

# NATIVE AMERICAN LANDSCAPES OF ST. CATHERINES ISLAND, GEORGIA

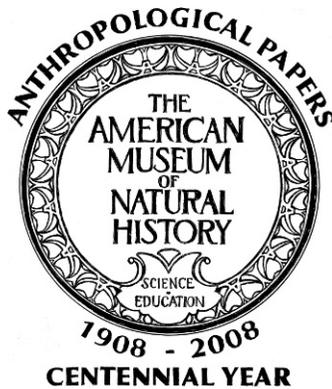
## I. THE THEORETICAL FRAMEWORK

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## DEDICATION

This monograph is respectfully dedicated to two individuals who helped shape our perspective in very different ways.

- To Dr. Lewis Larson, whose innovative and influential research on coastal Georgia archaeology clearly presaged the theoretical framework employed here.
- To Greg Paulk, a long-time friend of St. Catherines Island archaeology and a guy who touched the lives of all he knew. We all miss you, Greg.

## ABSTRACT

Four deceptively simple questions have guided our long-term research into the aboriginal lifeways of St. Catherines Island:

1. How and why did the human landscape (settlement patterns and land use) change through time?
2. To what extent were subsistence and settlement patterns shaped by human population increase, intensification, and competition for resources?
3. What factors can account for the emergence of social inequality in Georgia's Sea Islands?
4. Can systematically collected archaeological evidence resolve the conflicting ethno-historic interpretations of the aboriginal Georgia coast (the so-called "Guale problem")?

Over a span of four decades, the American Museum of Natural History has addressed these four fundamental questions using a broad array of field and analytical techniques.

We conducted a 20 percent probabilistic transect survey of St. Catherines Island, walking and probing for buried sites across a series of 31 east–west transects, each 100 m wide. During this initial survey we located 122 archaeological sites, which we tested with more than 400 one-meter by one-meter units. Because the transect sampling was heavily biased toward sites with marine shell, we also conducted a systematic shovel testing program. We also augmented these systematic surveys with a direct shoreline reconnaissance (mostly following the late Holocene surfaces), recording roughly 84 additional shoreline sites on St. Catherines Island. By plotting the distribution of these known-age sites across the Holocene beach ridges, we have developed a detailed sequence documenting the progradation and erosion of beach ridge complexes adjacent to tidal estuaries and oceanward shorelines on the island.

To evaluate the results of the 1000+ test explorations and excavations on St. Catherines Island, we have processed 251 radiocarbon determinations, including two dozen dates on "modern" mollusks (known-age specimens collected prior to atomic bomb contamination) to compute a "reservoir" correction factor specific to the estuaries around St. Catherines Island (of  $\Delta R = -134 \pm 26$ ). The results have been compiled into a dataset of 239 radiocarbon determinations for samples from St. Catherines Island. One hundred and ten of these dates (from 31 distinct mortuary and midden sites) could be directly associated with datable ceramic assemblages, which were classified according to Chester DePratter's (1979, 1991) Northern Georgia Coast chronology. By comparing the results of typological classification with the radiocarbon evidence currently available from St. Catherines Island, we propose a slightly modified ceramic chronology for St. Catherines Island.

We analyzed the seasonal growth increments in modern hard clams (*Mercenaria mercenaria*) for a 9-year interval (beginning in 1975). *Mercenaria* suitable for seasonal analysis were recovered from nearly 85 percent (110 of 130) of the sites identified and sampled in the Island wide survey. We analyzed about 2000 individual hard clam shells recovered from these shell middens and, of these, 1771 individual specimens (or fragments) provided usable growth increment estimates, enabling us to address seasonal patterns during the 5000 years of human history. This study is reinforced by an oxygen isotope study of modern and ancient clams from St. Catherines Island.

This transect survey produced an extensive and diverse set of vertebrate faunal remains collected systematically from archaeological sites tested across the entire island. Elizabeth Reitz and her colleagues analyzed this vertebrate faunal assemblage, which contains at least 586 individuals represented by 14,970 vertebrate specimens weighing 21,615 g. These materials provide a solid basis for refining hypotheses not only for St. Catherines Island, but for most coastal locations. With the exception of the first and last occupations (the St. Simons and Altamaha periods), the samples suggest a stable pattern of resource use through time, with little variation through time or across space (although the small sample sizes for each time period and circumscribed geographical setting might constrain this interpretation). She also notes the presence of numerous seasonal indicators in the vertebrate zooarchaeological samples recovered from archaeological sites on St. Catherines Island—including unshed deer antlers, juvenile deer dentition, and shark and sea catfish remains. But we also recognized

the importance of examining diverse sources of seasonal information in our attempt to flesh out overall patterns of site utilization. We also include analysis of the vertebrate zooarchaeological assemblages from Meeting House Field and Fallen Tree, two additional sites intensively investigated by the American Museum of Natural History and the University of Georgia.

The intensive program of mortuary archaeology has recovered the remains of more than 725 individuals from 18 archaeological sites on St. Catherines Island. More than 90 percent of these remains were analyzed by Clark Spencer Larsen and his colleagues, using a variety of microscopic, biomechanical, and stable isotopic techniques.

In this monograph, we address the archaeology of St. Catherines Island using the broad-based theoretical approach known as optimal foraging theory, which is grounded in the more general paradigm of human behavioral ecology (that studies human behavior by applying the principles of natural selection within an ecological context). The broad rubric of “optimal foraging theory” encompasses a broad range of specific models, each of which employs a unique set of simplifying assumptions and constraints, and each can be used to derive testable hypotheses about foraging behavior under certain environmental circumstances. Each model is a formal, mathematical construct and they share the key assumption that during “economic” pursuits, the forager will operate to maximize the overall rate of energetic return.

Specifically, we have employed three basic models to address the archaeology of St. Catherines Island. The *diet-breadth (or prey choice) model* addresses the issue of which foods should an efficient forager harvest from all those available on St. Catherines Island. Diet-breadth models predict that foragers will optimize the time spent capturing prey, and employ the simplifying assumptions that all resources are randomly distributed (without patches) and that “capture/handling” and “search” times represent the sum total of all time spent foraging. We also apply the *patch choice model*, which, combined with the central limit theorem, predicts that foraging effort will correlate directly with efficiency rank order, meaning that foragers should spend more time working the higher-ranked patches and less time in patches with lower energetic potential. Finally, we likewise employ the *central place foraging* model to investigate the time/energy spent processing resources at temporary camps before transport to a residential base. We find central place foraging theory to be useful for addressing the role and location of the residential base as a locus for provisioning offspring and mates or potential mates.

This monograph also reports the results of optimal foraging experiments conducted over a 2-year period on St. Catherines Island, specifically addressing procurement and return rates for key marine and terrestrial resources that would have been available to aboriginal foragers on St. Catherines Island.

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*On the covers of the three parts:* This remarkable watercolor by John White (appointed Governor of Roanoke Island in 1587) depicts the coastal Indians of North Carolina (Lorant, 1946: 180-184, 189, 251). This image—literally hand-carried to England from Walter Raleigh’s second colony—is Europe’s very first glimpse of America and its indigenous inhabitants. The painting depicts key elements of aboriginal life along the southern tidewater. In the background, several spearfishers work the flats with green cane spears, tips sharpened and fire hardened (or reinforced with horseshoe crab and stingray spines). Several massive fishing weirs project into a stretch of water between the Albemarle and Pamlico sounds, with a species of ray (or perhaps skate) trapped inside (see Larson, 1980a: 120). A small dipnet leans against the canoe prow in the foreground. Of particular interest is the fire basin amidships in the closest canoe, likely used for night fishing. The clay-lined basin was elevated slightly above the gunwhale to attract fish and illuminate the waters. Although we must be wary of the details, John White’s elegant rendering provides valuable insights into the broad range of technologies likely available to aboriginal peoples living along the Georgia Bight.

## A PERSONAL PREFACE

DAVID HURST THOMAS

Thomas D. Nicholson, a former director of the American Museum of Natural History, was fond of saying “It’s not science until it’s published.” Tom was right, and he knew that “science” sometimes takes a while to finish.

The truth is that most of the fieldwork described here was finished by 1980, and this monograph could (should) have been published a quarter-century ago.<sup>1</sup> But it wasn’t, and something really needs to be said about the delay.

In looking back, I believe the problem arose from a series of interrelated procedural, analytical, and theoretical complications that arose in the early 1980s. So, as a preamble to the empirical and theoretical dialogue that follows, let me explain those contexts and address some of the roadblocks encountered along the way.

After my first visit to St. Catherines Island (in 1974), we set out a modest research agenda to locate and test the various burial mounds scattered across the island. Our team also spent some time testing the various shell middens at Meeting House Field, a well-known late prehistoric site not far from the research compound. Encouraged by our initial results, the Edward John Noble Foundation invited me to frame a longer-term research design for St. Catherines Island, and I did that.

The most concrete result of this little visionary exercise was the ambitiously-titled monograph *The Anthropology of St. Catherines Island: 1. The Natural and Cultural History*, published as an Anthropological Paper of the American Museum of Natural History (Thomas et al., 1978). My coauthors were (1) ethnohistorian Grant Jones, who presented a brilliant reanalysis of the Guale Indians, the last aboriginal population to live on St. Catherines Island, (2) Roger Durham, a coastal Georgia historian who fleshed out complexities of post-Spanish historiography, and (3) Clark Spencer Larsen, my coprincipal investigator in those early mortuary excavations (who soon

thereafter defended his doctoral dissertation on the bioarchaeology of St. Catherines Island).

The “natural and cultural history” monograph has aged reasonably well over the decades. It remains in print and still provides a useful overview of St. Catherines Island ecology. But its enduring legacy, in my view, is Grant Jones’ contribution entitled simply “The Ethnohistory of the Guale Coast through 1684” (Jones, 1978). In this 33-page mini-classic, Grant not only summarized his comprehensive reevaluation of the key French and Spanish sources, but he also presented a still-controversial thesis. By taking exception to the prevailing ethnographic view of the 16th century Guale Indians (derived largely from the early Jesuit documents), Jones suggested an entirely new way of viewing the long-extinct aboriginal residents of the Georgia coast. Jones believed that the Jesuits had overstated the isolation of the Guale from the interior, the unproductivity of Guale horticulture, and the scattered quality of Guale settlements. Instead, he argued that, despite environmental and adaptive differences from better-known Mississippian groups, the Guale and the interior groups shared many basic features, including chiefdom-level political organization, military federations, matrilineality, and dual aspects of organization. Thus arose the “Guale problem,” the singular issue that would frame the next 3 decades of our landscape research on St. Catherines Island.

One can feel free to argue either position—because there’s ample support for both arguments in the extant ethnohistorical literature. A more satisfactory resolution to the Guale problem, it seems to me—then as now—is to articulate the conflicting ethnohistorical documentation with the wealth of archaeological evidence that lies out there, somewhere, buried beneath the live oaks, the palmetto thickets, and the hickory ridges that dominate the modern St. Catherines Island landscape.

Intrigued by the possibilities and promise of the archaeological record, we framed an Island-wide transect survey, setting out to recover the data necessary to resolve the Guale problem. Here's where we encountered our first *procedural* problem, an unintended consequence of our ambitious regional approach.

In framing a 20 percent, randomized, probabilistic transect survey across the entirety of St. Catherines Island, we defined two explicit objectives: (1) to obtain a relatively unbiased sample of the surviving archaeological record, and (2) to locate the long-lost Mission Santa Catalina de Guale (Thomas, 1987). Over a 3-year period (1977–1980), we accomplished both goals. Although locating and testing 122 archaeological sites in the Island-wide survey—and defining the empirical backbone of this monograph—we quickly became distracted with testing and exploring the newly discovered mission site. And this distraction with Mission Santa Catalina de Guale lasted more than 2 decades (Thomas, 1987, 1988, 1992, 1995).

We did not, of course, completely ignore the Island-wide survey throughout the 1980s and 1990s. We analyzed most of the resulting collections—the ceramics, the *Mercenaria* and radiocarbon samples, and so forth—in our laboratories at the American Museum of Natural History in New York City. Elizabeth Reitz and her students at the University of Georgia identified and interpreted the vertebrate zooarchaeological remains. Gale Bishop and Harold Rollins, working with students and associates, tackled the long-term geomorphological evolution of St. Catherines Island. But make no mistake about it—the precontact archaeological sites discovered and tested during the Island-wide survey took a backseat to our intensive excavations at Mission Santa Catalina de Guale.

And even beyond the rush of exploring, hands-on, a Franciscan mission that had been lost for more than 300 years, we were also forced to confront complexities arising from the unruly dataset consisting of 122 Island-wide transect survey sites. We lacked the guidelines and protocols for approaching such an extensive, regional sample, and

several major *analytical* problems conspired to undermine (at least temporarily) our understanding of these archaeological results, uncertainties that further stalled publication of our findings.

The first issue was microchronological. As discussed in chapter 17, we spent a decade (during the 1970s and 1980s) trying to find a way for monitoring seasonal variability across the surviving aboriginal sites on St. Catherines Island. Working with modern and archaeological specimens of hard clams (*Mercenaria*), we turned up some unexpected results and were unsure how best to proceed. Previous studies of seasonality in *Mercenaria* along the eastern seaboard—all of them conducted north of the Chesapeake Bay region—had defined a characteristic pattern of rapid summer growth, followed by quiescence during the colder winter months. Translated to archaeological specimens, this meant that fast-growth was a summer phenomenon, and slow-growth took place in the winter. But our research, conducted in close collaboration with George R. Clark II, demonstrated just the opposite pattern—rapid wintertime growth followed by severely slowed growth during the summer months. Although our modern *Mercenaria* control sample confirmed this patterning, we were reluctant to project these results onto the large sample of sites generated in the Island-wide transect survey without some convincing, independent confirmation. But where to find such “convincing, independent” evidence?

We were stalemated for a decade, until Elizabeth Reitz suggested that her student, Fred Andrus, undertake a detailed study of oxygen isotopes in modern and archaeological populations of *Mercenaria*. Funded for a year by the Edward John Noble Foundation and the American Museum of Natural History, Andrus spent the next year visiting St. Catherines monthly to collect a systematic sample of modern hard clams (in the process, earning himself the moniker “Full Moon Fred” among St. Catherines Island staffers). This research, reported here in chapter 18, provided the linkages and confirmations necessary to support our initial

findings: Indeed, as it turns out, hard clams along Georgia Bight grow much more rapidly in the winter than in the summer (and independent research by Douglas Jones and Irvy Quitmyer further confirmed these same results, as discussed in chap. 17). Andrus' findings confirmed our preliminary findings and paved the way for the extensive analysis of incremental growth and seasonality that anchors the approach to foraging variability presented in this volume.

A second analytical problem arose in the radiocarbon chronology of St. Catherines Island. More than 3 decades ago, Joseph Caldwell recognized the potential for combining radiocarbon dating with ceramic analysis to establish the cultural chronology of the Georgia coast (Caldwell, 1970). But, given the realities of coastal archaeology, Caldwell found it necessary to process both charcoal and marine shell samples to assess the ceramic chronology; at the time, he commented that the marine dates seemed somehow older than the charcoal dates. Although Caldwell used marine and charcoal dates interchangeably in his chronological analysis, he cautioned that "of course we shall continue to look for an oyster shell correction factor and other factors based on the available amount of radiocarbon in the biosphere at a particular time" (Caldwell, 1971: 1). Ten years later, in our own excavations of several Refuge-Deptford burial mounds on St. Catherines Island, we followed Caldwell's lead. While paying lip service to potential problems with "reservoir effects," we basically dismissed the problem (Thomas and Larsen, 1979: 138).

But as we worked through the data, we eventually accumulated nearly a dozen paired charcoal-shell dates that convincingly demonstrated the degree to which reservoir effects were skewing our St. Catherines Island results. This is why, in the mid-1980s, we set out to "solve" the reservoir problem for the southeastern Atlantic coastline. Contacting a number of natural history museums with relevant collections, we obtained nine mollusk samples that seemed to provide a diversified mix of known-age, pre-bomb specimens, spanning the Atlantic coastline from Beaufort (North Carolina)

to Cocoa (Florida). By radiocarbon dating each specimen, we hoped to derive a regionally consistent *reservoir correction* for processing marine shell dates from archaeological specimens.

But the results of this pilot study were disappointing: Because of the tremendous variability in the radiocarbon determinations on these known-age specimens, we gave up trying to resolve the reservoir problem for the Georgia Bight. A decade passed before we decided to move away from an overarching reservoir correction spanning the Carolina-Georgia-Florida coastline. Instead, we decided to focus our efforts strictly on St. Catherines Island (which was, after all, the reason for our interest in the "reservoir correction" in the first place).

*But where to find a decent sample of (1) known age, (2) pre-bomb mollusks, (3) from St. Catherines Island, Georgia?* After kicking this problem around with Mr. Royce Hayes (Superintendent of St. Catherines Island), one of us—we each credit the other for this insight—realized the relevance of the late 19th century oyster industry that once thrived on St. Catherines Island. Over the years, we both had repeatedly visited the three rusty oyster boilers that still survive on the island, mute testimony to the once-flourishing oyster business in the tidal waters of St. Catherines Island. Each boiler is today surrounded by huge factory middens, comprised of *Crassostrea* harvested between about 1900 and 1920. Anticipating that such known-age, pre-bomb mollusk shells might be a useful addition to the reservoir effect study, Royce Hayes harvested the first of these industrial oyster samples in 1987, and we processed several additional samples in the process of reservoir correction research. This is how the 19th century commercial oyster samples helped us solve our second analytical problem.

The oyster boiler samples provided the internally consistent results necessary to derive an accurate reservoir correction factor for St. Catherines Island ( $-134 \pm 26$  radiocarbon years) that brings the charcoal and marine shell samples into line. As a direct result, we now have a workable database of

251 comparable  $^{14}\text{C}$  dates from archaeological contexts on St. Catherines Island. Of these, we could extract 110 radiocarbon dates that were convincingly associated with aboriginal ceramic assemblages. These data allowed us to test Chester DePratter's (1979, 1991) northern Georgia ceramic chronology against independent chronostratigraphic evidence (a test that Chester himself had called for a decade earlier). The resulting St. Catherines Island ceramic chronology enabled us to control the temporal dimension across the hundreds of sites discussed in this monograph. This solved our third analytical problem.

But, even with the issues of microchronology, macrochronology, and ceramic sequence satisfactorily resolved (for now), we still faced a *theoretical* difficulty, and, in many ways, this was the most difficult problem of all. While making some headway to resolve the procedural and analytical issues raised in our study of aboriginal landscapes on St. Catherines Island, we still lacked the theoretical framework necessary to merge the parts with the whole.

During our initial fieldwork on St. Catherines Island (in the mid-1970s), we were simultaneously struggling to establish a workable epistemological framework to address the archaeology of Monitor Valley, Nevada. How could Binford's (1980) forager-collector model capture the broadscale adaptive diversity, but fail to explain why an almost global level of variability should exist in such a small area? At the time, I lamented that "we currently lack the theoretical models to explain that variability" (Thomas, 1983a: 39) and optimistically suggested that such a general theory would likely evolve through the interplay of innovative archaeological fieldwork and continued research in mid-range theory building.

Although noting the potentials of optimal foraging studies to bridge the gap between archaeological data and general theory (Thomas, 1983a: 18, 1986a, 1989: 543–550), I was critical of the way in which the archaeological evidence was treated in early applications of optimal foraging theory. I felt that general theoretical grounding would evolve through an intensive focus

on building mid-range archaeological theory (to attribute meaning to our empirical observations). But I was wrong.

The breakthrough in general theory, as it turns out, came from a different direction. Particularly over the past decade, research in human behavioral ecology has achieved a remarkable symbiosis that articulates general evolutionary theory with high-quality archaeological data. My earlier reservations notwithstanding, I now understand that human behavioral ecology does indeed provide a workable general theoretical framework for approaching the long-term archaeological record of St. Catherines Island (and elsewhere). As discussed at some length (in part I of this monograph), we have wholeheartedly embraced the overarching theoretical framework known as optimal foraging theory, an outgrowth of the more general paradigm of human behavioral ecology. In particular, we have drawn upon a series of specific models—the diet-breadth model, the prey-choice model, and central place foraging theory—adopting certain simplifying assumptions and constraints, then deriving testable hypotheses about foraging behavior under certain environmental circumstances. Our research team has buttressed this approach with 2 years of optimal foraging experiments on the resource base of modern St. Catherines Island, in which we attempted to derive procurement and return rates for key marine and terrestrial resources. This monograph presents the results of these experiments and argues for their relevance to the archaeological record of St. Catherines Island.

This, then, is why the Island-wide research remained unpublished for a quarter century. This delay is regrettable because some of our collaborators dutifully finished their contributions in a timely manner and were forced to watch (gracefully, in most cases) their best efforts languish for too long a time. We also failed in making the basic field data available to our colleagues working on the Georgia coast and to those interested in coastal foragers elsewhere in the world. Timely publication should always remain an archaeological virtue, and I apologize for taking so long.

But the upside is this: Except for the bar-est descriptions, much of what we would have published 25 years ago would have been wrong—big time. Our seasonal inferences would have been largely unsupported; our radiocarbon comparisons would have been suspect, our faith in the ceramic chronology would have been just that (“faith”), and our theoretical grounding would have been incomplete, if not misguided.<sup>2</sup>

This is why I see this publication as a mixed blessing—beyond late, but probably, better for the delay.

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## INTRODUCTION

Four deceptively simple questions have guided our long-term research into the aboriginal lifeways of St. Catherines Island:

1. How and why did the human landscape (settlement patterns and land use) change through time?
2. To what extent were subsistence and settlement patterns shaped by human population increase, intensification, and competition for resources?
3. What factors can account for the emergence of social inequality in Georgia's Sea Islands?
4. Can systematically collected archaeological evidence resolve the conflicting ethnohistoric interpretations of the aboriginal Georgia coast (the so-called "Guale problem")?

In this monograph, written by more than two dozen collaborators, we divide the presentation into three major parts, each one developing a somewhat different perspective on the aboriginal landscapes of St. Catherines Island.

Part I provides a context for the inquiry, describing the current thinking about the nature of Guale Indian society and reconstructing the changing coastal environments in which these aboriginal people (and their ancestors) lived for 5 millennia. This is a story of shifting physical and intellectual landscapes, from the dynamics of coastal geomorphology to the differing paradigms that archaeologists brought with them to St. Catherines Island. We also address the theoretical landscape that informs our current research program. We employ the general paradigm of human behavioral ecology, describing the specific models employed, addressing the assumptions involved with each approach, and summarizing the results of the extensive optimal foraging experiments that we conducted across the diverse habitats of St. Catherines Island. This part concludes with a series of specific, testable hypotheses regarding the subsistence and settlement practices of these aboriginal foragers and farmers, framed into the research design we employed to test these hypotheses.

Part II defines the chronological controls derived to monitor the temporal landscape of St. Catherines Island. We discuss the

strengths and weakness of radiocarbon approaches available to us, and derive an island-specific reservoir correction factor necessary to integrate results from marine and terrestrial sampling. After developing a database of 251 radiocarbon dates from St. Catherines Island contexts, we compare this radiocarbon chronology with the established ceramic sequence for the region. We also develop a method of incremental growth sequencing in *Mercenaria mercenaria* to establish seasonality estimates for nearly 100 of the archaeological sites tested in the Island-wide survey.

Part II also presents the specifics of the archaeological landscape, sampled across the diverse habitats of St. Catherines Island. We present the site-by-site results of the Island-wide and shoreline archaeological surveys, describing the artifacts and zooarchaeological remains recovered. We also include a critical reanalysis of the mortuary evidence from St. Catherines Island and summarize our findings for the more extensive excavations at the Meeting House Field and Fallen Tree sites.

Part III draws together and synthesizes the diverse evidence presented in the first two parts of the monograph. Chapter 29 and chapter 30 combine the geomorphological and archaeological findings to reconstruct, in some detail, the changing configuration of St. Catherines Island during the past 5 millennia. We then summarize the aboriginal landscape on a phase-by-phase basis, addressing the available information regarding chronology, settlement pattern, subsistence, seasonality, bioarchaeology, and ritual activity from the Late Archaic through Spanish mission periods.

Finally, we examine the various hypotheses advanced through the paradigm of human behavior ecology. Chapter 31 and chapter 32 addresses the expectations derived from the diet-breadth model, particularly looking at prey choice and resource depression among the highest-ranking taxa, especially white-tailed deer, diamondback terrapin, salt-water fishing, and shellfish collecting. The next chapter looks at central place foraging

and patch choice modeling, evaluating long-term trends in site positioning on the Pleistocene core and Holocene beach ridges of St. Catherines Island. Finally, in chapter 33, we evaluate the evidence for population increase, occupational periodicity, resource intensification, and the emergence of social inequality along the aboriginal Georgia coast. The monograph ends with a reconsideration of the Gule problem in light of the new data available on economic intensification, residential mobility, and paleoclimatic fluctuations.

## NOTES

1. Actually, the excavations at Fallen Tree and Meeting House Field continued through the mid-1980s, and we have conducted a number of additional, follow-up studies in recent years. We are also engaged in long-term excavations at the St. Catherines Shell Ring (mentioned briefly in chap. 20, this volume). Chapter 1 explains how the various archaeological projects on St. Catherines Island fit together.

2. And I certainly harbor no illusions that we've offered anything approaching a "final word" in these pages. We have not.

# CHAPTER 1. HISTORY OF ARCHAEOLOGICAL RESEARCH ON ST. CATHERINES ISLAND

DAVID HURST THOMAS

The Euro-American history of St. Catherines Island—a 5670 ha (14,000 acre) tract (including the salt marsh) situated approximately 6 km east of the Georgia mainland (fig. 1.1)—is detailed elsewhere (Thomas et al., 1978: chap. 4). This chapter summarizes the history of archaeological research on St. Catherines Island, serving as a preamble to introduce the research design for the Island-wide archaeological survey presented in this monograph (fig. 1.2).

## CHARLES COLCOCK JONES, JR.

The first known archaeological investigation on St. Catherines Island was conducted by Charles Colcock Jones (1831–1893), eldest son of the locally well-known Rev. C. C. Jones of Midway, Georgia. Born in Savannah, Jones spent his childhood in Liberty County. Quite early in life, he developed an intense interest in the local archaeology and began to collect relics before attending college at Princeton and Harvard. With the outbreak of hostilities surrounding the war between the states, Jones returned to Savannah to serve in the Chatham Artillery. After the Civil War, Jones moved to New York City in 1866, where he practiced law before returning to Georgia in 1877 (see Myers, 1972: 1568 for a biographic sketch of C. C. Jones, Jr.).

Jones discussed his artifact collection in several publications (1859, 1873, 1883) and claimed to have opened more than 100 prehistoric mounds on the Georgia Coast (Jones, to the American Museum of Natural History, March 5, 1877). He also described finding a wooden canoe submerged in the Savannah River (Jones, 1871–1872).

While practicing law in New York City, Jones became aware of the fledgling American Museum of Natural History, which he described as “already [in 1877] a most valuable thesaurus, seems destined to become, of its kind, the chief glory of these people”

(Jones, to the American Museum of Natural History, March 15, 1877). Despite what he described as “liberal offers from England,” Jones offered two-thirds of his collections to the American Museum of Natural History, including those specimens he described in his 1873 publication. The Jones collection was formally accessioned by the American Museum of Natural History in 1877. Of the several thousand artifacts included in his collection, only one—a green quartzite celt—is definitely from St. Catherines Island (illustrated in Thomas et al., 1978: fig. 14).

## CLARENCE BLOOMFIELD MOORE

Clarence Bloomfield Moore (1852–1936) was the next archaeologist known to have visited St. Catherines Island. Son of a wealthy Philadelphia socialite, Moore received his B.A. degree from Harvard University in 1873. At the age of 24, Moore traveled extensively across South America. His father died shortly thereafter, and Moore was astonished to learn that his estate allowed him ample means. Freed from financial concerns, Moore led a life of whim and fancy, following the social circuit, rambling throughout Europe and joining safaris into exotic Africa. By 1892, Moore had suffered a serious eye injury, inflicted by an errant tennis ball. Having tired of his socialite lifestyle, Moore began seeking more consequential (and perhaps less hazardous) pursuits.

At age 40, C. B. Moore was transformed from gentleman socialite into gentleman archaeologist. Smitten by his new pastime, Moore purchased a specially equipped flat-bottomed steamboat, named the *Gopher*, and he set off to explore the seemingly endless waterways of America’s Southeast, excavating the major archaeological sites he encountered (Pearson et al., 2000). Particularly drawn to the hundreds of burial and

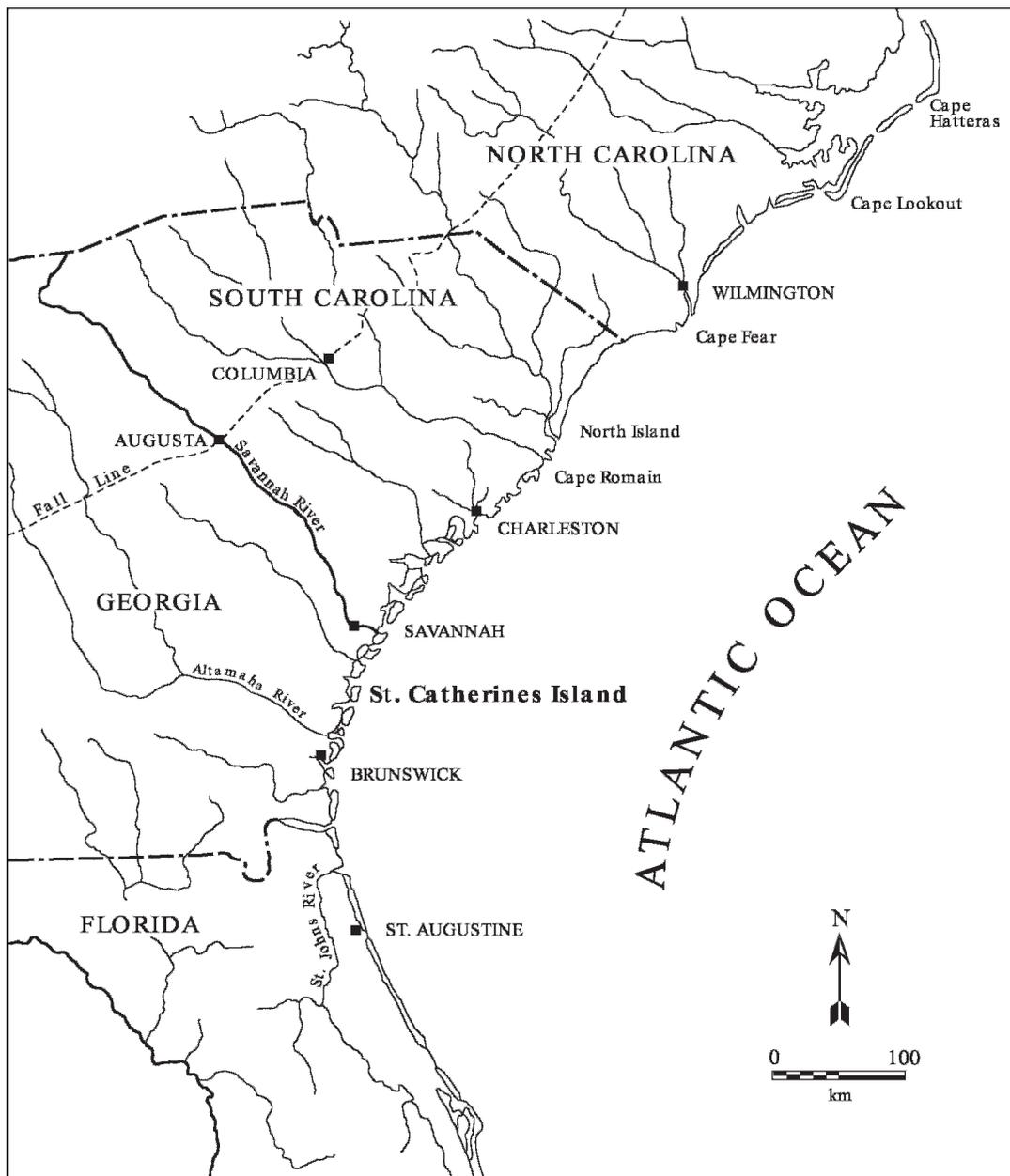


Fig. 1.1. The location of St. Catherines Island, Georgia.

temple mounds, Moore enlisted the services of Dr. Milo G. Miller as secretary, physician, colleague, and friend.

Moore prepared detailed excavation reports for publication, distributing the more unusual artifacts to major archaeological institutions such as the Peabody Museum

at Harvard, the Smithsonian Institution in Washington, D.C., and the American Museum of Natural History in New York City. The bulk of the collection, however, was entrusted to the Philadelphia Academy of Natural Sciences, and was later sold to the Museum of the American Indian in New

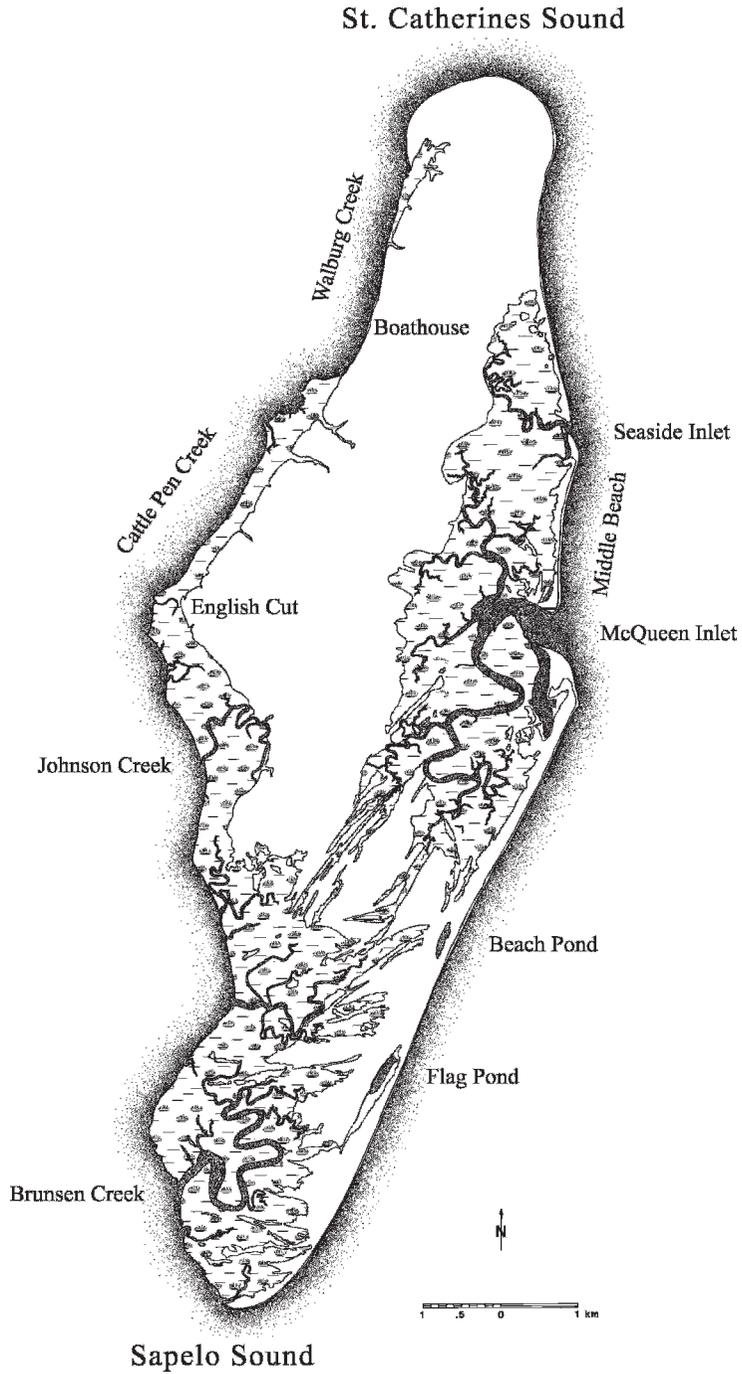


Fig. 1.2. Landmarks on St. Catherines Island, Georgia.

York City. Initially conducted in secrecy, the transfer was quickly publicized by H. Newell Wardle, then assistant curator at the Philadelphia Academy, who resigned from her position in protest.

During the fall and winter of 1896–1897, Moore concentrated his efforts on the burial mounds of the Georgia coast. During this 5-month campaign, Moore “demolished” [his word] more than 50 such mounds, seven of them on St. Catherines Island (for the exact locations, see fig. 20.1). His findings were published by the Philadelphia Academy of Natural Sciences (Moore, 1897; see also Larson, 1998). Although Moore’s field methods can be criticized from a modern perspective, his techniques seemed wholly acceptable to his contemporaries, and his prompt publications continue to serve as a model even for today’s archaeologists. Moore took careful field notes during his excavations, and, with the help of Dr. Miller, the human skeletal remains were identified and described in the field. Examination of the original field notes (then housed in New York’s Huntington Library and since transferred to the Cornell University library) indicates that Moore’s descriptive volume published these notes almost verbatim. The mound fill was described in terms of morphology, coloration, and content. Burial descriptions included orientation, type (extended, flexed, bundle, cremation), general age (adult or subadult), sex, grave goods, and obvious pathologies.

Moore (1897) described his investigations of seven burial mounds on St. Catherines Island: Mound near South-End Settlement, Mound near Middle Settlement, Mound in King’s New Ground Field, Mound in Greenseed Field, Mound near Lighthouse, Low Mounds at North-end (fig. 20.1; see also Thomas et al., 1978: fig. 15). In all, about 120 burials from St. Catherines Island were exposed and described. Moore apparently saved only selected crania and pathological specimens, which were later donated to the National Museum of Natural History, the Army Medical Museum, Harvard’s Peabody Museum of Archaeology and Ethnology, and New York’s Heye Foundation. Six whole vessels from St. Cath-

erines Island were donated to the Peabody Museum, the Heye Foundation, and the American Museum of Natural History; the remaining sherds and bones were discarded in the field. Although such practices differ radically from current standards, Moore’s work remains important because he meticulously described the human material, including orientation and rough estimates of sex and age.

C. B. Moore’s excavations are important contributions not only to Georgia coastal archaeology, but to the history of North American archaeology as well. Moore was among the first to define an explicit goal, conduct archaeological fieldwork to answer a set of specific questions, and publish his findings in a clear, concise manner. For additional assessments of Moore’s archaeology, see especially Knight (1996), Neuman (1984), Wardle (1956), Aten and Milanich (2003), and Pearson and Cook (2003).

#### LEWIS LARSON (GEORGIA HISTORICAL COMMISSION)

Just weeks after purchasing St. Catherines Island (in the winter of 1943), Mr. Edward John Noble announced that he was “intensely interested in all things historical and archaeological pertaining” to the island, specifically expressing his desire to find the site of Mission Santa Catalina de Guale (Lane, 1943). The next step in this long process took place in 1952, when Lewis Larson visited St. Catherines Island as part of the Georgia Historical Commission search for 16th and 17th Spanish mission sites along the Georgia Coast. Among the “good candidates for the location of a mission,” Larson (1952: 2; see also 1953: 11, 31) listed “Wamassee Head on St. Catherines as the location of Santa Catherina de Guale,” but he cautioned that “no final and conclusive identification of a mission site can be made until adequate excavation ... has been undertaken.”

Site form 9Li13 (formerly 9Lb8), prepared by Larson on August 12, 1952, reports “a series of shell mounds [that] ranged along the marsh edge [of Wamassee Head]. They are approximately 3’ high and 50’ in

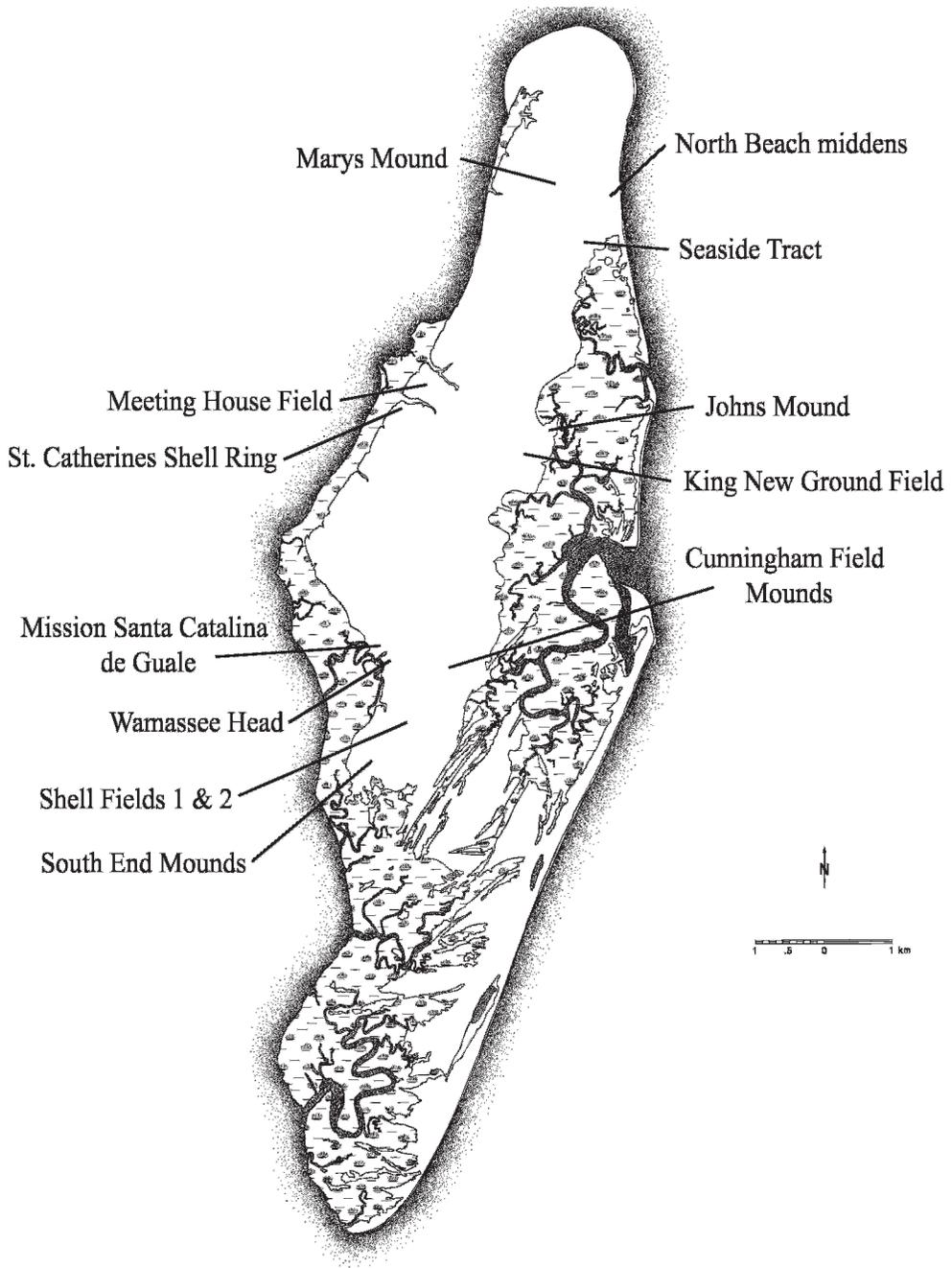


Fig. 1.3. Some important archaeological sites on St. Catherines Island, Georgia.

diameter.” Larson’s excavations recovered Spanish and aboriginal sherds, thereby subjecting geographic and historic conjecture to scientific archaeological investigation (fig. 1.3).

Three years later, this same site was “re-discovered” by Mr. John W. Bonner, Jr., and Ms. Carroll Hart, who were retained in 1955 by Mr. Edward John Noble to prepare a historical overview of the island

(Hart and Bonner, 1956). Apparently unaware of Larson's research, Hart and Bonner were curious to see if they could find any signs of the mission. Relying heavily on the 1687 Dunlop account, Bonner and Gaffney Blalock explored the coast southward from Persimmon Point. Although they encountered several archaeological sites in the area, they were particularly impressed with the quantity of historic sherds washing out of the Wamassee Creek cut (John Bonner and Gaffney Blalock, personal communication); they photographed and collected several olive jar and majolica fragments from the creek bed, correctly pinpointing Wamassee Creek as the general location of Santa Catalina de Guale.

Larson returned to Wamassee Creek in 1959 to conduct the first archaeological investigations in the general vicinity of Mission Santa Catalina. The excavated sample contained evidence of a wide range of aboriginal occupations, but most of the sherds were aboriginal ceramics that dated to the Spanish period (see Brewer, 1985). Larson also recovered olive jar sherds and characteristic types of Spanish majolica ware that were known from Spanish mission sites in Florida. No structural evidence of Santa Catalina emerged in these preliminary tests.

JOHN W. GRIFFIN  
(NATIONAL PARK SERVICE)

At the request of Mr. Alger B. Chapman (Executor of the estate of Edward John Noble), John W. Griffin (former Staff Archaeologist, U.S. National Park Service) visited St. Catherines Island on April 5–9, 1965. The primary purpose of Griffin's visit was to gather information regarding the eligibility of the site of the Santa Catalina Mission as a Registered National Historic Landmark. Griffin first traveled to Georgia State University, where he examined the collection of artifacts and field notes from Larson's excavations at Wamassee Head. Charles Fairbanks (University of Florida) also supplied Griffin with notes on historic Spanish documents relating to the mission on St. Catherines Island.

Griffin prepared a report addressing the specific whereabouts of Mission Santa Catalina (Griffin, 1965b), correctly concluding that "the location of Santa Catalina mission in the seventeenth century [may] ... be fixed with assurance ... to the area known as Wamassee Head [where] abundant shell midden refuse is found, dominated by Indian potsherds of the correct time period for the mission settlement" (Griffin, 1965b: 6). Griffin's suggestions regarding Mission Catalina de Guale have been discussed in some detail elsewhere (Thomas, 1987: 105–106).

In addition, Griffin prepared a more detailed summary of his archaeological reconnaissance on St. Catherines Island (Griffin, 1965a). In the company of Mr. John Toby Woods (former Superintendent of St. Catherines Island), Griffin visited numerous archaeological sites on the island, including Meeting House Field, Shell Fields 1 and 2 (located to the south of Larson's test at Wamassee Head), and an eroding shell midden on the bluff at North Beach. Griffin noted two curious sites apparently dating to the historic period. At two points along the western shore of the Island, Griffin noted "tabby blocks ... rather formless masses of lime and oyster shell" situated in the "draws" or "cuts" emptying into the marsh edge. Griffin (1965a: 5–6) concluded: "I hesitate to say what they are, but advance the suggestion that they may be spots in which oyster shell, removed from aboriginal middens, was burned to make lime for tabby construction which was commonly used on the island in the plantation period. This is, however, only hypothesis."<sup>1</sup>

Griffin (1965a: 7–8) also noted an "enigmatic log structure" in the marsh immediately south of Meeting House Field. He mapped this construction, built of waterlogged small poles arranged in a rectangle measuring 34' 4" by 28' 8". Although unable to offer a convincing explanation for this structure, Griffin (1965a: 8) warned that "before writing the site off as some unexplained but recent structure, it would probably be well to investigate it more thoroughly." As part of our Island-wide reconnaissance, we did indeed explore this

curious log feature, and the results are reported in chapter 16.

After completing this brief field reconnaissance, John Griffin (1965a: 10–11) made the following recommendations to the Edward John Noble Foundation:

St. Catherines Island is richly endowed with archaeological resources [and] to properly understand the total prehistoric and historic picture of man's occupation of this coastal island, considerable more work is needed.

The first need is for a detailed and systematic archaeological survey which would pinpoint all locations of human activity, test them to determine their depth and extent and cultural affiliation, and analyze the materials from surface collections and tests to establish a program of investigation of the most significant remains. It is obvious even now that a rather complete record of prehistoric times stretching back into the fiber-tempered period, as much as 2000 B.C., and up through the mission period into the historic plantation era is available on the island. There may even be earlier remains, from the preceramic Archaic period. The opportunity exists to study the human use of a well-defined insular area through a long period of time. ...

While further work on the site of Santa Catalina mission is in some respects of the highest priority, it is the total of the archaeological resources (including the plantation period), which gives the archaeology of the island its somewhat unique nature. (Griffin, 1965a: 10–11)

JOSEPH R. CALDWELL  
(UNIVERSITY OF GEORGIA)

Largely as a result of Griffin's report to the Noble Foundation, Joseph Caldwell and his students from the University of Georgia were permitted to conduct three seasons of archaeological fieldwork on St. Catherines Island. Supported by the Edward John Noble Foundation, Caldwell and his associates excavated both burial mounds and shell middens. Particularly enlightening was the excavation of John's Mound, which resulted in the definition of a new cultural period, known as the St. Catherines period (Caldwell, 1971). John's Mound was almost completely excavated

and Caldwell noted that "this is the earliest occurrence of a burial mound on the Georgia Coast." Mary's Mound, a second St. Catherines period site and Seaside Mound I, a Refuge-Deptford period site were also tested. In addition, Caldwell mapped 10 middens in the general area. In total, the University of Georgia excavated approximately 75 human burials. Caldwell also tested several shell middens along the eastern and western banks of the Island, a Wilmington–Savannah II period site in the Seaside Tract, and several middens in King New Ground Field.

During the summer of 1970, the University of Georgia crew brought a mobile archaeological laboratory to the island (Noakes and Schneider, 1971). Transported to the island by barge and driven to the sites under investigation, the mobile laboratory was equipped with "micro-fraction extractors capable of retrieving small plant and animal remains, radiocarbon dating instrumentation and support systems, and photomicrographic equipment" (Noakes and Schneider, 1971). While on St. Catherines Island, the mobile laboratory analyzed various samples from shell middens and processed several radiocarbon dates. Included in the present analysis, these dates are discussed in chapter 13.

Caldwell also dug several test pits in the Wamassee Creek area. These limited soundings turned up, among other things, three Altamaha Line Block Stamped bell-shaped pots in addition to olive jar, majolica, and Spanish iron fragments. Water screening in the creek bed also recovered several dozen glass trade beads. In unpublished fieldnotes, Caldwell speculated:

Surface collections made by Mr. John Tobey [sic] Woods and various students and test excavations made by the University of Georgia party show the following sequence of materials at Wamassee.

1. A small appositely beveled flint knife found on the surface by Mr. Smith of a type which is generally older than 2500 B.C. in the Southeast. If more of these can be found we will have a terminus ante

quem for such a Sea Island as St. Catherines.

2. On the north side of the site test excavations A, B, D, and E all yielded Deptford III Period pottery in the lower levels. A radiocarbon determination for Deptford III from Excavation B was 490 A.D.  $\pm$  90 years (UGA 116) and fits nicely in our Coastal sequence.
3. On the south side of the site the lower levels of the Fallen Tree shell midden showed a distinctive protohistoric pottery complex which we have named Fallen Tree.
4. Blanketing the entire site and extending far beyond the area shown on the preceding map are pottery and artifacts of the Spanish Mission Period. There is no reason to believe, at present, that this is not the site of the mission of Santa Catalina. So far, however, our excavations have yielded little structural detail. (Caldwell, 1972)

A second radiocarbon date was processed on a shell sample from Excavation A at Wamassee: 270 B.P.: A.D. 1680  $\pm$  65 (UGA 120). This date, and the Wamassee excavations in general, were briefly discussed in Caldwell (1971: 92; see also chap. 13, this report).

Joseph Caldwell summarized the University of Georgia field schools during the summers of 1969, 1970, and 1971 as follows: "The objectives were exploration, establishment of a chronology, and determination of particular historic and prehistoric conditions and events. These objectives have been only partially achieved." In a letter written on February 21, 1973, Caldwell wrote that "the possibilities on St. Catherine's are still exciting to me, and I should like very much to continue."

But Caldwell's death on December 23, 1973 brought a halt to any further investigations and delayed the publication of his important excavations. Only one summary statement of chronology was located (Caldwell, 1971), and several unpublished manuscripts relating to archaeological investigations of St. Catherines Island remain on file at the University of Georgia.<sup>2</sup>

Such was the state of knowledge regarding the location of Mission Santa Catalina when the American Museum of Natural History began long-term archaeological fieldwork on St. Catherines Island in 1974.

## AMERICAN MUSEUM OF NATURAL HISTORY

In 1972, the American Museum of Natural History entered into an agreement with the Edward John Noble Foundation to encourage and facilitate scientific research on St. Catherines. After Caldwell's untimely death, Thomas was asked to consider working on the island, and the resulting program has enabled hundreds of scientists and students to conduct research on various aspects of the natural and cultural history of St. Catherines Island.

### AN ARCHAEOLOGICAL PERSPECTIVE

Since 1974, field crews from the American Museum of Natural History have conducted intensive and extensive archaeological investigations as part of this overall research program. The results of these inquiries have been reported in several monographs grouped within the general rubric "The Anthropology of St. Catherines Island"; each appeared as an Anthropological Paper of the American Museum of Natural History. The first volume in this series (Thomas et al., 1978) provides an overview of the natural and cultural history of St. Catherines Island and also serves as a backdrop for this monograph.

The St. Catherines Island archaeological project initially focused on the Refuge and Deptford mortuary complex (Thomas and Larsen, 1979). Crews from the American Museum excavated nine burial mounds between November 1974 and May 1977. These investigations clarified the temporal affiliations of these subtle, inconspicuous sand mounds and also yielded the first real data regarding religious and ritual practices during these early periods. The program in mortuary archaeology continued in 1977 and 1978, when we excavated two St. Catherines period burial sites: Marys Mound and Johns Mound (Larsen and Thomas, 1982). Ceramic and <sup>14</sup>C evidence suggest that both mounds were constructed during the late 12th and early 13th centuries A.D. (see also Larsen, 1981, 1982, 1984).<sup>3</sup>

We have also reported on subsequent archaeological excavations at two additional

prehistoric burial mounds on St. Catherines Island (Larsen and Thomas, 1986). South End Mound I is an Irene period mortuary site (ca. A.D. 1300–A.D. 1600) that had been initially excavated by C. B. Moore during the winter of 1896–1897 (Larsen, 2002). South End Mound II, a previously unrecorded St. Catherines period burial mound, was discovered not far from Moore's excavations. Related mortuary excavations on St. Catherines Island are reported elsewhere (Thomas et al., 1978).

While still pursuing the biocultural research, we initiated an Island-wide archaeological survey. The first step was to conduct a 20 percent systematic randomized sample of St. Catherines Island, disclosing and testing approximately 135 archaeological sites. This regional randomized survey forms the basis of the present discussion.

The Island-wide survey completed, we shifted our focus to search for and excavate the 16th and 17th century Franciscan mission at Santa Catalina de Guale (Thomas, 1988a, 1988b, 1991, 1992). Between 1981 and 1990, the research and excavations focused almost exclusively on the mission compound at Mission Santa Catalina. Beginning in 1991, we expanded the scope of our investigations on the island to include the Native American village (pueblo) at Santa Catalina. Two research monographs (Thomas, 1987; Larsen, 1990) have been published documenting our excavations at Mission Santa Catalina. We have also published two volumes (Bushnell, 1994; Worth, 1995) providing a documentary context for these excavations, derived from the study of mission records and firsthand accounts of life in the Spanish missions on the Georgia coast. We are presently preparing several additional monographs describing the archaeology of Mission Santa Catalina de Guale.

For the next decade, we scaled back the archaeological investigations on St. Catherines Island, focusing instead on analysis and conservation of the archaeological and paleoenvironmental collection. Most of this work took place in the Nels Nelson Laboratory of North American Archaeology (American Museum of Natural History,

New York), where all the artifacts in the St. Catherines Island collection were catalogued, stabilized, and analyzed in preparation for publication. The most valuable and most fragile artifacts were kept in a high-security area in the Nelson laboratory, where they were maintained under temperature- and humidity-controlled conditions. Those items needing additional stabilization and/or conservation were treated in the New York laboratory.

With stabilization and analysis largely completed, most of the archaeology collection was packed for transport to the temporary holding facility on St. Catherines Island. By 2001, roughly 1000 archive-style boxes were stored in the on-Island facility, where they were housed under controlled conditions, awaiting transfer to one or more local research institutions. After considerable research and discussion, the Edward John Noble Foundation decided that the Paleoenvironmental Collection from St. Catherines Island should be transferred to the Florida Museum of Natural History (Gainesville) and the St. Catherines Island Archaeological Collection would be donated to the Fernbank Museum of Natural History (Atlanta). Physical transfer of both collections took place in 2003 (although some of the most valuable and/or sensitive artifacts still remain at the American Museum of Natural History, available for transfer as the appropriation circumstances permit).

Beginning in 2003, the American Museum of Natural History began a new, three-part program of archaeological research and conservation, still under the auspices of the Edward John Noble and St. Catherines Island Foundations.

The eastern shore of St. Catherines Island is presently experiencing an unprecedented episode of erosion. During each hurricane season of the 21st century, the island has lost at least 2–3 m of the exposed Pleistocene-age bluff during a 2-month period. This loss was most severe along the northeastern bluffs, which contain numerous Late Archaic occupations. We know the exact location and nature of only 20 percent of these sites (from the systematic, randomized site survey described above), so we have be-

gun to locate and document all of the still unknown sites in this threatened area.

We have also been monitoring all the other archaeological sites in imminent danger of destruction anywhere on St. Catherines Island, excavating the most threatened sites, and conducting all necessary archaeological clearances for on-going construction projects on the island. The American Museum of Natural History is advising about potential impacts (both primary and secondary) on the archaeological record and mitigate those impacts which are unavoidable. While we cannot stop the sites from disappearing, we can preserve an important part of the information contained within these doomed sites.

We have also renewed our research program of field archaeology on St. Catherines Island, specifically directed at complementing and amplifying the results reported in this volume. Given the overall theoretical framework discussed in Part II (this volume), we found it necessary to conduct a comprehensive series of optimal foraging experiments on St. Catherines Island, each designed to produce estimates of post-encounter return rates for key island resources. Target resources include clams, oysters, blue crabs, periwinkles, knobbed whelks, loggerhead turtles, diamondback terrapins, live oak and laurel oak acorns, and pignut hickories. The results of these return rate experiments appear in chapters 6–8.

Beginning in March 2006, we also began intensive mapping and testing of the St. Catherines Shell Ring (9Li231, initially located in the Island-wide survey and described briefly in chap. 20, this volume). This large Late Archaic site is the earliest evidence of human occupation on St. Catherines Island, and we are presently experimenting with appropriate excavation and recovery strategies to relate this St. Simons period occupation to the initial emergence of St. Catherines Island itself.

#### A BIOCULTURAL PERSPECTIVE

In 1974, when we began our research program on St. Catherines Island, it was rare that an archaeologist would invite a consult-

ing osteologist to visit the excavation site, much less to solicit advice regarding the best way to test the site and to excavate human burials. Since then, however, a new brand of physical anthropologist has emerged who works closely with field archaeologists primarily to study the prehistoric biological system. Termed *bioarchaeology* (after Larsen, 1997), this relatively new subdiscipline recognizes the need for cooperation between archaeologists and biologists in order to work toward a common goal.

The archaeological program on St. Catherines Island has benefited immensely from our close collaboration with Clark Spencer Larsen, a full-fledged member of the research team from its inception. Thomas invited Larsen, then a graduate student at the University of Michigan, to join the very first American Museum-sponsored dig on St. Catherines Island (in November 1974). Since then, Larsen has been intimately connected with all excavations involving human remains. We generally directed the stratigraphic excavations at the various mortuary sites, and Larsen personally supervised the exposure, recording, and removal of all human remains encountered. The early mortuary mounds of St. Catherines Island formed the basis of Larsen's doctoral research (Larsen, 1982). With the discovery of Mission Santa Catalina de Guale, as part of the Island-wide archaeological survey discussed in this monograph, Larsen continued to share responsibility for the 15-year-long excavation program. Throughout the program, Thomas directed the structural and architectural excavations at Mission Santa Catalina and Larsen supervised the excavation of the cemetery area, located inside the mission church (see Larsen, 1990). From 1991 to 1993, Larsen returned to St. Catherines Island to personally direct the reexcavation of South End Mound I, which turned out to be Moore's "Mound Near South-End Settlement" (Moore, 1897: 74–81; Thomas and Larsen, 1986; Larsen, 2002).

Bioarchaeology has been a major focus of the St. Catherines Island archaeological program for 3 decades. Clark Spencer Larsen, his students, and his colleagues have generated important new insights from the

bioarchaeological analyses conducted on the human remains recovered from St. Catherines Island. These carefully excavated remains have been studied by a number of independent techniques, including biomechanical analysis, microscopic examination of dentition, reconstruction of ancient demographic profiles, and stable isotope analysis, and the results of these diverse studies have been completely published (e.g., Thomas and Larsen, 1979; Larsen, 1982, 2001, 2002; Larsen and Thomas, 1982, 1986; Hutchinson and Larsen, 1988, 1990; Larsen et al., 1990, 1991, 1992; Ruff and Larsen, 1990; Schoeninger et al., 1990; Simpson et al., 1990; Larsen and Hutchinson, 1992; Larsen and Harn, 1994; Larsen and Ruff, 1994; Hutchinson et al., 1998).

The bioarchaeological results have been synthesized with the various nonmortuary archaeological activities reported in this volume (esp. chaps. 20 and 25).

#### AN ETHNOHISTORICAL APPROACH

Despite what might seem to be a community of interest, archaeologists and historians tend to appreciate each other the way that Vandals appreciated Romans. They regard each other's research as so much booty to be plundered, and they pay little attention to how or why it was originally assembled. (White, 1992: 155–159)<sup>4</sup>

American archaeologists and American historians frequently cross paths, but these interdisciplinary encounters seem to be less productive than one might wish.

Stereotypes too often prevail, with archaeologists viewing historians as hopeless particularizers, whose research had only limited applications to the search for general laws of cultural systematics (e.g., Cleland and Fitting, 1986; Schuyler, 1979: 201–202; South, 1977: 5–13; see also Carneiro, 2000). Likewise, historians have sometimes viewed archaeology not as a discipline, but more as a set of techniques used to recover information that was passed along to historians for appropriate analysis and synthesis (e.g., Frost, 1970; Wilderson, 1975; Deagan and Scardaville, 1985: 32). Archaeologists continue to be chastised for attempting to “write

history,” the operative assumption being that archaeologists (by definition not trained professional historians) will inevitably abuse documentary evidence. This assumption has proved as distressing to some archaeologists as the assumption that “if one can use a shovel, one can do archaeology” is to others (Deagan and Scardaville, 1985: 33).

Although taking note of the long-standing friction between archaeological and historical viewpoints, John Griffin clearly manifested his own archaeological perspective:

All of us who are archaeologists know that historians were slow to recognize the possible contributions of archaeology to their studies. ... It was in the 1960s that significant numbers of historical archaeologists began to disparage the relevance of documentary sources to their understanding of archaeological sites and materials. I know that more than once I heard “all history is a lie” seriously espoused by some of my colleagues. It is certainly true that many questions that archaeologists would like historians to answer are not the ones that seem pertinent to the historian, and vice versa ...

But as more and more historians have been exposed to anthropology ... it has become easier for them to understand our concerns, if not necessarily adopt them. I also get the impression that more archaeologists are understanding the stance of the historian, appreciate the real potential of documentary context for archaeology, and perhaps even coming to enjoy narrative history for its own sake. (Griffin, 1990: 405–406)

With all of this as background, we experienced a certain degree of trepidation during the early days of the St. Catherines Island research, as we approached the available documentary record for early Native American occupations of the Georgia coast.

These reservations evaporated when we discussed the possibilities of ethnohistorical collaboration with Grant D. Jones, an ethnohistorian with extensive experience working with protohistoric Maya groups (e.g., Jones, 1989). As part of the American Museum of Natural History's archaeological program on St. Catherines, we asked Grant D. Jones to consider taking on a research project addressing Guale ethnohistory. Jones had just completed a similar study

on lowland Maya intervillage alliances (Jones, 1977), and we asked him to initiate an exploratory investigation into the resources available for a much broader ethnohistorical study on St. Catherines Island. His preliminary results were so promising that we encouraged Jones to prepare a summary of Guale ethnohistory, which was published as part of the *Natural and Cultural History of St. Catherines Island* (Jones, 1978).

Jones cautioned that a more detailed study of the primary sources was warranted, "but the interpretational problems are considerable" (1978: 241–242). Many of the early historical sources (e.g., Bolton, 1921; Lanning, 1935; Geiger, 1937; Chate-lain, 1941) overlooked material of considerable anthropological relevance. Source reliability is highly variable, particularly in the important early Jesuit reports. Although Jones consulted many original documents and transcripts, he was often forced to rely on available English translations, clearly indicating that more detailed exploration of the original sources is required. He also emphasized the importance of assessing the degree of temporal and social change reflected in the various documentary sources, especially as regards the changing context of colonial rule. Finally, Jones' reconstruction of 16th century Guale settlements largely omits the majority of smaller settlements, a problem further compounded by inconsistencies in spellings of Guale places and names. Jones (1978: 243) cautioned that his reconstruction of Guale chiefdom organization is "greatly oversimplified" and necessarily downplayed the role of intracommunity social organization. He concluded that "in certain respects [my model] is similar to Lanning's (1935: 11–15) 'common sense' model of Guale political organization. There is a certain comfort to be derived from the fact that one has attempted, however, to provide a more detailed, more revealing reading of the same data through the application of stricter procedures of analysis" (Jones, 1978: 243).

After we discovered Mission Santa Catalina de Guale in 1981, the scope of the St. Catherines Island research broadened significantly to consider the European impact on

Native American cultures living on the island. Realizing the importance of linking document-based research with ground-level archaeological perspectives, we began exploring the possibility of bringing a Spanish Borderlands historian onto the Mission Santa Catalina research team. At this point, we were extraordinarily fortunate to meet Amy Turner Bushnell, a distinguished historian with the Historic St. Augustine Preservation Board and specialist in the study of Hispanic American peripheries (e.g., Bushnell, 1978, 1981, 1990). In 1982, during a visit to our excavations at Mission Santa Catalina, Bushnell raised dozens of questions that a directed re-reading and reinterpretation of the relevant documentary record might answer. We were inspired by the possibility of collaboration with Dr. Bushnell, who began searching documentary sources for relevant historical data to bring to bear on the archaeological investigations in progress.

In 1986, we formalized our collaboration, and Dr. Bushnell agreed to research and write a volume that addressed the material manifestations of the Franciscan mission effort in Spanish Florida. The result was a monograph entitled *Situado and Sabana* (Bushnell, 1994), a groundbreaking study documenting the mixed support system by which Spain maintained an economically unprofitable but strategically critical outpost on the contested eastern coast of North America. Bushnell answered many questions about Hispanic life on the Franciscan frontier during the 16th and 17th centuries: what food was grown and consumed, how forced Indian labor was controlled, what specific religious and mortuary practices were emphasized (and which were overlooked), how garrisons were provisioned, and how economic items flowed into and away from the missions. In short, *Situado and Sabana* places St. Augustine and its associated mission chains with Spain's grand scheme to colonize the entire New World.

Our ethnohistorical perspective of our St. Catherines Island research evolved through an unexpected collaboration with John E. Worth, then a University of Florida graduate student conducting doctoral research in the Archivo General de Indias (Seville, Spain).

While researching the Timucuan sources (published as Worth, 1998a and 1998b), Worth made a startling discovery. Amidst a stack of routine notary records from St. Augustine was a long-forgotten packet of 16th-, 17th-, and 18th-century documents. As Worth soon discovered, this “marvelous assortment” of documents had been pulled together in 1739 at the bequest of Don Manuel de Montiano, Governor of Spanish Florida. Acting upon direct orders from King Philip V of Spain, Governor Montiano assembled the primary sources documenting Spain’s claim to territories contained within James Oglethorpe’s new English colony of Georgia.

Amazingly, Montiano’s archival package had escaped the view of modern historians. Worth was well aware that historians and archaeologists working on the early contact period in coastal Georgia had long suffered from the lack of published historical sources. Contained within Governor Montiano’s extraordinary parcel was a wealth of previously unavailable documents: bureaucratic reports from former governors, a variety of correspondences (including a census of Indians living in the Guale and Mocamo mission provinces), assorted Franciscan mission records documenting a previously unknown visitation, letters sent by Franciscans quartered in Guale, and an original patent with notes signed by each Franciscan friar that served in those missions.

Once we learned of this extraordinary find, we suggested that Worth prepare the documents for publications as part of the ongoing ethnohistorical component of the St. Catherines Island research program. The final product, published as *The Struggle for the Georgia Coast* (Worth, 1995), addressed a number of key issues, including the circumstances and timing of the move-

ment of mainland Guale missions and villages to their new barrier island locales. Worth’s overview also provided new information and fresh interpretations, integrating earlier historical syntheses with newly available data on Native Americans that inhabited coastal Georgia.

Worth’s research complements the ethnohistorical account prepared by Grant Jones (1978). Whereas Jones concentrated mostly with the period from first European contact to 1606, he only briefly visited subsequent events to 1684, noting that considerable additional research would be required to illuminate the 17th-century mission period in Georgia. Worth’s monograph did much to fill this void, carrying the documentary record forward well into the 18th century.

The ethnohistorical studies by Grant Jones, Amy Turner Bushnell, and John Worth provided much needed supportive documentation for the continued archaeological research on St. Catherines Island. Their documentary evidence also appealed to a much broader group of archaeologists, anthropologists, geographers, church historians, and Native Americans interested in this still misunderstood period of history in the American Southeast.

## NOTES

1. We have since mapped several of these tabby concentrations and offer an alternative explanation in chapter 20.

2. As noted in the next section, several of Caldwell’s excavations have been reanalyzed and published as part of the ongoing program of St. Catherines Island archaeology sponsored by the American Museum of Natural History.

3. These data are reanalyzed in light of new data in chapter 24, this volume.

4. Parts of this section revisit previous discussions by Thomas (1994, 1995).

## CHAPTER 2. THE GUALE PEOPLE

DAVID HURST THOMAS

This chapter provides a general description of what the documentary sources tell us about the Guale Indians of St. Catharines Island, among the first indigenous peoples met by Europeans exploring north of Mexico. This overview of the Guale life-way during the contact era provides a baseline from which we can encounter the archaeological evidence available about the long-term history of the Guale people and their ancestors.

After brief contact with the Spanish in 1526, this Muskogean-speaking group later encountered the French in 1562–1563. Then, beginning in 1566, the Guale experienced a long and intensive period of Spanish colonization. By 1684, the gradual southern withdrawal of the Spanish coupled with the southward expansion of the Carolina colony fostered relocation and reorganization of the vastly reduced Guale population.

The most important literary sources that address the nature of Guale coastal adaptations include Swanton (1922, 1946), Sturtevant (1962), Larson (1969, 1978, 1980), Jones (1978), and Worth (1993, 1995, 2004, 2007); see also Bushnell (1990), Crook (1986), Jones (1873), Hann (1986a, 1986b), and Saunders (2000a, 2000b).

### ABORIGINAL LIFE IN THE GEORGIA TIDEWATER

Guale settlements occurred mostly within Larson's (1980a: chap. 2) Coastal Sector environmental zone. According to Larson, during the prehistoric period, aboriginal populations were concentrated almost entirely within the Lagoon and Marsh section.<sup>1</sup> This area is characterized today by a broad variety of floral and faunal resources. Of these, the most essential to aboriginal subsistence included the hardwood forest on high ground, mollusks and fish in the aquatic range, a variety of birds, and, of course, the white-tailed deer. The Strand

and Delta sectors were thought to have insufficient resources to attract large or stable aboriginal populations. The interior Pine Barrens Sector was likewise considered to have little value to aboriginal populations beyond seasonal utilization of the floodplain for fishing and perhaps occasional agricultural exploitation.

Contact-period Guale Indians followed a similar settlement pattern, except that permanent populations were located along the banks of major rivers, with enclaves extending beyond the bounds of estuarine saline water and into the Pine Barrens Sector proper. Relatively little is known about specific locations of Guale communities, although the available evidence strongly suggests that such settlements existed in a wide variety of microenvironments. Approximate boundaries of the various Guale chiefdoms suggest that, due to the ecological variability evident within and between chiefdoms, there was considerable potential for exchange of both wild and cultivated resources. Not only was this variability associated with the efficient distribution of communities across microenvironments, but the development of political institutions also served to redistribute important resources and products between various communities.

The Guale planted maize, beans, and varieties of squash and melons. Little is known about their agricultural technology or the specific distribution of planted fields relative to soil types or botanical features. Although the ethnohistorical sources are silent on the subject, investigators have long assumed that a form of swidden agriculture was employed, utilizing a series of fallow cycles. One 17th century English account suggests that more than one crop could be harvested each year (Hilton, 1911).

Maize was parched and ground into flour, from which both a drink and a form of flat, round cake were prepared (Hann, 2001). The preparation techniques of other crops

are unknown. During the fall season, the Guale gathered acorns, which were stored and eventually ground into large flat cakes (similar to those made from maize). Later sources (e.g., Carteret, 1911; Hilton, 1911) report that “root cakes” were also prepared. Hickory nuts were also consumed.

Oyster beds were present throughout Guale territory, and oysters were important components to the Guale diet, particularly to offset failure of agricultural crops and other wild foodstuffs. During the colonial period, shellfish collecting provided insurance against Spanish threats regarding maize supplies. Deer were commonly hunted, and their skins were important for clothing and trade (at least during the later historical periods); bears and wild turkeys were also taken.

Reliable evidence illuminating Guale settlement pattern is difficult to obtain from documentary sources. The following account of the town of Orista (probably on or near Edisto Island, South Carolina) in 1666 might be applicable to most Guale towns:

The Towne is scituate on the side or rather in the skirts of a faire forrest, in which at several distances are diverse fields of maiz with many little houses straglingly amongst them for the habitations of the particular families. (in Sandford, 1911: 91)

Guale settlements were likely located along the banks of rivers or tidal creeks; maize plots would have been located behind the town center, opposite the river or creek banks. Local differences in shellfishing, hunting, and horticultural productivity may also have fostered some degree of economic specialization, enhancing the need for an organized system of intercommunity exchange. Although most Guale apparently maintained permanent residence in a single community, some Guale seem to have shifted their winter residence to be near areas for hunting, fishing, or shellfishing. Individuals were also temporarily absent from their communities while collecting wood, hunting, or fishing.

The Guale were town dwellers, though the concept of “town” means something quite different today than it did during

Guale times. A “town” was not so much a specific place as it was a discrete group of people governed by consensus, fully capable of changing locality, building new shelters, and planting fields in one place after another. The town of Santa Catalina de Guale, onetime capital of Guale Province, is a case in point. Bushnell (1994) traces this town to at least seven known sites between 1564 and 1728.

## GUALE SOCIAL ORGANIZATION

During the contact period, the Guale were aligned into a number of highly organized, politically stratified chiefdoms (Jones, 1978, 1980; Worth, 1995, 2004). Although boundaries and membership of these chiefdoms shifted in response to changing external politics, three principal chiefdoms existed throughout the period between initial European contact and the early 17th century (fig. 2.1). Each chiefdom had two principal towns in which the leader and some family members and retainers lived. The town centers included a large, round, community building in which periodic councils and intercommunity feasts were held. The ritual *chunkey* game, common to many Southeastern aboriginal groups, was performed with poles and a disk-shaped stone in a playing ground adjacent to the community buildings (de San Miguel, 1902; Sandford, 1911; Hudson, 1976).

Primary leadership of each chiefdom was rotated between the two principal towns. The principal leader of a chiefdom was known as the *mico*. Some Spanish reports define another office, the *mico mayor*, suggesting that these were two hierarchically related officers, each of whom lived in one of the two principal towns. A leadership council was comprised of the two primary individuals, plus a number of secondary leaders (often termed *caciques* and *principales* in the Spanish sources). *Micos* were commonly accompanied by other important, titled leaders (variously termed *mandador*, *aliagita*, *tunaque*, and *heredero* [or heir to the *mico*]). The roles and duties of the latter are poorly known, although they may have also resided in the principal towns.

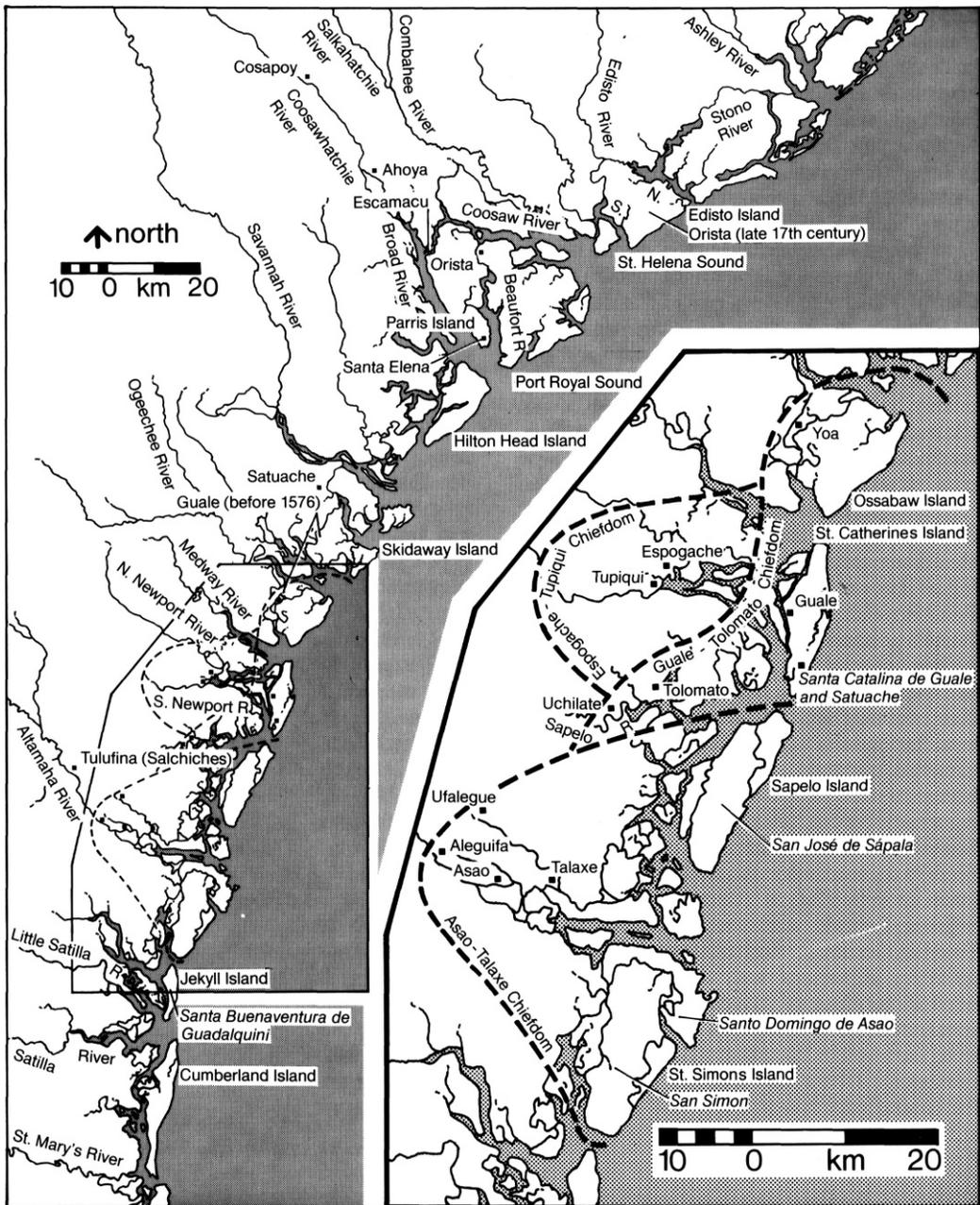


Fig. 2.1. Approximate locations of Spanish period towns and settlements along the Georgia Coast. The dashed line denotes approximate boundaries of southern chiefdoms (after Jones, 1978: fig. 17).

The principal leaders were probably the heads of clans, in which descent was traced matrilineally. Positions of authority were commonly inherited by a younger brother, sister's son, or (in later years), by a sister's

daughter. During the 17th century, female leaders became increasingly common, perhaps because of the effects of repeated epidemics, reduced participation of males in mission communities, and a Spanish policy

requiring men to participate in extensive labor projects, in St. Augustine and elsewhere. At times, Franciscans opposed the principle of matrilineal succession, but their more vocal opposition centered on the common practice of polygamy among the rulers. Male leaders often had multiple wives, each of whom resided in a separate house; the wives were sometimes sisters. The friars' attempts to abolish polygamy and disrupt traditional lines of succession were major factors in the revolt of 1597.

Due to the fact that the Guale settlement pattern fostered some degree of economic specialization between communities, chiefdom organization became a primary means of integrating the regional economy. Chiefs served as collectors and redistributors of food and other products. The most common mode of redistribution was the periodic ritual feast, in which items such as maize, fish, oysters, and acorns were lavished on guests. Early French sources suggest that chiefs either owned substantial agricultural land or at least maintained authority to collect tribute of maize for their own use, as well as for future distribution in the community feasts (Laudonnière, 1975). Chiefs also compensated their supporters in military activities with valued items such as deerskins, shell money, and metal tools received in European exchange. Moreover, the Indians did not have endless stores to offer the French and Spanish intruders. Running dangerously short on supplies, Laudonnière was forced to offer his Indian hosts something more valuable than mirrors and hawk bells. He put his military technology at their disposal, at times taking sides in their internecine wars.

Archaeological evidence suggests that the Guale participated in an active, long-distance trade network with inland peoples (Larson, 1980). The exchange involved mostly elite or nonessential goods, indicating that the Guale political hierarchy may have played a central role in regional as well as local trade.

These are the so-called historical facts, although even some of these remain in dispute. Even if it was possible to get all these

"facts" straight, however, the ethnographic and ethnohistorical meaning attributed to such "facts" remains elusive. Whereas the Guale may be the best known of the 16th and 17th century Muskogean coastal groups, even basic details of subsistence and social organization are disputed. As Grant Jones puts it, "The 'ethnohistoriographic' problems inherent in a study of the Guale are immense" (1978: 242).

Strictly speaking, debates over the meaning of these French and Spanish ethnohistoric sources inform us only about conditions relating to the 16th-century Guale Indians. But the "Guale problem" has provided the *raison d'être* for nearly 3 decades of archaeological research on St. Catherines Island. As the archaeological record spans the last 5 millennia, however, there exists an unparalleled opportunity to address the evolution and underpinnings of the Guale problem in a diachronic perspective.

Specifically, then, the following questions can be tested against the archaeological record of St. Catherines Island:

1. How and why did the human landscape (settlement patterns and land use) change through time?
2. To what extent were subsistence and settlement patterns shaped by human population increase, intensification, and competition for resources?
3. What factors can account for the emergence of social inequality in Georgia's Sea Islands?
4. Can systematically collected archaeological evidence resolve the conflicting ethnohistoric interpretations of the aboriginal Georgia coast (the so-called Guale problem)?

In subsequent chapters, we present a theoretical perspective that allows greater archaeological examination and exploration of these questions.

#### NOTE

1. We now understand that Larson's argument regarding the Pine Barrens is incorrect, for many time periods in the past; Anderson (1985) and Sassaman et al. (1990) provide two counterarguments.

## CHAPTER 3. STRATIGRAPHY AND GEOLOGIC EVOLUTION OF ST. CATHERINES ISLAND

DAVID LINSLEY, GALE A. BISHOP, AND HAROLD B. ROLLINS

The Sea Islands of Georgia have generally been characterized as Holocene beach-ridge type barrier islands with Pleistocene cores. Many of the Sea Islands are in fact “double islands”, the products of varying degrees of accretion of Holocene barrier complexes to relic core sands (DePratter and Howard, 1977). Some are distinct couplets, such as Blackbeard and Sapelo, or Wassaw and Skidaway, that possess extensive wedges of living salt marsh between the Holocene and Pleistocene components. Other islands, such as Ossabaw and St. Catherines, possess very limited Holocene deposits along their eastern margins. Each island is the product of sea level changes and unique sedimentary dynamics that are influenced by distance from fluvial sediment sources, difference in shoreline configuration, and migration of tidal inlets (DePratter and Howard, 1977, 1980; Oertel, 1975).<sup>1</sup>

Isolated from proximal fluvial sedimentation, St. Catherines Island is nestled in the apex of the Georgia Bight, where it receives the brunt of overwash activity (Deery and Howard, 1977). As such, the eastern margin of the Island contains a record of relatively rapid Holocene facies tract migration against the Pleistocene core. This juxtaposition of Holocene and Pleistocene components creates a very complex, but condensed, stratigraphic sequence (Howard and Frey, 1980). “Docking” of the transgressive Holocene barrier complex to the older core, about cal 3700 B.C. (5000 years B.P.) followed the late Wisconsinan sea level lowstand ca. 17,000 years ago. Vibracores less than 10 m deep taken along the eastern margin of the Island usually encompass its entire Holocene history and extend into Pleistocene sediments. In addition, present-day wave erosion of the east-central portion of the Island has exposed long outcrops of relic marsh deposits that provide three-dimensional views of the last few

thousand years of depositional history (Morris and Rollins, 1977; Pemberton and Frey, 1985; Sherrod et al., 1989; West et al., 1990; Goodfriend and Rollins, 1998). With the possible exception of Ossabaw Island, none of the other Sea Islands affords comparable opportunity to reconstruct geological history of the Georgia Bight. This information has not been obtained by submarine coring eastward in the Georgia Bight, where offshore vibracores have disclosed only a veneer of Holocene and Pleistocene sediments, usually less than 4 m thick (DePratter and Howard, 1980; Pilkey et al., 1981). The Holocene transgression marched rapidly westward from a maximum lowstand of at least 60 m below present mean sea level, reworking the sediments of the modern continental shelf.

### GOMORPHOLOGY OF ST. CATHERINES ISLAND

St. Catherines Island is composed of three major geomorphic systems: (1) Island core, (2) beach ridge complexes, and (3) salt marsh (fig. 3.1). The Island core comprises the northeastern third of the Island, is flat-lying, and has the highest average elevation (4–8 m). Island core vegetation is characterized by a mature, mixed deciduous–pine forest and fallow agricultural fields in various stages of succession. A series of parallel to subparallel ridges with an average elevation of 3–4 m, the beach ridge complexes, is located at the northern tip of the Island as well as to the south and southeast. Adjacent beach ridges are separated by swales that may contain intertidal to low supratidal tidal creek–marsh meadows or freshwater ponds. The ridge complexes are forested primarily by cabbage palm, hickory, pine, and live oak. The salt marsh appends to the Island core on the east and the southwest and consists of meandering tidal creeks sep-

arated by planar expanses of marsh grass (*Spartina alterniflora*) at the elevation of mean high tide.

The Island core sediment is predominantly tan, bioturbated, fine- to medium-grained sand. In this sediment, plants are the major agents of bioturbation. In a wave-cut cliff exposure near the site of cross section A-A' (fig. 3.2) palmetto and longleaf pine roots penetrate the sand substrate to depths of 2 and 2.5 m, respectively. Below this depth (3–4 m above mean low tide) some sedimentary structures are preserved, and the color changes from tan to light gray. Primary sedimentary structures at this depth consist of 2–4-cm-thick beds of high angle cross-stratified fine- to medium-grained sand. Upper laminae often contain abundant opaque minerals, which provide a color contrast that defines bed boundaries. The cross-stratified bedsets decrease in thickness and angle of inclination to an elevation of 1.5 m above mean low tide. Other Island core exposures exhibit similar features, although thicknesses and inclinations of bedsets vary.

The beach ridge complexes are Holocene accretionary features that formed with the achievement of a nearly modern mean sea level position. In the Georgia Bight, beach ridges are generally found on the northern and southern ends of the island cores or along the oceanward sides. Where rates of fluvial sedimentation are high, such as around the Savannah and Ogeechee rivers, marked progradation of the beach ridge accretionary terrains has occurred (Oertel, 1979). Because St. Catherines Island lacks an immediate fluvial source, sand for beach ridge growth must come from longshore transport of reworked continental shelf sand or from the Island core and estuaries. South Beach presents a sequence of beach ridge complexes that become progressively younger to the east and southeast, and that can be seen on aerial photographs and orthophotomaps to possess discrete dichotomous boundaries. These sediment “packages” may represent periods of rapid accretionary activity during the Holocene punctuated with periods of erosion due to autogenic (inlet mouth migration) and possibly allogenic (sea level) changes. They can be

chronologically sequenced from oldest to youngest using cross-cutting relationships (see Oertel, 1975, 1979), although beach ridge complexes can form quite rapidly. Rollins et al. (unpublished) describe how three distinct beach ridges were deposited over a 5-year interval at the north end of St. Catherines Island following Hurricane Hugo in 1989. In this case, sedimentary dynamics included depositional bypassing following isolation of the downdrift shoal at the southern margin of St. Catherines Sound. These dynamics are similar to those in a model proposed by Kana et al. (1999). The presence of beach ridge complexes at both ends of St. Catherines Island, oriented perpendicular to the present-day northeast–southwest trending beaches must represent Holocene changes in the channel margins of St. Catherines Sound and Sapelo Sound. This indicates that the sounds and Pleistocene cores of the Georgia Sea Islands are rather stable features, but the mouths of the sounds are relatively unconstrained and historically act somewhat like loose fire hoses, whipping rapidly back and forth along the coastline, generating the erosional boundaries and accretionary packages of the beach ridge complexes. Oertel (1975, 1979) and Kana et al. (1999) discussed the sedimentary dynamics associated with beach ridge complexes adjacent to inlets and inlet shoals.

St. Catherines Island beach ridges are parallel linear features hundreds of meters long and 2–4 m high. A wave-cut exposure of a beach ridge was examined at Engineer Point East (at the north end of the Island). It serves as a model for the following description of beach ridge sediments and demonstrates how beach ridge stratigraphy can be used to reconstruct sea level positions.

St. Catherines Island beach ridges are composed of very fine- to fine-grained sand. Upper surfaces of beach ridge deposits are typically bioturbated to a depth of 1–1.5 m. Sedimentary structures between 3 and 5 m above mean low tide are decimeter-scale bedsets and commonly have high-angle (25–35°) thin beds and laminae. Laminae are often defined by light (quartz) and dark (heavy minerals) color contrasts. The bed-

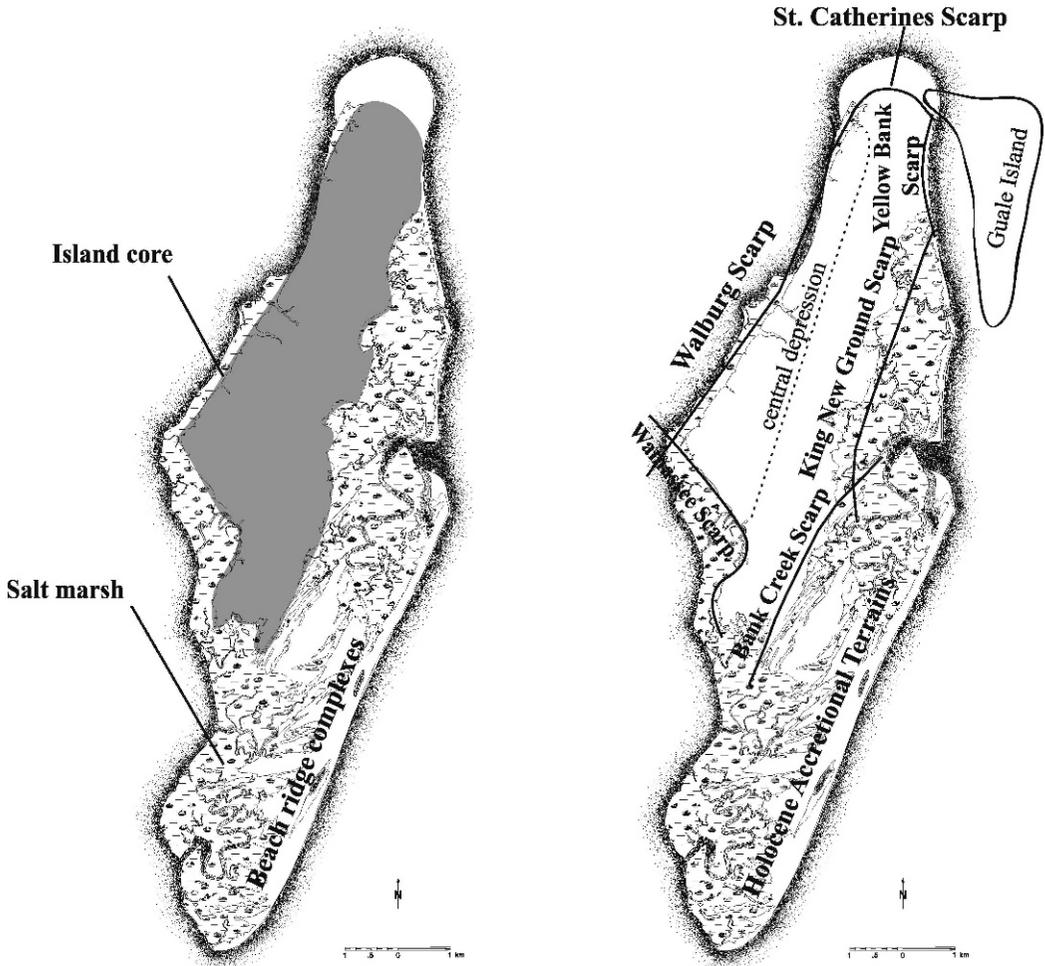


Fig. 3.1. The three major geomorphic components of St. Catherines Island (left) and the geological structure of St. Catherines Island, showing the hypothetical "Guale Island" and the major escarpments ("scarp") that define the modern geomorphological landscape.

sets are commonly cross-cutting and the beach ridges exhibit vertical gradations: the color changes upward from gray to tan, and bedset thickness and angle of bedding increase upward. These changes in sedimentary structures apparently represent an upward vertical transition from foreshore swash zone and backshore overwash into an aeolian depositional regime. Thus, beach ridges represent accretionary progradational features established by the infilling of estuaries or the marine shoreface. The change from planar (low-angle) bedding to high-angle bedding is interpreted to represent the lowest level of aeolian scour,

which is controlled by the elevation of wetted sand. This interface should occur slightly above mean high tide, and, in the aforementioned beach ridge exposure on St. Catherines Island, the base of aeolian bedding is 0.7 m above the present high tide wrack line. This suggests that this beach ridge formed when sea level was within 1–2 m of its present position.

The salt marsh and tidal creek environment of St. Catherines Island is typical of the Georgia Sea Islands and is a complex three-dimensional mosaic of intertidal and subtidal sedimentary facies. In the modern Georgia marsh system, the distribution of

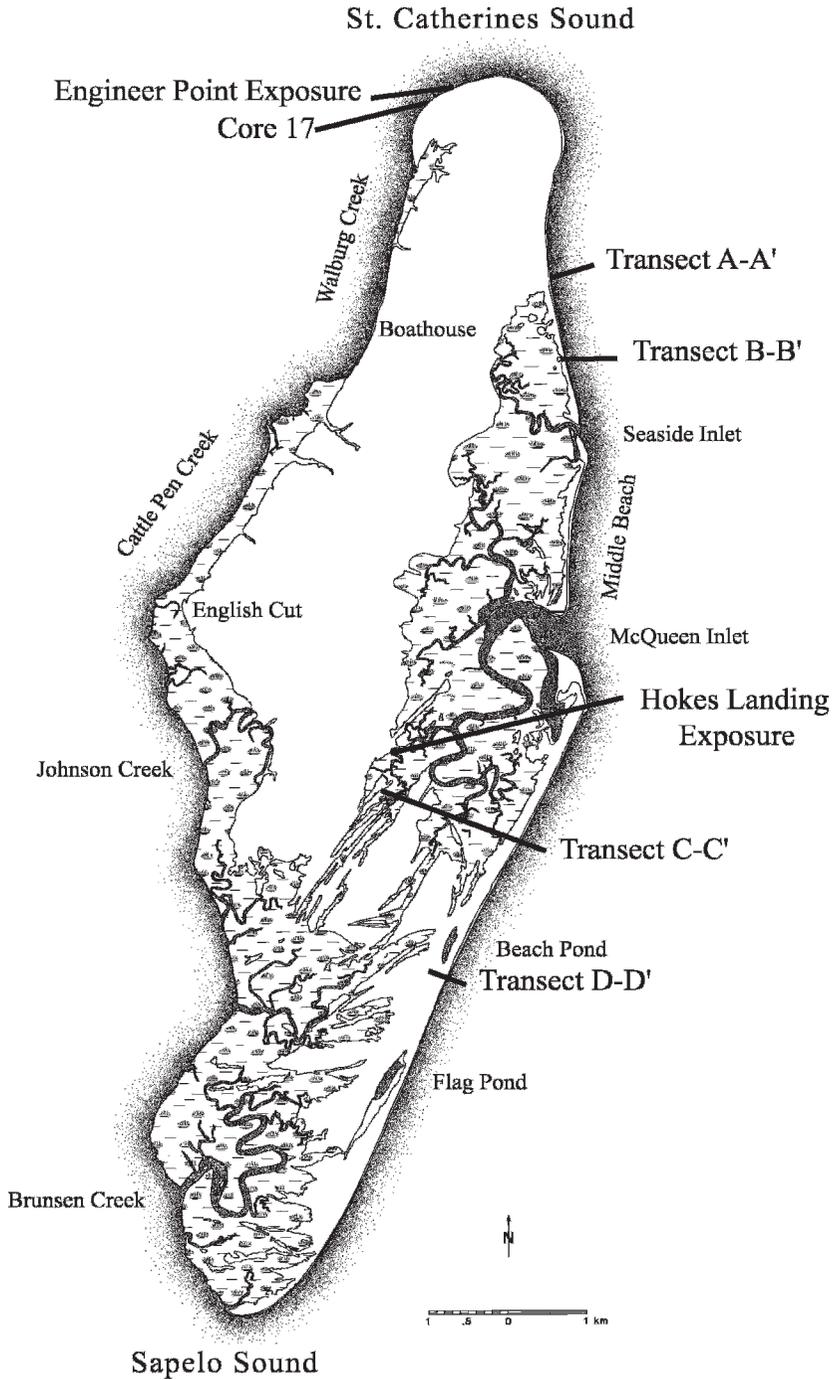


Fig. 3.2. Location of the vibracore transects and exposures mentioned in the text.

the different facies is a function of elevation and proximity to the shoreline. The maximum depth of the marsh sedimentary system is equivalent to the maximum scour depth of the tidal creek channels. The depth of erosion in the sounds between individual Sea Islands is 10–15 m (Henderson and Frey, 1986). Large tidal creeks can also incise to depths exceeding 10 m (Duc and Tye, 1987). Smaller tidal creeks (less than about 50 m wide) are often very sinuous and resemble meandering fluvial systems, migrating laterally through time and producing meander cutoffs, levees, and extensive point bars. Piracy of tidal creeks is a common phenomenon. The asymmetrical bimodal tidal flow (ebb dominated) in the tidal creek environment produces, however, subtle differences from meandering fluvial systems. Double cut banks and point bars may occur and the point bar of the ebb tide may be the cut bank of the flood tide. Rates of lateral migration on cut banks may reach 1–2 m per year (Letzsch and Frey, 1980) with erosional depths dependent upon channel depth. In 20–50-m-wide tidal creeks, erosion averages 2–4 m below mean low tide. Lateral migration of tidal creeks is accompanied by the development of point bars that infill behind the channels. This model of tidal creek dynamics predicts substantial reworking of sediment and virtually ensures that the stratigraphic units generated will exhibit a lateral and vertical patchiness regarding type and age. As noted by Duc and Tye (1987), this is a challenge to reconstructive stratigraphy. Successful stratigraphic correlation requires the recognition and use of genetic surfaces that reflect base level changes. Such genetic surfaces are often subtle, as Georgia salt marsh estuaries rarely exhibit late stage succession and development of high marsh vegetation that might lead to the stratigraphic emplacement of multiple peats (Letzsch and Frey, 1980).

#### STRATIGRAPHY OF ST. CATHERINES ISLAND

Reconstruction of the geological history of St. Catherines Island relied largely upon

available vibracore stratigraphy, but complementary information was provided by radiocarbon dates of plant and shell materials obtained from cores, exposed stratigraphic sections, archaeological sites, geomorphic analyses of available aerial photographs (including satellite imagery), historical maps and written accounts, and use of relevant archaeological sequencing.

Twelve vibracores were taken along three transects: A–A', B–B', and C–C' (figs. 3.3 through 3.9). Transects A–A' and B–B' were located on the northeastern portion of St. Catherines Island and extended from points adjacent to the Island core eastward to the modern shoreface. Cores 1 and 4 of transect A–A' were sited in the upper shoreface sands and cores 2 and 3 were taken in the exposed relic marsh muds (figs. 3.3). Transect B–B' extended from core 5, on the modern beach, westward to a sand barren/overwash fan site (core 6), northward to a low elevation hammock (core 7), and then to within 30 m of the Island core (core 8). Transect C–C' extended along Cracker Tom Causeway in the east-central portion of the Island (figs. 3.4). Core 9 was located on the present Island core, and core 10 was taken on the high marsh surface at Cracker Tom Scarp. Core 11 was atop Cracker Tom Hammock and core 12 penetrated the low marsh near Cracker Tom Bridge (presently the site of a trunk for control of tidal flow).

#### DESCRIPTION AND INTERPRETATION OF VIBRACORE *FACIES*

The vibracore facies can be broadly categorized as sand-, mud-, or shell-dominated, although occasional peat zones occur. Unlike box cores, vibracores have great vertical penetration and facilitate documentation of vertical gradations and facies associations. However, lateral aspects of bedforms are constrained by the 3" core diameter and are difficult to discern in vibracores. Consequently, the following descriptions emphasize vertical sequences and gradations rather than bedding styles. The facies are described relative to their elevation above and below mean low tide (U.S.G.S. datum).

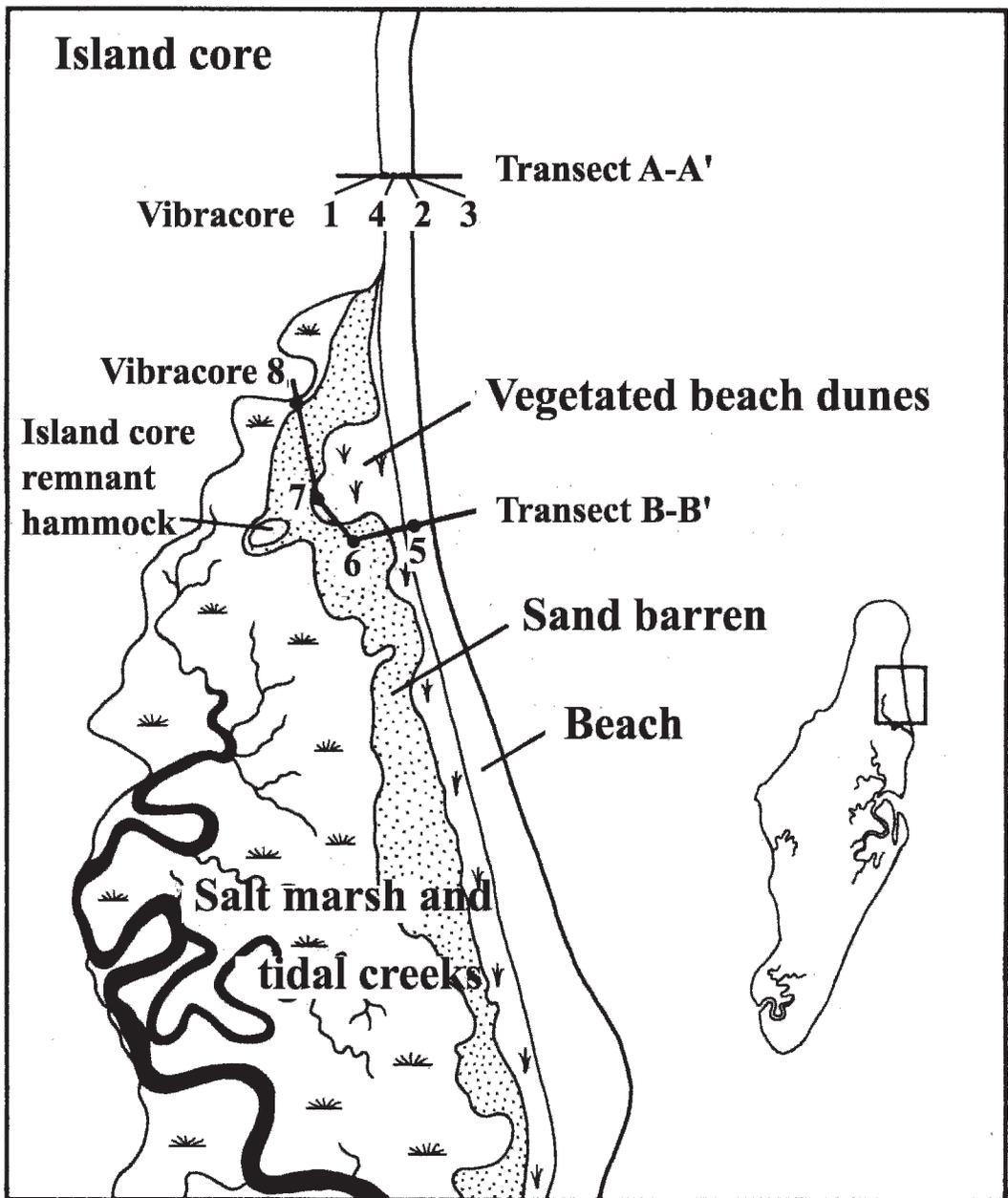


Fig. 3.3. Location of vibracore transects A-A' and B-B' on North Beach and Seaside Inlet, St. Catherine's Island.

#### SAND FACIES

Sand facies are defined as those containing more than 80–90 percent sand. Bedding styles and vertical associations of the sand units vary as follows.

1. Sand beds 20–40 cm thick with thin, planar laminated fine- to medium-grained sand may contain rare to common heavy mineral laminae. The laminae do not have sharp bases and there are no apparent erosive surfaces within the beds. The sand beds have abrupt,

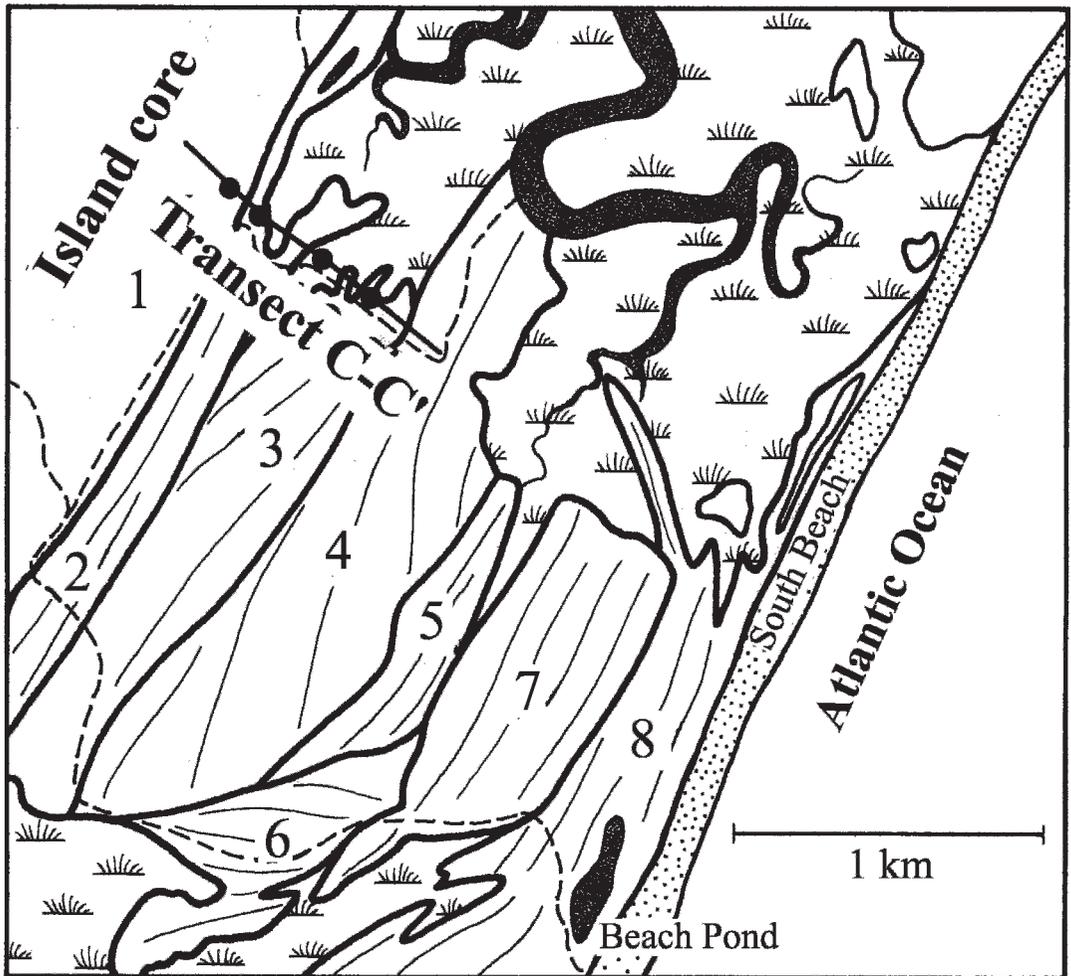


Fig. 3.4. Location of vibracore transect C-C' across Holocene dune ridges at Cracker Tom causeway, St. Catherines Island.

planar to angular basal contact with underlying bioturbated muddy facies. These units grade upward into bioturbated muddy sand and may have fine (1–2 mm thick), vertically penetrating mud-rich zones. Mud also occurs in these sands as small (1–2 mm) clasts disseminated within the bed but increasing in abundance upward. Typically, this type of sand bed is underlain by bioturbated mud and overlain by bioturbated muddy sand. Rarely this occurs above a similar sequence and is separated from the subjacent bioturbated muddy sand by a planar base. In such cases, the muddy sand sequence may not be present. These sand beds do not occur above +0.5 m elevation. We interpret these beds as

modern overwash fan deposits. The muddy bioturbated intervals at the top of this facies represent the reestablishment of high marsh. Marsh grass (*Spartina alterniflora*), marsh periwinkle (*Littoraria irrorata*), fiddler crabs (*Uca spp.*), and ribbed mussel (*Geukensia demissa*) colonize the sandy substrate of storm overwash deposits. The marsh grass traps clay derived from fecal pellets and produces the muddy texture observed near the top of this facies. Subsequent storm overwash deposits elevate the surface to a level uninhabitable by the full complement of high marsh taxa (1.2–1.4 m above mean low tide in the modern marsh). These higher elevation overwash deposits are often colonized by salt

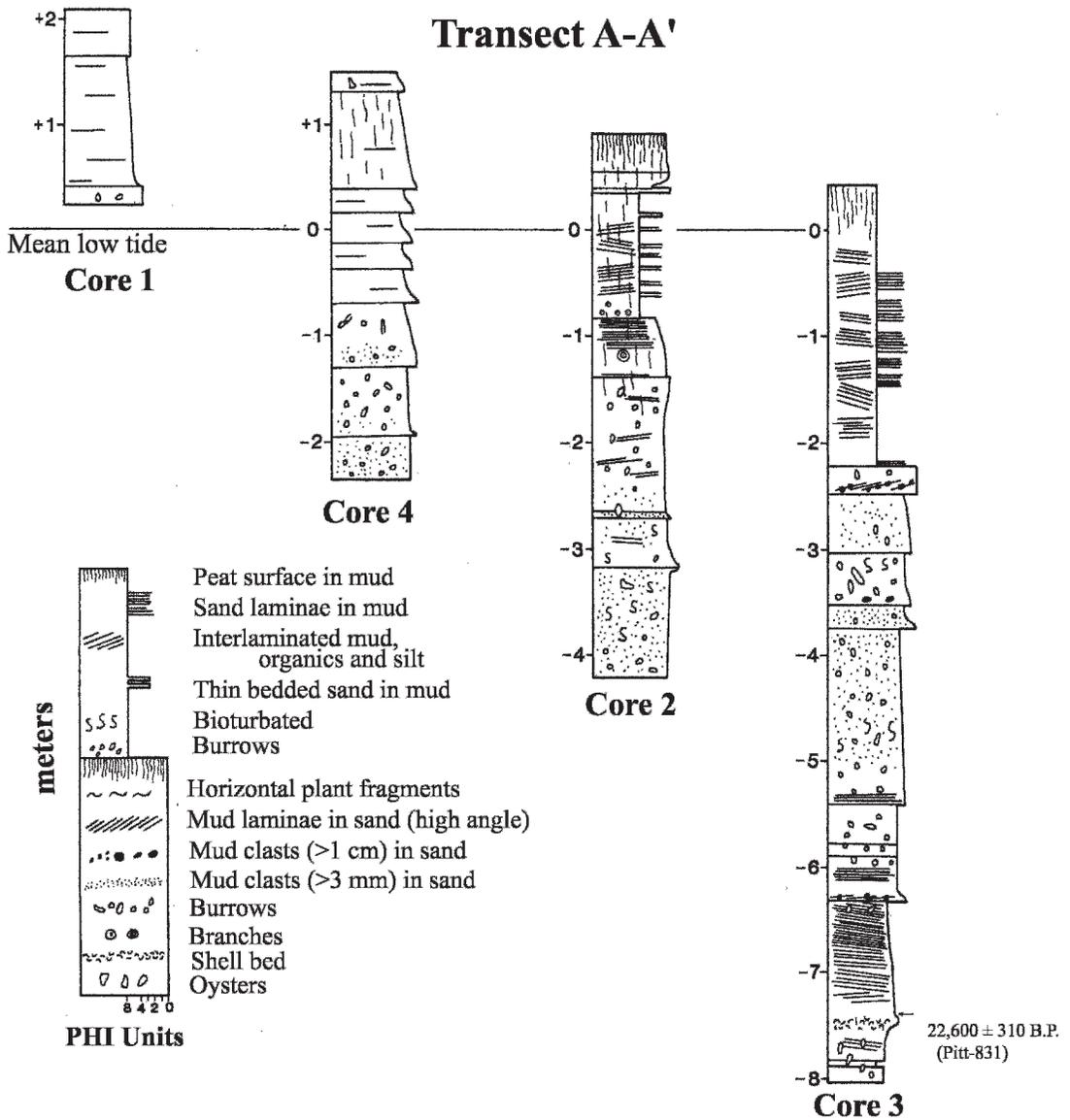


Fig. 3.5. Sedimentary structures in vibracores 1-4 (Transect A-A').

grasses (*Salicornia* and *Distichlus*) as well as short *Spartina* and other grasses characteristic of the aeolian beach dune substrata.

2. Laminated to bedded, high angle medium- to coarse-grained sand may occur from -4.0 to -1.5 m elevation. Bedsets are fining upward sequences 10-40 cm thick, with an erosive, often high-angle, basal surface. These units grade rapidly upward from poorly sorted coarse-grained sand to medium-grained sand. The coarse- to very coarse-grained sands at the base of the bedsets typically are

thin (2-5 cm) units and fine upward into poorly sorted medium-grained sand. Bedding inclinations range from 0° to 25° with most measurements between 10° and 20°. Dip angles of laminae may be opposite between bedsets but are uniform within bedsets. Mud is associated with this style of bedding: as thin laminae, or flasers, between sand beds (particularly in the upper portion of bedsets), as rare interbeds within the sand, as 1-5-cm rounded mud clasts at the bases of bedset sequences, or as small (1-3-mm) clay clasts.

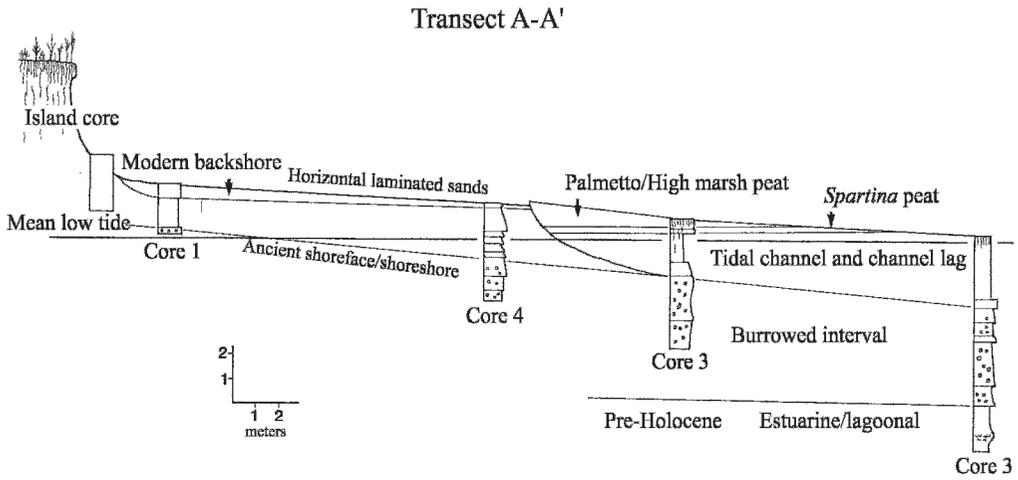


Fig. 3.6. Interpretation of transect A-A'.

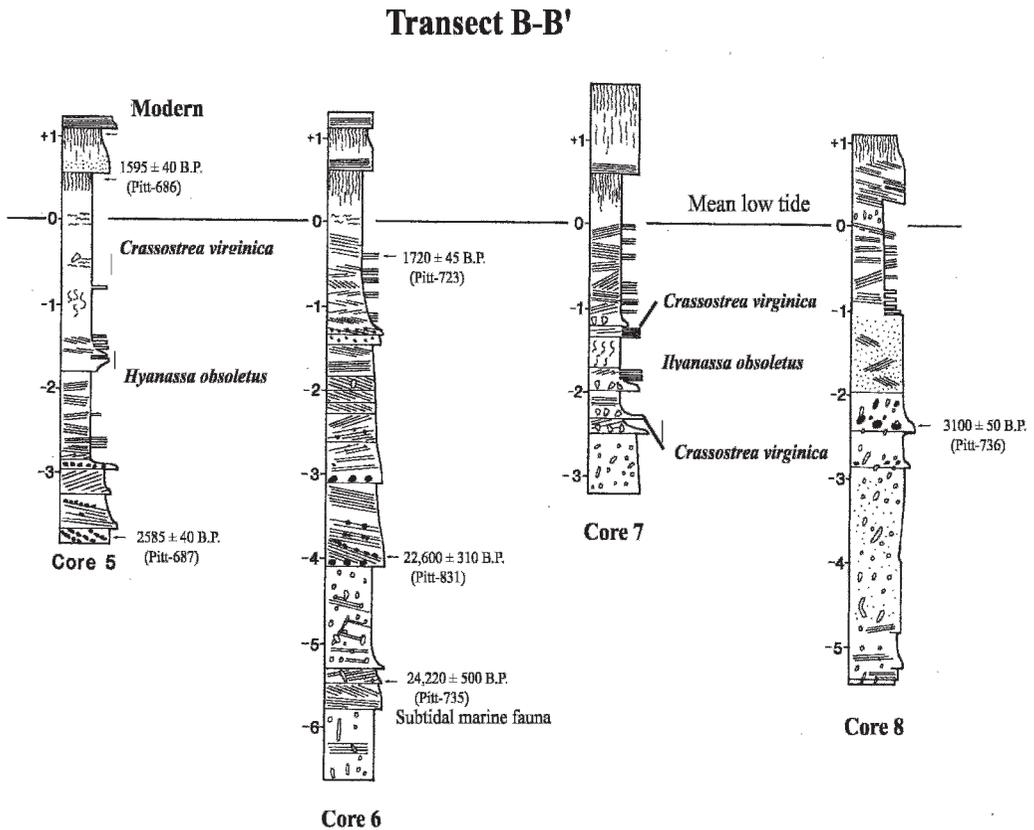


Fig. 3.7. Sedimentary structures in vibracores 5-8 (Transect B-B').

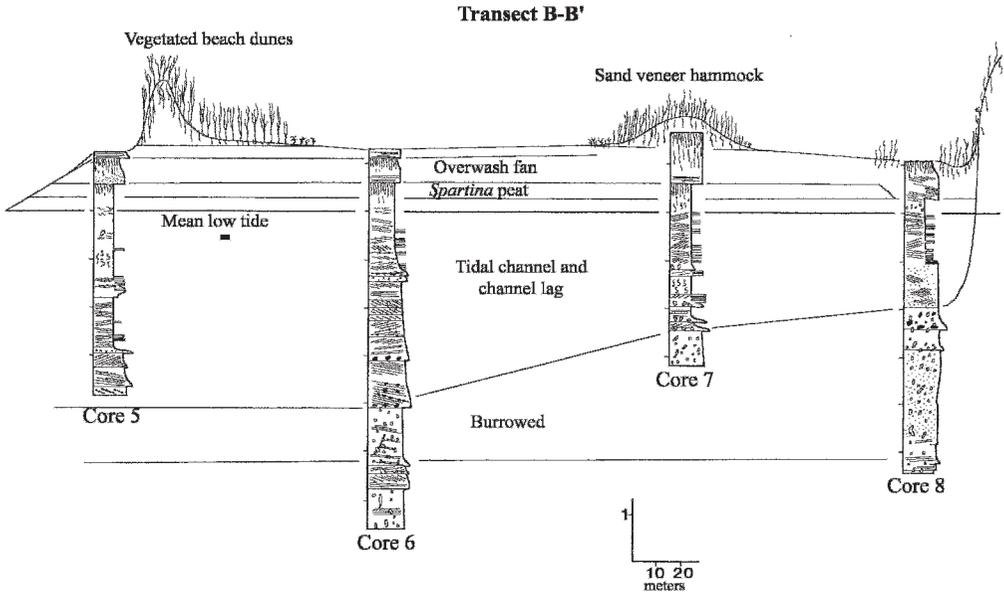


Fig. 3.8. Interpretation of transect B-B'.

This type of sand bed has an erosive base and is underlain by bioturbated sand or by a repetition of the same type of bed. The beds grade upward into interbedded sand and mud or may have abrupt contact with the overlying mud. These beds represent tidal creek channel and basal lag deposits. They are the bases of large-scale bedforms in the bottoms of tidal creek channels and grade

upward into the sandy mud facies as a result of lateral migration of point bars. Such deposits are subtidal in both the core samples and in the modern environment and form the base of the Holocene marsh sequence. Coarse-grained lag deposits with centimeter-scale rounded mud clasts are found at the base of these sequences and form stacked deposits with several channel lags on top of

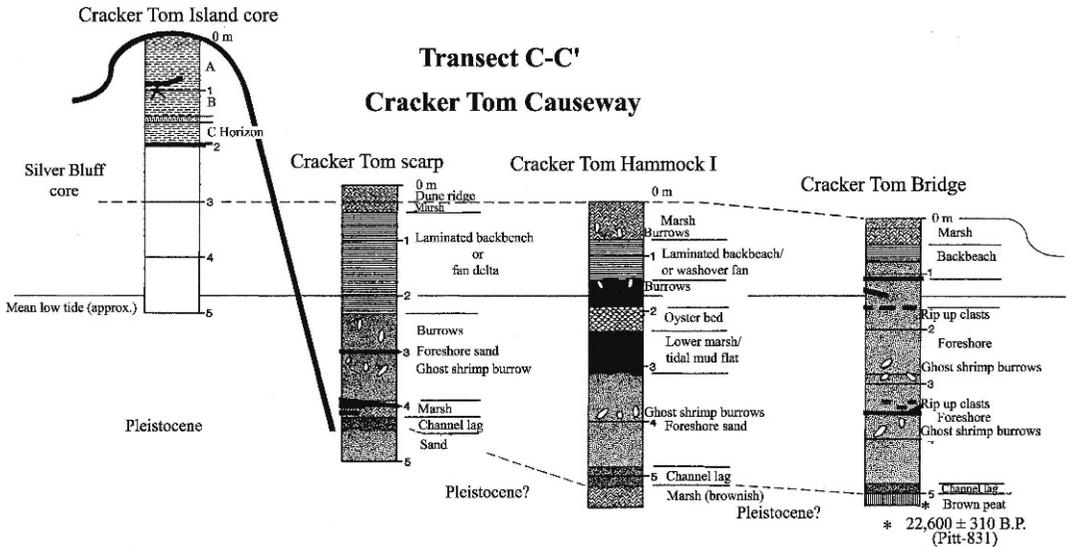


Fig. 3.9. Interpretation of transect C-C'.

one another. Mud clasts are presumably eroded fragments of higher elevation marsh mud deposits transported in tidal creek channels. Mud clasts at the base of the cores contain plant material that is macroscopically similar to *Spartina* in the low marsh environment.

3. Burrowed sand may occur in any grain size range and rarely preserves primary sedimentary structures. The burrows are 1.0–1.5 cm in diameter and may be vertical, horizontal, or oblique. Burrows are infilled with sand that is often lighter colored than the surrounding sand. Clay rims 2–5 mm thick nearly always surround the burrows. The inner boundaries of the clay rims are abrupt, and the outer boundaries are gradational with the surrounding sand. Burrows occasionally crosscut bedding planes but are rarely truncated by bedding. The burrows are located predominantly in sand-rich facies but are also found in muddy sand. Where bedding is visible, the burrowed intervals occur in sands with decimeter-scale fining upward sequences and interbedded sand and mud. The elevation of the clay-rimmed, burrowed sands is between –1.5 and –6.5 m. The burrowed sands are gradational with subjacent thin intervals of sand and mud. Upper boundaries are commonly erosive. The burrowed sand occurs below the erosive base of the modern marsh system and may not be associated with Holocene deposition. The burrows resemble those of the ghost shrimp (*Callianassa*; Weimar and Hoyt, 1964). In modern environments, *Callianassa* lives in sand or muddy sand substrata at elevations from 10 m below mean low tide to low intertidal (Dorjes, 1972). They are commonly found along beaches but also inhabit estuarine channels (Howard and Frey, 1975). *Callianassa* burrows penetrate 60–150 cm deep (Weimar and Hoyt, 1964), and in the cores the burrows occur in a 1.5–3.0-m-thick interval. No individual burrows exposed in core cross sections extend for more than 10 cm and are primarily oblique or horizontal. The stratigraphic position of these burrows in the cores is consistently below the base of the modern marsh environment.

#### SANDY MUD FACIES

Interbedded to interlaminated, low- to high-angle sand and mud is common between elevation intervals of –8 to –6 m

and –1 to –2.5 m. Sand and mud bed thicknesses are less than 3 cm, and sand may occur only as thin laminae within the mud. Sand beds decrease in thickness upward. Bedding angles dip in opposite directions, and vary from planar to 20°, with most between 12° and 18°. Contacts between the sand and mud beds are generally abrupt. Bedsets in this facies range from 5 to 30 cm, and fine upward concomitant with increasing thicknesses of mud beds and decreasing thicknesses of sand beds. The sandy mud facies grades downward into the sandy facies and upward into interlaminated silts, muds, and organics. A second association of sand and mud is found at the tops of cores above the planar laminated sand and is capped with a peat surface. The sandy mud facies occurs at two stratigraphic intervals within the cores. In its lower occurrence (–8.0 to –6.0 m) the interbedded sand and mud grade up into burrowed sand and in core 6 contains a shell bed with a mixed marine and estuarine/marsh fauna. In the upper interval (–2.5 to –1.0 m) this facies is above the high-angle bedded sand and below the interlaminated mud. Interbedded sand and mud is common in the marine estuarine and marsh environments and is not very diagnostic (Howard and Frey, 1985). This facies must be interpreted with respect to its context in a stratigraphic sequence. The lower occurrence is interpreted to represent an estuarine or lagoonal environment based upon the contained shell material. The upper sequence is considered part of a fining upward point bar deposit in a marsh environment. Discrete mud clasts were observed in the high-angle bedded sand facies. In contrast, mud beds in the sandy mud facies were constructed of vertically flattened mud clasts, particularly when supported by small quantities of sand. Fine-grained beds are often considered the result of settling of suspended clay particles during periods of quiet water deposition. The mud beds and laminae in the marsh deposits are composed of compacted millimeter- to centimeter-sized clay clasts that could only be transported in moderate to high velocity currents.

### MUD FACIES

The muddy facies range from well-laminated mud and silt to structureless muddy peat. Volumetrically, mud comprises a high percentage of the salt marsh and tidal creek system. In the cores, mud facies formed about 40 percent of the lithotypes. Significantly, fine-grained sediments can be deposited and preserved in high-energy environments. The mud facies occurred in three bedding styles.

1. Interlaminated silt, mud, and organic material is common above the sandy mud facies from  $-2.5$  to  $-0.5$  m. These three components are not always present, and mud may be interlaminated with silt, sand, or organics. Lamination angles range from planar to  $40^\circ$ , but are typically between  $15^\circ$  and  $25^\circ$ . Bedsets vary in thickness from 10 to 150 cm. Bedding angles within thicker units may dip oppositely at base and top and be internally gradational. In thinner units, bedding angles change between bedsets and may dip oppositely. Circular, 1–1.5-cm vertically oriented burrows may be present in this facies and are infilled with organic-rich muddy sand. This facies may have a gradational or abrupt contact with the subjacent sandy mud facies or the bedded sand facies. Upward, this facies grades into structureless mud.
2. Structureless mud occurs between  $-0.5$  and  $+0.3$  m. This is gradational with the *Spartina* peat surface above. The lower contact is also gradational, with interlaminated mud, silt, and organic matter.
3. The *Spartina* peat mud is at an elevation of between  $+0.6$  and  $+0.9$  m in both the exposed relic marsh deposits and in the modern marsh.

The interlaminated mud, silt, and organic facies may be unique to the salt marsh system. In the relic marsh deposits exposed along North and Middle Beaches, this facies occurs adjacent to tidal channel deposits on the inside of meanders. Dip directions of the relic deposits are toward the ancient tidal creeks and angles range from  $8^\circ$  to  $30^\circ$ . Dip angles between  $40^\circ$  and  $80^\circ$  occur rarely in the relic laminated deposits and are probably the result of rotated slump blocks. Burrows in the relic point bar muds are common and well preserved, but are rarely found in the cores. The interlaminated mud, silt, and

organic facies are interpreted as point bar deposits of small, mud-dominated tidal creeks. In the modern environment, this facies ranges in elevation from midintertidal to 1–2 m below mean low tide. In the cores, these deposits underlie the *Spartina* peat and bioturbated mud and overlie the sandy mud and bedded sand facies. The elevation of this facies in the cores is quite similar to the modern elevation of fine-grained point bar deposits, which indicates a near present-day sea level at the time of deposition. Structureless mud is found in the 30–50-cm interval below the rooted *Spartina* peat mud in the modern marsh, and this corresponds closely to its position in the cores. The mud is bioturbated by *Spartina* roots and decapods. The *Spartina* peat mud in the cores is at approximately the same elevation as the modern low marsh surface, indicating a near present position of sea level at the time of the peat formation.

### SHELLS

Preserved shells are rare in the cores, as they are in the exposed relic marsh deposits. Taphonomic intensities are high in the lowered pH of the salt marsh environment; thus shells are preserved in the mud facies only when an abundance of shell material locally buffers the acidic conditions by elevating the pH. These conditions occur most noticeably within oyster banks, tidal creek shell lag deposits, and occasionally on low marsh surfaces associated with gregarious taxa such as the mud snail *Ilyanassa* and the ribbed mussel *Geukensia*. In the cores, oysters (*Crassostrea virginica*) and mud snails (*Ilyanassa obsoleta*) were typically found at the base of bedsets in the sandy mud or interlaminated mud facies. Additionally, oysters were found in the interlaminated mud facies associated with thin, coarse-grained sand beds and centimeter-sized mud clasts.

### DEPOSITIONAL SEQUENCES AND EVENTS

The vibracore samples record two notably different depositional sequences that are separated by a hiatus of unknown duration.

