100 Turtle Eggs

by Archie Carr

When a green turtle comes ashore she lays roughly a hundred eggs. Compared to the number of eggs layed by wholly aquatic animals, such as mackerel or lobsters, a hundred is not very many, but it is more than a lizard lays or a setting hen sets on. The eggs are big, round, and white, and they seem a great many when you see them all together.

All sea turtles lay more than once in a season. The usual green turtle comes ashore at least four times during her sojourn at the nesting beach. She often lays a few more than a hundred on her midseason trips ashore and fewer on her first and last trips. But the average is close to a hundred per nest, and there is a great deal of biology packed into that figure. The biology is still mostly unknown, but it is clearly there. The whole race and destiny of the creature are probably balanced at the edge of limbo by the delicate weight of that magic number of eggs. One marvel of the number is how great it is; but another is, how small. When you think of the unpromising future that confronts a turtle egg and the turtle hatchling that comes out of it, you wonder why sea turtles don't give up their stubborn, reckless old way of leaving their new generation on shore and instead carry one big, well-tended egg in a pouch or release myriads of turtle larvae to join the plankton, to swamp the laws of chance with teeming millions of largely expendable progeny.

The answer is that the turtles have already hit on the formula for outwitting predators or, at least, for surviving in spite of them. The formula is simply one hundred turtle eggs. For the green turtle, predation, combined with the other kinds of environmental resistance the race must meet, is measured, in a manner of speaking, as four hundred eggs per season. Any fewer, and the predation prevails and the race wanes. Any more, and the eggs are too heavy to carry in one turtle's belly, or too costly to fill with the right amount of yolk.

Perhaps I should not have started talking this way about turtle eggs, because there is no end to it, really. But I feel strongly that everybody ought to know that the size of a complement of turtle eggs is no mere accident and not simply the payload that a lady turtle is able to swim with. It is a number that is replete with ecology and evolution. So many factors are involved in setting it, in fact, that I think it may be worthwhile to try to make an inventory of them, to see how they work and how they get so interwound with each other that thinking about them makes you finally feel that almost everything the race of the turtle does, or that happens to it, is to some degree reflected in the number of eggs the female drops into the hole she digs in the sand.

