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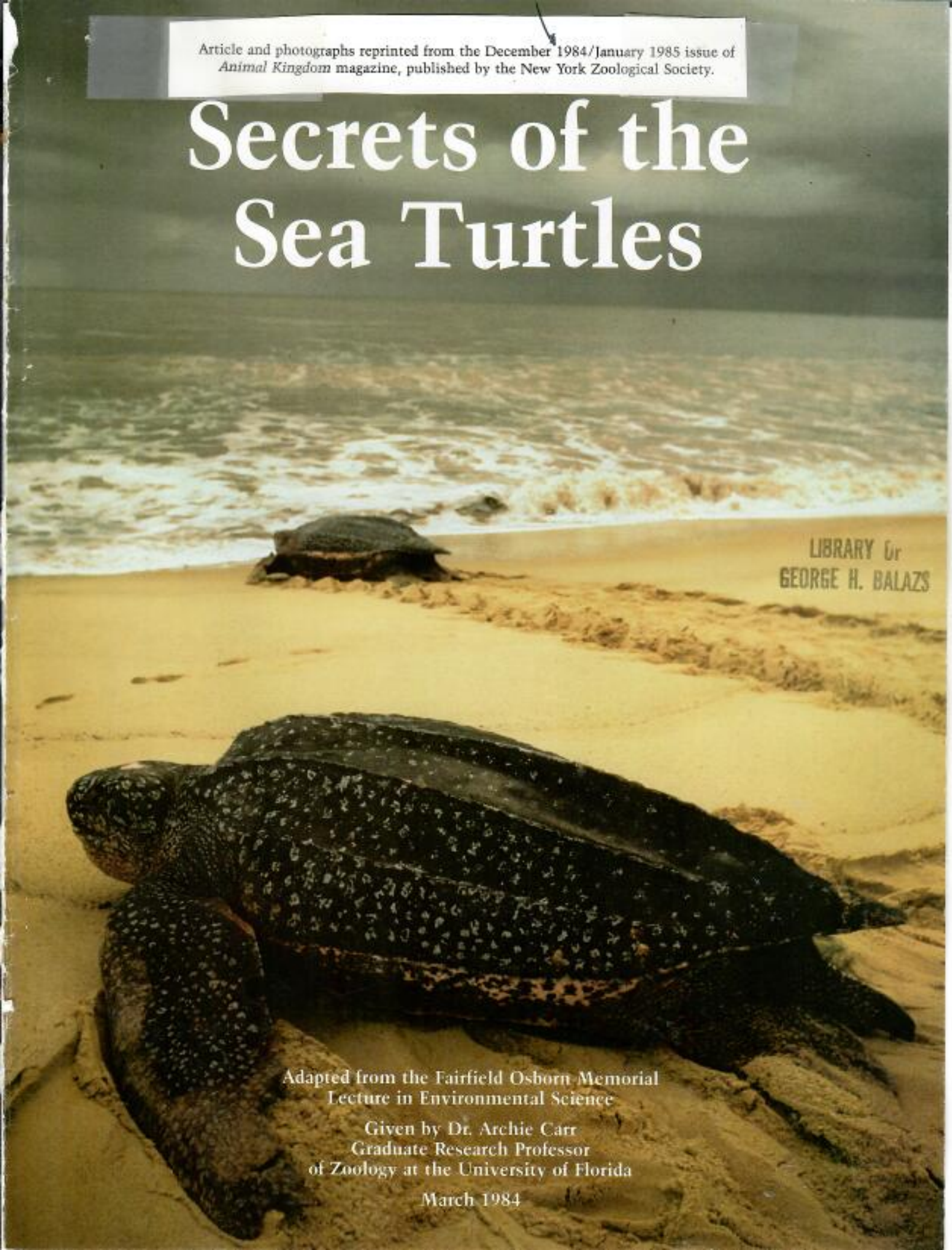
Secrets of the Sea Turtles



Adapted from the Fairfield Osborn Memorial Lecture in Environmental Science

Given by Dr. Archie Carr
Graduate Research Professor
of Zoology at the University of Florida

March 1984

The Friends of Fairfield Osborn have established this Lectureship to commemorate Fairfield Osborn's many contributions in the area of environmental science. These lectures are offered in annual rotation by the Rockefeller University, the New York Zoological Society, and the Conservation Foundation.

Overleaf: Female leatherbacks, their nesting done, return to open waters to cruise along their mysterious paths until the onset of maternity urges them back to their beach once more. (*Nadine Zuber–World Wildlife Fund*)

How do sea turtles navigate in vast open waters? . . . Where do the babies hide out for their first year? . . . Scientists still ponder these and many other

Secrets of the Sea Turtles

BY ARCHIE CARR

THIRTY-FIVE YEARS AGO, when I wrote *Handbook of Turtles*, I listed half a dozen areas of ignorance that had to be cleared up before effective sea turtle conservation programs could be devised. Today those gaps have been at least partly filled, but in the meantime others have appeared. Despite growing interest, our ignorance of the biology and ecology of the world's sea turtles still seems the most fundamental obstacle to their survival.

