GREEN TURTLE SOMATIC GROWTH MODEL: EVIDENCE FORDENSITY DEPENDENCE

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Abstract. The green turtle, *Chelonia mydas,* is a circumglobal species and a primary herbivore in marine ecosystems. Overexploitation as a food resource for human populations has resulted in drastic declines or extinction of green turtle populations in the Greater Caribbean. Attempts to manage the remaining populations on a sustainable basis are hampered by insufficient knowledge of demographic parameters. In particular, compensatory responses resulting from density-dependent effects have not been evaluated for any sea turtle population and thus have not been explicitly included in any population models.

Growth rates of immature green turtles were measured during an 18-yr study in Union Creek, a wildlife reserve in the southern Bahamas. We have evaluated the growth data for both straight carapace length (SCL) and body mass with nonparametric regression models that had one response variable (absolute growth rate) and five potential covariates: sex, site, year, mean size, and recapture interval. The SCL model of size-specific growth rates was a good fit to the data and accounted for 59% of the variance. The body-mass model was not a good fit to the data, accounting for only 26% of the variance. In the SCL model, sex, site, year, and mean size all had significant effects, whereas recapture interval did not.

We used results of the SCL model to evaluate a density-dependent effect on somatic growth rates. Over the 18 yr of our study, relative population density underwent a sixfold increase followed by a threefold decrease in Union Creek as a result of natural immigration and emigration. Three lines of evidence support a density-dependent effect. First, there is a significant inverse correlation between population density and mean annual growth rate. Second, the condition index (mass/$(SCL)^3$) of green turtles in Union Creek is positively correlated with mean annual growth rates and was negatively correlated with population density, indicating that the green turtles were nutrient limited during periods of low growth and high population densities. Third, the population in Union Creek fluctuated around carrying capacity during our study and thus was at levels likely to experience density-dependent effects that could be measured.

We estimate the carrying capacity of pastures of the seagrass *Thalassia testudinum,* the major diet plant of the green turtle, as a range from 122 to 4439 kg green turtles/ha or 16–586 million 50-kg green turtles in the Caribbean. Because green turtle populations are probably regulated by food limitation under natural conditions, carrying capacity can serve as a baseline to estimate changes in green turtle populations in the Caribbean since pre-Columbian times and to set a goal for recovery for these depleted populations.

Finally, we compare the growth functions for green turtle populations in the Atlantic and Pacific oceans. Not only does the form of the size-specific growth functions differ between the two regions (monotonic declining in the Atlantic and nonmonotonic in the Pacific), but also small juvenile green turtles in the Atlantic have substantially higher growth rates than those in the Pacific. Research is needed to evaluate the causes of these differences, but our results indicate that demographic parameters between ocean basins should only be extrapolated with great caution.

Key words: Australia; Bahamas; carrying capacity; Chelonia mydas; *demography; density-dependent effect; green turtles; growth models; growth rate; marine turtles; nonparametric regression; sustainable use.*