
DENSITY AND SIZE CLASS DISTRIBUTION OF YELLOW-BELLIED SLIDERS (*TRACHEMYS SCRIPTA SCRIPTA*) INHABITING TWO BARRIER ISLAND WETLANDS

BRETT A. DEGREGORIO¹, ANDREW M. GROSSE, AND J. WHITFIELD GIBBONS

Savannah River Ecology Lab, University of Georgia, Drawer E, Aiken, South Carolina 29802, USA

¹Corresponding author, e-mail: Baretta66@hotmail.com

Abstract.—An abundance of physical barriers and physiological challenges often prevent reptile and amphibian species from arriving at, and subsequently colonizing, barrier islands. Despite the high diversity of herpetofauna in the southeastern United States, only a small subset of those species persist on the myriad of barrier islands present just offshore. The Yellow-bellied Slider (*Trachemys scripta scripta*) is a versatile habitat generalist that can often be found in freshwater wetlands on barrier islands. We used a mark-recapture approach to study the population size and demographics of two populations of Yellow-bellied Sliders on two barrier islands. The estimated turtle density of 2,200/ha on Bald Head Island, North Carolina, USA is the highest yet reported in the literature and is much higher than that of Capers Island, South Carolina, USA (387/ha). Furthermore, turtles of both sexes captured on Bald Head constituted a wide range of size classes; whereas, those on Capers Island were mostly female (3f:1m) and were significantly larger (plastron length). Selective predation between size classes or sexes can be an important driver of turtle population dynamics and behavior and we suggest that the abundance of large American Alligators (*Alligator mississippiensis*), an important turtle predator, present on Capers Island is likely responsible for the absence of small size classes of Yellow-bellied Sliders from this wetland.

Key Words.—barrier islands; demographics; freshwater turtles; predation pressure; population density

INTRODUCTION

The southeastern coast of the United States supports a high diversity of herpetofauna (Conant and Collins 1991; Gibbons and Dorcas 2005; Buhlmann et al. 2008); however, many of these reptile and amphibian species are often absent from adjacent barrier islands (Hillestad et al. 1975; Gibbons and Coker 1978). Barrier islands are separated from the mainland by rivers or salt marsh, which act as formidable barriers for would-be herpetofaunal colonizers. If and when reptile and amphibian species do reach barrier islands, they often encounter inhospitable conditions including the absence of standing freshwater, highly porous and saline soils, erosion, salt spray, and exposure to extreme episodic storm events (i.e., hurricanes and nor'easters) all of which characterize this highly dynamic environment. Perhaps because of their rarity, little is known about the ecology and population dynamics of herpetofauna that do successfully colonize barrier islands.

The Yellow-bellied Slider (*Trachemys scripta scripta*) is one reptile species shown to be successful in colonizing many southeastern barrier islands (Engels 1942; Gibbons and Coker 1978). The Yellow-bellied Slider is a versatile habitat generalist, regularly occupying lakes, swamps, farm ponds, canals, sloughs, reservoirs, and urban wetlands (Ernst and Lovich 2009).

Where present, this species is conspicuous and can attain high population densities (Rose and Manning 1996; Dreslik et al. 2005; Reehl et al. 2006) making it a model organism for population studies (Gibbons 1990). The relatively few studies investigating barrier island populations of the Yellow-bellied Slider have revealed high population biomass (Congdon et al. 1986), rapid individual growth rates (Gibbons et al. 1979), and larger female body sizes (Gibbons et al. 1979); indicating that populations on barrier islands may use different resources and operate under different limitations and thresholds than mainland populations.

More detailed investigations of the population sizes and demographics of sliders may yield valuable insight into the underlying mechanisms driving population dynamics. For example, population trajectory can often be derived from a study of the demographics of resident turtles. Absence or scarcity of smaller size classes may indicate high levels of selective predation on smaller individuals (Dorcas et al. 2007) or lack of suitable nesting habitat (Spinks et al. 2003; Marchand and Litvaitis 2004) and suggest a declining and vulnerable population. The scarcity of reproductively mature females can indicate terrestrial dangers (road mortality or predation) associated with nesting forays (Congdon et al. 1994; Aresco 2005; Steen et al. 2006).

