GEOARCHAEOLOGY OF ST. CATHERINES ISLAND, GEORGIA

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AND

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ABSTRACT

This edited volume addresses the geoarchaeology of St. Catherines Island (Georgia). The field of geoarchaeology has typically been defined as either *geology pursued within an archaeological framework* or (sometimes the reverse) *as archaeology framed with the help of geological methodology*. Either way, the formalized objectives of geoarchaeology define a broad range of pursuits, from placing archaeological sites into relative and absolute temporal context through the application of stratigraphic principles and absolute dating techniques, to understanding the natural processes of site formation, to reconstructing the landscapes that existed around a site or group of sites at the time of occupation.

The editors of this volume have generally followed the lead of G.R. Rapp and C.L. Hill (2006, *Geoarchaeology: The Earth-science Approach to Archaeological Interpretation*) by stressing the importance of multiple viewpoints and methodologies in applying geoscience techniques to evaluate the archaeological record. In the broadest sense, then, *Geoarchaeology of St. Catherines Island* applies multiple earth science concepts, techniques, or knowledge bases to the known archaeological record and the processes that created that record.

This volume consists of 16 papers presenting the newest research on the stratigraphic and geomorphological evolution of the St. Catherines Island landscape. Of particular interest are presentations addressing the relative timing and nature of sedimentation, paleobiology, sea level change, stream capture, hydrology, and erosional patterning evident on St. Catherines Island (and to some degree the rest of the Georgia Bight). These papers were initially presented at the Fourth Caldwell Conference, cosponsored by the American Museum of Natural History and the St. Catherines Island Foundation, held on St. Catherines Island (Georgia), March 27–29, 2009.

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PREFACE

Gale A. Bishop, Harold B. Rollins, and David Hurst Thomas

The Fourth Caldwell Conference was organized to bring together a small group of researchers interested in addressing questions relating to the archaeology, geoarchaeology, and paleobiology of the American Southeast. The topic of this symposium was *Geoarchaeology of St. Catherines Island and the Georgia Bight*. The various papers discuss the newest research relating to the stratigraphic and geomorphological evolution of the St. Catherines Island landscape. Of particular interest are presentations addressing the relative timing and nature of sedimentation, sea level change, stream capture, hydrology, and erosional patterning evident on St. Catherines Island and the Georgia Bight. The papers in this volume were presented at that conference, which was sponsored by the American Museum of Natural History and held on St. Catherines Island (Georgia), March 27–29, 2009.

David Hurst Thomas begins the volume with a consideration of *geoarchaeology* as played out on St. Catherines Island and the Georgia Bight. After considering several widespread definitions of geoarchaeology, he defines three generations of "geoarchaeological" thought among American archaeologists. The pioneers relied heavily on the seminal organizing principles of geology—the concepts of *superposition* and *index fossil*. Thomas Jefferson was the first geoarchaeologist (at least in America) and Thomas argues that the legacy of first-generation geoarchaeology has conditioned archaeological practice until fairly recently, perhaps only two or three decades ago. The second generation of geoarchaeology (in which Thomas includes himself) spans the late 1970s through the present. Most of the archaeology of St. Catherines Island was conducted under this paradigm and Thomas suggests that these archaeologists transcended the purely temporal-spatial to explore more far-reaching objectives with a plethora of new methods and technologies. The third (contemporary) generation of geoarchaeology has the opportunity to build upon this foundation, elucidating and merging the natural

Participants in the Fourth Caldwell Conference, standing in front of the stratified paleosols exposed at Yellow Banks Bluff on the northeastern margin of St. Catherines Island, March 27–29, 2009: (*left to right*) Gale Bishop, Royce Hayes, Patty Stahlman, Anna Semon, Tim Chowns (in the back), Tony Martin (in the front), Frank Vento, Bud Rollins, Rachel Cajigas, Stan Riggs (seated in the front), Fred Rich, Brian Meyer, Kelly Vance, Bran Potter, Lori Pendleton, Bob Booth, Chester DePratter, Dave Thomas, Christina Friberg, and Ginessa Mahar.

and cultural past in unprecedented ways. Thomas concludes chapter 1 with a six-pack of suggestions for third generation geoarchaeologists working on St. Catherines Island and her surrounding waters.

In chapter 2, Fredrick J. Rich, Anthony Vega, and Frank J. Vento review the evolution of Late Pleistocene climates and environments in the American Southeast, with special emphasis on St. Catherines Island and the Georgia Bight. They order their contribution in chronological fashion, beginning with discussions of the oldest-dated deposits, and proceeding to the time of first European contact.

The most ancient floras in this area date back more than 50,000 years, an artificial limit defined by the accuracy of radiocarbon technology. The Wisconsinan glacial phase of the Pleistocene Epoch peaked at approximately 18,000 ^{14}C yr B.P., when permanent ice covered most of North America north of the Ohio River and extended across the pole to cover much of Europe and Asia. Glacial maximum winds were primarily from the northwest and most of North America was within the cold, dry, circumpolar vortex leading to a boreal climatic regime for eastern North America. During this glacial maximum, sea levels fell as much as 170 m (550 ft) below current levels as vast stores of water were locked in the continental ice sheets.

