APPENDIX A

ZOOARCHAEOLOGICAL METHODS AND MATERIALS

Zooarchaeology refers to the study of animal remains excavated from archaeological sites (Reitz and Wing, 2008). It is a broad and interdisciplinary field, which reflects the many anthropological, biological, ecological, and physical concepts and methods used to study animal remains.

The primary purpose of zooarchaeological research is to learn about the interactions of people and animals and the consequences of these relationships for people and their environments. Most animal remains in archaeological contexts are the result of complex human and nonhuman interactions with resources in the environment, cultural perceptions of those resources, and the technological repertoire used to exploit them. One of the most fundamental uses of animals is to meet nutritional needs. This is the foundation of subsistence strategies and of economic and other cultural institutions. Nonetheless, much of an animal's carcass may be used for nonnutritional purposes. Animals also signify cultural attributes such as social affiliation, interpersonal relationships, and belief systems. All of these behaviors reflect the ecology of people, their interactions with the biotic and abiotic elements of ecosystems, and the consequences to people, their cultural systems, and to other ecosystem components. Zooarchaeologists use many methods to examine these phenomena; all have strengths and weaknesses. In the following sections, we summarize the methods used in this study, indicate the relationships between these methods and the research questions, and briefly describe the materials studied.

ZOOARCHAEOLOGICAL METHODS

In this study, the term *specimen* is used to refer to a complete bone, a bone fragment, a tooth, or a tooth fragment (Reitz and Wing, 2008: 9). The term *element* refers to a single complete bone or tooth. If a specimen is complete it is an element and, if it is broken, it is a fragment of an element. Intact elements are rare; fragmentary specimens constitute most of these archaeofaunal samples. A *sample* is from a unique archaeological provenience or context that is identified and segregated in the field. Samples contain multiple faunal specimens from various taxa that presumably had some relationship before excavation began. All samples from a single time period from a single site constitute a *collection*. Many sites have multiple occupations of different time periods and these constitute *assemblages*.

The vertebrate materials reported here were examined using consistent methods. Identification and analysis of faunal materials from St. Catherines Island and the Convento de San Francisco were accomplished using the comparative skeletal collection at the Zooarchaeological Laboratory, Georgia Museum of Natural History, University of Georgia.

The methods used in this study are described and evaluated in detail elsewhere (Reitz and Wing, 2008), and are only summarized here. Specimens of all taxa were counted and weighed to determine the relative abundance of the species identified. *NISP* refers to the Number of Identified Specimens obtained by counting these specimens. Cross-mending specimens were counted as one specimen. Specimens identified

only as Indeterminate vertebrate were weighed but not counted. A record was made of the symmetry and the portion of the element represented by each specimen. Age, sex, and modifications were noted when observed. Artiodactyl specimens and their modifications (except for burning) were sketched to facilitate analysis. Where preservation allowed, measurements were taken of selected mammal and bird specimens following the guidelines published by Angela von den Driesch (1976). The anterior centrum width of fish atlases and fish otoliths also were measured. The otolith dimensions are the greatest lateral/medial breadth (GB) and the greatest anterior/posterior length (GL). Measurements are presented in appendix F.

For many years a distinction was drawn between Old World rats and mice (Muridae, *Rattus norvegicus, R. rattus, Mus musculus*) and New World mice and rats (Cricetidae, *Peromycus* spp., *Oryzomy* spp., *Sigmodon hispidus*). Taxonomic research demonstrates that rodents in these two families should be considered members of the same family: Muridae. This is problematic for American zooarchaeology because for decades Muridae were only identified in post-Hispanic contexts (i.e., post–A.D. 1492). The distinction is clearly an important one because, under the old nomenclature, a murid identification would signify either a post-Hispanic context or one in which pre- and post-Hispanic stratigraphy was mixed. As many of the species included in this monograph were identified before this name change took place, the term Cricetidae is a common designation. All of the taxa designated as Cricetidae during the original identification are renamed Sigmodontinae in this volume and taxa identified as Muridae are renamed Murinae in order to maintain the distinction between Old and New World rodents that the now-invalid, previous nomenclature facilitated. A second rodent subfamily (Arvicolinae) occurs in the study area. This subfamily includes voles (*Microtus* spp.), round-tailed muskrats (*Neofiber alleni*), and common muskrats (*Ondatra zibethicus*), but none of these rodents have been identified in the collections reported here.

