged. Only the backbone contains some marrow for producing red blood cells. The animal can adjust its depth by changing the volume of its lungs. Its lips are large, studded with bristles, and prehensile—forming a kind of abbreviated trunk. The long, paddlelike flippers are used to manipulate food and to walk stealthily along the bottom. Counts of growth layers in ear bones suggest that the manatee's normal life-span is about 60 years.

By examining the stomach contents of manatees, Catherine A. Beck and her colleagues at the National Biological Survey in Gainesville, Fla., have found that the diet has much variety. For instance, manatees eat most local aquatic plants, as well as acorns from overhanging oak trees. Unfortunately, their stomachs also include refuse, such as plastics, condoms, fishing line and steel hooks—some of which have led to their death.

Also in the 1970s biologists began to study live, captive manatees, thereby uncovering some intriguing facts about the rate at which the animals consume energy. The metabolic rate is related to the amount of oxygen a mammal consumes per unit time divided by its body weight. Most species consume energy at

rates that depend on their size. For example, small mammals have a large surface area for their weight. Because heat is lost through the surface and mammals have to expend energy to maintain a constant body temperature, smaller mammals use more energy relative to their size and have higher metabolic rates.

On a mouse-to-elephant curve of metabolic rates for mammals of different weights, most kinds of marine mammals fall where they should—going by their respective sizes. But Blair Irvine of the U.S. Fish and Wildlife Service and C. James Gallivan and the late Robin C. Best of the National Institute for Amazon Research in Brazil found that manatees deviate sharply from this pattern. Amazon manatees metabolize energy at only 36 percent of the rate expected for mammals of their size; in Florida, manatees come in at a mere 15 to 22 percent of the predicted values.

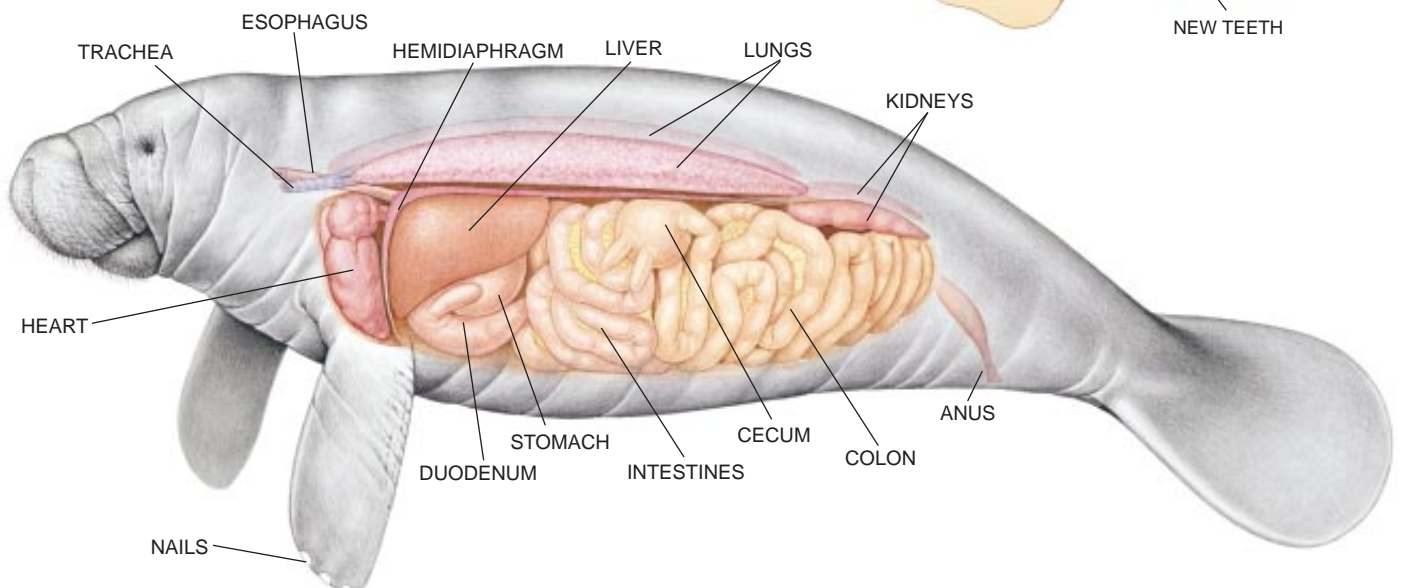
What are the ramifications of such low metabolic rates? One of the most astounding is the capacity that the Amazon manatee has for prolonged fasting. As in earlier days of sirenian evolution, seasonal flooding in the upper Amazon gives rise to large floating meadows of grasses and other vegetation. Amazon manatees swim through the treetops of the flooded forests in times of plenty, but during the dry season they can become isolated for months in lakes and pools devoid of vegetation [see "Flood-