During the last glacial maximum (18,000 ^{14}C yr B.P.), the average jet stream position migrated to approximately the Gulf Coast region and much of eastern North America was overlain by cold and dry polar air. For much of the American Southeast, jet stream amplifications were relatively unimportant as the region lay primarily within persistent cool, dry conditions. St. Catherines Island, and all the other barrier islands on the East Coast were far inland and must have been incorporated as parts of the coastal plain. Familiar southeastern plant taxa include *Pinus*, *Quercus*, *Carya* (probably pecan), and *Liquidambar* and there is quite a diversity of herbaceous plants, including grasses, sedges, ferns, and *Sphagnum*. Assuming that the flora of the Southeast remained fairly stable during the Late Glacial Maximum, and for the first few thousand years following glacial retreat, it would appear that the major environmental variable to affect the Georgia coastal plain was the presence or absence of the ocean itself.

Following two meltwater pulses, a period of ice mass stabilization, the Younger Dryas cold interval ensued and lasted until about 11,500 ^{14}C yr B.P. While the cause of the Younger Dryas is still debated, it was likely centered on atmospheric and oceanic circulation changes induced by cold meltwaters from the retreating Laurentide Ice Sheet. The authors review the sparse palynological and paleobotanical evidence from the Southeast during the Younger Dryas, which ended as a new atmospheric/oceanic equilibrium and renewal of climatic amelioration began. Evidence indicates that the Younger Dryas ended as abruptly as it began.

The period 9000–8000 ^{14}C yr B.P. marked a continuation of cool-season zonal flow, but potentially higher warm-season evapotranspiration rates led to prominent drying throughout the American Southeast. Conditions abruptly changed during the Atlantic (8000–4500 ^{14}C yr B.P.) climatic episode, as wetter conditions prevailed. The subboreal, at 4500–3000 ^{14}C yr B.P., marks another abrupt transition to a drier climate regime. The dryness was likely induced by expansion of the Bermuda-Azores anticyclone, particularly during the warm season. By the Sub-Atlantic period (3000–2000 ^{14}C yr B.P.) the climate system transitioned to conditions similar to the present. This engendered more frequent and greater magnitude midlatitude cyclone migrations throughout the study region, resulting in an overall increase in moisture.

In chapter 3, Gale A. Bishop, Brian K. Meyer, R. Kelly Vance, and Fredrick J. Rich summarize the history of geological research on St. Catherines Island. Programs by the University of Pittsburgh, the American Museum of Natural History, Sewanee University, and Georgia Southern University developed relatively independently over the past two or three decades, primarily because of asynchronous living constraints on St. Catherines Island. But these programs have become more collaborative and synergistic over time, culminating in the highly collaborative research published as *Native American Landscapes of St. Catherines Island* (Thomas, 2008: esp. chaps. 3, 4, 5, and 29). This three-volume monograph summarized what was known about the geological foundation and origin of the island, and the history of colonization by the first St. Catherines islanders. Geoarchaeology to date has largely focused on the timing and the history of sea level change on St. Catherines Island (and along the Georgia Bight) and its eventual effect on human occupation of

St. Catherines Island. This chapter reviews that literature and traces the lines of thought about the geologic history of the Georgia Bight, with a particular focus on St. Catherines Island.

As sea level continues its inexorable rise due to global warming, other anthropogenic conditions (damming of upstream rivers and dredging of the Savannah ship channel) on the southeastern coast have combined to decrease the southward longshore sediment flow along the Atlantic Coast, significantly increasing erosion of St. Catherines Island, Georgia's most vulnerable sentinel island.

In chapter 4, Frank J. Vento and Patty A. Stahlman argue that paleosols as allogenic genetic units (now buried cumulic A horizons) document prolonged episodes of stability and afford excellent chronostratigraphic marker horizons recognizable throughout the eastern United States. On the other hand, autogenic genetic units (e.g., a sand horizon from a large flood or hurricane is a one-day event) are locally developed, the result of a circumscribed event that is constrained geographically and/or environmentally. Genetic units can also provide important information on the responses of near-shore marine and fluvial systems to Holocene climate change, and aid in archaeological site prediction. The driving mechanisms for prolonged changes in the sea levels and fluvial regimes in the eastern United States were ablation of the Laurentian ice sheet and changes in atmospheric circulation. Paleosols on stable/fixed barrier islands along the coast of Georgia appear to reflect these changes in eustatic sea level and atmospheric circulation.

