

turtles will exceed the drain that can reasonably be imposed on the natural nesting colonies.

The obvious remedy for that is to keep breeding stock. Here again, nothing is known about possibilities or procedures. *Chelonia* is a strongly migratory animal. Its migrations are presumably a feature of an integrated reproductive pattern, and nobody knows whether it will reproduce in confinement. Turtle ranchers of the future will have to get their hatchlings from nests on artificial beaches. The nests will be made by female turtles that have mated with males living behind fences. No one knows for sure how big the enclosures will have to be, or what the specifications of a suitable artificial beach will be. These and many other questions will have to be answered. A technology of green turtle husbandry will have to be developed. Once that is worked out it will be a double blessing: people will be fed and species will be saved.

EPILOGUE

During the fifteen years since *So Excellent a Fishe* was written there have been great changes in the sea turtle world. Much has been learned that was unknown then, and the relationship between turtles and the human race has evolved, too, for better and for worse.

To get an idea of the nature and scope of the changes you should go to a big book, *Biology and Conservation of Sea Turtles*, that appeared in 1982. Published by the Smithsonian Institution and World Wildlife Fund, Inc., it was edited by Karen Bjorndal. The book and the symposium of which it records the proceedings represent the most dramatic advance in sea turtle affairs since turtles and mankind first came in contact with each other.

The symposium took place in the State Department Building in Washington, DC, in November 1979 and was attended by government representatives and private turtle people from forty different countries. More than three hundred names appeared in the conference register, and sixty-three papers were presented at the meetings. A world sea turtle conservation strategy was developed, turtle colonies deserving special attention were identified,

and a set of recommendations for conservation action was composed.

People left the symposium with increased motivation to learn even more about sea turtles, or to do more to save them from destruction—or, in some cases, even to clear the way for commerce in turtles. So, since the symposium, the rate of change in the study and conservation of marine turtles has accelerated, and there is no way this epilogue could bring a reader fully up to date. But *So Excellent a Fish* was partly a historical account to start with, so all I will do is record a few outcomes and afterthoughts most closely related to one or the other of the themes of the book, and otherwise hope that the changes that have occurred in sea turtle science and survival outlook may impart historic value that will compensate for any reduced timeliness.

Down at Tortuguero the Caribbean Conservation Corporation (CCC) has continued its program with no interruption of the twenty-six-year-old regimen of tagging and monitoring the green turtle nesting population. In 1981 the organization suffered a serious loss in the death of John H. Phipps. Ben, as he was everywhere known, was president and steadfast supporter of the CCC since its beginning. The presidency has passed along to his son, Colin Phipps, and headquarters of the organization remain in Tallahassee, Florida. The Tortuguero station has been named the John H. Phipps Green Turtle Research Station.

At Tortuguero, quarters for the tagging crew have moved from the Miskito Indian shack that housed Leonard Giovannoli in 1955 to the tiny thatched house where Larry Ogren put up for three seasons with Leo Martinez and his family; then on to our charming leaf-house on tall poles in the *cocal* between the lagoon and the sea at Mile 2½; and finally into a less picturesque but more comfortable structure, acquired when a tarpon-fishing camp went broke, down near the *boca*. The work on the beach is done by teams of five or six volunteers from the United States and from Caribbean countries, helped out by varying numbers of people

hired in the village. Some of both sets of taggers have grown up with the work; some have even grown old and then retired.

The incomparable Sibella has moved to Limón to take care of grandchildren in school, but she passed on her genes and lore to her daughter Junie, who now brightens the victualing at the station. With the coming of Tortuguero National Park, and to set a righteous example for the villagers, the old succulent wild-meat dishes are no longer staples in our fare, and turtle has been totally eliminated. But despite the distressing deletions from her palette, Junie continues to work a daily magic that gladdens the hungry, weary, sandy turtle people, and haunts their dreams now in the same way Sibella's cooking did in the past.

The CCC has never wavered in its financial support for the Tortuguero operation. The main burden has been borne by the Phipps Florida Foundation. While the yearly budget is not large—as compared with the numbers of people, projects, and unbudgetable expenses that have been subsidized—the support has been generous and continuous. Everybody in the organization has subscribed to the original concept that its most important attributes are a single-minded resistance to any distraction from the central aim of keeping watch over the Tortuguero nesting colony and a determination to make it the most thoroughly studied sea turtle population in the world. This policy has not only increased knowledge of the green turtle; it has also reinforced the immunity of the colony to destruction by poachers. The continued CCC presence at Tortuguero has given heart to the Costa Rican government agencies responsible for wildlife conservation. Without any doubt whatever, the CCC program has saved the Tortuguero green turtle colony—by far the most important population in the Caribbean—from the total destruction that it faced in the 1950s. The continuity of the operation through more than a quarter of a century has produced unique insights into various aspects of the reproductive ecology of the turtle colony. Scientific results have been—and will continue to be—reported in a long list of published papers.

As of February 1983 about twenty thousand turtles have been

tagged at Tortuguero. There have been 1605 international recaptures, and many more subsequent returns to the beach by tagged females. One kind of insight that this contact with the population provides is suggested by the history of turtle No. 3438, an admirable old wind-turtle, as the local people call the ponderous, outsized females that often come ashore with strong winds. The record of her observed nestings is no doubt the longest ever compiled for a sea turtle. Her tag was first put on in 1965. When she came ashore the last time in the 1982 season, she had made twenty-six nesting emergences on Tortuguero Beach, in seven different seasons. Besides illustrating the reproductive periodicities of her kind—the characteristic remigration and re-nesting intervals—No. 3438 shows the remarkable green turtle ability to locate and go back to one particular short section of that beach, whether in returning after the two-week internesting interval, or after the two- or three-year absences between migrations from the home feeding ground. This nest site fidelity is not absolute, and it is easy to see why that is so, because too great rigidity would kill off a population when storms destroyed the nesting shores; and the trait is more strictly expressed in some females than others.

An even more impressive site fidelity record is that of turtle No. 5806, which also last appeared in 1982. She was first tagged in 1969. The record of her returns to the beach (which is 22 miles long, and is marked off in one-eighth-mile sections) is as follows:

YEAR	DATE	MILE MARKER	YEAR	DATE	MILE MARKER
1969	24 July	4 ⁵ / ₈	1977	3 Aug	4 ⁵ / ₈
	3 Aug	4		14 Aug	4 ⁵ / ₈
1971	25 July	3 ³ / ₈	1980	24 Aug	4 ⁵ / ₈
	6 Aug	4 ⁷ / ₈		3 Sept	4 ⁷ / ₈
	26 Aug	4 ⁷ / ₈		14 Sept	4 ⁵ / ₈
1974	17 July	4 ⁵ / ₈	1980	31 July	4 ⁵ / ₈
	18 July	3 ³ / ₈		9 Aug	4 ³ / ₈
	31 July	4 ⁷ / ₈			
	21 Aug	4 ⁷ / ₈			

How such homing-site tenacity could have been achieved on a shore such as Tortuguero, where the beach, the shore vegetation, and the underwater contours off the beach are constantly being remodeled by waves and wind, is wholly unknown.

Although the continuous monitoring of the nesting colony has been the main aim of the CCC program, many short-term projects have also been undertaken from time to time. Graduate students have done their research at Tortuguero; and other scientists have come down to take advantage of the resources of the tropical seaside locality, the roof over their heads, the turtles, and especially Junie Martinez's cooking; and they have carried out physiological, behavioral, and ecological studies of many different kinds.

Many of the tagging crew members have gone on to high places in sea turtle research, conservation, and management. Larry Ogren, who was the spirit of the place during several of the earliest lonely years, is now Sea Turtle Specialist for the U.S. National Marine Fisheries Service. René Marquez went home to Mexico and became the first government sea turtle official in the world. With astonishing consistency members of the Tortuguero tagging crews have gone away and done good deeds for turtles and the natural world. It is chilling to think what shape Caribbean green turtles would be in today if there had been no Caribbean Conservation Corporation.