The name for domestic dogs (*Canis familiaris*) currently is placed as a synonym of the wild ancestor, the wolf (*Canis lupus*), even though *C. familiaris* has priority by its description on a preceding page of the *Systema Naturae* (Linnaeus, 1758). Although dogs and wolves do interbreed, they usually can be distinguished and traditionally have been referred to by different trivial names. Traditional zoological binomial nomenclature has important and overriding value despite the inherent problems of using it for domestic animals. Recognizing this, Gentry and her colleagues (Gentry et al., 1996, 2004) proposed retaining the Linnaean system of nomenclature for some domestic animals. This proposal was approved by the International Commission on Zoological Nomenclature (Opinion 2027, March 2003).

In the case of pigs, however, we do not follow the opinion of the International Commission on Zoological Nomenclature. The zooarchaeological tradition in the Americas is to refer to all pigs or hogs introduced during European colonization as *Sus scrofa*, following a long-established convention. This nomenclature also is used to refer to feral domestic pigs as well as animals of domestic ancestry that have established wild populations throughout the former territory of Spanish Florida. *S. scrofa* was not present in the Americas prior to 1492, after which time domestic pigs were introduced in many parts of the hemisphere. Some of these escaped or were intentionally released throughout the lower coastal plain and have established wild populations from originally domesticated stock (Bonner, 1964: 30; García, 1902:187; Golley, 1962: 198; Jones, 1978; Ribault, 1927: 72). This wild stock is often intentionally, or not, supplemented by newly released, or escaped, domestic pigs (Golley, 1962: 199). To complicate the distinction further, it is likely that many of the pigs whose remains are present in the archaeological record were free-ranging, if not wild, and never lived in a traditional domestic state (see Reitz and Scarry, 1985: 69–70). European wild boars, the ancestral, but truly wild, progenitors of domestic pigs, were introduced into the mountains of North Carolina (USA) and elsewhere after 1912 to improve recreational hunting (Golley, 1962: 199).

Following Gentry et al. (1996, 2004), the name of the animals from domestic stock should be *Sus domesticus*, *Sus scrofa* should refer only to the European wild boar introduced in the 20th century. Switching to this nomenclature would make the post-1492 American zooarchaeological record ambiguous. The tradition of referring to domestic/feral/wild pigs as *S. scrofa* is followed here because it is important to understand that all members of the genus *Sus* were introduced to the

Americas and, until recently, all of these were at least nominally domesticated or originally from domestic stock. Use of the term *S. domesticus* would make earlier identifications unclear and give the false impression that animals referred to as *Sus scrofa* in the American literature were European wild boars. All of the suids referred to in this monograph were introduced as domestic forms, though some promptly became feral and subsequent wild populations became established in many areas. All of the animals identified from Spanish Florida and all other historic sites in the Americas are *S. domesticus* using current nomenclature; none are European wild boars.

Estimates of the Minimum Number of Individuals (MNI) are based on paired elements and age. In most cases, MNI is estimated for the lowest taxonomic level, i.e. species, rather than genus or family. Occasionally, more individuals are estimated if all specimens identified to a family, such as Ariidae, are considered together, rather than if specimens identified to a lower taxonomic level are considered separately. For example, in some cases more individuals are estimated if all specimens identified to some taxonomic level within the sea catfish family (Ariidae) are considered than if hardhead catfish (*Ariopsis felis*) and gafftopsail catfish (*Bagre marinus*) specimens are considered separately. In such cases, MNI is estimated for each taxonomic level and the larger estimate is used in subsequent calculations. The lower MNI estimates are included in the species lists in parentheses for information only and are not included in the total for each list or in subsequent calculations. Summary tables and figures as well as estimates of richness, diversity, equitability, and mean trophic level only use those biomass estimates that are associated with taxa for which MNI is estimated in order to ensure that the MNI and biomass estimates are derived from the same sample universe.

Although MNI is a standard zooarchaeological quantification medium, the measure has several problems (Reitz and Wing, 2008: 205–210). One source of bias is that some elements are more identifiable than others and the number of individuals may appear more significant in the species list than they were in the diet. Gar scales (*Lepisosteus* spp.), mullet vertebrae (*Mugil* spp.), and pig teeth are examples of elements that are readily identified and may enhance the relative proportions of these animals beyond what was truly the case. MNI emphasizes abundant small species over uncommon larger ones and presumes that the entire carcass was consumed within the excavation area being studied. For example, though 20 catfishes represent a larger number of individuals than do four white-tailed deer (*Odocoileus virginianus*) the latter could supply a substantially larger quantity of meat. A related problem is the assumption that all edible parts of deer were consumed at the studied location. From ethnographic evidence, we know this is unlikely, particularly with large animals for which portions of the carcass may have been left behind at the kill site, for animals whose meat may have been redistributed or used in ritual displays, or for animals whose carcasses provided important by-products (e.g., Thomas, 1971; White, 1953). This is an especially relevant issue when dealing with historic samples where trade in processed animal products was substantial or where animals and animal by-products were included in tithes or subsidies.