Beginning in April of 2008, Vento and Stahlman began preliminary geomorphological investigations at St. Catherines Island, identifying and dating a series of now buried terrestrial paleosols at Yellow Banks Bluff, an extensive outcrop of Pleistocene sand on the eastern shore of St. Catherines Island. The uppermost paleosol has been dated to about 6440 ^{14}C yr B.P. Three lower buried A horizons have yielded dates of approximately 10,800, 13,600, and 22,800 ^{14}C yr B.P., while a probable cultural feature lying above these paleosols has yielded a date of 6270 ^{14}C yr B.P. These paleosols potentially provide important information on eustatic sea levels, climate change, and the occurrence of deeply buried prehistoric cultural resources.

In chapter 5, Anthony J. Martin and Andrew K. Rindsberg also discuss the outcrop at Yellow Banks Bluff, previously interpreted as containing marine hardgrounds formed during a pre–Silver Bluff Pleistocene highstand. Their interpretation of the outcrop and its trace fossils favors storm-washover fans deposited behind dunes, and rejects a marine origin. Trace fossils within thin, dark-brown beds within the outcrop are identified as burrows made by fiddler crabs (*Uca* spp.), which formed on washover fans as poststorm colonization surfaces. This interpretation is based on the burrows' distinctive J-shaped forms and networks (*Psilonichnus* [ichnospecies] and *Thalassinoides* [isp.], respectively), as well as analogous colonization by fiddler crabs observed in modern washover fans on the island. Vertical root traces crosscut the Yellow Banks Bluff deposits in places; infaunal insects then burrowed root traces, as evidenced by pervasive and multiple generations of backfilled burrows (*Taenidium* isp.). At least a few root and insect traces within the outcrop, however, are modern, potentially complicating paleoenvironmental interpretations. In one exposure south of (and below) Yellow Banks Bluff, a black peaty mud containing pinecones and terrestrial wood represents a freshwater-swamp channel deposit, further corroborating a terrestrial context to laterally adjacent and crosscutting facies. Facies of Yellow Banks Bluff are thus interpreted as eolian (foredune) succeeded by washover fans and backdune meadows. Biogenically reworked tree-root traces and associated facies are similar to those interpreted in the Raccoon Bluff formation (Pleistocene) on Sapelo Island, hinting at possible paleoenvironmental and stratigraphic equivalence. In short, the sea level history of Yellow Banks Bluff facies indicates sea level only slightly higher than that at present. Martin and Rindsberg suggest that research should focus on further confirmation of age determinations, possible correlation of Yellow Banks Bluff with similar outcrops in the Georgia barrier islands, and interpretation of distinctive trace fossil assemblages that may be diagnostic of specific paleoenvironments.

In chapter 6, Fredrick J. Rich and Robert K. Booth discuss the Quaternary vegetation and depositional history of St. Catherines Island. Arguing that St. Catherines is one of the least disturbed of the barrier islands along the Georgia coastline, they summarize a suite of studies, conducted over the past several decades, on the geological development, current vegetation, and vegetational history. Maps and descriptions of the principal plant communities currently on the island have been developed by several investigators and ethnobotanical studies reveal some information on the composition of plant communities prior to European disturbance. A longer-term perspective on the vegetation and developmental history of the island is provided by lithostratigraphic studies of pollen preserved in a range of depositional environments. Rich and Booth distill and summarize the palynological work performed on St. Catherines Island over the past decade. The distribution of sites is scattered, the ages of deposits are not systematically distributed, and the available records are discontinuous, so this compilation cannot be seen as the result of a comprehensive study. But the accumulation of data of different ages from many localities shows that the sediments of St. Catherines Island contain a wealth of palynological and paleoecological information that bears on our understanding of ancient terrestrial ecosystems of the Georgia coastal plain.

Rich and Booth conclude that, in very general terms, the core of St. Catherines Island is of Pleistocene age, though it is unclear just when the island first took form, or if it developed over a long period of time and intermittently. The oldest floras from that ill-defined period of island development appear to come from Yellow Banks Bluff and the greatest depths at Cracker Tom and the St. Catherines Shell Ring. Between about 6000 and 4000 years ago, the island began to flood, and the now-vanished feature known as Guale Island disappeared as a rising sea level brought the forces of erosion and longshore drift to the eastern margin of St. Catherines Island. The establishment of current hammock and marsh plant communities at the Cracker Tom locality occurred some time after 3200 ^{14}C yr B.P. The southern end of the island (south of the Cracker Tom locality) subsequently developed, and the flora that was encountered by Spanish explorers came to occupy the island. The rapidity of the physical and biological changes that occurred during that episode of island development probably cannot be overstated.

In chapter 7, Donald B. Potter, Jr., reports on recent shoreline erosion and vertical patterns evident on St. Catherines Island, a Holocene-Pleistocene barrier island with no artificial structures on the beach. Measurement of shoreline retreat on the east and north shores, begun in 1974 by Donald McClain, has been expanded over the past 20 years to include more than 30 stations. On the north shore a 1.0 to1.5 m/yr southward migration of the beach into a forested Holocene dune field has left dead standing pines below the high tide mark. Growth of a large bar at the northeastern tip of the island has provided protection from wave energy for Holocene beach sands and the northernmost Pleistocene bluff along the east shore of the island, where up to 20 m of lateral accretion has occurred below the 4 m high bluff. In contrast, the southern 0.5 km long stretch of this Pleistocene bluff has eroded at rates ranging from 1.6 m/yr to 2.7 m/yr since 1996.