ed Forests of the Amazon," by Michael Goulding; *SCIENTIFIC AMERICAN*, March 1993]. Like mammals of colder zones preparing for winter dormancy, the creatures put on large quantities of fat during the flood season, which allows them to survive the lean times of the dry season. Best calculated that Amazon manatees can go without feeding for almost seven months by subsisting on stored fat and by expending energy at their customarily low metabolic rates.

We do not know if there is a similar link between metabolism, fattening and seasonal fasting for other species of manatees. But the influence of low metabolic rates on the distribution of Florida manatees is well known. The animals do not live north of Florida or Georgia on a year-round basis. Unable to metabolize energy fast enough to counter heat lost to cool surrounding waters, manatees probably cannot expand beyond subtropical climes. Nearly all sirenians throughout geologic time have lived in warm regions.

Almost every year, however, manatees are sighted north of their typical range. These summer wanderers return south in autumn or die and wash ashore in Virginia or the Carolinas later in winter. The carcasses are marked by an absence of fat deposits and other signs of long-term exposure to cold. Wanderers have been verified as far north as the

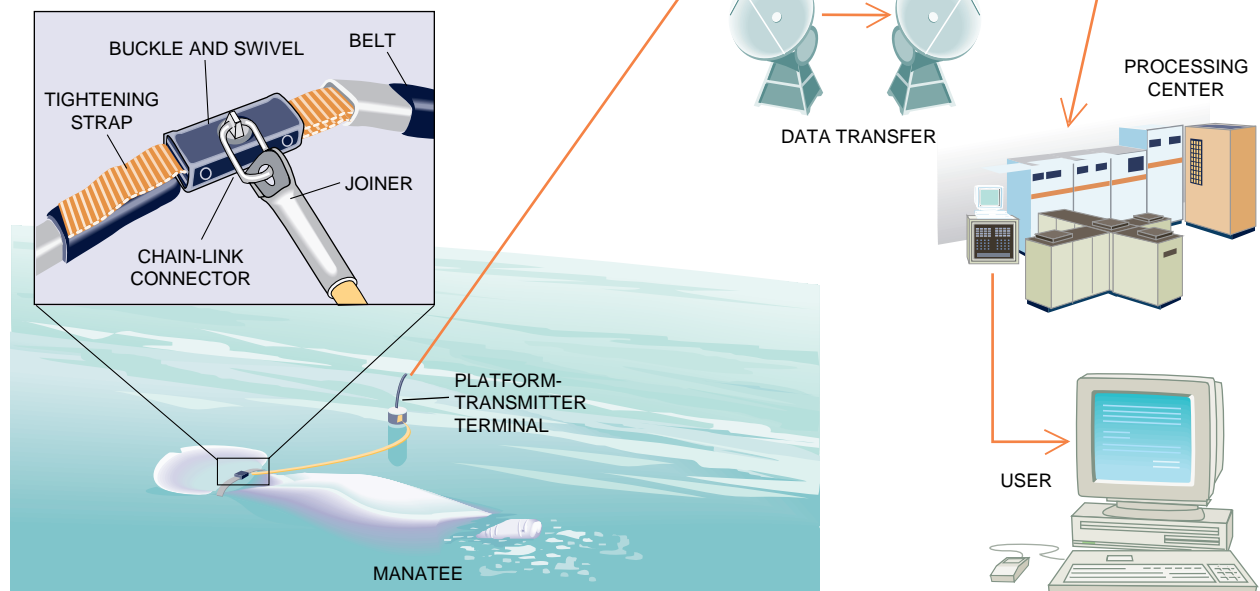
**ANATOMICAL DRAWING of a manatee reveals several adaptations to life as an aquatic grazer. Lungs lying along the back help to keep the animal horizontal under water. Flippers and a prehensile upper lip are used to manipulate food. New teeth (right) are constantly generated at the rear of each tooth row and move forward. Eventually, teeth worn out by chewing abrasive grasses drop out. The food is digested as it passes through the long hindgut (cecum to anus) for several days.**



## Satellite Tracking

The travels of Florida manatees are monitored by satellite telemetry. A floating platform-transmitter terminal is attached to a belt on a manatee. The belt falls off after a few months. The inset shows the belt buckle; the swivel minimizes drag, while the joiner frees the manatee if the tether snags.