We don't even know how many kinds of sea turtles there are. Procedures of taxonomy (the science of classification) have advanced greatly in recent times, but the field has lost vogue—before the job of classifying living species is anywhere near complete.

It is the avowed obligation of modern biological conservation to save genetic diversity. A crude measure of this is the multitude of checklists of species and subspecies that already have scientific names. But there are hidden differences among widely separated breeding populations of a species, so to accept the lists as adequately representing diversity invites disastrous losses.

As for sea turtles, only eight kinds are recognized with scientific names. According to that list, diversity would technically be preserved even if each named species dwindled to a single breeding population. A more valid inventory must be made, to identify genetically unique populations.

This is well illustrated by the genus *Chelonia*, the green turtles. It is easy to distinguish between populations in the Atlantic and along the Pacific coast of tropical America. Throughout the rest of the Indopacific, however, green turtle taxonomy is a mess. The breeding islands are mere pinpoints in the vastness of the Pacific Ocean. The tiny islands of Micronesia alone are spread over an area equal to that of the United States. Green turtles have a strong breeding-site fidelity, so if long geographic isolation engenders genetic drift from ancestral stocks it is ridiculous to assume that any one of the populations in the Pacific and Indian oceans embodies the whole genetic makeup of the group.

Bill Wood-Seaphot Ltd.

A green turtle: Just how many kinds of sea turtles are there?

It is much the same in the Atlantic–Caribbean system, where there are four good-sized breeding populations. They all go by the name *Chelonia mydas*. They are all reproductively isolated, however, and live under different ecological regimens. There seems little doubt that if studied genetically

they would prove deserving of specific recognition.

Just how much energy and resources should be devoted to taxonomic splitting is hard to say, but we ought to be mindful of what is being lost if we neglect to tally the multiplicity of living things.

WHILE WE WAIT for a new breed of genetic taxonomist to say how many kinds of sea turtles there are, other gaps in our lore badly need to be filled. It is not known, for example, how long it takes a sea turtle to reach sexual maturity. Not only is this embarrassing, it also stands in the way of effective management: It is impossible to calculate the size and makeup of a whole population merely by sampling at the nesting ground, which is almost the only place where counts can readily be made; and *this* makes it impossible to be certain of the results of techniques such as head-starting—rearing hatchlings until they're too big for predators—and restoring colonies by releasing young where populations have disappeared.

Peter C.H. Pritchard

A hatchling green turtle: headed for its "lost" year at sea

Back in 1968 the Caribbean Conservation Corporation (dedicated to preserving biological resources in the Caribbean) set out on a venture we called Operation Green Turtle. In eight years, with the help of navy amphibian aircraft we distributed more than 100,000 hatchlings and a great many eggs in 18 localities in the Caribbean, the Bahamas, Florida, and Bermuda. In those days all data on sea turtle growth and development came from aquarists, and their records indicated that turtles probably matured in about six years. When eight years passed and no nesting had been reported on the beaches visited by the operation, we began to get uneasy; after the ninth year the project was abandoned except for yearly shipments to Bermuda.

But recent research indicates that we may have despaired too soon and that results could yet be expected. The new data suggest that green turtles in natural habitat, feeding on sea grass and algae instead of the high-protein diets they get in captivity, may take 40 or even 50 years to reach breeding age.

The evidence for this came from scientists in Hawaii, Bermuda, the Bahamas, and Australia's Great Barrier Reef. Repeated recoveries of immature sea turtles tagged in those places revealed growth rates so slow that it is not unreasonable to think they may take 50 years to reach sexual maturity.

This big change in estimated maturation time hides trends in population dynamics and makes it hard to learn or predict the effects of both exploitation and conservation. It will be the year 2000 or later before we can expect to find out whether Operation Green Turtle did any good.

Some even newer research introduced other management problems and uncertainties, such as the effects of nest temperatures on the sexes of incubating green turtle embryos.

In humans and various other creatures, differences in the kinds or numbers of chromosomes instigate the processes by which an embryo becomes a male or a female. For nearly 10 years it has been known that some freshwater turtles lack certain sex chromosomes and that sex is determined by incubation temperature. Cool temperatures (75 to 81°F) produce males; warm temperatures (88°F and above) favor femaleness. A few years ago some loggerhead eggs incubated in a laboratory also showed indications of thermal control of sex.

Realizing how important this could be for hatchery operations in green turtle management, a team of investigators directed by James Spotila—a zoology professor at the State University of New York at Buffalo—set out to study sex determination in the green turtle and the olive ridley. The work was done at the CCC's green turtle station at Tortuguero, on the Caribbean coast of Costa Rica, and on the *arribada* (referring to the arrival of an enormous aggregation of nesting turtles) beach of the ridley at Nancite, in Santa Rosa National Park, on the Pacific coast of Costa Rica.