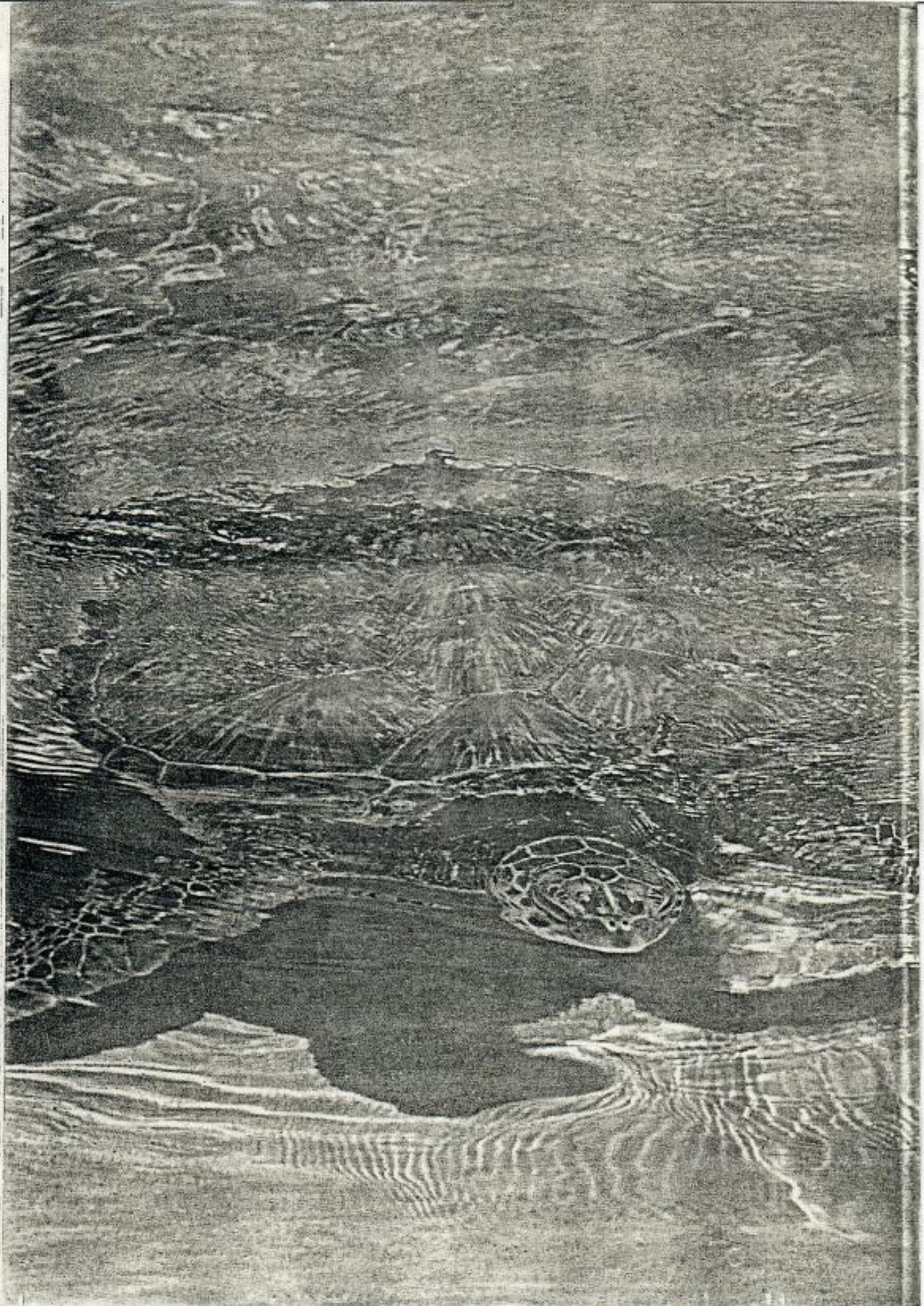
A World Eager to Eat Them

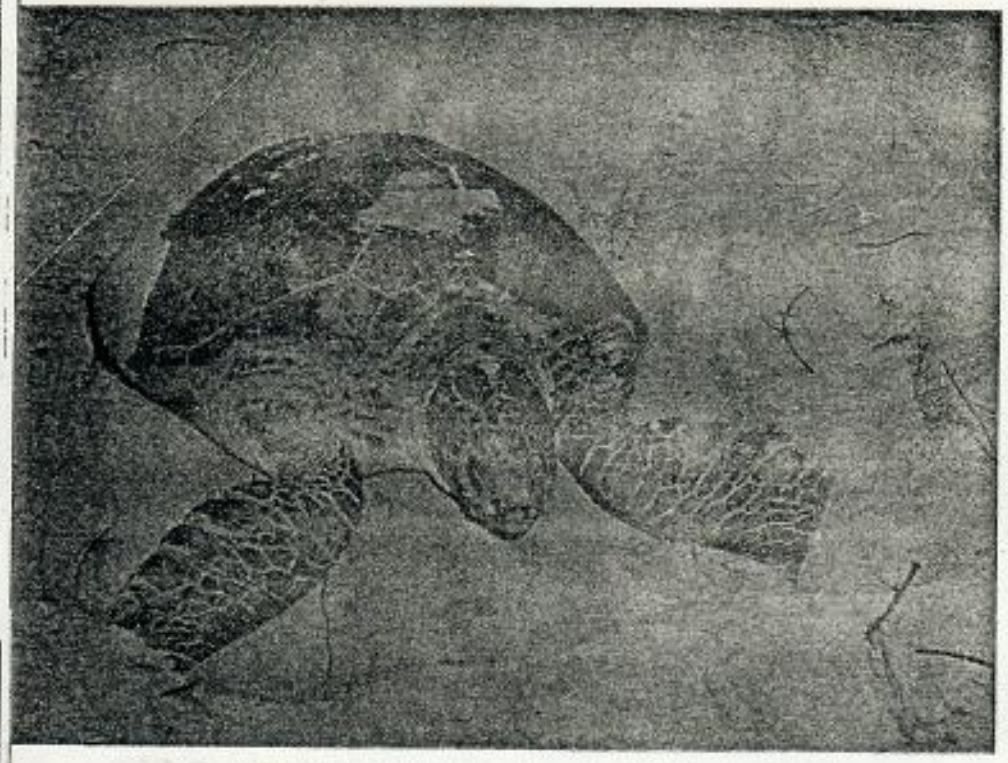
Predation is the most obvious factor. If there were no predators there surely would be fewer eggs laid. So one reason the green turtle lays a hundred eggs is that most of them, or most of the hatchlings they produce, and probably even a few of the grown-up turtles are bound to be eaten by predators. A fully grown sea turtle has few important enemies. Big sharks attack them once in a while, and on shore jaguars and tigers sometimes kill them. But the main mortality is in the nest and among the hatchlings. The whole world seems against the hatchlings both during their trip from the nest to the surf and for an unknown time after they enter the sea.

If you were able to get a complete list of the animals that prey on turtle eggs and young, it would surely include most of the carnivores and omnivores, both vertebrate and invertebrate, that live near a turtle-nesting beach. The predators range in size from ants and crabs to bears and Bengal tigers. Some of them live along the beach itself, some in the coastal scrub. Some come from far back in the interior, showing up for the turtle season as the Siquirres dogs at Tortuguero used to do, and as the Rancho Nuevo coyotes do to this day. At Tortuguero nowadays the most important non-human predators are dogs and buzzards.

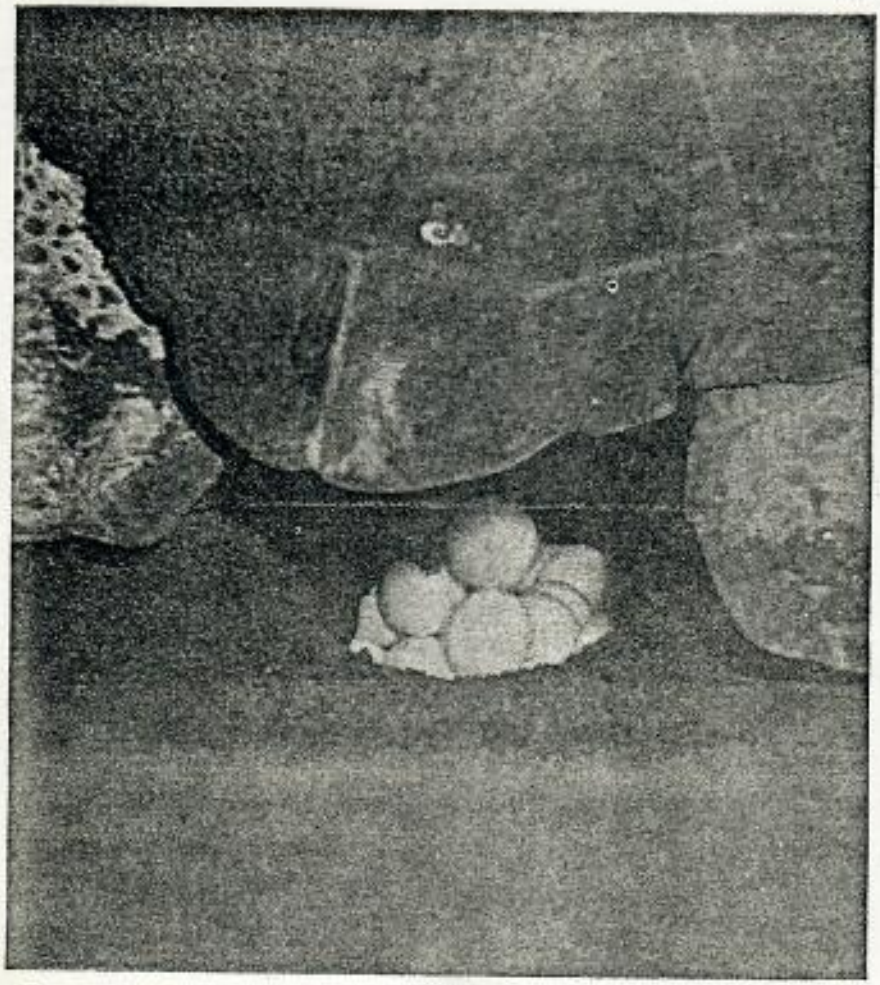
By chance or by adaptive arrangement, a turtle nest is safe from most natural enemies during the greater part of the sixty-day period it takes the eggs to hatch. The egg-eaters are a menace while the eggs are being laid and for a day or two afterward. After that, however, there follows a peaceful period when no animal seems able to locate turtle eggs in the nest. Why this is, nobody knows. But then comes the time of hatching and emergence, and because there is usually a strong peak in nesting intensity there is also a peak in hatching intensity: for a few weeks there may be little turtles by the thousands on the beach. For them, the danger begins when they have risen together in the nest almost to the surface of the sand. They lie there for a while as if awaiting some signal—for the thin crust over the nest to reach a certain temperature, perhaps. Whatever it is they wait for, it usually happens at night, most often after midnight, and apparently most frequently during or after light rain.

