



CHAPTER 15 MODELING INDIGENOUS HUNTING AND HARVESTING OF SEA TURTLES AND THEIR EGGS ON THE GEORGIA COAST

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Marine turtles have captivated the human imagination for millennia.... There is no doubt that marine turtles, at different places and in different times, have enriched the human spirit in countless ways.

—Jack Frazier (2003: 29)

As Jack Frazier so cogently expresses it, people have long interacted with sea turtles and they still do (Bjorndal, 1979; Wing and Reitz, 1982; Frazier, 1996, 2006; Schaffer and Thunen, 2001; Frazier, 2003; Spotila, 2004; Bishop and Thomas, 2008).¹

When Columbus encountered the Cayman Islands in 1503, he named them *Las Tortugas*, because the ocean was so filled with green turtles (perhaps as many as 100,000,000 individuals), with loggerhead numbers reaching into the “tens of millions” (Spotila, 2004: 63). Columbus is said to have watched Native Americans hunting hawksbills along the southeast coast of Cuba in 1494. Early mariners captured green sea turtles in the Caribbean, holding them tipped over in holds as a source of food (Spotila, 2004: 68). This exploitation, particularly when sea turtle meat entered the cash market beyond indigenous exploitation, decimated sea turtle populations around the world, including the Caribbean and Gulf of Mexico (de Oviedo, 1526).

In this chapter, we review historical and contemporary patterns of sea turtle behavior and exploitation, then meld these data into a new model for anticipating the archaeological record of St. Catherines Island and elsewhere.

THE MODERN HUMAN SEA TURTLE TAKE

Sea turtles are hunted and captured around the world and utilized for their meat. Hunting techniques range from capturing nesting females on the beach by tipping them over on their backs, through various fishing techniques, to true hunting from canoes or boats. “Adult loggerheads in the southeastern United States have a mean straight carapace length of 92 cm (36.2 in.) and weigh about 113 kg (249 lbs)” (NMFS, USFWS 1991). The loggerhead sea turtle was listed on July 28, 1978, as a threatened species under the Endangered Species Act of 1973 (43 FR 32800). “Internationally, it is considered endangered by the International Union for Conservation of Nature and Natural Resources (IUCN) and is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).”

Many cultures continue to exploit sea turtles and sea turtle eggs as food items (Schaffer and Schaffer, 2008). In Myanmar (Burma) “beaches were leased by the Colonial Administration to local businessmen, who harvested and sold eggs. About 1.5 million olive ridley turtle eggs and 1.6 million green turtle eggs were harvested annually (Thorbjarnarson, Lagueux, and Bolze, 2000; Thorbjarnarson, Platt, and Khaing, 2000).

Thorbjarnarson, Lagueux, and Bolze (2000), Thorbjarnarson, Platt, and Khaing (2000), and Campbell (2003: 312) have marshaled an impressive listing of countries currently exploiting sea turtle meat, including (in no particular order), the United States, Ecuador, Peru, Madagascar, Nicaragua, Venezuela, Seychelles, India, Sri Lanka,

Japan (fishing from others' waters), Indonesia, Australia, Torres Strait, Papua New Guinea, Bangladesh, Liberia, Egypt, Equatorial Guinea, Cuba, Costa Rica, Belize, Mexico, and the Caribbean islands of Antigua, Barbuda, Bahamas, British Virgin Islands, Cayman Islands, Grenada, Haiti, Saint Kitts, Nevis, Trinidad, Tobago, and Turks and Caicos.

Hunting turtles is a manly activity in many traditions and provides a rich, although seasonal, source of protein to indigenous societies to be distributed through cultural tradition across the local population, providing status and rank to the clan or tribe. Havea and MacKay (2009: 16) report that during 2007 in the Kingdom of Tonga in the South Pacific an estimated 608 sea turtles were taken by hunting methods that included spearing (harpooning), netting, and live capture by swimming. In both O'ua and Ha'afeva the average catch was 7.6 turtles per fisherman while in Tungua it averaged 23.9 turtles per fisherman with four fishermen catching from 30 to 100 turtles per year (perhaps reflecting a new commercial market for sea turtle meat).

The cultural significance of sea turtle hunting runs deep. In the culture of the Miskito Indians of Nicaragua (Nietschmann, 1973, 1979; Campbell, 2003) the sharing of green sea turtle meat with kin and friends was a significant component of social relationships, satisfying cultural obligations and responsibilities. The Miskito Indians of Costa Rica captured green sea turtles offshore at the mouth of the Tortuguero River for consumption and the sea turtle's importance in legend is celebrated by the rock called the Turtle Mother and *Cerro Tortuguero* at the mouth of the Tortuguero River (Rudloe, 1979). Lefever (1992) cites the restocking of European vessels with sea turtles as early as the 17th century. Consumption of turtle meat continued, at least, into 1999, and undoubtedly operates illegally yet today during poor years. The Seri (Comcaac) Indians on the Sonoran coasts of Mexico have integrated sea turtles into their culture (Nabhan et al., 1999) as "turtles are not just food, but 'the symbolic foundation of their marine resource based culture.'" In Venezuela the Wayuu Indians relate sea turtles to fertility, thinking consumption of meat and blood enhances masculine fertility (Campbell, 2003: 314), while turtle crania are hung in fruit trees to enhance their growth. Suarez and Starbird (1996) describe leatherback hunting in the Kai

Islands of Indonesia forming a body of tradition, ritual, and beliefs (*adat*) that guide the hunt. Meat harvested in *adat* is used for subsistence purposes and is not sold. In Papua New Guinea (Spring, 1995) sea turtles form the basis of oral history, legend, and material items used in bride-price traditions. In the Caroline Islands, McCoy (1979) reported that sea turtles are hunted from dugout canoes and their cultural importance exceeds the significance of the protein harvested. In Australia, indigenous populations still hunt sea turtles for noncommercial uses (Kowarsky, 1995; Rick, Kennett, and Erlandson, 2005). Harpooning turtles in the Gulf of Carpentaria and hunting green sea turtles is still important in the traditional life of the Yanyuwa people of Borroloola (see www.ozoutback.com.au).

These traditions survive into modern day in many societies, as, for example, in Lenten consumption of sea turtles in Pacific Mexico (Nichols and Palmer, 2006), who state: "When turtle meat is shared among families and friends the process is imbued with symbolism—consciously or not. An offer of a turtle feast is considered among the highest honors and displays of trust" (Delgado and Nichols, 2005: 89–104).

There is an equally extensive listing of countries that today harvest sea turtle eggs (Thorbjarnarson, Lagueux, and Bolze, 2000; Thorbjarnarson, Platt, and Khaing, 2000): virtually all countries on the Atlantic coast of Central America, Mexico, Iran, Saudi Arabia, India, Thailand, Malaysia, Indonesia, Philippines, Papua New Guinea, Suriname, Costa Rica, Guatemala, Panama, Honduras, Bangladesh, and Myanmar (Campbell, 2003). Gathering of sea turtle eggs in many indigenous societies remains a seasonal tradition usually done by the women and children. The ingestion of turtle eggs provides a rich protein resource and has developed an aura of aphrodisiac in many cultural settings. The value of sea turtle eggs as a sustenance source of protein almost certainly is significant regardless of the "reason" for their ingestion. A legal, commercial egg collection has been allowed at Ostinal, Costa Rica, where 70% of households derive primary cash flow from the take (Campbell, 2003).

Overall sea turtle "take" includes not only meat from hunting the animals and the eggs from rookeries, but also turtle products (skin, bone, etc.) derived from killing the turtles. One of the traditional products of this take is "tortoiseshell," the source of ornamental artifacts made from the

carapace of hawksbill sea turtles (*Eretmochelys imbricata*). Tortoiseshell (bekko) ornaments, combs, hairpins, bowls, etc., are especially highly sought in Japan.

Much of this take is now illegal as all species of sea turtles are either listed as endangered or threatened, however, some legal cultural take is allowed in indigenous societies under the CITES treaties. "It should not be surprising," write Nichols and Palmer (2006: 8) "that recently enacted laws against killing sea turtles and collecting their eggs would fail to halt the centuries old traditions of consuming turtle meat and eggs." Sea turtle conservationists are striving to maintain sustainable world sea turtle populations while accommodating indigenous take (e.g., Kowarsky, 1995; Hunter and Williams, 1998; Prince, 1998; Kennett et al., 2008).

ANTICIPATING THE ARCHAEOLOGICAL RECORD

Thomas (2008; see also chap. 1, this volume) has discussed how the overarching theoretical framework of human behavioral ecology has helped archaeologists develop a series of specific and testable hypotheses about the subsistence and settlement practices of aboriginal St. Catherines islanders who, for 5000 years, called this place their home.

THE DIET-BREADTH (PREY CHOICE) MODEL

Particularly relevant is the diet-breadth (or prey choice) model, which poses a deceptively simple question (Thomas, 2008: chaps. 6–9; see also O'Connell and Hawkes, 1981, 1984; Hames and Vickers, 1982; Kaplan and Hill, 1992; Smith, 1991; Hawkes et al., 1992): *Which foods should an efficient forager harvest from all those available on St. Catherines Island?*

To provide an answer to this question, one must first estimate the postencounter return rates inherent in the various prey taxa available to aboriginal foragers—meaning to measure (or estimate) how long it takes to collect and process a given resource, then calculate the net energetic return from these activities ("if I spend an hour harvesting and processing a food item, how much energy will I realize on my 60-minute investment?"). With these metrics in hand, it is possible to rank-order the available foodstuff on St. Catherines Island according to their energetic potential. Specifically, if you are a forager with an hour

to invest, we found that the "most efficient" thing to do is to hunt, kill, and process a black bear; you will receive a payoff of 37,352–61,434 kcal of energy for each hour of effort. By contrast, if you spend an hour collecting and processing marsh periwinkles, your payout will be 26–135 kcal. Take your pick. The diet-breadth model predicts that an energy-efficient forager will always harvest the highest ranked resources encountered. When lower ranking prey are included in the optimal set, the energy-conscious forager will always take any higher-ranking taxon first, whenever encountered.