The lower sequence is a Late Pleistocene estuary/lagoon deposit that can be interpreted on the basis of a mixed marine and marsh fauna. This facies is gradational with a burrowed sand and sandy mud facies. Traces of bedding in the burrowed interval suggest that sedimentary structures and textures were originally similar to those in the nonburrowed interval below. After deposition of the estuary/lagoon sediments, a change occurred that provided the necessary substrate for burrowing organisms. This event may have involved a lowering of sea level, a decrease in sediment supply, and/or aggradation to a shallower depth, rendering conditions more hospitable for burrowing organisms. Evidence from cores 1 and 4 suggests that shoreface or foreshore deposits, possibly grading upward to an aeolian sequence, immediately overlie the burrowed interval. This indicates the progradation of a beach ridge complex over the nearshore marine environment. This beach ridge complex now partially comprises the core of St. Catherines Island. Later, this phenomenon occurred repeatedly, resulting in beach ridge accretionary prisms appended to the early Island core. Note, for example, the vertical sequences of cores 10, 11, and 12 in the Cracker Tom transect C-C' (fig. 3.4). Modern examples of such beach ridge progradation over marine environments can be seen in Wassaw and Tybee Islands.

Holocene sediments disconformably overlie the Pleistocene deposits. The lateral extent and thickness of the Holocene deposits vary. The vibracores contain a sequence of salt marsh deposits up to 5 m thick. These deposits are tidal creek channel point bar sediments that exhibit a gradational fining-upward pattern. Ravinement contacts occur near the bottoms of the cores between the Holocene deposits and underlying Pleistocene burrowed sequences. Stacked channel lag deposits are found at the base of the Holocene sequence. The lag deposits often contain mud clasts with datable organic matter, presumably *Spartina*. Dated organic matter from core 6 provided a radiocarbon age of 4285 years B.P. Shell lags, while present in the cores at the base of bedset boundaries, are absent in the bottoms of the cores at the

contacts with the underlying Pleistocene deposits. In modern marshes, mud clasts of this type are indicative of cutbank erosion and tidal creek channel transport. *Spartina*-rich mud clasts suggest that a salt marsh was established at this early date. This appears to provide a minimal date for Holocene sea level stabilization, which is a bit earlier than some estimates for coastal Georgia (Oertel, 1979) but well within the generally accepted temporal framework. The deposits overlying the sandy channel sequences are point bar sediments formed during the lateral migration of tidal creek channels. They are fining-upward sequences with decreasing bed thicknesses. The different facies were controlled by the depth of the tidal creek channel and may be relatively precise indicators of sea level. The elevation of these sequences in the cores is very close to that for the same environments in the modern salt marsh, suggesting that when these deposits accumulated, sea level was close to its present position.

The multiple lag deposits represent sequential superposition of tidal creek channels through time. Assuming erosion rates were about 1 m per year and a tidal creek was 50 m wide, deposition of a vertical sequence equal to the distance from the channel bottom to the high marsh surface (3–5 m) could have taken less than 100 years. Radiocarbon dates from core 5 were obtained from the basal channel lag deposit and from the bioturbated mud zone below the high marsh *Spartina* peat. These dates have a 990 year disparity. The basal lag sample was taken from the lowest of five channel lag deposits. The highest lag deposit at –1.85 m (undated) should be very close to the age of the *Spartina* surface.

#### GEOLOGIC EVOLUTION OF ST. CATHERINES ISLAND

Integration of vibracore data with other lines of evidence, particularly chronological sequencing of crosscutting beach ridge/swale complexes and erosional scarps, permits a detailed reconstruction of the geological evolution of St. Catherines Island over the last 100,000 years.

## LATE PLEISTOCENE LAGOON/ESTUARY

Arguments for a high sea level stand during the last interstadial (about 120,000 years B.P.) are generally accepted. There is, however, controversy concerning the age of the Silver Bluff submergence and, thus, the genesis of the Pleistocene portions of the Georgia Sea Islands. Suggested ages for the Silver Bluff submergence range from a very conservative 120,000 years B.P., when sea level was about 8 m higher than present, to greater than 40,000 years B.P., or to around 25,000 years B.P. (Hoyt and Hails, 1967; DePratter and Howard, 1977; Oertel, 1979; Howard and Frey, 1985; Booth et al., 1999a, 1999b). In any case, sea level would have been at the time at least 1–2 m higher than present, and the region of the present-day Georgia Sea Islands would have been covered by a lagoon and/or estuary some meters deep. A freshwater peat, radiocarbon dated at over 40,000 B.P. (USGS #WW-1997) and overlain by a marine shell layer dated at cal 2980–2670 B.C. ( $4060 \pm 50$  B.P., USGS #WW-1262), was described from a vibracore sequence at Cracker Tom Bridge, on St. Catherines Island (Booth, 1998; Booth and Rich, 1999; see also table 29.1, this volume). The peat appears to have accumulated on the Silver Bluff terrace during a lowered sea level. If so, this may provide a minimal age constraint on the Silver Bluff submergence (Booth et al., 1999a, 1999b). If future vibracoring on St. Catherines Island were to penetrate the aforementioned deep burrowed facies beneath the Island core sands, and should radiocarbon dates of organic matter from the burrowed interval prove to be infinite (i.e., much greater than 30,000 years B.P.), an earlier than 40,000 B.P. age for the Silver Bluff submergence would be further supported.

## “CORE ISLAND”

A prograding beach ridge complex accompanied the sea level drop that followed the Silver Bluff highstand. The modern remnant Island Core provides considerable information regarding the dimensions of the Pleistocene barrier (termed “Island Core”).

STRUCTURAL ELEMENTS OF  
ST. CATHERINES ISLAND

St. Catherines Island exhibits a series of foundational or structural elements that controlled the evolution of the Island. Foremost among these are a series of erosional surfaces that can be traced long distances, often preserved as scarps or buried scarps that generally dip seaward beneath the transgressing Atlantic Ocean. Active scarps are present at Yellow Bank Bluff, Walburg Scarp, and along erosional parts of the beaches and Island Core. These scarps (fig. 3.1, right) form major boundaries between sediment packages in the Island interior or along the margin of the modern Island.

The western boundary of St. Catherines consists of a three scarps, Wamassee Scarp to the southwest, Walburg Scarp forming most of the northwest island edge, and St. Catherines Scarp, forming an ancient edge of the northwestern, northern, and north-eastern boundary between the Island Core and younger accretionary terrains that now form the northern edge of St. Catherines. Walburg scarp is currently undergoing erosional rejuvenation and was being so rapidly eroded that it had to be armored by riprap in 2005–06. St. Catherines Scarp wraps around the northeastern part of the Island to merge with Yellow Bank Scarp, which bounds the northern oceanic face of the Island, forming Yellow Bank Bluff, possibly the most highly eroded portion of St. Catherines, retreating at 1.8 m/year (Bran Potter, personal commun.). Ancient tidal creeks had eroded two oxbows in the south end of St. Catherines Scarp; the northernmost still remains while the southernmost has nearly been removed by erosion of Yellow Bank Bluff into the Island Core. The eastern and southeastern boundary between the Island Core and the Holocene accretionary terrains to the east consists of Back Creek Scarp to the south, an ancient island scarp marking a former shoreline. From Cracker Tom Road north the eastern bounding scarp, King New Ground Scarp, has been highly modified by lateral planation of tidal streams in Seaside Marsh and McQueens Marsh, eroding the once

straight scarp into a series of meander scars that now cut across King New Ground Scarp into the Island Core forming the modern version of King New Ground Emarginated Scarp. Two vestiges of the position of the Scarp are still marked by straight segments, which remain at their original positions.

The Island Core is comprised of at least two terrains, separated by what appears to be an ancient scarp or boundary forming a central depression the length of the Island Core. Another lineament, the Cemetery Lineament, may mark a boundary between two later Pleistocene terrains to the north and south of Cemetery Road. The nature of the southern boundary near South Plantation has yet to be explained.

The Holocene is preserved around the margins of the Island as a fringing marsh on the west and accretional terrains to the north, east, and south. The accretional terrains can be sequenced by crosscutting relationships, truncated boundaries, and stranded swales. The eastern accretional terrains were deposited as sedimentary packets upon destruction of Guale Island, which had formed probably in the later Pleistocene, before the last lowstand, and was remobilized during the last transgression some 6000 to 4000 years ago.

#### WISCONSINAN SEA LEVEL LOWSTAND

At about 18,000 years B.P. sea level dropped  $120 \text{ m} \pm 60 \text{ m}$ , subaerially exposing the Georgia Bight for tens of kilometers offshore to the edge of the modern continental shelf. A vast coastal plain extended eastward many kilometers from the present strandline. The Core Island was likely subjected to some fluvial erosion and progradation by rivers draining eastward. Significant erosional events are recorded as terraces or reentrants in the present-day Island Core. One such erosional event carved a terrace into the front (eastern) edge of the Island.

#### GAULE ISLAND

Rising sea level beginning ca. 12,000–10,000 years B.P. culminated in a rapid west-

ward transgression of a sequence of barrier islands that would eventually weld against the relic late Pleistocene strandlines. This “docking” event likely occurred about cal 3700 B.C. (5000 years B.P.) with the attainment of near modern sea level. A new offshore island, Guale Island, formed to the northeast of St. Catherines Island. Guale Island may have been similar in size and shape to the seaward components of such island doublets as Sapelo–Blackbeard and several of the other modern Golden Isles, although lack of proximal riverine sources and accompanying sediment starvation may have led to a smaller-sized Guale Island (see chap. 29). Guale Island effectively buffered the front of modern St. Catherines Island, allowing the formation and continued growth of an inter-island marsh that kept pace with rising sea level. The relic marsh system exposed along North and Middle Beaches is evidence of a more extensive inter-island marsh beginning at least cal 2400 B.C. (4200 years B.P., based on the oldest radiocarbon date obtained on tidal creek lag *Spartina* material from core 6, about 6 m below mean low tide). The Archaic shell middens atop Picnic Point Bluff indicate intensive harvesting of salt marsh shellfish from a spacious inter-island marsh. Meandering tidal creeks in this marsh periodically eroded into the adjacent, high-standing Pleistocene core. A major erosional event cut deeply into the southeastern part of the Pleistocene core. This was immediately followed by a lateral transport of sediment that formed the oldest preserved sedimentary accretionary terrain, comprised of beach ridges and a long northeast trending spit (Gardener’s Hammock) that reaches far into the marsh at Back Creek. Guale Island was eventually overtopped and spread as a broad shoal by rising sea level (see chap. 4). The loss of Guale Island led to more rapid movement of the facies tract on the eastern side of St. Catherines Island, and to the eventual development of the wave-dominated shoreline present along North and Middle Beaches today. The meager remains of the once extensive inter-island marsh are now subjected to more rapid destruction by

overwashing across a thin, low-standing, intermittent barrier-dune complex. Oertel and Chamberlain (1975) indicated an average beach retreat rate at Middle Beach of about 3 m per year during the period 1897–1975, and Goodfriend and Rollins (1998) documented a 4 m per year current erosional retreat of the seaward edge of the barrier beach at North Beach.

An interval of progradation with minor episodes of erosion followed the overtopping of Guale Island, building the accretionary terrains exposed on the inner part of Cracker Tom Causeway. This was followed by a major erosional event marked by the Zapala Erosional Scarp that occurred as Sapelo Sound swept northward, completely truncating the south end of St. Catherines Island. Similarly, the north end of St. Catherines Island exhibits three erosional events, all apparently associated with migrations of St. Catherines Sound. A sea level drop of about 2 m may have occurred after the inundation of Guale Island and played a role in the sedimentary dynamics accompanying the formation of the accretionary terrains and erosional scarps (chaps. 4 and 29; Gayes et al., 1992).

## NOTE

1. [ed] To facilitate discussion throughout this monograph, we will attempt to bridge the geological and archaeological dating conventions in the various chapters addressing geomorphological change along the Georgia Bight (including the present chapter, chap. 4, and chap. 29).

Specifically, because we will generally focus on the Holocene interval, we think it necessary to “correct” radiocarbon ages to calibrated calendrical years; accordingly, for dates more recent than 10,000 radiocarbon years B.P., we employ a dual nomenclature, first specifying the “calibrated age” (expressed as “cal years A.D./B.C.”), followed by the uncorrected age estimate (expressed as “radiocarbon years B.P.”), e.g., cal 1600 B.C. (3600 B.P.). When discussing the 239 radiocarbon dates presently available from St. Catherines Island, we will employ the dating protocols developed in chapter 14 (i.e., determining the cal A.D./B.C. conversions by applying the reservoir correction of  $-134 \pm 26$  years to marine samples). But for reasons set out in chapter 14, we do not feel justified in extending the application of the reservoir correction for St. Catherines Island to other coastal contexts; in such cases, we will follow the general protocols for geomorphological dating by using mean calibrated age estimates from elsewhere using the Marine04 conversation (Reimer et al., 2004), employing the global marine offset of 400 years (and not employing the St. Catherines Island-specific value of  $\Delta R$ ). These conventions apply only to marine samples; in the case of terrestrial dates, or situations in which different values of  $\Delta R$  might obscure comparisons between dates, a specific notation will be added.

# CHAPTER 4. LATE HOLOCENE SEA LEVELS AND THE CHANGING ARCHAEOLOGICAL LANDSCAPE OF ST. CATHERINES ISLAND

DAVID HURST THOMAS

Extending from Outer Banks (North Carolina) to Cape Canaveral (Florida), the configuration of the low-lying barrier islands of Georgia Bight has been conditioned by a mixed regimen of wave and tidal energy (Hubbard et al., 1979; Frey and Howard, 1986). The major embayment centers near St. Helena Sound (South Carolina), where tidal ranges approach 3 m, with a diminishing of tidal range both northward and to the south. The continental shelf along this area is gently inclined, approximating a 2 percent gradient (meaning a change of 1 m of depth for every 20 km of distance) and constant to about 95 km offshore. About 18,000 years ago, the shoreline was roughly 100 m below the present level and the shoreline about 100 km seaward of its present location (Miller, 1998: 43).

This shifting sea level has had a dramatic role in defining the shape of the Georgia/Florida coastline because, given the shallow inclination of the continental shelf, even relatively minor shifts in sea level were accompanied by significant horizontal displacement of the shoreline. In general, a rapid rising sea level will destabilize a coastal ecosystem, and with sea-level rise averaging about 1 cm/year, the coastlines of the Early Holocene must have been remarkably unstable (Colquhoun et al., 1981; Davis, 1997: 157–158). About cal 5500 B.C. (7000 B.P.), the rate of rise slowed to about 3 mm/year; but even at this rate, the shoreline at Sarasota (Florida), for instance (with an offshore shelf gradient averaging about 1:1000), would still have moved about 300 m/century, a migration still too rapid to permit the formation of large and relatively stable barrier islands.

As the sea-level rise along the Georgia Bight slowed and approached present levels, roughly cal 3000 B.C., the coastal Georgia landscape came to look quite similar to that of today

(DePratter and Howard, 1977; Oertel, 1979; Colquhoun et al, 1980; Howard and Frey, 1980; Miller, 1998: 39; Booth et al., 1999a, 1999b). Such relative stability provided an opportunity for waves, tides, and longshore transport to mould a coastline into the complex mix of barrier islands, inlets, estuaries, and marshes that today define the Atlantic coast off South Carolina, Georgia, and Florida. Stream gradients were reduced and stabilized, and the coastal biota was essentially modern, in a landscape considerably wetter than before.

As the Atlantic Ocean approached modern levels, new barrier islands formed, prograded, eroded, and reformed along the Georgia shoreline (DePratter and Howard, 1980). The presence of this offshore beach ridge system, some of it “welded” onto Pleistocene island cores, caused the barrier islands to grow seaward, typically assuming the characteristic butterfly, “double island” configuration still evident on Wassaw, Ossabaw, and St. Simons Islands (see chap. 9). Behind the barrier islands, bays gradually filled, fostering the formation of the extensive salt marsh system, with its tidal creeks and estuaries.

## MODELS OF LATE HOLOCENE SEA-LEVEL RISE IN THE GEORGIA EMBAYMENT

Despite the relative stability in Late Holocene sea levels and associated landforms, some significant (if less pronounced) fluctuations were yet to come (Fairbridge, 1961; DePratter and Howard, 1980: 33; Brooks et al., 1989: 96; Miller, 1998: 39)—and these changes had serious implications for foragers living along the Georgia Bight.

### THE GEORGIA COASTLINE

Crusoe and DePratter (1976: 2) suggest that large oyster beds did not develop be-

hind the barrier islands of coastal Georgia until the rising sea level flooded the previously freshwater lagoons, sometime between cal 3700 B.C. and 2100 B.C. (5000 and 4000 B.P.). The oldest recognizable shorelines date to cal 2800 B.C.–1700 B.C. (4500–3700 B.P.) and St. Simons ceramics are typically associated with these surfaces. Particularly notable are the numerous Late Archaic shell rings that characterize the Georgia Bight (Waring and Larsen, 1968; DePratter, 1975; Marrinan, 1975; Russo, 1996; Sassaman and Ledbetter, 1996). Speaking specifically of the Georgia coast, Howard and DePratter (1980: figure 15) suggest that shell rings existed on both sides of the barrier islands; the surviving shell rings tend to occur on the estuarine side of Pleistocene barrier islands, but with those on the seaward side have likely eroded away altogether.

The basal strata of the St. Simons period shell rings can lie as much as 1 m below the present marsh surface (Waring, 1968a, 1968c; DePratter, 1975; Marrinan, 1975), suggesting that when they were occupied, sea level must have been (at least) 1–2 m below present. At Bilbo, for instance, the basal zone contains fiber-tempered ceramics, dating to cal 1700 B.C.–2200 B.C. (3700–4125 B.P.), overlain by a lens of gravel lag deposits and freshwater mussel shell (Waring, 1968c: 155; Williams, 1968: 330). Brooks et al. (1986) interpret this sequence as reflecting a changing sea level, with the fiber-tempered strata lying more than 1 m below modern levels and the mussel level reflecting a drop in sea level and a seaward movement of the saltwater system.

DePratter and Howard (1980: 34–35) hypothesized that roughly cal 1700 B.C. (3700 B.P.) the sea level rose, from about –1.5 m at to a highstand of approximately present MSL by cal 800 B.C. (3000 B.P.); then, approximately cal 200 B.C. (2500 B.P.), sea level dropped once again, to about –4 m MSL. DePratter (1977b: 11) argues for a hiatus in shellfishing between cal 800 B.C. and 400 B.C. (3000 and 2700 B.P.), due to a sea-level regression that reduced the potential of the estuarine shellfishery on the northern Georgia coast (see also DePratter and Howard,

1977, 1981). He further argues that sites established in the cal 900 B.C.–A.D. 300 (3100–2100 B.P.) range should actually be submerged or buried seaward of the present shoreline, if not completely destroyed by subsequent sea-level rise. By cal 350 B.C. (2600 B.P.), sea level arose again, and extensive oyster beds reformed (Crusoe and DePratter, 1976: 2).

To test their hypothesis, DePratter and Howard (1981) searched the coastal zone of Georgia for additional evidence of lowered sea levels in the Late Holocene. They located a number of pine, oak, and cedar stumps exposed in eroding creek banks. These tree stumps, deeply rooted in salt marsh deposits and often overlain by younger salt marsh deposits, tend to date cal 700 B.C. to cal 450 B.C. (3100–2400 B.P.).<sup>1</sup> Based on these data, DePratter and Howard (1981) identified a single highstand along the Georgia coast from cal 3200 B.C.–1250 B.C. (4500–3000 B.P.). These investigators likewise employed undifferentiated marsh peat as an indicator for a similarly long temporal span during which the fluctuation was supposed to have occurred, but they were unable to constrain that event further.

Such shifting sea levels influence the availability of certain aquatic resources near the estuary mouths. A generally rising sea level with corresponding estuarine expansion causes an increased dispersion of some resources (such as small intertidal oyster beds in the expanding tidal creek network), which can be related to a shifting inland of the intertidal zone with associated increase in salinity (Bahr and Lanier, 1981). Similarly, at the Refuge and Second Refuge sites (located 20 km upriver from Bilbo) Brooks et al. (1985: 300) note the presence of a basal freshwater peat (dating approximately cal 1700 B.C.), shifting toward saline conditions that corresponds to the initial (Refuge period) occupation dated to cal 900 B.C. (3100 B.P.). As sea levels rose, oysters became more common, until a return to freshwater conditions during the terminal Refuge period (and lasting from the Deptford through Irene periods). These data suggested to Brooks et al. (1985: 10) that at cal 800 B.C. (3000 B.P.), the sea levels

stood -3 to -4 m below present MSL, rising once again, from cal 100 B.C. to A.D. 700 (2400-1700 B.P.).

#### THE SOUTH CAROLINA COASTLINE

Colquhoun et al. (1981) have documented that roughly cal 9000 B.C. (10,000 B.P.), sea levels were about 9 m lower than present, rising rapidly until cal 2300 B.C. (4200 B.P.), or slightly earlier, to within 3-4 m of present sea-level position.

Because sea level provides the hydrological base level for both surface and groundwater, this eustatic lowering of sea level exerted a great influence on the freshwater hydrological regimen of the Georgia Bight. Whereas numerous freshwater wetlands survive on the Lower Coastal Plain of the southeastern United States—the best-known examples including the Everglades and Big Cypress Swamp in Florida, Georgia's Okefenokee Swamp in Georgia, and the Dismal Swamp (Virginia)—Brooks et al. (1989: 91) suggest that prior to the Early/Middle Holocene, most of these present wetlands and lakes were dry.

The hydrological threshold for peat formation was surpassed about cal 3700 B.C. (5000 B.P.), suggesting contemporaneous local rise in relative sea level to within 3.5 m or so of the present elevation (Brooks et al., 1989: 91, figure 5.1). After this time, sea-level change primarily influences wetland-estuarine development and biotic shifts in climax forest communities, documenting a change from drier to wetter conditions. This was a time of tremendous increase in the number and area of peat depositing wetlands of the Lower Coastal Plain, and low moor (marsh or swamp) peat formation. "Thus, the direct influence of sea level as a base-level control acting upon the freshwater hydrologic regime in lowland, coastal areas appears to be considerable" (Brooks et al., 1989: 92).

The relative sea-level stability after cal 3700 B.C. (5000 B.P.) reflects considerably slower and lower magnitude changes compared with conditions during the Early Holocene, but conditions along the South Carolina coastline are by no means static. The

earliest known shell midden deposits along the South Carolina coast occur at cal 2400 B.C. (4200 B.P.), providing firm evidence for initial development of existing estuarine systems by this time. Large shell middens dating cal 2300 B.C.-cal 800 B.C. (4200-3000 B.P.), Stalling and Thom's creek period sites are generally located in the seaward areas of estuaries, usually adjacent to major channels (Brooks et al., 1989: 94). Many of these deposits have been heavily eroded by subsequent sea-level rise.

Based on data gathered between Winyah Bay and the Savannah River, Colquhoun and Brooks (1986) documented a highstand about cal 2100 B.C. (4000 B.P.), and it is possible that some midden sites established during the cal 1800 B.C. (3800 B.P.) regressive interval may have been completely submerged and/or buried under more recent deposits.

Between cal 800 B.C. and A.D. 1500 (3000-800 B.P.), Brooks et al. (1989: 94, fig. 5.2) note a general trend for shell middens to move inland and be more widespread, correlating with sea-level rise and associated estuarine expansion, suggesting "that estuarine systems on the South Carolina Coast have changed relatively little, either areally or in general configuration, in response to sea level over the last 2,000 years."

More recent research by Gayes et al. (1992) have refined this picture somewhat. Noting that Colquhoun and Brooks (1986) and DePratter and Howard (1981) have previously suggested that a highstand in relative sea level occurred about cal 2000 B.C. (4000 B.P.), Gayes et al. (1992) observe that the resolution of these studies was constrained by poor preservation of deposits and methodological constraints.<sup>2</sup> Using high-resolution data on foraminiferal zonation and closely spaced vibracores, Gayes and his associates have defined the relative sea-level fluctuations within Murrells Inlet, a small tidal-marsh inlet on the north coast of South Carolina.

Specifically, Gaye et al. (1992: 159, fig. 6) have determined that the late Holocene highstand began with a transgressive, 2-m rise in sea levels between cal 3300 B.C. and 2300 B.C. (5300 and 4300 B.P.). This was

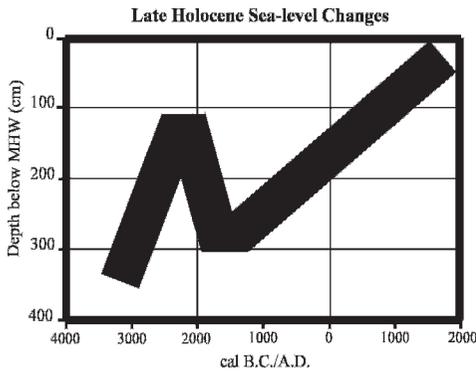


Fig. 4.1. Sea-level fluctuations extrapolated from radiocarbon evidence obtained from Murrells Inlet on the northern coast of South Carolina (after Gayes et al., 1992: fig. 6).

followed by a regressive phase, during which sea levels fell 2 m from cal 2300 B.C. to 1600 B.C. (4300 B.P. to 3600 B.P.). The rate of both rising and falling sea level during this period was 50 cm/100 year (Gayes et al., 1992: 159; fig. 6). Since cal 1600 B.C. (3600 B.P.), sea levels have risen slowly and steadily at a rate of 10 cm/century (until the present).

Figure 4.1 recapitulates the Gayes et al. (1992) formulation, upon which we will model the expectations for St. Catherines Island archaeology.

#### PROJECTING THE ARCHAEOLOGICAL RECORD OF ST. CATHERINES ISLAND

During the Late Holocene transgression, the landscape available to the St. Catherines Island forager blossomed, with high-ranking marine patches developing in close proximity to long-standing terrestrial patches, thereby minimizing transport costs from centrally placed residential bases.<sup>3</sup> But when the sea level dropped dramatically, as we believe it did, the estuarine oyster beds along the western margin of St. Catherines Island must have been heavily impacted. If patches of oyster beds survived at all, they did so at significantly diminished levels; any Late Archaic foragers exploiting this vastly reduced shellfishery would have created archaeological sites that are today either

eroded away or buried beneath 2 m of more recently deposited salt marsh sediments.

These same fluctuating environmental constraints created a vastly different ecological setting on the oceanfront side of St. Catherines Island. A new barrier island formed offshore, protecting a vast, new saltwater marsh and providing foragers with an alternative source of salt marsh resources. The formation and subsequent disappearance of Guale Island and Guale Marsh likewise had a major impact on the behavior of St. Catherines Island foragers and the archaeological record they left behind.

Following the seminal work of DePratter and Howard (1980, 1981), Brooks et al. (1989), Colquhoun et al. (1981), and especially Gayes et al. (1992), we can now offer some hypotheses regarding the influence of Late Holocene sea-level changes on the archaeological record of St. Catherines Island.

#### CAL 3300 B.C.—CAL 2300 B.C. (5300—4300 B.P.)

During this interval, sea level rose 2 m (at a rate of about 50 cm/century; see Gayes et al., 1992: 159, fig. 6).

Whereas most barrier islands along the Atlantic and Gulf coast are comprised of quartz-sand barriers deposited during the Holocene, a restricted zone of the Georgia Embayment contains an extremely significant series of carbonate-rich Pleistocene remnants fronting the open Atlantic Ocean (Hayes, 1994). From Cape Canaveral northward, several east coast barriers along the Florida–Georgia shoreline are stabilized by the underlying Pleistocene-age formations, anchoring high foredunes that prevent overwashing and landward migration. Related coastal features, including tidal inlets, tidal flats, marshes, and back-barrier bays, reflect the tidal range and the tide/wave energy balance (Davis and Hayes, 1984; Davis, 1997: 158). Along the Georgia Embayment, such tidal inlets tend to be wide and deep, with extensive tidal flats and marshes that typify this mixed-energy coastline.

With the rising sea levels during the cal 3300 B.C.–2300 B.C. interval, we see the correlative growth of the estuarine and interisland marshlands. The juxtaposition of the high-ranking resources of the Pleistocene core (especially the mast crop and newly isolated white-tail deer herds) and the equally high-ranking saltwater marsh provided human foragers with a suddenly diverse and closely spaced set of marine and terrestrial patches. We expect that St. Catherines Island was occupied by Late Archaic foragers shortly after the island core separated from the mainland, circa cal 3000 B.C. Earlier human occupations of this landscape may well have occurred, but without the presence of saltwater marsh resources, foragers would have had to rely more heavily on terrestrial and lower ranked, open saltwater resources. Further, in the absence of debris from harvesting saltwater shellfish populations (i.e., shell middens), archaeological sites of this earlier era would be difficult to find (and in the absence of marine shell, the acid soils of the Pleistocene core would likely have dissolved most of the organics, leaving mostly lithic debris behind).

We suspect that when the Late Holocene transgression topped out about cal 2300 B.C., and that sea level stood approximately 1.25 m below contemporary Mean High Water. Following the behavioral ecology models developed in Part II of this volume, we suspect that shell midden deposits from the earliest portion of the St. Simons (Late Archaic) period should be clustered along the salt marsh margin, situated to minimize transport costs of both terrestrial and marshland resources.

CAL 2300 B.C.–CAL 1600 B.C.  
(4300 B.P.–3600 B.P.)

During this regressive interval, sea level dropped quickly, at a rate of about 50 cm/century, reaching approximately 3 m below current Mean High Water (Gayes et al., 1992).

During the span of only seven centuries, the sea level dropped about 2 m. Such a dramatic shift should have had significant consequences for the foragers of St. Catherines

Island. The saltwater marshes along the estuarine (western) side of the Island must have been dramatically reduced, if not eliminated altogether; accordingly, we project that marshside settlements along the western side of St. Catherines Island should be dramatically reduced (or eliminated) during the cal 2300 B.C.–cal 1600 B.C. interval. If marsh remnants did survive in the estuary, then human settlements were likely moved to lower elevations to exploit the dwindling salt marsh resources; this means that along the western margin of St. Catherines Island, any archaeological evidence during this seven-century interval is likely submerged under a meter or more of marsh sediments that accumulated later (as the sea rose to approach modern levels).

But a different scenario pertains along the seaside (eastern) margin of St. Catherines Island. As noted previously (in chap. 3), the rising sea level of the early Holocene triggered a rapid westward transgression of off-shore barrier islands, eventually docking these barriers to the relic late Pleistocene landscape by cal 3000 B.C. or so. This is when the new offshore “Guale Island” formed along the northeastern margin of St. Catherines Island, effectively buffering the ocean front and fostering the development of an extensive, interisland marsh (“Guale Marsh”) that evolved as the sea level rose. Although Guale Island was eventually overtopped by the still rising sea level, it must have provided a refuge salt marsh habitat, along the eastern shoreline of St. Catherines, for foragers previously exploiting the estuarine salt marshes along the western side of the island.

In short, then, we project that during the interval cal 2300 B.C.–cal 1600 B.C., St. Simons/Refuge period archaeological sites should:

- Disappear along the western margin of St. Catherines Island (because the salt marsh had either evaporated or significantly retreated, meaning the sites resulting from exploiting the remnant saltwater marshes would have been flooded by subsequent sea-level rise), and
- Appear on the northeastern Pleistocene core remnant (where such settlements fronted the former expanse of Guale Marsh).

We also suspect that numerous St. Simons period archaeological sites might have once accumulated further to the east, on Guale Island (but they disappeared when Guale Island eroded).

CAL 1600 B.C.—PRESENT (3600 B.P.—PRESENT)

Sea levels have risen slowly and steadily (at a rate of 10 cm/century) from a low-water mark of roughly 3 m below Mean High Water to present levels.

As the sea levels rose after cal 1600 B.C., foragers of late St. Simons and Refuge-Deptford periods (circa cal 1600 B.C. to perhaps cal A.D. 1) likely witnessed:

- A deterioration of marshland resources along the eastern margin of St. Catherines Island (due to the overtopping of Guale Island and disappearance of Guale Marsh), and
- A resurgence of estuarine marshlands along the entire western margin of the island.

Accordingly, the archaeological landscape of St. Catherines Island should contain fewer Late Archaic and Refuge-Deptford sites along the northeastern corner of the island, with a progressive reoccupation of the western shoreline, as the estuarine marshland came back to its previous productivity.

Throughout the remainder of this monograph, we will generate archaeological evidence to test the above hypothesis on the archaeological record of St. Catherines Island.

#### NOTES

1. To calibrate the data on buried stumps and freshwater peats discussed in DePratter and Howard (1981), we have employed the terrestrial conversion IntCal04 (Reimer et al., 2004).

2. Because the radiocarbon dates cited in Gayes et al. (1992) are expressed at “corrected radiocarbon ages (k.a.)” we have converted these estimates to simple A.D./B.C. expressions, *without* applying additional correction factors.

3. The theoretical framework supporting this suggestion is developed in subsequent chapters.

## CHAPTER 5. A BRIEF NATURAL HISTORY OF ST. CATHERINES ISLAND

ELIZABETH J. REITZ, DAVID LINSLEY, GALE A. BISHOP, HAROLD B. ROLLINS, AND  
DAVID HURST THOMAS, WITH A CONTRIBUTION BY ROYCE H. HAYES

St. Catherines Island is part of the Atlantic Coastal Plain Province (Thornbury, 1965), defined by a series of short, relatively wide barrier islands separated by deep tidal inlets (fig. 1.1). The mainland portion of this coast is a low, flat region of well-drained, gently rolling hills and poorly drained flatlands, separated from the barrier islands by broad salt marshes (Shelford, 1974: 76; Wharton, 1977). The soils, sands, and sandy clays of the Coastal Plain are of marine origin, delivered to the coast by fluvial processes; they are usually acidic and possess a low natural fertility due to excessive leaching during weathering, erosion, and deposition of the sediments. The lower Coastal Plain is dominated by exchanges of seawater within a zone extending from the Wicomico relic marshes in the west to the sea, roughly defined by the Princess Anne Formation in Georgia. The tidewater zone (also termed the coastal zone) thus includes the mainland portions of coastal rivers influenced by tides as well as the lower reaches of estuaries and their associated salt marshes (coastal wetlands) and islands, which might also be called the coastal zone (Wharton, 1977: 60). The Georgia Coastal Plain records the progradational history of the Southeast during much of the Cenozoic Era.

The estuarine zone of the Georgia coast is part of a large embayment known as the Georgia Bight, extending from Cape Hatteras, North Carolina, to Cape Canaveral, Florida (Hubbard et al., 1979; Frey and Howard, 1986). An important feature of the Georgia Bight is a low lying series of coastal (or barrier) islands, separated from the mainland by marsh and from one another by tidal estuaries. While a chain of these islands stretches from New Jersey to Texas, the islands located approximately between Cape Romain, South Carolina, and Amelia Island, Florida, share similar Pleistocene and Holocene histories and

physiographic characteristics (Hoyt, 1967; Hoyt and Hails, 1967; Johnson et al., 1974: 11; Hayden and Dolan, 1979; Wenner et al., 1980; Frey and Howard, 1986). The barrier islands consist of Pleistocene barrier remnants and active Holocene beaches. Marsh islands (hammocks) are found between the barrier islands and the margins of the mainland where increasingly brackish waters grade into *Spartina* marshes. The barrier islands are separated from one another and from the marsh islands by meandering tidal creeks, sounds, and salt marshes, sometimes as much as 6 km in width. Low, sandy beaches border the seaward edges. Steep, sandy beaches adjoin the sound margins, and back-barrier salt marshes characterize the landward edges of barrier islands. Georgia's Sea Islands range from 5 to 15 km long and from 1 to 5 km across (Hubbard et al., 1979), with elevations that are usually less than 7 m, although individual dunes may be higher (Johnson et al., 1974: 11).

### PHYSICAL GEOGRAPHY

These Sea Islands—commonly known as Georgia's Golden Isles—are of mixed geological origins (fig. 5.1). Many of the forested islands, at least in part, are remnants of ancient (Pleistocene) barrier islands formed during an interval of higher sea level, whereas others were separated from larger islands by subsequent erosion. Many of the smaller islands, such as Tybee, have accreted to the Pleistocene cores during the Holocene. Ballast dumping by ships and more recent channel dredging by the U.S. Army Corps of Engineers has also significantly modified the marshland configuration. Extensive shoal systems exist seaward of the inlets (ebb tidal deltas) and the central island sectors.

Six of Georgia's eight major barrier islands are composites of a Pleistocene-age

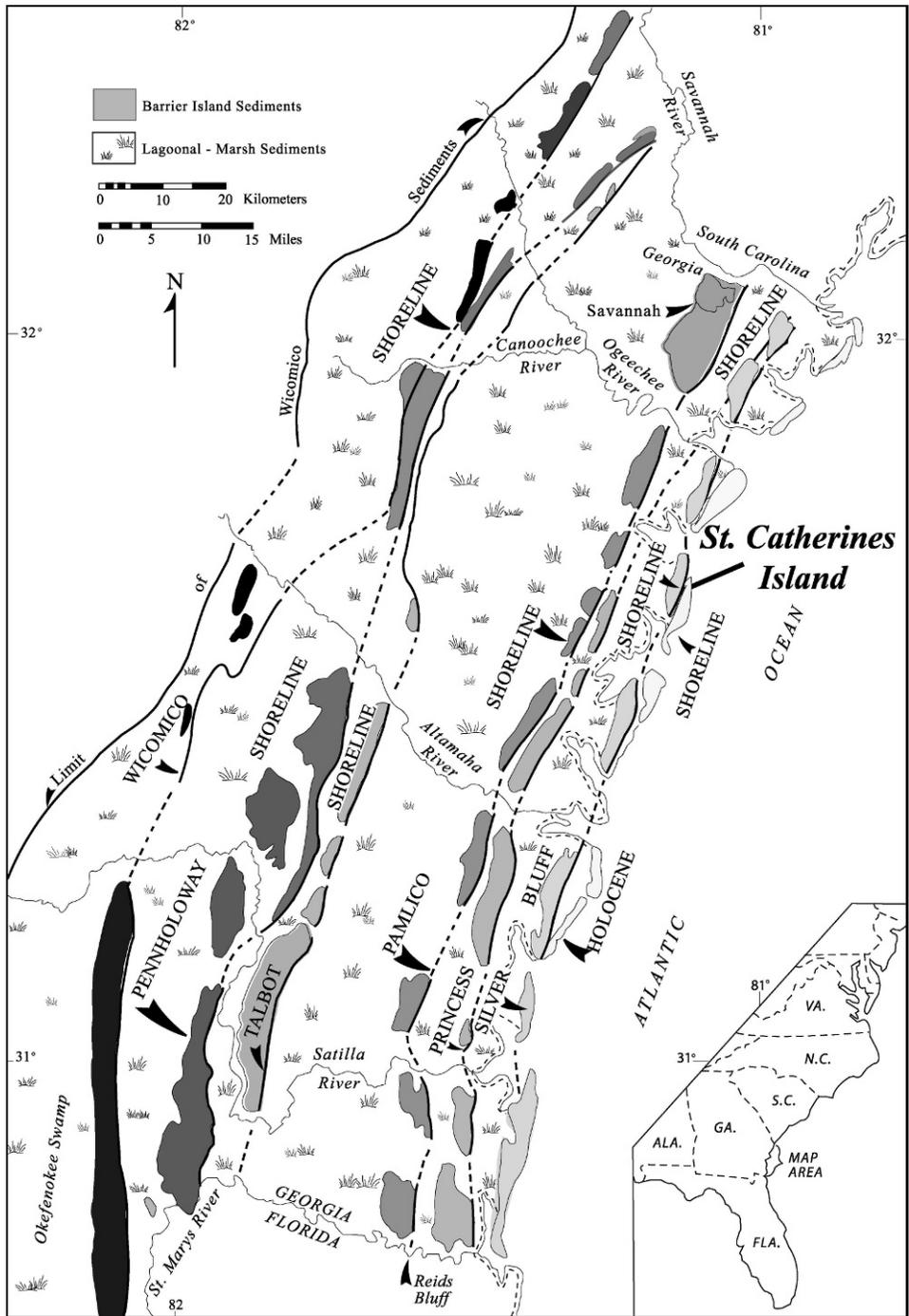


Fig. 5.1. Location of St. Catherines Island showing the Silver Bluff composite islands and five earlier Pleistocene shorelines (after Hails and Hoyt, 1969).

core of beach and dune deposits, created during an interglacial sea-level highstand. Following an extensive lowering during the last ice stand of the Pleistocene (Wisconsinan), analogous deposits were deposited as Holocene sea level rose (fig. 5.1). These Pleistocene and Holocene sediments are similar in texture, but differ in other respects. Pleistocene deposits generally have well-developed podsoils and humate zones containing coarse-grained sands and rather featureless surficial geomorphic terrains. Some sedimentary structures and fossils are preserved in these strata. More recent Holocene deposits generally lack well-defined soil zones, are light tan in color, and unweathered. They are composed mainly of fine, well-sorted, angular quartz grains with highly textured surficial geomorphic features, abundant sedimentary structures, and fossil shells.

In contrast to this general pattern, Tybee and Wassaw Islands are broad-ended Holocene deltaic deposits of the Savannah River, separated from the older Pleistocene Wilmington and Skidaway Islands. A genetically similar, but smaller delta occurs immediately south of the Altamaha River, where Sea Island and Little St. Simons are the enlarged Holocene deltaic components of St. Simons Island. The Pleistocene-age salt marshes reflooded during the Holocene rise in sea level, creating complicated systems with tidal creeks and marshes that separate the barrier islands from the mainland.

During sea-level lowstands (glacial epochs), the barrier islands were stranded in higher relief as the estuarine systems became entrenched. Subsequent erosion further modified the morphology of the stranded islands and the following sea-level rise inundated the estuarine systems.

The modern Golden Isles (as they are commonly known along the Georgia Coast) exhibit dune ridge systems separated from adjacent older dune ridge mosaics by erosional discontinuities. Holocene dune ridges may exceed 10 m in height, but the barrier islands are generally characterized by low elevations, ranging between 5 and 8 m above mean sea level. A series of dune ridges typically extends parallel to the

shoreline immediately landward of the high spring tide level. Storm surges and spring tides tend to erode the seaward sides of the dunes, smoothing geomorphic irregularities and straightening coastal margins. The landward sides of the ridges are less regular, and may be characterized by wash-over fans behind breaches in the dune ridges or secondary dunes built on top of the primary dunes. Multiple dune ridges commonly occur and are spaced at intervals ranging from a few to several hundred meters. Each ridge records the position of the back beach during the time of its formation.

### GENERAL GEOLOGICAL SETTING

The modern sea islands of Georgia, arrayed along the apex of the coastal emargination known as the Georgia Bight, are the most recent manifestations in the complex history of a broad asymmetrical syncline known as the Southeast Georgia Embayment. Downwarping of this tectonic basin has occurred intermittently since the latest Paleocene, and the region has undergone extensive Plio-Pleistocene erosion and progradation (Winkler and Howard, 1977; Colquhoun and Brooks, 1986). Over the last two million years along this stretch of coast, sea level highstands have left a record of relic strandlines known, from oldest to youngest, as the Trail Ridge, Effingham, and Chatham Sequences (Winkler and Howard, 1977).

The origins of the Georgia Sea Islands are intimately linked to the events that occurred during accumulation of the Chatham Sequence, which contain evidence of one, if not two, major cycles of late Pleistocene sea-level change. However, present understanding of the "deep history" of the Georgia sea islands is clouded by controversy over the magnitude, timing, and frequency of major sea-level fluctuations. There is strong evidence of a highstand about 120,000 years B.P., during the last interstadial when sea level reached 6–8 m above its present position (Hoyt and Hails, 1967; Bloom, 1983). Another highstand about 1 m above present-day mean sea level, termed the Silver Bluff submergence, has been repeatedly reported for the interval 37,000 years to

25,000 years B.P. (Hoyt et al., 1968; DePratter and Howard, 1980). Bloom (1983), among others, has challenged the evidence for a Silver Bluff highstand above present mean sea level citing overemphasis upon infinite  $^{14}\text{C}$  dates, the paucity of finite  $^{14}\text{C}$  dates, and apparent contradiction with the deep-sea oxygen isotope record and the dates of emerged coral reefs. More conservative interpretations envision an ongoing drop from  $-38$  m to  $-42$  m (below present mean sea level) between 40,000 and 28,000 years B.P. (Bloom, 1983). Alternate explanation of a Mid-Wisconsinan age for the Silver Bluff strandline calls upon rapid uplift of up to 2 m per 1000 years along this portion of the southeastern U.S., a rate quite inconsistent with uplift along passive continental margins. Parsimony dictates an older age assignment (about 120,000 years B.P.) for the so-called Silver Bluff submergence.

#### THE CONTEMPORARY ESTUARINE ENVIRONMENT

The barrier island interiors are forested primarily by oak, pine, and palmetto. Along inlet margins and the often wide sandy beaches, a variety of dune grasses and shrubs thrives, including sea oats (*Uniola paniculata*), sea croton (*Croton punctatus*), and salt meadow grass (*Spartina patens*). Marsh vegetation consists mainly of smooth cordgrass (*Spartina alterniflora*), ringed by black needlerush (*Juncus roemerianus*), spiked saltgrass (*Distichlis spicata*), and glassworts (*Salicornia* sp.) in the higher reaches. These plants are adapted to a humid subtropical climate of mild winters, hot summers, high rainfall, and frequent ground fires.

Michael Dahlberg defined two major habitats for the marine organisms of the Georgia Bight (1975: 4–10). The offshore zone encompasses the broad, shallow continental shelf that lies east of the sea island beaches. The Georgia Bight is tidally dominated and the low wave energy exists along coastal Georgia because of the relationship between shoreline alignment, wind direction, and the broad, shallow shelf (Johnson et al., 1974: 89; Frey and Howard, 1986).

Average wave height is less than 0.1 m in the central Georgia coast, increasing to the north and south (Hubbard et al., 1979).

The inshore zone includes the waters along beaches, in salt marsh estuaries, and in riverine estuaries. Narrow expanses of salt marsh habitat are occasionally sandwiched between the forested barrier island interiors and protective dune beach ridges. Salt marsh estuaries are characterized by mud flats, oyster bars, and mazes of meandering tidal creeks, as well as by deep sounds fed by rivers that drain the coastal plain. Salt marsh estuaries lie protected from storm events behind the barrier islands but are subject to regular tidal fluctuations through a series of inlets (sounds) that separate the islands from one another. Inlets are usually deeper than adjacent coastal or estuarine waters. The tidal range is generally greater than 2 m, and a spring high tide may produce a 50 percent increase over mean high tide level (Frey and Howard, 1986a). Coastal Georgia experiences the greatest tidal ranges in the Georgia Bight, so Georgia's inlets and marshes are larger than those located to the north or south (Hubbard et al., 1979).

Few baseline studies exist documenting the marine invertebrate macrofauna of coastal Georgia. A series of box cores taken along coastal Georgia estuarine channels by Howard and Frey (1975) listed 73 species, 51 of which had also been reported from the adjacent continental shelf by Dorjes (1972). Howard and Dorjes (1972) found 50 macro-invertebrate species, dominated by crustaceans and polychaetes, on the beaches of Sapelo Island, Georgia. Howard and Reinbeck's (1972) transect from beach to offshore in coastal Georgia tabulated 268 species of macro-invertebrates, mostly polychaetes and crustaceans. Prezant et al. (2002) documented 340 macro-invertebrate species, dominated by crustaceans, molluscs, and polychaetes, from the inshore habitats of St. Catherines Island, Georgia.

The salt marsh estuaries of coastal Georgia afford diverse habitats for marine macro-invertebrates. Vegetated marsh areas harbor great numbers of the sand fiddler crab (*Uca pugilator*), the marsh periwinkle

(*Littorina irrorata*), as well as an abundance of the ribbed marsh mussel (*Geukensia demissa*), attached to the roots of smooth cordgrass (*Spartina alterniflora*). Mats of wrack (mostly needlerush) cover populations of the coffee bean snail (*Melampus bidentatus*). The muddy point bars of marsh tidal creeks locally contain large numbers of the southern quahog (*Merccenaria mercenaria*) and the mud snail (*Ilyanassa obsoleta*). The oyster (*Crassostrea virginica*) effectively constructs bars and dams along the marsh tidal creeks that provide homes to many different invertebrate species.

Beach environments of coastal Georgia have conspicuously abundant populations of the dwarf surfclam (*Mulinia lateralis*) and live and dead shells of this bivalve commonly accumulate among the thousands forming piles of shells in the shoreface intertidal zone of higher energy beaches. More protected lower energy beaches serve as home to a diverse association of macroinvertebrates, including such gastropods as the knobbed whelk (*Busycon carica*), the channeled whelk (*Busycotypus canaliculatus*), the lettered olive (*Oliva sayana*), the eastern auger (*Terebra dislocata*), and the white baby-ear (*Sinum perspectivum*). Also common in the lower intertidal reaches are the grass and shell-studded tubes of the burrowing plumed worm (*Diopatra cuprea*) and holes marking the burrows of several species of ghost shrimp (*Callinassa*).

Riverine estuaries can be divided into upper, middle, and lower reaches, each with subtle boundaries and considerable variability in temperature, salinity, and turbidity due to storms, freshwater drainage, tidal action, offshore currents, and geographic features (Odum, 1971; Dahlberg, 1972; Johnson et al., 1974: 86–94; Hackney et al., 1976). The salinity gradient associated with riverine estuaries such as the Altamaha is much greater than that in salt marsh estuaries isolated from riverine influence (Frey and Howard, 1986a). Salinities in the lower portions of riverine estuaries may range between 21.4 and 28.9 ppt (Dahlberg, 1972). The middle reaches have a range of 11.7 to 29 ppt and the upper stretches have the lowest salinity, from 0.3

to 18.7 ppt (Dahlberg, 1972). There is considerable overlap and daily variability. During years of drought highly saline waters extend upstream, and associated organisms may be found as far as 40 km inland (Frey and Howard, 1986a).

The marine waters between Cape Hatteras, North Carolina, and Cape Canaveral, Florida, constitute a transitional zone between the tropical fauna of the Caribbean and the temperate fauna of the Middle Atlantic Seaboard (Ekman, 1953: 46–49; Briggs, 1974: 214–218). This area has been termed the Carolina Province and is coincident along most of its length with the Georgia Bight. Although species abundances may fluctuate from one season to another, individuals of many species may be found inshore throughout the year. Seasonal variations in some species appear to correlate with salinity of the water rather than temperature, and this can change dramatically at any given location within just a few hours (Hackney et al., 1976). More species may actually be present in fluctuating environments than in stable ones (Hackney et al., 1976). There is a gradual change in fish species abundance from the southern end of the Carolina Province to the northern limit, but species composition remains constant throughout (Bearden, 1961; Dahlberg, 1972; Mahood et al. 1974; Freeman and Walford, 1976). Thus, while some variation in aboriginal subsistence practices might reflect differing locations, the differences should not be as great within the Carolina Province as they would be between that province and the Middle Atlantic or the Caribbean Provinces.

Marine vertebrates typical of archaeological sites in the region are primarily members of the sea catfish and drum families, but also include sharks, rays, killifish, groupers, jacks, sheepshead, mullets, and flounders; we will describe some of these taxa that were prominent in the aboriginal diet.

Sharks and rays are common in inshore waters and archaeological collections. Most sharks are found here only during the warm months of the year and are more common along beaches and in the lower reaches than in middle or upper ones (Dahlberg, 1972).

Rays exist in a variety of salinity conditions and may be found in estuaries either year-round or only during warm months depending upon the species (Dahlberg, 1975: 28–31; DEIS, 1978: D426).

Sea catfishes (Ariidae) are very common in the estuarine environments. The hard-head catfish (*Ariopsis felis*) is more common than the larger gafftopsail (*Bagre marinus*) and tolerates a greater salinity range. Sea catfishes are present in the inshore area year-round, although most leave during cold weather (Dahlberg, 1972).

Members of the drum family (Sciaenidae) are common in coastal habitats and are usually the most common vertebrate forms recovered on archaeological sites. Silver perch (*Bairdiella chrysoura*) are found year-round throughout the estuary, spawning primarily between April and May in estuarine and coastal waters (Powles and Stender, 1978). Small aggregations of spotted seatrouts (*Cynoscion nebulosus*) are present in inner bays throughout the year, whereas silver seatrouts (*C. nothus*) are more common off beaches. Weakfishes (*C. regalis*) may leave estuaries during cold months of the year (Dahlberg, 1972), but spawn inshore (Powles and Stender, 1978). Spots (*Leiostomus xanthurus*) are found in the inner bay during warm months; however they spawn offshore during the winter months (Powles and Stender, 1978). The Atlantic croaker (*Micropogonias undulatus*) is a small but common drum fish found throughout the coastal habitat in warmer months. Adults in Georgia leave the estuary to spawn offshore between September and April (Powles and Stender, 1978). Young croakers are not as abundant in shallow waters as young spots and, unlike young spots, are not found in freshwater (Dahlberg, 1972). The two largest drums are the black drum (*Pogonias cromis*) and the red drum or redfish (*Sciaenops ocellatus*). Small black drums are present year-round. The red drum spawns in coastal waters near shore (Powles and Stender, 1978), but otherwise it is present year-round inshore. Star drums (*Stellifer lanceolatus*) are small fishes that are found in greatest numbers during the summer and fall.

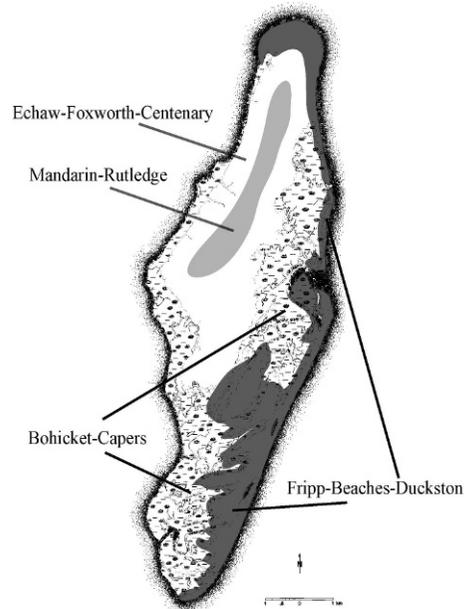


Fig. 5.2. The distribution of major soil types on St. Catherines Island (after Loooper, 1982).

Also part of the estuarine fauna are mullets (*Mugil spp.*) and flounders (*Paralichthys spp.*). Striped mullets spawn from September through April, and white mullets between March and September (Dahlberg, 1972). Many of the small fishes can be found in shallow, brackish waters, although adults prefer slightly deeper, more stable conditions. Depending on species, adults may be present throughout the year, although when temperatures drop below 7° Centigrade even the striped mullet (*M. cephalus*) will leave (Dahlberg, 1972). Flounders are bottom-dwelling carnivores that may be present throughout the year depending on species.

#### SOILS OF ST. CATHERINES ISLAND

The following descriptions of St. Catherines Island soils follow Loooper (1982; see also fig. 5.2).

##### CENTRAL PLEISTOCENE CORE

The relatively high Island core comprises the northeastern third of St. Catherines, and hosts a mature, mixed deciduous pine forest and fallow agricultural fields. The

central portion of the Pleistocene core is characterized today by two rather poorly drained soils that are sandy throughout.

**MANDERIN FINE SAND:** This somewhat poorly drained, nearly level soil occurs on broad ridges, in patches between 5 to 80 ha. Slope is 0 to 2 percent. The strongly acidic Mandarin soil is low in natural fertility and organic matter content. This soil is not well suited to row crops, small grains, and pasture because of its low available water capacity.

**RUTLEDGE FINE SAND:** This very poorly drained, nearly level soil occurs in shallow depressions and bays, in areas from 2 and 120 ha in size. It is commonly flooded and ponded for brief periods during winter and spring. Slope is 0 to 2 percent. The extremely acid Rutledge soil has high to very high organic matter content, but is low in natural fertility. On the broad ridges, natural vegetation consists of saw palmetto, gallberry, waxmyrtle, and longleaf pine. In the depressions and bays, natural vegetation is generally composed of blackgum, cypress, sweetgum, pond pine, and water oak. Because of high water content, most of the soils in this unit are moderately well suited to pine woodland and are poorly suited for use as farmland.

#### ISLAND CORE PERIPHERY

The Pleistocene core is ringed by different soils that are characterized by nearly level and gentling sloping, moderately well-drained areas that are sandy throughout and not subject to flooding. These soils are referred to as the Echaw-Foxworth-Centenary complex.

**ECHAW AND CENTENARY FINE SANDS:** This undifferentiated group consists mainly of moderately well-drained, nearly level soils that occur on ridges. Areas are generally 40 to 80 ha in size, with slopes between 0 and 2 percent. These soils are medium to very strongly acidic and are consequently low in natural fertility and organic content. The Echaw and Centenary soils are moderately suited to use as farmland.

**FOXWORTH FINE SAND:** This moderately well-drained, nearly level and very gently

sloping soil (0 to 3% slope) occurs on broad ridges and small knolls, commonly in areas of 6 to 60 ha. Strongly acidic, the Foxworth soil is low in natural fertility and organic content. This soil is poorly suited to row crops, but moderately suited to use as pasture. This soil type hosts a natural vegetation of loblolly and longleaf pine, live oak, and turkey oak. Some areas have an understory of waxmyrtle and yaupon. Because of the low availability of water, most of the soils in this unit are moderately suited to pine woodland and farmland.

#### HOLOCENE BEACH RIDGES

Restricted to the northern tip and the southeast quarter of St. Catherines, the beach ridge complexes on the Island are Holocene accretionary features. These ridges are roughly parallel, average about 3 m in elevation, and are separated by swales comprised of intertidal marsh meadows or freshwater ponds. South Beach preserves a sequence of beach ridge complexes that are progressively younger to the east and south.

The Holocene age beach ridges on St. Catherines Island are nearly level to moderately steep, with excessively drained to poorly drained soils that are sandy throughout.

**FRIPP-DUCKSTON COMPLEX:** These soils are unsuitable for agriculture or woodland. This complex consists of small areas, generally from 25 to 100 ha, and has a slope between 1 and 20 percent. It occurs on both undulating to rolling dunes, as well as in the shallow depressions and flats between dunes and marshes. These areas are frequently flooded for brief periods throughout the year. Low in natural fertility and organic matter content, these soils are medium acidic throughout. Most Fripp-Duckston soils are forested with live oak, brush, and grasses. Natural vegetation on the dunes is primarily sea oats and cabbage palm, while the beaches are devoid of vegetation. Other vegetation mainly consists of waxmyrtle.

Situated between the beach ridges and the Island core lie the poorly drained, nearly level soils of the Bohicket-Capers series,

TABLE 5.1  
**Areal Extent of Vegetation Types on St.  
 Catherines Island (after Somes and Ashbaugh,  
 1972)**

Vegetation type	Extent	
	Acres	Hectares
Meadows	378	153
Scrub	245	99
Savannas	399	161
Forests	5537	2241
Upland grasslands	326	132
Herbland	8	3.2
Aquatic plants	18	7.3
Upland subtotal	6911	2796.5
Tidal marsh	7328	2966
Total	14,239	5762.5

which are loamy to a depth of 50 cm and clayey to a depth of 150 cm or more.

**CAPERS SILTY CLAY:** The Capers soil is high in natural fertility and organic matter content and ranges from neutral to mildly alkaline. This very poorly drained, nearly level soil occurs in tidal salt marshes that interfinger into the mainland and barrier islands, as well as in floodlands that extend inland from the ocean. This soil occurs in areas of 2 to 200 ha and experiences tidal flooding in the spring. In some localities, Capers soils receive more frequent flooding. Natural vegetation is needlegrass, rush, and sand cordgrass. The soils in this unit are used primarily for wetland wildlife and are poorly suited for most other uses.

#### VEGETATION OF ST. CATHERINES ISLAND

Following Somes and Ashbaugh (1972), we will divide the vegetation of St. Catherines Island into several major types (table 5.1).

**TIDAL MARSH:** Tidal marshes flank large reaches of the eastern and western portions of the Island. The predominant marsh vegetation is smooth cordgrass (*Spartina alterniflora*), which occurs in pure stands except near the upper marsh elevations. The banks of the tidal creeks are bounded by tall stands of cordgrass, sometimes reaching 5 feet or taller. Other tidal marsh

species include salt hay (*Spartina patens*), perennial saltwort (*Salicornia virginica*), beachwort (*Batis maritima*), sea oxeye (*Borrchia frutescens*), and spike grass (*Distichlis spicata*).

**MEADOW:** Meadows occur in nontidal areas where freshwater reaches the soil surface most of the year. Nearly 120 ha of the meadowlands on St. Catherines Island are located along the upper margins and heads of the tidal marshes, near low-water stands of cordgrass, and near upland ponds. These meadows are dominated by rushes, especially black rush (*Juncus roemerianus*), soft rush (*Juncus effesus*), spike-rush (*Eleocharis quadrangulata*), and bul-rush (*Scirpus sp.*).

Saw grass (*Cladium jamaicense*) meadows occur in low swales near the tidal marshes, whereas broomsage (*Andropogon virginicus*) meadows are found in four upland depressions on the northern and central parts of the Island. At South Beach, a small cat-tail (*Typha glauca*) marsh stands near the ponds. Pond grass meadows consist of soft rush Bermuda grass (*Cynodon dactylon*).

**FOREST:** Forests cover nearly 40 percent of St. Catherines Island. Forest composition is heavily influenced by disturbances such as plantation agriculture, fire, grazing, and mechanical management during the historic period.

Approximately one third of the modern forest is comprised of mixed pine and oak trees. Stands of slash pine (*Pinus elliottii*) are common, with scattered individuals of laurel oak (*Quercus laurifolia*) and live oak (*Quercus virginiana*). Pine-oak forests develop on previously cultivated fields and generally antedate pure stands of pines. In general, recently fallowed fields lack substantial undergrowth. In less disturbed areas, however, the undergrowth consists of saw palmetto, buckthorn, waxmyrtle, yaupon, and sparkleberry.

On sites with minimal disturbance, live oak and laurel tend to dominate the mixed pine-oak association. The least disturbed areas on the Island host oak forests, usually dominated by live oak. Spanish moss and resurrection fern are abundant amidst the oaks and red bay, as are scattered individ-

uals of carriage palm, laurel oak, hickory (*Carya glabra*), and paper mulberry (*Broussonetia papyrifera*).

**UPLAND GRASSLAND:** Upland grasslands grow in areas that are not subjected to regular tidal inundation, such as beaches, foredunes, forest clearings, and recently cultivated fields. Bermuda grass comprises more than 70 percent of the grasslands on St. Catherines Island. The older fields support stands of spangle grass (*Uniola liza*), orange broomsedge (*Andropogon virginicus*), and thoroughwort (*Eupatorium capillifolium*).

Sea oats (*Uniola paniculata*) grow in the dunes behind the ocean front beaches, and are commonly associated with seaside pennywort (*Hygrocotyle bonariensis*), sandspur (*Cenchrus tribuloides*), and beachtea (*Croton punctatus*).

**SCRUB:** Scrublands consist largely of waxmyrtle (*Myrica cerifera*) mixed with buckthorn (*Bumelia tenax*), yaupon (*Ilex vomitoria*), winged sumac (*Rhus copallina*), Hercules-club (*Zanthoxylum calva-herculis*), saw palmetto (*Serenoa repens*), century-plant (*Agave decipiens*), cabbage plam (*Sabal palmetto*), and marshelder (*Iva frutescans*). Occasional individuals of live oak also grow in these habitats.

**SAVANNA:** Man-made savanna consists of grasslands with scattered trees. The largest savanna on St. Catherines is located on the north end of the island and was created in the 1950s to establish a grazing area for cattle, and this area has been purposefully maintained with set fires and bulldozing. The major grass species include Bermuda, spangle grass, and purple broomsedge. Slash pine, leaf pine (*Pinus palustris*), live oak, and laurel oak are the major trees growing on the savanna. A more limited live oak savanna occurs sporadically throughout the Island.

#### HYDROLOGY OF ST. CATHERINES ISLAND

ROYCE H. HAYES AND DAVID HURST THOMAS

When Fray Andrés de San Miguel and his shipwrecked companions stumbled ashore on Wolf Island (or perhaps Little

St. Simons Island) in 1595, they were parched, having run out of water 2 days before. Finally ashore, however, Fray Andrés was “diligent in searching for it [and] no great effort was necessary because the merciful goodness of God provided it soon from some pools that we found close to where we landed and with a little hole that we made on the beach up to three yards away from the sea, where we found sweet and very good water” (de San Miguel, 2001: 55). To their everlasting gratitude, de San Miguel and his shipmates learned what Indians of the Georgia coast had known for millennia: Cool, sweet freshwater is abundant and easy to find almost everywhere on the Sea Islands. Those days are long past, though to understand the nature of aboriginal agriculture on St. Catherines Island, it is first necessary to understand the preindustrial hydrology of the Guale coast.

Coastal Georgia is underlain by unconsolidated sedimentary strata overlying carbonate rocks known as the Floridan Aquifer, one of the most productive groundwater reservoirs in the United States. This water-bearing stratum is comprised of Eocene-age limestone, dolostone, and calcareous sands, confined between impervious layers. The Floridan Aquifer extends from South Carolina to Florida and reaches inland as far as Alabama. Near Brunswick (Georgia), the sedimentary strata are 600 m thick and deeply buried beneath more than 150 m of sand and clay; this sequence becomes thinner and closer to the surface as it approaches Savannah, where the carbonate strata are less than 150 m and lie 15–50 m below the surface (Miller, 1998: 23).

Such was the hydrological regime when, millennia ago, the first foragers visited St. Catherines Island, and the same conditions prevailed when Fray Andrés de San Miguel and his mates arrived on the 16th century Georgia coast. The recharge and discharge of the aquifer system remained in proximate equilibrium so long as the Upper Floridan aquifer was recharged by rainfall in the interior, where it lay near the ground surface. Because the aquifer was confined (under “artesian” conditions), water flowed

naturally to the surface in springs (with their characteristic domes of yellow sand) and seepage to rivers, ponds, wetlands, and other surface-water bodies throughout most of coastal Georgia. At Brunswick, the artesian water pressure was about 20 m above sea level, and 10 m above sea level at Savannah.

Above the primary aquifer lies a surficial reservoir of groundwater (the “nonartesian aquifer”), which lacks sufficient hydrostatic potential (or “head”) to create artesian flow. Height of the local water table is conditioned by supply and demand conditions in the nonartesian aquifer (which reflect the local hydrological budget and is sensitive to variations in rainfall and microtopographic differences). Whenever the water table is higher than the land surface, water accumulates in ponds or swamps or flows in streams. Nonartesian groundwater has always been the major source of water in coastal Georgia (Stephenson and Veatch, 1915; Krause and Clark, 2001).

Through the early 20th century, the principal source of water supply in coastal Georgia was obtained from shallow wells, ranging from 3 to 30 m in depth (Stephenson and Veatch, 1915: 122). In Liberty County, such wells ranged from 3 to almost 10 m deep, and provided the primary source of domestic water. These wells were relatively easy to construct since they generally penetrated only unconsolidated sands and clays. They commonly yielded sufficient water for ordinary household needs, but could fail in times of drought (but along the coast, such failure is unusual).

Beginning in the 1880s, the Upper Floridan aquifer was tapped (and depleted) by numerous deep wells. McCallie (1898: 111; 1908: 139) reports that Jacob Rauer had drilled five wells on St. Catherines Island, each of them reaching a depth of about 90 m, with a head pressure of 10 m above the surface; “the flow is said to be slightly affected by the tides, which cause a difference of pressure equal to a variation of about 18 in [45 cm] in head.” Mr. W. J. Floyd drilled an additional well on St. Catherines Island in 1909 at the south end of the island (where the land stands about

6 feet above sea level). According to Floyd’s drilling log, this well was 133.5 m deep, cased to 70 m, and flowed 225 liters a minute (with a static head of 12.8 m above the surface; Stephenson and Veatch, 1915: 314).

Over the past century, groundwater pumping has significantly lowered the water level in the Upper Floridan aquifer through the entire coastal area, resulting in cones of depression around major population centers (Warren, 1944). Numerous wells along the Georgia coast and many freshwater springs have stopped discharging; freshwater wetlands and ponds that fed in the 19th century by flow from the Upper Floridan aquifer are now dry. Salt-water contamination has also occurred in places lateral to the induced cones of depression.

It is difficult for the modern observer to appreciate the magnitude of the hydrological change over this past century. By looking closely at the historical sources and tracing out the surviving geomorphological evidence, however, it is possible to reconstruct (in tentative fashion) what St. Catherines Island looked like before the deep drilling changed the hydrology forever.

We can a glimpse these preindustrial conditions in the journal pages of Jonathan Bryan, who visited St. Catherines Island on August 10–11, 1753:<sup>1</sup>

This afternoon we ran into a smart Thunder Squall but secured our Selves from its violence by running into the small Creek. In the evening we crossed St. Catharine’s Sound and got to Mr. Bosomworth’s about Eight at night.<sup>2</sup> Mr. Adam Bosomworth entertained us very kindly, and the next day being the Eleventh Instant We took our tour across the Island on foot to view it. This Island is one of the most pleasant and agreeable Place[s] in all Georgia, it is in Length about Eighteen Miles and three or four Miles Broad, and separated from the Main Land with Rivers & Marshes and distant from the Main about three Miles, the front is wash’d by the Sea and Banks very high Shaded by fine spreading Live Oaks, the middle of the island appears a perfect Meadow being a large Savanna of about a Mile or Mile and half wide and four or five Miles long, and finely water’d with Springs. this Island with little Improve-

ment would make one of the finest Seats for a Man of Fortune, in all Georgia. Here Spreading Oaks invite the Southern Breeze and rising Bar [sandbar] repel the foaming Seas, the cristial [crystal] Streams in winding rills proceeds the rising Mounts and flow the verdant meads. after about three Hours Walk we return'd with a fine young Buck which gave us good diversion on the Sea Beech with Mr. Bosomworth's Hounds. This Evening we proceeded up the Newport River ..." (Jonathan Bryan [1753] in Wood and Bullard, 1996: 19–20).<sup>3</sup>

Bryan's "perfect Meadow," that once dominated the central reaches of St. Catherines Island, has long since disappeared; it was drained by dragline ditches cut in the 1930s. The extent of this large freshwater lagoon can clearly be delimited on pre-1930 topographic maps, on early aerial photographs, and in geomorphic clues still present on the Pleistocene core of St. Catherines Island.<sup>4</sup>

Working from this baseline evidence, we now understand that the "large Savanna" on St. Catherines Island corresponds almost precisely to the distribution of Rutledge fine sands, the very poorly-drained remnant soil that developed in the shallow depressions and bays of the former central meadow (Looper, 1982; see also chap. 1). Figure 5.1 reconstructs this freshwater lagoon based on the contemporary distribution of (1) soil types and (2) the dendritic pattern of relic ground water outflows (Bryan's spring-fed "cristial [crystal] Streams in winding rills") that once drained the "perfect Meadow" into the marsh. Because it heavily conditioned the aboriginal settlement pattern on St. Catherines Island for millennia, the importance of reconstructing this now extinct freshwater lagoon cannot be overemphasized.

A second, related point emerges from Bryan's journal entry of 1753. Other corroborating sources (including Fray Andrés de San Miguel and William Bartram) have emphasized the abundance of flowing freshwater on the Georgia coast (see also Hilton [1666] in Sanford, 1911; Matthew, 1911 [1670]; Hvidt, 1980). Freshwater has always been abundant on St. Catherines Island, available virtually everywhere except dur-

ing periods of extreme drought. In several places, the Floridan aquifer provided freshwater on the ground's surface. Where water was unavailable from the deep aquifer, a relatively shallow well could tap the surficial reservoir of nonartesian water. This means that—at least prior to the early/mid-20th century—nonartesian groundwater could be found almost anywhere on St. Catherines Island. Water was always more available in low-lying locales, and became relatively more difficult to obtain with increased elevation. This was true especially in the high ground across the northeastern sector of the island.

#### ANTEBELLUM AGRICULTURE ON ST. CATHERINES ISLAND

To understand the nature of aboriginal farming practices on the Georgia coast, it is necessary to first understand the agricultural complex that dominated St. Catherines Island for a century during the plantation period, when almost half (roughly 650 ha) of the island was clear-cut to cultivate rice (Carney, 2001) and to plant Sea Island cotton (Johnson, 1930). As noted above, the contemporary vegetation of St. Catherines is an amalgam that reflects the diverse natural and cultural history of the island, and the most visible such impact took place during the antebellum plantation period (see also Thomas et al., 1978). These agricultural fields were generally bordered by windrows of virgin hardwood forest, and ditches were often excavated to outline field boundaries. Isolated live oaks ("slave trees") were left standing to provide shade for plantation workers.

Early in our St. Catherines Island fieldwork, we commissioned cartographer Richard Gubitosa to prepare a detailed map of the antebellum field boundaries. In the mid-1970s, he walked out and mapped each of the field margins using a transit and tape, and the resulting map (fig. 5.3) employs field names taken from a circa 1890 map. Knowing the exact extent of these antebellum fields and their boundary ditches was critical for the various survey crews operating on St. Catherines Island because (prior

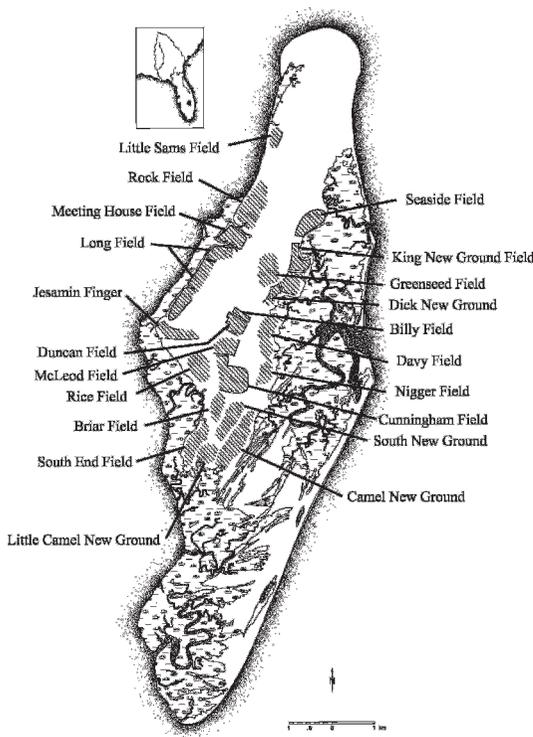


Fig. 5.3. The distribution of antebellum fields on St. Catherines Island.

to the advent of GPS/GIS mapping technology) these landmarks provided the most reliable means of plotting site location.<sup>5</sup>

The 21 known antebellum fields range in size from 5 to 60 ha, but average about 30 ha. To our knowledge, only one of these fields (Rice Field, located immediately inland from Mission Santa Catalina de Guale) was constructed to cultivate rice on St. Catherines Island. It is suspected that Rice Field was subdivided into smaller plots, with “trunks” controlling the water flow into each field.<sup>6</sup> The land was probably prepared for planting in March, then seeded and flooded. Over the summer, the rice plots were periodically irrigated and then allowed to dry out, after which weeds were hoed. Finally, the fields were flooded for a couple of months as the rice plants fully ripened. Water was drained off and the rice was harvested in late August and September.

The 20 additional antebellum fields were planted in Sea Island cotton, a strain of long-stable (or “black-seed”) cotton originally in-

troduced to the Georgia coast in the late 18th century (Johnson, 1930; Sullivan, 1990: 115–117, 232–234). Sea Island cotton seeds were planted in the early spring and hoed several times before they germinated (usually in early July). The cotton crops were picked between September and early December, then ginned (probably on St. Catherines Island).<sup>7</sup> Johnson (1930: 47) estimates that “on the average [Sea Island] plantation it required from fifty to sixty days of labor to cultivate and gin a bale of fine cotton.”

The soils on St. Catherines Island are generally quite acidic and low in natural fertility and organic content. The most desirable agricultural soil is the Foxworth fine sand, followed by Echaw and Centenary fine sands (Soil Conservation Service, 1982). As shown in table 5.2, the vast majority (18 of 21) of the antebellum fields on St. Catherines Island were constructed on Foxworth soils. This moderately well-drained, nearly level, and very gently sloping soil occurs on broad ridges and small knolls, commonly in patches of 6 to 60 ha. In general, the strongly acidic Foxworth soils are low in natural fertility and organic content. By modern agricultural standards, such soils are considered to be poorly suited to row crops (and moderately suited to pasture).

The other three antebellum clearings (Long Field, Billy Field, and Jesamin Finger) were constructed on Echaw and Centenary fine sands. Rated “moderate” in its modern farmland potential, this undifferentiated soil group consists of moderately well-drained, nearly level soils that generally occur on ridges in 4- to 80-ha patches. The slope ranges from 0 to 2 percent. These soils are low in natural fertility and organic content; they are medium to very strongly acidic.

As indicated on figure 5.3, the southern half of the Island core was covered almost entirely with antebellum fields. North of Persimmon Point, however, the plantation fields are clustered along the eastern and western margins of the island—clearly avoiding the low-lying, poorly drained freshwater lagoons that once dominated the north-central portion of the Island core. With the sole exception of Little Sams

TABLE 5.2  
**The Known Antebellum Fields of St. Catherines Island, Georgia**

Name	Size (ha)	Primary soil type	Secondary soil type
Little Sams Field	15	Foxworth fine sand	
Rock Field	50	Foxworth fine sand	Echaw & Centenary fine sands
Seaside Field	35	Foxworth fine sand	
Meeting House Field	30	Foxworth fine sand	
Long Field	60	Echaw & Centenary fine sands	
King New Ground Field	20	Foxworth fine sand	
Greenseed Field	30	Foxworth fine sand	Echaw & Centenary fine sands
Dick New Ground	12	Foxworth fine sand	Echaw & Centenary fine sands
Billy Field	5	Echaw & Centenary fine sands	Foxworth fine sand
Jesamin Finger	30	Echaw & Centenary fine sands	Mandarin fine sand
Davy Field	40	Foxworth fine sand	
Duncan Field	25	Foxworth fine sand	Echaw & Centenary fine sands
McLeod Field	25	Foxworth fine sand	Echaw & Centenary fine sands
Nigger Field	18	Foxworth fine sand	Echaw & Centenary fine sands
Rice Field	35	Foxworth fine sand	Echaw & Centenary fine sands
Briar Field	20	Foxworth fine sand	
South New Ground	45	Foxworth fine sand	
Cunningham Field	30	Foxworth fine sand	
South End Field	45	Foxworth fine sand	Echaw & Centenary fine sands
Camel New Ground	60	Foxworth fine sand	
Little Camel New Ground	20	Foxworth fine sand	Echaw & Centenary fine sands

Field, not a single field was constructed north of the Seaside–Rock Field boundary. Elsewhere on the island, fields were not constructed on the low-lying Mandarin–Rutledge soils.

Note the almost complete absence of antebellum fields along the northern quarter of St. Catherines Island—despite the large, continuous band of Echaw–Foxworth–Centenary soils (the favored soil type elsewhere on the island). The absence of agricultural fields on the northern end of the island can be attributed primarily to topography and drainage. This area contains considerable “high ground”—stabilized dune ridges in places several meters above mean sea level. The prevailing natural vegetation of the northern part of St. Catherines Pleistocene core is long-leaf pine, a species known for its deep-reaching tap roots that penetrate to a sufficient level to reach the underlying water table. This land is ill suited for agriculture, and despite the prevalence of relatively desirable, well-drained soils in this area, cotton would not grow in these relatively high elevations because access to the water table is difficult.

An advertisement in Savannah’s *Daily Georgia* (September 1, 1838) describes the condition of antebellum fields on the Johnston plantation (basically the southern one third of St. Catherines Island):

For Sale

That most valuable cotton plantation on the south end of St. Catherines Island, about 50 miles from Savannah; consisting of 650 acres of planting land, all except eight acres of which have been manured with marsh mud one two and three years, and a large portion of compost besides. There is a flag pond of 70 acres, 40 of which were cultivated three years, and produced good crops of corn. Also from 150 to 200 acres of old fields, grown up which with manure would produce well. The tract contains about 2500 or 3000 acres of pastureland ... not surpassed by any in the low country—horses, cattle, and hogs keeping fat on it through the season.

This account documents the degree to which the tidewater planters enhanced their yields by using salt marsh mud to fertilize the fields (Johnson, 1930; Sullivan, 1990: 234). Salt marshes were within easy reach of most barrier island cotton fields, and

slaves commonly loaded marsh mud onto boats in the nearby tidal rivers and salt marsh flats, then spread the mud onto the fields (at a rate of about forty ox cart loads to the acre). The organics contained in marsh mud provide an effective fertilizer, but it was also somewhat acidic. This is why some Sea Island planters (including Thomas Spalding of Sapelo Island and John Couper of St. Simons Island) laid down a layer of crushed oyster shell before applying marsh mud to their cotton fields. Others mulched their fields with manure or with cut marsh grass that was allowed to rot during the summer and then applied directly to the fields.<sup>8</sup>

Later in Part I, we build upon the known natural and cultural background presented in this (and preceding chapters) to develop a theoretical framework appropriate to understanding the aboriginal landscape of St. Catherines Island.

#### NOTES

1. Mr. Bryan was accompanied on this exploratory tour by William Gerard DeBrahm, a well-known cartographer and the most prolific Southeastern mapmaker of his era (DeVorse, 1971; Cumming, 1998: 29–30; see also chap. 29).

2. Under the treaties and understandings of 1733–1739 between James Oglethorpe and the local Indians, St. Catherines Island was reserved for Creek tribal use, and in April, 1744, the Yamacraw Indians living in a village near Savannah moved to the Island (Wood and Bullard, 1996: 70). The Yamacraw planted several corn fields and in 1745, and Edward Kimber wrote that St. Catherines Island contained “the most fruitful Soil,

and ... [with] larger Tracts of open Land than any I have observed, and to abound in all Kinds of Game, on which the good *Indians* regaled us” (quoted in Wood and Bullard, 1996: 70). By 1746, Thomas Bosomworth (husband of Mary Musgrove) brought a herd of cattle and six slaves to St. Catherines Island. Adam Bosomworth (brother of Thomas Bosomworth and brother-in-law of Mary Musgrove) served with Oglethorpe’s Regiment and apparently received a land grant in 1749.

3. Wood and Bullard (1996: 70) find it “curious” that Bryan did not mention the Spanish ruins of Santa Catalina de Guala, which were quite obvious to Colonel Dunlop only 66 years before (Dunlop, 1929 [1687]). But from Bryan’s account it is clear that his “three Hours Walk” took him to the beach and back. If we assume that his landfall was near Bosomworth’s house (evident on the 1760 De Brahm’s map), he was at all times a good 3 miles north of the mission ruins.

4. For several years, Hayes has discovered and mapped these relic outflows of ground water, each of which appears to have flowed during precontact times. These data are incorporated on figure 5.3.

5. The Island vegetation has likewise been influenced by more recent land management practices. At various times over the past century, St. Catherines has been logged, grazed, and burnt. A feral hog population, introduced in the 1930s, kept the understory relatively sparse for decades. We were fortunate to conduct our archaeological survey during this period—when the ground surface was relatively visible. The local hog population was drastically thinned out in the late 1970s, and the plant understory has rebounded significantly.

6. For a description of such “trunks”, see Sullivan (1990: 178).

7. James Holmes (“Dr. Bullie”) reports inspecting Jacob Waldberg’s “new cotton gin” on St. Catherines Island sometime between 1810 and 1812 (Holmes, 1976: 144; see also Thomas et al., 1978: 223–225); the ruins of the cotton gin are still visible.

8. There is no evidence to suggest that aboriginal people in the Southeast added mulch or fertilizer to their horticultural fields during the precontact period.

## CHAPTER 6. ABORIGINAL FORAGING STRATEGIES ON ST. CATHERINES ISLAND

DAVID HURST THOMAS

The documentary sources demonstrate some of the great variety in Guale diet, and we may assume that Guale settlements were distributed so that availability of food resources and horticultural lands was maximized. . . . Further research is needed in order so specify the particular advantages of individual locations for horticulture, plant gathering, fishing, shellfish collecting, and hunting. (Jones, 1978: 196)

Ethnohistorian Grant Jones, in the passage cited above, perfectly describes the purpose of the next three chapters: (1) to explore the resource structure of St. Catherines Island, (2) to characterize the subsistence options available to the aboriginal people who have populated the island, and (3) to spell out “the particular advantages of individual locations” for each of these subsistence options.

We touched upon the “Guale problem” in chapter 2, and this discussion provides the obvious point of departure to approach the archaeological record of St. Catherines Island. We will address the relative merits of the Larson/Crook and Jones reconstructions of Guale subsistence, settlement pattern, and sociopolitical organization. Because of the extraordinary archaeological record available to us, however, we will also use this opportunity to address the more fundamental questions of residential mobility, economic intensification, and the evolution of social complexity over the past 5 millennia.

The ethnohistoric record from the earliest period of Spanish contact indicates that the Guale people, like most Southeastern Indians, “enjoyed a diversified food supply that included both wild and domesticated foods, and it is important to realize that wild food was historically the more basic of the two” (Hudson, 1976: 272; see also Swanton, 1922, 1946; Smith, 2006). Because of this subsistence diversity, the Guale cannot be comfortably pigeonholed as either foragers or farmers; they were clearly both.

We begin the conversation by exploring the “foraging” aspect of the Guale Indians and their ancestors on St. Catherines Island.

### HUNTER-GATHERERS AS OPTIMAL FORAGERS

Over the past couple of decades, a diverse cadre of scholars has collaborated to develop a broad-based theoretical approach known as optimal foraging theory, which is grounded in the more general paradigm of human behavioral ecology (that studies human behavior by applying the principles of natural selection within an ecological context). The optimal foraging framework attempts to identify a set of models general enough to apply to a broad range of animal species, yet sufficiently rigorous and precise to explain the details of behavior exhibited by a particular forager (Bettinger, 1980, 1987, 1991; O’Connell and Hawkes, 1981; Smith and Winterhalder, 1981, 1992; Winterhalder, 1981, 2001; Smith, 1983; Stephens and Krebs, 1986; Simms, 1987; Cashdan, 1990; Kelly, 1995; Winterhalder and Kennett, 2006). In an early, programmatic paper, O’Connell and Hawkes (1981: 116) argued that if successfully applied, the perspective of evolutionary biology may provide a way to understand long-term changes in diet and land-use patterns. “The value of such theory lies in its role as a reference dimension, as a source of testable hypotheses about the organization of subsistence-related behavior in a wide range of environmental, technological, and social circumstances.”<sup>1</sup>

Optimal foraging theory is comprised of a series formal, mathematical constructs (“models”) that share a key assumption, namely, that during “economic” pursuits, the forager will operate to maximize the overall rate of energetic return. That is, a given forager will optimize the time/energy invested during whichever pursuit is be-

ing modeled at the time. Commonly, such optimization involves the rate at which items are captured and handled, but the models of optimal foraging theory can potentially address any behavior that impacts foraging success. The implication is that individuals who employ efficient strategies in hunting and food collection will either provide more food or their behavior will allow more free time to pursue additional (fitness-related) activities with their family, offspring, or mates, once the basic provisions are at hand (Broughton and O'Connell, 1999: 154; Barlow, 2002: 70). The broad rubric of "optimal foraging theory" encompasses a broad range of specific models, each of which employs a unique set of simplifying assumptions and constraints, and each can be used to derive testable hypotheses about foraging behavior under certain environmental circumstances.

In chapters 7 through 9, we examine the *diet-breadth (or prey choice) model*, asking: Which foods should an efficient forager harvest from all those available on St. Catherine's Island? The model predicts that foragers will optimize the time spent capturing prey and employs the simplifying (and sometimes unrealistic) assumptions that all resources are randomly distributed (without patches) and that "capture/handling" and "search" times represent the sum total of all time spent foraging (O'Connell and Hawkes, 1981, 1984; Winterhalder, 1981, Hames and Vickers, 1982; Kaplan and Hill, 1982; Smith, 1991; Hawkes et al., 1992; Grayson and Delpuch, 1998; Grayson and Cannon, 1999; see also Kelly, 1995: 349, fn 5). This requires that we know the return rates of the potential food resources, which can be obtained through ethnoarchaeological and experimental research (Broughton and O'Connell, 1999). In chapter 9, we expand our diet-breadth models to address the horticultural technologies introduced to St. Catherine's Island within the last thousand years. (Barlow, 1997, 2002, 2006).

We will also examine the *patch choice model* (see chap. 11), which some investigators consider to be a "special case" of the diet-breadth model (Bettinger, 1991: 87–88; see also Smith, 1991: 245–285). That is,

when a forager confronts an array of patches, each differing with respect to the energy contained therein, and the time necessary to extract that energy, these patch types can be rank-ordered according to their return rates (the net rate of energy intake/unit of foraging time, which is the sum of search and handling times in the patch). The highest ranking patches will produce the best returns per unit of foraging time. Both prey and patch models rank the alternatives according to their return rates, but whereas prey items occur in a "package" that must be pursued and processed as a whole, foragers can partially exploit a patch. So in the shift from prey choice to patch choice modeling, the forager's decision becomes "relative to my other options, should I enter a patch, and if so, how long should I stay?" rather than "should I search or handle?" Commonly, the return rate of a given patch will decrease with the time spent there, and exactly when a forager elects to travel from one patch depends on the marginal return rate between of this and other patches and the expected encounter rate with other patches in that habitat (Charnov and Orians, 1973; Charnov, 1976; Stephens and Krebs, 1986: 24–32).

Although the earliest publication on patch choice modeling (MacArthur and Pianka, 1966) required several assumptions, the rate of resource depletion was not addressed (Charnov and Orians, 1973: 69–70; Charnov, 1976; Stephens and Krebs, 1986: 28; see also Smith, 1991: 251). More recent efforts recast patch utilization in terms of the "marginal value theorem". The upshot is that the optimal utilization of a patch choice (or any foraging alternative) requires knowledge not only of the given patch, but also all other alternatives: If returns from another patch change, then the optimal utilization of the initial patch may change as well—even though conditions in the initial patch are unchanged. The marginal value theorem also models how patch depletion and environmental fluctuations (such as droughts) relate to patch choice decisions according to relative returns offered by the prey items in each patch types (see chap.

11). Accordingly, if the initial constraints hold, and the alternative patches can be ranked according to their relative efficiency, then the marginal value theorem predicts that foraging effort will correlate directly with efficiency rank order, meaning that foragers should spend more time working the higher ranked patches and less time in patches with lower energetic potential (Smith, 1991: 258–259).

Finally (in chap. 10), we employ the *central-place foraging* model to investigate the time/energy spent processing resources at temporary camps before transport to a residential base. In general, central-place foraging theory addresses the assumption that a forager maximizes the energetic return to the home/nest/central place (Orians and Pearson, 1979; Stephens and Krebs, 1986). Metcalfe and Barlow (1992) applied central-place foraging theory by modeling field-processing and transport behavior of human foragers. In general, central-place foraging theory has proven useful in addressing the decisions and behaviors of human foragers, especially the role of the residential base as a locus for provisioning offspring, mates, or potential mates. In chapter 9, we address the range of nonagricultural resources available to foragers on St. Catherines Island.<sup>2</sup>

#### THE DIET-BREADTH MODEL

We begin our consideration of the diet-breadth (prey choice) model by asking the following question (after MacArthur and Pianka, 1966; Stephens and Krebs, 1986; Winterhalder and Goland, 1997; Winterhalder and Kennett, 2006)<sup>3</sup>: From the array of available resources, which foods should an efficient forager harvest and which should be passed over? “Think of picking up change in tall grass” write Winterhalder and Kennett (2006: 14): “if there are enough silver dollars and quarters the income-minded gleaner will ignore the dimes, nickels and pennies, no matter how frequently they are encountered.”

The diet-breadth model, a classic formulation “at the heart of optimal foraging theory” (Smith, 1991: 197; see also Hawkes

and O’Connell, 1992: 63), employs a simplified version of the real world, in which available resources are ranked according to the number of calories gained per hour minus those required to collect and process them. Resources that should be added to this “set” are only those items that increase the net gain in food energy during the time spent foraging. Sometimes known as the “encounter-contingent” approach, the diet-breadth model makes a conceptual distinction between the “search costs” (a function of resource density) for an acceptable food item and the “pursuit and handling costs” for each resource type (Winterhalder and Goland, 1997: 128). “One of the assumptions of the diet-breadth contingency model,” writes Kennett (2005: 20) “is that individuals make decisions during a limited period of time in very specific, spatially limited, environmental and cultural contexts. The sum of these decisions across space and through time results in the long-term subsistence shifts that may be evident in the archaeological record.”

The problem for the researcher is to specify which and how many resources this hypothetical forager should pursue in order to achieve the highest net rate of intake. This is a difficult proposition because the diet-breadth model does not actually predict the proportions or amounts of the various potential food items. Instead, the model predicts that each prey item included in the optimal diet should be taken each and every time it is encountered (and, thus, the relative importance of a given food will, once it is added to the “optimal” diet, would determine its quantitative importance).<sup>4</sup>

Specifically, the diet-breadth model predicts that foragers will include those foods that yield the greatest net gain in food energy during time spent foraging. In this way, potential food items are ranked according to “post-encounter return rate”, defined as number of calories/hour required to collect and process them.

#### ESTIMATING POST-ENCOUNTER RETURN RATES

In the following two chapters, we develop a series of mutually comparable energy va-

lues for the range of food items available to aboriginal foragers on St. Catherines Island. But before turning to the specifics, let us pause here to consider the general way in which post-encounter return rates are computed.

The basic idea is to measure (or estimate) how long it takes to collect and process a given resource of interest, then calculate the net energetic return from these activities. As noted above, the diet-breadth model breaks the costs of resource acquisition into “search costs” (the time required to locate a resource) and “handling costs” (the time necessary to dispatch and process a resource for consumption). These costs, conventionally expressed as caloric return per unit time (e.g., kcal/hr) can be derived from directed ethnoarchaeological research, ethnohistoric accounts, or experiments aimed at reconstructing aboriginal technologies (e.g., Simms, 1987: chap. 5; Kelly, 1995: 78–97, table 3-3; Barlow and Heck, 2002; Gre-million, 2002, 2004).

Simms (1987: 41) has discussed some of the issues involved in estimating the range and variability of handling costs as derived in processing time experiments. In his own research on Great Basin resources, Simms notes that although the same resource could be collected under several field conditions, the “typical” value was employed to reflect “the condition most often encountered when observing and/or collecting each resource. Thus, the typical values may represent as few as one experiment in what is seen as the typical situation with other experiments identifying the range of variability.... [Although] it would be impressive to amass ten or twenty experiments per species, but for many ordinal level applications to archaeological contexts, this is apparently not essential. ... It is questionable that an increase in precision with this type of modeling process would add more accuracy” (Simms, 1987: 41–42).

In a number of instances, we have been able to obtain these energy estimates through directed ethnoarchaeological and experimental research in which we derive estimates of post-encounter return rates for several shellfish taxa (Blair and Thom-

as, chap. 7, this volume), for hickory nuts (Sanger and Thomas, chap. 8, this volume), and for live oak and laurel oak acorns (Se-mon and Thomas, chap. 8, this volume). But in other cases, we have been forced to rely on first-order estimates—guestimates really—for the suite of resources available to an aboriginal forager living on St. Catherines Island prior to Spanish contact. Such guestimates are based on the best available ethnohistoric and ethnographic sources from the coastal Southeast and from limited comparisons to relevant cases elsewhere. But regardless of whether we draw on our own experimental results or the directed research of others, all estimates of post-encounter return rates involve the following assumptions and empirical constants:

**AVERAGE LIVE WEIGHT:** Where possible, average live weights were compiled from biological studies specific to the Georgia coast; when such specific estimates were unavailable, they were extrapolated from the comparable data derived in other regions. Following White (1953), if the weight of the female is only 25–30 percent less than the weight of the male, the two biomass estimates were averaged. Weights of exceptionally large individuals were excluded. “Average live weight” estimates are expressed in kilograms.

**ADJUSTED LIVE WEIGHT:** Where appropriate, average live weight was reduced by 20 percent to account for the harvesting of female and immature individuals.

**USABLE PERCENTAGE OF LIVE WEIGHT:** What one considers “edible” or “usable” is a culturally defined construct, which might (or might not) include marrow, tongue, brains, visceral organs, antlers, bone, and/or skin (Reitz and Wing, 1999: 222). We generally follow estimates derived by White (1953), Stahl (1982), and Simms (1987: 64).

**MEAT WEIGHT/INDIVIDUAL:** In general, the term “meat weight” refers to the total weight of an organism minus skin, viscera, bone, and/or shell (following Reitz and Wing, 1999: 222). “Meat weight/individual” is expressed in kilograms.

**FOOD ENERGY:** All caloric estimates have been derived experimentally by the U.S. Department of Agriculture (as summarized

by <http://www.nutritiondata.com>). Where possible, these estimates were derived on cooked (roasted) samples. Summaries of nutrients (carbohydrates, fat, and protein) are provided in chapter 7. "Food energy" is expressed as kcal/100 g.

**PURSUIT TIME:** Following Simms (1987: 43–46), we assume that "pursuit time" (expressed in hours), begins when suitable prey is encountered. If the hunter(s) can make a successful kill, the resulting pursuit can be quite short (sometimes just a matter of minutes). If, however, the hunter(s) must stalk the animal, pursuit time might take an hour or more.<sup>5</sup>

**PROCESSING TIME:** We assume that "processing time" (generally expressed in hours/individual prey item) is the time required to prepare a resource for consumption. For animals, this can involve gutting, skinning (when appropriate), and butchering into "manageable portions" (Simms, 1987: 46). These butchered body parts do not necessarily correspond to modern meat cuts. For plant resources, processing time typically involves removing the husk and/or shell, extracting the edible portion, and sometimes additional processing asks (such as boiling to extract the oil or leaching to remove the tannic acid). Processing time assumes immediate consumption and does not include the costs of preserving the edible portion.

**ESTIMATED RETURN RATE:** To estimate the post-encounter return rates, we have divided the food energy/individual by the total handling time (which is the sum of pursuit time and processing time). "Estimated return rate" is expressed in kilocalories per hour (kcal/hr).

Before proceeding, a few caveats are required to evaluate experimentally derived estimates of net return rates. First of all, we must emphasize the care required to generate reliable return rate estimates. For each prey item, it has been necessary to critically evaluate the appropriate level of processing and handling foods before consumption. In some experimental studies, investigators completely process a resource for consumption, but in other studies on the same food

item, only minimal processing might occur. These disparate methods can potentially skew the estimated return rates (and the predictions of the model employed): Whereas overprocessed resources will appear to be lower ranked relative to other prey items, underprocessed foods (because of their lower handling cost estimates) will be ranked higher than they should be. For the return rate estimates for St. Catherines Island, we have attempted to standardize and spell out clearly the degree of processing involved.

We must likewise emphasize the variability in processing efficiency in modern experimentation (see Kelly, 1995: 88). It seems unlikely that modern experimenters can effectively replicate such subsistence activities with the skill and efficiency that approximates lifelong foragers (Gardner, 1997: 166–167; Barlow and Heck, 2002). Throughout this exercise, we often find conflicting estimates of the time required to collect and process key resources. In choosing between estimates, we will attempt to consistently err toward greater efficiency in processing, because we understand that the aboriginal foragers of St. Catherines Island were "experts", "professionals" in such matters, and their results would have most certainly exceeded the best efforts of modern experimenters.

Such experiments are typically conducted over such a brief periods of time, some as short as 5 min (e.g., Petruso and Wickens, 1984: 366), raising doubts about whether such yields are sustainable over longer intervals of collecting and processing. Experimentally derived return rates (e.g., Simms, 1987; Barlow and Metcalfe, 1996) are commonly based on a very limited number of observations, which can skew the project prey rankings (Madsen and Schmitt, 1998; F. Thomas, 2002: 203). These results also typically ignore (or seriously underestimate) patch-to-patch, season-to-season, and/or year-to-year fluctuations. Even well-documented "average" returns might have only limited relevance to highly knowledgeable (and presumably highly selective) lifelong foragers. Furthermore, there is no reason to suspect that the limited experiments con-

ducted to date fully exhausted the possibilities for exploiting a specific resource.

We must also consider the extensive transformations of North American habitats in recent centuries. These transformations make it difficult to assess how closely modern collecting sites reflect aboriginal conditions—even in a particular locale. Hales and Reitz (1992) have documented the degree to which body size in Atlantic croaker has declined since the mid-Holocene. In addition, we believe that trawling activities by the numerous shrimp boats operating along the Georgia coast have significantly altered fish size structure over the past few decades of mechanical fishing, with this nonselective predator impacting all species captured in the nets (Bruce Saul, personal communication). As a result, contemporary estimates undervalue the degree to which Native Americans managed their environments to favor productive conditions.

#### ASSUMPTIONS AND CONSTRAINTS

We began this chapter with a deceptively simple question: From the array of available resources, which foods should an efficient forager harvest and which should be overlooked? The diet-breadth model predicts that foragers will include those foods that yield the greatest net gain in food energy during time spent foraging; potential food items can be ranked according to post-encounter return rate, defined as number of calories/hour required to collect and process them. This is why we have gone to some effort to estimate the caloric return rates for key food resources on St. Catharines Island. In the last section, we derived a number of generalizations and implications to inform archaeological investigations; these are presented in the remainder of this volume.

With these first-order estimates and projections in hand, it now seems appropriate to revisit the assumptions and constraints that undergird the diet-breadth model (after Winterhalder, 1987; see also Bird, 1997: 292–293; Bird et al., 2004: 188; Winterhalder and Kennett, 2006):

#### CURRENCY

1. Some optimal foraging models assume that the hypothetical organism attempts to maximize its net rate of energy intake while foraging; other approaches use different currencies.

#### CONSTRAINTS

2. Prey is encountered randomly and sequentially (that is, the next kind of prey encountered is independent of the last encountered).
3. For a particular diet breadth, the hypothetical organism either takes a prey item or it does not (there are no “partial” preferences).
4. The “quality” of a prey type can be evaluated independently of the others in terms of its energetic ranking (defined as net energy value per unit of pursuit and handling time).
5. “Foraging” consists of two independent phases. Predators first “search” all prey jointly, then “pursue” the target prey singly.
6. The density of prey remains constant throughout the foraging interval.
7. Costs and benefits associated with resources are treated as firm expectations (without considering statistical variability).

In practice, these constraints and assumptions are commonly approached as hypotheses to be tested.

So viewed, foraging models routinely address hypotheses regarding (1) the foraging goals, (2) the alternative ways of achieving these goals, (3) the costs and benefits associated with these alternative strategies, (4) the currencies in which these costs and benefits are measured, and (5) the time frame in which these goals are met. That is, *if* a forager is behaving “optimally” with respect to the specified goals and *if* the currencies are appropriate, *then* certain predictions about behavior will follow. If these predictions are not met, however, then one or more of the various hypotheses may be judged to be incorrect. Optimal foraging models, as such, are never actually tested. The same holds true for the issue of optimality, which is assumed.

Several investigators have commented that foraging models are often sufficiently

robust to withstand modest violations of the underlying assumptions and still generate successful predictions (e.g., Smith, 1991: 205–208; Kelly, 1995: 90; Sih and Christianen, 2001; Gremillion, 2002: 146). While this may be true, we feel it is necessary to explore violations of one key assumption with regard to our research on St. Catherine's Island.

We are particularly concerned about the second constraint listed above, the “fine-grained assumption” which requires that “prey is encountered randomly and sequentially”. This assumption actually consists of two parts: (1) resources are distributed homogeneously and (2) foragers search randomly (MacArthur and Pianka, 1966; Stephens and Krebs, 1986: 9–11, box 2.2); the next kind of prey encountered is independent of the last encountered. This constraint assumption holds that because prey are encountered at random, finding one appropriate individual does not change the probability of encountering other items of that type (Smith, 1991: 206–207; Broughton, 1997: 847; Bird et al., 2004: 188). The appropriate statistical model is a Poisson distribution that remains constant and does not change systematically with regard to the probability of encountering more items of that prey type. The assumption of a “fine-grained encounter foraging pattern” is important because it requires that a forager encounters food items in proportion to their density (and without this condition, search costs would not predictably increase as prey density declines).

Many potential prey items on St. Catherine's Island are distributed in Poisson fashion, including white-tailed deer, loggerheads (taken at sea), alligators, raccoons, whelks, and most fishes. The fine-grained assumption is violated, however, when prey resources live a clumped, patchy, non-Poisson distribution; on St. Catherine's Island, such “patchy” food items include schools of shads and herrings, oysters, clams, mussels, and acorns. Without doubt, finding a single shad, clam, or acorn markedly raises the probability of encountering many others. In cases of patchy resources—meaning that search times for different prey sets are mu-

tually exclusive—investigators may wish to apply alternative foraging models (Stephens and Krebs, 1986; see also Bird, 1997: 293). Some investigators have rejected the diet-breadth model altogether because applications too often violate the fine-grained assumption (see Smith, 1991: 206).

Mass collecting technology likewise violates this assumption by changing the foraging efficiency of taking certain taxa (Madsen and Schmitt, 1998; Grayson and Cannon, 1999; Ugan, 2005). On St. Catherine's Island, harvesting oyster reefs or setting fish weirs could be viewed as violating the second constraint listed above, because (1) an array of items is taken simultaneously rather than sequentially, and (2) prey items that might not normally be passed over are harvested en masse (thereby restructuring the attack thresholds set out in the sequential foraging of individual items).

In the case of St. Catherine's Island, the energy return from spearing a single hardhead catfish is quite different than capturing that same catfish in a trap. Return rates likewise differ for catching a spotted sea trout on a trotline as opposed to fishing for this same individual with a handline. In other words, mass collected invertebrates (such as grasshoppers or oysters) and according to Lindstrom's (1996) estimate, fish (either taken while spawning or in weirs) can provide returns many times greater than individually acquired big game (see also Ugan, 2005: 79). Even the smallest organisms can return extremely high rates if they can be taken through mass harvesting or if they can be eaten without modification (thereby drastically reducing the handling costs), collected, and processed in the aggregate (Ugan, 2005: 82). Moreover, because plant resources are sessile, there can be (in a literal sense), no “pursuit” of an acorn. Ugan (2005) suggests that, ideally, such mass collection strategies will produce characteristic archaeological signatures. This is unlikely for bulk-harvested technologies on St. Catherine's, which include fish traps, trotlines, and animal drives.

Smith (1991: 228) has discussed this same problem, noting that several of the prey hunted by the Inujjamiut actually live in

“clumped” or nonrandom distributions; eider ducks and geese, for instance, typically live in small flocks, and ptarmigan seek cover together in the fall. Madsen and Schmitt (1998: 446) suggest that such violations to the “fine-grained assumption” required in diet-breadth modeling “can be overcome” by ignoring the individual prey item in favor of the overall aggregate (such as a “swarm” of insects or a “school” of fish). In effect, this recognizes that a single food or resource type can be many “prey types”, depending on the abundance encountered or the technology employed. We have followed this practice in this chapter, in which the same resource may be seen as multiple prey items, depending on the harvesting technology employed.

These caveats notwithstanding, we believe that post-encounter return rates provide a useful starting point for understanding the nature of various subsistence activities on St. Catherines Island. The remainder of this chapter evaluates the most attractive and high-return resource targets, discussing each in terms of its predictability, aggregation, body size, and caloric value; the tables in chapters 7 and 8 provide comparative nutritional and caloric returns for the major resources discussed here. Although only a few of the requisite time/motion experiments have been conducted in these habitats, we believe that useful information can be extracted from our own limited experiments, from the available ethno-historical sources, and from contemporary natural resource management data. But we reiterate that the following discussion is, at best, a first-order heuristic.

#### GENDER AND FORAGING: “THE TWO SEXES WERE ALMOST LIKE DIFFERENT SPECIES”<sup>6</sup>

Before deriving the post-encounter return rates for St. Catherines Island resources, two major issues remain to be adequately addressed. One concern is the role of gender as it relates to the overarching goals of foraging behavior.

To this point, we have discussed foraging behaviors in a general sense, without specif-

ic reference to the differential gender roles—effectively assuming that optimizing male and female foragers provisioned for the common good. But anthropologists conventionally consider the sexual division of labor to be basic in the organization of hunter-gatherers, and recent ethnoarchaeological research demonstrates that the two sexes do not necessarily share a common diet breadth or patch choice (e.g., Hill et al., 1987; Hawkes, 1996; Zeanah, 1996: chap. 6, 2003, 2004: 2; Bliege Bird, 1999, Barlow, 2002: 82; Hawkes and Bliege Bird, 2002). This would imply that gender-specific foraging activities can reflect differing, even conflicting, goals for men and women.

The underlying thinking goes like this: In the perspective of human behavioral ecology, selective pressures are perceived as operating on the individual rather than the groups (Zeanah, 2003). Because females have relatively fewer reproductive opportunities than males, women are most likely to benefit most, in a fitness sense, from the economics of caring for their own offspring. Child rearing tends to constrain female mobility, making it difficult for them to pursue larger game and placing limits on their learning to hunt such game effectively (e.g., Hurtado et al., 1985). This is why women tend to pursue foraging strategies that emphasize parental investment (Zeanah, 2003: 3), commonly dealing with smaller resource “packages”—gathering plants, collecting shellfish, and taking smaller animals closer to home (Bliege Bird, 1999)—prey items that can generally be collected by any individual and are commonly distributed to children and other family members (Hawkes, 1990).

Males, on the other hand, have many more mating opportunities throughout their lifetime, each bearing lower costs and fewer risks. According to this argument, then, male fitness is enhanced not by providing for a single mate and her offspring, but rather by sharing relatively large meat packages in the hope of fostering increased mating opportunities with multiple mates. In considering gender differences in various foraging behaviors Hawkes (1990, 1991, 1993) writes of high-risk, “boom or bust”

hunting forays, in which the best hunters have the potential for “bringing in jack-pots”, in the process “behaving as show-offs” (Hawkes, 1990: 33). Such a boom or bust fixation on big game hunting may not be particularly adaptive for the hunter’s individual family, but such high-risk, high-prestige hunting could confer fitness-related benefits to the larger community.

In general, then, men’s prey tends to be mobile and rare, commonly involving considerable search costs, but women’s resources tend to be stationary and more abundant (relatively cheap to find, but expensive to handle). From a fitness perspective, one would suspect that, in general, women could earn overall higher foraging returns than men in all seasons, even though males were pursuing higher ranked prey (as well illustrated in the ethnographic literature; see Kelly, 1995). There is also a suggestion that the key difference between male and female foraging may reflect variability in anticipated returns. Because females must nourish their children on a *daily* basis, the high-risk uncertainty involved in hunting larger game may suggest that they should pursue smaller, more predictable prey.

We return to this topic at the end of this volume. But in order to apply the diet-breadth model, we must first apply these general arguments about gender and foraging behavior to the specifics of the Georgia coast. Writing about Southeastern Indians in general, Charles Hudson (1976: 259, 269–270) has described a pervasive duality that once punctuated everyday life of aboriginal people. The Cherokee, for instance, divided the year “rather sharply” into cold and warm seasons: The cold season (“the time of the eagle”) ran from the new moon in October through the new moon in April; the warm season (“the time of the snake”) extended from April through October. Men’s roles were most evident during “the time of the eagle”, when they were preoccupied with hunted deer and holding council in the town house. Women contributed heavily during the “time of the snake”, when they tending the fields while when men made war and played the ballgame.

These were seasonal extremes, to be sure, because subsistence was a year-round pursuit for both sexes. Among the Creek, women “dried and cooked food, did most of the work of preparing skins and making clothing, pounded corn, gathered nuts and acorns and extracted oil from them, shared with the men the cultivation of the town fields and did all of the work on the individual house lots, cut and brought in firewood, sometimes from long distances, though they were often helped in this by the old men. ... Besides contributing to the care of the town fields, men hunted, fished, warred ... cut up and brought meat back when game had been killed at a distance from home” (Swanton, 1946: 715; see also 1928: 358–367; Hudson, 1976: 264).

Although ethnohistoric sources are generally silent about the sexual division of labor involved in shellfishing, a global sample of shellfishers indicates that “women and children are principal shellfish gatherers in subsistence economies, although men make proportionally greater contributions for the time they invest, concentrating on activities requiring greater physical strength. ... Generally, when men gathered shellfish by hand, they collected and carried back to camp significantly larger amounts than did women, although in no society did men participate in these activities as often as women (except when commercial gathering overshadowed subsistence shellfishing” (Waselkov, 1987: 97, 99).

With respect to maize horticulture, Swanton (1946: 713) makes it clear that whereas Timucuan women planted the fields, men were responsible for preparing the ground. We believe that the physical planting maize and harvesting the mature ears in coastal Georgia by aboriginal horticulturalists was very similar to the way in which wild plant foods were collected, stored, processed, and distributed. Given these conditions, Barlow (2002: 82) has hypothesized that during the earliest experiments with horticulture, “women foragers, not men ... gained the greatest economic advantage for adding maize and other cultigens to Archaic food collection strategies (Barlow, 2002: 82).

We are brought back to Hudson's (1976: 260) conclusion, namely, that the division of labor among Southeastern Indians was so sharp and the roles of men and women so different "that the two sexes were almost like different species."

#### DEFINING "HUNT TYPES" ON ST. CATHERINES ISLAND

The second lingering issue concerns the "fine-grained assumption" required by the diet-breadth model. Smith (1991: 227) suggests that this undergirding assumption in the prey choice modeling is "unlikely to be met in detail in any natural foraging system (including that of hunter-gatherers). Nevertheless, if applied with discrimination (i.e., within patches or other contexts with fine-grained encounter, with prey types suitable defined, with attention to current conditions and constraints, etc.) the fine-grained model has initial plausibility as an approximation of the principles that lie behind hunter-gatherer prey choice" (Smith, 1991: 227). We touched on this issue above, but it remains to amplify that discussion with respect to the habitats of St. Catherines Island and the associated post-encounter return rates for comparison in prey choice modeling.

In its most elemental application, the diet-breadth model simply pools all potential prey items—by assuming that all resources are distributed homogeneously in space—then compares the respective post-encounter return rates. In their pioneering applications of diet-breadth models to the Aché of eastern Paraguay, for instance, the investigators combined all prey taxa taken over the entire period of harvesting, without partitioning by either patch or season (Hawkes et al., 1982; Hill and Hawkes, 1983; Hill et al., 1987). In this way, the post-encounter return rates of all 16 prey species—including hunted species (such as peccaries, armadillo, and deer) and plant resources (including oranges, honey, and palm fruits)—could be grouped together under the assumption of simultaneous search into a single rank-ordering of cost/benefit relations. This procedure was justified with the demonstration that prey was indeed (1) encountered at ran-

dom throughout the year, (2) with little seasonal variation in resource abundance or return rates (Hill et al., 1984).<sup>7</sup> As such, the diet-breadth model could be applied in a straightforward fashion.

But when analyzing foraging behavior among the Inujjuamiut foragers on the east coast of Hudson Bay, Eric Smith (1991: 156–169, 209) found serious violations to the assumption of simultaneous search. Still wishing to apply the prey choice model, Smith devised a series of "hunt types" that enabled him to subdivide and analyze diet breadth among the Inujjuamiut. Because we believe that Smith's approach can facilitate our own analysis of the St. Catherines Island resource base, we will explore the notion of "hunt types" in more detail.

Smith (1991: 156) operationally defines a "hunt type" as

a constellation of factors that indicate specialization in the foraging process and that lead to an expected foraging outcome that differs predictably from other types of foraging. A specific hunt type may be associated with a particular prey species, a particular patch type (microhabitat) or set of patch types, specialized methods of search or capture, specialized transport or foraging technology, particular seasons or environmental conditions, or any combination thereof.

Among the Inujjuamiut, marine hunt types include canoe forays (analyzed separately for spring, summer, and fall), beluga whale hunting (in July), ocean netting of arctic char (July–August), and shellfish collecting (April–September). Terrestrial hunt types include winter caribou hunting (December–March), spring goose hunting (May), and lake ice jigging (February–May).

Similarly, Bird and Bliege Bird (1991) have defined several "hunt types" (in the sense of Smith, 1991) to characterize foraging behavior among the Meriam people of the Torres Strait. Within the bounded habitat of the reef flat, reef flat collecting, rocky shore harvesting, and spearfishing comprise three simultaneously available options within the ecological habitat "reef flat at low tide" (Bird and Bliege Bird, 1997, 2000). Although other hunt types are simul-

taneously available, these three types account for 90% of adult foraging time spent on the reef (Bliege Bird et al., 2002: 10).

Among the Inujjamiut and the Meriam, these hunt types insure that the assumption of fine-grained foraging can be satisfied within each set of prey taxa. Specifically, this means that *within each hunt type* (1) all prey items are located in random sequence, and (2) encountering one member of the prey taxon does not increase the probability of encountering another item of that type. Because prey items within each hunt type are searched for simultaneously, pure randomization is not required; it is only necessary that the forager be unable to predict which prey type (within the prey set) will be encountered next (Smith, 1991: 228). These assumptions are critical to justify the assignment of search costs to a set of resources *in toto*, rather than to individual items or types. In other words, by grouping and assessing the various foraging decisions in hierarchical fashion, Smith (1991: 207) could apply the prey choice model *within each patch and/or hunt type* because each is defined to insure a fine-grained encounter pattern.<sup>8</sup> So defined, some patches and hunt types turned out to be *monotypic*—meaning that only a single prey taxon falls within the forager's diet breadth (Smith, 1991: 207). In effect, Smith tested the prey choice model seven different times, once for each hunt type with sufficient data.

In a superficial sense, then, we find that aboriginal foraging patterns on St. Catherines Island much more closely resemble those of the Inujjamiut and the Meriam than the Aché. For one thing, the changing month-to-month availability of key prey taxa on St. Catherines Island—especially mast, small seeds, and sea turtles—imposed a distinctly seasonal pattern on the subsistence foraging practices. For another, the St. Catherines Islanders—like the Inujjamiut and the Meriam—exploited both terrestrial and marine ecosystems simultaneously (often on the same day). Simply put, no forager on St. Catherines Island can expect to encounter a patch of ripe acorns while tending a fish weir in the tidal

marsh. Nor does a forager collecting loggerhead eggs expect to encounter a cluster of hard clams. The combination of distinct seasonality and the overlap between marine and terrestrial ecosystems means that the assumptions of homogeneous resource distribution and random encounter cannot possibly be applied to entire resource set available on St. Catherines Island.

This is why we will model aboriginal foraging on St. Catherines Island in terms of seven hunt types (or, perhaps more accurately, “foraging types”) which incorporate key variability in patch type, season, technology, and group composition. The idea here is to emulate the decision making from the perspective of the individual forager who must determine which hunt type to pursue on a given day. By isolating a set of seven distinct foraging options, we can marry an element of individual forager choice with empirically measurable differences in foraging outcomes:

#### Marine foraging

- Collecting shellfish
- Saltwater fishing

#### Terrestrial foraging

- Hunting
- Sea turtle harvesting (summer)
- Small turtle harvesting
- Harvesting mast (fall)
- Harvesting wild plants (late summer through early fall)
- Cultivating maize (post-A.D. 1000)

As Smith (1991: 157) has noted, “there is an inherently subjective aspect to any hunt type classification, and as in taxonomy one can choose to be a ‘lumper’ or a ‘splitter.’” Given the massive uncertainties involved here, my own categorization of hunt types on St. Catherines Island decidedly belongs to “lumper” school of thought; we could, surely, utilize more fine-grained divisions to capture the additional variability in habitat and seasonality.

#### NOTES

1. In addition to optimal foraging theory, the field of behavioral ecology offers an even larger set of models that transcend foraging behavior to address issues such as mate choice, time spent with offspring, sex ratios, de-

gree of altruism, optimal group size, territorialism, conflict, and storage strategies—basically the range of behaviors thought to ultimately affect reproductive success or the number/quality of offspring ultimately produced.

2. In chapter 9, we examine the potential impact of maize agriculture on the resource structure of St. Catherines Island.

3. Diet-breadth models are also sometimes termed “optimal prey choice” models (e.g., Smith, 1991: 204).

4. As we discuss below, the diet-breadth model assumes that food items are randomly distributed throughout the target habitat; if these foods occur “in patches”—as some resources certainly do on St. Catherines Island—then potentially serious problems arise in applying the diet-breath model.

5. As Simms (1987: 46) points out, these arbitrary estimates are quite error prone, but since the objective is “primarily a function of how long it takes to process the animal *relative* to its body size ... even doubling the pursuit time for deer to two hours instead of a maximum of one, only lowers the return rate of deer [by 30%].”

6. Hudson (1976: 260).

7. We must note that in an overview article addressing Aché foraging practices, Hill et al. (1987: 1) noted that “men’s and women’s abilities and foraging patterns differ enough that they should be treated separately in all OFT analyses.”

8. Barlow (personal commun.) terms these “nested foraging decisions”.

## CHAPTER 7. MARINE FORAGING ON ST. CATHERINES ISLAND

DAVID HURST THOMAS, WITH A CONTRIBUTION BY ELLIOT BLAIR

Tens of thousands of shell middens surviving today on St. Catherines Island leave little doubt about the importance of American oysters to aboriginal foragers. To provide a historical perspective on this critical resource, we begin this chapter with a historical overview of the commercial oyster industry in coastal Georgia; as we will see in this, understanding the rise and fall of commercial oystering provides a significant insight into oyster collection (and management) strategies of the more remote past. After examining the (relatively sparse) ethnohistoric evidence on oyster procurement, we derive a range of estimates for post-encounter return rates for American oysters along the eastern seaboard. Against this background, we present the results of our experimental research on shellfish return rates. In 2005 and 2006, we conducted multiple procurement and processing experiments on the modern shellfish populations of St. Catherines Island, focusing on the six most abundant shellfish taxa recovered from aboriginal middens on the island—American oysters, hard shell clams, ribbed mussels, knobbed whelks, blue crabs, and marsh periwinkles.

We then turn to saltwater fishing as an important hunt type for aboriginal foragers on the barrier islands. Although we can draw on recent month-by-month monitoring of the saltwater fishery of St. Catherines Island (courtesy of Dr. Bruce Saul, Department of Biology, Augusta State University), numerous analytical problems attend the post-encounter return rate estimates for saltwater fishes, especially the changes in fish size through time (Hales and Reitz, 1992), the allometric issues of estimating mean adult fish size, and the hazards involved in projecting the use of intensification technologies (including fish traps and weirs) on the basis of zooarchaeological evidence.

Table 7.1 presents the currently available energetic and nutritional analyses for the ma-

ior marine resources of coastal Georgia. These results arise from laboratory analyses on specimens recovered during our recent optimal experiments on St. Catherines Island; in other cases, we are forced to rely on more generic U.S. Department of Agriculture estimates and other references in the literature.

### SHELLFISH COLLECTING

The tidal marsh surrounding St. Catherines Island provides home and feeding ground for myriad lifeforms, which are sheltered from wind and waves by the barrier island. This low, uninhabitable marshland is carved by a vast network of interconnected rivers, creeks, and lagoons. The tides sweep in twice daily to stir up nutrients and to bring ocean fish and microscopic marine lifeforms to feed. The low tide carries out nutrients in the form of dissolved organic matter and decayed marshgrass, in addition to living plants and animals that become part of the offshore food chain. The exposed marsh mud is home to shellfish and insects, which provide food for birds, raccoons, and other animals.

The term “shellfish” denotes a variety of aquatic invertebrates, dominated by mollusks (bivalves and gastropods), but also including crabs, sea urchins, barnacles, and shrimp. These species are universally small, but often plentiful and accessible. For more than a century, scientists have debated the role shellfish have played in past human diets (e.g., Morgan, 1877; Uhle, 1907; Sauer, 1962; Meehan, 1977b; Osborn, 1977; Yesner, 1980; Waselkov, 1987; Erlandson, 1988, 2001; Raab, 1992; Fitzhugh, 2003). Below, we will review what is known about the oyster industry along the Georgia Coast, then discuss the optimal foraging experiments conducted to generate estimates of post-encounter return rates for the various shellfish taxa available to aboriginal foragers on St. Catherines Island.

TABLE 7.1  
**Macronutrients and Caloric Returns for the Major Marine Resources Available on St. Catherines Island, Georgia (Unless indicated otherwise, all estimates are based on raw samples)**

Species	Energy, kcal/100 g	Carb. %	Fat %	Protein %	Source
SHELLFISH					
<i>Crassostrea virginica</i> (American oyster)					
USDA estimate	68	3.9	2.5	7.1	USDA website
USDA estimate (cooked, dry heat)	72	4.8	1.9	8.3	USDA website
St. Catherines Island	36–64	0.4–4.9	0.4–1.2	5.4–10.8	QC Laboratories, this vol. (see also table 7.4)
St. Catherines Island (grilled/broiled)	49–81	0–4.6	0.6–1.5	6.9–12.9	QC Laboratories, this vol. (see also table 7.4)
<i>Mercenaria mercenaria</i> (hard clam)					
USDA estimate	74	2.6	1.0	12.8	USDA website
USDA estimate (cooked, moist heat)	148	5.1	2.0	25.6	USDA website
St. Catherines Island (cooked)	102	4.1	1.2	18.7	QC Laboratories, this vol.
<i>Geukensia dimissa</i> (Atlantic ribbed mussel)					
USDA estimate (blue mussels)	86	3.7	2.2	12.0	USDA website
USDA estimate (blue mussels, cooked, moist heat)	172	7.4	4.5	23.8	USDA website
St. Catherines Island (grilled/broiled)	65	2.4	0.6	12.6	QC Laboratories, this vol.
<i>Littorina irrorata</i> (marsh periwinkle)					
USDA estimate	74	—	1.4	15.3–18.0	Waselkov (1987: table 3.4)
St. Catherines Island (cooked)	69–105	2–7	1–2	13–15	QC Laboratories, this vol.
<i>Busycon carica</i> (knobbed whelk)					
USDA estimate	137	7.8	0.4	23.8	USDA website
St. Catherines Island	87	2.5	0.3	18.7	QC Laboratories, this vol.
<i>Callinectes sapidus</i> (blue crab)					
USDA estimate	87	—	1.1	18.1	USDA website
USDA estimate (cooked, moist heat)	102	—	1.8	20.2	USDA website
St. Catherines Island (cooked)	66	—	0.5	15.4	QC Laboratories, this vol.
Shrimp	106	0.9	1.7	20.3	USDA website
SALTWATER FISH (all USDA estimates)					
Sheepshead	108	—	2.4	20.2	—
Atlantic croaker	104	—	3.2	17.8	—
Flounder	91	—	1.2	18.8	—
Spot	123	—	4.9	18.5	—
Drum	119	—	4.9	17.5	—
Sea trout	104	—	3.6	16.7	—
Catfish	95	—	2.8	16.4	—
Shark	130	—	4.5	21.0	—
Mullet	117	—	3.79	19.35	—

#### AMERICAN OYSTERS ON THE GEORGIA COAST

Fr. Andrés nearly starved after his ship wrecked on the south Georgia coast in 1595. Following several failed foraging efforts along the beach line, he finally discovered several large oysters (*ostiones*) lodged

in the roots of upturned pine trees, and, for the rest of his life, Fr. Andrés believed that these oysters saved him (de San Miguel, 2001: 55).

The American (or eastern) oyster, *Crassostrea virginica*, is found in abundance from the Gulf of St. Lawrence (in Canada) to the

Gulf of Mexico and into the West Indies (Galtsoff, 1964). In archaeological shell middens preserved along the Georgia coast, oysters are always the principal component, reflecting their intensive exploitation over the past 4500 years (Wallace, 1975; Larson, 1980a; Crook, 1992; Keene, 2002).

In coastal Georgia, oysters thrive within the intertidal estuaries, along saltwater rivers and tidal creeks that dissect the expansive *Spartina* marsh. The species tolerates a relatively broad range of habitat conditions, but favors microhabitats with little movement of bottom sediments and with semihard mud. Within a given locality, oyster growth depends on bottom conditions, degree of salinity, water temperature, and tidal movement. Oysters are never found along the strand section. Oysters growing on hard bottom tend to develop round shells. Those living on soft, muddy bottoms, and so-called raccoon (also “coon” or “snapper”) oysters that grow in clusters and reefs along the banks of subtidal creeks and rivers tend to have long, slender, thin shells (Oemler, 1889: 3; Galtsoff, 1964: 18; Lorio and Malone, 1994).

**A BRIEF HISTORY OF GEORGIA’S OYSTER INDUSTRY:** A century ago, coastal Georgia was among the world’s leading oyster harvesters, rivaling the celebrated, oyster-rich waters of the Chesapeake. The magnitude of Georgia’s oyster industry in the early 20th century can be gleaned from a publication by the Brunswick (Georgia) Board of Trade (Irving, 1902):

There are over 50,000 acres of oyster beds in the country, and about one half of which are partly cultivated and protected. The Glynn County, or better known as the Brunswick oysters, are of superior quality, and command a premium in the markets. Thousands of bushels are shipped to the interior markets each season; and the two canneries pack and shop 30,000 cases of oysters annually. This industry affords excellent opportunities for further development.

By the 1880s, overharvesting and pollution threatened Georgia’s shellfishery. The State legislature commissioned J.C. Drake (Ensign U.S. Navy and Assistant in the U.S.

Coast and Geodetic Survey) to document the geographic locations, the spatial extent, and present condition of Georgia’s oyster resources.

Between October 1888 and February 1889, Drake worked his schooner *Ready* southward from the Savannah River to the Florida state line, recording the specific gravity of the waters and commenting on the tidal currents he encountered (fig. 7.1).<sup>1</sup> For the most part, the mean rise and fall is about 2 m “and the deviation from this is unimportant.” These currents ranged between 1 and 2 knots per hour and “present the most favorable features for the successful and rapid growth of oysters that can be claimed for the waters examined” (Drake, 1891: 182). In addition, Drake carefully noted predation on the oyster beds, singling out drum and star fish as particularly active predators. “On the southern shore of St. Catherine’s Island ... there are washed up a large quantity of dead oyster shells, and almost half of the shells have a small hole drilled near the ‘eye’ of the shell, which would rather indicate that the oyster had been killed by drills” (Drake, 1891: 201).