When they come out they waste no time about it. Their trip across the sand to the surf is fast as well as direct. For the turtles of each nest, this time of maximum peril in the life of the species is not really a long time at all. It is only a minute or two, or a little longer if the way to the sea should be blocked by many obstacles. Still it seems to a human observer a foolhardy violation of common sense to leave young ones far back from the sea on the hungry shore, behind dunes or debris that, chances are, cut off the way to the sea and hide it from view. The little turtles come out into a world eager to eat them. They have to go fast and straight toward the ocean even though they can't see it, never saw it before, and know of its existence only as a set of signals to react to instinctively. It





A nesting female green turtle rests in the body pit she has excavated. With her back legs, she digs the actual nest at the bottom of the body pit. Below, she has probably already laid more than eight dozen eggs.



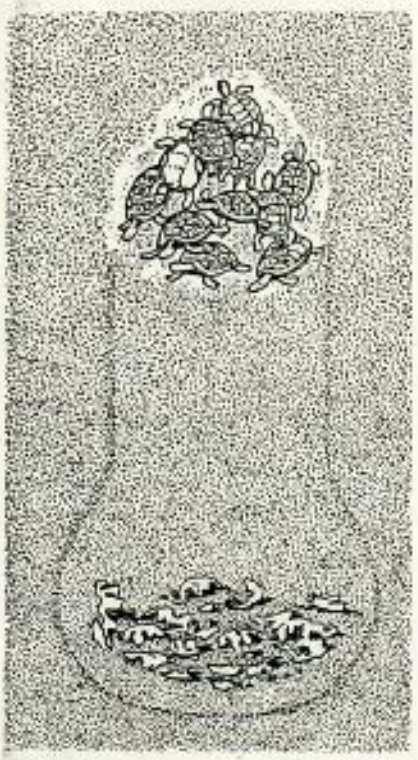
seems a little odd—the mother turtle leaving the new generation in such a predicament. Her doing it is certainly one reason she has to lay so many eggs. Serves her right, you might feel like saying; but before getting indignant you have to look at some other factors that the turtle, and the race behind her, had to take into evolutionary consideration.

I have no doubt that, back in the days before turtles evolved the way they are, if somebody had suggested to their race that they ought to have fewer offspring and take better care of them—not leave them behind on land, but tend them in the sea, perhaps in the admirable way a porpoise does—the ancestral turtles would have been amenable. That this never happened doesn't necessarily mean it would have been impossible, that natural selection could not possibly have built child-care into a turtle. What it means is that except for the recent ruin humanity has brought them to, turtles are a satisfactory product of natural selection, and despite seeming flaws, they are really doing all right. They are a surviving, and thus evidently successful, animal, in spite of what seems to a man the desperate plight of their young on shore. This just adds a bit more proof to the proposition that the hundred eggs a turtle lays is a package pregnant with meaning and history. In other words, ravening as the turtle predators are, they have not killed off the turtles.

But just swamping the predators, overflooding the menace of enemies at the nest, on the beach, and in the sea, is not, as I have said, the only factor that keeps turtles laying a basketful of eggs at once. There are other, subtler ways in which many eggs laid together quite clearly are destined to produce more new mature turtles than eggs laid singly would produce. Some of these factors are hard to demonstrate, but a colleague, Harold Hirth, and I once set out to do so and we learned enough to be sure that the nest of a sea turtle is more than a hole full of independent embryos or hatchlings.