Thomas (2008: table 8.27) ranked leatherback turtles extremely high in the energy hierarchy available to St. Catherines Island foragers. Male and female leatherbacks return an estimated 26,825–62,792 kcal/hr—second only to black bears, with American alligator running a distant third (at 22,000 kcal/hr). Loggerhead turtles (male and female) wind up fourth on the energetic hierarchy, returning an estimated 21,360 kcal/hr (only slightly trailing American alligators) and well ahead of white-tailed deer (at 12,096–19,895 kcal/hr).

The upshot? The diet-breadth model predicts, simply stated, that anytime a sea turtle was encountered near St. Catherines Island, the forager seeking to maximize net energy return should take it—every single time. But how are these postencounter return rates derived?

Thomas (2008: 131) relied on quantitative return-rate calculations for Meriam people hunting green turtles in the Torres Strait (Bliege Bird and Bird, 1997; Bliege Bird, Smith, and Bird, 2001: 11; Bliege Bird et al., 2002). In the past, when the Meriam spotted an appropriate turtle, they pursued in dugouts, armed with harpoons, ropes, and sometimes turtle hooks (modern Meriam hunters employ outboard motorboats). The captured turtle was brought alongside, then hoisted into the boat, alive, to be butchered and cooked later. The all-male Meriam turtle hunters spent hours doing this, demonstrating considerable skill, experience, and courage to all.

Although several species of sea turtle pass through Georgia waters—including hawksbill (*Eretmochelys imbricata*), Kemp's Ridley (*Lepidochelys kempii*), leatherbacks (*Dermochelys coriacea*), and green (*Chelonia mydas*) turtles, Thomas (2008: 131) relied on the loggerhead (*Caretta caretta*) for transplanting the Meriam model to St. Catherines Island. He assumed that

4 person-hours would be required to pursue and subdue a swimming turtle and further estimated that 2 person-hours would be required to butcher each adult loggerhead so captured. The estimated return rate (for male and female loggerheads) ranges between 8010 and 13,350 kcal/hr (Thomas, 2008: table 8.10).

CENTRAL PLACE FORAGING

Postencounter return rates are an elementary, yet critical, aspect of diet-breadth modeling. Thomas (2008: 211) also asked another simple, correlative question: "To what extent can we expect past diet-breadth decisions to be accurately reflected in archaeological midden deposits?" Drawing again on ethnoarchaeological research, Douglas Bird and Rebecca Bliege Bird discovered that, among contemporary Meriam islanders, significant problems existed between correlation of take and midden remains when return rates and direct observations of foraging behavior were translated into interpretation of the shell middens that the Meriam themselves created.

The prey choice model predicts that Meriam foragers should always harvest the highest ranked resources (in this case, the large tridacnid clams and *Lambis*) upon encounter, and they almost always do so. 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, with the lowest ranking rocky shore resources dominating the archaeological assemblage. 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. Bird and Bliege Bird ultimately concluded that differential field processing strategies were likely the most critical factor in shaping the archaeological record of Meriam shellfishers.

Thomas (2008: chap. 10) also applied 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, Hawkes, and Blurton Jones, 1988, 1990; Jones and Madsen, 1989; O'Connell and Marshall, 1989; Metcalfe and Barlow, 1992; Barlow and Metcalfe, 1996; Bettinger, Malhi, and McCarthy, 1997; Bird, 1997; Grayson and Cannon, 1999; Bliege Bird et al., 2002; Zeanah, 2004).

At its heart, central place foraging theory addresses the tradeoff between increasing the utility of a load (through field processing) and increasing the amount being harvested (which involves foraging and travel time; see Bettinger, Malhi, and McCarthy, 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: (1) more field processing is expected as distance from residence increases; and (2) 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.

FIELD PROCESSING/TRANSPORT MODELS

The field processing/transport model provides a way to approach this problem, by positing 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 Barlow (1992), Bird and Bliege Bird (1997) computed several *processing thresholds*—the time/distance at which field processing is expected to occur—for various shellfish resources exploited by the Meriam.

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 firsthand how the procurement, the processing, and the discard of shellfish directly condition the resulting archaeological record:

Variability in intertidal prey choice is reflected archaeologically only through a filter of differential 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, Bliege Bird, and Richardson, 2004: 195)

We will never have the opportunity to observe the aboriginal sea turtle hunters 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 the archaeological observations.

Thomas (2008: 223–224; table 10.5) computed terrestrial transport thresholds for loggerheads and leatherback taken at sea, employing an estimated live weight as the average weight differential between adult males and females. These terrestrial z -scores are rather unrealistic, of course, since watercraft are mandatory for procuring turtles at sea. He also computed a separate z -value for female loggerheads that were taken while nesting.

On St. Catherines Island, sea turtles nest only on sandy beach margins, a habitat type that is restricted to the extreme eastern (and northeastern and southeastern) 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.

Thomas (2008: 230, table 10.7) concluded that for male and female leatherback turtles (with a one-way terrestrial transport threshold of

400–667 m), hunters would only “sometimes” field process the carcass before returning to the residential base. He also concluded that for male and female loggerheads (with field transport thresholds of 2206–3677 m), the carcasses would “almost never” be field butchered before returning to residential base. In archaeological terms, then, this conclusion meant that nearly all loads of sea turtle meat would be transported in bulk for processing at the central base. If this model holds true, then the discarded, inedible parts of sea turtles should be abundant in the middens associated with residential bases, and virtually absent elsewhere.

ACTUALISTIC RESEARCH ON SEA TURTLE EGG HARVESTING: ST. CATHERINES ISLAND

This is where things stood when Thomas published his assessment of Native American foraging on St. Catherines Island (Thomas, 2008). Under the direction of Bishop and Meyer, the St. Catherines Sea Turtle Program has continued to monitor sea turtle nesting behavior and a number of additional observations are now possible, allowing us to refine and expand the previous optimal foraging models.

Under climatic conditions similar to today, sea turtle eggs could be harvested along the Georgia coast from May to August—either by directly catching them as they were deposited in egg chambers at night or by postnesting excavation during daylight (see fig. 15.2). The latter case would likely be preferred due to the difficulty of nighttime activity on the beach when darkness and insect activity prevails. Using torches would have negatively impacted nesting, spooking potential nesting females before they began to lay eggs. The hypothesized exploitation (fig. 15.3) scenario during early morning light, when the beach is also cooler, would have included “reading of sign” (fig. 15.1) in nest areas above crawlways from the sea, digging for eggs (see fig. 15.2) with “found tools” (fig. 15.3), and the transportation of the eggs to temporary or permanent seasonal camp sites on the seaward side of the island.

Indigenous peoples were astute observers of their environment, including seasonality, especially as marked by the appearance or disappearance of their food resources or particularly hazardous times of the year (Baity et al., 1973;

Powers, 1975). Celestial events form the basis of many ancient religions and, in societies in which they were not officially documented, certainly were important as temporal markers throughout the year. In the case of sea turtle nesting on St. Catherines Island, there is a remarkably close approximation of historical peak nesting to the summer solstice, about June 20 or 21. Indigenous St. Catherines islanders undoubtedly understood the timing of sea turtle events, the northward migration of leatherback sea turtles in April, and the peak nesting by loggerheads at the summer solstice. Timing the collection of eggs with the summer solstice would have assured a maximum return for the investment of walking the beaches

at that particular time.

The identification of loggerhead crawlways (see chap. 14, this volume) by following the shoreline (table 15.1) would have allowed the egg gatherers to locate potential nests that could then be identified by nesting criteria (differential lengths of entrance and exit crawlways, the presence of thrown sand radiating from an elliptical covering pit). Locating the egg chamber beneath the disrupted surface layer stirred up during covering would either have been based upon locating the egg discontinuity, comprising 1.01% of the covering pit (table 15.1), or by probing or by excavation through the surficial, bioturbated sediment overlying the egg chamber