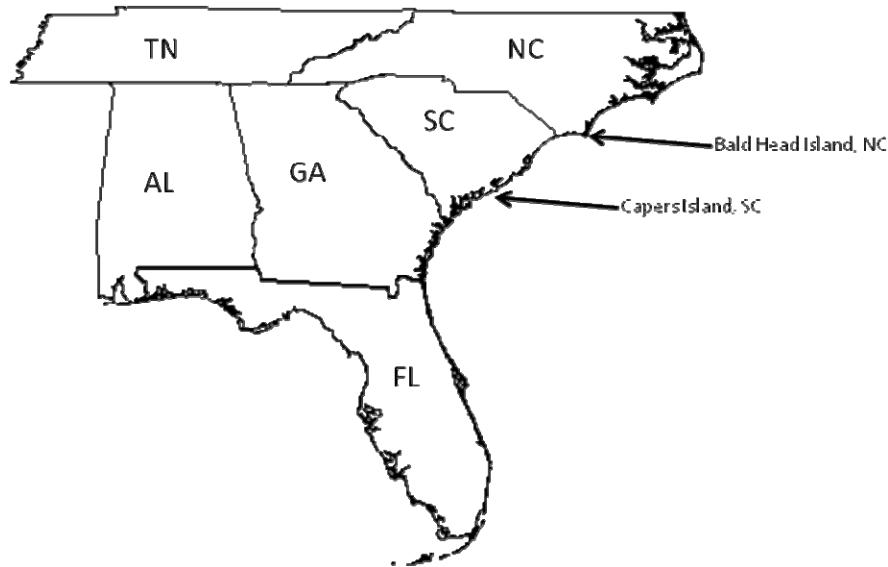


FIGURE 1. Location of Bald Head Island, North Carolina and Capers Island, South Carolina, USA. Yellow-bellied Sliders (*Trachemys scripta scripta*) were studied at both locations.

Furthermore, information about the density or population size, combined with demographics, can yield insight into the quality of available habitat and the impact of surrounding land use practices (Marchand and Litvaitis 2004). Such demographic studies of slider turtles may be especially interesting on barrier islands, as faunal community composition and selective pressures may be different from those acting on mainland populations. Herein, we present data from populations of Yellow-bellied Sliders inhabiting two barrier island wetlands located on Bald Head Island, North Carolina and Capers Island, South Carolina. Our objectives are to: (1) use mark-recapture techniques to estimate population sizes, densities, and sex ratios for sliders inhabiting these two wetlands; (2) compare the size class distributions and sex ratios of populations between the two wetlands; and (3) compare our results with those from similar studies in mainland wetland habitats.

MATERIALS AND METHODS

Study sites.—We studied slider populations in two freshwater wetlands located on two different barrier islands (Fig. 1). Capers Island (hereafter referred to as CI) is located near Charleston, South Carolina, USA (32°52'N, 79°40'W). The wetland studied on CI is approximately 0.15 ha and is largely devoid of floating aquatic plants or floating mats of vegetation. Although occasionally inundated during severe storms, the salinity

of the wetland is less than 10 ppt. The island is undeveloped and the wetland is surrounded by maritime forest.

The other wetland studied is located on Bald Head Island (BHI), North Carolina, USA (33°50'N, 78°00'W). BHI is largely forested with moderate development and currently supports approximately 1,200 homes, a public marina, and a golf course. No standing, permanent freshwater wetlands naturally occur on BHI, including the wetland we studied, which was built as part of the golf course in 1983. The wetland is approximately 0.11 ha, is also largely devoid of aquatic plants or floating mats of vegetation, and is encircled by a narrow buffer of maritime forest. Beyond the buffer strip are a manicured golf course, a paved two-lane road, and residences with forested yards.

Data collection and analysis.—We collected turtles on CI at least once per year (range: 1–3 times, mean = 1.6 sampling periods) from May 1978 to January 1986 and on BHI at least once per month (range: 1–7, mean = 3.5 sampling periods) from April 2009 to July 2010. We collected turtles using a combination of muddling for buried individuals (Cagle 1950), dip-netting and cast-netting of swimming individuals, seining, hand-capture of basking individuals, and hand capture of turtles making overland movements for nesting purposes. Using secondary sex characteristics such as claw and tail length (Ernst and Lovich 2009), we identified each captured individual as either male or female. We filed unique notch combinations into the marginal carapace

TABLE 1. Reported densities of Yellow-bellied Sliders (*Trachemys scripta*) from published literature.