The Synchrony of Hatching

Until recent years most people, if they ever thought about the matter



When they are ready, the hatchlings dig and squirm their way up to the surface almost as a single unit.

at all, believed that in a turtle nest the individual hatchlings, as they emerged from the shell, dug their separate ways up to the surface, through the inches or feet of sand or soil that make the roof of the nest. People should have known better. Anybody familiar with a sea turtle beach knows that baby sea turtles come out as a sort of small eruption. For years it has been known also that various kinds of fresh-water turtles do the same thing, and that in some nests the hatchlings stay in the nests through the winter or through prolonged periods of drought and then quickly break through to the surface when they somehow feel that things are right outside—or perhaps just a period of rain or thawing makes it mechanically possible for them to break the drought-hardened or frost-hardened roof of the nest. These overwintering turtles are not separate agents that just happen to have timed their actions in the same way. They are really a kind of little team, a simple-minded, co-operative brotherhood, each member of which is to some degree better off because his siblings are there. They all contribute, to small, vital degrees, to the job of getting the group out of the group predicament of being buried in the earth. Then, after they get out they go on working mindlessly together to lower the penalties of being succulent on a hostile shore.

This is not moonshine. It is elementary, fairly sound, and decidedly fundamental natural history. You can see it happening. Larry Ogren—also a biologist—Harold Hirth, and I were able to watch the things that go on in sea turtle nests by digging up to a nest from one side and replacing the wall with a pane of glass, or by simply reburying eggs at the usual depth in a box of sand, lodging them at one end of the box against a glass pane. In a paper that Dr. Hirth and I wrote we gave this account of what we saw in nests of green turtles:

> The first young that hatch do not start digging at once but lie still until some of their nestmates are free of the egg. Each new hatchling adds to the working space, because the spherical eggs and the spaces between them make a volume greater than that of the young and the crumpled shells. The vertical displacement that will carry the turtles to the surface is the upward migration of this chamber, brought about by a witless collaboration that is really a loose sort of division of labor. Although the movements involved are only a generalized thrashing, similar to those that free the hatchling from the egg, they accomplish four different and indispensable things, depending on the position of the turtle in the mass. Turtles of the top layer scratch down the ceiling. Those around the sides undercut the walls. Those on the bottom have two roles, one mechanical and the other psychological: they trample and compact the sand that filters down from above, and they serve as a sort of nervous system for the hatchling superorganism, stirring it out of recurrent spells of lassitude. Lying passively for a time under the weight of its fellows, one of them will suddenly burst into a spasm of squirming that triggers a new pandemic of work in the mass. Thus, by fits and starts, the ceiling falls, the floor rises, and the roomful of collaborating hatchlings is carried toward the surface.

So there is no parental care and no teaching or guarding by any mature turtle. The little survival team is not trained or prompted by any coach, nor does it consciously work toward any common end. It is just a lot of baby turtles getting restless and becoming annoyed with one another, but in useful ways. Their petulance at being crowded, jostled, and trod upon makes them flail about aimlessly. It is the aimless flailing that takes them steadily up to the surface.

To demonstrate the real utility of this involuntary teamwork (or "proto-cooperation," as such relationships were named by Dr. Clyde Allee back in the twenties) you only have to bury single eggs at nest depth and then keep track of their fate. Their fate is dismal. In our tests, out of twenty-two eggs that hatched singly, only six of the hatchlings reached the surface of the sand. All these were too weak to continue across the sand to the water. As more eggs are added to the experimental groups, arrivals at the surface increase, although maximum success was achieved by clutches of eggs far smaller than the average one-hundred-egg clutch laid by sea turtles. We found, in fact, no increase in emergence-success in groups greater than ten. A ten-turtle team seems just as able to reach the surface as a group of one hundred.

The Rewards of Being Many

There are other social advantages in the big groups, however. These have not yet been investigated carefully, but there seems no doubt that the unconscious co-operation continues during the trip from the nest to the surf. Once the hatchlings are out on the beach the bonds that integrate the band of nestmates loosen, and each hatchling is more completely dependent on his own senses to take him across the sand in the right way to find the sea. Even here, however, the hatchling that is one of a hatful of nestmates seems to have a slight advantage over one that comes out alone. In tests with young hawksbills, hatchlings that were allowed to crawl singly across the beach stopped more often than siblings released in groups, and seemed to lie still longer during stops and perhaps to orient less surely toward the surf line during bursts of travel. Single turtles, thus,

