Letter from the Desk of David Challinor
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Shortly after I arrived at the Smithsonian in the late 1960s, Secretary S. Dillon Ripley began enticing some of the Institution's scientists out of their laboratories and into the new and rapidly evolving area of conservation field research. Technologies to track and study large mammals were advancing from low- to high-tech, and Dr. Ripley was determined that the Institution seize the opportunity to position itself at the forefront of this area of investigation. To further his aim, he hired a distinguished mammalogist, Hal Buechner, to head a new conservation initiative.

Buechner had spent years in east Africa studying the Uganda kob—a relatively large antelope whose males establish and defend their exclusive breeding sites, known as leks. The leks, roughly 10-15 m in diameter, are rather uniformly spread over a large area of grassland. When ready to breed, a female dashes among the leks to reach that of her preferred male, trying to avoid being waylaid en route by a competing male. In this and similar studies of ungulate behavior, identification of individual animals is crucial. Traditional capture and marking procedures were stressful to the animals and also very expensive, and the researchers were engaged in vigorous efforts to develop electronic tracking devices.

About this time, the National Aeronautics and Space Administration (NASA) agreed to make one of its satellites available for an animal tracking experiment, and Buechner jumped at the opportunity, but early efforts at remote monitoring were to prove cumbersome, frustrating and inaccurate. In cooperation with state and federal agents and the well-known Craighead brothers, who had spent their lives studying the megafauna of Yellowstone, they fitted a cow elk in the Jackson Hole herd with an unwieldy, heavy (22 lb) U-shaped collar. Bull's necks swell during the rut, so it was only feasible to try the collar on cows. The collar sent a signal to the satellite when it passed overhead, reporting the elk's location in Wyoming and transmitting this information to NASA Goddard in Maryland. Out in the field, staff could easily spot the bright yellow collar with binoculars, and—using a grid and triangulation—were able to compare the cow's actual location with NASA's estimate in Maryland. The satellite's report proved to be accurate only within two or three kms. This early tracking effort ended in even greater disappointment when the cow, its collar askew, wandered out of the park and was shot by a hunter. I have told this tale to illustrate the early history of satellite tracking, a field that has made incredible strides during my time at the Institution.

Since those early days, Smithsonian scientists have exploited new, vastly improved monitoring methods to expand their knowledge about the behavior of large mammals and other wildlife in this country and in many parts of the world. Secretary Ripley's passion for the advancement of the Smithsonian's international conservation efforts started to bear fruit with the National Zoo's initiation of the Nepal Tiger Project in 1972. By the time permits had been obtained and research started, radio collars had shrunk to about a kilogram—an easy weight for a tiger to wear. During the next decade in the Royal Chitwan National Park in the lowlands of south central Nepal—one of the last refuges of the Bengal tiger—Zoo researchers, with additional financial support from the World Wildlife Fund (WWF), greatly advanced knowledge about tiger behavior in this park.

The decision was made to collar only about 20 adults of the estimated 50 in this study (a barely viable number to avoid inbreeding), and their territory size varied considerably. Fifty collars were applied during the study because at that time their batteries lasted only about two years, and the collars were designed to drop off at about that time for retrieval and reuse. Super males, it was learned, defended against rival males as many as five females, each with her own adjacent territory, although most male harems were limited to two or three. The defending male patrols his harem's territory regularly, and marks his boundaries by claw scrapes on trees and by spraying urine backwards between his hind legs on boulders, stumps or other large objects. Sexually mature male cubs dispersed widely—one more than 100 km from the park. Females were slower in scattering.

Collared tigers were generally monitored by radio triangulation from elephant back, although when funds were available, we hired a plane that, with a receiving antenna under each wing, was flown by one of the researchers. In this way we could cover the whole park in a few hours and plot the location of each collared tiger to within a 10 m diameter circle. The day I flew on the survey we located about 15 of the 20 collared animals, although I never actually saw one. By the usual measures of scientific progress as well as by Smithsonian standards, this was a successful endeavor. The research done there resulted in four Ph.D.s—two Nepali and two U.S.— thereby amply fulfilling the Institution's mandate to "increase knowledge."