Density	Location	Habitat	Citation
28/ha	Texas	Pond	Ingold et al. 1986
42/ha	South Carolina	Farm Pond	Congdon et al. 1986
57/ha	Illinois	Pond	Dreslik et al. 2005
58/ha	Chiapas, Mexico	Pond	Dean 1980
61.5/ha	South Carolina	Carolina Bay	Congdon et al. 1986
190/ha	Panama	River	Moll and Legler 1971
247/ha	Texas	Farm Pond	Rose and Manning 1996
333/ha	Texas	Farm Pond	Rose and Manning 1996
361/ha	Florida	Pond	Auth 1975
387/ha	South Carolina	Island Lagoon	Our findings
513/ha	Texas	Farm Pond	Rose and Manning 1996
983/ha	Texas	Farm Pond	Rose and Manning 1996
2,200/ha	North Carolina	Golf Course Pond	Our findings

scutes to unambiguously mark each individual. Using calipers, we measured the straight line plastron length of each turtle and when possible aged them by counting growth rings on their plastron scutes when visible.

We calculated the mean number of captures for each individual encountered during the study periods. To calculate population sizes based on our mark-recapture data, we assumed closed populations at each location. We used the pre-defined models provided in Program CAPTURE within Program Mark (White and Burnham 1999) to determine the most appropriate model to generate slider abundance estimates for each of our study wetlands. At CI we combined sampling periods to assume one sampling period per year; whereas, at BHI we combined sampling periods and assumed one sampling period per month for the duration of the study. We defined the aquatic habitat as the approximate area of standing water present over the period of study. We then delineated the boundary of each wetland using ArcMap 9.3 (ESRI Inc., Redlands, California, USA) and calculated the area of each wetland by digitally tracing the outline of the wetlands on contemporary orthophotos (obtained from USGS, Seamless Server, 2011, <http://usgs.seamless.gov>). We calculated the density of turtles within each wetland by dividing the estimated population size by the wetland size.

For each wetland, we placed individuals into size classes with 20-mm intervals (plastron length) and calculated size class distributions for all sliders and again for each of the sexes. To determine if the size class distribution of sliders was different between the two wetlands, we used Chi-square analysis. To determine if sex ratios deviated from a 1:1 ratio, we used a McNemar's test. We used a t-test to compare the mean plastron length of individuals from BHI to those of CI. For all tests, $\alpha = 0.05$.

RESULTS

We captured 60 individual Yellow-bellied Sliders 254 times on CI and 163 individuals 355 times on BHI. Each turtle on CI was captured an average of 4.2 ± 0.04 (± 1 SE) times, while those on BHI were captured an average of 2.1 ± 0.01 times. The female to male sex ratio on BHI was 1f:1.06m and did not differ statistically from the expected sex ratio of 1:1 ($\chi^2 = 0.06$, $P = 0.81$). The female to male sex ratio on CI was 3.07:1 and was different than an expected 1:1 ratio ($\chi^2 = 10.16$, $P < 0.001$). Sliders on CI had larger mean plastron lengths (236 ± 4.90 mm) than those captured on BHI (193 ± 3.15 mm; $t = 7.33$, $df = 212$, $P < 0.001$).

Based on our results from Program CAPTURE, the most appropriate model for determining the abundance of Yellow-bellied Sliders on CI was the predefined model that allows for temporal and heterogeneity changes in a closed population, while the best model for determining the abundance of Yellow-bellied Sliders on BHI was the predefined model dependent on temporal changes. Using these models, we estimated the Yellow-bellied Slider population size to be 242 individuals (SE = 15.18; 95% CI = 218–278) for BHI and 58 (SE = 3.22; 95% CI = 55–68) for CI. Extrapolating these population estimates outwards, we calculated a density of 2,200 sliders/ha for BHI and of 387 sliders/ha for CI.

Chi-square analysis indicated that the size class distribution of sliders captured in the two wetlands were unequal ($\chi^2 = 233.64$, $P < 0.001$). On BHI, captured individuals represented a full range of size classes ranging from 80 to 260 mm (Figure 2a). On CI, turtles below 160 mm were relatively uncommon, with the majority of captured turtles larger than 220 mm in length, a size greater than all but the largest females captured on BHI.

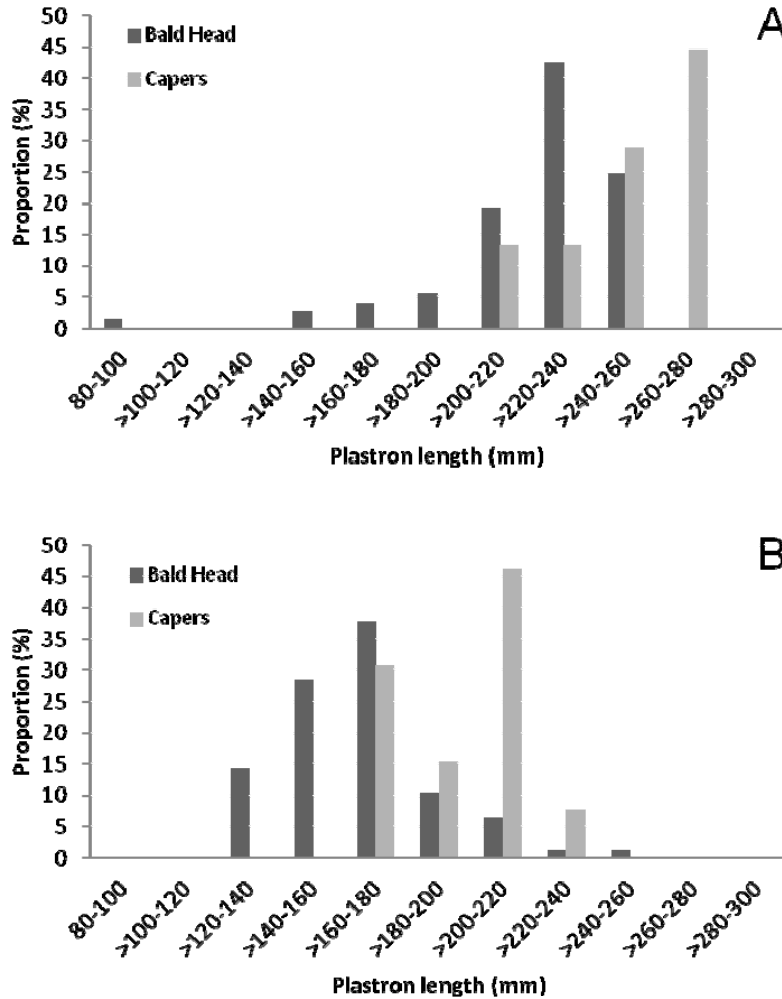


FIGURE 2. Size class distribution of (A) female and (B) male Yellow-bellied Sliders (*Trachemys scripta*) captured on Bald Head Island, North Carolina and Capers Island, South Carolina, USA.

DISCUSSION

This study presents data on a large number of Yellow-bellied Sliders from two very dissimilar populations inhabiting two similarly sized barrier island wetlands. Because relatively little research has focused on the herpetofauna inhabiting barrier islands, these findings present novel insight regarding the population dynamics of freshwater turtle populations residing within these unique ecosystems. Despite the nearly equal sizes of the two wetlands (0.11 ha and 0.15 ha), the estimated population sizes of sliders are markedly different. The wetland on BHI contained an estimated 242 sliders compared to 58 on Capers Island resulting in respective estimated densities of 2,200/ha and 387/ha. Other reported densities of sliders may vary considerably

between wetlands and geographic regions (Table 1), although caution must always be used in determining population sizes of turtle species because of the effects of immigration and emigration (Burke et al. 1995). Reported densities of Yellow-bellied Sliders in the United States range from 28/ha (Ingold et al. 1986) and 57.6/ha (Dreslik et al. 2005) to as high as 513/ha and 983/ha (Rose and Manning 1996).

The reported density of 2,200/ha of turtles on BHI is the highest density yet reported in the literature for this species (but see Brown and Haver 1952 who captured 81 sliders in a 3.6-m long roadside culvert); however, density of slider turtles can fluctuate dramatically from year to year. For instance, Rose and Manning (1996) reported a slider density of 983/ha for a West Texas pond in one year and 333/ha in the same pond the

following year. Density likely fluctuates as a function of resource availability, habitat quality, and water levels. Rose and Manning (1996) hypothesized that their observed reduction in density may have been a result of turtles avoiding their trapping efforts. Additionally, there may be variation in estimates resulting from the analyses employed between studies. Because the wetland on BHI is an artificial wetland created approximately 30 y ago, this is likely a young population that is still growing. Early biological surveys of BHI indicated that no slider turtles were present (Lewis 1946), suggesting the turtles likely colonized at some point after the golf course wetlands were created.

Thus, although density at BHI is currently very high, further monitoring is needed to observe long-term changes to this population. Density on CI, an established natural wetland, did not appear to change over the duration of the sampling period. Most turtles were captured multiple times (mean = 4.2) and only four unmarked turtles were captured after the first two years of study.

The most interesting aspect of our results was the observed difference in size class distribution between the two wetlands. The size class distribution of a population of turtles varies according to environmental quality, predatory pressures (including harvest), and numerous other variables (reviewed in Ernst and Lovich 2009). The wetland on BHI contained a more complete range of size classes than did CI. In fact, turtles on CI tended to be larger and were more likely to be female than turtles captured on BHI. Because female sliders are considerably larger than males (Ernst and Lovich 2009), sexual dimorphism likely accounts for some of the discrepancy in size of individuals between the two wetlands. Understanding the mechanism responsible for the difference in size class distribution between the two wetlands may aid in understanding the discrepancy in density and sex ratios between the wetlands. Population size and density of freshwater turtles in the Southeast can be driven by bottom-up processes (resource availability), top-down pressures (predation), or a combination of the two (Aresco 2009). We suggest that because the two wetlands are similarly sized and superficially similar, differences in density and size class distribution between the study areas were driven by predation, namely by the American Alligator (*Alligator mississippiensis*).

Selective predation between size classes or sexes can be an important driver of turtle population dynamics and behavior (Gibbons and Lovich 1990; Tucker et al. 1999). For instance, if traps are considered analogous to gape-limited predators, crab pots have selectively removed smaller size classes from certain Diamondback Terrapin (*Malaclemys terrapin*) populations (Dorcas et al. 2007). Likewise, mortality associated with roads has removed

significant portions of adult females from certain turtle populations (Aresco 2005; Steen et al. 2006). In some Florida wetlands, the presence of alligators has been shown to impact the population size of resident turtles (Aresco 2009), although no mention is made of the impact on the size class distribution. The wetland studied on CI is always inhabited by at least one very large (3–4 m) American Alligator along with numerous smaller individuals (pers. obs.). Alligators are an important predator of turtles across the Southeast (Valentine et al. 1972; Barr 1997; Delaney and Abercrombie 1986) and have been commonly found on CI since attaining legal protection under the Endangered Species Act of 1972 (pers. obs.). We suggest that the constant presence of alligators in the CI wetland has led to a removal over time of smaller, more vulnerable sex and size classes of Yellow-bellied Sliders. Slider turtles studied on nearby Kiawah Island, an island with a significant alligator presence, have also been shown to be significantly larger than expected (Gibbons et al. 1979). Conversely, BHI with its relatively new wetlands, has a smaller population of alligators. Alligators, like Yellow-bellied Sliders, likely became established on Bald Head after the construction of the golf course and were first documented breeding on the island in 2007 (unpubl. data). Not every wetland on BHI has resident alligators and alligators are often documented moving between wetlands. Furthermore, most of the alligators on BHI are small to medium-sized (1–2 m); larger males are often removed from the island by local police when they are considered a threat to human residents. Relaxed predation pressure on BHI likely allows for higher slider densities and greater parity among size classes. Continued monitoring of the Yellow-bellied Slider and American Alligator populations on BHI may reveal a decrease in turtle abundance and a shift in their size class distribution as alligators become larger and more abundant.

Acknowledgments.—Thanks to everyone who assisted in turtle capture and marking on Bald Head Island especially Jacob Hill, Patrick Barnhart, Eric Nordberg, Mary Mack Gray, David Kurz, Tom Hancock, Katherine Stepanoff, Kara Campbell, Meredith Atwood, and Kevin Coon. We thank the numerous individuals who have assisted in the capture of slider turtles on Capers Island, in particular Judy Greene, Steve Bennett, the late Julian Harrison, and Laura Gibbons who caught the first one in 1978. The Bald Head Island Property Owners Association and Bald Head Island Club graciously allowed us access to the wetland on BHI. Manuscript preparation was aided by the Environmental Remediation Sciences Division of the Office of Biological and Environmental Research, U.S. Department of Energy through the Financial Assistance

Herpetological Conservation and Biology

Award no. DE-FC09-96SR18546 to the University of Georgia Research Foundation. Turtle collecting was conducted under permit number 10-SC00408.