South Beach has the highest rates of erosional retreat. Freshwater Flag Pond, 1.5 km long, was breached by 10.4 m of lateral erosion by storm waves in the winter of 1992–1993 and is now flooded daily at high tide. Breaching is underway at Beach Pond, the remaining fresh water pond along the eastern shore. Retreat between Beach and Flag ponds has averaged 1.6 m/yr for the past eight years. Estimates for longer periods of erosion, based on comparisons of aerial photographs and present shoreline positions, reveal erosion rates for the Flag Pond area of 2.3 m/yr from 1972 to 2008 and rates of 5.4 m/yr in the southernmost marsh at latitude 31 33' 50".

In chapter 8, Harold B. Rollins, Kathi Beratan, and James E. Pottinger assess the effects of Hurricane Hugo in 1989 on the geomorphology of the northern end of St. Catherines Island. During the fall of 1995 and late spring of 1996, they made detailed field maps of beach ridges observed at two specific locations along preselected baselines (at North Beach and also Picnic Point). They also employed panchromatic and natural color aerial photographs, dating back to the 1950s and ranging in scale from 1:10,000 to 1:60,000; to minimize effects of differences in tidal cycles, these aerial photographs were standardized by locating the High Water Line (HWL) on each photograph. Photographs were georectified and corrected for distortion. Combining these methods, the authors demonstrate how this single storm event was correlated with the construction of a set of three beach ridges along the northern end of the island. Hurricane Hugo apparently triggered an interval of net import of sediment shoreward in this area, interrupting the normal ebb-dominant export of sediment to a more offshore marginal shoal. Perturbation of inlet dynamics appears noticeable over mesoscale intervals of time correlating with fluctuating intervals of violent and quiescent Atlantic coastal storm activity.

In chapter 9, Timothy M. Chowns examines drainage changes in the Ossabaw, St. Catherines, and Sapelo sounds, and discusses their significance to island morphology and spit building on St. Catherines Island. He argues that the Holocene transgression has encouraged the straightening of river estuaries on the Georgia coast so that most flow directly into the ocean and form a right angle with the coast. Chowns hypothesizes that many of these estuaries were formerly diverted to the south by the development of spits, probably during a minor regression between about 4300 and 3600 cal B.P. He argues that by decreasing the volume of the tidal prism, and releasing sand to the longshore transport system, stillstand (or minor regression) favors wave over tidal processes. By contrast, the modern transgression has increased the volume of the tidal prism and trapped sediment upstream in the estuaries, thus initiating the present tide-dominated system that prevails at the head of the Georgia Bight.

Chowns suggests that the modern inlet at Ossabaw Sound is of recent origin, formed by the breaching of Silver Bluff and Holocene beach ridges by storm avulsion. St. Catherines Sound and Sapelo Sound are possible locations of earlier breaches. The breaching of Sapelo Sound may have decapitated a spit at the southern end of St. Catherines Island to form Blackbeard Island and left an abandoned channel beneath Blackbeard Marsh. Similarly, the breaching of St. Catherines Sound may have dissected a spit at the southern end of Ossabaw Island to form “Guale Island” with an abandoned channel beneath “Guale Marsh.” With the infilling of Blackbeard and “Guale” marshes, Blackbeard Island became part of Sapelo Island and Guale Island became part of St. Catherines.

A conservative interpretation ascribes these changes to the local switching of distributaries between adjacent existing inlets, while a more radical interpretation suggests that the breaches may have formed as the result of flooding and segmentation of the lower Ogeechee valley. In this case the Ogeechee may have occupied the low country between the Princess Anne and Silver Bluff beach ridges as an original tributary of the Altamaha. In either case avulsion is most likely to have occurred as a consequence of storm flooding in the back-barrier marshes.

Chowns suggests that to test these hypotheses and to provide a time line, it is necessary to establish absolute dates for the proposed changes. To this end, he has begun a program of ^{14}C and luminescence dating of the inlet breaching and the redistribution of sand onto St. Catherines Spit. The approximate ages of beach ridges on St. Catherines Island are known from archaeological sites but these might be refined with luminescence dates from quartz sands from the old dune lines. In this way, he could establish a correlation between changes in inlet position and the formation of different sets of beach ridges. Perhaps there is a connection to settlement patterns and cultural changes on the islands.