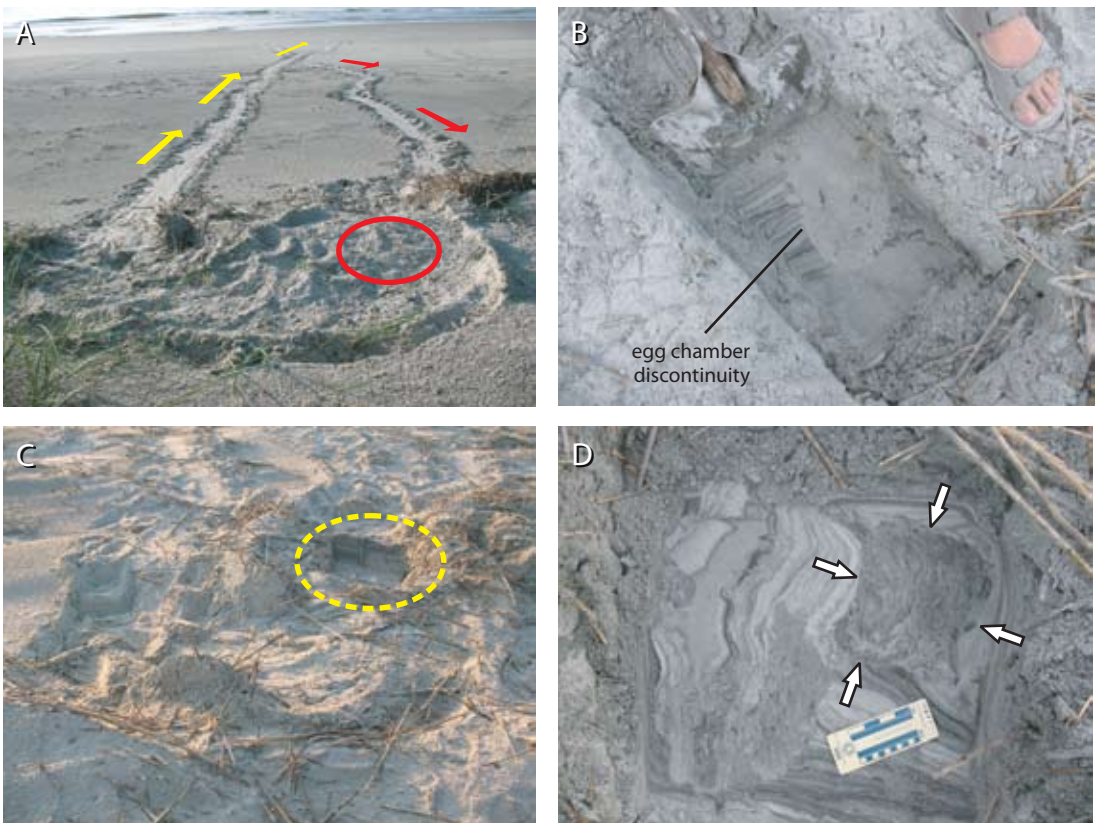


Fig. 15.1. The search for loggerhead sea turtle eggs in the St. Catherines Island Sea Turtle Program entails **A**, reading the nest [Nest 07-048] to identify where the turtle *probably* dug her egg chamber; **B**, carefully removing loose sand from the covering pit [Nest 07-030]; **C**, using a magic titanium square-ended sand shovel to excavate beneath the target site (yellow oval in this nest [08-023]); **D**, defining egg chamber discontinuity [Nest 08-001]. Scale = 10 cm.



Fig. 15.2. Neo-Native search for loggerhead eggs on St. Catherines Island. **A**, Probing for eggs with shaft of sawtooth palmetto in 2005. Using found tools to validate clutches of eggs: **B–C**, shell of the giant Atlantic cockle; **D**, decorated shell of a knobbed whelk; **E**, a paddlelike, keeled segment of the frond shaft of a cabbage palm. Scale = 10 cm.

until the neck of the egg chamber was located. The eggs could then have been easily harvested by following the egg chamber neck downward to the clutch of eggs.

During the 18 years of monitoring, the St. Catherines Island Sea Turtle Project had record-

ed 2093 sea turtle nests deposited on the ~20 km of sandy beaches of St. Catherines Island. Loggerhead nests comprise the vast majority of these, in fact, constituting 2087 of the known nests, (99.71%) on St. Catherines Island, while five leatherback nests have been observed (0.24

%), and one green sea turtle nest (0.05 %) has been documented.

Thomas previously (Thomas, 2008: chap. 8, table 8.9) presented an overview of historical nesting on St. Catherines Island and we can update these data with numbers of nests for 2005 (115 nests), 2006 (124 nests), 2007 (51 nests), 2008 (146 nests), 2009 (102 nests), and 2010 (152 nests). Clutch size remains close to an average of 113 eggs per clutch and hatch rates at ~72%. Because of the continuing deterioration of the sea turtle habitat (Bishop and Marsh, 1994) on St. Catherines Island (see Bishop and Meyer, chap. 14), the success rate of nesting attempts by loggerhead sea turtles has dramatically declined, reducing the ratio of nonnesting to nesting attempts (1:1) seen in the mid-1990s to 2.62:1 in 2008. New data collected in 2006–2008 indicate that an average loggerhead on the Georgia coast deposits 5.2 clutches per year (determined

by mtDNA run on one loggerhead egg from each clutch deposited on the Georgia barrier islands; Brian Shamblin, personal commun.).

Overall, then, we know that sea turtle egg resources currently available on St. Catherines Island consist of an average of 112 loggerhead sea turtle nests/year and an average clutch size of 113 eggs/clutch. Thomas discussed the harvesting of loggerhead sea turtle eggs (2008: chap. 8: 159) and we believe these nests were easily exploited and represent a significant, seasonal high-protein food resource. They were undoubtedly harvested by foragers along the Georgia coast. An average egg weighs ~30.2 g, providing a total nutrition package of 3.412 kg/nest when harvested. The reported (USDA) nutritional value of each green sea turtle egg is 89 kcal/100 g, while loggerhead eggs tested in 2005 (Silliker Inc., Laboratory Report 12/06/05) returned a nutritional value of 200 kcal/100 g



Fig. 15.3. The preferred Native American digging tool consists of stem fronds of cabbage palm used to locate clutches of eggs of the loggerhead sea turtle. They can be manufactured from **A**, green fronds of cabbage palm, or from fronds that have dried out naturally; **B**, and are then; **C**, broken into segments approximately 14 in long.

TABLE 15.1
Maximum Nesting between South Beach Entrance and McQueen Inlet

Species	Crawlway #	Emergence Type	Nest ID	Latitude	Longitude	Relocated = R In-Place = I	Hatch Date	No. of Eggs	No. Hatched	% success
CC	1	N	08-056a	31.681	81.137	R	8/17/2008	159	99	62.3%
CC	2	N	08-050	31.630	81.130	I	8/15/2008	124	111	89.5%
CC	3	N	08-051	31.627	81.133	I	8/13/2008	128	91	71.1%
CC	4	N	08-052a	31.625	81.134	R	8/14/2008	113	106	93.8%
CC	5	N	08-053a	31.622	81.136	R	8/17/2008	103	74	71.8%
CC	6	FB	—	31.618	81.137	—	—	—	—	—
CC	7	FB	—	31.618	81.137	—	—	—	—	—
CC	8	N	08-054a	31.616	81.139	R	—	100	67	67.0%
CC	9	N	08-055	31.614	81.140	R	8/13/2008	91	65	71.4%
CC	10	FB	—	31.608	81.144	—	—	—	—	—
CC	11	FA	—	31.608	81.144	—	—	—	—	—
CC	12	FA	—	31.607	81.144	—	—	—	—	—
CC	13	FA	—	31.607	81.145	—	—	—	—	—
CC	14	FA	—	31.604	81.145	—	—	—	—	—
CC	15	FA	—	31.603	81.146	—	—	—	—	—
CC	16	FA	—	31.597	81.149	—	—	—	—	—
CC	17	FA	—	31.596	81.150	—	—	—	—	—
CC	18	FA	—	31.595	81.150	—	—	—	—	—
CC	19	FA	—	31.594	81.151	—	—	—	—	—
CC	20	FA	—	31.577	81.159	—	—	—	—	—
CC	21	FA	—	31.567	81.164	—	—	—	—	—
					Total Eggs Collectable		818			
					Average Number of Eggs/Nest		117			

(Thomas, 2008: chap. 8: 161). This means that a clutch of 113 eggs (weighing an average of 32.7 g/egg with a nutritional value of 200cal/100g) provides a total caloric value of 291.4 kcal (Thomas, 2008: chap. 8; table 15.1: 136).

Anecdotal evidence suggests that the numbers of loggerhead turtles nesting on St. Catharines Island was significantly greater in the past, perhaps substantially greater in the precontact

past, and that some sea turtle eggs have been gathered until the mid-20th century for local use and barter trade.

LOCATING THE EGGS

Understanding the loggerhead nesting ethogram (Hailman and Elowson, 1992; and see Bishop et al., this volume, chap. 13) makes the search for clutches of eggs a relatively easy endeavor as

the pattern of sedimentary structures produced by the ethogram is very consistent and can be read by the observant searcher using “sign” to predict the location of the clutch of eggs buried within the beach. The nesting structures of loggerhead sea turtles consist of two discrete units, a suite of surface structures (fig. 15.1A) that are readily apparent to the observer (entrance crawlway, covering pit, and exit crawlway) and a hidden, or buried suite of structures (fig. 15.1B, D) disguised by the covering pit (the body pit, the egg chamber with its clutch of eggs, and an egg chamber neck that has been backfilled with sand by the female).