The aim of the research was to learn whether and how temperature and sex are related under both natural and artificial conditions and to answer a number of other questions. First it had to be firmly established whether temperature consistently influences sex in natural nests and, if so, whether nests in different parts of the beach produce different proportions of males and females because of different exposures.

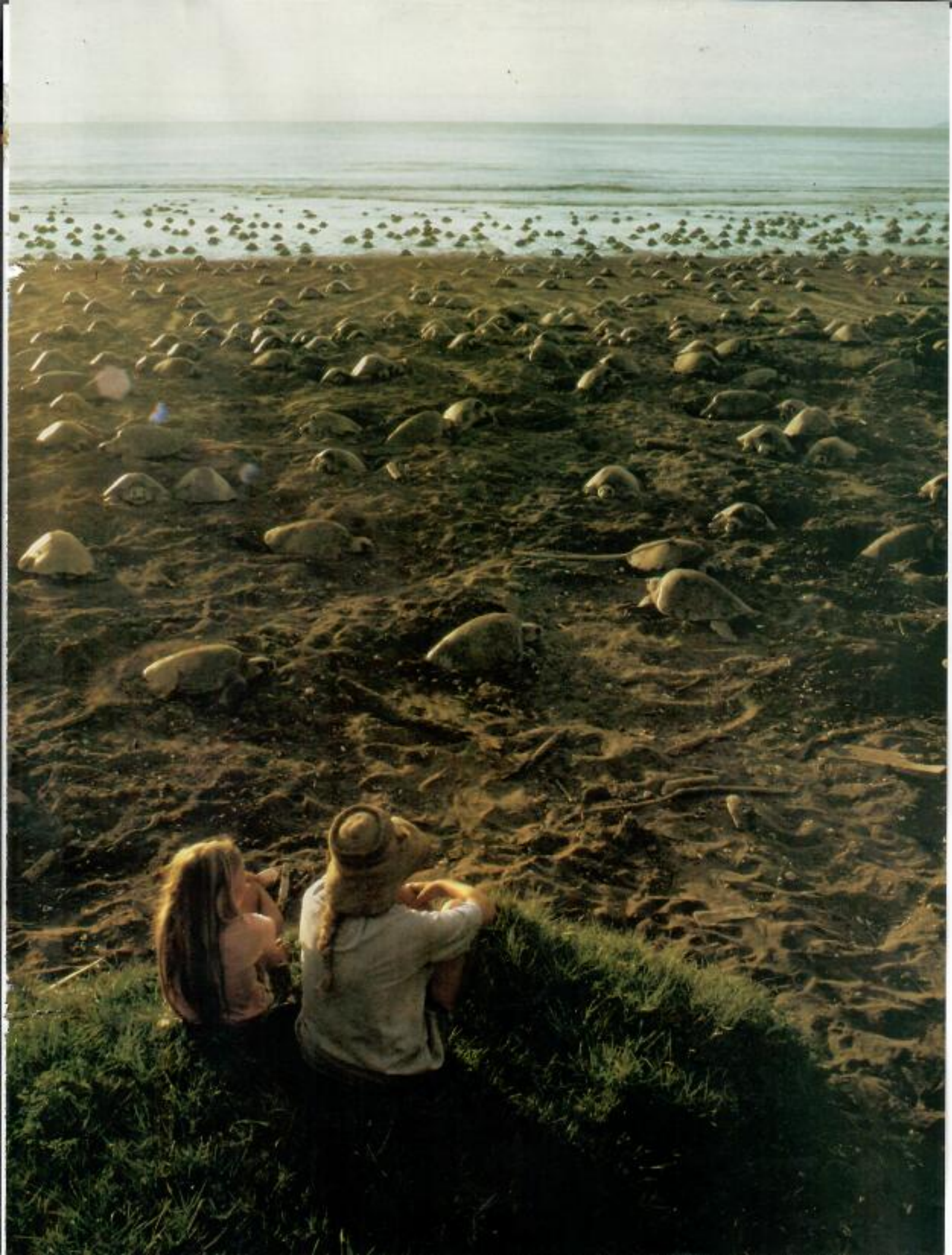
It had long been known that when eggs incubate, their life processes generate heat and raise the nest temperature a little, so the experimenters asked whether the eggs in the center of a clutch heat up more and thus produce more females than those in the cooler, outer parts of the nest.