Drake commented that excessive collecting led to “a general depletion” of natural oyster beds along the Georgia coast:

The nearer the market the more were the beds depleted. In fact, the area which I have indicated on the charts as natural oyster beds really include all the area where oysters have grown, and practically nothing but shells now remain; it also allows for a reasonable expansion of the beds. As a rule it includes all the raccoon oysters attached to the edge of the marshes, and in a few instances may include small areas which have been planted. (Drake, 1891: 201)

The oyster stands were so devastated that Drake suggested the remaining beds be sold immediately to the highest bidder and destroyed as rapidly as possible: “The establishment of factories for the canning of oysters [will, in the end] ... be of great benefit to the State, because the sooner the natural beds are depleted the sooner will the citizens engage in private cultivation, and enact

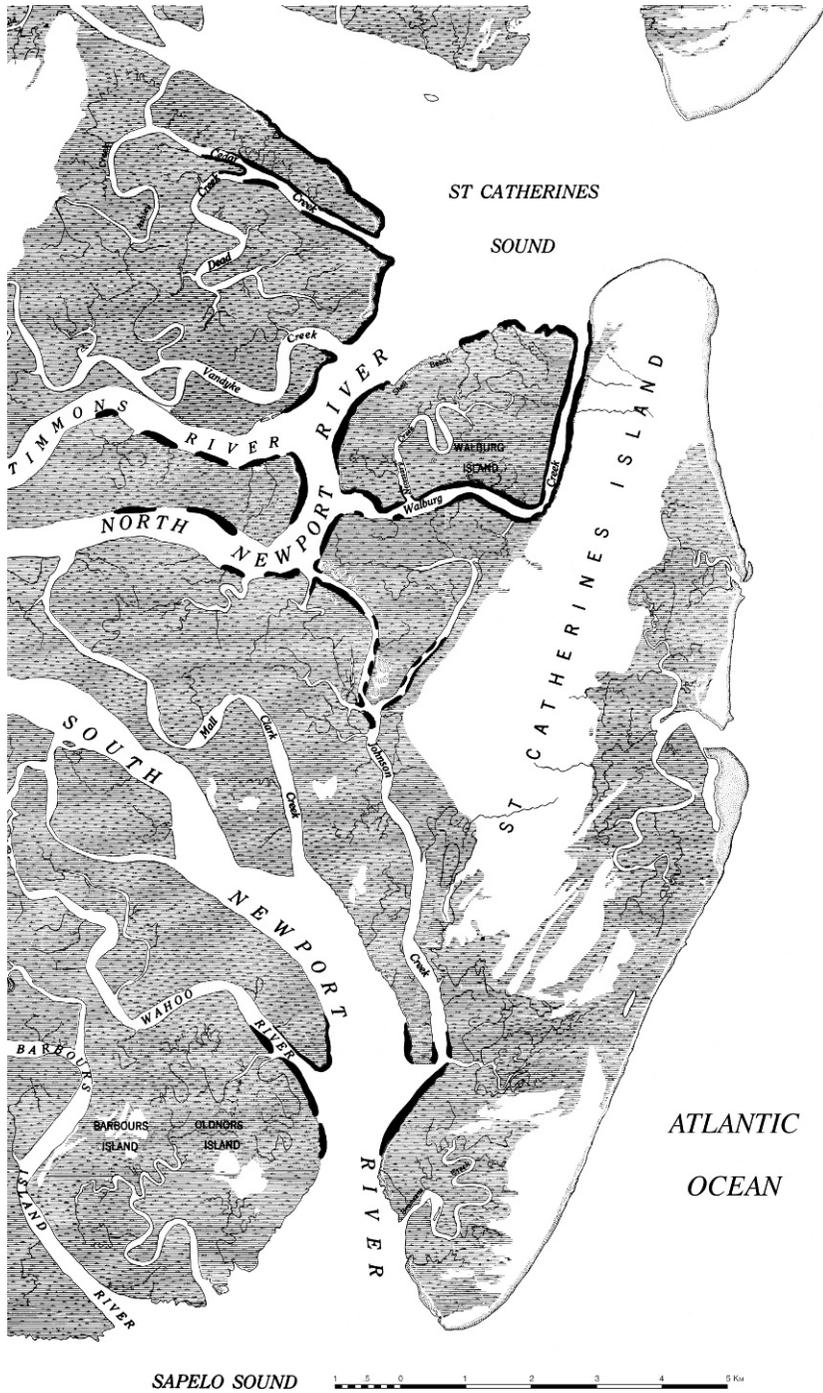


Fig. 7.1. Distribution of oyster beds in the vicinity of St. Catherines Island, as recorded by Drake (1891).

laws that will give inducement to capital". (Drake 1891: 201)

Specifically with respect to the waters surrounding St. Catherines Island, Drake (1891: 190–192) made the following observations (see also fig. 7.1).

*St. Catherine's Sound* "is about  $1 \frac{3}{8}$  miles in width, and extends inland into the marshes about 2 miles. This sound is totally unfit for the cultivation of oysters by reason of the water being too salt, by reason of its exposure to the heavy seas, especially the north-east gales, and also by the large amount of its area being very shoal."

*Medway River* "is the principal tributary to St. Catherine's Sound, of which it appears as the prolongation. That part of it examined extends about 7 miles inland. ... The character of the bottom is sand and soft mud, and sand being, as a rule, shifting and making shoals. It is therefore unsuitable for oyster cultivation, unless possibly in the vicinity of Sunbury. Along the shores are a series of natural oyster beds of the raccoon type, the total area of which is 49 acres. There are a few beds which do not ebb out and they show the oysters to be of a very superior quality, although the size of the oysters indicated that the beds are very much depleted by excessive fishing."

*Cedar Creek* "is a small stream coming out of St. Catherine's Sound on the southwest side. It extends in a westerly direction about  $2 \frac{1}{2}$  miles, has a depth of water running from 5 to 20 feet, and an average width of 200 yards. Along the shores are a series of scattered oyster beds, found on both side, being almost a continuous streak. They are small and crowded together, and generally of the raccoon type. The bottom is hard and sticky along the shores and for a considerable distance along the channel, beyond which it is very soft. ... The total area is 256 acres; beds of natural oysters, 23 acres."

*North Newport River* "enters St. Catherine's Sound to the southward and westward. ... It has an uneven bottom like Medway River, and the greater portion consists of sand and is subject to shifting during heavy seas. There are a few natural oysters along the shores, which is the most favorable bottom for the cultivation of oysters."

*Timmon's River* "is a tributary of North Newport River, into which it flows on the north

side 2 miles from its mouth. ... The depth of the water ranges from 9 to 30 feet, there being frequent shoals extending out from the shores. The bottom is not liable to shift, however, and in the sticky portions will be found suitable ground for oyster cultivation. This, however, is a small area. Scattered along the shores are a series of small oyster beds and numerous dead shells. The total area of the river is 512 acres; that of natural oyster beds, 20 acres."

*Walburg Creek* "enters St. Catherine's Sound close to the north point of St. Catherine's Island. ... The bottom is soft mud, becoming a little sticky near the shores, along which is a streak of natural oyster beds of an inferior quality and small size. In the marshes there are some raccoon oysters."

*Johnson's Creek* "is a narrow stream about 5 miles in length, and connects North Newport and South New Port Rivers. It is the inside passage to Sapelo Sound, and separates St. Catherine's Island on the east from the marshes of the main land on the west. It has an average width of about 100 yards, and the depth ranges between 10 and 20 feet. There are several small beds of oysters scattered along the edges, and these partly ebb out. They are small and of an inferior quality. The character of the bottom varies from hard sand to soft mud, the latter prevailing. ... The total area of the creek is 310 acres. The area of natural oyster beds, 27 acres."

*South Newport River* "enters Sapelo Sound on its northern side. It runs through marsh on both banks in a northwesterly direction for about 7 miles, where it joins with North Newport River. It has a width of  $1 \frac{3}{4}$  miles at its mouth, but narrows rapidly, and 2 miles above averages one-half mile. The depth of water ranges from 6 to 20 feet for about two-thirds of the area; the remaining portion being a series of shoals and shifting bottom, partly ebbing out at low water. The deeper portion of the river has a muddy bottom ranging from soft to hard and sticky. The shoals consist for the most part of sand. ... The total area is 2,300 acres; that beyond 1,000 feet from the shore, 622 acres. Area of natural oyster beds, 32 acres."

*Wahoo River* "enters South Newport River at its mouth on the south side. It extends in a northwesterly direction for about 3 miles, averaging about 300 yards in width, and having a depth ranging from 6 to 20 feet.

TABLE 7.2  
**The Distribution of Oysters in the Waters  
 Surrounding St. Catherines Island  
 (Harris, 1980: table 2)<sup>a</sup>**

Body of water	1890 m <sup>2</sup>	1974–1977 m <sup>2</sup>
Wahoo River	80,878	9301
Brunsen Creek	—	1046
Johnson Creek	149,624	81
Harris Neck Creek	—	81
South Newport River	12,904	3441
North Newport River	173,888	8310
Timmons River	80,878	816
Mollclark River	24,263	72
Walburg Creek	194,107	861
Necessary Creek	—	72
McQueen Inlet	—	1100
Medway River	198,151	6644
Total	914,693	31,825

<sup>a</sup> Documented intertidal and subtidal oyster patches located near St. Catherines Island during a 1974–1977 survey; numbers in parentheses are those documented during Drake's 1890 survey.

The bottom is hard and sticky along both shores, with an occasional sounding of soft mud. The channel it is, for the most part, soft and unsuitable. . . . The total area of the river is 256 acres. Area of natural oyster beds is 20 acres.”

*Sapelo Sound* “separates St. Catherine's Island on the north from Black Bear and Sapelo Islands on the south. It is only 1 mile in width at its entrance, but extends inland to the westward about 4½ miles, with an average width of about 1½ miles. The main body of this sound is deep and the bottom hard, but the water is too salt for oyster culture.”

The Georgia oyster harvest peaked in 1908 (at 8 million lbs), with 14 canneries operating along the coast (Harris, 1980). By 1910, this total had declined drastically (to about 3 million lbs) a trend that continued over the next 4 decades. The quantity of oyster meat landed annually, however, fluctuated widely; see table 7.2 for records from 1880–1978 (after Harris, 1980: fig. 1).

A follow-up survey in 1925 documented no significant changes from Drake's earlier findings (Galtsoff and Luce, 1930). A third survey, conducted in 1966–1967 by the University of Georgia Marine Institute (Linton,

1969), noted few changes in the distribution of intertidal oysters since 1925. According to Carley (1968), between one third and one half of the estuarine area suitable for oyster growth is polluted, and the oyster beds are closed to harvest for public health reasons (see also Johnson et al., 1974: 101–103, appendix 35). All oysters commercially harvested during this period were taken from privately held areas, and their distribution was severely restricted due to pollution and predation. By 1978, only nine operators were licensed to harvest oysters in Georgia, and only one of these shucked oysters and sold the meats (the others simply sold their harvest as shell stock). Table 7.2 lists the distribution of intertidal and subtidal oyster patches located in the vicinity of St. Catherines Island, while figure 7.2 reproduces the distribution of known oyster beds in the vicinity of St. Catherines Island (per Linton's survey of 1977–1978).

A more recent survey, conducted between 1974 and 1977, documented intertidal oyster beds in almost every body of water in coastal Georgia (Harris, 1980: 10). The distribution of intertidal oysters in Georgia waters was remarkably similar to that which Drake recorded in 1889, except that the extent of live oysters was considerably reduced and that the overall Georgia oyster resources had declined dramatically. Harris implicated several factors in the downfall in Georgia's oyster population: overharvesting, development, erosion from increased boat traffic, and drought. He noted that since the late 1950s *Minchinia nelsoni* disease had caused mass mortalities in Delaware, Virginia, and Maryland, as well as that the parasite *Perkinsus marina* was involved in oyster mortalities throughout the Gulf and South Atlantic coasts. Whereas the parasitic oyster fungus was previously reported present in Georgia oysters, Harris (1980: 10) argued that the role of these specific diseases was not completely responsible for the mortalities in Georgia oysters. Additional factors, while not directly depleting the resource, caused “extreme hardships on the industry itself”. These included pollution and lack of shellfish sanitation programs, which resulted in the closing of



Fig. 7.2. Distribution of oyster beds in the vicinity of St. Catherines Island, as recorded in 1966–1967 by Thomas L. Linton (Johnson et al., 1974: appendix VI).

about 75 percent of Georgia's oyster-growing waters. Harris (1980: 10) cited the failure to replace harvested shell material as "probably the most significant reason for the depletion of Georgia's oyster resources. ... Oystering is a farming operation and one cannot continue to harvest without re-seeding."<sup>2</sup> He also blamed the decline on poor management policy; although "good laws, especially those requiring the harvester to return a portion of the harvested shells harvested to the growing area," have been part of the Georgia Code since the 1880s, they have never been adequately enforced.

An even more recent survey (Walker and Cotton, 2001) documents the extent of oyster beds within the Duplin River area, on the Sapelo Island National Estuarine Research Reserve (located to the west of Sapelo Island and immediately to the southwest of St. Catherines Island). From August 1999 through August 2000, investigators individually surveyed and examined 209 oyster beds within the Duplin River, covering a total survey area of 4.4 ha (30.1%). In a previous examination of this same area, Drake (1891) plotted 8.9 ha of oyster beds. The new survey results suggest that massive quantities of oyster reefs (4 ha) have disappeared from the Duplin River over the past century.<sup>3</sup>

This means that if Drake's account was accurate, then half of the oyster beds within the Duplin River have vanished since 1890 (note that in table 7.2, an even more severe decline has taken place in the waters near St. Catherines Island). Walker and Cotton (2001), however, believe that Drake's estimates (at least for the Duplin River) were unrealistically high. To be sure, commercial harvesting coupled with storm and/or erosion impacts could account for some oyster bed losses, although the 1926 and 1967 oyster surveys detected little change from conditions present in 1891. Walker and Cotton conclude that "reef distribution along the Georgia coast has changed little over the last 90 years. Oyster reefs occur (in general) today in approximately the same locations where they occurred in 1889. ... The living oyster reef area, however, significantly has

declined in the same period." The results suggest that whereas the overall area of oyster beds appears to have remained fairly constant within the Duplin River area, "the coverage by live oysters has decreased significantly due primarily to past commercial fishing activities."

Oral history suggests another possible reason. Long-term Sapelo Island residents remember a time when the headwaters of the Duplin River were fed by freshwater aquifers, and they claim that freshwater fish could be caught in the headwaters of the Duplin. Without doubt, the deep aquifers have dried up due to the lowering of water tables over the past century. Walker and Cotton (2001) suggest that this loss of freshwater headwaters could account for gradual movement of oysters away from places like the Duplin River over time.

During the late 19th century, Augustus Oemler erected an oyster factory on the south end of St. Catherines Island, with two additional factories added shortly thereafter along McQueens Inlet. The apparently inexhaustible supply of oysters disappeared sometime during the 1920s, forcing the once flourishing oyster factories of St. Catherines Island to close. The rusting boilers and massive spoil heaps of oyster shells remain visible today (these oyster deposits have been radiocarbon dated, see chap.13, esp. figs. 13.3 and 13.4). The Oemler's oyster factory at Harris Neck operated until 1928 (Sullivan, 1990: 694).<sup>4</sup>

These oystermen collected so-called raccoon oysters by hand; they picked the oyster clumps that grew along the banks of subtidal creeks and rivers and were accessible at low tide (Oemler, 1889: 3). Operating from small, shallow draft bateaux, they used rakes and tongs to collect oysters, which were then piled into the boats and sometimes offloaded to specially designed oyster sloops (Sullivan, 1990: 692).

The oyster tongs used were similar to posthole diggers; if the handles were long enough, oysters could have been tonged in water up to 25 feet deep. The "harvesting end" of the oyster tongs looked like two rakes and was used to scoop oysters off the bottom. The boats were pulled along-

side the oyster bed, and the harvester used these hang tongs to place them in the boat; this kept the harvester from having to keep moving the boat or from having to walk through the mud bottom to put oysters into the boat. An experienced oyster tonger harvests 25 to 30 bushels per day.<sup>5</sup> Oysters are also dredged by boats using metal basket-dredges (1 to 2 bushels per drag; Lorio and Malone, 1994: 8).

Whereas oysters can be harvested and processed year-round, meat yield varies by season (Lorio and Malone, 1994). This is because bivalves may put 50 percent to 90 percent of their energies into reproduction. In American oyster, gametogenesis starts during the winter. During this time, oysters fatten up and become cream-colored due to the presence of glycogen; "fat" oysters may yield about 73 g/liter (8 lbs/sack, 1.5 bushels).<sup>6</sup> Spawning starts in April or May, and most oysters on the Georgia coast are watery by August because most gametes have been released; this is why oysters are "milky" in appearance, yielding only about 55 g/liter (6 lbs/sack), with a low of roughly 36 g/liter (6 lbs/sack). In other words, wintertime yields a 50 percent to 100 percent increase in edible meat over oysters harvested during the summer.<sup>7</sup>

Writing specifically about the Georgia coast, Oemler (1889: 24) noted that oysters "are so watery in July and August that it requires two and a half bushels, or more, to open a gallon, whereas later one bushel will yield a gallon of opened oysters; yet the deal pays to the poor oysterman, who has to tong two and a half fold the quantity, and to his wife, who has to open them, the same price per gallon, and they are without remedy. Furthermore there is a loss of one and a half bushels of food material." Many commercial harvesters in coastal Georgia cease collection during the warmer months, and instead sometimes can vegetables in their oyster factories throughout the spring and summer (Sullivan, 1990: 693).

The average protein and carbohydrate content also varies significantly by season. The percentage of protein is the highest during the summer months, peaking in August. Protein levels decrease throughout the

winter months, reaching an annual low point in May. By contrast, carbohydrate levels are relatively high from autumn through spring, dropping notably during the summer months.

ETHNOHISTORIC EVIDENCE: Meehan (1982: 7) has commented on the generally poor quality of ethnographic studies on modern shellfishers, who practiced a subsistence strategy sometimes disparaged as "a low form of human existence". In fact, Meehan's (1982) now classic research among the Gidjingali (Anbarra) of Arnhem Land (Australia) was inspired by "the dearth of shellfish-gathering studies". The same holds true for the American Southeast, where surprisingly little ethnographic information is available to document aboriginal shellfishing methods.

Swanton (1946: 377-378) documented one relevant account of oyster harvesting and drying by Gulf Coast tribes during the 18th century:

When the sea is low and allows these savages the liberty of laying in a supply of oysters, they go to fill up their dugouts, and afterwards, having withdrawn to the bank, they open them and put them in a bowl. While one part of these savages is occupied in this work, others light a fire, and place on opposite sides two forked sticks planted in the earth, on which there is a crosspiece which holds the handle of a kettle, and make them boil slightly until they are partly cooked, after which they remove them, and throw them into a basket or big sieve, in order that all of the water may drain out. During that time, they construct a kind of grill of four forked sticks planted in the ground and four sticks placed crosswise on which they place pieces of cane. Afterward, having spread their oysters on this grill, they make a fire underneath, and by this means bucan or smoke them, thus drying them and giving them a yellow and golden color. After having smoked them on one side in this manner, they turn them over in order to treat the other side similarly, and they continue this operation until all that they have collected are bucaned. Then they put them in jars or in sacks, which they hang from a nail after their return to the village, taking care to place them in a dry spot, and one not exposed to the heat. Seeing these oysters in this condition one would take them for the common beans on

which are fed the crews of our vessels. When they wish to serve them, they begin by putting them to soak in fresh water for an hour. Afterwards the water is changed and they are cooked. After that, whether one eats them as sauce with chickens, fried or as dough made into fritters, they are equally good and never smell of the smoke. (Dumont, 1753 [vol 2]: 273–276)

Other accounts indicated that Middle Atlantic groups, most notably 17th century Wampanoag and Algonquian groups, also dried oysters on cane grills and hung them on strings for storage (see Waselkov, 1987: 109, table 3.1). Preserved this way, dried shellfish could have been consumed in times of scarcity and used to provision trips to the inland. Smoked oysters were traded by the basket load to the British; dried oysters were stored in baskets and traded, smoked on cane grills, or hung on strings for storage. The implication for archaeologists, of course, is that oysters could be harvested, shucked, and dried at one place, yet consumed many months later and many miles away.

The limited ethnographic information available suggests that oysters were generally opened and cooked in a single operation. Roasting on open fires is a highly efficient method for opening hundreds of oyster shells in a few minutes (making field processing of oysters unlikely). Once extracted from the shell, oyster meat must either be consumed immediately or preserved for storage. Unfortunately, the ethnohistorical information does not indicate whether the practice of drying oyster meat dates to the precontact period or whether this was an adaptation to the postcontact landscape in which Europeans usurped the best shellfishing areas.

Despite the paucity of reliable ethnographic record, we will attempt to reconstruct some details of aboriginal shellfishing practices based on modern experiences in the coastal Georgia marshland (see also Larson, 1980a; Quitmyer, 1985; Crook, 1992).

**PEDESTRIAN HARVESTING STRATEGIES:** Salt marsh collectors can harvest oysters from near shore environments by working the

reef communities scattered along the larger tidal streams, near the edge of high and relatively firm marshes. Pedestrian shellfish collectors can also collect oysters from the living reef communities that grow on a dead oyster substrate (up to 2 m thick). Because most of the living oysters occupy the upper surface of the reef, they can readily be gathered by crossing the marsh on foot when the receding tide exposes the reef community. Shellfish could also have been collected on visits to check fish traps.

Small clumps of two to six oysters sometimes grow in the lower intertidal zone along small tidal creeks. Although these single oysters have a high meat/shell ratio, such small clusters require a soft mud substrate and are relatively rare. Single oyster stands are commonly found along small tidal creeks near land, and they can usually be approached on foot at low tide (Crook, 1992). The most desirable time for shellfish collection is at dead low daytime tide, when the oyster beds are fully exposed. Along the Georgia coast, the tides have amplitude of 2–3 m (the greatest along the southeastern United States coastline).<sup>8</sup> Whelks can also be found along the base of the oyster reefs, and they would likely have been collected if encountered (the same holds true for blue crabs).<sup>9</sup> Such species could be readily collected during the spring and fall, when moderate temperatures permit whelks to migrate into the intertidal flat (where they prey on clams and oysters). Atlantic ribbed mussels and periwinkles, which flourish in clustered patches on the hard marsh, are also easily reached on foot.

Pedestrian collecting could have been a highly effective strategy for exploiting near shore intertidal habitats; however foragers doing so would have been limited to (at most) a few hundred meters from the marsh edge. It is suspected that harvesting the near shore zone was undertaken by individuals or by small groups of collectors, which may have included children and the aged. Such oyster collection required little in the way of specialized technology, because the targeted oyster beds were exposed at low tide; harvesting was likely carried out

“with a stick used as a lever or hammer to pry or knock loose the oysters from the base upon which they were growing” (Larson, 1980a: 66–70). Pedestrian foragers would be required to return to the island margin once a single load was secured. Field processing of shellfish would certainly be a consideration (discussed below), but at a minimum, most foragers would likely remove the dead shells from oyster clusters to minimize inedible weight and bulk.

While foragers could effectively cover the near shore habitats, their mobility is severely limited. The intertidal zone is comprised primarily of very soft marsh mud, which makes walking almost impossible since any human forager will immediately sink into calf- to hip-deep mud. Walking sticks and snowshoe-like footwear can help, but collectors walking through the marsh can rarely forage more than a few hundred meters beyond the island edge.

**WATERCRAFT-BASED STRATEGIES:** By employing boats and/or canoes, human foragers could dramatically increase effective foraging range and significantly lower transport costs of returning resources to the island-based residential area. Most of the oysters within the bank communities that bordered the stream beds are accessible only by boat (the marsh expanse separating these oyster beds from the dry land will not support human foot traffic). These cluster communities are scattered along firm-bottom, large tidal creeks adjacent to stream channels or along softer muddy bottoms of tidal flats. In such communities, small clumps of 10–30 oysters are attached in clusters, thereby lowering the meat/shell ratio. These concentrations are common throughout the tidal range, but the various oyster surveys (discussed above) have not documented their full distribution.

Oysters also grow in communities clustered along the banks of larger tidal streams throughout much of the intertidal range; this is the dominant community structure for oysters along the Georgia coast as well as the primary source for commercial oyster harvesters. The oysters are found in contiguous clusters of 30 or more attached oysters

that often form linear aggregations (2–4 m wide) sometimes more than 50 m along the stream bank. While some cluster and bank communities of oysters are adjacent to land, and can thereby be reached on foot, the larger communities along the tidal streams are accessible only by watercraft at low water.

Lewis Larson (1980a: 69) suggests that use of watercraft was “essential” to exploit oysters in the Georgia salt marsh. Aboriginal foragers must have timed their trips to the oyster beds around the tides. Launching a canoe into a fast-moving saltwater creek has been and still is a dangerous endeavor; it is likely that people launched their canoes at high water from carefully selected locations near the marshland, chosen so that everyone could get into and out of the dugouts comfortably and safely. Then they traveled on the receding waters (perhaps at half tide), paddling along the natural openings in the marsh grass. By canoeing to the oyster beds on an ebb tide, the foragers could closely time their arrival to coincide with dead low tide, when the individual oyster clusters were exposed. If they arrived early in the tidal cycle, this would have provided an opportunity for fish during the wait until full low tide (as fish stay in the marsh until the water leaves and then move into the saltwater streams).

Within a given locality, only certain places can be expected to produce oysters. Depending on the size of the boats, individual collectors could be dropped off at several beds, and then picked up when the tide began to rise. The shellfishers could have piled oysters and/or clams into loose mesh baskets or bags or loaded them directly into the dugouts before returning home on the rising tide. Another possibility is that they collected on the outgoing tide in one small creek, keeping the canoe floating nearby, then proceeded to connecting creeks, working each oyster bed without going aground. As the tide came rushing back in, the shellfishers had the option of returning to the original launch site (which would be flooded and would provide easy access inland) or they could have returned to an alternative launch site. This would likely de-

pend on the location of the residential base.<sup>10</sup>

ESTIMATING SHELLFISH RETURN RATES ON  
ST. CATHERINES ISLAND

BY ELLIOT BLAIR AND DAVID HURST THOMAS

We have already highlighted the need for actualistic experimentation on the contemporary resource base of St. Catherines Island. Whereas the various shellfish taxa have been severely impacted over the past century and the contemporary shellfishery is a pale reflection of aboriginal conditions, we nevertheless think it imperative that carefully controlled optimal foraging experimentation take place on the extant shellfish populations of the central Georgia coastline (table 7.3).

In January, 2005, we began a series of long-term, controlled experiments to determine the post-encounter return rates for the contemporary shellfish populations of St. Catherines Island. We have focused on six shellfish taxa—American oysters, ribbed mussels, hard clams, marsh periwinkles, blue crabs, and knobbed whelks. Beyond the strictly energetic returns (expressed as kcal/hr), our experiments also addressed the relative efficiency of protein acquisition (expressed as grams of protein/hr). We did this because some investigators have suggested that protein return might be a more appropriate currency for assessing shellfish importance to diet in coastal societies (Yesner, 1980; Claassen, 1986a, 1986b, 1991; Erlandson, 1988; see also chap. 31). As Yesner (1980: 733) notes, shellfish “are notoriously low in calories. Diets based primarily on shellfish ... would be dangerously low in calories.” Yesner also argues that while caloric return rates are low, an individual’s daily need in protein can be obtained from shellfish with relative ease, even in time of famine (see also Nietschmann, 1973; Meehan, 1977a, 1977b).

With such considerations in mind, we conducted more than four dozen procurement and processing experiments on St. Catherines Island. Several pilot projects were instigated between January 22 and January 27, 2005, with more focused efforts con-

ducted between October 17 and October 31, 2005. Follow-up collections were completed on January 31, 2006, from February 22 to March 1, 2006, and on May 10, 2006. The experiments were conducted as focal individual follows and home processing sequences (Altmann, 1974: 242–247; Bird and Bird, 2002: 269–297; Kennedy, 2004: 49). Each “follow” involved a three-person team: the primary collector, an assistant (to transport the shellfish being harvested and to point out promising collection areas), and an observer (to record the ongoing experimental results). Each focal follow was timed and photographed; in our field laboratory, we recorded live weights and meat weights for each “shellfish lot” recovered. When appropriate, we also recorded counts and weight for individual specimens. Several shellfish meat samples from the October 2005 experiments were submitted to QC Laboratories for nutritional analysis (see tables 7.1 and 7.4). Samples collected in late January 2006 were also analyzed nutritionally, and the meat yields from these samples were used to calculate our return rates for January oysters. Figure 7.3 shows the locations of the various procurement areas.<sup>11</sup>

**AMERICAN OYSTERS (*CRASSOSTREA VIRGINICA*):** To estimate *procurement time*,<sup>12</sup> we collected oysters from intertidal beds exposed along saltwater creeks adjacent to St. Catherines Island. All collection experiments were conducted within an hour of dead low tide. During each episode, the primary collector was instructed to collect one bucketful of oysters (approximately one-half bushel) as rapidly as possible, while still attempting to be selective by choosing the largest specimens and avoiding empty shells and dead oysters. A stick was utilized to assist in removing oysters from clumps and to assist in removing dead oysters and empty shells from each clump.

The oysters being collected during these follows are raccoon oysters that required harvesting en masse (see above discussion). Though some selectivity could be employed during the collection process, the nature of these patches is such that “individual” oy-

TABLE 7.3  
**Postencounter Return Rates for the St. Catherines Island Shellfishery, Including Experimental Results and Modified Estimates**

Species	Av. live wt. (kg)	Usable %	Meat wt.	Food energy/ species (kcal/ 100 g)	Food energy/ unit <sup>a</sup>	Collection time (hr/ lot)	Processing time (hr/indi- vidual)	Return rate (kcal/hr)
Mass collecting, cooked (experimental)	23.32 kg/bushel	American oyster 5.34%	1.25 kg/bushel	49	614 kcal/bushel	0.13	4.28	139
Mass collecting, cooked (modified estimate, no shucking time)	23.32 kg/bushel	5.34%	1.25 kg/bushel	49	614 kcal/bushel	0.13	0.71	731
Mass collecting, cooked (modified estimate, 50% larger <sup>b</sup> )	—	—	1.88 kg/bushel	49	921 kcal/bushel	0.13	4.28	209
Mass collecting, cooked (modified estimate, 50% larger and no shucking time)	—	—	1.88 kg/bushel	49	921 kcal/bushel	0.13	0.71	1096
Mass collecting, raw (experimental)	23.32 kg/bushel	7.02%	1.64 kg/bushel	46	757 kcal/bushel	0.13	6.26	119
Collecting as singles (estimate; $n =$ 1492; 5 g/individual <sup>c</sup> )	—	—	7.46 kg/lot	49	3655 kcal/lot	0.67	4.90	656
Collecting as singles (modified estimate; $n = 1492$ ; 7.5 g/ individual <sup>d</sup> )	—	—	11.19 kg/lot	49	5483 kcal/lot	0.67	4.90	984
Collecting as singles (modified estimate; $n = 1492$ ; 13 g/ individual <sup>e</sup> )	—	—	19.40 kg/lot	49	9506 kcal/lot	0.67	4.90	1707
Collecting as singles (modified estimate; $n = 1492$ ; 5 g/ individual; no shucking time)	—	—	7.46 kg/lot	49	3655 kcal/lot	0.67	2.97	1004
Collecting as singles (modified estimate; $n = 1492$ ; 7.5 g/ individual; no shucking time)	—	—	11.19 kg/lot	49	5483 kcal/lot	0.67	2.97	1506
Collecting as singles (modified estimate; $n = 1492$ ; 13 g/ individual; no shucking time)	—	—	19.40 kg/lot	49	9506 kcal/lot	0.67	2.97	2612
Mass collecting, cooked (experimental)	22.77 kg/bushel	American oyster (summer adjusted) 3.74%	0.85 kg/bushel	81	686 kcal/bushel	0.13	4.28	155
Mass collecting, cooked (modified estimate—no shucking time)	22.77 kg/bushel	3.74%	0.85 kg/bushel	81	686 kcal/bushel	0.13	0.71	817

TABLE 7.3  
(Continued)

Species	Av. live wt. (kg)	Usable %	Meat wt.	Food energy/ species (kcal/ 100 g)	Food energy/ unit <sup>a</sup>	Collection time (hr/ lot)	Processing time (hr/indi- vidual)	Return rate (kcal/hr)
Mass collecting, cooked (modified estimate, 50% larger)	—	—	1.28 kg/bushel	81	1037 kcal/bushel	0.13	4.28	231
Mass collecting, cooked (modified estimate, 50% larger and no shucking time)	—	—	1.28 kg/bushel	81	1037 kcal/bushel	0.13	0.71	1235
Mass collecting, raw (experimental)	22.77 kg/bushel	4.61%	1.05 kg/bushel	64	676 kcal/bushel	0.13	6.26	106
Collecting as singles (estimate; $n = 1492$ ; 3.2 g/individual <sup>b</sup> )	—	—	4.77 kg/lot	81	3844 kcal/lot	0.67	4.90	690
Collecting as singles (modified estimate; $n = 1492$ ; 4.8 g/individual)	—	—	7.16 kg/lot	81	5800 kcal/lot	0.67	4.90	1041
Collecting as singles (aboriginal estimate; $n = 1492$ ; 8.3 g/individual)	—	—	12.4 kg/lot	81	10,044 kcal/lot	0.67	4.90	1803
Collecting as singles (modified estimate; $n = 1492$ ; 3.2 g/individual)	—	—	4.77 kg/lot	81	3844 kcal/lot	0.67	2.97	1056
Collecting as singles (modified estimate; $n = 1492$ ; 4.8 g/individual)	—	—	7.16 kg/lot	81	5800 kcal/lot	0.67	2.97	1593
Collecting as singles (aboriginal estimate; $n = 1492$ ; 8.3 g/individual)	—	—	12.4 kg/lot	81	10,044 kcal/lot	0.67	2.97	2759
Contemporary St. Catharines Island, collecting as singles ( $n = 648$ )	60.52 kg/lot	8.4 g/individual	Hard clam 54.40 kg/lot	102	5573 kcal/lot	0.67	1.82	2246
Contemporary St. Catharines Island—collecting as singles ( $n = 648$ )	60.52 kg/lot	8.4 g/individual	54.40 kg/lot	102	5573 kcal/lot	0.67	0.61 <sup>§</sup>	4379

TABLE 7.3  
(Continued)

Species	Av. live wt. (kg)	Usable %	Meat wt.	Food energy/ species (kcal/ 100 g)	Food energy/ unit <sup>a</sup>	Collection time (hr/ lot)	Processing time (hr/indi- vidual)	Return rate (kcal/hr)
Contemporary St. Catherine's Island, collecting as singles ( <i>n</i> = 1450)	14.36 kg/lot	2.5 g/individual	Ribbed mussel 3.63 kg/lot	65	2363 kcal/lot	0.67	5.45	387
Contemporary St. Catherine's Island, collecting as singles ( <i>n</i> = 1450)	14.36 kg/lot	2.5 g/individual	3.63 kg/lot	65	2363 kcal/lot	0.67	1.21 <sup>g</sup>	1259
Collecting and processing as singles	0.175 kg	30%	Knobbed whelk 0.053 kg/individual	87	46 kcal/ individual	0.02	0.02	1381
Collecting and processing as singles	0.100 kg	30%	Channeled whelk 0.030 kg/individual	137	41 kcal/ individual	0.02	0.02	1231
Processing as singles ( <i>n</i> = 1725)	—	0.19 g/individual	Marsh periwinkle 0.33 kg/lot	69–105	225 kcal/lot	0.67	7.95	26–40
Mass processing (smash and winnow; <i>n</i> = 1725)	—	0.16 g/individual	0.28 kg/lot	69–105	189 kcal/lot	0.67	1.42	91–138
Mass processing (spire removal; <i>n</i> = 1725)	—	0.18 g/individual	0.31 kg/lot	69–105	213 kcal/lot	0.67	1.75	88–135
Collecting and processing as singles ( <i>n</i> = 16)	0.20 kg/individual	20%	Blue crab 0.04 kg/individual	87	557 kcal/lot	0.67	1.13	310

<sup>a</sup> Rounded.<sup>b</sup> After Gunter (1938).<sup>c</sup> After Crook (1992).<sup>d</sup> After Crook (1992), modified by Gunter (1938).<sup>e</sup> After Crook (1992).<sup>f</sup> All adjusted summer weight values for oysters collected as singles are calculated at 64% of winter weight.<sup>g</sup> Cooking and shucking times have not been included with processing time.

TABLE 7.4  
**Energy and Nutrient Analysis of St. Catherines Island Oyster Samples (Ash-Free Dry Weight)**

Collection date	Locality	Processing method	Energy (kcal/100 g) <sup>a</sup>	% Carb. <sup>b</sup>	% Protein <sup>b</sup>	% Fat <sup>b</sup>	% Moisture <sup>a</sup>
10/2005	Cemetery Road Marsh II	Raw	64	33.0	59.1	7.8	82.9
10/2005	Cemetery Road Marsh II	Cooked	81	24.1	69.5	6.4	78.2
1/2006	King New Ground Marsh North	Raw	46	17.1	74.5	8.4	84.8
1/2006	King New Ground Marsh North	Cooked	49	23.7	68.9	7.5	86
2/21/2006	Cemetery Road Marsh II	Raw	53	30.0	64.6	5.5	84.5
2/21/2006	Cemetery Road Marsh II	Cooked	63	16.4	74.6	9.0	82.8
2/22/2006	King New Ground Marsh South	Cooked	66	24.3	67.0	8.6	81.4
2/22/2006	King New Ground Marsh South	Raw	63	33.3	58.4	8.3	81.8
3/1/2006	King New Ground Marsh North	Raw	57	15.8	75.3	8.9	84.8
3/1/2006	King New Ground Marsh North	Cooked	61	15.0	73.9	11.1	82.1
5/10/2006	King New Ground Marsh South	Raw	58	11.5	81.2	7.2	81.7
5/10/2006	King New Ground Marsh South	Cooked	67	12.0	80.8	7.3	80.1
5/10/2006	King New Ground Marsh North	Raw	64	22.1	71.7	6.2	80.4
5/10/2006	King New Ground Marsh North	Cooked	61	7.0	84.2	8.7	80.1
5/10/2006	Cemetery Road Marsh II	Raw	55	3.6	87.7	8.7	81.9
5/10/2006	Cemetery Road Marsh II	Cooked	59	0	90.8	9.2	79.1
6/21/2006	King New Ground Marsh North	Raw	36	20.4	74.8	4.8	87.7
6/21/2006	Cemetery Road Marsh II	Raw	41	34.4	59.1	6.5	87.6
7/22/2006	King New Ground Boiler Marsh	Raw	39	35.1	58.9	6.0	87.8
7/22/2006	King New Ground Marsh North	Raw	37	16.6	77.4	6.1	88.7
7/22/2006	Cemetery Road Marsh II	Cooked	53	37.3	56.5	6.1	84.1
8/21/2006	King New Ground Boiler Marsh	Raw	38	29.7	65.9	4.4	88.1
8/22/2006	King New Ground Marsh North	Raw	40	19.9	74.1	6.1	88.1
8/22/2006	Cemetery Road Marsh II	Raw	39	18.3	73.3	8.4	88.5
9/16/2006	King New Ground Boiler Marsh	Raw	39	28.7	63.5	7.9	88.7
9/16/2006	King New Ground Marsh North	Raw	41	24.3	71.2	4.5	88.1
9/16/2006	Cemetery Road Marsh II	Raw	38	17.2	74.7	8.1	87.9
10/14/2006	King New Ground Boiler Marsh	Raw	43	26.0	67.1	6.9	87.6
10/14/2006	King New Ground Marsh North	Raw	47	28.7	63.4	7.9	86.9
10/14/2006	Cemetery Road Marsh II	Raw	44	25.7	65.2	9.1	87.9
10/24/2006	King New Ground Marsh South	Raw	50	30.2	65.4	4.4	82.8
10/24/2006	King New Ground Marsh South	Cooked	63	25.9	69.3	4.9	81.3
10/24/2006	King New Ground Marsh North	Raw	56	36.2	60.3	3.6	82.1
10/24/2006	King New Ground Marsh North	Cooked	53	26.4	66.2	7.5	84.4
10/27/2006	Cemetery Road Marsh II	Raw	52	29.9	66.4	3.7	83.0
10/27/2006	Cemetery Road Marsh II	Cooked	54	32.6	63.1	4.3	83.7

<sup>a</sup> These are the wet weight values reported by QC Laboratories.

<sup>b</sup> These values are calculated based on ash-free dry weights.

sters cannot be selected. Our collection strategy was therefore predominantly one of semistripping (rather than either plucking or stripping). This process undoubtedly lowers the post-encounter return rates than what might otherwise be obtained (White, 1989; Jones and Richman, 1995).

The oyster return rate estimates presented here are based almost exclusively on the October 2005 experiments (because the follow-up collections were conducted solely for the purpose of estimating seasonal variability in nutrition and meat yield). We also emphasize that the collection time

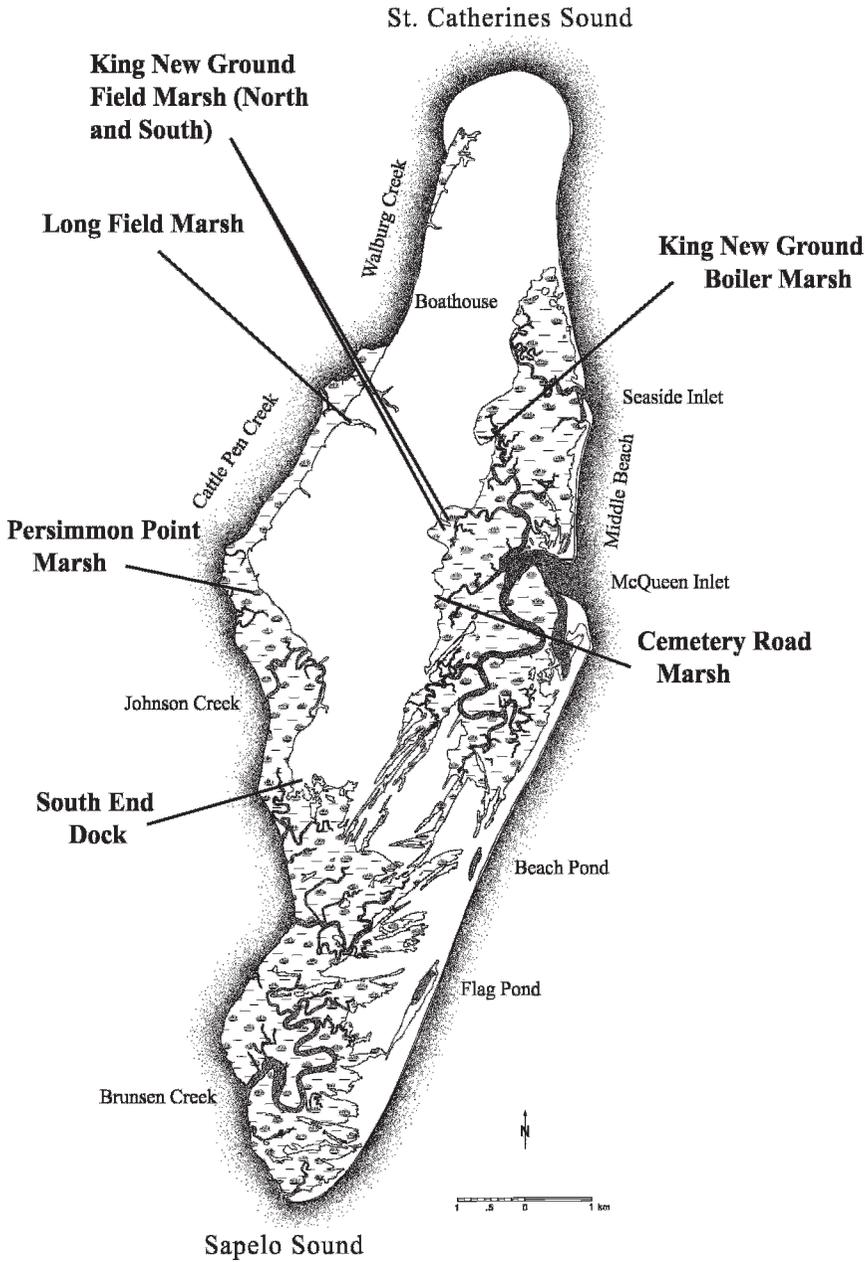


Fig. 7.3. Locator map of shellfish procurement experiments on St. Catherines Island.

and location of our primary sample—St. Catherines Island in late October—means that we were collecting “summer weight” oysters only. At this latitude, warm-climate, “nonwatery” oysters do not become available until late December or early January (Drake 1891: 182); we were able to supple-

ment our results with a sample of January oysters. It is generally thought that winter oysters produce a significant increase in post-encounter return rates, though it has also been suggested that the optimal oyster season may in fact occur in May or June—when the size of oysters can be up to two to

TABLE 7.5  
**Oyster Procurement Results (St. Catherines Island)**

Trial no.	Collector/ helper	Collection zone	Collection method	Procurement time (hr)	Total live wt. (kg)	Total mass (kg) collected/min
J-1.1	EB/MT	South End Dock I	Semistrip	0.18	9.84	0.89
J-1.2	ND/MS	South End Dock I	Semistrip	0.38	9.20	0.40
J-1 mean	—	—	—	0.28	9.52	0.65
J-2.1 <sup>a</sup>	AS/EB	South End Dock I	Strip	<i>0.08<sup>b</sup></i>	<i>9.66</i>	<i>2.15</i>
J-2.2	MS/ND	South End Dock I	Strip	<i>0.11</i>	<i>7.60</i>	<i>1.17</i>
J-2 mean	—	—	—	<i>0.09</i>	<i>8.63</i>	<i>1.66</i>
O-1.1	RF/LH	Cemetery Road Marsh I	Semistrip	0.19	9.24	0.79
O-1.2	SB/BM	Cemetery Road Marsh I	Semistrip	0.22	8.80	0.66
O-1.3	AC/LE	Cemetery Road Marsh I	Semistrip	0.21	9.82	0.79
O-1.4	MS/GM	Cemetery Road Marsh I	Semistrip	0.20	11.02	0.91
O-1.5	QO/RP	Cemetery Road Marsh I	Semistrip	0.11	6.48	1.01
O-1 mean	—	—	—	0.19	9.07	0.83
O-2.1	LH/RF	Cemetery Road Marsh II	Semistrip	0.13	6.38	0.80
O-2.2 <sup>c</sup>	BM/SB	Cemetery Road Marsh II	Semistrip	<i>0.25</i>	—	—
O-2.3	LE/AC	Cemetery Road Marsh II	Semistrip	<i>0.17</i>	<i>9.60</i>	<i>0.94</i>
O-2.4	GM/MS	Cemetery Road Marsh II	Semistrip	0.09	8.74	1.55
O-2.5	RP/QO	Cemetery Road Marsh II	Semistrip	0.20	8.14	0.69
O-2 mean	—	—	—	0.17	8.22	0.99
O-3.1	LE/GM	Cemetery Road Marsh II	Semistrip	0.04	8.86	3.69
O-3.2	MS/AC	Cemetery Road Marsh II	Semistrip	0.03	6.56	4.05
O-3.3	RF/LH	Cemetery Road Marsh II	Semistrip	0.11	9.06	1.33
O-3.4	SB/BM	Cemetery Road Marsh II	Semistrip	0.10	7.78	1.27
O-3.5	RP/QO	Cemetery Road Marsh II	Semistrip	0.04	10.10	4.45
O-3 mean	—	—	—	0.06	8.47	2.96
Total mean	—	—	—	0.15	8.67	1.55

<sup>a</sup> The J-2 collection trials were carried out with instructions to strip clumps of oysters from the beds as rapidly as possible—with no efforts being made to select “choice” specimens or eliminate empty shells.

<sup>b</sup> Values in italics are not included when calculating the total mean value due to abnormalities of some sort—such as those described above and below.

<sup>c</sup> The O-2.2 and O-2.3 trials have been excluded from the total mean value due to a mistake in which the collectors gathered mussels and oysters indiscriminately.

four times greater than during the late summer and early fall (Toth and Cray, 1964). We think that our October and January samples provide an adequate baseline from which to present the seasonal variability in nutrition and meat yield—representing both summer and winter oysters. However, we also believe that a greater explication of oyster seasonality is required; monthly collections and laboratory analysis are ongoing.

Numerous variables can influence the results in shellfish foraging experiments, including individual foraging ability, patch location and quality, and season of collection. We are also aware that rarely will nov-

ice foragers to be able to replicate the handling rates of experienced aboriginal shellfishers. We found that with practice, our experimental foragers steadily improved their harvest rates, overshadowing issues of patch choice and perhaps even season of collection. Table 7.5 (and figs. 7.4 and 7.5) indicates, for instance, that collection trials O-1 and O-2 (conducted in the Cemetery Road Marsh I and II patches) are reasonably comparable, even though the location changes from a lower quality patch (CRM I) to a higher quality patch (CRM II). Collection times improved between the O-2 to the O-3 trial groups on

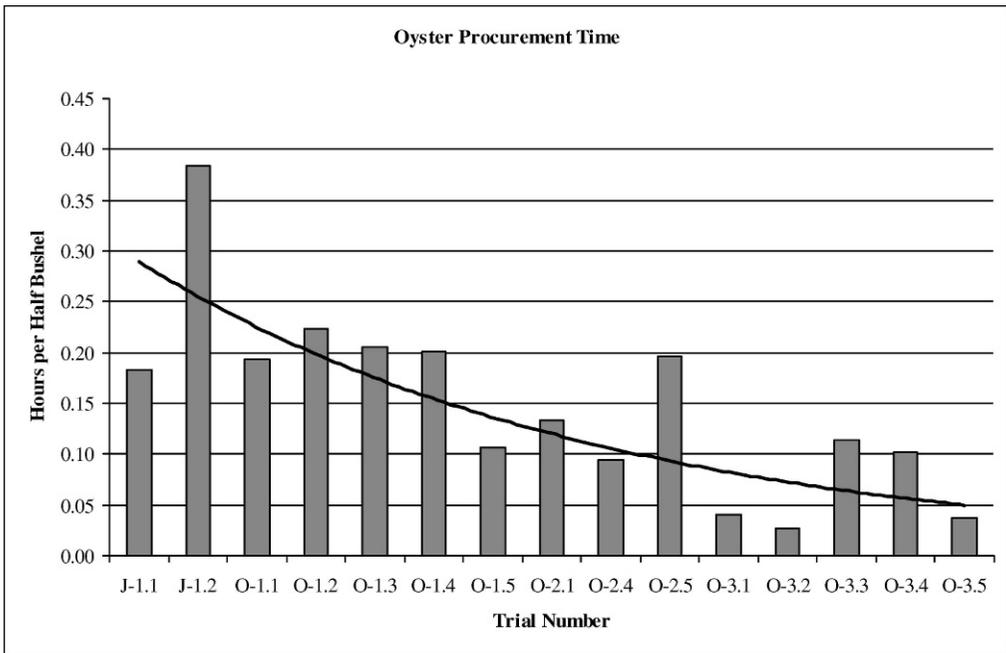


Fig. 7.4. Procurement time for oysters on St. Catherines Island.

both the individual and the group level, all within the same oyster patch. Note further that each subsequent block of collection trials bests the previous effort, suggesting

that experience may be the most critical variable in determining collection time.

For present purposes, we will employ the mean results from the O-3 collecting trial as

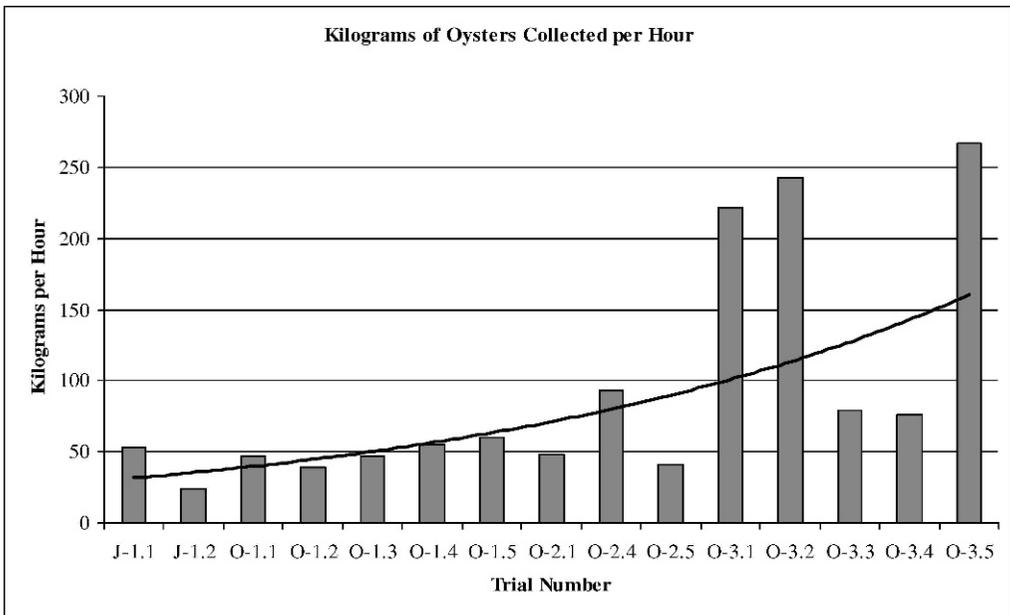


Fig. 7.5. Oyster mass (in kilograms) per hour collecting time.

the best estimator of procurement time for oyster collection. The experimental rate of 0.06 hr/half bushel (2.96 kg/min) suggests that aboriginal foragers could procure one bushel of oysters (with a live weight of 22.77 kg in October and 23.32 kg in January) in 0.13 hr.

To compute *handling time* we prepared the collected oysters for consumption. Before the shellfish can be shucked, each oyster clump must be thoroughly cleaned to remove all mud and other adhering debris. As part of our optimal foraging experiment, we timed two individuals who cleaned all half-bushel oyster batches with a scrub brush and hose. With only a few exceptions (the J-1/J-2 trials and Trial O-2.3), all the oysters in this experiment were cleaned by two individuals (LE and QO). By standardizing the cleaning process, we attempted to hold individual skill as a constant and measure the influence of increased experience. Table 7.6 and figures 7.6 and 7.7 show that cleaning times became faster and more consistent as the cleaning team gained experience. For present purposes, we will employ the O-3 group mean cleaning rate (32.05 kg/hr) to estimate that one bushel of St. Catherines Island oysters can be cleaned in 0.71 hours.

We weighed the cleaned oysters to generate estimates of live weight and meat yield. As summarized in tables 7.7 and 7.8, oysters collected in October from the waters surrounding St. Catherines Island have an average raw meat mass of 4.61 percent of total live weight. For cooked oysters, the edible proportion declines to 3.74 percent for October oysters. The corresponding figures for January oysters are 7.02 percent and 5.34 percent respectively, measured from of a sample of oysters collected on January 31, 2006, from King New Ground Field Marsh North. Based on these experimental values, we project that one bushel of October-collected oysters yields 1.05 kg of raw oyster meat and 0.85 kg of cooked meat. For January-collected oysters the proportional yield increases to 1.64 kg of raw meat and 1.25 kg of cooked meat.<sup>13</sup>

We then prepared the clean oyster clumps for consumption (both raw and

TABLE 7.6  
Oyster Cleaning Results (St. Catherines Island)

Trial no.	Cleaning time (hr)	Total mass (kg)	Cleaned (kg/hr)
J-1.1	0.87	9.84	11.35
J-1.2	0.80	9.20	11.50
J-1 trial mean	0.83	9.52	11.43
J-2.1	0.67	9.66 <sup>a</sup>	14.49
J-2.2	0.53	7.60	14.25
J-2 trial mean	0.60	8.63	14.37
O-1.1	0.34	9.24	27.18
O-1.2	0.67	8.80	13.12
O-1.3	0.44	9.82	22.29
O-1.4	0.52	11.02	21.35
O-1.5	0.33	6.48	19.37
O-1 trial mean	0.46	9.07	20.66
O-2.1	0.24	6.38	26.09
O-2.2	0.49	—	—
O-2.3	0.60	9.60	16.08
O-2.4	0.34	8.74	26.00
O-2.5	0.70	8.14	11.55
O-2 trial mean	0.47	8.22	21.22
O-3.1	0.32	8.86	27.83
O-3.2	0.19	6.56	34.23
O-3.3	0.28	9.06	32.61
O-3.4	0.23	7.78	33.75
O-3.5	0.30	10.10	33.30
O-3 trial mean	0.26	8.47	32.34
Total mean	0.46	8.67	22.37

<sup>a</sup> Values in italics are not included in total averages due to abnormalities.

cooked). The raw oysters were shucked using standard oyster knives by teams of three to seven individuals, and the shucking time was recorded. After a lot was shucked, the meat mass and empty shell weight was also recorded. No specimen count was possible due to the logistical difficulties involved with such clusters of “coon” oysters, which invariably included numerous dead shells.<sup>14</sup>

To relatively compare handling times, we also cooked a number of oyster samples prior to shucking. The live oyster clusters were broiled for 12 min to simulate the ethnohistoric and ethnographic accounts of direct dry heat mass cooking by grilling or roasting on an open fire (Waselkov, 1987: 122–123). We held cooking time for all oysters batches (as we did for all other shellfish), finding that a 12-min interval was suf-

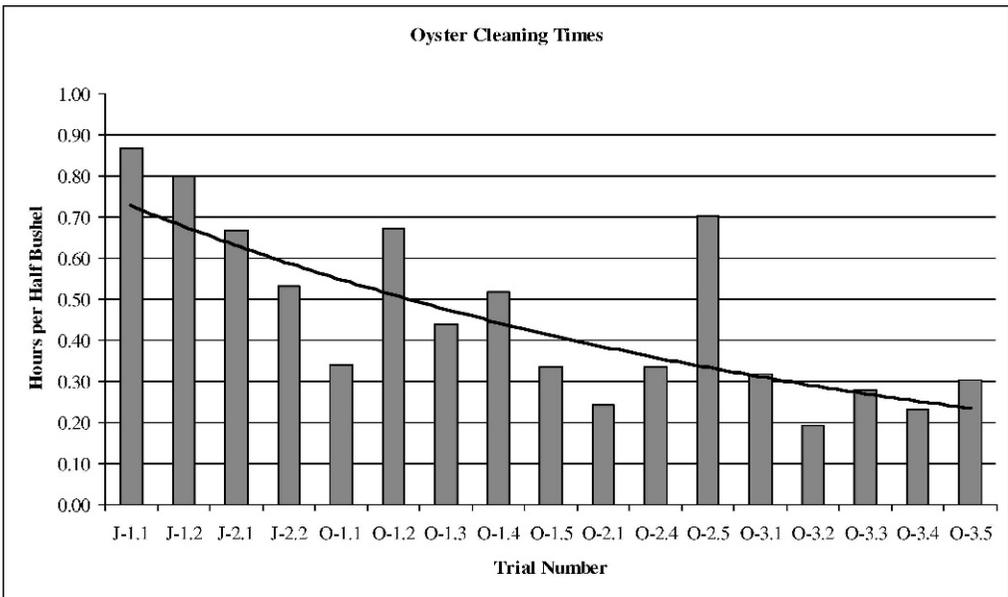


Fig. 7.6. Oyster cleaning times.

ficient to open nearly all specimens. We then shucked the cooked oysters, once again using teams of three to seven. We recorded the shucking time, edible meat mass, and empty shell weights.

We can now compute shucking time based on the oyster meat yield shucking rate (thereby eliminating the empty shells and dead oyster masses that would otherwise skew our results). For raw October-collected oysters,

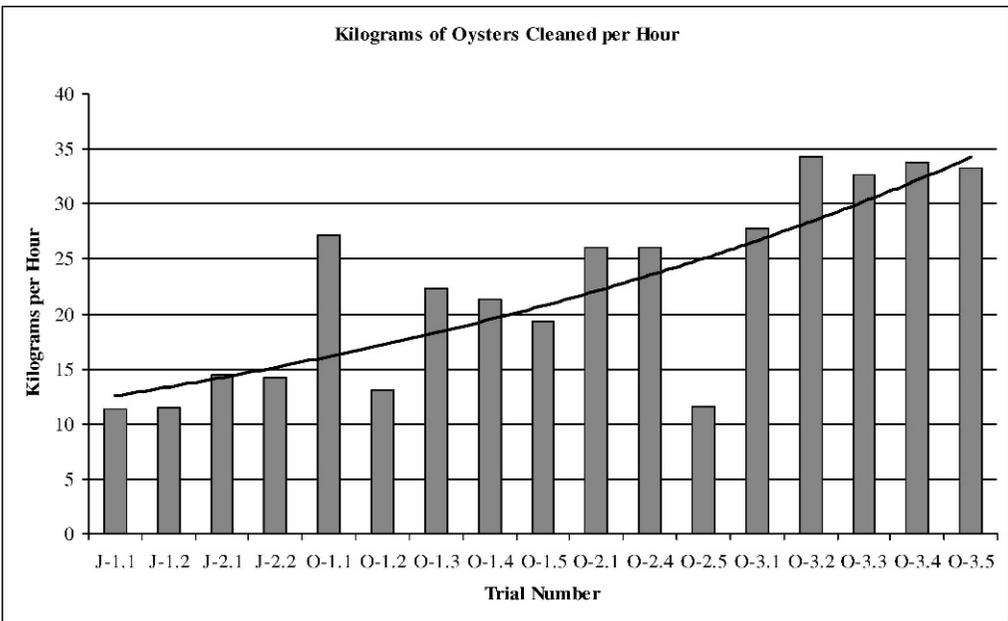


Fig. 7.7. Kilograms of oysters cleaned per hour.

TABLE 7.7  
**Raw Oyster Shucking Results (St. Catherines Island)**

Trial no.	Shuck time (hr)	Live weight (kg)	Oyster meat mass (kg)	% meat	Meat yield (kg/hr)
O-1.1	2.87	9.24	0.30	3.25	0.10
O-1.4	3.50	11.02	0.46	4.17	0.13
O-1 trial mean	3.18	10.13	0.38	3.71	0.12
O-2.1	2.00	6.38	0.38	5.96	0.19
O-2.3	1.80	9.60	0.34	3.54	0.19
O-2.5	2.67	8.14	0.50	6.14	0.19
O-2 trial mean	2.16	8.04	0.41	5.21	0.19
O-3.1	1.80	8.86	0.40	4.51	0.22
O-3.3	2.92	9.06	0.38	4.19	0.13
O-3.5	2.93	10.10	0.52	5.15	0.18
O-3 trial mean	2.55	9.34	0.43	4.62	0.17
Total mean	2.56	9.05	0.41	4.61	0.16

we employ the O-2 trial mean (0.19 kg/hr), which translates into a shucking time of 5.55 hr/bushel. For cooked oysters, we will use a rate of 0.25 kg/hr—the rate from the O-2.4 and O-3.4 shucking trials, our two fastest trials. The shucking time is estimated at 3.40 hr/bushel.

At this point the raw and cooked oyster meat is available for immediate consumption. But as noted earlier in this chapter, a number of ethnohistoric accounts from the Middle Atlantic and Gulf areas suggest that oysters were commonly preserved by drying and/or smoking. To replicate this

TABLE 7.8  
**Grilled/Broiled Oyster Shucking Results (St. Catherines Island)**

Trial no.	Shuck time (hr)	Total mass (kg)	Meat mass (kg)	% meat	Meat yield (kg/hr)
J-1.1	1.25	9.84	0.44	4.49	0.35
J-1.2	1.42	9.20	0.35	3.82	0.25
J-1 trial mean	1.33	9.52	0.40	4.15	0.30
J-2.1	1.13	9.66	0.33	3.40	0.29
J-2.2	1.40	7.60	0.45	5.91	0.32
J-2 trial mean	1.26	8.63	0.39	4.65	0.31
Total J trial mean	1.30	9.08	0.39	4.40	0.30
O-1.2	2.75	8.80	0.30	3.41	0.11
O-1.3	1.80	9.82	0.42	4.28	0.23
O-1.5	1.50	6.48	0.22	3.40	0.15
O-1 trial mean	2.02	8.37	0.31	3.69	0.16
O-2.2	<i>0.82<sup>a</sup></i>	—	<i>0.26</i>	—	<i>0.32</i>
O-2.4	1.28	8.74	0.32	3.66	0.25
O-2 trial mean	1.05	8.74	0.29	3.66	0.28
O-3.2	1.52	6.56	0.22	3.35	0.15
O-3.4	1.35	7.78	0.34	4.37	0.25
O-3 trial mean	1.43	7.17	0.28	3.86	0.20
Total O trial mean	1.70	8.03	0.30	3.74	0.18
Total mean	1.54	8.45	0.34	4.01	0.22

<sup>a</sup> Values in italics have not been included in average values due to abnormalities.

process, we strung a number of cooked oyster meats on needles and thread made from the leaves of the Spanish bayonet (*Yucca aloifolia*), then preserved the strung oysters by sun-drying and smoking on a grill (using hickory nuts to generate the smoke). Times for making the needle and string, then stringing 100 g of oysters ranged from 13 to 29 min, with a mean of 19.36 min handling time per 100 g of oysters strung. We found that strung oysters could be preserved by smoking within 2 hr and by air-drying within 8 hr.

Table 7.9 details our expected return rates based upon diet-breadth assumptions extrapolated from the individual component handling rates obtained in our experiments. Expected return rates have been calculated in two different ways: The first includes all handling times that occur during harvest until the specimens are ready for consumption, while the second excludes cooking, drying, and smoking times. In the second scenario, we discount these various times as representing zero-cost activities because an individual could be embedded in other activities while the resource is being cooked, dried, or smoked; we do this to attempt to eliminate those cost values that seem to require little to no energetic input. Also, return rates have been calculated for oysters collected during both late January and mid-October. It is believed that these two collection times will provide a fair approximation of the physical changes that occur between summer and winter weight oysters.

Table 7.9 clearly shows that grilled/broiled oysters always produce the highest return rate for oysters, while smoking and drying activities significantly reduce return rates. However, the additional costs associated with smoking and drying is not necessarily a net negative. Perlman (1980: 290) notes that storage reduces return rates, but “by incurring greater costs in one season, costs during other less productive seasons and possibly during the entire annual cycle will be minimized.” Also incurring the storage costs of shellfish allows these items, still high in protein, to be traded to non-coastal groups for food items higher in cal-

ories (Stark and Voorhies, 1978; Yesner, 1980).

It is strikingly apparent that our experimental oyster return rates are extremely low—even taking into account the notoriously “low-calorie shellfish” perception (Yesner, 1980). We understand that oyster productivity varies significantly along the Atlantic and Gulf coasts and depends on water temperature, salinity, and substrate (Galtsoff, 1964: 382–383; table 39). The recorded yield of market oysters in the waters of Delaware and further north varied between 3.0 and 3.36 kg/standard U.S. bushel. Yields are much lower in the southern Atlantic and Gulf states, ranging from 1.43 to 2.3 kg/bushel. Galtsoff’s (1964: 383) estimated yield, 3.15 lbs (1.43 kg), of oyster meat/bushel for the Georgia coast compares favorably with our experimental results from St. Catherines Island (table 7.9), which range from 0.85 to 1.64 kg/bushel.<sup>15</sup>

Reitz and Wing (1999: 68) report that shell weight of eastern oysters (*Crassostrea virginica*) is approximately 78 percent of their total body weight.<sup>16</sup> Small oysters, however, have a proportionally greater shell weight (86%) compared to large oysters (77% shell weight). Dame (1972) suggests that subtidal oysters average about 40 percent larger meat weights than intertidal oysters of comparable size and proportions (see also Crook, 1992). Our experimental results indicate a much higher proportional shell weight for modern St. Catherines Island oysters, ranging between 90 percent and 95 percent (table 7.9).

Insensitive collection will, of course, quickly skim off most oysters of an edible size; injudicious harvesting can readily wipe out an oyster bed. But if the oysters are merely thinned out, then the survivors have more space and greater access to nutrients. When this occurs, the survivors will grow more rapidly and will be available (as individuals) for successive harvests (Crook, 1992: 494–495). To some degree, the very act of harvesting can foster “cultivation”, meaning that through judicious harvesting practices, foragers can increase the post-encounter return rates for oysters by targeting and husbanding a specific patch for imme-

TABLE 7.9  
**Calculated Nutritional Yields for One Bushel of Oysters (St. Catherines Island)**

Processing type	Procurement time (hr)	Cleaning time (hr)	Shucking time (hr)	Cooking time (hr)	Other handling time (hr) <sup>a</sup>	Total handling time (hr)	Total mass (kg)	Total meat mass (kg)	Total calories/lot	Protein (g/hr)
Oct., raw	0.13	0.71	5.55	—	—	6.39	22.77	1.05	676	106
Jan., raw	0.13	0.71	5.55	—	—	6.39	23.32	1.64	757	119
Oct., grilled/broiled <sup>b</sup>	0.13	0.71	3.40	0.20	—	4.41	22.77	0.85	686	155
Oct., grilled/broiled <sup>c</sup>	0.13	0.71	3.40	—	—	4.21	22.77	0.85	686	163
Jan., grilled/broiled <sup>b</sup>	0.13	0.71	3.40	0.20	—	4.41	23.32	1.25	614	139
Jan., grilled/broiled <sup>c</sup>	0.13	0.71	3.40	—	—	4.21	23.32	1.25	614	146
Oct., air-dried <sup>d</sup>	0.13	0.71	3.40	0.20	10.75	15.16	22.77	0.85	686	45
Oct., air-dried <sup>e</sup>	0.13	0.71	3.40	—	2.75	6.96	22.77	0.85	686	99
Jan., air-dried <sup>d</sup>	0.13	0.71	3.40	0.20	12.02	16.43	23.32	1.25	614	37
Jan., air-dried <sup>e</sup>	0.13	0.71	3.40	—	4.02	8.23	23.32	1.25	614	75
Oct., smoked <sup>d</sup>	0.13	0.71	3.40	0.20	4.75	9.16	22.77	0.85	686	75
Oct., smoked <sup>e</sup>	0.13	0.71	3.40	—	2.75	6.96	22.77	0.85	686	99
Jan., smoked <sup>d</sup>	0.13	0.71	3.40	0.20	6.02	10.43	23.32	1.25	614	59
Jan., smoked <sup>e</sup>	0.13	0.71	3.40	—	4.02	8.23	23.32	1.25	614	75

<sup>a</sup> Other handling time includes the time it took to make a needle and thread and then string the oysters for drying and smoking—drying or smoking time is included whenever cooking time is included.

<sup>b</sup> Includes cooking time.

<sup>c</sup> Excludes cooking time.

<sup>d</sup> Includes cooking and drying/smoking time.

<sup>e</sup> Excludes cooking and drying/smoking time.

ciate culling and subsequent harvesting. On the other hand, separating individual oysters and dropping them back to the bottom also greatly increases their vulnerability to predation by crabs, starfish, and whelks (Randal Walker, personal commun.).

Recent changes in oyster habitat, management practices, and poaching in the waters surrounding St. Catherines Island make it difficult to estimate the accelerated return rates that are possible when the oyster beds are “nurtured” through thoughtful harvesting. Relative to aboriginal conditions, these low return rates for oyster procurement can likely be attributed to habitat deterioration, our reliance on “virgin beds” (patches that have not been enhanced by various oyster cultivation techniques). Above, we described the decline of the Georgian oysters beds at some length, citing the surveys of Drake (1891), Galtstoff and Luce (1930), Linton (1969), Harris (1980), and Walker and Cotton (2001). These studies clearly document both the declining quality of the oyster beds and also the degree to which the oyster patches reverted to a “virgin” state (because harvesting oysters increases both the overall quality of the bed and size of individual oysters). Given that all of our collection experiments took place in such “virgin” (unharvested and uncultivated) oyster beds, we could not employ the more productive “plucking” method described by Jones and Richman (1995) because the available specimens did not reflect the increased meat package size associated with “cultivated” oysters (see also Lunz, 1938).

Available information strongly suggests that individual oyster sizes have decreased over time. By comparing oyster shells from prehistoric coastal South Carolina middens with contemporary (1938) oysters harvested in nonpolluted South Carolina waters, Gunter (1938) found that the precolonial oysters were 61 percent longer and 43 percent wider than modern oysters. Though we presently lack suitably taxonomic specific, allometric models that would allow us to equate dimensional increases, of the variety suggested by Gunter (1938), with quantitative meat mass increases, we can still assume that the increased shell sizes observed do translate into

increased meat masses, and subsequently into increased return rates.

But we cannot take Gunter’s (1938) data at face value. As noted above, oysters that grow on a hard substrate within the subtidal zone tend to be larger and more round than those that grow on a softer substrate in the intertidal zone (Oemler, 1889: 3; Galtstoff, 1964: 18; Lorio and Malone, 1994). Gunter (1938) describes both the modern samples and the precolonial samples as being of the latter variety, hence attributing the increased size of the precolonial oysters entirely to environmental conditions and foraging strategies and intensities, rather than to habitat variation. This may not be correct. From personal observation of archaeological samples of oyster shells from St. Catherines Island, it appears that there is indeed variation in the oyster habitats that were exploited in the past—with both rounded and elongated oyster shells appearing in the archaeological record (Irvy Quitmyer, personal commun.). Further research is required here, both to illuminate past oyster habitat exploitation practices and also to learn more about decreasing oyster size through time.

Beyond the results calculated strictly from our experimental returns, table 7.3 provides estimated return rates for oysters—calculated from parameters adjusted to replicate aboriginal conditions. For mass collected oysters, return rates have been calculated in three different ways:

- We have eliminated the shucking component of processing time (considering it to be a part of the eating process—much like gnawing the meat from a bone).
- We have recalculated the meat yield for a bushel of oysters. As noted above, Gunter (1938) calculates that oyster shells were roughly 50 percent larger in the past, and though we know that equating this with a 50 percent increase in meat yield is not the correct allometric correlation, we will employ it as a gross estimate of past meat yields.
- We have also combined these two modifications for a third return rate estimate.

These same estimates have also been calibrated for summer weight oysters, using our experimentally obtained meat yield de-

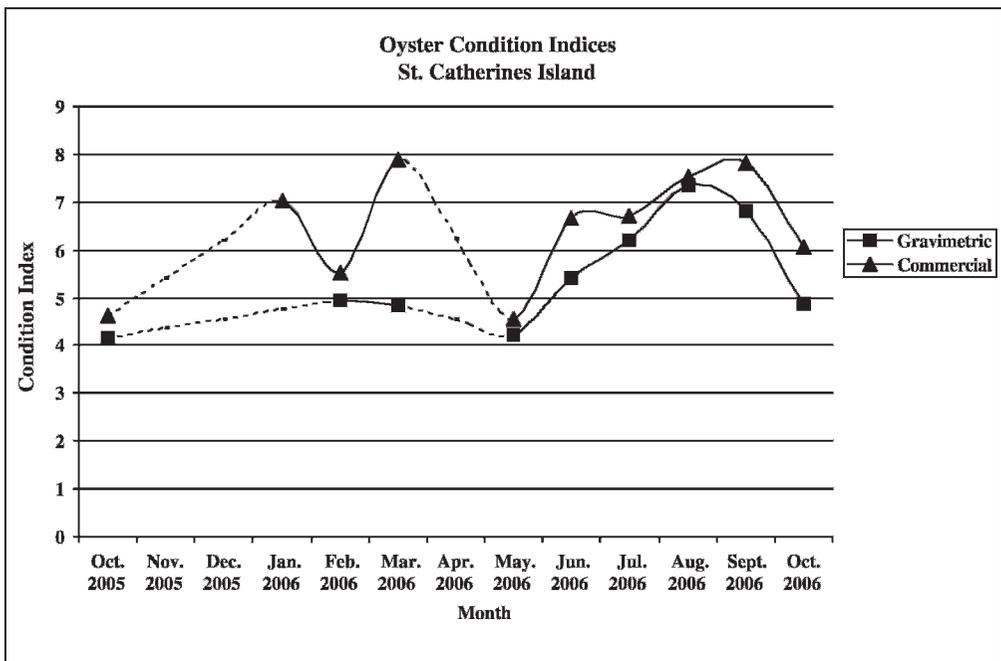


Fig. 7.8. Oyster condition indices for St. Catherines Island samples, with dotted lines connecting nonconsecutive samples. The “gravimetric condition index” has been calculated as  $CI = (100 \times \text{dry meat weight}) / (\text{live weight} - \text{shell weight})$ . The “commercial condition index” is  $CI = (100 \times \text{wet meat weight}) / (\text{live weight})$ .

creases discussed above. Using these new estimates, we arrive at a range of 209–1096 kcal/hr for winter oysters, and 231–1235 kcal/hr for summer oysters.

Table 7.3 also presents return rate estimates for oysters collected as singles and roasted open. These estimates are an attempt to reconstruct oyster return rates that better reflect oyster procurement from subtidal environments or for procurement from nonvirgin/cultivated beds—based on similar numbers produced by Jones and Richman (1995: 47) for *Mytilus californianus* harvested in the nonvirgin beds of Davenport Landing. Six different estimates are provided for both summer and winter conditions: using three different meat weight/individual values and both excluding and including shucking costs. The 5 g/individual estimate is obtained from Crook (1992), the 7.5 g/individual reflects the 50 percent increase provided by Gunter (1938), and the 13 g/individual is the high-end value obtained from Crook (1992)—hypothesizing today’s high-end value might reflect the av-

erage size in the past. As above, summer weight adjustments reflect our experimental results for meat package differences between October and January. The processing time components of cleaning and shucking were calculated from the mean rates obtained experimentally from mussels and clams. We hypothesize that shucking and cleaning oysters as singles would occur at a rate in between that of mussels and clams—in that they would be harder to clean and shuck than clams and easier than mussels (due to the lack of *byssal* threads—commonly called “beards”).

In addition to the lower than expected overall return rates, we were also puzzled by the results generated during our attempts to control for seasonality. We presumed that our two collection times, January and October, would reflect the seasonal difference between winter and summer oysters.<sup>17</sup> Although it is true that meat package size and meat yield increase considerably from October to January, standard nutritional analysis of these same specimens showed

significant drops in kilocalories, protein, fat, and carbohydrates in the January-collected oysters (while reflecting increases in moisture and ash). Although this nutritional decline is certainly tied to the oysters' reproductive cycle, we could not fully explain the results without a more extensive program of oyster collection and analysis.

For this reason, we began a more intensive study of seasonal variability in the oysters of St. Catherines Island. To augment our primary sample (collected in October 2005 with a January 2006 follow-up), we instigated a year-long systematic oyster collection project, with tighter monitoring of variables such as water temperature and salinity, begun in February 2006 and continued from May 2006 to May 2007.<sup>18</sup> To monitor the seasonal variability, oyster samples were gathered monthly from each of three standardized collecting stations, with live weight, shell weight, and meat weight recorded for all specimens. QC Laboratories conducted nutritional analyses of kilocalories, moisture, ash, protein, carbohydrates, fat, vitamin C, iodine, iron, and calcium content. This process, by subtraction, also produces dry weight values.

This project was designed to address three concerns: (1) to understand the seasonal fluctuation of meat yield or quality, (2) to model seasonal net energetics, and (3)

to assess the seasonal biochemical composition of oysters on St. Catherines Island. Initially, we had hoped to correlate our new empirical results with previously published studies (that suggest winter-harvested oysters are fat and full of carbohydrates, whereas summer-harvested oysters are watery and full of protein). Our preliminary results (we are still gathering samples for some missing months) do not easily correspond with previous work and may reflect important changes in the oyster reproductive cycle. Until we complete our collections and generate a year-round data set, however, we will postpone reporting these results.

To summarize: Despite more than two years of intensive experimentation with the modern oyster populations of St. Catherines Island, we are left with considerable uncertainty over post-encounter return rates relevant to the aboriginal period, with estimates ranging from 106 kcal/hr to 2759 kcal/hr (depending on the assumptions employed regarding meat weight, procurement, and processing times). Experiments continue at this writing, but for present purposes, we will employ midrange estimates of 750–1200 kcal/hr for mass collected oysters (all seasons), and 1000–1700 kcal/hr for oysters collected as singles (all seasons). For reasons discussed above, we think that both estimates provide a real-

TABLE 7.10  
Mussel Procurement Results (St. Catherines Island)

Trial no.	Collection zone	Collector/helper	Procurement time (hr)	No. specimens	Specimens/hr
O-1.1	Persimmon Point Marsh	LE/GM	0.25	697	2790
O-1.2	Persimmon Point Marsh	BM/SB	0.25	378	1512
O-1.3	Persimmon Point Marsh	RP/QO	0.25	307	1230
O-1.4	Persimmon Point Marsh	LH/RF	0.25	176	702
O-1.5	Persimmon Point Marsh	MS/AC	0.25	694	2778
O-1 trial mean	—	—	0.25	450	2076
O-2.1	Persimmon Point Marsh	GM/LE	0.17	377	2262
O-2.2	Persimmon Point Marsh	SB/BM	0.17	223	1338
O-2.3	Persimmon Point Marsh	QO/RP	0.17	111	666
O-2.4	Persimmon Point Marsh	RF/LH	0.17	336	2016
O-2.5	Persimmon Point Marsh	AC/MS	0.17	581	3486
O-2 trial mean	—	—	0.17	379	2274
Total mean	—	—	—	—	2178

istic post-encounter return rate for oysters throughout the aboriginal period.

**ATLANTIC RIBBED MUSSELS** (*GEUKENSIA DEMISSA*): Ribbed mussels range from the Gulf of St. Lawrence to northeastern Florida; in coastal Georgia, they generally live in patchy colonies on the hard marsh, high marsh grasslands, and mudflats; they also live in pockets among oyster reefs. Mussels grow hinge down, buried, with 2–3 cm of the shell projecting above the substrate, covered only by the highest tides. Atlantic ribbed mussels are thin-shelled, making them easy to locate and harvest (see also Larson, 1980a: 72).

Despite the common presence of mussel shells in archaeological sites of the area, we are unaware of any ethnohistoric accounts of mussel exploitation by Southeastern Indians and must look elsewhere for appropriate analogies. Jones and Richman (1995) summarize the relevant ethnographic evidence for mussel collection in aboriginal California. Simple hand collection by women and children seems to be the most common harvesting technique, although there are accounts of swimming and diving. The Chumash used a hardwood bar or stick (similar to a digging stick) or whale bone to knock the shellfish away, then transported the mussels in large collecting bags. Mussels were generally roasted or boiled on hot coals to open the shells. They were sometimes sun-dried to avoid spoilage (and sometimes traded in great numbers), then rehydrated by boiling (Gifford, 1939: 315; Kroeber and Barrett, 1960: 112; Greengo, 1952: 77). Mussels can live for days inside their shells, but spoil quickly when removed; this factor mitigates against field processing (Jones and Richman, 1995: 49).

As mentioned previously, Jones and Richman (1995) conducted harvesting experiments on the California sea mussel (*Mytilus californianus*), one of the most abundant bivalves found in the archaeological record of the west coast of North America. Hundreds of California shellmiddens demonstrate the extent to which aboriginal Californians exploited sea mussels, sometimes transporting mussel shells 25 km or more inland (Bettinger et al., 1997: 896).

In reporting their experiments of collecting *Mytilus californianus*, Jones and Richman (1995, table 4) report return rates of 543–574 kcal/hr (for harvesting by individual “plucking”), and 214–445 kcal/hr (for mass stripping, which includes many smaller individuals). Recent experiments in harvesting sea mussels at Bodega Bay (California) have confirmed Jones and Richman’s (1995) estimated return rates (Kennedy, 2004: 54–55, table 7).

With these Pacific Coast studies in mind, we conducted a series of mussel collecting and processing experiments on St. Catherine’s Island. These optimal foraging experiments were carried out in much the same way as the oyster experiments. We collected ribbed mussels from sediments of the intertidal zone, often with the assistance of a short digging stick. The primary collector gathered as many mussels as possible during 10–15-min trials, with a helper assisting by holding the collection bucket and by providing a second set of eyes during the search for mussels.

Table 7.10 details the individual results and summary statistics for our mussel collecting experiments. Two trials, O-1.4 and O-2.3, have extremely slow rates of collection, and we excluded these outliers when computing the overall sample mean for specimens collected per hour. Because both mussel trial groups in our experiments occurred at the same location, Persimmon Point Marsh (see fig. 7.2), and no individual collected more than once, we can infer nothing from our results regarding patch location or increased experience as variables affecting rates of mussel collection. Therefore we will use the total mean calculation for procurement time.

The resulting collection rate of 2178 mussels/hr allows us to calculate that during a 0.667-hr collection period, an average of 1450 mussels would be collected. Our experiments show that the ribbed mussels of St. Catherine’s Island average  $9.9 \text{ g} \pm 3.8 \text{ g}$ , with an average meat weight of  $2.5 \text{ g} \pm 1.1 \text{ g}$ , thus yielding 25.6 percent edible mass. Using these figures, we estimate that a standardized sample of 1450 mussels should yield 3626 g of mussel meat.

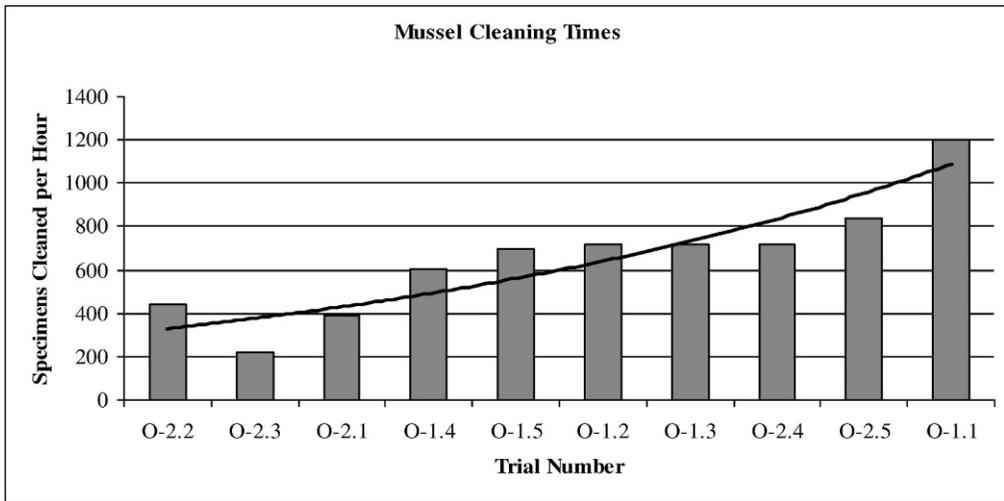


Fig. 7.9. Mussel cleaning results by time.

Following the collection time trials, teams of two experimenters cleaned the raw mussels using scrub brush and hose; we then recorded live weights and counts. We did not remove the mussel *byssal threads* (or “beards”) during the cleaning process (they were discarded as part of shucking the mussels). Our cleaning experiments suggested that mussel processing is influenced by increasing experience (fig. 7.9). Two individuals (LE and QO), who cleaned all the mussel samples, improved their cleaning rate (specimens cleaned per hour) between almost every trial. Accordingly, we will employ their final cleaning trial in our return rate calculations (because we think it best approximates the rate for an experienced aboriginal forager). We therefore estimate that the sample of 1450 mussels collected during a 0.667-hr interval could be cleaned in 1.21 hr (at a cleaning rate of 1198 specimens/hr).

The cleaned mussel samples were then broiled until open (the attempt being to simulate the dry, direct heat method of cooking over an open fire). As with the oyster experiments, we held cooking time as a constant, finding that 5 min under a broiler was sufficient to open all the valves.

We then shucked each mussel by hand (simply using fingers to rip the flesh from the shell). As indicated in table 7.11 the

shucking rates for mussels are perplexing because they generally decrease through time (suggesting increased experience somehow negatively impacts shucking speed for ribbed mussels). Although we cannot explain this trend, we do note that—unlike the cleaning component of handling time—we did not use the same selected individuals for each trial. Obviously, in our mussel shucking experiment, individual ability and experience influenced the handling rates, and for this reason, we will employ the mean shucking rate (rather than the most efficient rate) in the following calculations. We conclude that a standardized sample lot of 1450 ribbed mussels could be shucked in 4.15 hr (at a rate of 348 specimens/hr).

TABLE 7.11  
Mussel Shucking Results (St. Catherines Island)

Trial no.	Shuck order	Shuck time (hr)	No. specimens	Specimens/hr
O-1.4	1	0.35	176	504
O-2.2	2	0.45	223	498
O-1.3	3	1.00	307	306
O-2.1	4	1.10	377	342
O-2.4	5	1.46	336	228
O-1.2	6	1.33	378	282
O-2.5	7	2.07	581	282
Total mean	—	—	—	348

TABLE 7.12  
**Post-encounter Return Rates for Ribbed Mussels from St. Catherines Island**

Procurement time (hr)	No. specimens	Meat mass (kg)	Cleaning time (hr)	Cooking time (hr)	Shuck time (hr)	Total handling time (hr) <sup>a</sup>	Kcal/lot	Kcal/hr	Protein (g/hr)
0.67	1450	3.63	1.21	0.08	4.15	6.11	2363	387	74.7
0.67	1450	3.63	1.21	—	—	1.88	2363	1259	243.4

<sup>a</sup> Calculated both to include and exclude cooking and shucking handling times.

We must note that removing mussel meat from its shell is relatively easy, a low-intensity task. This differs markedly from oysters, which require considerable effort for both raw and cooked specimens. We think it reasonable to conclude that once a batch of mussels has been steamed and opened, the actual act of removing the meat should be considered as an act of consumption (rather than a component of handling time); after all, we do not include “roasting time” when computing the return rate for white-tailed deer (and we also do not include the time/energy involved in collecting firewood for the cooking process).

For this reason, we have calculated the return rates for ribbed mussels in two ways, both including and excluding “shucking time” (table 7.12). If we define handling time to include cooking and shucking, then the post-encounter return rate for ribbed mussels is 386.6 kcal/hr. But if, as we suggest above, consider the shucking time as an act of consumption, then the return rate increases to 1259 kcal/hr (which we consider to be a more realistic estimate).

Experimental results from the Pacific Coast of the United States also compare favorably with the St. Catherines Island return rates. Jones and Richman (1995), working in Monterey and Santa Cruz Counties (California), calculate a mean return rate of  $444.4 \pm 162.9$  kcal/hr for California sea mussels (*Mytilus californianus*), with a value of  $558.7 \pm 21.9$  when using a plucking method and a value of  $330.1 \pm 163.8$  when using a stripping method. Our return rate for mussels, 386.6 kcal/hr, is midway between these two values. Our results likewise agree with those of Kennedy (2004), who computes return rates of

469.7 kcal/hr for sea mussels collected at Bodega Bay, California.

For present purposes, we will employ the experimentally determined post-encounter return rate of 387–1259 kcal/hr for ribbed mussels on St. Catherines Island.

**HARD CLAMS (*MERCENARIA MERCENARIA*):** Hard clams (also known as northern quahogs) tend to live on a substrate of sandy mud (or shell) in the intertidal zone of coastal Georgia. Unlike hard clams further north along the mid-Atlantic coast, those in coastal Georgia are restricted to intertidal regions, usually growing among oysters on intertidal oyster bars, in the upper reaches of tidal creeks, and in small tidal creeks (Walker and Tenore, 1984: 21). Here, they exploit a range of microhabitats, such as along mud creek banks, in pools of water dammed by oyster reefs at low tide, in shell bottoms, along intertidal oyster beds, and amid marsh grass roots. They can also be found from the headwaters to the mouth of various salt marsh tidal creeks. *Mercenaria* are sometimes interspersed with oyster beds, but they also live in the uppermost reaches of tidal creeks and along small feeder creeks (places where oysters do not grow).<sup>19</sup> *Mercenaria* occur in a patchy distribution; in ideal habitats, local population densities up to 101 per square meter were recorded in intertidal regions of small creeks, headwaters of major creeks, and in shell deposits associated with oyster bars (Walker et al., 1980: 2–4; Walker and Tenore, 1984; Walker and Rawson, 1985; Walker, 1987).<sup>20</sup> Hard clams on the Georgia coast are available and safe to consume year-round.

The hard clam fishery in coastal Georgia dates back to the 1880s, while the peak landings of clams occurred in 1908 (Walker

and Stevens, 1988: table 1). Yields continued to decline into the 1930s, as commercial clamming in Georgia became sporadic. More recently, an increased demand coupled with pollution and overharvesting of northern waters has generated interest in reestablishing mariculture of *Mercenaria* in Georgia waters. Since 1981, largely due to the efforts of the Shellfish Research Laboratory (University of Georgia) and the Georgia Department of Natural Resources, the hard clam fishery in Georgia has reemerged. Today, *Mercenaria* is the most commercially important species of clam harvested in the United States (out of 14 species exploited). Despite the fact that hard clams account for only 7 percent of clams harvested, they also account for 53 percent of dockside value (Lorio and Malone, 1995: 1).

Some *Mercenaria* have been known to live for 3 decades, but they generally reach marketable size in 24 to 36 months. At harvest (with a length of 3–5 cm), a 3-year old hard clam has a meat weight of 18–20 g (although there is considerable variability in growth rates, with “fast growers” reaching twice the size of “slow growers” at 10–16 months of age). Blue crabs (*Callinectes sapidus*), one of the major predators of hard clams in the Southeast, can kill *Mercenaria* as long as 1.5 inches (Walker, 1987: 9). Other predators include mud crabs, whelks, sting rays, horseshoe crabs, and snails.

The extent and distribution of hard clams in Georgia is still largely unknown. Godwin (1967, 1968) surveyed a total of 432 stations in the estuaries and creeks of coastal Georgia. Finding hard clams at only 41 of the stations, he reported a mean clam density of 5 clams/m<sup>2</sup>. A resurvey that concentrated on the headwaters of major creeks, however, revealed small feeder creeks and existing clam beds with much higher densities, up to 100 clams/m<sup>2</sup> (Walker et al., 1980; Walker, 1983; Walker and Tenore, 1984: 21).

Because hard clams live just below the mud surface in the intertidal zone, their presence is easily detected by collectors walking over the tidal flats. This so-called treading involves standing in knee- to waist-

deep water, then waddling along with feet closely spaced and parallel, twisting them as they move sideways to feel the hard clams. Once located, clams are collected by hand (or by using one leg to scoot the clam up the other leg to be collected). This procedure is surprisingly effective, largely because of the absence of rocks in the marsh mud; virtually everything “felt” is a mollusk shell—often a live clam, but occasionally a dead clam valve, oyster shell, whelk shell, or piece of wood. Although never approaching the density of oysters, *Mercenaria* can be easily raked or simply picked out of the mud in great numbers. Larson (1980a: 68, 70) reports that simply by wading and collecting, he was able to harvest a bushel or more in less than 1 hr (which, if taken literally, translates to 45 liter/hr).<sup>21</sup>

Fr. Andrés had a similar experience with gathering clams in the waters near St. Augustine in 1595:

Being engaged in this fishing, when it was already low tide and when the water in that arm was below the knee, the [Spanish] solider said to me that if I wanted clams that I should get out of the canoe and gather them while he took the fish with the casting net. I lowered myself into the water and in place of putting my feet on the sand or mud, I put them on top of clams (*almejas*) as big as a fist, and with both hands, as if I were taking them from a pile, I threw as many as I wished into the canoe. From this abundance of clams and from what I have said about the oysters, one can gather how abundant is every type of shellfish in this land of Florida. (de San Miguel, 2001: 73)

As with oysters, there is some ethnographic evidence indicating that clam meat was sometimes preserved for subsequent consumption. Writing in the mid-18th century, Peter Kalm described how the Indians of coastal New York dried quahog clam meat:

When these people inhabited the coast they were able to catch their clams, which at that time made a great part their food; but at present this is the business of the Dutch and English, who live in Long Island and other maritime provinces. As soon as the shells are caught, the fish is taken out of them, drawn upon a wire, and hung up in the open air, in

order to dry by the heat of the sun. When this is done, the flesh is put into the proper boats, and carried to Albany upon the river Hudson; there the Indians buy them, and reckon them one of their best dishes. Besides the Europeans, many of the native Indians come annually down to the sea-shore, in order to catch clams, proceeding with them in the manner I have just described. (Kalm [1749], 1937)

Commenting on the role of hard clams in the diet of coastal Indians in the northeastern United States, Ingersoll (1883: 598) observed:

The Indians, who had no machinery for aiding them, caught them by wading in and feeling for them with their toes, something the early colonists quickly learned to do. Another way was by diving; this was the work of the [women] and the older children, and was, of course, exceedingly laborious. The chief use of clams in the early days was in summer and fall. Then the Indians came to the sea-shore for their greatest festival, that of green corn. On such occasions a great assembling of sages and warriors with their families was held at the beach. Clams, succulent ears of corn, and seaweed were roasted together in astonishing quantity. So good a custom merited perpetuation, and has, indeed, survived to the present day in the "clam-bake."

Ingersoll (1883) also mentioned that the Indians preserved quahogs and oysters for winter use by drying their meat in the sun on pieces of bark (quoted in MacKenzie et al., 2002).

When it comes to *estimating return rates*, MacKenzie et al. (2002) estimated the variability in edible meat/bushel along the coast of eastern North America:

10–12 lbs/bushel (4.55–5.46 kg/bushel) in coastal New England  
 8–10 lbs/bushel (3.64–4.55 kg/bushel) along the New York/New Jersey coast  
 6–8 lbs/bushel (2.73–3.64 kg/bushel) in the Virginia tidewater  
 8 lbs (3.64 kg/bushel) for the Carolina–Georgia–Florida coastline.

Experiments conducted by the Harbor Branch Oceanographic Institute (2005) in

Ft. Pierce, Florida, indicate that hard clams average about 60 lbs/bushel (27.22 kg/bushel; <http://www.hboi.edu>). The average of 15 percent edible meat/clam (cited in Waselkov, 1987: table 3.2) seems slightly high. Figures cited in MacKenzie et al. (2002) indicate that the live weight/edible meat weight ratio ranges between 7.5 percent and 16.1 percent along the Atlantic coast. But it is important to note that the contemporary population of hard clams in the St. Catherines Island marshes is rarely harvested. It is possible that, with more sustained usage, the collection times would likely increase (perhaps significantly).<sup>22</sup> MacKenzie (1992) records that a single "treading" forager working in the waters of Raritan Bay, New Jersey, could collect up to 4 bushels of *Mercenaria* in 2 hr. Under such conditions, the collection time is 0.5 hr/bushel. MacKenzie suggests an average meat weight of 3.64 kg/bushel for this area, which leads to an overall estimated return rate of 1210 kcal/hr.<sup>23</sup>

We can compare these figures with those derived from our own experiments on St. Catherines Island, which followed the general protocols already discussed for the oyster and mussel experiments. We collected hard clams from sediments in the bottom of saltwater creeks just below the low tide water line. In seeking productive patches, we could fortunately draw on the experience of Bud and Jude Rollins, who had been studying the dynamics of hard clam populations of St. Catherines Island for the past 3 decades (Morris and Rollins, 1977; Rollins et al., 1990; Prezant et al., 2002). They pointed us to our two collection areas: The King New Ground Boiler Marsh patch and the South King New Ground Field patch (see fig. 7.2). Our experimental teams collected hard clams either for a 10-min time trial or until one-half bushel of clams had been procured—which ever occurred first. Some experiments involved an assistant/follower, others did not.

Table 7.13 sets out the results from our various clam collection trials. In the calculations below, we will employ our most efficient and most consistent procurement rate (trials O-3), for a mean value of

TABLE 7.13  
Clam Procurement Results (St. Catherines Island)

Trial no.	Collection zone	Collector/helper	Procurement time (hr)	No. specimens	Specimens/hr
O-1.1	King New Ground Boiler Marsh	BM	0.12	109	936
O-1.2	King New Ground Boiler Marsh	LE	0.17	59	354
O-1.3	King New Ground Boiler Marsh	EB	0.17	113	678
Trial O-1 mean	—	—	0.15	94	654
O-2.1	King New Ground Boiler Marsh	BM	0.17	94	564
O-2.2	King New Ground Boiler Marsh	LE	0.17	59	354
O-2.3	King New Ground Boiler Marsh	EB	0.17	46	276
Trial O-2 mean	—	—	0.17	66	396
O-3.1	King New Ground Marsh South	LE/RP	0.16	127	780
O-3.2	King New Ground Marsh South	RF/GM	0.09	103	1122
O-3.3	King New Ground Marsh South	RP/LE	0.09	102	1080
O-3.4	King New Ground Marsh South	GM/RF	0.13	120	900
Trial O-3 mean	—	—	0.12	113	972
Total mean	—	—	0.14	93	702

972 clams/hr. From this rate, we estimate that an average of 648 clams would be collected during a standardized 0.67-hr collection interval. Based on the hard clams collected on St. Catherines Island, we estimate the average live weight of hard clams to be  $93.4 \text{ g} \pm 36.2 \text{ g}$  with a mean meat weight of  $8.4 \text{ g} \pm 3.7 \text{ g}$ , for an average edible portion ranging from 7.0 to 10.5 percent. Extrapolating these estimates, we conclude that our control sample of 648 clams should yield 5.44 kg of edible clam meat.<sup>24</sup>

Following our collection time trials, two-person teams cleaned the hard clams using a garden hose, then recorded lot weights and counts (table 7.14). Compared with the other bivalves studied in the St. Catherines Island experiments, *Mercenaria* are very easily cleaned, having none of the attendant difficulties associated with clumps of oysters or mussel *bissels*. In subsequent calculations, we will employ the O-2 cleaning trial, which translates into a mean cleaning time of 0.61 hr for a standardized lot of 648 hard clams.

We steamed the clams for a standardized interval of 25 min, which was sufficient to open all the valves, and then "shucked" them, with teams of four experimenters using their fingers to dislodge the flesh from the shells. We conducted only three such

clam shucking trials because, as with ribbed mussels, we determined that clam meats could be removed with incredible ease (making further trials redundant). Using our best experimental rate of 818 clams/hr, we estimate that our standardized lot of 648 hard clams can be shucked in 0.79 hr.

Table 7.15 summarizes the calculations for post-encounter return rates for *Mercenaria* recovered in the saltwater creeks abutting St. Catherines Island. As with the ribbed mussel experiments, we present two different sets of calculations (with and without cooking and shucking times). If we include all possible handling times, then the return rate for hard clams is 2246 kcal/hr. But if we amortize the costs of roasting and shucking as an act of "consumption" rather than "handling", then the return rate increases to 4379 kcal/hr.

In either case, *Mercenaria* procurement within the modern St. Catherines Island environment is a much higher-ranking strategy than either oyster or ribbed mussel harvesting. Both figures are likewise much more efficient than those suggested by MacKenzie (1992) for Raritan Bay, New Jersey. This efficiency leads one to wonder why clams do not comprise a larger component of St. Catherines' shell middens. This

TABLE 7.14  
Clam Processing Results (St. Catherines Island)

Trial no.	Cleaning time (hr)	No. specimens	Specimens/hr
O-1.1	0.17	109	654
O-1.2	0.07	59	888
O-1.3	0.13	113	846
Trial O-1 mean	—	—	798
O-2.1	0.10	94	942
O-2.2	0.07	59	888
O-2.3	0.03	46	1380
Trial O-2 mean	—	—	1068
O-3.1	0.12	127	1026
O-3.2	0.11	103	966
O-3.3	0.16	102	642
O-3.4	0.09	120	1308
Trial O-3 mean	—	—	984
Total mean	—	—	954

relative absence is almost certainly tied to habitat conditions of coastal Georgia—conditions that ensure that the hard clam is less abundant and less predictably available than the oyster (see Rollins, submitted manuscript).

For present purposes, we will employ the experimentally determined post-encounter return rate of 2246–4379 kcal/hr for hard clams harvested on St. Catherines Island.

**MARSH PERIWINKLE (*LITTORINA IRRORATA*):** Periwinkles, also known as marsh snails, are common in archaeological middens of the Georgia and South Carolina coast (e.g., Kings Bay; see Quitmyer, 1985: 32). On St. Catherines Island, *L. irrorata* are particularly abundant in the high marsh habitats, are commonly attached to the stems of *Spartina alterni-*

*flora*, and occur in densities up to 174 individuals/m<sup>2</sup> (Fierstien and Rollins, 1987: 21–22). More recent research (Silliman and Newall, 2004) indicates that marsh snails do not actually eat the live plant stalks, and instead they subsist on fungi growing on the cordgrass leaves. The shell of the periwinkle is sealed by a horny, protective operculum, attached to the foot, an adaptive mechanism to protect against desiccation (Johnson et al., 1974: 81).

Periwinkles are available year round and easily harvested by simply picking them off grass stems. They can be boiled whole or extracted after the apex is removed (Quitmyer, 1985: 32). Periwinkles are considered a delicacy in some locales, sometimes marketed in Cantonese restaurants as “sea snails”. As such, they are often served in a heap covered with hot chili and black bean sauce (with plenty of garlic). The little shells look like miniature escargot, and the nugget of meat is prized out with a toothpick.

We began our collecting and handling experiments on periwinkles (*Littorina irrorata*) living on St. Catherines Island in January 2005. After some casual reconnaissance, we selected a promising patch of periwinkles in the hard marsh immediately to the west of the wooden walkway and floating dock at South End Settlement. The patch consisted of numerous *Littorina* growing on the stalks of *Spartina alterniflora*. The periwinkles were fairly densely concentrated (although we have certainly observed concentrations of even greater density on the island; see also Fierstien and Rollins, 1987). Within this patch we collected periwinkles from two slightly different environments: the first (South End

TABLE 7.15  
Post-encounter Return Rate Calculations for Hard Clams from St. Catherines Island

Procurement time (hr)	No. specimens	Cleaning time (hr)	Cooking time (hr)	Shucking time (hr)	Total handling time (hr) <sup>a</sup>	Meat mass (kg)	Kcal/100 g	Kcal/lot	Kcal/hr	Protein (g/hr)
0.67	648	0.61	0.42	0.79	2.48	5.44	102	5573	2246	411
0.67	648	0.61	—	—	1.27	5.44	102	5573	4379	801

<sup>a</sup> Calculated to both include and exclude cooking and shucking handling times.

TABLE 7.16  
Periwinkle Procurement Results (St. Catherines Island)

Trial no.	Collection zone	Collector/helper	Procurement time (hr)	No. specimens	Specimens/hr
J-1.1	South End Dock II	MT/MS	0.33	942	2826
J-1.2	South End Dock II	ND/EB	0.33	773	2322
Trial J-1 mean	—	—	—	858	2574
J-2.1	South End Dock III	MS/MT	0.33	1120	3360
J-2.2	South End Dock III	EB/ND	0.33	1252	3756
Trial J-2 mean	—	—	—	1186	3558
O-1.1	Persimmon Point Marsh	LE/GM	0.17	141	846
O-1.2	Persimmon Point Marsh	BM/SB	0.17	487	2922
O-1.3	Persimmon Point Marsh	RP/QO	0.17	310	1860
O-1.4	Persimmon Point Marsh	LH/RF	0.17	313	1878
O-1.5	Persimmon Point Marsh	MS/AC	0.17	671	4026
Trial O-1 mean	—	—	—	384	2304
O-2.1	Persimmon Point Marsh	QO/RP	0.17	194	1164
O-2.2	Persimmon Point Marsh	GM/LE	0.17	353	2118
O-2.3	Persimmon Point Marsh	SB/BM	0.17	653	3918
O-2.4	Persimmon Point Marsh	RF/LH	0.17	525	3150
O-2.5	Persimmon Point Marsh	AC/MS	0.17	347	2082
Trial O-2 mean	—	—	—	414	2484
Total mean	—	—	—	—	2586

Dock Patch II) from a high marsh habitat with slightly soft mud and few periwinkles on the plant stalks and the second (South End Dock Patch III) from the highest portion of the hard marsh—with slightly harder mud and periwinkles sitting more above the surface of the marsh (see fig. 7.2).

In January, four novice foragers collected periwinkles for 20-min intervals. Each experimenter was asked to work swiftly and effectively, but not to hurry or to race each other. During our archaeological fieldwork during October 2005, we noted the density of periwinkles clinging to the stalks of taller specimens of *Spartina alterniflora*, and we decided to expand our previous foraging experiments on periwinkles. The stalks were approximately 1.5 m tall, with periwinkles clinging to them at roughly two thirds of their height above the ground. Specimens were collected by grabbing a stalk below the specimens and then running one's hand along the length of the stalk to remove the periwinkles. In our collecting time trials, the primary collector gathered as many periwinkles as possible during 10-min trials,

while the follower/assistant provided a second set of eyes and help holding the collecting bag (see table 7.16).

Our results, averaged over all 14 trials conducted during January and October, was  $2586 \pm 996$  periwinkles/hr with a mean size of 0.675 g/individual. During our collection experiments we had expected that Persimmon Point Marsh, with the tall stalks of *Spartina alterniflora*, should provide the best environment for collecting periwinkle. But looking at individual results, it is difficult to conclude that one patch was actually more productive than another—especially since the best and worst collection rates occurred at Persimmon Point Marsh. We likewise lack data to address whether increased experience actually influences the collection rates. Accordingly, we will use the total sample mean rate of 2586 periwinkles/hr in our calculations estimating the post-encounter return rate. In so doing, we conclude that during a standardized, 40-min collection episode, one should harvest 1725 periwinkles, which would weigh, in the aggregate, 1.16 kg.

TABLE 7.17  
**Periwinkle Cleaning Results**  
**(St. Catherines Island)**

Trial no.	No. specimens	Cleaning time (min)	Specimens/min
O-1.1	141	0.88	160
O-1.2	487	1.17	416
O-1.3	310	1.65	188
O-1.4	313	1.15	272
O-1.5	671	1.08	621
Trial O-1 mean	384	1.19	332
O-2.1	194	0.88	221
O-2.2	353	0.82	431
O-2.3	653	1.00	653
O-2.4	525	1.13	465
O-2.5	347	0.93	373
Trial O-2 mean	414	0.95	428
Total mean	—	1.07	380

Following the collecting time trials, we washed, cooked, and extracted the edible meat from the periwinkles. Cleaning periwinkles is an extremely simple task, requiring only a basket and a water source (we used a colander and a hose; see table 7.17). Our team could clean an average of 380 periwinkles/min (permitting us to estimate that our standardized sample of 1725 periwinkles could be cleaned in only 4.54 min).

We then experimented with various ways of handling the periwinkles to facilitate consumption. In January we found that baking the live periwinkles for 20 min (at 200–300° F) worked best. During the October experiments, we elected to boil all periwinkle samples in sea water for 10 min. Following Gibbons (1964: 78), we found this process to be the most effective because seawater “serves to shrink and toughen the meat of the periwinkle until it can be ‘unscrewed’ from the shell in one piece.”

To extract the cooked meat from the valve aperture, we found that a small (#12) long-shanked fishhook worked quite well. We conducted 11 trials during January and October, with crews of one to four members working for 10- and 15-min intervals. A total of 1135 periwinkles were handled with a mean meat yield of 0.19 g of meat per specimen. Table 7.18 details our picking results, including rates of extraction

and meat mass per specimen. For our calculations we have used the October trial mean of 222 periwinkles/hr, a rate obtained with consistent cooking times and extraction methods (and which seems to represent a set of trials that show improvement through increased periwinkle picking experience). So doing, we calculate that our standardized lot of 1725 periwinkles could be picked from their shells in 7.71 hr and would yield 0.33 kg of meat.

We also processed periwinkles from St. Catherines Island by using a smash-and-winnow technique, meaning that the cleaned periwinkles were smashed with a mortar and pestle, then winnowed from their shells by water sorting. This method has been described ethnographically for the Southwestern Pomo and the Mattole of California, who used this technique on turban snails (Kennedy, 2004: 47; Gifford 1967: 21; Kroeber and Barrett, 1960: 113). Raab (1992) has found some archaeological evidence on San Clemente Island, California, suggesting the antiquity of this technique, and Kennedy (2004) employed the smash-and-winnow technique experimentally. Table 7.19 shows the results of our smash-and-winnow extraction experiments (unfortunately, the first two such trials were carried out without first acquiring specimen counts). The estimated values are computed based on rates from the second two trials. If we rely on the mean of the final two trials for extraction time and meat yield, we find that the standardized lot of periwinkles would yield 0.28 kg of edible meat in 1.18 hr. Although more meat is clearly lost during processing using the smash-and-winnow technique, the significant increase in extraction rate makes it a much more efficient and productive process.

By combining the handling rates derived above with the nutritional values obtained from QC Laboratories (table 7.1), we calculate a post-encounter return rate of 26.1 kcal/hr for individual picking of periwinkles and 90.7 kcal/hr for the smash-and-winnow technique (see table 7.3).

While excavating the St. Catherines Island Shell Ring (9Li231) in May of 2006, we recovered numerous archaeological per-

TABLE 7.18  
**Periwinkle Picking Results (St. Catherines Island)**

Picking trial no.	Cooking time (hr)	Shucking time (hr)	No. specimens	Meat mass (g)	Specimens/hr	Meat mass (g)/specimen
1-J	0.33	0.17	46	8.7	276	0.19
2-J	0.33	0.17	28	6.7	168	0.24
3-J	0.33	0.17	13	2.7	78	0.21
4-J	0.08	0.33	68	14.7	204	0.22
5-J	0.17	0.33	53	12.6	162	0.24
6-J	0.25	0.33	75	24.2	228	0.32
7-J	0.33	0.33	95	14.7	288	0.15
J trial mean	—	—	—	—	198	0.22
1-O	0.17	1.00	163	19.3	162	0.12
2-O	0.17	1.00	221	26.2	222	0.12
3-O	0.17	1.00	235	28.7	234	0.12
4-O	0.17	0.50	138	23.2	276	0.17
O trial mean	—	—	—	—	222	0.13
Total mean	—	—	—	—	210	0.19

iwinkle specimens, and initial observations suggested to us that many of these had been processed through the removal of the spire of the shell (also the method of processing when served in Cantonese restaurants). These specimens, as well as modern periwinkle from the adjacent Long Field Marsh, impressionistically seemed larger than the other modern samples we had been studying, and in order to further examine these observations, additional periwinkle foraging and processing experiments were conducted. At this time periwinkles were collected during a 10-min period, live weights and counts were obtained for each sample, and the periwinkles were processed.

One lot of 137 periwinkles was boiled for 10 min, picked from the shell with pins, and had its meat weight and shell weight re-

corded. This lot was subsequently sent to QC laboratories for nutritional analysis. Another lot of 363 periwinkles had its spires removed with a cleaver (this process was timed) and the entire lot was boiled into a soup. This soup, including broth, was also sent to QC laboratories for nutritional analysis. Surprisingly, these samples (excluding the soup broth) had significantly higher numbers of kcal/100 g than our earlier samples. This could be due to issues of periwinkle seasonality and habitat or it could be a result of the small samples with which we were working. Further work would be needed to resolve this issue.

These additional experiments both confirmed and refuted some of our impressionistic observations. The meat yield of the Long Field Marsh samples was not larger

TABLE 7.19  
**Periwinkle Smash-and-Winnow Results (St. Catherines Island)**

Trial no.	Shuck time (hr)	No. specimens	Meat mass (g)	Total mass (g)	Meat (g)/specimen	Specimens/min	Total mass (g)/specimen
5-O	0.36	248 <sup>a</sup>	25.2	198.5	<i>0.10</i>	<i>11.37</i>	<i>0.80</i>
6-O	0.32	710	63.1	568.2	<i>0.09</i>	<i>37.38</i>	<i>0.80</i>
7-O	0.18	243	38.0	200.0	0.16	22.65	0.82
8-O	0.16	255	42.2	200.0	0.17	26.15	0.78
Mean	—	—	—	—	0.16	24.40	0.80

<sup>a</sup> Numbers in italics are estimated and have not been included in the mean values.

per individual than other samples we had processed (though we have not yet determined how the size of the archaeological specimens compares with the modern samples). Our experiments indicate, however, that removing the spires of the periwinkles is a workable processing method. Using this method we were able to obtain a maximum processing rate of one periwinkle every 3 sec. Boiling periwinkles that had been processed by spire removal into soup created a flavorful broth and caused them to release from their shells to an extent that they could easily be extracted during consumption. Using these new handling rates we calculate a return rate of 135 kcal/hr for Long Field Marsh periwinkles. These same techniques combined with our earlier nutritional results yield a post-encounter return rate of 88 kcal/hr (see table 7.3). Regardless of which nutritional values are used, the return rates generated by both the smash-and-winnow technique and the spire removal are comparable—though the spire removal results are perhaps more interesting in that we have observed archaeological evidence of spire removal and have observed no evidence of a smash and winnow process in the St. Catherines' archaeological record.

Although comparable return rates are not available for the eastern seaboard, we do note that Kennedy (2004) has generated return rates for three snail taxa that correspond closely to our findings for periwinkles; *Tegula funebris* (black turban snails) and *Tegula brunnea* (brown turban snails) were processed with a technique comparable to our smash-and-winnow technique, generating return rates of  $114.14 \pm 40.11$  and  $90.58 \pm 12.25$  kcal/hr, respectively. This matches well with our comparable return rate for periwinkle of 90.70 kcal/hr when using the smash-and-winnow technique. Kennedy's results for dogwinkle (*Nucella emarginata* and *Nucella canaliculata*), 41.43 kcal/hr, are likewise comparable to our periwinkle results, although it is unclear whether he obtained this result through individual picking or through a smash-and-winnow process. Ferneau (1998: 93–97) conducted a turban snail experiment at San Luis Obispo, generating

a return rate of 64.68 kcal/hr, while using an individual picking method (and excluding cooking time in his calculations); this result is quite similar to our periwinkle results of 26.6 kcal/hr.

For present purposes, we will employ the experimentally determined post-encounter return rate of 26–138 kcal/hr for marsh periwinkles harvested on St. Catherines Island.

**WHELKS:** Four species of whelk (Family Melongenidae) occur in Georgia waters (Walker, 1988): Knobbed whelk (*Busycon carica*) is the most abundant species, followed by lightning whelk (*Busycon sinistrum*) and pear whelk (*Busycotypus spiratus*), which is uncommon in Georgia, but common in Florida. The modern range of channeled whelk (*Busycotypus canaliculatum*) extends only northward to northeastern Florida. Whelks were important to aboriginal peoples as a food source. Additionally, because coastal Georgia lacks lithic resources, whelk shell was commonly fashioned into implements and ornaments.

The shells of knobbed whelks can sometimes grow to up to 9 inches in length, although they are significantly smaller than Queen Conch (*Strombus gigas*). This large marine shell common to Caribbean waters has a large and heavy shell often that often weighs 5 lbs and that grows to more than 30 cm (Larson, 1980a: 76).

Whelks are both predators and scavengers, preying on marine bivalves such as oysters, clams, mussels, scallops, and arks; in some Atlantic waters, *Busycon* whelks are controlled as pests to protect the shellfishery. In Georgia, whelks inhabit the numerous saltwater creeks and rivers that dissect the extensive coastal salt marsh.

The whelk is probably the most serious predator in the oyster beds (although oyster drills and many fishes, such as black drum, also prey on oysters); channeled whelks are primarily scavengers, whereas knobbed and lightning whelks are predators that attack oysters and clams (and rarely eat carrion).

Whelks are generally found in the subtidal areas along the Georgia coast or in underwater areas below the lowest tidal level. They move by crawling on their massive

foot muscle. During the spring and fall, when whelks migrate into the intertidal oyster reefs to search for oysters and clams, they are easily exposed and collected at low tide (Walker et al., 2004). During winter and summer, when the whelks cannot survive the extreme air temperatures, they are generally absent on the intertidal flats, remaining in the subtidal area, where they generally prey on arks (a primitive bivalve, *Anadara* sp.).

Commercial whelk fishing began in coastal Georgia in 1980, largely because blue crab fishermen could also harvest channeled whelk as a by-product (because other whelk species will not enter the trap). Until 1997, whelk harvesting was managed under the crab trawl regulations. With poor shrimp harvest in coastal waters, however, an intensification of whelk fishing began the late 1980s and early 1990s. After the shrimping season closes along the Georgia coast, some local fishermen trawl for whelks (during the winter through the early spring). Whelks are also sometimes harvested on encounters by commercial shellfishers, who will often pick up knobbed whelks, lightning whelks, and channeled whelks in the intertidal zone while gathering oysters and clams.

Although all four species are fished commercially, knobbed whelk is the most important because it is the most abundant in coastal Georgia (Walker, 1988). Whereas knobbed whelks are generally fished offshore by shrimp boats working the off-season, the channeled whelk is most commonly harvested inshore as a by-product of blue crab trawling. Whelk meat is today in great demand for use in conch chowder, salads, fritters, and in Italian cuisine (served as scungilli). As the numbers of Caribbean Queen conch decline, Georgia whelks are marketed elsewhere as "conchs", which they are not (Georgia whelks belong to the Family Melongenidae, while true conchs belong to the Family Strombidae).

Whelk size can be estimated from data generated in recent trawl catches from the Georgia coast (Alan Power, University of Georgia, personal commun.). For male channeled whelks (*Busycon canaliculatum*),

the mean weight is 55.61 g ( $\pm$  28.80;  $n$  = 687); for females, the mean weight is 81.53 g ( $\pm$  66.79,  $n$  = 909). For channeled whelks from South Carolina, Anderson et al. (1985) reports an overall mean weight of 141.5 g (shell weight = 60.1 g; tissue wet weight = 81.4 g). For present purposes, we will employ an overall mean weight of 100 g for channeled whelks.

For male knobbed whelks (*Busycon carica*) from the Georgia trawl data, the mean weight is 103.7 g (standard deviation = 55.49 g); for female channeled whelks, the mean weight is 150.99 g ( $\pm$  61.57). Anderson et al. (1985) report similar figures from South Carolina: mean male weight for *B. carica* is 149.8 g and female mean weight is 299.6 g (with a 27% wet tissue weight/overall total weight). Georgia's Department of Natural Resources employs a live weight/meat weight ratio of 3:1 for commercial whelk harvesters (Patrick Geer, DNR, personal commun.), which corresponds well with the 26 percent to 27 percent proportions noted above.

In conversations with Gale A. Bishop, who was directing the sea turtle program on St. Catherines Island in May 2006, we devised a brief experiment to estimate post-encounter return rates for the knobbed whelk populations (*Busycon carica*) available locally. On Thursday, May 18, 2006, Bishop traversed the low tide line of lower South Beach to determine whether knobbed whelks were present. After encountering the first whelk at dead low tide, he marked the position with a stake and collected for 51 min, slowly driving along the low tide line, collecting whelks as they were identified by their beach signature. During this interval, Bishop encountered and collected 20 whelks (2 channeled whelks and 18 knobbed whelks), plus five Atlantic Lettered Olives (*Oliva sayana*) and five Moon Snails (*Polinices dullicatus*) (one each were collected for the sample). During the collection he made three miscalls on the presence of a whelk based upon its sedimentary signature. After placing wet sand and fresh sea water over the sampled specimens, Bishop continued to monitor South Beach for sea turtle crawlways.

The beach signature for knobbed and channeled whelks is a sand “trap door”, a wet, cohesive clump of sand that is lifted above the whelk as it moves horizontally beneath the sand, searching through the near-shore habitat for preferred food items such as bivalves (Bishop, 1975; personal commun.). Whelks attack their prey with their aperture margins, rocking, pulling, and grinding the bivalve until the whelk’s powerful foot succeeds in opening the bivalve, after which the whelk’s proboscis is inserted and the inner bivalve contents consumed. Such attacks frequently break or abrade the whelk’s aperture margin, forming irregular, rehealed breaks in the growth pattern.

The collection patch for knobbed and channeled whelks lies very low along the sandy beach, at the lower part of the foreshore (with occasional whelks washed higher by waves). Bishop (personal commun.) believes, but has never proven, that the size of the whelks may increase subtidally, meaning that the exposed lower foreshore today might be hosting young animals who inhabit the fringes of the “best” habitat. During a spring tide, more of the lower foreshore would be exposed (to an elevation of  $-0.01$  m) and “whelk hunting” should be much more productive.

On the basis of Bishop’s experiment, we estimate the post-encounter procurement time for harvesting channeled whelks to be roughly 1 min/organism. Blair then processed Bishop’s whelk harvest, recording live weight for each specimen. The edible portion was then extracted by hooking the foot of each whelk with a fish hook and suspending the organism until the meat detached from the shell or until the muscle could be easily severed from the shell with a knife.<sup>25</sup> After separating the guts and operculum from the edible portion, the shell, gut, operculum, and meat weights were recorded (table 7.20). One sample of whelk meat was sent to QC laboratories for nutritional analysis (see table 7.1), providing a result of 87 kcal/100 g.

As indicated in table 7.20, the average live weight of this sample of knobbed whelks is  $0.175 \pm 0.134$  kg, and the edible portion averages  $5.30 \pm 2.06$  percent. When

this edible portion is calibrated for moisture lost during the extraction process, the usable percent is in almost perfect agreement with the wet tissue weight percentages above. In the calculations of table 7.3, we employ our localized mean live weight of 0.175 kg, an edible weight of 30 percent, and a minimal collection time upon encounter (0.0167 hr/individual). For channel whelks we use a mean live weight of 100 g due to the limited sample size. Based upon our own experiments, we will assume that the edible meat can be extracted and cleaned within a single minute per individual.

Taking into account all of these assumptions, we compute a post-encounter return rate of 1381 kcal/hr for knobbed whelk and 1231 kcal/hr for channeled whelk.

**BLUE CRAB:** Of the several species of crab found along coastal Georgia, blue crab (*Callinectes sapidus*) is the largest and most abundant, found year-round throughout the lower reaches of the estuary. Blue crabs mate in shallow, near shore waters from March to July and October to December. They are readily taken with dip nets, seines, tongs, pointed sticks, traps, or baited lines (Quitmyer, 1985: 29).

In a limited experiment (conducted in January 2005), we trapped a dozen crabs in McQueens Inlet and prepared them for consumption under controlled conditions. We do not know specifically how aboriginal foragers took blue crabs, but we estimate a collection time of 2.5 min (0.042 hr)/individual. The crabs weigh an average of 0.20 kg/individual. After boiling the crabs (which took about 0.33 hr/lot), we hand-picked the meat from each one (averaging 0.05 hr/individual); these blue crabs averaged 20 percent usable meat/individual. Using a standardized collection time of 40 min (0.667 hr), yielding a lot of 16 crabs, in table 7.3, we compute the post-encounter return rate for an individual blue crab to be 310 kcal/hr.

#### SALTWATER FISHING

Figure 7.10 reproduces John White’s classic watercolor of coastal Indians of

TABLE 7.20  
**Experimental Results for Whelks Harvested on South Beach, St. Catherines Island**

Specimen no.	Taxon	Live wt. (kg)	Meat wt. (kg)	Operculum wt. (kg)	Gut wt. (kg)	Shell wt. (kg)	Edible portion (%)
1	<i>Busycon carica</i>	0.535	0.048	0.004	0.017	0.388	9.02
3	<i>Busycon carica</i>	0.349	0.013	0.001	0.008	0.229	3.80
4	<i>Busycon carica</i>	0.120	0.004	0.001	0.001	0.088	3.64
5	<i>Busycon carica</i>	0.082	0.004	0.000	0.001	0.066	5.45
6	<i>Busycon carica</i>	0.089	0.005	0.000	0.002	0.066	5.90
7	<i>Busycon carica</i>	0.192	0.006	0.000	0.002	0.143	3.02
8	<i>Busycotypus canaliculatum</i>	0.113	0.011	0.001	0.003	0.045	9.83
9	<i>Busycon carica</i>	0.161	0.006	0.000	0.009	0.119	3.51
10	<i>Busycon carica</i>	0.043	0.004	0.000	0.001	0.023	8.64
11	<i>Busycon carica</i>	0.045	0.004	0.000	0.001	0.027	8.65
12	<i>Busycon carica</i>	0.105	0.005	0.000	0.003	0.073	4.73
13	<i>Busycon carica</i>	0.133	0.004	0.000	0.001	0.103	2.72
14	<i>Busycon carica</i>	0.084	0.005	0.000	0.001	0.067	5.50
15	<i>Busycon carica</i>	0.102	0.006	0.000	0.001	0.071	6.02
16	<i>Busycon carica</i>	0.220	0.012	0.001	0.004	0.158	5.67
17	<i>Busycon carica</i>	0.127	0.003	0.001	0.001	0.096	2.24
18	<i>Busycon carica</i>	0.381	0.015	0.001	0.004	0.264	3.96
19	<i>Busycotypus canaliculatum</i>	0.063	0.008	0.000	0.003	0.025	12.30
20	<i>Busycon carica</i>	0.308	0.021	0.001	0.008	0.200	6.97
21	<i>Busycon carica</i>	0.349	0.013	0.001	0.008	0.229	3.80
Mean <sup>a</sup>		0.175 ± 0.134					5.30 ± 2.06

<sup>a</sup>This calculation only includes knobbed whelks, *Busycon carica*; channel whelks, *Busycotypus canaliculatum*, have been excluded.

North Carolina during the 1580s<sup>26</sup> (Lorant, 1946: 180–184, 189, 251),<sup>27</sup> which shows several large fishing weirs being operated in the late 16th century along a protected stretch of water between the Albemarle and Pamlico Sounds, on the eastern shore of Roanoke Island (see Larson, 1980a: 120). Despite the cautions elaborated above, we can draw a number of limited inferences regarding aboriginal fishing technology along the Carolina–Georgia coastline (see also Swanton, 1922: 358; Hudson, 1976: 283; Larson, 1980a: 101; Reitz, 1982b; Milanich, 1996: 175).

White's watercolor suggests several key elements in the aboriginal saltwater fishing technology used by Southeastern Indians. In the background, several spearfishers are working the flats, likely using green cane spears with sharpened, fire-hardened points (or perhaps tipped with horseshoe crab and stingray spines. A species of ray (or perhaps

skate) is shown trapped in the weir. Several canoes contain other fishermen apparently using pronged fish leisters to take fish from the dugout; a small dipnet leans against the canoe prow in the foreground.

Several weirs and fish traps that project into the channel are also prominently featured. This tidal trap consists of a single line of poles that extend at right angles from the shoreline to create a diversion fence (or weir), with a holding pen constructed midway along the fence line. Clearly, these weirs were designed to work on a single tide (flood or ebb, it is unclear which). Men attending the weir are using scoop nets to harvest the entrapped fish.

Of particular interest is the fire basin shown amidships in the closest canoe. It seems likely that this fire hearth was used for night fishing, with the clay-lined basin elevated slightly above the gunwale to attract fish and illuminate the waters (see also



Fig. 7.10. John White's watercolor rendering of aboriginal fishing in the 1580s along the North Carolina coast (Lorant, 1946: 189).

Hudson, 1976: 284; de San Miguel, 2001: 61). Loskiel (1794: 95, fig. 1) mentions that, "In Carolina the Indians frequently use fire in fishing. A certain kind of fish will even leap into the boats which have fire in them." Flounders and rays could have readily been speared at night (during warm periods) in the shallow waters surrounding St. Catherines Island. Jones (1873: 27) notes that "fishes were often captured by means of a bright fire, kindled in which was paddled by night over their feeding-grounds. Frightened, blinded, and at the same time attracted by the light, they leaped toward it, and in doing so frequently fell into the boat. This mode was particularly successful on the coast, and those who are familiar with the customs of that region will bear witness that to this day many mullets are caught in this manner by Negroes carrying torches in their cypress canoes."<sup>28</sup>

So-called mullet jumping remains a common sport along the contemporary Georgia-Florida coastline. Using flashlight beams (and sometimes a white sheet suspended over the midline of the boat), modern "mullet jumpers" can commonly take several dozen mullet in less than an hour—attracted by the light, the fish literally jump on board, sometimes with considerable force and in great numbers. The on-board fire could also have been used to light torches for nighttime fishing, for food preparation in transit, and/or processing resources for transport (e.g., cooking shellfish so that the shells could be discarded instead of transported).

These observations are confirmed by archaeological evidence from Florida's wetlands. While it is likely that some evidence of burning within the dugout would survive from the construction process, Purdy (1991: 282) has documented a number of circular fired areas amidship in archaeological-recovered dugouts (one of them dating 1100 radiocarbon years B.P.).

John White's watercolor suggests the broad range of technologies likely available to aboriginal people seeking to exploit the Georgia coast, an area where archaeological sites contain fish bones in profusion (e.g., Larson, 1980a, chap. 6; Reitz, 1982a, 1988c, 1990; Reitz and Quitmyer, 1988). In

this preliminary study, we will address the dietary role of fish in aboriginal exploitation strategies on St. Catherines Island in three steps: (1) describe the fish species likely available in the waters of the northern Georgia coast; (2) examine the available ethnohistoric, ethnographic, and archaeological records that document the specific fishing practices of southeastern Indians (see Swanton, 1922, 1946: 332-344; Dickinson, 1975 [1699]; Hudson, 1976: 284; Larson, 1980a; Quitmyer, 1985: 24-28; Reitz, 1985; Reitz and Quitmyer, 1988; Walker, 1992; Hann, 1996); and (3) derive an approximate, first-order estimate of energy return rates for fishes likely exploited during the precontact period on St. Catherines Island.

#### FISH SPECIES OF COASTAL GEORGIA

Multiple sources document the diversity of fishes that occur today in the waters surrounding St. Catherines Island,<sup>29</sup> and we have drawn from this literature to inform the research described below (especially Dahlberg, 1972, 1975; McClane, 1974; Powles and Stender, 1978; Saul, 2002, 2003, 2004; see also Reitz, 1982a, this volume).<sup>30</sup> Table 7.21 estimates size for the most important species.

