Insights into the Ecology of Hatchlings of the Green Turtle, *Chelonia mydas* : Implications for the Life Histories of the Marine Turtles.

Thesis submitted by

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DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for a degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

E Gyuris
28 March 1993

Note: Part of the work presented in Chapter 3 is to be published by the journal "Coral Reefs" under the title "The rate of predation by fishes on the hatchlings of the green turle (*Chelonia mydas*)." Part of the work presented in Chapter 4 has been published under the title "Factors controlling the timing of green turtle hatchling emergence from the nest" Wildlife Research 20(3): 345-353

PERMITS

Appropriate permits and approvals to carry out the experimental work described in this thesis were granted by the following state and federal agencies and authorities: Queensland National Parks and Wildlife Service; Fisheries Branch, Queensland Department of Primary Industries; the Great Barrier Reef Marine Park Authority and The James Cook University of North Queensland Animal Research Ethics Committee.

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ABSTRACT

By reviewing the literature, I examined the validity of earlier explanations of the differences in body size, fecundity and other life history parameters amongst testudines. I concluded that while many life history parameters, such as survivorship, growth and age to maturity are similar for marine, terrestrial and freshwater turtles, the large body size and high fecundity of marine species are exceptional. In general, high fecundity is considered to occur because of high mortality during the early life stages. Yet, mortality of sea turtles to one year of age has been considered to be significantly lower than that of the less fecund freshwater turtles. Estimates of mortality however were based largely on beach-based studies as few empirical data on hatchling survival after entry into the sea have been available.

This study quantified survivorship of hatchlings after entry into the sea and during reef crossing at Heron and North-West Islands, two coral cays at the southern end of the Great Barrier Reef. Predation rates were quantified by two independent methods.

The first method involved following individual hatchlings (n=1740) tethered by a 10 m monofilament nylon line, as they swam from the water's edge towards the reef crest. Predation rates under particular combinations of environmental variables (tide, time of day, and moon phase) were measured in 84 separate, 10 minute trials, with 20 hatchlings in each. Predation rates varied from 0 to 85% with a mean of 31% (S. E. ± 2.5%).

A series of nested logistic regression models was used to examine the effect of the environmental variables. Tide and moon phase had a significant effect on predation rate: Predation was lowest during the combination of new moon and high tide and was highest during low tide around the full moon.

The second method estimated hatchling mortality by quantifying, from a collection of 232 reef fishes, the proportion whose foreguts contained turtle hatchlings. Of the 89 fishes which had identifiable stomach contents, hatchlings were found in the guts of six specimens of *Lutjanus carponotatus* and one of *Epinephelus spp.* Extrapolating from data obtained in an unrelated study on the biomass of these species per unit area of reef flat, I estimated that these two species together consumed approximately 3800 (95% confidence interval 1593-7220) hatchlings, or 84% (42 - 100%) of the hatchlings that had entered the water during the study period. Around full moon, the same lunar phase during which the fish were collected by spearing, predation rates obtained by the tethering experiments varied, depending on the state of the tide, between 30-70%.

Although predation rates were significantly influenced by environmental variables, no correlation could be found between the timing of emergence from the nest and periods of reduced risk of predation in the water. Frequency distribution of emergence events were similar between nights that differed markedly in the times of high and low tides (Kolmogorov-Smirnov two sample test statistic = 0.20, p = 0.68).

Three possible models predicting the timing of emergence were generated and tested against the observed pattern. Hatchlings did not emerge uniformly throughout the diel cycle (Uniform emergence model, $X^2 = 59.986$, df = 6, $p < 0.001$) but emerged primarily in the early evening. The timing of emergence was found to be associated with changes in sand temperature gradients within the top ten centimeters of the sand column (Thermal gradient model, $X^2 = 4.239$, df = 3, $p \approx 0.25$) and not, as previously believed, by a given temperature of the surface of the sand (Threshold model, $X^2 = 12.736$, df = 4, $p < 0.025$) . I concluded that nocturnal emergence is more likely an adaptation to reduce mortality caused by physiological stress of the day time heat than a predator avoidance mechanism. These findings were supported by experimental manipulation of temperature gradients within the top 10 cm of the sand column in an artificial hatchery.

Behavioral and morphological adaptations increasing survivorship after the hatchlings enter the water were identified: 1) qualitative observations suggest that rapid early dispersal of hatchlings increases their probability of survival; 2) experimental trials showed that predation was significantly greater upon hatchlings painted black on the ventral surface than on those displaying the natural, countershaded pattern (McNemar's symmetry test , $X^2 = 6.231$, df = 1, $p = 0.013$).

Using a population model based on the Lefkovitch stage class matrix, the intrinsic growth rate of the eastern Australian green turtle population was found to be more sensitive to changes in survivorship in the pelagic and juvenile stages than to changes in any other stages of the life cycle. This is primarily due to the relatively low annual survivorship and the associated long duration of those two stages. Change in hatchling survivorship in the shallow water reefal habitats was also found to have a significant effect on the intrinsic growth rate of the population and was similar in effect to the doubling of fecundity. Restricting the release of hatchlings to periods of high tides would result in an approximately 2 % increase in annual population growth rate.

Sea turtle biologists consider that hatchlings spend as short a time as possible in nearshore waters because of the high predation pressure in those habitats. The results of this study lend substantial support to that view. However, one species, *Natator depressus*, the only species of sea turtle without a pelagic phase in its life cycle, has apparently overcome the problem of predation in shallow water coastal habitats by producing larger, but fewer, hatchlings. No other sea turtle has taken up this evolutionary option and the costs and benefits of a life cycle involving a pelagic phase remain subject to speculation.

QUOTATION.

"I should not perhaps have got 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 packed with ecology and evolution. There are so many factors 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 turtle does, or that happens to it, is to some degree reflected in the number of eggs that the female drops into the hole she digs in the sand."

(The eloquent words of the late Archie Carr, in his classic chapter titled "A Hundred Turtle Eggs" In : So Excellent a Fishe, Anchor Natural History Books, 1973)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES