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GROWTH MEASUREMENTS OF YOUNG CAPTIVE ATLANTIC SEA TURTLES IN TEMPERATE WATERS

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ABSTRACT: Rapid growth is indicated for all young sea turtles.

Growth data are presented for the first three years of life for green turtles, *Chelonia m. mydas*, and these results, coupled with findings from published sources, are used to postulate an age at first maturity for this species of approximately 13 years in temperate waters and some eight years in tropical seas.

Limited growth data on hatchling and/or juvenile individuals are included for the hawksbill, *Eretmochelys i. imbricata*; for the loggerhead, *Caretta c. caretta;* and for the ridley, *Lepidochelys kempi*. It is postulated that the loggerhead may mature at approximately 6 or 7 years of age in temperate seas.

Captive green turtles were conditioned to respond to a bell signaling feeding time.

A ridley turtle was shown to continue normal activity, which includes considerable swimming, even though it refused to eat for the five months preceding death.

During the past few years, growth records have been accumulated, covering varying lengths of time, on captive sea turtles of several species. All of the results are surprisingly consistent in indicating rapid growth, although they vary due to the circumstances of each individual's captivity and with the species concerned. These findings are now presented to reinforce the premise that young sea turtles grow rapidly in captivity. The results may be applied, with reservations, to growth rates under natural conditions.

One of the more perplexing problems in the study of sea-turtle natural history has been the scarcity of records of small turtles seen in nature as compared with adult or sub-adult individuals. As I suggested in an earlier paper (Caldwell, 1960: 6), such a phenomenon is undoubtedly in part a result of biologists not looking in the right places, but also of much more rapid growth rates in young sea turtles than once was supposed.

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METHODS

All measurements were made in accord with Carr and Caldwell (1956: 4). Hereafter, the term "length" refers to carapace length, and the term "width" refers to carapace width. Original weights and measurements were made in pounds and grams, inches and millimeters, or combinations of both. Where appropriate, all were converted to the metric system for this paper using 454 grams to the pound (28.4 grams to the ounce) and 25.4 millimeters to the inch.

The water temperatures in the oceanarium tanks closely approximated those in nature (at the site of captivity) as the water was continually being pumped in from the nearby sea.

An effort was made by the aquarists in charge to approximate the known natural diet of the turtles.

Lengths at first maturity noted in this paper are based on the lengths of the smallest nesting females so far recorded for the given species. Males may mature at a different size.

SPECIES LIST

Atlantic Green Turtle, *Chelonia mydas mydas* (Linnaeus)

Carr and Caldwell (1956: 12) summarized the meager knowledge of growth rates for Atlantic green turtles. Reasonably long-term data are now added on a number of very small green turtles. Using these data, and information taken from the literature, an age at maturity (length of 35 inches, *fide* Carr and Ogren, 1960: 8) of no more than 13 years, and perhaps little more than half of that, can be postulated—depending on latitude.

Twenty-five green turtles, each approximately 50 mm. in length at hatching, and from the same initial hatching at Tortuguero, Caribbean Costa Rica, were kept under various conditions of captivity and diet—at the Seahorse Key laboratory at Cedar Key, and at Florida's Gulfarium, both on the northwestern coast of Florida, and at Marine Studios on the northeastern coast of the state. It was noteworthy that despite variation in conditions of captivity, the mean results at comparable ages were remarkably similar. The similarity of these findings adds weight to the use of such data as an order-of-magnitude representation of natural growth for young sea turtles at a given latitude.

All of the turtles were fed on a cut-fish and shrimp diet (in varying proportions at the different locales of captivity) which is believed by aquarists, using trial and error methods, to represent closely the natural diet of green turtles of this size, although older individuals are herbivorous. Very young captive green turtles refused plant food. Four of the individuals were maintained almost three years before circumstances demanded that they be released into a large fenced-off bay where they could no longer be captured for measuring. Individuals maintained elsewhere were like-

wise released, or died for reasons other than diet deficiency before the end of three years.

GROWTH RATE BASED ON LENGTH: Combining all of the results, and interpolating the irregularly-collected data to one-year intervals, an estimated rate of length increase was obtained for the nearly three years of the experiment. These estimations are: 100 mm. the first year, 115 mm. the second year, and 115 mm. the third year. Turtles larger than these at capture in the northwestern Gulf of Mexico (estimated from these data to have been three to four years old), and also fed on cut-fish and shrimp, grew only about 50 mm. per year.