The people in the CCC have begun to ponder how the organization should be guided in the increasingly complicated years to come. Times have changed at Tortuguero and in the world at large. There are new problems and new opportunities. A fundamental change was the coming of the canal that connects the natural coastal lagoons between Puerto Limón and Nicaragua, and provides easy water transportation from Limón to Tortuguero and on beyond to Barra del Colorado. This not only brings the villagers more of the emoluments of civilization—including the basic privilege of getting out to see a doctor if the need arises—but also is generating tourism. The tourists are not just Costa Ricans and wandering gringos, but people from as far away as Switzerland and West Germany.

The other big change has been the coming of the Tortuguero National Park. The park is a 19,000-hectare tract of beach, coastal forests, and streams. It extends for 15 miles along the coast from Jalova to a point just south of Tortuguero Village, and thus includes most of the nesting beach, and by far the most heavily used part of it. Even before the park was developed the turtle colony was protected by law, but now control of poaching is the responsibility of the park, and it is a heavy burden. The Limón *cayucas* still come up the coast and harpoon the cooting and courting turtles just off-shore. The new access to Tortuguero lagoon that is provided by the canal system has brought in egg-poachers from Limón, La Barra, and the railroad crossings up the coastal streams; and though access to the beach from the lagoon is difficult there are trails out to it, and people able to stomach the sight, or thought, of the *terciopelos* there are beginning to use them in their egg-poaching forays. The CCC has donated funds to support the effort of the National Park Service to scare off the egg-poachers, but systematic, continuous surveillance is needed on the beach. Off-shore, the only control imposed on the harpoon boats is bad weather, and nothing better can be expected until a fast, seaworthy patrol boat is available to the Park Service or the Coast Guard. So the new accessibility of once remote Tortuguero is a mixed blessing.

Although the place is no longer a sequestered outpost approachable at times only by a little airplane landing on the beach, it retains much of its original charm. The forests and woodland streams around Tortuguero are dramatic samples of tropical landscape—and every year the turtles keep coming ashore.

These things are what the tourists are coming for, and the job that Costa Rica and the Park Service and the people of the village face is to turn this new popularity to their collective advantage by meticulously preserving the values the visitors come to savor. For this to work, tourists will have to be screened in ways that will bring in only nature-loving folk. Water routes and woodland trails that display the diverse beauty of the lowland forests should be laid out; and a program of beach walks, carefully

supervised by park rangers, will have to be organized if the nesting colony is to be perpetuated as a tourist resource. Personally, I would rather nobody ever went out on the beach among the quiet turtles except me and a few trusted colleagues. But, sadly, that is no longer the way the world is. The new people are bound to see the turtles, and the only thing to do is to turn this new popularity—and its economic promise for the village and the Republic—into ammunition with which to combat poaching and the perennial lobbying by turtle dealers for relaxation of protective legislation.

So despite the nostalgia for the tranquil magic of the days when there was no canal, when blowdowns blocked the Caño de Palmas route to La Barra, and the lagoon to Parismina would get choked up with continuous rafts of water hyacinths—despite the yearning for those halcyon years, when you waited a week on the beach up at Bertie's for the little worn-out airplane to pick you up, and there was no beer, and one cured the people the *terciopelos* bit by feeding them leaves and roots and kerosene and putting on snake brain poultices—despite the lost virtues of the old lonely, lovely Tortuguero, one has to accept the new times and make the best of the influx of outsiders. And a properly organized, edified clientele of visiting observers of the turtles and the wild woods will reinforce the motivation of the Costa Ricans and their government to save them both.

Recognizing the obligation to deal with the changes, we recently applied to the Tinker Foundation for funds to be used for a couple of modest ventures in public relations. One of these is a little information center at Tortuguero Village; the other is a small endowed fellowship to support participation in the Tortuguero beach work by qualified Central American students.

The aim of the information center is to orient the growing numbers of tourists, both Costa Rican and foreign, who are coming to Tortuguero over the new intracoastal waterway. When these people are put ashore at the village they find simple accommodations, but no means of satisfying their curiosity about sea turtles, the town, Tortuguero National Park, or the work of the Caribbean Conservation Corporation. The function of the informa-

tion center will be to explain the history and interaction of all these. This not only will help visitors to feel less lost when they go ashore, but also will alleviate the embarrassment of the villagers over the sparse amenities of their community, and will prevent disturbance to nesting turtles by visitors untutored in turtle-watching. It will also relieve our overworked tagging teams of the obligation to double as tourist guides.

The proposed fellowship is a response to the spread of interest in sea turtle conservation and research during the last ten years. The CCC receives numerous requests for aid and advice in setting up programs elsewhere. To help meet this need, we decided to invite a qualified Central American student or conservation officer to Tortuguero from time to time to get experience in sea turtle work by collaborating in the tagging program. In 1981 the Nicaraguan chief of wildlife conservation and three young colleagues were brought in by bus from Managua and put up for three weeks as working visitors. The good that such people can do for sea turtles when they return to their home country with new experience and understanding is obvious. Back in the early years, our first Latin American collaborator was, as I have said, René Marquez, who now, fifteen years later, is head of the sea turtle section of the Mexican Institute of Fisheries. Another visitor, Mario Hurtado of Ecuador, went home and became coordinator of marine turtle and conservation research for the Galapagos Islands and mainland coast of Ecuador. An early Costa Rican collaborator was Alvaro Ugalde, who worked on the beach for one summer, and then went to the University of Michigan with a small CCC grant, received a master's degree in wildlife ecology, and became director of the renowned National Park Service of Costa Rica.

Both the center and the fellowship will bear the name of Joshua B. Powers, instigator of the CCC concept, whose verve and enthusiastic interest have for twenty-six years been an inspiration to its members and a major influence in its success.

Of the upshots of trends and events recorded in this book, none are as stirring as those involving the ridleys—not just Kemp's

ridley (*Lepidochelys kempi*) of the Atlantic, but now the Pacific olive ridley (*Lepidochelys olivacea*) as well. It is strange how these turtles so consistently generate emotion and evoke superlatives. They do astonishing things, and astonishing things happen to them. Today, twenty-nine years after "The Riddle of the Ridley" saw the light as a chapter in my book *The Windward Road*, and sixteen years after *Arribada* appeared in the first edition of this volume, the superlatives are still in order, the stirring dramas continue. The old riddle of the ridley has dwindled before one ridley surprise and disaster after another.

The reverses have affected both species. The nesting colony of Kemp's ridley at Rancho Nuevo on the Gulf Coast of Mexico has diminished from the forty thousand nesting females that came ashore at the time the Andres Herrera film was made, in 1947, to no more than four hundred to six hundred nesters in the years from 1979 to 1982. The belated effort to save the species is probably without precedent as an example of international cooperation in a species preservation effort. The Mexican *Departamento de Pesca* has installed a permanent field station at Rancho Nuevo, and biologists and Marines are sent down to the beach each nesting season. Seven U.S. groups and agencies are collaborating with the Mexicans: Fish and Wildlife Service, National Marine Fisheries Service, National Park Service, Texas Park Service, U.S. Coast Guard, U.S. Navy, and Florida Audubon Society. During three seasons, Peter Pritchard of Florida Audubon supervised a group of students from the University of Central Florida who helped in tagging, egg collecting, and patrolling the beach. During the past two seasons Pat Birchfield, Director of the Gladys Porter Zoo in Brownsville, Texas, has been field director of the U.S. party. The work of this unprecedented posse is to reduce natural and human predation by constantly patrolling the beach, locating nests, and moving eggs to a central hatchery at Rancho Nuevo. During the 1982 season, 48,000 little turtles emerged at the hatchery and were released on the beach there.