The terminal emits signals at an ultrahigh frequency. The transmissions—encoding the identity of a manatee, the water temperature and the angle at which the platform is tipped—are received by a passing satellite of the U.S. National Oceanic and Atmospheric Administration. Equipment on board the satellite calculates the transmitter's position and relays all the information to stations on the earth. Data next pass through telecommunications satellites to processing centers and then via telephone links to personal computers at biologists' desks.



lower Potomac; I strongly suspect that the "Chessie" sea monsters of Chesapeake Bay in the 1970s and 1980s were errant Florida manatees.

Even in Florida, manatees find winter temperatures stressful. They respond by migrating to the southern third of the peninsula or to local sources of warmer water. These include artesian springs, such as Crystal River on the Gulf Coast, and effluents of pulp mills and electric power plants. On the coldest days, 300 or so animals aggregate at several of these sites. For many years, winter aggregations gave biologists the only window into the lives of manatees in the wild.

In the early 1950s Joseph C. Moore of Everglades National Park noted that individual manatees can be distinguished by boat-propeller scars; he was thus able to make some basic behavioral observations. His initial study

was followed in the 1960s by Daniel Hartman, then a graduate student at Cornell University. Hartman tracked individual females and their offspring at Crystal River. Currently the National Biological Survey maintains a computer-based scar-pattern catalogue identifying hundreds of Florida manatees from sites throughout their range.

Dozens of wild females have now been observed for more than a decade—some for 20 to 25 years—giving us insight into their reproductive cycle. A female attains sexual maturity as young as three years of age and continues to reproduce for more than 20 years. One calf is born every two to three years; there are occasionally even twins.

Social interactions seem to revolve around reproduction. Manatees are basically solitary animals, but when a female is in estrus, she is pursued by a herd of six to 20 jostling and wrestling males. About a year after mating, ap-

parently with several males, the female selects a secluded area for birthing. Mother and calf stay together as a nursing pair for at least a year, maintaining contact by faint, squeaky vocalizations.

A few females and their calves have been seen together for up to a year after weaning and perhaps continue to recognize one another for much longer. Sometimes nursing females will "adopt" and suckle calves that are not their own. Manatees will occasionally socialize in transient groups, which individuals join and leave seemingly at random.

In 1978 speed zones for boats were established at winter aggregation sites. Still, manatees and boats continued to collide at other times and places. If they were to protect the creatures in their diverse habitats, policymakers needed to know more about the distribution and migration patterns of manatees. In the 1980s advances in radiotelemetry provided a means of observing mana-

tees in their travels over long distances.

Manatees in the waters of Brazil and Florida were first to be tracked by radio in the 1970s. Investigators attached a transmitter to a belt—designed to corrode and fall off after the study—around the constriction between a manatee's body and its spatulate tail. The technique was not, however, useful in coastal habitats, where saltwater impedes the passage of radio waves.

So my colleagues Galen B. Rathbun, James P. Reid and James A. Powell designed a floating transmitter attached to the belt by a two-meter-long flexible nylon tether. The tether was equipped with swivels to minimize drag and with breakaway links to prevent the manatee from getting trapped should the tether snag. The device put the antenna in the air during most manatee activities in shallow waters. We could locate animals as far as 20 to 30 miles away from light aircraft and five to 10 miles away from boats or shore.

