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Transocean Migrations of the Green Turtle

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One aspect of the program of studies of marine turtles being carried out at the University of Florida[1] has been a small tagging project at Ascension Island, in the South Atlantic between Brazil and Africa. The aim was to test the assumption that the green sea turtle, *Chelonia mydas,* is capable of long-range open-water navigation. Our much more extensive tagging data from Tortuguero, Costa Rica (3,000 green turtles tagged; 120 international returns) have shown clearly that *Chelonia* is a periodic long-distance migrant. The mainland location of that nesting ground, however, makes it difficult to prove that the turtles do not locate the place by following shorelines.

At Ascension Island 206 turtles were tagged by Harold Hirth in 1960 (Carr and Hirth, 1962). Eight of these have been recovered from the coast of Brazil. The recoveries were made both north and south of the bulge, at sites located downstream in both the Equatorial Current and the Brazil Current. There has been no return from the African coast, the nearest mainland shore to the island. Returns are shown in Fig. 1.

Although the tag returns strengthen our original belief that Brazilian turtles go to Ascension to nest, they still do not prove it. To test the idea further, a tag-check patrol was made at three of the Ascension beaches during the 1963 season, three years after the original tagging year, when the major three-year reproductive rhythm characteristic of the genus should have sent some 70 per cent of the surviving 1960-nesters back to the island to nest again. Three of the 1960 tags were found, each on the same short strip of beach on which the turtle had been tagged. During the current season (1964), four years after the original date of tagging, the smaller component of the population that nests on a two-year cycle should be making its second round trip to the island. So far this season (as of May 1, 1964), two more tags have been recovered, one at the place where both had been tagged, the other at a newly-formed beach, a short way to the north.

Chelonia apparently never nests in two successive seasons. Its returns to the beach are every two, or more often every three, years. Because each year, after June, the disappearance of green turtles from Ascension waters is complete and because the mature female turtles that occur along the Brazilian coast do not nest there, it is logical to conclude that the three tagged animals retaken at Ascension in 1963 had returned for the first time since 1960 and had spent the interim in Brazil The two 1964 recoveries almost surely represent the smaller contingent that nests each two years, returning for a second time during the four-year period since it had been tagged.

The growing solidity of the case for such regular long-range migration enhances the importance of Ascension Island as a site for experimental study of navigation problems. There seems to be no wholly satisfactory explanation for oriented open-sea travel by animals, over distances where compass-sense alone would be insufficient to keep them on a successful course. The finding of Ascension Island, for instance, obviously requires more than compass-sense, and it also seems impossible to explain the turtles' arrival there by any process of piloting. The feat thus appears to be practically *prima facie* evidence of some sort of bicoordinate navigation. The problem here is to account for the necessary position-finding in the open sea, where there is no fixed reference by which to measure sun azimuth. All current explanations of island finding — by birds, green turtles, or any other animal — appear to rest upon somewhat tenuous theoretical grounds. The several theories can only be finally tested when migrating animals can be precisely followed or tracked and the guidance processes in operation at successive stages of the travel courses can be determined. It is a fundamental weakness in the outlook for research in animal navigation that in the case of the most spectacular of all guidance adaptations — navigation through and over the open sea — the travel courses have not even been plotted.

The periodic reproductive travel of animals to small mid-ocean islands seems a bizarre complication of the life cycle. The Ascension-Brazil system, however, may offer slight extenuations of the orientation problem. For one thing the island, though tiny now, is a peak of the Atlantic Ridge and may have been much larger at the time the travel patterns of ancestral green turtles were evolved by the species, by the genus, or by whatever ancestral stock evolved them. A slow shrinking of the old island would have allowed the gradual selective refinement of the orientation capacity to find it. Today the Ascension-bound migrants are compelled to find a five-mile rock after a swim of over a thousand miles; but the early, less refined stages of the adaptation did not have to evolve under the current physiographic conditions.