Sharks and rays (Chondrichthyes) are common in inshore waters and archaeological collections (Reitz, 1982a; Quitmyer, 1985: 25; Weinand et al., 2000). Most sharks (Squaliformes, Lamniformes, and Carcharhiniformes) appear in the shallow estuarine waters during the warm months of the year. Modern fishery research in the waters of St. Catherines Island most commonly encounter the blacktip (*Corchachinus limbatus*) and Atlantic sharpnose sharks (*Rhizoprionodon terroenouae*); bonnethead (*Sphryna tiburo*) are also common, but are rarely netted (Bruce Saul, personal commun.). Long-line and trawl samples from sandy bottoms elsewhere along the Georgia Bight indicate the nurse and sandbar sharks are the most abundant, followed by the tiger, smooth dogfish, Atlantic sharpnose, spiny dogfish, scalloped hammerhead, lemon, dusky, sand shark, and silky shark. Along the Georgia coast,

TABLE 7.21  
**Estimated Weights for Some Fish Species Common to the Georgia Coast, Ranked by Size**

Species <sup>a</sup>	Common <sup>a</sup> name	Size <sup>b</sup>	Maximum wt. (kg)	Average wt. (kg)	Comments	Source
<i>Galeocerdo curvieri</i>	Tiger shark	Very large	—	1000	—	—
<i>Negaprion brevirostris</i>	Lemon shark	Very large	—	290+	—	—
<i>Carcharias taurus</i>	Sand shark	Very large	—	159	—	—
<i>Ginglymostoma cirratum</i>	Nurse shark	Very large	190	150	—	—
<i>Dasyatis centroura</i>	Roughtail stingray	Very large	200	90	—	—
<i>Carcharhinus obscurus</i>	Dusky shark	Very large	—	69	Range 2–270	fishbase.org
<i>Sphyrna lewini</i>	Scalloped hammerhead	Very large	—	47	Range 5–166	NOAA (1996)
<i>Dasyatis americana</i>	Southern stingray	Very large	—	45	—	NOAA (1996)
<i>Rhinoptera bonasus</i>	Cownose ray	Very large	—	45	—	McClane (1975)
<i>Carcharhinus plumbeus</i>	Sandbar shark	Very large	—	30	Range 1–104	McClane (1975)
<i>Carcharhinus limbatus</i>	Blacktip shark	Very large	—	30	—	NOAA (1996)
<i>Carcharhinus falciformes</i>	Silky shark	Very large	—	22	Range 4–88	NOAA (1996)
<i>Carcharhinus signatus</i>	Night shark	Very large	—	15	Range 3–102	NOAA (1996)
<i>Sciaenops ocellatus</i>	Red drum (or redfish)	Very large	40.82	15	—	Freeman and Walford (1976)
<i>Mustelus canis</i>	Smooth dogfish	Very large	—	12	—	McClane (1975)
<i>Rhizoprionodon terraenovae</i>	Atlantic sharpnose	Very large	7	5.4	—	McClane (1975)
<i>Squalus acanthias</i>	Spiny dogfish	Large	9.8	3.2–4.5	—	FLMNH (2004)
<i>Lepisosteus ossseus</i>	Longnose gar	Large	22.8	1.56–2.06	—	Robins et al. (1991); Tyler et al. (1994)
<i>Dasyatis Sabina</i>	Atlantic stingray	Large	—	1.6 (m), 2.2 (f)	—	—
<i>Archosargus probatocephalus</i>	Sheepshead	Large/medium	13.61	0.45–1.36	Over 5.44 unusual	Freeman and Walford (1976)
<i>Pogonias cromis</i>	Black drum	Large/medium	66.22	0.45–1.36	Over 27.22 unusual	Freeman and Walford (1976)
<i>Paralichthys dentatus</i>	Summer flounder	Large/medium	13.61	0.45–1.36	Over 5.44 unusual	Freeman and Walford (1976)
<i>Paralichthys lethostigma</i>	Southern flounder	Large/medium	5.90	0.45–0.91	Over 4.54 unusual	Freeman and Walford (1976)
<i>Bagre marinus</i>	Gafftopsail catfish	Large/medium	2.72	0.34–0.68	Over 1.36 unusual	Freeman and Walford (1976)
<i>Cynoscion nebulosus</i>	Spotted sea trout	Medium/small	7.48	0.34–0.57	Over 2.72 unusual	Freeman and Walford (1976)
<i>Larimus fasciatus</i>	Banded drum	Medium/small	—	0.45	—	McClane (1975)
<i>Menticirrhus saxatilis</i>	Northern kingfish	Small	—	—	—	McClane (1975)
<i>Brevoortia tyrannus</i>	Atlantic menhaden	Small	1.6	0.30–0.45	—	McClane (1975)
<i>Fundulus majalis</i>	Striped killifish	Small	—	—	—	McClane (1975)
<i>Cynoscion regalis</i>	Weakfish	Small	13.61	0.23–0.45	Over 1.36 unusual	Freeman and Walford (1976)
<i>Bairdiella chrysoura</i>	Silver perch	Small	0.34	0.11–0.45	Over 0.23 unusual	Freeman and Walford (1976)
<i>Menticirrhus americanus</i>	Southern kingfish	Small	1.36	0.15–0.45	Over 0.91 unusual	Freeman and Walford (1976)
<i>Menticirrhus littoralis</i>	Gulf kingfish	Small	1.59	0.15–0.45	Over 0.91 unusual	Freeman and Walford (1976)

TABLE 7.21  
(Continued)

Species <sup>a</sup>	Common <sup>a</sup> name	Size <sup>b</sup>	Maximum wt. (kg)	Average wt. (kg)	Comments	Source
<i>Mugil cephalus</i>	Striped mullet	Small	8.0	0.40	—	FLMNH (2004); SEAMAP (2002); Ibanaz Aguire et al. (1999)
<i>Micropogonias undulatus</i>	Atlantic croaker	Small	2.27	0.11–0.45	Over 0.68 unusual	Freeman and Walford (1976)
<i>Cynoscion nothus</i>	Silver seatrout	Small	0.91	0.15–0.30	Over 0.68 unusual	Freeman and Walford (1976)
<i>Ariopsis felix</i>	Hardhead catfish	Small	1.36	0.15–0.30	Over 0.68 unusual	Freeman and Walford (1976)
<i>Mugil curema</i>	White mullet	Small	—	0.115–0.20	—	SEAMAP (2002); Ibanaz Aguire et al. (1999)
<i>Leiostomus xanthurus</i>	Spot	Very small	1.02	0.057–0.113	Over 0.23 unusual	Freeman and Walford (1976)
<i>Menidia beryllina</i>	Inland silverside	Very small	—	0.009	—	McClane (1975)
<i>Anchoa mitchilli</i>	Bay anchovy	Very small	—	0.04	—	McClane (1975)
<i>Anchoa hepsetus</i>	Striped anchovy	Very small	—	0.04	—	McClane (1975)

<sup>a</sup>Scientific and common names follow the conventions established by the American Fisheries Societies (Nelson et al., 2004).

<sup>b</sup>Fish sizes: very large (more than 5 kg); large (3.41–1.37 kg); medium (0.86–0.68 kg); small (0.34–0.23 kg).

sharks are more common along beaches and in the lower reaches than in middle or upper ones (Dahlberg, 1972). Their cartilaginous skeletons make archaeological identification problematic. Quitmyer (1985: 25) suggests that aboriginal fishermen could have used substantial nets and/or weirs to acquire sharks in shoal waters or tidal creeks. Larson (1980a: 81–86, 103) emphasizes the desirability of sharks as a food source for southeastern Indians, but he likewise points out the difficulties in catching them. He suggests that even if sharks ended up in the fish weirs, they would likely have been avoided because of the difficulty in harpooning or spearing them.

Atlantic stingray (*Dasyatis sabina*), southern stingray (*Dasyatis americana*), and bluntnose stingray (*Dasyatis say*) have been collected near St. Catherines Island (Saul, 2004). Although some live in the estuaries year-round, they are more common during the warmer months (Dahlberg, 1975: 28–31). They search for clams, crabs, shrimps, and small fishes in shallow, open areas of sand and mud bottoms; modern fishery researchers report capturing up to 10 rays at a time, each weighing more than 9 kg (B. Saul, personal commun.). Rays can be taken by dip nets, clubs, and spears; they also turn up in the haul of weirs and fine mesh nets (Quitmyer, 1985: 25). The cownose ray (*Rhinoptera bonasus*), a migratory species, visits the Georgia coast in the spring and early summer, and its presence in archaeological deposits might be an indicator of site seasonality (Weinand et al., 2000).

Although primarily a freshwater species, long-nose gar (*Lepisosteus osseus*) are often caught in saltwater along the Georgia coast (Dahlberg, 1975: 33). They often take a baited hook, particularly in slack water.

Herrings and shad (Clupeidae), especially Atlantic menhaden (*Brevoortia tyrannus*), and Atlantic thread herring (*Opisthonema ogilnum*) are abundant in the estuaries of coastal Georgia (Saul, 2004), especially from May through November (Dahlberg, 1975: 38). Menhaden is the most important commercial finfish in the United States (McClane, 1974: 65), most commonly taken with purse seines. Because these small fish

swim in schools, shad and herrings would also have been easy targets for aboriginal nets and weirs (Quitmyer, 1985: 26).

Bay anchovy (*Anchoa mitchilli*) and striped anchovy (*Anchoa hepsetus*) are abundant in the lower estuary; they live year-round in densely packed schools, often mingling with other baitfish such as silversides (*Menidia menidia*). Anchovies live year-round in the estuary; they can be taken with dip nets, fine mesh nets, and/or enclosures (Quitmyer, 1985: 26). All such small fishes (such as anchovies and silversides) could probably have been dried and ground into meal.

Mummichog (*Fundulus heteroclitus*) are rare in the surf, but common in the brackish and freshwaters of St. Catherines Island; striped killifish (*Fundulus majalis/similes*) are very common in the surface, but rare in brackish and freshwater (Saul, 2004; personal commun.). They are year-round residents, swim in loose schools, and are readily captured with fine-mesh net or dip nets, perhaps in conjunction with enclosures.

Sea catfishes (Ariidae) are periodically abundant in the estuarine environment (though their number has declined in recent years). White catfish (*Ictalurus catus*) is a freshwater species present in the estuary, but the natal rivers are quite a distance from St. Catherines Island; if present, they could be taken on a baited hook or captured with weirs or nets (Quitmyer, 1985: 26). The hardhead catfish (*Ariopsis felis*) is more common than the larger gafftopsail (*Bagre marinus*) and tolerates a greater salinity range than the gafftopsail. Sea catfishes are present in the inshore area year-round, although most leave during cold weather (Dahlberg, 1972). Both hardhead catfish and the larger gafftopsail catfish could be taken on baited hooks, but nets would be required for the deeper waters of the estuary.

Several species of Carangidae occur in the vicinity of St. Catherines Island (Saul, 2004), including the Atlantic bumper (*Chloroscombrus chrysurus*) and crevalle jack (*Caranx hippos*), both of which are found in archaeological sites at Cathead Creek (Reitz and Quitmyer, 1988) and Kings Bay (Quitmyer, 1985). Both species can be collected in lower

estuarine reaches, where Atlantic bumper occur between June and December (especially during August). These smallish fish can be taken with hook and line; nets and impoundments could also be used.

Members of the drum family (Sciaenidae) are often the most common vertebrate forms to occur in archaeological sites of the Georgia coast. Thirteen species of drum occur here (Dahlberg, 1975; Saul, 2004), and Saul (personal commun.) reports netting both black and banded drum in the surf nets. He also notes that, except for star drum, all sciaenids could be taken on a baited hook. Larger individuals could be harvested by fish traps, gill nets, and hook-and-line technology; juveniles require fine mesh nets (Quitmyer, 1985: 27). Spots (*Leiostomus xanthurus*), a small member of the croaker family, are found in the inner bay during warm months (Dahlberg, 1975: 71). They spawn offshore during the winter months and are readily taken on hook and line during peak runs (McClane, 1974: 950).

The Atlantic croaker (*Micropogonias undulatus*) is a most common species, historically an important food and gamefish; trawls, gillnets, and pound nets are commonly employed for commercial harvests, though hook-and-line angling is also quite successful. Atlantic croakers are commonly found throughout coastal habitats during warmer months. In Georgia, adults leave the estuary to spawn offshore between September and April. Young croakers are not as abundant in shallow waters as young spots and, unlike young spots, are not found in freshwater (Dahlberg, 1972).

The two largest drums are the black drum (*Pogonias cromis*) and the red drum or redfish (*Sciaenops ocellatus*). Small black drums are present year-round; the red drum spawns in coastal waters near shore, but otherwise is present year-round inshore. Star drums (*Stellifer lanceolatus*) are small fishes found in great abundance in shallow waters during the summer and fall. Silver perches (*Bairdiella chrysoura*) are found year round throughout the estuary and spawn primarily between April and May in estuarine and coastal waters (McClane, 1974: 380; Powles and Stender, 1978).

Spotted sea trout (*Cynoscion nebulosus*), one of the most popular inshore saltwater gamefish in the southern United States (McClane, 1974: 955), is present in inner bays throughout the year, while part of the population moves into the ocean during the winter. Silver sea trouts (*C. nothus*) are more common off beaches than inside bays. Weakfishes (*C. regalis*) may leave estuaries during cold months of the year (Dahlberg, 1972), but spawn inshore.

Striped mullets (*Mugil cephalus*) are very common in coastal Georgia, and they spawn from September through April (Dahlberg, 1972; B. Saul, personal commun.). Young mullets are found in shallow, brackish waters while adults prefer slightly deeper and more stable conditions. Depending on the species, adults may be present throughout the year, though when temperatures drop below 7° C even the striped mullet will seek another location that has warmer and more stable waters (Dahlberg, 1972). Today, mullets are most easily caught with a cast net, although they can also be snagged or speared as they travel in dense schools.

Sheepshead (*Archosargus probatocephalus*) are particularly common around underwater structures, and likely would have been captured in traps constructed in the estuary.

Flounders (Bothidae) are bottom-dwelling carnivores, some species of which are present throughout the year. Five species of flounder are known to be present in waters around St. Catherines Island (Saul, 2004). The southern flounder (*Paralichthys lethostigma*) lives in relatively shallow waters over mud bottoms in bays, sounds, and lagoons (McClane, 1974: 910). These fish are commonly gilled with a spear as they rise to a light or torch at nighttime. The summer flounder (or fluke, *P. dentatus*) lives in deeper waters during the winter, but frequents the shallows during the summer and is readily taken on a hook and line.

#### ESTIMATING LIVE WEIGHT FOR COASTAL GEORGIA FISHES

Estimating live weight for fishes is highly problematic because, unlike the prey species considered above under "hunting", fish

have no reliable "mean body size". Literature typically reports the record size (the largest individual ever caught for a given species); some sources report a size range while others estimate what a "typical size" might be. Unfortunately, there is no reliable species-specific "average size".

In an attempt to estimate the size of actual fish represented in archaeological assemblages, Elizabeth Reitz has developed formulae based on skeletal elements commonly preserved archaeologically to project biomass (using, for instance, measurements on atlas vertebrae or otoliths from the drums; see Reitz and Cordier, 1983; Reitz et al., 1987; Reitz and Wing, 1999). The allometric formulae in Reitz et al. (1987), however, employ data from modern fish samples present in the Florida Museum of Natural History collections, and these numbers do not represent contemporary wild fish population or ancient populations that once inhabited the southeastern coastline. Additionally, Hales and Reitz (1992) have also documented the degree to which body size in Atlantic croaker has declined since the mid-Holocene. As Reitz (personal commun.) noted, "mean body size and mean edible meat weight is not only difficult to assess for an animal that grows throughout its life, but a moving target over archaeological time and space."

It is apparent that severe allometric issues continue to plague zooarchaeological analysis, particularly in conjunction with the study of fish bones in archaeological sites. Despite these issues, however, we believe it is worthwhile to derive a first-order approximation of the role fish resources played in the overall aboriginal subsistence patterns on St. Catherines Island. Table 7.21 provides an incomplete listing of size estimates for the most common fish species on the Georgia coast. These data, intended only as approximate background estimates, are pooled into five ordinal categories based on average weight (following, in part, the divisions established by Lindström, 1996)<sup>31</sup>:

Very large fish av. weight exceeds 5 kg (about 11 lbs)

Large fish av. weight between 3.4 kg (7.5 lbs) and 1.37 kg (3 lbs)



Fig. 7.11. Le Moyne's rendering of "How They Cook Their Meat, Fish and Other Food", depicting Timucua Indians in the 1560s in northeastern Florida (Lorant, 1946: 83).

Medium fish av. weight between 0.86 kg (1.9 lbs) and 0.68 kg (1.5 lbs)

Small fish av. weight between 0.34 kg (0.75 lbs) and 0.23 kg (0.5 lbs)

Very small fish av. weight less than 0.017 kg (0.6 oz)

Table 7.21 converts these data into energy estimates for each of these fish species (expressed as kcal/individual). The edible portion is estimated to be 75 percent (see Jochim, 1976: 71; Meehan, 1977a: 368; Lindström, 1996). Macronutrients are computed, and in some cases interpolated, based on figures available at [www.nutritiondata.com](http://www.nutritiondata.com) (table 7.1).

#### ESTIMATING PURSUIT AND PROCESSING TIME

The energetic estimates in table 7.21 are insufficient to fully understand human ex-

ploitation of fish population, as it is also necessary to factor in the pursuit and processing costs involved with each fish capture. In the sections to follow in this chapter, we derive estimates of the total pursuit costs associated with various aboriginal strategies that were employed to collect fish on the Georgia coast. First, we address the processing costs required to prepare fish for consumption, regardless of the method by which they were captured (see fig. 7.11; after Lorant 1946: 83).

#### HOW THEY COOK THEIR MEAT, FISH AND OTHER FOOD

When the natives have caught enough fish, they assemble in a place where they can easily prepare them. They stick four stakes of equal height in the ground with a number of posts across them. The fish are laid upon the platform, and a fire is built beneath it.

While the people of Florida dry and cure their fish in the smoke for winter storage, these savages preserve nothing; they always use up everything at once, and whenever they need more fish, they again roast or boil them fresh. After the platform is full of fish and will hold no more, the rest of the catch is hung at the sides or on sticks close to the fire, until there is room for them. So they cook their whole catch at once, taking good care not to burn the fish. As soon as some are cooked, they are replaced by others; in this way they continue to cook their game until they think they have enough.

Aboriginal people could have prepared "small" and "medium" fish (defined above as weighing 0.23–0.34 kg and 0.34–0.68 kg, respectively) in several ways. Using a modern steel filleting knife, a "small" fish (such as a mullet) can be scaled and filleted using the "single fillet" method, which leaves the tail, backbone, and ribs in place (after Lindström, 1996). The side fillet method is faster and facilitates the removal of two fillets per fish without the tail, though most of the meat along the backbone is lost. Using either method, a small fish could be readily filleted in about 20–30 sec.

Slightly less time is required to gut and prepare a small/medium-size fish for cooking, which results in more available meat and less time spent scaling (because the scales come off with the skin from the cooked fish). Some local fishermen split mullet down the back (leaving the head intact), then hang the fish over a wire for smoking. Although slightly larger, sea trout and weakfish can take even less time to process than mullet because they are easier to scale; simply gutting the fish for cooking takes about 30 sec. Overall, we estimate handling time for small/medium fish to be 30 sec (0.0083 hr)/individual.

We further estimate that larger fish (1.37–3.4 kg), such as drum or sheepshead, require an average of 2 min (0.033 hr)/fish. Very large fish, such as black drums, were probably carved into sections for cooking and consumption, with the processing time averaging 7 min (0.1167 hr)/individual. It is likely that very small fish (those weighing less than 0.017 kg) were consumed whole, without any cleaning or processing.<sup>32</sup>

Beyond the costs of preparing fish for consumption, additional costs were sometimes incurred when fish was dried or smoked for storage. René Laudonière mentions smoked fish used as travel food (cited in Swanton, 1922: 360). As Rostlund (1952: 138) notes, "the smoking or drying of fish can be regarded only as special forms of the general practice of smoking or drying any kind of food for preservation processes widely known and used, I suppose, by every Indian tribe in North America." Rostlund questions the importance of fish preservation along the Georgia–Carolina littoral:

How much was stored is impossible to say. It may have been a respectable amount ... [but] the people in this region probably had a better chance than most of the others in North America of keeping themselves supplied with fresh fish at all times, and they could have done as Hariot says about the Secotan, 'broile and spend away all att once and reserue nothinge for store; for on the morrow another catch could always be made.' The fact that fish was dried and stored under such circumstances can only mean that it was considered an important item in the economy.

In commenting that "roots, fruits, herbs, and fish of different types" were commonplace food for the coastal Timucuan people, Le Challeux commented that fish along the northern Florida coast were so plump that the Timucuan extracted this fat to use as butter and sauce (Hann, 1996: 98).

Because we do not know the importance of smoking, drying or rendering fish fat, the "processing times" employed below only address energetic estimates for gutting and cutting up fish for consumption, without considering costs of preserving meat flesh for future consumption.

#### FISH WEIRS

According to Rostlund (1952: 101–102), "traps and weirs were used in almost every region [of North American] where any fishing was done. ... They were not only the most widely but, so far as can be judged from the record, the most commonly employed fishing gear. I venture to say that

more fish was captured each year in native North American with traps and weirs than by any of the other methods." Rostlund further notes that "the function of every weir is to obstruct the passage of the fish in order to facilitate its capture, and the purpose of every trap is to impound the fish so that it cannot get away. Weirs and traps were often used separately, but in the most effective Indian weir fishery the two ideas of obstruction and impoundment were combined by providing the weir with one or more traps" (see fig. 7.12).

Several ethnohistoric accounts document the importance of fish traps and weirs among the Timucua of the St. Johns River area (see Swanton, 1922: 357–358; Larson, 1980a: 121; Quitmyer, 1985; Hann, 1996: 100; de San Miguel, 2001: 73). Theodore de Bry's engraving of the Le Moyne painting shows similar traps observed during Jean Ribault's 1562 expedition to the St. Marys River. These fish traps consist of stationary walls that extended approximately 200 m from the mainland (see Mila-nich, 1996: 142); according to Hann (1996: 100), some Timucuan weirs extended for the reach of a musket shot (about 230 m). The weirs observed by the Ribault expedition were built and operated by the Timucuan people living along the River Seine (Lorant, 1946: 41), in the vicinity of the St. Marys or Satilla River (Larson, 1980a: 119–120) roughly 70 km north of the mouth of the St. Johns (known as the River May to the French). The Timucuan weirs consist of double diversion fences formed by two lines of parallel poles, with a holding pen located at the end of the two fences. Larson (1980a: 120) suggests that the Timucuan structures were built to work both tides—to capture fish moving into the inlet on a flood tide and to follow the shoreline as they move out of the inlet during the ebb.

According to Ribault's account of 1562 (cited in Swanton, 1922: 357–358), such weirs along the St. Johns River of northern Florida were built "so well and cunningly set together after the fashion of a labyrinth, with many turns and crooks, which it was impossible to construct without much skill and industry." Ribault continues, noting

that according to Laudonière, "the king ordered us to be provided with fish, which was done speedily. They went to their weirs, or enclosures, made out of reeds like a maze, and loaded us up with trout, mullet, flounder, turbot, and a multitude of other species which are different from ours" (Bennett, 1975: 20). This account clearly indicates that fish were kept alive inside the weir, to be harvested at will. Fr. Andrés de San Miguel writes that in 1595:

Florida Indians constructed weirs along the coast, some simply of stakes driven into the ground, and these are small. They make others bigger, which enclose an area equivalent to the reach of a musket-shot, out of stakes and reed grass, all driven into the ground and well-tied together, placed in line in the manner in which one would make a sweepnet. And in the middle between the two arms, where it is the deepest they make a small enclosure (*corral*) where the fish collect when the tide goes out. And they catch them with a cast net. (de San Miguel, 2001: 73)

As discussed below, there remains some uncertainty as to whether the cast net was used in precontact times.

Writing of aboriginal fishing practices in the North Carolinas, Brickell (1737: 366) describes a fish trap with extended wings, one reaching to the shore, the other stretching out into the water. The trap is constructed of canes or small poles, stuck upright in the marsh mud. Closely spaced, they rise a few feet above the water level, fastened securely together with parallel ropes or withes to create a "hedge or rustic fence through which the fishes are unable to force a passage. In the middle is an opening leading into a circular enclosure. This, by a circuitous opening, communicates with a second pen, and this in like manner to a third, and that, in turn, in a similar way with a fourth—each somewhat smaller than the former."

Both the Timucuan and the North Carolina tidal traps were designed to catch fish in great quantity, either due to natural flow or artificially induced movement by human predators. In all such tidal traps and weirs, "the principal was the same ... the trapping or stranding of fish behind an obstruction

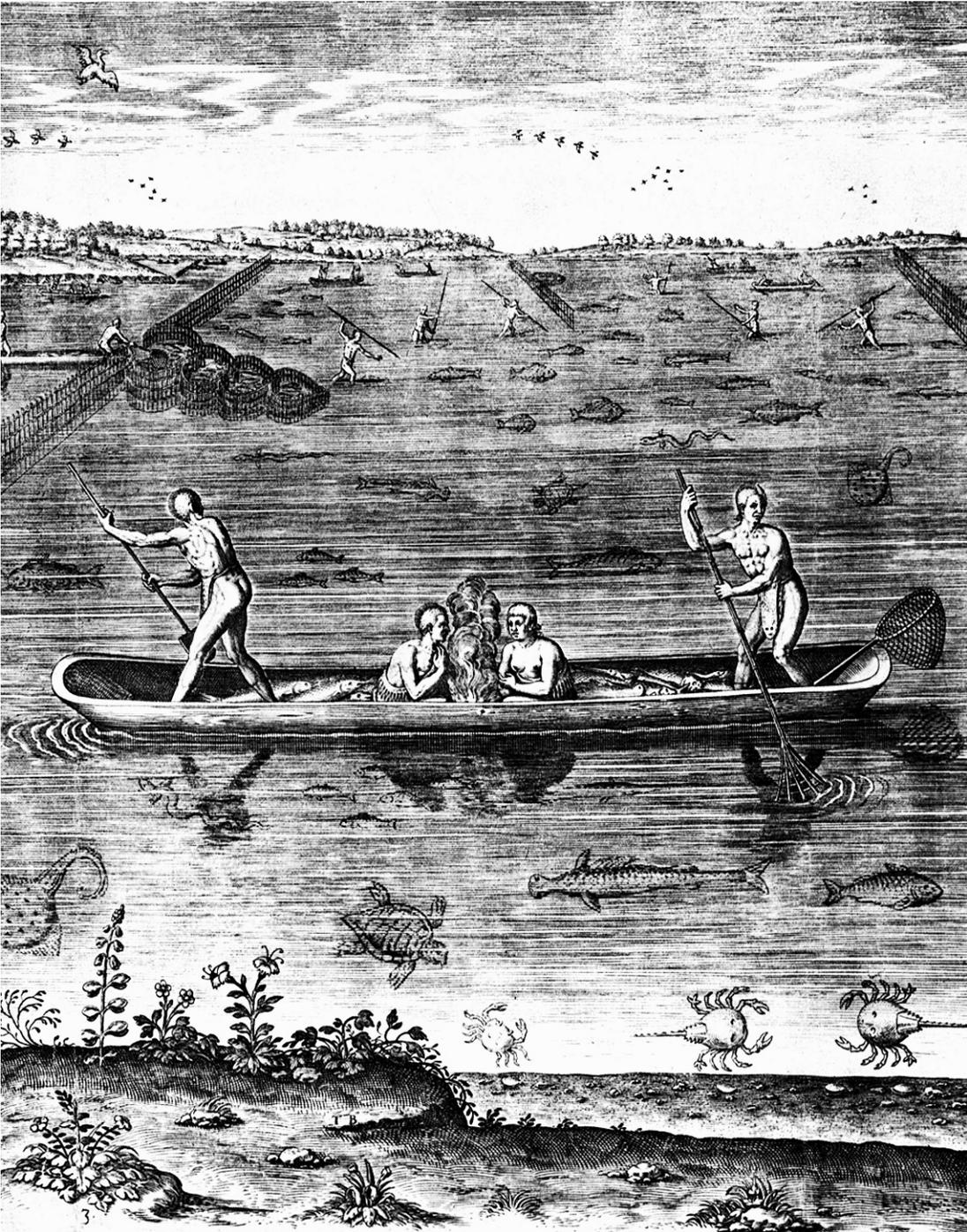


Fig. 7.12. Le Moyne's rendering of "How They Catch Fish" (Lorant, 1946: 250-251).

with the fall of the tide” (Rostlund, 1952: 101). Such traps are known from both shallow and deep-water zones, from places where the tide is less than 2 feet to others where the tide exceeds 30 feet. The basic idea remains constant: establish a barrier across a tidal or shallow creek to slow the progress of fish returning to the ocean, in order to net, herd, and spear them.

Considerable construction and maintenance costs are required to operate such weirs, which likely involved a large number of people. Because fish weirs had to withstand the twice daily tidal surge, they must have been quite expensive to construct and maintain (and standard methods for computing resource return rates do not adequately account for the capital investment in constructing and maintaining such facilities; see Lindström, 1996). Once fully operational, however, a well-situated fish weir provided a cost-effective and dependable way to harvest large quantities of fish.

Larson (1980a: 123) notes that the ethnohistoric record indicates that tidal traps were discontinuously distributed along the Atlantic seaboard. Because Dickinson and San Miguel fail to mention the use of weirs or traps to the south of the St. Johns River, Larson (1980a: 124) concludes that “it seems almost certain that these methods were not used by the local Indians.” He also notes the apparent absence of fish weirs between Cape Hatteras and the St. Johns estuary, which Larson attributes in part to the high tides characteristic of the Georgia Bight, and also because he believes that nonsedentary lifeways of the Georgia Coast were incompatible with the construction and operation of such large-scale fish weirs.

We suspect that weirs were considerably more common along the Georgia coastline, likely built in the shallow tidewater areas bordering places like St. Catherines Island (see also Crook, 1986: 28). Suitable fishtraps could have been readily constructed of small poles driven into the nearshore substrate, then made fishproof with reeds and/or wooden splints interwoven amid the uprights. In this way, fish could easily swim into the trap, but found it difficult or impossible to escape. In other situations,

weirs could have been constructed across small tidal creeks, trapping fish at low tide.

Ethnographic data for western North America (summarized in Lindström, 1996), suggests that freshwater basket traps could be set and emptied in 5 min each; she further estimates that a trap, left unattended, could have caught up to 12 large, medium, small, or tiny spawning fish per set. For the massive saltwater fishtraps constructed along the Southeastern shoreline, these procurement costs and overall productivity are obviously much higher.

For the purposes of this exercise, we must make several assumptions about how fish weirs could have been operated by aboriginal people on St. Catherines Island. First, we assume that all harvesting and transport of fish was facilitated by use of dugout canoes (thereby minimizing transport costs). We further estimate that at least two people were required to operate a weir (such as those illustrated in the de Bry engravings), taking perhaps 15 min (per person) to set the trap. Second, we assume that the mesh size of such large weirs was insufficient to contain small fish (such as mullet) and very small fish (such as herrings and anchovies). We also assume if an average of 12 medium-sized fish (such as spotted seatrout or black drum) were entrapped per set, they were then netted and individually clubbed (1 min/fish), then cleaned and cut up (0.5 min/fish). Let us also assume that these large saltwater weirs trapped an average of three large/very large fish (such as sheepshead or redfish) per set. The entrapped fish were then probably netted, speared or harpooned, then clubbed (estimated at 5 min/fish). Per the discussion above, we assume that 2 min are required to clean and cut up a large fish (perhaps 7 min would be required for very large fish); we believe these to be very conservative figures.

To demonstrate how these figures can be used to estimate overall return rates, let us compute the energy return from a single spotted seatrout captured in a saltwater fish weir as follows:

*Spotted sea trout (an individual weighing 0.7 kg)*

Setting trap 30 min/15 fish = 2 min/fish

Landing catch 1 min/fish

TABLE 7.22  
**Estimated Post-encounter Return Rates for the Saltwater Fishing Hunt Type Around  
 St. Catherines Island**

Size	Harvesting method	Av. live wt. (kg)	Usable wt./ individual <sup>a</sup> (kg)	Kcal/ individual <sup>b</sup>	Catch time (hr)	Clean & cut up (hr/ind)	Est. return rate (kcal/hr)
Very large fish	fish weir	>5.0	>3.75	>4125	0.1167	>0.1167	>17,673
Large fish	gill net	1.37–3.41	1028–2558	1131–2814	0.02	0.0333	21,216–62,792
	trot line	1.37–3.41	1028–2558	1131–2814	0.0333	0.0333	16,982–42,252
	fish weir	1.37–3.41	1028–2558	1131–2814	0.1167	0.0333	7540–18,760
	spear/harpoon	1.37–3.41	1028–2558	1131–2814	0.1667	0.0333	5655–14,070
Medium fish	gill net	0.68–0.86	0.51–0.65	561–715	0.02	0.0083	19,823–25,265
	trot line	0.23–0.34	0.51–0.65	561–715	0.0333	0.0083	13,486–17,188
	fish weir	0.68–0.86	0.51–0.65	561–715	0.05	0.0083	9623–12,265
	spear/harpoon	0.23–0.34	0.51–0.65	561–715	0.1667	0.0083	3206–4086
Small fish	gill net	0.23–0.34	0.1725–0.255	190–280	0.02	0.0083	6714–9894
	trot line	0.23–0.34	0.1725–0.255	190–280	0.0333	0.0083	4567–6731
	spear/harpoon	0.23–0.34	0.1725–0.255	190–280	0.1667	0.0083	1086–1600
Very small fish	—	<0.017	0.05325	<69,225	—	0.0	—

<sup>a</sup> Usable weight assumed to be 0.75 of mean live weight.

<sup>b</sup> Employs 130 kcal/100 g (an average of all available species-specific caloric assessments).

Clean/cut up 0.5 min/fish

Edible weight  $0.7 \times 0.75 = 0.525$  kg

Energy 104 kcal/100 g

Energy/individual  $0.525$  kg @ 104 (kcal/100 g) = 546 kcal/fish

Estimated return rate  $546$  kcal/3.5 min (0.0583 hr) = 9365 kcal/hr

Using the same protocols, the estimated energetic return rate for a red drum weighing 3.0 kg is calculated as follows:

*Red drum (a large-sized individual weighing 3.0 kg)*

Setting trap 30 min/15 fish = 2 min/fish

Landing catch 5 min/fish

Clean/cut up 2 min/fish

Edible weight  $3.0 \times 0.75 = 2.25$  kg

Energy 119 kcal/100 g

Energy/individual  $2.25$  kg @ 119 (kcal/100 g) = 2677.5 kcal/fish

Estimated return rate  $2677.5$  kcal/7 min (0.1167 hr) = 22,942 kcal/hr

These protocols have been used to estimate generic return rates for medium, large, and very large fish procured in saltwater weirs (see table 7.22).

#### GILL NETS

Rostlund (1952: 81) defines a fish net as

a trap, snare or impounding device made for the purpose of catching fish in quantity and

constructed of material so light that maximum dimensions and minimum weight are combined. It is consequently the largest possible fishing implement that can be handled per unit of man power. Furthermore, a fish net captures fish in mass, it captures any species of fish, and ... whenever nets can be used, more fish can be taken with them and with less effort than by any other method.

Although netting and cordage are rarely recovered in the archaeological sites of the American Southwest, the waterlogged site of Key Marco, Florida, preserved large quantities of fiber, cordage, netting, and rope (Cushing, 1897: 366; Gilliland, 1975), including fine-meshed nets and (apparently) square dip nets, mostly made of palm fibers. Unfortunately, the present condition of most specimens precludes the detailed analysis, although Gilliland (1975: 244) estimated that several surviving specimens (presumably gill nets) had mesh sizes that ranged between 3 and 6 cm.<sup>33</sup>

Such gill nets were likely anchored with stakes or weights, positioned in places to intercept transit. At Key Marco, net weights (Gilliland, 1975: 184–187, 224–229, plate 133) were constructed of stone plummets and heavy sections of clam shell (*Venus* sp.), fashioned into roughly rectangular shapes and notched; pierced arca and

cockle shells also turned up, several with net cordage still attached.

Float pegs were the most numerous wooden artifacts recovered at Key Marco, many with cord still attached (Gilliland, 1975: 152, plates 100, 101). These floats were strung at short intervals across the entire length of the net, apparently to keep the upper edge of the net at the water's surface. Some floats were recovered intact, strung together with intervals at 1–2 cm, regardless of the size of the float pegs. Gourds may have also been used to create fishnet floats.

To derive a first-order approximation of return rates associated with gill nets, we will rely on an informal experiment conducted some years ago by two men working on St. Catherines Island.<sup>34</sup> Paddling together in small boats, they set a 100-foot gill net in the large embayment located on the northeastern margin of St. Catherines Island. Over a period of 4 hr, they circled and pulled the gill net, capturing a total of 400 fish, mostly striped mullet and sea trout.

According to the figures marshaled in tables 7.21 and 7.22, striped mullet average about 0.4 kg live weight and spotted sea trout and weakfish (the two species of "sea trout" common to the Georgia coast) average 0.34–0.57 kg and 0.23–0.45 kg, respectively. Using the criteria employed in table 7.21, this means that weakfish are a "medium-size" fish, and both spotted mullet and spotted sea trout fall between the "small" and "medium" size criteria. Let us also assume that a few "large" fish were included in the catch.

Based upon these assumptions, we can calculate the return rate for small fish as follows:

*Small-sized fish (av. size range 0.23–0.34 kg)*

Average catch time/fish: 480 min (8 person-hours)/400 fish = 1.2 min (0.02 hr)/individual  
Clean/cut up 0.5 min/fish (0.0833 hr)

Edible weight ranges from 0.23 kg  $\times$  0.75 = 0.1725 kg to 0.34 kg  $\times$  0.75 = 0.225 kg

Energy 110 kcal/100 g

Energy/individual ranges from 0.23 kg @ 110 (kcal/100 g) = 253 kcal/fish to 0.255 kg @ 110 (kcal/100 g) = 281 kcal/fish

Estimated return rate ranges from 253 kcal/0.02833 hr = 8930 kcal/hr to 281 kcal/0.02833 = 9901 kcal/hr

Similar computations were made for gill net capture of medium- and large-size fish of the Georgia coast.

#### SPEAR, LEISTER, AND HARPOON

Aboriginal foragers commonly speared fish with three different kinds of tools—simple fish spears, leisters, and harpoons.<sup>35</sup> The *spear* has perhaps been succinctly defined by Adair (1775: 403), who described the implements used by fishermen working the Savannah River: "They strike fish with long sharp-pointed green canes, which are well bearded and hardened in fire." Smith and Strachey observed aboriginal fishermen using "staves, like unto javelins, headed with bone" (quoted in Swanton, 1946: 338–339); Southeastern Indians sometimes speared fish with long arrows tied to lines. The *leister* employs wide, flexible prongs with inward facing barbs to grasp the fish from the sides "in a manner resembling that of ice tongs" (Rostlund, 1952: 105; see the White watercolor depicted in the beginning of this section). *Harpoons* are implements for piercing and retrieving fish through use of a movable head.

John White's watercolor and Harriot's accompanying narrative provide a graphic example of aboriginal North Carolina fishing technology in action (Lorant, 1946: 189; see also Larson, 1980a: 121). Spears in hand, several Algonkians prowl the shallow lagoon between beach ridge and the mainland "with poles made sharpe at one ende, by shooting them into the fish after the manner as Irishmen cast dartes, either as they are rowing in their boates or els as they are wading in the shorelines for this purpose" (Harriot, 1946 [1588]; Larson, 1980a: 122). The fisherman at the stern of the dugout holds a three-pronged leister, which was especially well suited for torchlight fishing from canoes at night (Rostlund, 1952: 106). Teit (1900: 252) also emphasizes that leisters are particularly effective for spearing from canoes because the fish is struck from above.

The remarkable accuracy of aboriginal spearfishers was recorded by Fr. Andrés,

who recorded his early summer experiences (in 1595) near St. Augustine, Florida:

Early in the morning one day we arrived at a hut where there was a pot placed at the fire with mullet as whole as God had created them. I noted that they were wounded in the little fin that they have in the middle of their back. They wound them with a thin pointed stick like a little harpoon stuck in a rod, and they are so skilled that they do not miss the fin at which they aimed, because it must be better to grasp it there than at any other point. (de San Miguel, 2001: 79)

A century later, Jonathan Dickinson observed aboriginal fishermen charging into schools of fish (probably mullet) and impaling them with a spearlike staff (Dickinson, 1975: 13; see also Hann 1996: 100); this took place along the northeastern Florida coast, perhaps 250 km south of St. Catherine's Island. Dickinson also recorded that

this morning the Casseekey ... sent his son with his striking staff to the inlet to strike fish for us; which was performed with great dexterity; for some of us walked down with him, and though we looked very earnestly when he threw his staff from him could not see a fish at which time he saw it, and brought it on shore on the end of his staff. Sometimes he would run swiftly pursuing a fish, and seldom missed when he darted at him. In two hours' time he got as many fish as would serve twenty men: there were others also fishing at the same time, so that fish was plenty.

A few days later, about midnight, Dickinson "espied some Indians in a canoe with their torch a-fishing" (Dickinson, 1975: 21).<sup>36</sup> In tidewater Virginia, Lawson (1860: 341; quoted in Swanton, 1946: 339) observed how "the youth and Indian boys go into the night, and one holding a lightwood torch, the other has a bow and arrows, and the fire directing him to see the fish, he shoots them with the arrows, and thus they kill a great many of the smaller fry, and sometimes pretty large ones."

In Adair's 1775 account, referenced briefly above (1775: 404–405; quoted in Swanton, 1946: 38), he reports that

in Savannah River, I have often accompanied them in killing sturgeons with these green swamp harpoons, and which they did with much pleasure and ease; for, when we discovered the fish, we soon thrust into their bodies one of the harpoons. As the fish would immediately strike deep, and rush away to the bottom very rapidly, their strength was soon expended, by their violent struggles against the buoyant force of the green darts: as soon as the top end of them appeared again on the surface of the water, we made up to them, renewed the attack, and in like manner continued it, till we secured our game.

Further inland, Bartram (1973 [1792]: 44) described how a "very large salmon trout, weighing about fifteen pounds" was speared on a branch of the Broad river in Georgia:

The Indian struck this fish with a reed harpoon, pointed very sharp, barbed, and hardened by fire. The fish lay close under the steep bank, which the Indian discovered and struck with his reed; instantly the fish darted off with it, whilst the Indian pursued, without extracting the harpoon, and with repeated thrusts drowned it, and then dragged it ashore. (quoted in Swanton, 1946: 338)

The information contained within these sketchy ethnohistoric accounts is buttressed to some degree by Cushing's (1897) finds at Marco Island, Florida, which included single-barbed bone harpoon points, stingray-spine spear points, and long, barbless, spikelike, alligator bone spear points (Gilliland, 1975: 212–213, plates 125 and 129).

Based on the limited ethnohistoric information on fishing practices by Southeastern Indians and the more abundant evidence available from freshwater habitats in western North America (as synthesized by Rostlund, 1952, and Lindström, 1996), it is possible to derive some estimated, first-order approximations of return rates for fish spearing along the Georgia coast. Bear in mind that these are post-encounter estimates, and therefore do not include search time. Let us assume that, once a suitable fish has been spotted, it takes an average of 10 min for an experienced spearfisherman to position himself, thrust the spear, retrieve the catch, and club the fish. Leister

fishing from a canoe probably takes less time, and spearfishing on foot in shallow water might take more time, but we believe that 6 fish/hr is a reasonable estimate of post-encounter catch time.

The estimated return rate for a (mullet-sized) small fish is computed as follows:

*Small-sized fish (av. size range 0.23–0.34 kg)*  
 Catch time 10 min/fish (0.1667 hr/fish)  
 Clean/cut up 0.5 min/fish (0.00833 hr)  
 Edible weight ranges from  $0.23 \text{ kg} \times 0.75 = 0.1725 \text{ kg}$  to  $0.34 \text{ kg} \times 0.75 = 0.225 \text{ kg}$   
 Energy 110 kcal/100 g  
 Energy/individual ranges from  $0.23 \text{ kg} @ 110 \text{ (kcal/100 g)} = 253 \text{ kcal/fish}$  to  $0.255 \text{ kg} @ 110 \text{ (kcal/100 g)} = 281 \text{ kcal/fish}$   
 Estimated return rates range from  $281 \text{ kcal/} 0.117499 \text{ hr} = 2391 \text{ kcal/hr}$  to  $281 \text{ kcal/} 0.117499 \text{ hr} = 2387 \text{ kcal/hr}$

Table 7.22 contains similarly calculated return rate estimates for medium- and large-size fish obtained by spear, leister, or harpoon.

#### TROT LINES

Use of the freshwater trotline is described by Pénicaut when he was living with the Acolapossa and Natchitoches in the vicinity of Lake Ponchartrain, Louisiana, around 1700 (as quoted by Rostlund, 1952: 116):

After dining we went to see their fisheries. They drew from the lake their nets which were filled with fishes of all sizes. These nets are really only lines about six fathoms long a number of small lines are fastened to these a foot apart. At the end of each line is a fish-hook where they put a little piece of hominy dough or a little piece of meat. With that they do not fail to take fishes weighing more than fifteen to twenty pounds. The end of each line is attached to a canoe. They draw them in two or three times a day, and many fish are always taken when they draw them. This fishery does not interfere with their work in the fields, for it is accomplished in less than half an hour.

As Rostlund points out, this last sentence deserves emphasis because the trotline, unlike hook-and-line angling, permits the fisherman to conduct other work once the line is set.

Speck (1909: 25) also documents the use of trotline fishing among the Yuchi:

Gaff-hooks for fishing do not seem to have been used, according to the older men, until they obtained pins from the whites, when the Yuchi learned how to make fish hooks of them. Prior to this, nevertheless, they had several gorge-hook devices for baiting and snagging fish. A stick with pointed reverse barbs whittled along it near the end was covered with some white meat and drawn, or trolled, rapidly through the water on a line. When a fish swallowed the bait the angler gave the line a tug and the barbs caught the fish in the stomach. Another method was to tie together the ends of a springy, sharp-pointed splinter and cover the whole with meat for bait. When this gorge device was swallowed the binding soon disintegrated, the sharp ends being released killed the fish and held it fast. Lines thus baited were set in numbers along the banks of streams and visited regularly by fishermen.

Archaeological evidence of fishing gear, including fishhooks and plummets, has been recovered from Key Marco, Florida (Cushing, 1897: 367; Gilliland, 1975: 224–229; see also Widmer, 1988: 251).

C. C. Jones (1873: 326) suggested that “Fishing with hook and line seems to have obtained to a very limited extent, if we may judge from the remarkable absence of any thing like bone, flint, and shell hooks in the mounds and refuse-piles. Very few hooks have been found, so far as our information extends, and they were made of bone.” Despite his extensive discussion of fishing technology used by Southeastern tribes, Swanton rarely cited accounts of using fishhooks south of Virginia (1911: 346; 1928: 694; 1931: 55; 1942: 138; 1946: 339; see also Larson, 1980a: 117–126). Swanton (1946: 339) further suggested that the failure to find many references to the use of hook and line was because the European colonists were so accustomed to this method of fishing that they took it for granted. As support for this selective reporting, he cited archaeological evidence that bone fishhooks have been recovered in all stages of manufacture. Rostlund (1952: 124) argues precisely the opposite, correctly pointing out that hook-and-line fishing technology was hardly ignored by ethnohistoric observers elsewhere in North America. He instead suggests that

“a more probable reason for the rare references to line fishing in the South is that it was rarely seen.” Commenting on the archaeological evidence for hook-and-line technology, Rostlund suggests that angling techniques may well have been used during the prehistoric period, but use seems to have declined prior to European contact.

Although the specifics likely vary between this freshwater case and saltwater fishing with trotlines, the basic procurement tasks are parallel. Following the estimates derived by Lindström (1996), we will assume that 30 min are required to bait 15 fishhooks, to set the line by throwing, stake the line to shore, retrieve the line, and remove the fish from hooks. Assuming a return rate of 1 fish/hook, the average catch time is 2 min/fish (0.033 hr/fish). By factoring in the differential handling times involved for the variously sized fish classes, it is possible to estimate the return rates as follows:

*Small-sized fish (av. size range 0.23–0.34 kg)*

Catch time 2 min/fish (0.033 hr/fish)

Clean/cut up 0.5 min/fish (0.0083 hr)

Edible weight ranges from 0.23 kg  $\times$  0.75 = 0.1725 kg to 0.34 kg  $\times$  0.75 = 0.255 kg

Energy 110 kcal/100 g

Energy/individual ranges from 0.23 kg @ 110 (kcal/100 g) = 253 kcal/fish to 0.255 kg @ 110 (kcal/100 g) = 281 kcal/fish

Estimated return rates range from 253 kcal/0.04167 hr = 6072 kcal/hr to 332 kcal/0.04167 hr = 6731 kcal/hr

Table 7.22 contains similarly calculated return rate estimates for medium- and large-size fish obtained on trotlines.

#### ADDITIONAL FISHING TECHNIQUES

Aboriginal people of North America employed several additional fishing techniques, including poison, scoop nets, casts nets, and line fishing. For reasons discussed below, however, these technologies are not modeled in the present discussion.

We previously mentioned the difficulties in locating documentation of line fishing among Southeastern Indians. For present purposes, we accept Rostlund's (1952: 114) conclusion that whereas “line fishing

contributed something to the food supply of the Indians [of North America], on the whole it played a small role in what might be called the stable fishery.”

Similar problems attend the aboriginal use of fishing nets (except for gill nets, which were discussed above). The earliest picture depicting the use of nets north of Mexico is John White's painting (fig. 7.13) reproduced with Hariot's account of Indians near Roanoke Island (Rostlund, 1952: 83). However, the issue of authenticity remains, as Hariot mentions only two technologies for fishing (with spears and weirs); he does not mention fish nets. De Bry's engravings clearly took certain liberties with White's watercolors. The depiction of men in a canoe at the weir occupied with a dip net was added by De Bry; the trap in the weir illustrated in the original White picture is much more elaborate in the De Bry version, and the picture of men broiling a fish was also added by De Bry. “Whether the dip net that appears over the stern of a canoe in one of White's paintings was actually drawn from reality or was an artistic touch like that of De Bry's cannot, of course, be determined” (Rostlund, 1952: fn. 4, 83). Dip nets were likely used on the Georgia coast, both to retrieve fish already captured in weirs and also to capture schooling fish in the saltwater creeks. Unfortunately, a lack of sufficient evidence makes it impossible to estimate the potential return rates involved in this method.

Similar skepticism surrounds the aboriginal use of cast nets. As noted above, Fr. Andrés observed the use of cast nets in the saltwater creeks near St. Augustine in 1595, but it is unclear from the context whether the practice was native or introduced by the Spanish (de San Miguel, 2001: 72). Jones (1873: 340) wrote that “Nowhere, so far as our personal information goes, have either cast-nets or trolling-nets been particularly mentioned or described by the early narrators. In the present state of the inquiry, it does not become us, however to say that such nets were not in use among Southern Indians. The probability is that they did have such contrivances.” On the other hand, Rostlund (1952: 82) writes that “To my knowl-

edge there is no clear evidence that the casting net was used during pre-Columbian time in any part of North America, perhaps not in any part of the New World."<sup>37</sup>

Although it is likely that very small fish, such as mummichog and shad, were taken with fine-mesh nets, we have not attempted to model these mass-capture activities. Similarly, it is probable that very large fish, such as sharks, occasionally washed ashore. Although their carcasses were likely exploited by foragers on St. Catherines Island, we have no way to model such windfall events.

#### REPTILES AND MAMMALS ENCOUNTERED WHILE FISHING

Although saltwater fishermen doubtless relied on the abundant fishery off the coast of St. Catherines Island, these aboriginal foragers likely encountered a number of nonfish taxa in the process. When defining the overall prey set, then, it is important to include these additional prey items within the "saltwater fishing" hunt type.

In chapter 8, we discuss sea turtle harvesting as a terrestrial hunt type (involving the exploitation of nesting females, collection of turtle eggs, and hunting the raccoons that are consistently encountered in the vicinity of sea turtles nests). But it is also likely that sea turtles were encountered by offshore fishing parties during the summertime, and we must include this activity within the saltwater fishing hunt type.

Loggerhead turtles (*Caretta caretta*) frequent coastal Georgia from early May through August. Loggerheads of both sexes could be captured at sea—likely during an offshore fishing expedition—but the process is considerably more complex, hazardous, and expensive than the terrestrial collection of gravid females, who are completely helpless during nesting. To understand the process of hunting turtles at sea, we draw an analogy to the Meriam, who hunt green turtles in the Torres Strait (Bliege Bird and Bird, 1997; Bliege Bird et al., 2001: 11; Bliege Bird et al., 2002). The appropriate turtle, once spotted, was pursued by the Meriam in one or more dugouts, armed with harpoons (or perhaps

ropes and/or turtle hooks). But the modern Meriam hunters employ outboard motors in their pursuit; this method would be challenging using aboriginal technology. Once captured, the turtle could be brought alongside and hoisted into the boat. The turtles were brought back alive, then butchered and cooked. Cooperative hunts such as this among the Meriam can take several hours, and they are all-male pursuits requiring considerable skill, experience, and courage.

To model the hunting of loggerheads at sea, we will assume that a total of four person-hours are required to pursue and subdue a swimming turtle. We further estimate that in each case, two person-hours would be required to butcher an adult loggerhead. The estimated return rate (for male and female loggerheads) ranges between 8010 and 13,350 kcal/hr.<sup>38</sup>

Several other species of sea turtle pass through Georgia waters—including hawksbill (*Eretmochelys imbricate*), Kemp's ridley (*Lepidochelys kempii*), and green (*Chelonia mydas*) turtles—but only the leatherback (*Dermochelys coriacea*) appears with sufficient frequency to be considered here.

The leatherback turtle is the largest reptile in the world. Adult male leatherbacks range in size from about 500 to 900 kg; adult females weight 300–600 kg; in table 7.22, we employ an average weight range of 300–900 kg. They can dive a kilometer deep, while maintaining a core body temperature up to 18°C above the surrounding water. This adaptability has enabled the leatherback to establish the largest distribution of any known reptile, today ranging from the Atlantic to the Pacific to the Indian Oceans. Whereas all other sea turtles have bony hard plates on the shells, the leatherback's carapace is slightly flexible, with a rubbery texture. The front flippers of a leatherback are also longer than in the other marine turtles, even taking into account the leatherback's massive size (<http://www.turtles.org/leatherd.htm>).

Female leatherbacks nest an average of six times, every 2 to 3 years. In Florida, the nesting season lasts from April through July. Once a female leatherback finds a suitable spot, she deposits an average of 82 bil-

liard ball-sized eggs into the egg chamber. In the next chapter, we discuss the evidence for leatherbacks nesting on St. Catherines Island. Some local sportsmen suggest that because of their size and because they spend considerable time swimming on the surface, leatherbacks might be easier to hunt by boat than loggerheads (who rarely surface and are difficult to spot). For this reason, we will include the post-encounter return rate for loggerheads in the saltwater fishing hunt type. In table 7.22, we compute the return rate for male and female leatherbacks taken at sea (note that we have doubled the estimated processing time from that used for loggerheads). We estimate the range of return rates for leatherbacks to be 26,825–80,100 kcal/hr.

Finally, there is the question of sea mammal hunting in the water surrounding St. Catherines Island. Like Larson (1980a: 140–143, 145–164; see also Swanton, 1946: 329), we are skeptical of the lurid (and generally sketchy) ethnohistoric accounts of significant whale hunting along the middle Georgia coast. When it occurred, whale hunting was likely a seasonally specialized and sporadic activity carried on to the south, perhaps in south Georgia, more likely in Florida waters. Certainly beached whales became available from time to time, but we will not model whale hunting into the present diet-breadth framework.

Atlantic bottlenose dolphins today frequent the waters surrounding St. Catherines Island; they are commonly spotted in the lagoons and saltwater creeks of Liberty County, particularly on an incoming tide. But the speed and intelligence of these animals would, we suspect, make their capture quite difficult using aboriginal techniques, and we will not include dolphins in this analysis.

## NOTES

1. Drake was assisted in his survey by Dr. A. Oemler, who lived on Wilmington Island, near Savannah, “an authority on the biology and propagation of the oyster, through whose efforts I was enabled in many ways to expedite the survey” (Drake, 1891). Oemler (1889) reviewed the profitability and success of oyster cultivation from Virginia to Massachusetts and con-

cluded that the oyster industry of the Georgia coast was in dire need of legal protection. He cited figures of dropping productivity and “exclusive of a few beds near private landings, the raccoon oysters are already practically exterminated in Chatham and Bryan Counties” (Oemler 1889: 19). “As my sons have been engaged in the business of shipping oysters for years, and as I am living nearer to the best and most extensive oyster grounds in our waters, I have been better situated to note the rapid depletion of the beds and outrageously improvident manner of fishing them. Knowing, therefore, perhaps better than any other, that without the aegis of legislative protection the oyster industry of the State is doomed, I felt longer inaction on my part would partake of dereliction of duty” (Oemler, 1889: 16–17). Oemler presented a draft of potential legislation, arguing (among other things) that, for oyster beds between April 15th and September 1st, all culling be done over the beds and that cultivated beds be protected from poachers. Drake ultimately lost his bid to protect the Georgia shellfishery, as opponents argued that the oysters on the Georgia coast were in no need of protection, “inasmuch as the beds are not being exhausted, and that thousands of them are being formed every year. Every oysterman knows this is false” (Drake, 1891: 19).

2. This is a problem because as adult oysters mature, they release millions of fertilized eggs that must attach themselves to another hard substrate (ideally another oyster shell) in order to survive. Oyster larvae and young oysters (“spat”) need a hard, clean surface on which to attach and grow into adults in the soft mud flats and bottoms of tidal creeks and rivers. Dead oyster shells provide that surface, and even emit chemical clues to attract larvae and spats. Today, the University of Georgia Marine Extension supports a program to rebuild oyster reefs in tidal creeks and rivers. After the meat is harvested, oyster shells are cured (to rid them of disease), placed in plastic mesh bags, then planted onto suitable bottom during spawning season. The relaying of oyster shells must be timed to the spawning; returning oyster shells at the wrong time is a wasted effort (Randal Walker, personal commun.).

3. Walker and Cotton (2001) likewise document many small oyster beds in areas previously reported by Harris (1980) and Linton (1969) to have contained no oysters.

4. In addition to the major operation at Harris Neck, The Deed Record Book (Sullivan, 1990: 694) notes that the “Oemler Oyster Cannery”—a motor boat with one 30-horse power engine—services St. Catherines Island and its four oyster bateaux.

5. One bushel = 36.4 liters.

6. Throughout this discussion, we will employ the conversion for the “struck measure” bushel, which is equivalent to 35.238 liters.

7. “As a rule the oysters are not fat until late in December or early in January, which is probably due to the length of the warm seasons, and, in some localities, to the absence of rains. The past winter was known as a very dry season—far more so than the average, and was also a very warm winter. Hence we heard the native oystermen complain that the oysters were unusually

poor and unfit for market until January and February” (Drake, 1891: 182).

8. In contrast, the State of Florida has an average tidal range of only 30–60 cm.

9. The Gidjingali (Anbarra) undertake no special expeditions to gather gastropods; they are merely taken as they are encountered during trips that focused on other prey (Meehan, 1982: 105).

10. For their canoe-based expeditions (Meehan, 1982: 100), the Gidjingali (Anbarra) sometimes stock firewood and drinking water into the watercraft before paddling out to the oyster bank. They get a fire burning on the beach but do not eat raw oysters for danger of diarrhea. Sometimes they eat a few while collecting, but they normally prefer to eat lightly cooked flesh that still retains juices (what the Gidjingali call “gravy”). They occasionally overnight there.

11. For purposes of this discussion, we denote each collection trial by alphanumeric identifiers by shellfish type. A collection is first identified by a letter to denote when the collection episode took place (J or O, representing the month January or October), followed by a number indicating collection block and individual trial. Trial J-1.1, for instance, represents a single follow that occurred during the first block of collection episodes in January (2005). Each block of collection trials included from two to five individual follows.

12. It should be noted that all oyster procurement and handling rates were calculated based on October live weights. The times generated by these rates have then been held constant across season—with the expectation that rates would increase across season as live weight and meat yield increase, but that these contingent increases would balance into constant procurement and handling times.

13. January live weights and meat yield were calculated to reflect an experimentally obtained raw meat yield increase from October to January of 2.41 percent, or a 55.9 percent meat package increase.

14. Lunz (1943) calculates that the percent of dead oysters (i.e., empty shells) for “coon” oysters in coastal Georgia ranges from 9 to 11 percent per square yard. Due to our selectivity in collecting (semistripping method), however, we think that the percentage of dead oysters in our sample is probably less than this.

15. On nearby Sapelo Island (immediately to the south of St. Catherines Island), Ray Crook (1992, table 1) determined from oyster harvesting experiments in five different localities that meat weights ranged from about 2.5 to 13 g/individual.

16. Shell weight varies significantly by latitude. In the Gulf of Mexico and the Chesapeake Bay areas, oysters have much heavier shells than do oysters of the same size from the Georgia and South Carolina coasts (Randal Walker, personal commun.).

17. January and October are both “R” months, and common knowledge would suggest that both months would yield oysters that are ideal for consumption. As discussed earlier, however, St. Catherines’ October oysters are from a sufficiently southern latitude as to not reach “winter” conditions until late December or early January (Drake 1891: 182). Additionally, the “R” month convention for oyster edibility is part myth, part Euro-centrism, and part a holdover from the past. Oy-

sters are neither poisonous nor dangerous nor necessarily unpalatable to eat during warm non-R months. The European oyster, *Ostrea edulis*, holds its brood within its shell during spawning, making them “gritty” and unpalatable during warm months. American oysters, an entirely different genus, do not do this. During spawning, the American oyster, *Crassostrea virginica*, discharges all eggs and sperm. In the past, before refrigeration, spoilage during shipping and preservation of oysters was a concern, though immediate consumption by coastal societies and modern refrigeration technology negate this concern. The common opinion that spawning oysters taste “watery” or “milky” is a matter of cultural and regional preference.

18. We gratefully acknowledge the assistance of Irvy Quitmyer, Nicole Cannarozzi, and Royce Hayes in procuring these additional oyster samples.

19. Actually, two species of hard clam can be found in the coastal waters of southern Georgia, the southern quahog (*M. campechiensis*) and northern quahog (*M. mercenaria*). The difference is difficult to distinguish in archaeological specimens, and the two species are known to hybridize (Hayes and Menzel, 1972: 313; Quitmyer 1985: 31). For the purposes of this monograph, we will describe all hard clams from St. Catherines Island, both ancient and modern, as belonging to *M. mercenaria*.

20. Larson has argued that because hard clams are mobile and cannot penetrate into the oyster beds, “the collection of oysters would not result in the coincident gathering of quahogs” (Larson, 1980a: 68). This was not our experience on St. Catherines Island, where clam beds were often found directly adjacent to oyster patches.

21. This measure is based upon a “heaping bushel,” which is 1.278 larger than a “level measure” bushel (comprising 35.238 liters).

22. This assumption may be false. According to MacKenzie et al. (2002: 8), “Through history, fishermen have observed as they harvested quahogs that seed has continued to set and survive in the beds, and some believed harvesting quahogs with rakes may increase setting densities. In the 1990’s, fishermen in Narragansett and Raritan Bays related similar observations, saying, ‘We keep taking quahogs from these beds and they keep coming.’ These observations were confirmed by studies in Narragansett Bay by Rice et al. (1989), who showed that active fishing, which removed adult quahogs from beds, might have led to an increase in the abundance of juveniles.”

23. By comparison, Erlandson (1988: 103–104) reported a return rate of 1814 kcal/hr by experienced collectors working in heavily exploited clam beds on Baranof Island in southeastern Alaska, though it is difficult to tell whether he includes processing times when calculating his return rate or whether he relies exclusively on procurement times.

24. Parenthetically, we note that Trial O-2 appears to represent a collection attempt within a depleted patch (since the same group of collectors working in this same location likely reduced the clam density significantly from trial O-1 to O-2). We cannot invoke experience as the explanation for the increased rate of collection in the third trial, since only one experimenter in the group (LE) had collected clams during a previous

trial. Whatever the reasons for the successes of the final trial, however, we will use it to approximate Guale clam collection rates on St. Catherines.

25. Further experimentation in whelk collecting and processing would seem warranted, with processing being done by either breaching the shell or by boiling or steaming the whelk whole.

26. In several places throughout this monograph, we will discuss the LeMoynes' illustrations of Timucua subsistence practices, and a word is in order about the reliability of these engravings. Jacques Le Moynes du Morgues accompanied the first French Huguenot expeditions under Jean Ribault, which sailed in February 1562, landing at Fort George Island, near St. Augustine (Hann, 1996: 36). They entered the St. Johns River, then sailed up the coast to enter a Timucuan village about 3 leagues into the estuary of the St. Marys, and a village, likely on Cumberland Island. Ribault and his party eventually sailed northward to South Carolina, where they established a small colony near Beaufort, then returned to France. A second voyage returned to the New World in 1564, under the command of René Goulaine de Laudonnière; they sighted Florida about 30 leagues south of the St. Johns, established communications with Indians, and explored the mainland, finally picking out a place on the south bank of the St. Johns River to erect Fort Caroline. Occupied by the French between July 1564 and September 19, 1565, the fort was captured by Pedro Menendez de Aviles, bringing an end to the brief French colonial enterprise in Florida.

Although Le Moynes might have painted the watercolors in Florida, some scholars believe that he created them after returning to Europe. The Flemish engraver Theodore de Bry published a series of 14 illustrated books, including renderings of Le Moynes' watercolors of Florida's Timucuan peoples—long considered to be among the earliest European renderings of Indians living on mainland North America—providing a “privileged view into the past” (Milanich, 2004c: 3). All but one of Le Moynes' original watercolors have vanished.

As John Hann (1996: 20) has pointed out, however, de Bry's illustrations are “not an unmixed blessing” (Hann, 1996: 20). It is unclear how much of de Bry's engravings were based directly on Le Moynes' first-hand observations and how much derived from de Bry's imagination (or from details of Brazil's Indians from other early French explorers).

Sturtevant has warned that none of the ethnographic details in the de Bry engravings can be automatically accepted as fact (1977: 70): “Ethnographic and cultural-historical importance of Le Moynes' record is very equivocal, ... [and] the artifacts and activities shown cannot be taken as reliable representations of Timucuan life.” He notes that when Swanton (1922) assembled the available information on Timucuan culture, he relied heavily on Le Moynes' text, but elected not to publish the de Bry engravings because he thought they “contain so many errors that Le Moynes must have entrusted the execution to someone entirely unfamiliar with his subject, or else extreme liberties must have been taken with the originals” (Swanton, 1922: 345). In his 1946 compendium, however, Swanton reversed himself, when he published a dozen of the

engravings. “A modern ethnologist familiar with Southeastern Indian culture must agree that these [engravings] are very misleading,” writes Sturtevant (1977: 70), “even after one discounts the Greco-Roman bodies and the artificial European compositions, the artifacts and activities shown unfortunately cannot be taken as reliable representations of Timucuan life.” In a similar vein, Faupel (1992: 160, n. 26, 178) has analyzed the details in more than three quarters of the de Bry engravings, concluding that whereas “13 of these principally reflect Le Moynes' own work ... at least twelve had nothing to do with Le Moynes and have been composed by the engraver entirely from Laudonnière's text.”

In studying the Timucuan engravings, Milanich (2004c: 6) also made several critical observations: The French soldiers were depicted wearing their helmets backwards, the black drink ceremony showed cups made of nautilus shells (unavailable in coastal Florida), several of the Timucuan feather headdresses closely resemble those worn by Amazonian Indians, and several events depicted by Le Moynes are historical events that date to 1562 (and Le Moynes was not a participant in the 1562 expedition).

Milanich (2004c: 8) has recently taken Sturtevant's cautions a step further: “I honestly question whether Jacques Le Moynes actually did any paintings or drawings of Florida Indians at all.” He cites Carl Sauer's (1971: 211) critique that “‘Le Moynes did not write [the narrative in de Bry] nor did he supervise the engraving.’ We might expand Sauer's comments to argue that neither did Le Moynes write any of the captions for the engravings.”

27. The color version of John White's illustration appears on the cover of this monograph.

28. The shipwrecked Fr. Andrés de San Miguel describes a 1595 fishing expedition near St. Augustine, in the company of a Spanish soldier: “We would go out into a canoe, and we would enter some narrow arm of the sea. ... When it was high tide, we would block the passage with a piece of wickerwork or stretch of reed patches that were long and close together. I remained in the canoe while we roamed at will among the reeds. As the tide began to go out, the fish began to go back out again. Many of them, and especially the mullet, as they dumped into the reed beds, jumped up over the reeds, which were more than two yards higher than the water. Some fell into the canoe and more passed from the other side, from having the canoe well-positioned” (de San Miguel, 2001: 72).

29. We gratefully acknowledge the contribution of Elizabeth Reitz (Georgia Museum of Natural History, University of Georgia) in helping to develop this discussion. Professor Reitz has been a long-term collaborator in the archaeology program on St. Catherines Island (see chaps. 22 and 27), and she has been extraordinarily helpful in preparing this preliminary overview.

30. We are also fortunate that Bruce M. Saul (Professor of Biology, Augusta State University) is pursuing an on-going study of seasonality in fish species of the St. Catherines Island fishery, with a long-term goal of generating an index of contemporary biological integrity. Professor Saul and his students have sampled the beach

and freshwater fish populations on a monthly basis since August 1996 (Saul, 2002, 2003, 2004). The quality of this longitudinal research is unequalled in the south-eastern states, and we have drawn upon Professor Saul's experience and expertise in preparing the following preliminary discussion of aboriginal fishing practices on St. Catherines Island.

31. For another saltwater adaptation of Lindström's (1996) pioneering research in the Truckee River drainage, see Kennett (2005).

32. While it is likely that fish were commonly dried and/or smoked, preservation costs are not included in the energetic estimates below.

33. Bruce Saul (personal commun.) notes that gill nets are most effective when the filaments are "invisible" to the fish and the net is used in turbid waters (although it is possible that aboriginal foragers actually "drove" the fishes into the nets). Gill nets tend to catch larger fish because smaller ones do not usually "push" themselves into the mesh. The ideal girth of a fish (to be captured in a gill net) is approximately 1.25 times the perimeter of the mesh (in each "square" opening). Fishes more or less than 20 percent of this approximate value are not caught in this size mesh. Net factors such as size, elasticity, flexibility, strength, and visibility as well as deployment frequency, time of day, and season can influence the catch. In general, smaller diameter mesh filaments capture larger fish.

34. I am grateful to Mr. Royce Hayes for providing information about this gill net experiment.

35. Jones (1873: 328) also mentions the use of bows and arrows in fishing.

36. Cited in Swanton (1922: 390).

37. This debate centers on whether cast nets were observed by members of the De Soto expedition. In *Antiquities of the Southern Indians*, Jones (1873: 39) takes the expression "e por muito que tiravam" (Elvas, 1907: 209, 1940: 101) to mean that casting nets were used at Pacaha (in north Georgia). This phrase was translated by Buckingham Smith—Jones' authority in this case—as meaning "however much might be the casting." Rostlund (1952: 82) argues that the phrase "casting the nets" is misleading and employed in the biblical sense of "casting a net into the sea" (Mark 1:16), where use of a casting net could not possibly be implied.

38. These estimates compare favorably with the return rates derived for the Meriam (Smith and Bliege Bird, 2000; Bliege Bird et al., 2002, table 1; Smith et al., 2003). The prey species in this case is green turtle (*Chelonia mydas*), with a live weight averaging 100–150 kg. For female green turtles collected while nesting by the Meriam, Bliege Bird et al. (2002: table 1) compute a post-encounter return rate of  $20,034 \pm 2090$  kcal/hr (a figure statistically identical to the loggerhead estimate for St. Catherines Island). The Meriam figure for hunting green turtles (both sexes) is  $5615 \pm 1830$  kcal/hr (considerably lower than the estimate of 8010–13,350 kcal/hr estimate for St. Catherines Island).

## CHAPTER 8. TERRESTRIAL FORAGING ON ST. CATHERINES ISLAND

DAVID HURST THOMAS, WITH CONTRIBUTIONS BY MAUREEN KICK, MATTHEW SANGER, AND ANNA SEMON

This chapter estimates post-encounter return rates for the most important terrestrial resources available to aboriginal St. Catherines Islanders (table 8.1). By necessity, some of these estimates rely on previously published return rates from elsewhere, but we also report the results of optimal foraging experiments on St. Catherines Island involving diamondback terrapins, pignut hickories, and acorns (live oak and laurel oak).

### HUNTING

This catchall hunt type basically encompasses all nonmarine hunting conducted on St. Catherines Island—with the important exception of sea turtle harvesting that materializes during the summer months (and will be discussed in the next section). To be sure, there is considerable seasonal variability in the available game. In the fall, for instance, the deer are prime, fat from gorging on the mast; but beginning in the late autumn, their body weight will continue to drop until the acorns come right again. But the basic suite of terrestrial game is fairly constant. We begin this examination of the St. Catherines Island resource base by attempting to estimate post-encounter return rates for those prey species available to pre-contact aboriginal hunters during the fall, winter, and springtime (roughly September through mid-May).

To reiterate the logic of the prey choice model, we expect that the resources within the terrestrial fall–spring hunt type will be ranked in order of decreasing post-encounter return rate; specific prey items will be harvested so long as their realized return rate exceeds the mean return of all higher ranked taxa. The fine-grained assumptions are met to a reasonable degree: Specifically, all prey types are encountered in a fairly random way, the taxa are distinct on the basis of post-encounter return rates, and

they are harvested singly, with a low probability of additional encounters during the pursuit.

### WHITE-TAILED DEER

White-tailed deer (*Odocoileus virginianus*), the smallest deer species in North America, are the only hoofed animal native to coastal Georgia. White-tailed deer now exist on most barrier islands, although many extant populations do not derive entirely from native stock (Johnson et al., 1974: 59).

St. Catherines Island has long been known for its unusually dense and well-nourished deer herd. This is partly due to the land management practices of Jacob Rauers, who acquired the island in the 1870s. Unlike the other Sea Islands of the Georgia coast, St. Catherines was the property of a single owner, who converted the island into a world-class game preserve by discouraging tourism and prohibiting commercial construction on the island. To encourage a return to wilderness conditions, Rauers strictly limited the number of people living on the island and curtailed virtually all cultivation; he imported new blood strains into the herd to counteract inbreeding. Hart and Bonner (1956: 56) estimate that the white-tailed deer population on St. Catherines Island in 1904 numbered 10 to 20 thousand white-tailed deer (approximately 35 to 70 individuals per 100 ha). After a cursory inventory in the early 1970s, Anderson (1972, 1973) estimated that fewer than 400 deer (roughly 14 individuals/100 hectares) lived on St. Catherines Island at the time.<sup>1</sup>

Because of the dense island vegetation, visiting hunters during the early 20th century found stalking individual deer to be almost impossible. Instead, they engaged in larger scale communal hunts, assisted by

TABLE 8.1  
**Macronutrients and Caloric Returns for the Major Terrestrial Resources Available on St. Catherines Island, Georgia**  
 (Unless indicated otherwise, all estimates are based on raw samples.)

Species	Energy (kcal/100 g)	Carb. %	Fat %	Protein %	Source
Rabbit (wild)	114	1	18	81	USDA
Duck	123	0	31	69	USDA
Wild turkey	160	1	45	54	USDA
Goose (domesticated)	161	0	40	60	USDA
Squirrel	120	0	24	76	USDA
Deer	120	0	18	82	USDA
Opossum <sup>a</sup>	146	0	42	58	USDA
Raccoon <sup>b</sup>	168	0	51	49	USDA
Alligator	100	76	2	22	Lutz et al. (2003)
Turtle (green)	89	6	5	89	USDA
Diamondback terrapin	75–156	6–30	1–24	69–94	QC Labs (this vol.; see table 8.8)
Hickory nuts, generic estimates					
nutmeat, raw	657	1.1	8.2	0.7	USDA
nutmeat, raw	657	1.83	6.44	1.27	Gremillion (2002: 149)
Hickory nuts, St. Catherines Island					
nutmeat, raw	700	1.8	.6	1.3	Silliker Lab (this vol.)
nut oil	40	5	0.5	0.4	Silliker Lab (this vol.)
Acorns, generic estimates					
raw	387	41	24	6	USDA
dried	509	54	31	8	USDA
Acorns, St. Catherines Island					
live oak, raw	298	60	5	3	QC Labs (this vol.)
live oak, dried	405	78	8	4	QC Labs (this vol.)
live oak, roasted	288	56	6	3	QC Labs (this vol.)
live oak oil	1	0.16	0.05	—	QC Labs (this vol.)
laurel oak, raw	381	55	17	4	QC Labs (this vol.)
laurel oak, roasted	438	55	23	3	QC Labs (this vol.)
laurel oak, dried	502	65	25	4	QC Labs (this vol.)
laurel oak, oil #1	4	0.12	0.32	0.13	QC Labs (this vol.)
laurel oak, oil #2	3	0.51	—	—	QC Labs (this vol.)
white oak, raw <sup>c</sup>	279	62	3	3	QC Labs (this vol.)

<sup>a</sup> USDA figures for raw opossum not available, so cooked (roasted) value adjusted downward by one-third.

<sup>b</sup> USDA figures for raw raccoon not available, so cooked (roasted) value adjusted downward by one-third.

<sup>c</sup> White oak acorns were not available on St. Catherines Island; therefore acorns were collected from white oaks in Atlanta, Georgia.

hounds and experienced “beaters”. Such drives were often staged in the long-leaf pine forests on the northern end of the island, though successful deer drives also took place near the marsh and beach strand. Bucks living in the small island hammocks could be driven to the broad beaches, where they were easily ambushed (some often escaped by swimming to more distant hammocks). The drive areas ranged from 2 to 3 square miles down to an area of

perhaps 200 × 200 square yards (Cunningham, 1900: 371).

DIET OF WHITE-TAILED DEER IN THE SEA ISLANDS: Miller (1988) and Rowland (1989) have studied the reproductive biology and population genetics of white-tailed deer on Cumberland Island. Epstein et al. (1983, 1985) has analyzed deer populations on South Island, South Carolina.

The most comprehensive study of sea island deer populations is Osborne et al.

TABLE 8.2  
**Proximate Chemical Analysis of Major Fall and Winter Deer Food on Blackbeard Island, Georgia (Osborne et al., 1992: table 6; see also Halls, 1977: 229–230)**

Taxon	Common Name	Percent dry matter		
		Protein	Fat	Fiber
<i>Quercus virginiana</i>	Live oak	5.1	8.1	15.3
<i>Q. hemisphaerica</i>	Laurel oak	4.2	20.9	21.9
<i>Serenoa repens</i>	Dense saw palmetto	5.7	10.0	15.2
<i>Sabal palmetto</i>	Cabbage palm	7.6	3.0	15.7
<i>Myrica cerifera</i>	Wax myrtle	12.5	2.4	22.7

(1992), an in-depth consideration of population ecology of white-tailed deer on Blackbeard Island. Based on their analysis of 228 rumen samples, Osborne et al. (1992: 13) reconstructed the diet and seasonal round in great detail (see tables 8.2 and 8.3).

Mast, especially acorns, is clearly the food of preference for white-tailed deer on Blackbeard, eaten whenever available and, as we will see below, the high energy return of acorns played a critical role in deer population dynamics on Blackbeard. Although acorns are most important in the fall, white-tailed deer consume them throughout the year, depending on availability. Live oak and laurel oak are the most abundant mast producers, and total mast failure of both species is uncommon. The flowering stalks and fruits of saw palmetto (which appear only irregularly) are likewise important and may even have been taken in preference to acorns when available (Osborne et al., 1992: 24). Each of these mast crops is relatively high in fat content; the composition of saw palmetto fruits is similar to that of live oak acorns, but laurel oak acorns are more than 2.5 times that of live oak acorns (see table 8.2). Cabbage palm is an important emergency mast food, consistently eaten after the acorn crop had been depleted. Other mast fruits include red bay, black gum, prickly pear, muscadine, and china-berry (table 8.3).

Especially during the springtime, white-tailed deer eat green leaves and the stems of

woody plants (especially broad-leaved evergreens; Osborne et al., 1992: table 3), and they feed on such browse to some extent throughout the year (except in the fall, when acorns are available). Lay (1969) considers heavy browsing of wax myrtle to be an indicator of heavy pressure on food resources, and this species is conventionally considered to have only “medium” palatability for deer populations of the middle Atlantic. At least on Blackbeard Island, wax myrtle is the most important woody browse component species (especially in the winter and fall, after the mast supply had been exhausted) and may have been an important survival food for deer throughout the Georgia coast (Osborne et al., 1992: 25). Other browse of lesser importance includes the green leaves of live oak, laurel oak, pignut hickory, mistletoe, red bay, greenbrier, and sea ox-eye. Broad-leaf herbaceous plants also form an important part of the white-tailed deer diet, particularly during the spring and fall. Smartweed is the most important green forb; deer also ate lesser quantities of beach pennywort, resurrection fern, grasses, rushes and sedges (see also table 8.3).

Extrapolating from the rumen contents, Osborne et al. (1992: 28–29) reconstructed the seasonal movement of white-tailed deer on Blackbeard Island.<sup>2</sup>

- For the monthly intervals sampled (16 months in 1978–1979), the maritime forest habitat supplied more than 60 percent of the white-tailed deer diet;<sup>3</sup> during the fall, this proportion increased to 80–100 percent. Even in times of acorn scarcity, the maritime forest habitat supplied the browse necessary for survival.
- Freshwater wet-site habitats (inland ponds and wet savannahs) host more than two dozen species of herbaceous plants, which contribute significantly to the spring and summertime deer diet (and the least during the fall); in March of 1976, this habitat type contributed 71 percent of the diet.
- White-tailed deer can often be spotted feeding along the highest portions of the salt marsh, particularly during the late winter and early spring, when the quality and availability of upland vegetation is low. Marsh soils (with their abundant nutrients) support a succulent and nutritious suite of marsh plants, including glasswort, sea ox-eye, cordgrass, salt grass,

TABLE 8.3  
Major Foods in the Diet of Blackbeard Island Deer from Fall, Spring, and Summer 1974–1977<sup>a</sup>

October–December diet	Common name	Aggregate percent volume			
		1974 (n = 71)	1975 (n = 48)	1976 (n = 38)	1977 (n = 37)
<b>Woody plants (fruit)</b>					
<i>Quercus hemisphaerica</i>	Sand laurel oak	6	50	28	23
<i>Quercus virginiana</i>	Live oak	1	7	15	67
<i>Sabal palmetto</i>	Cabbage palmetto	18	8	5	3
<i>Serenoa repens</i>	Saw palmetto	—	tr <sup>b</sup>	32	—
<i>Persea borbonia</i>	Red bay	2	1	3	tr
<i>Nyssa sylvatica</i>	Blackgum	3	tr	—	tr
Other (14 items)		3	2	2	1
Subtotal		33	85	68	94
<b>Woody plants (green leaves and stems)</b>					
<i>Myrica cerifera</i>	Wax myrtle	14	2	1	—
<i>Quercus virginiana</i>	Live oak	4	1	tr	tr
<i>Quercus hemisphaerica</i>	Sand laurel oak	3	1	1	—
<i>Phoradendron serotinum</i>	Mistletoe	3	1	1	tr
<i>Carya glabra</i>	Pignut	3	tr	tr	—
Other (37 items)		9	3	3	2
Subtotal		36	8	6	2
<b>Woody plants (dried leaves and stems)</b>					
<i>Vitis rotundifolia</i>	Muscadine	2	8	tr	—
Other (22 items)		9	1	tr	2
Subtotal		11	9	tr	2
<b>Herbaceous plants</b>					
<i>Polygonum punctatum</i>	Water smartweed	4	5	2	tr
Grasses, rushes, sedges		5	1	1	1
<i>Limnobium spongia</i>	Frog's bit	3	1	tr	—
Other (34 items)		3	5	tr	1
Subtotal		15	12	3	2
<b>Fungi</b>					
Subtotal		4	2	3	1
<b>Miscellaneous &amp; unidentified</b>					
Subtotal		1	tr	4	tr
Total		100	99	101	101

Spring, summer diet	March 1975	March 1976	April 1975	June 1975	August 1974
<b>Woody plants (leaves and stem)</b>					
<i>Myrica cerifera</i>	Wax myrtle	44	11	5	2
<i>Serenoa repens</i>	Saw palmetto	tr	—	32	—
<i>Vitis rotundifolia</i>	Muscadine	—	—	4	13
<i>Persea borbonia</i>	Red bay	2	6	2	3
<i>Smilax</i> spp.		2	tr	5	4
<i>Borrchia frutescens</i>	Sea ox-eye daisy	1	—	8c	—
<i>Quercus virginiana</i>	Live oak	1	—	5	1
Other (28 items)		9	9	9	17
Subtotal		59	26	70	40

TABLE 8.3  
(Continued)

Spring, summer diet	March 1975	March 1976	April 1975	June 1975	August 1974
Herbaceous plants					
<i>Poaceae</i>	24	2	8	1	26
<i>Linnobium spongia</i> Frog's bit	6	30	tr	7	—
<i>Polygonum punctatum</i> Water smartweed	tr	11	4	11	tr
<i>Hydrocotyle bonariensis</i> Water pennywort	7	12	tr	tr	tr
<i>Cyperaceae</i>	1	13	4	tr	tr
<i>Centrosema virginiana</i> Butterfly pea	—	—	tr	13	4
<i>Polypodium polypodioides</i>	tr	tr	tr	4	6
<i>Lippa nodiflora</i>	—	—	1	—	5
Other (33 items)	tr	3	9	6	8
Subtotal	38	71	26	42	53
Fungi	4	3	1	10	25
Subtotal	4	3	1	10	25
Miscellaneous & unidentified	—	—	3	9	tr
Subtotal	—	—	3	9	tr
Total	101	100	100	101	101

<sup>a</sup> From rumen analysis. Major foods are those comprising  $\geq 5\%$  volume in any month and sampling period. Sample sizes: August 1974: 7, other months, 6 each.

<sup>b</sup> tr: trace amounts.

<sup>c</sup> Insect leaf galls.

ridged sedge, and grousel-bush; but only in March does the salt marsh contribute more than 5 percent of the total diet (Osborne et al., 1992: 29).

- Beach and dune plants contribute mostly in springtime, when beach pennywort was consumed sometimes in significant amounts. But during the rest of the year, deer occasionally fed on beach and dune plants including fog-fruit, groundcherry, horse nettle, bear-grass, and prickly pear.

**CHANGING BODY SIZES:** The biomass of white-tailed deer is known to vary greatly through time and across space (Koch, 1986; Purdue, 1986, 1989, 1991; Purdue and Reitz, 1993). In the American Midwest, for instance, small-sized deer adapted to the warm and dry middle Holocene conditions; as the climate became more mesic during the late Holocene, white-tailed deer became larger.

Johnson et al. (1974: 59) estimate a mean weight of 27 kg for deer on Blackbeard Island, roughly 18 kg less than the mean live weight for white-tailed deer on the contemporary Georgia mainland (see also Crook, 1986: 9; Reitz, chap. 22, this volume).

Throughout the Sea Islands, white-tailed deer are today much smaller than the mainland counterparts, and we now understand that Sea Island deer were approximately the same size as their mainland counterparts during the initial period of human occupation of the barrier islands (when deer were still adapted to mainland conditions).

Purdue and Reitz (1993) investigated body size changes in the American Southeast by studying both modern and archaeological collections from several sites (table 8.4). To represent "mainland" deer populations in Georgia and South Carolina, they selected four samples that span the past 4 millennia: contemporary deer bones from Aiken and Barnwell counties (Purdue, 1986, 1989) and archaeological samples from the Lewis site (Aiken County, 750 B.P.; Sassaman et al., 1990), the Stallings Island site (Columbia County, 3,700 B.P.; Claflin, 1931; Sassaman, 1991; others), and the Fennel Hill site (Allendale County, 4400 B.P.; Trinkley 1974; Sassaman, 1991).

The sample of white-tailed deer from the barrier islands of coastal Georgia consists

TABLE 8.4  
**Changes in White-Tailed Deer Body Weight (after Purdue and Reitz, 1998)**

Analytical unit	Age <sup>a</sup>	Body weight (kg)			Source
		♂	♀	Mean <sup>b</sup>	
South Carolina and Georgia Mainland					
Savannah River Site (Aiken and Barnwell Counties, SC)	Modern	59	43	51	Purdue (1986, 1989)
Lewis Site (38AK228; Aiken County, SC)	A.D. 200	72	45	58.5	Sassaman et al. (1990)
Stallings Island site (9CB1; Columbia County, GA)	1750 B.C.	65	47	56	Sassaman (1991)
Fennel Hill Site (38AL2; Allendale County, GA)	2450 B.C.	78	53	65.5	Sassaman (1991); Trinkley (1974)
Georgia Barrier Islands					
Ossabaw Island (Chatham County)	Modern	40	34	37	Purdue (1986, 1989)
Mission Santa Catalina de Guale (St. Catherines Island, Liberty County)	A.D. 1650	47	34	41.5	Thomas (1987), Reitz (in press)
St. Catherines Island (composite Irene, St. Catherines and Wilmington period sites)	A.D. 1000	54	41	47.5	Reitz (this vol.)
Composite St. Simons Period Sites (St. Catherines Island and Cane Patch site [9CH35], Ossabaw Island)	1650 B.C.	85	60	72.5	Reitz (this vol.), DePratter (1979a, 1979b)

<sup>a</sup> Expressed as uncalibrated years A.D./B.C.

<sup>b</sup> Computed as the unweighted average of male and female body weight estimates.

of a modern control sample from Ossabaw Island (Purdue, 1986, 1989) and three archaeological collections (1) from Mission Santa Catalina de Guale (325 B.P.; Thomas, 1987), (2) a composite late prehistoric assemblage from the Irene, St. Catherines, and Wilmington phase occupations (average age, 950 B.P.; Reitz, this volume), and (3) a composite St. Simons phase collection (3600 B.P.) from St. Catherines Island (Reitz, this volume) and from the Cane Patch site, Ossabaw Island (DePratter, 1979a, 1979b).

Purdue and Reitz (1993) focused their study on the astragalus (a bone from the hind foot) for several reasons: They are commonly preserved unbroken in archaeological deposits, ontogenetic variation is minimal (because the astragalus is near adult size in 6-month-old fawns), because sex can readily be determined on astragalus bones, and because the astragalus is a good indicator of adult body size (Purdue, 1987). The various statistical procedures are described in Purdue and Reitz (1993: 283–287).

Figure 8.1 documents the changing body size over the last 3000–4000 years for main-

land and barrier island white-tailed deer populations (as described above; see also tables 8.4 and 8.5). Body size changed most dramatically in the Georgia Sea Island samples. At about 1600 B.C. (during the St. Simons phase), the mean adult body weight of island deer is estimated to be 72.5 kg, slightly larger than their counterparts on the South Carolina mainland (with a mean weight of 65.5 kg).<sup>4</sup> Thereafter, the body size of island deer populations shrinks markedly; the male–female mean body size

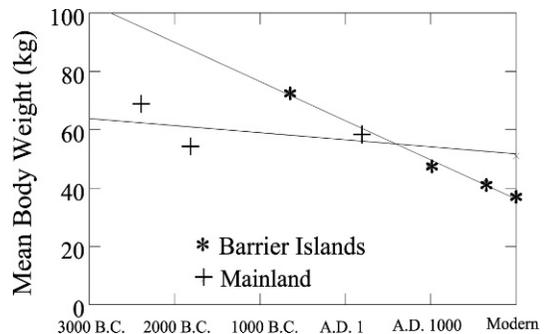


Fig. 8.1. Changing body size in white-tailed deer body from the barrier islands and mainland of the Georgia Bight over 5000 years (after Purdue and Reitz, 1993).

TABLE 8.5  
**Changing Return Rates for White-Tailed Deer (unweighted mean between male and female size)**

Temporal changes	Years		Average live wt. (kg)	Adj. live wt. (kg)	Usable %	Meat wt./ind.	Energy (kcal/100 g)	kcal/ind.	Pursuit time (hr/ind.)	Processing time (hr/ind.)	Return rate (kcal/hr)
	A.D./B.C.										
Modern	A.D. 1950		37	—	60	22.2	120	26,640	0.02–1.0	1.5	10,656–17,526
Mission period	A.D. 1650		41.5	—	60	24.9	120	29,988	0.02–1.0	1.5	12,096–19,659
Irene/St. Catherines/ Wilmington Period	A.D. 1000		47.5	—	60	28.5	120	34,420	0.02–1.0	1.5	13,768–22,500
St. Simons Period	1600 B.C.		72.5	—	60	25.2	120	43,500	0.02–1.0	1.5	17,400–28,618

for contemporary white-tailed deer populations on Ossabaw Island is only 37.0 kg. Note that body size of mainland white-tailed deer likewise also decreases during the late Holocene from peak mean body weight of 78 kg (at about 2400 B.C.) to a modern size of 59 kg (representing a 24% decrease in live weight).

So it was that, when aboriginal people first colonized St. Catherines Island—shortly after the Pleistocene core became isolated as an island<sup>5</sup>—they encountered deer roughly the size of those on the mainland. But the longer the island deer population was isolated from the mainland population, the smaller became the island deer. Post-Pleistocene climatic change may be a factor here, since mainland deer are also getting somewhat smaller during this interval (Purdue, 1980; Purdue and Reitz, 1993). By the time of Spanish contact, the deer of St. Catherines Island were much smaller and quite distinct from their mainland counterparts. Aboriginal hunters living at Mission Santa Catalina de Guale pursued white-tailed deer that were, quite literally, half the size of those hunted by their Late Archaic ancestors.<sup>6</sup>

ISLAND POPULATION ECOLOGY OF WHITE-TAILED DEER: Georgia's barrier islands, with their relatively infertile, sandy soils, are generally considered to provide low-quality habitat for browsers, and hence white-tailed deer population densities should be low in the Sea Islands. But in fact, the northern Sea Islands in Georgia generally sustain more deer than the adjacent mainland habitats. Shelford (1963: 80) estimated that in 1943, the Blackbeard National Wildlife Refuge supported a density of 15 deer/100 ha; but a systematic deer harvesting program was initiated 4 years later, and the deer density jumped to a sustained level of roughly 50 individuals/100 ha (Osborne et al., 1992: 1). Estimates for nearby St. Catherines Island range from about 36 to 70 deer/100 ha (during the early 20th century); but after the introduction of cattle and hogs, this figure dropped to fewer than 14 individuals/100 ha (in 1972–1973). In their 1979 survey of the vertebrate fauna of Fort Pulaski National Monument (located on

Cockspur Island, near Savannah, Georgia), Rabolli and Ellington (1999) estimate deer density to be 24 individuals/100 ha (63 deer/mile<sup>2</sup>) and they report comparable densities for Jekyll Island (29 deer/100 ha) and for Ossabaw Island (17 deer/100 ha).

These deer density estimates in the Sea Islands compare favorably with comparable figures for the nearby mainland. For the Coastal Plain in general, Goodrum and Reid (1959: 140) estimate an overall population density of one white-tailed deer for every 11 acres in the Coastal Plain, which Larson (1980a: 170) lowers slightly to 50 individuals per square mile (19.3 deer/100 ha). In the Georgia Deer Management Plan for the years 2005–2014, Bowers (2005) estimates that the 2004 prehunt deer herd across the entire State of Georgia averaged only about 13 deer/ per 100 ha of forested habitat. To be sure, island deer are smaller than their mainland counterparts, but despite the smaller body size, the islands tend to support a biomass at least as great as most mainland habitats. To understand this counterintuitive finding, we return to the Osborne et al. (1992) study of the population ecology of white-tailed deer on Blackbeard Island (immediately to the south of St. Catherines Island), which provides both a cautionary tale and a useful model for exploring long-term hunter–prey relationships.

Blackbeard Island is comprised entirely of closely spaced Holocene-age dune ridges, “docked” on the northeastern margin of Sapelo Island. Blackbeard Island covers a total of 2275 ha comprised of uplands (1180 ha), ocean beach and dunes, freshwater ponds, and tidal marsh (845 ha). The island is about 9.7 km long and averages 3.2 km wide on the northern half, 0.8 on the southern half. Blackbeard Island has long been home to a dense population of smallish white-tailed deer (*O. v. nigribarbis*). A 1937 census counted 600 individual white-tailed deer, which translates to about 50 deer per 100 ha patch of uplands.<sup>7</sup>

Blackbeard Island offers a unique window into the population ecology of white-tailed deer in barrier island ecosystems because mortality due to nonhunting losses (in-

cluding predating, poaching, automobile accidents, and emigration) are “almost nil” (Osborne et al., 1992: 70). Blackbeard Island is essentially a closed system, separated from nearby Sapelo Island by about 550 m of open water and tidal salt marsh; the nearest point to the mainland is about 10 km, and the distance to St. Catherines Island is 3 km (across Sapelo Sound). Although deer occasionally swim in the waters off Georgia’s barrier islands, Osborne et al. (1992) assume the immigration and emigration of deer on Blackbeard Island is effectively zero. Losses to American alligator, the only potential nonhuman predator, are minimal.<sup>8</sup> Blackbeard Island is virtually free of poaching, and the only human residents are the refuge manager and family. Parasitism and disease has been a factor, particularly before screwworm was eradicated in 1958; other ectoparasites, especially lone star ticks and lice, are present, but created no observable debility during the study period. Deer competed with cattle for food (until 1931) and with hogs until about 1960. Nevertheless, during the first half of the 20th century, deer densities on Blackbeard Island remained quite high, and the browsing intensity was extreme.

Privately owned until 1800, Blackbeard Island was purchased by the U.S. Navy Department as a source of live oak timber for shipbuilding (Osborne et al., 1992: 16–20). Allen (1948) reports an aerial survey of deer living on a relatively small barrier island in Georgia (almost certainly Blackbeard Island), a place without hunting pressure because human trespassing was strictly forbidden. A herd of roughly 200 (highly inbred) deer lived here. They were overpopulating the small island (roughly 5 miles long and 2 miles wide). They were extremely thin and undernourished. Allen (1948) believed that these were the only deer within the State of Georgia suffering such severe food shortage.

In 1947, the U.S. Fish and Wildlife Service sanctioned a program of controlled archery hunting on Blackbeard Island, a practice that has continued to this day. A tightly regulated number of archers were permitted to take deer without regard to sex or age,

and they removed a substantial proportion of the deer population annually. Complete records exist regarding the hunters and the deer they killed during the annual archery hunts held between 1947 and 1987 (Osborne et al., 1992). Numerous specimens were also harvested for scientific study. In other words, over the past several decades, legal hunting (by archers) has been the primary cause of mortality among the deer on Blackbeard Island.

Osborne et al. (1992: vii) conclude that, whereas browse was adequate on Blackbeard Island, much of it was of low quality; the fact is that Blackbeard Island deer depended heavily on acorns and other mast for basic energetic needs. They found that deer condition in the fall was more a reflection of the size of the acorn crop than deer density “because acorn availability was the overriding factor in nutrition.” Acorns commonly remain in sufficient abundance to constitute a substantial portion of deer diets into December—sustaining a dense deer population on Blackbeard Island. But in most years, the combined efforts of white-tailed deer and raccoons (the other major consumer of acorns, absent human foragers) deplete the acorn crop before the spring green-up, forcing deer to subsist by browsing on woody plants (especially wax myrtle). Osborne et al. (1992: 36) argue that, through time, such pressure must have eliminated many of the desirable woody browse species: “A dense deer population fueled by mast may insure that the few good woody browse species present never became abundant, thus when mast is not available, deer have few good quality buffer foods to which they may turn.”

In his study of white-tailed does on Blackbeard Island, Whittington (1963; cited in Osborne et al., 1992: 47) found an extremely low reproductive performance, which he attributed to high population density and poor nutrition due to the marginal barrier island habitat. This reproductive rate is similar to that for white-tailed deer on Cumberland Island and the flatwoods/sand pine-scrub oak areas in Florida, but considerably lower than most mainland habitats, including New York State, where

deer suffered chronic winter starvation (Cheatum and Severinghaus, 1950).

Despite this low reproductive rate, infertile soils and low-quality forage, the deer herd on Blackbeard Island has sustained a significant and sustained annual harvest for decades (Osborne et al., 1992: 1). In most white-tailed deer populations, deaths due to nonhunting factors (nonharvest losses) tend to equal or exceed those due to hunting. But on Blackbeard Island, the hunting harvest accounts for more than two thirds of the total loss: “This helps to explain how the Blackbeard Island population, with a low reproductive rate, sustained a harvest rate higher than populations on better ranges that have higher reproductive rates” (Osborne et al., 1992: 54).

Animals commonly regulate their own population numbers based on cyclical availability of food and appropriate habitat. In the absence of nonhuman predators, this means population density is regulated by lack of nutrients necessary for survival and reproductive success. In places with poor forage quality, reproductive potential also drops (McCown, 1991). Conventional models of game management assume, often implicitly, (1) there is a simple and direct relationship between deer numbers and the quantity of woody browse available and (2) that small size in deer reflects the poor quantity of browse available.

But Osborne et al. (1992: ix) caution that such density-dependent models, upon which most deer management programs are based, simply cannot account for the population dynamics observed on Blackbeard Island, where the deer population depends almost exclusively on a high-energy diet of mast. This finding is important because it means that the overall carrying capacity is not greatly influenced by deer numbers. Because of the overriding impact of density-independent factors—in this case acorn mast productivity—the island deer populations of the Georgia Bight do not respond as expected to conventional game management prescriptions (Osborne et al., 1992: ix).

The variety of resources available to the deer populations of Blackbeard Island is quite limited (and hence readily studied).

Without a doubt, the “availability of acorns overrides the effects of deer density on the nutritional status of the deer population” (Osborne, 1992: 71), meaning that density of deer living on Blackbeard is almost completely independent of acorn productivity.<sup>9</sup> When acorn productivity is up, the deer population can withstand a harvest of about 28 percent. But the peaks in deer harvests generally coincided with poor acorn crops, probably because deer feed more frequently during the daytime when mast is scarce. This is why, when acorns were scarce, the deer population decreased due to higher hunter success, followed by lower reproductive rates and higher than normal postseason mortality. The combination of these two factors (poor mast and more successful hunting) lowered the deer population the succeeding year. As a result, fewer hunters pursued deer on Blackbeard in the following year (and the harvest yield spiraled downward). Human harvest generally remained low for the next couple of years, until the deer population rebounded—the result of good mast productivity and reduced hunting pressure.

The overall white-tailed deer population on Blackbeard Island was thus regulated by density-independent factors—the availability of acorns and the pressure of the human harvest (Osborne et al., 1992: 65–67). Deer reproductivity and growth does not respond significantly to herd reduction, at least in the short term. “This pattern is, we believe, not restricted to the conditions specific to Blackbeard Island, and likely apply to many habitats in the Southeast” (see Osborne et al., 1992: 71). This example is important to the present inquiry because it suggests an alternative view of the dynamics of deer procurement in Georgia’s Sea Islands and demonstrates, conclusively, the potential benefits of culling a deer herd because some hunted populations can actually maintain higher population growth rates than nonhunted deer populations.

**HUNTING WHITE-TAILED DEER:** Aboriginal foragers on St. Catherines Island probably hunted white-tailed deer in several ways. Deer are particularly vulnerable to human hunters during the rutting season,

which extends from late September through January (with a peak in November), because bucks relax their usual defenses and become aggressive. This is also a time of maximum biomass because acorns have already fallen and many native fruits are ripe. Deer are easier to hunt during the fall and early winter because they are concentrated in oak forests. In the late winter and early spring, white-tailed deer are lean and fewer in number due to winter kills; they are also solitary and less mobile as the fawning season approaches.

Le Moyne described the use of deer decoys among the Timucua in the mid-16th century (fig. 8.2; after Lorant, 1946: 85):

#### HUNTING DEER

The Indians hunt deer in a way we have never seen before. They hide themselves in the skin of a very large deer which they have killed some time before. They place the animal’s head upon their own head, looking through the eye holes as through a mask. In this disguise they approach the deer without frightening them. They choose the time when the animals come to drink at the river, shooting them easily with bow and arrow.

Larson (1980a: 170) agrees that the terrain of the barrier islands is ideal for communal hunting. The numerous spits, hammocks, and marsh inlets form natural barriers to assist the setup of an ambush. Hunters could also drive deer into corrals or tidal creeks, with others waiting in canoes. Hudson (1976: 276) believes that the fire surround was also important, not only for procurement of deer (and other game), but periodic controlled fires would also have helped to prepare fields and keep the woods open and free of underbrush, seedlings, and saplings.

Giving all due credence to such accounts, we believe that (then as now) hunters commonly stalked and ambushed individual deer; Fr. Fray Andrés de San Miguel claimed that the Guale hunters he observed in 1595 were so skilled that they could “run after the deer shooting them with arrows without losing sight of them” (de San Miguel, 2001: 65).<sup>10</sup> We will restrict the present effort to model a single hunter in pursuit of a single white-tailed deer.

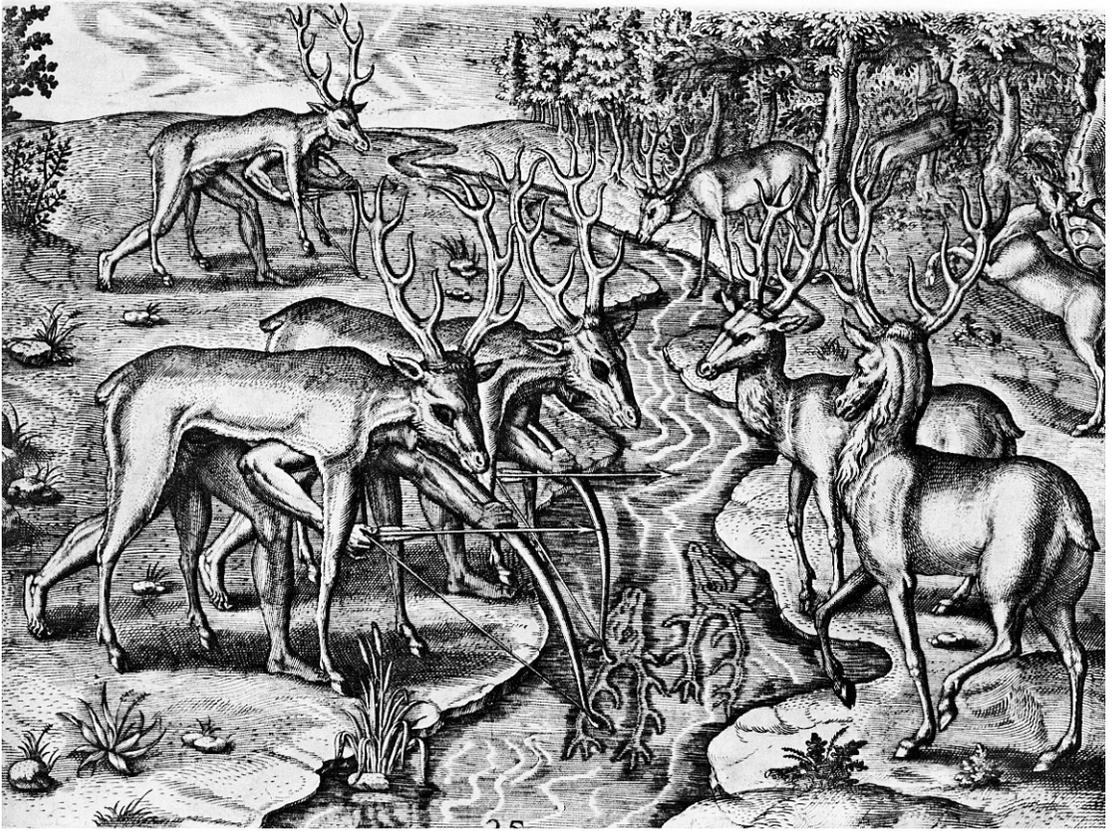


Fig. 8.2. Le Moynes's rendering of "Hunting Deer" by Timucua Indians in the 1560s along the northeastern Florida coast (Lorant, 1946: 85).

ESTIMATING MEAN RETURN RATES FOR DEER HUNTING: Pursuit begins when the deer is encountered (Simms, 1987: 43); if the hunter can make a successful kill, then pursuit time is only a minute or two. If the hunter must stalk the deer, however, pursuit time might take hours. For white-tailed deer on St. Catherines Island, we will compute pursuit times for (1) near-instantaneous kills (at 0.2 hr/individual) and (2) a more prolonged pursuit time of 1 hr/individual. Fire surrounds and other communal hunting techniques may have somewhat lowered the pursuit time (hence increasing post-encounter return rates). We also assume that one individual can gut, clean, skin, and butcher an average deer in 1.5 hr (table 8.6).

If we assume a mean live weight of 42 kg (averaged across males and females) and

follow Christianson (1981: 74–75) and Simms (1987: 64) in utilizing a figure of 60 percent edible fraction for deer, we arrive at an estimated return rates for white-tailed deer ranging between 12,096 and 18,895 kcal/hr.<sup>11</sup>

SHIFTING RETURN RATES THROUGH TIME: As discussed above, the mean live weight of white-tailed deer has varied considerably during the human occupation of St. Catherines Island. Above, we computed the post-encounter return rate for white-tailed deer employing an estimated live weight of 42 kg—slightly smaller than the contemporary mean live weight of male/female, but considerably larger than that for earlier deer populations. We also estimated post-encounter pursuit time to range between 0.02 and 1.0 hr and processing to be 1.5 hr/individual. In table 8.6, we have estimated

the return rates for the various (reconstructed) live weights during late Holocene and historic period on St. Catherines Island (see also fig. 8.1).

Holding both pursuit and processing time constant, we employ an overall live weight estimate of 42 kg for white-tailed deer on St. Catherines Island, projecting an post-encounter return rate of 12,096–19,659 kcal/hr. Because of the significant change in live weight through time, this estimate is probably quite realistic for the mission period, a slight underestimate for the Irene phase, and a significant underestimate for the St. Simons phase. Even with this fluctuation in return rates through time, it is clear that white-tailed deer have always been an extremely high-ranking resource on St. Catherines Island (table 8.6).

#### BLACK BEAR

Black bears (*Ursus americanus*) are found on occasion in the lagoon and marsh sector of coastal Georgia (Neuhauser and Baker, 1974; Larson, 1980a: 173–175). Although the small bear in America, black bears are the largest carnivore in eastern North America. Black bears formerly ranged throughout much of North America. Today, the largest populations in Georgia live in remote forests and swamplands such as the Okefenokee Swamp and the Blue Ridge Mountains; today, the State of Georgia sanctions controlled hunting from September to December. Perhaps 1500 black bears survive in Florida.

Adult black bears stand 1.5–1.8 m tall. In the Southeast, adult male black bears probably average about 160 kg, with adult females averaging 70 kg. They mate between May and July, and the cubs are born in January or February. They reach full adult size in about 6 years. Although black bears living in Georgia go dormant during the wintertime, they never truly hibernate.

Although noting a few “incidental notes” regarding the use of bearskins and bear grease, Swanton (1946: 321) has commented that “it is surprising how few descriptions of bear hunting have been preserved.”

The available accounts, which mostly derive from the 18th century and involve firearms, indicate a preference for winter hunts, when females with cubs were favored. Larson (1980a: 174) suggests that black bears along the Georgia coast were likely trapped rather than stalked. Hudson (1976: 279) recognizes black bear as “a valued game animal in the Southeast, but it was valued in a different way than deer”, meaning that despite their relative scarcity, bears provided valuable oil that could be extracted from its fat.

Writing in 1570, the Jesuit Fr. Antonio Sedeño mentions “deer, bears, and lions” in the province of Guale (Zubillaga, 1946: 424). Moore (1840) reports that black bears were living St. Simons Island, but he did not see them personally and Leigh (1883) discusses two bear cubs on St. Simons, but does not indicate where they were born. Spruant (1936) reports that black bears were living on Cumberland Island (see also Ober, 1880; Bangs, 1898; Harper, 1927). More recently, black bears have been reported from areas between Ossabaw Island and the mainland, and between St. Catherines and Colonel’s Island (Neuhauser and Baker, 1974).

We have two additional reports of black bears on St. Catherines Island. In an essay that originally appeared in *London Magazine* sometime between August 1745 and December 1746, Edward Kember reported that “[we] arriv’d at *St. Catherine’s*, which is an Island reserv’d to the *Indians* by Treaty. We found about eight to ten Families upon it, who had several Plantations of Corn. It seems to be a most fruitful Soil, and to have larger Tracts of open Land than any I have observed, and to abound in all Kinds of Game, on which the good *Indians* regaled us, and for Greens, boiled us the Tops of China-Briars, which eat almost as well as Asparagus. When we departed, they gave us a young Bear which they had just kill’d, which prov’d fine eating” (in Hayes, 1998: 33). More than two centuries later, Sydney Anderson, in his overview of recent mammals of St. Catherines Island, wrote that “John Toby Woods [former Superintendent of St. Catherines

TABLE 8.6  
**Estimated Post-encounter Return Rates from Terrestrial Hunting on St. Catherine's Island**

Species	Av. live wt. (kg)	Adj. live wt. (kg)	Usable %	Meat wt./individual (kg)	Energy (kcal/100 g)	kcal/individual	Pursuit time (hr/individual)	Processing time (hr/individual)	Return rate (kcal/hr)
Black bear	160 (♂) 70 (♀)	115	50	58.0	161	93,380	0.02–1.0	1.5	37,352–61,434
American alligator	160 <sup>a</sup>	128 <sup>b</sup>	43	55.0	100	55,000	1.0	1.5	22,000
White-tailed deer	42 <sup>c</sup>	—	60	25.2	120	30,240	0.02–1.0 <sup>d</sup>	1.5	12,096–19,895
Softshell & snapping turtle	4.5–16	10.25	20	2.1	130	2730	0.08–0.167	0.25	6547–8273
Raccoon	4.5–9	6 <sup>b</sup>	70	4.2	168	7056	0.02–0.25	0.5	9408–13,569
Eastern wild turkey	3.6–5 (♀) <sup>e</sup> 7.7– 9.5 (♂)	5.2 <sup>b</sup>	70	3.64	160	5824	0.02–0.25	0.5	7765–11,200
Virginia opossum	2–6	3.2 <sup>b</sup>	70	2.24	146	3270	0.02–0.25	0.25	6540–12,111
Canada goose	1.5–6.0	3 <sup>b</sup>	70	2.1	161	3381	0.02–0.25	0.25	6762–12,522
Swamp rabbit	1.6–3.0 <sup>f</sup>	1.84 <sup>b</sup>	70	1.29	114	1471	0.02–0.25	0.25	2942–5248
Small turtles	2.0–5.0	3.5	20	0.7	130	910	0.08–0.167	0.25	2182–2758
Marsh rabbit	1.4–1.8	1.28 <sup>b</sup>	70	0.896	114	1021	0.02–0.25	0.25	2042–3781
Duck	0.7–1.1	0.72 <sup>b</sup>	70	0.50	123	615	0.02–0.25	0.25	1230–2278
Diamondback terrapin <sup>g</sup>	0.5	—	20	0.10	130	130	0.0167	0.083	1304
Eastern gray squirrel	0.36–0.65	0.40 <sup>b</sup>	70	0.28	120	336	0.02–0.25	0.25	672–1244

<sup>a</sup> Georgia Department of Natural Resources; Behler and King (1979); Leak et al. (2003).

<sup>b</sup> The mean live weight has been adjusted downward by 20 percent to account for females and/or immature individuals.

<sup>c</sup> Computed at 60 percent edible fraction (per Simms, 1987: 64); Reitz and Wing (1999: 174).

<sup>d</sup> Per Simms (1987: table 4).

<sup>e</sup> DNR; National Wild Turkey Federation; upper male and female weights averaged, then dropped 20 percent.

<sup>f</sup> Per White (1953).

<sup>g</sup> Numbers represent only female diamondback terrapins.

Island] reported to me that more than one fisherman independently told him of seeing a black bear on the south end of the island in October 1972. He said that bears have appeared at intervals of several years usually and that these do not remain for long. They are good swimmers" (Anderson, 1972: 4).

To estimate the post-encounter return rates, we will assume that (1) a near-instantaneous winter kill (made while the bear is trapped inside a den) would take 0.2 hr/individual and (2) a more prolonged pursuit time of 1 hr/individual. We further assume that one individual could gut, clean, skin, and butcher an average-size black bear in 1.5 hr (table 8.6). Further, we estimate the average live weight to be the difference between the mean male weight (160 kg) and mean female weight (70 kg), yielding a mean of 115 kg. Then, assuming an average edible weight at 50 percent of total weight, we estimate that the average meat weight/black bear can be estimated at 58 kg. Since raw black bear meat has an energy value of 161 cal/100 gm, we derive an estimated energy potential of 93,380 kcal/black bear. Factoring in range of pursuit times and 1.5 hr processing time, we estimate the average return rate for black bear ranges between 37,352 and 61,434 kcal/hr (see table 8.6).

#### AMERICAN ALLIGATOR

The alligator (*Alligator mississippiensis*) occupies a variety of fresh and brackish wetland habitats, including marshes, swamps, rivers, ponds, and lakes. When the weather is hot, alligators are primarily nocturnal; from November through March, alligators commonly inhabit dens and enter a state similar to hibernation. During courtship and breeding season (April to May), alligators prefer open waters. During the rest of the year, males prefer open, deep water while females seek out nesting habitat in shallow, heavily vegetated and secluded areas (Behler and King, 1979).

René Laudonière observed that the Timucua Indians of northern Florida and southeastern Georgia "eat the flesh of cro-

codiles and, in fact, it is good and white. However, it has a musky smell. We have often eaten it with them" (Bennett, 1975: 15). Here is Le Moyne's lurid account of Timucuan alligator hunting (fig. 8.3; after Lorant, 1946: 87):

#### KILLING ALLIGATORS

This is how they attack alligators. Near the river they put up a little hut full of cracks and holes. In this hut one of their men keeps watch. From this hiding place he can see and hear the animals, even if they are a long way off. Then the alligators, driven to the shore by hunger, give themselves away by their loud bellowing, which can be heard at a great distance.

The watchman in the hut now calls his companions, who are waiting in readiness, and they set out for the hunt. They take with them a ten-foot pointed pole, and when they come upon the monster—who usually crawls along with open mouth, ready to attack—they push the pole quickly down its throat. The rough tree bark of its sides prevents the pole from slipping out again.

Then the beast is turned over on its back and killed by beating it with clubs and piercing its soft belly with arrows. The alligators are such a menace that a regular watch has to be kept against them day and night. The Indians guard themselves against these animals just as we guard ourselves from our most dangerous enemies.

Although the Frenchman obviously overstates the alligator menace, his description likely reflects the "outsiders'" irrational fear of the unknown. Swanton (1922: 358) believed that "the description of the hunt ... may be perfectly correct."

To derive a first-order approximation of post-encounter return rates, we will make a number of assumptions. For present purposes, let us assume that, in the long run it takes two hunters about 0.5 hr to kill an average-size alligator. For very large alligators, such as those depicted by Le Moyne, more people may be required; a single hunter could probably dispatch a smaller alligator, so the disparity may cancel out.

Alligators are difficult to dress because of the osteoderms; we assume that one person could skin and butcher an alligator in 1.5 hr. This process involves skinning the alligator,

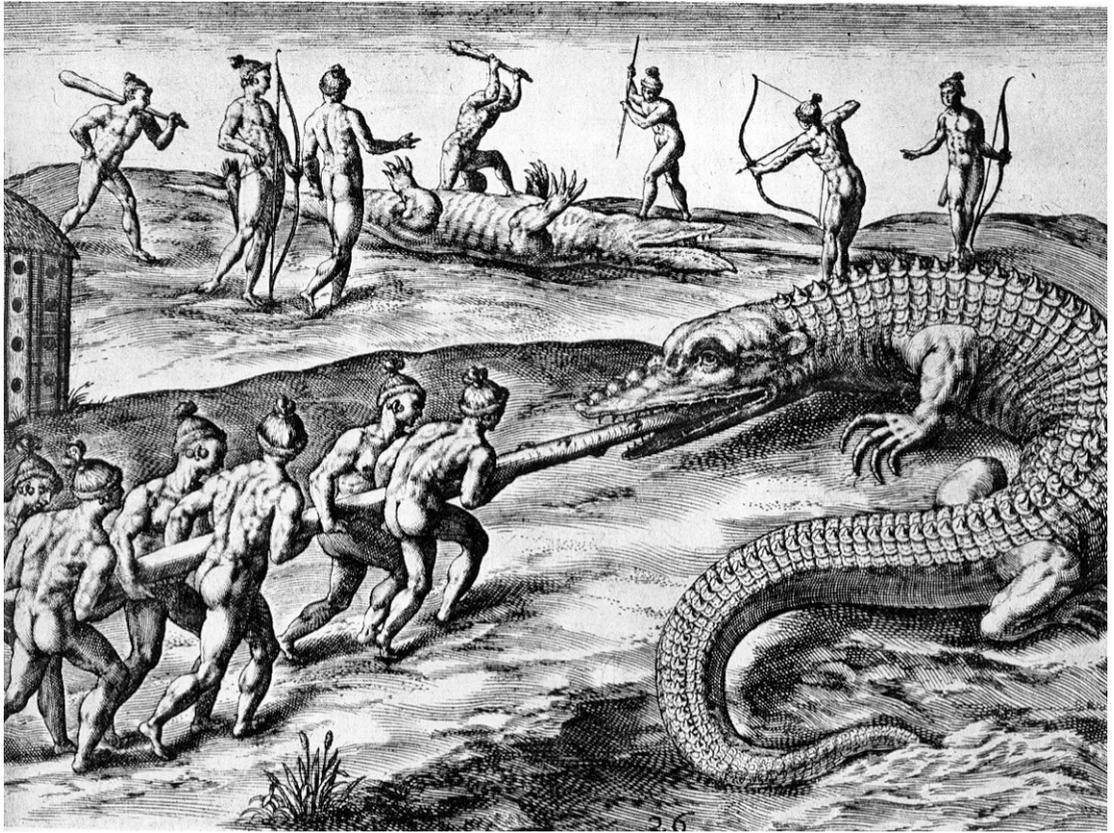


Fig. 8.3. Le Moynes's rendering of "Killing Alligators" by Timucua Indians in the 1560s in north-eastern Florida (Lorant, 1946: 87).

then butchering the carcass into seven separate muscle groups: tailmeat (11.4% of live weight), tendertail (3%), tenderloin (0.8%), backstrap (3.6%), rib (3.5%), jowl (1.4), and processing meat (17.1%).<sup>12</sup> In addition, we assume the average live weight for alligators is about 160 kg, adjusted downward by 20 percent (to 128 kg) to allow for females and immature males. Judging from butchering experiments on farm-raised alligators in Florida, we can estimate the proportion of edible meat at 43 percent of live weight (Leak et al., 2003), meaning that the average meat weight/alligator is estimated to be 55 kg.

Compared with beef and pork, alligator meat is relatively high in protein and low in fat. Since raw alligator meat has an energy value of 100 kcal/100 g (Lutz et al., 2003), we derive an estimated energy potential of

55,000 kcal/alligator. Factoring in 1.0 hr pursuit time and 1.5 hr processing time, we estimate the average return rate for alligators to be 22,000 kcal/hr (see table 8.6).

#### BRACKISH AND FRESHWATER TURTLES

The pond turtle family (Emydidae) includes box turtles, chicken turtles, cooters, sliders, and diamondback terrapins. The eastern box turtle (*Terrapene carolina*) is the most common terrestrial turtle in the eastern United States. They do not burrow, but spend hot, dry periods underneath logs, in leaf litter, or in puddles. They are often near water, where they might soak for days. We estimate the mean live weight to be 3 kg.

Yellow-bellied sliders (*Trachemys scripta*) are abundant in a wide variety of ponds,

sloughs, and streams of the Southeast. Slider turtles are often seen basking on water logs near freshwater, and they sometimes travel considerable distances overland between bodies of water. We estimate the mean live weight to be 3 kg.

The chicken turtle (*Deirochelys reticularia*), known for its extremely long neck, lives in freshwater lakes, ponds, ditches, marshes, and sloughs. It is the most terrestrial of the freshwater turtles. We estimate the mean live weight to be 3 kg.

The diamondback terrapin (*Malaclemys terrapin*) is the only living turtle species adapted to life in brackish and saltwater. These smallish turtles, with legs and clawed toes that are only slightly adapted to terrestrial life, lives exclusively in brackish estuaries, tidal flats, and lagoons behind barrier beaches (Behler and King, 1979). Female diamondbacks average 0.9–1.1 kg and males are much smaller (averaging roughly 0.3 kg; Butler, 2000: 31). We will estimate that, on the average, live weight is about 0.75 kg.

Diamondback terrapins are found out of water for extended periods between early May and mid-/late July, when females seek nesting sites in the sandy high ground to lay one (or more) clutches of leathery eggs, which are the size of very large grapes (averaging about 6 g). On St. Catherines Island, diamondback terrapins usually nest well behind the storm high tide line, sometimes nesting behind the beaches (Bishop and Marsh, 1995), with the eggs hatching 60–120 days later. They typically hibernate within the intertidal salt marsh from December through February into March (Butler, 2002: 1)

During the late 19th and early 20th centuries, demand for turtle soup near drove the diamondback terrapin population into extinction. Although the species rebounded, the numbers are today declining rapidly, primarily due to loss of marsh habitat. In more urbanized areas, gravid females are commonly roadkilled in midsummer while seeking nesting sites.

Today, the most successful method for taking diamondback terrapins is to hand capture of the gravid females, especially 2 hr before and 1 hr after high tide (Butler,

2002: 7, 31). Most nests are located near the upper high tide line or beyond it in several sandy, sparsely vegetated areas; nesting at high tide insures that the eggs will not be flooded (Butler, 2002: 32). Most nests can readily be spotted by following their crawls.

Diamondback terrapins can also be taken in modern crab traps, where the terrapins enter in search of bait set for blue crabs. Although terrapins can spend hours underwater, prolonged submersion can lead to drowning. Someone skilled at taking mullet by cast net can also have great success in taking diamondback terrapins (Butler, 2002: 10).

The mud turtle (*Kinosternon spp.* family Kinosternidae) is adapted to fresh marsh, pond, and stream habitats. The eastern mud turtle (*Kinosternon subrum*) can often be found in the high marsh. They are most active at night and rarely observed basking. The striped mud turtle (*Kinosternon baurii*) is more terrestrial and rarely found in salt marsh habitats. Striped mud turtles typically wander throughout the intertidal areas, sloughs, and ponds. We estimate a mean live weight of 3 kg for both species of mud turtle.

Snapping turtles (*Chelydra serpentine*) belong to the family Chelydridae. Characterized by massive heads, powerful jaws, and long tails, snapping turtles spend most of their time underwater, where they rest on the bottom, mouth open, attempting to lure fish by flicking their tongues. Living mostly in ponds sloughs and even brackish waters, snapping turtles are most commonly observed as they seek terrestrial nesting sites. Instead of basking, they tend to rest in warm, shallow freshwater, commonly burying themselves in the mud, with only eyes and nostrils exposed. We estimate a mean live weight of 10 kg.

Softshell turtles (*Apalone ferox*) belong to the family Trionychidae. Like most aquatic turtles, they enjoy basking and will rest on any object that extends above the water's surface. Many people today feel that softshell turtles make the best eating of all freshwater taxa. We estimate a mean live weight of 10 kg.

In their brief survey of extant amphibian and reptiles on St. Catherines Island, Zweifel and Cole (1974) encountered only the common mud turtle (*Kinosternon subrubrum*). Based on more recent and more thorough observations, we can now add the diamondback terrapin (*Malaclemys terrapin*), Florida cooter (*Pseudemys floridana*), yellow-bellied slider (*Trachemys scripta*), and chicken turtle (*Dierochelys reticularia*). Martof (cited in Zweifel and Cole, 1974: iv) also reports the presence of snapping turtle (*Chelydra serpentina*) and eastern box turtle (*Terrapene carolina*) on nearby Sapelo Island.

Freshwater turtle bones have been recovered from a number of archaeological sites along the Georgia coast (see also Larson, 1980a: 134–138). Late prehistoric and mission-period shell middens at the nearby Harris Neck National Wildlife Refuge (Braley et al., 1986: tables 14, 17, 18) contained remains of diamondback terrapin, eastern box turtle, and eastern mud turtle and unidentified bones of the Emididae family (pond, marsh, and box turtles). On Sapelo Island, Crook (1978b: table 12) reports numerous turtle bones in the Kenan Field middens, including box turtle, diamondback terrapin, chicken turtle, cooter/slider, and mud turtle. Martinez (1975: 91) and Marrinan (1975: 72) recovered diamondback terrapins on St. Simons Island. Milanich (1971:75) recovered diamondback terrapins from two sites on Cumberland Island. Pearson (1979a: Appendix III) recovered remains from diamondback terrapin, eastern mud turtle, and unidentified freshwater turtle on Ossabaw island. At Grove's Creek, on Skidaway Island, Keene (2002: table 8.10) recovered bones of mud turtle, Emydidae, diamondback terrapin, river cooter, and eastern box turtle (?). Snapping turtle (*Celydra serpentina*) remains were recovered in the Kings Bay excavations (Smith et al., 1981; Quitmyer, 1985: 19).

**TURTLE PROCUREMENT:** Larson (1980a: 136) suggests that freshwater turtles “were likely collected incidentally to other activities” and this is undoubtedly true. But given the relatively high return rates involved, we suspect that freshwater turtles

were also harvested deliberately and consistently upon encounter.

Freshwater turtles can be taken in several ways. Most turtles can simple be picked up while sunning or by “noodling” (feeling underwater along the cut banks and pulling the turtles to the surface). Modern anglers sometimes catch snapping turtles on hand-lines, trot lines, or float lines, each baited with cut or live bait. So-called jug lines consist of a large fish hook (baited with fish or dead meat) snapped onto a wire leader, which is suspended from a plastic jug and dropped into a pond or lake; jug lines are typically left overnight and tended by wading or boating.

Since turtles commonly lay out on logs, rocks, or other flat spots above the waterline, “sunning traps” (also known as “floating” or “barrel” traps) are quite effective. In effect, this trap offers a resting place for turtles to lay out and absorb the sun. Turtles can easily access the trap via the inclined ramps located on either side. Freshwater turtles are often taken in “barrel” (or “basket” traps), which are set halfway submerged, with bait inside and a ramp leading to the edge; smelling food, the turtles simply climb the ramp, falling into a barrel or holding net, alive yet confined.

Hoop traps (also known as Fyke traps) consist of fine-mesh netting open at one end and gathered around an open “hoop” at the other. They are typically baited with fish, then staked in place along the margin of a pond, with the top of the trap extending a few inches above the water surface. Turtles enter the funnel, which prevents exit. This method allows for multiple catches, provided sufficient bait is available.

**HANDLING:** Today, snapping turtles are often kept in a tub of clean water for a week or two, to purge the meat prior to processing. Some people also prefer to parboil large turtles before cleaning.

When butchering a turtle, modern harvesters commonly use a small axe or pliers to cut off the head, sometimes removing the claws and hanging the carcass to drain the blood (Ernst et al., 1994). The butcher then usually slices around the bottom edge of the *plasteron* (bottom shell), then cuts through

the joint between the plastron and *carapace* on each side. Once the two shell components are separated, it is easy to remove the internal organs, discarding the entrails but often saving the liver and any eggs present. Turtles contains several kind of meat, including the legs, neck, and various cuts contained inside. The legs and necks are cut loose from inside the carapace, skinned and cooked (by parboiling, stewing, grilling, roasting, or rendering into a broth or roux). Some of the cuts are tough and require slow cooking, while others are more tender.