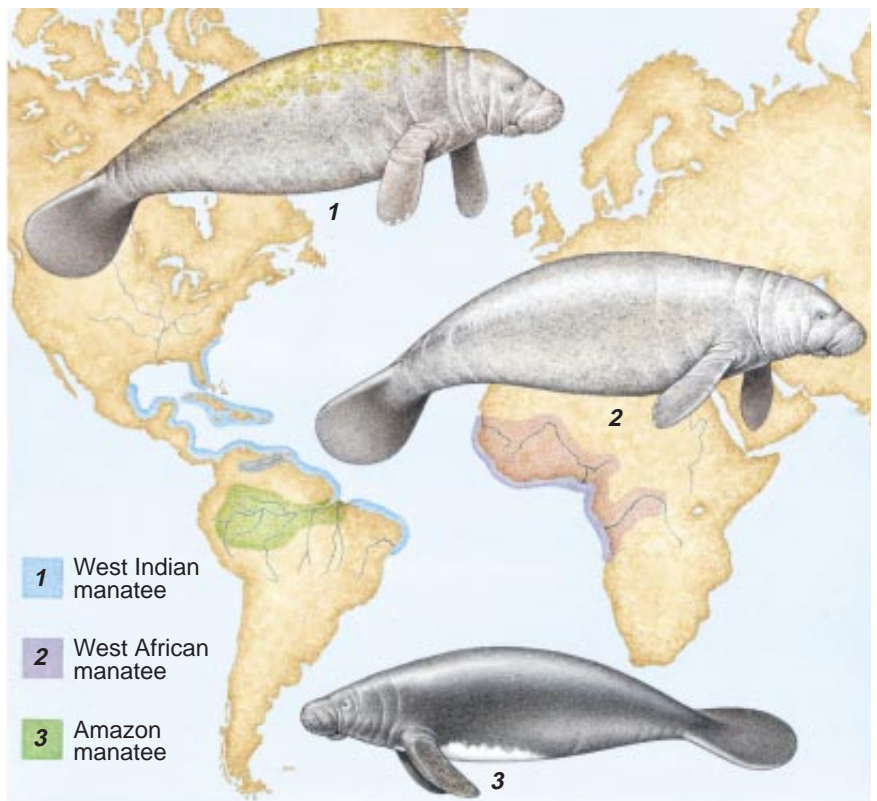
Soon we were able to take the floating-transmitter concept a step further. Bruce Mate of Oregon State University had been trying to track great whales in the open ocean. He solved this tremendous logistical problem by attaching to the whales "platform-transmitter terminals" monitored by satellites. These transmitters, used to track weather balloons and vessels at sea, emit ultrahigh-frequency signals. Satellites receive the signals and pass on the encoded information to processing centers on the earth. From the centers it travels via telephone links to personal computers. Within hours or less of the last pass of a satellite over a transmitter, a scientist can know a whale's location.

In 1985 Rathbun, Mate and Reid released a manatee with a floating satellite transmitter off Florida's Gulf Coast. Its signals were received by satellites of the National Oceanic and Atmospheric Administration. Since then, we have tracked more than 100 manatees with tethered transmitters, most by satellite. The technique has been adopted by the Florida Department of Environmental Protection, is being used in Puerto Rico and has been applied to dugongs in Australia.

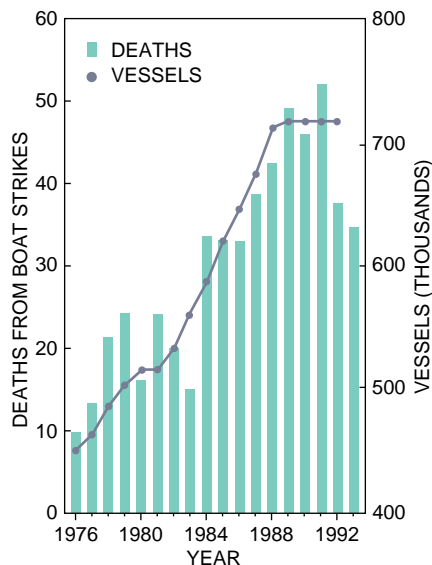
The satellite link reveals a manatee's location (within 100 meters), the water's temperature and the number of times the transmitter is tipped—giving clues about the animal's activity. In Florida, this information is correlated with maps of sea-grass beds, warm waters and other manatee resources at the Marine Research Institute of the Florida Department of Environmental Protection in St. Petersburg. Earlier, it was believed Florida manatees moved slowly



**WATER HYACINTH**, a floating plant, is held down with a flipper and stripped of its broad leaves by a Florida manatee in the Crystal River National Wildlife Refuge.