By reading the signs of nesting the probable presence of a nest can be discerned, most apparent by crawlways emerging from and back to the edge of the sea, forming tirelike markings from the edge of the water to the nest (if one is present). Entrance crawlways (those leading from the water onto the beach) and exit crawlways (those leading from the nest back to the sea) can be identified by V-like patterns made by the front flippers (Vs opening in the direction of crawling), by crosscutting relationships with the last crawlway (the exit crawlway) crossing over the earlier or entrance crawlway, or by differential lengths of the entrance crawlway (short) and the exit crawlway (long) if the turtle nested on an ebbing tide. The presence of a nest is indicated by an elliptical disturbed area at the head of the crawlways made by the covering activity of the turtle camouflaging the site of her clutch after nesting. In addition to the covering pit, there is almost always evidence of thrown sand scattered away from the covering pit as the turtle flipped sand with her front flippers. The covering pit is formed by the turtle rotating and stirring the surface sand layers with her body and flippers, forming a disturbed, or *bioturbated*, surface layer of loose sand 20–30 cm thick. Beneath the loose sand of the covering pit, lies the undisturbed, laminated sediment of the backbeach facies, which contains the urn-shaped egg chamber (and its clutch of eggs) dug down into it as well as the neck of the egg chamber that has been backfilled with sand by the turtle. The backfilling sand has lost its internal textural integrity and will often appear as a marbled or *brecciated* texture with a strength approximating that of soft butter. The process of finding the clutch of eggs involves either carefully probing through the covering pit with a probe until the soft sand filling the neck of the egg chamber is found by the probe dropping into it, or, by care-

fully removing the loose sand of the covering pit until the neck of the egg chamber forms a textural bull’s-eye surrounded by the laminated sand of the backbeach, which appears as a contour-like pattern due to the nearly horizontal laminations of alternating light-colored quartz sand and dark-colored heavy minerals (fig. 15.1C, D). The clutch is validated by following the egg chamber neck downward until the ping-pong ball-sized eggs are encountered, which can be harvested or, in the St. Catherines Island Sea Turtle Program, relocated if necessary.

The search process (fig. 15.2) would involve: (1) locating crawlways onto the beach by walking along the beach; (2) determining if a nest was deposited by morphology of the covering pits; (3) reading of traces to identify the entrance crawlway; (4) following the midline of the turtle into the covering pit (defining the pathway the turtle crawled); (5) excavating through the loose, bioturbated sand of the covering pit along the midline from the edge of the covering pit into the covering pit until the mottled sand of the egg chamber discontinuity cutting through the surrounding laminated sand of the undisturbed backbeach is crossed; and (6) following the egg chamber neck downward until the clutch of eggs is found.

Once a probable nest is located by crawlways emerging from the ocean and an elliptical nesting area, the presence of eggs is substantiated by validation. Entrance and exit crawlway lengths, thrown sand, crosscutting relationships on crawlways, and covering pit geometry are currently used to determine the probable presence and location of the egg chamber beneath the stirred-up surface sand (Brannen and Bishop, 1993; Bishop and Marsh, 1994; Bishop et al., this volume, chap. 13). Most modern sea turtle programs locate egg chambers and the contained eggs using a blunt probe, such as a wooden dowel rod, systematically inserted into the soft, bioturbated sand of the covering pit delimiting the firm sand of the underlying, undisturbed backbeach facies. This process is effective, but potentially prone to pierce the eggs once the probe enters the soft sand of the egg chamber neck.

In the St. Catherines Island Sea Turtle Program we use a different search technique, semi-archaeological excavation of the bioturbated soft sand of the covering pit (but not constrained by orthogonal survey units). Nests are first read, identifying the entrance and exit crawlways by “opening forward” Vs made by front flipper

claws, by asymmetrical push marks made by the rear flippers (steep side forward), or by crosscutting relationships of the last crawlway made (the exit crawlway) crossing over the entrance crawlway (fig. 15.1A). Occasionally the exit crawlway of the covering pit may also be obvious. Normally, the egg chamber will be on the entrance crawlway midline about half the turtle length (50–60 cm) inside the rim of the covering pit. The surface sand above this “target” area is carefully removed centimeter by centimeter with a sharpened flat sand shovel until the firm, laminated sand of the backbeach is encountered beneath the covering pit. The horizontally layered, interlaminated sand presents as both a firm substrate (in contrast to the loose overlying soft sand of the covering pit) with an acoustic rasping sound as the shovel scrapes across it and with a strong visual signal of contourlike patterns produced as the laminated sand is shaved off. When the egg chamber neck is encountered, it presents as a circular to oblong “bull’s-eye” of marbled, bioturbated sand surrounded by the contourlike patterning of the backbeach facies (fig. 15.1D). These generalities may be contradicted when the nest is deposited in homogeneous sand, in heavy mineral sands, or in lightly laminated and steeply dipping festooned cross-bedded sand of dunes. Native American foragers would have gone through a similar process of nest reading and validation, prior to exploitation of the egg resource.

NEST SIZE AND EGG DEPTH

The covering activity significantly camouflages the position of the clutch of eggs. Data taken in 1994 documents the average size and shape of loggerhead nests on St. Catherines Island. Nests average 2.35 m long (usually parallel to the shoreline) and 1.99 m wide with a surface area that averages 3.72 m² in size, camouflaging the underlying egg chamber necks, which average 318.2 cm², presenting a “predation target” of only 1.01% to numerous egg predators, that today include raccoons (*Procyon lotor*), feral hogs (*Sus scrofa*), ghost crabs (*Ocypode quadrata*), and fire ants (*Solenopsis invicta*). Covering behavior undoubtedly evolved to evade egg depredation by these predators, as well as the best egg predator of all, *Homo sapiens*. “In the U.S., killing of female loggerheads (for meat harvest) is infrequent. However, in a number of areas, egg poaching and clandestine markets for eggs are not uncommon. From 1983 to 1989, the Florida Marine Patrol,

DEP, made 29 arrests for illegal possession of turtle eggs” (Multi-Species Recovery Plan for South Florida). The only documented instance of human depredation on nests on St. Catherines Island was Nest 09–002 in 2009, which we believe was taken by humans.

EXPERIMENTAL EGG EXPLOITATION

Ancient egg gatherers would have had to dig eggs using either their bare hands or with found tools (fig. 15.3), natural items found near the beach, including shells, sticks, or fronds. It is thought that Native Americans, like us, would have found the effectiveness of tools to be a significant advantage, and would have used tools in their search for sea turtle eggs. Preferred shells would have been large, like those of the giant Atlantic cockle (*Dinocardium robustum* [Lightfoot, 1786] or one of the whelks, the knobbed whelk (*Busycon carica* [Gmelin, 1791]), lightning whelk (*Busycon perversum*), or the channeled whelk (*Busycotypus canaliculatus* [Linnaeus, 1758]). Shafts of the fronds of cabbage palm (*Sabal palmetto*) would have been used both as probes and scraping tools.

Exploitation of eggs was tested in 2004 and 2005 by using “found tools” to validate in situ loggerhead clutches on St. Catherines Island in order to replicate a cost/benefit analysis of energy in egg finding. We discovered that by combining reading the nest with excavation by found tools, the actual expenditure of energy was minimal, and the payback was large.

Tools of choice for digging were tested experimentally and include abundant shells of hand-sized local molluscs such as the knobbed whelk (*Busycon carica* [Gmelin, 1791]), channeled whelk (*Busycotypus canaliculatus* [Linnaeus, 1758]), and the giant Atlantic cockle (*Dinocardium robustum* [Lightfoot, 1786]), all found to be wanting in terms of manipulative potential and because they lack a straight, sharp edge. Broken tree branches and the stems of saw palmetto were tried and were successful, especially in locating egg chambers by probing.

The digging tool of choice, determined after two years of experimental “native” digging using various found tools, is the stem fronds of cabbage palm (*Sabal palmetto*), which has a broadly concave-convex stem with sharp keels on either edge (fig. 15.2E). When broken into short pieces the fronds form trowellike hand tools that easily move sand and also can be used to scrape the surface of