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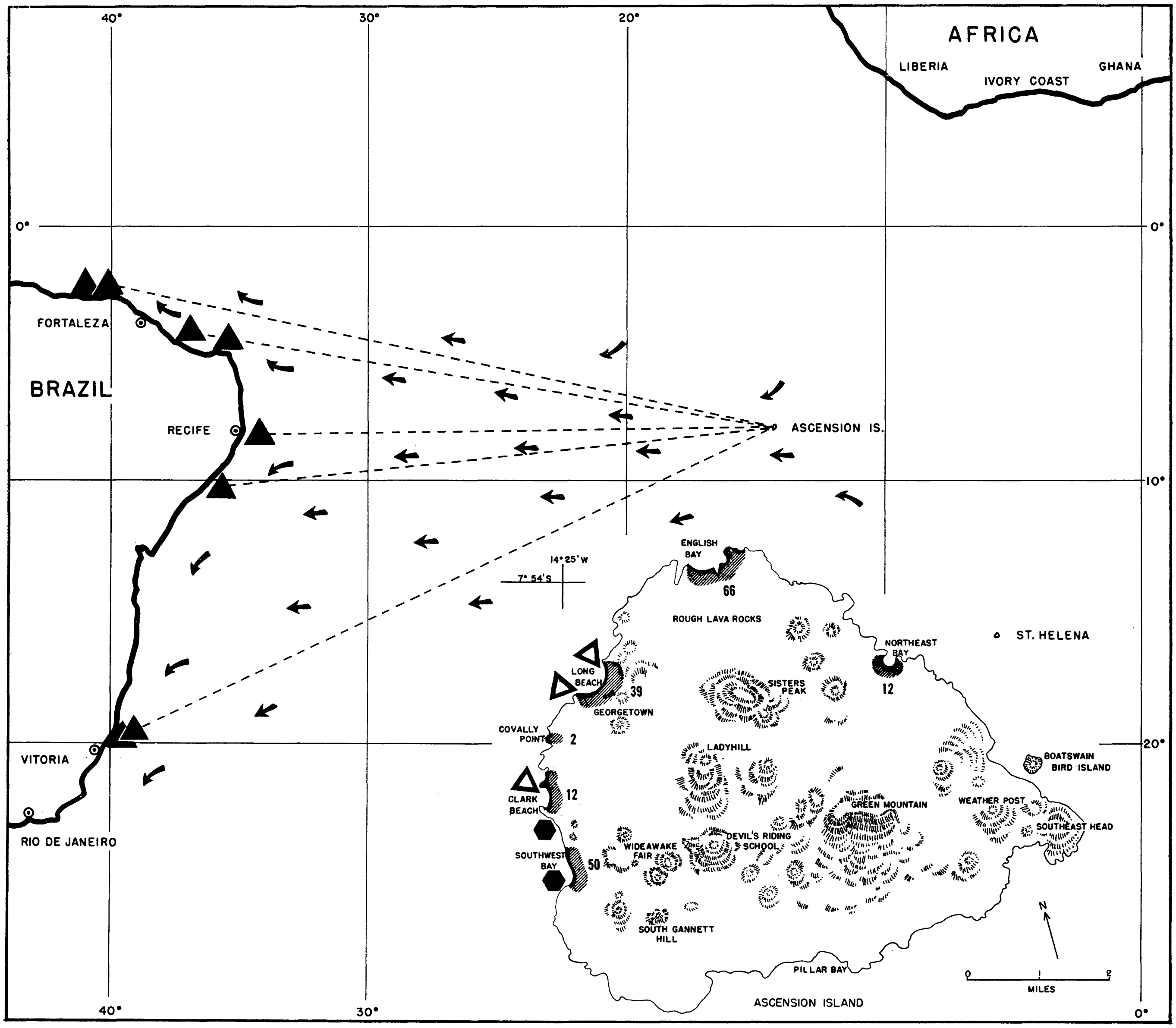

FIG. 1. History of a tagging project at Ascension Island. Two hundred and six turtles were tagged on the six nesting beaches in 1960. The figure next to each nesting beach is the number of turtles tagged there. Solid triangles show mainland recoveries, all from Brazil. Hollow triangles show recoveries of turtles that had returned to nest in 1963 after a three-year interval. Hexagons represent turtles returning in 1964, presumably for a second time, after two round trips to Brazil. All but one of the recovered turtles had gone back to the original tagging site. The one that failed to home precisely came out on an adjacent beach formed by recent wave action. Arrows represent current trends.

Another conceivably significant advantage in the commuting between Ascension and Brazil — one that might reduce the minimum requirements in hereditary travel information — is the possibility of passive transportation of the naive hatchlings from the nesting ground to Brazil by the Equatorial Current. If they behave as mere plankton on the westward trip, the three-knot Equatorial Current and its branches could carry them within short distances of any of the localities from which our mainland tag-returns have come. The Ascension-Brazil relationships may even simplify the navigation problem on the eastward trip to the island. Perhaps the outbound migrants move northward or southward along the shore, turn eastward at some imprinted coastal landmark in the latitude of Ascension, and, from there out to the point at which the island landfall is made, have only latitude to determine. Between Ascension and the nearest part of the bulge of Brazil, the Equatorial Current would complicate navigation with much less, and less variable, displacement than would plague migrants making a direct approach to the island from north or south of the bulge and crossing the current at a changing slant that would make constant position-finding and course-correction necessary. Until the migrating turtles have been tracked, it will of course remain impossible to say whether these natural geographic advantages are actually exploited.