ESTIMATING RETURN RATES FOR BRACKISH  
AND FRESHWATER TURTLES  
BY MAUREEN KICK, ANNA SEMON,  
AND DAVID HURST THOMAS

To obtain realistic estimates of post-encounter return rates for the various freshwater and brackish turtle taxa, we studied six diamondback terrapin (*Malaclemys terrapin*) carcasses, generously provided by Terry Norton (veterinarian at the St. Catherines Island Center). The diamondback terrapins were all gravid females, killed on the Tybee Island causeway (approximately 45 km north of St. Catherines Island) as they were attempting to nest and lay eggs in May 2006. Nearly 200 diamondback terrapins are killed annually on this stretch of U.S. 80 (between Wilmington and Tybee islands) as the females head from the tidal marshes and estuaries to higher ground to lay their eggs.<sup>13</sup> We dissected the six diamondback terrapin carcasses to obtain “edible portion” estimates and samples for nutritional analysis.

Each turtle was assigned a number (1 through 6), weighed on a digital scale, then measured prior to dissection. On specimen 1, the shell and plastron were removed first, and then the body was sectioned into forelimbs, hindlimbs, head, neck, and pelvis. Each body part was then weighed and measured separately. The digestive tract, chest organs, and remaining eggs were removed, weighed, and bagged separately. Each section was skinned and all available meat was

removed from the bone. Skin, meat, and bone from each section was weighed and bagged separately. Because of the toughness of the skin, the steel knives dulled quickly; razor blades and/or surgical scalpels would be better suited for the task.

Specimens 2 through 6 were butchered primarily for the meat, skin, viscera, and eggs, to provide additional comparative weights and to provide a larger sample to be sent to the laboratory for nutritional analysis. After each carcass was weighed and measured, we removed the plastron and extracted all available meat. Because specimens 2 and 6 were in advanced states of decomposition and the flesh of these specimens was desiccated, we decided to group the meat, skin, and viscera together for these turtles. We also combined the meat, skin, eggs, and viscera from turtles 3, 4, and 5 to provide a larger sample for analysis.

Table 8.7 summarizes the dissection results. These figures indicate that gravid female diamondback terrapins provide a “usable portion” of  $18.7 \pm 5.79$  percent of live weight (assuming that the edible portion consists of meat, skin, and eggs), and we will employ an average estimate of 20 percent in the calculations below. The energy and nutritional analyses of these diamondback terrapin specimens are summarized in table 8.8. The terrapin egg sample has a particularly high energy content (184 kcal/100 g), followed by the skin and meat samples.<sup>14</sup> Overall, we think an estimate of about 130 kcal/100 g adequately represents the average energetic return for edible parts of *Malaclemys terrapin*.

If we estimate a pursuit time of 1 min, a processing time of 5 min (merely cracking the carapace and plastron, then removing the viscera), and an average live weight of 500 g, we derive a post-encounter return rate of 1262 kcal/hr for gravid female diamondback terrapins (table 8.8).

These parameters can also be extended to the larger freshwater and brackish turtle taxa. For the largest of these, softshell and snapping turtles (*Apalone* and *Chelydra*), we employ an average live weight of 10 kg, with a usable meat proportion of 20 percent. Estimating the pursuit time be-

TABLE 8.7  
**Experimental Results for Gravid Female Diamondback Terrapins *Malaclemys terrapin* from Tybee Island, Georgia**

Specimen no.	Live wt. (g)	Meat wt. (g)	Shell wt. (g)	Bone wt. (g)	Skin wt. (g)	Viscera wt. (g)	Egg wt. (g)	Edible portion <sup>a</sup> (%)
1	620	69.0	240	89.8	41.6	72.3	20.55	21.2
2	460	65.3	200	104.6	39.7	—	— <sup>b</sup>	25.0
3	560	40.3	240	135.9	27.3	63.6	9.6	13.8
4	480	41.7	180	130.1	— <sup>c</sup>	62.7	18.4	17.8
5	500	26.7	200	142.8	24.9	67.2	0.76	10.4
6	580	89.4	260	74.8	34.6	68.9	15.65	24.0

<sup>a</sup> Edible portion includes meat, skin, and eggs.

<sup>b</sup> For the purpose of computing edible portion, we assumed an egg weight of 10 g.

<sup>c</sup> Skin weight is included with bone weight. For the purpose of computing edible portion, we assumed a skin weight of 25 g.

tween 5 and 10 min and a processing time of 15 min we derive a return rate of 6235–7874 kcal/hr. Using these same estimates of pursuit and processing times for the smaller freshwater turtles (*Kinosternon*, *Deirochelys*, *Trachemys*, and *Terrapine*), we derive a return rate of 1871–2364 kcal/hr.

#### RACCOON

Lewis Larson (1980a: 175) noted that raccoon (*Procyon lotor*) bones are second only to deer bones in abundance in archaeological sites of the Georgia coast. Raccoons are extremely abundant on St. Catherines Island (Hardin, 1978; Hudson, 1978;

Lotze and Fleischman, 1978; Harman and Stains, 1979; Lotze, 1979; Anderson, 1980, 1981; Anderson and Willis, 1982), especially in moist and forested habitats, such as timbered swamps, and riverbanks. Based on his long-term study of raccoons on St. Catherines Island, Anderson (1981: 7) estimates that the overall raccoon population size “probably fluctuates somewhere between 400 and 4,000 raccoons, and is probably usually between 1,000 and 2,000.”

Aboriginal foragers could have hunted raccoons by trapping, individual stalking, and simple garden hunting. Although ethnographic evidence suggest that dogs were used to chase raccoons, rabbits, opossums,

TABLE 8.8  
**Energy and Nutrient Analysis of Diamondback Terrapins from Tybee Island, Georgia<sup>a</sup>**

Specimen no.	Body element	Energy (kcal/100 g)	% Carb.	% Fat	% Protein	% Moisture
1	Skin	110.5	29.7	1.0	69.3	71.7
2 & 6	Skin	134.7	17.2	8.0	74.8	66.7
3, 4, & 5	Skin	155.9	10.4	23.9	65.7	68.9
1	Leg meat	75.5	—	—	—	78.2
1	Body meat	77.9	7.3	0.7	92.0	79.6
2 & 6	Meat	95.5	6.0	0.7	93.8	75.0
3, 4, & 5	Meat	86.4	8.9	1.2	89.9	77.4
1	Eggs	—	—	—	—	67.6
3, 4, & 5	Eggs	183.7	3.4	33.7	62.9	49.5
1	Organs	75.6	—	—	—	81.7
1	Guts	71.9	2.2	3.3	94.5	81.2
2 & 6	Viscera	76.7	8.2	7.2	88.6	80.3
3, 4, & 5	Viscera	76.2	14.6	3.5	81.9	80.6

<sup>a</sup> All analyses conducted on raw samples by QC Laboratories.

and squirrels, Swanton (1946: 330) believes this practice was introduced “rather in late times rather than in the aboriginal period.” One of the de Soto chroniclers also recorded the use of deadfalls with a trigger and logs (Swanton, 1946: 330).

White (1953: table 14) suggests an average live weight of 11.4 kg for raccoons. A more appropriate figure for St. Catherines Island is 4.7–9 kg to account for female and immature animals; however, we adjusted this average downward to 7 kg. In table 8.6, we estimated two post-encounter return rates, one based on instantaneous kill (0.02 hr), the other based on 15 min pursuit (0.25 hr); we estimate that one person could gut, skin, and cut up a raccoon in 0.5 hr. Because raccoon meat is extremely fatty (51% fat content; see table 8.6), the energy value is 168 kcal/100 g, the highest of any animal considered in this study with the exception of duck. As a result, the post-encounter return rate for raccoon is estimated to range between 10,281 and 15,281 kcal/hr (a figure that significantly overlaps and is only slightly lower than comparable estimates for white-tailed deer).

#### VIRGINIA OPOSSUM

The opossum (*Didelphia virginiana*) is the only marsupial native to North America; their bones are sometimes found in archaeological sites of the Georgia coast (Larson, 1980a: 177). There is no evidence that opossums have lived on St. Catherines Island since 1900 (Anderson, 1972), but *Didelphia* are common on the mainland and could have been island residents in the more distant past. Virginia opossums prefer the deciduous woodlands, but they range widely across all habitats within their ecological tolerances. They are primarily nocturnal and do not hibernate. Opossums are adept at climbing, running, and swimming. Although there is a lack of ethnohistorical accounts that describe how opossums were procured, their relatively slow pace made them easy prey for hunters; they could also be trapped.

The live weight of adult Virginia opossums ranges between 2 and 6 kg; adjusting

the median biomass downward by 20 percent, we will employ a live weight estimate of 3.2 kg. Opossum meat is quite fatty (42%), yielding 146 kcal/100 g (third highest after raccoon and duck of the animals considered here; see table 8.6). The estimated post-encounter rate for opossum ranges between 9900 and 18,333 kcal/hr.

#### EASTERN WILD TURKEY

Turkeys (*Meleagris gallopavo*) are common today throughout the eastern half of the United States, and William Bartram recorded seeing huge flocks of wild turkeys during his travels across Georgia in the late 1700s. Although wild turkeys have lived on St. Catherines Island sporadically during the 20th century, none inhabit the island today.

Ethnohistoric evidence for hunting wild turkeys is sparse, but Swanton (1946: 330) suggests the possibility of fire hunting several species of smaller game, including turkeys. Creek hunters noted that after encountering several wild turkeys in a grove of trees, they would take a few, then follow the others to the next grove. Speck (1909) records that the Yuchi called in turkeys with bone whistles and rasps; the Seminoles also used turkey calls.

Modern gobblers average 7.7–9.5 kg at maturity, with hens weighing 3.6–5 kg; if we average these figures and reduce the result by 20 percent (to account for immature individuals), the average adjusted weight for wild turkeys becomes 6.5 kg. Assuming a pursuit time of 0.02–0.25 hr by a single hunter and a processing time of 0.5 hr, the post-encounter return rates for wild turkeys (with males and females averaged) ranges from 9707 to 14,000 kcal/hr.

#### COTTONTAIL RABBITS

The swamp rabbit (*Sylvilagus aquaticus*) is fairly large, averaging 1.6–3.0 kg live weight. They prefer forested wetlands and never stray very far from the water’s edge. Swamp rabbits live in heavy cover and run swiftly, in a zigzag fashion. They are good swimmers and can hide in water. Marsh

rabbits (*Sylvilagus palustris*) are smaller, averaging about 1.4 to 1.8 kg live weight at maturity. They live in coastal marshes, swamps, and isolated island habitats. When flushed, they are capable of swimming from one hiding place to another. Rabbit hunting likely involved individual pursuit (perhaps aided by dogs). In the interior Southeast, the Gentleman of Elvas, one of the de Soto chroniclers, recorded that rabbits were snared “by means of stout springs which lift the feet off the ground and a noose of strong cord fastened to which is a joint of cane, which runs to the neck of the rabbit, so that it can not gnaw the cord” (Robertson, 1933: 205).

Using the protocols discussed above, we estimate the post-encounter return rates for swamp rabbit and marsh rabbit to be 3830–7093 kcal/hr and 2302–4264 kcal/hr, respectively (see table 8.6).

#### EASTERN GRAY SQUIRREL

The eastern gray squirrel (*Sciurus carolinensis*) is common throughout the forests of eastern North America. They prefer dense hardwood and mixed coniferous–hardwood forests and their distribution is closely correlated to that of oak, hickory, and (formerly) chestnut. Swanton (1946: 311) records that in Arkansas, Indian boys commonly hunted squirrels using blowguns and bows and arrows (1946: 331). In table 8.6, we compute the post-encounter return rate for the eastern gray squirrel to be 870–1613 kcal/hr.

#### ADDITIONAL TAXA

Table 8.6 also includes estimates of post-encounter return rates for Canada goose and various species of duck; numerous additional taxa were likely hunted as well.<sup>15</sup>

#### HARVESTING MARINE TURTLES

Sea turtle harvesting differs significantly from hunting terrestrial game. For one thing, this special-purpose foraging was carefully timed around the season, the tides, and the nighttime cloud cover. Summer sea

turtle harvesting also involves everyone living at the residential base camp. Two people—whether male or female—can readily flip a nesting loggerhead, and, although butchering the turtle carcass is laborious, anybody can do it: This is “harvesting”, not “hunting”. Similarly, young and old alike can walk the beach, searching for crawlways and digging up turtle eggs. And most people, even the elders, can help out bring down the ever-present raccoons, always a presence during loggerhead nesting season.

#### HARVESTING FEMALE LOGGERHEADS

Five of the world’s seven species of sea turtles are known from coastal Georgia waters, but only the loggerhead (*Caretta caretta*) regularly nests on the barrier islands. Hawksbill (*Eretmochelys imbricate*), Kemp’s ridley (*Lepidochelys kempii*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) turtles nest in warmer waters and use the Georgia coast primarily as a travel corridor (and only occasionally to nest on St. Catherines Island).<sup>16</sup>

LEATHERBACKS: Female leatherbacks nest an average of six times, every 2–3 years. In Florida, the nesting season lasts from April through July. Once a female leatherback finds a suitable spot, she deposits an average of 82 billiard ball-sized eggs into the egg chamber. Only twice in the past 3 decades have leatherbacks attempted to nest on St. Catherines Island, once in the 1970s, and on May 8–9, 2005, a leatherback female made an (aborted) attempt to nest on South Beach. Bishop’s account appears below:

Some experts believe that leatherback turtles may nest significantly earlier than loggerheads along the Georgia coast (and as a result, their nests might go undetected by those monitoring loggerhead nesting behavior). In 2005, Gale Bishop monitored the beaches of St. Catherines Island in late April and May (well before the standard nesting season for loggerheads). Bishop observed and documented two leatherback crawlways on South Beach (May 8 and May 9); archaeologists assisted Bishop in excavating the earlier nest, but no eggs were



Fig. 8.4. Clint Collins with a nesting female leatherback turtle on St. Catherines Island (courtesy of Gale Bishop).

found. On July, 2005, Nancy Marsh observed unhatched leatherback egg shells from the second nest, scattered along the beach after predation by ghost crabs and raccoons. A third leatherback was observed nesting on the night of July 05, 2005. This small leatherback continued digging her nest and began depositing eggs about midnight. The process lasted nearly an hour

At about 1:05 AM the turtle began an extensive covering repertoire that continued until 2:15 AM. This repertoire first involved back-filling and tamping the egg chamber with rear flippers, then piling of sand mounds with synchronous front flipper sweeps, followed by repeatedly crawling across and around the covering area that apparently resulted from excavation of an open egg chamber to the north end of the nesting area. The turtle then left her nest and crawled approximately 240 feet (xx m) across the sandy back-beach and relict mud on the fore beach to the water's edge and into the sea for approximately another 100–150 feet (xx m) to reach water of sufficient depth to swim. Because this leatherback was observed nesting, the position of the clutch

was marked by lines outside the nesting area and the nest was extensively documented by sketching and photography the next morning and the clutch of 105 eggs relocated to a lower risk site (05–070a) further north on North Beach (31.68809N; 81.13305W) where it was screened and caged. This leatherback nest was 7.0 m long and 3.0 m wide oriented N14oE parallel to the beach and constrained on the west by a pine piling or log. (Gale Bishop, unpublished fieldnotes, quoted with permission).

Today, only loggerheads commonly nest on Georgia's barrier islands. Leatherbacks and Kemp's Ridleys migrate through coastal Georgia waters, and Green sea turtles have been known occasionally to nest on Georgia beaches. St. Catherines Island has three major beaches fronting on the Atlantic Ocean: North Beach, Middle Beach, and south Beach (fig. 8.4). These beaches, and their sandy margins, provide approximately 20 km of potential nesting habitat for loggerhead sea turtles (Bishop and Marsh, 1995). Female loggerheads mature at about

TABLE 8.9  
**Loggerhead Nesting Records for St. Catherines Island (Courtesy of Gale Bishop and the St. Catherines Sea Turtle Conservation Program)**

Year	No. of nests	No. of eggs (est.) <sup>a</sup>	No. of nesting females/yr (est.) <sup>b</sup>	Hatchlings to sea
1979	250	28,250	69.4	— <sup>c</sup>
1984	182	20,566	50.5	—
1986	83	9379	23.0	—
1989	98	11,074	27.2	6150
1990	145	16,385	40.3	9260
1991	105	11,865	29.2	3271
1992	148	16,724	41.1	7312
1993	74	8362	20.6	4898
1994	184	20,792	51.1	8110
1995	136	15,368	37.8	3211
1996	118	13,334	32.8	6980
1997	96	10,848	26.7	7369
1998	86	9718	23.9	4144
1999	125	14,125	34.7	6900
2000	112	12,656	31.1	9960
2001	51	5763	14.2	3378
2002	77	8701	21.4	3739
2003	141	15,933	39.2	11,683
2004	59	6667	16.4	3785

<sup>a</sup> Based on an average of 113 eggs/clutch.

<sup>b</sup> Based on an average of 3.6 clutches/female loggerhead/head.

<sup>c</sup> Data from Anderson (1981: 4).

20 to 30 years of age. After mating in the ocean, they crawl onto sandy beaches to deposit their eggs. Nesting females deposit an average of 3.6 clutches/year. But because loggerheads do not nest every summer, the number of nesting females varies significantly from year to year (see table 8.9).

Loggerheads generally come ashore in Georgia to nest from early May to mid-August, and hatching continues until late October. Sea turtles along the Georgia coast nest from mid-May through August. They emerge shortly after darkness falls, typically taking about an hour to nest and deposit the eggs. Females are entirely vulnerable while nesting, and they generally return each nesting season to the region. From evening through morning hours, the gravid female first drags herself out of the water and crawls across the beach into the dunes or the backbeach (Hailman and Elowson, 1992). She wallows to damp sand and uses her back flippers to dig an egg chamber where she deposits her eggs. Before returning to the ocean, she disguises the nest by

backfilling the egg chamber and flinging sand over it. Hatchlings emerge after about 2 months, usually after dark, and scramble to the ocean water.

Table 8.9 documents the available evidence for loggerhead nesting on St. Catherines Island (courtesy of Gale Bishop and the St. Catherines Sea Turtle Conservation Program). Over the past quarter-century, the number of nests/year has varied between a high of 250 nests (recorded in 1979; see Anderson, 1981: 4) and a low of 51 nests, recorded in 2001. Table 8.9 clearly demonstrates the decline in sea turtle populations around the world. A film made in 1947, for instance, dramatically documents 40,000 female Kemp's Ridley turtles as they nested on a single day at Rancho Nuevo, Mexico; in 1966, only 1300 females nested on the same beach, and, since then, the numbers have steadily declined by about 14 nests per year; comparable data on loggerhead nesting on Little Cumberland Island, Georgia, demonstrate a decline of about 3 percent/year over the past 3 decades

(Bishop and Marsh, 1995), and a similar trend is evident in table 8.9. Multiple factors seem responsible for the dramatically declining numbers of sea turtles (Magnuson et al., 1990), including, predation, disease, parasites, erosion of nesting habitat, and thermal stress. Human interactions are also partly responsible, especially due to shrimp fishing and dredging (although the installation of “turtle excluding devices” on shrimp nets have dramatically reduced the losses due to shrimping). All sea turtle taxa are presently listed as “endangered” or “threatened” species.

Gravid females can easily be collected when they come ashore to lay eggs on sandy beaches. Because sea turtles move onto the beach during the night and often appear in abundance, they can readily be harvested by those familiar with their habits (see also Larson, 1980a: 132). When a turtle crawls onto the beach, she can be flipped, trussed, and hauled away (probably by boat) or butchered on the beach. Particularly when conducted on a cloudless night, the acquisitions costs are quite low (and the encounters free of danger).

An adult female loggerhead averages about 68 kg (Larson, 1980a: 131). We estimate that only 15 min (0.25 hr) would be required to flip and truss a gravid female loggerhead; for the purposes of diet breadth, this is the pursuit time.

Butchering sea turtles for consumption is another matter. Modern dissections of sea turtles require a fairly diverse array of instruments: a saw, snips, knives, scalpels, and pliers. Turtle skin is tough, quickly dulling knife and scalpel blades (Wynken, 2001; see also Spotila, 2004). The first step, removing the plastron, requires an incision around the exterior seam. Once the attachment to the pectoral apparatus (shoulder bones) is severed, the various muscles and blood vessels can be pulled away and the plastron removed intact. At this point, the three major muscle groups are exposed—the longitudinal muscles along the neck, the large pinnate (feather-shaped) “chest” muscles used for swimming, and the fan-shaped pelvic muscle group. Once the viscera (heart, liver, lungs, kidneys, gas-

trointestinal tract, bladder, etc.) are removed, the limbs can be skinned out and the muscles removed. For loggerhead turtles, we estimate that 2 person-hours are required to butcher a gravid female.

According to Archie Carr, the amount of edible meat in a sea turtle ranges “from about 40 percent to about 80 percent of live weight depending upon how much was considered meat. Most cognoscenti eat practically everything inside the shell. Dabblers eat only steaks cut from voluntary muscles” (quoted in Larson, 1980a: 131). We will employ the 80 percent figure in our estimations, which converts to an estimated post-encounter return rate of 21,360 kcal/hr for harvesting female loggerheads while they are nesting.

#### COLLECTING LOGGERHEAD EGGS

When a female loggerhead crawls from the ocean to the backbeach, she leaves a distinctive “crawlway,” a tracklike depression created by the medial plastron and laterally flanked by flipper marks. After she crosses the high tide line, she digs a “body pit”—roughly the size of the turtle—working downward until reaching the underlying damp sand (which is capable of supporting a vertical face). The posterior part of body pit tends to be dug somewhat deeper, in preparation for digging the egg chamber.

Then, using her rear flippers, the loggerhead excavates an urn-shaped egg chamber (approximately 19–20 cm in diameter), in which she deposits the egg clutch. On St. Catherines Island, loggerhead clutches average 113 eggs (Gale Bishop, personal commun.; see also Miller, 1997; table 3.3). Each egg is the size, color, and shape of a ping-pong ball, averaging about 35 g/egg. After backfilling the neck of the egg chamber, the gravid female then disguises the entire nesting area by scooting forward, rotating, and throwing sand over the body pit; the disturbed, bioturbated sand is tamped firm with the rear flippers. On St. Catherines Island, these elliptical loggerhead nests average about 2.33 m long and 1.97 m wide (Bishop and Marsh, 1995). The female loggerhead then crawls back to the sea, leaving



Fig. 8.5. A loggerhead crawlway on St. Catherines Island. (courtesy of Gale Bishop).

a distinctive exit crawlway. Predators, especially raccoons and crabs, commonly follow these crawlway back to the nests. Loggerhead turtles deposit an average of 3.6 clutches/year. As noted above, table 8.9 documents a quarter-century of loggerhead nesting behavior on St. Catherines Island. Over this period, investigators estimate that only about half of the nesting attempts are successful, the nonnesting crawlways documenting the failure to find a suitable nesting area.

The egg-collecting forager must first locate the loggerhead nests, which are clearly evident on the beach as an elliptical "covering pit" linked to distinctive entrance and exit crawlways (see fig. 8.5). Beneath the disturbed sand of the nesting area lies the disguised body pit and the urn-shaped egg chamber. After determining that a loggerhead crawlway likely represents an actual

nest (as opposed to an aborted nesting attempt), the aboriginal forager must "read the nest" by examining the surviving clues left behind during nesting.

Because a turtle generally faces shoreward when depositing her eggs, the egg chamber generally lies buried on the seaward side of the nest, along the medial line of the line left as the plastron drags across the sand and generally one-quarter the distance across the covering pit. But turtles occasionally rotate prior to digging the egg chamber, meaning that the egg chamber might be offset somewhat from the expected position. By accurately predicting the subsurface structure of the nest, the forager minimizes excavation of the disturbed nest sediments and focuses directly on discovering the egg chamber neck, a discontinuity that contrasts against the surrounding laminated beach or dune sediments.

TABLE 8.10  
**Estimated Post-encounter Return Rates from Sea Turtle Harvesting on St. Catherines Island**

Species	Av. live wt. (kg)	Adj. live wt. (kg)	Usable %	Meat wt./ clutch (kg)	Energy (kcal/100 g)	Kcal/ clutch	Pursuit time (hr/ind.)	Processing time (hr/ind.)	Return rate (kcal/hr)
Loggerhead turtle ( <i>Caretta caretta</i> )									
Collect (nesting ♀ only)	68	—	80	54	89	48,060	0.25	2.0	21,360
Loggerhead eggs (by clutch)	3.955 <sup>a</sup>	—	94	3.718	200	7420	0.5	0.25	9893

<sup>a</sup> Based on an average weight of 35 g/egg and 113 eggs/clutch.

To estimate a post-encounter return rate for collecting loggerhead eggs, we will consider pursuit to begin once a new nest is encountered. Modern sea turtle researchers on St. Catherines Island, using steel shovels, take 3–60 min to excavate a loggerhead egg chamber (Gale Bishop, personal commun.); in estimating aboriginal pursuit time, we will employ a median value of 30 min.<sup>17</sup> As indicated in table 8.10, we compute a post-encounter return rate of 4,183 kcal/hr for harvesting loggerhead eggs.

In October 2005, Gale Bishop provided us with a sample of unhatched sea turtle eggs from a nest on St. Catherines Island. As indicated in table 8.1, the caloric return is 200 kcal/100 g (per results by Silliker, Inc., laboratory report, 12/6/05).

### HARVESTING MAST

The forests of St. Catherines Island produce two major mast crops: pignut hickory nuts (*Carya glabra* and *C. ovalis*) and a variety of acorns (*Quercus* sp.). Of all the modern forest communities on St. Catherines Island, the oak forests seem to be least disturbed by human activities. Live oaks (*Quercus virginiana*) grow almost everywhere on St. Catherines Island. Live oak trees are relatively parasite free and clearly the most productive species on the island. Live oak acorns mature in a single year. The nuts are large, averaging about 0.75–1 in. in length (390/lb; 1.2 g/acorn) with fruit forming in clusters of 3–5 acorns (Larson, 1980a: 188). More significantly, live oak acorns are

“sweet”, meaning that they do not require leaching prior to consumption.

In the maritime live oak forest, *Q. virginiana* predominate, thriving on sandy soils of old dune ridges (Johnson et al., 1974: 45). The maritime live oak forest is a long-lived, near-climax community that becomes established under conditions of reduced competition from other species, especially in areas protected from large-scale fire. Oak trees increase in size toward the interior of the island, developing large trunks and spreading crowns. Species diversity also increases toward the island interiors. A smaller “sand live oak” (*Q. geminate*) grows mostly along the beach and in high, sterile habitats (such as pastures, dune ridges, hammocks, and newly formed land).<sup>18</sup> The two varieties of live oak tend to ripen at different times, producing complementary acorn cycles that differ both spatially and temporally.

In the northern and central parts of the island, live and laurel oak dominate the canopy, with scattered slash and longleaf associations. Mixed-species forest are common to formerly cultivated fields, with oaks (mostly live and laurel, less commonly water) and pine growing in approximately equal numbers; pignut hickories also occur in the understory. In the oak-palm forest, cabbage palm forms the predominant associate of live oak in the canopy, covering about 400 acres in the southern forest region. Although easily harmed by fire, live oaks are tolerant to salt spray and infertile soils and are commonly the first forest community to establish on the

south beaches and coastal sand dunes of St. Catherines Island. This creates a competitive advantage, which enables the live oak forest to persist indefinitely as a near-climax community. Furthermore, the danger of fire is minimized in the newly established dunes areas, such as along the eastern shore of St. Catherines Island, where the oak and oak–palm forests are exposed to salt spray.

On the savanna, live and laurel oak (with slash and longleaf pine) are the principal tree species; water oaks also sometimes grow here. Live oak is the most common overstory component in the oak savanna forest type (which today forms 17% of the savanna vegetation). Even in the pine savanna forest, live oaks form a minor part of the canopy association. In the palm savannah forest, live oaks and laurel oaks are associated with the cabbage palm overstory. The pine–oak forest of St. Catherines Island, which today forms about one third of the island's forest cover (especially on formerly cultivated sites), is habitat to longleaf pines in addition to scattered individuals of laurel oak, live oak, and pignut hickory.

Coile and Jones (1988) also record the following species on St. Catherines Island: *Q. alba* (white oak), *Q. austrina* (bluff red oak), *Q. falcate* (spanish oak or southern red oak), *Q. hemisphaerica* (sand laurel oak), and *Q. nigra* (water oak). Laurel oaks are second only to live oaks in modern abundance. As noted in table 8.11, white oaks produce the largest acorns on St. Catherines Island, but only a dozen individuals of *Q. alba* exist on the island today. Because St. Catherines Island occupies the lower edge of their present range, it is unlikely that white oaks were ever abundant in this habitat.

Acorn and hickory nut productivity is enormously high. A single shellbark hickory (*Carya laciniosa*) can produce three bushels of nuts per tree (Schopmeyer, 1974: 271; cited in Gardner, 1997: 163). Watt and Merrill (1975) have calculated that a per-tree yield of 19 kg of edible nutmeat would provide 2200 kcal for 56 days, meaning that seven hickory trees could feed

TABLE 8.11  
Acorn Size for Various North American Taxa<sup>a</sup>

Species		cc <sup>3</sup>	g/acorn
St. Catherines Island taxa			
<i>Quercus alba</i>	White oak	1.4	3.3
<i>Quercus geminata</i>	Sand live oak	—	1.2+
<i>Quercus virginiana</i>	Live oak	0.9	1.2
<i>Quercus falcate</i>	Southern red oak	1.8	0.6
<i>Quercus nigra</i>	Water oak	1.1	0.7–1.5
<i>Quercus hemisphaerica</i>	Sand laurel oak	—	0.8
<i>Quercus austrina</i>	Bluff red oak	—	??
Midwestern taxa			
<i>Quercus macrocarpa</i>	Bur oak	9.1	6.1
<i>Quercus alba</i>	White oak	1.4	3
<i>Quercus velutina</i>	Black oak	3.7	1.8
<i>Quercus rubra</i>	Red oak	8.1	0.8
California taxa			
<i>Quercus lobata</i>	Valley oak	5.9	6.1
<i>Quercus garryana</i>	Garry oak	5.5	<4.5
<i>Lithocarpus densiflora</i>	Tanbark oak	—	4.1
<i>Quercus kelloggii</i>	Black oak	6.0	4
<i>Quercus crysolepis</i>	Golden cup oak	17.1	3
<i>Quercus douglasii</i>	Blue oak	4.1	2.5
<i>Quercus agrifolia</i>	Coast live oak	2.9	2.3
<i>Quercus gambelii</i>	Scrub oak	—	??

<sup>a</sup> Sources: USDA (1948); Larson (1980: 188–195); Aizen and Patterson (1990: 327–332); Coile and Jones (1988); see also Barlow and Heck (2002: table 11.3).

one person for a year. Gardner (1997: 163–164) provides comparable figures for mast production in Ohio: Within a 10-km catchment, the average acorn production is more than 1.9 million kg, with hickory nutmeat production of 235,000 kg, leading him to conclude that “exploitation of nuts by human foragers would not seem to be constrained by average forest productivity.” Crook (1986: 20) marshals similar figures for the Georgia coast, suggesting that a stand of 20 live oak trees would support a group of 13 individuals during the 15-week acorn dispersal season.

All mast resources require processing to make them edible. At a minimum, the edible kernels must be removed from their shells—and many acorns require leaching prior to human consumption. Southeastern Indians prepared acorns for consumption in several ways: baking into bread, thickening in venison broth, extracting into oil, and



Fig. 8.6. Le Moyne's rendering of "Preparing for a Feast," depicting Timucua Indians in the 1560s in northeastern Florida (Lorant, 1946: 91).

making acorn soup (Bartram, 1909: 49–50; Hudson, 1976: 301; Larson, 1980a: 187; Hann, 1986: 94).

LeMoyne depicts the processing of plant foods in figure 8.6 (Lorant, 1946:91).

#### PREPARING FOR A FEAST

There is a time of the year when the natives feast each other. For this purpose they choose special cooks. These cooks take a great round earthenware pot (which they bake so well that water can be boiled therein as easily as in our own kettles) and put it over a large wood fire. The head cook empties the raw food into the large pot; another keeps the fire going with a small hand fan; still others pour water into a hole in the ground; women bring water in large vessels; herbs to used for seasoning are ground on a stone.

Although they give big feasts, they never overeat, and therefore usually live to a great

age. One of their chiefs swore that he was three hundred years old and that his father, whom he pointed out to me, was fifty years older than himself—and indeed he looked to be nothing but skin and bones. Such facts might well make us Christians ashamed, for we are so immoderate in both our eating and our drinking habits that we shorten our lives thereby. We might easily learn sobriety and wisdom from these men whom we consider only as savages and beasts.

The activities depicted in "Preparing for a Feast" have been interpreted by various anthropologists seeking to derive ethnographic information.<sup>19</sup> Lewis Larson (1980a: 196–197) has criticized the associated caption, suggesting that it was written by de Bry (after Le Moyne's death) and "ignores or is vague about important matters (e.g., the food being cooked ...)," devoted instead to "wholly irrelevant moralizing

about European gluttony and the Indian lack of same." Larson believes that the engraving actually shows the preparation of acorn meal. The man in the lower left is pouring water into a hole in the ground and the person in the lower right is dumping something (likely flour or meal) onto the ground. A third person stands nearby, holding a large vessel of water. Elsewhere, men and women are shown grinding, picking, and cooking something that appears to be the same substance as that being poured on the ground. Larson (1980a: 197) suggests that "while a feast may be in preparation, it is also possible to interpret the engraving as representing the series of steps involved in making and cooking acorn meal, i.e., the grinding of the acorns, the leaching and cleaning of the meal, and finally the boiling of the meal." John Hann's (1986) alternative interpretation of this figure is presented in the next section.

When Fr. Andrés arrived on the Georgia coast in 1595, the Guale provided him with "some pieces of cake (torta) [made] of parched corn and others made from live oak acorn flour" (de San Miguel, 2001: 60–62). But the Europeans found the acorn cakes to be "sharp-tasting and bitter ... we were unable to eat them." By contrast, Alonso de Leturiondo, a pastor working in St. Augustine a century later, found the native acorn bread to be

sweet and delicious. ... The Indians make bread from the bitter acorn, and the method of processing it is, after having removed the husk, to grind the acorn in a hand mill and to bury it underground in some holes, the which, after remaining in [the ground] for eight or more days, removes the bitterness and the injurious elements and then by placing it, made into small loaves, on something like wooden spits, they place it over the fire and cook it. (Hann, 1986: 202)

Hann (1986: 224, fn23; 1996: 96) suggests that, perhaps during the 17th century, the Spanish helped the Indians to improve their acorn processing.<sup>20</sup>

Fr. Alonso de Escobeda, who was assigned to the mission at Nombre de Dios (St. Augustine) in 1587 (Hann, 1996: 71),

described how the Timucua ground acorns into cakes called *gacha* or *ogacha*:

They gather large amounts of the acorn which is small and bitter and peel the hull from the meat. They grind it well and during the time they bury it in the ground the earth is warm from the heat of the sun. Since low temperature spoils the dough, they do this about noon. After the dough is taken from the earth, they sprinkle it with water so intensely hot that it cooks the dough into the form of a loaf. By the above water and earth process the acorn loaf acquires a pleasant taste. The cacique of Florida eats this dish and is usually one of his most appreciated delicacies. It is reserved for gentlemen only, and, of course, "la gacha" is greatly relished by all. (Covington and Falconers, 1963: 150–151; quoted in Milanich 1996: 139–140)

Southeastern tribes also derived "sweet oil" from both acorns and hickory nuts. Thomas Hariot (1946 [1588]: 236), speaking for the Indians of Virginia, reported, "*Oil*. There are two kinds of walnuts, both of which yield oil, though one far more plentiful than the other. If there were mills or other devices of the sort, large amounts of oil could be obtained. Three different kinds of oak acorns also grow there, and were told by the inhabitants that these acorns yield very good, sweet oil." Hariot also noted that "besides their eating of them after our ordinarie maner, they breake them with stones, and pound them in mortars with water to make a milk which they use to put into some sorts of their spoonmeate; also among their sodde wheat, peaze, beans, and pompions which maketh them have a farre more pleasant taste" (1590: 18). Such cooking oil was sometimes mixed with corn flour and/or parched maize meal, sometimes fortified with dried persimmons and blueberries "to serve as a sort of K ration on the trail" (Hann, 1996: 96).

Writing specifically about the live oak (in Waselkov and Braund, 1995: 44, 238), Bartram noted:

It bears a prodigious quantity of fruit; the acorn is small, but sweet and agreeable to the taste when roasted, and is food for almost all animals. ... The Indians [also] beat them to

flower in wooden mortars, & mix with corn flower which makes good bread; they also beat the acorn to pieces then heat them in water over the fire which afforded a great deal of very sweet mild oil, which they use in cookery instead of Bear Oil or Butter, they roast the acorn & eat them as we do chestnuts—Oil from acorns, widespread in among SE indians, even though it contains far less oil than hickory nuts.

Benjamin Hawkins estimated that “one bushel of [red oak] acorns makes about a pint of oil” (Waseklov and Braund, 1995: 235). Bartram also noted that

[t]he indians hold in great esteem all kinds of sweet Hicory nuts. ... [T]hey crack the nuts, & beat them in mortars, this they boil in water & save the Oil, but the most favorite dish the Indians have amongst them is Corn thin Drink seasoned with hictory nut Oil. They pick out the kernel, beat them to a paste & boil with Indian Corn flower, which being seasoned with a lixivium made of Pea straw ashes, give it a consistence & taste something like cream or rich new milk & is called by Traders hictory milk (in Waseklov and Braund, 1995: 238; see also Jones, 1873: 317; Battle, 1922).

Mast, of course, is available only in the fall, a time of relatively plenty for Southeastern Indian foragers. Well-fed and vulnerable during the rut, deer are easier to hunt, and many native fruits are ripe, making mast just one of many fall resources. Late winter and early spring, however, are notorious times of shortage: Game is lean, fewer in number (due to winter kills), more solitary, and less mobile as the fawning season approaches. This is why stored resources, especially mast, can assume great importance—perhaps even greater importance than during the initial fall collection.

Edible mast usually disappears from the forest floor within a few weeks because it is consumed by other woodland animals including jays, turkeys, squirrels, and white-tailed deer; those nuts left on the ground soon became inedible (due to worms or mold). This is why foragers collected and stored acorns immediately after they fell. Fortunately, mast storage is not that difficult because the nutmeats come from na-

ture “prepackaged in their own individual containers” (Gardner, 1997: 172). Simple parching of the nuts prevents sprouting (by killing the embryos that would germinate during storage) and kills molds, fungi, and insects (Tlalay et al., 1984; Gardner, 1997: 174). High caloric content of nutmeat implies that significant numbers of calories can be stockpiled despite the bulk involved with the inedible shells.

LeMoyné depicts a Timucuan storage facility, which presumably stored mast crops, dried maize, and venison:

There are in that region a great many islands, producing abundance of various kinds of fruits, which they gather together twice a year, and carry home in canoes, and store up in roomy low granaries built of stones [likely tapia, or “tabby”, a natural cement made of lime and/or oyster shell] and earth, and roofed thickly with palm-branches and a kind of soft earth fit for this purpose. These granaries are usually erected near some mountain [likely a forest or grove], or on the bank of some river, so as to be out of the sun’s rays, in order that the contents may keep better. Here they also store up any other provisions which they may wish to preserve, and the remainder of their store; and they go and get them as need may require, without any apprehensions of being defrauded. (Le Moyné, 1875: 9; as cited in Swanton 1922: 361)

Perhaps acorns were stored in facilities like corn cribs (Swanton, 1922, 1946; Hudson, 1976: 299), raised 7 or 8 feet above the ground, supported by polished poles (to deter rodents), and sealed with mud plaster. Also like maize, it is possible that acorns were kept in special storage rooms within dwellings.

Available nutritional studies of hickory nuts and acorns (USDA, 1984) suggest that hickory provides the better source of calories. Only 340 g (dry weight) of hickory nuts are required to meet USDA (1974) recommended daily individual energy intake of 2200 kcal and for acorns, this figure is 427 g; by comparison, 604 g of maize are required. Whereas maize and acorns are high in carbohydrates, hickory nutmeat has a much higher fat content. Some ethnoarchaeological evidence reasons that cer-

tain groups of foragers deliberately sought out fatty foods, even though so doing reduces their overall foraging efficacy, because stored mast (especially hickory nuts) could have helped balance nutritional requirements (Hill, 1988). Speth and Spielman (1983) argued that some prehistoric North American hunters suffered significant fat shortages in late winter and early spring due to their heavy reliance on ungulates such as deer, animals that were especially lean during that part of the year. Hickory nuts also provide good sources of essential amino acids (9 of 10), while acorns provide lesser amounts than even maize, a notoriously poor protein source (Gardner, 1997: table 8.2). On strictly nutritional grounds, hickory nuts are a food resource superior to both acorns and maize.

Because acorns and hickory nuts are such a highly nutritious resource, they provide a potential complement to lean game. But mast production is somewhat periodic, with considerable species-to-species variability. The extraction and processing costs are fairly high, and the restricted seasonal availability requires large-scale storage. On St. Catherines Island, hickories tend to be restricted to the fine sandy soil habitats, often growing on well-drained ridges. But oak trees (like fresh water) were found almost everywhere on the island.

#### ESTIMATING RETURN RATES FOR HICKORY NUTS ON ST. CATHERINES ISLAND

BY MATTHEW SANGER AND DAVID HURST THOMAS

Archaeological and ethnographic evidence leaves little doubt that Southeastern Indians have exploited hickory nuts for millennia (Swanton, 1946; Asch and Asch, 1979, 1985; Chapman and Shea 1981; Yarnell and Black, 1985; Smith, 1986; Gardner, 1997; Gremillion, 1998). Numerous investigators have attempted to quantify the post-encounter return rates for hickory nuts, which require processing either by crushing and boiling the nuts or by cracking and picking the nutmeat free by hand. Talaley et al. (1984, cited in Gardner, 1997: 166) calculated the mean cost of processing hickory nuts using three different methods of extraction.

The mean cost of collecting, cracking, and picking the meat from three different species of hickory required an average of 43 hr/kg. Collecting, crushing with a nutting stone, and boiling the hickory nuts reduced the time to 3.5 hr/kg. The most effective method was collecting, crushing with a wooden mortar and pestle, and boiling the nuts, which had a mean cost of 2 hr/kg. Talaley et al. (1984: 356) concluded that hickory nuts required a crushing and boiling technology to make them energetically worthwhile.<sup>21</sup>

Given the importance of hickory nut oil for Southeastern Indians, we suspect that the “streamlined” oil production procedures—basically pounding, boiling, and straining, per Bartram’s description (cited above)—seems to minimize the processing costs. Gremillion (2002: table 3) derives three estimates for hickory nut return rates (based on experiments reported by Talalay et al., 1984): (1) to crack the nuts with a hammerstone and hand pick the nutmeats (164 kcal/hr), (2) to crush with a nutting stone and boil (2112 kcal/hr), and (3) to crush using a wooden mortar and boil (3114 kcal/hr).

To derive comparable evidence regarding procurement techniques and processing strategies, we conducted a series of optimal foraging experiments on the hickory nut presently available on St. Catherines Island.

**PROCUREMENT:** Hickory nuts are relatively large, dense nuts that ripen in the fall (generally from late September and November). As noted in chapter 5, pignut hickory trees (*Carya glabra*) are relatively common on St. Catherines Island (Coile and Jones, 1988), typically growing in dense stands along well-drained ridge tops (“hickory ridges”).

To measure procurement time, we conducted numerous 15-min collection experiments during which two-person teams gathered ripe hickory nuts throughout various patches on St. Catherines Island. One experimenter did all the collecting for each team (aided by the assistant, who carried the harvest and identified promising collecting areas nearby); the helper’s role was minimal, and, in the calculations to follow, we tally only the effort expended by the primary collector.

The 2005 experiments on hickory nut procurement were conducted within five distinct collection patches, deliberately selected to reflect the diversity in hickory nut-collecting habitats on St. Catherines Island. Specifically, between October 24 and 28, 2005, we conducted 22 independent experiments, collecting hickory nuts in a variety of patches that varied considerably with respect to density of on-the-ground hickory nuts, ground cover, and visibility (meaning the amount of light available at the forest floor, basically a function of time of day, quantity of leaf litter, and cloud cover).

The Power House patch is located on the western edge of the island (see fig. 8.7).<sup>22</sup> This patch had the lowest overall density of hickory nuts, the sparsest ground cover, and the highest rate of visibility (table 8.12). The densest concentration of hickory nuts occurred in the Cemetery Road patch, also characterized by a relatively high degree of visibility. As indicated in figure 8.8 and table 8.13, the Cemetery Road patch was more than twice as productive as the other four patches and its high resource density clearly had a major impact on collection rate. But we must also note that the Power House patch had the second highest overall collection rate, despite the lowest ranking resource density (available on-the-ground hickory nuts). Similarly, Yankee Bridge North patch has the second highest resource density, but the lowest collection rate.

While one certainly cannot discount resource density—nobody can collect hickory nuts when they're completely absent—these preliminary findings suggest that ground cover and visibility have a major impact on the overall collection rate of hickory nuts. Aboriginal collectors on St. Catherines Island were doubtless aware of this problem, and we suspect that sometimes they enhanced hickory nut procurement by improving the habitat conditions in the best resource patches. Such preharvest intensification likely included burning the forest duff (to eliminate ground cover and especially to remove the old hickory nut shells that seriously hamper collection of newly fallen nuts). Because hickory trees trend to

be shade intolerant (see Larson, 1980a: 187), aboriginal foragers may have selectively removed competitive tree species to facilitate growth and production of mature hickory trees. Such preharvest strategies could readily improve the procurement rates in even marginal resource patches.

The greatest disparity between individual performance is evident in the Cemetery Road patch, when RF collected more than twice as many nuts as QO (table 8.13). But QO was the most productive collector in the Yankee Bridge South patch, suggesting that individual collector productivity will be a difficult variable to model with any degree of confidence. These results also demonstrate that, despite individual performance differences, variability in patch potential remains the critical variable in projecting harvesting rate. Note, for instance, that whereas individual RF collected approximately one-third more hickory nuts than LE within the Cemetery Road patch, both experienced roughly a 360 percent increase in collection rate over that of the Yankee Bridge North patch. Our experiments thus suggest the degree to which individual ability and productivity can influence the overall collection rate (although this influence remains secondary to resource density, ground cover, and visibility).

At the beginning of this chapter, we took note of the problems involved in conducting optimal foraging experiments using untrained, inexperienced individuals in contemporary environments to address issues of aboriginal technology and resource return rates. Even setting aside issues of habitat degradation, such experiments will inevitably underestimate the efficiency and overall returns from the aboriginal circumstances they are designed to replicate (Petrucci and Wickens, 1984: 366; Simms, 1987; Kelly, 1995: 88; Barlow and Metcalfe, 1996; Gardner, 1997: 166–167; Madsen and Schmitt, 1998; Barlow and Heck, 2002; Thomas, 2002). With such biases in mind, we will employ the most productive collection trial in our  $n = 22$  experiments—that for individual RF working in the Cemetery Road patch—as the best single estima-

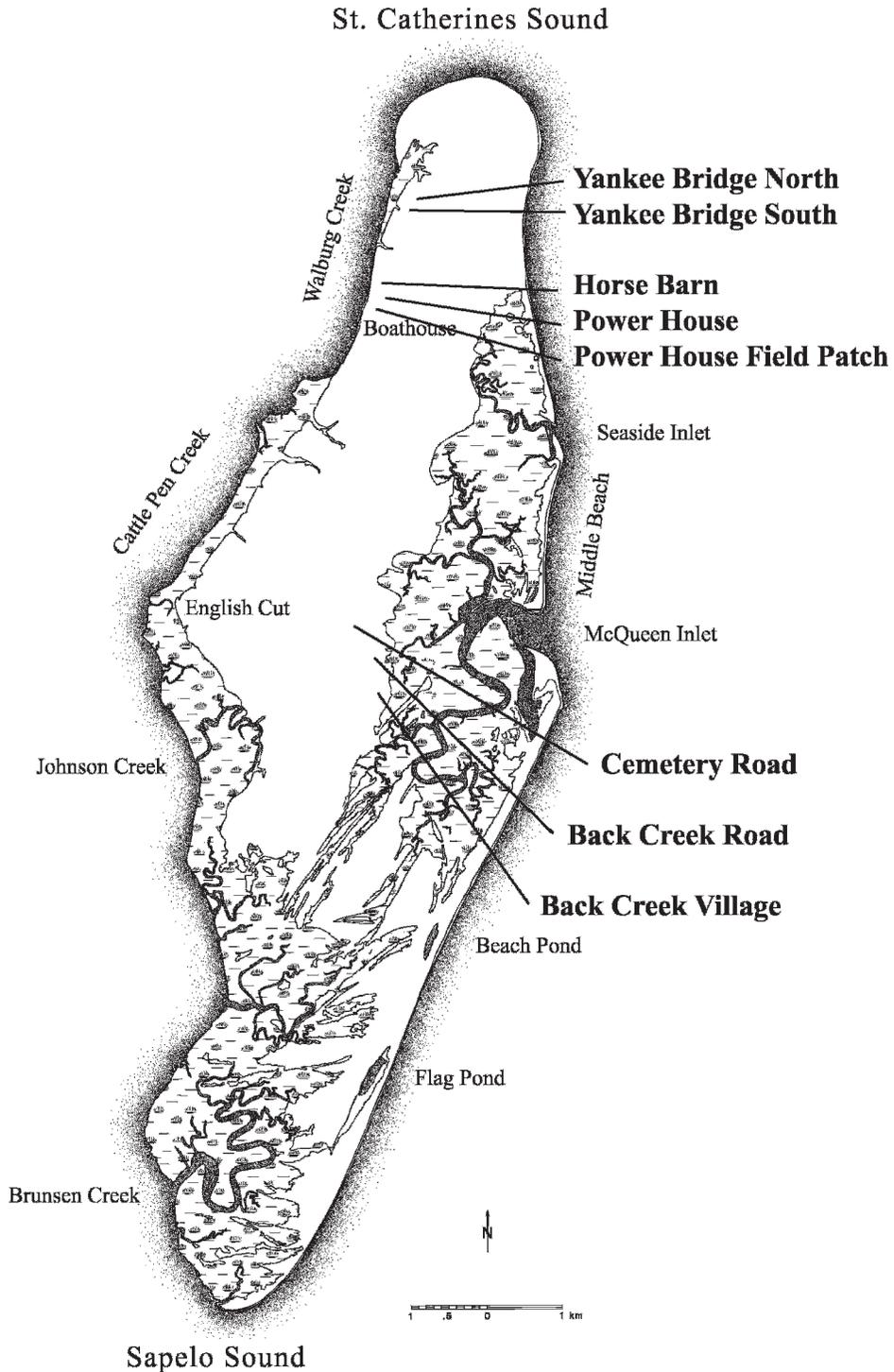


Fig. 8.7. Locator map of hickory nut and acorn experiments on St. Catherines Island.

TABLE 8.12  
**Attributes of Selected Hickory Nut Patches on St. Catherines Island**

Zone no.	Patch	Resource density <sup>a</sup>	Ground cover <sup>a</sup>	Visibility <sup>a</sup>
1	Power House	1	1	5
2	Yankee Bridge South	4	5	2
3	Yankee Bridge North	2	4	1
5	Back Creek Village	3	3	3
7	Cemetery Road	5	2	4

<sup>a</sup> 1 = lowest, 5 = highest.

tor of aboriginal collection rates on St. Catherines Island. Based on this particular time trial, we will estimate an overall procurement rate for 1 hr of hickory nut collection to be 3960 nuts/hr (57.04 kg/hr live weight). This procurement rate is significantly higher than the 5 kg/hr reported by Reidhead (1976: 249), who included hulling

time in his experiment (a task that we include as processing time, as discussed below).

**MANUALLY EXTRACTING HICKORY NUTMEATS:** The edible meat encased inside a hickory nut can be extracted in several ways. The most obvious method is to crack open the shell, remove the edible portion, then either consume the nutmeat directly or process into meal, flour, or mush. Our experiments show that these various options have significantly different implications in determining the overall post-encounter return rates for hickory nuts.

Ripe hickory nuts have three distinct parts (see fig. 8.9). The *husk* forms the outer protective layer, typically an extremely resilient, fibrous coating. In relatively fresh hickory nuts, the husk is the primary impediment to accessing the meat. The husk is usually a deep green–brown color when the nut drops from the tree, but it darkens to nearly black through time. The *shell* lies

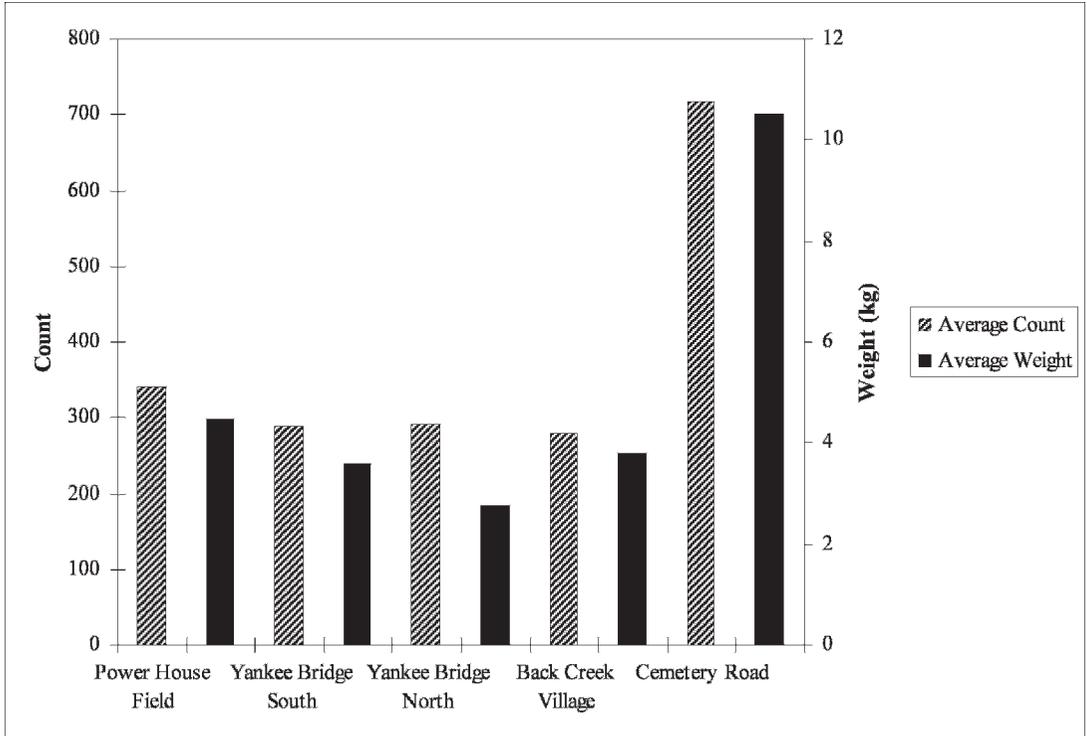


Fig. 8.8. Hickory nut procurement rates by patch on St. Catherines Island (20-min trials).

TABLE 8.13  
**Results of Hickory Nut Procurement  
 Experiments (St. Catherines Island, October 2005)**

Collection zone	Collector	Wt. (kg)
Powerhouse Field	GM	4.36
Powerhouse Field	MS	5.82
Powerhouse Field	RF	4.94
Powerhouse Field	LE	2.78
Yankee Bridge South	QO	4.38
Yankee Bridge South	BM	2.76
Yankee Bridge South	LH	3.28
Yankee Bridge South	AC	3.88
Yankee Bridge North	GM	3.06
Yankee Bridge North	MS	3.54
Yankee Bridge North	RF	2.72
Yankee Bridge North	LE	1.73
Back Creek Village	LH	5.26
Back Creek Village	GM	4.1
Back Creek Village	EB	3.96
Back Creek Village	SB	2.56
Back Creek Village	LE	3.16
Cemetery Road	LE	9
Cemetery Road	QO	6.82
Cemetery Road	RF	14.26
Cemetery Road	BM	10.18
Cemetery Road	EB	12.36

immediately inside the husk, with the *nutmeat* contained therein. Unlike acorns and peanuts, the shell of a hickory nut is more than a simple protective coating; instead, the hickory nutshell extends from the inner edge of the husk to the very center, with meat nut interspersed in small cavities throughout the shell. In other words, because there is no center meat mass (as in walnuts), extracting hickory nutmeat is a difficult and extremely labor-intensive process, requiring that shell be picked through bit by bit.

Cracking a hickory nut is a surprisingly difficult process. As described above, the aboriginal foragers on St. Catherines Island probably used wooden mortars and oversized hardwood pestles for this task. But lacking such tools, we estimated the energetics of manually extracting meat from hickory nuts by first cracking the nuts with a 10-pound sledge hammer, then removing the meat from the shell (using ice picks and small nails). In our  $n = 50$  trials, we found that exacting hickory nutmeat takes an av-

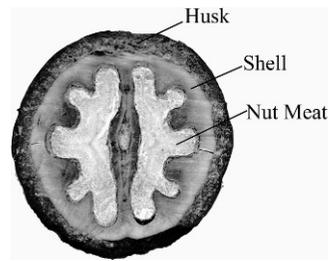


Fig. 8.9. Internal structure of a hickory nut (*Carya glabra*), from St. Catherines Island. Maximum diameter is 3.5 cm wide.

erage of 15 min/specimen. Based on our sample of hickory nuts recovered from St. Catherines Island, we determined that the average live weight is  $16.882 \pm 2.22$  g. These nuts produced an average of  $2.011 \pm 0.338$  g (see table 8.14).

The relative meat weight varied considerably, ranging between 7.3 and 15.4 percent of the gross nut weight, with a mean figure of 11.97 percent of total weight. This figure is considerably lower than previously published results. Battle (1922: 182) used a figure of 19.5 percent for edible nut weight per hickory nut, and Reidhead (1976: 248) estimated 25–30 percent of edible nutmeat/specimen. Some of this disparity can probably be attributed into interspecies differences, because the pignut hickories we collected generally produce lighter nuts than the white hickory nuts discussed by Battle (1922) or the shagbark nuts analyzed by Reidhead (1976; see also Larson, 1980a: 196). But because Battle and Reidhead both hulled their hickory nuts in the field (to reduce the transport weight), their figures might overestimate the actual shell:nutmeat ratio. In our experiments, the husk (or hull) of the hickory nuts accounts for 42 percent of the total harvested weight. When we subtract the husk weight from the St. Catherines specimens, the edible nut weight increases to 20.5 percent of the total harvested weight.

We submitted a variety of St. Catherines Island hickory nut samples to the Silliker Laboratory for constituent analysis and the results appear in table 8.1. These results are quite similar to those of Gremillion (2004: 220). Based on USDA data, Gremil-

TABLE 8.14  
**Results of Time Trials for Manual Extraction of Edible Meat from Hickory Nuts (St. Catherines Island)**

Zone	Total wt. (g)	Meat wt. (g)	% Meat	Extr. time (min)	g removed/hr
1	17.4	2.6	14.94	13	12.00
1	14.6	1.8	12.33	15	7.20
1	15.4	1.9	12.34	12	9.50
1	15.5	1.7	10.97	18	5.67
1	21.8	1.6	7.34	14	6.86
1	18.9	1.8	9.52	10	10.80
1	19.4	2.3	11.86	16	8.63
1	15.8	2.2	13.92	16	8.25
2	13.7	1.2	8.76	14	5.14
2	17.3	2.2	12.72	18	7.33
2	22.7	2.6	11.45	15	10.40
2	16	1.3	8.13	12	6.50
2	18.1	2	11.05	16	7.50
2	16.3	2.1	12.88	19	6.63
2	17.2	2.3	13.37	17	8.12
3	14.8	1.7	11.49	13	7.85
3	20.7	2.8	13.53	12	14.00
3	18.4	2.4	13.04	10	14.40
3	17.4	2.1	12.07	14	9.00
3	16.6	2.2	13.25	16	8.25
3	13.2	1.5	11.36	15	6.00
3	18.1	2.1	11.60	17	7.41
3	20.1	2.3	11.44	16	8.63
3	14.3	1.9	13.29	12	9.50
3	16.2	1.8	11.11	13	8.31
5	15.8	2.1	13.29	19	6.63
5	17.6	2.4	13.64	16	9.00
5	19.5	2.1	10.77	14	9.00
5	14.3	1.7	11.89	15	6.80
5	13.2	1.9	14.39	12	9.50
5	18.5	2.5	13.51	15	10.00
7	17.7	2.2	12.43	16	8.25
7	12.9	1.7	13.18	14	7.29
7	15.8	1.75	11.08	19	5.53
7	15.4	2.2	14.29	15	8.80
7	16.1	2.1	13.04	14	9.00
7	14.9	2.3	15.44	21	6.57
7	19.1	1.8	9.42	17	6.35
7	20.2	2.1	10.40	18	7.00
7	15.4	2.1	13.64	15	8.40
7	14.8	1.7	11.49	14	7.29
7	16.1	1.7	10.56	13	7.85
7	16.5	1.5	9.09	19	4.74
7	19.1	1.9	9.95	14	8.14
7	18.5	2.1	11.35	17	7.41
7	16.3	2.2	13.50	15	8.80
7	15.5	1.8	11.61	12	9.00
7	14.9	1.7	11.41	14	7.29
7	18.4	2.5	13.59	13	11.54
7	17.7	2.1	11.86	20	6.30

lion (2004: 22) states that 1 kg of nutmeat equals 6570 kcal, 183 g carbohydrates, 644 g fat, and 127 g of protein.

Recall our previous estimate that a single collector could harvest an average of 57.04 kg of hickory nuts/hr. Based on an average of 12 percent edible meat, this means that a total of 6.845 kg/hr of edible hickory nutmeat would be available in this standardized sample. Using our most efficient trial at removing edible meat from nut (14.4 g/hr; see table 8.14) as a proxy for aboriginal efficiency, we conclude that a whopping 475.3 hr would be required to extract the 6.845 kg of edible meat from a batch of hickory nuts that could be collected in a single hour. Using the energetic figure of 700 kcal/100 g (obtained from Siliker Laboratory for hickory nuts from St. Catherines Island hickory nuts; see table 8.1), we conclude that our standardized sample of 57.04 kg of hickory nuts (the estimated average yield from 1 hr of harvesting) contains 4791.3 kcal. We must then divide this gross energetic return by the sum of procurement time (1.0 hr) and processing time (475.3 hr). This means that manually extracting hickory nutmeats from St. Catherines Island produces an expected post-encounter return rate of 101 kcal/hr (see table 8.15). These results are slightly less than the 165 kcal/hr reported by Talalay et al (1984: 356) and the 164 kcal/hr computed by Gremillion (2002: 151). Clearly, with a return rate ranging between 100 and 165 kcal/hr, the manual extraction of edible meat from hickory nuts is an extraordinarily expensive process. Fortunately for the aboriginal forager, much better alternatives existed.

**PREPARING HICKORY NUT OIL:** The available ethnohistoric and ethnographic sources agree that the preferred method for processing hickory nuts was to boil the ripe nuts and extract the highly nutritious oils contained inside (e.g., Hariot, 1893; Speck, 1909; Battle, 1922; Swanton, 1946; Newcomb, 1956; Reidhead, 1976; ). In October 2005, we conducted a series of experiments to determine the energetic potentials involved with extracting hickory nut oil.

TABLE 8.15  
Post-encounter Return Rates for Hickory Nuts from St. Catherines Island (with comparative values from Gremillion, 2002, and Gardner, 1997)

Process	Av. live wt. (kg)	Usable %	Meat/oil wt. (kg)	Energy (kcal/100 g)	kcal/lot	Total time (hr/lot)	Return rate (kcal/hr)	Source
Manual extraction	57.04	12	6.8448	700	4791.36	476.3	100.6	this vol.
Crushing, boiling	15	—	4.802	400	1920.8	0.86	2233.5	this vol.
Manual extraction			1	657	6570	40.11	163.8	Gremillion (2002)
Crushing (nutting stone) and boiling			1	657	6570	3.11	2112.5	Gremillion (2002); this vol.
Crushing (wood mortar) and boiling			1	657	6570	2.11	3113.7	Gremillion (2002); this vol.
Manual extraction			1	696	7000	43	165	Gardner (1997)
Crushing (nutting stone) and boiling			1	696	7000	3.5	2030	Gardner (1997)
Crushing (wood mortar) and boiling			1	696	7000	2	3480	Gardner (1997)

TABLE 8.16  
**Handling Times for Hickory Nuts (St.  
 Catherines Island)**

Count	Wt. (kg)	Cracking (min)	Nuts cracked/hr	kg cracked/hr
211	2.78	8	1582.50	20.85
464	5.82	18	1546.67	19.40
339	4.94	21	968.57	14.11
345	4.36	20	1035.00	13.08
272	4.38	9	1813.33	29.20
990	14.26	111	535.14	7.71
288	3.28	13	1329.23	15.14
274	2.72	11	1494.55	14.84
295	3.88	19	931.58	12.25
301	2.76	16	1128.75	10.35

One begins the oil-making process by cracking open the individual nuts (breaking them into relatively small pieces), then removing the husk and shell fragments from the edible meat through water sifting. As before, we used a 10-pound sledge hammer as a substitute for the wooden mortars and pestles doubtless used in aboriginal times. This way, we could crack open 50 kg of hickory nuts in about 4 hr. As in most of our optimal foraging experiments, individual ability varied widely, ranging from 7.708 kg/hr to 29.2 kg/hr (table 8.16). Rather than take a simple average of these individual experiments, we will attempt to compensate for our lack of experience and skill by employing the most efficient individual result for crushing newly harvested hickory nuts (namely, 29.2 kg/hr).<sup>23</sup>

After cracking the hickory nuts, we needed to separate the pieces of husk from the shell and meat fragments, which proved to be a relatively simple process. By dumping the broken-up nuts into a tub of water, we could float lighter husk fragments to the surface, then easily skim them away and discarded. Even with a large sample of crushed hickory nuts, the skimming process required only about 5 min to accomplish.

At this point, we extracted a 15-kg representative subsample of the residual shell and meat fragments, which we boiled over a concentrated heat source. After about 30 min, the hickory nuts began to release

their oils, which formed in small pockets across the water surface. We skimmed off the floating hickory nut oil as the residual mixture continued to cook. After about an hour, all nuts appeared to have given up their supply of oil and the experiment ended.

Because it proved impossible to gather only oil from the boiling nut mixture, we were forced to collect a slurry of oil and water. By the end of the experiment, we had gathered 4,802 g of liquid, and we submitted a sample to Silliker Laboratory for nutritional analysis. As indicated in table 8.1, this hickory nut oil/water mixture contained 40 cal/100 g and was comprised of 5 percent carbohydrates, 0.5 percent protein, and 0.4 percent fat. This meant that our total sample of 4802 g produced the equivalent of 1920.8 calories of energy (and 240.1 g of carbohydrates, 24.01 g of protein, and 19.208 g of fat).

Using our highest experimental procurement rate (57.04 kg/hr), we estimate that 0.263 hr would be required to collect the 15 kg of nuts used for extracting this hickory nut oil sample. Applying the most efficient handling time, we estimate that 0.514 hr would be required to crack the 15-kg sample of nuts. Separating husks fragments from the shell/meat residuals would take only 0.083 hr. Combining these best estimates, we conclude that 0.86 hr would be required to process 15 kg of nuts fragments, which produced 4802 g of hickory nut oil/water mixture.<sup>24</sup>

Knowing from the nutritional analysis that the hickory nut oil/water slurry contained 1920.8 kcal (which was produced in 0.86 hr), we conclude that the post-encounter return rate for making hickory nut oil results is 2234 kcal/hr. This result corresponds rather closely with findings of Gardner (1992), who suggested that a return rate of 2565 kcal/hr can be expected from crushing and boiling hickory nuts. Talalay et al. (1984: 356) reported a return rate of between 2030 and 3480 kcal/hr for crushing hickory nuts boiled into oil. Based on similar data, Gremillion (2002: 151) calculated a return rate between 2112 and 3114 kcal/hr.<sup>25</sup>

ESTIMATING RETURN RATES FOR ACORNS ON  
ST. CATHERINES ISLAND

BY ANNA SEMON AND DAVID HURST THOMAS

Available ethnohistoric information on acorn harvest and preparation is sparse and generalized for the Southeastern United States, and, for this reason, we turn to ethnographic information from elsewhere in North America.

Aboriginal California is particularly relevant to this discussion, as anthropological studies have long documented the richness and abundance of acorn resources (e.g., Kroeber, 1925; Heizer, 1958). Gifford (1936: 87) called acorns a "vast new food supply of high nutritive value" and Mayer (1976: 29) went so far as suggesting the Miwok "enjoyed an almost unheard of luxury: a month's worth of collecting for a year's worth of work." Archaeologist Peter Schultz (1981: 43) argued that if one considers "the facility with which acorns can be gathered, their nutritional value, the moderate expenditure of energy needed to process them, and their potential for long term storage, it is hardly surprising that ethnographic accounts testify with near unanimity to their paramount status in the native dietary." Martin Baumhoff (1963) noted the high correlation between oak production and aboriginal population density, as acorns have conventionally been considered to be a high quality resource of choice. Despite the competition from deer, rodents, and birds for acorns, nut production seems to have vastly exceeded subsistence demands. Baumhoff (1981: 81) suggests that in the southern North Coast Ranges of California, oak tracts could have supported a population density 50–65 percent higher than that estimated at the time of Euro-American contact.

After examining California's acorn economy in some detail, Mark Basgall (1987) found that acorns are "very expensive" to process relative to their caloric returns, and acorn processing seems to have become increasingly important only during the late Holocene. Some see this as implying that overall foraging return rates decline later due to human population growth and/or

absolute declines in the abundance of high-ranked prey. Given the prevalence of nutshell in archaeological sites throughout the eastern Woodlands, archaeologists (e.g., Caldwell, 1958; Gardner, 1997) have likewise argued that nut gathering has long been an importance subsistence activity in this area as well. Mere abundance of a resource, however, must be tempered by the cost/benefit relationships involved in mast exploitation.

Although acorns are both nutritious and abundant in many habitats, the practical value to foragers would be considerably lessened if such yields were available at only irregular intervals. "Eastern forests are capable of yielding enormous amounts of mast. However, calculations of average forest yields probably have little relevance to investigations of human subsistence" (Gardner, 1997: 171); such variability seems to be the rule wherever mast crops have been studied in detail. In fact, Gardner (1997: 167) has found for the Midwest that it is rare to get two good successive harvests. That some of this variability is due to internal, genetic controls makes potential yields somewhat more predictable. Considerable stochastic variability, however, results from weather (as when cold weather during the springtime pollination and fruit-set can result in poor yields).

Despite the documented variability in mast production, a number of investigators have attempted to estimate return rates for acorns. For the Hupa of California, Goldschmidt (1974) observed that to prepare acorn mush from 6 lbs (2.7 kg) of shell acorns required 3 hr of pounding into meal, 4 hr of leaching, and an additional 0.5 hr of cooking, which produced an end product of 46 pounds (21 kg) of wet mush. Augmenting these figures with his own estimates of transport and shelling costs, Basgall (1987: 20, 29) determined the return rate for California acorns to be 1073 kcal/hr. In addition, Basgall emphasized the high yields of acorn production (approximately 600–800 kg/ha), the high nutritional content (rich in fat and calories), the low search time, and the long-term storability. Overall, Basgall (1987: 23) concluded that acorns pro-

vide “a resource of such high caliber that its use would be expected within any subsistence adaptation.”

In another experimental replication, Petruso and Wickins (1984) computed time costs ranging from 0.7 hr/kg for bur oak acorns to 8.3 hr/kg for white oak acorns, with caloric return rates that ranged from 290 kcal/hr to 3500 kcal/hr (1984: 367). In this experiment, no allowance was made for leaching. Reidhead (1976) began with these numbers and added a factor for processing bitter acorns (1.6 hr/kg) for a return rate of 2940 kcal/hr (1976: 299). He estimated that leaching pounded acorns in a running stream was considerably more cost effective than boiling the meal.

Helen McCarthy’s (1993) work among the Western Mono of the central Sierra Nevada provided detailed data on the exploitation of black oak (*Quercus kelloggii*), known for its large fruit (roughly 4 g/acorn) and high fat content, making black oak the preferred acorn throughout most of California, with a yield of 4835 kcal/kg (raw) and 4443 kcal/kg (leached, after Bettinger et al., 1997: 893). McCarthy found that the following tasks were required to generate 5 kg of leached black oak acorn meal (roughly the amount required to feed a single family for 10 days):<sup>26</sup>

1. Gather the acorns using poles used to dislodge nuts from higher branches and picking nuts off the ground (1.4 hr).
2. At residence or the collection site, spread the nuts out to dry to reduce the weight rather than the volume (0.12 hr).
3. Store the acorns, either in large, beehive granaries elevated on platforms or nestlike caches resting on bedrock (0.19 hr, excluding the time spent constructing the granary).
4. Recover the acorns from storage, crack each one with a nutting stone, remove and discard the shells, and winnow to remove the bitter, paperlike covering of the nutmeat (9 hr).
5. Clean (7.8 hr).
6. Pound (6.9 hr).
7. Leach (2.3 hr).
8. Cook (0.7 hr).

From these data, McCarthy (1993) computed a return rate of 848 kcal/hr for black oak acorns.

TABLE 8.17  
Oak Trees Known from St. Catherines Island  
(after Coile and Jones, 1998)

Species	Common name
<i>Quercus alba</i>	White oak
<i>Quercus austrina</i>	Bluff white oak
<i>Quercus falcate</i>	Southern red oak
<i>Quercus geminate</i>	Sand live oak
<i>Quercus hemisphaerica</i>	Sand laurel oak
<i>Quercus nigra</i>	Water oak
<i>Quercus virginiana</i>	Live oak

Gremillion (2002) computed return rates for various plant resources common to the eastern United States. Her figures are based on several assumptions: The trees are not significantly clumped, travel costs are based on a 1-km round trip from residential base at a rate of 2.5 km/hr, and differing rates of waste (shell) are reflected for each species, assuming no field processing took place (Gremillion, 2002: 148). Return rate estimates are not available for (1) acorns processed only by roasting and shelling and (2) acorns and hickory converted to “sweet oil”.

Barlow and Heck (2002: 135) have further refined these return rate estimates by attempting to standardize the methods used to compute energetic values for acorns. They have synthesized published experimental results of acorn weights for each processing stage (excluding cooking times), concluding that gross post-encounter return rates for seven California acorn species range between about 850 and 1350 kcal/hr. Barlow and Heck (2002) also detect a strong, positive correlation between acorn size and estimated caloric return rate. The larger acorns can be collected and shelled at a faster rate than smaller acorns (Petruso and Wickins, 1984), resulting in higher return rates than for smaller acorns, which have a lower overall caloric value and require additional processing time per unit weight.

ST. CATHERINES ISLAND ACORN EXPERIMENTS: As noted previously, Coile and Jones (1988) list seven oak species growing on the contemporary St. Catherines Island (see table 8.17). But since bluff white oaks are unknown on the island today (Royce

Hayes, personal commun.), we concentrated on the six additional oak taxa: the red/black oak group (which includes southern red oak, laurel oak, and water oak) and the white oak group (which includes live oak, sand live oak, and white oak). In general, the red/black oaks have lobe-shaped leaves, usually with bristle tips, produce ripe acorns every 2 years, and their acorns normally have a bitter taste when compared to white oaks (Harrar and Harrar, 1946: 174). White oaks have lobed leaves without bristle tips and produce “sweet” tasting ripe acorns every year (Harrar and Harrar, 1946: 174).

In October 2005, we began a series of optimal foraging experiments on the acorns crops available on St. Catherines Island. Of the six potential species identified, only two (live oak and sand laurel oak) were producing ripe acorns upon our arrival. Live oaks are the most abundant oak tree on the island, and except for the leaf shape, they are extremely similar to sand live oaks. During our October fieldwork, live oaks were producing moderate quantities of acorns and the sand live oaks were not (perhaps they produced acorns in December, but we cannot verify this).

On St. Catherines Island, sand laurel oaks and water oaks are difficult to distinguish from one another (Royce Hayes, personal commun.) because, even though the two species have defining characteristics (i.e., a true water oak has a distinct leaf shape compared to laurel oaks) most of the individuals on St. Catherines Island are cross-bred, with very few true water oaks living on the island. For this reason, we have grouped both species, identified here as “laurel oak”, the second most abundant oak tree currently growing on St. Catherines Island (second only, of course, to live oaks).

In framing the optimal foraging experiments discussed here, we were limited to the oak species that were producing acorns. However, we believe that aboriginal people on St. Catherines Island would most likely take advantage of larger sized acorns and “sweet” acorns.<sup>27</sup> White oak (*Quercus alba*) and live oak (*Quercus virginiana*) acorns would have met both criteria. Although white oak acorns are the largest available

on St. Catherines Island, it is difficult to estimate the extent to which aboriginal foragers could have regularly consumed white oak acorns because St. Catherines Island today provides only a marginal habitat for this species.<sup>28</sup> Besides being one of the oak species producing acorns at the time of our visit, live oak is an important acorn-producing species, for several reasons:

- Live oak trees can be found almost everywhere on the island; today, approximately 60 percent of the living oak trees on the island are *Q. virginiana*
- Live oak acorns are relatively large in size (of all the oak tree species growing on St. Catherines Island, only white oak produces larger acorns)
- Live oak trees grow with multiple stalks, allowing an individual tree to cover up to one hectare of land, thereby producing an extremely abundant and localized acorn crop
- Live oaks produce “sweet” acorns, which means the nutmeat can be consumed without leaching (the other species being the white oak).

Taking these factors into account, we initially believed that the estimates for California valley oak, black oak, and Garry oak (computed by McCarthy, 1993; Basgall, 1987; Barlow and Heck, 2002)—which range between about 850 and 1350 kcal/hr—should provide the best analogs for St. Catherines Island live oaks. Although California acorns are somewhat larger than their East Coast equivalents, we thought that perhaps the fact that live oak acorns do not require leaching would likely cancel out the size effect.

While it is certainly possible that bitter acorns, including those of southern red oak, water oak, and sand laurel oak, were processed into an edible form on St. Catherines Island,<sup>29</sup> the leaching time required (to remove the bitter taste) prior to consumption would likely involve return rates significantly lower than that of live oak. However, based on McCarthy’s (1993) research on the Mono, taste does not necessarily make acorns less desirable.

PROCURING LIVE OAK ACORNS ON ST. CATHERINES ISLAND: Live oak trees grow

TABLE 8.18  
Procurement Results for Live Oak Acorns (St. Catherines Island)

Collection patch	Teams (collector/helper)	Count	Wt. (g)	Procuring time (min)	Acorns/min	g/min
Cemetery Road	AC/LE	258	440.0	20	12.9	22.00
Cemetery Road	RP/EB	382	688.8	20	19.1	34.44
Cemetery Road	BM/LH	212	343.8	20	10.6	17.19
Cemetery Road	RF/GM	672	1199.9	20	33.6	60.00
Cemetery Road	SB/QO	103	202.3	20	5.15	10.12
Totals		1627	2874.8	100	81.35	143.75
Means		325.4	574.95	20	16.27	28.75
Back Creek Road	LE/AC	285	601.1	20	14.25	30.06
Back Creek Road	GM/RF	401	866.6	20	20.05	43.33
Back Creek Road	LH/BM	424	932.5	20	21.20	46.63
Back Creek Road	EB/RF	523	1151.0	20	26.15	57.55
Back Creek Road	SB/QO	226	533.8	20	11.3	26.69
Totals		1859	4085.0	100	92.95	204.26
Means		371.8	817.0	20	18.59	40.85
Totals		3486	6959.8	200	174.3	348.01
Total means		348.6	695.98	20	17.43	34.80

approximately 12–15 m tall (but can grow over 30 m tall), with a trunk diameter of 0.9–1.2 m (Harrar and Harrar, 1946: 179). Leaves are green in color and oblong/elliptical in shape, measuring approximately 5–12.7 cm in length and 1.27–6.35 cm in width (Harrar and Harrar, 1946: 176). Acorns are produced in clusters of 3 to 5, ripen each year in the late fall or early winter, are ellipsoid in shape, are brownish-black in color when ripe, measure approximately an inch in length, and only have a slightly bitter taste.

In October, there were moderate quantities of mature acorns located on the ground surface<sup>30</sup>; however, much larger quantities of green acorns were still growing on the various oak trees, suggesting that late October marked the very beginning of ripening season. The live oak acorns from St. Catherines measured a mean length of  $21.13 \pm 1.16$  mm ( $0.83 \pm 0.05$  in).<sup>31</sup> After a preliminary reconnaissance of the available acorn resources on St. Catherines, we identified potential collections zones, characterized by relatively high concentrations of mature (seemingly nonbuggy) acorns lying on the ground surface.<sup>32</sup> We also selected experimental areas with low-density surface

vegetation to enhance the greater visibility of acorns to be collected.

As in the other optimal foraging experiments described above, we divided the experimental crew into two-person teams, with a primary collector and a helper. In our 20-min collection episodes, the primary collector gathered acorns as rapidly as possible, with the helper holding the collection bag and pointing out locations of mature acorns. Even though these two people worked together, the helper's role was basically negligible (and not included in the return rate computations below).

We collected live oak acorn in two patches, located on Cemetery Road and Back Creek Road (see fig. 8.7 for the location of these collection zones). The Cemetery Road patch is located on the central island core, almost immediately north of McLeod Mound (see chap. 24). The surface vegetation was relatively open, consisting of grass and leaf litter. Five experimental teams gathered live oak acorns for 20 min. A total of 1627 acorns were gathered from the Cemetery Road patch. The team totals ranged from 103 to 672 live oak acorns, with live weights ranging from 202.3 to 1199.9 g (see table 8.18 and fig. 8.10).

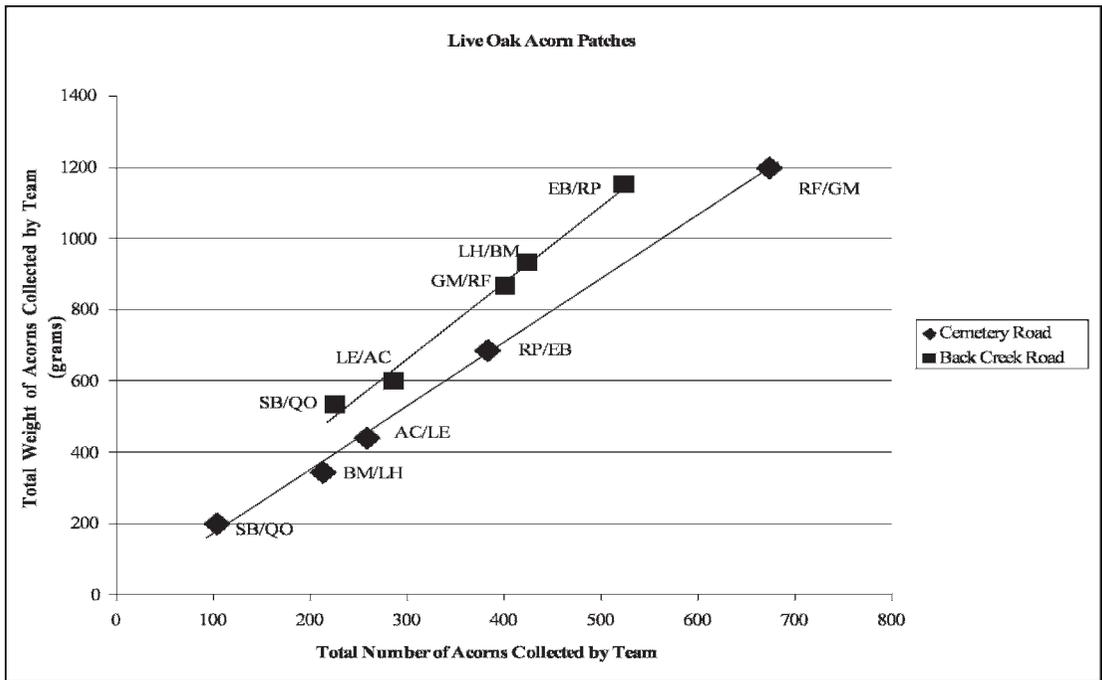


Fig. 8.10. Procurement rates for live oak acorns on St. Catherines Island.

The Back Creek Road patch is located along Back Creek Road, just south of Cemetery Road (see fig. 8.7). The exposed sand road allowed for 100 percent visibility of acorns in the roadbed, and the surface vegetation on the road margins was mostly grass and leaf litter. Five two-person teams collected live oak acorns for 20 min at the Back Creek Road patch. A total of 1859 acorns were gathered, with the team totals ranging from 226 to 523 acorns and live weights ranging from 533.8 to 1151.0 g.

Table 8.18 presents the procurement results for the live oak acorns. The Back Creek Road patch produced the largest quantity of acorns, which were also slightly larger in size than those collected within the Cemetery Road patch. The 10 individually timed trials amassed a grand total of 3486 acorns (weighing 6989.8 g) during a period of 200 min (3.33 hr). This translates to a mean procurement time of 17.43 acorns/minute (34.8 g live weight/min). For both patches the collection of acorns per minute varied. The collection rate ranged from 5 to 33 acorns/min within the Cemetery Road

patch and 11 to 26 acorns/min in the Back Creek Road patch. These results suggest that procurement times depend on several factors, such as visibility, collector's skill, and the abundance of resource available at time of collection. It is important to note, of course, that our procurement experiments doubtlessly underestimate the rates realized by experienced foragers; for this reason, we decided to use our best available team results (Cemetery Road patch, RF/GM) in order to calculate an estimated procurement rate for St. Catherines Island. The best team collected 672 acorns (1199.9 g) in 20 min. This means that a single hour of "pursuit" should produce an estimated 2016 live oak acorns, weighing 3599.7 g.

Acorns are relatively simple nut packages, comprised merely of shell and nutmeat. Live oak acorns have more meat/specimen than most nuts, such as hickory nuts, walnuts, and some other acorns. To determine the mean acorn size and edible proportion, we selected a sample of 10 live oak acorns (one from each timed experiment; see table 8.19). The raw acorns were

TABLE 8.19  
 Raw Live Oak Acorn Samples (St. Catherines Island)

Collection patch	Teams (collector/helper)	Acorn wt. (g)	Meat wt. (g)	Shell wt. (g)	Meat content
Cemetery Road	AC/LE	2.8	2.1	0.7	0.75
Cemetery Road	RP/EB	3.0	2.3	0.7	0.77
Cemetery Road	BM/LH	3.4	2.7	0.7	0.79
Cemetery Road	RF/GM	2.6	2.1	0.5	0.81
Cemetery Road	SB/QO	2.9	2.2	0.7	0.76
Means		2.94	2.28	0.66	0.78
Back Creek Road	LE/AC	2.5	1.7	0.8	0.68
Back Creek Road	GM/RF	3.0	1.9	1.1	0.63
Back Creek Road	LH/BM	2.8	1.8	1.0	0.64
Back Creek Road	EB/RP	3.1	2.2	0.9	0.71
Back Creek Road	SB/QO	2.9	1.9	1.0	0.66
Means		2.86	1.9	0.96	0.66
Total means		2.9	2.09	0.81	0.72

carefully cracked open using the end of a butter knife. The shell fragments were peeled away and the nutmeat removed; both fractions were then weighted on a digital scale. The live weight ranged from 2.5 to 3.4 g, with a mean live weight of  $2.9 \pm 0.30$  g. The nutmeats weighed an average of  $2.1 \pm 0.29$  g and weights ranged from 1.7 to 2.7 g. The mean edible proportion for live oak acorns is 72 percent (ranging from 63% to 81% in our samples). To summarize our October 2005 experiments: with a collection rate of 3.6 kg/hr and a mean edible proportion of 72 percent, we estimate a *procurement rate* of 2.59 kg of edible meat/hr for live oak acorns from St. Catherines Island (which can also be expressed as 0.27 hr/kg of live oak weight or 0.39 hr/kg of edible meat).

**HANDLING TIME (WITHOUT LEACHING) FOR LIVE OAK ACORNS:** Following the procurement experiments, our attention turned toward experiments pertaining to handling/processing times. As mentioned earlier, handling was defined as the time required to process the live oak acorns into an edible form. As noted by Gremillion (2002) and Barlow and Heck (2002), processing times can vary depending on the desired result (i.e., flour, mush, etc.). Handling time also varies by species because of the leaching required to remove

the higher concentrations of tannin (or tannic acid)<sup>33</sup> from some acorn taxa. No leaching is required for “sweet” acorns, but during our October experiments, we tasted several live oak acorns and found sufficient tannic acid to suggest that leaching may be required to render them edible. We will compute handling times with and without leaching times factored in.

We began the harvesting experiments by selecting a grab sample of 100 acorns (picking specimens that appeared to be free of bug infestations) from each collection patch, and one experimenter was assigned to process each batch and record handling times (see table 8.20). Our experiments focused on shelling and pounding of live oak acorns.<sup>34</sup> The shelling of 100 live oak acorns (weighing 251.3 g) from the Cemetery Road patch took 42 min and produced 151.7 g of meat. Based on the above numbers, the handling time is estimated to be 2.79 hr/kg. Using our best collection rate of 3.6 kg/hr (live weight) or 2.59 kg/hr (edible weight), we calculated a *handling time* of 7.23 hr.

One hundred live oak acorns from the Back Creek Road patch were shelled (weighing 245.0 g) in 68 min and produced 154.6 g of meat. Based on these numbers the handling time is estimated to be 5.51 hr/kg. Using our best collection rate

TABLE 8.20  
**Handling Times for Live Oak Acorns**  
**(St. Catherines Island)**

	No. acorns processed	Shelling time (hr)	Leaching time (hr)	Total time (hr)
Without leaching				
Cemetery Road	100	0.70	—	0.70
Back Creek Road	100	1.13	—	1.13
With leaching				
Cemetery Road	100	0.70	0.80	1.5
Back Creek Road	100	1.13	1.32	2.45

of 3.6 kg/hr (live weight) or 2.59 kg/hr (edible weight), we calculated a *handling time* of 14.25 hr.

We then submitted nutmeat samples (raw, roasted, and dry) to QC Laboratories for nutritional analysis (see table 8.1 for the results). Live acorn samples from St. Catherines Island have significant amounts of carbohydrates and very little fat and protein. Dried live oak acorns have 1.3 times more calories than raw acorns, thus suggesting the benefit of drying and storing acorns. We also note that our samples of raw live oak acorns have a lower caloric value than those processed during the USDA analysis.

Based on our best experimental numbers, we conclude live oak acorns (without leaching) have a post-encounter return rate of 1012 kcal/hr.

**HANDLING TIME (WITH LEACHING) FOR LIVE OAK ACORNS:** As mentioned earlier, we tasted some of the live oak acorns prior to processing and, because the acorns were somewhat bitter to the taste, we decided to water-leach the whole nutmeat (in a standard frying pan). For the Cemetery Road patch, water was brought to a boil and oil accumulated on the water surface.<sup>35</sup> We scooped off this acorn nut oil, and saved it for subsequent nutritional analysis, replacing the yellowish water with fresh water. The same leaching process was repeated over

a period of 48 min. The acorns were occasionally tasted to test the bitterness. Although the acorns were somewhat less bitter after five washes, we suspect that considerable tannic acid remained in the nutmeat.<sup>36</sup> Adding the above leaching time (48 min) to the shelling time (42 min), we derived a total handling time of 1.5 hr. Based on the above numbers, the handling time is estimated to be 5.97 hr/kg. Using our best collection rate of 3.6 kg/hr (live weight) or 2.59 kg/hr (edible weight), we calculated a *handling time* of 15.46 hr.

A similar handling experiment was conducted on the sample of live oak acorns collected in the Back Creek Road patch, except that the fresh water leaching process was continued over an interval of 79 min. The acorns were occasionally tasted to test the bitterness, and although the acorns were somewhat less bitter after eight washes, we suspect that considerable tannic acid remained in the nutmeat. Adding the above leaching time (79 min) to the shelling time from the patch (68 min) we come up with a total handling time of 2.45 hr. Based on the above numbers, the handling time is estimated to be 10.0 hr/kg. Using our best collection rate of 3.6 kg/hr (live weight) or 2.59 kg/hr (edible weight), we calculated a *handling time* of 25.9 hr.

We submitted a sample of live oak acorn oil (which was taken during the leaching stage) to the QC Laboratories for nutritional analysis (see table 8.1 for results). The oil sample contained only 1.09 kcal/100 g, an extremely low value; clearly, further experimentation will be required before we can adequately estimate the energetic returns for live oak acorn oil.

Based on our best experimental numbers, we conclude live oak acorns (with leaching) have a post-encounter return rate of 486 kcal/hr.

**PROCURING LAUREL OAK ACORNS ON ST. CATHERINES ISLAND:** Laurel oak trees grow approximately 15–18 m tall (but can grow over 30 m tall), with a trunk diameter of 0.9 to 1.2 m (Harrar and Harrar, 1946: 200). Leaves are green in color and elliptical in shape, measuring approximately 5–10 cm in length and 1.3–2.5 cm in width (Harrar

and Harrar 1946: 200). Acorns grow mostly solitary, ripen by the winter of the second year of growth, are ovoid in shape, are brownish-black in color when ripe, measure approximately 1.27 cm in length, and have a very bitter taste. As with the live oak acorn harvest in October 2005, we found moderate quantities of mature laurel oak acorns located on the ground surface<sup>37</sup>; but much larger quantities of green acorns were still growing on the various oak trees, suggesting that late October marked the very beginning of ripening season. The laurel oak acorns collected in October 2005 were quite small averaging about  $12.31 \pm .48$  mm ( $0.48 \pm 0.02$  in).<sup>38</sup> After a preliminary reconnaissance of the available acorn resources on St. Catherines, we identified potential collections zones, characterized by relatively high concentrations of mature (seemingly nonbuggy) acorns lying on the ground surface. We also selected experimental areas with low-density surface vegetation to enhance the greater visibility of acorns to be collected.

As described above for the live oak acorns, we divided the experimental crew into two-person teams, with a primary collector and a helper. In our 20 min collection episodes, the primary collector gathered acorns as rapidly as possible, with the helper holding the collection bag and pointing out locations of mature acorns. Even though these two people worked together, the helper's role was basically negligible (and excluded from return rate computations below).

We collected laurel oak acorns in three patches: the Horse Barn patch (located within the northeastern corner of the primary living compound), the Back Creek Road patch (along the eastern margin of the Pleistocene core of St. Catherines Island) and the Power House patch (located in the southern end of the primary compound; see fig. 8.7 for the exact location of these collection zones).

The Horse Barn patch is located within the compound near the cemetery east of the antebellum horse barn and northeast of the Button Gwinnett House. The surface vege-

tation was relatively open, consisting of grass and leaf litter. Four experimental teams gathered laurel oak acorns for 20 min. A total of 1651 acorns were gathered from this patch. The team totals ranged from 181 to 550 laurel oak acorns, with weights ranging from 120 to 300 g (see table 8.21 and fig. 8.11).

The Back Creek Road patch is located along Back Creek Road, just south of Cemetery Road (see fig. 8.7). The exposed sand road allowed for 100 percent visibility of acorns in the roadbed, and the surface vegetation on the road margins was mostly grass and leaf litter. Six two-person teams collected laurel oak acorns at the Back Creek Road patch, each collecting interval lasting 20 min. A total of 2800 acorns were gathered, with the team totals ranging from 408 to 1183 acorns and weights ranging from 312.1 to 477.9 g.

The Power House patch is located within the compound northeast of the current power house structure (see fig. 8.7). Surface vegetation consisted of grass and leaf litter. Four two-person teams collected laurel oak acorns at the patch, each collecting interval lasting 20 min. A total of 1082 acorns were gathered, with the team totals ranging from 213 to 340 acorns and weights ranging from 246.7 to 421.2 g.

Table 8.21 presents the procurement results for the laurel oak acorns. The Back Creek Road patch produced the largest quantity of acorns and larger size. Even though the Back Creek Road patch had more teams for the experiment, we believe that the patch contained more available resources and more visible acorns than the other patches (as seen by clustering of patches in fig. 8.11). The 14 individually timed trials amassed a grand total of 5533 acorns (weighing 4530.0 g) during a period of 280 min (4.67 hr). This translates to a mean procurement time of 19.76 acorns/min (16.18 g of live weight/minute). The acorns collected per minute varied from patch to patch. The collection rate ranged from 9 to 29 acorns/min within the Horse Barn patch, 20 to 30 acorns/min in the Back Creek Road patch, and 10 to 17 acorns/min in the Power House patch. These results

TABLE 8.21  
Procurement Results for Laurel Oak Acorns (St. Catherines Island)

Collection patch	Teams (collector/helper)	Count	Weight (g)	Procuring time (min)	Acorns/min	g/min
Northeastern Compound	BM/AS	550	300	20	27.50	15.00
Northeastern Compound	QO/GM	181	120	20	9.05	6.00
Northeastern Compound	LH/RF	488	260	20	24.40	13.00
Northeastern Compound	AC/LE	432	240	20	21.60	12.00
Totals		1651	920	80	82.55	46.00
Means		412.75	230	20	20.64	11.50
Back Creek Road	LH/RF	417	392.3	20	20.85	19.62
Back Creek Road	AC/MS	410	334.5	20	20.50	16.73
Back Creek Road	EB/AS	583	458.3	20	29.15	22.92
Back Creek Road	GM/LE	502	426.4	20	25.10	21.32
Back Creek Road	SB/BM	404	312.1	20	20.20	15.61
Back Creek Road	QO/RP	484	477.9	20	24.20	23.90
Totals		2800	2401.5	120	140.00	120.10
Means		466.67	400.25	20	23.33	20.01
Power House	MS/RF	340	421.2	20	17.00	21.06
Power House	SB/RP	213	290.1	20	10.65	14.51
Power House	QO/LH	285	246.7	20	14.25	12.34
Power House	LE/AC	244	250.5	20	12.20	12.53
Totals		1082	1208.5	80	54.10	60.44
Means		270.50	302.13	20	13.53	15.11
Totals		5533	4530	280	276.65	226.54
Total means		395.21	323.57	20	19.76	16.18

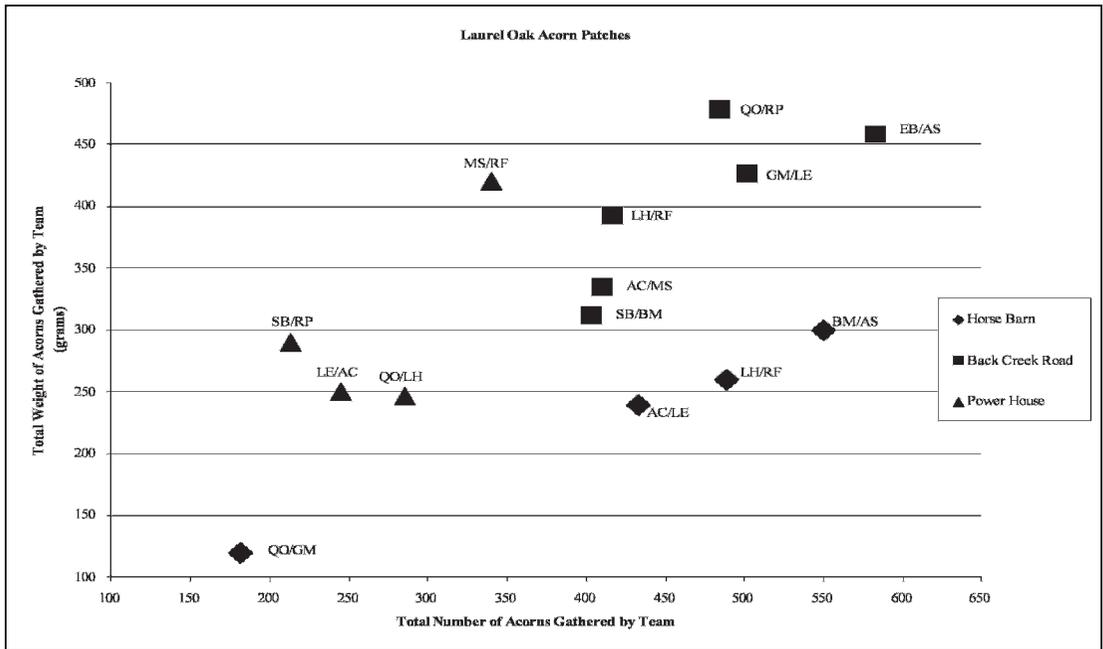


Fig. 8.11. Procurement rates for laurel oak acorns on St. Catherines Island.

TABLE 8.22  
**Raw Laurel Oak Acorn Samples (St. Catherines Island)<sup>a</sup>**

Collection patch	Teams (collector/helper)	Acorn wt. (g)	Meat wt. (g)	Shell wt. (g)	Meat content
Back Creek Road	LH/RF	1.1	0.8	0.3	0.73
Back Creek Road	AC/MS	1.1	0.7	0.4	0.64
Back Creek Road	EB/AS	1.1	0.7	0.4	0.64
Back Creek Road	GM/LE	0.9	0.6	0.3	0.67
Back Creek Road	SB/BM	1.0	0.8	0.2	0.80
Back Creek Road	QO/RP	1.3	1.0	0.3	0.77
Means		1.1	0.77	0.32	0.71
Power House	MS/RF	1.3	0.9	0.4	0.69
Power House	SB/RP	1.7	1.2	0.5	0.71
Power House	QO/LH	1.3	1.0	0.3	0.77
Power House	LE/AC	1.7	1.2	0.5	0.71
Means		1.5	1.08	0.43	0.72
Total means		1.3	0.93	0.38	0.72

<sup>a</sup> All numbers are rounded.

suggest that procurement times depended on several factors, such as visibility, collector's skill, and the abundance of resource available at time of collection. It is important to note, of course, that our procurement experiments doubtlessly underestimate the rates realized by experienced foragers; for this reason, we decided to use our best available team results (Back Creek Road patch, QO/RP) in order to calculate an estimated procurement rate for St. Catherines Island. The best team collected 484 acorns (477.9 g) in 20 min.<sup>39</sup> This means that a single hour of "pursuit" should produce an estimated 1452 laurel oak acorns, weighing 1433.7 g.

Laurel oak acorns are about half the size of live oak acorns. To determine the mean acorn size and edible proportion, we selected a sample of 10 laurel oak acorns<sup>40</sup> (one from each timed experiment; see table 8.22). We cracked open the raw acorns, using the end of a butter knife, then peeled away the shell fragments and removed the nutmeat; we weighed both fractions on a digital scale. The sample of whole laurel oak acorns weighed between 0.9 and 1.7 g, with a mean live weight of  $1.3 \pm 0.27$  g. The nutmeats averaged  $0.93 \pm 0.21$  g (ranging between 0.6 and 1.2 g). The mean edible proportion for laurel oak acorns is 72 percent (ranging from 64% to 80% in our samples). Despite their smaller size, the laurel

oak acorns from St. Catherines Island generally have the same proportion of edible meat as live oak acorns.

To summarize the October 2005 experiments: With a harvesting rate of 1.4 kg/hr and a mean edible proportion of 72 percent, we estimate a *procurement rate* of 1.01 kg of edible meat/hr for laurel oak acorns from St. Catherines Island (which can also be expressed as 0.71 hr/kg of laurel oak weight or 0.99 hr/kg of edible meat).

**HANDLING TIME FOR LAUREL OAK ACORNS ON ST. CATHERINES ISLAND:** In this research, we defined "handling" as the time required to process the laurel oak acorns into an edible form. Based on our field taste tests, laurel oak acorns definitely cannot be considered a "sweet" acorn and considerable leaching is required to make the nutmeat edible. This is why handling times for laurel oak acorns must be computed with leaching times included.

As in the live oak acorn experiments, we began the harvesting experiments by selecting a grab sample of 100 acorns (picking specimens that appeared to be free of bug infestations) from each collection patch, and one experimenter was assigned to process each batch and record handling times (see table 8.23). A hundred acorns (weighing 98.6 g) from the Back Creek Road patch were shelled in 42 min and produced 68.3 g of meat.<sup>41</sup> The shelling step was fol-

TABLE 8.23  
**Handling Times for Laurel Oak Acorns**  
**(St. Catherines Island)**

Collection patch	No. processed	Shelling time	Leaching time	Total time
Back Creek Road	100	0.70	1.27	1.97
Power House	100	0.47	0.85	1.3

lowed by leaching (whole nuts), which consisted of covering the nutmeat with water inside a standard frying pan. The water was brought to a boil, which resulted in the formation of oil on the water surface. The resulting acorn nut oil was scooped off and saved. Once all the oil was removed, the yellowish water was replaced by fresh water and the process repeated over a period of 76 min.<sup>42</sup>

We tasted the acorns occasionally for bitterness. Although the acorns were somewhat less bitter after nine washes, we suspect that considerable tannic acid remained in the nutmeat. The total handling time for this experiment was 118 minutes (1.97 hr). Based on the above numbers, the handling time is estimated to be 19.95 hr/kg. Using our best collection rate of 1.4 kg/hr (live weight) or 1.01 kg/hr (edible weight), we calculated a *handling time* of 20.15 hr.

A hundred acorns from the Back Creek Road patch (weighing 93.9 g) were also shelled; however this took only 28 min and produced 59.5 g of meat. The shelling step was followed by leaching, which consisted of covering the nutmeat with water inside a standard frying pan. The water was brought to a boil, which resulted in the formation of oil on the water surface. The resulting acorn nut oil was scooped off and saved. Once all the oil was removed, the yellowish water was replaced by fresh water and the process repeated over a period of 51 min. The acorns were occasionally tasted to test the bitterness. Although the acorns were somewhat less bitter after seven washes, we suspect that considerable tannic acid remained in the nutmeat. The total handling time for this experiment was 79 min (1.3 hr). Based on the above num-

bers, the handling time is estimated to be 14.02 hr/kg. Using our best collection rate of 1.4 kg/hr (live weight) or 1.01 kg/hr (edible weight), we calculated a *handling time* of 14.16 hr.

We then submitted samples (raw nutmeat, dried nutmeat, and oil) to QC Laboratories for nutritional analysis (see table 8.1 for results). Laurel acorn samples from St. Catherines Island have significant amounts of carbohydrates, followed by fat, but very little protein. We also note that our samples of raw laurel oak acorns have a higher caloric value than those processed during the USDA analysis and the live oak acorns from St. Catherines Island. The caloric difference between live and laurel is associated with tannin concentrations. Black/red oak trees (of which laurel oaks are part) have higher concentrations of tannin compared to live oak or other white oak species. The dried laurel acorns have a slightly lower caloric value than acorns processed for USDA analysis. The laurel oak oil samples indicate relatively low caloric values; however, the laurel results are higher than the live oak oil (1.09 kcal/100 g). Even though ethnohistoric accounts (Swanton, 1946; Hann, 1986b) document the use of acorn oil, our experiments provided very limited information for analysis and further work is needed.

Based on our best experimental numbers, we conclude laurel oak acorns (leached) have a post-encounter return rate of 254 kcal/hr.

IMPLICATIONS AND CONCLUSIONS: Although acorns are relatively simple nuts (shell and nutmeat), they can require numerous and often varying stages of preparation to be rendered edible (shelling, pounding, cleaning, pounding, winnowing, leaching, and cooking). If we add times related to searching, collecting, transporting, drying, and storing, then acorns can become very costly. Our optimal foraging experiments on St. Catherines Island were divided into procuring and handling costs. Our procuring costs consisted only of collecting times; we did not account for locating and transporting times.<sup>43</sup> Our handling experiments con-

sisted of only shelling time or shelling and leaching times.<sup>44</sup>

Table 8.24 summarizes the results from our experimental return rate studies on live oak and laurel oak acorns from St. Catherines Island; we also include comparative return rates for acorns from Barlow and Heck (2002) and Gremillion (2002).

For live oak acorns, our experiments show (if we select our best timed results) that we can collect 3.6 kg of acorns/hr, which would provide 2.59 kg of edible nutmeat. Time expended includes 0.39 hr for collecting acorns and 7.23 hr for shelling, which gives a total time of 7.62 hr/kg. This total time provides an estimated post-encounter return rate of 1012 kcal/hr for live oak acorns on St. Catherines Island. If we leached the live oak acorns, our best timed experiments give a total handling time of 15.85 hr and a post-encounter return rate of 486 kcal/hr. Based on our experiments, shelled raw live oak acorns have a higher caloric return (2 times more) than leached live oak acorns. These estimated return rates could most likely increase with future experimentation.

For laurel oak acorns, our best experiment times show that acorns can be gathered at a rate of 1.4 kg/hr or 1.01 kg/hr for edible nutmeat. Experimental time consists of 0.99 hr to collect acorns and 14.16 hr to shell and leach laurel acorns, which gives a total time of 15.15 hr. Our estimated post-encounter return rate is 254 kcal/hr. Although this rate is very low, we believe that it can be improved with future experimentation. Even though our nutritional analysis has identified laurel acorns with a higher energy value (381 kcal/100 g) when compared to live oak acorns (298 kcal/100 g), laurel oak acorn size and higher concentrations of tannic acid seem to hinder its caloric benefits. We believe the size of the acorn is a factor particularly when it comes to shelling acorns. The larger the acorn the easier it is to shell and remove the edible nutmeat.

Comparing our experimental return rates for live oak and laurel oak acorns with Gremillion's (2002) and Barlow and Heck's (2002) numbers, we acknowledge our rates

TABLE 8.24  
Estimated Post-encounter Acorn Return Rates (St. Catherines Island)

Species	Average raw wt. (kg)	Edible content	Meat wt. (kg)	Energy (kcal/kg)	Kcal/lot	Total time (hr/lot)	Est. return (kcal/hr)	Source
Live oak acorns ( <i>Q. virginiana</i> )								
Collecting & shelling	3.6	.72	2.59	2976.7	7709.65	7.62	1012 <sup>a</sup>	this vol.
Collecting, shelling, & leaching	3.6	.72	2.59	2976.7	7709.65	15.85	486 <sup>a</sup>	this vol.
Collecting & shelling			1	2976.7	2976.7	3.06	973 <sup>a</sup>	this vol.
Collecting, shelling, & leaching			1	2976.6	2976.7	6.24	477 <sup>a</sup>	this vol.
Unidentified acorn species								
Collecting & shell			1	3870	3870	1.31	2954	Gremillion (2002)
Soak			1	3870	3870	8.71	444	Gremillion (2002)
Boil in skin or basket			1	3870	3870	4.71	821	Gremillion (2002)
Black oak acorns ( <i>Q. kelloggii</i> )								
Collect, shell, pound, winnow, & leach	1	.73	0.73	4937-5405	3604-3946	3.29	1091-1194	Barlow and Heck (2002)
Laurel oak acorns ( <i>Q. hemisphaerica</i> )								
Collecting, shelling, & leaching	1.4	.72	1.01	3810.4	3848.5	15.15	254 <sup>a</sup>	this vol.

<sup>a</sup> Numbers rounded.

are considerably lower. We believe that there are several factors why our numbers are lower than the other two sources. One difference is related to analysis of varying taxa.<sup>45</sup> Live oak acorns are much smaller than most California oak acorns. Another difference (and possibly the most important) is the amount of time spent on procurement and handling. When we calculate the estimated times for 1 kg of live oak nutmeat (collected, shelled, and leached) and compare it to Barlow and Heck's (collected, shelled, pounded, winnow, and leached), our total handling time is 2 times longer. Perhaps one reason why our times are long pertains to the different leaching methods used. We leached whole kernels of nutmeat while Barlow and Heck leached acorn flour. Our total handling time compared to Gremillion (2002) is 2 times longer for collecting and shelling and 1.3 times longer than Gremillion's collecting and boiling. Gremillion's data indicate that less time was spent leaching the acorns compared to our data. One reason why our handling times are higher than the others is because of our lack of handling experience. Leaching is a very beneficial stage for making acorns edible; however, we learned during our experiments that determining if an acorn is edible is very subjective (i.e., the Cemetery Road patch only required five washes and the Back Creek Road patch required eight washes).

For laurel oak acorns, our experiments indicate a total time of 15.15 hr is required; this is 4.6 times longer than Barlow and Heck's total time and 3.2 times longer than Gremillion's total time. Our estimated return rate for laurel oak acorns is 3.7 times lower than Barlow and Heck's, 2.8 times lower than Gremillion's estimates, and 1.6 times lower than our live oak acorns. Our rate can most likely improve with future experimentation. However, based on our current experimental estimates, live oak acorns are more cost effective than laurel oak acorns.

As indicated by our nutritional analysis, dried acorns (both live and laurel) provide more calories than raw acorns (see table 8.1). This indicates at least one benefit of drying and storing acorns. Drying is a necessary step prior to storing for three

reasons: (1) It stops mold from growing, (2) it kills bugs, and (3) it stops the acorn from germinating. Drying could consist of laying acorns out in the sun or parching acorns with heated stones.<sup>46</sup>

These estimated return rates (summarized in table 8.25) help estimate the potential contribution of mast crops to the diet and suggest how their distribution in the habitat might condition the relative efficiencies of various foraging strategies when the food items were incorporated in the diet (Barlow and Heck, 2002: 128–129). These estimates are best viewed as maximums, since factors such as animal competition, insect infestation, mold, and rot reduce the number of edible nuts actually available for human consumption. Mentioned earlier we believed that the estimates for California valley oak, black oak, and Garry oak (computed by McCarthy, 1993; Basgall, 1987; Barlow and Heck, 2002)—which range between about 850 and 1350 kcal/hr—would provide the best analogs for St. Catherines Island live oaks. Our estimated post-encounter return rates for live oak acorns was 1012 kcal/hr, which falls within the range of the above mentioned numbers. In other words, our assumption was correct. We anticipate that future acorn foraging experiments will improve the existing data and provide further information related to processing techniques for acorns on St. Catherines Island.

Table 8.25 summarizes the post-encounter return rates for all mast crops on St. Catherines Island.

## HARVESTING WILD PLANTS

Small seeds, root crops, wild vegetables, berries, fruits, nuts, and seeds were commonly explored by aboriginal foragers within the foraging radius of each settlement (Larson, 1980a: 197–204; Ruhl, 1990, 1993, 2000). Saw palmetto berries and persimmons ripened in the fall, grapes were available in the late summer and early autumn, and cabbage palm fruit ripened during the winter. Blueberries and blackberries were collected in springtime and early summer, as were greens such as poke. In

TABLE 8.25  
**Estimated Post-encounter Return Rates for Mast Crops on St. Catherines Island<sup>a</sup>**

Species		Return rate (kcal/hr)	Comments and source
Acorns (prepared as meal and/or bread)			
<i>Q. virginiana</i>	Live oak	1012	Collecting, shelling, no leaching. This vol.
<i>Q. virginiana</i>	Live oak	486	Collecting, shelling, leaching. This vol.
<i>Q. hemisphaerica</i>	Laurel oak	254	Collecting, shelling, leaching. This vol.
Midwest U.S.	Various species	290–3500	No leaching. Petrusco and Wickins (1984).
Midwest U.S.	Various species	2940	Same data as above, with leaching. Reidhead (1976).
<i>Q. gambelii</i> (Utah)	Scrub oak	2976	Pick from ground, processing limited to removing caps. Simms (1987).
<i>Q. gambelii</i> (Utah)	Scrub oak	1488	Pick from trees, processing to removing caps. Simms (1987).
<i>Q. lobata</i>	Valley oak	1135–1138	Barlow and Heck (2002)
<i>Q. kelloggii</i>	Black oak	1166–1276	Barlow and Heck (2002)
<i>Q. kelloggii</i>	Black oak	1091–1194	Barlow and Heck (2002)
California		1070	Gremillion (2002)
<i>Q. garryana</i>	Garry oak	1004	Barlow and Heck (2002)
<i>Q. kelloggii</i>	Black oak	848	Talaley et al. (1984)
<i>Q. chrysolepis</i>	Golden cup oak	979	Barlow and Heck (2002)
<i>Q. douglasii</i>	Blue oak	915–919	Barlow and Heck (2002)
<i>Lipocarpus desiflora</i>	Tanbark oak	866	Barlow and Heck (2002)
Acorns (prepared as oil)			
Soak		2954	Gremillion (2002)
Boil in skin/basket		444	Barlow and Heck (2002)
Boil in pot		821	Barlow and Heck (2002)
Hickory nuts (manual extraction)			
<i>Carya glabra</i>	Pignut oil	101	St. Catherines Island. This vol.
Midwest U.S.		164	Gremillion (2002); Talaley et al. (1984).
Hickory nuts (prepared as oil)			
<i>Carya glabra</i>	Pignut oil	2235	St. Catherines Island: Crushing, boiling.
<i>Carya glabra</i>	Pignut oil	2123	St. Catherines Island: Crushing, nutting stone. This vol.
Midwest U.S.		2,113	Crush with nutstone and boil. Gremillion (2002); Talaley et al. (1984).
Midwest U.S.		3114	Crush with wooden mortar and boil. Gremillion (2002); Talaley et al. (1984).

<sup>a</sup> The estimates credited to Barlow and Heck (2002: 135) employ previously published estimates using published experimental results and acorn weights in each processing stage (excluding cooking times). Noting the considerable variability in previous methods used to compute energetic values for acorns, Barlow and Heck (2002: 135) have attempted to standardize methods and reduce the ambiguity.

this brief overview, we will concentrate on the mast crops, starchy roots, and small seeds that were doubtless consumed during the aboriginal period.

We will model the wild plant harvesting “hunt types” as follows.

#### SMALL GRAINS

Although small grains are rarely mentioned in the ethnohistoric sources relating

to Southeastern Indians, Swanton does comment that sunflower (a domesticate) and cockspur grass seeds were consumed by the several Southeastern tribes (Swanton, 1946: 265–304, table 2; Hann, 1986: 99). Based on a number of ethnographic, experimental, and nutritional studies, such small seed sources generally offer low return rates relative to many alternative resources, leading to characterizations as “famine foods” and “second-line re-

sources” (e.g., O’Connell and Hawkes, 1981; Basgall, 1987; Hawkes and O’Connell, 1992; Bright et al., 2002; Gremillion, 2004: 215).<sup>47</sup>

Smith (2001) has found that in some areas of eastern North America, small seeds achieved some degree of dietary importance in the past. Between 3000 and 1000 B.P., these so-called lost crops were weeds in disturbed habitats, often targeted for eradication rather than consumption (e.g., Smith and Cowan, 1987). Gremillion (2004: 217) has examined optimal foraging models in an attempt to understand the decisions made by ancient foragers with respect to harvesting (or not harvesting) such lost crops. These small, relatively dry fruits are commonly rich in oils and/or carbohydrates and, despite their virtues, such native grains often returned to “weed status” after maize became an important cultigen. Winterhalder and Golland (1997) use the diet-breadth model to project a number of alternative pathways for domestication of small grains in the eastern United States. They posit low profitability of eastern small grains, which receives strong empirical support from archaeological evidence from the Cumberland Plateau of eastern Kentucky (summarized in Gremillion, 2004: 227).

Drawing upon available information, we can estimate the potential returns of small grains on St. Catherines Island.<sup>48</sup>

**AMARANTHACEAE:** *Amaranthus* seeds are tiny (less than 1.5 mm in diameter), with a protective seed coat that comprises about 30 percent of the total seed weight (Gremillion, 2004: 218). The seeds become available in the late summer and early fall (approximately the same time as maize kernels). Ruhl (1990: 562) reports that pigweed (*Amaranthus* sp.) seeds were recovered from our excavations at Mission Santa Catalina de Guale on St. Catherines Island. Based on a reanalysis of the account by the Gentleman of Elvas, Dobyns (1983: 221–228) has argued that Timucuan fields of the 1530s contained abundant quantities of *Amaranthus* and perhaps chenopods as well. At least two members of the amaranth, alligator weed (*Alternanthera philoxeroides*) and cottonweed (*Froelichia flori-*

*dana*) grow today on St. Catherines Island (Coile and Jones, 1988: 9). Talaley et al. (1984) and Gremillion (2002) estimate a post-encounter return rate of 1359 kcal/hr for amaranth—the highest energetic return of any small seed crop considered in this report.

**MAYGRASS:** The starchy seeds of maygrass (*Phalaris caroliniana*; family Poaceae) are available in the late spring and early summer, with a reported return rate of 457 kcal/hr. Maygrass has not been reported on St. Catherines Island (Coile and Jones, 1988); however between the 1930s and the 1970s, cattle overgrazed the island, likely obliterating several grass species. Perhaps this unrecorded species still survives in small pockets.

**WILD SUNFLOWER:** *Helianthus annuus* (common sunflower) grows today on St. Catherines Island (Coile and Jones, 1988: 10) and the seeds generally ripen in mid-summer. Sunflower, sumpweed, and giant ragweed all produce fruits (“achenes”) that consist of an oily kernel protected by a fibrous covering (pericarp). Gremillion (2002, 2004: table 4) reports a return rate of 489 kcal/hr for wild sunflower.

**WILD SUMPWEED:** Although *Iva frutescens* (marsh elder) and *Iva imbricate* (coastal marsh elder) grow today on St. Catherines Island (Coile and Jones, 1988: 10), *Iva annua* (wild sumpweed) is unreported. Gremillion (2004: table 4) reports a return rate of 272 kcal/hr for wild sumpweed.

**WILD CHENOPOD:** *Chenopodium ambrosioides* (Mexican tea) grows today on St. Catherines Island (Coile and Jones, 1988: 9), but goosefoot (*Chenopodium berlandieri*) is not reported. We do note that seeds of *Chenopodium berlandieri* were found in our excavations at Mission Santa Catalina de Guale (Ruhl, 1990: 562) and at the Fallen Tree midden (see chap. 26, this volume). Gremillion (2004: table 4) reports a return rate of 433 kcal/hr for wild chenopods.

**LITTLE BARLEY:** *Hordeum pusillum* is an annual grass that ripens in late spring/early summer. Although no members of the Poaceae family are reported today on St. Catherines Island (Coile and Jones, 1988),

Poaceae seeds were recovered at Mission Santa Catalina (Ruhl, 1990: 562). Gremillion (2002, 2004: table 4) reports a return rate of 274 kcal/hr for little barley (*Hordeum pusillum*).

**KNOTWEED:** More than 20 species of *Polygonum* occur in the Midwest, and they are commonly recovered in archaeological sites from that area. Two members of the buckwheat family (Polygonaceae)—smartweed (*Polygonum hydropiperoides*) and water smartweed (*Polygonum punctatum*)—grow today on St. Catherines Island (Coile and Jones, 1988: 12). Smartweed prospers in areas grazed by cattle (because they outcompete other grasses). This species was widespread on the Island before the 1970s; however since cattle were removed, smartweed is less abundant than it used to be. Ruhl (1990: 562) reports finding Poaceae seeds at Mission Santa Catalina. Murray and Sheehan (1984; cited in Gremillion, 2004) report a return rate of 286 kcal/hr for erect knotweed (*Polygonum erectum*).

**CATTAIL:** Two species of cattail today grow on St. Catherines Island (Coile and Jones, 1988: 9), *Typha latifolia* (common cattail) and *Typha domingensis* (southern cattail). Simms (1987: 133, table 2) conducted several experiments on cattail stands (*Typha latifolia*) in Utah (see also Jones and Madsen, 1991).

Aboriginal people in the Great Basin prepared a bread from cattail pollen, which was available only during a brief period in the early summer (Wheat, 1967: 11; see also Simms, 1987: 133). Basketfuls of pollen were harvested by shaking the flower tops into a basket. After green cattail leaves were laid across a bed of coals, small loaves of pollen (mixed with a little water) were placed on the leaves, then covered with more leaves and coals and finally baked. Because cattail pollen could be easily harvested and quickly handled, the return rate was estimated by Simms (1987: table 2) to vary between 2750 and 9360 kcal/hr.

Cattail roots were also exploited by Great Basin people and Simms (1987: 132) experimented with digging up the roots, washing, and drying the rhizomes. The ex-

periments suggest a return rate of only 128–267 kcal/hr (Simms, 1987: table 2); Jones and Madsen (1991: 71–72) derive a comparable rate of 40–260 kcal/hr.

**BULRUSH:** *Scirpus americanus* (three-square bulrush) and *Scirpus validus* (great bulrush) currently grow in the freshwater marshes on St. Catherines. As discussed in the next chapter, they would have been vastly more abundant on the island before the central swamp was drained in the 1930s.

Bulrush is similar to the cattail in edibility, although it is purportedly sweeter. Young shoots coming up in the spring can be eaten raw or cooked. Bulrush pollen is eaten as flour in bread, mush, or pancakes. Later in the season, the seeds can be beaten off into baskets or pails, ground into a similar meal, and used as flour. The large rhizomes are eaten raw or cooked; sometimes they were dried in the sun, then pounded into a kind of flour.

Simms (1987: table 2, 128–130) conducted several experiments on bulrush stands in the Great Basin, reporting that *Scirpus* sp. (bulrush) pollen has a return rate that ranges from 302 to 1699 kcal/hr, depending on the species. He also harvested bulrush seeds, collecting them with a seed-beater into a basket (though he found that sometimes it was easier to rub off the seeds by hand). The return rate for bulrush seeds was about 900 kcal/hr (Simms, 1987: 128). Great Basin foragers also dug bulrush roots, sometimes chewing them to obtain the starch, then expectorating the remaining fibrous mass as quids. Simms estimates the return rate from bulrush roots to be only 146–160 kcal/hr.

**GIANT RAGWEED:** *Ambrosia artemisiifolia* occurs today on St. Catherines Island (Coile and Jones, 1988: 10). Giant ragweed (*Ambrosia trifida*) has a return rate of only 110 kcal/hr (Cowan, 1985; cited in Gremillion, 2004).

To summarize, we estimate that the harvesting rates for eastern small grains are quite similar to those for Great Basin seed crops, on the order of 0.04 to 0.59 kg/hr (Gremillion, 2004: 219; Simms, 1987). With the exception for amaranth and cattail pollen, the post-encounter return rates for

small eastern grains are quite low in comparison to those from hickory nuts, walnuts, and acorns (depending on the processing method employed and excluding travel and transport costs; see Gremillion, 2004: 222). However, most small grains (including little barley, giant ragweed, sumpweed, and knotweed) offer return rates around 400 kcal/kg, which are considerably lower than the minimum expected for acorns and comparable to expected returns from ribbed mussels and whelks.

Table 8.26 summarizes the post-encounter return rates for harvesting wild plants on St. Catherines Island.

STARCHY ROOTS

As discussed elsewhere, Lewis Larson (1980a) argued that Le Moyne’s “Preparing for a Feast” (reproduced as fig. 8.6) may depict the various steps involved in processing acorns into meal. In his translation of the Leturiondo account, historian John Hann (1986: 91) suggests that the engraving depicts the processing of *ache*, a (unidentified) starchy root that could have played an important subsistence role in coastal Georgia. Leturiondo’s account reads as follows (Hann, 1986: 201–202):

Other types of roots and fruit also grow [in coastal Georgia and north Florida], which are called *Ache*, *Zebaca*, and *Pinoco*, which the Indian use a great deal, even though they have the regular wheat of that land, which is maize; but they are so strong and poisonous that, if they do not process them very well, the people burst open as two Indians did burst open four years ago because they did not properly prepare the small fruit of the *Pinoco*. But the root of the *Ache*, which is similar to the yucca, well processed, yields a flour whiter than that from wheat; and, by pounding it in a hand mortar, throwing water on it the pungency and poison is removed, and it is possible to make everything from the dough that can be made from wheat, without one being able to distinguish them either in the whiteness or in the flavor. And it is a very good bread and much more desirable than that which is made from maize, but if it is not processed well the dough comes out very black, and, if the pun-

TABLE 8.26  
Estimated Post-encounter Return Rates for Harvesting Wild Plants in North America<sup>a</sup>

Species	Return rate (kcal/hr)	Comments and source
Amaranth	1359	Gremillion (2004, table 4)
Chestnut	914	Gremillion (2004)
Walnut	568	Gremillion (2004)
Sunflower (wild)	489	Gremillion (2004: table 4); Gremillion (2004)
Maygrass	457	Gremillion (2004: table 4); Gremillion (2004)
Chenopod (wild)	433	Gremillion (2004: table 4)
Sumpweed (wild)	272	Gremillion (2004: table 4)
Little barley	274	Gremillion (2004: table 4); Gremillion (2004)
Cattail		
Pollen	2,750–9,360	Simms (1987)
Roots	128–267	Simms (1987)
Bulrush		
Pollen	302–1699	Simms (1987)
Seeds	900	Simms (1987)
Roots	146–160	Simms (1987)
Knotweed	286	Gremillion (2004: table 4); Gremillion (2004)
Giant ragweed	110	Gremillion (2004: table 4); Gremillion (2004)

<sup>a</sup> The estimates credited to Barlow and Heck (2002: 135) employ previously published experimental results and acorn weights in each processing stage (excluding cooking times). Noting the considerable variability in previous methods used to compute energetic values for acorns, Barlow and Heck (2002: 135) have attempted to standardize methods and reduce the ambiguity.

gency is not removed, the mouth is set afire and they are in danger of bursting. And the removal of this root or tuber requires a lot of work because it grows in mudholes full of water, and the entire tuber has so many roots, like a horse’s mane or like hair, that in order to pull it out of the ground some very strong levers are needed on which one may expend his strength and throw the weight of his body in order to dislodge.

As Hann (1986: 224, fn 22) points out, Fr. Leturiondo had personal experience with such starchy roots shortly before he wrote his narrative. In a letter written in 1697, Leturiondo records that after his maize stores were exhausted, he went to the woods to dig *ache* roots, at times working in water up to his knees.

The French accounts (Lorant, 1946: 36, 58, 96) likewise stress the importance of roots as an excellent source of flour for bread; Laudonière also appears to mention roots growing in a freshwater lake between Charlotte Harbor and Cape Canaveral and near the mouth of the St. Johns River. His vague descriptions render it difficult to know what roots are referenced. Larson (1980a: 199–201) further discusses the possible use of root crops by Southeastern Indians to prepare bread, with particular reference given to freshwater tubers. Hann (1986: 92) believes that *ache* was the food being prepared depicted in the Le Moyne drawing (fig. 8.6). It is true that acorn processing could not have been completed in a single day as preparation for a feast. However, employing the processes described by Leturiondo, *ache* (or another starchy root) could easily have been rendered into flour at a single sitting.

### CULTIVATING MAIZE

We will postpone our consideration of maize cultivation until chapter 9, where we develop this “foraging type” in considerable detail.

### WHAT THE DIET-BREADTH MODEL SUGGESTS ABOUT ABORIGINAL FORAGING ON ST. CATHERINES ISLAND

Table 8.27 summarizes the various post-encounter return rates derived for each of the six hunt types discussed in this chapter. Before proceeding, it is necessary to once again emphasize that these estimates are merely first-order approximations, badly in need of additional experimentation and documentation. That said, we will conclude this chapter by examining the implications

of the diet-breadth model for anticipating the archaeological record of St. Catherines Island.

Although we have assumed a constant technology and nutritional value, these post-encounter return rates are not themselves constants. These energy estimates are subject to seasonal availability, changes in body fat (as in white-tailed deer or oysters) throughout the yearly cycle, and differences in an individual forager’s skill. Such changes could include (after Kelly, 1995: 78–90; Winterhalder and Goland, 1997: 128):

- Improved transport in pursuit (such as watercraft)
- Improved harvest technology (such as fish nets, weirs, leisters, and poisons for fishing; firearms for procuring terrestrial prey)
- Increased capacity for transporting harvested resources (such as light-weight containers, dugouts, and rafts)
- Improved methods for food processing (more efficient ways of cutting, cracking, grinding; better fuels; better ways of cooking, such as improved heat transfer through better pottery)
- More efficient ways to store resources (smoking oysters, jerking venison) by reducing storages losses or reducing construction costs
- Morphological changes in a resource that increases its profitability (such as genetic changes from domestication)

Any such change that increases the pursuit and handling efficiency of an unharvested resource above the marginal foraging efficiency will move that item into the optimal set.