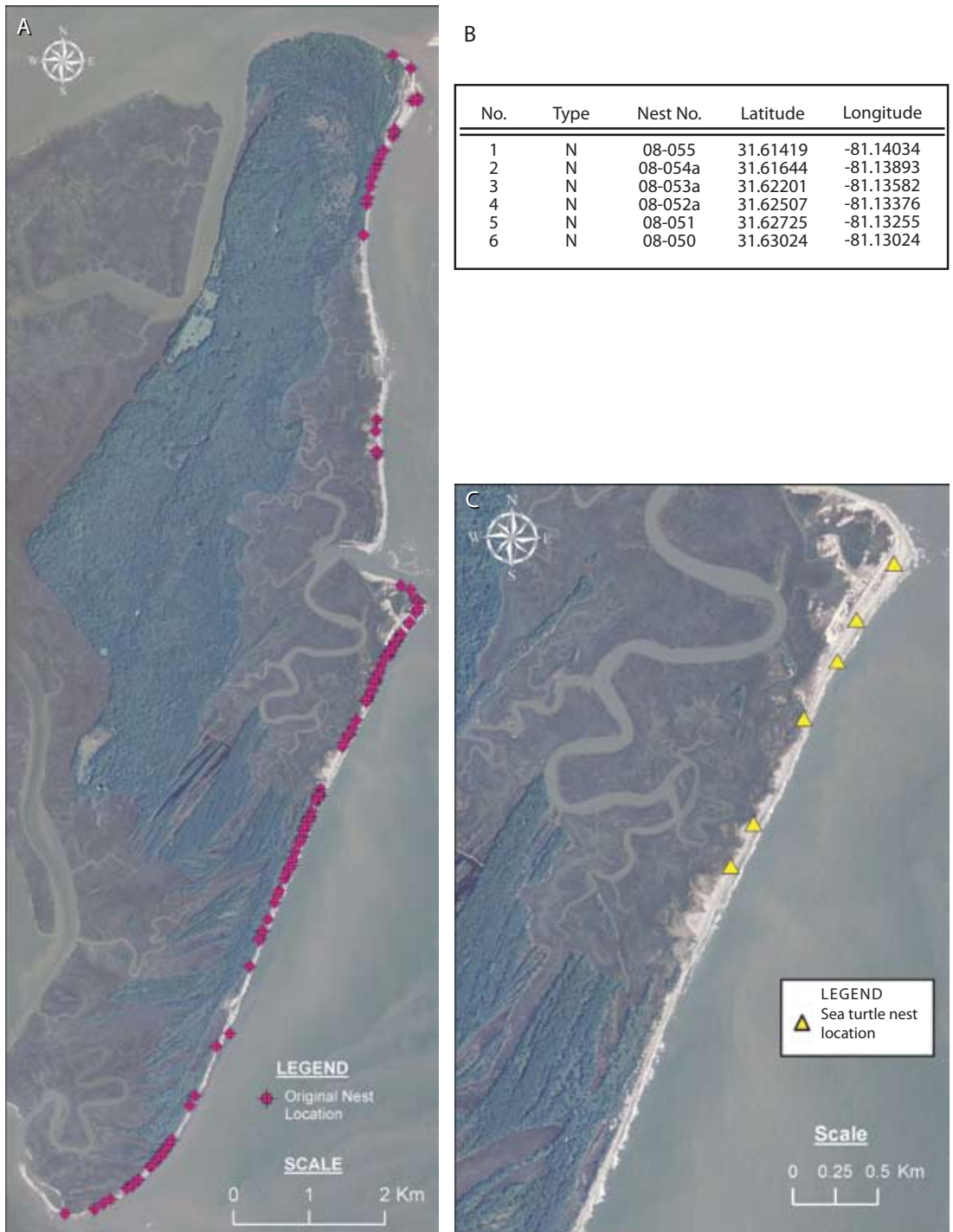


Fig. 15.4. Distribution of loggerhead sea turtle nests deposited on St. Catherines Island in 2008 showing **A**, distribution of all nests; **B**, a list of nests from South Beach Entrance to McQueen Inlet on June 19, 2008; and **C**, a map of their distribution.

TABLE 15.2
Time It Takes to Locate and Validate a Clutch of Loggerhead Sea Turtle Eggs

Nest	Species	Date	Latitude	Longitude	Dug by	Time (mm:ss)	Technique	# Eggs	Avg. wt/egg (g)	Cal/egg (200 kcal/200g)	Recovered calories (kcal)	Caloric cost (kcal)	Net benefit (kcal)
1	Leatherback I	5/8/2005	31.589	81.153	Archaeologists	180	shovel	0	—	—	—	—	—
2	05-090w	5/9/2005	31.602	81.147	GAB	165	shovel	94(27)	—	—	—	—	—
3	05-056	7/1/2005	31.625	81.134	NAM	6	shovel	133	32.7	32.7	4349.1	450	3899
4	05-057a	7/1/2005	31.625	81.134	GAB	4	shovel	85	32.7	32.7	2779.5	450	2330
5	05-059	7/2/2005	31.609	81.143	Univ. So.-Ashley	19	shovel	116	32.7	32.7	3793.2	450	3343
6	05-060a	7/2/2005	31.567	81.164	GAB	5	shovel	117	32.7	32.7	3825.9	450	3376
7	05-061a	7/3/2005	31.686	81.135	NAM	1	shovel	151	32.7	32.7	4937.7	450	4488
8	05-062a	7/3/2009	31.571	81.161	—	3	shovel	150	32.7	32.7	4905.0	450	4455
9	05-063a	7/3/2005	31.599	81.148	GAB	12	shovel	100	32.7	32.7	3270.0	450	2820
10	05-064	7/3/2005	31.663	81.150	GAB	3	shovel	127	32.7	32.7	4152.9	450	3703
11	05-065a	7/4/2005	31.589	81.152	—	10	shovel	114	32.7	32.7	3727.8	450	3278
12	05-066a	7/4/-7/05	31.597	81.149	—	4	shovel	112	32.7	32.7	3662.4	450	3212
13	05-070a	7/6/2005	31.674	81.138	GAB	1	shovel	105	32.7	32.7	3433.5	450	2984
14	05-072a	7/7/2005	31.679	81.137	GAB	2	shovel	96	32.7	32.7	3139.2	450	2689
15	05-088	7/19/2005	31.631	81.130	RKV&LV; GAB&NAM	9	GPR	63	32.7	32.7	2060.1	450	1610
16	05-091a	7/21/2005	31.674	81.138	RKV	9:30	shovel	76	32.7	32.7	2485.2	450	2035
17	05-092a	7/21/2005	31.633	81.132	GAB	1:00	shovel	91	32.7	32.7	2975.7	450	2526
18	05-093a	7/21/2005	31.615	81.140	GAB	1:05	shovel	96	32.7	32.7	3139.2	450	2689
19	05-094a	7/22/2005	31.594	81.150	GAB	1:05	shovel	113	32.7	32.7	3695.1	450	3245
20	05-095	7/28/2005	31.630	81.130	CC	10:00	palmetto & whelk	washed out	32.7	32.7	—	—	—
21	05-097	7/30/2005	31.362	81.084	CC	15:00	palmetto & whelk	washed out	32.7	32.7	—	—	—
22	05-104	8/9/2005	31.590	81.152	KT, JT, MW, GB	21	palmetto & whelk	washed out	32.7	32.7	—	—	—
23	05-105	8/10/2005	31.629	81.131	GAB	0:44	shovel	76	32.7	32.7	2485.2	450	2035
24	05-114	8/19/2005	31.590	81.152	GAB	1:55	shovel	washed out	32.7	32.7	—	—	—
25	06-002a	5/20/2006	31.632	81.130	Kim Stewart	11	shovel	139	32.7	32.7	4545.3	450	4095
26	06-005	5/24/2006	31.606	81.145	GAB	3	palmetto, Dinocardium	132	32.7	32.7	4316.4	450	3866
27	06-006	5/26/2006	31.626	81.134	GAB	15	palmetto, knobbed whelk	in situ	32.7	32.7	—	—	—
28	06-008	5/27/2006	—	—	GAB	2	shovel	103	32.7	32.7	3368.1	450	2918

TABLE 15.2 — (Continued)

	Nest	Species	Date	Latitude	Longitude	Dug by	Time (mm:ss)	Technique	# Eggs	Avg. wt/egg (g)	Cal/egg (200 kcal/200g)	Recovered calories (kcal)	Caloric cost (kcal)	Net benefit (kcal)
1	06-039	<i>C. caretta</i>	6/14/2006	31.627	81.133	GAB	05:20.5	palmetto & shovel	43	32.7	32.7	1406.1	450	956
2	06-040	<i>C. caretta</i>	6/14/2006	31.680	81.137	GAB	09:08.7	palmetto, knobbed wheelk	141	32.7	32.7	4610.7	450	4161
3	06-043	<i>C. caretta</i>	6/16/2006	31.619	81.137	GAB	00:35.4	palmetto, knobbed wheelk	80	32.7	32.7	2616.0	450	2166
4	06-046	<i>C. caretta</i>	6/19/2006	31.626	81.134	GAB	00:54.2	shovel	116	32.7	32.7	3793.2	450	3343
5	06-047	<i>C. caretta</i>	6/19/2006	31.618	81.138	GAB	02:12.6	shovel, foot	106	32.7	32.7	3466.2	450	3016
6	06-048a	<i>C. caretta</i>	6/19/2006	31.586	81.154	GAB	02:00.8	palmetto, knobbed wheelk 2	112	32.7	32.7	3662.4	450	3212
7	06-049	<i>C. caretta</i>	6/20/2006	31.612	81.142	GAB	07:03.4	palmetto, knobbed wheelk 2	135	32.7	32.7	4414.5	450	3965
8	06-051	<i>C. caretta</i>	6/21/2006	31.626	81.134	GAB	07:08.5	shovel	93	32.7	32.7	3041.1	450	2591
9	06-053	<i>C. caretta</i>	6/22/2006	31.628	81.132	GAB	04:47.0	shovel	95	32.7	32.7	3106.5	450	2657
10	06-054a	<i>C. caretta</i>	6/22/2006	31.623	81.135	GAB	02:15.2	shovel	115	32.7	32.7	3760.5	450	3311
11	06-055a	<i>C. caretta</i>	6/22/2006	31.606	81.145	GAB	02:23.2	palmetto, knobbed wheelk 3	130	32.7	32.7	4251.0	450	3801
12	06-056	<i>C. caretta</i>	6/23/2006	31.614	81.140	GAB	03:30.0	shovel	96	32.7	32.7	3139.2	450	2689
13	06-057	<i>C. caretta</i>	6/23/2006	31.601	81.147	GAB	06:09.1	palmetto, knobbed wheelk 4	109	32.7	32.7	3564.3	450	3114
14	06-059a	<i>C. caretta</i>	6/26/2006	31.605	81.145	GAB	03:14.9	palmetto, wheelk 4, "scrapper"	128	32.7	32.7	4185.6	450	3736
15	06-060a	<i>C. caretta</i>	6/26/2006	31.562	81.170	GAB	03:39.2	"scrapper" frond, wheelk 4	118	32.7	32.7	3858.6	450	3409
16	06-061a	<i>C. caretta</i>	6/27/2006	31.666	81.136	GAB	02:15.4	"scrapper" frond	108	32.7	32.7	3531.6	450	3082
17	06-062	<i>C. caretta</i>	6/29/2006	31.620	81.137	GAB	02:23.8	"scrapper"	118	32.7	32.7	3858.6	450	3409
18	06-063a	<i>C. caretta</i>	6/30/2006	31.623	81.135	GAB	01:00.6	shovel, foot	129	32.7	32.7	4218.3	450	3768
19	06-064a	<i>C. caretta</i>	6/30/2006	31.625	81.134	GAB	00:55.9	"scrapper"	114	32.7	32.7	3727.8	450	3278
20	06-066	<i>C. caretta</i>	6/30/2006	31.669	81.138	GAB	02:02.0	shovel	129	32.7	32.7	4218.3	450	3768
21	06-071a	<i>C. caretta</i>	7/1/2006	31.562	81.170	GAB	02:34.6	shovel	131	32.7	32.7	4283.7	450	3834