are on the open beach longer and are more likely to be caught by a ghost crab or, if emergence has been by day, to dry up. When a nestful of hatchlings comes out all at once or in a few smaller contingents, periods of hesitations are fewer and shorter simply because the turtles keep bumping into one another. If a sprinkling of hatchlings has stalled for a time, and a nestmate comes charging up from behind and touches one of them, the one touched springs into action, the action spreads, and the whole group scrambles away toward the sea as if you had wound them up like toys and set them down together. Here the advantage of being one of a group is simply that each member may remain less long sunk in recurrent spells of lassitude. There is also some evidence that the path of members of a big group of hatchlings trends usually more directly toward the sea than that of turtles traveling separately. The main body of the group is nearly always well oriented. When a single hatchling strays in a way that takes him across the stream of traffic, he usually corrects his heading to conform with the group course.

These observations have been casual and are not supported by data. They came back to mind clearly, however, when William Hamilton, of the University of California, told me of finding that migratory groups of birds are able to guide themselves better than birds migrating singly.

Such advantages are almost surely part of the reason that a green turtle lays a lot of eggs instead of only one. There are no doubt many more reasons, even less easy to see at work or to prove by statistics. There is some indication, for instance, that eggs heat up slightly from their own vital functioning. Another zoologist, John Hendrickson, found the temperature to be higher in turtle nests than outside, and so did Harry Hirth at Ascension Island. By simple rules that apply to volumes and surfaces, a big bunch of eggs should warm itself more than a single egg does, and being a little warmer may be some help in incubation.

After the hatchlings enter the sea they may regroup somewhere and somehow gain more advantage from being a group again. Nothing can be said about this because nothing is known about baby turtles once they have entered the sea.

So far I have talked a good deal about possible reasons why sea turtles lay so many eggs, but have said nothing about why they don't lay more. The lowness of the number one hundred has to be explained, too, because there are definite advantages in producing a great many offspring. I doubt that it is just an accident. A number of factors are probably at work to keep the number from rising. One way to increase the number of eggs would be to make them smaller. To do this the amount of food for the embryo would have to be reduced. This would be bound to cut down the size of the hatchling and thus to turn it out into the world less well equipped to scramble, to resist drying up, and then to do whatever is required of little turtles to get through their first hidden year in the ocean.

An increase in the number of eggs with no accompanying decrease in their size would almost surely overburden the female. The female green turtle may have to swim a thousand miles to her nesting ground, and once there, to fast throughout the period of time it takes her to complete the assembling of, say, four successive sets of shelled eggs for the four nestings of her season at the breeding ground. Here again, nothing at all is known about the amounts of energy involved, but it would obviously be pretty unreasonable to suggest that a sea turtle should haul more eggs around.

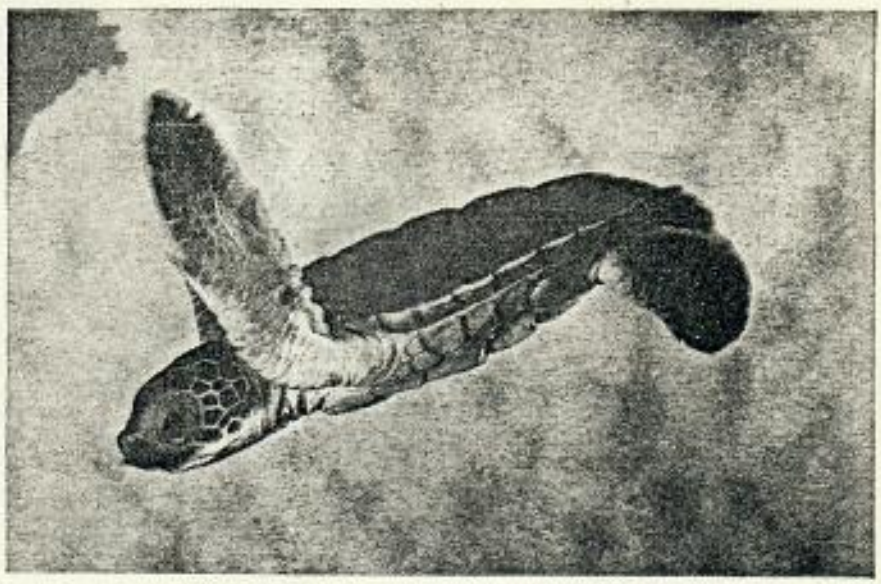
Even if the female turtle could carry more eggs to the beach, she would probably have trouble housing the bigger clutch in a proper nest. A proper nest is one with the right conditions of temperature and humidity, as well as one with a roof thick enough to hide the eggs. The nest a sea turtle digs is not just a pit. It is an elegantly flask-shaped, slightly lopsided chamber; the spherical section communicates with the surface by a narrow neck. From the care with which the turtle adheres to the standard pattern in making this cavity, and from observations of hatchlings emerging both from such bottle-shaped natural nests and from artificial nests of straight-sided cylindrical shape, there seems to be some advantage in the flasklike conformation. In the natural nest the emergence-group appears to be a little less troubled by heavy cave-ins that cover them in loose sand, slow down emergence, and break the group into smaller units that come out at different times or not at all.