**THREE SPECIES OF MANATEES** now live in tropical and subtropical waters. The West Indian manatee, shown with algae on its back, most closely resembles the earliest trichechid. The African manatee is descended from dispersed West Indian manatees. The Amazon species feeds on grasses and has the most complex dentition.



SOURCE: Florida Department of Environmental Protection

**BOAT-KILLED MANATEE** displays slashes inflicted by a propeller. The graph details the increase in the number of boats registered in Florida and in the number of manatees killed by boats since the mid-1970s. The correlation, while not proving a cause-and-effect relationship, is highly suggestive. The rise in the number of boats also indicates that their use for recreation is increasing. Consequently, so is their destructive effect on the manatee habitat.

and were essentially nomadic. Now we know they can travel fairly fast—sometimes 50 kilometers a day—and their seasonal movements can be quite directed. Some females, for instance, will often graze in roughly the same areas every summer and head for the same hot spots every winter. Offspring appear to learn the mother’s migration patterns.

Generally, though, manatees are flexible in the kinds of habitats they occupy. We have tracked individuals from southern Georgia and northeastern Florida—where the primary forage is salt-marsh grass available only on banks at high tide—traveling in less than five days to the Merritt Island National Wildlife Refuge, where they feed almost exclusively on submerged, rooted marine angiosperms. After lingering in this region, rich in classic Florida wildlife such as wading birds, sea turtles, bottlenosed dolphins and alligators—which sometimes seize and detach the trailing transmitters—the same manatees may continue southward, arriving in the urban environs of Fort Lauderdale and Miami for the coldest weeks of the year.

**I**ncreased knowledge about the adaptability of manatees to diverse habitats and about their rate of reproduction has made us guardedly optimistic about the survival of manatees in Florida—once they are adequately protected. Administrative efforts by the state of Florida, the U.S. Fish and Wildlife Service and local governments to

reduce accidents have a high potential for paying off. We have combined the resighting histories of manatees in the scar-pattern catalogue with recent statistical theories to estimate the year-to-year survival rate of adult manatees. Chances of survival are good in areas with solid histories of protection, like Crystal River. The population there has grown from about 60 animals some 20 years ago to nearly 300 now. In Florida as a whole, 1,856 have been counted by air in winter.

We do not know how many manatees were missed in these counts. Although the general pattern from the 1970s through the 1980s pointed to an increase in manatees in several regions of Florida, trends in most recent years leave doubt about whether the population is growing at all. Along with lower estimates of survival in less protected regions (from our mathematical models) and more manatees being found dead from human activities, uncertainties in the recent population data call for continued efforts for conservation focused on some key areas of Florida. Should such efforts maintain their momentum—and barring unforeseen catastrophes—the Florida manatee could become a rare success story for endangered species.

Ultimately what will save these creatures is a sympathetic public. In this regard, there has been some genuine progress. Manatees have become extremely popular. For example, walking into my

daughter’s elementary school classroom, I was pleasantly surprised to see—in the permanent alphabet displayed above the blackboard—along with “A” for apple, “M” for manatee.

Internationally, the situation is less encouraging. Although most of the 40 to 45 nations in which manatees live offer them legal protection, the laws are not well enforced. Also, few attempts have been made (outside of Florida) to protect their habitat. Guatemala created the world’s first manatee reserve some 30 years ago. The secretive animals are rarely glimpsed there, but the reserve is still maintained. Along the coast of Panama, where Dampier provisioned his crews centuries ago, meager numbers of manatees persist in rivers of the Bocas del Toro region, and Panamanian conservation groups are working on their behalf.

It will be an uphill battle. But similar attempts are starting elsewhere. A new generation of conservation biologists from the tropical Atlantic is increasingly enthusiastic and concerned about manatees. The energy of these scientists was evident at the First International Conference on Manatees and Dugongs held at the University of Florida this past spring. Efforts to learn more about manatees in the tropics and to apply this information to conservation seem to be growing, providing seeds of hope for the future.

The Warauno Indians of the Orinoco Delta Territory of Venezuela refer to the Milky Way Galaxy as “the road of the manatee.” I remain hopeful that the underwater roads of the manatee will continue to be traveled along our tropical Atlantic rivers and coastlines here on the earth, to the marvel and delight of future generations.

#### FURTHER READING

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