TABLE 15.2 — (Continued)

Nest	Species	Date	Latitude	Longitude	Dug by	Time (mm:ss)	Technique	# Eggs	Avg. wt/egg (g)	Cal/egg (200 kcal/200g)	Recovered calories (kcal)	Caloric cost (kcal)	Net benefit
22	06-073a	C. caretta	7/2/2006	31.623	81.135	GAB	02:49.3	shovel	107	32.7	3498.9	450	3049
23	06-074	C. caretta	7/2/2006	31.596	81.150	GAB	02:58.1	"scraper" 2	131	32.7	4283.7	450	3834
24	06-076a	C. caretta	7/3/2006	31.683	81.136	GAB	03:16.1	Scraper 3	119	32.7	3891.3	450	3441
25	06-085a	C. caretta	7/5/2006	31.565	81.166	GAB	03:28.4	scraper 3	89	32.7	2910.3	450	2460
26	06-089a	C. caretta	7/9/2006	31.623	81.135	GAB	02:07.2	shovel	119	32.7	3891.3	450	3441
27	06-091a	C. caretta	7/9/2006	31.604	81.145	GAB	01:30.4	scraper 4	74	32.7	2419.8	450	1970
28	06-095	C. caretta	7/12/2006	31.608	81.144	LK-L	21:06.1	scraper 4	111	32.7	3629.7	450	3180
29	06-096	C. caretta	7/12/2006	31.604	81.146	LK-L, GAB	17:20.9	—	76	32.7	2485.2	450	2035
30	06-103	C. caretta	7/18/2006	31.627	81.133	Class	20:28.3	scrapers	69	32.7	2256.3	450	1806
31	06-105	C. caretta	7/20/2006	31.605	81.145	SS	07:16.2	scraper	103	32.7	3368.1	450	2918
32	06-108a	C. caretta	7/24/2006	31.676	81.137	ED, JB	28:11.2	shovel	114	32.7	3727.8	450	3278
33	06-109a	C. caretta	7/25/2006	31.562	81.169	GAB	02:31.2	shovel	71	32.7	2321.7	450	1872
34	06-111a	C. caretta	7/28/2006	31.624	81.135	GAB	02:51.1	shovel	107	32.7	3498.9	450	3049
35	06-114a	C. caretta	8/1/2006	31.604	81.146	GAB	01:39.6	shovel	64	32.7	2092.8	450	1643
36	06-116	C. caretta	8/6/2006	31.608	81.144	GAB	01:23.2	shovel	wo	32.7	—	—	—
37	06-117	C. caretta	8/6/2006	31.603	81.146	KAM	06:11.9	shovel	121	32.7	3956.7	450	3507
38	06-119	C. caretta	8/10/2006	31.625	81.134	GAB	10:46.5	shovel and scraper	80	32.7	2616.0	450	2166
					Digging with Shovel		33:09.6						
					Digging with Whelk Shell		27:20.5						
					Digging with a Frond Scraper		12:32.10						
					overall average		18:23.5	average clutch size	105				

the undisturbed laminated beach sand beneath the covering pit, exposing the egg chamber neck as a bull's-eye contrasting with the contourlike patterns of the undisturbed backbeach sediment.

Data on the time it takes to locate and validate a clutch of sea turtle eggs was collected in 2005 and 2006 on St. Catherines Island. Initial times in 2005 were kept using a wristwatch with a second hand, becoming more precise as the data collecting progressed. In 2006, a stopwatch was used to time the egg finding activity (table 15.2). Although a sample of variable precision, these data at least give an approximate measure of time to find eggs. The 2006 data increased the precision of the egg locating activity.

Various combinations of tools were used throughout the season (to compensate for experience across the year). The location of eggs in the loggerhead nests took an overall average of 18 minutes and 23.5 second to locate, with the shovel (modern) technique taking longest (33 min 09.6 sec), probing and digging with a whelk shell was slightly more efficient (27 min 20.5 sec), and digging with a frond scraper was significantly more efficient (12 min 33.0 sec). These data are certainly biased in the sense that more difficult nests would have been dug by shovel, the modern tool of choice, resulting in the longer digging time for shoveling (more complex nests). However, the same bias probably does not exist for nests dug with a scraper, as all "neo-native" nests were selected in the same way (they were not the complex, obstructed nests dug by shovel). This could be tested by random selection of nests to dig, if it were important enough to replicate.

Two aspects of egg gathering activity that are not timed are the time to locate a possible nest by walking along the shoreline and the time it takes to remove the eggs from the egg chamber once it is located by the digging activity. The time to return to the eating site and effort of transportation would also be added as part of the total cost of acquisition. Most timed nests were loggerhead sea turtle nests, however three leatherback nests were also deposited in 2005 on St. Catherines Island and a variety of experimental digging tools were used on different nests, including small, square-ended sand shovels that we usually use in the modern program.

ECONOMICS OF EGG GATHERING

Nest location can be estimated by assuming an adult would walk (4 mi/hour) along a beach

(fig. 15.5). By knowing that nests cluster along a beach (learned by experience), certain segments of beach to walk would be favored by Native American gatherers (fig. 15.5). For this exercise we might assume a group would walk from the present location of South Beach entrance northward to McQueen Inlet (fig. 15.5C), a distance of 5.5 km. and back (a total of 11 km; 15.6). Ainsworth has compiled a compendium of the effort for various human activities in terms of a metabolic equivalent (MET), "the ratio of the work metabolic rate to the resting metabolic rate." According to her calculations, "One MET is the rate at which adults burn kcal at rest, ... approximately 1 kcal per kilogram (kg) of body weight per hour (expressed as 1 kcal/kg/hr). The caloric cost of collecting a clutch of eggs by walking from South Beach entrance to McQueen Inlet by a 100-pound native person can be calculated using metabolic equivalents (Ainsworth, 2002).

During nesting season 2008 the number of nests deposited between South Beach entrance and McQueen Inlet ranged from 0 to a maximum of 7 nests/day. The likelihood of encountering a nest (or nests) would be high in this portion of the beach (fig. 15.5), especially during the height of the nesting season of loggerheads, around the summer solstice. Each nest dug using a palm frond tool would have taken an average of 12 minutes 33.0 seconds and (assuming a MET equivalent of 5.0; Ainsworth, 2002) would involve an expenditure in energy of $3.833 \text{ kcal/min} \times 12.55 \text{ min} = 48.10 \text{ kcal}$. Removing the eggs from the nest is estimated to take approximately 3 minutes and would cost ($3 \text{ min} \times 3.833 \text{ kcal/min}$) approximately 11.50 kcal. Transporting the gathered eggs would be a relatively expensive proposition, estimated to be approximately $818 \text{ eggs} \times 32.7 \text{ g/egg} = 26.747 \text{ kg}$ (58.7 pounds). This is added to the assumed 100 pound gatherer's weight = 158.7 pounds \times walking 5.5 km @ a moderate rate of 3.22 km/hr (2.0 mph) = 1.70 hr. This is equal to $3.833 \text{ kcal/min} \times 51.24 \text{ min} = 133.68 \text{ kcal}$ (see table 15.3, *opposite*).

The cost/benefit ratio computed (adding the rapid walk, nest digging, unloading, and return carry would total 813 kcal). The return caloric content for an average clutch is 7940 kcal, producing a positive economic return of $\sim 9.77:1$ on energy expended, if only one clutch were collected, and a maximum bonanza ($\sim 68.4:1$) if seven clutches were collected!

The possibility also exists that native forag-

TABLE 15.3
Energy Expenditure for Nesting between South Beach and McQueen Inlet

1. Walking the beach.....	5.5 km @ 6.4 km/h @ 2.500 kcal/min	= 128.9 kcal
2. Digging a nest.....	12.55 min @ 3.833 kcal/min	= 48.10 kcal
3. Loading the eggs.....	3 min @ 3.833 kcal/min	= 11.50 kcal
4. Return walk (loaded with eggs).....	5.5 km @ 3.2 km/h @ 6.057 kcal/m	= 624.63 kcal
Total caloric cost/clutch		= 813.13 kcal

ers would occasionally come across nests with hatchlings emerging from the beach surface after the eggs hatch beneath the beach. It is possible that such an enticing food source might have been utilized by Native Americans, perhaps as a basis for a soup or stew, although no references have been seen alluding to this behavior, nor have any references to modern analogs of the eating of hatchling sea turtles. It should be noted, however, that the raccoon (*Procyon lotor*) and the feral hog (*Sus scrofa*) do not hesitate to eat hatchlings when they are caught emerging, and in fact, will follow the hatchlings back to their emergence crater and dig out the nest to eat the rest of the hatched clutch of eggs.