In a supplementary transplantation effort, 2000 eggs were flown to Padre Island, Texas, where it is hoped that a new colony

can be installed. Because it is possible that hatchlings are imprinted by specific tastes or smells of the natal shore or shore-water and later use these as reproductive homing cues, Padre Island sand is sent down to the Mexican hatchery, and the eggs are put into this sand and shipped to a hatchery on Padre Island. When they emerge there the young turtles are subjected to an eccentric-looking procedure that regrettably was not followed in our old *Operation Green Turtle*, and conceivably may have been the missing ingredient responsible for our lack of success in establishing new nesting colonies. The Padre Island hatchlings are allowed to crawl down to the sea, and once beyond the surf, they are netted and flown to Galveston, Texas. There, in the laboratory of the National Marine Fisheries Service, they are reared to the age of about a year and then released at various localities in the Gulf of Mexico.

The aim of this laborious and costly process—a procedure known as head-starting—is to circumvent predators. The idea is that yearlings fit fewer predaceous mouths than hatchlings do. As to whether the pen-reared young will one day rejoin the ancestral breeding population, there is some room for doubt; but in a case as dire as that of Kemp's ridley, the chance seems worth taking.

Our laboratory at the University of Florida has furnished tags, rewards, and coordinating correspondence for the yearling releases of the first two years. To people who return the tags we pay the rewards from a fund sent us by Mrs. Ila Loetscher, president of Sea Turtles, Inc., of South Padre Island, Texas. Results of this tagging experiment have not yet been published by the National Marine Fisheries Service, but the returns have been numerous and very interesting. Whether or not the operation ever establishes a nesting colony on Padre Island, the Galveston head-starting project has been productive as an experimental exercise. Besides the head-started yearlings, others have been sent to major aquaria to be kept as captive stock, against the possible eventual total loss of the natural species.

The big threat to *kempii* today is no longer the coyotes or egg hunters that brought about the original decline. The factor to

reckon with now is incidental catch by shrimp trawlers. With the breeding population down to no more than twelve hundred mature females, each turtle caught by a net dragged for other species represents a significant loss. So despite the most powerful rescue effort that any sea turtle has ever received, Kemp's ridley is by all odds the most precariously ensconced marine turtle in the world.

The saga and plight of the olive ridley (*Lepidochelys olivacea*) of the Indo-Pacific and tropical West Atlantic are, although on a markedly different scale and without the loom of early extinction, no less melodramatic. Back during the years when I was obsessed with the puzzle of ridley reproduction, I had no inkling that *olivacea* was an *arribada* breeder. I lived in Honduras in the 1940s, and we used to go over to Isla Ratones on the Gulf of Fonseca to watch ridleys nest there. The density of that nesting colony was no greater than usual on any good sea turtle nesting beach anywhere. During the next fifteen years I walked many miles of beaches and talked ridleys with multitudes of coastal people from Costa Rica to Baja California. I learned that ridleys nested at scattered points all along the Pacific coast, but I heard no word of mass nestings anywhere. Seamen and airplane pilots told me or wrote me about sighting huge aggregations of turtles in the open sea off the coast between Mexico and Panama—such as the one Jim Oliver reported in 1945—but nobody had anything to say about *arribadas* on shore. I find this passing strange—incomprehensible, really. The most spectacular gap in the ridley story, as told in *So Excellent a Fish*, is the total absence of any hint of the bewilderingly redundant assemblages of nesting *olivacea* that have since been revealed in Mexico and Costa Rica.

The first olive ridley *arribada* to come to light was over in the Atlantic range of the species, in Surinam, on the coast of northern South America. This was a relatively modest aggregation, of around five hundred females, at a place called Eilanti. It was first reported by Joop Schulz of the Surinam Forest Service. The turtles were later studied and tagged during two seasons by Peter Pritchard.

Then, one after another as if just invented, ridley *arribadas*

began to turn up along the Pacific coast of Mexico. In 1967 Antonio Montoya of the Mexican Instituto Nacional de Investigaciones Biológica-Pesqueras reported great numbers of *oliuacea* nesting on the Pacific coast of Mexico in northern Guerrero. Huge assemblages came to light in Jalisco, Guerrero, and Oaxaca. But then, at a meeting of the Marine Turtle Specialist Group in 1971, Gustavo Casas Andreu of the Mexican Sub-Secretaria de Pesca reported that 751,350 olive ridleys had been killed in one year. He said the number was compiled from official government figures and was thus probably much lower than the real number killed. He quoted as follows from the December 1970 issue of the Mexican journal *Técnica Pesquera* (trans.):

The obstacles that the Mexican turtle program is encountering and the increased clandestine exploitation of eggs, meat, and turtle skin are causing Mexican and foreign biologists to worry over the fate of the Pacific ridley . . . which is intensively exploited. All along the Pacific coast exploitation during the closed season continues. The situation is particularly scandalous in the State of Guerrero. These adverse factors are nullifying the efforts of the Mexican turtle program, which was once pointed to as a world example of its kind.

So, just as in the case of Kemp's ridley, the existence of the Pacific *arribadas* was made known to the outside world only after their destruction was far along. Within a half dozen years, three of the original four Mexican aggregations had been destroyed to supply the leather trade. The fourth, at Escobilla near Puerto Angel in the state of Oaxaca, was still strong, but was being exploited at what most observers believed was an unsustainable level. The trade that was killing off *oliuacea* met no utilitarian need. It supplied luxury items only—shoes for Italian pimps, as a friend of mine put it.

At Escobilla, the exploitation and the responsibility for enforcing regulations were taken over by a private operation known as PIOSA (Pesqueras Industriales de Oaxaca, S.A.), owned and

operated under government license by an extraordinary Spaniard named Antonio Suarez. When attacked by critics in Mexico and outside for taking profit from the last of the phenomenal *arribadas*, Suarez pointed out that the old government-imposed harvest quotas and controls had not been enforced, that he was enforcing them, and that without the strong hand of his company the Escobilla *arribada* would quickly go the way of the other lost aggregations. He was no doubt right. In ways that were never clearly documented he had intimidated the tough Oaxaca *costeños*—fishermen and politicians alike—and had replaced their random slaughter of the ridleys with his own disciplined mayhem. The trouble was that that, too, clearly exceeded the breeding potential of the species.

Toward the end of his tenure at Escobilla, Antonio Suarez invited a group of nine turtle-oriented people from the United States to come down and hear his version of what PIOSA was doing. I was a member of the group. Don Antonio told us many things. When asked how it felt to be known as the man who had killed more sea turtles than any other, he replied that what really concerned him was his young daughter's worry that her father might one day be known as the man who caused the *golfinos*—the olive ridley—to become extinct. He was an admirable host. He gave us a three-hour talk on his background and philosophy. He was obviously in control of everything that went on around Puerto Angel. The main flaw in his operation—humane considerations aside—was the fuzzy concept of population dynamics from which he worked. Like most people who exploit marine resources on a basis of "maximum sustained yield," he appeared to have no real idea what his inroads were doing to the population.

We were especially bemused by one thing Suarez said. He pointed out that his enterprise was an example of *industrialización completa*—that is, complete use of the turtles killed, as in slaughterhouses where hogs are totally turned to useful purposes. Thus, he explained, the inroads of PIOSA at Escobilla were far more justifiable than the unregulated killing that had wrecked the

other Mexican *arribadas*. He said this with the clear conviction that a policy of complete use went far toward justifying the using up of a wild species.