In chapter 10, Gale A. Bishop, David Hurst Thomas, Matthew C. Sanger, Brian K. Meyer, R. Kelly Vance, Robert K. Booth, Fredrick J. Rich, Donald B. Potter, and Timothy Keith-Lucas discuss the various vibracores and vibracore transects that have been drilled on St. Catherines Island to date. Stratigraphic relationships and ^{14}C dates constrain the Central Core of St. Catherines as at least Pleistocene in age, and basal strata of fern peats indicate that sea level had risen to -4.0 m by approximately 6020 ^{14}C B.P., surrounding the island with brackish water and cutting it off from the mainland.

The Cracker Tom Transect penetrates the Holocene accretional terrains on the Atlantic front of the island, and extends into the underlying Pleistocene, thereby connecting Back Creek Village to the ancient geomorphology along the front side of St. Catherines Island. The St. Catherines Shell Ring Transect penetrates through marsh mud and oyster bioherms into the Pleistocene substrate and connects St. Catherines Shell Ring into the ancient geomorphology of the back side of St. Catherines Island. In both transects, basal peat was penetrated at total depth of vibracoring and dated with ^{14}C methods. The peat beds were dominated by *Woodwardia* fern spore and detritus, providing the oldest dates on St. Catherines Island (47,620 ± 2500 ^{14}C B.P. at Cracker Tom Bridge and 39,110 ± 660 ^{14}C B.P. at the St. Catherines Shell Ring). Oyster shell from a marsh mud at St. Catherines Shell Ring also provided an old date (> 44,800 ^{14}C B.P.). Overlying the terrestrial peat deposits in the Cracker Tom Transect, evidence of aerial exposure, charcoal, and shell was found, providing much younger dates of 6020 ± 50 ^{14}C B.P. and 4060 ± 50 ^{14}C B.P., respectively, documenting the return of marine conditions shortly before colonization of St. Catherines Island by its earliest known human population.

Vibracoring also provides a mechanism to rapidly provide ground truth to geophysical anomalies with minimal detriment to the site while maximizing return of stratigraphic, archaeological, and sedimentological data within its confining context. Vibracoring of the St. Catherines Shell Ring and the McQueen Shell Ring, followed by archaeological testing and ^{14}C dating, confirm the earliest known cultural event at the St. Catherines Shell Ring at 2540–2290 cal B.C.

In chapter 11, R. Kelly Vance, Gale A. Bishop, Fredrick J. Rich, Brian K. Meyer, and Eleanor J. Camann report results from a Ground Penetrating Radar (GPR) survey running more than 20 km in length. The reflection profiling (using 100 MHz and 250 MHz antennae) indicates a gross island suprastructure consisting of at least 6–8 m of sand-dominated strata that thin westward to 2–5 m. The sand-dominated succession overlies one or two persistent basal reflectors of a lower facies that may represent clay rich or saltwater-saturated sediments characterized by horizontal, subparallel radar elements. The middle sand-dominated facies (Pleistocene?) is widespread and characterized by sigmoidal radar elements produced by prograding (regressive) beach deposits. The middle beach facies appears to have been truncated (at least locally) and overlain by overwash and eolian deposits that filled local marshes forming an upper facies that grades upward into largely horizontal elements overprinted by pedogenic processes and humate cementation. Investigations near South Pasture reveal an apparent disconformity marked by an irregular contact between sand and an underlying dense, blue-gray clay at ~2.7 m depth. Sag structures have been discovered in the northern, middle, and southern portions of the island in regions that coincide with the distribution of Mandarin-Rutledge soils within the Central Depression. Profiling indicates subsidence of 2–5 m in these structures with subsequent accumulation of sediment within these basins. These features may have been generated by subsidence along minor faults or through fault-joint focused dissolution of carbonates at depth with consequent sag of overlying strata. The faults and joints were probably essential conduits for artesian springs that fed former freshwater wetlands of the Central Depression.

In chapter 12, Robert S. Prezant, Harold B. Rollins, and Ronald B. Toll present the results of their two year study of postsettlement dispersal and repopulation of adult *Mercenaria mercenaria* in fringing marsh and tidal creek habitats at Engineers Point West and Long Creek. During a single low-tide interval (August 1989) a series of quadrats were established at Engineers Point West using a laser level and elevations were recorded; 12 hours later each quadrat was totally defaunated of clams. Approximately 100 of the collected clams were marked, measured, and weighed, and then replaced randomly within each quadrat. During subsequent visits, in January 1990, October 1990, and February 1991, each quadrat was remapped, and all clams within the quadrats were harvested, measured, weighed, and aged (via annual growth ring counts). Recruits were sequentially numbered and replaced in each quadrat, along with those of the original and subsequent collections. Isopleth maps were prepared for each quadrat, documenting net changes in erosion and aggradation. To assess reproductive maturity, 20 clams were randomly collected from areas adjacent to the quadrats and their gonads examined by standard histological procedures. Concurrently, another mark/recapture study was carried out on one of the point bars in Long Creek, on the eastern side of St. Catherines Island.