TRANSPORTING THE EGGS TO THE RESIDENTIAL BASE

Transportation from the beach to residential bases and/or temporary summer campsites was likely a problem (in the absence of cheap, plastic, five gallon pails!) because the number of round, ping-pong-sized eggs gathered from a single nest would number about 113; those dug from as few as 10 nests would amass an impressive 1130 eggs. Transportation to an eating site would probably entail skin bags, baskets woven of grasses (perhaps smooth cord grass *Spartina alterniflora*), or some other light carrying mechanism (maybe even transport in a canoe or raft).

Once transported to an eating site, the eggs would likely have been eaten raw with little preparation as their storage would be difficult and preparation by heating does not coagulate the albumin as in chickens' eggs. Because of the difficulty of preparation, sea turtle eggs may have formed the basis of a summer solstice feast or celebration, perhaps in conjunction with the dim beginnings of the concept of perceived aphrodisiac effects of sea turtle eggs at the summer solstice.

Archaeological evidence of egg harvesting and eating would rapidly disappear from the re-

cord as egg shells (the only preservable "hard" evidence) were trampled and decomposed in the area. Evidence of preservation of eggshells returned to nests and subsequently eroded out due to scarp retreat (fig. 15.6) indicates a residence time of at least a year in "old nests." An experiment will be designed to test the survivability of eggshells over time, and enhance our limited observational evidence.

Acid environments of coastal sand soils are not amenable to preservation of organic evidence (bone, shell, or grass fabric) of this seasonal sea turtle-based economy, therefore much of the nutritional story of sea turtle egg economics in indigenous societies of coastal Georgia will remain speculative. Just what sea turtle eggshells in middens might look like is a pertinent question here. The fragile, leathery shells rapidly dry to a brittle condition and would be easily destroyed by even moderate trampling, rapidly reducing the preserved egg remains to tiny fragments and carbonate dust. Again, an experiment ought to be designed to put eggshells into a midden environment and measure how long sea turtle eggshells survive.

HARVESTING SEA TURTLE MEAT: ST. CATHERINES ISLAND

Harvesting nesting females and harvesting sea turtle eggs were clearly differentiated by Thomas (2008: 156) from hunting activities that occurred offshore. Harvesting nesting female loggerheads would have easily been accomplished by patrolling the beach at night and, when a nesting female was encountered, simply tipping her onto her back, immobilizing her until she was either killed or bound and transported onto the island. As Thomas pointed out, two adults, or even youngsters, can tip a loggerhead sea turtle when she is nesting on a beach. An adult female averaging 68 kg (Larson, 1980) could be tipped and tied in 15 minutes and, as Thomas pointed out



B

No.	Type	Nest No	Latitude	Longitude
1	FA		31.59677	-81.14924
2	FA		31.60342	-81.14597
3	FA		31.60400	-81.14528
4	FA		31.60656	-81.14456
5	FA		31.60746	-81.14407
6	FA		31.60793	-81.14380
7	FB		31.60840	-81.14350
8	N	08-055	31.61419	-81.14034
9	N	08-054a	31.61644	-81.13893
10	FB		31.61820	-81.13730
11	FB		31.61838	-81.13722
12	N	08-053a	31.62201	-81.13582
13	N	08-052a	31.62507	-81.13376
14	N	08-051	31.62725	-81.13255
15	N	08-050	31.63024	-81.13024
16	N	08-056a	31.68094	-81.13662
17	FA		31.59556	-81.14983
18	FA		31.59491	-81.15011
19	FA		31.59377	-81.15065
20	FA		31.57656	-81.15871
21	FA		31.56744	-81.16394

Fig. 15.5. Map of north end of South Beach with nonnesting and nesting crawlways encountered in monitoring nests on June 19, 2008. **A**, location of sea turtle event sites, both nesting and nonnesting crawlways that would have been encountered by native foragers; and **B**, a list of the sites encountered on one day near the summer solstice of 2008.

(2008: 159), would then have had to be butchered, taking an estimated two hours, yielding a return rate of 21,360 kcal. However, this activity would almost certainly have had to be performed in the dark of night, as that is when most loggerhead sea turtles nest. Without sharpened tools of steel, stone, or volcanic glass it would have been virtually impossible to butcher a fresh sea turtle, as their skin is extremely tough. We suggest here that the normal procedure for turtle preparation would more likely have involved cooking a turtle whole, using its carapace as a roasting container. Most of the turtles that were consumed locally in Tonga are cooked in the shell in an earthen oven (*Umu*), following which the shells were discarded (Havea and MacKay, 2009: 16). Regardless of preparation techniques, the payback for harvesting loggerhead sea turtles would

have been impressive.

Hunting or harvesting of loggerhead sea turtles for meat was a likely seasonal economy, as nesting loggerheads could be easily “tipped” after nesting, prepared on the beach by roasting using flotsam wood, and distributed to tribal members. It is also speculated that a canoe-based harpoon or spear fishery may have existed exploiting loggerhead sea turtles and migrating leatherback sea turtles (a very oily species and a likely source of cosmetic oils), an industry that would provide oil for the economy and prestige and status for the hunter during annual migrations of leatherbacks past St. Catherines Island (April and October). It is likely that cooking and butchering of sea turtles would have been done on or near the beach, leaving virtually no preserved record in seasonal habitation sites. There

are no data on the quality of meat from common sea turtles found in Georgia (loggerheads [*Caretta caretta*], green sea turtles [*Chelonia mydas*], leatherbacks [*Dermochelys coriacea*], and Kemp's Ridley [*Lepidochelys kempi*]), but the literature abounds with accounts of turtle ingestion. Even as late as the 19th century, the green turtle was once highly sought for its greenish colored body fat, or *calipee*, a key ingredient in the popular delicacy, "green turtle soup."

THE OBSERVED ARCHAEOLOGICAL RECORD

To reiterate:

(1) The diet-breadth model predicts that (based

on postencounter return rates) every St. Catherines Island forager (seeking to maximize net energy) should harvest every single sea turtle encountered.

(2) 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). Terrestrial transport thresholds project that foragers should only "sometimes" field process the carcasses of male and female leatherback turtles before returning to the residential base. Similar computations for male and female loggerheads indicate that the carcasses would "almost never" be field butchered before returning to residential base.

(3) Actualistic experimentation on St. Cath-

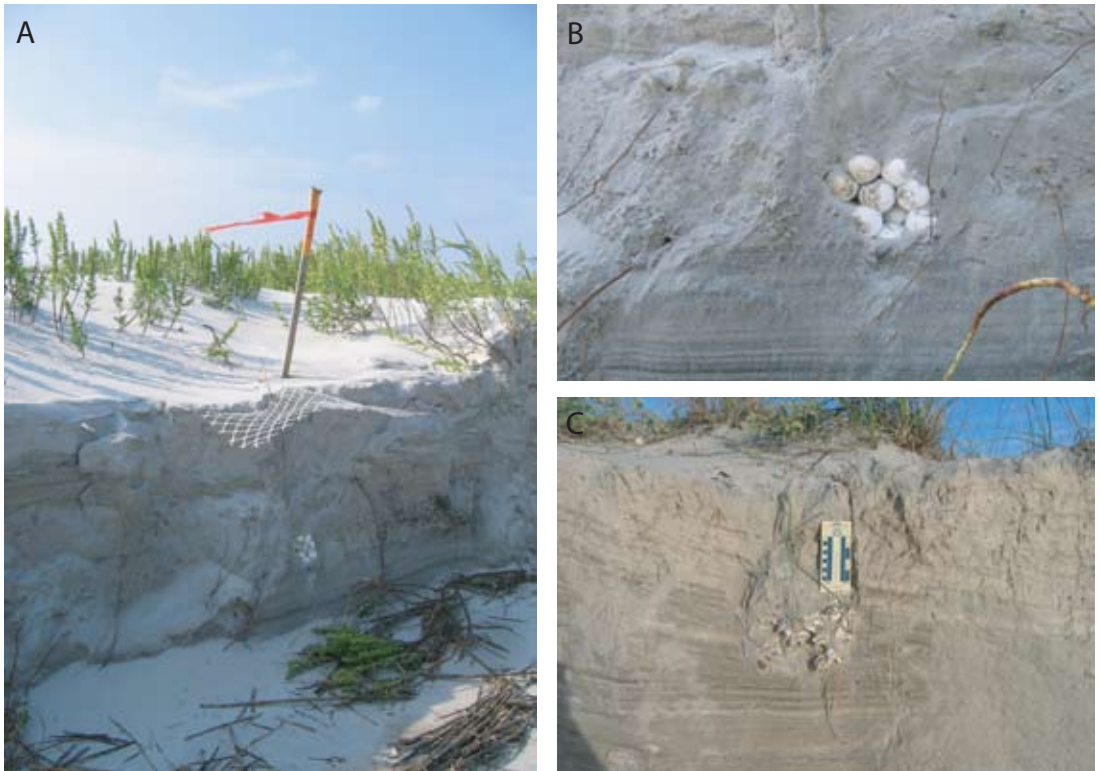


Fig. 15.6. Exposed old and new nests preserve eggshells that have a residence time of at least one year. **A**, naturally exposed clutch in scarp on McQueen Dune Field eroded during a nor'easter; **B**, close view of exposed clutch of loggerhead sea turtle eggs seen in A [Nest 06-119]; and **C**, naturally exposed clutch of hatched eggshells from a relocated nest [Nest 05-074a] deposited in a dune called the turtle bowl 3 m behind the scarp, eroded out during nor'easter a year later, and exposed to view, proving at least a one-year residence time in eggshells in dune sand.

erines Island demonstrates a very high cost-benefit ratio for harvesting sea turtle eggs, suggesting that the energy-efficient foragers should always take such eggs upon encounter.