During a break in our deliberations Don Antonio showed us around the slaughterhouse, hatchery, and laboratory, and then said it was time for us to go up to see how PIOSA captured the ridleys at Escobilla. He put us all—the nine gringo visitors, and assorted local *boteros* and turtle divers—into two boats. We cruised several miles up the coast from Puerto Angel to Escobilla, where the *arribada*—or *morriña*, as the Oaxacanos call it—occurs. In Castilian *morriña* means melancholy or homesick, so the Oaxaca people's application of the word to the homing frenzy of the ridleys seems a logical and not unpleasant anthropomorphism. Anyway, as we entered the edge of the *morriña*, a lot of sea snakes began to turn up; and these prompted me to an eccentric act that revealed unexpected strength in Suarez's character—and perhaps a weakness in mine. I relate this anecdote because it shows what an enigmatic man Suarez is, and because it illustrates the aura of strangeness that ridleys engender.

Sea snakes are a kind of cobra. They kill fish with a venom that is said to be exceedingly virulent. But *vis-à-vis* the human race, they are curiously docile even when handled. I knew that; Suarez did not. That makes his reaction to my behavior doubly admirable.

What I did was to indulge personal pride in a snake-snatching technique that I had developed in my youth. As we drew near one of the sea snakes, I leaned over the bow and with a single motion snatched it out of the water and threw it into the air. I meant for it to fall back amidships, but I must have misjudged the forces at work—the speed of the boat, perhaps the height of the snake's rise into the air, or the spin of the earth—because instead of falling back among Peter Pritchard, George Balazs, Carlos Nagel, Richard Felger, and a cluster of Indian divers and boatmen, the snake fell straight into Antonio Suarez's lap.

I don't cite this as a constructive move on my part—our aim, after all, was to conciliate Suarez and mold him into a better person; but

I did it, and Don Antonio's reaction revealed a single-minded aplomb that we found incredible. What he did was yell oops! or *¡queseso!* or something of that sort, draw his feet up from the floorboards where the snake was writhing in the inept way of sea snakes on solid substrates, hold that position while I scraped the snake back over the gunwale with a paddle, and then continue his discourse on *explotación completa*.

So now I have the probably totally unique distinction of having thrown a deadly snake into Antonio Suarez's lap; and he can lay claim to the most civilized reaction ever made to a similar affront.

The whole Escobilla story and its outcome, including the curious events that ended Antonio Suarez's reign at Escobilla, are altogether astonishing, and are further positive proof of my long-held conviction that ridleys are bewitched.

No sooner had the existence and destruction of the Mexican *arribadas* been made known than the discovery of two more breeding assemblages was reported in 1972. Both were in Costa Rica. One was at Nancite, up near the Nicaraguan frontier in Santa Rosa National Park; the other was at Playa Ostional about a hundred kilometers to the south. Both were found by Joseph Richard and David Hughes during the course of an aerial survey along the Pacific coast. There is a settlement at Playa Ostional, and the *arribada* there was being heavily exploited for eggs—some of which were being fed to hogs. At Nancite the turtles have undergone no exploitation at all. Later on, David Hughes took up residence there to observe the *arribada*, and was rewarded by a rare daytime emergence. The photographs that Hughes took rank with the great animal photographs of all time.

When the Nancite *arribada* came to light the government was immediately importuned by outside entrepreneurs seeking concessions to exploit it. One of these threatened to kill Billy Cruz, vice president and Costa Rican representative of the CCC, if he should try to block the effort. Billy tried anyway, and he lives on; and it is a good thing because we would be hard pressed to get along without him. The government has staunchly resisted all efforts of hide people to get concessions to exploit the colony.

Nobody lives near Nancite, and the 2-kilometer crescent of beach is washed by heavy surf and hovered by rocky headlands and rugged inland hills. The beach is located in Santa Rosa National Park, and the *arribada* is by all odds the best protected one in the world. Access to it is extremely difficult. During the last three seasons Dr. Steve Cornelius has attended the gatherings there, under contracts with World Wildlife Fund, Inc., and the U.S. Fish and Wildlife Service. In 1981 the CCC donated funds to the Costa Rican Park Service for construction of a small building to house surveillance and research personnel.

So the Nancite *arribada*, one of the great ecological treasures of our time, seems safe from the egg hunters and the avid leather people. I have never successfully connected with any *arribada* on shore. But one day I did see the whole Nancite fleet massed in the little bay, ready to go ashore, and the sight was stupendous. We came suddenly upon it after flying up the rocky coast for 20 miles. The pilot of the plane yelled *Santa Madre!* and jerked us into a diving turn. For ten minutes we circled 400 feet over the little bay, looking down, not on water, but on a 300-acre mosaic of ridley backs, little high-shelled females and long-tailed males, massed shoulder-to-shoulder in a tight tile deck of turtles on top of the sea. We circled too fast to see what they were doing down there, waiting for their signal to swarm up onto the shore in their wild, unaccountable, self-destructive nesting horde. It was high noon of a brilliant Guanacaste day. The olive ridley leans to windy nights as times for *arribadas*, and I could count only half a dozen overeager females moving up from the surf toward the trees and the thin ridley trails of a few others up the flat to the tree line.

After a lot of backing and filling, the poaching at Playa Ostional, where the ridleys arrive in an inhabited area, appears to be at least partly under control. A managed egg harvest is permitted there. The turtles are tagged each season by students of the University of Costa Rica supervised by Douglas Robinson. In 1982 the President of the Republic declared Playa Ostional a "protected area," and

though there was no clear definition of that designation, it has an encouraging sound. So the Nancite colony is not only one of the biggest *arribadas* on earth, it is the only one in the world that is free of human abuse.

Even the discovery of the Costa Rican *arribadas* was not the end of the olive ridley saga. The next development was a report of massive slaughter of ridleys far down on the Pacific coast of Ecuador. This was doubly astonishing because no ridley nesting was known to occur south of Panama. In due course it came out that the Ecuadorian turtles were not a breeding aggregation, but were vast flotillas of subadults that evidently migrated down there to feed on the teeming macroplankton in coastal upwellings. As in Mexico, the turtles were being killed for their hides; and these were going to the same European markets that received Antonio Suarez's exports from Oaxaca. Antonio took a dim view of this enterprise, and he pointed out indignantly that the Ecuadorians were not even allowing the turtles to mature before they killed them. You hear this quite a lot from the harvesters of sea turtles. The reasoning on which it is based is very strange.

As of 1979, up to 148,000 ridleys per year were being killed in Ecuador; and this was disillusioning, because that country is known for its conservation conscience—as revealed in the Galapagos, for example. It later was revealed that the slaughter had been permitted because of a breakdown of communication between local government and the CITES (Convention on International Trade in Endangered Species) authority. In July 1981 the killing of turtles in Ecuador was made illegal by the Ministry of Natural Resources.

Shortly after that sensation had quieted down the next one came. There was sudden word that in India, Robert Bustard had located the biggest *arribada* ever seen anywhere, on the Orissa coast near Wheeler's Island, on the western shore of the Bay of Bengal. According to the report, Bustard had put tags on 158,161 Orissa ridleys during one fortnight. There was not time to ponder that development before word came that ruinous exploitation of both eggs and turtles was going on there. After that, still another

huge ridley aggregation came to light in West Bengal, and with that news came word that this one too was being decimated, to supply Calcutta markets.

At that point some people began to feel worn-out with emotion over *olivacea*—irrationally exasperated with the poor creature for the expenditures of adrenaline it evoked, and outraged with the Mexicans and Bengalis for their treatment of it. In the *Marine Turtle Newsletter* for December 1982, Nicholas Mrosovsky, Peter C. H. Pritchard, and Harold Hirth pointed out quite correctly that there was a fundamental difference in the exploitation that *olivacea* was suffering in Mexico, where rich entrepreneurs and European pimps were the chief benefactors, and in India, where hunger was being assuaged. They wrote as follows:

Meat from the turtles killed in West Bengal and eggs from the beaches also find their way into the markets in Calcutta. Here they go to feed . . . people who need better nutrition. The price of turtle meat and eggs is not especially high—they are not just luxury items. We have here a classic clash between the immediate needs of people and the conservation of resources. In the long run, of course, these are compatible. There will be less food available if these ridley *arribadas* go the way of those . . . in Mexico. So we urge you, whatever your conservation philosophies, to write Mrs. Gandhi, urging her to look into the matter, and devote more research funds to divining ways of improving the situation.