Prezant and colleagues conclude that rapid population replacement by adult clams following loss of adults within quadrats demands an explanatory model involving wholesale movement of otherwise sedentary adult bivalves. They determined that clams were transported in a saltational manner associated with specific hydrodynamic events such as episodic storms, perhaps in combination with the effects of ebb-tidal flow. Stochastic models of adult repopulation might explain the commonly observed lack of a range of year classes in clam population age class structure of coastal Georgia quahog populations. Moreover, the fate of postsettlement juvenile and adult bivalves under varying physical conditions has significant meaning for the paradigm of “supply-side” ecology, which predicts that larval recruitment would produce a series of age (size) classes reflecting the variable success of adult reproductive events. While certainly the dominant controlling factor for sessile biota, the numerous reports of recruitment patterns for several other sedentary (but not permanently attached) marine organisms document irregular or unpredictable settlement patterns that cannot be explained by small (planktonic) propagules.

This study of hard clam dispersal on St. Catherines Island addresses one of the major gaps in our knowledge involving the role of passive dispersal of fully grown adults. In particular, these stochastically redistributed and reproductively mature bivalves can help support and sustain locally dispersed metapopulations. The relative roles of larval recruitment, postsettlement juvenile dispersal, differential survival, and adult movement (both passive and active) have yet to be assessed under varying hydrodynamic situations.

In chapter 13, Gale A. Bishop, Fredric L. Pirkle, Brian K. Meyer, and William Pirkle report the results of studies documenting recent nesting behavior of loggerhead sea turtles on St. Catherines Island.[1] They argue that these behaviors provide a model for the suite of sedimentary structures produced by nesting sea turtles, and an analog for trace fossils in ancient near-shore marine sedimentary rocks, including: (1) large crawlways produced by mature female turtles, (2) small-scale crawlways made by hatchlings, (3) distinctive disrupted sediments of the nest, and (4) depredated nests. They suggest that this study of loggerhead and leatherback sea turtle nests provides the background to understand deterioration of sea turtle habitat that reflects the recent erosion of St. Catherines Island and establishes the background information necessary to understand the harvesting of sea turtle eggs and hunting of sea turtles by precontact Native Americans.

Chapter 13 also describes nest types on St. Catherines Island that range from simple to complex; are both unobstructed and obstructed; and situated in backbeach, dune, washover fan, and forebeach habitats. Nests consist of disrupted elliptical surface layers filling a broad, shallow covering pit approximately 20–30 cm deep, overlying a smaller body pit, and both overlying a vertical-walled, urn-shaped egg chamber. Subsequent erosional or predatory events may modify or obliterate the sediments and entrained nest structures, making them easy to overlook or misinterpret if seen in the fossil record. The authors also discuss fossilized nesting structures discovered in the Cretaceous Fox Hills Sandstone of Colorado, including two egg chambers, a body pit, a crawlway, and associated backbeach sedimentary structures that exhibit structures, proportions, and attributes of modern sea turtle nests documented on St. Catherines Island.

In chapter 14, Gale A. Bishop and Brian K. Meyer discuss the deterioration of sea turtle habitat on St. Catherines Island. Accelerating changes in sea turtle nesting habitat became apparent in the early to mid-1990s on St. Catherines Island with breaching of Flag Pond, enhanced scarping and development of washover fans, and shoreline retreat along most of the beach. These factors affected the loggerhead sea turtle nesting habitat resulting in increasing relocation of in situ nests into higher quality habitat in 1995. This trend is documented by qualitative assessment of the entire beachfront in 1998 and quantified annually beginning in 1999 using a new Rapid Habitat Assessment tool.

The repetitive Rapid Habitat Assessment was designed to score habitat efficacy on a scale of 0 to 10 (poor to good) along the beachfront using a GPS grid with a spacing of 0.001 degrees (~110 m). Rapid Habitat Assessment data show a beachwide decrease in habitat quality over the last decade with rapid deterioration along approximately 85% of St. Catherines beaches resulting in low-quality sea turtle nesting habitat. Clutches of eggs moved from doomed nests and at-risk nests have increased hatching productivity from an estimated 5% to an actual success of 72% when they are relocated into sea turtle nurturies having slightly higher elevation in a more protected natural habitat.

Bishop and Meyer argue that deterioration of sea turtle nesting habitat provides an independent measure of beach erosion attributed to (1) sea level rise, (2) sand deprivation due to removal of sand from the longshore system caused by regional sediment impoundment in dammed rivers and dredging and removal of sand from the Savannah Ship Channel, and (3) lack of proximal sources of fluvial sand at St. Catherines Island. Deteriorating nesting conditions at St. Catherines Island may be a predictor of future conditions expected to spread up and down the coast of the Georgia Bight.

In chapter 15, Gale A. Bishop, David Hurst Thomas, and Brian K. Meyer employ contemporary data from St. Catherines Island to model the hunting and harvesting of sea turtles (and their eggs) along the Georgia Bight. They note that indigenous peoples around the world have harvested (and continue to harvest) sea turtle meat and eggs as nutritional resources, use sea turtle skeletal elements as useful tools and ornaments, and incorporated sea turtles into their mythologies and traditions. Gathering of sea turtle eggs provides a low-cost, high-benefit source of seasonal nutrition to many societies in the past and in historical time.