LITERATURE CITED

- Aresco, M.J. 2005. The effect of sex-specific terrestrial movements and roads on the sex ratio of freshwater turtles. *Biological Conservation* 123:37–44.
- Aresco, M.J. 2009. Environmental correlates of the abundances of three species of freshwater turtles in lakes of northern Florida. *Copeia* 2009:545–555.
- Auth, D.L. 1975. Behavioral ecology of basking in the yellow-bellied turtle, *Chrysemys scripta scripta* (Schoepff). *Bulletin of the Florida State Museum of Biological Science* 20: 1–45.
- Barr, B.R. 1997. Food habits of the American Alligator, *Alligator mississippiensis*, in the southern Everglades. Ph.D. Dissertation. University of Miami, Miami, Florida, USA. 243 p.
- Brown, B.C., and J. Haver. 1952. An unusually large congregation of turtles. *Herpetologica* 8:2.
- Buhlmann, K.A., T.D. Tuberville, and J.W. Gibbons. 2008. *Turtles of the Southeast*. University of Georgia Press, Athens, Georgia, USA.
- Burke, V.J., J.L. Greene, and J.W. Gibbons. 1995. The effect of sample size and study duration on metapopulation estimates for Slider Turtles (*Trachemys scripta*). *Herpetologica* 51:451–456.
- Cagle, F.R. 1950. The life history of the Slider Turtle, *Pseudemys scripta troostii* (Holbrook). *Ecological Monographs* 20:31–54.
- Conant, R., and J.T. Collins. 1991. *A Field Guide to Reptiles and Amphibians: Eastern and Central North America*. Houghton Mifflin Company, Boston New York, USA.
- Congdon, J.D., A.E. Dunham, and R.C. Van Loben Sels. 1994. Demographics of Common Snapping Turtles (*Chelydra serpentina*): implications for conservation and management of long-lived organisms. *Integrative and Comparative Biology* 34:397–408.
- Congdon, J.D., J.L. Greene, and J.W. Gibbons. 1986. Biomass of freshwater turtles: a geographic comparison. *American Midland Naturalist* 115:165–173.
- Dean, R.H. 1980. Selected aspects of the ecology of the Central American mud turtle, *Staurotypus salvinii*. M.S. Thesis, Texas A&M University, College Station, Texas, USA. 53 p.
- Delany, M.F., and C.L. Abercrombie. 1986. American Alligator food habits in north central Florida. *The Journal of Wildlife Management* 50:348–353.
- Dorcas, M.E., J.D. Willson, and J.W. Gibbons. 2007. Crab trapping causes population decline and demographic changes in Diamondback Terrapins over two decades. *Biological Conservation*, 137: 334–340.
- Dreslik, M.J., A.R. Kuhns, and C.A. Phillips. 2005. Structure and composition of a southern Illinois freshwater turtle assemblage. *Northeastern Naturalist* 12:173–186.
- Engels, W.L. 1942. Vertebrate fauna of North Carolina coastal islands. *American Midland Naturalist*. 25:273–304.
- Ernst, C.H., and J.E. Lovich. 2009. *Turtles of the United States and Canada*. Johns Hopkins University Press, Baltimore, Maryland, USA.
- Gibbons, J.W. (Ed.). 1990. *Life History and Ecology of the Slider Turtle*. Smithsonian Institution Press, Washington, D.C., USA.
- Gibbons, J.W., and J.W. Coker. 1978. Herpetofaunal colonization patterns of Atlantic coast barrier islands. *American Midland Naturalist* 99:219–233.
- Gibbons, J. W., and M.E. Dorcas. 2005. *Snakes of the Southeast*. The University of Georgia Press, Athens, Georgia, USA.
- Gibbons, J.W., and J.E. Lovich. 1990. Sexual dimorphism in turtles with emphasis on the Slider Turtle (*Trachemys scripta*). *Herpetological Monographs* 4:1–29.
- Gibbons, J.W., G.H. Keaton, J.P. Schubauer, J.L. Greene, D.H. Bennett, J.R. McAuliffe, and R.R. Sharitz. 1979. Unusual population size structure in freshwater turtles on barrier islands. *Georgia Journal of Science* 37:155–159.
- Hillestad, H.O., J.R. Bozeman, A.S. Johnson, C.W. Berisford, and J.I. Richardson. 1975. The ecology of the Cumberland Island National Seashore, Camden County, Georgia. Georgia Marine Science Center Technical Report 75–5. 299 p.
- Ingold, D.A., S.E. Willbern, and D.M. Roberts. 1986. A population estimation technique for aquatic turtles. *Bulletin of the Maryland Herpetological Society* 22:1–5.
- Lewis, T.H. 1946. Reptiles and amphibians of Smith Island, North Carolina. *American Midland Naturalist* 36:682–691.
- Marchand, M.N., and J.A. Litvaitis. 2004. Effects of habitat features and landscape composition on the population structure of a common aquatic turtle in a region undergoing rapid development. *Conservation Biology* 18:758–767.
- Moll, E.O., and J.M. Legler. 1971. The life history of a Neotropical Slider Turtle, *Pseudemys scripta* (Schoepff), in Panama. *Los Angeles Co. Museum Science Bulletin* 11:1–102.
- Reehl, M., J. Thompson, and J.K. Tucker. 2006. A three year survey of aquatic turtles in a riverside pond. *Transactions of the Illinois State Academy of Science* 99:145–152.