Where it all will end nobody can say. Whether the destruction of the beleaguered *arribadas* can be stopped, and whether, if not, the species can be sustained by the widespread separate nesting that occurs—both are imponderable.

One point stands out, however: in its very redundancy, an *arribada* is one of the wonders of the natural world. The losses that ridleys have suffered have degraded two related natural assets—the wild species involved, *L. kempi* and *L. olivacea*, and the *arribadas* in which both reproduce. Concern over the threat to the existence of wild species is widespread, but the obligation to preserve biological phenomena and organization is less widely

recognized. Like the Serengeti fauna, the hawks of Hawk Mountain, and the monarch butterflies of the Sierra Chinqua, the *arribadas* are phenomenal, mind-gripping examples of biologic order, scientific and esthetic treasures of the living world. There is no civilized way to escape the obligation to save them.

One of the changes in my outlook since this book first appeared in 1967 has been the realization that farming turtles for international trade, instead of being a conservation tool, is more likely to complicate the problem of protecting wild populations from abusive overexploitation. Back in the days when I saw promise in turtle mariculture, the strategy I visualized was to rear young turtles from hatcheries to an age at which they could graze and digest turtle grass, then place them on tracts of ungrazed pasture to grow to maturity or marketable subadulthood. I saw this as a way to accomplish the dual aim of feeding people and saving wild populations of the green turtle.

A basic weakness in that vision was the impracticability of penning turtles in the open sea—even the shallow open seas where *Thalassia* grows. So, when the present big turtle farm was set up on Grand Cayman, growing turtles on natural pastures was never even attempted. The little turtles were raised to market size in magnificent big aquaria set up on shore. At first an effort was made to feed them on fish and on turtle grass mown on local flats by an ingenious machine. But that too proved impractical, and an artificial, well-constituted, high-protein pellet was adopted. At that point any resemblance to my old notion of turtle farming was lost.

I am no longer a proponent of raising turtles for international commerce. My most serious objections are that it will keep alive and expand markets for turtle products, stimulate poaching, and provide a customs screen for smuggling operations.

A major potential for trouble in sea turtle conservation is the insatiability of international markets, once demand has been awakened. It is this factor that makes the poaching and smuggling of turtle products so hard to control. Not long after *So Excellent*

a *Fishe* appeared, the green turtle was given endangered status in the *Red Data Book* of the Species Survival Commission of IUCN (International Union for the Conservation of Nature and Natural Resources). A few years later the advent of CITES offered the first mechanism for effective international controls. When the first meeting of the Marine Turtle Specialist Group of IUCN was held in Morges, Switzerland, in 1969, John Lusty, purveyor of turtle soup to His Majesty, The King, told us that international commerce in green turtles was largely confined to imports of green turtles for his soup kettles. He estimated that commerce in *Chelonia* beyond local subsistence trade involved no more than ten thousand turtles a year, most of which were used to make soup. A few years later, during the last months of the Somoza regime, three Nicaraguan packing plants were exporting ten thousand turtles from Miskito Bank alone, mostly to U.S. markets. The demand there was not by makers of soup. As Mr. Lusty pointed out, the U.S. soup market has always been weak. The U.S. demand was for meat.

With the return of personnel from abroad after World War II, more open-minded eating habits spread rapidly in the United States. More exotic dishes appeared on restaurant menus, and the demand for seafood of all kinds grew apace. Rising prices stimulated overfishing, and there was a serious decline in the fisheries of American waters. To fill the gap there has been a steady growth of demand for novelty items for the menus of restaurants in the United States and throughout the burgeoning tourist islands of the West Indies. This is a serious threat to Caribbean *Chelonia*. Given free access to Caribbean sea turtle populations, the restaurant demand could destroy them in a decade or less.

The main deterrent has been CITES. In 1978 importation of green turtle products from turtle farms was made illegal in the United States. This was a blow to Cayman Turtle Industries, the present name of the enterprise which, under my uneasy gaze, has grown from its beginnings as a few hundred Tortuguero hatchlings in live cars in the Florida Keys to a multimillion-dollar investment in tanks, plumbing, and personnel in the Cayman Islands. Various features of the Cayman operation were cited in

imposing the ban. One was the difficulty the immunity of farmed products caused for the border agents who had to distinguish the farmed shipments from poached products. Very recently, CITES has reduced its effectiveness by getting involved in hair-splitting, making more or less irrelevant distinctions between "farming" and "ranching" that encourage maneuverings by signatories to apply for exemptions that will permit turtle mariculture for international trade. For those who believe that taking eggs from wild populations is the principal sin of farming, these exceptions are worthy of debate; but the loss of wild eggs is usually not the most important issue. It is the stimulus to poaching and smuggling that comes from the expansible international markets that farmed products keep alive.

The problem is very real. A fantastic example of what can occur came to light recently through the ingenuity and quiet dedication of Special Agent Charles Fuss of the Law Enforcement Group of the National Marine Fisheries Service. Long after the U.S. ban on turtle products went into effect, Mexican sea turtle meat—probably mainly or entirely that of the olive ridley—was still being imported into Texas under the fictitious label "Tabasco River Turtle." The irony of this was that the Tabasco turtle (*Dermatemys mawii*) is itself an excessively rare species that is increasingly exploited by Mexicans for food. Instead of getting the protection it badly needs, its name was being used as cover for smuggled ridley meat. This is a peculiar twist to the "look-alike" problems that customs people face; but over a quarter of a million pounds of "river turtle" meat was confiscated by the National Marine Fisheries Service.

And that was ridley meat, which is far less palatable than green turtle. The demand for green turtle meat, though not of the magnitude of the market for marijuana, is capable of generating the same kinds of intractable problems of control.

At the time I write, a strong lobbying campaign has been mounted by the turtle farms to bring about a retraction of the U.S. ban, and government agencies show signs of weakening. If the ban is lifted, the outlook for wild Caribbean turtle populations

will decline and the stimulus to turtle farming will weaken the position of *Chelonia* in other parts of the world. This new threat comes at a time when the restaurant demand has eradicated soft-shell turtles from much of their former habitat in Florida; the huge alligator turtle, *Macrochelys*, is disappearing from whole stream systems; and the common freshwater snapping turtle is declining nearly everywhere. There is today a lively trade in illegal alligator meat that by far exceeds the volume that could possibly have been derived from gators taken under license. And all the time, seafood prices and demand are rising, supplies are shrinking, and the poachers and smugglers are eagerly awaiting the customs screen that will allow a renewal of their operations in the Caribbean.

Of the gaps that persist in what is known about sea turtles, none is more irksome than not knowing how many kinds there are. Not only is that scientifically embarrassing, but to try to carry out realistic conservation programs without knowing what genetic entities are being dealt with is a simple-minded exercise. Our ignorance is partly a result of the loss of prestige that taxonomy suffered when the study of small bits of animals became so much more rewarding to graduate students than the old concern with entire, assembled creatures. But partly, also, it is because sea turtles are intractable subjects for taxonomic study. The five major groups of sea turtles—the genera—are quite distinct; but when anybody asks how many species and subspecies there are, turtle people look insecure, and justifiably so. There is not time to go very far into the reasons for this, but a rough inventory of the troubles is as follows.

Three of the genera of marine turtles, *Caretta*, *Eretmochelys*, and *Dermochelys*, are currently each considered a single worldwide species. We thus speak of *Caretta caretta*, the loggerhead; *Eretmochelys imbricata*, the hawksbill; and *Dermochelys coriacea*, the leatherback. In my *Handbook of Turtles* I followed old authors in recognizing separate Atlantic and Indo-Pacific subspecies of each of these three. In his *Encyclopedia of Turtles*, Peter Pritchard

did not. The distinguishing characteristics on which the old separations were based were very weak, and today most turtle workers call each of the three genera a single kind of turtle. That makes no sense of course, but to delineate the different races that are actually involved will take a lot more attention than the problem is getting at present.

The other two genera, *Chelonia* and *Lepidochelys*—the green turtles and the ridleys—are a little more in line with classic zoogeographic expectations, though not much. Each, at least, is clearly represented on the American shores of the Atlantic and Pacific by different species—or, in the case of *Chelonia*, possibly subspecies. In *Lepidochelys*, Kemp's ridley (*L. kempii*) breeds only at one place in the Gulf of Mexico and ranges through the Gulf to Florida and northward along the Atlantic coast. It is totally absent from the Caribbean. The olive ridley (*L. olivacea*) was once called the "Pacific" ridley because it was known to breed only on Indo-Pacific shores. It differs from *kempii* in shell shape, jaw structure, scale number, feeding regimen, behavior, and temperament. In recent years it has been found to breed on the Atlantic coasts of Africa and South America; and it is this kind of ridley that turns up as a straggler along the outside of the Antillean island chain as far as Cuba. These Atlantic ridleys are no doubt genetically different from those of the Pacific, but nobody has ever made a serious effort to show this. All in all, ridley zoogeography, like everything else about the creatures, is curiously anomalous. But at least the genus comprises two clearly distinguishable forms, *kempii* and *olivacea*.

In *Chelonia* there is an extremely distinctive animal, *C. depressa*, restricted to northern Australia and adjacent New Guinea. For the rest, the genus is a taxonomic mess. If you confine your concern to its members on the Atlantic and eastern Pacific shores of the Americas, green turtles are easy to split apart. In common usage, the eastern Pacific kind, which is little, black, and high-shelled, and mostly an eater of algae, is called *Chelonia agassizi* or *C. mydas agassizi*, depending on how much you think you know about its interbreeding and merging with other populations out

in the Indo-Pacific somewhere. But apart from that glimmer of light, the taxonomy of *Chelonia* is no better than that of the other genera. It is worse, actually. The name *agassizi* was first applied long ago to specimens of *Chelonia* from Guatemala. Therefore, any population that is demonstrably different from that one, by classic regulations and for practical reasons, needs another name. Another name was once bestowed on the population on the Mexican coast. David Caldwell described it as *Chelonia mydas carrinegra*, but nobody has since been able to show how *carrinegra* differs from the black turtles of Guatemala—though it quite likely does. In any case, most people apply the name *agassizi* to all the black turtles of eastern Pacific waters.

But when you leave the mainland coast and go west across the Pacific the real trouble begins. There is a sizable population of *Chelonia* in the Galapagos Islands. Superficially, it is a lot like Guatemalan *agassizi*, but the question of whether the two are the same or different has not been seriously investigated. Farther west, out in the Hawaiian Islands, there is another colony of *Chelonia*. In some ways it is like mainland *agassizi* but it is a much bigger turtle. George Balazs, who works extensively with the population and knows the mainland forms as well, believes the two are different. So do I. Why the Hawaiian turtles have not been given a name is partly because there is even greater confusion still farther on across the Pacific.

In the western Pacific and Indian Ocean there are several good-sized, more or less isolated populations of *Chelonia*. Every one of them that I know anything about seems somehow or to some extent different from Guatemalan *agassizi*, but they are all bewilderingly variable, both within the populations and from one of them to another. Color illustrations of Indian Ocean *Chelonia* published by Jack Frazier and slides made by Peter Pritchard in New Guinea show the hopelessness of trying to use color and pattern to separate races of *Chelonia* in the Indo-West Pacific. The depressing fact is that in all the vast territory from the Pacific coast of the Americas throughout the Pacific and Indian oceans, *Chelonia* is a taxonomic shambles. The current, defeatist

policy is to call everything out there *Chelonia mydas*; but some of the people who do that then speak of the mainland black turtle as *Chelonia mydas agassizi*. By implication that makes the name of all the other green turtle races of the Indo-Pacific grab bag *Chelonia mydas mydas*. And that of course is altogether intolerable.

I am not sure the alternative is much better. It is to look around in the scattered Pacific turtle literature and select the name with the greatest seniority that has ever been applied to a population of Pacific *Chelonia* within the grab bag area. That is what, in my own mind, I do—realizing the weakness of the recourse. What you find is that the Japanese population was long ago given the species name *japonica*. Inasmuch as nobody can say how the Japanese turtles differ from the other grab bag races, as a desperate measure *japonica* could be applied to all the green turtles of the Indo-Pacific, except for mainland *agassizi*. That leaves a lot of messes to be cleared up, but it is not nearly as bad as calling every green turtle from Hawaii to Ceylon *Chelonia mydas mydas*.

Once you go around Cape Horn and the Cape of Good Hope you get into solid *Chelonia mydas* territory. Carl Linnaeus first described *Testudo mydas* from specimens from Ascension Island, so that colony becomes the meter stick for any attempt to bring order into the nomenclature of the green turtles of the world.

The other Atlantic populations of *Chelonia*—those in Surinam and Costa Rica, and on Aves Island, and the small ones in Yucatán and Florida—are all similar in general appearance to the Ascension Island colony, although the latter are bigger—the biggest in the world. But even in the Atlantic, *Chelonia mydas* cannot be thought of as a homogeneous group. The four largest colonies have all been tagged and studied for long periods of time. They are strongly site-fixed in their nesting, and copulation takes place on the way to the nesting beach. Everything that has been learned about them indicates that they are genetically isolated from each other. It is thus logical to expect that divergence has occurred, but this is by no means easy to see. Although they differ noticeably in size and in details of reproduction behavior, coloration, and conformation, they are all quite similar.

The lack of useful information from the kind of taxonomic studies that modern electrophoretic procedures make possible is a grievous deprivation. It furthers the pronouncement of commercial exploiters that if you have saved one turtle population you have saved the species. Analyses of serum and tissue proteins of the various colonies have been undertaken, and some interesting insight into the relationships among the genera has come out of them. But the biochemists have been dimly slow in providing a reliable inventory of the kinds of sea turtles in the world.

As if the conditions of sea turtle taxonomy weren't already bad enough, there is the possibility that turtle farms will make things worse. When Cayman Turtle Industries found itself overstocked with young green turtles because of the U.S. ban on its products, Dr. Judith Mittag, one of the proprietors of the farm, wrote Robert Scott, Executive Officer of the Species Survival Commission of IUCN, asking what the IUCN attitude would be if a couple of thousand farm-bred turtles should be released in the Caribbean. Mr. Scott wrote me, as an old turtle specialist, to ask my opinion. I replied as follows:

This is in reference to Mrs. Mittag's letter of August 5 to you, asking whether the IUCN would advise her to release excess green turtle hatchlings at Grand Cayman. This exemplifies the kind of problem that farming wild species generates. The present one may appear trivial, but to those of us who are concerned over the elementary state of sea turtle taxonomy it does not seem so. If the Cayman release were successful it would add to the difficulty of determining affinities and differences among the green turtle populations of the western Atlantic. If the hatchlings to be released are from captive-reared females, they could be hybrids of the three Atlantic breeding colonies—those of Ascension Island, Surinam, and Costa Rica, all of which, at one time or another, have been present in the Cayman breeding crawl. The release might thus involve turtles that would either fail to breed, or would modify the natural West Atlantic strains, and thus exacerbate the troubles facing any effort to use modern, fine-scale taxonomic procedures in the systematic study of the group. Nevertheless, if the release were certain

to be a single isolated exercise, I, personally, would say go ahead with it—believing that so few of the hatchlings would grow to maturity that even the most discriminating biochemical tests of affinity would not be biased by their presence in the population. But there is also the precedent to consider. There are aspirant turtle farmers all over the world, and the kind of zoogeographic disarray that they could produce by indiscriminately releasing farm-bred hatchlings could completely block any effort to sort out the green turtle stocks of the world.