Carr and Caldwell (1956: 12) reported, on the basis of one fragmentary tagging return, that one sub-adult green turtle, living under natural conditions on the northwest coast of Florida (near Cedar Key), could have increased its length a minimum of one inch in approximately three warm summer months, or a maximum of 6½ inches. The great range in possible growth for this turtle is a result of the loss of the tag (although the turtle was clearly identifiable as having been one of those tagged during the study) and these figures are maxima and minima based on the largest and smallest size that the turtle could have been at tagging (see Carr and Caldwell for a more detailed discussion of this recapture). The findings with the small turtles in captivity, noted above, show that there are about six warm months in which most of their yearly growth is made in these temperate latitudes, with most of that during the three warmest summer months. Using this six-month growing time as a point of departure, one may assume that the sub-adult turtle reported by Carr and Caldwell would have grown somewhere between two and 13 inches per year. Unverified findings on cabbage-fed captive turtles of this size, in approximately the same latitudes, reported to me by aquarists, indicate that the smaller figure is more realistic. Assuming therefore, an arithmetic (which my data indicate, and Hendrickson, 1958, assumes) two-inch increase in length per year after the third year, the smallest nesting female green turtle (35 inches in length) noted above would have been about 13 years of age. A logarithmic increase, which Dr. Archie Carr writes he believes may occur, would result in a somewhat earlier maturity in these temperate latitudes.

As I have frequently noted, the above findings are all based on green turtles reared in temperate latitudes, north of the usual breeding range of the species. Green turtles living in the perpetually warm waters of their more expected tropical range, or under warm-water controlled laboratory conditions, might be expected to grow significantly throughout the year, rather than having only approximately six months in which to do most of their yearly growing. If this is the case, then the tropical turtles should reach maturity at an even earlier age than the 13 years proposed for their temperate-living siblings. Schmidt's (1916) findings on tagged individuals of 5 to 45 pounds living in nature in the tropical Danish West Indies

indicate a monthly growth rate similar to that for similar-sized turtles during the summer months of the temperate zone and lend further credence to those results. Individual turtles living out their lives in the tropics might be expected to grow twice as fast per year, for they have twice as many warm months to do so. If this were really the case, then size sufficient for maturity would be reached in approximately five years—less than half the time required in temperate waters because of the greatly increased rate during the first years. However, Hendrickson's (1958) results for the first two years of growth in tropical Asian green turtles (possibly the same subspecies as that of the western Atlantic) indicate that this is excessive, although the rate of growth per year is much higher than my results indicate in temperate waters.

Hendrickson (1958: 519) assumed that there is no marked decrease in growth rate after the first two years and that maturity should be attained in four to six years. My findings, and those of aquarists working with juvenile and sub-adult turtles in temperate latitudes indicate that there *is* a marked (by a factor of about half) decrease in growth rate of green turtles after their first years (after about three, based on my own studies). Hendrickson and I are both probably low in our similar estimations of age at maturity—estimations which we deduced by following different paths. Each of us have data which seem to show a fallacy in the other's reasoning (*i.e.*, Hendrickson's data indicate that growth rate in the tropics is not twice that in temperate seas, and my data indicate that growth rate decreases after the first three years). A more realistic figure for the attainment of a size sufficient for sexual maturity in the tropics probably lies at a point in age of somewhere between five and thirteen years, (but not over this wide a range). Thirteen years is believed to be a reasonable figure for temperate waters as it is based more on actual findings. Hendrickson's findings indicate a rate of growth for the first two years of approximately 70% of my suggested doubled rate of growth for tropical over temperate-living individuals. Applying this correction to all my doubled yearly rates for tropical growth, I would conclude that instead of requiring five years to reach a minimum size for maturity, the tropical Atlantic turtles would require some eight years.

More data must be accumulated from tagging studies on turtles of all sizes living under natural conditions before this question can be resolved satisfactorily. However, in making any statements on rate of growth on sea turtles, general latitude and/or water temperature should always be considered as an important qualification, and tropical growth data should only be compared with temperate results when the latter are for the warm summer months (or their equivalent under laboratory conditions).

WEIGHT INCREASE: For the four green turtles noted above, which were maintained for nearly three full years, the mean weight increase amounted

to about 135 grams the first year, 2725 the second, and 5000 the third year.

Some turtles maintained during my study were much heavier than their siblings of similar or even greater length. This extra weight can be attributed in part to differences in width, but primarily to variation in the thickness of the turtle. Although this dimension could not accurately be measured, due to the momentary state of lung inflation, some turtles obviously are still much thicker-bodied, or deeper, than others. This variation was noted for larger, juvenile or sub-adult individuals by Carr and Caldwell (1956: 13), and must be taken into consideration in any study of length-weight relationships in sea turtles.

BEHAVIORAL NOTE: An interesting aspect of green turtle behavior was described to me by Mr. Cliff Townsend at Marine Studios.

After almost three years, when the turtles grew too large for the tank in which they were being maintained, they had to be removed to an approximately one-acre pond formed by blocking off an embayment of a brackish creek. While they were no longer available for measuring, Mr. Townsend reported that he had managed to condition the turtles to respond to a bell which was rung to summon them to feed in his immediate vicinity.

Atlantic Hawksbill Turtle, *Eretmochelys imbricata imbricata* (Linnaeus)

A single specimen of this species, hatched (at about 50 mm. length) at Tortuguero, Costa Rica, was maintained for nearly three years at Marine Studios. The tropical hawksbill is not normally found even as a straggler in these regions, and the temperature of the water used in the holding tanks may have been too far below optimum for anything approaching a normal feeding behavior and consequent rate of growth—especially in the winter and early spring. However, the data are included, for they do indicate surprisingly rapid growth even under poor conditions. The hawksbill is normally a carnivore and should be expected to utilize efficiently its fish and shrimp diet fed during this study.