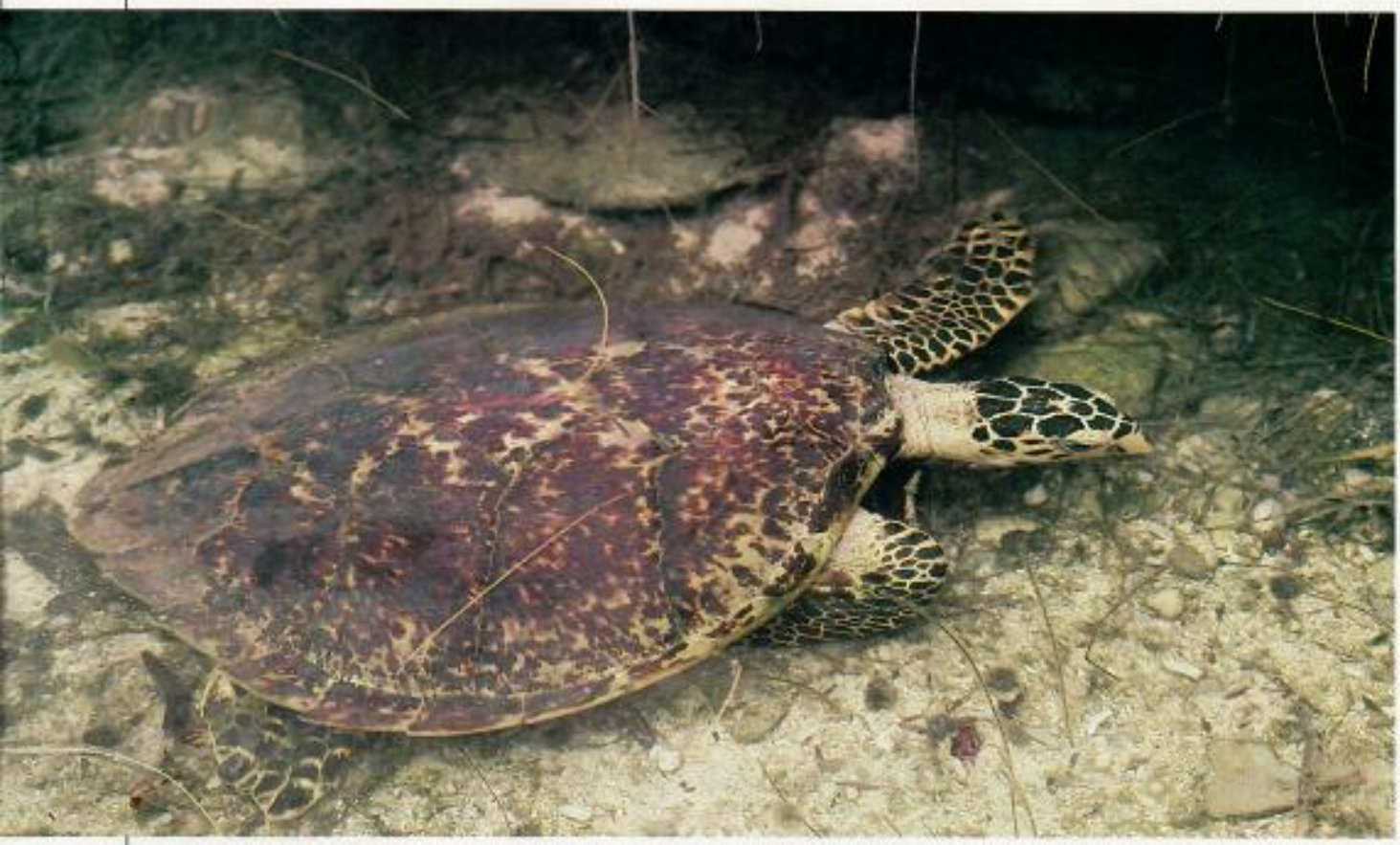
The procedures followed in the experiments were thorough and statistically solid. To measure temperatures at Tortuguero Beach, no fewer than 600 thermocouples were installed—in 10 natural nests in each of three beach zones, from just above wave wash clear up to where the nests were partly shaded by shrubs and coco palms. Temperatures were measured throughout the 60-day incubation.

The results were earthshaking. There was no doubt about it. The cool nests produced males, the warm ones fe-

Olive ridley arribada: For millennia, females came in great numbers to nest on this Costa Rican beach and others in the world. Today the turtles are nearly gone.

David Hughes





Jeanne Mortimer—World Wildlife Fund

A hawksbill: The species is on the way to extinction because artisans use its shell to make ornaments and utensils.

males. Along the beach profile, where exposure varied from part shade to full sun, sand temperatures varied accordingly and so did the sex ratio of the hatchlings. The effect was so clean-cut that a nest located where pivotal temperatures prevailed produced males in its cool outer region and females in the warm interior.

Once the questions were answered for natural nests, the same had to be done for artificial ones. Aspirant sea turtle managers everywhere were digging up eggs and putting them into artificial nests or plastic-foam boxes to protect them from predators and poachers. Again sex was found to vary with both the degree of shading and the outside temperature.