Besides the indications from tag returns, much can be deduced about migration patterns of *Chelonia* from the known ecological geography of the populations. This clearly shows that specialized guidance processes are used. In an effort to fill gaps in one of these patterns and to locate a possible new site for tagging and tracking experiments, I visited the coast of the western Indian Ocean during September and October, 1963. A specific aim of the trip was to gather data bearing upon the possibility that the main green turtle populations of East African shores migrate to the island of Aldabra to nest. On the coasts of Kenya, Tanganyika, and Madagascar, I visited feeding grounds, collected information on age-groups, and investigated reports of local nesting beaches. All the latter proved to involve species other than the green turtle. Results of the survey suggest that the young and subadult green turtles that now occur on the East African coast are derived from rookeries located elsewhere. The situation resembles that on the Gulf Coast of peninsular Florida where, each summer, similarly immature schools of green turtles turn up in April from unknown origins and then disappear completely in November. In Malagasy waters, both two-year-old and mature green turtles were found, but there, also, all evidence indicated that there has been no nesting in recent decades.

Along the African coast north of Mombassa, I made contact with the Bajun Island turtle fishermen, the traditional hunters of green turtles for the East African export trade. These people still use leashed sucking-fish in their turtling. The remoras are kept in tubs, cared for solicitously, and on calm days taken out in the dhows and dugouts to the turtling grounds. A line is fastened to the tail of the fish. When the head of a turtle is sighted, the remora is taken from its tub and dropped into the water. Special words of encouragement are said to it, and line is paid out. The remora, following its natural urge to fix itself to some larger animal, moves away in widening arcs, evidently guided by scent. It eventually intercepts the turtle and fastens to its shell. Then, either a diver goes down the line and takes hold of the turtle or other remoras are paid out to furnish more secure attachment. When three or four fish have taken hold, the pull that can be exerted on the several lines is strong enough to immobilize a good-sized green turtle.

The Bajuni people claimed that there is still some nesting by green turtles on a small island near the Somaliland frontier. Like other inhabitants of the coast, however, they said that most of the Kenya turtles "come from somewhere far off." All evidence pointed to Aldabra as the only important rookery remaining in the western part of the Indian Ocean, with the possible exception of one rumored to exist on the coast far to the south in Zululand.[1]

The recent delimitation of the breeding range of the Mexican ridley, *Lepidochelys kempi* (Hildebrand, 1963; Carr, 1963), reveals an extraordinary example of trenchant isolation between sea-turtle populations within a single ocean system. In this case the isolation is reflected by a fairly well-marked morphologic difference between the separated populations. Taxonomic divergence among separate nesting colonies of green turtles is mostly trivial, however, and on many feeding grounds it is not possible to distinguish between turtles from different breeding areas except perhaps on weakly statistical grounds. In some of the predominantly dark, high-shelled Pacific populations, however, an occasional light-colored, often yellowish, flat-shelled individual can be noted. I have seen such variants in the mid-Pacific — at French Frigate Shoal and on the islands of Pearl and Hermes Reef where *Chelonia* still emerges to bask on the sand among monk seals and albatrosses, at Espiritu Santo Island near the mouth of the Gulf of California, and in the Bay of Fonseca off Honduras and El Salvador — and others have told me of seeing them elsewhere. The single light-colored, flat yearling seen at French Frigate Shoal was especially

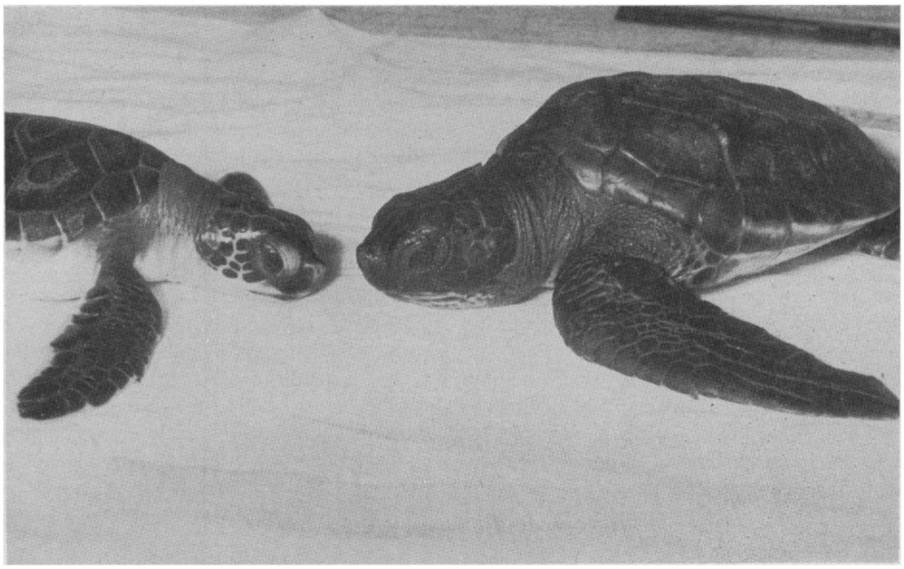

FIG. 2. First-year *Chelonia* from Atlantic (left; Tortuguero, Costa Rica) and Pacific (right; French Frigate Shoal), showing deeper body and heavier black pigment characteristic of most East Pacific stocks.