If, for any reason, the highest ranked items decline in the overall foraging efficiency, then the diet should expand stepwise to include lower ranked items (because the changing “marginal rate” of foraging efficiency determines the boundary of whether an item is in or out of the optimal set). For the St. Catherines Island resources, this means that items of high enough rank should be included in the optimal set of resources to be pursued if encountered. On the island, the highest ranking resources have estimated post-encounter return rates of more than 20,000 kcal/hr. This means that lower ranked food items should be ig-

TABLE 8.27  
**Estimated Post-encounter Return Rates for Six Hunt Types on St. Catherines Island (in kcal/hr)**

Saltwater fishing <i>male activity</i>	Terrestrial hunting <i>male activity</i>	Sea turtle harvesting <i>male and female activity</i>	Harvesting mast <i>female activity</i>	Collecting shellfish <i>female activity</i>	Harvesting wild plants <i>female activity</i>
	Black bear (37,352–61,434)	Leatherback turtle, ♀ and ♂ (26,825–62,792)			
Large fish, gill net (21,216–62,792)					
Large fish, trot line (16,982–42,252)					
Medium fish, gill net (19,823–25,265)	American alligator (22,000)	Loggerhead turtle, nesting ♀ (21,360)			
Very large fish, fish weir (>17,673)	White-tailed deer (12,096– 19,895)				
Medium fish, trot line (13,486–17,188)					
Large fish, fish weir (7,540–18,760)	Raccoon (9408–13,569)				
Medium fish, fish weir (9623–12,264)		Loggerhead turtle, ♀ and ♂ (8010–13,350)			
Large fish, spear/harpoon (5655–14,070)		Loggerhead eggs (9893)			
	Canada goose (6762–12,522)				
	Wild turkey (7765–11,200)				
	Virginia opossum (6540– 12,111)				
Small fish, gill net (6714–9894)	Large turtles (6547–8273)				

TABLE 8.27  
(Continued)

Saltwater fishing <i>male activity</i>	Terrestrial hunting <i>male activity</i>	Sea turtle harvesting <i>male and female activity</i>	Harvesting mast <i>female activity</i>	Collecting shellfish <i>female activity</i>	Harvesting wild plants <i>female activity</i>
Small fish, trot line (4567–6731)					Cattail pollen (2750– 9360)
Medium fish, spear/harpoon (3206–4086)	Swamp rabbit (2942–5248)		Acorn oil (2954)	Hard clams (2250–4,400)	
	Marsh rabbit (2042–3781)		Hickory nut oil (2100– 2200)		
	Small turtles (2182–2758)				
	Duck (1230–2278)			Knobbed whelks (1380)	Amaranth (1359)
Small fish, spear/harpoon (1086–1600)				American Oysters, collected as singles (1000–1700)	
	Diamondback terrapin (1304)			Channeled whelks (1230)	
	Eastern gray squirrel (672– 1244)		Live oak acorn meal (390–1260)	American Oysters, mass collected (750–1200)	Bulrush seeds (900)
				Ribbed mussels (390– 1260)	Sunflower, wild (489) Maygrass (457) Chenopod, wild (433)

TABLE 8.27  
(Continued)

Saltwater fishing <i>male activity</i>	Terrestrial hunting <i>male activity</i>	Sea turtle harvesting <i>male and female activity</i>	Harvesting mast <i>female activity</i>	Collecting shellfish <i>female activity</i>	Harvesting wild plants <i>female activity</i>
			Laurel oak acorn meal (254)	Blue crabs (310)	Knotweed (286) Little barley (274) Sumpweed wild (272) Cattail roots (128-267) Bulrush roots (146-160) Giant ragweed (110)
				Marsh periwinkles (26-135)	

nored whenever alligators, white-tailed deer, and nesting female loggerheads are encountered.

By projecting which resources a forager should take or ignore when encountered, the diet-breadth model predicts whether a particular hunt type is narrow and focused on a few select foods or broad and generalized. The model further predicts that, as high return rate resources become rare, the diet should expand to include low return rate resources (thereby lowering the marginal foraging threshold). In effect, those foragers employing the resources listed at the bottom of table 8.27 should be working much harder than those exploiting the highest ranked resources listed near the top of the table, as they are spending more time pursuing resources that yield increasingly lower caloric returns.

The diet-breadth model has been lauded for generating a number of testable, archaeologically observable hypotheses—some of them considered to be “nonintuitive” (Bettinger, 1991: 87; see also Kelly, 1995: 86). With reasonable estimates of relevant post-encounter return rates in hand, it is possible to derive a number of testable predictions from the diet-breadth model. In subsequent chapters, we will compare and contrast these predictions with those derived from alternative optimal foraging models.

#### ON RESOURCE ABUNDANCE

The diet-breadth model predicts that—*within each hunt type*—the highest ranked prey should always be taken upon encounter. Inclusion of lower ranked prey into the optimal set depends only on the encounter rate of the higher ranked prey; the abundance of a lower ranked item does not condition its inclusion in the optimal diet (Stephens and Krebs, 1986: 23). Conversely, if a higher ranked resource were to decline in abundance, the search time for that item would increase and the overall harvesting efficiency would decrease (with the diet breadth expanding accordingly). Bettinger warns, however, that “under no circumstance is any resource that is in the diet to begin with dropped from the diet as food

grows scarcer nor is any resource dropped simply because it has become scarcer" (1991: 87; see also Hawkes and O'Connell, 1992: 63; Kelly, 1995: 86–90; Kennett, 2005: 217–218).

In its most elemental form, then, the diet-breadth model predicts that foragers will select food in a manner that maximizes net energy return. As forager population densities increase, the model predicts that a disproportionate number of high-ranked prey will be harvested, resulting in decreased encounter rates with the most desirable taxa.

#### ON RETURN RATES AND PREY SIZE

Reviewing the range of food resources available on St. Catherines Island (table 8.27), it is clear that post-encounter return rates are highly correlated with "package size". All of the very highest ranked resources—including black bears, alligators, sea turtles, white-tailed deer, red drum, stingrays, and sharks—are very big animals, each with average weights greater than 15 kg (and in most cases, much greater). Nature has packaged all of the lowest ranked food items—periwinkles, mussels, small seeds, whelks, oysters, mullets, silversides, and menhaden—in much small containers. All else being equal, the bigger the organism, the higher the caloric return rate.

This is hardly surprising. Considerable research indicates that prey body size is the most critical dimension of hunter preference ranking due to the close relationship between body size and return rate: "The larger the animal, the higher the post-encounter return rate" (Broughton and O'Connell, 1999: 155). Broughton (1994a, 1994b, 1997) suggests that for singly handled animal prey, post-encounter return rates are generally scaled to prey body mass (see also Bayham, 1979; Winterhalder, 1981; Hawkes et al., 1982; Hill et al., 1987; Simms, 1987: 77; Smith, 1991; Broughton, 1994a, 1994b; Bird, 1996; Broughton, 1997: 847). Similar patterns have also been found for other resource classes, especially mollusks (Botkin, 1980; Raab, 1992; Broughton, 1994a: 274–275). According to Broughton and Bayham

(2003) "Body size really does seem to be the truest general measure of hunter preference ranking."

But there is still reason for caution with the "bigger is better" argument (Broughton, 1997: 847; Madsen and Schmitt, 1998; Grayson and Cannon, 1999; Erlandson, 2001; Ugan, 2005). While Madsen and Schmitt (1998) agree that body size is indeed a satisfactory proxy for sequential encounter hunting of individual prey items, they question this relationship for resources collected in mass: "When netting birds from a flock," for instance, "the appropriate comparative unit is the total body weight of all birds caught in a single netting episode, not the weight of an individual bird" (Madsen and Schmitt, 1998: 448). Mass-collected invertebrates and fish taken while spawning or in weirs (e.g., Lindström, 1996) can provide return rates vastly greater than returns for individually acquired big game. Moreover, some of the smallest food items, such as tiny fish, can be ingested whole, with only negligible processing costs. This means that some very small organisms can be both collected and processed in the aggregate (Lindström, 1996; Ugan, 2005: 82), yielding extraordinarily high caloric returns. This is particularly important when dealing with marine resources, where many prey items occur in very small packages.

In other words, mass collecting and processing can significantly increase foraging efficiency of taking small organisms; in some cases, archaeological signatures may exist to distinguish these mass-collected specimens from their lower ranked, individually acquired counterparts (Ugan, 2005: 76). In Southeastern shell middens, archaeologists occasionally find clumped, still-attached oyster shells, which indicate that they were gathered in a clutch (e.g., Walker, 1992: 299). A fine-grained analysis of oyster shape could indeed produce significant information regarding the ways in which the oysters were harvested. For the various fish species, it is impossible to tell whether an individual spotted seatrout or a banded drum was collected in a fish weir, on a trot-line, or by spearing.

Overall, the largest prey available on St. Catherines Island are fishes and—not surprisingly—large fish (especially those susceptible to mass capture in fish weirs, gills nets, and trotlines) are the highest ranking taxa. But without the technologies for mass capture, the post-encounter return rates for even the largest fish would drop precipitously (due to the major pursuit costs involved in individual capture). In other words, while body size is commonly highly correlated with prey ranking, it is essential to avoid an unwarranted assumption that small animals are universally low ranked or that large animals are universally high ranked (Kennett, 2005: 217–218; Ugan, 2005: 86).

### NOTES

1. This figure uses a figure of 2796.6 ha for the upland extent of St. Catherines Island; see table 5.1.
2. Because Blackbeard Island consists strictly of linear, parallel Holocene beach ridges, white-tailed deer can readily move from one habitat to another within a short airline distance (Osborne et al., 1992: 28–29); other barrier islands (including St. Catherines Island) contain large, relatively undifferentiated Pleistocene remnants, which could significantly modify seasonal movements of white-tailed deer.
3. The lone exception was during March of 1976, when maritime resources contributed only 26% of the monthly diet.
4. The mean adult body weight is averaged across male and female samples.
5. It is entirely possible, of course, that the Pleistocene-age surface of St. Catherines Island was utilized by human foragers before this landscape became isolated as a barrier island. But we have been unable to identify any occupations prior to the Late Archaic (perhaps because such sites were likely not associated with shell middens, which vastly increase our ability to find archaeological sites).
6. In Part III, we will consider some possible mechanisms behind the remarkable size change in barrier island populations of white-tailed deer.
7. This estimate increases to 70 deer/100 ha if one considers only forest and dune habitat (852 ha; Osborne et al., 1992: 5).
8. Bobcats (*Lynx rufus*) are known from the sea islands, including Ossabaw, Sapelo, and Cumberland (Neuhauser and Baker, 1974).
9. The exception would be that, in the long run, deer browsing might effect tree regeneration over the long timescale.
10. While lodged at the Guale village of Asao, Fr. Andrés and his colleagues also observed Indian children engaged in small-scale hunting: “Even though they were very small fellows, all brought their bows and arrows proportioned to their bodies and stature.

All of them positioned themselves to shoot at the top of a the tree where we had slept, chattering happily with one another without our understanding them or knowing to what purpose they were shooting there until we saw a small snake falling from the tree, its little head pierced with an arrow. One of those little boys came up very proud and, raising the pierced snake on his arrow, showed it happily to all of us as a conqueror and more skillful than the others his peers” (de San Miguel 2001: 64).

11. The assumed average biomass is slightly less than the contemporary mainland figures available from Ft. Stewart (near Hindsville, Georgia; <http://www.stewart.army.mil/dpw/wildlife>), where field dressed deer carcasses had an average weight of 36–45 kg.

12. These figures are based on experiments with farm-raised alligators in Florida (Leak et al., 2003). Each of the cuts—except for ribs, which were left bone-in—is boneless and closely trimmed of fat (the mean weight of these alligators was 21.3 kg, with a mean length of 1.71 m). Under aboriginal conditions, the “amount of edible meat” might be somewhat higher.

13. We gratefully acknowledge Sarah Bergh, Amber Creighton, and Lovely Elysee for their assistance with the diamondback terrapin experiments on St. Catherines Island.

14. For Turtle 1, the meat was divided into body meat (consisting of pelvis and neck meat) and leg meat (consisting of forelimbs and hindlimbs). There was virtually no difference in the nutritional breakdown between the leg meat and body meat samples from this specimen.

15. We take note of the ethnohistoric accounts of whale hunting by Florida Indians (e.g., San Miguel, 2001: 79; see also Larson, 1980a: 188.132); Swanton (1946: 329) rejected the possibility. More recent investigators believe that serious hunting of sea mammals likely occurred, but only in the extreme southern part of Florida—not in Georgia (Goggin and Sturtevant, 1964: 184–185; Larson, 1980a: 161).

16. I gratefully acknowledge the input of Gale Bishop (St. Catherines Island Sea Turtle Program) on this section.

17. An alternative approach would be to include the time spent excavating nonnesting features—crawlways and beach disturbances that result from unsuccessful attempts to lay eggs. Modern researchers estimate that roughly half the loggerhead nesting attempts on St. Catherines Island are unsuccessful. If explorations of such “empty nests” are included in the pursuit costs, the post-encounter return rate would be significantly lowered.

18. Some authorities classify “sand live oak” (*Q. geminate* Small) as a subspecies of *Q. virginiana* (Coile and Jones, 1988: 11).

19. We must keep in mind Sturtevant’s (1977: 70) caution that “the artifacts and activities shown unfortunately cannot be taken as reliable representations of Timucuan life.”

20. But then again, as Hann (1986: 94) notes, “inasmuch as Leturiondo was born in Florida, his taste-buds may have been more inured to such fare than those of the average Spaniard.”

21. Other methods, including “snarfing and spitting”, might be the most efficient of all (Lawson in Lefler 1967: 105; Gardner, 1997: 175).

22. The hickory collection patches are recorded in our fieldnotes as follows: Powerhouse Field (collection zone collection 1, Hayes Field), Yankee Bridge South (collection zone 2, Hickory Ridge), Yankee Bridge North (collection zone 3, Yankee Bridge), Back Creek Village (collection zone 5), Cemetery Road (collection zone 7, Spotted Field).

23. Our handling time for crushing the hickory nuts is considerably more efficient than the results reported by Talalay et al. (1984), in which experiments required 2 hr to crush 1 kg of whole nuts. The difference is whereas Talalay et al. (1984) pulverized their specimens, we found it sufficient simply to break each hickory nut into 6–10 pieces.

24. We exclude cooking time because there was no need to continuously watch the nuts as they cooked. Rather, the mixture could have been put on the fire and left alone for an hour, leaving the cook free to pursue other tasks.

25. The range of return is based on whether a nutting stone and cracking stone (low end return) or a larger wooden mortar and pestle (high end return) were utilized.

26. At least among the Western Mono, acorn processing is never carried forward from beginning to end on a single batch of nuts (due to an economy of scale realized in working on large batches). The process is staged across several batches, with considerable emphasis placed on blending to stress the taste and appearance of the final product.

27. Larger acorns most likely were desired because they are easier to shell (McCarthy, 1993) and “sweet” acorns because they do not require leaching.

28. According to Mr. Royce Hayes, white oak trees were harvested for wood (personal commun.).

29. Fr. Alonso de Leturiondo’s account (Hann, 1986a: 200; see also 1986b: 94) specifically mentions that “an oil is also extracted from ... bitter acorns [*vel-lota amarga*].”

30. The mature acorns located on the ground surface were most likely knocked down by strong winds and rain that hit the island prior to the late October visit.

31. One hundred acorns collected in January 2006 from an area located near the intersection of Cemetery Road and Back Creek Road were measured to obtain the mean length.

32. McCarthy (1993) mentioned that the Mono would not collect bad/buggy acorns.

33. Tannins are water soluble phenolics. Tannins have an astringent quality, which gives the nutmeat a bitter taste.

34. We performed some basic drying/parching and pounding experiments with the live oak acorns; however, we obtained varying results that require further analysis.

35. Historic accounts (Swanton, 1946; Hann, 1986b) indicate that acorns were used for oil as well as mush.

36. It is possible that leaching time could be decreased if nutmeat is pulverized first. This is to be done in future experiments.

37. The mature acorns located on the ground surface were most likely knocked down by strong winds and rain that hit the island prior to the late October visit.

38. One hundred acorns collected in February 2006 from an area located just south of the intersection of Cemetery Road and Back Creek Road were measured to obtain the mean length.

39. It is important to note that this was not the team that procured the most nuts, but rather the team that had the largest weight.

40. This excludes acorns from the northeastern compound patch due to the fact that most acorns gathered were overripe.

41. We performed some basic drying/parching and pounding experiments with the laurel oak acorns; however, we obtained varying results that require further experimenting and analysis.

42. It is possible that leaching time could be decreased if nutmeat is pulverized first. This is to be done in future experiments.

43. Locating mature acorns can be done while performing other tasks, and transporting time can vary too much to be successfully calculated.

44. In our experiments, handling was defined as the time required to process acorns into an edible form.

45. Gremillion (2002) does not explicitly mention which oak taxa were employed. Barlow and Heck’s (2002) estimates are for the California black oak acorn (*Q. kelloggii*), which includes leaching time.

46. During our experiments, we tried drying live oak acorns on a table in the sun; this resulted in a mass exodus of acorn weevils.

47. Following Gremillion (2004) we use the term “small grains” to distinguish them from larger seeds (including hickory nuts and acorns) and from economically important domesticates (including maize and rice).

48. For comparative purposes, we also provide return rates for both chestnut and walnut. Neither species grows on St. Catherines Island today (Royce Hayes, personal commun.; see also Coile and Jones, 1988: 9), but they could have in the past.

## CHAPTER 9. WHEN SHOULD A FORAGER FARM? <sup>1</sup>

DAVID HURST THOMAS

We have already briefly introduced the conflicting views of maize horticulture among the 16th and 17th century Guale people (chap. 2). Lewis Larson (1978, 1980a) argued that whereas agriculture was indeed practiced in late prehistoric times, “its importance seems to have been slight. ... The Guale were a coastal people whose economy was centered on the tidal waters where they derived a subsistence from fishing. Agriculture and hunting were of relatively minor importance” (Larson, 1978: 122, 137). To Larson, the soils of the Georgia coast were too patchy, too permeable, and too poorly drained to permit the Guale to “cultivate and fallow fields in sequence around a fixed house site let alone a sedentary village” (personal commun. in Thomas 1987: 60). Conversely, Grant Jones (1978, 1980) has questioned the veracity of the early French and Jesuit accounts of agriculture along the South Carolina–Georgia–Florida coast, concluding that Guale horticulture “was sufficiently productive, in combination with other subsistence and productive activities, to account for the presence of permanent towns, a chiefdom level of social organization, temporary federations of chiefdoms under centralized leadership, and long distance trade networks.”

Over the past 3 decades, our archaeological research on St. Catherines Island has been largely directed toward shedding some empirical light on this issue. We will postpone the settlement and social implications of this dispute and concentrate at present on the specifics of aboriginal maize agriculture on St. Catherines Island.

### MODELING GUALE HORTICULTURE

Southeastern Indians lived for millennia by hunting, gathering, and fishing, supplemented at times by simple horticulture of native North American plant foods, such as sunflower, sumpweed, chenopodium,

and pigweed. Perhaps as early as 1000 B.C., some aboriginal foragers began to cultivate squash. Maize was cultivated in the Southeast as early as A.D. 175–250 (Chapman and Crites, 1987), but it remained relatively unimportant for centuries (Smith, 1992b: 272; Fritz, 1993: 56; Anderson, 1998; Jefferies, 2004: 122). By about A.D. 800–1000, eastern flint corn and beans was commonly added to Southeastern gardens (Hudson, 1976: 290–305; Hally, 1994; Smith and Cowan, 2003: 117).

Charles Hudson sees maize agriculture in the Southeast as “something of a puzzle”, resembling “slash-and-burn agriculture in some respects, but its main vegetable was corn, which exhausts land quickly, yet it supported a large and stable population” (1976: 290–291). Given the apparent lack of fertilizing technology and the numerous ethnohistoric accounts of Indian “old fields”, one might justifiably imply that most Southeastern Indians farmed their fields for 2 or 3 years, then allowed the land to lie fallow for a decade or so. On the global scale, however, such slash-and-burn systems tend to support large, stable settlements only when root vegetables (such as manioc or yams) are the major crop, as they are easy to cultivate and place few demands on soil fertility.

In addressing this “puzzle”, Hudson notes that domesticated foods supplied only a portion of the Southeastern Indian diet. He emphasizes that productivity of intensive farming occurred in the bottomlands, where the loamy alluvial soils were more readily replenished by runoff flooding. In the so-called riverine system, Southeastern Indians initially cleared their fields by girdling trees, burning the fields, and letting the stumps rot. Although agriculture was largely a woman’s pursuit, men generally undertook the initial clearing of the fields. Women planted the smaller gardens, but labor in the larger fields was communal. Because suitable soils for riverine agriculture were scarce, most Southeastern farm-

ers attempted to maximize the yield in their relatively small fields by intercropping (planting several kinds of vegetables in the same field) and multiple cropping (planting two successive crops on the same field in a single season; see Hudson, 1976: 297). More intensive methods of cultivation involved “hilling” the corn, watering the fields, monitoring the fields during the day to scare away birds and animal pests (sometimes burning nighttime fires for the same reason), and vigilant weeding.<sup>2</sup>

A number of investigators have found relevance of the models of human behavioral ecology to be useful in assessing the relationship between foraging for wild food and growing domesticated crops. In an early application of human behavior ecology to the trade-offs involved between foraging, cultivation, and domestication, Hawkes and O’Connell (1992) stress that the prey choice model divides foraging into two mutually exclusive components, search and handling. Keegan (1986) applied the diet-breadth and patch-use models as direct analogs in examining food production (see also Layton, 1991). Winterhalder and Goland (1993, 1997) contrast the applicability of the diet-breadth model with alternative approaches for exploring agricultural origins, both in terms of scale and specificity (see also Bayham, 1979; O’Connell and Hawkes, 1981; Winterhalder, 1981; Smith, 1983, 2006: 289; Keegan, 1986; Simms, 1987; Hurtado and Hill, 1989; Layton, 1991; Hawkes et al., 1992; Winterhalder and Smith, 1992; Winterhalder and Goland, 1993, 1997; Kelly, 1995; Gremillion, 1996, 2006; Piperno and Pearsall, 1998; Barlow, 2002, 2006; Kennett and Winterhalder, 2006; Tucker, 2006). In chapters 6–8, we employed the diet-breadth model to estimate post-encounter return rates for the range of hunting, fishing, and wild plant collection options available to aboriginal foragers on St. Catherines Island. We now extend this approach to compare the effective return rates of various maize farming strategies relative to strictly foraging activities.

Barlow has emphasized that “maize farming should be viewed not as a transition

from ‘being’ a forager to ‘being’ a farmer, but as the outcome of a series of foraging decisions made by various points throughout the growing season” (Barlow, 2006: 97; see also Bettinger, 2006: 312–314, 316–317). So viewed, maize horticulture is approached as a sequence of subsistence-related activities—analogueous to hunting white-tailed deer, netting mullet, or collecting oysters—each of which is expected to yield an anticipated energetic return. Foragers are expected to invest time in a particular farming activity (such as burning grass, planting maize, hoeing weeds, or harvesting ripe ears) only when doing so generates an overall increase in net energy gained from foraging (see also Gremillion, 1996; Winterhalder and Goland, 1997: 126).

The degree to which an individual elects to forage or to farm, then, depends on the anticipation of project returns in food energy for each activity. These activities are subject to the following constraints (Barlow, 2006: 95):

- At a given moment, foraging and farming are mutually exclusive activities (“an hour spent foraging cannot also be spent farming”)
- Time spent foraging results in an anticipated increase in maize yields at harvest
- Because foraging and farming are costly endeavors, individuals are expected to adopt foraging and farming strategies that maximize the rate of caloric gain in both (during the agricultural cycle).

As with all optimal foraging models, these constraints carry an implicit assumption that those individuals employing efficient food acquisition strategies are more likely to parent more offspring (or more successful offspring) than are less productive individuals (Stephens and Krebs, 1986; Simms, 1987; Kaplan and Hill, 1992; Winterhalder and Smith, 1992; Winterhalder and Goland, 1993, 1997; Piperno and Pearsall, 1998; Barlow, 2002, 2006).

In this perspective, time spent farming is analogueous to time spent exploiting wild foods, transporting them back to the residential base, and processing them for storage or immediate consumption. Rather than the average expected return rates from farming versus foraging, this approach em-

phasizes the expected increases in projected harvest yields relative to present foraging opportunities—regardless of investments already made in the current agriculture cycle. “A forager should spend the next hour (or day) farming when the rate of calories gained from additional cultivation is greater than the immediate return rate for spending the next hour (or day) foraging” (Barlow, 2006: 95).

In the springtime on St. Catherines Island, for example, foraging opportunities are relatively restricted to hunting terrestrial mammals (white-tailed deer are lean this time of year), collecting mollusks in the marsh, or taking small estuarine fish. The last springtime frost generally occurs in mid-March and signals the beginning of a new agricultural cycle. At this point in the season, the immediate decision is whether to discontinue foraging in order to invest several days in clearing a field and planting maize (in anticipation of increasing the future harvest, which might be expected to yield, say, from 0 to 10 bushels of maize per acre). The forager knows that if she doesn't plant the maize initially, she will be bypassing the agricultural cycle for an entire year (so one might expect her to plant the maize). Over the next several weeks, that same forager/farmer will face additional decisions involving whether (a) to continue foraging or (b) to invest one or more days in weeding that same maize field (an activity which might increase expected yields only from 10 to 12 bushels per acre).

Barlow (2006: 96) points out that “whether she invests time weeding should be strongly influenced by foraging opportunities at ‘weeding time’.” The benefits that accompany weeding might be expected to diminish with time. Whereas weeding during the first several days might be expected to increase the expected yield by a couple of bushels per acre, continuing to remove weeds over the next 2 or 3 weeks will probably not dramatically increase the anticipated yield. Thus, the decision to weed the garden must also be weighed against the anticipated yields of foraging opportunities at that moment. If a stranded whale turns up on north beach or loggerhead turtles be-

gin nesting on south beach, our hypothetical forager will likely stop weeding her field in favor of these higher ranked foraging opportunities. Similarly, if prolonged drought conditions threaten to wipe out the summer maize harvest, the forager might downplay her weeding of fields in favor of collecting mollusks or seeking summer-ripening wild grapes or blackberries.

The aggregate of such decisions will determine whether an individual, a household, or a community pursues a “farming”, a “foraging”, or a “mixed” subsistence strategy for that given year. The obvious implication, then, is that farming investments intensify when higher ranked foraging opportunities diminish, and farming activities decrease when higher ranked foraging opportunities increase. So, rather than viewing maize horticulture as a cultural complex or an all-encompassing lifestyle (to be embraced or rejected), we approach aboriginal farming practices on the Sea Islands as an amalgam of economic behaviors of varied intensity and complexity, depending on the circumstances at hand.

#### SLASH-AND-BURN HORTICULTURE ON ST. CATHERINES ISLAND

Two parallel accounts document the slash-and-burn farming technology employed by the Timucua of the northeastern Florida coast between 1562 and 1565. According to René Laudonnière:

The Indians sow their corn twice a year, in March and June, replanting the same soil. This corn, from the time it is sown until the time it is harvested, is in the ground for about three months, and the land is allowed to rest during the other six months of the year. They also gather good pumpkins and very good beans. They do not fertilize their ground except when they start to sow it. Then they set the weeds on fire, which has been growing for six months, and burn them all away. They work the ground with a wooden hoe [and] ... plant two grains of corn together.... In the harvest season all of the grain is carried into the public house and distributed to each according to his quality or rank. They do not sow any more than they feel is necessary for a period of six months, scarcely that. (Bennett, 1975: 15)

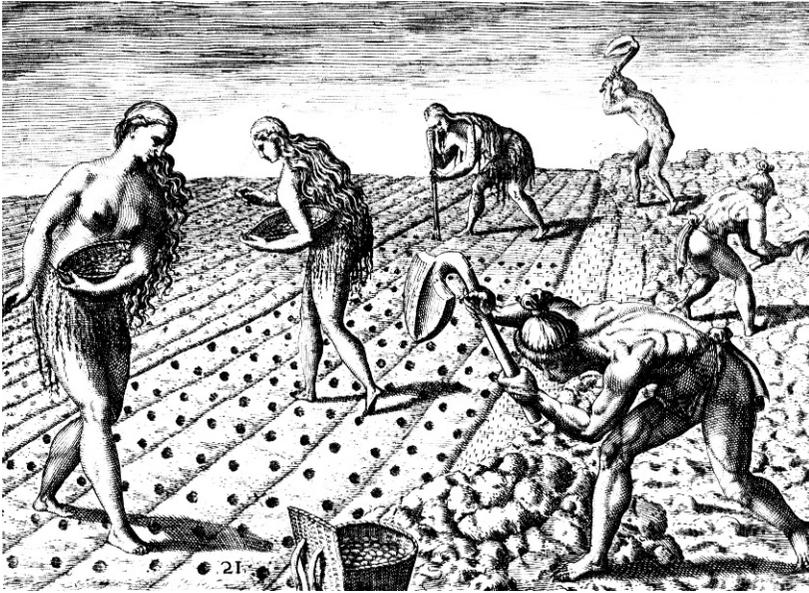


Fig. 9.1. Le Moyne's rendering of "How they Till the Soil and Plant" (Lorant, 1946. plate 21).

Laudonnière also commented on the "small outhouses" that were constructed near the fields, to house watchers posted to drive away the crows.

The second French account accompanies De Bry's engraving of the Jacques Le Moyne drawing (Lorant, 1946: 77; see fig. 9.1):

#### HOW THEY TILL THE SOIL AND PLANT

The Indians cultivate the earth diligently; and the men know how to make a kind of hoe from fish bones, which they fit into wooden handles, and with these they prepare the land well enough, as the soil is light. When the ground is sufficiently broken up and leveled, the women come with beans and millet, or maize. Some go first with a stick, and make holes, in which the others place the beans, or grains of maize. After planting they leave the fields alone, as the winter in that country ... is pretty cold for about three months, being from the 24<sup>th</sup> of December to the 15<sup>th</sup> of March; and during that time, as they go naked, they shelter themselves in the woods [in small huts]. When the winter is over, they return to their homes to wait for their crops to ripen. After gathering in their harvest, they store the whole of it for the year's use, not employing any part of it in trade, unless, perhaps some barter is made for some little household article.

To the north, in the province of Guale, Father Antonio Sedeño made similar observations in his letter of March 6, 1570 (as cited in Larson, 1980a: 208):

It is full of huge pines and barren forests; and this is the reason as I have written at other times to your excellency, that the few Indians that are there are so scattered; because as they do not have that with which to clear the trees for their fields they go where they find a small amount of land without forest in order to plant their maize; and as the land is so miserable they move with their households from time to time to seek other lands that they can bring to productivity.

Larson (1980a: 208) suggests that the "small amount of land without forest" likely refers to fallow fields.

The harvested maize was stored in large communal and privately owned granaries. Le Moyne depicted one such Timucua granary, in which both agricultural and wild resources were stored together (Lorant, 1946: 79; fig. 9.2):

#### STORING THEIR CROPS IN THE PUBLIC GRANARY

Many of the islands produce an abundance of fruits. These are gathered twice a year, carried

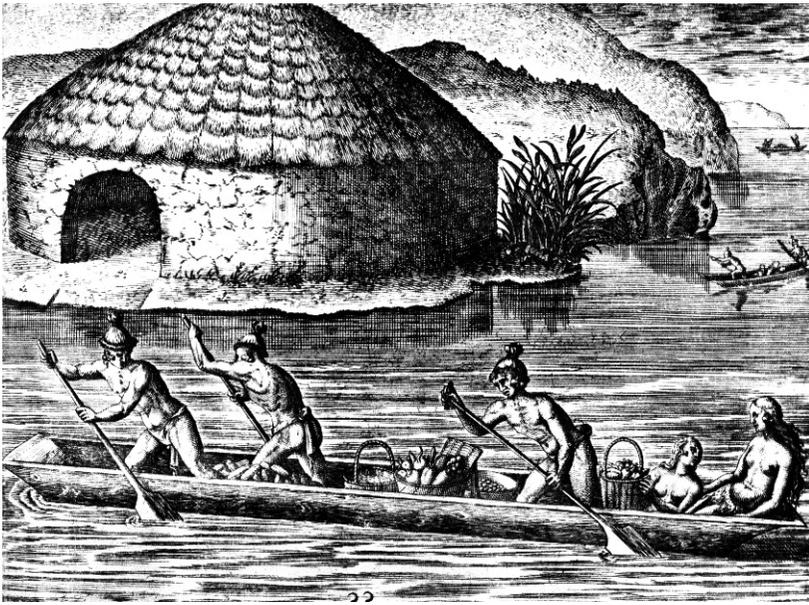


Fig. 9.2. Le Moynes's rendering of "Storing Their Crops in the Public Granary" (Lorant, 1946, plate 22).

home in canoes, and stored in low and roomy granaries, built of stones and earth and thickly roofed with palm branches and a kind of soft earth.

To keep the contents better, the granaries are usually erected near a mountain or in the shade of a river bank, so as to be sheltered from the direct rays of the sun. There the Indians store everything they wish to preserve, and there they go for supplies whenever they need anything—no one fears being cheated. Indeed, it would be good if among Christians there were as little greed to torment men's minds and hearts.

In 1595, Fr. Andrés de San Miguel (2001: 68) observed how the Guale Indians prepared their maize after harvest:

The people occupied in ... grinding maize, on which they expend a great deal of effort, because they grind it in deep and narrow wooden mortars. The hand is the guide for the rammer, that is more than two yards in height, and rammer moves upward, and the thin end in the mortar. The cakes that they make from this flour are a little smaller than *comales* [a flat earthenware pan is used in Mexico to cook maize cake] and two fingers thick. ... They cook them under the embers. It is very deli-

cious bread and various nourishing. They make little of this. What they eat the most is the gruel (*atole*)<sup>3</sup> and cakes [made] from acorn. Most of our provisions was in flour, which, because it consisted of parched corn, is also eaten in powdered [form].

Elsewhere, Fr. Andrés describes the corn-cakes (*torta de mayz*) as "big and two fingers thick ... [with] a pleasant taste because they were toasted" (de San Miguel 2001: 62).

To summarize, the available ethnohistorical sources describe a pattern of part-time slash-and-burn horticulture that was likely practiced on St. Catherines Island during and prior to the 16th century. Aboriginal gardeners probably girdled the larger trees, allowed them to die, burned and cleared the land of brush, palmettos, and/or old corn-stalks, and perhaps composted the charred plant remains and worked them back into the soil. After the last killing frost (likely in mid-March), they planted maize kernels and secondary crops by hand (perhaps re-seeding on occasion). Weeds were probably removed from amid the young plants and the shoots may have been hilled. Young plants were protected from birds, rabbits, squirrels, white-tailed deer, camp dogs,

and human intruders. Ripe ears were probably harvested in late June or early July, then transported and stored in both communal and private granaries. The dried ears were then laboriously processed for consumption as flour, bread, or *atole*.

#### THE ENERGETICS OF SLASH-AND-BURN HORTICULTURE

We can estimate the return rates for maize cultivation on St. Catherines Island by drawing on a comparable series of ethnographic data sets from Zinacantan in Chiapas, Mexico (Cancian, 1965), Panajachel in Guatemala (Tax, 1963), and Peru's Upper Montaro Valley (Hastorf, 1993). Barlow (2002, 2006) has filtered these ethnographic cases, selecting those using technologies analogous to precontact conditions (involving machetes, axes, hoes, and digging sticks). Caloric returns (which factor in the costs of cultivation and processing costs) are reported in bushels of shelled, dried maize kernels harvested per acre; in general, postharvest processing costs account for 45–90 percent of the time spent farming (see also Gremillion, 2006: 54; Piperno, 2006: 146). Barlow further estimates the postharvesting processing costs (using stone manos and metates) for agricultural activities, defined as “the food energy gained from maize per acre of cultivated land, and dividing that by the sum of hours per acre spent in each field activity during the growing season and the total time required to process the harvested maize” (2002: 73). Barlow concludes that, overall, maize agriculture using simple hand tools produces a gross energetic gain of 300–1800 kcal/hr, with average maize harvesting of approximately 3–50 bushels/acre: “There is no single, average field-investment strategy that typifies maize farming” (2002: 73).

These comparative data are extracted in figure 9.3, which plots caloric return estimates (expressed in kcal/hr) against the average annual maize harvest (in bushels/acre). This graph demonstrates the diminishing returns involved in maize farming. The best energetic yield in the Latin American ethnographic case is about 1700–

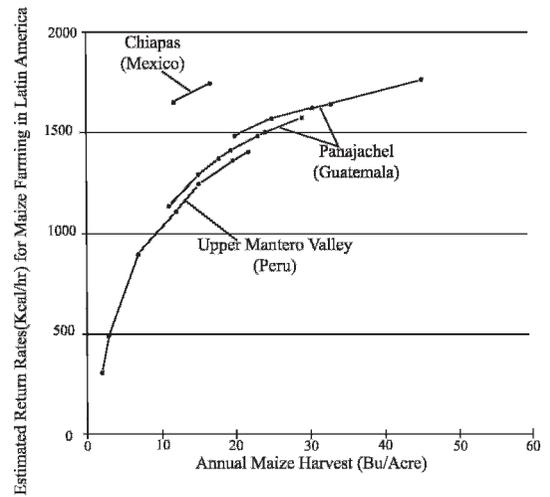


Fig. 9.3. The relationship between time spent in maize fields and average annual maize harvests in Latin America (modified from Barlow, 2002, Fig. 3). The lowest curve represents maize farming in the Upper Mantaro Valley (Peru), with an annual investment of 383 hr/acre and maize harvests of 2–22 bu/acre (Barlow, 2002, Tables 2, 3). The two curves at the center represent data from fields in Panajachel (Guatemala) with field investments of 334 and 384 hr/acre. The short, uppermost curve near the top of the graph denotes a low investment, “slash and burn” strategy from cases from Chiapas (Mexico), with annual investments of 104 acre/hour and harvests of 12–17 bu/acre.

1800 kcal/hr—regardless of whether the harvest yields 10 or 50 bushels/year.

Slash-and-burn horticulture is most commonly practiced in tropical lowland habitats, ecological settings that favor both maize farming and growth of dense stands of indigenous vegetation (Kennett et al., 2006: 126). Full-time slash-and-burn gardeners in Zinacatan (Cancian, 1965), for instance, clear and/or burn the brush-covered woodland, then plant and eventually harvest their maize crop without spending much effort on the fields during the growing season. This relatively low-investment, slash-and-burn strategy yields net caloric return rate of about 1650 kcal/hr, even with yields as low as 12 bushels/acre. This is the highest single energetic return among the modern full-time subsistence farmers studied in Latin America (Barlow, 2002: 74–75,

80; Piperno, 2006: 164). For part-time forager gardeners, a more realistic estimate would likely fall in the range of 1100–1500 kcal/hr (for a 200 hr/acre investment).

We believe that Zinacatan slash-and-burn gardening, described above, is an appropriate analog for modeling the slash-and-burn strategy observed during the 1560s by Fr. Rogel at Orista (North Carolina), Fr. Sedeño on the Guale coast (Georgia), and René Laudonière and Jacques Le Moyne among the Timucua of northeastern Florida. We will assume that comparable returns were realized when this slash-and-burn technology was applied to the most arable soils (especially Foxworth fine sand) on St. Catherines Island.

#### A “PLANT AND HARVEST” STRATEGY

Slash-and-burn horticulture was almost certainly the most prevalent form of aboriginal horticulture on St. Catherines Island. But Bryan’s 1753 journal and the 1838 advertisement for the Johnston plantation on St. Catherines Island (both cited in chap. 5, this volume) suggests another possibility.

The *Daily Georgia* account mentions that Flag Pond, on the south end of St. Catherines Island (fig. 5.3), produced “good crops of corn” for three consecutive years; 40 (of the 70) acres were placed under cultivation. Today, one can clearly see the 19th century ditches constructed to drain Flag Pond. Figure 5.3 reconstructs the large, central freshwater lagoon that dominated the Pleistocene core of the island. Before they were artificially drained, such freshwater ponds undoubtedly flooded and dried up entirely on their own. The poorly drained Rutlege fine sands that characterize all such features are low in natural fertility. Although they were avoided by all known antebellum agricultural fields, these sands contain extremely high concentrations of organic matter. Rainwater collects in these low areas, and a number of springs also fed the freshwater ponds and island sloughs, drowning terrestrial plants and preserving the open-water system (which provides important breeding grounds for aquatic life including frogs, insects, and fish). During

dry periods, when water levels fall, the frogs and fish provide an essential food source and resting place for waterfowl (which feed on pondweed, bulrushes, and other aquatic flora). The sloughs and ponds sometimes dry out completely, exposing and killing the aquatic plants, which, left unchecked, can choke out the open water. The decomposing organics of leaves, twigs, and guano from visiting waterfowl recycle critical nutrients into the slough bottomland (Johnson et al., 1974: 50–53), creating first-rate zones readily exploited by aboriginal gardeners. Certainly during plantation times, and likely during the aboriginal time frame as well, these temporarily dry slough and pond bottomlands provided an excellent microhabitat for maize horticulture.

Barlow (2002: 79, fig. 5) defines a “plant and harvest strategy” in which subsistence gardeners simply plant their maize kernels with a digging stick, without any field preparation. Although her sample of ethnographic Latin American cases does not include an example of a “plant and harvest” strategy, Barlow’s (2002, 2006) simulations may well approximate returns realized by aboriginal horticulturalists planting the margins of island sloughs and freshwater ponds on St. Catherines Island. As water levels fell during the growing season, maize kernels could have been planted in the rich compost of decomposing organics. The number of appropriate habitats for such horticulture are limited; however, the progressive drying cycle from spring during summertime introduced the possibility of multiple planting episodes, thereby producing ripe ears over several weeks (even months) during harvest.

With a planting cost of only about 25 hr/acre and the harvesting time (by hand) ranging from 20–28 hr/acre, this strategy is the very lowest level of field investment possible for maize horticulture.<sup>4</sup> For a harvest of about 2–5 bushels/acre, the estimated net energetic gain is about 1300–1700 kg/hr. This strategy is likewise similar to way in which foragers of the Kalahari grow maize, melons, and other foods (Hitchcock and Ebert, 1984). By so doing, even highly mobile foragers find it relatively

easy to scatter several small plots of maize throughout a foraging environment, increasing energetic returns without incurring substantial changes in diet, foraging technology, or settlement pattern.

#### AGRICULTURE AT MISSION SANTA CATALINA DE GUALE

Precontact aboriginal horticulture of St. Catherines Island likely involved only the slash-and-burn and plant-and-harvest strategies. More intensive agricultural practices were almost certainly employed during the Spanish mission period, both on St. Catherines Island and elsewhere throughout La Florida.

New crops accompanied Christianity to La Florida (Reitz and Scarry, 1985). Wheat, watermelons, peaches, figs, hazelnuts, oranges, and garbanzo beans have all been identified at mission sites in Spanish Florida. Various historical accounts likewise document the presence of European greens, aromatic herbs, peas, sugarcane, garlic, melons, barley, pomegranates, cucumbers, European grapes, cabbages, lettuce, and sweet potatoes, all of which may have been grown in mission fields (Hann, 1988b: 239; see also Milanich, 1999: 145–146). Considerable hybridization also took place during the mission period between native and pre-Columbian forms of maize and new strains of corn imported by the Spanish into Florida (likely from Cuba and the Yucatan; Lyons, 1976; Kohler, 1979).

As part of the missionization process, native populations were aggregated into centralized villages, with direct association to the missions (as on St. Catherines Island) or to nearby visitas (Loucks, 1979; Bushnell, 1994: 22–23). The “sabana” system was a native institution for public finance, in which the missionized Southeastern Indians grew maize for local consumption, for export (to St. Augustine or shipped abroad), or for direct sale. “In each doctrina they dig one sabana for maize—in half a day they dig it, all of them together. The harvest goes to sustain the ministers, helps cover the costs of maintenance and repair for the

churches, and remedies the lack of ornaments and things necessary for divine worship” (Bushnell, 1994: 111). In 1592, one chief sold 263 arrobas of corns (about 3 tons) to the Spaniards for “fifty silver dutats, six axes, three hoes, fifty varas of bur-lap cloth, and some thread” (cited in Lyons, 1992; see also Milanich, 1995: 202; Hann, 1988a). Maize, in fact, became a currency of exchange between Indians and the townspeople of St. Augustine (Milanich, 1999: 153). According to a 1602–1603 report to the crown by Governor Canzo, “the labor [the Indians] endure in the many cultivations that are given is great, and, if it were not for the help of the Indians that I make them give, and they come from the province of Guale, Antonio, and from other caciques, it would not be possible to sow any grain” (quoted in Larsen, 1990: 16).

During the mission period, the Spanish required the “doctrineros” to clear, cultivate, and harvest a field sufficiently large to cover church expenses (Bushnell, 1994: 111). In practice, this meant that once (or twice) a year, the commoners in an Indian town prepared and planted two kinds of fields—individual fields for the cacique, the principales, the medicine man/woman, the interpreter, the ballplayers, and anyone else they saw fit to support. There was also one large communal field, the harvest of which would feed widows, orphans, and travelers, finance public feasts, and rations for those working on construction projects, long-distance trade, or military campaigns. The Spanish of La Florida called these fields “sabanas” or sometimes used terms from elsewhere (including “milpas” and “charcas”). At St. Augustine, men were required to labor “in the service of the king”. Twice a year, the “indios de cava” cleared, dug, and planted the fields, did the first, second, and third hoeings, gardened the ripening maize, and harvested the ripe ears. “Each procedure was probably done by a different set of hands, as in an assembly line” (Bushnell, 1994: 122).

In 1675, Bishop Díaz Vara Calderón described the intensive form of agriculture as practiced in the missions of Spanish Florida:<sup>5</sup>

During January they burn the grass and weeds from the fields preparatory to cultivation. ... In April they commence to sow, and as the man goes along opening the trench, the woman follows sowing. ... During January they burn the grass and weeds from the fields preparatory to cultivation, surrounding them all one time with fire so that the deer, wild ducks and rabbits, fleeing from it fall into their hands. (Wenhold, 1936: 13)

Although Spanish friars sometimes complained about the damage caused by such annual burning, it improved browse for game, and the missions Indians emphasized the importance of setting fires to catch deer and other animals (Hann, 1988b: 192, 1996: 98–99).

At San Luis, almost 2 tons of maize seed was needed to plant the community field (Hann, 1988a: 145; see also McEwan, 2000: 74). The mission Indians in Apalachee planted European wheat in October and harvested it in June (Hann, 1988b: 127). The friars described three successive plantings within a single year. In this conscious, sustained effort to create the necessary surplus required for tribute, the mission Indians planted more acreage with the help of iron tools (including machetes, axes, and mattock-like hoes) to clear and weed the fields. Milanich (1999: 146) suggests that other than intensification, basic aboriginal slash-and-burn cultivation continued unchanged.

Mission Santa Catalina de Guale was attacked by Carolinians and abandoned in 1680 (Bushnell, 1994: 145–147; Worth, 1995: 30–32; Philips, 2001). Shortly after, Spanish Governor Márquez Cabrera described his plans to import 100 families from the Canary Islands to repopulate St. Catherines Island “because it is fertile and abounding in provisions” (cited in Bushnell, 1994: 149). After speaking to soldiers formerly stationed on St. Catherines Island, Alonso de Leturiondo added that “the settlement of Santa Catalina was of very great utility ... And unanimously and in agreement everyone from Florida said that since the said island has been abandoned. ... They have experienced a very great need because from the said island they brought

to sell to the presidio the maize, beans, hogs, butter [or lard?] (*mantecca*), rabbits, deer, pumpkin (*calabasas*), sweet potatoes (*boniatos*) and other necessities that it produced in such abundance that it was the role recourse of the *presidio* [at St. Augustine] for its necessities ... because of the fecundity of the said island ... it has good grazing for hogs. That the ones produced there were very corpulent and of very flavorful meat. And also for the sowing of grain and fruits that they gather at a good rate and in great abundance” (Hann, 1986: 197–198).

Although we lack first-hand reports describing Mission Santa Catalina de Guale, these ruins were described on April 28, 1687, by a Captain Dunlop, sailing south from South Carolina:

We came about noon to the North east of St. Catharine where resting a while we came to the further point of that Isle [probably Persimmon point] where the great Settlement was we see the ruins of severall houses which we were informed the Spaniards has deserted for ffeare of the English about 3 years agoe; the Settlement was great, much clear ground in our view for 7 or 8 miles together (Dunlop, 1929 [1687]: 131).<sup>6</sup>

In May 1736, Saltzburger Philip Georg Friedrich von Reck landed on the northwestern shore of St. Catherines Island “to take on some fresh water there. The island is 12 English miles long. There is much good land on it, especially on the shore of the river [likely Wamassee Creek], where more than 100 acres had previously been cleared and cultivated by the planters but it had been ruined by the Indian wars, and now lie deserted” (Hvidt, 1980: 39). We suspect that the extensive mission-related agricultural complex so severely impacted the soils in this area that colonial period planters deliberately avoided this previously cultivated area. While not exactly “virgin” forest, the vegetation growing on and near the 16th and 17th century ruins of Mission Santa Catalina appeared as undisrupted climax forest that began to mature immediately after the abandonment of the mission complex in 1680.

Considering the overall intensification of agricultural practices during missionization

## Energetic Returns for Foraging and Farming

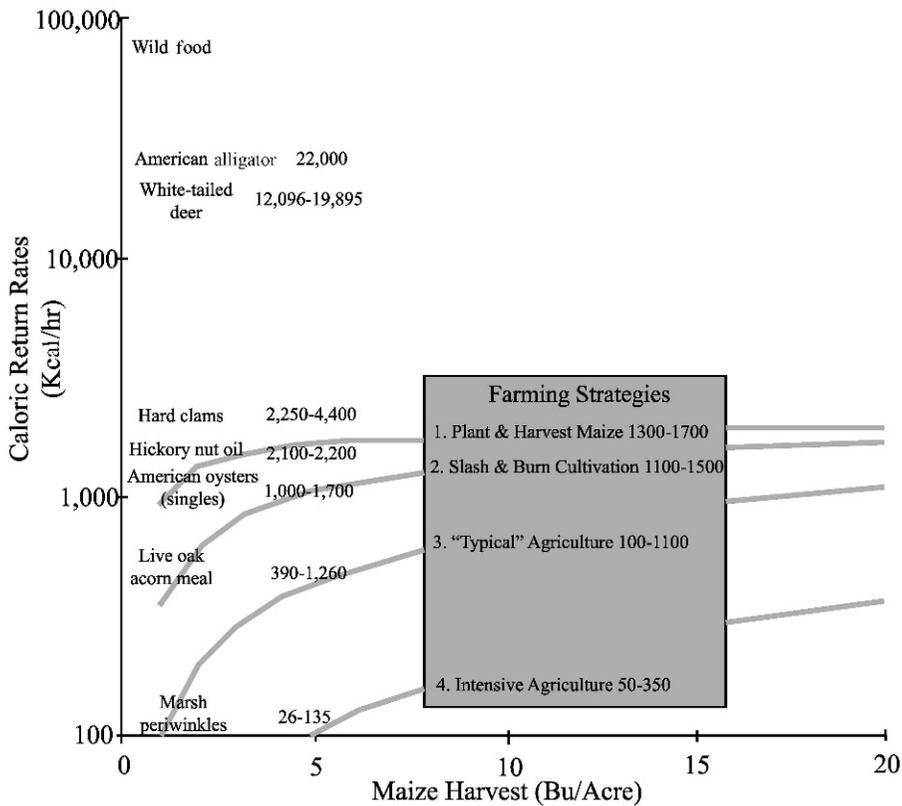


Fig. 9.4. Comparison of estimated caloric return rates from foraging and maize cultivation on St. Catherines Island (returns from cultivation modified from Barlow, 2002: fig.5).

of Spanish Florida, we suspect that 17th century farming at Mission Santa Catalina de Guale is similar to the “typical Latin American” agricultural strategy as practiced today in Chiapas, Guatemala, and Peru (Barlow, 2002: tables 2 and 3). Working without benefit of draft animals, chemical fertilizers, or significant irrigation technology, such “typical” farmers commonly invested 30–50 person-days/acre, producing 2–50 bushels of maize, with an energetic return ranging from 300–1700 kcal/hr (depending on the yield at harvest and the intensity of field investment).

#### OPTIMAL FARMING AND FORAGING

In an attempt to explicate the relationship between wild and cultivated resources

for coastal Georgia, figure 9.4 compares the estimated energetic rates from slash-and-burn horticulture with returns rates for hunting, fishing, and collecting indigenous taxa on St. Catherines Island. Wild resources are ranked by decreasing net efficiency for the pursuit and handling phase of foraging, with the highest gross caloric return shown at the top. These post-encounter return rates, reported in kilocalories per hour and arrayed on a logarithmic scale, are derived in chapters 7 and 8 by factoring in pursuit, collection, and processing time for each resource (without consideration of their abundance or frequency in the foraging environment).

The top-ranked resource will always be included in the diet. According to the following principle, the diet-breadth model predicts how far down this ranked list an

“optimal” forager will proceed: “Add the next item if its pursuit and handling efficiency is greater than the overall foraging efficiency of the diet without it and, conversely, stop expanding the diet and ignore the first item for which the return on pursuit and handling is less than the average return for search, pursuit, and handling of higher-ranked items” (Winterhalder and Goland, 1997: 128). Lower ranked foods should always be ignored when the highest ranking resources (such as alligators, loggerheads, and white-tailed deer) are sufficiently dense that “a forager cannot take a step without encountering one of them” (Barlow 2002: 77). When higher ranked resources are scarce, however, foragers may spend so much time searching for them that the overall return rates fall below the post-encounter returns of lower ranked resources (such as rabbits, acorns, and oysters).

Intuitively, it is expected that the more energy invested in maize farming, the greater the harvest yields. While this is sometimes true, the caloric return rate from farming actually tends to diminish as more energy is put into the fields. At least in the ethnographic Latin American cases discussed here, Barlow (2002, 2006) found no significant relationship between increased investments in field time and the average maize yields per field—suggesting that factors other than the abundance of maize at harvest time must condition the decision to invest in agricultural activities. The highest returns on investment occur on low- to moderate-expected harvests—meaning that doubling the time spent in the fields does not double the yield. It is likely that the kinds and availability of wild food (and their respective post-encounter return rates) have a major impact on the decision to forage or to farm. Intensifying field efforts likely accompanied increasingly lower returns and lower overall economic success (Barlow, 2002: 75, fig. 4). These lowered expectations reflect an apparent reality in moderate to rich agricultural settings; modern subsistence farmers in Latin America get better energetic returns when they minimize their agricultural investments. If so, then “intensification” can be expected to

occur only in time of *decreased* energetic efficiency (i.e., an overall broadening of diet breadth).

Figure 9.4 plots the estimated energetic return from slash-and-burn agriculture (based on the Latin American analogies previously discussed; after Barlow, 2002, 2006). The curve plots estimate return rates with increasing maize harvests (but without additional field time); the maize harvests along the *x*-axis apply only to gardening and farming, while those from foraging are ranked independently of their actual abundance. Although considerable variability in field investment is expected, Barlow’s (2002: 77) simulation is designed to array strategies evident in modern foragers and horticulturalists. The specific slash-and-burn strategy is shown as a curve, representing an investment of 200 hr/acre (roughly 20 days/acre) in slash-and-burn plots each year. The rate is calculated for harvesting 1–20 bushels/acre and includes estimates of maize processing costs.

When we combine the results of the above analysis with the post-encounter return rates derived in chapters 7 and 8, we conclude from that slash-and-burn horticulture (yielding 1100–1500 kcal/hr) overlaps the net returns from oysters and ribbed mussels, spearing small fish, hunting gray squirrels, and preparing acorn meal (see fig. 9.4). Hunting rabbits and ducks, collecting clams, and preparing hickory nut oil are higher ranked foraging activities; only some forms of shellfish collecting and small seed harvesting rank lower. The curve representing caloric return rates for low-investment, “plant and harvest” gardening (plotted on fig. 9.4) ranks slightly higher than that for slash-and-burn horticulture and overlaps the return rates for resources ranking lower than American oysters. The curve for the “typical Latin American” agricultural strategy—which we take as a proxy for mission-period agriculture at Mission Santa Catalina—has a return rate of only 100–1100 kcal/hr.

For comparative purposes, an energetic return curve for Barlow’s (2002: 78, fig. 5) “intensive agriculture” strategy of 800 hr/acre is included. This method involves the

maximum level of field investment observed among modern, full-time subsistence farmers in Latin America. This intensive strategy is quite rare and expected only when overall return rates of foraging and farming are quite low. In Latin America, only maize farmers working in the high-elevation (*tierra fria*) community of Colotenango invest so intensively, and the return rates (about 850 kcal/hr) are among the poorest for all maize farmers in Guatemala (Barlow, 2002: 81–82).<sup>7</sup>

Figure 9.4 thus formalizes the implications of the diet-breadth model for the three female-specific “foraging types” on St. Catherines Island: harvesting mast, collecting wild plants, and cultivating maize (per table 8.27). We also include the “turtle collecting” hunt type because females likely played an active role in harvesting gravid females and their eggs. From figure 9.4, it is clear that, depending on local conditions, maize cultivation might generate slightly better caloric returns than shellfishing and collecting wild plant foods, but in general, foragers will do better preparing oil from hickory nuts and acorns and collecting hard clams than they will working slash-and-burn fields through the agricultural cycle. We conclude, therefore, that if higher ranked collecting options exist, then female foragers will likely invest only sporadic and minimal efforts in cultivating maize crops.

These generalizations are, of course, independent of search time. Whenever overall foraging rates are lowered (for whatever reasons) and if potential horticultural locations are available locally—then foragers might find it worth their while to become part-time farmers. The point is that an increased investment in maize farming should coincide with decreased foraging yields and not increased maize yields, per se (Barlow, 2006: 101).<sup>8</sup>

It is important to keep in mind that the diet-breadth model does not directly address the issue of dietary importance, but merely predicts that all resources “in” the optimal diet should be pursued or collected on every encounter. This means that individuals operating “at the bottom of the chart” work harder than those living at

the top, spending their time pursuing resources that yield increasingly lower energetic returns. Both low-ranking foraging and intensive agriculture should be abandoned whenever encounter rates of higher ranked wild foods increase or when a chance to engage in less intensive foraging is present. Farming, in other words, became an everyday way of life not because agricultural productivity was so high, but rather because the foraging alternatives were so poor.

#### IMPLICATIONS FOR MISSISSIPPIAN ARCHAEOLOGY

These conclusions—forage when you can and farm when you must—run contrary to common sense, the Protestant ethic, and much archaeological literature.

The general expectation has long held that growing maize—and farming in general—invariably yields a net increase in harvested food energy over that provided by foraging alone (which has conventionally been viewed as less productive, less reliable, and certainly less desirable). In his classic *Antiquities of the Southern Indians*, for instance, Charles C. Jones, Jr. extolled the virtues of maize agriculture for native people:

Maize, an American plant ... has received ready acknowledgment wherever introduced to the notice of civilized man. Regarded as a direct gift from the Author of Life to his red children, it was highly prized and held in peculiar esteem. ... Attached to the soil, often building considerable towns fortified by palisades and composed of huts and houses substantial after their kind ... they lifted themselves at least somewhat above that rude, beggarly, and precarious existence which so painfully characterized the condition of so many of the aborigines inhabiting other portions of this country, oppressed by greater penury and contending against the rigors of more tempestuous seasons. (Jones, 1873: 296–297)

Jones’ characterization of foraging as “rude, beggarly, and precarious” typifies a long-held attitude toward making a living as a hunter, a gatherer, or a fisher. More

recently, Charles Hudson has reflected on a Mississippian cultural tradition that uplifted hunter-gatherers in the Southeast—in an almost bootstrap fashion—from their “bleak” Archaic roots: “[A]griculture did not replace food gathering in the [interior] Southeast, but existed side by side with it, *making life more pleasant and secure*” (Hudson, 1976: 288–289, emphasis added).

The projections from St. Catherines Island suggest otherwise. Farming does not tap a new energy source that alleviates the uncertainties of foraging. John Worth (1998: 6) has chided the conventional wisdom that sees a more intensive agricultural base as providing additional leisure time and an “inevitable florescence of elaborate cultural achievements such as art and public architecture. [The] emergence of an agriculture economy in the Southeast (and indeed around the world) was actually accompanied by a substantial *increase* in the need for collective human labor in order to effectively implement such a system.”

## NOTES

1. The title of this chapter is adapted from Barlow (1997, 2006).

2. Thomas Hariot (1946 [1588]: 244) described such intensive agriculture in some detail: “The planted ground [in North Carolina], compared with an English acre of forty rods in length and four in breadth, yields at least two hundred London bushels of corn, beans, and peas, in addition to the crop of [pumpkins, melons, and gourds], [mountain spinach], and sunflowers. In England we think it a large crop if an acre gives forty bushels of wheat. “[You] may know how much that country’s corn is to be preferred to ours, I thought it good to tell you this. Besides the many ways it may be used for food, the yield is so great that little labor is needed in comparison with what is necessary in England. Of this I can assure you, for according to our experiments we found that one may prepare and cultivate as much ground (which has borne corn before) with less than twenty-four hours’ labor as will supply him food in abundance for a year. This is true even though he has no other food save what was grown in that ground, and of no other kinds than those I have spoken of, and even if the plot were only twenty-five yards square. If it were

necessary, two crops could be raised on the same plot. For the natives sow at any time from the middle of March until the end of June and can still plant after they have eaten from their first harvest” (Thomas Hariot, 1946 [1588]: 245–246).

3. In Latin America, the term *atole* refers to a gruel made of boiling maize flour in water or milk.

4. All estimates include soil preparation before planting, tending and weeding young plants, and various field activities throughout the growing season (see Barlow, 2002).

5. In her preliminary analysis of archaeobotanical remains recovered at Mission Santa Catalina de Guale (St. Catherines Island), Ruhl (1990, 1993, 2000) reports the presence of hazelnut, acorns, hickory, walnut, persimmon, and plum/cherry, plus numerous commensals including knotweed, amaranth, and goosefoot. The historic period middens at Pine Harbor contained an assemblage of chenopod, poke, persimmon, grape, and cherry, suggesting to Richard Yarnell and Lewis Larson (1980a: 206) that local cultivation of these weedy plants did occur; they further conclude that these plant remains reflect weedy and pioneer communities typical of abandoned or old fallow fields (Larson, 1980a: 206; see also Ruhl, 2000: 561).

6. The next day, Dunlop’s party arrived at Sapelo Island about noon “to very large plantations where we see the ruins of houses burned by the Spanish themselves. We see the Vestiges of a ffort; many great Orange Trees cut down by the Spaniards in sept. last. There was great plenty of ffigs peaches; artechocks onions etc. growing in the preists garden his house had been of Brick & his small chappell, but all had been burned to Ashes last harvest by themselves” (Dunlop 1929 [1687]: 131–132).

7. We do not expect that high-investment agriculture ever took place on St. Catherines Island, at least not by aboriginal farmers. But it may be that the ridge field systems uncovered beneath Mound D at Ocmulgee, on the Macon Plateau, could have approximated this level of field labor (Riley, 1994: 101–104). Because they are located in the uplands of the Macon Plateau (rather than along the more fertile river bottoms), it may be that these regular ridges, furrows, and hillocks resulted from the kind of intensification strategy that required more than 600 hr/acre. Investments like this imply extreme nutritional stress, and such intensive agricultural practices were likely discontinued whenever energy returns—from either foraging or farming—increased (Barlow, 2002: 82).

8. To test these relationships, it should be possible to conduct experiments to determine energetic foods costs and gains from various agricultural activities in the Sea Islands (clearing, planting, weeding, harvesting) to estimate food preparation costs.

## CHAPTER 10. CENTRAL PLACE FORAGING: THE FIELD PROCESSING/TRANSPORT MODEL

DAVID HURST THOMAS

In the last few chapters, we have employed the diet-breadth (prey choice) model to rank subsistence alternatives according to energetic return on time invested (after a potential food item has been located). While a number of investigators have found merit in applying the diet-breadth model to archaeological circumstances, others have suggested that this approach “suffers a variety of important complications” (Bettinger et al., 1997: 887; see also Bettinger, 1991: 86–87; Broughton and Grayson, 1993; Madsen, 1993; Broughton, 1994a; Kelly, 1995: 89–90; Bird et al., 2002: 458). Beyond the potential violations of underlying assumptions and constraints (already discussed in chap. 6), it is clear that the accumulation of archaeological deposits involves processes far beyond those anticipated in the simple on-encounter diet-breadth model (e.g., Jones, 1991; Stein, 1992; Grayson and Delpech, 1998).

We now redirect the discussion toward the archaeological record of St. Catherines Island by asking two specific and interrelated questions:

- In this chapter, we ask: To what extent can we expect past diet-breadth decisions to be accurately reflected in archaeological midden deposits?
- In the next chapter, we ask: To what extent did foragers and part-time horticulturalists position their settlements with the intent to minimize travel and transport costs?

### A CAUTIONARY TALE FROM THE TORRES STRAITS

Having derived a series of post-encounter return rates that reflect diet-breadth modeling, it seems appropriate to ask how these estimates of past prey choice and selectivity might be visible in the archaeological record. When Douglas Bird and Rebecca Bliege Bird explored this issue among contemporary Meriam Islanders, they encoun-

tered significant problems when return rates and direct observations of foraging behavior were translated into the shell middens that the Meriam themselves created.<sup>1</sup> This research is considerably relevant to our discussion of aboriginal foraging on St. Catherines Island.

Prey choice modeling projected that *Tridachna gigas* (giant tridachna clam) is the highest ranking of all shellfish resources in the Meriam Islands. These huge mollusks yield more than 500 g of meat per individual, but they are rarely harvested during reef flat collection since they are subtidal (collectors usually must dive for them); the post-encounter return rate is roughly 13,000 kcal/hr. Two other tridachnid clams, *Hippopus hippopus* and *H. maximalsquamosa* (which also yield more than 150 g of meat per individual) have an average return rate of roughly 4500–6800 kcal/hr. A third reef flat taxon, a medium-sized spider conch (*Lambis lambis*), yields about 25 g of meat per specimen and has a post-encounter return rate of 3400 kcal/hr. Many other types of edible shellfish are also found on the reef flat, but most have post-encounter return rates of less than 1000 kcal/hr and are therefore rarely exploited.

While Meriam people often pass over low-ranked prey in the reef flat, they sometimes harvest lower ranking shellfish that live on the rocky shore, including sunset clams (*Asaphis violascens*), small bivalves that live in dense clusters and average about 9 g of meat/specimen. They also harvest nerites, small grazing gastropods (*Nerita* spp.). Like *Asaphis*, these organisms dwell on the mid- and upper-littoral reef flat, though nerites yield only about 2.5 g of meat per individual. Sunset clams and nerites are the lowest ranking shellfish taxa for the Meriam shellfishers, returning only about 400–500 kcal/hr.

The prey-choice model predicts that Meriam foragers should always harvest the

highest ranked resources (in this case, the large tridachnid clams and *Lambis*) upon encounter, and they almost always do so. Large tridachnids comprise about 20 percent of all shellfish harvested (by number) and more than 60 percent (by weight). But Bird (1997; Bird and Bliege Bird, 1997) found that these high-ranking prey types were dramatically underrepresented in the shell middens created by modern Meriam people. *Tridachna* and *Hippopus* shells comprise merely 1 percent by number and 15 percent by shell weight. The lowest ranking rocky shore resources, however, *Asaphis* and *Nerita*, which diet-breadth modeling suggests should have been commonly passed over, show up in abundance in the Meriam middens (that comprise 16% of the shell deposits by weight and more than 70% by number).<sup>2</sup> In other words, if an archaeologist were to extrapolate Meriam subsistence based strictly on shell counts from the middens, the results would be spectacularly incorrect.

After exploring several explanations that shed light on the dramatic disparity between diet-breadth predictions and archaeological reality, Bird and Bliege Bird ultimately decided that differential field processing strategies were likely the most critical factor in shaping the archaeological record of Meriam shellfishers.<sup>3</sup> Specifically, Meriam foragers working on the reef flat can quickly accumulate more shellfish than they can carry, though much of this bulk is inedible shell. “Foragers then face a decision: should they spend the time to cull parts of low utility (which cuts into time that they could continue foraging) or should they haul more unprocessed loads back and forth from the reef (which cuts into the utility of each load)?” (Bird et al., 2002: 462).

In general, the field processing/transport model suggests that prey taxa will be transported whole if they meet the following conditions: (1) They are relatively difficult to field process (measured as time), (2) they provide little increase in proportion of edible flesh when field processed, and (3) they were gathered near the central place. Using equations derived from Metcalfe and Bar-

low (1992), Bird and Bliege Bird computed several *processing thresholds*—the time/distance at which field processing is expected to occur—for various shellfish resources exploited by the Meriam.<sup>4</sup>

The processing threshold for *Hippopus* and *Tridachna* indicates that when these taxa are harvested more than 3–5 min away from the “central place”, then the Meriam are expected to stop foraging, discard the inedible shell, and transport only the edible meat. Assuming a walking speed of 3 km/hr, this translates to a distance of only 70–120 m from the central place. This model suggests that the highest ranking shellfish resources should be virtually invisible in the middens of contemporary Meriam people, since the bulky tridachnid clamshells should almost always be discarded at the locus of procurement to increase the utility of the load that is transported home.

In contrast, the travel threshold for sunset clams is about 2400 m, a considerable distance that reflects the intensive field processing required to cull *Asaphis* waste materials before transport. For this reason, sunset clams should almost always be transported in bulk (without field processing), and this is why *Asaphis* shells are so common in the Meriam household middens. The same is true for nerites, which have a processing threshold of 5300 m, the greatest distance for any shellfish collected by the Meriam. This high threshold suggests that foragers should virtually always transport *Nerita* without any field processing: “In most cases foragers cannot walk far enough from a central place on the islands to make field processing worthwhile” (Bird et al., 2004: 195).<sup>5</sup>

The Meriam example is compelling. By applying the field processing/transport model, Bird and his colleagues have derived explicit, empirical expectations regarding shellfish discard behavior in the Torres Straits. They have also observed first-hand how the procurement, the processing, and the discard of shellfish directly conditions the resulting archaeological record:

Variability in intertidal prey choice is reflected archaeologically only through a filter of differ-

ential field processing and transport, the constraints on age-linked foraging efficiency, and patch utilization. ... The Meriam data go a step beyond cautionary tales to test basic foraging models ethnographically in order to evaluate their archaeological potential and demonstrate circumstances where their assumptions are warranted. (Bird et al., 2004: 195)

We will never have the opportunity to observe the aboriginal shellfishers of St. Catherines Island. But we can employ the transport and field processing model as first-order heuristics to anticipate the nature of the surviving archaeological evidence. Lacking the requisite ethnohistoric and experimental evidence, we will estimate the various processing times, load utilities (reflecting the proportion of edible to inedible portions of each resource), and resource distributions necessary to compute the transport thresholds relevant to St. Catherines Island. We hope that these rough-and-ready estimates will provide an appropriate baseline that will allow, in time, for investigators to improve both the predictive models and also the archaeological observations.

#### THE TERRESTRIAL FIELD PROCESSING/TRANSPORT MODEL

We will now draw on *central place foraging* theory to investigate the time/energy spent processing resources at temporary camps before transport to a residential base (Orians and Pearson, 1979; Stephens and Krebs, 1986; O'Connell et al., 1988, 1990; Jones and Madsen, 1989; O'Connell and Marshall, 1989; Metcalfe and Barlow, 1992; Barlow and Metcalfe, 1996; Bettinger and Mahli, 1997; Bird, 1997; Grayson and Cannon, 1999; Bliege Bird et al., 2002; Zeannah, 2003, 2004). Central place foraging theory, in general, addresses the assumption that a forager will maximize the energetic return to the home/nest/central place (Orians and Pearson, 1979; Stephens and Krebs, 1986). Metcalfe and Barlow (1992) attempted the first anthropological application to draw on the general assumptions of central place foraging theory; by employing

a unique set of assumptions and constraints, they devised a method for modeling the field processing and transport behavior of human foragers. Because the fine-grained prey choice model assumes that foragers consume all food as they go, central place foraging theory has proven more useful in addressing the decisions and behaviors of human foragers—especially because of the critical importance of the residential base as a locus for provisioning offspring, mates or potential mates, or other family or group members.

Central place models generally assume that foragers will expend less energy if they process resources at the home base. Foragers only resort to field processing when doing so results in more food energy being transported to the residential base per hour than could be obtained by transporting resources without such processing (Metcalf and Barlow, 1992). These models involve an assumption that efficient strategies will produce a net yield of food at the residential base (thereby increasing the “fitness” of foragers).<sup>6</sup>

The “field processing/transport” model predicts that foragers should employ procurement strategies of collection, processing, and transport that yield the greatest rate of useful material returned home from logistic forays to collect resources. Designed to produce long-term behavior over multiple foraging episodes, this model assumes that efficient strategies will produce a net increase of food at a residence, thus ultimately increasing the fitness and survival of foragers.

Field processing/transport models are distinguished from the larger body of optimal foraging approaches because they address the spatial component of maximizing the utility of various food resources as well as raw materials for artifact manufacture, particularly when such items are procured in one locality yet used in another. Specifically, after a particular resource has been collected, the forager must determine whether conducting one (or more) stages of field processing will increase the overall efficiency by which these resources are delivered to a central place.

By introducing the spatial component, the field processing/transport model (Metcalf and Barlow, 1992) assesses the degree to which inherent, innate differences between prey taxa should influence the relative efficiency of various processing behaviors and condition the location of such processing. Designed to produce long-term behavior over multiple foraging episodes, this model assumes that efficient strategies will maximize the delivery rate of food to a residence, thus ultimately increasing the fitness and survival of foragers. In their field processing/transport model, Metcalfe and Barlow (1992) presented a formal mathematical model that utilizes central place foraging to explore the benefits for returning food to a home/nest/central place rather than consuming food as encountered (Orians and Pearson 1979, Stephens and Krebs 1986; see also Barlow and Metcalfe, 1996). The original formulation by Metcalfe and Barlow (1992) has subsequently been revised (Barlow and Metcalfe, 1996) and extended by several investigators specifically to address discard behaviors as reflected in the archaeological record (Jones and Madsen, 1989; Bird, 1996, 1997; Bettinger et al., 1997; Bird and Bliege Bird, 1997; Grayson and Cannon, 1999; Zeanah and Simms, 1999; F. Thomas, 2002; Barlow and Heck, 2002; Cannon, 2003; Zeanah, 2003, 2004; see also Bettinger, 1991: 93–97, Kelly, 1991, 1995: 133–141). In the next chapter, we also show that foraging theory provides a useful backdrop for understanding residential mobility and storage practices.

#### COMPUTING TERRESTRIAL TRAVEL THRESHOLDS

At its heart, this application of central place foraging theory addresses the trade-off between increasing the utility of a load (through field processing) and increasing the amount being harvested (which involves foraging and travel time; see Bettinger et al., 1997: 888). While field processing can decrease the amount of waste that is transported, doing so increases the time expended per unit of useful material at the

foraging location (and decreases the time that could be spent on greater collection and transportation of a resource). Barlow and Heck (2002: 138) emphasize two particular predictions that derive from the field processing/transport model:

- More field processing is expected as distance from residence increases
- Inherent, innate differences between prey taxa should influence the relative efficiency of various processing behaviors and condition the location of such processing.

It follows, then, that field processing decisions hinge on (1) the amount of processing time required, (2) the degree to which processing increases the utility of the material being transported, and (3) the distance from procurement locus to the central place. Metcalfe and Barlow (1992) and Barlow and Metcalfe (1996) devised a series of equations to address this problem; Bettinger et al. (1997: 888) propose a “simpler alternative solution” for computing terrestrial travel thresholds.

Critical to the field processing/transport model is the concept of *relative utility*, defined as the proportion of a resource that can actually be used. If a completely edible food item, such as a seedless grape, has a relative utility of 1.0, then the carcass of a white-tailed deer can be said to have a relative utility of 0.60—because about 40 percent of the live weight is comprised of inedible bones, hide, and guts. Likewise, we determined in chapter 7 that a ribbed mussel has a relative utility of 0.256, because roughly one-quarter of the live weight is comprised of edible flesh.<sup>7</sup> Since the goal of efficient transport is to “optimize the delivery of useful material, *in whatever state*, from foraging location to central place, any processing that might be subsequently required at the central place is irrelevant, and hence ‘costless’ and preferred by default” (Bettinger et al., 1997: 888).

#### CONSTRAINTS AND ASSUMPTIONS

To calculate terrestrial transport thresholds, it is necessary to estimate “processing costs” (the mean time invested to field process various prey into different stages of

utility) and “proportional load utility” (the portion of load comprised of targeted resource with various investments in field processing).

**TRAVEL RATE:** With regard to walking speed, most investigators employ a walking speed of 3–5 km/hr (e.g., Jones and Madsen, 1989; Barlow and Metcalfe, 1996; Bettinger et al., 1997: 875; Bird and Bliege Bird, 2000, 2002; Bird et al., 2002: table 1; Barlow and Heck, 2002: 139; Zeanah, 2004: 21; Bird et al., 2005) they have extensively documented travel and collection speeds for the Meriam and Mardu; these results indicate a fairly constant adult search speed of about 3 km/hr and a travel time of 4 km/hr. Depending on their size, children search at about 1.5 km/hr and travel about 3 to 4 km/hr. The computations below employ a range of 3–5 km for adult terrestrial transport, except for the case of terrestrial transport in the salt marsh, which slows to a rate of 3 km/hr (at best).

**LOAD SIZE:** Investigators have employed a broad range of load size estimates when computing rates of terrestrial transport. Bettinger et al. (1997: 892) have argued that a trained adult forager is capable of carrying loads up to 70 percent of body weight without undue hardship. Jones and Madsen (1989), Barlow and Metcalfe (1996), and Barlow et al. (1993) have estimated load size by measuring museum specimens of ethnographic Great Basin baskets. Bettinger et al. (1997) repeated this exercise on a large collection of ethnographic burden baskets from California and found that the basket volumes defined a distinctly bimodal distribution. As a result, these investigators propose that the smaller baskets (with a mean volume of about 20 liters) were used for residential transport, such as daily round-trip excursions from a base camp to procurement locations within the effective foraging radius (Binford, 1982). These estimates are consistent with those of Barlow et al. (1993) for Great Basin baskets. Bettinger et al. (1997) further suggest that larger burden baskets (designed to carry an average of 56 liters) were used for logistical transport, in which resources were collected outside the effective foraging radius (from

a task-specific field camp) and ultimately transported back to the base camp (see also Zeanah, 2004: 21). Bird (1996) has documented that unprocessed shellfish loads for the Meriam average about 13 kg. For Mardu hunters, any load over 25 kg will require significant field processing before transport (Douglas Bird, personal communication.).

In this study, we follow the guidelines of Barlow and Heck (2002: 139), who assume a standard of 10 kg load for acorns and cereals to be “a common load among hunter-gatherers who collect and transport plant foods in tropical and temperate climates” (citing Barlow et al., 1993). Larger transport loads will, of course, yield more calories and a greater return rate.

**Z-VALUE TRANSPORT THRESHOLDS:** In the following sections, we derive processing thresholds based strictly on terrestrial transport estimates.<sup>8</sup> Variable *z*, the key operator in the field processing/transport model, is defined as *the minimum round-trip travel time, for which field processing would maximize the load utility delivered to a central locality* (Metcalf and Barlow, 1992: 344; see also Barlow and Metcalfe, 1996: 357; Bettinger et al., 1997: 888–889; Bird 1997: table 16.2; Bird and Bliege Bird, 1997). In the sections below, we compute the estimated field processing thresholds for the various terrestrial and marine resources available on St. Catherines Island. These “z-values” project the time and distance at which field processing will maximize the rate at which food will be delivered to a central place.

We begin by applying central place foraging to harvesting of mast, then work our way through the various resource sets available on St. Catherines Island.

#### MAST

Live oak (*Q. virginiana*) was almost certainly the most important acorn-producing species for aboriginal people on St. Catherines Island (see Semon and Thomas, chap. 8, this volume). Not only do live oak trees grow almost everywhere on the island, they comprise roughly 60 percent of the living

oak trees on the island. While live oak acorns are fairly small when compared to those of California species, fruits of *Q. virginiana* are among the largest acorns available from species growing on St. Catherines Island. Moreover, live oaks produce the only “sweet” acorns available on St. Catherines Island, meaning that the nutmeats can be consumed without leaching (see discussion in chap. 8, this volume). Taking these factors into account, we estimated post-encounter return rates between 390 and 1260 kcal/hr for the St. Catherines Island live oaks, processed as acorn meal.

The issues surrounding field processing and transport of acorns can be put this way (paraphrasing Bettinger et al., 1997; Barlow and Heck, 2002): *Suppose that a St. Catherines Island forager, working one-half hour’s walk from her residence, collects a large load of Quercus virginiana acorns from the maritime live oak forest. Should she simply pack up the acorns and walk home? Or should she stop collecting, shell the acorns, and transport only the nut meats?*

Our hypothetical forager, in effect, is addressing the trade-off between processing time and travel time. If she transports only unshelled acorns, then she’ll spend more time harvesting, but the transported load will have a lower utility (because she has carried back the inedible acorn shells). If she elects to remove the nutmeats and discard the shells, however, then she will be transporting a higher utility (and completely edible) load back home. The transport decision thus involves three key questions:

1. How much time will field processing require?
2. To what degree does field processing improve the utility of the load?
3. How far must the load be transported?

**MODELING FIELD PROCESSING AND TRANSPORT COSTS:** Barlow and Heck (2002) address these questions in the context of food production during the Natufian–Neolithic transition, and their findings are relevant to aboriginal foraging on St. Catherines Island. Drawing on the equations derived by Barlow and Metcalfe (1996) and Barlow and Heck (2002: tables 11.4 and

11.5), we can estimate that a 10-kg load of “small” acorns can be expected to yield 22,790 kcal/hr if collected 1.5 km away from home. Assuming a travel rate of between 3 and 5 km/hr, the terrestrial threshold is about 70 km. This means that a forager weighing off the cost–benefits of field processing versus transport in bulk should always carry a 10-kg load (unprocessed) back to the residential base, provided that base camp is closer than 70 km away from the harvesting locale.<sup>9</sup>

We can now repeat this exercise employing somewhat different assumptions and constraints. Bettinger et al. (1997: 888) modified the Barlow and Metcalfe (1996) formulation to derive their own “simpler alternative solution” to model transport and field processing costs for black oak (*Quercus kelloggii*) in California, and we extend this application to St. Catherines Island.<sup>10</sup>

Bettinger et al. (1997: 888–892) defined a solution to the central place foraging problem (“When is it more advantageous to field process or transport in bulk?”) by expressing the critical field processing travel threshold this way:

$$z_j = p_j \left[ \frac{(u_{j-1})}{u_j - u_{j-1}} \right]$$

where  $z_j$  represents round-trip travel time,  $p_j$  represents the time required to process a load at stage  $j$ , and  $u_j$  represents the relative utility of a load at stage  $j$  (with “relative utility” defined as the proportion of a resource “that can actually be used”; per Bettinger et al., 1997: 888). This equation establishes the travel threshold at which processing to a certain stage will increase transport efficiency. Note that the  $z$ -score determined only the utility of the resource, the time required to reach that stage, and the increased relative utility brought about by that processing; the result is independent of collecting time and prior processing costs.

The above equation projects the parameters of contemporary acorn production among the Western Mono people of the

western Sierra Nevada (California), as recorded by Helen McCarthy (1993). Bettinger et al. (1997: 893–895) express the energetics in terms of a target product of 5 kg of leached acorn meal, the approximate quantity required to feed a single family for 10 days (after which time the acorn bread would spoil). Table 10.1 establishes the field processing parameters and individual travel thresholds associated with each processing stage. The one-way travel thresholds were originally expressed in both time (min) and distance (km), computed for both 15-kg and 36-kg loads, based upon a walking speed of 5 km/hr (Bettinger et al., 1997: 895). In table 10.1, we have converted these estimates to the rate and load constants employed in this chapter.

These results indicate that field drying will definitely increase efficiency in delivering black oak acorns to the residential base, even when travel time is moderately short (less than 45 min for a 36-kg load). Bettinger et al. (1997: 895) caution, however, that “the utility of field drying is contingent on time spent in the field, which is not always sufficient to achieve complete drying.”

Table 10.1 likewise indicates that, beyond simple drying, field processing of black oak acorns is so time-consuming that it was rarely attempted under aboriginal conditions. The considerable time required to crack, shuck, and winnow the acorns, for instance, would increase transport efficiency only when travel time exceeded 83 min for each kilogram in the load. For a load of 36 kg, the one-way travel threshold is a whopping 125 km. This extreme distance far exceeds the transport limits for aboriginal people in both California and the Great Basin (Rhode, 1990). In terms of the resulting archaeological record, this means that “nearly all waste-producing acorn processing would have occurred at central places” (Bettinger et al., 1997: 895).

Although the Barlow and Heck (2002) and Bettinger et al. (1997) studies involve slightly different assumptions and computations, each model predicts that field processing of acorns is beyond the assumed reasonable foraging range. This means that the harvesting locations, scattered through-

TABLE 10.1  
**Collecting and Processing Times for California Black Oak (*Quercus kelloggii*) by Stage, Weight, and Volume, Based on McCarthy's (1993) Data for the Western Mono People in the Central Sierra Nevada of California (after Bettinger et al., 1997: table 2; the travel thresholds are converted to 10-kg loads)**

Activity	Weight (kg/min)	Time (min/kg)	Time	Utility (%)	z round-trip travel threshold (min/kg)	One-way travel threshold 10 kg loads (hour)	One-way travel threshold 10 kg loads (km)
Gather	15.90	84.6	5.32	0.31	—	—	—
Dry	13.00	7.1	0.55	0.38	2.45	0.20	613–1021
Shuck/winnow	6.50	540.5	83.15	0.77	83.15	6.93	20,787–34,653
Clean	5.58	468.0	83.87	0.90	508.70	42.39	127,170–212,373
Pound	5.00	411.8	82.36	1.00	710.00	59.17	177,500–295,892
Leach	5.00	140.0	28.00	1.00	—	—	—
Cook	28.00	44.0	1.57	0.18	1.91	0.16	478–796

out the maritime live oak forests, are likely to be archaeologically invisible. The discarded acorns hulls and shelling equipment should be associated with residential sites, not processing locations.<sup>11</sup>

FIELD PROCESSING/TRAVEL TRANSPORTS FOR MAST ON ST. CATHERINES ISLAND: We can apply the same central place foraging model to terrestrial mast collection on St. Catherines Island, using data generated in the optimal foraging experiments conducted in October 2005, as part of the overall research program described here. We begin with the acorn harvest data derived by Seman and Thomas (chap. 8, this volume; table 8.21).

Selecting among the 10 individually timed trials for collecting live oak (*Quercus virginiana*) acorns on St. Catherines Island, we determined that (employing the best available results) a forager could harvest 3.6 kg/hr, which provide 2.59 kg of edible nutmeat (providing a utility rate of 72%). Hand-shelling this volume of live oak acorns required 7.23 hr (439 min; see table 10.2). According to the terrestrial transport model derived above, we determine that the z-value transport threshold to be 415.6 min/kg for live oak acorns on St. Catherines Island. This figure converts to a one-way travel threshold (for a 10-kg load) to be 34.63 hr and 1039–1732 km (for a walking rate of 3–5 km/hr).

Table 10.2 provides even more extreme results for laurel oak (*Q. hemisphaerica* and *Q. nigra*) acorns on St. Catherines Island. Seman and Thomas (chap. 8, this volume) found that the best experimental times (from the 14 individual time trials) showed that laurel oak acorns could be collected at a rate of 1.4 kg/hr; our experimental team required 14.16 hr (850 min) to yield 1.01 kg/hr of edible nutmeat. Using the constraints and assumptions developed above, we find the z-value transport threshold to be 2117 min/kg (35.3 hr/kg) for the laurel oak acorns of St. Catherines Island. This figure converts to a one-way travel threshold (for a 10-kg load) of 176.4 hr and 5293–8823 km (for a walking rate of 3–5 km/hr).

Sanger and Thomas (chap. 8, this volume) present comparable data for pignut hickory

TABLE 10.2  
**Terrestrial Transport Thresholds for Mast from St. Catherines Island; the One-Way Terrestrial Travel Thresholds for 10-kg Loads Are Shown for Time in Hours and for Distance in Kilometers (assuming a walking rate of 3–5 km/hour; after Bettinger et al., 1997; table 3)**

Resource	Activity	Weight (kg)	Time (min)	Time (min/kg)	Utility (%)	z round-trip travel threshold (min/kg)	One-way travel threshold, 10-kg loads (hr)	One-way travel threshold, 10 kg loads (m)
Live oak acorns	harvesting	3.6	60	16.67	72	—	—	—
	shucking	2.59	439	167.4	100	415.6	34.63	103,903–173,207
Laurel oak acorns	harvesting	1.43	60	41.96	72	—	—	—
	shucking	1.03	850	823.3	100	2117.1	176.4	529,264–882,283
Pignut hickory nuts	harvesting	57.04	60	1.05	12	—	—	—
	extraction	6.76	28,500	42.16	100	5749	479	143,727–239,594

(*Carya glabra*) nuts presently growing on St. Catherines Island (table 8.12). Using the best results from a total of 22 time trials conducted in October 2005, we conclude that 57.04 kg (3960 individual nuts) can be harvested in 1 hr. Further experiments on manually extracting hickory nutmeat from the shell is extremely time consuming, requiring an average of 15 min/nut; these figures indicate that a total of 475.3 hr could be required to exact all the nutmeat from the standard sample, yielding 6.845 kg of edible meat (for a utility rate of 12%). Table 10.2 indicates a  $z$ -value of 5749 min/kg, reflecting a one-way travel threshold of 479 hr and a range of 1427–2396 km for the one-way distance threshold.

Without doubt, our experimental data are preliminary, and we are presently conducting additional experiments to refine these estimates. But even allowing for a high degree of experimental error, it is clear that both the acorn and hickory nut field process/transport thresholds—involving days and hundreds of kilometers—are vastly greater than comparable data for the Western Mono people of the Sierra Nevada of California (see chap. 8). Because the maximum terrestrial distance on St. Catherines Island is only 16.1 km—meaning that a forager could travel to any point on the island and return home within the same day—we conclude, in substantive terms, table 10.2 indicates that the acorns and hickory nuts *should never have been field processed prior to transport on St. Catherines Island*. This suggests that virtually all waste from acorn processing should be generated at the central place.

#### SHELLFISH TRANSPORT

We can further extend the central place foraging model to shellfish collection on St. Catherines Island, and the basic question can be expressed this way: Suppose that a forager has walked out in the saltwater marsh to mass collect a 10-kg load of oysters. Should she simply pack up the oysters and walk home? Or should she stop, make a fire, steam the oysters, remove the meat, discard the shells, then continue collecting

and shucking until she has a 10-kg load of edible meat to carry back home? Similar questions could be phrased for all the shellfish taxa considered in chapter 7 of this volume.

Table 10.3 summarizes a series of (terrestrial) transport thresholds for seven shellfish taxa available in the marshes surrounding St. Catherines Island; each of these estimates is grounded in data generated through several dozen optimal foraging experiments conducted by our research group throughout 2005 and 2006 (see Blair and Thomas, chap. 7, this volume).

Table 10.3 employs the data developed in chapter 7 to derive terrestrial transport thresholds for the St. Catherines Island shellfishery. But prior to discussing the substantive significance of these estimates, we will first demonstrate how these transport and field processing thresholds were generated from our experimental data, using American oysters (*Crassostrea virginica*) and hard clam (*Mercenaria mercenaria*) as case studies. Specifically, if we denote “stage  $j$ ” as “shucked” (all edible meat removed from the discarded oyster shell), then “stage  $j - 1$ ” is “unshucked” (when the meat was still attached to the shell). Experiments on American oysters from the intertidal beds exposed in the salt creeks adjacent to St. Catherines Island indicate that aboriginal foragers could procure 1 bushel of oysters (with a live weight of 22.77 kg in October and 23.32 in January) in 8 min (0.13 hr); we have used the January figure in table 10.3. Using a utility index of 5.3 percent (derived from our experimental results), an edible meat weight of 1.25 kg is available from a bushel of summer oysters. The combined cleaning time (0.71 hr) and shucking time (3.4 hr) is 4.11 hr (247 min). This extraction rate can be converted to a  $z$ -score using Equation 8 from Bettinger et al. (1997: 888), where  $p_j$  is the 1.0 hr required to shuck a bushel of oysters,  $u_j$  is 100 percent (indicating the completely edible utility of shucked oyster meat), and  $u_{j-1}$  is 20 percent (the partial utility of an unshucked oyster). The  $z$ -value (round trip travel threshold) is 11.04 min/kg. We estimate that the one-way travel threshold (for

TABLE 10.3  
**Terrestrial Transport Thresholds for Shellfish from St. Catherines Island; the One-Way Terrestrial Travel Thresholds for 10-kg Loads Are Shown for Time in Hours and for Distance in Kilometers (assuming a walking rate of 3–5 km/hr; after Bettinger et al., 1997; table 3)**

Resource	Activity	Weight (kg)	Time (min)	Time (min/kg)	Utility (%)	<i>z</i> round-trip travel threshold (min/kg)	One-way travel threshold, 10-kg loads (hr)	One-way travel threshold, 10-kg loads (m)
Oyster (mass collecting)	harvesting extraction	23.32	8	0.343	5.3	—	—	—
		1.25	247	197	100	11.04	0.92	2760–4602
Hard clam	harvesting extraction	60.52	40	0.66	9.0	—	—	—
		5.45	36.6	6.73	100	0.664	0.055	166–277
Ribbed mussel	harvesting extraction	14.36	40	0.359	25.6	—	—	—
		3.68	72.6	19.72	100	6.79	0.57	1696–2827
Knobbed whelk	harvesting extraction	—	—	—	30	—	—	—
		2.1	40	19.05	100	13.33	1.11	3333–5557
Marsh periwinkle	harvesting extraction	1.16	40	34.48	28	—	—	—
		0.325	462.6	1423.4	100	553.5	46.13	138,386–230,690
Channeled whelk	harvesting extraction	—	—	—	30	—	—	—
		1.2	40	33.33	100	47.62	3.97	11,905–19,845
Blue crab	harvesting extraction	—	—	—	20	—	—	—
		0.64	40	62.50	100	15.63	1.30	3906–6512

a standardized 10-kg load) is 0.92 hr. The one-way travel distance for field processing (computed at a walking rate of 3–5 km/hr) is 2.76–4.60 km.<sup>12</sup>

Table 10.3 presents comparable terrestrial thresholds for hard clams (*Mercenaria*) growing today in the waters surrounding St. Catherines Island. Blair and Thomas (chap.7, this volume, esp. table 7.13), employing the most efficient experimental results, estimate that an average of 648 hard clams can be collected in a standardized 0.67-hr collection interval, with a mean live weight of 93.4 g/clam and an average meat weight of 8.4 g/clam. Factoring in the relevant cleaning and shucking times, we derive a  $z$ -value threshold of 0.664 min/kg. The one-way travel threshold (for a 10-kg load) is computed to be only 0.0554 hr (3.3 min), with an associated one-way travel distance (walking at a rate of 3–5 km/hr) of only 166–277 m.

Let us rephrase these statistical results in terms of the question that began this section: If a forager has walked into marsh and collected 10 kg of shellfish, should she pack the shellfish and walk home? Or should she stop, make a fire, steam open the shellfish, extract the meat, discard the shells, then continue collecting and shucking until she has a 10-kg load of edible meat to carry back home?

Table 10.3 suggests this: If our hypothetical forager is collecting oysters, she should stop and field process whenever she is more than 0.92 hr (2.76–4.60 km) away from home. But if she is collecting hard clams, she should field process whenever she is 3.3 min (166–277 m) from her home base.

Simply put, these results reflected in table 10.3 should have a dramatic impact on the archaeological record of St. Catherines Island:

- Except for fairly lengthy foraging trips (i.e., those more than an hour or so from the residential base), oysters will usually be brought back intact and the shells discarded at the home base.
- But except for extremely short-term foraging trips (i.e., those within a few minutes of the home base), hard clams will usually be shucked in the marsh and clam shells should

be dramatically underrepresented in the shell middens of St. Catherines Island. These are starkly different implications for the archaeological record, reflecting largely the excessive cleaning/shucking times required for oysters and the higher utility rates for *Mercenaria*.

Table 10.3 also presents comparable terrestrial thresholds for five additional shellfish taxa available on St. Catherines Island: ribbed mussels, knobbed and channeled whelks, periwinkles, and blue crabs. Based on the relative distance of the time/distance thresholds, we find that ribbed mussels are somewhat more likely to be field processed than, say, oysters. The travel thresholds for knobbed whelks are fairly similar to those for oysters, and channeled whelks are much higher. Because of the excessive extraction costs, we doubt that marsh periwinkles were ever field processed before transport to the central place.

#### TERRESTRIAL GAME

We have already estimated the post-encounter return rates for various terrestrial taxa on St. Catherines Island. Black bear and American alligator are the highest ranking prey species, with estimated return rates exceeding 22,000 kcal/hr (table 8.27). White-tailed deer fall in the range of about 12,000–20,000 kcal/hr, followed by numerous mid-sized birds and mammals including raccoon, opossum, wild turkey, and Canada goose (with associated return rates between about 5000 and 13,000 kcal/hr). Several smaller taxa return less than 4000 kcal/hr.

Table 10.4 presents the one-way travel thresholds for various terrestrial prey taxa available to aboriginal people on St. Catherines Island. In deriving the various  $z$ -values, we have followed the computational procedures outlined by Bettinger et al. (1997), modified for a 10-kg load and a transport rate of 3–5 km/hr.

We hope that further research will significantly refine these first-order estimates. As noted above, the  $z$ -values for terrestrial mammals and reptiles were derived following the same basic procedure already outlined for shellfish. That is, when harvesting

TABLE 10.4  
**Terrestrial Transport Thresholds for Terrestrial Hunting on St. Catherine's Island; the One-Way Terrestrial Travel Thresholds for 10-kg Loads Are Shown for Time in Hours and for Distance in Kilometers (assuming a walking rate of 3-5 km/hr; after Bettinger et al., 1997: table 3)**

Resource	Activity	Weight	Time (min)	Time (min/kg)	Utility	z threshold (min/kg)	One-way travel, 10-kg loads (hr)	One-way travel, 10-kg loads (m)
Black bear	Pursuit	115	90	0.783	50	—	—	—
	Field dressing	58.0	90	1.565	100	1.57	0.13	391-652
American alligator	Pursuit	128	90	0.703	43	—	—	—
	Field dressing	64	90	1.406	100	1.41	0.12	352-586
White-tailed deer	Pursuit	42	90	2.14	60	—	—	—
	Field dressing	25.2	90	3.57	100	5.36	0.45	1339-2233
Softshell and snapping turtle	Pursuit	10.25	4.8-10	0.468-0.976	20	—	—	—
	Field dressing	2.05	15	7.317	100	1.83	0.15	457-762
Raccoon	Pursuit	7.0	30	4.29	70	—	—	—
	Field dressing	4.9	30	6.12	100	14.29	1.19	3571-5954
Eastern wild turkey	Pursuit	6.50	30	4.62	70	—	—	—
	Field dressing	4.55	30	6.60	100	15.38	1.29	3840-6401
Opossum	Pursuit	2.24	15	6.70	70	—	—	—
	Field dressing	1.56	15	9.62	100	5.63	1.30	3906-6511
Canada goose	Pursuit	4.80	30	6.25	70	—	—	—
	Field dressing	3.36	30	8.98	100	20.83	1.74	5208-8682
Swamp rabbit	Pursuit	2.4	15	6.25	70	—	—	—
	Field dressing	1.2	15	12.50	100	20.83	1.74	3830-7093
Small turtles	Pursuit	3.5	4.8-10	1.37-2.86	20	—	—	—
	Field dressing	0.7	15	21.43	100	5.36	0.45	1339-2233
Marsh rabbit	Pursuit	1.44	15	10.42	70	—	—	—
	Field dressing	1.01	15	14.88	100	34.72	2.89	8680-14, 470
Ducks	Pursuit	0.88	15	17.05	70	—	—	—
	Field dressing	0.62	15	24.35	100	56.82	4.74	14,205-23,679
Diamondback terrapin	Pursuit	0.5	10	20	20	—	—	—
	Field dressing	0.1	15	150	100	37.5	3.125	9375-15,628
Eastern gray squirrel	Pursuit	0.52	15	28.85	70	—	—	—
	Field dressing	0.36	15	41.21	100	96.15	8.01	24,038-40,072

most shellfish, the processing options are binary: either shuck the clam or transport it whole. Because it is impossible to half-shuck a mollusk or gastropod, the resulting stage  $j$  utility is always 1.0 (“ready to eat”). Crustaceans are a partial exception, because it is conceivable to “field process” a blue crab by removing the claws and body meat, then discarding the guts. This would leave cracking and extracting the crabmeat for subsequent processing at the home base. In fact, when modern crabbers find stone crabs in their crab traps, they commonly break off a single claw and toss the organism back into the saltwater (presumably to grow another claw).

Here, we have modeled the field processing of terrestrial mammals and reptiles as a simple binary process: either transported whole or field butchered. If we were to conduct a well-designed ethnoarchaeological study of field processing on the terrestrial resources base of St. Catherines Island, we could likely record “relative utility” along a sliding scale monitoring the proportion of a resource that can actually be used at each stage. When Helen McCarthy studied acorn processing among the Western Mono, for instance, she recorded the following processes, each with a relative utility at that stage: (1) gathering, (2) drying, (3) shucking and winnowing, (4) cleaning, (5) pounding, (6) leaching, and (7) cooking (after McCarthy, 1993; Bettinger et al., 1997: 892–895). With suitable ethnohistoric and/or ethnoarchaeological input, it is possible to assign a relative utility to each stage.

Several stages are doubtless involved in field processing the various terrestrial mammals and reptiles available on St. Catherines Island. With the appropriate experimental procedures, it should be possible to determine the relative utility of stages involved in butchering various prey taxa, from basic field dressing through “ready to eat.” For mammals with a live weight of greater than 5 kg—basically raccoon-sized and larger—it is likely that “field dressing” (gutting, culling the feet, and perhaps quartering the carcass) requires considerably less time than does the complete processing of the carcass for consumption.

In so doing, it is likely that several “low utility” bones would be discarded at the kill site. For the larger taxa, however, “field dressed” carcasses are generally transported with many low-utility bone elements still attached to avoid the butchering time required to remove them.

There are other considerations as well. Most modern hunters, for instance, prefer to bleed out and gut a carcass immediately after the kill, and not just deer, but also raccoons, opossums, rabbits, and squirrels. This process prevents contamination of the meat by the blood and various juices from the entrails, especially considering that meat cools more rapidly when the guts are removed. These considerations address currencies other than the energy constraints involved in the field processing/terrestrial model, except, of course, to the degree that such field dressing lightens the load for transport and thereby increasing the utility.

So, while recognizing the importance of considering “butchering stage” and “relative utility” in deriving terrestrial transport thresholds, the first-order estimates developed here lack the necessary empirical support to subdivide the various processing stages.

#### SEA TURTLES

Loggerhead and leatherback turtles can be hunted offshore in the late spring and summer, and nesting females can be harvested on the beach. On St. Catherines Island, loggerheads usually come ashore to nest between early May and mid-August. Although we defined two hunt types for exploiting sea turtles (in chap. 8), the method of capture is irrelevant when considering the field processing/transport model.

Table 10.5 presents the terrestrial transport thresholds for loggerheads and leatherback taken at sea; the estimated live weight is the average between adult males and females. These terrestrial  $z$ -scores are rather unrealistic, of course, since watercraft are mandatory for procuring turtles at sea. We also compute a separate  $z$ -value for female loggerheads that were taken while nesting.

TABLE 10.5  
**Terrestrial Transport Thresholds for Sea Turtles on St. Catherines Island; the One-Way Terrestrial Travel Thresholds for 10-kg Loads Are Shown for Time in Hours and for Distance in Kilometers (assuming a walking rate of 3–5 km/hr; after Bettinger et al., 1997: table 3)**

Resource	Activity	Weight (kg)	Time (min)	Time (min/kg)	Utility (%)	z round-trip travel threshold (min/kg)	One-way travel threshold, 10 kg loads (hr)	One-way travel threshold, 10 kg loads (km)
Loggerhead (♀ only)	pursuit	68	120	1.77	80	—	—	—
	butchering	54.4	120	2.21	100	8.82	0.74	2206–3677
Loggerhead (♂ and ♀)	pursuit	90.5	120	1.33	80	—	—	—
	butchering	72.4	120	1.66	100	6.63	0.55	1657–2763
Leatherback (♂ and ♀)	pursuit	600	240	0.40	75	—	—	—
	butchering	450	240	0.53	100	1.60	0.13	400–667

On St. Catherines Island, sea turtles nest only on sandy beach margins, a habitat type that is restricted to the extreme eastern (and northeastern) margins of the island. If foragers conducted their turtle hunts strictly on foot, then terrestrial transport is a distinct possibility, with the turtle meat and turtle eggs (if any) carried back to the central place. However, since all beaches selected by nesting loggerheads are likewise accessible by native watercraft, it is entirely feasible that nesting females could have been kept alive and transported by boat. As discussed below, marine watercraft can significantly lower the transport thresholds computed for terrestrial travel.

FISH

Due to the allometric problems associated with the study of fish bones in archaeological sites, we pooled the sizes for the most common fish species on the Georgia coast into five ordinal categories based on average weight (modified from Lindström, 1996): very large fish (average weight >5 kg, large fish (average weight 3.4–1.37 kg), medium fish (average weight 0.86–0.68 kg), small fish (average weight 0.34–0.23 kg), and very small fish (average weight <0.017 kg). Figure 7.22 provides post-encounter return rate estimates for each of these fish species, assuming an edible portion of 75 percent (except for very small fish, which were assumed to be 100% edible).

In table 10.6, we present the terrestrial transport thresholds for the St. Catherines Island fishery. We must sound a note of caution here because (as was stressed in chap. 7) virtually all aboriginal fishing conducted by St. Catherines Island foragers was likely facilitated by watercraft. Gill nets and fish weirs were almost always set by fishermen working from dugouts, and the hauls of fish obtained this way were probably transported in pirogues (canoelike vessels) capable of holding more than a dozen people. Below, we consider the impact and significance of waterborne transport for aboriginal foragers of the Georgia coast; without doubt, the judicious use of boats dra-

TABLE 10.6  
**Terrestrial Transport Thresholds for the St. Catherines Island Fishery**

Resource	Activity	Weight (kg)	Time (min)	Time (min/kg)	Utility (%)	z round-trip travel threshold (min/kg)	One-way travel threshold, 10-kg loads (hr)	One-way travel threshold, 10-kg loads (m)
Very large fish	pursuit	5.0	—	—	75	—	—	—
	processing	3.75	7	1.87	100	5.60	0.47	1400–2338
Large fish	pursuit	2.39	—	—	75	—	—	—
	processing	1.79	2	1.12	100	3.35	0.28	837–1397
Medium fish	pursuit	0.77	—	—	75	—	—	—
	processing	0.58	0.5	0.87	100	2.50	0.22	649–1084
Small fish	pursuit	0.21	—	—	75	—	—	—
	processing	0.16	0.5	3.11	100	9.36	0.78	2339–3899

matically lowered transport costs for many (if not most) of the resources on St. Catherines Island.

That said, it is certainly possible to operate gill nets, fish weirs, trot lines, and handlines while standing ashore. Aboriginal fishermen probably fished the surf while standing on the sandy beaches, and they certainly could have exploited the rich salt-water rivers that in places cut into the island's margin (as do modern fishermen today). Terrestrial foragers could also spear or harpoon fish while walking along the marsh edge or the seashore, as previously cited in Jonathan Dickinson's account of aboriginal foragers charging into schools of fish (probably mullet) and impaling them with a spearlike staff (Dickinson, 1975 [1699]: 13; see also Hann, 1996: 100).

With these terrestrial alternatives in mind, table 10.6 presents the various *z*-values associated with the St. Catherines Island fishery.

#### MARINE TRANSPORT

Much has been written about the importance of water transport for moving people, food, and raw materials, thereby conserving thousands of calories available for other tasks (e.g., Meehan, 1982: 100; Croes and Hackenberger, 1988; Purdy, 1991: 281; Bliege Bird and Bird, 1997; Mackie, 2001; Ames, 2002). Obviously, waterborne transport is vastly more efficient than dry-land, on-the-back transport: As Ames (2002: 39) puts it: "Weights that are daunting on foot are trivial in many boats: What is 15 kg in a boat that can easily carry 2000 kg?"

What we cannot find, however, is a single rigorous, quantitative study that effectively compares the energetics of marine and terrestrial transport.<sup>15</sup> This is a problem in the present context because the transport/field processing model, developed above, assumes a constant load size. This means that at some point in the foraging episode, a forager must choose between transporting additional load and culling low-utility parts. Following Barlow and Metcalfe (1996) as well as subsequent modifications, we have only modeled terrestrial transport (using

conventional constraints of a 3–5-km/hr travel rate and a standardize load size of 10 kg). When water transport is available, however, these terrestrial constraints become wildly inappropriate.

For this reason, we can address the issue of water transport in qualitative terms only, although it is our hope that this preliminary discussion will serve as a first-order heuristic to generate much needed research on this topic.<sup>14</sup>

#### ABORIGINAL WATERCRAFT ON THE GEORGIA COAST

We consider it axiomatic that aboriginal foragers of the Georgia coast had access to high-quality water transport throughout the duration of their occupation of this area. The earliest ethnohistoric observers chronicle a sophisticated and diverse array of watercraft available to Southeastern Indians; in chapter 7 (and on the cover of this monograph), we reproduced John White's watercolor of coastal Indians during the 1580s (Lorant, 1946: 189). Although we were primarily interested in the fishing weirs that White painted in the background, we also commented on the several dugouts evident in figure 7.8. The closest canoe has a fire basin blazing amidships, and we speculated that this fire hearth was likely used for night fishing (especially mullet-jumping).<sup>15</sup> The on-board fire could also have been used to light torches, for food preparation in transit, and/or processing resources for transport (e.g., cooking shellfish so that the shells could be discarded instead of transported).<sup>16</sup>

Specifically with regard to the Georgia/northern Florida coast, Jean Ribault noted in the early 1560s that the Timucuan pirogues (a canoelike vessel) were capable of holding 15–20 men who paddled while standing upright. Ribault (1927: 80–81; cited in Hann, 1996: 100) likened these dugouts to “floating troughs”, and the oars to shovels.<sup>17</sup> Ribault's account is amplified by the Jacques Le Moyne drawing of the same vessels, rendered as “Storing Their Crops in the Public Granary” (reproduced above as fig. 9.2) and is instructive on several points. The square-

ended dugout in the foreground is powered by three standing paddlers, with two additional passengers on board. Loose ears of maize are piled in the bottom of the dugout, along with basket loads of roots, fruits, and (apparently) shellfish.<sup>18</sup> Two additional canoes are rendered in the background, with two paddlers maneuvering each and various foodstuffs piled loosely amidships.

While shipwrecked on the Georgia coast in 1595 (roughly 50 km south of St. Catharines Island), Fray Andrés de San Miguel noted that the Guale Indians equipped their dugouts with “a smoldering log”, presumably to use for preparing fire upon arrival at their destination (de San Miguel, 2001: 61). Later that same year, Fr. Andrés commented on the native (presumably Timucuan) watercraft:

From the time we left the port, pirogues [full] of Indians were constantly coming out to meet us with things to trade [including fish, turtles, and amber]. All of them had as many people as they would hold. They all paddled standing up with long paddles (*caneletes*) two yards [in length]. The blades were a little over five inches wide and half a yard long and the handle like a lance, all well worked from one piece of strong wood. ... Although we never waited for them, the pirogues were so swift that by dint of rowing they always overtook us (de San Miguel, 2001: 77).

Timucuan also fashioned a raftlike vessel (*balsa*) for crossing rivers, and Bishop Díaz Vara Calderón crossed a river in Timucuan territory in two canoes lashed together (cited in Hann, 1996: 110).

The ethnohistoric evidence thus establishes the dugout, the *balsa*, and the catamaran as tools of central importance among aquatic foragers of the Georgia Bight. The deep antiquity of this boat-building tradition is confirmed by the numerous finds of ancient dugouts, in both saltwater and freshwater contexts. C. C. Jones, Jr., reports the recovery of a cypress dugout from the Savannah River, just a few miles from the city of Savannah (Jones, 1873: 52–53). It measured approximately 3.35 m long and 75 cm wide, with a flat bottom, rounded sides, and no evidence of

a keel. This shallow depth and narrow beam suggests use by very experienced canoeists. The Savannah River dugout was made of a single log, constructed by judicious use of fire and shaped by “rude incisive implements”, likely made with shell or stone; this procedure follows the precise process depicted in the de Bry engraving.

The earliest dugouts in the Southeast date to 3200 B.C. (Milanich, 1994: 70; Newsome and Purdy, 1990), but the use of watercraft—based on woodworking tools recovered—is assumed to date back to Dalton times, perhaps as early as 9500 B.C. (Morse, 1997). These archaeological finds further chronicle the diversity in shapes and sizes. While some dugouts were built for speed, sacrificing stability and storage, other ancient canoes maximized stability and load-carrying capacity.<sup>19</sup> We believe that a variety of dugouts and other kinds of watercraft have been manufactured and utilized from the initial human occupation of St. Catherines Island.

As noted in chapter 7, the availability of seaworthy watercraft has major implications for the effective exploitation of the estuarine resources in the waters off St. Catherines Island. Not only are the acts of saltwater fishing, shellfish collecting, and marine hunting greatly enhanced by the availability of canoes and dugouts, but the energetics of moving these prey items (once procured) to a central place is radically reconfigured by waterborne transport.

#### THE DUGOUT AS DELIVERY VEHICLE

The most common view of watercraft emphasizes their role as delivery vehicle—a relatively efficient means of transporting a load to the home base. Presumably, the use of boats permits larger loads of unprocessed maritime resources to be delivered in a more energy-efficient manner. Employing the terrestrial transport model as a baseline, we can examine both travel rates and load capacities for watercraft available to aboriginal foragers on St. Catherines Island.

**TRAVEL RATES:** All life in the salt marsh revolves about the ebb and flow of the tides. It is impossible to overemphasize the

importance of tidal power for aquatic foragers exploiting an estuarine or marshland environment.

It goes without saying that native people were accustomed to working the tides on a daily basis. The gentle inland sweep of the Georgia Bight produces an intensive, amplified tidal movement. The tidal range, or the elevational differential between low and high tides, is commonly 7 feet. During spring tides, however, which are caused by the convergence of lunar and solar cycles, tides can swell to nearly a dozen feet. Tidal currents reverse directions every 6 hr, with currents generally running between 1 and 2 knots; between flood and ebb, tidal shift can produce stronger currents (reaching 3 knots in some locations).

Judicious use of tidal power can significantly extend the range of even marginal watercraft. Along the Georgia coast, especially before World War II, local residents would frequently row their small (unpowered) boats to the outermost barrier islands, using the outgoing tide to get there and the incoming tide to return home (Randal Walker, personal commun.). Rising tides would likewise allow aquatic foragers to access the attractive feeder creeks and streams that are often blocked by shallow sand bars. Because the incoming tide enters through the sounds at both ends of islands like St. Catherines, the tides begin to fill the rivers from opposite directions, and toward the middle of the island, the two flood tides meet. These so-called dividings shift depending on the range of the tide. Navigating the marsh at high tide is quite easy, but when the tide drops, many of the saltwater creeks are blocked by sandbars, and modern boaters are sometimes stuck in the mud for hours waiting for sufficient water to flood the creek.

We likewise assume that all foragers living in barrier island habitats were intimately familiar with the diurnal and lunar tidal cycles; some times of the day and some weeks of the months are cheaper for transport of resources than others. Effective use of tides can dramatically decrease transport costs of bringing marsh and saltwater resources back to a terrestrial base camp.

We can assume, for instance, that most canoe-based procurement sessions commenced when the marsh was flooded, generally 2 hr prior to full flood tide (up to 4 hr on a spring tide). Once the saltwater level flooded the marsh grass, the dugouts could easily and safely depart from their launching area (likely situated adjacent to the residential base or perhaps a short distance away). With the high water, it is a simple matter to follow the existing channels in places where the grass is thinner than others and to meander throughout marsh, temporarily independent of the incised stream channels.

Depending on tide, wind conditions, and load, modern kayakers can paddle comfortably at 8–10 km/hr<sup>20</sup> and sustain 11–13 km/hr in short bursts. For modern racing sea kayaks, sprint speed is about 13–15 km/hr and surf speeds have been recorded at 16 km/hr. We estimate that an aquatic forager paddling an empty dugout might average about 8–10 km/hr, roughly twice the pace of the standard walking rate of 3–5 km/hr (e.g., Jones and Madsen, 1989; Barlow and Metcalfe, 1996; Bettinger et al., 1997: 875; Bird et al., 2002: table 1; Barlow and Heck, 2002: 139; Zeanah, 2004: 21).

This estimated paddling rate translates to a maximum one-way distance of about 50–100 km/day, compared with a maximum one-way walking distance (over varied terrain) of roughly 20–50 km/day. We concur with Ames (2002: 35), who estimates the aquatic foraging radius at about 30 km, although a fast-moving group might be able to cover 50 km under the right conditions.

**LOAD CAPACITIES:** We have previously employed a standard 10-kg load for computing the terrestrial transport thresholds (following Barlow et al., 1993; Barlow and Heck, 2002: 139). Water-based transport, however, does dramatically increase the potential load capacity; as Purdy (1991: 281) has pointed out, dugout canoes are like pack animals, except they do not have to be fed. Swanton (1922: 355) notes that some Natchez canoes reached 40 feet in length and were capable of carrying 11,000 kg (12 tons).

Several museum collections of ethnographic watercraft and dozens of archaeo-

logical dugouts have been recovered from Southeastern waters over the years (e.g., Wheeler et al., 2003). Coupled with a close reading of the ethnohistoric evidence and perhaps experimentation with modern “watermen”, it should be possible to study these dugouts to determine gross load capacity, number of rowers, average speed, and so forth. Several investigators have conducted similar experiments on museum collections of ethnographic basketry (e.g., Barlow et al., 1993; Bettinger et al., 1997) to determine load capacity for acorns and pine nuts. Although huge assumptions are required here, such proxies have proven useful for understanding how resource and patch selection is influenced by handling and terrestrial load size constraints.<sup>21</sup>

It seems likely that when transporting smaller prey items, such as shellfish and small fish, the individual organisms were containerized (into baskets and bags) to minimize posttransport handling costs. Although the Le Moyne engravings sometimes show fish and ears of corn scattered loose on the bottom of the dugout, they also show several baskets and bags crammed with foodstuffs. Recognizing the problems with interpreting material culture details from these engravings, it might be possible to derive appropriate estimates of load size (expressed in weight and/or volume), processing times, and prey utility to model waterborne transport costs, processing threshold, and travel times for dugout technology.

#### THE DUGOUT AS A “MOBILE CENTRAL PLACE”

One innovative approach to the terrestrial/marine transport problem is to treat the canoe or dugout as if it is a mobile “central” place (Douglas Bird, personal commun.):

The Meriam do this all the time: cruise over to Dauar Islet, park the dinghy at a decent landing, and forage out from there. On such occasions, for analysis, we treated the landing—which is also often a dinner-time camp—as the central place, (assuming that if you can haul your shellfish back to the boat, you’ll be “home-free”, so to speak). You could use the same type of analysis to make predictions

about when it might pay to make a dinner-time camp as opposed to transporting all back "home."

Conceptualizing the dugout-as-central-place takes advantage of three prior conditions, each of which hold for littoral foraging in the Meriam Islands: (1) the watercraft must be "landed" before foraging can begin, (2) field processing must take place on dry land (rather than "on board") and (3) the processing costs once arriving "back home" are zero.

For St. Catherines Island foragers, only the third constraint (zero "at home" processing costs) seems to hold. Depending on the tide, modern shellfishers and fishermen can work their watercraft into virtually all the saltwater creeks that dissect the marshland. This means that foragers need not "land" their watercraft prior to foraging; many subsistence activities can be undertaken from within the boat, and even if one must wade in the marsh (say, to collect clams and oysters), the watercraft can be easily brought along with a tow rope. In other words, the "terrestrial" travel time between procurement locus and boat-as-mobile-central-place always approaches zero.

We also know from ethnohistoric sources (cited above) that on-board resource processing was always an option for coastal Georgia foragers because of their size and due to the fact that many dugouts were apparently equipped with on-board fire hearths. This would be another way of conceptualizing watercraft as a "mobile home base", analogous to the conventional residential base, where processing costs drop to zero.

Tidal constraints also come into play here. In many cases, foragers could time the tides to collect and load a batch of shellfish into the dugout at slack water, then simply paddle back to the home base. If the tides required that the foragers stay in the procurement area, though, perhaps to wait for an incoming tide to flood a small feeder stream, then field processing the load might become a worthwhile way to invest the downtime. That is, depending on the

tidal constraints, the same watercraft could sometimes serve as the delivery vehicle, other times as the central place. At present, we lack the information necessary to determine the differential payoffs and local constraints that would allow adequate modeling of the multiple strategies that were undoubtedly employed.

When watercrafts are involved, the concept of a mobile central place can even spill over to influence decision making for terrestrial transport. Suppose, for instance, that a forager has accumulated a 50-kg load of terrestrial food items (baskets of unshelled acorns, ears of corn, deer carcasses, etc.). In a strictly terrestrial setting, the decision making reflects the field processing/transport model developed above: Is it better to carry the unprocessed resources back home or should the low-utility elements be discarded before transport? If watercrafts are available, then a third option exists: Transport the load (processed or unprocessed) to the nearest landing spot, transfer the load to a dugout, and then paddle home. As we discuss in the next chapter, the geomorphic configuration of barrier islands favors this combined terrestrial/marine transport strategy. Because barrier islands, including St. Catherines, tend to be long (north-south), if a load of terrestrial resources can be hand carried (east-west) to the marsh (usually less than 1-2 km away), then it is almost always possible to bring a dugout into the transport picture.

#### ASSESSING WATERBORNE TRANSPORT COSTS

We have already estimated the costs associated with collecting and processing key resources, the load restrictions of each, and the projected transport thresholds using the terrestrial model. If we knew about the differential processing costs for a range of available resources, and the corresponding shift in load utilities for field processing, it might be possible to make predictions about the payoffs of water transport technology (relative to simply moving the central place closer to the resource patch).

We have solid archaeological evidence that dugouts have been used from the very

first colonization of the barrier islands. When considering the advantages of aquatic over terrestrial transport, it is certainly necessary to factor in the considerable costs of building and maintaining boats and rafts. It seems likely that an investment in watercraft technology (both start-up and maintenance costs) were amortized (“piggy-backed”) across virtually all aspects of aboriginal life on St. Catherines Island, including nonfood concerns such as warfare, moving people, maintaining trade networks, and paying tribute. In other words, we believe that boat cost, then as now, is an inescapable cost of living on (or near) the barrier islands.

#### HYPOTHESES FROM CENTRAL PLACE FORAGING

We have discussed both terrestrial and waterborne strategies for transporting resources to a central place. On a barrier island such as St. Catherines, it is impossible to overemphasize or overestimate the importance of waterborne transport. We believe that throughout the entire human occupation of the Georgia coast, a broad array of watercraft was employed to transport people and resources in great bulk and across great distances. Many estuarine and open-saltwater habitats are entirely inaccessible except by boat, and watercraft expand the effective foraging radius for marine resources of all kinds. We also suspect that the availability of water transport lowered transport costs of select terrestrial resources.

Due to the fact that we lack adequate models to project waterborne transport costs, we have addressed only terrestrial transport and field processing. In this chapter, we have developed a series of estimated terrestrial transport thresholds ( $z$ -values) for the resource base of St. Catherines Island, projecting the time and distance at which field processing will maximize the rate at which food items are delivered to a central place. These one-way projections were adjusted to reflect a terrestrial travel rate of 3–5 km/hr and a standardized load size of 10 kg. We view these terrestrial transport thresholds as *maximum extremes*;

we suspect that waterborne transport could have greatly reduced these terrestrial costs.

With these strictures in mind, we concentrate on the implications of the terrestrial thresholds derived in this chapter. To interject a more concrete spatial component into these projections, we once again draw on the ethnoarchaeological studies of Bird et al. (2002: 463–464), who offer some general guidelines for evaluating the behaviors implied by these  $z$ -value (terrestrial) thresholds:

- If the field processing threshold for a given taxon is less than about 100 m from the central base, then foragers working beyond this distance can always be expected to field process prior to transport. When the load is comprised of shellfish, for instance, this means that (1) all of the shells for that species should be discarded at the procurement location and (2) these shells should be absent from central place middens.
- When the  $z$ -value for a prey species exceeds 500 m, we expect that the forager will never field process, instead transporting the organisms in bulk for processing at the central base. In the case of shellfish, this means that shells of the particular prey species should be abundant in the residential midden (and virtually absent elsewhere).
- For prey species with  $z$ -values that fall in the mid-range (between about 100 and 500 m), the decision of whether to field process should generally reflect the distance from the central base—the closer the procurement locale, the less field processing can be expected.

Table 10.7 projects these  $z$ -value thresholds for the various prey taxa available on St. Catherines Island.

In the next chapter, we examine the specific foraging landscape of St. Catherines Island in considerable detail. To evaluate terrestrial transport decision making, though, we must point out a simple geographic fact: *the maximum one-way terrestrial distance on St. Catherines Island is 16 km* (see fig. 11.12).<sup>22</sup> This means that, employing the constraints adopted above, a forager carrying a load of 10 kg could walk to any location on St. Catherines Island in 3–5 hr. As we will see below, island geomorphology has some major implications for field processing and residential settlement patterning.

TABLE 10.7  
**One-Way Terrestrial Transport Thresholds for Prey Items on St. Catherines  
 Island (parameters after Bird et al., 2002: 463–464)**

Prey	When to field process before transport Distance to central place (m)			
	0	100	500	10,000
	Always	Sometimes	Almost Never	Never
Hard clam		[166–277]		
American alligator		[352–586]		
Black bear		[391–652]		
Leatherback turtle ♀ ♂		[400–667]		
Medium fish			[649–1084]	
Large fish			[837–1397]	
White-tailed deer			[1339–2233]	
Very large fish			[1400–2338]	
Loggerhead turtle ♀ ♂			[1657–2763]	
Ribbed mussel			[1696–2827]	
Loggerhead turtle ♀			[2206–3677]	
Small fish			[2339–3899]	
American oysters <sup>a</sup>			[2760–4602]	
Knobbed whelk			[3333–5557]	
Raccoon			[3571–5954]	
Eastern wild turkey			[3840–6401]	
Opossum			[3906–6511]	
Blue crab			[3906–6512]	
Swamp rabbit			[5208–8682]	
Marsh rabbit			[8680–14,470]	
Channeled whelk			[11,905–19,845]	
Ducks			[14,205–23,679]	
Eastern gray squirrel			[24,038–40,072]	
Live oak acorns <sup>b</sup>			[103,903–173,207]	
Marsh periwinkle			[138,386–230,690]	
Pignut hickory			[143,727–239,594]	
Laurel oak acorns			[274,525–457,633]	

<sup>a</sup>Mass collected

<sup>b</sup>Includes only shucking and winnowing (and excludes leaching time).

Looking strictly at terrestrial transport, then, we hypothesize that aboriginal foragers only rarely field processed food resources of St. Catherines Island. Table 10.7 projects that hard clams would often be shucked, and the shell discarded, with only the edible meat being transported to the central place. Alligators, black bears, and loggerhead turtles would sometimes be field dressed prior to transport. But the terrestrial transport thresholds suggest that, overall, field processing was likely quite rare on St. Catherines Island. And when we consider the impact of waterborne transport, partic-

ularly for alligators and leatherbacks, it must be hypothesized that field processing prior to transport almost never happened.

Due to the large transport thresholds, we expect that aboriginal foragers on St. Catherines Island only rarely processed prey items at the procurement locus. Instead, we expect that nearly all loads of shellfish were transport in bulk, to be processed at the central base. If so, then discarded inedible parts from virtually all prey taxa should be abundant in the middens associated with residential bases and virtually absent elsewhere.<sup>23</sup>

We began this chapter with a deceptively simple question: *To what extent can we expect past diet-breadth decisions to be reflected in archaeological midden deposits?*

We then briefly examined a cautionary tale from the Torres Strait, in which Douglas Bird and Rebecca Bliege Bird documented how the prey choice model quite adequately predicted foraging behaviors of Meriam shellfishers, but the archaeological middens resulting from these very same activities poorly reflected such decision making (due primarily to major field processing in anticipation of terrestrial transport). As we stated earlier, “if an archaeologist were to extrapolate Meriam subsistence based strictly on shell counts from middens, the results would be spectacularly incorrect.”

So we turned to central place foraging theory to determine whether similar field processing strategies were likely to significantly impact the archaeological record on St. Catherines Island.

At this point, we can hypothesize probably not, and throughout the rest of this volume, we can test this hypothesis using archaeological data now available from St. Catherines Island.

## NOTES

1. This discussion draws heavily on Bird (1997), Bird and Bliege Bird (1997), and Bird et al. (2002, 2004).

2. Prehistoric middens on the Meriam Island produced very similar results (Bird et al., 2002: fig. 5; Bird et al., 2004: table 2), with *Hippopus* ranking 10th and *T. maximalsquamosa* 7th out of 10 prey types recovered archaeologically. See also F. Thomas (2002) for similar results among shellfishers in Western Kiribati, Micronesia.

3. Later in this chapter, we consider the field processing/transport model in some detail; for now, let us skip over the specifics and the calculations to see how the transport model links shellfishing behavior to the archaeological record.

4. Note that this expectation is relative to a specific goal that, for archaeological purposes, is quite different from maximizing energy return rate while foraging. Whether or not to “take” a specific prey item is predicted by the standard prey choice model. But the assumption here is that the shellfisher’s goal is to maximize the rate at which edible flesh can be *delivered* to a central place. Through this assumption, we can model (in a very specific way) the trade-off between field processing (to increase load utility) and bulk transportation (which leaves more time for foraging). As a result, a forger concerned with maximizing delivery rate will

bulk transport *everything* within the  $z$ -threshold and field process everything beyond that threshold.

5. These predictions regarding prey choice and field processing vary by the age of the foragers involved. Due to the increased costs for children handling some of the resources that fall into their “optimal diet”, the field processing model predicts that when children forage, they should further exaggerate the trend toward the overrepresentation of lower ranked prey (Bird and Bliege Bird, 2000; Bird et al., 2004).

6. This is a “theoretical” assumption, namely that the currency selected is fitness related; there is no assumption of a causal linkage between increased food and the number of descendant traits.

7. For present purposes, we will assume that sea shells have a value of zero utility (meaning that through field processing, one goes from fractional utility to complete utility). On St. Catherines Island, however, is a habitat characterized by a complete lack of lithic raw materials (the nearest such lithic source is 100 km away). This means that lithic toolstone is an extraordinarily expensive commodity in the Sea Islands and, as a result, we find that other, more locally available resources were harnessed to fulfill the role conventionally played by stone tools. Over thousands of years, for instance, discarded potsherds were recycled into abrading tools, used for a variety of manufacturing and maintenance tasks (including scraping hides, smoothing wood or bone, and perhaps even employed as hand grips for fire-drills; see Waring, 1968a: 207; DePratter, 1976; Thomas and Larsen, 1979: 44–47). Similarly, we know that marine shells were commonly fashioned into cutting tools, pounding implements, ornaments, and vessels (e.g., Marquardt, 1992). In subsequent analysis, it would be of interest to explore other goals and currencies related to tool manufacture, trade, and symbolic value of marine shells.