DeGregorio et al.—Yellow-bellied Sliders on Barrier Islands.

Rose, F.L., and R.W. Manning. 1996. Notes on the biology of the slider, *Trachemys scripta elegans* (Reptilia: Emydidae), inhabiting man-made cattle ponds in West Texas. *Texas Journal of Science* 48:191–206.

Spinks, P.Q., G.B. Pauly, J.J. Crayon, and H.B. Shaffer. 2003. Survival of the Western Pond Turtle (*Emys marmorata*) in an urban California environment. *Biological Conservation* 113:257–267.

Steen, D.A., M.J. Aresco, S.G. Beilke, B.W. Compton, E.P. Condon, C.K. Dodd, Jr., H. Forrester, J.W. Gibbons, J.L. Greene, G. Johnson, et al. 2006. Relative vulnerability of female turtles to road mortality. *Animal Conservation* 9:269–273.

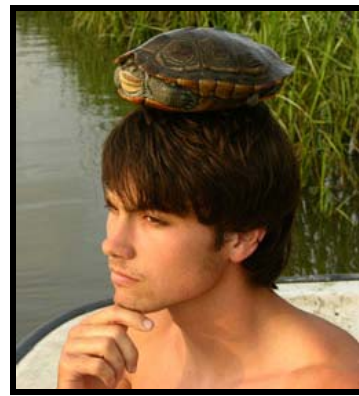
Tucker, J.K., N.I. Filoramo, and F.J. Janzen. 1999. Size-biased mortality due to predation in a nesting freshwater turtle, *Trachemys scripta*. *American Midland Naturalist* 141:198–203.

Valentine, J.M., J.R. Walther, K.M. McCartney, and L.M. Ivy. 1972. Alligator diets on the Sabine National Wildlife Refuge, Louisiana. *The Journal of Wildlife Management* 36:809–815.

White, G.C., and K.P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. *Bird Study* 46 Supplement, 120–138.



BRETT A. DEGREGORIO is currently a Ph.D. student at the University of Illinois studying the predator-prey interactions between songbirds and ratsnakes on the Savannah River Site. For several years he was lucky enough to be a research technician at the Savannah River Ecology Laboratory studying reptile conservation, tortoise head-starting, and eco toxicology. (Photographed by Daniel Meyers)



ANDREW M. GROSSE is a Research Laboratory Assistant at the Savannah River Ecology Laboratory currently involved in various projects regarding amphibian and reptile ecology, conservation, and management. (Photographed by Daniel van Dijk)



WHIT GIBBONS is Professor Emeritus of Ecology at the University of Georgia and Head of the Environmental Outreach and Education program at the Savannah River Ecology Laboratory. Whit has been involved in herpetological research for more than a half century. (Photographed by Judy Greene)