adults is most prominent at the posterior edge of the orbit, well in advance of the ear. For identification purposes, female *G. kohni* 100 mm or more in carapace length will have the head contained in the carapace length 6.25 times or less, whereas in *G. pseudogeographica* the head is contained 7 times or more. For males with carapaces 80 mm or more, the head is contained 6.25 times or less in *G. kohni*, and more than 6.25 times in *G. pseudogeographica*.

The association of such differentiating features, head width and postorbital markings, in these sympatric animals strongly suggests that *Graptemys kohni* and *G. pseudogeographica ouachitensis* are specifically distinct. I find additionally that skulls of *G. p. ouachitensis* and *G. p. sabinensis* are very similar and both can be readily distinguished from *G. kohni* by the much greater anterior projection of the frontals. Although *G. pseudogeographica* reaches a greater recorded carapace length than *G. kohni* (Ernst and Barbour, 1972), *G. p. ouachitensis* run smaller than *G. kohni* in Louisiana (Fig. 1). Distribution maps in Conant (1958) and Ernst and Barbour (1972) show that *G. kohni* and *G. pseudogeographica* are not sympatric in eastern Louisiana and southwestern Mississippi. Lousiana records known to me indicate that *G. pseudogeographica* range in Louisiana is more extensive than illustrated by either Conant or Ernst and Barbour. However, even with this broader range sympatry is still unknown in the lower Sabine River in southwestern Louisiana where only *G. pseudogeographica* occurs; likewise, only *G. kohni* is known in southeastern Louisiana east of the Mississippi River.

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HAROLD A. DUNDEE, *Department of Biology, Tulane University, New Orleans, Louisiana 70118.*

OBSERVATIONS ON THE BASKING HABIT IN THE CAPTIVE JUVENILE PACIFIC GREEN TURTLE.—Although basking is a common behavioral trait in many fresh water turtles, the only marine forms presently known to display this characteristic are certain members of the genus *Chelonia* which inhabit the Pacific. Past reports on green turtle colonies in which basking has been noted are limited in number and restricted to a few remote and widely spread localities, namely the Northwestern Hawaiian Islands, 24° N., 164° W. to 28° N., to 176° W. (Mellen, 1925) and the Galapagos Islands, 0°, 19° W. (Dampier, 1906; Rogers and Courtney, 1814). Billings (1856) reported green turtles sleeping in 15 cm of water at D'Entrecasteaux Reef, 18° S., 163° E., off the Northern tip of New Caledonia, however it is unlikely that these were true baskers. They were probably animals which had recently nested and were awaiting the incoming tide before returning to the open ocean. In the Wellesley Isles females alone are known to come ashore during the breeding season for the purpose of avoiding males (Bustard, 1972).

Both the Galapagos Islands (Carr, 1967) and the Northwestern Hawaiian Islands (Amerson, 1971; Kenyon and Rice, 1959) have been mentioned in recent years as still having basking green turtles. At this latter location males and females are frequently seen in relatively large numbers throughout the year resting on select sand beaches at French Frigate Shoals, Laysan, Lisianski, and Pearl and Hermes Reef. Emergence from water at several of these locations has been observed at night. Mellen (1925) reported that baskers were seen on rock ledges at Necker (24° N., 164° W.), a high volcanic island in the Hawaiian chain. Kridler and Olsen (1973) have indicated that basking turtles are still occasionally observed on this

island. The smallest sub-adults noted on any of the beaches were estimated to be not less than 7 kg, however most turtles seen basking in the Northwestern Hawaiian Islands are in excess of 45 kg. As at other nesting locations, hatchlings are not seen from the time they leave the nest and enter the water until they weigh approximately 3 kg or more.

Cagle (1950), Boyer (1965) and Pritchard and Greenhood (1968) have discussed possible reasons for basking in fresh water species with brief mention being given to this behavior in the Pacific green turtles. Theories relating to thermoregulation, skin and shell drying, removal of ectoparasites, social interaction, vitamin D synthesis and facilitation of digestion have all been offered to explain basking.

During August and September of 1972, 121 green turtle hatchlings were captured shortly after emergence from nests at French Frigate Shoals and transported to the facilities of the Hawaii Institute of Marine Biology located on the island of Oahu. Animals were subsequently reared under laboratory conditions in 75 l aquaria on experimental diets. At 6 months of age, 65 of these turtles, ranging in weight from 250 to 1100 g were transferred to a 5400 l oval flow through sea water tank measuring 4.5 m by 2.8 m with a depth of 0.4 m. Water temperature averaged 28 ± 1 C. Tile blocks were positioned at each end of the tank to present a 0.24 m² sloping dry area above the water's surface at each location. Although outdoors, this tank was fitted with a protective shade roof containing a skylight which measured 1.8 m by 1.2 m.

Since placing the animals in this tank, basking has been observed to occur frequently. On several occasions the blocks have been so crowded with basking turtles that animals were lying one on top of the other. Numerous observations have been made on individuals first starting to crawl out in order to determine if animals were randomly floating or swimming into the sloped dry areas. It was concluded that distinct efforts were involved in order to purposely crawl up onto the basking areas. More turtles have been noted basking on the one area illuminated during morning hours by direct sunlight entering through the skylight. On days when there was heavy cloud cover, subjective observations indicated that no special preference seemed to be given to either basking area and turtles were sporadically present on both locations even though radiant energy was much reduced. Turtles were noted to exhibit little activity while basking except for a periodic lifting of the head accompanied by breathing. The movement of the head in this manner is apparently a protective mechanism to ensure that the mouth and nostrils are completely out of the water at the time of inhalation. It was interesting that this reflex behavior occurred even when the animals were not in the water.

No previous reports could be found in the literature on the occurrence of the basking habit in captive green turtles. It seems unlikely that such behavior, if observed, would have gone unreported. Carr (1967) in describing rearing techniques stated that young Atlantic green turtles, kept in pens that enclosed a shoreline, tended to "crawl foolishly ashore and dry up there." Holding turtles in such enclosures was thus deemed undesirable. No mention was given as to whether these animals would eventually return to the water on their own accord, as do the turtles described in this paper. It thus seems unlikely that the animals mentioned by Carr were exhibiting a true basking habit.

Green turtle basking is a little studied behavioral trait which deserves in-depth consideration. Experiments designed to determine the mechanisms which stimulate Galapagos and Hawaiian green turtles to bask have not been initiated. This has probably been due, in part, to the difficulties involved in working with adult and sub-adult wild animals on inaccessible Pacific islands. Observations presented in this paper tended to indicate that studies relating to basking might be successfully carried out using juvenile animals held in captivity.

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GEORGE H. BALAZS, *Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, Hawaii 96744* and ERNEST ROSS, *Department of Animal Sciences, University of Hawaii, Honolulu, Hawaii 96822.*

SURVIVAL RATE OF THE GREEN TURTLE, *CHELONIA MYDAS*, NECESSARY TO MAINTAIN STABLE POPULATIONS.—There has recently been a spate of popular accounts pertaining to survival rates of marine turtles in nature. No doubt some of this publicity has been brought about by the belief that certain marine turtles are excellent candidates for marine farming or ranching. Herein we discuss the minimal natural survival rates of *Chelonia mydas* necessary to maintain stable populations. Data provided here may be helpful in evaluating future management and conservation programs involving these endangered reptiles.

One of the best known aspects of the green turtle's life history pertains to the fecundity of adult females (for literature review, see Hirth, 1971). Most green turtles lay between 4 and 6 clutches per season at 10 to 15-day intervals. The number of eggs per clutch averages slightly in excess of 100. Hatching success seems to vary in different parts of the world, but limits of from 50% to 75% would include most of the work reported in the scientific literature (Hirth, 1971). Thus, assuming an equal sex ratio, each adult female produces 100 to 225 female hatchlings per nesting season. Females surviving beyond the first nesting season usually

renest every 2 or 3 years. Survival rates between nesting periods are not well-known, but in areas where adult female turtles are exploited on their nesting beaches and on their feeding pastures, survival rates between nesting seasons probably fall between 0 and 50%. Adult male survival probably exceeds that of adult females as males rarely leave the water and hence are not subject to predation on the beaches.