8. Undoubtedly, watercraft were frequently employed by aboriginal foragers on St. Catherines Island for the duration of human occupation. Later in this chapter, we consider the implications of watercraft use as related to transport costs and field processing strategies.

9. The central place/transport model projects that whenever large acorns are collected at a distance of more than 16 km from the residential base, they should be processed prior to transport to residence (Barlow and Heck, 2002: 140). Moderate-sized acorns, on the other hand, should be processed only at distances greater than 25–35 km.

10. As noted in table 8.11, black oak acorns, the preferred acorn fruit among most aboriginal people in California, are considerably larger than the live oak acorns available on St. Catherines Island. Barlow and Heck (2002) emphasize that smaller acorn size generally increases handling costs, and thereby decreases the desirability of field processing prior to transport.

11. Beyond the energetics, there are other important considerations regarding field processing of mast crops. For one thing, removing the hard-shell “packaging” from acorns leaves the nutmeat vulnerable to insects and decay, and provides another incentive for transporting acorns in bulk.

12. We should caution here that our return rate estimates, cited here, are based strictly on “summer

oysters". We are presently attempting to refine these estimates on an annual basis.

13. In their research among the Meriam Island turtle hunters, Bliege Bird and Bird (1997: 56, fn 4) make a start in this direction. They computed the cost of dingy travel by calculating the costs of a 40-hp motor and the attendant fuel costs, dividing the cost of fuel used to hunt turtles against the opportunity lost to purchase chickens, the most abundant and highest ranked terrestrial meat item available.

14. We are aware that Brian McEneaney (University of Utah) has been researching central place transport issues in the offshore islands along the coast of Maine. His work on individually handled intertidal resources (such as oysters, mussels, clams, and whelk) holds great promise for clarifying the relationship of terrestrial and marine transport models.

15. Purdy (1991: 282) has documented a number of circular fired areas amidships in archaeological-recovered dugouts (one of them dating 1100 radiocarbon years B.P.).

16. Meehan (1982: 100) describes a canoe-based expedition by the Anbarra: firewood and drinking water were loaded into a dugout, which was then paddled to the oyster bank where they built a fire on the beach and sometimes stayed overnight.

17. Jones (1873: 53) believes that some dugouts in the Southeast were large enough to convey 40 people.

18. As noted previously, one cannot rely on the Le Moyne drawings for accurate detail regarding material culture (Sturtevant, 1977: 70; Milanich, 2004c).

19. When drought conditions lowered water levels at Newnans Lake (near Gainesville, Florida) the remains of more than 100 dugouts appeared; radiocarbon evidence indicates that 41 of the 55 canoes studied date to the late Archaic period, between 2300 and 5000 B.P. (Wheeler et al., 2003). Investigators measured 95 com-

plete and fragmentary canoes at Newnans Lake; they averaged 4.57–7.06 m long. Some of the dugouts were roughly hewn, averaged 3.6 m in length, were blunted with bow and stern indistinguishable. A second, larger group averaged 5.6 m and had ends that were beveled slightly upwards. A third kind of dugout had overhanging platform ends (see also Newsom and Purdy, 1990).

20. Ames estimates about 3 km/hr for slow canoe paddling (2002: 35)

21. I am grateful to Brian McEneaney for suggesting this possibility.

22. We have already noted, of course, that the size and shape of St. Catherines Island has changed dramatically during the past 5 millennia (see chap. 3) In chapters 29 and 30, we chart the changing shape of St. Catherines Island and estimate the *maximum travel distance* for each cultural period; these estimates will be employed when the central place foraging models are applied to actual archaeological data. For now, it is sufficient to note that 16 km is a reasonable estimate of the maximum one-way terrestrial travel distance throughout the period of human occupation on St. Catherines Island.

23. We must not forget that some shells and/or bones are worked into artifacts. Because St. Catherines Island contains no lithic resources at all, we find that shell and bone tools are commonly present in archaeological deposits. Particularly common are modified whelk shells (converted to hammers and battering tools, gouges, dippers, and shell beads), turtleshell rattles, clamshell beads and disks, and deer bone awls and pins. These completed artifacts (and the byproducts of their manufacture) must be taken into account when considering how accurately midden contents reflect prey procurement.

# CHAPTER 11. FORAGERS AND COLLECTORS, FISHERS, AND FARMERS: IMPLICATIONS FOR ST. CATHERINES ISLAND ARCHAEOLOGY

DAVID HURST THOMAS

In this chapter, we explore the spatial aspects of the behavioral ecology models developed previously. Specifically, we employ the patch choice and central place foraging models to address two interrelated questions:

- Where, specifically, should residential bases (the “central places”) be located?
- What, specifically, should be the mobility strategy? Residential? Logistic? Both?

We begin by building a general model of settlement patterning and residential mobility for the Sea Islands of coastal Georgia, which we then apply to the specifics of St. Catherines Island.

## SUBSISTENCE AND SETTLEMENT STRATEGIES OF THE 16TH/17TH- CENTURY GUALE

In chapter 2, we set out the basic ethnographic basics regarding the Guale Indians who inhabited the Georgia coast until the late 17th century. But we also took note of the conflicting ethnohistorical accounts describing the subsistence and settlements patterns of the aboriginal Guale coast. We now develop this topic in some detail, with specific reference to the archaeological record of St. Catherines Island.

### THE JESUIT COMMENTARY

Building on Swanton’s (1922) all-encompassing synthesis of “The Creek Indians and Their Neighbors”, Lewis Larson narrowed the focus to the Southeastern Coastal Plain (Larson, 1969, 1980a). He found the environmental potential for cultural and social development to be seriously constrained, and argued that poor soil conditions so severely constrained maize horticulture that only a highly dispersed, seasonally mobile population could have survived there.

Contrasting the Guale with the considerably more sedentary groups of Apalachee Florida, Larson suggested that Guale horticulturalists shifted “their cultivation as it became necessary to fallow a field. Because the soils suitable to agriculture occurred in small and widely scattered patches, it was necessary for them to shift their residences each time a new field was opened to cultivation and an old field allowed to lie fallow” (1980a: 221). Larson (1978: 122, 127, 137) argued that whereas agriculture was practiced in late prehistoric times, “its importance seems to have been slight. ... The Guale were a coastal people whose economy was centered on the tidal waters where they derived a subsistence from fishing. Agriculture and hunting were of relatively minor importance” (Larson, 1978: 122, 137).

Larson’s interpretation relies heavily on the surviving Jesuit accounts from their visits to Orista (present-day South Carolina) and the Guale area (coastal Georgia) in 1569 and 1570 (esp. Larson, 1969: 293–297). After abandoning his mission post at Santa Elena and Orista, Fr. Jean Rogel wrote that the Indians<sup>1</sup>

were congregated together [to plant and tend crops], but when the acorns ripened they left me quite alone, all going to the forests, each one to his own quarter, and only met together for certain festivals, which occurred every two months, and this is not always in the same spot. ... The inhabitants of these twenty houses [at the main village of Orista] scattered themselves in twelve or thirteen different villages, some twenty, some ten, some six, and some four. Only two family remains. ... For nine out of the twelve months they wander without any fixed abode (Sturtevant, 1964: 169–170).<sup>2</sup>

Father Antonio Sedeño, who was stationed at the town of Guale, reported that “the people there work and plant and thus have

something to eat” (Zubillaga, 1946: 416), but he found that the villages tended to be small (ranging in population from about 40 people up to settlements with 30 adult males). In another letter, Fr. Sedeño characterized the terrain as “the most miserable thing ever discovered”:

On [the coast] no fruit other than palmettos and wild nuts are found, which are so wretched that there is hardly anyone who takes advantages of them. The animals found are deer, bears, and lions. It is full of large pine forests and unproductive forests; this is the cause ... that the few Indians that there are so scattered; for as they have nothing with which to fell the forest for their plantings, they go where they can find a little land without woods to sow their maize; and as the land is so miserable, they move with their *ranchos* from time to time in search of other lands which can bear fruit. (Zubillaga, 1946: 424)

René Laudonière had a similar impression based on his experiences among the Timucua at Outina (present-day northeastern Florida) in 1564:<sup>3</sup>

“the Indians are accustomed to leave their houses and retire into the woods for a space of three months, namely January, February, and March, during which time you do not see an Indian anywhere, because during this time they only hunt game and live in little cabins in the woods, living upon what they take in the chase. This is the reason why we could get no foodstuffs from them during this period. (Bennett, 1975: 121)<sup>4</sup>

From the accounts of Rogel at Orista and Sedeño at Guale, Larson (1980a: 209) concludes that the fragmented groups observed at planting time correlates with soil distributions, suggesting that the small pockets of various soil types and the general infertility of coastal soils were “the primary reason for the scattered and small size of the agricultural production unit.” Soil depletion, he wrote, required that fields be planted “only a few seasons before they were abandoned or permitted to lie fallow. ... The abandonment of fields brings about a shift not only of the cultivation plot but also of the farmstead because of the small

and scattered areas of soil suitable for tillage” (Larson, 1980a: 218).

Larson concluded that, “The first missionaries in the Guale area complained bitterly about the fact that the Indians neglected agriculture in favor of hunting and fishing, which meant that permanent settlements were not the rule, for long seasonal junkets in pursuit of game mitigated against a settled populace” (Larson, 1978: 122; see also 1969: 293–297; 1980a: 206–209). Aspects of Larson’s views on Guale subsistence and settlement have been shared and amplified by a number of investigators (e.g., Wallace, 1975: 265–271; Pearson, 1977a: 62–63; Crook, 1978b: 48–49, 280, 1984, 1986, 2004; Reitz and Scarry, 1985: 46; Reitz, 1988a, 1988b).

By the mid-1980s, Larson amplified his previous views on Guale subsistence and mobility patterns:

I have argued that Guale agricultural productivity was low; that Guale agricultural technology was swidden technology; that Guale subsistence depended not only on agriculture but also on hunting and gathering. ...

On the Georgia coast extensive areas of soil suitable for agriculture did not exist. The area is broken into small pockets of different kinds of soil, some are too poorly drained, some are too permeable, all are characterized by acidity and poor moisture retention. My understanding of the suitability of the Georgia coast for swidden cultivation bears out the Jesuit commentary on Guale agriculture. Without techniques to renew soil fertility I do not believe the Guale could cultivate a given acreage for many seasons, perhaps for no more than one, without fallowing for a long period, at least 10 years or longer. The small areas of drained (but not too permeable) land made it difficult to cultivate and fallow fields in sequence around a fixed house site let alone a sedentary village. The priests in the post-Jesuit, Franciscan period seem to have brought about a marked change in Guale subsistence by introducing new cultigens and probably new techniques of manuring that allowed long term cultivation of fields. Perhaps more extensive areas could also be cultivated. ... Pre-Franciscan Guale cultivation required other subsistence activity which in turn required that group to disperse at certain times of the year (e.g., in the fall to harvest mast). ...

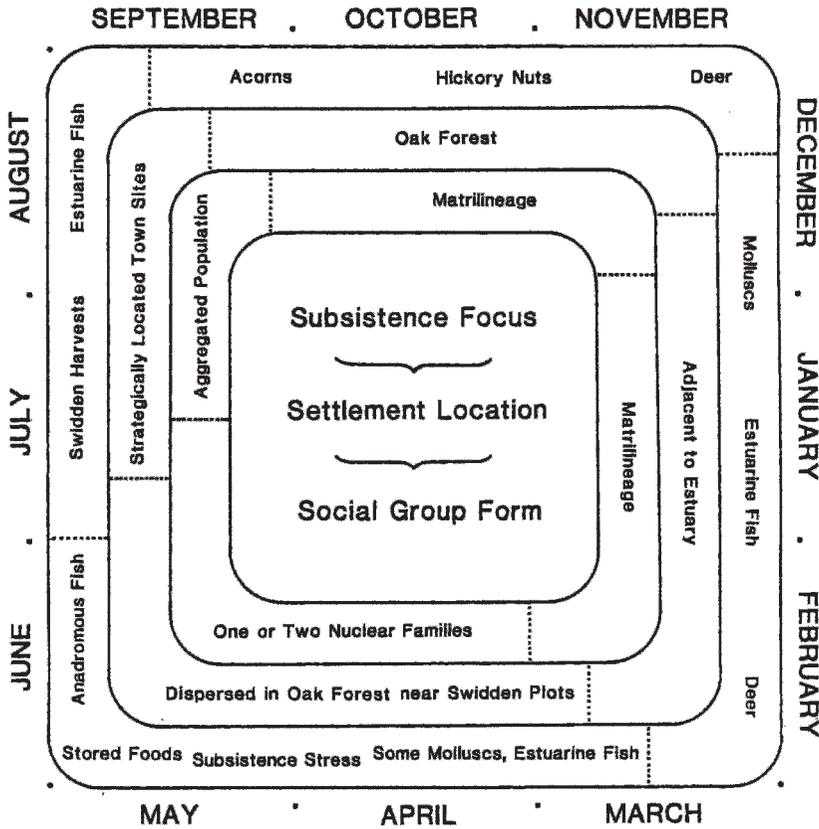


Fig. 11.1. Morgan R. Crook's "Annual Model" of Guale subsistence (after Crook, 1986: fig. 2).

I would no longer characterize the Guale in the same manner as I did in the 1978 paper. ... That paper was written almost 25 years before it was published and apparently circulated in a manuscript form for a number of years. ... I would no longer make the statement that "permanent settlements were not the rule" (1978: 122), and I now feel that the Guale had large permanent towns but that swidden agriculture was the rule and that the populace did seasonally leave the towns to cultivate and exploit other seasonal resources (e.g., acorns).

I did not characterize the Guale as a chiefdom in the 1978 paper because that terminology was not applied by Sahlins and Service until about 1958 or 1959 after Kirchoff's paper was finally published in 1955 and its significance began to be recognized. I did not use the term chiefdom in the dissertation or in the 1980 published version because I did not discuss Guale social organization. However in my own defense I would point out that the 1978 paper certainly discusses the Guale political structure in terms of titles, ranks, territorial

jurisdiction, central leadership, etc. (Lewis Larson, personal communication; cited in Thomas 1987: 60)

Morgan R. Crook, Jr., has translated Larson's perspective into a concrete "Annual Model", reproduced here as figure 11.1 (after Crook, 1986: fig. 2, p. 17; see also Crook, 1984: 260, 1986: 18-20). Arguing that his reconstruction represents a "purely aboriginal form", Crook (1986: 28) defined "four distinctive settlement and seasonal components [that] are indicated within the Guale annual cycle. Each seasonal subsistence activity was executed by particular social units. The form of each social unit was a response to the nature of the resources and the technology available for exploitation."

According to Crook's interpretation, Guale wintertime settlements (mid-December through mid-March) depended primar-

ily on mollusks, estuarine fish, and deer. These minimal settlements consisted of a single matrilineage “dispersed within a more restricted environmental area ... adjacent to tidal streams which permitted access to the estuarine system” (1986: 22). Crook believed that during the springtime (mid-March through June), the Guale dispersed still further, into one or two nuclear family settlements spread throughout the oak forest. These small, “scattered” settlements were located near swidden plots in which the Guale planted maize, beans, and squash. He suggested that springtime was a time of subsistence stress, with the Guale surviving on stored foods, mollusks, and estuarine fish (supplemented by anadromous fish which became available in June). According to Crook’s (1986: 19, 20) “Annual Model”, the Guale then “resided in towns from the first part of July until the middle of September when they dispersed to gather nuts” (Crook, 1986: 20). Summer-time subsistence depended on swidden harvests supplemented by summer-specific fish species (such as sea catfish).

Crook (1986: 21) suggested that by mid-September, the Guale once again dispersed, probably into probably a “matrilineage segment with four or five nuclear families forming the social core,” several related families living together in dispersed settlements located throughout the oak forest, subsisting on acorns, hickory nuts, and communal deer hunts, with occasional aggregation for feasting. Because the “food energy available from the nut harvest was substantial and capable of supporting larger groups in one area than the one or two nuclear families that were involved in the cultivation of swidden plots,” the fall settlements were basically chiefly compounds “defined by towns composed of temporary and changing populations, as opposed to the seasonally stable population of the summer towns. A mico, his wives and children, and members of his lineage were probably permanent occupants of the town site, and exploited nearby oak groves during the acorn season.”

Crook (1986: 53) summarized his “Annual Model” as consisting of “large villages

primarily occupied during the summer, smaller settlements occupied either multi-seasonally or during the fall-winter season, and small sites occupied for very short periods of time do exist.”

More recently, Crook (2004) has presented a “revised mobility model [adjusted] to allow for short-term movement, perhaps by very small groups, from town sites during the summer months for subsistence activities that included oyster collection, fishing, and the exploitation of other resources such as sea turtles. In addition, the ‘winter season’ of settlement along title creeks should be amended to include the late fall months of October and November.” This revised view is represented in table 11.1.

#### DID THE JESUITS GET IT WRONG?

Grant Jones (1978, 1980) has proposed an alternative view of late prehistoric settlement and subsistence patterns along the Georgia coast, a “tentative and exploratory” model. “On the empirical level I believe that [the conventional wisdom, outlined above] has led to an overstatement of the isolation of the Guale from the interior, the unproductivity of Guale horticulture, and the scattered quality of Guale settlements” (Jones, 1978: 189).

At issue here are the specific Jesuit accounts cited above. Whereas Larson and Crook accept the Jesuit evidence at face value, Jones believes that

Guale horticulture ... was sufficiently productive, in combination with other subsistence and productive activities, to account for the presence of permanent towns, a chiefdom level of social organization, temporary federations of chiefdoms under centralized leadership, and long distance trade networks. The chiefdoms were characterized by dual features of political organization and an emphasis on matrilineal succession. ... I strongly suspect that the Guale inhabitants were scattering in order to avoid contact with the missionaries, whom they refused to listen to or accept. Significant factors in their resistance would have been the practice of forced tribute payment in maize to the Santa Elena garrison and the epidemic of 1569–1570, which was blamed on the priests. Sedeño’s letter read as if they were intention-

TABLE 11.1  
**Crook's "Revised Mobility Model" for the Late Prehistoric and Protohistoric Guale**  
 (after Crook, 2004: Table 4)

Season	Subsistence focus	Settlement location	Social group form
Summer (late June–early September)	swidden harvests, estuarine fish, sea turtles	strategically located town sites; limited visits to fishing places	aggregated population; small groups may leave for short fishing trips
Early fall (early September to mid-October)	acorns, hickory nuts, white-tailed deer	dispersed in oak forests; small residential groups remain in towns; periodic reassembly in towns	matrilineages; chiefly lineages remain in towns
Late fall and winter (mid-October to early March)	mollusks, estuarine fish, rarely white-tailed deer	dispersed near tidal creeks and estuaries; periodic reassembly in towns	matrilineages; chiefly lineages remain in towns
Spring (early March to late June)	anadromous fish, some mollusks and estuarine fish, stored foods	dispersed near swidden fields in oak forests/near estuarine areas/lower reaches of freshwater rivers; periodic reassembly in towns to access stored foods	nuclear family matrilineage segments; chiefly lineages remain in towns

ally exaggerating the 'misery' of the land and the recalcitrance of the pagans, perhaps in order to procure a transfer. Rogel's letter is clearly an apology for his abandonment of the mission, placing the blame for his failure on the intransigent natives and the policies of the secular authorities. ... The Jesuit portrait of a highly mobile, dispersed population with insufficient maize to last the year and a weakly developed political system does not conform with the earlier French reports or with subsequent documentation. ... The Jesuit reports were exaggerated and misleading" (Jones, 1978: 179, 191).

Thus, while accepting that the Guale practiced shifting cultivation, Jones (1978: 191–192) believes that the Jesuits mistakenly depicted the Guale as a highly mobile, dispersed population with a weakly developed political system.

In his own reconstruction of Guale subsistence and settlement patterns, Jones (1978: 194) proposed that the Guale lived in "dispersed towns," defined as a small central area surrounded by a forest-marsh area in which there were scattered horticultural plots and associated houses. ... The town center itself seems to have been small, and the bulk of the population was probably distributed among individual farm plots. Unfortunately, population figures are almost entirely lacking for the

sixteenth century, and there is no way of estimating the size of these towns or their outlying dependencies.

In the central area of the principal dispersed towns were located the households of the *mico* or other principal leaders, which included separate houses for their wives. In all probability, close kin of those chiefly individuals also resided in the town center. Towns sometimes contained secondary leaders of the chiefdom as well, and these may have occupied the central area. (Jones, 1978: 191–198)

The ethnohistorical evidence ... provides only a partial description of a Guale town. There is no doubt that there was a town center with a large round community building, a chunky field, and some residential structures. The regular presence of some form of mortuary structure is likely. The town center was surrounded by dispersed households practicing shifting horticulture. Intergroup and intragroup economic exchanges and redistribute systems, in a context of considerable resource variability contributed toward a dependable food supply that probably required little regular seasonal residential mobility. (Jones, 1978: 200)

Whereas Fr. Rogel reported that the Guale dispersed seasonally to gather acorns, Jones (1978: 193) questions whether it was necessary to abandon the "dispersed town" in order to harvest the mast. With respect to shellfish, Jones notes that whereas some im-

portant Guale towns lay beyond the oyster beds, “there is no documentary evidence that [the Guale] spent seasonal periods downstream or along the inland waterways to exploit the oysters.” Citing Robert Sandford’s 1666 account for the North Edisto River (South Carolina), Jones suggests that concentrations of oysters were sufficiently close to the maize fields “that the beds could be exploited without seasonal shifts in residence” (Jones, 1978: 193).

Jones (1978: 193) also takes specific note of Rogel’s “enthusiastic” letter of 1568 that boasts of “very good laborers. They cultivate the soil and plant and harvest maize in its season. And during the winter, when the soil cannot be cultivated, they devote themselves to hunting deer and wild turkeys, of which there are so many there they never come back empty handed.” But, Jones adds that “Rogel did not say that the hunters actually changed residence during the winter, and I have not found any earlier documents to indicate a seasonal residential pattern based either on winter hunting or winter oyster collecting. The location of Guale settlements along rivers and tidal creeks seems to have actually been a strategic measure to be near shellfish, hunting grounds, and horticultural lands without having to change residence seasonally.”

Grant Jones (1978: 209) summarizes his position this way:

Larson’s ... reliance on the Jesuit view of the sixteenth century-Guale ... led him to consider the Guale as an isolated, distinctive adaptation. While it is significant that the Guale were adapted to special environmental conditions, I have argued that these conditions neither created isolation nor impeded the development of a complex level of sociocultural integration. ... Despite their environmental and adaptive differences, the Guale and the interior groups shared such basic features as chiefdoms, military federations, matrilineality, and dual aspects of organization. ... [I]t is of considerable theoretical importance that such an exploration eventually be attempted, for the Guale case seems to demonstrate that more than one set of adaptive conditions may well combine to create highly similar features.

#### ANTICIPATING THE ARCHAEOLOGICAL RECORD

Although the details have blurred somewhat with the various restatements, the Larson/Crook and Jones reconstructions of Guale subsistence and settlement pattern provides a solid point of departure for approaching the archaeology of St. Catherines Island.<sup>5</sup> Clearly, the “Guale problem” turns on issues of economic intensification and residential mobility.

Relying heavily on the Jesuit commentaries, the Larson/Crook interpretation downplays the importance of maize agriculture in the prehistoric Guale diet. The argument goes like this: The Guale practiced swidden agriculture on poorly drained, isolated pockets of highly acidic soils that required extensive fallow period (at least a decade) between harvests. The agricultural patches were difficult to cultivate, and the lengthy fallow sequence precluded settlement around a fixed house site, let alone a sedentary village. That is, due to seasonal variability, shortages of agricultural produce, and local variability in resource base, the Guale were forced to practice shifting cultivation, with highly dispersed settlements, and relatively small-scale mobile exploitative units moving frequently in search of fallow land. Viewed from the perspective of human behavioral ecology, the Larson/Crook interpretation suggests—not that maize agriculture was too poor—but rather that exploiting the higher ranked foraging choices will offer better opportunities than did settling down near the corn fields and acorn groves. This interpretation suggests that the Guale should abandon their fields and caches whenever a higher ranking foraging opportunity presented itself by residually moving directly to those patches.

In contrast, Jones believes that this view overstates the unproductivity of Guale horticulture and the scattered nature of Guale settlements (Jones, 1978:189): “Guale horticulture, I suggest, was sufficiently productive, in combination with other subsistence and productive activities, to account for the presence of permanent towns, a chiefdom level of social organization, temporary fed-

erations of chiefdoms under centralized leadership, and long distance trade networks.” Expressed as human behavioral ecology, the Jones position holds that those foraging opportunities ranked higher than maize cultivation were insufficiently productive to make residential shifts worthwhile. By this view, the Guale certainly foraged for higher ranking resources, but they did so through logistical movement between residential bases and procurement patches.

Chapter 10 took exception to the general expectation that growing maize—and farming in general—invariably yields a net increase in harvested food energy over that provided by foraging alone (which has conventionally been viewed as less productive, less reliable, and certainly less desirable). So viewed, farming alleviates the uncertainties of foraging, provides additional leisure time, and inevitably leads to cultural elaboration, as expressed in art, public architecture, and public feasting. Adopting the perspective of human behavioral ecology, we view the decision to cultivate (or not) as the outcome of a sequence of foraging decisions made at various points throughout the growing season. The degree to which someone elects to forage or to farm depends on the anticipation of projected returns in food energy for each activity. The long-term aggregate of such decisions determines whether an individual, a household, or a community will pursue “farming”, “foraging”, or “mixed” subsistence strategies for that given year. Farming investments should intensify when higher ranked foraging opportunities diminish, and farming activities should decrease when higher ranked foraging opportunities increase.

This conclusion—forage when you can and farm when you must—runs contrary to much archaeological literature. Rather than viewing maize horticulture as a cultural complex or a all-encompassing lifestyle (to be embraced or rejected), we approach aboriginal farming practices on the Sea Islands as an amalgam of economic behaviors of varied intensity and complexity, depending on the circumstances at hand. Adoption of maize cultivation did not trigger a transition from foraging life to farming life. In

fact, we think that the emergence of maize horticulture was actually accompanied by a substantial *increase* in the need for collective human labor in order to effectively implement such a system. In the next chapter, we set out the specifics of an archaeological research design appropriate for determining the antiquity and importance of maize horticulture to the aboriginal people of St. Catherines Island.

Beyond the relative importance of maize horticulture, the “Guale problem” also raises issues about patterns of settlement and mobility. As noted above, the earliest ethnohistorical sources suggest a pattern of significant residential mobility and seasonal dispersal. Accepting this evidence at face value, Crook (1986, 2004) proposed a fission–fusion settlement model for the pre-contact Guale people (as discussed above).

Analyzing these same documentary sources, Grant Jones (1978: 179, 191) concluded that the Jesuit reports deliberately exaggerating the “misery” of the land. Specifically with regard to settlement pattern and mobility, Jones (1980: 220) concluded that most Guale “apparently maintained permanent residence in a single community.” As with the issue of horticultural intensity, we can turn to the archaeological record to address the issue of variability of residential settlement patterns.

#### ADDRESSING VARIABILITY IN FORAGER SETTLEMENTS

Before we can derive concrete hypotheses about the aboriginal settlement patterning on St. Catherines Island, we must merge the available ethnohistorical evidence with a more precise terminology appropriate to addressing a foraging landscape from the perspective of human behavioral ecology. In this section, we will define more specifically the nature of residential and satellite settlements that comprise the biogeographic nexus along the Georgia coast.

#### THE RESIDENTIAL BASE

It is axiomatic that foragers live in residential base camps—what Julian Steward

(1933: 238) termed the “headquarters” and Lewis Binford (1980: 9) called “the hub of all subsistence activities” (see also Thomas, 1983a: chap. 5; Kelly, 1985: chap. 4). When speaking of part-time horticultural societies, researchers more commonly use the terms “town” or “villages” to denote these residential settlements (e.g., Swanton, 1946: 629; Jones, 1978: 191–200). But the differences are can readily be subsumed under the term “residential base”, which is appropriate to settlements inhabited by foragers and collectors, fishers, and farmers.

Although the ethnohistoric sources fail to provide a single, all-encompassing description of a Guale “residential base” or “town”, it is possible to piece together a composite description from multiple observers, including Lucas Vázquez de Ayllón ([1526] in de Oviedo, 1959), René Laudonnière, and Jacques le Moyne de Morgues ([1564] in Lorant, 1946: 5–120), Fr. Fray Andrés de San Miguel ([1595]; de San Miguel, 2001), William Hilton ([1663] 1911), Robert Sandford ([1666] 1911), and Jonathan Dickinson [1699] 1975). Virtually all Guale “towns” contained the chiefly compound, the principal residence of the *mico* and/or other major leaders, with separate houses for their wives. On the Georgia coast, residential bases also contained a number of public facilities, including a large, round communal council house capable of sleeping several hundred people (called by the Spanish the *buhío*) and a large field (or plaza) for playing the chunky game, plus a large and scattered assortment of everyday residential houses with outlying horticultural fields. Because the Guale residential bases served as centers for economic exchange and chiefly redistribution, they generally contained public (and private) granaries and storage facilities. Sometimes, the Guale erected a special building to contain the remains of the dead (de San Miguel, 2001; Jones, 1978: 198; Swanton, 1922: 92–93; 1946: 406). While some of these manifestations were likely added during late prehistoric times, some form of residential base doubtless characterized central-place settlements of foragers for thousands of years along

the Georgia coast. The specific nature of the archaeological assemblages deposited there and their degree of archaeological visibility varies broadly, depending in large part of how the base camps were integrated into the overall subsistence and social framework.

Base camps are typically positioned to provide adequate life-space, protection from the elements, and a location central to subsistence resources (Binford, 1980; Wagner, 1980: chap. 8; Kelly, 1995: chap. 4; Binford and Binford, 1966: 268; Fitzhugh and Habu, 2002; Zeanah, 2003, 2004; Kennett, 2005). The exact location of a residential base might be conditioned largely by access to drinking water, firewood, and a well-drained, relatively flat terrain that would allow for the establishment of a community. And for marine foragers, siting of a residential base might also involve consideration of the potential landing locations and docking areas for watercraft.

Although the specifics of the two landscapes differ markedly, we can draw some insights from the work of David Sanger and his colleagues on the prehistoric coastal settlement pattern of the Boothbay region of central Maine (esp. Sanger, 1996; Kellogg, 1994: 78). The aboriginal settlement pattern along this complex, predominantly rock coastline clearly reflects an adaptation to the use of small boats along the coastline, where a primary concern is access between the terrestrial and marine environments. Along the Boothbay coastline, foragers settled around adequate boat landing spots, meaning that most archaeological sites are located within 100 m of the beach shoreline, generally in places protected from storm waves. Sanger (1996) and Kellogg (1994) demonstrated that factors other than food sources dictated settlement choice along the coast of central Maine. In particular, shelter from wind and the availability of a beach suitable for landing small watercraft were more important, as was proximity to travel routes. “It should be noted ... that, with suitable boat technology, distance from camp to food source may not be as critical as it would be to pedestrian hunter-gatherers”

(Sanger, 1996: 517). Erosion is likewise a important factor. The “ideal” settlements are thus situated at the confluence of a few, relatively rare environmental factors; “viewed in this framework, the archaeological record becomes an artifact of several intersecting variables, some cultural and some not” (Sanger, 1996: 517).

As we emphasized in chapter 10, the residential base can be viewed analytically as a “central place”, in the parlance of human behavior ecology. This way, we can address the degree to which a forager maximizes the energetic return to the home/nest/central place (Orians and Pearson, 1979; Stephens and Krebs, 1986). Metcalfe and Barlow (1992) employed the general assumptions of central place foraging theory to model field-processing and transport behavior of human foragers. Central place foraging is grounded in the critical importance of the residential base as a locus for provisioning offspring, mates or potential mates, or other family or group members. By centralizing such activities, foragers can greatly reduce processing costs by taking advantage of the facilities and people who are unavailable for field processing. Such models likewise assume that efficient strategies will produce a net yield of food at the residential base (thereby increasing the “fitness” of foragers). And importantly, central place models apply best to long-term behaviors—those involving multiple episodes of collection and transport—precisely the kind of behaviors that are reflected in the archaeological record.

Foraging theory also emphasizes that the residential base, as a central place, “represents an agglomeration of activities carried out by people with different foraging goals (men, women, elderly, children, high status, low status, etc.)” (Kennett, 2005: 224). Older children commonly participate in day-long or partial-day food procurement trips within about 5 km of camp, and women often bring along infants, who are carried along with the food items being collected (e.g., Meehan, 1977a, 1982; Blurton Jones and Sibly, 1978; Hawkes et al., 1989; Bird and Bliege Bird, 2000, 2002; Barlow and Heck, 2002: 141).

## THE FIELD CAMP

Foragers and part-time horticulturalists commonly employ “field camps” as temporary centers of operation, places where a special-purpose task groups sleep, eat, and otherwise maintain themselves while absent from the residential base (Binford, 1980: 10). Field camps are established whenever task groups are required to travel beyond the daily foraging radius (discussed below). On the Georgia coast, field camps might include field houses (constructed near the maize fields), fish camps, turtling stations, and acorn camps.

Because people actually *live* at a field camp, its position is partially determined by the same factors conditioning residential base camp placement (including shelter, fuel, temporary food supplies, and water). But domestic criteria can readily be swamped by transport costs of bulky resources, the distance to mass collecting facilities (such as fish weirs and deer drive fences), or the whereabouts of convenience places to land a watercraft. Field camps are usually task specific and their structure is quite variable, reflecting the differentiation in both target resources and overall positioning strategies.<sup>6</sup>

When procurement and consumption occur in different places, the archaeological record should be heavily conditioned by the nature of resource transport from field camps/locations to residential bases. As Binford (1978) has noted with regard to faunal remains, “what is left in the field cannot end up at home, and vice versa, field and residential assemblages will present opposite pictures of essentially the same strategic position” (see also Bettinger et al., 1997: 887).

## THE LOCATION

“Procurement locations” are places where foragers carry out their daily extractive activities—collecting shellfish, gathering acorns, ambushing game, harvesting nesting loggerheads, operating fish traps, and so forth.

Meehan (1982: 86) has described the “dinnertime camp”, a specialized kind of procurement and processing location some-

times used by Anbarra shellfishers. While many Anbarra shellfish collectors return home to cook the haul, some elect to tarry in so-called dinnertime camps, which are located near the shell beds just harvested and sometimes only a short distance from home base. Meehan (1982: 100) describes one canoe-based expedition in which the Anbarra loaded firewood and drinking water into a dugout, then paddled to the oyster bank. After harvesting was complete, they returned to a “dinnertime camp”, commonly situated in a well-watered, shady place—sometimes quite close to a beach. They built hot, quick fires to open the bivalves, which are piled amid brush and then torched. Sometimes the foragers ate the extracted meat on the spot, but they also prepared cooked flesh and raw meat in the shell for transport back home (Meehan, 1982: 112). In the old days, they used pointed stone and bone tools to break up the shell and pick out the flesh. Today, they use a hammer and nail for the same purpose. Although many dinnertime camps were used only once, those in favorable locales were used repeatedly. These processing sites had little internal structure—maybe a couple of hearths, discrete piles of shellfish, and some other debris. Sometimes, the Anbarra spend the night (which technically, would make these places “field camps” rather than “procurement locations”).

On St. Catherines Island, terrestrial foragers could have established dinnertime camps up and down the shoreline from the residential base, basically as “jumping off points” for work parties to exploit near-shore oyster bars. Shellfishers could even shuttle back and forth, between island-based dinnertime camps and procurement locations in the marsh, with cooking and collecting taking place simultaneously.

But given the high terrestrial transport thresholds of the St. Catherines Island resource base and the availability of watercraft (see chap. 6, this volume), we hypothesize that most resources were transported in bulk, with relatively little field processing. If so, then procurement locations may have a very low archaeological visibility because both spent processing tools and ined-

ible byproducts were generally discarded at the residential base.

#### THE CACHE

We have already discussed a number of ethnohistoric accounts of large-scale storing facilities constructed by aboriginal people of the Georgia coast (see chap. 7 and 8). In the Jacques Le Moyne drawing “Storing Their Crops in the Public Granary” (reproduced as fig. 9.2, this volume) we see a “low and roomy” thatched wattle and daub granary, used to store “an abundance of fruits gathered twice a year, carried home in canoes.” Such caches commonly contained corn cribs, smoked fish, shellfish, meat, and storable plant foods including mast. As noted above, some of these storage caches were public, with access strictly controlled by the cacique, and others belonged to private households.

In this context, DeBoer (1988) suggests that across much of eastern North America, storage facilities commonly shift from belowground to aboveground facilities. DeBoer associates belowground pit storage with a strategy of seasonal mobility (and attempts to hide surplus from political elites, enemies, etc.) and correlates aboveground granaries with sedentism, sociopolitical complexity, and so forth. Although the Island-wide survey lacks the fine-grained, community-level information to address this issue, DeBoer’s (1988) suggestion raises a question about whether storage pits *ever* occurred on St. Catherines Island because the use of strictly aboveground storage features would certainly carry implications about mobility that would be relevant for resolving the “Guale problem.”

#### THE STATION

A “station” is where a special-purpose task group engages in information gathering (Binford, 1980: 12). In figure 8.3, we reproduced Le Moyne’s rendering of Timucuan alligator hunting (Lorant, 1946: 87), showing how hunters erected “a little hut full of cracks and holes” near the river, from which a spotter monitored movement

of alligators in the marsh, alerting his companions when a likely target prey was located. Stations may also have been established to look out for nesting sea turtles.

### HUMAN FORAGING ZONES

These various human settlements—residential bases, field camps, locations, and so forth—are articulated in an overarching foraging landscape. In figure 11.2, we set out a generalized model of the concentric foraging zones that interrelate the various settlement types.<sup>7</sup>

#### THE CAMPGROUND RADIUS

The innermost circle is the *campground radius*, the zone containing the immediate working of the residential base (after Binford, 1982; see also Thomas, 1983a: 87; Kelly, 1995: 128; Fitzhugh and Habu, 2002). Wild food resources within a campground radius are typically overexploited and contribute relatively little to the diet. Localized, nonfood resources (especially firewood and water) are critical in determining the positioning of residential bases (and, hence, the associated campground radius). This nearby zone also typically contains other lightly exploited resources, such as basketry materials and various roots and herbs for medicines, as well as a close-by hinterland for low-density encounter hunting of small game, such as rodents, reptiles, and birds. Horticultural fields (if present) typically fringe the campground radius. The campground generally extends for a kilometer or so (although this distance can vary considerably, especially if the base camp straddles an edge between terrestrial and tidewater resources).

#### THE EFFECTIVE FORAGING RADIUS

The *effective foraging radius* extends beyond the campground radius to include the zone systematically searched and exploited by task-specific work parties and individual foragers who leave the residence to forage, but return home each night. Some horticultural fields can also be positioned within the

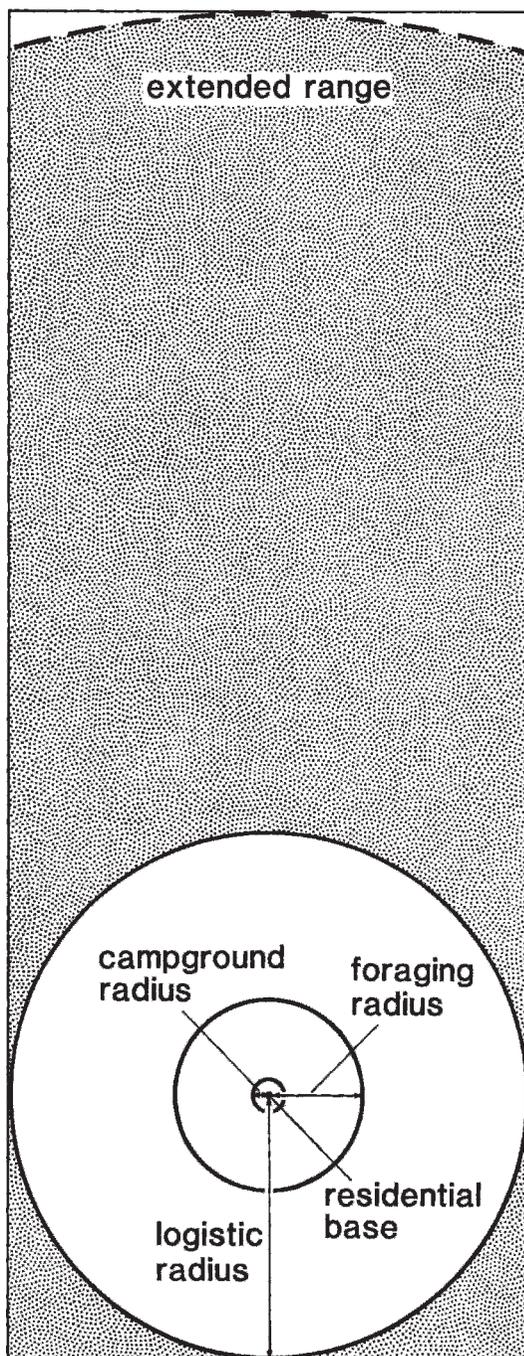


Fig. 11.2. An idealized model of logistic foraging around a central place (after Thomas, 1983a: fig. 11).

effective foraging radius (sometimes with diurnal field houses erected for temporary shelter for those protecting the crops). A broad range of resource procurement locations can occur within the foraging radius, including areas for plant and shellfish harvesting, fishing, encounter and limited intercept hunting, salt collection, and clay procurement. Beyond this distance, it is generally more efficient to establish a field camp for overnight accommodation of work parties. In the case of high-bulk resources, residential bases are commonly re-established to be nearer to that resource (to minimize transport costs).

The foraging radius basically defines where groups range daily during their stay at a given residential camp, effectively delimiting the point of diminishing returns as “largely a product of the return rates of the available resources and the degree of dependence on them” (Kelly, 1995: 135). Binford (1980) suggests that in terrestrial landscapes, this foraging radius is rarely more than 10 km or so beyond the residential base, and Kelly (1995: 135) employs a relatively conservative figure of 4–6 km.<sup>8</sup> Bettinger et al. (1997: 896) suggest that most hunter-gatherers restrict their daily foraging within a 2-hr, one-way travel time distance (which, at a walking rate of 3–5 km/hr, likewise defines an effective foraging radius of 6–10 km. But Barlow and Heck (2002: 140) note that tropical foragers routinely employ a 16-km daily foraging radius, returning loads of 3–18 kg of seeds or nuts from procurement locations to their base camps (see also Jones and Madsen, 1989; Rhode, 1990; Barlow et al., 1993; Zeanah, 2000).

The extensive use of dugouts, rafts, and canoes could dramatically increase the effective foraging range and lower transport costs of bringing food resources back to the island-based residential area. The importance of boat transport lies in the ability to move and process large amount of resources, even across small distances, “thus easing potential problems in intensification of production and simultaneously opening possibilities for intensification that would otherwise not be economical” (Ames,

2002: 47). By extending the foraging range, watercraft play such a major role in exploiting marine habitats, simultaneously broadening the effective foraging radius and lowering transport costs. In his study of aquatic foraging, Ames concludes that the size of hinterlands—as defined by the effective foraging radius—is surprisingly similar between terrestrial and aquatic hunter-gatherers (2002: 46). This suggests that the transport capacity of watercraft allow more time spent foraging, multiple day trips, and the ability to haul large and bulky loads. By significantly lowering the terrestrial transport thresholds, waterborne transport likely enables aquatic foragers to concentrate bulk processing of both marine and terrestrial resources at the residential home base.

#### THE LOGISTIC RADIUS

Still further out is the *logistic radius*, the economic zone exploited by specialized task groups who stay away from the residential base overnight (or longer). Among logistically organized groups, such field camps might be inhabited for a matter of weeks, even months. Each of these economic zones exists within the *extended range*, an area commonly monitored relative to resource abundance and distribution. The extent of the extended range varies broadly and is heavily conditioned by the resources involved and the nature of the intergroup communication. Southeastern Indians living inland, for instance, commonly sent out winter hunting parties in the winter and springtime fishing groups, sometimes ranging as far as 200 or 300 miles. Runners sometimes kept these logistic parties in touch with those remaining at the residential base (Hudson, 1976: 272). As we will explore below, the degree of logistical organization along the aboriginal Georgia coast remains a matter of considerable controversy (e.g., Larson, 1969, 1978, 1980a; Jones, 1978: 200; Crook, 1986, 2004; Thomas, 1986a) and, in fact, constitutes one of the primary research agendas of the present monograph.

The field processing/transport model (discussed in chap. 10) suggests that, as

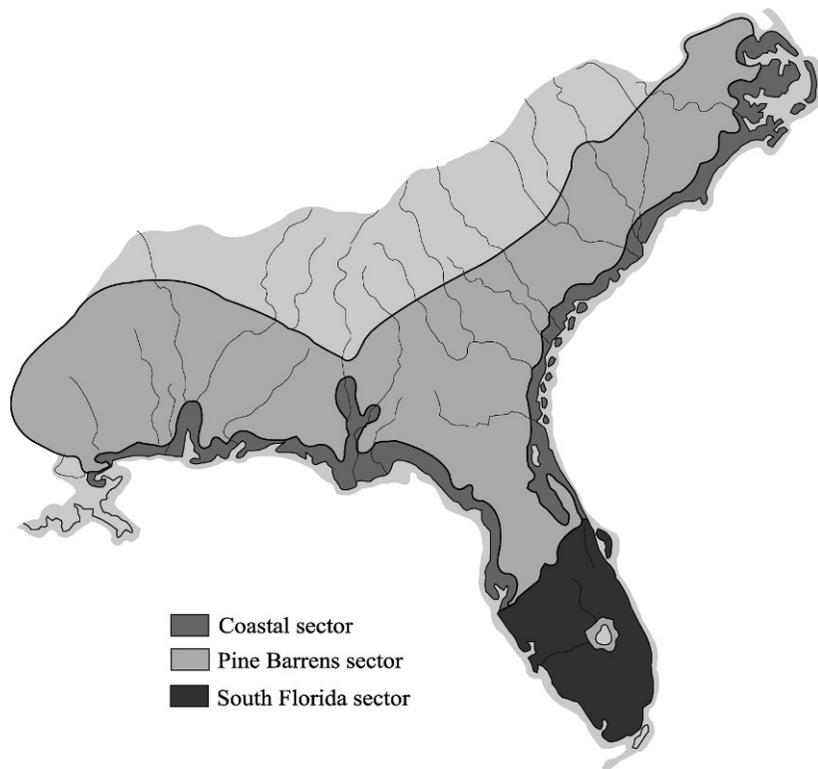


Fig. 11.3. The Southeastern coastal plain, subdivided into Lewis Larson's three sectors: Coastal sector, Pine Barrens sector, and South Florida sector (after Larson, 1980a: fig. 1).

search and transport costs increase with increased distance from the residential base, the lower ranked resources drop off the list of food items that can be harvested profitably. These models provide a way to address the "effective foraging radius" that defines the limit of profitability for a given resource—meaning that as the distance from the residential base increases, foragers more frequently limit their attention to high-return prey. As the return rate declines, so does the effective foraging radius for that resource. Central place foraging models can also help determine whether the circumstances that consider resources, should be brought home whole or be processed prior to transport.

#### BUILDING A SEA ISLAND SETTLEMENT MODEL

Returning to the specifics of aboriginal foraging on the Georgia coast, we must

now redefine the scale of analysis to fit the archaeological realities at hand. In his now-classic study of the Southeastern coastal plain, Lewis Larson (1969, 1980a) subdivided his eight-state target universe into five *sectors*, each defined as "that area of biotic and abiotic features exploited or capable of exploitation by a single society using a limited variety of techniques during a calendar year" (Larson, 1980a: 4): the coastal sector, south Florida sector, the pine barrens sector, the interior valley sector, and the lower Mississippi valley sector (fig. 11.3).

Of particular relevance here, of course, is the coastal sector, spanning the Atlantic seaboard from Cape Hatteras (North Carolina) southward to Cape Canaveral (Florida) and the Gulf of Mexico, from Tampa Bay north and westward to the Texas Gulf coast. Within the coastal sector, Larson (1969, 1980a: chap. 2) recognized three primary subdivisions, the strand, the lagoon and marsh, and the delta sectors. So de-

fined, Larson’s “coastal sector” spanned a 1300-mile-line coastline (more than 2000 km), a suitable province for his purposes—“to identify different adaptive areas ... at the time of European contact” (1980a: 5)—but much too large for our present purposes.

We will constrain the focus of this study specifically to Georgia’s so-called Sea Islands (or, more poetically, the “Golden Isles” of coastal Georgia; see fig. 5.1). So defined, the study area includes about 175 km of Atlantic coastline, including eight major barrier islands, their outliers, and associated marshlands (tables 11.2 and 11.3).<sup>9</sup> To develop a foraging model relevant to the entire Sea Island complex of coastal Georgia (not just St. Catherines Island), we briefly consider the dynamics of barrier island formation, after which we can define the five major patch types appropriate to this study.

BARRIER ISLAND DYNAMICS

Barrier islands are typically elongate concentrations of unconsolidated sands (or other sediments) that run parallel to coastlines with gentle slopes and moderate tidal ranges. Barriers comprise roughly 15 percent of the world’s coastlines, found along the edges of all continents except Antarctica (Hayes, 1979; Davis and FitzGerald, 2004: 133). Barrier islands are most conspicuous along the eastern seaboard of North America, where they extend southward from New England, down the Atlantic coast, around the Gulf of Mexico south to Mexico. Although the Pacific Coast has several “barrier beaches,” true barrier islands are absent.

Forming a barrier island requires a huge supply of sand and a moderate level of wave energy to shape the island (typically as spits, drowned dune ridges, or sand bars). The longest of these islands can extend 160 km or more, but barrier islands are more typically truncated by tidal inlets; the number of such inlets (and hence, the length of the island), reflects the combined forces of waves and tides. Longer barrier islands typically form in places of low tidal range and moderate to high wave energy.

TABLE 11.2  
Plant Zonation Across a Typical Georgia Barrier Island (After Clayton et al., 1992: Table 3.6)

Lower salt marsh	Upper salt marsh	Forest-marsh transition	Freshwater wetlands	Maritime forest	Dune forest	Backdune	Interdune meadows	Foredune
<i>Spartina alterniflora</i>	glasswort sea ox-eye daisy	sea ox-eye daisy salt meadow hay	cattail rush willow	oak red cedar palmetto	live oak wax myrtle yaupon holly	wax myrtle saw palmetto buckthorn	wax myrtle yuca cabbage palmetto	sea oats beach grass panic grass
	spike grass salt meadow hay <i>Spartina alterniflora</i> <i>Juncus</i> sp.	marsh elder grousel tree red cedar yaupon holly wax myrtle cabbage palmetto		pine red bay	red bay saw palmetto buckthorn Virginia creeper <i>Smilax</i>	yaupon holly <i>Smilax</i> prickly pear cactus yuca	slash pine <i>Smilax</i>	beach croton beach pennywort sandspur Russian thistle

TABLE 11.3  
**Size and Geometry of the Georgia Sea Islands (Data from Griffin and Vernon, 1984)**

Island name	Max length (km)	Max width (km)	L/W	Max elev. (m)	High ground <sup>a</sup> (ha)
Tybee/Little Tybee	4.4	4.0	1.10	4.6	1250
Wassaw	8.7	3.2	2.72	4.0	1000
Ossabaw	14.6	8.7	1.68	4.6	4800
St. Catherines	16.4	5.5	2.98	6.0	2900
Sapelo/Blackbeard	19.0	7.6	2.50	7.5	6000
Wolf	4.8	4.2	1.14	1.5	—
Little St. Simons	8.4	5.8	1.45	8.5	950
St. Simons/Sea Island	18.7	6.1	3.07	6.5	5450
Jekyll	11.9	3.7	3.22	9	1800
Cumberland/Little Cumberland	26.4	6	4.40	13	6750

<sup>a</sup> Acreages include forested area, pastures, beaches and dunes, and freshwater marsh and ponds (salt marsh excluded); based on contemporary U.S.G.S. maps, after Johnson et al. (1974: table 4).

The width of barrier islands is a function of sediment supply and sea-level fluctuations. Conventionally, rising eustatic sea level causes erosion and landward transgression (retreat) of most barrier islands. But when islands receive large amounts of sediments, they can prograde (build seaward) despite rising sea levels. Island width also reflects prevailing wind patterns because cross-island winds promote the formation of large transverse dunes (in contrast, narrow barrier islands are common in places with prevailing winds blowing along the barrier axis).

Barrier islands are usually backed on the landward side by estuaries and wetlands, which may range in size from small lagoons to extensive sounds. These estuaries are extraordinarily productive, critical in the life cycle of numerous open ocean species. The beaches, dunes, and inlets associated with barrier islands effectively protect the coastline from severe storms by absorbing the power of waves and storm systems common to the open sea. These are extremely dynamic ecosystems, shaped and regulated by wind, wave, and tidal energies.

The Georgia Bight exhibits the systematic alteration of coastal morphology, largely the product of differential wave and tidal energy, which is itself a function of continental shelf width (Nummedal et al., 1977; Hayes, 1979; Davis and FitzGerald, 2004: 161–163; see fig. 11.4). That is, along the

arcate-shaped coastline from Cape Hatteras to Cape Canaveral, the broad continental shelf tends to increase the amplification of the tidal wave as it moves landward, resulting in larger tidal ranges. Conversely, the inner continental shelf flattens out along this same coastline, which attenuates a large proportion of deep-water wave energy. In general, then, tidal energy increases and wave energy decreases from North Carolina to Georgia, creating dramatic differences in the barrier island system along the Georgia Bight.

Within the Georgia Bight, Zeigler (1959: 225–226) recognized three kinds of barrier islands—erosion remnant islands, marsh islands, and beach-ridge islands. To the north, the wave-dominated Outer Banks consist of long, linear beach-ridge barriers punctuated by a few tidal inlets and separated from the mainland by broad, shallow estuaries. Loftfield (1988: 106) has extolled the climate and richness of the central coast of North Carolina “the reliability of which is equaled in few other areas of eastern North America.” But he also cautions that “the area of great food productivity is not geographically extensive” and laments that the barrier islands of the North Carolina coast “produce limited food because they are physically small, are composed almost entirely of unconsolidated beach sand, and experience severe climatic impacts from ocean winds, salt spray, and irregular mas-

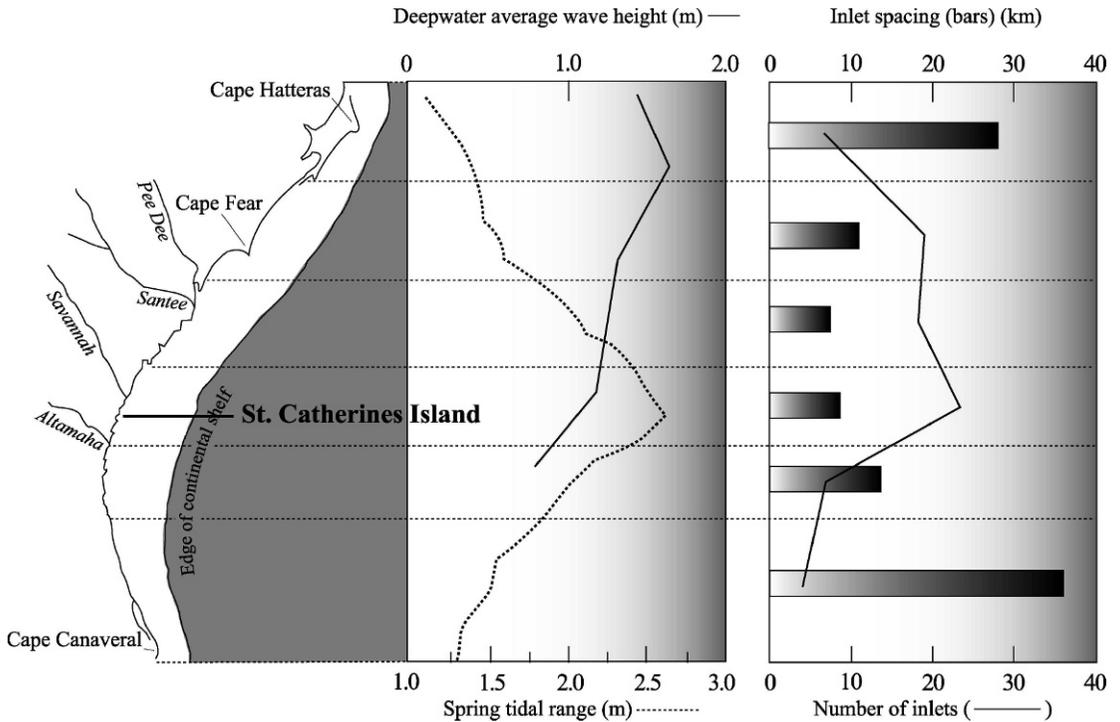


Fig. 11.4. The barrier island configuration along the Georgia Bight demonstrates a systematic change in coastal morphology, largely the product of change in wave versus tidal energy, which itself is a function of continental shelf width (after Davis and Fitzgerald, 2005: fig. 8.27).

sive damage from hurricanes.” From an aboriginal foraging perspective, then, it is the configuration of the barrier islands along the North Carolina coastline (the mainland shoreline), which provides primary access to the resource-rich estuaries, salt marshes, and swamps.

In contrast, the mixed energy ecosystem of the Georgia coastline hosts a series of relatively short beach-ridge barriers, separated from one another by large tidal sounds with well-developed sand shoals. Such *erosion remnant islands* are found only south of Charleston, extending along the Georgia coastline to the Florida boundary (evident as the Silver Bluff terrace, which is named for a riverbank exposure about 4 km downstream from Augusta, on the South Carolina side of the Savannah River; Cooke, 1943; MacNeil, 1950). Although the Silver Bluff formation centers on the State of Georgia, it retains some geomorphic identity into South Carolina and Florida, where this formation occurs either as an

onshore terrace or a series of onshore dunes. But the barrier island expression of the Silver Bluff formation is restricted to the Georgia coastline. The topography of such erosion remnant islands is distinctive and “in no way resembles beach-ridge or barrier-beach topography” (Zeigler, 1959: 232). Even though the surface cover of these islands is sand, ancient dune topography is entirely absent and the surface appearance and lithology resembles that of the mainland.

Particularly south of the Edisto River (South Carolina), the barrier islands are separated by sounds; north of there are only vast marshes, narrow beach-ridge islands, and fewer rivers (Zeigler, 1959: 224). The Silver Bluff lagoon and salt marsh is 6.5–8 km wide along much of this coast (Hails and Hoyt, 1969: 58). Such barrier islands along the Georgia coast tend to be relatively short and broad, averaging only 8 km long—and contrasting markedly with barrier islands further north and southward,

which attain lengths as long as 38 km (Brown, 1977; Hayes, 1994; Thieme, 2005). The Georgia Sea Islands are separated by large estuaries and backed by extensive salt marshes. This well-defined band of broad marshes (4–5 km wide) developed into a long, narrow valley, extending continuously for more than 175 km from the Savannah River southward to the St. Marys River.

The largest of Georgia's Sea Islands consist of a Pleistocene-aged core of beach and dune sediments with well-developed podsols and humate zones. Holocene-age beach and dune ridge complexes, with less obvious soil development, are typically "docked" on the southern reaches of these large islands (see chap. 3, this volume).<sup>10</sup> The barrier islands are separated from the mainland by extensive salt marshes that likewise formed contemporaneously with the Pleistocene parts of the islands, then reflooded during the Holocene sea level rise (Oertel, 1975; DePratter and Howard, 1977, 1980). The in-shore zone includes the waters along beaches, in salt marsh estuaries, or in riverine estuaries. Narrow expanses of salt marsh habitat are occasionally sandwiched between the forested barrier island interiors and protective dune beach ridges. The general ecological configuration of the Georgia barrier islands has been summarized in figures 11.4 and 11.5.

The subsequent, Holocene-age barrier system along the Georgia Bight is characterized by low relief, comprised of fine- to medium-grained quartz sands. Holocene barrier islands range in length from 10 to 30 km, ranging in width from 3 to 6 km (Hails and Hoyt, 1969: 62); they are much shorter and broader than barriers along the North Carolina shoreline (table 11.1; Hayden and Dolan, 1979; Howard and Frey, 1980: 69). The largest of the Holocene barriers along the Georgia coastline are found to the south of the Savannah and Altamaha Rivers (including the eastern part of Ossabaw Island, Tybee and Wassaw Island, Little St. Simons, Sea Island, and the southeastern corner of St. Simons Island). Smaller Holocene barriers include the northern end of Cumberland, south end of

Jekyll, Sapelo Island Beach, Blackbeard Island, and the south and eastern parts of St. Catherines Island.<sup>11</sup> We believe that St. Catherines Island is the only place along the Georgia coastline where Pleistocene deposits are being directly eroded into the Atlantic Ocean.

The Pleistocene-age deposits of the Silver Bluff terrace have deep podsols with widely distributed humates (water-soluble organics), likely the result of leaching of decaying plant materials (humus) on the land surface (Swanson and Palacas, 1965). These humates are commonly carried by surface and subsurface waters and they typically cement or impregnate the barrier island sands. Humus also accumulates in (and beneath) marsh deposits, near groundwater seepages, and an organic sediment in brackish or saline water (Hoyt and Hails, 1969: 58).

We are unaware of any comparable analog—certainly none in the continental United States and perhaps not even within the global context—where these soil types and habitats come together as in the Georgia Sea Islands. No place else, so far as we are aware, has an ancient Pleistocene terrain (with its attendant nutrient richness, temporal longevity, and stability) coupled directly to the largest and mostly productive mesotidal salt marsh in North America (to say nothing of the ample store of artesian freshwater). Unlike most barrier islands, the Sea Islands of coastal Georgia support relatively broad expanses of climax maritime forest habitat, the major factor contributing to the biodiversity available to aboriginal foragers. To the human forager, this geomorphic configuration means that patch diversity is maximized by latitude and minimized longitudinally—simply put, the broader the island, the greater is the expected patch diversity. This is why the erosion remnant barrier islands, rather than the mainland, provide the best access to the rich and diverse habitats of the Georgia coastline.

#### SEA ISLAND PATCH TYPES

In this study, we employ the "patch" concept in two rather different ways. In

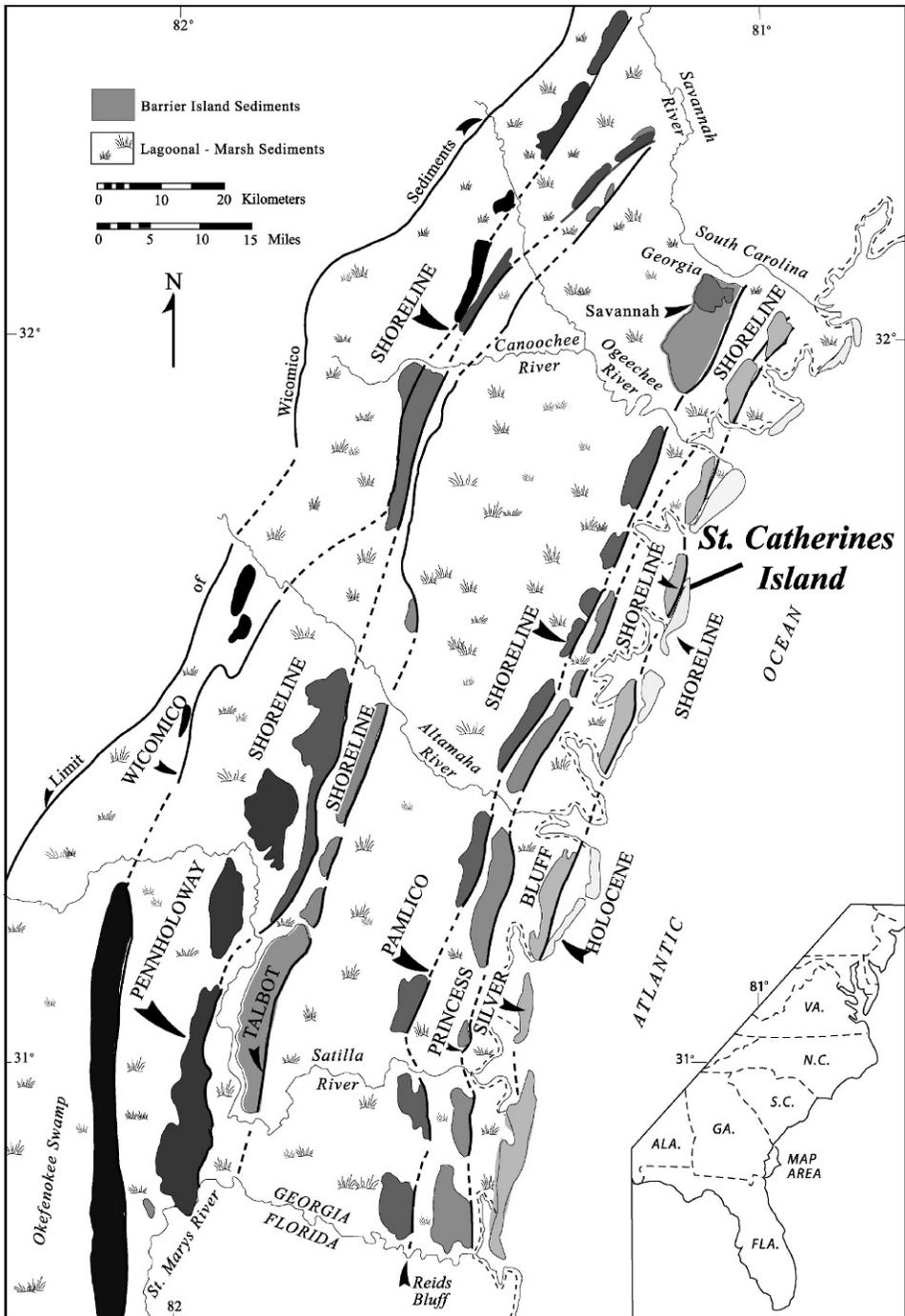


Fig. 11.5. Distribution of the Silver Bluff shoreline, and earlier Quaternary shorelines on the coastal plain of Georgia (after Hails and Hoyt, 1969).



Fig. 11.6. The sandy beach and offshore (Atlantic Ocean) along North Beach, St. Catherines Island.

chapters 6–9, we considered “patches” to be *broad but well-defined entities with characteristic return functions* (Smith, 1991: 249) with only the most general spatial referent. In this way, even an individual prey item can be considered as a patch (Stephens and Krebs, 1986: 32ff), as could alternative subsistence strategies (such as hunting vs. gathering; Hawkes et al., 1982) and the various “hunt types” among Inujjamiut hunters (Smith, 1991) and the foragers of St. Catherines Island (chap. 6–9, this volume).

But since our present objective is to spell out the particular advantages of individual locations for these various hunt type options, we will apply the term “patch” in a narrower (and more conventional) sense to mean “a spatially bounded entity characterized by the set of prey (of one or more types) contained within it and by a predictable (expected) return rate curve and gain function.

Any patches that are similar enough in those characteristics are said to belong to a given ‘patch type’” (Smith, 1991: 249).

Although many species typically exploit only a single habitat during short-term foraging, human foragers commonly exploit more than one habitat within a relative short interval, using transport technology (including baskets, tumplines, and dugouts) to transport their cargoes from habitat to habitat. For this reason (and because of the first-order nature of this study), we will operate at the coarse end of this spectrum and consider only broadly defined habitats (such as marine, terrestrial, freshwater) as patch types with distinctive (sometimes seasonally specific) return rates. This will lead to some specific expectations about where foragers should establish their residential bases.

An ocean-to-marsh transect across a typical barrier island in Georgia reveals the



Fig. 11.7. Sea oats growing on the dune ridges located adjacent to North Beach, St. Catherines Island.

following patch types, each with a distinctive geomorphic configuration and vegetation association (Kurz, 1942; Johnson et al., 1974; Howard and Frey, 1980; Clayton et al., 1992: 36–39):<sup>12</sup>

1. **OFFSHORE (ATLANTIC OCEAN):** The offshore littoral encompasses the broad, shallow continental shelf that lies east of the sea island beaches. The Georgia Bight is tidally dominated, and the generally low wave energy of coastal Georgia is due to the relationship between shoreline alignment, wind direction, and the broad, shallow shelf (Johnson et al., 1974: 89; Frey and Howard, 1986). Average wave height is less than 0.1 m in central Georgia, increasing to the north and south (Hubbard et al., 1979).

2. **THE SANDY BEACH (FIG. 11.6):** The Georgia strand contains not only beaches and dunes, but also washover fans, relict

salt marsh deposits, spits, and tidal flats. The shifting sandy beach sand is mostly eroded from the Piedmont and Appalachian highlands. Waves and currents continue to shape and reshape the intertidal and upper beach, but only major storms affect the dune ridges. All plants growing here (such as dune greenbriar and sea-beach croton) must be salt tolerant to some degree; those living in the marshes must tolerate saltwater inundation, those growing further inland must abide salt spray. With the exception of nesting loggerheads and a locus of surf fishing, this area generally lacks the prey resources sought by aboriginal foragers, including fresh water; “not surprisingly, it was largely unsettled by the native populations” (Larson, 1980a: 13).

3. **THE DUNE RIDGES (FIG. 11.7):** A series of active and arrested dune ridge runs



Fig. 11.8. Mixed pine and oak maritime forest growing on the northwestern Pleistocene core of St. Catherines Island.

parallel to the shoreline immediately landward of the high spring tide level. The average elevation is 3–4 m. Storm surges from the seaward side erode and remove the irregularities from these dunes. Adjacent beach ridges are separated by swales that may contain intertidal to low supratidal tidal creek–marsh meadows or freshwater ponds. This is a relatively hostile environment, with high salt content, sandy soil, and relatively little fresh water. The landward side of the dune ridges is more irregular, sometimes punctuated by wash-over fans passing through breaches in the dune ridge. Arrested dunes typically host yucca, yaupon holly, and loblolly pine. The interdunal spacing ranges from a few meters to several hundred meters.

Sand dunes are the vanguard of island building. The roots of sea oats and other

foredune vegetation stabilize the dunes, and their shoots slow the winds, enabling more sand to be deposited. Species diversity increases as one moves away from the beach. The swales between the dune ridges host plants thriving in protected microenvironments (less wind, more water, richer soil), sometimes as rich interdunal meadows. The forest growing along the dune system and salt marsh consists of transitional shrubs, including yaupon holly, live oak, and wax myrtle, each commonly trimmed by salt spray.

4. THE MARITIME FOREST (FIG. 11.8): Inland lies the upland maritime forest communities, commonly dominated by mature, mixed deciduous–pine forest (live oaks and mixed hardwoods), and fallow antebellum fields in various stages of succession. Saw palmetto typically forms



Fig. 11.9. The upper boundary of the estuarine salt marsh, immediately north of Persimmon Point, St. Catherines Island.

a dense understory in the maritime forest. As noted above, because Georgia's Sea Islands are relatively short and wide, they host a expanse of maritime forest rarely found on barrier islands. This extremely diverse patch type contains nkumerous terrestrial habitats and spans several different soil types (reflecting a range of arability; see chap. 5).

Before the deep water table was lowered in the late 19th century, the central part of the island core supported numerous year-round meadows and seasonally filled sloughs (see chap. 5, this volume). These freshwater habitats added appreciably to the island's biodiversity, providing critical habitat for migrating and overwintering birds, alligators, otters, frogs, freshwater fish, and turtles. This patch type is isomorphic with the Rutledge fine sand soil type.

5. THE SALT MARSH (FIG. 11.9): Along the Georgia coast, the "tidal flats" are so dissected by tidal streams and host such dense vegetation that the term "salt marshes" is more commonly employed (Howard and Frey, 1980: 114). Unvegetated tidal flats do occur in Georgia's estuaries, but they tend to be aerially restricted. Salt marsh estuaries are characterized by mud flats, oyster bars, and mazes of meandering tidal creeks, as well as by deep sounds fed by rivers draining the coastal plain.

Salt marsh estuaries lie protected from storm events behind the barrier islands but are subject to regular tidal fluctuations through a series of inlets (sounds) that separate the islands from one another. Inlets are usually deeper than adjacent coastal or estuarine waters. The tidal range is generally greater than 2 m, and a spring high tide

may produce a 50 percent increase of marshlands over mean high tide level (Frey and Howard, 1986). These low-lying areas on the sound side of a barrier island are generally divided into high marsh (flooded twice monthly by spring tides) and low marsh (flooded twice daily by high tides). Coastal Georgia experiences the greatest tidal ranges in the Georgia Bight, so Georgia's inlets and marshes are larger than those to the north or south (Hubbard et al., 1979).

The upper boundary of the salt marsh ordinarily abuts against a Pleistocene or Holocene barrier island remnant, although small, isolated remnants ("hammocks") are scattered like islands in the marsh. The transition between maritime forest and salt-water marsh is abrupt, with upper-marsh plants (including *Spartina* and *Juncus*) defining the maximum extent of spring tides.

Several Sea Islands likewise host smaller, interior salt marshes (such as McQueens Inlet on St. Catherines Island), entirely distinct from the marshlands on the mainland side. Although they lack the freshwater input of a true estuary, these highly productive interior saltmarshes were extraordinarily important to aboriginal foragers. For purposes of this discussion, we will include both estuarine and inland salt marshes in a single patch type.

Overall, Georgia's salt marshes and estuaries comprise one of the world's most naturally fertile areas, with a net production amounting to 2000 g/m<sup>2</sup>/year (about 10 tons, dry weight) per acre of organics. This means that the salt marsh is several times more productive than the most productive farmland (Johnson et al., 1974: 82).

To summarize, then, we have defined five patch types that characterize the Georgia Sea Islands: offshore (Atlantic Ocean), sandy beach, dune ridges, maritime forest, and the salt marshes (both estuarine and interior). Because patch diversity increases by latitude, several patch types can occur within a kilometer or two (in an east-west direction). Except for the sounds that separate the Sea Islands one from another, the longitudinal (north-south) axis is notable for its patch homogeneity. As we will see,

this fact of island biogeography (latitudinal diversity and longitudinal redundancy) has important implications for aboriginal settlement patterning, particularly as the inland becomes increasingly "packed" as a result of human population increase.

#### SITUATING THE RESIDENTIAL BASE: A PATCH CHOICE MODEL

Decisions about where to forage are broadly similar to those regarding which prey taxa to include in the diet. Once an item (prey or patch) has been encountered, the optimal forager should exploit that item if (and only if) the energetic return realized is greater than could be obtained by continuing the search for another item. Clearly, the prey and patch choice models follow the same fundamental logic, "so much so that the patch choice model can be regarded as a special case of the basic model of diet breadth" (Bettinger, 1991: 87-88; see also Smith, 1991: 204, 245-285).

That is, the forager confronts an array of patches—each differing with respect to the energy contained therein, and the time necessary to extract that energy. As in the prey choice model, patch types can be rank-ordered according to their return rates (the net rate of energy intake/unit of foraging time, which is the sum of search and handling times in the patch). The highest ranking patch type will produce the best return per unit of foraging time. But whereas both prey and patch models rank the alternatives according to their return rates, prey items occur in a "package" that must be pursued and processed as a whole; patches can be partially exploited. In this shift from prey choice to patch choice modeling, the forager's decision is no longer "should I search or handle?" but rather "relative to my other options, should I enter a patch, and if so, how long should I stay?" Often, the return rate of a given patch will decrease with the time spent there. The point at which a forager elects to leave one patch and travel to another will depend on the marginal return rate within this and other patches and the expected encounter rate with other patches in that habitat (Charnov and Orians, 1973;

Charnov, 1976; Stephens and Krebs, 1986: 24–32).

The seminal publication on patch choice modeling (MacArthur and Pianka, 1966) required several assumptions (after Smith, 1991: 250): random encounter with patches (or patch types), unidimensional ranking of patches (by expected return rates), mean travel time between areas (passing by places devoid of utilized resources), and complete information about the other three factors. Based on these assumptions, “foragers estimate the mean return rate from utilizing a given suite of patch types, including travel time, and use these to make an optimal choice of patches by adding patch types (in decreasing rank order) until the savings in mean travel time are offset by the decline in mean within-patch return rates” (Smith, 1991: 250). As initially stated, patch choice decisions considered whether patches were included in a forager’s itinerary (or not) based on known constraints.

This approach did not address resource depletion (Charnov and Orians, 1973: 69–70; see also Smith, 1991: 251) and Charnov (1976) recast patch utilization in terms of the “marginal value theorem”, which makes the following assumptions (Stephens and Krebs, 1986: 28): (1) Foraging time consists of two mutually exclusive (and exhaustive) components—between-patch travel time and within-patch hunting time (which may also include searching for prey); (2) encounters with patches are sequential and follow a Poisson distribution; (3) return rate within any patch is “negatively accelerated” (meaning it is depleted by forager intervention), (4) foragers have complete information regarding patch identity, productivity, and availability (but do not use this information to alter foraging behavior during that trip).

The marginal value theorem implies that what is optimal for a given patch depends on return rates in the other potential foraging areas and travel time to those areas, since these are included in determining the average return from all available alternatives. The upshot is that the optimal utilization of a patch choice (or any foraging alternative) requires knowledge not only of

the given patch, but also all other alternatives. So if returns from another patch change, then the optimal utilization of the initial patch may change as well—even though conditions in the initial patch are unchanged; below, we return to this important and nonintuitive conclusion that derives from the marginal value theorem.

The marginal value theorem also models how patch depletion and environmental fluctuations (such as droughts) relate to patch choice decisions according to relative returns offered by the prey items in each patch type (Smith, 1991: 252). In this initial approximation, we do not directly address the issue of patch depletion, although in subsequent, finer scale considerations, perhaps depletion from foraging can be included in the patch choice model.<sup>13</sup>

Instead, we will assume that the barrier island patch types discussed here are essentially nondepleting, at least within the time frame involved in a given foraging decision. Under this deliberately simplified scenario—the *one-best-patch* rule can be approximated by simple habitat choice: “On any given day, allocation of foraging effort to one habitat ... may be more productive than foraging in another habitat ... and if foragers can judge this to be the case (by past experience, reports from others, or weather clues) we might expect them to choose the more efficient habitat with little concern for depletion” (Smith, 1991: 257).

The patch choice projection, then, becomes this: If the initial constraints hold, and the alternative patches can be ranked according to their relative efficiency, then the marginal value theorem predicts that foraging effort will correlate directly with efficiency rank order, meaning that foragers should spend more time working the higher ranked patches and less time in patches with lower energetic potential. Smith (1991: 258–259) phrases the hypothesis this way: “Mean net return rate is positively correlated with total foraging time, such that in each time period (season, month) the alternative(s) with higher return rate receives greater foraging effort.”

To do this, we must translate diet breadth to patch breadth. In chapters 6–9, we devel-

oped a first-order diet-breadth model estimating the relative foraging efficiencies involved with each target taxa and ecological circumstances making each resource set attractive to aboriginal people on Georgia's barrier islands. Now we will employ these same cost-benefit estimates to examine how these various hunt types relate spatially to well-defined patch types contained within the barrier island ecosystem (and how such activities might condition their archaeological representation). Ultimately, then, we can estimate the relative efficiency of different foraging strategies when both were included in the diet (Barlow and Heck, 2002: 129).<sup>14</sup>

The hunt types developed previously are quite flexible, meaning that they do not require: (1) definition of spatially bounded units, (2) a strict distinction between search time and travel time, and (3) the assumption of simultaneous search for all prey types or specialization on a single prey type per hunt. "In these respects, hunt type choice is a synthetic decision category, and the one that seems well-suited to empirical applications of foraging theory to humans" (Smith, 1991: 269). But whereas the hunt type "concept" is quite fluid, the associated on-the-ground behaviors are often (by definition) fairly rigid and mutually exclusive. This is true even when different hunt types take place simultaneously, in the same place. Commonly, the choice of foraging activity requires "gearing up" ahead of time with the appropriate tool kit, making it difficult to shift between hunt types. Among the Meriam, for instance, foragers geared up to undertake spearfishing would be ill equipped for shellfishing, even in the same patch (Bliege Bird et al., 2001; Bliege Bird and Bird, 2002; Bird and Bliege Bird, 2002).

The choice of optimal hunt type depends on the ranking of alternative hunt types according to a common currency. With the hunt types suitably rank-ordered, the optimal set is determined by the relationship of *harvest potential* and net capture rate. Without modeling the constraints on harvest potential, this approach is analogous to patch choice without resource depression, in which the forager simply specializes on the highest ranked hunt type. Thus we will as-

sume that, on a hunt-to-hunt basis, aboriginal foragers on the barrier islands will allocate foraging time to the hunt type that yields the highest expected return rate *at that point in time*. We must likewise recognize that the efficiency rank order of alternatives may shift often (due to seasonal variability, weather, local game abundance, and so forth) to favor a mix of habitats, patches, and hunt types.<sup>15</sup>

#### SPATIAL IMPLICATIONS: LINKING HUNT TYPES TO PATCH TYPES

Rather than using estimates (or simulations) of encounter rates to model the harvest potential (e.g., Simms, 1987; Zeanah, 2004), we assume that aboriginal foragers on the barrier islands will allocate foraging time to the hunt type that yields the highest expected return rate at that point in time. Further, we employ the one-best-patch rule to link the various hunt types (derived in chap. 7-9) to their specific biogeographic correlates (the patch types) contained within the barrier island ecosystem (see table 11.4).<sup>16</sup>

**SALTWATER FISHING:** This hunt type has the highest year-round post-encounter rate in the Georgia Sea Islands. The activities in this hunt type play out across two patch types—the offshore (Atlantic Ocean) and the salt marsh—each with an overlapping yet distinctive set of prey taxa. The salt marsh has the highest year-round post-encounter return rates in the Sea Islands, ranging between 1100 and 50,000 kcal/hr (with a 50th percentile of 7540-18,760 kcal/hr). Aquatic foragers can likewise fish for saltwater taxa in the offshore (Atlantic Ocean) patch type, but fish traps and weirs cannot be operated in this open-water environment. The offshore offers the opportunity to pursue high-ranking sea turtles, who use coastal Georgia as a travel corridor, but their availability is restricted to May-August. Although the range and 50th percentile of return rates are quite high, we rank the offshore (Atlantic Ocean) habitat somewhat lower than the salt marsh in overall energy potential due to these seasonal and technological constraints.

TABLE 11.4  
The Linkage Between Hunt Type and Patch Type in the Georgia Sea Islands

Hunt type	Patch type	Availability	Potential return rates (kcal/hr, rounded)	
			Range	50th percentile
Saltwater fishing (♂)	Salt marsh	year-round	1500-50,000	7540-18,760
Sea turtle harvesting (♀)	Offshore (Atlantic Ocean)	summertime	1500-60,000	13,486-17,188
Terrestrial hunting (♂)	Sandy beach	late spring-midsummer	9890-21,360	15,600
Harvesting mast (♀)	Maritime forest	year-round	960-49,000	6500-12,000
Hickory nuts	Maritime forest (hickory ridges)	fall	2150	2150
Acorns	Maritime forest (everywhere)	fall	390-2950	1670
Maize horticulture (♀)	Maritime forest (Rutledge soil type)	late summer-fall	1300-1700	1500
Plant and harvest	Maritime forest (Foxworth soil type)	late summer-fall	1100-1500	1300
Slash and burn	Maritime forest (Foxworth soil type)	late summer-fall	300-1700	1000
Intensive horticulture	Salt marsh	year-round	26-4400	2200
Collecting shellfish (♀)	Maritime forest	midsummer-fall	110-5000	360
Harvesting wild plants (♀)				

**SEA TURTLE HARVESTING:** This seasonal hunt type returns about 21,360 kcal/hr for gravid female loggerheads and 9893 for loggerhead eggs. The relatively high 50th percentile (15,300) might justify a second-place ranking (depending on how one computes such things). Loggerheads nest only in late spring through midsummer and exclusively on the sandy beach.<sup>17</sup>

**TERRESTRIAL HUNTING:** This hunt type ranks second (or perhaps third, see below) in year-round potential return rates on St. Catherines Island, ranging from 960 to 49,000 kcal/hr, with a 50th percentile of 6500-12,000 kcal/hr. Terrestrial hunting takes place exclusively in the maritime forest patch type.

**HARVESTING MAST:** This seasonal hunt type returns about 3100 kcal/hr for hickory nut oil and 3000 for acorn oil. If the mast harvesting returns are low enough to return acorn meal, then the rate dips to 390-1260 kcal/hr. Live oak acorns can be harvested almost anywhere in the maritime forest, but pignut hickory trees grow on distinctive "hickory ridges", a highly restricted set of patches within the maritime forest.

**MAIZE HORTICULTURE:** Overall, this "prey type" returns 300-1700 kcal, and the 50th percentiles suggest a relative ranking between mast harvesting and shellfish collection. All horticulture takes places within the maritime forest patch type, but given the technological diversity contained within the "maize horticulture" classification and the spatial separation of each method, our patch choice model treats each strategy separately.

- **Plant-and-harvest cultivation**, which generates the highest return rates, takes places only on the margins of the Rutledge soil type.
- **Slash-and-burn cultivation** is restricted to the Foxworth soil type.
- **Intensive horticulture** is confined to the Foxworth soils.

**COLLECTING SHELLFISH:** The returns for this year-round hunt type range from 26 to 4400 kcal/hr (with the 50th percentile range of about 2200 kcal/hr). Shellfish can only be harvested from the salt marsh patch type.

**HARVESTING WILD PLANTS:** The lowest ranking hunt type ranges from 110 to 9360 kcal/hr, with a 50th percentile range of 128–489 kcal/hr). Such wild plants can be harvested anywhere in the maritime forest, but the collecting season is restricted to the summer and early spring.

These hunt type-patch type linkages are summarized on table 11.4.

To summarize procedures so far: In chapters 6–8, we used the prey choice model to project resource choice decisions within a particular patch, once somebody has chosen to forage there. If a forager elects to collect shellfish in the salt marsh, then the model predicts the ranking of various prey taxa she might encounter; if a forager hunts terrestrial game, then diet-breadth considerations should condition his behavior when he encounters a lower ranking taxon (such as a swamp rabbit or a gray squirrel). Then, to anticipate the decision of where a forager might elect to work on a given day, we switched models, from prey choice to patch choice. In general, we can see from table 11.5 that the salt marsh is the highest ranking patch, with the maritime forest second, well ahead of the sandy beach and the ocean front. We will now refine this hypothesis by examining the way in which the sexual division of labor impacts patch breadth and distribution.

#### THE IMPACT OF GENDER-SPECIFIC FORAGING

We previously quoted Charles Hudson's opinion that the division of labor among Southeastern Indians was so sharp, roles of men and women so distinct, "that the two sexes were almost like different species" (1976: 260). We also briefly summarized some recent ethnoarchaeological research demonstrating that the two sexes do not necessarily share a common diet breadth (e.g., Hill et al., 1987; Hawkes, 1996; Zeanah, 1996: chap. 6, 2003, 2004: 2; Bliege Bird, 1999; Barlow, 2002: 82; Hawkes and Bliege Bird, 2002; see also Kelly, 1997: 26). This would imply that gender-specific foraging activities can reflect differing, even conflicting, goals for men and women.

This is one reason why we partition the overall resource base into seven distinct "hunt types", explicitly recognizing the degree to which men and women share a common diet breadth (or not). From a fitness perspective, one might expect that women generally earned overall higher foraging returns than men across all seasons, despite the fact that males pursue much higher ranked prey. These hunt types likewise reflect the possibility that male and female foraging may reflect considerable variability in anticipated returns. Since women must nourish their children on a daily basis, the high-risk uncertainty involved in hunting larger game becomes unacceptable in female foraging strategies. By recognizing the possibility of differential diet breadths, we emphasized not that shellfish and acorns are a low-ranked resource relative to the entire range of available prey items—a generalization that would violate the fine-grained assumption required by the diet-breadth model—but rather that the salt marsh and maritime forest patch types offer the very highest ranking resources available to female foragers on the Sea Islands. Framed this way, even the lower ranking resources may have been critical for the female forager emphasizing parental investment. The upshot is that men and women within the same environment likely entertained different foraging objectives and focused on different resource sets, each with its own associated diet breadth.<sup>18</sup> Because the foraging goals of men and women, the young and old, are likely to be quite different (Zeanah 2003, 2004; Kennett 2005: 224), it seems worthwhile to rank-order the patch types according to diet breadth and sexual division of labor for the seven Sea Island hunt types (tables 11.4 and 11.5).

Viewed from the perspective of the male forager, the salt marsh is clearly the highest ranked patch type (with year-round saltwater fishing associated with potential return rates ranging from 1500 to more than 50,000 kcal/hr, and a 50th percentile return of 7540–18,760 kcal/hr). Second ranked is the offshore (Atlantic Ocean) patch type, which offers high-ranking sea turtles during

TABLE 11.5  
**Estimated Post-encounter Return Rates for Seven Hunt Types on St. Catherines Island (in kcal/hr)**

	Saltwater Fishing <sup>a</sup> <i>Offshore, Salt marsh, or both</i>	Terrestrial Hunting <i>Maritime forest</i>	Sea Turtle Harvesting <i>Sandy beach</i>	Harvesting Mast <i>Maritime forest</i>	Collecting Shellfish <i>Salt marsh</i>	Harvesting Wild Plants <i>Maritime forest</i>	Cultivating Maize <i>Maritime forest</i>
		Black bear (37,352–61,434)					
	Leatherback turtle, ♀ and ♂ (26,825–62,792)						
	Large fish, gill net (21,216–62,792)						
	Large fish, trot line (16,982–42,252)						
	Medium fish, gill net (19,823–25,265)	American alligator (22,000)					
	Very large fish, fish weir (>17,673)		Loggerhead turtle, nesting ♀ (21,360)				
	Medium fish, trot line (13,486–17,188)	White-tailed deer (12,096–19,895)					
	Large fish, fish weir (7540–18,760)	Raccoon (9408–13,569)					
	Medium fish, fish weir (9623–12,264)		Loggerhead turtle, ♀ and ♂ (8010–13,350)				
	Large fish, spear/harpoon (5655–14,070)		Loggerhead eggs (9893)				
		Canada goose (6762–12,522)					
		Wild turkey (7765–11,200)					

TABLE 11.5  
(Continued)

Saltwater Fishing <sup>a</sup> <i>Off/shore, Salt marsh, or both</i>	Sea Turtle Harvesting <i>Sandy beach</i>	Terrestrial Hunting <i>Maritime forest</i>	Harvesting Mast <i>Maritime forest</i>	Collecting Shellfish <i>Salt marsh</i>	Harvesting Wild Plants <i>Maritime forest</i>	Cultivating Maize <i>Maritime forest</i>
Small fish, gill net (6714-9894)	Virginia opossum (6540-12,111)	Large turtles (6547-8,273)			Cattail pollen (2750-9360)	
Small fish, trot line (4567-6731)						
			<b>Energy Threshold 5000 kcal/hr</b>			
Medium fish, spear/harpoon (3206-4086)	Swamp rabbit (2942-5248)			Hard clams (2,250-4400)		
			<b>Energy Threshold 3000 kcal/hr</b>			
	Marsh rabbit (2042-3781)				Acorn oil (2954)	
	Small turtles (2182-2758)				Hickory nut oil (2100-2200)	
			<b>Energy Threshold 2500 kcal/hr</b>			
	Duck (1230-2278)					Plant and harvest cultivation (1500-1700)
			<b>Energy Threshold 1500 kcal/hr</b>			
				Knobbed whelks (1380)		Amaranth (1359)



TABLE 11.5  
(Continued)

Saltwater Fishing <sup>a</sup> <i>Offshore, Salt marsh, or both</i>	Terrestrial Hunting <i>Maritime forest</i>	Sea Turtle Harvesting <i>Sandy beach</i>	Harvesting Mast <i>Maritime forest</i>	Collecting Shellfish <i>Salt marsh</i>	Harvesting Wild Plants <i>Maritime forest</i>	Cultivating Maize <i>Maritime forest</i>
			Laurel oak acorn meal (254)		Little barley (274) Sumpweed, wild (272) Cattail roots (128– 267) Bulrush roots (146–160) Giant ragweed (110)	
				Marsh periwinkles (26–135)		

<sup>a</sup> The leatherback turtle is hunted offshore only, gill-net and trot-line catch are harvested both offshore and in salt marsh, and fish-weir catch is harvested in salt marsh only.

the summertime (but fish traps and weirs cannot be operated here). Although the potential returns from the offshore patch type are quite high, these seasonal and technological constraints limit the overall energetic potential. For men, the mature maritime forest patch type ranks third, with return rates ranging from 1000 to 49,000 kcal/hr (with a 50th percentile of 5300–12,000 kcal/hr). For males and females alike, the sandy beach is important mostly during the summertime, when sea turtle collecting generates relatively high returns (10,600–15,600 kcal/hr); the beach strand also provides limited potential for terrestrial surf fishing opportunities. The dune ridges are the lowest ranking patch type in Sea Islands, for male and female forager alike.

Female foraging requires a more complex model. In the fall, the maritime forest patch type, with return rates of roughly 3000 kcal/hr for acorns and hickory nuts (prepared as oil); other low-ranking wild plants are also available in this prey type during the late summer–fall. After about A.D. 1000, the maritime forest likewise provides suitable habitat for maize cultivation: If the average diet breadth falls below 1300–1700 kcal/hr, then plant and harvest maize cultivation can be expected in terrestrial patches adjacent to patches of Rutledge soil. Should the threshold return rate drop below 1100–1500 kcal, then we also expect that slash-and-burn maize agricultural plots would be cultivated on patches of Foxworth soils. Then, beginning in the late fall—after the acorns and hickory nuts have fallen, and the maize crops (if any) have been harvested—then the salt marsh becomes the highest ranking resource patch for women. Although the individual taxa in the shellfishery return 125 and 2000 kcal/hr, their year-round availability makes the salt marsh a high-ranking patch type for female foragers. This underscores the point, made earlier, that patch choice decisions require knowledge not only of the specific patch in question, but also of other alternatives. Although return rates for most shellfish remain unchanged throughout the year—oysters being an important exception here—the optimal utilization of the salt marsh is

likely influenced by conditions in other resources patches (in this case, prey items in the maritime forest).

As noted above, collecting gravid sea turtles is the single highest-ranking patch type for female foragers; but (1) the joint, male–female procurement possibility, (2) the short-term temporal duration, and (3) the fact that the sandy beach produces no additional prey types makes it difficult to evaluate the relative ranking of this patch type.

#### PATCH BREADTH IMPLICATIONS

Because we have not elected to simulate (or otherwise estimate) the various encounter rates, we will instead employ the diet-breadth model to predict the effect of changes in overall patch return rates on specific patch type distributions (see tables 11.4 and 11.5).

**When the diet breadth is extremely narrow (i.e., >5000 kcal/year),** the patch breadth involves four patch types (table 11.5), with the salt marsh emerging as the highest ranked. The maritime forest ranks second (due primarily to the all-seasonal availability of prey types). During the summertime, the offshore (Atlantic Ocean) patch type might assume a relatively high ranking (due to the availability of migrating sea turtles) and during this same interval the sandy beach might also achieve (temporally) paramount ranking due to the arrival of nesting female loggerheads.<sup>19</sup>

**When the diet breadth is broader (i.e., >3000 kcal/year),** the salt marsh remains the highest ranking patch type (with the important addition of hard clams).

**When the diet breadth broadens still further (i.e., >1500 kcal/year),** the maritime forest becomes more important for female foragers as the fall mast (hickory nuts and acorns, rendered as oil) comes into play.

**When the diet breadth becomes extraordinarily broad (i.e., <1500 kcal/year),** the full range of female foraging options kicks in, from shellfishing, though less efficient mast processing, and (during the late prehistoric period), maize cultivation across a broad range of technological possibilities. When this happens, the salt marsh and maritime

forest become even more important as critical patch types.

These are effectively the same predictions as those derived from the diet breadth model—with the distinctive advantage of adding a spatial element. To summarize: We hypothesize that regardless of diet breadth, the patch breadth for Sea Island foragers will include four basic habitat types: the offshore, the salt marsh, the maritime forest, and the sandy beach (summertime only). The energetic ranking of these patch types appears to be relatively stable, even in the fact of shifting diet breadth.

#### SITUATING THE RESIDENTIAL BASE: A CENTRAL PLACE FORAGING MODEL

Central place foraging embodies the same microeconomic principles that undergird prey choice and patch choice modeling (Orians and Pearson, 1979; Stephens and Krebs, 1986: 53–60). Whereas the diet-breadth model has the advantage of generating relatively simple questions and hypotheses, the fine-grained assumption requires that resources be distributed homogeneously in space, and that all foragers share the goal of maximizing net energy intake. This is why, in chapters 6–10, we divided the foraging landscape into seven hunt types.

Kennett (2005: 224–229) found that the diet-breadth model generated several worthwhile hypotheses about California's northern Channel Islands. While these projections proved to be generally consistent with the available archaeology, the diet-breadth model did not permit more fine-grained analysis due to the uneven distribution of key resources in the Channel Islands and because of potential disparities in the foraging goals of men and women (and also the young and old).

This is why he augmented his diet-breadth approach with a consideration from central place foraging theory (Kennett, 2005: chap. 2 and 8), projecting the following hypothesis from central place foraging theory: "All other variables being

equal, foragers will select their residential base locations that maximize the net central place foraging returns given the pursuit, handling and transport costs of resources from different patches.” Given the highly productive intertidal habitats and the “depauperate” nature of terrestrial resources in the northern Channel Islands, Kennett predicted that residential bases of the initial settlers should have been located at the mouths of major drainages (reducing transport costs by using coastal locations), along the western margins of the island (because of increased productivity on an east–west cline), and also near a larger estuary on eastern Santa Rosa Island. He concluded that “[g]roup sizes and population densities along coasts tend to be larger than adjacent interior areas because of the productivity of marine ecosystems, their juxtaposition with terrestrial habitats which increases the diversity of resources available, and the linear distribution of subsistence resources” (Kennett, 2005: 36; see also Yesner, 1980; Smith, 1991; Erlandson, 2001).

In sum, the central place foraging model predicts that foragers should establish residential bases in places that maximize the average central place foraging returns relative to transportation costs associated with logistic forays (specifically pursuit, handling, and transport costs; Zeanah, 2004: 21; Kennett, 2005: 31).

#### PATCH TYPE POTENTIALS

We believe that a similar central place foraging approach is relevant to this examination of aboriginal foraging behaviors on coastal Georgia. But the ecological structure of these two island ecosystems is rather different, and these differences between the Sea Islands and California’s Channel Island have important implications for aboriginal foragers.

We have already expanded the diet-breadth model to rank-order the energetic potential of the various patch types available in the Sea Islands:

**THE SALT MARSH (OVERALL RANK 1):** For men, the salt marsh is the highest

ranked patch type year-round, and for women, it ranks highest for more than half the year (late fall through late spring/early summer).

**THE MARITIME FOREST (OVERALL RANK 2):** For women, the mast harvest elevates the maritime forest to highest ranking during the fall (and for horticulturalists, the maritime forest is likewise important in the late summer through fall harvest). For male foragers, the maritime forest ranks second (behind the salt marsh).

**THE OFFSHORE (OVERALL RANK 3):** For males, it is unclear exactly how the offshore patch type ranks relative to the maritime forest. Certainly in the summer, when sea turtles are available, the offshore ranks higher, but we suspect that on an annual basis, the maritime forest ranks higher. For females, the offshore habitat offers no potential foraging opportunities.

**THE SANDY BEACH (OVERALL RANK 4):** The joint male–female collection of loggerhead turtles (and their eggs) creates an important, but short-lived patch type.

**THE DUNE RIDGES (OVERALL RANK 5):** No significant potential for human foraging.

In other words, irrespective of the specific diet breadth, the salt marsh is always the highest ranking patch type, followed by the maritime forest, the offshore (Atlantic Ocean), the sandy beach (summertime only), and the dune ridges. Expressed as patch breadth, then, the barrier islands of coastal Georgia contrast markedly with the Channel Islands, where marine resources hold vastly more potential than terrestrial sources.

Central place foraging theory allows us to hypothesize that the residential base should be positioned so as to maximize the *average central place foraging returns* (relative to the costs associated with pursuit, handling, and transport costs). Taking into account the potentially conflicting foraging goals of males and females, we can develop a model that addresses the cost–benefit relationships of foragers *as individ-*

uals (Zeanah, 2004: 20–21): “If male and female foragers in a camp pursue different sets of prey to achieve different objectives, whose individual interests are served by positioning camps to minimize travel and transport?” One way to model these trade-offs is to assume that foragers select a central place to maximize the highest combined rate that both men and women can return to everyone living there.

When modeled from the perspective of the individual forager, somebody living in a residential location that offers the highest combined central place foraging returns should enjoy a fitness advantage over those living in places where only men’s (or women’s) foraging goals are exclusively served. Further, if a critical constraint for women is to store sufficient food to buffer against future shortage, then women should prefer a residential base camp located to maximize the overall intake rate of food—even if that location is not within the woman’s highest ranking patch type. This simplifying assumption suggests that the issue of competing fitness goals can be modeled by treating men and women as individuals pursuing different prey sets “while avoiding empirical generalizations about the relative mobility of men and women” (Zeanah, 2004: 21).

#### SEA ISLAND SETTLEMENT PATTERNING

Given the above constraints, we will hypothesize that the optimal central place in the Sea Islands is the intersection of the two highest ranking patch types (in this case, straddling both terrestrial and marine ecosystems). This suggests that the residential base (as an optimal central place) should be deliberately sited to provide maximum access to both the salt marsh (the highest ranking patch type) and the maritime forest (the second ranking patch type). In the Sea Islands, the upper margin of the salt marsh generally abuts directly against a Pleistocene and/or Holocene beach remnant, defining an abrupt scarp, with the upper-marsh plants (including *Spartina* and *Juncus*) defining the maximum extent of spring tides. Specifically, then, we hypothesize that the *marshside settlement type*—defined as the

maritime forest high ground located immediately adjacent to the salt marsh—offers the highest combined central place foraging rate of any barrier island location. For the Sea Island landscape, the marshside residential base should be the optimal central place.

We will also define a *secondary (suboptimal) central place* based on the spatial relationship of the two next highest ranking resource patches, in this case, between the maritime forest (second highest ranking patch type) and the offshore (Atlantic Ocean) patch type, which ranks third.<sup>20</sup> As noted above, neither the sandy beach nor the dune ridge patch types offer suitable life-space conditions for sustained human settlement. So the seaward edge of the maritime forest provides the closest interface with offshore marine resources. These same settlement locations, located on the leeward side of the primary dune ridge, also provide easiest logistic access to the sandy beach patch type (which may be the highest ranking patch for both sexes during the summertime, when loggerheads come ashore to nest). Specifically, then, we hypothesize that the *seaside settlement type*—defined as the maritime forest margin providing closest access to the Atlantic Ocean—will offer the second highest combined central place foraging rate of any barrier island location.

#### ADDITIONAL RESTRAINTS ON SETTLEMENT PATTERNING

We have hypothesized that marshside and seaside central place settlements broadly define the foraging landscape in the Sea Islands. But a number of additional constraints potentially influence the precise location of residential bases in these barrier islands.

It may be that satisfying a single, overriding locational constraint may not leave foragers much leeway in shifting their central place. If, for instance, potential watercraft landing spots or patches of arable soil are extremely rare, then we could expect that forager settlements might be “tethered” to such spots (Kelly, 1995: 126–127), and, given the relatively small size of

the Sea Islands—the mean area (of high ground) is only about 3430 ha/island (see table 11.3)—a few such “tethered” settlements would seriously constrain the possibilities for central place locations. Further, if most hunt types map onto landscapes located only a few kilometers from these constrained central places, then minimizing transport costs might not be much of a problem. Or, if some patch types are quite distant from the tethered settlements, then one could target these resources as a particular transport problem.<sup>21</sup>

For this reason, we will pay especial attention to the potentially “tethering” effects of three factors: adequate conditions for human life-space, landing facilities for watercraft, appropriate supplies, and conditions for everyday life, and access to arable soils (for maize cultivators).

**ADEQUATE CONDITIONS FOR HUMAN LIFE-SPACE:** As noted previously, base camps are generally positioned on relatively flat terrain to provide adequate life-space, protection from the elements, and access to firewood. These conditions of the “campground radius” were doubtless important to the aboriginal foragers of the Sea Islands.

But the availability of drinking water, a common factor in siting residential bases around the world (e.g., Kelly, 1995: 126–127; Kennett, 2005: 224), was a minor consideration to foragers on the Georgia coast.<sup>22</sup> The Floridan aquifer delivered fresh water in several places, and on the ground’s surface and where water was unavailable from the deep aquifer, a relatively shallow well could tap the surficial reservoir of nonartesian water. This means that—at least prior to the early 20th century—nonartesian groundwater could be found almost anywhere on St. Catherines Island (except during periods of extreme drought). Water was always more available in low-lying locales and became relatively more difficult to obtain with increased elevation. This was true especially in the high ground across the northeastern sector of the island.

**ADEQUATE LANDING FACILITIES FOR WATERCRAFT:** The ethnohistoric evidence clearly establishes the dugout, the *balsa*,

and the catamaran as everyday tools to the aboriginal foragers of coastal Georgia (see chap. 6, this volume). The deep antiquity of this boat-building tradition is likewise confirmed by the numerous finds of ancient dugouts, in both saltwater and freshwater contexts. We believe that a variety of dugouts and other kinds of watercraft have been manufactured and utilized from the initial human occupation of the Sea Islands.

As Fitzhugh (2002: 262) has noted for aquatic foragers, residential flexibility should be inversely proportional to the complexity of coastal geography “Occupants of linear coastlines are more limited residentially (and to a lesser extent logistically) than those living in archipelagos of closely spaced islands or along deeply embayed landscapes. Linear rocky coastlines afford fewer residential opportunities, and we would expect maritime hunter-gatherers to be more tethered to accessible locations (river mouths, spits, and bays).”

Given the importance of this specialized transport technology, we believe that virtually all residential bases in the Sea Islands were situated with watercraft in mind. Getting in and out of a canoe comfortably and safely in this environment is dangerous, a real concern today (even for kayakers putting on from relatively stable floating docks). Most modern boaters try to avoid the fast water of tidal salt creeks, preferring instead to launch into the marsh, particularly at high tide. Safe storage of watercraft is also an issue, given the considerable capital investment involved. But, as Larson (1980a: 14–15) had noted, not all high ground along the marsh margin provides ready access. In fact, only rarely do the saltwater creeks actually abut the land (beyond the reach of the high tide). More commonly, these tidal creeks are dissecting older, stabilized beach ridge deposits, creating steep, inaccessible cutbanks; at low tide, access is furthered hindered because the creek margins are often fronted by extensive mud flats.<sup>23</sup>

This is why the availability of suitable landing spots is critical for situating the residential base. Today, we can find several ideal launching spots along the marsh mar-

gin, places where dugouts could easily be pulled into shallow, slackwater inlets to discharge passengers and cargo (and then dragged onto the high ground for storage until the next use). Naturally occurring landing spots could also be readily enhanced by clearing vegetation and digging out (and building up) the hard marsh; these aboriginal foragers were, after all, “mound-builders”, fully accustomed to modifying the landscape when appropriate.

But unlike a rocky coastline, where a certain degree of geological continuity can be assumed, the exact topography and configuration of the marsh margin has doubtless shifted over time. The salt marsh is an extraordinarily dynamic environment, with the dendritic salt creeks changing course frequently. We can certainly use the available stratigraphic and geomorphological evidence to reconstruct the changing shape of marshlands along St. Catherines Island over the past several millennia (see chap. 29), but these reconstructions are relatively coarse grained and we cannot hope to recreate the exact configuration of the marshland-maritime forest margin with any accuracy.

Although we believe that watercraft landing areas were a vital factor in conditioning the location of residential bases, we believe that numerous such facilities (both naturally occurring and/or artificially enhanced) would have always been available along the marsh margin. We do not believe that potential landing areas of watercraft would have “tethered” residential settlements (in the fashion, say, of the rocky coastline of the Channel Islands and elsewhere).

**ACCESS TO ARABLE SOILS (FOR MAIZE CULTIVATORS):** During the late prehistoric period, Sea Island foragers apparently had the option of cultivating maize. Diet-breadth modeling suggests that whenever the overall female diet breadth expands to about 1500 kcal/hr, we expect that plant-and-harvest cultivation should be included in the optimal set of activities conducted within the mature maritime forest. Because this form of maize cultivation is closely associated with the distribution of Rutledge sandy soils, access to patches of

this poorly drained soil type may have been an important factor in situating residential bases during the late prehistoric period.

Similarly, if the overall return rate for female foraging were to drop to 1000 kcal/hr, then we expect late prehistoric foragers to engage in slash-and-burn cultivation, which we believe was exclusively practiced on relatively low-lying but well-drained patches of the Foxworth fine sands. Should female diet breadth expand to 500 kcal/hr, then intensive techniques of maize cultivation would likely be pursued (which also presumably took place on appropriate patches of Foxworth soils).

In short, the specific placement of both marshside and seaside settlements during the prehistoric period was likely constrained by ready access to both Rutledge and Foxworth soil types. The distribution of various soil types varies considerably across the Sea Islands, and their impact on aboriginal foraging settlement patterning must be assessed on an island-by-island basis; later in this chapter, we will conduct such an assessment for St. Catherines Island.

#### CENTRAL PLACE FORAGING AND SEA ISLAND CONFIGURATION

We have used central place foraging theory to project the optimal positioning for the (primary) *marshside* settlement—on the high ground situated along the extreme leeward margin of the maritime forest and directly adjacent to the salt marsh—which can be modeled as a probability distribution arrayed along the intersection of these two high-ranking patch types (fig. 11.10). We can likewise plot a similar probability distribution defining the optimal positioning for the (secondary) *seaside* settlement type (defined as the maritime forest margin with the closest access to the Atlantic Ocean). The means of each probability band run along the interface between the two patch types involved, projecting the most probable location for each optimally positioned central place.

As indicated in figure 11.10, the variances of associated with such site distribu-

## Optimal Positioning for Central Place Settlements in the Sea Islands of Georgia

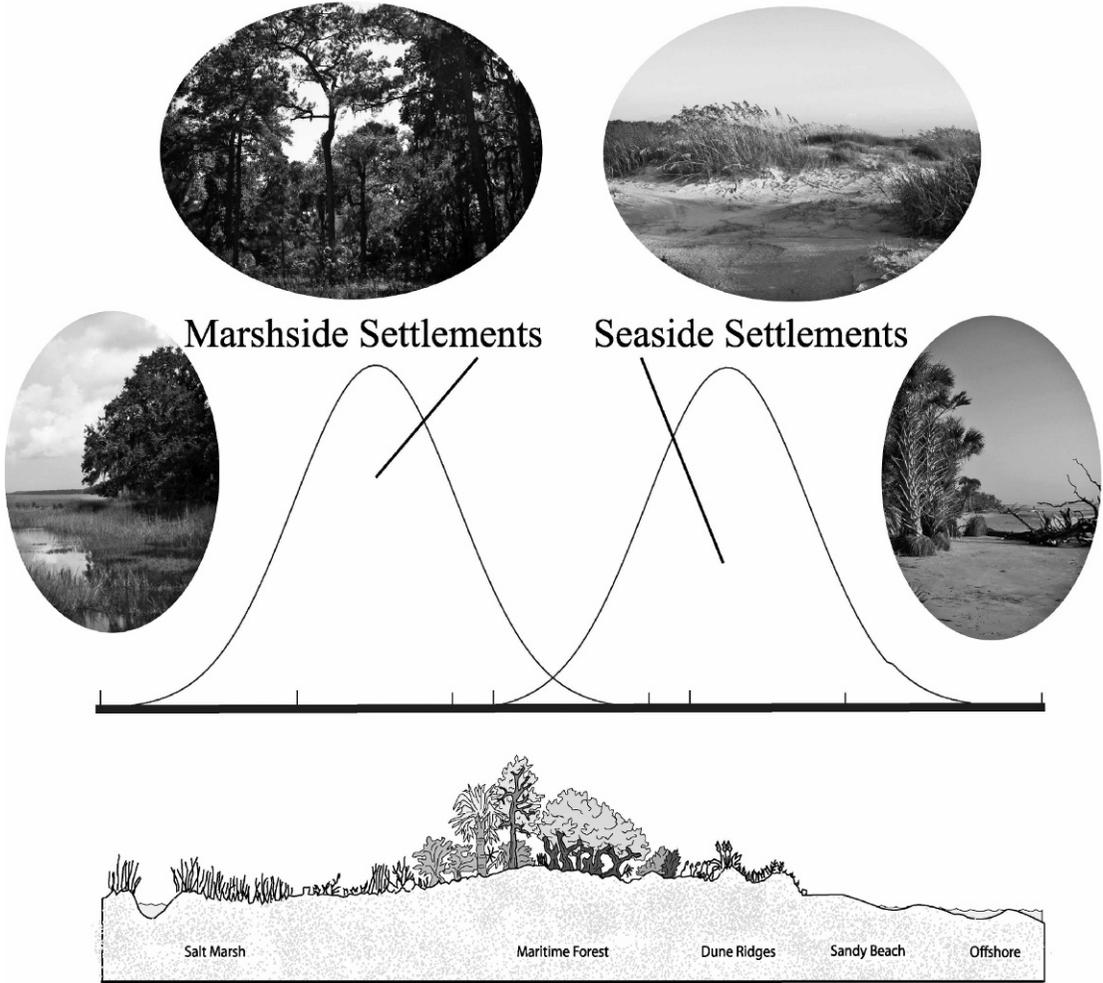


Fig. 11.10. The probabilistic distribution of optimal central places in the Sea Islands of coastal Georgia.

tions are likely to be asymmetrical, conditioned by multiple factors involving life-space constraints, topographic and geomorphic variability, availability of arable land (for cultivators), location of adequate docking facilities, access to saltwater creeks that dissect the salt marsh, crowding by neighboring settlements desiring the same optimal positioning, and so forth. For the marshside settlements, for instance, we

might expect the variance to be asymmetrical—steeper toward the salt marsh/maritime patch margin, then trailing off into the terrestrial patch type. This asymmetry reflects, of course, the geomorphic fact that the salt marsh/high ground margin is an abrupt boundary, defined by the upper reach of the spring tides and forming a barrier to settlements beyond that point (because, of course, a residential base cannot

be set up in the marsh). Settlements situated in more inland patches of the maritime forest were not subject to any such barrier.<sup>24</sup>

Keep in mind that, by definition, the two hypothesized settlement types are rank-ordered relative to one another: All else being equal, the marshside settlement should produce higher central place foraging rates (because it maximizes access to the highest ranking patch types). Seaside settlements, situated between the next lower ranking patch types, should generate lower combined returns. But because the return rates for the maritime forest and offshore (Atlantic Ocean) patch types vary significantly by season, they potentially shift the relative rankings of these patch types and raise the question of mobility (residential and/or logistic) between the two most optimal central places.

We can now further define the distribution of these hypothesized probability distributions by returning to the geomorphic constraints that created the Sea Island landscape (fig. 11.11). We have already emphasized that island length is largely irrelevant to barrier island foraging (because of the overriding longitudinal redundancy in this ecosystem). The most significant habitat variability occurs along a latitudinal (east-west) axis, a fact of geomorphology and biodiversity with significant implications for aboriginal foraging in the Sea Islands: The wider a barrier island, the more extensive (and more diverse) will be the terrestrial resource base. Because Georgia's Sea Islands tend to be relative broad, they offer much higher energetic returns than most barrier islands located elsewhere in North America.

The converse is likewise of interest. As noted in table 11.3, the barrier islands along the Georgia coastline vary considerably in size, and on the narrower islands, the absolute distance between terrestrial and offshore/estuarine patch types is decreased—thereby reducing transport costs to the optimal central places. Should a barrier island become narrow enough, then the two most probable central places—the *marshside and seaside settlements*—will merge into a single, optimally situated cen-

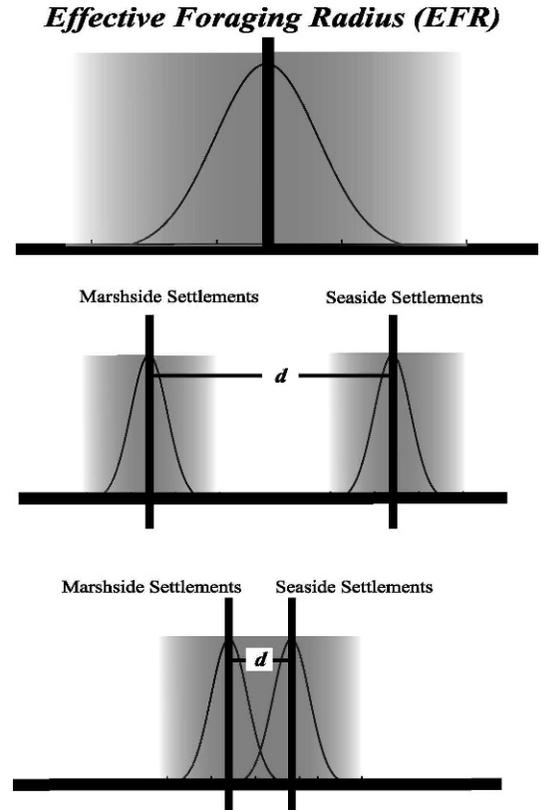


Fig. 11.11. Relationship between the *effective Foraging Radius (EFR)* and the distance ( $d$ ) separating optimal central places for marshside and seaside settlements.

tral place, with reasonable access to all three high-ranked patch types. We can model this situation as follows.

At the top of figure 11.11, we array the *effective foraging radius (EFR)*, discussed above, as the zone systematically searched and exploited by individual foragers who return home each night. In the Sea Island model discussed here, every home base will have an attendant effective foraging radius associated with the peak of the probability distribution about the highest ranking central place.<sup>25</sup> In a bimodal settlement pattern—involving both marshside and seaside settlements— $d$  represents the distance between the peaks of the probability distributions representing the two highest ranking central places on a hypothetical Sea Island.<sup>26</sup>

In terms of the Sea Island model articulated above, this means that whenever the highest ranking (marshside) settlements are separated from second-ranking central places (the seaside settlements) by a distance greater than the effective foraging radius, *then* we should expect a relatively high degree of residential mobility from the foragers utilizing both settlements (depending, of course, on resource seasonal and overall diet breadth). So, given a significant spatial separation between the highest ranked patch types, those foragers seeking to maximize the net central place returns should shuttle between these central places, depending on the pursuit, handling, and transport costs of prey items as they become seasonally available or as the diet breadth shifts.

Figure 11.11 shows what happens when the barrier is so narrow that the distance  $d$  is significantly less than the effective foraging radius. In this case, the marshside and seaside settlement types become statistically (and spatially) indistinguishable. We hypothesize that in narrow barrier islands (defined as  $d < \text{EFR}$ ), the seaside settlement type should disappear altogether because the *three* highest ranking patch types (in this case, the salt marsh, the maritime forest, and the marine offshore) can each be readily accessed from the optimally positioned marshside settlement place (a possibility modeled at the bottom of fig. 11.11).<sup>27</sup>

### BEYOND FORAGERS AND COLLECTORS?

Critical here is the distinction between **residential mobility** (movement of the entire group or some subset from one residential base to another) and **logistical mobility** (movements of individuals or small task-specific groups in and out of the residential base). These two mobility patterns are not opposing structural principles; instead, they are organizational alternatives that may be employed in varying mixes in different settings. In general, when residential mobility is reduced, logistical mobility increases, and these residential strategies, in their various iterations, have significant ecological and

social consequences. Over the past quarter-century, several investigators have found merit in employing Binford's (1980) "forager-collector continuum" (Kelly, 1980, 1983, 1995: 111–120; Schalk, 1981; Thomas, 1981, 1983a, 1985; Binford, 1982; Saville, 1987; Ames, 2002: 34–35; Barlow and Heck, 2002: 140–141; Habu and Fitzhugh, 2002).

In this formulation, a **foraging strategy** moves consumers to where the plants and animals live, thus "mapping onto" key resource locations within a particular habitat.<sup>28</sup> Foragers generally follow a strategy of high residential mobility, moving their residential base through a sequence of resource patches. Foragers typically gather low-bulk food on an encounter basis, rarely storing their food and usually returning to their residential base daily. Foraging strategies are most effectively applied to a set of largely undifferentiated habitats, where food is available (more or less) year-round, in places such as the tropical rainforest and other equatorial settings (Binford, 1980).

The contrasting **collecting strategy** relies on larger, more stable residential bases, relying when necessary on logistical forays by small "task groups" of men or women to bring the plants and animals back home. That is, collectors restrict residential mobility in favor of movement by task-specific groups who often stay away from the residential base for considerable intervals. The locations of such residential bases were not necessarily tied to specific resource patches, but sometimes were sited relative to key resources other than food (with water, firewood, and ready access to hinterland areas often being critical factors). Collectors tend to rely more heavily on food storage (at least during part of the year). The collector strategy is commonly found where resources are patchy and/or available only seasonally (where maximum efficiency is obtained by aggregating in a central place and sending out foraging parties; Kelly, 1995: chap. 6).

At this basic level, then, foragers move people to resources, and collectors move resources to people. Foragers procure most of their resources within the effective foraging radius. Collectors do this as well, but

they also acquire more distant resources by sending out task groups to harvest, process, and return to home base with processed products—mass processing thus usually takes place away from home.

Binford (1980) and Kelly (1995) emphasize that mobility can also be conditioned by factors other than subsistence resource distributions—including location of fresh water, fuel, shelter, or defensive locations. Kelly (1995) also argues that residential mobility is generally motivated by diminishing returns of near camp resources—regardless of the productivity of more logistically targeted resources that can be pursued from a number of alternative camp sites. Because foragers occupy only residential bases and task-specific locations, their archaeological visibility can sometimes be diminished, and because collectors commonly utilized residential bases, field camps, stations, and caches, the archaeological visibility often increases (especially when high-bulk processing takes place away from the residential base).

Binford (1980, 1982) has argued that spatial incongruity between two resources available at the same time would encourage logistic (rather than residential) mobility as a way to bring people and resources together—meaning that patchy environments would favor logistic procurement strategies and decreased residential mobility. But temporal variability likewise encourages storage strategies—and storage itself increases the effective patchiness of the environment by increasing the costs of residential mobility (due to costs of transporting stored resources). Patchy environments tend to have the shortest growing seasons, meaning that logistical collecting and storage are often correlated in ethnographic samples. Technology—which modifies the capacity for transport, procuring resources in bulk, and better processing—can also condition the effective patchiness of a given environment.

The forager and collector options represent extreme positions on a strategic continuum, along which various hunter-gatherer mobility and subsistence patterns can be scaled (Binford, 1980). The forager-collec-

tor continuum attempts to address the processes through which hunter-gatherers cope with specific habitat mosaics, the integration of various components across that landscape, and the definition of the attendant economic zones surrounding each component.

Several papers in the volume entitled *Beyond Foraging and Collecting* (Fitzhugh and Habu, 2002) address the continuing role, if any, of the foraging-collector continuum in light of newer methods of understanding the hunter-gatherer landscape. The editors of this volume “are unified in the conviction that Binford’s model has been, and continues to be, one of the best tools for understanding a major source of variation in hunter-gatherer subsistence-settlement dynamics” (Habu and Fitzhugh, 2002: 4). But beyond this initial common ground, the participants suggested a number of ways in which Binford’s initial formulation requires a 21st century update.

Several authors noted the potential of behavioral ecology to broaden the forager/collector model and to help derive more testable hypotheses from the baseline formulation (e.g., Fisher, 2002; Fitzhugh, 2002; Kipnis, 2002; Zeanah, 2002). Habu and Fitzhugh (2002: 6) emphasize the degree to which “hunter-gatherers in the past may have shifted along the forager/collector continuum quite frequently [e.g., Habu, 2002] and that settlement patterns may have varied even at a local level [Bar-Yosef, 2002; Habu, 2002; Zeanah, 2002].” Ames (2002) feels that the forager-collector model must be expanded beyond the initial, somewhat restrictive cases on which it was based, particularly when it comes to addressing mobility strategies and settlement patterns of aquatic foragers. Aldenderfer (2002), Cannon (2002), and Fisher (2002) argue that Binford’s model must be modified to address larger, “evolutionary scale” changes and to consider long-term changes in hunter-gatherer subsistence (Habu and Fitzhugh, 2002: 6–8). Cannon (2002) notes that as originally stated, the forager-collector continuum fails to take into account the role of social constraints and ideology. Aldenderfer (2002: 387) suggests that the for-

ager–collector continuum is “foundational” to modern archaeological practice, and the volume editors conclude that “we now recognize that variability is the dominant characteristic of hunter-gatherer economic, social and political organization ... [and] Binford’s forager/collector model remains a vital tool for understanding a portion of this variability across space, and it provides a useful starting point for modeling evolutionary change through time” (Habu and Fitzhugh, 2002: 9).

With this reassessment in mind, perhaps a word is appropriate about my earlier use of Binford’s (1980) forager/collector model and how the present application differs from that previous effort. In our long-term project in Monitor Valley, Nevada (esp. Thomas, 1981, 1983a), we attempted to anticipate the archaeological record by reanalyzing the settlement and mobility patterns of several ethnographic Great Basin hunter–gatherers, groups that typified what Kroeber (1925: 583) once called the “poverty of Nevada civilization”. I was particularly interested in examining the adaptive variability evident in these Great Basin Shoshonean groups (see also Fowler, 1977, 1982).

Specifically, I dissected three case studies: the Kawich Mountain Shoshone, the Reese River Shoshone, and the Owens Valley Paiute (Thomas, 1983a: 6–39). All three groups lived in the arid Great Basin uplands (within 100 km of one another), spoke mutually intelligible and closely related Numic languages, and shared an essentially identical technology. “In a normative sense,” I wrote (Thomas, 1983a: 27), “they were all the same.”

True enough, but with regard to their subsistence and settlement patterning, these three ethnohistoric groups differed markedly, running the behavioral gamut from pure foragers (the Kawich Mountain Shoshone) through seasonally mixed foragers and collectors (the Reese River Valley Shoshone), to full-time collectors (the Owens Valley Paiute). In this controlled comparison, we found the forager–collector continuum to be a useful model because “logistical and residential variability [were] not viewed as

opposing principles but as organizational alternatives which may be employed in varying mixes in different settings” (Binford, 1980: 19).

My concern at the time was to establish a workable epistemological framework for approach the archaeology of Monitor Valley. Specifically, by exploring the nature of synchronic variability over a relative small area, we attempted to establish clear-cut linkages between the known (the protohistoric behavior patterns) and the unknown (the archaeological record). After considering the available plant and animals resources in some detail, we developed five intersecting, midrange theoretical models—“operational vehicle[s] for anticipating the archaeological record of the Monitor Valley” (Thomas, 1983a: 5). The dilemma at the time was this: Whereas the forager–collector model did indeed capture the broadscale adaptive diversity, it failed to explain why such variability occurred in a region lacking the global-scale differences in *effective temperature* (cited by Binford, 1980, as the driving force behind these diverse adaptive patterns). At the time, I noted simply that “we currently lack the theoretical models to explain that variability” (1983a: 39).

Looking toward the future, I optimistically suggested that such general theory would likely evolve through the interplay of innovative archaeological fieldwork and continued research in midrange theory building. While noting the potential of optimal foraging studies to bridge the gap between archaeological data and general theory (Thomas, 1983a: 18, 1986a, 1989: 543–550), I was somewhat skeptical about the way archaeological evidence had been used in early applications. By assuming that the objective of scientific inquiry was to explain—rather than explain away—variability, we focused on building midrange archaeological theory that attributed meaning to our empirical observations—an exercise that I viewed as an “intellectually independent exercise from building general theory to explain that past (per Binford, 1981: 29).

As it turns out, I was wrong.

As Zeanah (2002: 232) correctly notes, “substantial headway has been made in for-

mutating the theoretical models that Thomas found lacking in 1983, but the progress results from a research tack different from that he anticipated” (Zeanah and Simms, 1999). Particularly over the past decade, research in human behavioral ecology has achieved a remarkable symbiosis that articulates general evolutionary theory with high quality archaeological data (and is clearly evident in the multiple sources cited at the end of chap. 6, this volume). Zeanah (2002: 251) suggests that the presently available theoretical models are “providing the theoretical tools necessary to investigate variability in logistic and residential mobility strategies”—in the Great Basin and elsewhere.<sup>29</sup>

I agree completely.

#### RESIDENTIAL MOBILITY IN THE SEA ISLANDS

We have already noted that the earliest available ethnohistorical sources suggest a pattern of significant residential mobility and seasonal dispersal along the Georgia coast. Speaking of his experiences at Orista in the late 1560s, for instance, Fr. Rogel claimed that “for nine out of the twelve months they wander without any fixed abode” (Sturtevant, 1964: 170). Fr. Sedeño wrote “that the few [Guale] Indians that there are are so scattered; for as they have nothing with which to fell the forest for their plantings, they go where they can find a little land without woods to sow their maize; and as the land is so miserable, they move with their *ranchos* from time to time in search of other lands which can bear fruit (Zubillaga, 1946: 424). According to René Laudonière’s account of 1564 “the Indians [of Outina] are accustomed to leave their houses and retire into the woods for a space of three months, namely January, February, and March, during which time you do not see an Indian anywhere, because during this time they only hunt game and live in little cabins in the woods” (Bennett, 1975: 121).

Let us assume, for the moment, that the Jesuits accurately described the seasonal movement of people along the South Carolina/Georgia/northeastern Florida coast.

If so, then we can perhaps draw a legitimate parallel to the subsistence pattern for the Reese River Shoshone, a seasonal round involving the fission–fusion around a primary residential base supplemented by seasonal dispersal areas, task-specific locations, and temporary field camps. This is the same pattern for which Crook (1986, 2004) proposed a fission-fusion settlement model for the precontact Guale people (see fig. 11.1). During at least part of the year, then, this was a classic “foraging” strategy that moved consumers to where the plants and animals live, thus “mapping onto” key prey species within particular patches; for at least part of the year, these coastal Georgia foragers employed a strategy of high residential mobility, moving their residential base through a sequence of resource patches. Although the resource bases of coastal Georgia and upland Nevada differ dramatically, the Jesuit accounts certainly seem to suggest that a combination forager–collector pattern (*sensu* Binford, 1980) played out along the Southeastern coastline in the 1560s.

But when he analyzed these same documentary sources, Grant Jones (1978: 179, 191) came to a different conclusion, deciding that the Jesuit reports deliberately exaggerated the “misery” of the land. Specifically with regard to settlement pattern and mobility, G.D. Jones (1980: 220) concluded:

Some Guale possibly changed their winter residence in order to be nearer hunting, fishing, or shellfish collecting grounds; most individuals apparently maintained permanent residence in a single community. Trips for the purpose of hunting, fishing or collecting wood undoubtedly took individuals away from the community on a temporary basis. Guale settlements were located primarily along the banks of rivers and tidal creeks, in a pattern that seems to indicate a strategy of being simultaneously near shellfish, hunting grounds, and horticultural lands.

Certainly the locations of these early Guale settlements correspond to the Sea Island model (developed above), and in this passage, Jones is describing a classic “collec-

tor” strategy involving large, relatively stable residential bases, out of which logistical forays of small “task groups” brought plants and animals back home.

DEFINING THE CURRENCIES THAT  
UNDERWRITE THE “GUALE PROBLEM”

In the final section of this chapter, we provide some clear-cut, specific archaeological consequences that should allow us to distinguish between alternative interpretations of the early ethnohistoric evidence from the Georgia coast. But before doing this, we believe that these conflicting interpretations of the contact period Guale settlement patterns require some additional consideration.