Nesting loggerhead sea turtles likely provided a significant seasonal nutritional resource to precontact and postcontact indigenous occupants of Georgia's barrier islands. St. Catherines Island has existed in several iterations for over 40,000 years as a barrier island, but has been occupied by indigenous Native Americans for only the last 5000 years or so.

Although the archaeological visibility of harvesting sea turtle eggs is limited, it is logical to speculate that indigenous inhabitants harvested eggs and meat of loggerhead sea turtles that nest on St. Catherines barrier island beaches from May to September in Georgia. Hunting sea turtles and gathering sea turtle eggs represent high benefit to expenditure seasonal activities that resulted in acquisition of important protein resources during the summer and early fall months. The paucity of archaeological evidence may be explained as taphonomic biases due to food preparation at remote beach sites and by the lack of preservability of eggshells in summer camps.

In the final chapter, Harold B. Rollins and David Hurst Thomas examine interrelationships among many ecological, geomorphological, and sedimentological factors that define what they term the "zone of optimal shellfish harvesting" (ZOOSH) available to prehistoric Native American populations of St. Catherines Island, They argue that prehistoric foraging strategies were constrained by these interactions. They also discuss how such strategies should be framed in the context of relative sea level change. Expansion and contraction of the ZOOSH of St. Catherines Island was influenced by a complex of ecological and geomorphological interactions. The ecological dimensions included between-habitat and within-habitat specificity of shellfish taxa, stochasticity of shellfish resource distribution, and interspecific interactions, such as predation, competition, and trophic cascading. Geomorphological factors included inlet migration and sediment supply, antecedent topography, changes in tide versus wave dominance, relative rates of sea level rise or fall, the asymmetrical effects of sea level rise versus fall, gradual versus episodic change, proximity to hinterland resources, climate change, and prehistoric anthropogenic factors, among others. Temporal changes in the ZOOSH of St. Catherines Island may be summarized as follows:

(1) 5300–4300 cal B.P.—following the Holocene transgression now eroded Guale Island formed adjacent to the eastern margin of the Pleistocene Silver Bluff shoreline. A short-lived lagoonal embayment was replaced by an extensive interisland marsh (Guale Marsh) and over an interval of a few centuries to a few millennia the ZOOSH changed from shoreface to open lagoon to intertidal marsh with bountiful, if somewhat unpredictable, oyster and clam resources. Geographic compression of maritime forest and marsh resources contributed to a high diversity of shore-parallel terrestrial and marine resources and enabled operation of a central-place foraging strategy.

(2) 4300–3600 cal B.P.—a relatively rapid 2 m drop in sea level led to destruction of marshland on both western and eastern sides of St. Catherines Island and wave dominance supplanted tidal dominance. Guale Island eroded and the marshland ZOOSH was significantly degraded, or disappeared. The shoreface ZOOSH became increasingly isolated from human settlements and the central-place foraging strategy was no longer operational.

(3) 3600 cal B.P. to recent—sea level rose slowly, transgressing over remnants of Guale Island. The tidal prism was reestablished but Guale Marsh had diminished presence, and the Guale Marsh ZOOSH never achieved its former stature and did not play a prominent role as a source of marine resources in post–St. Simon cultures.

The volume also contains two appendices relating directly to the geoarchaeology of St. Catherines Island: (1) a compendium of all available (>350) radiocarbon dates from both natural and "cultural" contents and (2) a detailed listing of the vibracore, artesian wells, and measured section record to date from the island.

A WORD ABOUT RADIOCARBON DATING

Throughout this volume, we report and discuss radiocarbon evidence according to the standards established by the journal *Radiocarbon* in their "Instructions for Authors" (promulgated 22 August, 2005, and updated 28 August, 2006). The standard reference on the calculations and terminology follow Stuiver and Polach (1977). Whenever possible, calibrated dates are reported using the latest available international calibration curve (currently INTCAL04 and MARINE04); if a computer program was used to calibrate dates, authors have included the name and version number of the program in reporting calibrated ages.

Uncalibrated Ages: b.p.

In this volume, "b.p." is understood to signify "conventional radiocarbon years before a.d. 1950." Ordinarily, then, uncalibrated radiocarbon dates are reported in this form:

Beta-21408: 3470 ± 80 b.p.

where Beta-21408 is the laboratory number for the sample and 3470 ± 80 b.p. is the uncalibrated age of the sample (with 3470 being the age in radiocarbon years before 1950, and 80 is the laboratory's estimate of error at the 1σ [one standard deviation level]). Because "b.p." is conventionally understood to mean "years before 1950," the form "yr b.p." is usually redundant. But in some cases, we employ the expression "^{14}C yr b.p." to distinguish conventional ages from those corrected to calendar estimates.