If a turtle population is to remain constant in size, each female must replace herself, i.e., leave one surviving female offspring. By assuming different between-nesting survival rates among adult females, we can calculate the survival rates among immatures (from hatching to first laying) necessary to maintain constant numbers. In making these calculations, we will assume equal mortality in both sexes before first laying, and survival rates among adult males sufficient to achieve fertilization of all females returning to breed.

Let B equal the number of female hatchlings produced by an adult each season. Also let C equal the survival rate of hatchlings to reproductive maturity, and P the survival rate of adult females between nestings. Then, if population size is constant,

$$1 = CB + CBP + CBP^2 + \ldots + CBP^w \quad 1)$$

where because of aging, a female can reproduce at most $w + 1$ times (see Connell et al., 1970:4–17, for an introduction to the mathematics of population growth). Notice that, for the moment, we assume that C, B, and P are independent of age and constant in time.

When the maximum number of spawnings is small, equation 1) can be solved directly for C. For example, if a female can only breed once, $C = 1/B$; if two breedings are possible, $C = 1/\{B(1 + P)\}$; etc. If the maximum number of layings is quite large, we can calculate C by noting that equation 1) can be rewritten

$$1 = CB \sum_{i=0}^{\infty} P^i \qquad 2)$$

Then, since P is by definition less than 1,

$$1 = CB \{1/(1 - P)\} \qquad 3)$$

or

$$C = (1 - P)/B \qquad 4)$$

Using these techniques, we have constructed Fig. 1 in which the number of

hatchlings per thousand that must survive through the first nesting season is plotted against the survival rate of adult females between nestings. Two situations, which we feel represent the upper and lower limits of female fecundity, are considered—400 eggs laid in a season with a 50% hatch, and 600 eggs laid with a 75% hatch. In addition, we have indicated the effects of aging by placing upper limits on the number of times a female can nest. The figure shows, as expected, that the required survival rate among immatures decreases as adult survival and clutch size increase. Thus, if females breed only once, and during this season produce 400 eggs of which 50% hatch, a hatchling survival rate of 10 per 1000 is required to maintain a stable population. On the other hand, if females can breed up to three times with a 50% mortality rate after the first and second breedings, and in each breeding season produce 600 eggs of which 75% hatch, then only 2.5 hatchlings per 1000 need survive to adulthood. Increasing the maximum number of seasons in which a female can breed (if she survives) does not measurably lower this figure. In the limiting case where an infinite number of breedings can occur, the necessary survival rate for hatchlings would be 2.2 per 1000. This slight reduction reflects the fact that as long as between-nesting mortality does not decline with age, the chances of females surviving to breed more than 3 or 4 times are quite small.

It is important to emphasize that these calculations probably underestimate the minimum survival rate among hatchlings to maintain a stable population. This follows from our assumption that the life history statistics, **B**, **C** and **P** do not fluctuate from year to year. Such an assumption is clearly unrealistic and, since population growth is a multiplicative process, ignoring such variations leads to a calculated value of **C** smaller than that necessary to ensure long-term population survival (Lewontin and Cohen, 1969). Such effects are likely to be particularly important in small populations.

Also, on some islands, the extent of suitable nesting sites may be small compared to the number of turtles laying eggs. In such cases late arriving females may uncover and destroy eggs laid by earlier nesters. As a consequence, hatching success could be even less than our lower limit of 50% and thus our estimates of the hatchling survival rates
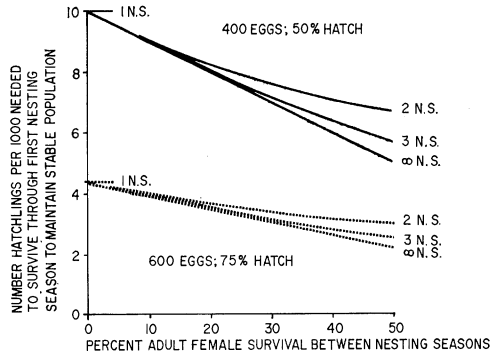

Fig. 1. Survivorship of hatchlings necessary to maintain a stable green turtle population. (N.S. = Nesting Season/s) Solid lines and dotted lines refer to 200 and 450 hatchlings respectively per nesting season.

necessary to maintain constant populations would also be too low. However, barring compensatory reductions in mortality at other stages in the life cycle, high numbers of nesting females and high rates of egg destruction would not persist indefinitely because of density dependent nest destruction (Bustard and Tognetti, 1969).