The results of this work were published in 1982. I had been in contact with the investigators all along and was aware of the trend of their findings; but reading the awful truth in the stark prose of the journal *Science* was unsettling. What the data meant was that for the hundreds of thousands of artificially incubated hatchlings hopefully released during the preceding 20 years, and for the tens of thousands of laboriously and expensively raised yearlings put into the sea in head-starting projects around the world, nobody had the vaguest idea what the sex ratios were.

But there was yet another complication. When Jim Spotila told me how things were going at Tortuguero, my first thought was to alert all members of the IUCN's (International Union for Conservation of Nature and Natural Resources) Marine Turtle Specialist Group to spread the information and urge the far-flung managers of sea turtle destinies to incubate eggs at temperatures that would produce the proper balance between the sexes. Sex ratio must be a basic and delicately adjusted adaptation, I figured, so great pains should be taken to reproduce the natural ratio if you're going to hatch turtles artificially.

Then came the realization that nobody had the vaguest idea what the *natural* sex ratio is. Almost the only place the two sexes get together is along the breeding shore, off the nesting ground. They may mix on the feeding ground too, but there is no way to make a census there, let alone a sex tally. Counting turtle sexes out in the sea, just beyond the surfline—either from the air or by diving among them—is next to impossible. Males gang up and squabble over a female; unready females cruise back and forth along the shore or get together on hard bottom and await the return of maternal urges. Besides that, only some of the females in a population go to the nesting beach in a given year.

So, accurate sex tallies are almost impossible to make.

Archie Carr has directed green turtle research at Tortuguero since 1955, when the Caribbean Conservation Corporation was founded. This article was adapted from the Fairfield Osborn memorial Lecture in Environmental Science which Dr. Carr delivered earlier this year at Rockefeller University under the sponsorship of the New York Zoological Society.

The only hope appears to be to take some young from natural nests all along the transect of changing temperatures—from the wide-open lower beach up to the shaded foreshore—and determine the sexes of the hatchlings in the sample. Dr. Spotila's team is doing that and, when their results appear, at least the *present* ratio of green turtle hatchlings produced at *Tortuguero* will be known. Meanwhile, only the old female turtles know; they must somehow have evolved a knack for placing the three to six nests they dig in a season so the sexes come out in the right proportions. If sex ratio is indeed critical in population dynamics and thus in survival, the techniques by which the balance is brought about in nature seem quite imponderable.

It is not unreasonable to think that a sea turtle may take 50 years to reach sexual maturity.

ANOTHER AREA of ignorance that has long puzzled sea turtle students is what we used to call the lost-year interlude—the disappearance of the young for the first few months after they enter the sea. They clearly are not present in any inshore habitat, so they must be pelagic, must somehow find life possible in the open ocean. But they can't reach the bottom to feed out there; and over most of the face of the sea, any kind of food usable by little hatchling turtles is so thinly dispersed that life would seem impossible.

The prevalent theory, which for 20 years has been growing stronger, is that off some shores at least, they lodge in drifting mats of the floating alga sargassum. These house a specialized community of other little vertebrate and invertebrate animals and could provide both food and refuge from aerial as well as aquatic predators.

During the last four years, with support from the World Wildlife Fund, I've made a special effort to gather information on the notion that sargassum mats are hatchling habitat and that the young turtles stay in them and drift with them for long periods over long distances. It now appears that the weed rafts really are used in this way. Many people have found little sea turtles in them, and observations indicating that they stay in the rafts for months have accumulated.

The weed-raft theory is reinforced by the tendency of sargassum and other flotsam to line up along the downwellings where two currents meet. This alignment of surface drift not only makes it easy for hatchlings to find their refuge—swimming straightaway from their natal shores as they do—but also must be generally important in the ecology of the open ocean. Flotsam aligns at and near the surface along current borders, where masses of water of different densities come together, and even along the axes of continuous strong winds. In the Sargasso Sea, for example, the usual condition of the weed is not a random dispersion of mats but a pattern of multiple bands, in which the rafts are lined up downwind.

Despite the growing evidence of the ecological importance of these drift lines as hatchling habitat, the sargassum-raft theory seemed weakened by the fact that off some breeding shores there is no sargassum. In most of these localities, however, there are the same current edges that cause sargassum to align elsewhere, and these concentrate floating objects of all kinds, including planktonic organisms of appropriate forage sizes for the young turtles.

This striation of the sea surface by drift lines is, ecologically, a double-edged sword. In one way it improves pelagic habitability for a great many creatures. When planktonic life is swept in, plankton-eaters follow. When trash and weeds gather, many kinds of shelter-seeking fishes arrive. If floating debris big enough to support their weight is there, seabirds light on it, pick up anything edible, defecate, and so further the ecological activity and organization of the habitat. In their richness these convergence lines suggest the edge effect in the ecotones—the contiguous borders—between terrestrial ecological communities, where the diversity and the abundance of organisms may be far greater than in the adjoining areas.

But inevitably the driftlines also gather man-made wastes. To get an idea of the worldwide spread of spilled petroleum the place to look is in the weedlines. Along the Atlantic coast of Florida, young turtles wash up in sargassum wrack during northeastern storms nearly every autumn. Sometimes the mats and the turtles come in smeared with newly spilled oil. At other times, the oil has come from far away and congealed into tar pellets. The hatchlings chew on these, their jaws stick together, and they arrive on the beach dead or starving. The same thing happens at Tortuguero during the January storms.

Our growing understanding of the lost year suggests no way to intervene to help the turtles out of this dilemma. It merely brings additional evidence that mistreatment of the oceans is coming home to haunt us.

In the beginning the lost-year puzzle was intellectually challenging, just as a curious gap in natural history. Now what we have learned about it indicates that it is an increasingly hazardous period. Oceanographers could have predicted this all along but they don't talk much with practitioners of natural history, and when they do they are hard to understand. So after all the long wondering about the lost year, we find the little turtles in a man-made trap with no clear way out.

Still unexplained about sea turtle travel is the ability of some or all of them to navigate to pinpoint destinations on long open-sea journeys. I used to do a lot of fussing with the navigation problem, but I never learned how island-finding is done. Lately some astonishing orientation adaptations—among them sun-compass sense and magnetite-particles sense—have been revealed, but these have not been tested as possible cues for open-sea navigation.

The chief obstacle to applying what is known about sensory physiology and about terrestrial animals is our ignorance of the travel routes of sea turtles. Among marine migrants, whatever the paths they take turn out to be, it seems likely that borders between ocean currents are used as guides. Therefore, when our attention was focused on driftlines as hatchling habitat, we realized that the adult turtles too face hazards in them.

It has long been known that leatherbacks feed mainly on

jellyfishes and travel great distances to areas where these are seasonally abundant. Jellyfishes concentrate at the edges of ocean currents and their eddies, and only recently have we learned that at times green turtles and loggerheads forage along shears, where at numerous places in the Caribbean islands fishermen regularly harpoon them.

For the adult turtles the danger in the driftlines is the plastic junk that often strings out in them. Plastic bags are particularly attractive; evidently they look like jellyfishes to a turtle. In any case a great many sea turtles are found dead with their guts impacted by Pliofilm.

A more hypothetical concern over petroleum in driftlines is that it may affect the long-range navigation of migrating turtles. If, as we suspect, olfaction is important in travel guidance, the edges of currents surely are used as cues (inside a current everything smells or tastes the same); and there is no way of knowing what disruptions of migration may be caused by the aligned pollution. And the most frustrating aspect of marine pollution is that nobody can think of anything to do about it.

George H. Balazs

A nesting green: digging above, laying below—exhausting, and she must yet cover her eggs and haul herself back to the sea. The eggs will incubate for about 60 days; then hatchlings, unaided, will emerge and make for the water.

Walter Dean Snyphot Ltd.

AS DISCONCERTING as the remaining gaps in the known natural history of sea turtles are, there is an even greater threat to their survival: exploitation by man—especially international commerce. Ever since people first settled warm seashores, turtles have been a source of food. The green turtle particularly, because of its succulence and its tendency to aggregate on feeding and breeding grounds, has from time out of mind lent itself to exploitation as a subsistence resource for coastal peoples.

Once the mariner's compass was invented and long voyages could be made, the green turtle became more than a local food source. For 300 or more years it was a major factor in the logistics of exploration and colonization. In American waters it was destroyed to support mariners and feed the slaves of the new colonists. This exploitation was not wanton and intemperate like the obliteration of the bison; it occurred because the green turtle was wonderfully good to eat. But it was not nearly so abundant as the huge gatherings at feeding grounds and nesting shores indicated. The killing was too heavy for most colonies to bear and many of them disappeared.

During the past few decades, eating of green turtles by people has again accelerated. When the turtle station was set up at Tortuguero, 30 years ago, one of the first things we did was agitate for prohibition of the killing of nesting turtles to supply commercial packing plants for the export trade. When laws ending the practice were passed and gradually enforced, they provided for limited subsistence use by local people. A few turtles could be taken every week to feed Tortuguero Village, which had always depended on the resource, and we were strongly in favor of that. But there was great outcry from the commercial turtlers and slaughterhouse people in Puerto Limón. They said they were being inhumanely deprived of a subsistence resource, that their families had been "subsisting" on their earnings from turtling and the packing plant operation.

This semantic distortion of the term *subsistence* is a widespread problem in biological conservation. For example, the mainland shores and islands of the Caribbean are being settled up fast and the demand for green turtle meat is growing. But most of the green turtles caught today are sold—not eaten by the turtlers and their families. One's natural reluctance to deprive local people of a hereditary element of their diet fades away when the last of the Caribbean turtles are being purveyed to city restaurants and tourist hotels or smuggled, frozen, up to Miami.

In recent years the CITES (Convention on International Trade in Endangered Species) treaties have to some degree slowed degradation of turtle populations by international trade. But, as with many other threatened and endangered animals, the CITES sea turtle restrictions—as well as local legislation and enforcement—are weakened by the subsistence claims for exemption. In some cases the need is real and decisions require the wisdom of Solomon. In others the economic or nutritional dependence may not be heavy but the exemption is insisted on because the use is traditional or ceremonial or religious. All in all, the resulting welter of kinds and degrees of involvement of local folk with local resources is complicating the endangered species program everywhere.

Eating turtles has been a Polynesian custom for a thousand or more years; and throughout Oceania there still are people on remote islands who not only relish turtle meat but derive a major part of their protein from it. Their sub-

sistence is real and it evokes sympathy at the very least.

But last year, in Hawaii and Samoa, the National Marine Fisheries Service was addressed with vociferous demands for exemption from endangered species regulations on the ground that they deprived Polynesians of a traditional component of their diet. NMFS biologist George H. Balazs made an evenhanded analysis of the claim and found that in every case the most vigorous claimants were persons who did indeed have a taste for green turtle steak but could easily afford to live on beef from the supermarket.

Which deserves more concern: the survival of a natural species or that of traditional artisanry?

A more complicated case of dependence has been revealed by Berkeley geographer Barney Nietschman, who tells the strange sad story of the degradation of social organization among the Miskito Indians—the turtle people they once were called—of the Caribbean coast of Nicaragua. During the Somoza regime, three packing houses were exporting the meat of 10,000 green turtles a year. The Indian turtlemen found the unprecedented prices being paid for turtles irresistible. They sold their catches instead of taking them home; and the commerce not only deprived the villagers of their main protein supply, it also disrupted a meat-sharing system that was a traditional and fundamental element of the social structure of the Miskitos.

TO FIND EXAMPLES of most of the kinds of obstacles to the survival of sea turtles and other wild species generally, one need look no farther than *Eretmochelys imbricata*—the hawksbill, or carey, as both the animal and its shell scales are called. The outlook for the carey is more critical than that of any sea turtle except the Kemp's ridley (also known as the Atlantic ridley), which may be terminal.

Habitat destruction, marine pollution, subsistence use, and, above all, international commerce, are taking their toll on diminishing populations. Hawksbill eggs are esteemed over all others, and in some places the meat is preferred to that of even the green turtle. Scattered throughout the tropical seaside world there is a curiously localized tendency for hawksbill meat to be poisonous. In spite of this the species is a food source over a vast area and, with the depletion it has already suffered, subsistence use alone has become a major factor in its position.

But the use of hawksbills as food is not the most serious threat to the species. The avid international trade in its shell is far worse. Since ancient times the species has been valued for the pattern, coloration, transluscence, texture, and workability of the scutes of the carapace (upper shell) and the plastron (lower shell). Ornaments made of it have been found in Egyptian burial sites from predynasty times. Cleopatra's bathtub is said to have been lined with it. According to James Parsons—another Berkeley geographer—in Zanzibar the value of a hawksbill used to be equal to that of a slave. From dimmest antiquity, turtles have been held in special regard in the Orient, and it is there that the art and craft of working carey has been most widespread. A thousand years ago Canton was the center of the tortoiseshell trade; today it is Japan.

Current prices for tortoiseshell exceed those of ivory; and there are interesting parallels in the trade in and uses of the two. Both are semiprecious materials, traditionally esteemed by Asian peoples. Both are bought, sold, and shipped about the world by the same tradesmen, and it is often the same craftsmen who work both. An even more primordial juxtaposition is revealed by ancient Hindu mythology, in which we learn that the world is held up by four elephants standing on the back of a gigantic turtle.

When the CITES signatories met in 1973, the hawksbill was listed on Appendix I—the classification for species so near to extinction that trade may be conducted only in exceptional circumstances, strictly regulated. Japan, by far the heaviest consumer, took reservation on the ground that tortoiseshell is the basis of a traditional artisanry deeply embedded in the national culture and economy.

The tortoiseshell preferred in Japan used to come from Indonesia, but today it comes from the Caribbean. It brings as much as $60 a pound. In most of the area the trade is illegal, but Panama is an export center for poachers and smugglers all around the western Caribbean. There is steady surreptitious traffic down the coast from Nicaragua to Colón, and up from Colombia.

Out in the Colombian islands of the San Andrés Archipelago—a traditional center of hawksbill abundance—where distances separating the islands, atolls, banks, and reefs are great, the carey held on long after it had been decimated along the mainland coast. Today's inflated prices, however, have stimulated increased turtling in the islands, and buyers fly in from the Cayman Islands to take loads of shell to Panama for export to Japan.