Because we now understand that the distribution of "radiocarbon years" is not linear, all ^{14}C dates reported in this volume will be "calibrated" (as below); but for the "heritage literature," meaning 1990s and earlier (when calibration protocols were not fully solidified), authors are encouraged to report "previously cited as XXX b.p." whenever appropriate.

Calibrated Ages: cal b.c., cal a.d., cal b.p.

The symbol "cal" is used to express calibrated radiocarbon ages (with "cal" understood to mean "calibrated," not "calendar"). Such "calendar ages" are absolute dates, whether known or inferred, but a "calibrated date" is an estimate grounded in statistical probability, and is therefore properly expressed as one or more ranges of calendar years, accompanied by an appropriate confidence interval.

In this volume, authors are encouraged to use either "cal b.p." or "cal b.c./cal a.d." (or both). Similarly, the use of 1σ and/or 2σ confidence intervals are left to the author's discretion.

Reservoir Corrections

In the early development of radiocarbon dating methods, investigators concluded that when living samples of freshwater organisms produced apparent ^{14}C ages of up to 1600 years (Taylor, 1987: 34), the materials had been contaminated by carbonates derived from bedrock limestone. As a result, ^{14}C determinations for marine samples will always appear "older" than ^{14}C dates on contemporary terrestrial samples. This difficulty can be overcome by computing correction factors based on such apparent age differences, which enables archaeologists to compare shell samples with ^{14}C ages of contemporary terrestrial samples. Using samples of *Crassostrea virginica* of known age, Thomas (2008: chap. 13) derived a reservoir correction specific to St. Catherines Island and surrounding waters. For all marine samples discussed in this volume, we employed the Marine04 curve, which takes into account the "global" ocean effects (Hughen et al., 2004); to accommodate estimated local effects on St. Catherines Island, we input the regional difference of $\Delta R = -134 \pm 26$.

Rounding Conventions

We also employ the rounding conventions advocated by Stuiver and Polach (1977: 362). That is, for all radiocarbon determinations, we supply one more digit than can be accurately accounted for; in reporting estimated ages and statistical uncertainties, figures like 8234 ± 256 or 42,786 ± 2322 are rounded, respectively, to 8230 ± 260 and 42,800 ± 2300. When the uncertainty is less than 100 years, rounding off to the nearest multiple of 10 will be followed between 50 and 100 years.

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NOTES

1. Chapters 13, 14, and 15 present new research on the loggerhead sea turtle population that nests on the beaches of St. Catherines Island. At first glance, this might seem to be an unusual contribution to *Geoarchaeology of St. Catherines Island, Georgia*. But we feel that the process of monitoring beaches for 130–140 days per year for 19 consecutive years—as Gale Bishop and his colleagues have done—provided an unprecedented opportunity to observe daily, monthly, annual, and decadal changes in these beach fronts. This opportunity is particularly timely because during this interval, global climate change altered sea levels, creating extensive barrier island erosion along the Atlantic seaboard during the initial stages of a modern marine transgression. The biogeographic upshot is that roughly 70% of the sea turtle nests on St. Catherines Island had to be located to better habitat during the last decade.

Two of these contributions directly address the *Geoarchaeology of St. Catherines Island, Georgia*. By documenting how the eroding seashore has impacted sea turtle nesting habitat, chapter 14 provides an alternative and independent methodology of documenting erosion rate and marine transgression on St. Catherines Island–by examining the rate of deteriorating sea turtle nesting habitat as a proxy of on-going climate change. Similarly, chapter 15 projects what the expected sea turtle utilization record ought to be, then reports the conflicting archaeological evidence showing something different. These findings raise significant questions about the nature of sea turtle utilization and its geoarchaeological visibility. Why should sea turtle exploitation appear so minimal on St. Catherines Island (and the other Georgia islands), but show up so significantly in the Caribbean, Mesoamerica, and many other parts of the world? To situate these two discussions, chapter 13 draws together–for the first time–a comprehensive body of detailed scientific information on the previously scattered, incomplete, descriptive morphology of loggerhead sea turtles nests in the Georgia Bight. In the tradition of interdisciplinary approaches to natural history, we think this preamble is essential to undergird the interpretations reflected in chapters 14 and 15. This approach also extends this geoarchaeological record into deep time by identifying the only other sea turtle nesting structures described thus far, on the western shoreline of the 70 million-year-old Cretaceous Western Interior Seaway southeast of Denver, Colorado.

We feel that this holistic treatment of historical science is appropriate to this volume because it draws together diverse information from (now) fragmented scientific disciplines (Somerville, 1834) into a "natural history" to celebrate the integrative process of scientific discovery (Gould, 1989) inherent in the mission of the American Museum of Natural History: "to discover, interpret, and disseminate–through scientific research and education–knowledge about human cultures, the natural world, and the universe." (http://www.amnh.org/about/mission.php)