In conclusion, it appears that even in constant environments no less than 2.2, and perhaps as many as 10, hatchlings per 1000 must survive to reproductive maturity to maintain stable green turtle populations. These figures should not be construed to mean, however, that it is sufficient to return two hatchery-reared yearlings to the sea for every adult female harvested at the end of her first nesting season. Before one can even begin to estimate the magnitude of stocking needed, it is necessary to determine survival rates for the different age classes—both hatchery-reared and natural—in the sea. Furthermore, it is essential to determine whether or not hatchery-reared turtles will follow a natural life cycle when released.

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HAROLD F. HIRTH AND WILLIAM M. SCHAFFER, *Department of Biology, University of Utah, Salt Lake City, Utah 84112.*

WEIGHT CHANGE, SURVIVAL RATE AND HOME RANGE CHANGE IN THE BOX TURTLE, *TERRAPENE CAROLINA.*—A field study was conducted on the eastern box turtle, *Terrapene carolina carolina* L., from August–October 1972. The objectives were to determine individual weight changes, survival rates and fluctuations in home range in a population of box turtles studied in 1968–69 (Dolbeer, 1969).

The study plot was composed of a 9.3-hectare tract of deciduous forest on the Cherokee Woodlot of The University of Tennessee. Dolbeer (1971) offers a good botanical and topographical description of the area.

Individual turtle weights were taken using a spring scale. Capture location to the nearest meter was recorded. File markings were recorded if present on the marginal scutes which were used by Dolbeer as a method of identification. The file cuts were readily discernible and were valuable in determining the survivors from the 1968–69 study. Sex was recorded based on plastron depression and eye color (Stickel, 1950).

Approximately 78% of the total population of turtles recovered from the 1968–69 study exhibited less than a 10% weight change (Fig. 1). These may represent the mature segment of the population which has remained relatively stationary in weight for a period of four years (Cluster A).

No turtles exceeded a 10% loss in weight since 1968–69, but many turtles demonstrated greater than a 10% weight gain in four years. These turtles comprise Cluster B.

The weights of turtles in Cluster A range from 250–475 g. Thus, there is apparently no definite weight which acts as an indicator of age. A turtle found in Cluster A weighing 250 g or one weighing 475 g may possibly be the same age.

The number of turtles recovered in 1972

TABLE 1. NUMBER OF TURTLES RECOVERED IN 1972 ACCORDING TO WEIGHT CLASS FROM 1968–69.

Weight Class (g) from 1968–69	Number Found in 1968–69	Number Recovered in 1972	% Recovery
0–50	3	1	33.3
51–100	5	0	0.0
101–150	9	3	33.3
151–200	13	2	15.3
201–250	24	8	33.3
Total	54	14	25.9
251–300	39	16	41.0
301–350	93	43	46.2
351–400	74	30	40.5
401–450	26	10	38.4
451–500	3	1	33.3
Total	235	114	42.5

from the 1968–69 study was compared to the number of turtles found in 1968–69 (Table 1). Survival rate was determined for each weight class by calculating a per cent recovery. The total recovery rate for all classes was 39.4%. Assuming four years have elapsed from the 1968–69 study to the 1972 study, there is an approximate 79.5% survival rate per year for all ages.

Turtles weighing less than 250 g are still growing (Fig. 1). Therefore, turtles exceeding 250 g in weight are considered "large" turtles, most of which are mature. Turtles below 200 grams in weight are designated as "small" turtles. If the turtles in the 201–250 g weight class is considered the transitional class, the differential survivalship between "small" turtles (21.0%) and "large" turtles (42.5%) can be obtained by the % recovery data (Table 1). However, X^2 is not significant (3.71, if the 201–250 g weight class is not included). Therefore, there is no significant difference in survival between "small" turtles and "large" turtles.

The sex ratio of the 1968–69 turtles was compared to that found in 1972 (Table 2). A contingency test on this data resulted in $X^2 = 5.07$. It appears that a differential higher mortality for females has occurred.

Dolbeer (1969) calculated an average home range diameter of 74.4 m. A displacement in location of capture from 1968–69 to 1972 greater than two average diameters of home range (148.8 m) was classified as a major change in home range. Only 2.8% of the