If I were you I would answer Mrs. Mittag by asking whether the genetic background of the stock to be released is known, how many turtles are involved, and what their age is. A few hundred very young hatchlings might not be worth worrying about. A few hundred yearlings of mixed origin probably would be.

I am sorry if I seem evasive, but when there is no real answer, there's no virtue in inventing one. The most nearly Solomonesque solution I think of at the moment would be to require Mrs. Mittag to rear the hatchlings to flourishing maturity, then to package and freeze their flesh and send it about to hungry people.

The farm went ahead and released the turtles, and there is no knowing what headaches for taxonomists of future times they may bring.

Of remaining threats to the future of sea turtles, one of the most direct and widespread is incidental catch, especially by shrimp trawlers. When turtle populations were big, and shrimp fleets and boats were smaller, their inroads were not demographically significant. Now, however, bigger trawlers drag bigger nets, usually in sets of two or even four, and the drag times are much longer than they used to be. More turtles are caught, and more of them are dead or moribund when they come up in the net. Reacting to growing concern over this problem in the United States, the National Marine Fisheries Service undertook the job of designing an excluder or ejector device that would reduce the number of turtles caught, but not the catch of shrimp.

After four years' work at the National Marine Fisheries Service

gear research laboratory at Pascagoula, Mississippi, a successful excluder has apparently been produced. They call it TED—Trawler Efficiency Device. The reassuring name reflects both its exclusion of big objects and what appears to be a small increase in the catch of shrimp by trawls equipped with it.

TED is a vertical grid, mounted in a frame that is sewn into the throat of the trawl—the place where the wings taper back into the bag. The grid slants upward and backward, and as the trawl moves forward through the water, shrimp are washed straight back through the grid and into the bag, while turtles, sponges, and the like are shunted upward to the top of the net and guided out through a framed trapdoor in the webbing.

Although the device increases trawl-drag by around 100 pounds, because it ejects jellyfish and other big objects before they reach the bag, drag is actually reduced and fuel saved. TED costs around \$600, and it is not hard to install or operate.

There now comes the problem of mounting an effective acceptance campaign, first among shrimpers of the southeastern United States, some of whom have already reacted favorably. Eventually the device will have to be introduced throughout all the other regions where the habitats or migration routes of shrimp and turtles overlap. The most critical encounters between turtles and trawlers today take place within the U.S. and Mexican range of the precariously surviving Kemp's ridley. But incidental trawler catch is worldwide, and the acceptance of TED will have to be worked for everywhere.

In looking through the chapters of this book for notions and trends that need reassessment, I was struck by the lack of progress that has been made in solving the most challenging scientific problem discussed. That is the guidance mechanism used by long-range migrants that travel in, on, or over the open sea and arrive on time at precise destinations. To account for this is the inescapable obligation of students of animal behavior; and it has by no means been accounted for. When I reread "The Way to *Isla Meta*" and pondered the spectacular gains made in the study of animal

orientation during the past sixteen years, I was struck by the contrast between recent advances in sensory physiology in revealing cues of and redundancy in the sensory guide-signs of short-range overland travel, and the durability of the puzzle of island-finding navigation. Ingenious investigations of the kinds and acuity of sensory signals that guide pigeons in homing flights have been carried out at Cornell University and elsewhere. The fact that the same bird may use different cues under different conditions corroborates the view that migratory animals must have evolved an ability to take advantage of every detectable guide-sign that the travel environment affords. The sun compass sense was long ago substantiated, but lately it has been shown that when signs from the skies are hidden, successful orientation can be achieved using backup signals. Recent tests show that pigeons respond to magnetic fields, polarized light, ultraviolet light, and low frequency sound—as from wind over broken ground, or from surf on the seashore. Italian scientists at the University of Pisa are convinced that the sense of smell can play an important part in the homing of pigeons.

It has long been evident that the homing of salmon to natal streams after their stay in the ocean is mediated by olfaction—by the special smell or taste of the water along the way. The climax of decades of work with the salmon came in some elegant experiments by Arthur Hasler of the University of Wisconsin and his colleagues. Salmon were hatched and reared in tanks treated with a specific chemical, and then tagged and released. When the time for their breeding return arrived, the tagged fish came back with clear statistical significance to streams treated with the same chemical that had been used in the nursery tanks.

Only recently it has been discovered that certain bacteria contain magnetic particles with which they orient themselves along lines of force in the earth's magnetic field. Later work has turned up such particles in a number of vertebrate animals, including sea turtles. When these little magnets came to light a lot of people started talking as if we finally had solved the navigation problem and shortly would be showing how long-range migrations of animals are guided. These are exciting discoveries, but they in no

way lessen the main burden of animal navigation theory, which has always been to visualize the natural selection process by which an animal can be equipped with the map and almanac sense that presumably is necessary if environmental information is used to correct for off-course displacement. This is the obstacle that is holding up research into what seems to many people one of the most dramatic instinctive achievements of animals.

In the case of magnetic field navigation, two of the three components of a navigation process—compass direction and latitude—might be provided by the newly found particles. Direction could be determined because the magnetic field orients north and south; latitude could be found because dip (the steepness of the vertical angle to the pole) increases as the pole is approached.

That leaves longitude, which could be reckoned by comparing magnetic and geographic north. To do that, however, celestial bodies and a biological clock are necessary, because there is no way in which a traveler using magnetic sense alone could detect geographic north. Thus, we have a dual magnetic-field and celestial-cue hypothesis, and this presupposes a genetic tour-de-force that seems no less staggering than the inherited earth-star almanac necessary for pure celestial bicoordinate position-finding. If the particle-bearing creatures do indeed use the particles as a compass and for detecting magnetic latitude from dip, this means that they have inherited an awareness of a grid of the whole earth in which dip-angle is plotted against polar differences; that they determine longitude from celestial sources; and then, after instinctively consulting an inherited grid of magnetic-field conditions, they locate their position on the grid and compare that place with respect to the location of the migratory destination as shown by an inherited geographic chart that is somewhere within reach of their senses.

I am not one to deprecate the power of natural selection. It has fashioned fantastic things in the biological world. I have to believe that a hybrid magnetic and celestial earth grid and map could be inherited—just as I once accepted navigation by celestial coordinates alone. But to accept either is a heavy responsibility.

The crux of the animal navigation problem is island-finding. The

most promising procedure for clearing the experimental field for studying it is to track migratory animals—fish, whales, turtles, albatrosses—any creatures that make long ocean journeys and arrive on schedule at a pinpoint destination. Satellite tracking is nowadays a wholly feasible way to bridge the befuddling gap between the departures and arrivals of animals, either migrating, or homing after experimental displacement, across open sea. With the electronic facilities available today, to theorize about signals and senses used by ocean migrants without knowing the paths they take is a sack race, a self-imposed handicap, and one that is no longer technologically necessary.