In archaeological terms, then, human behavior ecology projects that nearly all loads of sea turtle meat would be transported in bulk for processing at the central base. If so, then, the discarded, inedible parts of sea turtles should be abundant in the middens associated with residential bases, and virtually absent elsewhere. We believe that all archaeological evidence of egg harvesting and eating would rapidly disappear from the archaeological record.

We will now see how well these theoretical projections fare against empirical archaeological evidence.

SEA TURTLE EXPLOITATION IN ANTIQUITY

Even the most cursory examination of the archaeological record demonstrates, beyond doubt, that humans have a long history of exploiting sea turtles (e.g., Frazier, 2003). In the Middle East, abundant green sea turtle remains are found in archaeological sites at as-Sabiya in Kuwait and Dalma Island in the United Arab Emirates (Frazier, 2003). Sea turtles were a common food item during the Bronze Age (6000–4000 ¹⁴C yr B.P.) in the Persian Gulf (Mosseri-Marlio, 1998; Spotila, 2004: 64). Sea turtles were commonly captured for food in Greece ca. 2700 years ago and their shells were used as shelters. Smith et al. (2007) document the extensive exploitation of sea turtles along the Pacific coast of Mexico, where sea turtles are the most common reptilian remains in Late Archaic deposits (ca. 5500–4000 cal B.P.). Such hunting activity significantly reduced local availability during the next 3000 years, with sea turtle bones disappearing entirely in later deposit levels. Throughout the Caribbean basin, archaeological sites contain abundant marine turtle remains (e.g., Wing and Reitz, 1982; Frazier, 2003: 13–15).

SEA TURTLE EXPLOITATION ALONG THE GEORGIA BIGHT

By contrast, it must be noted that marine turtle remains are virtually absent from the archaeological record of St. Catherines and the Georgia Bight.

Despite the projected high return rates, only five sea turtle bones were recovered during the islandwide survey on St. Catherines Island (Re-

itz, 2008). All of these came from Little Camel New Ground Field, site number 5 (9Li206; AMNH-466), a medium-sized Irene period site (with a secondary St. Catherines period component) located 10 m east of South Beach Road (in transect J-1; Thomas, 2008: 588). Test Pit I (0–10 cm) contained one costal, one carapace (upper shell) fragment, and two “peripherals,” fragments from the edge of the carapace (Elizabeth Reitz, personal commun.). Given the stratigraphic position of these finds, we suspect that the sea turtle bones from 9Li206 likely derive from an Irene period context, estimated to range from cal A.D. 1300 to A.D. 1580 in the St. Catherines Island chronology (Thomas, 2008: table 15.3).

Recent excavations at the McQueen Shell Ring, also on St. Catherines Island (Sanger and Thomas, 2010), recovered a single sea turtle bone. Preliminary analysis indicates that this bone is probably the right humerus of a small loggerhead turtle, with four distinct butchering marks (Carol Colaninno and Betsy Reitz, personal commun.).² Fifteen radiocarbon dates that are currently available from the McQueen Shell Ring have been derived from three different contexts: shell deposits that constitute the ring itself, features found within the interior of the ring, and later (post-Late Archaic) features encountered at the ring (Thomas and Sanger, 2010: table 3.1). We believe that the vast majority of the shell mound construction derives from either the initial construction stage, dating between 2300 and 2120 cal B.C. (4250–4070 cal B.P.) and a later phase about 2130–1950 cal B.C. (4080–3900 cal B.P.). At present, these are the best age estimates for the loggerhead bone found at the McQueen Shell Ring.

Sea turtle bones are likewise rare in archaeological sites elsewhere along the Georgia Bight. At the Sapelo Shell Ring, Waring and Larson (1968: table 25) report finding a sea turtle humerus and part of a carapace, probably *Caretta caretta*. A total of 19 sea turtle bones (of unknown species) were recovered at the North End site, Little St. Simons Island (Weinand, Andrus, and Crook, 2000). A single Atlantic green sea turtle bone is reported from Kenan Field, on Sapelo Island (Reitz, 1982: table 1; Crook, 1978, table 2). Milanich (1971, table 6) identified two sea turtle bones from house excavations on Cumberland Island. Excavations in a historic-era midden produced six loggerhead bones, one Kemp’s Ridley turtle bone, and 42 additional unidentified sea

turtle bones (table 10 in Steinen, 1978).

Considering the large numbers of sea turtles that today nest along the Georgia coastline and the extensive archaeological excavations that have taken place here, the scarcity of marine turtle bones is striking indeed.

At least three hypotheses come to mind when considering this disparity:

(1) *Sea turtles were present along the Georgia Bight during the last five millennia, but foragers*

did not harvest them. This hypothesis suggests that the diet-breadth projections (based on high postencounter return rate estimates) are incorrect and foragers deliberately elected not to harvest marine sea turtles in great numbers.

(2) *Sea turtles were harvested, but butchered on the beach, with only edible portions returned to the residential base.* This hypothesis suggests that central place foraging projections (based on terrestrial transport thresholds) are incorrect and



Fig. 15.7. Skeletal remains of sea turtles on the beaches of St. Catherines Island. **A**, skeleton of loggerhead sea turtle buried in dune facing east, being eroded by beach retreat, South Beach; **B**, close view of another loggerhead sea turtle skeleton buried in the dunes near Sand Pit Road; **C**, scatter of disassociating skeletal elements of dead, stranded loggerhead sea turtle on South Beach; **D**, isolated carapace bone eroding out of North Beach after being buried for some time.

foragers routinely field-butchered sea turtles, which could explain the absence of marine turtle remains in residential sites.

(3) *Sea turtles were rare (or absent) from the Georgia Bight during the last 5000 years.*

The archaeological and paleobiological record of the Georgia Bight is currently inadequate to distinguish among these, or other, alternative hypotheses.

FUTURE RESEARCH DIRECTIONS

The residence time of sea turtle bones in the beach, in terrestrial soils, and in shell middens needs to be documented in a series of experiments. Experiments have been run in the past preparing loggerhead sea turtle skeletons for osteological research and study, indicating that sea turtles buried in the backbeach dunes decompose almost to clean, bare bone within one year (15.7A, B). This work should be continued by burying dead, stranded sea turtles in dune fields and in middens, excavating them after succeeding intervals of time, perhaps six, nine, and 12 months after burial, to investigate the survivability of sea turtle bone in sandy, backbeach soils (fig. 15.7). The experiment ought to be replicated by observations of buried sea turtles in shell middens. A third experiment would test the residence time and measure recovery of sea turtle skeletal elements disassociated in the beach environment, partly addressed by Knell (2004) as described in Bishop et al. (2009).

Future research should reexamine all turtle elements in the St. Catherines archaeological collections (fig. 15.9) to attempt to identify and assign each skeletal element to a genus- or species-level taxon in order to document the presence/absence and condition of all turtle taxa in St. Catherines' shell middens. These remains should be compared with observed sea turtle bones from known taphonomic settings (fig. 15.7).

Experiments should be designed to determine the residence time of sea turtle bone and sea turtle eggshells in the sandy acid soils of the Pleistocene core and Holocene accretional terraces (see Bishop et al., this volume, chap. 3), in the beach, and in the basic soils associated with shell middens.

NOTES

1. Many organizations have supported the research of the St. Catherines Island Sea Turtle Program over the last 19 years, including our major sponsors, the Georgia Higher Education Eisenhower/Improving Teacher Quality Program (~60% of funding) and the St. Catherines Island Foundation. Essential support of the teachers programs has also been received from Georgia Southern University, GeoTrec LLC of Fayette, Iowa, and the Georgia Department of Natural Resources (Non-Game Division). Grants have been received from the Edward John Noble Foundation (administered through the American Museum of Natural History), the St. Catherines Island Scientific Research Advisory Committee, the Turner Foundation, the JST Foundation, the M.K. Pentecost Ecology Fund, and the Partnership for Reform in Science and Mathematics (PRISM), an NSF-sponsored initiative designed to improve teachers' science and math content knowledge.

So many individuals have contributed to our program that we hesitate to name them for fear of leaving somebody out who deserves to be acknowledged, if we have done so, please accept our apology! We thank the St. Catherines Island staff for their day-to-day support for 18 years, especially Jeff Woods, Spyder Crews, Alan Dean, Richard Bew, Fred Harden, Lee Thompson, Ian Dutton, Kerry Peavler, Veronica Greco, Dr. Terry Norton, Jen Hilburn, and Mary-Margaret Pauley Macgill. Royce Hayes, Ed Davis (along with Doris Davis), Kelly Vance, Fred Rich, Brian Meyer, and Nancy Marsh provided service far above and beyond the line of duty in helping so many ways over so many years. Georgia Department of Natural Resources personnel who have helped with the Program include Charles Maley, Mike Harris, Brad Winn, Mark Dodd, and Adam Mackinnon. The Board Members of the St. Catherines Island Foundation, Inc. are collectively thanked for their continuing support of the St. Catherines Island Sea Turtle Program and its research programs.

2. No marine eggshells have been recovered from the archaeological sites on St. Catherines Island.