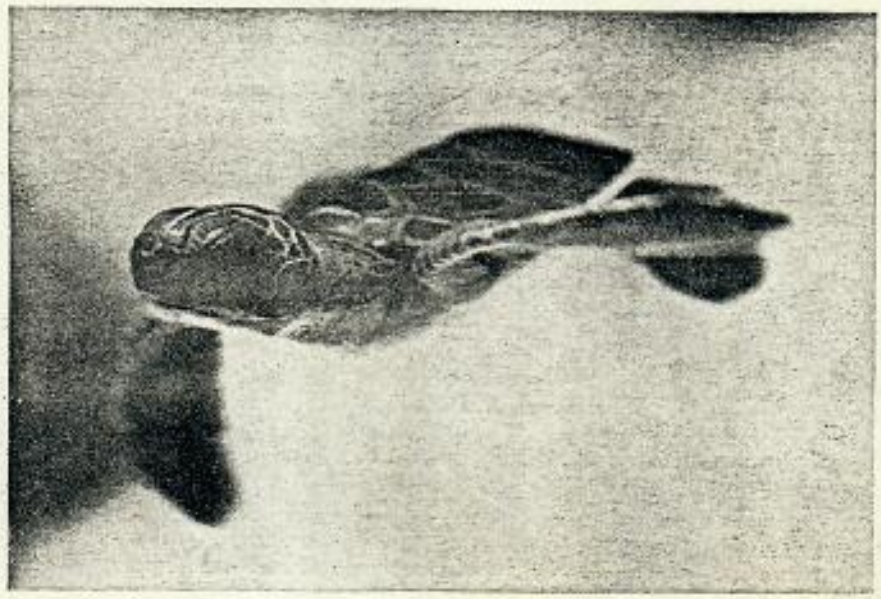
One important function of the nest is to provide the eggs and young with a way to avoid desiccation, flooding, and temperature fluctuations. The nest must be deep enough to damp down the daily changes in weather and to keep the eggs in continuously moist, continuously warm sand, and yet not so deep that high tides in the sea flood it and drown the embryos in salt water. All these considerations would seem by logic to be involved in determining the size of the nest, and logic also suggests that the size of the nest to some extent influences the volume of eggs that the race produces. And yet if you watch a sea turtle make her nest you might conclude that the only factor influencing the size and shape of the nest is the digging reach of the turtle that makes it. Every female sea turtle makes her nest just as deep as her back leg is

pivot of characteristic so hinds can dig deeper.

able to reach. There are two ways, therefore, that she is able to control the microclimate of the nest. One is to choose the right beach, and the right place on it; the other is to vary the depth of the body pit, the broad shallow basin that some sea turtles make to rest in while nesting. The nest proper is dug in the bottom of the body pit, and the depths of the body pits that green turtles make vary markedly. This gives the turtle the necessary leeway in locating the nest at the most appropriate level, despite her stereotyped insistence on digging the nest down as far as she can possibly stretch her back leg. How sea turtles divine proper beaches and nest sites is not known. That they do divine them seems obvious from the small number of badly placed nests one finds, and indeed, from the very existence of sea turtles.

To be continued in the next issue.





Young turtles, below, scuttle to open water. Once the hatchlings have found their way to the sea, they embark upon a journey whose course is a mystery. No one knows where the turtles go.