In pondering the migrations of green turtles, we have cleaned up the theoretical premises a bit by subdividing their long-range reproductive homing travel into three stages. One is the open-ocean travel, across abyssal water separating feeding and breeding grounds, where topography and local hydrography supposedly offer no signals, and where guided travel must be by some sort of true navigation that involves the forbidding map and almanac senses. The next migratory stage is to locate the general region of the far-off home shore—in the case of the colony we work with, the 22-mile-long nesting beach at Tortuguero. After that is found, a final discrimination process brings a female ashore, not just anywhere on the ancestral beach, and not just on a part most favored by the nesting colony, but back to a place on the beach that is statistically close to where she has nested previously—and where, another theory goes, she most likely was born.

This way of subdividing the green turtle migration process relieves the inevitable confusion observers get into when they try to select a single mechanism that would both guide a migrant across open sea and take it ashore at a home site on the nesting beach. For example, the discrimination process by which the proper regional landfall is made could well be mediated by current shears, river plumes, or bottom topography, all of which could provide signals in coastal waters. This leaves the open-sea segment unexplained but more inviting as a field for theory and experiment because it is uncluttered by the shore-zone piloting behavior.

Ironically, the mechanism involved in the final fine-scale stage of homing—the return to some one short segment of the shore—has remained eerily elusive.

More progress has been made during the last dozen years in revealing the sensory versatility of path-finding animals than in all the previous time since von Frische discovered the sun-compass in honey bees. But, as nearly as I can see, we are no closer to explaining the island-finding capacity of open-sea migrants than we were in 1967.

The material in one chapter of this book needs no updating. It is timeless, and can stand no tampering with. I refer to the letters in "Señor Reward Premio." They are as valid today as they were when they were received. They have kept coming since the book appeared, and they still bring the same charm of the back-country Caribbean people. There is no room for the new letters, however, and this is a shame. But just to show that the correspondence has lost none of its verve and savor I offer the following from a lively lady on Roatan Island, Honduras, who had failed to send us the tag when she told us of finding one of our turtles:

Dear Mr. Archie I just recive your letter and was glad to here from you I had give up hops on waiting on answer it was such a long time before I heard from you

So I am so glad I got your letter well I had the little tag here but it got miss place here in the house So I cant fine it right now but I will still look it up and mail it to you but I had check of the number of it and the address and I am sending it to you I will still send it as soon as I fine it my son had found another one but that one is out of plastice But I not seen him yet to get the address of but as soon as I see him I will get the address of and send it for you so I am sending the number for you and if you still want to send the boy the check they will appreciate it Very much thanks for your kindness to them

the number 4679
fla gainesville
fla usa

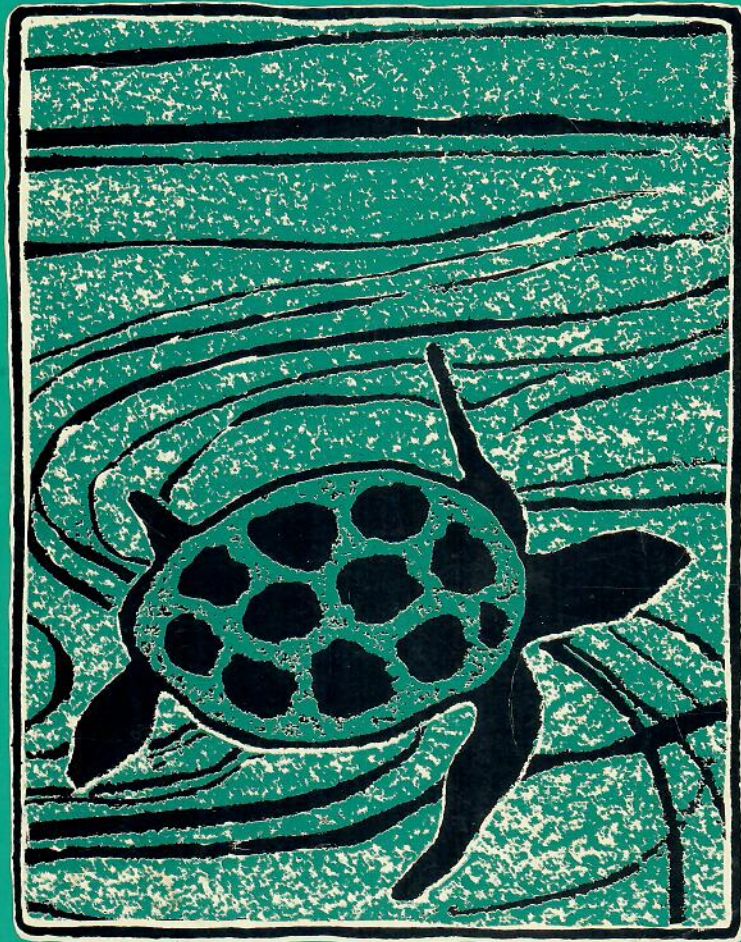
I want to ask you if it is either man up there that will like to have a wife I am looking a husband me and my husband sepered 15 years now and I really need one now but one the age about 49 to 50 or older Because I am trying to live for the Lord if it is either one that will be Instred in me he can send me his picture and I will send him mind right me right back quick and let me no from your friend. . . . Calabash Bight. Roatan, Honduras CA Write me by this address the one on the envelope is were the mail come but Calabash bight is my home town I will still get

The turtle was caught on a rock laying down they caught him with there hands the water was 4 feet deep in round the land Please answer me right back quick is you receive this letter

That is a real woman talking. Although we were not able to locate an appropriate companion for her I am sure a man could do a lot worse, and I sincerely hope that she will have found one. Meantime, her name is withheld on the grounds that it might somehow complicate a happy new matrimonial arrangement.

Archie Carr

THE SEA TURTLE
So Excellent a Fishe



"The true excellence of the sea turtle . . . lies in the mysteries of its life habits. What these mysteries are, what is being done to solve them, and the compelling reasons for doing so make Archie Carr's natural history of sea turtles worth reading."

—CHRISTOPHER LEHMANN-HAUPT

This expert study explores the wonder of one of nature's most fascinating seafarers—the sea turtle. First published in 1967 and revised in 1984 as *So Excellent a Fish: A Natural History of Sea Turtles*, this paperback edition offers a lively and authoritative account of this unusual creature written by a world expert in the field of marine turtle ecology. The book highlights important research developments since 1967 and includes many new photographs.

Included are Carr's fascinating theories to explain how the turtles guide themselves across the ocean, why the female lays a hundred eggs, where the young turtles disappear to after they are hatched. He describes the phenomenon of the *arribada*, when tens of thousands of ridley turtles come ashore to nest on a short stretch of beach. And he raises many intriguing questions that as yet remain unanswered. An eloquent plea for the survival of these endangered creatures, which hunters continue to kill for their prized meat and shells, *The Sea Turtle* emerges as a classic study in natural history.

ARCHIE CARR is graduate research professor in the Department of Zoology at the University of Florida in Gainesville. Since 1955 he has directed the green turtle research program at Tortuguero, Costa Rica—the last major green turtle rookery in the Caribbean. He is the author of numerous books, among them *The Windward Road: Adventures of a Naturalist on Remote Caribbean Shores*.

Other books in natural history

KINGDOM OF THE ICE BEAR

A Portrait of the Arctic

By Hugh Miles and Mike Salisbury

ISBN 0-292-70393-7 hardcover

BATS

A Natural History

By John E. Hill and James D. Smith

ISBN 0-292-70752-5 hardcover

THE AMAZING ARMADILLO

Geography of a Folk Critter

By Larry L. Smith and

Robin W. Doughty

ISBN 0-292-70375-9 hardcover

ISBN 0-292-70383-X paperback

DOMESTICATED ANIMALS

FROM EARLY TIMES

By Juliet Clutton-Brock

ISBN 0-292-71532-3 hardcover

Write for a free catalog of books in natural history

UNIVERSITY OF TEXAS PRESS

Post Office Box 7819 Austin, Texas 78713-7819

Printed in U.S.A.

ISBN 0-292-77595-4