A few years later, scientists at the Smithsonian Tropical Research Institute (STRI) exploited even smaller devices to study the foraging behavior of *Pelamus platurus*, an Indo-Pacific sea snake. This snake received notoriety in Congress when Smithsonian scientists testified at a hearing on a proposed sea-level canal across Panama, raising the specter of this venomous serpent gaining access to the waters of the resort beaches from Jamaica to Miami. I like to think that this threat may have been one factor in scuttling the Atomic Energy Commission's grandiose and alarming "Swords into Ploughshares" plan to use buried atom bombs to excavate the proposed waterway.

This sea snake itself is about a meter long, and its body and tail are dorsally/ventrally flattened for swimming. It is a slow swimmer and strikingly patterned with a bright canary yellow underside and a blue/black back. The fangs are so short (4-5 mm) that the snake would have to chew on a finger to release enough venom to harm a person. Local fishermen casually throw them back when they are accidentally netted. They tend to congregate along lines of wrack and flotsam, which on calm days often stretch for hundreds of meters. There, they feed on small fish attracted to the flotsam's shade.

Occasionally, the snakes submerge, and they can stay down for an hour. To find out why they do this, Smithsonian scientists sewed a little finger-sized monitoring device in the snake's tail. (Yes, they do have tails—the part behind its ventral orifice.) A short antenna stuck out, enabling scientists at the surface to find and identify individuals when they came up to breathe. Snakes do not have gills and do not actually breathe underwater. Rather, like some other aquatic reptiles, they absorb oxygen from the water through their skin. We learned that these sea snakes dove about 10-15 m deep where they seemed to move only a little and evidently fed on other fish at that depth. The snakes catch fish with a surprisingly rapid sideways strike. The impaled prey is held until it succumbs to the venom and is swallowed.

My final example of how scientists have benefited by new monitoring devices concerns a study of fin whale feeding behavior. We have known their precise diet for years from examinations of the stomach contents of butchered whales, and with the advent of scuba, we soon learned about the surface feeding techniques of humpbacks and related rorquals. Deep feeding strategies remained a mystery. Fin whales, the second largest whale after the great blue, takes short dives lasting less than 10 minutes, which was puzzling. Because of its size, the whale stores large amounts of oxygen in its muscle tissue and thus theoretically could remain submerged for a half hour or longer.

The mystery was solved about five years ago when scientists at Scripps Institution for Oceanography in California chased fin whales on the surface and attached monitors on their backs with suction cups. The cups eventually detached and were retrieved. The researchers had expected the monitors to play back the whale's songs, but instead of singing, the whales were feeding. After months of analyzing the data from the monitors, scientists learned that in their short dives the whales descended about 200 m, evidently in search of krill. Astonishingly, the monitors showed the diving whale abruptly stopping its descent in a few seconds. The scientists soon realized what was happening. They were lunge-feeding, a technique previously observed among surfaced blue whales. When approaching a shallow krill swarm, the whale opens its mouth while simultaneously increasing its fluke action. The jaws are thereby forced to open even more widely. The pleated throat is stretched to its limit as the whale comes to a sudden stop, its lower jaw at a right angle to its upper and its mouth full of water and krill. In three seconds, it shuts its mouth and, with its large tongue and muscles in the pleated throat, expels the huge volume of water laterally through the fringed baleen on the sides of its mouth, entrapping the krill and swallowing them. Lunge-feeding takes a great deal of energy, which explains why after five or six submerged lunges, the whale has to resurface to replenish its oxygen for the next feeding bout.

The technical advances that have allowed us to monitor the behavior of animals as huge as the whale and as small as the sea snake have taken place during the relatively brief span of my professional career. And the examples discussed in this Letter give just a sampling of the ways in which sophisticated monitoring techniques have become a critical tool of research into the behavior of the wondrous inhabitants of our natural world. It is our great good fortune to live in a country prosperous enough to value and support exploration into the seemingly endless mysteries that entice researchers. We will never run out of curious minds dedicated to filling in the gaps in what we know now, and the process should continue as long as mankind survives.

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P.S. Information on fin whale feeding came from an interesting piece in the *New York Times* by Carl Zimmer. (11 December 2007, page D3)