This recent commerce in San Andrés has so drastically reduced hawksbill populations throughout the archipelago that hunting would have dwindled despite inflated prices if divers had had to depend on turtles alone for profitable trips to the hawksbill reefs. But lobsters and snappers often occupy the same habitats, and prices paid for them are also unprecedented. So three or four divers in a little dugout with an outboard motor will risk their necks traveling 50 or more miles across wild water to a reef and, in one combination or another, the snapper-lobster-hawksbill catch will usually make the trip worthwhile.

Thus, the main threat to the survival of the hawksbill turtle is Japan's age-old traditional, virtually mystical preoccupation with carey. A weakness in the Japanese claim for immunity is that only a small fraction of their tortoiseshell imports actually goes to the guild of traditional artisans. Japan produces a great many of the same tawdry tourist-store and curio-shop items—combs, salt spoons, shoehorns, and ornaments—that are sold, legitimately or not, all around the warm sea edges of the world. There is, however, no doubt about the superb quality of the work of the Japanese tortoiseshell guild or the traditional nature of its craft. So the question is, which deserves more concern: the survival of a natural species or the survival of traditional artisanry?

PERSPECTIVE: Going to Bat for Sea Turtles

A HEARTENING DEVELOPMENT in the generally melancholy outlook for sea turtles is the widespread awakening of interest in their biology and survival problems. An impressive display of this was the 1979 World Conference on Sea Turtle Biology and Conservation in Washington, D.C., attended by 300 delegates from all over the world.

And in July 1983, scientists and fisheries officers from the entire Caribbean region met for the week-long West Atlantic Sea Turtle Symposium, in San Jose, Costa Rica. What is known and not known about sea turtle ecology and troubles was reviewed for those in charge of marine turtle populations in the area. The meeting was organized by the U.S. National Marine Fisheries Service. Though oriented toward commerce, that agency has in recent years—with strong encouragement from the New York Zoological Society—achieved an unusual level of sea turtle stewardship for such an agency.

Another sign of official concern has been the effort of the NMFS to relieve the problem of incidental catching and drowning of sea turtles by fishermen. With increasing frequency turtles are getting caught by people who are not out to catch them. They get tangled in the miles of longlines set along current borders where both fishes and turtles congregate. There are also enormous new squid nets—panels of small-mesh nylon monofilament up to six miles long and 60 feet deep—that drown turtles in dismal numbers.

But shrimp trawlers take the heaviest toll, and the NMFS recently developed a trawling efficiency, or turtle excluder, device. The TED allows shrimps to wash straight into the catch bag, and turtles and other incidentals are guided out through a trapdoor. It is easy to use and install and is not out of economic reach of the trawlers. It even seems to bring a small increase in the shrimp catch.

There remains the job of getting the TED accepted, not just in United States waters but also by the trawlers in all the warm sea edges of the world where marine turtle by-catch occurs. In the meantime, the TED project is an impressive example of a resource-oriented bureaucracy going to bat for a nonresource.

A. Carr

AND THEN THERE IS THE LITTLE KEMP'S RIDLEY, *Lepidochelys kempi*. It is in real trouble. It nests only on a short stretch of the Gulf coast of Mexico and may be on the verge of disappearing.

Kempi once nested in arribadas of 40,000. I had searched for its breeding ground for nearly 20 years when the arribada was revealed in a film made in 1947 by Andrés Herrera, a Tampico engineer. That was in 1961, and by then the breeding colony—the only one in the world—had been reduced by egg poaching to little more than a tenth its size at the time the film was made.

Since 1961, despite strenuous conservation efforts by government organizations and private individuals from both Mexico and the United States, the decline of *kempi* has continued and the arribadas—if so they can still be called—are *one one-hundredth* their 1947 size. Meanwhile, the shrimp trawlers not equipped with turtle excluder devices [see Perspective]—and most are not—go on catching ridleys. Not many, but the loss of any at all is disastrous when the breeding population is a minute fraction of its natural level.

Comparable losses have affected the arribadas of the olive ridley (also called Pacific ridley), *L. olivacea*. Its case is less desperate than that of *kempi* because it ranges far more widely and nests singly as well as in aggregations. But its arribadas also came to light only recently, and the turtles were being massacred for the leather trade when we learned of them. There were at least 10 olive ridley arribadas 25 years ago. Today all but one—at Santa Rosa National Park, in Costa Rica—have been partially or wholly destroyed.

I write of these tragedies again at this late date to make it plain that if the arribadas are lost, the loss would go beyond that of a species. Actually, Kemp's ridley might be preserved in ghostly outline in impounded water with sandy shores. And the olive ridley might save itself in some sort of genetic shape even if every one of the breeding aggregations should disappear. But can we contemplate the loss of this vast coming together to crowd the shore in what, for *kempi* at least, is the most intensive breeding effort, most concentrated in space and time, of any vertebrate animal? Can such a phenomenon be lost without hurt to the world?

I wrote of this in my book *So Excellent a Fishe*:

> *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 redundance, 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 biological order, scientific and esthetic treasures of the living world. There is no civilized way to escape the obligation to save them.* □