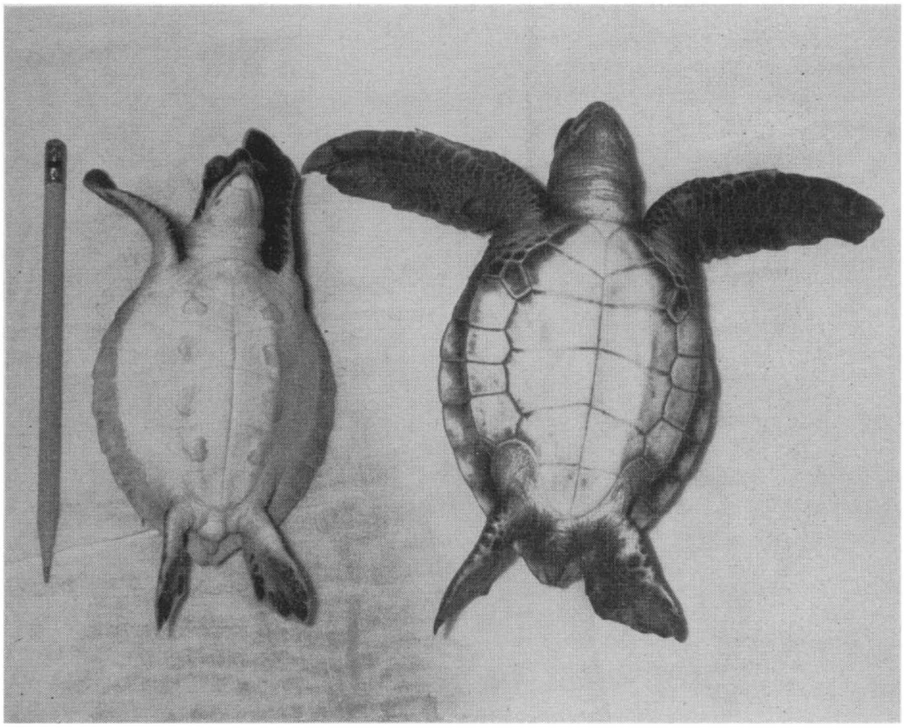

FIG. 3. Central view of the Atlantic (left) and Pacific *Chelonia* shown in Fig 2.

[1] Since this article went to press, the turtles of the Zululand Colony have been found to be the leatherback, *Dermochelys*.

striking because one of the few known nesting grounds of the dark form is located there. A six-month-old specimen from that colony is compared with a Caribbean green turtle in Figs. 2 and 3.

I have nowhere been able to decide whether the occasional yellow East Pacific turtles were variants of the local dark stock or waifs from some genetically different population. Two years ago I had an extraordinary letter from Mrs. Carmen Angermeyer of Santa Cruz in the Galápagos Islands. Mrs. Angermeyer, whose husband deals in turtle oil, wrote me that to her eye the Galápagos "green" turtles were of two kinds: a black, high-shelled one that nests locally, and a light-colored, yellowish, flatter kind that nests nowhere in the Islands but disappears for part of the year. The yellow turtle, according to Mrs. Angermeyer, yields large amounts of oil; the local strain yields much less. These observations not only indicate that two fairly well-marked stocks of *Chelonia* may converge in the Galápagos area but also emphasize the importance of studying fat-deposition in sea turtles, especially in *Chelonia*. The green turtle is both the most systematic long-range migrant of all marine turtles and the one that carries the most fat in the body cavity. If the fat is, as seems likely, a ration for migratory travel, then fat assays might furnish criteria helpful in the determination of migratory schedules and destinations, as they have in birds (Caldwell, Marshall and Odum, 1963).

The Galápagos Islands seem a promising place for such studies. Another is the coast of Brazil, where the main green turtle stock moves out to Ascension to nest while a small contingent goes no farther than the nearby island of Trinidad. Still another is the Gulf Coast of Florida, where the immature summer population clearly comes from some distant locality and probably goes back there when it leaves in October.

Acknowledgments

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