According to Fr. Rogel (cited above), the Jesuit missionaries failed on the Georgia/South Carolina coast in the 1560s because the native people could not live in permanent settlements—because soils of this region were unsuitable to allow for intensive agriculture and (secondarily) because of the disturbances caused by the Spanish garrisons’ dependence on the Indians for food. Grant Jones (1978, 1980) disputes this allegation, charging that the Jesuits distorted the poverty of the land and suggesting that the Guale were sedentary collectors.

At one level, this “Guale problem” is clearly about provisioning and if efficient provisioning were the only goal being pursued by 16th-century Guale people, then the existing models of human behavior ecology are sufficient to resolve the component issues: If hunter-gatherer mobility were strictly about efficient provisioning, then the forager-collector continuum might be irrelevant because the component decisions—Which prey items should I take? When should I change patches? Should I field process or transport in bulk? Where should I position my base camp?—could be addressed “piece by piece . . . into constituent economic choices” (Zeanah, 2002: 232). In this case, the available cost-benefit models from human behavioral ecology are sufficient to articulate specific hypotheses for testing against the archaeological record.

We have already evaluated, at some length, the energetics of aboriginal foraging on the barrier islands of coastal Georgia; we have attempted just this, developing a settlement model that hypothesizes a way in which foragers can maximize energetic returns in the food quest. Such energy-optimizing decisions have obvious payoffs in terms of long-term fitness goals (despite the fact that male and female foraging objectives might diverge considerably). At the level of efficient provisioning, then, these mobility strategies can best be perceived through the specifics of diet breadth, patch choice, and transport costs.

But by casting the “Guale problem” in terms of the forager-collector continuum, we are reminded that mobility patterning is never strictly about efficient provisioning. People move across the landscape, individually and in groups, for multiple reasons; to be sure, sometimes foragers move to position themselves relative to food and other resources, but residential mobility also minimizes social stress, helps maintain kin ties with distant relatives, fosters and maintains trade relationships, and provides certain defense advantages. From the more catholic perspective of the forager-collector continuum, we can be invited to explore the multiple “currencies” involved in the issue of residential mobility among the 16th century Guale foragers of the Georgia coast.

The ethnohistoric documents make it clear that during the late 16th century, the French and Spanish clearly harassed the Guale on St. Catherines Island with demands for food tribute (Jones, 1978). They also commenced a deliberate policy of moving Guale Indians from the mainland onto the Sea Islands, sometime between 1595 and 1609 (de San Miguel, 2001; Jones, 1978: 185). “From a Spanish point of view there were good reasons for insular reductions,” writes ethnohistorian Amy Turner Bushnell (1994: 65). “The islands, protected by marshes and moatlike waterways, offered vantage points from which to watch the coast for foreign intruders. They could be linked by ferries, forming a camino real all the way to the northern border. They put

space between converts and their converted kinsmen. And, not least, the limited areas of islands made it easier to keep an eye on the inhabitants and tap them for tribute and labor.” Such centralization helped the Spanish to control the native population by both providing a readily accessible labor pool and providing a stage to help acculturate the neophytes into tenets of Christianity. Moreover, the mission Indian populations and associated garrisons became key links in a defensive network to protect the frontier against French and British incursions (Jones, 1978).

At least among the important leaders, the Guale also practiced a form of sororal polygyny, with the wives keeping separate households. The Spanish adamantly opposed this practice, and conflicts over polygyny directly contributed to the so-called Juanillo Rebellion of 1597 (de Oré, 1936; Zubillaga, 1946: 418; Barcia, 1951: 182; Jones, 1978: 183–185). The Franciscan scholar de Oré has described the Spanish retaliation following this revolt and the complex problems it created for the Guale rebels: “Since all the Indians were hidden in the woods, the governor could neither punish them nor get in touch with them. They burned the foodstuffs of the Indians; the Indians themselves already burned their houses when they left. On this account and due to what followed, during the subsequent years they had no maize harvest. Moreover since they were removed from the sea, they could neither fish nor gather shellfish, with the result that they suffered great hunger. Though the Indians sowed, it was little, while the Spaniards destroyed it every year” (de Oré, 1936: 95).

We know that no fewer than eight major epidemics swept across peninsular Florida before 1562 (Dobyns, 1983), and aboriginal people along the Southeastern coastline may have deliberately avoided contact with the French and Spanish newcomers to escape the epidemic diseases they brought with them. Specifically with respect to the Guale, major episodes of disease have been documented for the years 1569–1570, 1582, 1649–1650, 1659, and 1672 (Bushnell, 1978; Larsen, 1990: 18). Thousands died during

the decade of 1649–1659 (Larsen, 1990: 18) and missions became a nexus for the spread of disease, where populations were centralized, providing ideal conditions for introduction of pathogens. In 1657, the governor of Spanish Florida commented on the drastic reduction of native population in the province of Guale “because they have been wiped out with the sickness of the plague and small-pox which have overtaken them in the past years” (quoted in Hann, 1986a: 378).

To summarize, then, it is clear that the Guale and other nearby coastal groups in the late 16th century were deliberately avoiding contact with the early French and Spanish newcomers for multiple reasons—to feed themselves and to avoid paying tribute to the colonizers, to minimize religious harassment, to avoid resettlement in so-called *reducción* settlements (Geiger, 1937; Bushnell, 1994: 22–23, 65, 126), and to avoid epidemic disease.<sup>30</sup> We suspect that residential mobility likewise was involved in attempts to maintain redistributive patterns that reinforced chiefly alliances. All of these factors beg the question of whether such religious, social, military, economic, and epidemiological considerations might actually outweigh net energetic returns.

As previously, numerous investigators (e.g., Bliege Bird et al., 2001, 2002; Hawkes and Bliege Bird, 2002; Smith et al., 2003; Bliege Bird and Smith, 2005) have argued that “symbolic” behavior can confer significant fitness-related advantages, meaning that certain foraging activities should be understood in terms of their social and competitive value, rather than merely their nutritional contribution. As archaeologists grapple with the implications of these various theoretical constructs, we must clearly recognize that all aboriginal foraging pursuits exist within “both a gastronomic and social context, each with potential evolutionary consequences” (Hildebrandt and McGuire, 2002: 232). Although both approaches can be subsumed under the rubric of human behavior ecology, models assuming efficient energy maximization differ significantly from those assuming social costs (such as “costly signaling”).

For these reasons, we will not assume (1) that a single currency underwrote the mobility strategies of the protohistoric Guale people or (2) that a single mobility strategy was somehow “typical” of the protohistoric people of the Georgia coast. Instead, we will attempt to explore how the logistic and residential strategies might vary in different localized landscapes across the Sea Islands and how they might change through time—despite the fact that these coastal foragers pursued identical hunt types across identical patch types using identical technologies (Thomas, 1983a; Zeanah, 2002: 251–252).

#### THE SEA ISLAND SETTLEMENT MODEL: A SUMMARY

Relative to barrier islands elsewhere in the United States, the Sea Islands of the Georgia coast are extraordinarily short and relatively broad (table 11.1). The upshot is that the barrier islands along the Georgia coastline support relatively broad expanses of the maritime forest patch type. This means that (1) aboriginal Sea Islanders had access to a terrestrial biodiversity and that (2) patch variability was maximized by latitude (east–west diversity) and minimized by longitude (north–south redundancy): Simply put, the broader the island, the greater is the expected patch diversity. Coupled with the ancient soils available on the Pleistocene island cores, this is why the Sea Islands of coastal Georgia offer significantly greater energetic returns than barrier island complexes elsewhere.

Prey choice, patch choice, and central place foraging models suggest that—regardless of changes in diet breadth—the highest ranking patch type in the Sea Islands will (almost) always be the estuarine/inland salt marsh, followed closely by the maritime forest patch type, well ahead of the sandy beach and the ocean front.

We can summarize the hypothesized Sea Island settlement model this way: The optimal central place is the *marshside settlement*, situated on a stabilized dune remnant within the maritime forest, immediately adjacent to the salt marshes and the tidal

streams that drain them. So situated, the marshside settlements offer ready access to the highest ranking marine and terrestrial patch types, each supporting multiple hunt types of plant and animal food sources. A secondary *seaside settlement type* was situated within the maritime forest margin on the leeward side of the dune ridges, with direct access to the sandy beach patch type. Such seaside settlements should offer the second highest combine central place foraging rate. Each of these central place locations should be situated to provide adequate conditions of human life-space, ready access to places for launching and storing watercraft, and (during the late prehistoric period) access to patches of arable soil within the maritime forest habitat.

The Sea Island settlement model is entirely consistent with Grant Jones’ (1980: 220) contention that “Guale settlements were located primarily along the banks of rivers and tidal creeks, in a pattern that seems to indicate a strategy of being simultaneously near shellfish, hunting grounds, and horticultural lands” (see also Milanich, 1994: 111–118; Russo, 1996: 197). At a more general level, the Sea Island settlement model likewise corresponds with the known settlement patterns of several aquatic foraging groups. Considerable ethnographic and archaeological evidence suggests that, when compared to their terrestrial counterparts, maritime foragers tend to live in relatively large, more residentially stable communities positioned along the coastline (e.g., Yesner, 1980; Erlandson, 2001; Ames, 2002; Kennett, 2005: 36). In effect, foragers exploiting maritime ecosystems tend to position themselves in a central place, from which they can forage logically (by sending out small work parties to capture appropriate prey items, which they transport back home using available watercraft). Smith (1991: 68), for instance, notes that most Inuit (including the Inujuamiut), have traditionally located their primary settlements along the coastline, affording easy access to both terrestrial and marine ecosystems: “The costs of utilizing more than one habitat in close succession can also be reduced by settlement location at the boundary be-

tween two habitats. Inuit have characteristically located settlements along the arctic coast—the boundary between the marine and terrestrial habitats. With few exceptions, Inuit foraging strategies have always incorporated this dual-habitat focus ... [so they can] decide whether to forage in the marine or in the terrestrial habitat—sometimes doing both in the same day” (Smith, 1991: 249).

### ST. CATHERINES ISLAND ARCHAEOLOGY: SOME HYPOTHESES

We now translate the general Sea Island settlement model to the specifics of St. Catherines Island and generate a series of archaeologically testable hypotheses.

#### DIET-BREADTH IMPLICATIONS

In chapters 7–9, we employed the diet-breadth (or prey choice) model to ask: Which foods should an efficient forager harvest from all those available on St. Catherines Island? The model predicts that foragers will optimize the time spent capturing prey and employs the simplifying assumptions that all resources are randomly distributed (without patches) and that “capture/handling” and “search” times represent the sum total of all time spent foraging (O’Connell and Hawkes, 1981, 1984; Winterhalder, 1981; Smith, 1991). This required that we know the return rates of the potential food resources, which were through ethnoarchaeological and experimental research (Broughton and O’Connell, 1999). In chapter 9, we expanded our diet-breadth models to address the horticultural technologies introduced to St. Catherines Island within the last thousand years (Barlow, 1997, 2002, 2005).

Rather than simply pooling all potential prey items (in effect assuming that all resources are distributed homogeneously in space), we defined a series of “hunt types” that enabled us to subdivide and analyze diet breadth among the aboriginal foragers of St. Catherines Island:

- Marine Foraging
  - Collecting shellfish
  - Saltwater fishing
- Terrestrial Foraging
  - Hunting
    - Sea turtle harvesting (summer)
    - Harvesting mast (fall)
    - Harvesting wild plants (late summer through early fall)
  - Cultivating maize (post-A.D. 1000)

The changing month-to-month availability of key prey taxa on St. Catherines Island—especially mast, small seeds, and sea turtles—imposed a distinctly seasonal pattern on the subsistence forager, who exploited resources in both terrestrial and marine ecosystems simultaneously (often on the same day). Such hunt types insure that the assumption of fine-grained foraging can be satisfied within each set of prey taxa.

The diet-breadth model predicts that—*within each hunt type*—the highest ranked prey should always be taken upon encounter. Inclusion of lower ranked prey into the optimal set depends only on the encounter rate of the higher ranked prey; the abundance of a lower ranked item does not condition its inclusion in the optimal diet. Conversely, if a higher ranked resource were to decline in abundance, the search time for that item would increase and the overall harvesting efficiency would decrease (with the diet breadth expanding accordingly). In its most elemental form, then, the diet-breadth model predicts that foragers will select food in a manner that maximizes net energy return. As forager population densities increase, the model predicts that a disproportionate number of high-ranked prey will be harvested, resulting in decreased encounter rates with the most desirable taxa.

With these post-encounter return rates in hand, the diet-breadth model allows us to make the following (testable) predictions about the archaeological record of St. Catherines Island (Broughton, 1994a, 2002; Cannon, 2000; Kennett, 2005: 18):

- If the abundance of higher ranked prey species increases, the diet breadth will decrease (mean-

ing that the variety of resources exploited will be smaller)

- If the abundance of high-ranking resources decreases (inflating search costs), then diet breadth will increase; this is why potential prey types enter the diet based on the abundance of higher ranked resources (not just because of immediate value)
- As human population densities increase, we expect the available of high-ranked prey species to decrease (although shifting climatic conditions can sometimes mask this outcome).

#### PATCH CHOICE IMPLICATIONS

We then turned to a patch choice model to generate a spatial component. As with the prey choice model, patch types can be rank-ordered according to their return rates (the net rate of energy intake/unit of foraging time). The highest ranking patch type should produce the best return per unit of foraging time. By shifting from prey choice to patch choice modeling, we emphasize not a forager's decision about "Should I search or handle?" but rather "Relative to my other options, should I enter a patch, and if so, how long should I stay?" By employing the "one-best-patch" rule, we assumed that foragers should spent more time working the higher ranked patches and less time in patches with lower energetic potential.

Five patch types characterize the Georgia Sea Islands: offshore (Atlantic Ocean), sandy beach, dune ridges, maritime forest, and the salt marshes (both estuarine and interior). The prey choice model allowed us to link the various hunt types to their specific biogeographic correlates (see table 11.4), irrespective of the specific diet breadth:

- The salt marsh should always be the highest ranking patch type on St. Catherines Island.
- The maritime forest patch type ranks second.
- The offshore (Atlantic Ocean) ranks third
- The sandy beach (important only during the summertime) ranks fourth
- The dune ridges have no significant potential for human foraging.

#### CENTRAL PLACE FORAGING IMPLICATIONS

Using central place foraging, we have hypothesized where Sea Island foragers

should establish their residential bases: All else being equal, these residential bases should be situated so as to maximize the net central place foraging returns given the pursuit, handling, and transport costs of resources from different patches.

- The optimal positioning for the primary *marshside* occurs along the intersection of the two highest ranking patches. These central place settlements should be constructed on the high ground situated along the extreme leeward margin of the maritime forest and directly adjacent to the salt marsh.
- The optimal positioning for the (secondary) *seaside* settlement type (defined as the maritime forest margin with the closest access to the Atlantic Ocean). These central place settlements should be constructed on the high ground situated along the extreme seaward margin of the maritime forest and directly adjacent to the salt marsh.

At the end of this chapter, we discuss how the specific biogeographic constraints of the St. Catherines Island landscape effect these central place implications.

#### RESIDENTIAL MOBILITY IMPLICATIONS

At the most basic level, then, we can model the Larson/Crook and Jones interpretations of Guale subsistence and settlement patterns in terms of relative mobility. Table 11.6 sets out the archaeological implications of these two strategies.

As Ames (2002: 43) has noted, aquatic foragers generally make relatively few residential moves per year: "This must reflect their ability to position themselves centrally and make multiple, short- and long-distance logistical forays. They can also field larger task groups with broad mixes of people, which means that a wide array of tasks can be undertaken from camps." Grant Jones is clearly proposing such a "collector" *strategy of low residential mobility* involving the fully sedentary utilization of "dispersed towns" located in a "forest-marsh area" (Jones, 1978: 193–194): "The location of Guale settlements along rivers and tidal creeks seems to have actually been a strategic measure to be near shellfish, hunting grounds, and horticultural lands without having to change residence seasonally."

TABLE 11.6  
**Archaeological Expectations for Aboriginal Mobility Options in the Georgia Sea Islands**

Season	Settlement locations	
	Residential base	Additional settlements
A Strategy of High Residential Mobility <sup>a</sup>		
Summer	Town site aggregations	None
Early fall	Sparse town site occupation	Dispersed residential sites in oak forest
Late fall–winter	Moderate town site occupation	Dispersed residential sites near tidal creeks and estuaries
Spring	Moderate town site occupation	Dispersed residential sites: oak forest, near estuarine areas & freshwater rivers
A Strategy of Low Residential Mobility <sup>b</sup>		
Summer	Dispersed town aggregations	None
Early fall	Dispersed town aggregations	None
Late fall–winter	Dispersed town aggregations	None
Spring	Dispersed town aggregations	None

<sup>a</sup> Expectations drawn from Crook (2004).

<sup>b</sup> Based on fully sedentary dispersed towns located along the margin of the maritime forest and salt marsh; specific expectations drawn from Jones (1978, 1980).

Such a strategy of minimal residential mobility should produce a distinctive archaeological record, characterized by of sustained, four-seasonal occupation of *marsh-side* settlements (as defined above), with only minimal evidence of single-season or biseasonal occupations elsewhere.

By contrast, Crook (1986, 2004; see also Larson, 1980a) proposes a *fusion-fission forager strategy of relative high residential mobility*. During part of the year, the Guale were “collectors” living in a residential base (“aggregate town site”) situated near the swidden corn field; such sites should produce archaeological evidence of a four-season settlement, but characterized by a broadly varying intensity of occupation: The heaviest occupation should occur during the summer, with a sparse occupation during the early fall, and moderate occupational intensity from the late fall through winter. But from the fall through the springtime, these Guale were residentially mobile and should produce archaeological evidence of (1) dispersed oak forest settlements (fall and springtime occupations only) and (2) dispersed marshside settlements (late fall–winter and springtime occupations only).

The next chapter proposes a series of specific archaeological techniques to generate

appropriate data from St. Catherines Island to test these propositions.

#### BIOGEOGRAPHIC CONSTRAINTS ON ST. CATHERINES ISLAND

Relative to the other Sea Islands of coastal Georgia, St. Catherines tends to fall in the midrange in terms of size, elevation, and geometry (table 11.3). But with respect to the details of aboriginal foraging ecology, several distinctive biogeographic aspects of St. Catherines Island create a distinctive habitat landscape.<sup>31</sup>

**EFFECTIVE FORAGING RADIUS:** Figure 11.12 shows St. Catherines Island, the surrounding salt marsh, the St. Catherines and Sapelo sounds, and the Atlantic Ocean. The maximum longitudinal (north–south) distance is 16.4 km and the maximum latitudinal (east–west) distance is 5.5 km. For comparative purposes, we have plotted two estimates of an *effective foraging radius* of 5.0 km and 10.0 km from the westernmost high ground on St. Catherines Island (Persimmon Point).

*Given the present configuration of St. Catherines Island, it is clear that an individual forager could systematically search and exploit any patch on the island, and still return home each night.* This geographical fact sug-

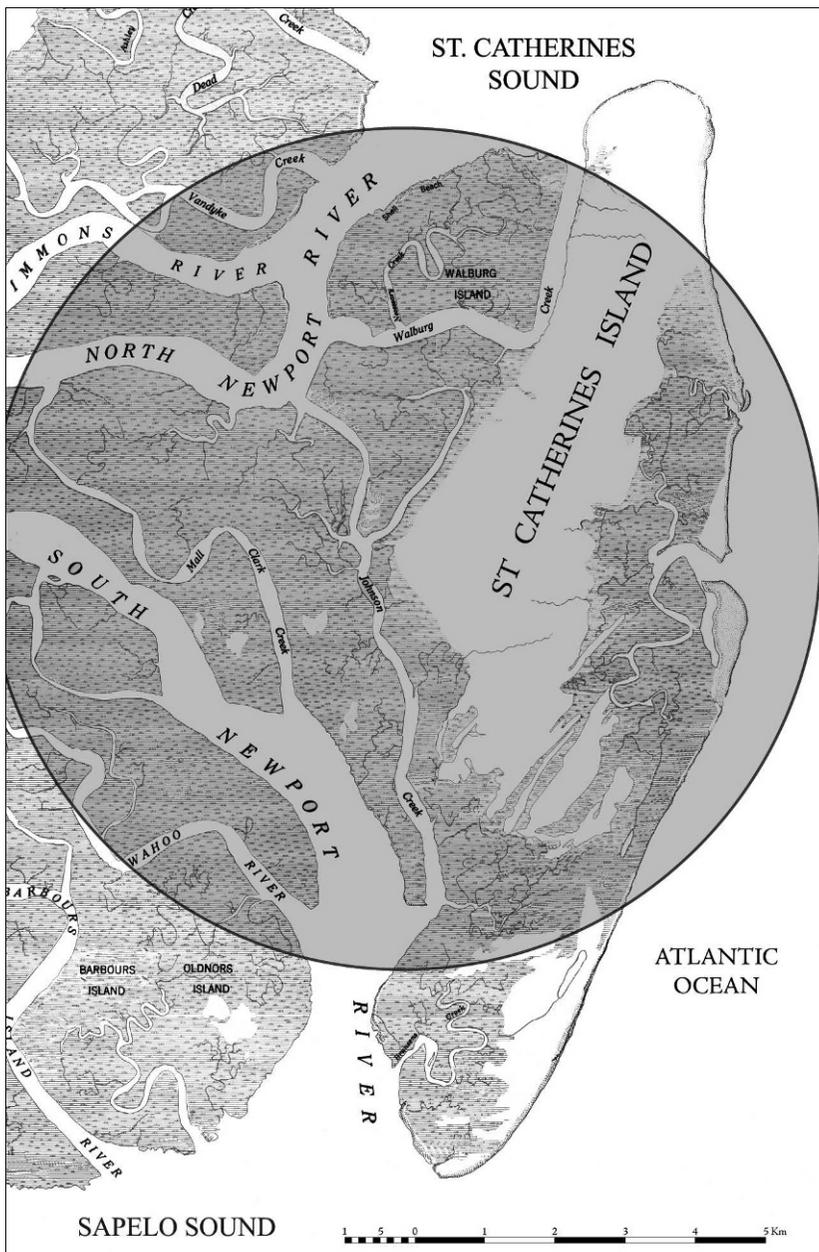


Fig. 11.12. An estimate of the effective foraging radius (5 km) projected from Persimmon Point, the western-most high ground on St. Catherines Island.

gests that St. Catherines Island foragers could have readily pursued a strategy of logistic procurement and low residential mobility should they have so chosen.

In addition, because St. Catherines Island is only about 3 km wide at its widest

point (and much narrower in most places), we know that the distance between the two highest ranking central places (distance  $d$ ) will almost always be less than the lower limit of the *effective foraging radius (EFR)*. Per the model set out in figure 11.11, on

relatively narrow barrier islands (like St. Catherines) with  $d < \text{EFR}$ , the marshside and seaside settlement types will likely merge into a single, high ranking central place. In fact, the seaside settlement type might disappear entirely because the optimally positioned marshside settlements would have ready access to the *three* highest ranking patch types (the salt marsh, the maritime forest, and the marine offshore, in that order).

#### MCQUEEN INLET AND THE ASSOCIATED SALT MARSH

St. Catherines Island has an extensive back-barrier environment, an estuarine system that spans the gap between the barrier island and the mainland (figs. 11.12 and 11.13). These estuaries, protected from shoreface high-energy waves by the barrier islands themselves, include estuarine channels, point bars, tidal flats, and extensive salt marshes (Howard and Frey, 1980: 100). Each of Georgia's Sea Islands protects an extensive salt marsh estuary along its western shoreline.

But St. Catherines Island also has a second, well-developed salt marsh system along most of its eastern margin (fig. 11.13). Along the seaward exposure of St. Catherines Island, Cracker Tom Creek and Fish Creek connect directly with the Atlantic Ocean and feed an expansive inland salt marsh with its characteristic dendritic drainage pattern. The McQueen salt marsh (which covers approximately 13.5 km<sup>2</sup>) is protected from high-velocity tidal energy by Beach Hammock, McQueen Hammock, and Black Hammock, which in turn are interconnected by a series of shifting wash-over fans and aeolian dunes. That is, although the salt marsh is typically thought to be an estuarine, back-barrier facies, salt marshes can sometimes occur in inland island locations, wherever wave and current energy are reduced (Howard and Frey, 1980: 95).

The importance of the McQueen salt marsh to aboriginal foragers cannot be overestimated: Both the leeward and windward sides of St. Catherines Island have di-

rect access to extensive marshlands—the extensive estuarine marshes lie to the west, and along most of the eastern shoreline lies the McQueen salt marsh, which is protected in the lee of shoals and prograding sand spits projecting from both North and South Beaches. As indicated in figure 11.13, more than 80 percent of the St. Catherines Island maritime forest coastline abuts directly on the margin of a salt marsh—effectively doubling the number of optimally positioned central places.

Taking into account the effective foraging radius and the location of the McQueen salt marsh on St. Catherines Island, we can hypothesize the most probable locations for central place/residential bases on St. Catherines Island (figs. 11.14 and 11.15):

- Potential locations for *marshside settlements*, the central place with direct access to the three highest ranking patch types (the salt marsh, the maritime forest, and the offshore), are widespread, covering approximately 80 percent of the shoreline on St. Catherines Island.
- The potential *seaside settlements* on St. Catherines Island are extremely limited (restricted to the northern and southern Holocene beach ridge complexes; see fig. 11.13); in fact, given the projected importance of marshside residences, this settlement type might not be present at all.

#### DISTRIBUTION OF ARABLE LAND

Throughout this chapter, we have emphasized the general principles of latitudinal variability and longitudinal redundancy in the Sea Island landscape. This is why the five key patch types were defined along an east–west gradient—to maximize the variability available to the aboriginal forager. But specifically with respect to St. Catherines Island, we must point out a certain degree of north–south (longitudinal) variability with respect to the distribution of arable soils (which assume considerable importance when maize cultivation enters the picture).

Figure 11.15 is a generalized summary of the soil type distribution on St. Catherines Island. The Pleistocene-age island core is

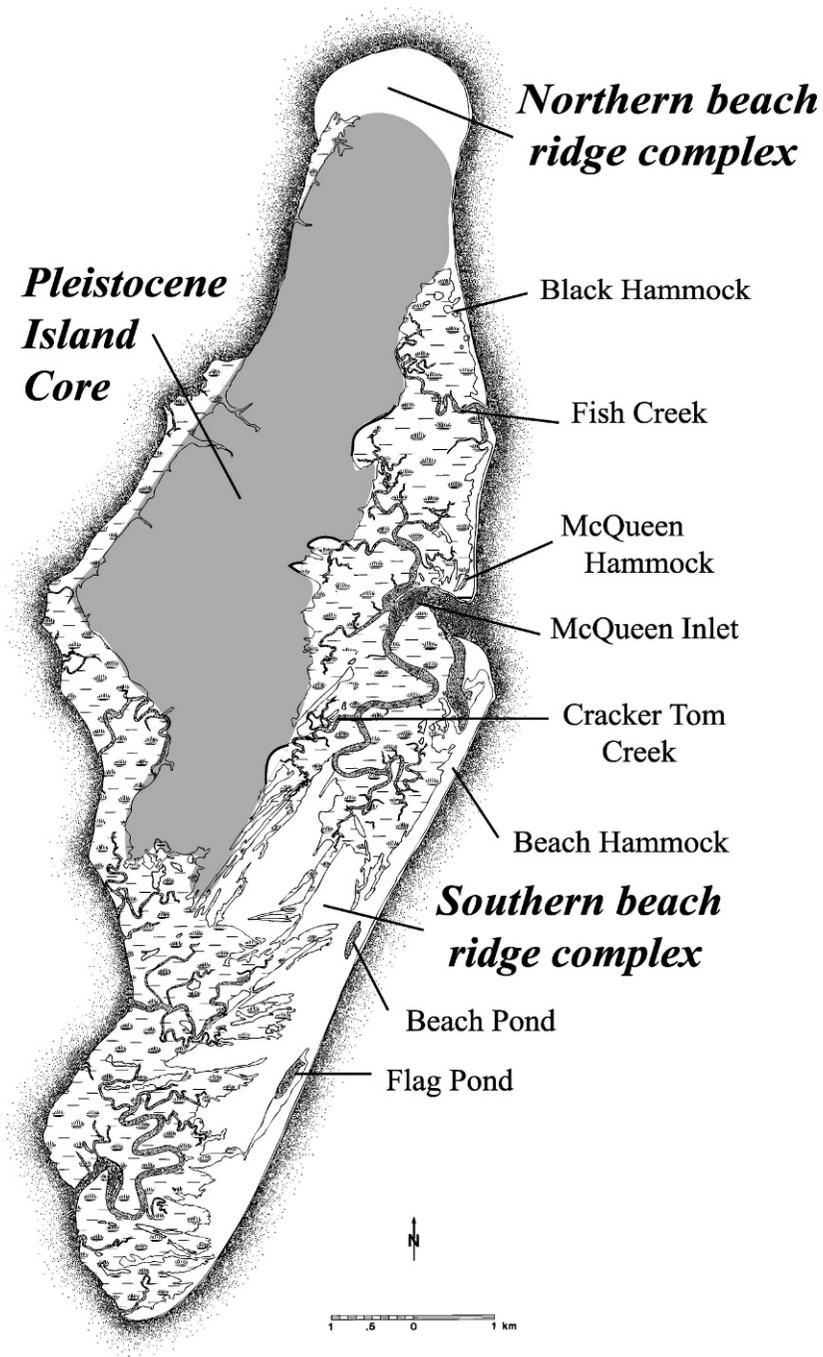


Fig. 11.13. The relationship of McQueen Inlet and the associated salt marsh relative to the Pleistocene core and Holocene beach ridge complex of modern St. Catherine's Island.

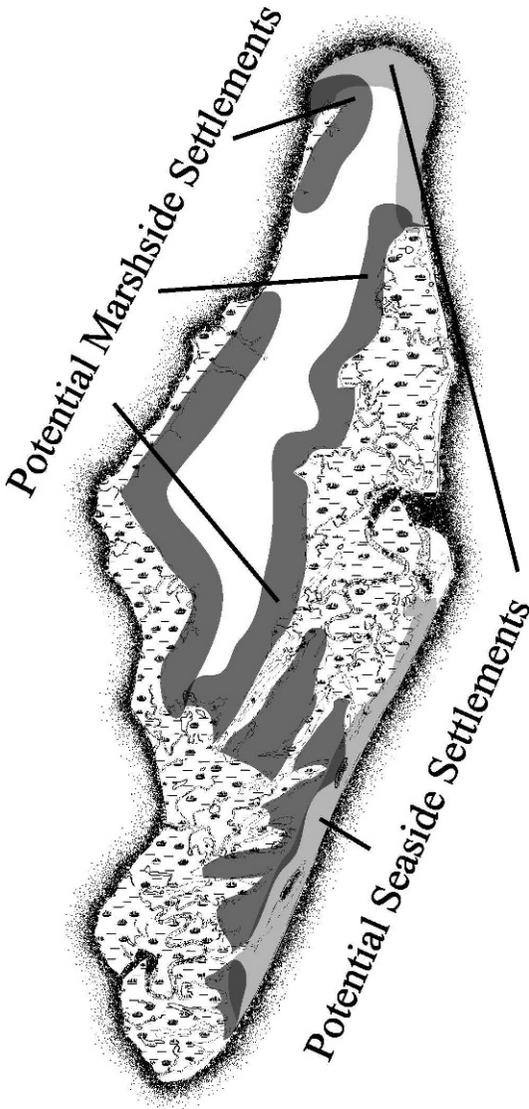


Fig. 11.14. Projected potential distributions of *marshside settlements* (central places with direct access to the three highest ranking patch types – the salt marsh, the maritime forest, and the offshore) and *seaside settlements* on St. Catherines Island.

characterized by a somewhat “concentric” pattern of soil morphology. The outer margins of the maritime forest patch type are underlain by a band of Echaw–Foxworth–Centenary soils, which are nearly level and very gently sloping, moderately drained, and not subject to flooding. This band of Echaw–Foxworth–Centenary soils extends

from the marsh margin inland to a distance of 0.5 to 2 km. These are the most fertile soils on St. Catherines Island: Most antebellum fields were constructed on Foxworth soils (with a few fields cleared on Echaw and Centenary fine sands).

Viewed in a larger geomorphological perspective, the distribution of arable soil types is likewise informative about preagricultural settlement potentials, particularly with respect to the Pleistocene island core.

In broad brush, the Pleistocene core of St. Catherines Island consists of two relic dune ridges running northeast–southwest and separated by a low-lying swale. The *western Pleistocene core* defines the estuarine marsh edge, running a total of 8 km from Wamassee Head (location of Mission Santa Catalina de Guale), northward past Persimmon Point (the westernmost extent of St. Catherines Island), continues to the northeast fronting Cattle Pen and Waldburg creeks, ending at the Northwestern Marsh. At its maximum width (due east of Persimmon Point), the western Pleistocene dune ridge is 1.2 km wide (fig. 11.15). The western island core is slightly elevated, well defined by elevational and drainage differentials.

The *central Pleistocene swale* borders the western dune ridge along its entire eastern margin. This discontinuous low-lying zone is characterized by poorly drained Rutledge soils (fig. 11.15) that mark the location of a large freshwater lagoon that once dominated the Pleistocene core of St. Catherines Island. Before they were artificially drained, this series of freshwater ponds and sloughs flooded and dried up with the seasons. Although Rutledge fine sands are low in natural fertility, these low-lying areas collected extremely high concentrations of organic matter. The decomposing organics of leaves, twigs, and guano from visiting waterfowl recycle critical nutrients into the slough bottomlands, creating first-rate fertility zones readily exploited by aboriginal gardeners. Certainly during plantation times, and likely during the aboriginal time-frame as well, these temporarily dry slough and pond bottomlands provided an excellent microhabitat for maize horticulture.

## Central Place Foraging Model

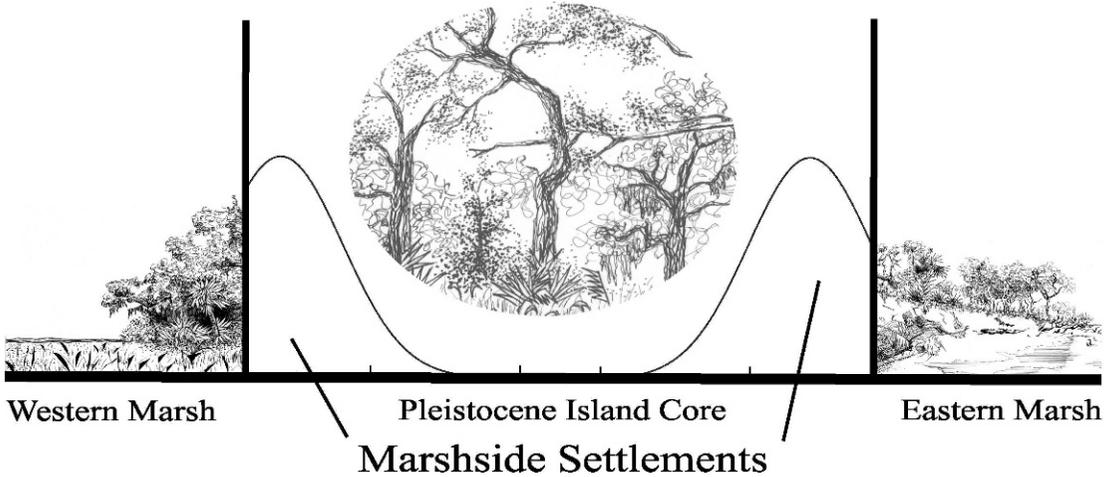


Fig. 11.15. The Central Place Foraging Model hypothesizes that Marshside Settlements should be distributed, in approximately normal fashion, within the mature maritime forest, but bordering the eastern and western marshlands of St. Catherines Island.

As noted in chapter 5, it is difficult to appreciate the magnitude of the hydrological change over this past century. But the documentary sources and extant geomorphological evidence has made it possible to frame a preliminary reconstruction of what St. Catherines Island must have been like before deep drilling changed the hydrology forever. In 1753, Jonathan Bryan described the “perfect Meadow” with its “cristial [crystal] Streams in winding rills proceeds the rising Mounts and flow the verdant meads” that once dominated the central Pleistocene swale which bisects St. Catherines Island and was drained in the 1930s by dragline ditches. But the full extent of this long, linear freshwater lagoon can clearly be delimited on pre-1930 topographic maps, on early aerial photographs, on soil distribution maps, and in surviving geomorphic clues that persist on the Pleistocene core of St. Catherines Island (fig. 11.16).

The near complete absence of antebellum fields on the northern quarter of St. Catherines Island is noteworthy, particularly in light of the large, continuous band of Echaw–Foxworth–Centenary soils (the favored soil type elsewhere on the island; see

fig. 11.17). The absence of agricultural fields on the northern end of the island can be attributed primarily to topography and drainage. This area contains considerable “high ground”—stabilized dune ridges in places several meters above mean sea level. The prevailing natural vegetation of the northern part of St. Catherines’ Pleistocene core is long-leaf pine, a species known for its deep-reaching tap roots that penetrate to a sufficient level to reach the underlying water table. This land is ill suited for agriculture, and despite the prevalence of relatively desirable, well-drained soils in this area, cotton would not grow in these relatively high elevations because access to the water table is difficult.

We have already discussed the agricultural potential of the low-lying Rutledge soils, particularly during arid summer months (chap. 9, this volume); but we must also keep in mind that under a pre-1930s hydrological regime, the central swale was frequently flooded, a long, linear, somewhat discontinuous freshwater lagoon, defining a nearly continuous eastern margin to the western dune ridge and constraining human settlement potentials. Except for a small (200-m wide) break due east of Persimmon

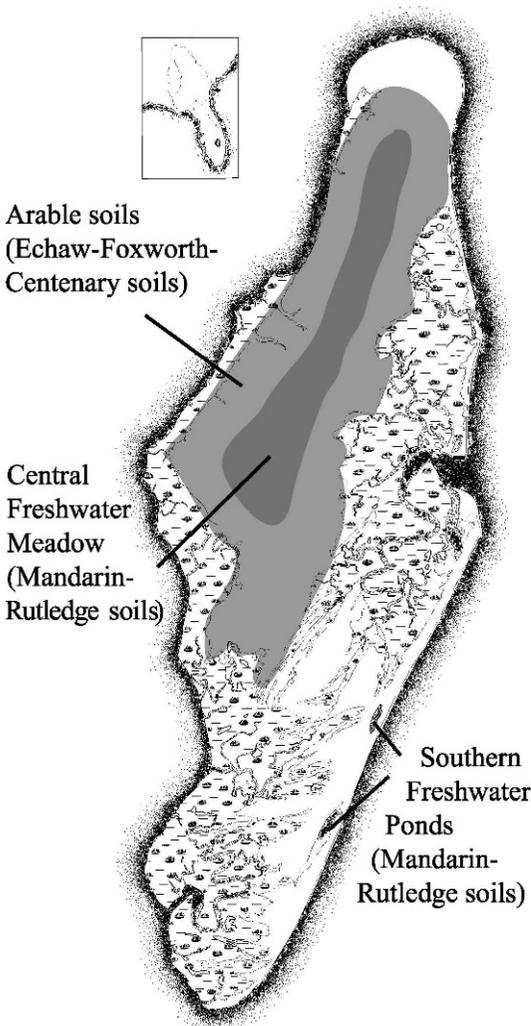
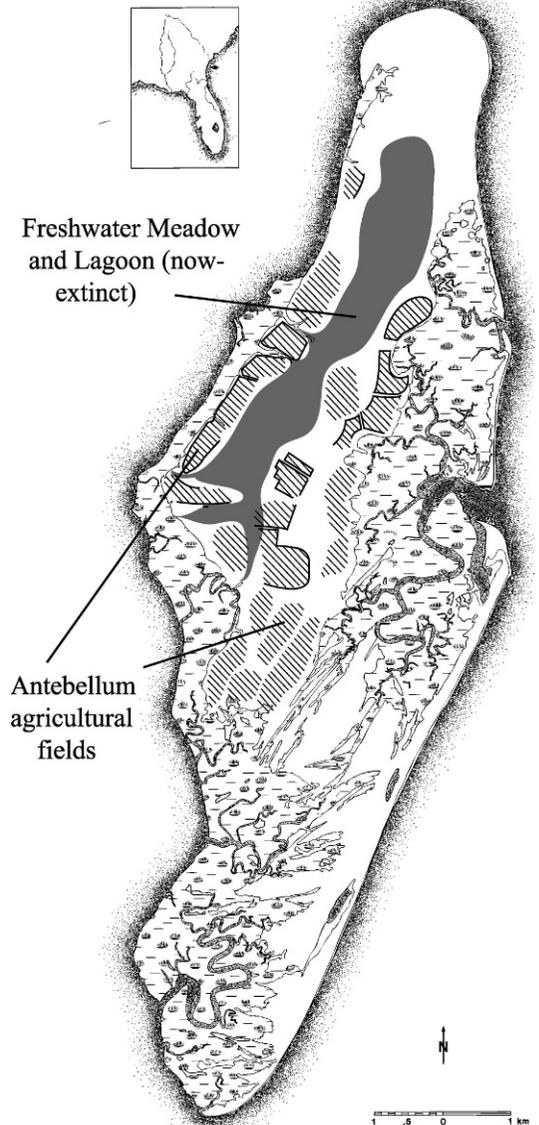


Fig. 11.16. Distribution of arable soils on St. Catherines Island.

Point, and a couple of larger breaks (500–600 m wide) on the northern end of the island, the central freshwater lagoon effectively prohibited the eastward expansion of human settlements along the western dune ridge (which plays out at Wamassee Head).

In terms of aboriginal settlement patterning, this means that marshside settlements along the western edge of St. Catherines Island—north, say, of Wamassee Head—were limited to a strip of high ground defined by (1) the western marsh edge and (2)

Fig. 11.17. Configuration of the now-extinct freshwater lagoon that once dominated the central reaches part of St. Catherines Island, compared with the known extent of plantation-era agricultural fields situated on the surrounding patches of arable soil. In 1753, Jonathan Bryan described this “perfect Meadow” as “a large Savanna of about a Mile or Mile and half wide and four or five Miles long, and finely water’d with Springs” (in Wood and Bullard, 1996: 19–20). The former distribution of this “perfect Meadow” can be delimited on pre-1930 topographic maps, on early aerial photographs, and in geomorphic clues still present on the Pleistocene core of St. Catherines Island.



the central freshwater lagoon. At its maximum width (at Persimmon Point), the maximum possible leeway for human settlements was only 1.2 km wide. To the north, parallel to Walburg Creek, this maximum settlement breadth narrowed to only about 300 m (although, as noted above, there are some breaks in the discontinuous distribution of freshwater lagoon deposits along the northern end of St. Catherines Island).

The *eastern Pleistocene core* defines the seaward extent of the Pleistocene core of St. Catherines Island. Like its western counterpart, this is relatively high ground characterized by the relatively well-drained Foxworth–Echaw soil types. At its maximum, the eastern Pleistocene core runs about 11 km, from South End Settlement, past Cracker Tom Hammock, along the western margin of McQueen and Seaside Inlet, through the North Pasture area, where it is capped by the late Holocene dune ridges that have accreted along the northern end of St. Catherines Island, fronting St. Catherines Sound.

Human settlement on the eastern Pleistocene dune ridge is likewise constrained to the west by the freshwater lagoons and meadows that dominate the central corridor of St. Catherines Island. The eastern margin of the Pleistocene core has been somewhat fluid since the mid-Holocene transgression, impacted by the southward-shifting salt marshes (as Guale Marsh migrated southward, evolved into the Seaside and McQueen marshlands), by the submerision of Guale Island/Guale Marsh, by the subsequent severe erosion of the North Beach bluff area, and by the expansion of late Holocene dune ridges accreting along the northern and southern margins of the Pleistocene core. In terms of aboriginal settlement pattern on the eastern Pleistocene dune ridge, this meant that (1) the *western limit* of human settlement was fixed (defined by the unchanging distribution of the central lagoon and its associated Rutledge soil type), but the *eastern limit* of human settlement was rather fluid, depending on the marsh and island configuration at that particular time.

The distribution of arable soils on St. Catherines Island can be summarized this way:

- The extreme northern end of the island has no agricultural potential. The Holocene-age beach ridges have infertile soils, and the potential of Echaw–Foxworth–Centenary soils is limited because relative high elevations reduce the availability of freshwater.
- The most arable soils occur along the margins of the maritime forest patch on the Pleistocene core. This band of the Echaw–Foxworth–Centenary soil group is well suited to slash-and-burn and intensive cultivation of maize (and immediately adjacent to the projected locations of the marshside settlements).
- The interior sector of the island core contains large patches of Rutledge fine sands, which are well suited for plant-and-harvest maize cultivation.
- Except for the two patches of Rutledge soils associated with Beach Pond and Flag Pond, the Holocene beach ridge complex contains no soils suitable for agriculture of any kind.

**FIRST- AND SECOND-TIER TERRESTRIAL HABITATS:** Figure 11.13 has plotted the spatial distribution of the Pleistocene island core, the Holocene-age beach ridge complexes, and the salt marshes associated with St. Catherines Island. As we consider the biogeographic constraints on St. Catherines Island foragers, we must distinguish between the *first-tier habitats available on the Pleistocene island core and the second-tier habitats that characterize the Holocene beach ridge complexes (on both the northern and southern ends of St. Catherines Island)*.

The Pleistocene core is a first-tier habitat for several reasons. The central portion of the Pleistocene remnant on St. Catherines Island today hosts mature, mixed deciduous–pine forest. As noted above, this central zone is characterized today by two rather poorly drained soils (Mandarin and Rutledge fine sands) that occurs on broad ridges and shallow depressions and embayment (Looper, 1982; see also chap. 5, this volume). On the broad ridges, natural vegetation consists of saw palmetto, gallberry, waxmyrtle, and long-leaf pine. In the depressions and bays, natural vegetation is generally composed of blackgum, cypress, sweetgum, pond pine, and water oak. Al-

though these extremely acidic soils are poorly suited for modern agriculture due to their lack of natural fertility and organic matter (as developed in chap. 5), we think these low-lying areas provided excellent habitat for maize cultivation using aboriginal technologies.

The periphery of the Pleistocene remnant is ringed by the relatively high-quality soils (Echaw–Foxworth–Centenary complex) that developed on the nearly level and gentling sloping terrain (fig. 5.2). These moderately well-drained ridges and small knolls are sandy throughout and not subject to flooding; they range in size from 5 to 75 ha. These soils are medium to very strongly acidic and are consequently low in natural fertility and organic content. By modern standards, these soils are poorly suited to row crops, but moderately suited to use as pasture; during the aboriginal period, this zone was admirably suitable to slash-and-burn methods of maize cultivation. The peripheral island core today hosts a maritime forest vegetation of loblolly and long-leaf pine, live oak, and laurel oak. Some areas have an understory of waxmyrtle and yaupon.

In contrast, the Holocene-age beach ridges are a distinctly second-tier habitat for aboriginal foragers on St. Catherines Island. Restricted to the northern tip and the southeast quarter of the island, these beach ridges' accretionary features run roughly parallel, averaging 3 m high and separated by swales comprised of intertidal marsh meadows or freshwater ponds. The South Beach preserves a sequence of beach ridge complexes that are progressively younger to the east and south (chap. 29). These Holocene beaches are generally accreted into hammocks, sometimes comprised of several individual ridges. The rolling beach ridge topography is generally inhospitable for human habitation, with little flat ground and plenty of vines, briars, swamps, and insects.

The overall patch size is quite small. Whereas the Pleistocene-age island core covers nearly 2000 ha, the 31 Holocene-hammocks on the south end of St. Catherines Island have an average size of less than 50 ha (ranging in length from 0.6 to 3.5 km

in length, with an average width of less than 0.3 km. The eight Holocene-age hammocks on the northern end of St. Catherines Island are even smaller, averaging only 6.1 ha in size.

These beach ridges range from nearly level to moderately steep and the associated Fripp–Duckston soils are low in natural fertility and organic matter content, making them unsuitable for agriculture in any form. Most Fripp–Duckston soils are forested with live oak, brush, and grasses. Situated between the beach ridges and the Island core lie the poorly drained, nearly level soils of the Bohicket–Capers series. This very poorly drained, nearly level soil occurs in tidal salt marshes that interfinger into the mainland and barrier islands, as well as in floodlands that extend inland from the ocean. Natural vegetation is needlegrass, rush, and sand cordgrass. The soils in this unit are used primarily for wetland wildlife, and are poorly suited for most other uses.

Although the Holocene beach ridges lack the relatively higher quality Echaw–Foxworth–Centenary soils that were utilized for slash-and-burn cultivation on the Pleistocene core, we know from historical accounts (discussed in chap. 5) that antebellum farmers planted maize in the poorly drained Rutledge fine sands at Flag Pond, on the south end of St. Catherines Island (and the same may have been true at Beach Pond as well). Although low in natural fertility, the Rutledge fine sands accumulate extremely high concentrations of organic matter such as decomposing leaves, twigs, and guano from visiting waterfowl, creating first-rate zones readily exploited by aboriginal gardeners, if they employed a “plant-and-harvest” strategy (after Barlow, 2002: 79; fig. 5; see also chap. 9).

Overall, then, several factors make the Pleistocene island core a first-tier habitat for aboriginal foragers: The relatively fertile soils and the extensive areas of moderately good drainage support a healthy and widespread maritime forest. The Holocene-age beach ridges offer only second-rate habitat for aboriginal foragers. Some of the larger hammocks (such as Cracker Tom) offer a more hospitable landscape, retaining the

characteristic rolling, beach ridge topography, but with sufficiently mature stands of oak and hickory that the underbrush is shaded out, creating the more open woodland aspect characteristic of the Pleistocene core. But because the Holocene beach ridges are relatively young, the poor soil quality generally supports dense, almost impenetrable scrub vegetation. The oak and hickory trees growing on these beach ridges are smaller and the mast production inferior compared to the production realized on the Pleistocene core. Furthermore, because of the small patch size, the beach ridge habitats contain relatively few mast-producing trees, without the redundancy evident in the extensive oak stands and hickory ridges that are widespread on the Pleistocene island core. In some years, perhaps, the beach ridge forest might produce the only available mast, but the dense vegetative cover make mast harvesting considerably more difficult (and expensive); acorns and hickory nuts are difficult to find in most resource patches (unless one is willing to invest considerable effort in preparing the surface in mast-production areas).

The lifespace conditions of the Holocene beach ridges likewise pose problems. Because of their small size and lower elevation, the Holocene hammocks are subject to storm surges and exposed to extreme winter weather; on the Pleistocene core, one can always move inland a few hundred meters to escape inclement weather. Resource transport costs are high. And although burning is a possibility to increase (temporarily) the available browse and open up the understory, it is clear that the dune ridges remain expensive, less desirable places to live. After all, burning will not change inherent problems with topography, soils, water, and exposure. Relative to the expansive Pleistocene island core, the Holocene beach ridges are highly expensive, less productive habitats, generally lacking in the basic conditions necessary for human lifespace.

With these hypotheses in mind, the next chapter will set out a research design appropriate to approach the archaeological record of St. Catherines Island.

## NOTES

1. Orista is a Cusabo town on the southern coast of South Carolina, after which Edisto Island and the Edisto River are named.

2. Here is the rest of the relevant passage from Fr. Rogel's letter to Pedro Menéndez de Avilés discussing the Jesuit failure at Orista (Zubillaga, 1946, as translated in Sturtevant, 1964: 172–173): “The Indians are so scattered, without any fixed abode for nine out of twelve months of the year. Even then, if they moved from one place to another all together, there would be some hope that by accompanying them one might make some impression by repetition (like water dripping on a hard stone). But each goes his own way, and thus I have experienced the converse of the principle which your excellence has so much at heart, that the faith must spread in this land. What I find is the opposite, that to win any of the blind and wretched souls of these provinces it is necessary first to give orders that the Indians join together and live in settlements, and cultivate the land to secure sustenance for the while year. After they are firmly settled, let the preaching be introduced. Because if this is not done, even though the religious go among them for fifty years they will have no more success than we had these four years that we have gone among them—which is none, not even the hope or semblance of any. To gather them in this manner, your excellency will understand, will require tremendous labor and a very long time, in order to do it lawfully as God our Lord commands, not forcing them nor with arms. There are two reasons for this: first, because they have been accustomed to live in this way for many thousands of years, and to want them to cease this manner of life seems to them equivalent to death; secondly, even though they should wish to do so, the soil will not permit it, being thin and miserable and quickly worn out. They themselves say it is for this reason that they live so scattered out and wander so much.”

3. Outina is a Timucuan settlement located just west of the St. Johns River (Worth, 1998: 21).

4. Elsewhere, Laudonière wrote that “during the winter they retire for three or four months into the woods where they make little huts of palm leaves and live on acorns, fish which they catch, oysters, deer, turkeys, and other animals which they hunt” (Bennett, 1975: 15–16).

5. Real differences exist between the two interpretations, differences that simply cannot be dismissed as merely temporal or acculturative (e.g., Crook 1986: 73). It is simply not true, per Crook (1986: 73), that the Jones model addresses only “the acculturated Guale”. Jones quite clearly spelled out that his reading of Guale ethnohistoric extended well back into the precontact period (1978: 179).

6. In subsequent chapters, we will discuss the problems of linking these behavioral constructions (base camp, field camp, location, etc.) with their archaeological correlates. For now, we simply note that repeated reuse through time (spatial redundancy) tends to blur the distinctive character of seasonally occupied residential bases and single-season logistic camps, generating palimpsests of unrelated assemblages and features. Elsewhere (Thomas, 1983a: chap. 5, 1989), we have

shown that for the Great Basin of western North America, the distinction between a residential site and a task site is often a consequence of how much of a site is sampled, rather than any empirical quality of the site itself. A big sample looks like a residential site, a small sample appears to be task specific.

7. The various economic zones are presented viewed here in an ideal sense, as concentric circles about a residential base. But in the real world, of course, each zone is strongly conditioned by the transport and labor costs of each resource, the local topography, distribution of resource patches, and tethering effects of water availability and migration routes.

8. Aquatic transport dramatically alters the cost-benefit relationships embodied in establishing the effective foraging radius (see Ames, 2002). We will have occasion to discuss these assumptions and implications for the effective foraging radius in more detail below, with regard to central place foraging and transport models.

9. Relative to Larson's three "sections" (1980a), the present study includes all of the strand (within the State of Georgia) and that part of the lagoon and marsh sector most directly associated with the barrier islands. Specifically excluded are the salt marshes and high ground associated with the mainland. We believe that future research in these "excluded" areas may well demonstrate rather different energetic relationships from those of the barrier islands.

10. In chapter 29, we discuss the changing shorelines of Georgia's barrier island. Drawing on the available hydrographic, topographic, and orthophotographic maps between 1858 and 1974, Oertel and Chamberlain (1975) superimposed the various shoreline positions on high altitude EROS photographs taken in May 1982. The resulting composite maps depict the historical changes in mean high water shorelines on St. Catherines Island during this 124-year interval (see chap. 29). In general, they conclude that between 1857 and 1925, there was no discernable shoreline erosion along the entire Georgia coast. But between 1924 and 1974, they found that the barrier island system maintained a "dynamic stability", with considerable deposition on Little St. Simons Island and Cumberland, and a "balanced erosion" on Tybee and St. Catherines Island (Oertel and Chamberlain, 1975). But during the interval 1954–1980, this erosion has been accelerating, coupled with rising sea levels.

11. Although the bluffs at St. Marys (in south Georgia) exhibits a similar Pleistocene/Holocene sequence as St. Catherines Island, Reid's Bluff is a barrier island that has been uplifted and eroded to expose a cross section of that ancient island (Rich and Pirkle, 1993).

12. The geomorphology, soil structure, and vegetation cover of these various barrier island components have been discussed in considerably more detail in chap. 3, 5, and 29 (this volume).

13. Patch choice models do not necessarily predict that resources will deplete within a patch. A forager will choose to remain in a given patch so long as the margin rate of gain (at the time of leaving) is equal to the overall return rate for the habitat. This is why the opportunity costs of remaining in a given patch often increase the

longer one stays there. An example: In some cases, local declines in overall return rates can actually spell an *increase* in the archaeological presence of high ranked resources. Cannon (2000) has shown that, with overall decreasing foraging return rates for a habitat, sometimes foragers switch to a more distant patch with higher ranked prey to maximize delivery rates. Counterintuitive conclusion: decreased overall return rates can result in increased archaeological presence of high ranking prey. A similar process likely happens among Meriam shellfishers (Bird, personal communication). Nerites and asaphis clams are truly low-ranked resources (in strictly cost-benefit terms); but they are worthwhile collecting (1) if one is foraging with really little kids or (2) when the tide is covering the mid-littoral—because both circumstances decrease encounter rates with higher ranked prey on the reef flat. Bird et al. (2004) argue that this is one reason why nerites and asaphis clams these are so common in Meriam shellmiddens.

14. We will not estimate search/encounter times because we already know where patch rates need to be (in terms of diet breadth in the patch) to make foraging in another patch worthwhile.

15. With respect to his fieldwork among arctic foragers, Smith (1991: 273) states that "although complicated factors intervene to prevent a simple rank order correlation between return rates and time allocation, the general pattern supports the view that Inujjuamiut allocate their foraging time to alternative hunt types in a moderately efficient manner."

16. For the purposes of this first-order heuristic, we use a low-level, "horseback" statistic to compare the various hunt types. Lacking the necessary data on encounter rate (estimated or actualistic), we have characterized the overall return rate for each hunt type in terms of estimated range and 50th percentile (where the  $p$ th percentile is a value such that roughly  $p$  percent of the data are smaller and  $(100 - p)$  percent of the data are larger. These numbers are, of course, slanted somewhat upward, since we have excluded the extremely low return prey items—those expected to have minimal impact on provisioning strategies (such as snakes, frogs, insects, and fiddler crabs). Had these lowest return prey taxa been included—and some of these return rates are negative—then overall post-encounter return rates for each hunt type would have been dragged downward.

17. Note that for present purposes, we are computing potential return rates only for loggerhead turtles (and ignoring leatherback procurement entirely).

18. As we have already seen, male and female foraging areas overlap considerably in the Sea Islands, enabling each to achieve high caloric returns within the same landscape. But even within the same patch type, the foraging self-interests might still conflict between male and female foragers. Clearly, for instance, it is worthwhile (for everyone) to cache sufficient mast as it ripens in order to keep competing species from eating all the live oak acorns and hickory nuts. But the adult male forager might well prefer to leave more mast on the ground, to attract and nourish the highly ranked white-tailed deer. But a female farmer, responsible for weeding the maize fields and keeping the predators away, would likely prefer that the deer herds were erad-

icated altogether, to enhance the more predictable maize harvest. "Given an evolutionary perspective of sexual division of labor, it seems likely that men bypassed plant resources that were in their optimal prey set because they received greater reproductive benefits by sharing large packages of meat. In contrast, women harvested plants that fell out of their optimal prey set, because doing so ensured provisioning their offspring, particularly during episodic food shortages" (Zeanah, 2003: 4).

19. This interpretation is highly unrealistic, since it includes virtually no role for female foragers. A differential diet-breadth perspective is discussed below.

20. Actually, the "secondary" central place should reflect the spatial relationship between the highest ranking and the third highest patch types. But in the case of Georgia's barrier islands, this would involve comparing two aquatic patch types—the saltwater marsh and the offshore (Atlantic Ocean)—neither of which provides the necessary terrestrial component for human residential settlement. This is why we have defined the secondary central place by comparing second- and third-ranked patch types.

21. I am indebted to David Zeanah for assistance on this point.

22. Looking at the modern Sea Islands, it is difficult to appreciate the magnitude of the hydrological change over this past century. But documentary records and the surviving geomorphological evidence allow us to reconstruct what St. Catherines Island looked like before the deep drilling changed the hydrology forever. As discussed in chapter 5 (this volume), Coastal Georgia is underlain by unconsolidated sedimentary strata overlying carbonate rocks known as the Floridan Aquifer, one of the most productive groundwater reservoirs in the United States. The recharge and discharge of the aquifer system remained in proximate equilibrium so long as the Upper Floridan aquifer was recharged by rainfall in the interior, where it lay near the ground surface. We estimate that at the time of European contact, the artesian water pressure on St. Catherines Island was about 50 feet above sea level. Under such conditions, water flowed naturally to the surface in springs (with their characteristic domes of yellow sand), with seepage to rivers, ponds, wetlands, and other surface-water bodies throughout most of coastal Georgia. Surface, nonartesian groundwater was also abundant until the early 20th century, when the Upper Floridan aquifer was developed (and depleted) by numerous deep wells.

23. Any residential base, of course, could have employed a more remote landing spot, but the additional transport costs made this a potential expensive option. Doubtless, the Sea Island foragers attempted to establish their residential bases as close as possible to adequate launch and docking facilities.

24. Because the seaside settlements do directly not abut the sandy beach or marsh edge, the associated variable would likely tend toward symmetry.

25. We are ignoring, of course, the likelihood that marine foraging (by watercraft) will have a considerably larger radius than terrestrial foraging (conducted on foot).

26. The aquatic foraging radius is potentially much larger (see chap. 10, this volume).

27. The problem with this scenario, from the perspective of the aboriginal forager, is that if an island narrows *too much*, then the maritime forest patch type becomes so contracted that the ecological diversity trails off, thereby dropping the patch type ranking.

28. In the previous two chapters, we have used the term *forager* as basically equivalent to *hunter-gatherer* (particularly when considering models deriving an optimal foraging theory). But in this section, and occasionally in subsequent chapters, we find it useful to distinguish between *foragers* and *collectors* (in the sense of Binford, 1980). We hope that the context will clarify the specific usage intended by the more-than-hand term *forager* (see also Kelly, 1995: 351, fn 2).

29. Zeanah (2002: 251–252) has recently applied central place foraging theory to issues of pinyon utilization in the aboriginal Great Basin. These findings "reveal no theoretical reason to expect any single strategy of pinyon exploitation as typical of Great Basin hunter-gatherers. Instead, they follow Thomas' lead to model formally how the logistic and residential strategies of hunter-gatherers, equipped with similar technologies and procuring similar resources, might vary in different local landscapes."

30. And, as discussed in chapter 28, new evidence has recently reemerged from dendrochronological studies on bald cypress to suggest that climatic factors may have been involved in the "Guale problem" as well (e.g., Blanton, 2004; Saunders, 2000b).

31. For present purposes, we employ the contemporary configuration of St. Catherines Island as a proxy for discussing aboriginal foraging patterns. But as noted in chapters 3, 29, and 30, we must reconstruct the shape of St. Catherines Island for each cultural period and use these geomorphological reconstructions to pin down the general settlement predictions tendered here.

## CHAPTER 12. ARCHAEOLOGICAL RESEARCH DESIGN

DAVID HURST THOMAS

In the previous chapters, we have harnessed the models of human behavioral ecology to explore the nature of aboriginal landscapes of Georgia's Sea Islands. We will now return to the basic research questions that have guided our long-term research into the aboriginal lifeways of St. Catherines Island:

1. How and why did the human landscape (settlement patterns and land use) change through time?
2. To what extent were subsistence and settlement patterns shaped by human population increase, intensification, and competition for resources?
3. What factors can account for the emergence of social inequality in Georgia's Sea Islands?
4. Can systematically collected archaeological evidence resolve the conflicting ethnohistoric interpretations of the aboriginal Georgia coast (the so-called Guale problem)?

This chapter frames an archaeological research design to address these questions.

### A WORD ABOUT ARCHAEOLOGICAL SYSTEMATICS

O'Brien et al. (2002: 442–443) have recently suggested that archaeologists need to evaluate critically, and perhaps discard, their traditional approach to systematics: “No shortage of schemes exists to keep track of time (and space) ... [in] the greater Southeast. ... Somewhere in the process, however, there developed a lack of differentiation between the analytical constructs used by archaeologists to keep track of time, space, and form and the empirical reality they were intended to describe” (O'Brien et al., 2002: 421). I agree that time–space constructions pose a real problem and believe it worthwhile to clarify, from the outset, the systematics employed in this study.

With certain modification, we will employ the relatively standardized framework used throughout much of the United States

to integrate chronological information into the regional landscape. Where possible, we follow the regional infrastructure initially set out by Gordon Willey and Philip Phillips in their influential *Method and Theory in American Archaeology* (originally published in 1958). Although nomenclature varies somewhat from region to region, the basic Willey–Phillips framework remains the most generally accepted system in North America.

### ARTIFACT TYPOLOGY

In our St. Catherines Island research, we rely heavily on aboriginally produced ceramics for chronological purposes and we will restrict the present discussion to the aboriginal ceramic chronology. As we discuss in chapter 14, Preston Holder (1938) began systematic inquiry into the coastal Georgia ceramic chronology with his Glynn County research (see also Waring, 1968a, 1968b, 1968c; DePratter, 1979a). Soon after, W.P.A.-sponsored excavations in Chatham County provided the badly needed stratigraphic controls to discriminate distinctive ceramic periods on the Georgia coast (Caldwell 1939a, 1943; Caldwell and Waring, 1939a, 1939b; Caldwell and McCann, 1941; see also DePratter, 1991: 157–158). This basic Chatham County sequence has evolved significantly in the half-century following Caldwell's earliest work (e.g., Larson, 1969, 1958a, 1978, 1980a; Steed, 1970; DePratter, 1975, 1977a, 1979a, 1984, 1989b; Cook, 1977, 1979; DePratter and Howard, 1977, 1980; Milanich, 1977; Pearson, 1977a, 1979a; Crook, 1978a, 1986; Cook and Snow, 1983). All of the aboriginal ceramics reported in this volume were classified into DePratter's (1979a, 1991) ceramic sequence for the Northern Georgia coast (chap. 14, this volume); in chapter 15, we examine these temporal estimates against the available <sup>14</sup>C data from St. Catherines Island.

Also in chapter 14, we set out the criteria that define the basic *attributes* that combine to define the *morphological types* used to classify the potsherds recovered on St. Catherines Island, which are then tested against the available archaeological record to define the *temporal types* necessary to assist building a ceramic chronology for St. Catherines Island. We define these critical terms as follows:

**ATTRIBUTES:** An *attribute* is an individual characteristic that distinguishes one artifact from another on the basis of its size, surface texture, form, material, method of manufacture, and design pattern (after Thomas and Kelly, 2006: 214).

**MORPHOLOGICAL TYPES:** The *type* is the basic unit of artifact analysis because, as an ideal construct, types allow archaeologists to transcend individual artifacts to consider more generalized categories. *Morphological types* are descriptive and abstract groupings of individual artifacts whose focus is on the overall appearance of a set of artifacts, rather than functional or chronological significance (after Thomas and Kelly, 2006: 211–212, 220). As such, morphological types are fundamentally descriptive, enabling the archaeologist to summarize large sets of individual artifacts into a few ideal categories. In chapter 14, we describe the *morphological types* used to classify the potsherds recovered on St. Catherines Island.

**TEMPORAL TYPES:** Unlike, morphological (“descriptive”) types, the *temporal type* serves a more specific function, namely to monitor how artifact forms change through time. Temporal types—also known as “time-markers” or “index fossils”—are best defined through stratigraphic analysis and association with absolute radiometric dates; acceptable temporal types cannot be defined on the basis of surface or plowzone associations. In chapter 15, we test the various morphological types from St. Catherines Island against the archaeological record that we have generated over the past 3 decades. Some of the morphological types have proven to be adequate time-markers, others are not.

#### SUPRA-ARTIFACT UNITS OF ANALYSIS

To work effectively at a regional level, we must take the next analytical step, to examine how the various time-markers (defined above) can be employed to define site-by-site chronologies for known locales on St. Catherines Island. A number of basic, synthetic archaeological units apply to the supra-artifact level of analysis.<sup>1</sup>

**COMPONENTS:** The first step in synthesizing patterns across the aboriginal landscape requires the definition of *components* (defined as a culturally homogeneous unit within a single site); this definition follows the Willey and Phillips (1958: 21) formulation, which itself builds on W.C. McKern’s 1939 definition. Several of the archaeological sites encountered on St. Catherines Island contain only a single component (meaning that the ceramic assemblage appears to be essentially homogeneous with respect to time), but most of the archaeological sites on St. Catherines Island are palimpsests (resulting from multiple occupations and containing more than one component). Determining what is “culturally homogeneous” is, of course, a somewhat subjective procedure, but in chapter 15, we define the operational protocols employed on St. Catherines Island.

**PHASES:** Ascending to the next analytical step requires that we employ the concept of archaeological *phase*—generally considered to be the practicable and intelligible unit of regional synthesis. In the St. Catherines Island research, we will employ the classic of Willey and Phillips (1958: 22) definition of *phase*: “an archaeological unit possessing traits sufficiently characteristic to distinguish it from all other units similarly conceived ... [and] spatially limited to the order of magnitude of a locality or region and chronologically limited to a relatively brief interval of time.”

Like “component,” the phase concept is wrapped in weasel words like “sufficiently characteristic”, “similarly conceived”, and “relatively brief interval”. No matter how many “operational definitions” and “analytical protocols” we might wish to employ, the truth is that some degree of wishy-wa-

shy imprecision will always linger, and our decisions still rely heavily on simple familiarity with the archaeological data at hand.

That said, we must recognize that the terms *period* and *phase* are used pretty much interchangeably on the Georgia coast. To maintain a level of consistency with previous usage, we will follow the protocols set out by DePratter (1979a, 1991; see also DePratter and Howard, 1980) using the term *period* for major archaeological units (described as “phases” above). This means that the *period* serves as our basic unit of a real synthesis. In the St. Catherines Island chronology (defined in chap. 15), each period is defined on the basis of temporally diagnostic ceramic types that have been calibrated against a large series of  $^{14}\text{C}$  dates within a tightly circumscribed area (the 14,000 acres of St. Catherines Island), and because the latest periods in the St. Catherines Island chronology overlap into the Spanish occupation, we also employ historical documentation to provide external temporal controls. The defining criteria are expressed in relatively objective fashion (although we do recognize that a certain degree of individualistic subjectivity is still involved); we have taken steps to minimize the subjectivity by standardizing descriptions and procedures. So defined, these phases and periods are not ambiguous and (within the limits of the available data), they do not overlap. In general, such archaeological periods are subdivided into two or more *phases*.<sup>2</sup>

The phase/period concept allows archaeologists to treat time—intrinsically a continuous variable—as if it were a discrete interval. The overall sequence for St. Catherines Island lasts about 5000 radiocarbon years. Whereas radiocarbon years provide a viable way to measure time, this unit of measurement can be applied to only a very, very select subset of sites (or parts of sites) on St. Catherines Island—even with a sample of more than 200  $^{14}\text{C}$  dates to work with. To augment the radiocarbon-derived chronology, we must divide our sites into a series of archaeological components, which can then be compared to another, and a regional chronology can be constructed. That is, using the

period/phase as our primary unit of synthesis, we can establish contemporaneity across the Island-wide survey.<sup>3</sup> The length of any given period/phase depends both on the nature of the archaeological remains involved and our contemporary knowledge of these remains. Period/phases can be as short as a few generations (especially in areas where the chronology is based on historical records). But some perfectly acceptable phase/phase span a millennium (or even more).

The job of archaeology’s phase/phase concept is to impose a set of minimal units on the time continuum. When we discuss, say, *the St. Catherines phase*, we are effectively treating a time span of two or three centuries as if it were an instant in time. So by definition, then, any two manifestations of the St. Catherines phase are simultaneous, provided that *simultaneous* is understood to span 2–3 centuries.

As our knowledge of the St. Catherines period expands, we may be able to distinguish divisions within the phase. It might be possible, for instance, to define an early St. Catherines component from a late St. Catherines component. When this happens, the initial period can be segmented into phases (or even subphases). This increasing subdivision reflects the amount of research accomplished on each period/phase and underscores the degree to which our knowledge of the archaeological record is a contemporary phenomenon. But, we hasten to point out, additional research can sometimes result in the *combination* of previously defined phases (if they can be shown to overlap in time), meaning that increasing the quality and quantity of research has created longer (but more accurate) phases.<sup>4</sup>

Let me be quite clear on one final point. *By period/phase I mean a slice of time in a particular place—no more and no less.* Periods and phases in the St. Catherines Island chronology do not mean a *culture* or *people*. They should not be confused with *stages*, *horizons*, or *traditions*. To me, the period/phase is the best way to operationally extend the  $^{14}\text{C}$  database to contexts for which radiocarbon evidence is unavailable.

STAGES: As archaeologists began to investigate the prehistory of this country,

they discovered that the Native American culture as documented by ethnographers and ethnohistorians had not always been there in the remote past. The aboriginal people who lived in the American Southeast some 8000 years ago, for example, were highly mobile foragers who knew nothing about maize or ceramics. As the chronologies of different culture areas were worked out, prehistory was organized into a series of slices of time that were given different names.

Archaeologists have long divided prehistory into *periods* based on gross changes in easily observable aspects of subsistence, settlement, or technology. These were sometimes labeled *stages*, although that term is rarely used today (because it reflects a theoretical paradigm that emphasized progressive evolution, an idea that anthropology has largely discarded. But the concept of *period* means something different in the present application. In his recent textbook *An Introduction to Native North America*, Mark Sutton (2000: 326–327) addresses “The Paleoindian Period (to ca. 10,000 B.P.)”, as the first human presence in the American Southeast. Next comes “The Archaic Period (ca. 10,000 to 3,000 B.P.)”, when people made heavier use of plant resources, began to develop distinctive region traditions in material culture, and experimented with agricultural crops. This use of “period” is perfectly appropriate for Sutton’s intent; it is just not the use of “period” employed here.

For Willey and Phillips (1958: 72), *stages* were generally thought to reflect “divisions of a fundamental technological and economic nature”, as, for instance, the schism between the Archaic and Formative stages generally reflecting the difference between hunting–gathering and farming economies. Willey and Phillips (1958: 77) were quite explicit about their stages being “developmental” rather than “evolutionary” because “there are no universal, irreversible processes of cultural development.”

Major transitions, including the appearance of ceramics, settled village life, mound-building, and farming were labeled *horizons*. These are analogous to (but should

not be confused with) soil horizons and marker beds in that they form cultural “fault lines” that can cross-cut archaeological cultures and even culture areas. They are unlike soil horizons and marker beds in that a horizon might have different ages in different regions. Maize was first domesticated in southern Mexico, then moved northward later in time. Thus, the agriculture horizon is progressively later in time as we move from southern Mexico to the Great Lakes region, the northern limit of maize horticulture. This concept is not heavily used in archaeology today because of its association with an out-dated evolutionary paradigm and because we now know that many transitions, including that from hunting and gathering to agriculture, are not as quick as the horizon concept assumes.

Nonetheless, like “archaeological cultures” the concepts of *periods* and *horizons* helped to map out major spatial and temporal patterns in material culture. Periods and horizons recorded change over time, while archaeological cultures record change over space. Knowing *how* and *when* material culture changed over time and space is an obvious first step toward explaining *why* those changes occurred. But periods, stages, and cultures were commonly conflated in the typological schemes of the 1940s and 1950s (and their descendants).

At this point, we find it necessary to distance ourselves with the regional systematics in the Willey and Phillips format. Over the past couple of decades, Southeastern archaeologists have felt increasingly constrained by stage-level building blocks. As noted above, we agree completely with O’Brien et al. (2002: 442–443) regarding the potential problems that can arise with the misapplication of archaeological systematics. These are concepts that must be used with great care, because they can readily “mask variability instead of highlighting it.”

This brings us to the Paleoindian–Archaic–Woodland–Mississippian sequence. For decades, Southeastern archaeologists have employed these concepts as sequential “stages” (*sensu* Willey and Phillips, 1958), charting a unilineal developmental se-

quence, from first human footprints through European contact. But increasingly, archaeologists have expressed their discomfort with this scheme. Sassaman and Anderson (1996: xvi), for instance, speak of an “anachronistic *conceptual* framework that portrays mid-Holocene hunter-gatherers as isolated, locally adapted, and ecologically constrained populations frozen in an evolutionary moment between the big-game hunters of the late Pleistocene and food producers of the late Holocene.” Viewed as a cultural “stage”, the Southeastern Archaic is trapped in stereotypes of “autonomous”, “self-contained”, “egalitarian” societies responding only to the vagaries of climate and geomorphology.

Similarly, the term *Woodland* in the Southeast refers both to a temporal span (ca. 700 B.C.–A.D. 1000) and a cultural tradition (Stoltman, 1978; Jefferies, 2004: 115). In his classic formulation, James B. Griffin (1967: 180–189) characterized the early Woodland stage as the first widespread use of ceramics across the Southeast, followed by the rise and decline of vast pan-regional interaction networks, followed by a period of political fragmentation, increased agricultural intensification, and population growth; so viewed, the Woodland stage set the stage for the ensuing Mississippian emergence. More recently, the Woodland period has been characterized as a time of increased reliance on wild or cultivated seed-bearing plants, dramatic increases in population and organizational complexity, decreased residential mobility, more elaborate mortuary ceremonialism, and widespread use of ceramics (Smith, 1986; Steponaitis, 1986; Anderson, 1995; Anderson and Mainfort, 2002; Jefferies, 2004: 115).

Sassaman and Anderson (1996: xvii, xix; see also Sassaman, 2002: 398) express dissatisfaction with “the [totally ambiguous] traits that traditionally divided the Archaic and Woodland periods at 3000 B.P. ... Pottery, mound building, social differentiation, mortuary ceremonialism, long-distance trade, and plant domestication all existed long before 3000 B.P.” and suggest that we must “lift forever” the “arbitrary dividing line” between Archaic and Woodland dis-

solving “the analytical impasse that keep hunter-gatherers in a category separate from food producers.” More recently, these same investigators suggest a more moderated positing, noting that whereas the “cultural-historical division between Archaic and Woodland traditions of the Late Holocene is difficult to defend on material traits alone ... the division is still useful in delimiting major historical trends in each of the respective periods” (Sassaman and Anderson, 2004: 101).

Finally, a formidable literature addresses the rise and spread of *Mississippian culture* to the evolution of Southeastern chiefdoms, an emergence conventionally tied to a major subsistence change by groups living in the Mississippian basin and elsewhere (Griffin, 1967, 1985; Schnell et al., 1981; Reitz, 1988a; Milner, 1990; Smith, 1990; Williams and Shapiro, 1990; Peregrine, 1992; Anderson, 1994; Knight and Steponaitis, 1998; Worth, 1998a: 6). The term *Mississippian* is commonly used in two ways, (1) to denote a cultural period (conventionally defined from A.D. 1000 to earliest Spanish and French contact) and (2) to delineate a distinctive “Mississippian culture”. In this latter sense, Griffin (1985: 63) has provided a comprehensive definition for Mississippian societies across the Eastern United States:

- Developed many cultural innovations over much of the culturally defined Southeast between A.D. 700 and 900.
- Added these disparate innovations to local cultural inventories by contact between neighboring and distant groups.
- Increased in population, resulting from an augmented energy input from a more effective agronomy.
- Constructed planned permanent towns and ceremonial centers, villages and subsidiary support hamlets, farmsteads, and other extractive camps.
- Had regional and temporal variations of a hierarchical social, political, and religious structure.
- Participated in an area-wide belief system that integrated and emphasized the complex interaction of the spirit world and man and ritualized these concepts in an elaborate symbolic iconography of marine shells, copper, ceramics, and stone.

- Had an extensive trade network, of rivers and trails, over which manufactured symbolic and mundane items and raw materials were moved either to neighboring or distant societies.
- Reached an areawide cultural crest between A.D. 1200 and 1500 and slowly receded to less formally organized and controlled groups during colonial times.

According to Anderson (1994: 111), Griffin's definition "reflects a general consensus among scholars working within the region about what constitutes Mississippian culture." But, seeking to focus on organization properties, Anderson offers the following, further definition: "Mississippian societies [are] multicomunity polities characterized by one or two decision-making levels above the local community and administered by hereditary elites."

To the extent possible, our discussion will proceed largely independent of stage-level phraseology, especially with regard to the standard Archaic–Woodland–Mississippian sequence. Too often, investigators find themselves intellectually hamstrung by trying to fit the archaeologically observed specifics into these theoretically driven pigeon-holes. But when these terms do crop up, they are used as follows:

- The Early and Middle Archaic cultural periods loosely correspond to the Early and Middle Holocene periods (Griffin, 1967: 178; Anderson and Sassaman, 2004: 87). The term *late Archaic* refers to the cultural period in the Southeast between ca. 5000–3000 B.P.<sup>5</sup>
- The term *Woodland* refers to cultural developments in the Southeast between ca. 3000 and 1000 B.P. (after Anderson and Mainfort, 2002: 3)
- The term *Mississippian* is used in two ways. The *Mississippian cultural period* refers to cultural developments in the Southeast between ca. 1000 B.P. and the earliest French and Spanish contact. The term *Mississippian culture* follows the definitions of Griffin (1985: 63) and Anderson (1994: 111) as cited above.

This is, to be sure, a bottom-up approach (in the sense of Binford, 2001), designed to fine-tune our powers of archaeological observation. We do this deliberately, to place the emphasis squarely on the archaeological record of St. Catherines Island.

## ESTABLISHING A WORKABLE CHRONOLOGY

Archaeology's initial objective must always be chronological—to establish a firm grasp on *time*. In our St. Catherines Island research, we draw heavily on radiocarbon dating to establish absolute chronological controls over the hundreds of archaeological sites encountered in the Island-wide survey. But because <sup>14</sup>C dating is insufficient, by itself, to provide the necessary chronological controls, we must likewise employ the type-fossil concept to monitor chronological change in the material culture of St. Catherines Island. Potsherds are the most common aboriginal artifacts recovered during our excavations, and we draw on the decades of previous research that has culminated in a ceramic chronology for the Georgia coast. Taken together, the <sup>14</sup>C and ceramic evidence from St. Catherines Island provides powerful tools for monitoring environmental and cultural change over the past 5 millennia. Finally, to answer the questions posed in previous chapters, we must employ microchronological dating techniques; below we discuss how *Mercenaria* thin sections have provided a first approximation for seasonal dating on St. Catherines Island.

## RADIOCARBON DATING

Radiocarbon dating, a physiochemical technique that monitors radioactive emission from organic specimens by determining the current rate of <sup>14</sup>C breakdown, estimates the length of elapsed time since the death of a plant or animal. Within the last couple of decades, physicists have discovered that the atmospheric level of radiocarbon has changed somewhat over the last several millennia, enabling archaeologists to "correct" their radiocarbon dates using an absolute chronology based on radiocarbon dating of known-age bristlecone pine samples. New advances in accelerator-based radiocarbon methods permit archaeologists to use extremely small samples, vastly stretching the potential of the method.

Some years ago, we reported the results of our excavations of several Refuge-Deftford-Wilmington burial mounds on St. Catherines Island (Thomas and Larsen, 1979). We analyzed 29 radiocarbon dates, nearly one quarter of them processed on marine shell. Although aware of potential problems associated with radiocarbon dates on sea shells, we followed the lead of Joseph Caldwell, who had also worked on St. Catherines Island: Caldwell concluded that “radiocarbon determinations made from oyster shell do not appear to differ significantly from determinations made from charred wood” (Caldwell, 1971: 1).

Today, we understand that this assumption was incorrect. A significant reservoir effect is operating here because, relative to the atmosphere, ocean water is depleted in  $^{14}\text{C}$ , transmitting this deficiency to marine organisms. This means that  $^{14}\text{C}$  determinations processed on marine samples will routinely appear to be older (in many cases, several centuries older) than  $^{14}\text{C}$  dates run on contemporary terrestrial samples. We found it necessary to derive a unique reservoir correction for St. Catherines Island and the results of this fieldwork and analysis are reported in chapter 13.

We must also clearly recognize that, by itself, the radiocarbon method tells us nothing about human activities in the past. A  $^{14}\text{C}$  date merely estimates when a certain tree or a specific clam died. In each case, the event being dated must be demonstrated to be coeval with a behavioral (cultural) event of interest. Unless properly applied,  $^{14}\text{C}$  dating can generate a massive degree of misinformation (and misplaced confidence) regarding the human past.

Throughout the St. Catherines Island research reported here, we have emphasized the importance of radiocarbon dating in both archaeological and geological perspectives. As we detail in chapter 13, this volume is grounded in a database of 254  $^{14}\text{C}$  determinations, 189 of them processed on “cultural” samples recovered from documented archaeological contexts on St. Catherines Island,<sup>6</sup> primarily burial mounds and shell middens. Eleven of these dates were processed previously by Joseph Cald-

well and his team from the University of Georgia; the remaining  $^{14}\text{C}$  determinations resulted from investigations by the American Museum of Natural History. We have an additional 41  $^{14}\text{C}$  dates from non-cultural contexts, primarily organics and marine shell samples collected in conjunction with vibracore sampling and surface geological reconnaissance (discussed in chap. 3 and 29). Each radiocarbon date was calibrated according to the conventions and protocols discussed in chapter 13.

#### THE ST. CATHERINES ISLAND CERAMIC CHRONOLOGY

All of the aboriginal ceramics recovered from the roughly 220 known archaeological sites on St. Catherines Island were initially classified according to Chester DePratter (1979a: table 30; as updated in DePratter, 1991: table 1; see also chap. 14 and 15, this volume). In this synthesis, DePratter grouped the various ceramic types into a chronological sequence of archaeological periods and phases for the northern Georgia coast (see figs. 14.1 and 14.2). He found that temper, surface decoration, rim form, and vessel form vary “asynchronously” (DePratter, 1979a: 122), meaning that some types (including Refuge Plain and Refuge Simple Stamped) survived for more than a millennium, but other types (particularly those defined by fine-grained distinctions in surface decoration, such as incising or net-marking) were considerably more restricted in time. This overall variability has been synthesized into a chronological sequence of seven major cultural *periods*, subdivided into nearly two dozen archaeological *phases*.<sup>7</sup>

Chapter 15 compares the existing ceramic and  $^{14}\text{C}$  chronologies for St. Catherines Island. As mentioned above, 189 radiocarbon dates have been processed on archaeological samples from St. Catherines Island, and 110 of these dates—from 31 distinct mortuary and midden sites—were directly associated with datable ceramic assemblages from the aboriginal phase. Sixteen of these dates were processed on charcoal recovered from archaeological contexts and

the remaining samples consisted of marine shells (either oyster or clam) or human bone; all marine determinations were corrected for reservoir effects according to the protocols mentioned above. We feel that this diverse sample of  $^{14}\text{C}$  dates, which spans more than 4 millennia, provides a workable set of radiometric controls on the ceramic chronology currently available for St. Catherines Island.<sup>8</sup>

#### MICROCHRONOLOGY

To this point, we have emphasized the importance of grounding our St. Catherines Island in a solid *macrochronology*—the ordering of events in segments such as years, centuries, and even millennia. By developing and combining the results of radiocarbon and ceramic chronologies, we are satisfied with the macrochronological framework for the St. Catherines Island research.

But the overarching theoretical framework (set out in chap. 8–11), requires that we also have more fine-grained temporal controls—certainly on the order of seasons, perhaps even months or weeks. Literally thousands of potential “seasonal indicators” were recovered during our excavations on St. Catherines Island and (following Aten, 1981) one can readily identify several commonly employed methods for determining seasonality in such sites: presence or absence of skeletal elements (such as bones from migratory species), demography (changing size of estuarine fishes as they mature through the annual cycle), morphological changes in shell contour during the annual cycle, microstructural changes correlated with the seasons of the year, and chemical changes in shell composition (such as shifting oxygen and carbon isotopes).

In chapters 22 and 27, Elizabeth Reitz discusses the presence of numerous seasonal indicators in the vertebrate zooarchaeological samples recovered from archaeological sites on St. Catherines Island—including unshed deer antlers, juvenile deer dentition, and shark and sea catfish remains. But we also recognized the importance of examining diverse sources of sea-

sonal information in our attempt to flesh out overall patterns of site utilization.

As we began planning our archaeological research design for St. Catherines Island, we saw great potential in developing a method for determining the seasonality of occupation by analyzing growth increments in the shell of hard clams (*Mercenaria mercenaria*), which occurred in some abundance in the local shell middens. In the mid-1970s, such studies were in their infancy, and only a small amount of literature was available (Clark, 1968, 1974; Weide, 1969, Coutts, 1970, 1975; Coutts and Higham, 1971; Ham and Irvine, 1975; Kennish and Olsson, 1975; Koike, 1975). Most of these pioneering studies emphasized the importance of modern controls for understanding the variability introduced by changing water temperatures and salinity, tides, predation, spawning, and other environmental factors.

We began collecting a modern control sample of *Mercenaria mercenaria* in 1975, a process that continued, somewhat sporadically, over a 9-year duration; an independent sample of modern *Mercenaria* was also collected between April 1994 and March 1995, in support of the oxygen isotope study discussed in chapter 14.

George R. Clark II (1979b) began the program of seasonal analysis of zooarchaeological mollusks on St. Catherines Island by analyzing *Mercenaria* recovered from Johns Mound, Marys Mound, and McLeod Mound, concluding that most hard clams interred in these mortuary sites had been harvested during winter months (see also Larsen and Thomas, 1982: 338). These samples were, of course, recovered from secondary context, and the complex formation processes involved precluded actual dating of the mortuary activities. But we were encouraged that seasonal patterns were indeed evident in the zooarchaeological samples, and we moved on to consider hard clam seasonality in the various occupational sites of St. Catherines Island.

*Mercenaria* samples were obtained from the Island-wide transect survey, as discussed in chapters 17, 18, and 20. Overall, we analyzed about 2000 individual hard clam shells from the shell middens on St.

Catherines Island; of these, 1771 individual specimens (or fragments) provided usable growth increment estimates, enabling us to address seasonal patterns during the 5000 years of human history on St. Catherines Island.

### RECONSTRUCTING ABORIGINAL LANDSCAPES THROUGH TIME

Chapters 9 and 10 drew on the central place foraging theory and patch choice models to hypothesize the distribution of forager settlements across the St. Catherines Island landscape. To examine these hypotheses archaeologically, it is necessary (1) to reconstruct the configuration of St. Catherines Island throughout the period of human occupation and (2) to sample the distribution of archaeological sites in a comprehensive and unbiased manner. For the past 3 decades, we have conducted extensive geomorphological and archaeological research with these goals in mind.

#### GEOMORPHOLOGICAL RECONSTRUCTION

Current evidence suggests that sea levels along the Georgia coast generally stabilized at present elevations about 4000–5000 years ago (DePratter and Howard, 1977; Oertel, 1979; Howard and Frey, 1980; Booth et al., 1999; Bishop et al., 2007). Many barrier islands and marsh lagoons reoccupied areas of previous, Pleistocene-age lagoons and shorelines, commonly prograding in a southward direction due to the predominantly northeasterly winds and southward drift of sediments. These barrier islands also tended to grow seaward and, of all the Georgia barrier islands, St. Catherines is currently farthest from a major river, and some (such as Griffin and Henry, 1984: 43) believe that this isolation from major deltaic systems may account for the extreme rates of erosion observed on St. Catherines Island during the historic period.

The modern configuration of St. Catherines Island has been conditioned by a complex blend of non-cultural factors, and we know that the St. Catherines Island of, say, 2500 B.C., was shaped vastly different than

the same island during the mission period. Understanding the aboriginal landscape of St. Catherines Island requires that we accurately reconstruct the island's geomorphic configuration during the past several millennia.

In so doing, we have been fortunate to work with a first-rate team of paleoenvironmental specialists who have researched St. Catherines Island over the past 3 decades. The numerous vibracore sample transects (esp. Morris and Rollins, 1977; Groce, 1980; Fierstien and Rollins, 1987; Booth et al., 1999; Linsley, 1993) are discussed in chapter 3, and the more than 3 dozen associated “non-cultural”  $^{14}\text{C}$  dates from St. Catherines Island are evaluated to interpret its geomorphic evolution. We have also drawn on a variety of historical maps to establish a geographical baseline by reconstructing the likely shape of the Island at key points in recent time (chap. 29, this volume).

#### ARCHAEOLOGICAL SITE DISTRIBUTIONS

Sassaman and Anderson (1996: 215) argue that “a regional perspective is ... essential if we are to understand the Southeast's earliest inhabitants, and if we are to have the informed theoretical perspective necessary to collect the kinds of information required to articulate large-scale models of human ecology, settlement organization and sociopolitical integration.” I agree completely.

Given the theoretical framework articulated in chapters 7–11, the fieldwork focus of the St. Catherines Island archaeological program must shift from a single-site to a regional (or “landscape”) orientation. Regional approaches have been a major theme in American archaeology for more than a half-century (for a review, see the papers in Billman and Feinman, 1999). By focusing on the relationships between people and the land, so-called *landscape archaeology* transcends a single site to determine overarching relationships within the complex cultural geographies defined by human societies. Regional archaeology recognizes the fallacy of taking a single site, no matter how com-

pling, as somehow typical or normal for a given society. Instead, the emphasis shifts toward seeking out variability between contemporary sites within a settlement pattern. A number of probability-based sampling designs have been devised to minimize bias in recovering settlement pattern data.

To understand the rationale behind these sampling designs, we need only look at John Griffin's recommendations to the Edward John Noble Foundation—made back in 1965:

St. Catherines Island is richly endowed with archaeological resources ... [and] to properly understand the total prehistoric and historic picture of man's occupation of this coastal island, considerable more work is needed.

The first need is for a detailed and systematic archaeological survey, which would pin-point all locations of human activity, test them to determine their depth and extent and cultural affiliation, and analyze the materials from surface collections and tests to establish a program of investigation of the most significant remains.

It is obvious even now that a rather complete record of prehistoric times stretching back in to the fiber-tempered phase, as much as 2000 B.C., and up through the mission phase into the historic plantation era is available on the island. There may even be earlier remains, from the preceramic Archaic phase.

The opportunity exists to study the human use of a well-define insular area through a long time phase. This study should take full advantage of the environment in which the human cultures operated, and the ecological inter-relationships between the two.

While further work on the site of Santa Catalina mission is in some respects of the highest priority, it is the total of the archaeological resources (including the plantation phase) which gives the archaeology of the island its somewhat unique nature. (Griffin, 1965b: 10–11)

In almost every way, Griffin's elegant and prescient statement defines the thinking behind the American Museum of Natural History's Island-wide archaeological survey of St. Catherines Island.<sup>9</sup>

Specifically, we crafted our regional survey of the island with two primary objectives in mind: (a) to generate a relatively unbiased sample of archaeological sites

from all time periods drawn from all part of the island and (b) to pinpoint the exact location of Mission Santa Catalina de Guale (occupied from ca. 1570s through 1680). The successful search for Mission Santa Catalina has been described elsewhere (Thomas, 1987, 1988a), and this monograph presents the results of the Island-wide systematic survey.

For reasons of logistics and budget, we accepted from the outset that a complete survey of St. Catherines Island was totally out of the question; given the demands for research programs on the island (with archaeological field seasons limited to roughly 6–9 weeks each year), we projected that a complete survey would have required roughly 15 years to complete. This was not a realistic proposition. Accordingly, we decided that more appropriate strategies were needed to direct our more limited efforts at archaeological survey of the 14,000 acres of St. Catherines Island.

**THE SHORELINE SURVEY:** In 1977, Chester B. DePratter (then of the University of Georgia) approached the American Museum of Natural History, requesting access to St. Catherines Island for the purposes of conducting a shoreline survey. At the time, we were planning our own regional sample of the Island, and we gladly granted such permission, eager to draw upon his extensive experience with archaeological survey techniques in coastal environments.

DePratter's proposed shoreline survey on St. Catherines Island was part of his larger reconnaissance of the entire Georgia coast, in which he was examining the relationship between archaeological sites and the geomorphic forms on which they occur (DePratter and Howard, 1977, 1980, 1981). The survey method involved "walking out" selected beach-ridge segments and hammocks in order to plot the distribution of archaeological sites relative to the coastal geomorphology. Shell deposits and archaeological ceramics were most commonly exposed by tidal action along the margins of ridge segments or hammocks, and this is where DePratter concentrated his survey efforts. Once a site was located, the ceramics

were collected, with appropriate provenience data and topographic detail recorded.

DePratter and James Howard used this archaeological survey strategy to document rates of deposition and erosion on beach dunes along the margins of the various barrier islands along the Georgia coastline. The oldest archaeological sites are, of course, found on the oldest beaches, and the more recent dunes contain the more recent archaeological sites.

Hoping that the distribution of prehistoric pottery could more precisely establish the chronological buildup of the various dune ridges, DePratter and Howard conducted a pilot study on Tybee Island. The earliest, fiber-tempered (St. Simons) ceramics were recovered about 3 miles from the modern shoreline. Knowing that St. Simons ceramics are more than 3000 years old, DePratter and Howard concluded that roughly 1000 B.C., the shoreline must have been about 3 miles inland (because the seaward beaches had not yet formed). Their survey also indicated that Deptford period ceramics were found up to 2 miles from the present beach line, but no closer (meaning that during Deptford times, the shoreline must have been about 2 miles inland from the current beach). Then, during the Wilmington–St. Catherines periods (roughly a thousand years ago), the shoreline was about a mile inland. Pottery from the Irene (late prehistoric) phase was found much closer to the present beach. These geological processes continue, of course, and future archaeologists will be able to date the late-20th-century shoreline from the Coke bottles and beer cans that litter today's beaches.

DePratter and Howard were, of course, employing the principle of horizontal stratigraphy, which also forms an important part of the St. Catherines Island research. To refine this approach, it is necessary, of course, to rely on a reliable ceramic chronology, preferably buttressed by an equally reliable sequence of  $^{14}\text{C}$  dates (an issue that is addressed in chap. 15).

DePratter conducted his shoreline survey on St. Catherines Island from March 22 through April 6 of 1977, covering the major Holocene exposures of the island. During

this period, the American Museum of Natural History was excavating at the Seaside mounds, and selected crew member accompanied DePratter throughout his survey. In this way, American Museum archaeologists became thoroughly familiar with DePratter's survey and recording methods, and these procedures were adapted to the systematic American Museum survey that followed. The results of DePratter's shoreline survey are reported in chapter 23.

**THE ISLAND-WIDE TRANSECT SURVEY:** While DePratter's shoreline survey provided valuable data regarding the relationship of archaeological sites to geomorphic features, the results were clearly restricted to those parts of the island that fronted directly on marshlands and open beaches. Given the research objectives set out in previous chapters, we needed a way to sample equitably all surviving parts of the island. Accordingly, we devised a systematic, randomized transect technique for the Island-wide survey (see fig. 12.1).

The transect survey research design is simplicity itself. We first selected a random point along the island's western margin; this was done by drawing a random number (from a table of random numbers), then matching it to the corresponding UTM coordinate. Using this coordinate as a baseline, we then divided St. Catherines Island into a series of east–west transects, each 100 m wide. Our initial survey design began with 10 percent coverage, but to generate a more complete dataset, we soon expanded the sampling fraction to 20 percent, obtained in a series of 31 east–west transects, each 100 m wide.

Conducting this survey was a two-part operation. Virtually uninhabited, St. Catherines Island is today blanketed with dense forest, briar patches, and almost impenetrable palmetto thicket. The survey team first located sites by systematically walking the east–west transects, from one margin of the island to the other. This team consisted of 11 archaeologists, spaced north–south at 10-m intervals. The survey was conducted, of course, prior to the advent of Global Positioning technology, so the transects were located on the ground by using aerial

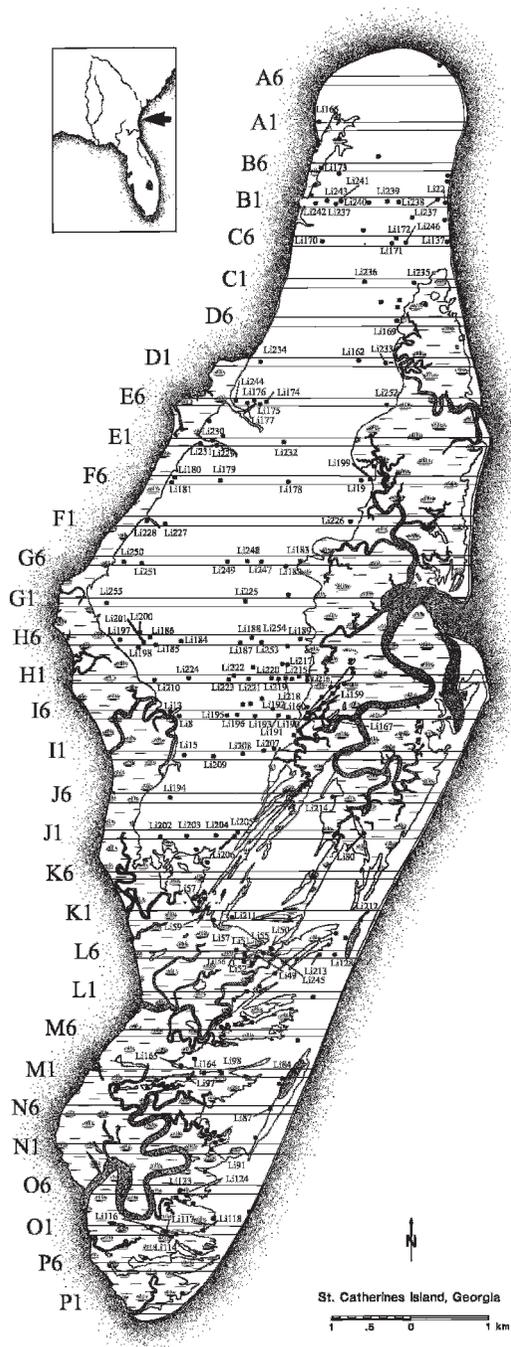


Fig. 12.1. The east-west transect survey plan for conducting the Island-wide archaeological survey. The 100-m wide transects are spaced at 500 m intervals.

photographs, and specially constructed maps showing modern roads and antebellum field lines (see fig. 5.3). Two crew chiefs, one at each end of the survey line, took frequent headings using Brunton compasses. The survey team maintained the 10-m spacing and proceeded at a constant rate along the transect. Each surveyor walked a straight line, searching the tree roots and cutbanks for deposits of oyster and clam shells. Equipped with a sharpened steel probe, each crew member probed for shells every two or three steps. The survey line paused whenever somebody encountered even the smallest shell deposit. Marking their position on the transect, the surveyors clustered around the initial discovery, probing for the margins of the shell deposit. If the crew chiefs judged that the shell concentration was indeed a potential archaeological site, they assigned a temporary (“AMNH”) site number, filled out a site-survey form, plotted the site location on the appropriate aerial photograph and topographic map, and schedule a follow-up session of test excavations.

Such a systematic survey is reminiscent of the “beeline hikes” once promoted in the Scouting program. Follow your compass heading, and walk through, over, or under any obstacle. If a tree lies across your path, go over it. If you run into a palmetto and briar patch, crawl through it. In this way, the randomized survey strategy forced us to look at the most unlikely, inaccessible places (even when we didn’t expect to find anything).

This research design must provide for meaningful negative evidence. In addition to telling archaeologists what sites occur in specific settings, these data likewise indicate those places that do not contain archaeological sites. Establishing a survey capable of providing valid negative evidence—only recently recognized as relevant to archaeological research—imposes some stringent yet necessary conditions on fieldwork, and this is why we elected to pursue a systematic, probabilistic approach to the archaeological survey.

During the initial phase of the archaeological survey, a *locus* was defined by a con-

centration of oyster and/or clam shells; rarely were cultural materials visible at this stage. This initial survey technique disclosed the presence of approximately 135 previously unrecorded archaeological sites, ranging from massive shell heaps to small, isolated shell scatters.

At some later time, an excavation crew returned to each locu, to map the surface indications and dig one or more 1-m<sup>2</sup> test units (following the procedures outlined in chap. 19). As a result of these test excavations, we sometimes defined the locus as an archaeological site, and sometimes combined several loci into a single site. On occasion, even in the absence of potsherds and other artifacts, we processed radiocarbon dates to determine the age of shell accumulation. When we found absolutely no evidence of a cultural presence, we rejected the locus and did not plot an archaeological site at this location. The results of the systematic transect survey are presented subsequently in this monograph.

**SYSTEMATIC SHOVEL TESTING:** Our transect survey strategy relied heavily on locating and exploring visible and buried shell concentrations—entailing the assumption, of course, of a one-to-one isomorphism between shell deposits and archaeological sites. While we believe that this assumption is generally valid on St. Catherines Island, we did worry about the presence of aboriginal sites that might not be associated with marine shell. We know, for instance, that along the Georgia coast, sites dating to the Refuge phase sometimes turn up in nonshell contexts (DePratter, 1977b; Thomas and Larsen, 1979, chap. 7). Not wanting to ignore such shell sites, the second stage of regional sampling on St. Catherines Island involved a series of systematic shovel tests.

We began this procedure by selecting a random point along the southern margin of transect C-6, located toward the center of the Island. We then dug and sifted a shovel test at this point. After this, we plotted and excavated similar pits at 50-m intervals along the entire southern margin of the C-6 transect; we then repeated the shovel testing for an additional 15 (“-6 series”) trans-

ects, which are spaced at 1-km intervals. The shovel tests were situated strictly according to randomized criteria, without regard to the presence or absence of known sites. As discussed in chapter 20, we excavated more than 450 such shovel tests across the island. As expected, most of these proved to be culturally sterile, but the exceptions are of considerable interest.

**GOOD OLD GUMSHOE SURVEY:** We have argued, above, for the relevance and importance of systematic, randomized archaeological surveys, and we think that the results of the Island-wide survey justify this belief. But to conduct a truly comprehensive archaeological survey, we must sometimes set aside these systematic, probabilistic approaches, to be certain that we were not missing the rare, but important archaeological site. We wanted, for instance, to locate all of the surviving mortuary sites on St. Catherines Island—and we knew that probabilistic sampling (even at a 20% sampling fraction) is a lousy way to find burial mounds.

The search for mortuary sites on St. Catherines Island—like most archaeological surveys over the past century—proceeded through a combination of happenstance, hard work, and trial and error. This is what archaeologist James O’Connell has called “gumshoe survey”, something akin to rudimentary detective work: Set out a problem, get some leads, track them down, and, if you’re fortunate, you crack the case. To an archaeologist, “cracking the case” can mean turning up just the right site to answer a question that’s bothering you.

When C.B. Moore arrived on St. Catherines Island in 1896, he probably asked around for advice from knowledgeable locals—those people who knew the landscape in an intimate, personal way; those who could intuitively distinguish the natural from cultural. Moore must have had good advice, for he located most (but not all) of the burial mounds still surviving on St. Catherines Island.

During our decades of research on the island, we have been fortunate to enlist the services of two very knowledgeable locals, men who knew the island landscape in a un-

ique, personal way. On my first trip to the Island (in November of 1974), I was shown around by Mr. John Toby Woods, then-superintendent of St. Catherines Island. Mr. Woods showed me shell middens on the Picnic Bluff, at Wamassie Creek, and along Persimmon Point. He took me to several burial mounds on the northern end of the island and pointed out a curious wooden structure in the marsh west of Long Field. As I learned more about the history of archaeology on St. Catherines Island, I realized that Mr. Woods had given nearly identical tours to Lewis Larson, John Griffin, and Joseph Caldwell, each of whom realized (as I did) that if you want to know about St. Catherines Island archaeology, ask the local expert. John Toby Woods had spent most of his life on the Island, and his daddy, Mr. Toby, had been Superintendent before Mr. Woods. Their cumulative experience on St. Catherines Island spanned more than half a century.

Mr. Woods retired in 1982 and Mr. Royce Hayes, Jr., became the Superintendent of St. Catherines Island. Mr. Hayes was a trained forester, who had been studying the woods on St. Catherines Island since his undergraduate days (when he received a Noble Foundation summer scholarship to work on the Island). When Royce Hayes looks at a forest, he can reconstruct aspects of its history in a way that will always amaze the archaeologist. Mr. Hayes has also amassed a near legendary grasp on the rich oral history of those people who have called St. Catherines Island their home.

Over the decades, Superintendents Woods and Hayes have provided invaluable input into our gumshoe survey of St. Catherines Island. Each has called to our attention archaeological sites and features that would otherwise have escaped our notice. Without their guidance, this would have been a much smaller monograph.

#### RECONSTRUCTING ABORIGINAL SUBSISTENCE PATTERNS THROUGH TIME

In chapters 7–9, we assessed the resource base of St. Catherines Island in some detail,

deriving seven “hunt types” that we believe were important to aboriginal Sea Islanders. The diet-breadth model asks: Which foods should an efficient forager harvest from all those available on St. Catherines Island? Archaeologists have a well-stocked arsenal of methods and techniques available for reconstructing the past subsistence activities, and several of these were employed in this study.

#### ZOOARCHAEOLOGY

The St. Catherines Island transect survey produced a diverse set of vertebrate faunal remains collected systematically from archaeological sites tested across the entire island (chap. 22, this volume). Because these remains span the entire sequence of known human occupation on St. Catherines Island, the vertebrate faunal sample has considerable potential for addressing the broadscale, regional hypotheses set out here.

We also include analysis of the vertebrate zooarchaeological assemblages from Meeting House Field and Fallen Tree, two sites intensively investigated by the American Museum of Natural History and the University of Georgia (see chap. 25 and 26 for an overview of these sites). The Irene period vertebrate faunal materials from Meeting House Field and other Irene sites on St. Catherines Island provide evidence for vertebrate use before the First Spanish Period began. In addition, this fauna forms a baseline against which change and stability during the 17th century mission effort can be measured. We likewise include faunal remains from several of the sites excavated by Joseph R. Caldwell (University of Georgia) in the late 1960s. Caldwell’s materials are important because they extend the range into the Spanish colonial phase (which would otherwise not be represented in the transect data).

The vertebrate materials were examined using standard zooarchaeological methods (Reitz, this volume). We have generally analyzed the St. Catherines transect fauna within a regional framework instead of the more conventional site-by-site basis.

To do this, Reitz grouped the transect sites in East, Center, West, and South sampling, and she also divided the sample by temporal period (chap. 22). With a few exceptions, the species listing are reported for each of four spatial strata; these aggregated zooarchaeological collections do not represent a coherent behavioral unit and it would be inappropriate to discuss site formation processes, butchering strategies, or redistribution systems for a specific site or time phase in the systematic survey sample; it is possible, for instance, that skeletal remains from a carcass field dressed at one site was distributed to several other sites if such sites were contemporaneous.

Specimens of all taxa were counted and weighed to determine the relative abundance of the species identified. Cross-mending specimens were counted as single specimens. A record was made of elements represented. Age, sex, and modifications were noted when observed. Both elements represented as well as any modifications were sketched to facilitate analysis. Where preservation allowed, measurements were taken of deer elements following the guidelines established by Angela von den Driesch (1976). The Minimum Number of Individuals (MNI) was estimated based on paired elements and age. In most cases, MNI was estimated for the lowest taxonomic level, that is, species rather than family.

Reitz (chap. 22, this volume) emphasizes several issues relative to the identification of deer remains in the transect survey sites. Deer remains are readily recoverable (even with the  $\frac{1}{4}$ " screen size employed in the Island-wide survey), and recovered elemental distributions can be projected to determine the various parts of the skeleton represented in a given site. Estimates of age at death for deer can be computed using the degree of tooth eruption sequences and epiphyseal fusion for diagnostic elements. The sex of deer is likewise an important indicator of hunting practices, but except for the skull, there are few osteological indicators of sex in deer elements. Antlers likewise can indicate season of death, and the presence of unshed antlers provides evidence of seasonal activity.

To date, no systematic examination of the nonvertebrate faunal remains has been attempted for St. Catherines Island. This is an important omission, because without a detailed knowledge of midden constituents (especially the relative frequencies of shellfish taxa), we are unable to assess diet breadth for this hunt type.

#### ETHNOBOTANY

We likewise lack comprehensive data on plant remains preserved in the archaeological sites of St. Catherines Island. To date, systematic paleoethnobotanical recovery and analysis have been conducted only at the Fallen Tree site (chap. 26) and at Mission Santa Catalina de Guale (Ruhl, 1990, 1993, 2003). Until appropriate ethnobotanical studies are conducted across the range of archaeological sites discussed in this volume, our knowledge of aboriginal diet breadth on St. Catherines Island will remain preliminary and incomplete.

#### BIOARCHAEOLOGY

Bioarchaeology has been a major focus for most archaeologists who have worked on St. Catherines Island. We have been fortunate to work with Clark Spencer Larsen, a full-fledged member of the American Museum of Natural History team since we began working on St. Catherines Island. While a graduate student (at the University of Michigan), Larsen joined the very first AMNH-sponsored dig on St. Catherines Island (in November, 1974) and since that time, he has been intimately connected with all excavations involving human remains. While Thomas directed the stratigraphic excavations at the various mortuary mounds, Larsen personally supervised the exposure, recording, and removal of all human remains encountered during the burial mound excavations, and this research formed the basis of his doctoral research (1982). With the discovery of Mission Santa Catalina de Guale, Thomas and Larsen shared responsibility for the 15-year-long excavation program: Thomas continued to direct the site structural and architecturally

based excavations, while Larsen supervised the excavation of the cemetery area, which was located inside the mission church (see Larsen, 1990). Larsen likewise returned to St. Catherines Island in 1991–1993 to personally direct the reexcavation of Moore’s “Mound Near South-End Settlement” (Moore, 1897: 74–81; Larsen, 2002). Overall, mortuary excavations over the past century have recovered the remains of more than 725 individuals from St. Catherines Island. Larsen and his colleagues have analyzed more than 90 percent of these remains, using a complex array of bioarchaeological techniques (which are discussed in chap. 24).

The varied techniques of bioarchaeological provide an important glimpse at aboriginal prey choice and diet breadth. In particular, the analysis of stable isotopes plays a critical role because, as Larsen and his colleagues (2001: 71) have pointed out, “the shifts in stable isotope ratios of carbon and nitrogen for St. Catherines Island provide one of the most detailed pictures of dietary change for this region ... and for North America in general.” These findings are relevant for reconstructing past diets because human bone reflects the isotopic ratios of the various plants ingested. By determining the ratios of carbon (and sometimes nitrogen) isotopes contained in bone collagen, bioarchaeologists can reconstruct the dietary importance of various economic plants and animals; using the  $\delta^{13}\text{C}$  value of bone collagen has become a proxy for estimating the relative degree of maize consumption (e.g., Vogel and van der Merwe, 1977; Buikstra et al., 1987).

Whereas the relative importance of each subsistence item can be also addressed by analyzing the zooarchaeological and ethnobotanical evidence recovered during our excavations, the importance of domesticates (particularly maize) is more difficult to assess. Because maize has only rarely been preserved in archaeological sites on the Georgia coast, the mere absence of recovered maize cannot be taken as reliably negative evidence of non-maize-based horticulture. Recognizing such limitations of our archaeological data, stable isotope analysis

provides a workable way to assess the relative importance of maize consumption.

Before stable isotopes can be used to reconstruct changes in diet breadth on St. Catherines Island, it is first necessary to develop the necessary middle-range theory linking specific isotopic ratios with the plants and animals involved. We discuss this issue in chapters 24 and 31, in which investigators have classified modern plants according to the appropriate photosynthetic pathway, then measured the carbon and nitrogen isotopic ratios; because of the variability observed living plants, average isotopic ratios were used as estimates. We summarize the middle-range expectations for carbon and nitrogen stable isotope ratios for plant and animal food sources available to residents of St. Catherines Island (after Larsen et al., 2001: fig. 3.1; see also Hutchinson et al., 1998). Situated against this framework, we have analyzed the stable isotope results from nine mortuary contexts on St. Catherines Island (see also Schoeninger et al., 1990; Hutchinson et al., 1998; Larsen et al., 2001). These stable isotope ratios leaves little doubt of an increased dependency on maize on St. Catherines Island, and a host of additional bioarchaeological techniques chronicle the health-related consequences of this shift (see chap. 24, this volume). In the concluding chapters, we will rely heavily on the bioarchaeological evidence to reconstruct patterns to reconstruct changing diet breadth, the impact of epidemics and food shortages, and the general state of nutrition over the past 4000 years on St. Catherines Island.

## THE EMERGENCE OF SOCIAL INEQUITY IN THE SEA ISLANDS

Nothing fortuitous or idiosyncratic marked the rise of chiefdoms. They were the determinate result of a regular and recurring process. (Robert Carneiro, 1998: 18)

Chapter 2 introduced the Guale people of the mid-/late 16th century that were aligned into a number of well-organized, politically

stratified chiefdoms (Jones, 1978, 1980; Worth, 1995, 1998a, 1998b, 2004; Milanich, 2004b). The Guale chiefdoms were regional polities in which two or more local groups were organized under a single chief, called the *mico* (who is the head of a ranked social hierarchy). Unlike autonomous bands and villages, chiefdoms consist of several more or less permanently aligned communities or settlements.

Up to six Guale chiefdoms existed throughout the period between initial European contact and into early 17th century. Each chiefdom was a ranked society, in which social status and political power were determined by the genealogical distance to a single noble lineage, from which the ruler must be drawn. The principal leader of a chiefdom was known as the *mico*, and the Guale seem to have maintained several subchiefs, titled leaders, who were probably the heads of clans, in which descent was traced matrilineally. It is likely that the *micos* claimed descent directly from the gods, where Guale commoners existed only to provide for the chiefly needs. Perhaps the chiefs owned the land in their respective villages, and they had larger houses and canoes than commoners, as well as distinctive clothing. Some *micos* may have had craft specialists in their employ, and chiefs controlled communal fishing gear and village production.

The *mico* also controlled the distribution of food and wealth items between the various dispersed towns. Periodically, he probably demanded tribute for special feasts and demonstrated his authority by redistributing food and goods to all who attended. The chief always retained some portion of the tribute for use by his household; chiefs also handed out punishments for social transgressions.

Because the Guale settlement pattern fostered some degree of economic specialization between communities, chiefdom organization was a primary means of integrating the regional economy. Chiefs served as collectors and redistributors of food and other products through periodic ritual feast, in which items such as maize, fish, oysters, and acorns were lavished on guests. Early

French sources suggest that chiefs either owned substantial agricultural land or at least maintained authority to collect tribute of maize for their own use, as well as for future distribution in the community feasts (Laudonnière, 1975). Archaeological evidence suggests that the Guale participated in an active, long-distance trade network with inland peoples (Larson, 1980a). The exchange involved mostly elite or nonessential goods, indicating that the Guale political hierarchy may have played a central role in regional as well as local trade.

There is a huge discrepancy between these ethnohistorical impressions of Guale chiefdoms and the conceptions of those same societies based on the long-term archaeological record of the Georgia coast (Larson, 1980a; see also Gallivan, 2003). As Milanich (1998: 248) notes, "were it not for the documentary record, we might not even recognize that the Timucua were organized into simple chiefdoms, much less that some groups formed more complex political entities." It is this discrepancy, between the evidence of ethnohistory and archaeology, that must be addressed here.

#### ORIGINS OF CHIEFDOMS IN THE AMERICAN SOUTHEAST

The first St. Catherines Islanders apparently arrived sometime during the Late Archaic period (probably between cal 2000 B.C. and 3000 B.C.), and they were likely organized into egalitarian, band-level societies.<sup>10</sup> But as noted above, the ethnohistoric sources make it clear that the Guale people of the mid-/late 16th century were organized into complex chiefdoms, multicommunity polities with centralized political control and an emphasis on ranked hierarchy. In other words, there is reason to believe that the archaeological record of St. Catherines Island reflects the transition from egalitarian to ranked status, from a band level of social organization to chiefdoms.

The rise of chiefdoms in the American Southeast is generally considered to be coeval with the emergence of Mississippian culture, which began in the Mississippi Riv-

er Valley about A.D. 700. As John Worth (1998a: 5) has noted, the “degree to which the Mississippian culture directly affected the prehistoric cultures of northern Florida, and southern Georgia is debatable ... [but] it is nonetheless impossible to discuss the emergence of Timucuan chiefdoms without understanding the Mississippian model” (see also Milanich, 2004a: 235). And the same would seem to hold for the Guale of the Georgia Coast (Milanich, 2004a; Worth, 2004).

By about A.D. 1000, Mississippian societies in interior Georgia lived in complex chiefdoms with the following characteristics (Earle, 1987; Hally and Mainfort, 2004: 273):

- Communities within a chiefdom were under control of a single leadership hierarchy.
- At the apex of this hierarchy was a “chief”, usually male, who was believed to be semidivine and, at least in some cases, descended from the Sun.
- Chiefly power was reinforced by an “ancestor cult” focusing on the chief’s direct ancestors and elaborate sumptuary rules setting the chief apart from other member of society.
- Chiefdoms were administered from towns with one or more earthen platform mounds, which were critical political and religious institutions in Mississippian chiefdoms. The chief resided atop the mound, as did a temple holding the remains of his/her ancestral bones. When the chief died, his house and temple were destroyed and the mound was refurbished and enlarged for his successor.
- Chiefs enjoyed considerable redistributive power over foodstuffs and wealth items.

Inheritance through the matrilineal line is a fundamental component of the Mississippian complex. The settlement hierarchy consisted of localized clusters of farmsteads, smaller hamlets and villages and a range of special-function sites, each administered under the leadership of individual village chiefs. The preeminent head chief administered the entire chiefdom, as described above. In sum, these Mississippian chiefdoms displayed the twin hallmarks of hereditary leadership and central administration above the level of the individual community.

The development and spread of Mississippian culture is generally viewed as accompanied by a major shift in subsistence base (Reitz, 1988a: 150). Pre-Mississippian people lived mostly by hunting and gathering, supplemented by simple horticulture of plant foods originally domesticated in the eastern United States (such as sumpweed, sunflower, chenopodium, and pigweed). Although maize was apparently in the Southeast for centuries prior to A.D. 700, Mississippian people pursued more intensive agricultural strategies, directed to one degree or another for growing of maize, beans, and squash; while still supplemented by foraging for wild plant and animal sources. Mississippian subsistence: (Scarry, 1993; Hally and Mainfort, 2004: 277–278).

Mississippian societies are characterized by considerable regional variability. Not all local societies in the Southeast became part of broader Mississippian culture, and others seem to have been involved hardly at all (Worth, 1998a: 7). Milanich (2004a: 235) notes that from A.D. 1000 to 1200, Mississippian ideas and lifeways “did not measurably influence the societies of the South Atlantic coastal plain”, which generally continued previous patterns of economic, ceremonial, and social practices from earlier times. But by A.D. 1200, a distinctly Mississippian impact was felt along the Georgia coast, likely due to an increase in maize cultivation (Reitz, 1988: 150). Although Mississippian-period mounds, villages, and homesteads were reasonably numerous in the interior coastal plain, the Irene site, near the mouth of the Savannah River, is a rare instance of temple mound construction on the Georgia coast (Caldwell and McCann, 1941; Anderson, 1994).

Although this impact varies considerably along the Georgia coast, we generally see an increase in Mississippian-period sites (likely reflecting a significant population increase) and the addition of certain items from the Southeastern Ceremonial complex (Larson, 1955; 1958a; Cook and Snow, 1983; Cook and Pearson, 1989). But unlike the Mississippian heartland, coastal Georgian archeology has disclosed no clear-cut site-size hierarchies; the archaeology of the late

precontact and early Spanish period conspicuously lacks the hallmarks of such multicomunity polities. Instead, the chiefdoms of the Georgia–north Florida coast appear to be relatively small, with populations in the neighborhood of a thousand, unlike Mississippian-style chiefdoms, which likely number in the thousand to tens of thousands (Milanich, 1998: 246; Worth, 1998a: 14).

Platform mounds are lacking among coastal populations of Georgia and north-eastern Florida, but Worth (1998: 14) argues that such mounds should not be considered a “hallmark” of chiefdom-level societies. While maize was undoubtedly important along the coast, only one of several subsistence options, Worth (1998a: 17) believes that environmental constraints on the overall productivity of maize cultivation “resulted in population densities and settlement systems that hindered the development of Mississippian-style chiefdoms.”<sup>11</sup>

#### ARCHAEOLOGICAL CORRELATES OF CHIEFDOMS ON THE GEORGIA COAST

In a now classic paper, Robert Carneiro (1981: 53–54) identified four key archaeological correlates of the chiefdom level of social organization:

1. Monumental architecture
2. Identification of ceremonial centers
3. Settlement hierarchy reflecting the structural differentiation of settlement types
4. “[D]ifferentiated burials in which difference in the quantity and quality of the grave goods points to a categorical distinction in status of a few individuals, presumably chiefs, and the general populace.”

We will evaluate the possibility of examining each correlate against the potentials of St. Catherines Island archaeology.

**CORRELATE 1. MONUMENTAL ARCHITECTURE:** According to Carneiro (1981: 53), the presence of monumental architecture serves to distinguish the archaeological remains of chiefdoms from those of autonomous villages. But he is also quick to add that chiefdoms do not inevitably leave behind monumental architecture: “[T]he chiefdom that extended along the Amazon

River, from Machiparo to Marajoara, did not. The only archaeological evidence of their high status is their elaborate ceramics” (Carneiro, 1981, fn 15).

With the exception of the Irene Mound complex (noted above), monumental architecture appears to be lacking along the entire Georgia coastline. Speaking of a similar “widespread absence of prehistoric substructure platform mounds” among the Timucuan immediately to the south, John Worth (1998a: 18) suggests that these small-scale chiefdoms were only loosely integrated into regional organization structures, most of which were either ephemeral political units or displayed limited locational stability with respect to the regional administrative center. Consequently, localized simple chiefdoms were not of sufficient scale to display platform mound construction as evidence of long-term chiefly power, while regional alliances between these local chiefdoms, which might be referred to as loosely integrated complex chiefdoms, were generally too unstable and short-lived for the emergence of platform mound construction as evidence of long-term regional chiefly power (with a few exceptions). Since we know from the ethnohistoric evidence that chiefdoms did indeed exist among the Guale during the mid- to late 16th century, we must set aside Carneiro’s first correlate within the coastal Georgia setting.

**CORRELATE 2. CEREMONIAL CENTERS:** According to Carneiro (1981: 53), the presence of spatially discrete ceremonial centers, which are “fewer in number than the villages they ostensibly served [and] would suggest that these villages were politically unified” (Carneiro, 1981: 53). We believe that the multiple archaeological survey strategies outlined above—the shoreline survey, the Island-wide transect survey, systematic shovel testing, and “good old gumshoe survey”—provide an appropriate way to test for the present of specialized ceremonial centers (and other such special-use areas).

**CORRELATE 3. A SETTLEMENT HIERARCHY REFLECTING THE STRUCTURAL DIFFERENTIATION OF SETTLEMENT TYPES:** In his initial definition, Carneiro (1981: 45)

emphasizes the chiefdom “as an autonomous political unit comprising a number of villages under the permanent control of a paramount chief.” This approach focuses attention on the chiefdoms as a *political* entity, brought into being by the “surmounting of village autonomy and held together as unified multi-village wholes by a powerful chief.” In other words, to explain the origin of chiefdoms, one must (1) demonstrate the emergence of inherited rank and (2) provide evidence for the loss of village autonomy (Marcus and Flannery, 1996: 93). With the research design employed here, we can address the first issue (see below), but not the second.

To monitor the loss of village autonomy, one must be able to define major village sites and their associated satellites, then define a hierarchy between and among contemporary sites (Marcus and Flannery, 1996: 108). Typically, attempts to determine decision-making hierarchies using archaeological evidence equate site size with administrative level (Anderson, 1994: 118). Pearson (1978), for instance, estimated the real extent of archaeological sites on Ossabaw Island by measuring the distribution of surface debris scatters, assigned temporal duration based on surface collections, then constructed a rank-size hierarchy. Lee (1977, 1978) proposed a similar hierarchical ranking based on surface survey of late Mississippian period sites on the Georgia Piedmont. As Anderson (1994: 117–120) notes, the use of surface data to reconstruct settlement hierarchies and reconstruct community-level data has fallen into disfavor in Georgia (Anderson and Mainford, 2002: 6).<sup>12</sup> Anderson and Joseph (1988) and Shapiro (1983) have noted the unreliability of surface data for defining site size and function (see also Schroedl, 1988; Anderson, 1994: 118, concerning the biases involved in using surface indications to generalize about temporal and functional nature of buried sites).

The archaeological data generated from the Island-wide survey strategies (outlined above) are completely insufficient for identifying regional settlement hierarchies and establishing interrelationships at the com-

munity/village level.<sup>13</sup> Specifically, given a research design committed to an *extensive, regional approach*, we are unable to characterize the hundreds of archaeological components now known from St. Catherines Island in terms of conventional community-based categories (such as single-family farmsteads, hamlets and villages, and a range of special-function sites). To do this will require a very different kind of archaeological survey and a different kind of follow-up excavation. As a direct result of the survey strategies employed here, we have little to say about the nature of community patterning or the loss of village autonomy on St. Catherines Island.

**CORRELATE 4. MORTUARY PATTERNING THAT REFLECTS STATUS DIFFERENTIATION:** The intensive program of bioarchaeology on St. Catherines Island, described above, is well suited to differentiate between patterns of achieved and ascribed status.<sup>14</sup>

## NOTES

1. We defer until chapter 19 our discussion of how we operationally define archaeological “sites”, archaeological “presences”, and archaeological “occupations” for the purpose of the Island-wide surveys.

2. We believe that our usage of *phase* is consistent with that employed by Williams and Shapiro (1990: 29), in which the Lamar “period” is divided into a series of localized “phases”.

3. Strictly speaking, of course, two events can never be truly contemporary, even if we measure time in milli-microseconds. Time has no intrinsic units, and the smallest subdivision can always (at least in theory) be subdivided.

4. For a concrete example of this, see our discussion of the “Savannah period” in chapter 15.

5. The dates cited in this section are expressed in uncalibrated radiocarbon years.

6. This apparent discrepancy arises because, in order to derive an accurate and reliable local reservoir correction, we processed a dozen radiocarbon dates on modern time prebomb samples.

7. As discussed earlier in this chapter, we modified DePratter’s terminology slightly to conform with the overall systematics employed in the St. Catherines Island research.

8. The St. Catherines Island results fine-tune yet overwhelmingly confirm the previous research on the ceramic chronology for Georgia’s north coast, particularly Joseph Caldwell, Antonio Waring, and Chester DePratter.

9. Griffin’s 1965 recommendations also included an exploration of plantation period archaeology, which (with rare exception) proved to be beyond the scope of

the American Museum of Natural History research design.

10. We should not automatically presume that late Archaic populations were necessarily egalitarian (Russo, 1994; Aten, 1999; Russo and Heide, 2002; Sassaman, 2004: 261); this is an empirical matter that should be addressed through the archaeological record.

11. Worth (2004: 238) believes that the Guale were organized “as a complex chiefdom, with at least two administrative levels above that of the community”; he ascribes “small-scale chiefdoms” to their Timucuan neighbors immediately to the south (1998: 18): Based in part on the widespread absence of prehistoric substructure platform mounds, as well as a substantial amount of supplemental ethnohistorical and archaeological information regarding the Timucua Indians, the basic unit of Timucuan sociopolitical organization is inferred to be a minimal version of the simple chiefdom, consisting of a limited cluster of small communities (perhaps averaging only a half a dozen or so distinct

settlements) under the hereditary leadership of a single noble matrilineage.

12. Archaeological follow-up on Lee’s (1977, 1978) survey in the upper Oconee River valley disclosed a number of site components not recognized in the surface survey (Anderson, 1994: 117–120).

13. With the exceptions of our research at Mission Santa Catalina de Guale (Thomas, 1987) and Meeting House Field (Russo, 1991; Dukes, 1993; Saunders, 2000a, chap. 22 and 27, this volume), our St. Catherines Island excavations do not reflect community-level patterning in any meaningful way.

14. Noting the importance of ranking assigned by Service (1962) and Fried (1967) as the most conspicuous feature of chiefdoms, Carneiro (1998: 20) has recently commented that “the emphasis on ranking strikes me as misplaced. To take ranking as the essence of a chiefdom is like defining an elephant by its tail instead of by its trunk... I would argue that ranking is an epiphenomenon of the chiefdom, and not its central core”.

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