Because measurements were not taken at exactly one-year intervals, some interpretation must be made. During the three years the turtle increased in length approximately 100 mm. the first year, 60 mm. the second, and 100 mm. the third year. These rates are slower than those established for individuals raised in the tropics by Schmidt (1916).

In weight, the respective increases were approximately 160, 900, and 2330 grams for the first three years.

Additional hawksbills, also hatched at Tortuguero, were maintained elsewhere in Florida. One group of three individuals, kept at the Seahorse Key laboratory at Cedar Key and fed a cut-fish diet, showed a mean increase in length of 26 mm. and a mean increase in weight of 50 grams, in 195 days. Five others, kept at Florida's Gulfarium, showed a mean increase in length of 73 mm. and a mean increase in weight of 234 grams on a

cut-fish diet in 224 days. The great increase in growth rate for this latter group over those kept at Seahorse Key can be accounted for by the 224-day period extending into the warm spring months when the water warmed considerably and feeding activity increased. The growth rates during the fall, winter, and early spring months were comparable at all three localities of captivity.

Atlantic Loggerhead Turtle, *Caretta caretta caretta* (Linnaeus)

Caldwell, Carr, and Hellier (1956) presented fragmentary growth data for several captive loggerhead hatchlings, and the findings of other workers with hatchlings were summarized. Findings made during the present study are comparable, but indicate more rapid growth than those given in the earlier paper.

Five individuals, 46.7-52.0 mm. in length when hatched at Jekyll Island, Georgia, were held in a small tank of warm water nearby. At the end of two early fall months the mean increase in length for these shrimp-fed specimens was 21.9 mm.

As the normal breeding and feeding range of the loggerhead is in temperate waters, and feeding and consequent growth might be expected to continue through much of the year there as it seemingly does with the green turtle in the tropics, an age at first maturity (approximately only 31 inches, *fide* Caldwell, Carr, and Ogren, 1959: 305) might be even less than that postulated for the tropical-living green turtle, or only some 6 or 7 years. Results indicating this order-of-magnitude rate of growth for captive individuals in temperate waters have been reported for young loggerheads by Hildebrand and Hatsel (1927) and Parker (1929). Unsubstantiated reports by aquarists working with captives of this species in temperate waters have indicated that the growth rate is very rapid in the sub-adult loggerhead turtles. As water temperature and diet were similar to those found nearby in nature, the results reported for loggerheads in oceanariums seem quite reliable.

Atlantic Ridley Turtle, *Lepidochelys kempi* (Garman)

My data on ridley growth are based on only two individuals measured initially at a considerably larger size than the other species treated in this paper.

At capture, one individual measured 260 mm. in length and weighed 3178 grams. After 316 days on a cut-fish diet, it had increased 45 mm. in length and 1589 grams in weight. This individual changed in body shape from a turtle wider than long to one longer than wide.

The second specimen at capture measured 279 mm. in length and weighed 2838 grams. After 330 days, also on a cut-fish diet, it had increased only 15 mm. in length and 1362 grams in weight. Almost exactly one year later it had increased an additional 46 mm. in length and 1816 grams in weight.

Both of these individuals were captured and maintained at Ft. Walton

Beach, Florida, within the normal feeding range of the species. The water temperatures were, thus, similar to those which the turtles would find in nature. However, while their fish diet suited them in their role as carnivores, it differed from the normal ridley diet in which crabs seem to predominate.

Nevertheless, these findings corroborate the general premise of fast growth rates in young sea turtles. The ridley is a smaller turtle (maturing at about 25 inches in length, *fide* Carr and Caldwell, 1958: 253) than the other species discussed herein, and a length increase of nearly two inches per year is proportionately more rapid than it would be for a species maturing at 31 (loggerhead turtle) or 35 (green turtle) inches.

It was found that some captive sea turtles do not eat, and consequently they do not grow. It is astounding, however, to consider the length of time that can transpire between capture and death due to starvation, even though the individual turtle remained actively swimming in an apparently normal and constant manner. Regular measurements were made on a small ridley caught in the surf near Ft. Walton Beach and kept in captivity at Florida's Gulfarium. While the ridley's tank mates (green turtles) fed regularly, it did not, although it swam just as actively from the date of its capture on 10 July until just before its death on 8 December. During this time it remained at a constant length of 216 mm., and at a constant width of 191 mm. It lost weight from 1362 grams at capture to 1022 grams at death. While it is not unusual for captive tortoises to live longer than this without feeding, such cases are usually based on the individual's being almost completely inactive during its period of starvation. Obviously, then, the ability for the ridley to live for long periods without food is an excellent survival factor for a species which must, at least at small sizes, be active in order to escape predators and yet which might find itself under conditions of reduced food supply. Such a survival factor undoubtedly applies to all sea turtles.

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