Additionally, MNI is influenced by the manner in which data from archaeological proveniences are aggregated during analysis. The aggregation of separate samples into one analytical whole (Grayson, 1973) allows for a conservative estimate of MNI. The maximum distinction method, which estimates MNI for each separate excavation context, produces a much larger MNI estimate. On the other hand, a modification of these two approaches may be used when samples represent discrete temporal units or distinct behavioral units. Increasing the number of analytical units generally increases the estimated number of individuals, whereas decreasing the number of analytical units generally decreases the number of individuals estimated. Details about the aggregations used for samples from each of the sites reported here are discussed below.

Estimates of biomass compensate for some of the problems encountered with MNI and provide information on the quantity of meat supplied by the animal (Reitz et al., 1987; Reitz and Wing, 2008: 238–242). In some cases the original live weight or size of an animal can be estimated. The predictions are based on the allometric principle that the proportions of body mass, skeletal mass, and skeletal dimensions change with increasing body size. This scale effect results from a need to compensate for weakness in the basic structural material, in this case bone. The relationship between body weight and skeletal weight is

described by the allometric equation:

$$Y = aX^b$$

(Simpson et al., 1960: 397). Many biological phenomena show allometry described by this formula (Gould, 1966, 1971). In this equation, *X* is the skeletal weight or a linear dimension of the specimen, *Y* is the quantity of meat or the total live weight, *b* is the constant of allometry (the slope of the line), and *a* is the *Y*-intercept for a log-log plot using the method of least squares regression and the best fit line (Reitz and Wing, 2008: 238–242). A given specimen weight or a specific skeletal dimension represents a predictable amount of tissue due to the effects of allometric growth. Values for *a* and *b* are obtained from calculations based on data at the Florida Museum of Natural History, University of Florida, and the Georgia Museum of Natural History, University of Georgia. The allometric formulae used here are presented in table A.1.

The astragalus dimension used to estimate body weight is the greatest length of the lateral half of the astragalus (GLl) described by Driesch (1976: 88). One problem with using the astragalus is that this element does not grow by epiphyseal fusion as the individual matures. This makes it difficult to distinguish adult from subadult specimens once the astragalus is no longer porous. Therefore, some of the weights predicted using the astragalus may be for older subadults rather than for adults.

Allometry can be used to predict kilograms of meat represented by kilograms of organic material where *X* is the archaeological specimen weight. This is a conservative estimate of meat and other soft tissues obtained from the faunal materials recovered from the site. The term *biomass* refers to the results of this calculation. Biomass reflects

TABLE A.1
Allometric Values Used in the Study[a]

Taxa	*N*	*Y*-Intercept (*a*)	Slope (*b*)	r^2
		Specimen weight (kg) to body weight (kg)		
Mammal	97	1.12	0.9	0.94
Bird	307	1.04	0.91	0.97
Turtle	26	0.51	0.67	0.55
Snake	26	1.17	1.01	0.97
Chondrichthyes	17	1.68	0.86	0.85
Actinopterygii	393	0.9	0.81	0.8
Non-Perciformes	119	0.85	0.79	0.88
Siluriformes	36	1.15	0.95	0.87
Perciformes	274	0.93	0.83	0.76
Sparidae	22	0.96	0.92	0.98
Sciaenidae	99	0.81	0.74	0.73
Pleuronectiformes	21	1.09	0.89	0.95
Greatest astragalus lateral length (GLl, mm) to body weight (kg)				
Artiodactyl	14	-6.999	5.499	0.88

[a] Key to abbreviations: Formula is $Y = aX^b$; where *Y* is biomass or meat weight; *X* is bone or shell weight; *a* is the Y-intercept; and *b* is the slope; *N* is the number of observations (Reitz et al., 1987; Reitz and Wing, 2008: 68). Astragalus measurement follows Driesch (1976).

the probability that only certain portions of the animal were used at the site. This would be the case where preserved or redistributed meats were consumed or where only a portion of the carcass was used in the sampled area. Just as MNI is related to the aggregation of archaeological proveniences, so too is the biomass estimate. In view of this, biomass is estimated for the same analytical units used to estimate MNI. Details about the aggregations used for samples from each of the sites reported here are discussed at the end of this appendix.

Biomass and MNI are subject to sample size bias. Casteel (1978), Grayson (1979, 1981, 1984), and Wing and Brown (1979) suggest a sample size of at least 200 individuals or 1400 specimens for a reliable interpretation. Small samples frequently produce short species lists with undue emphasis on one species in relation to others. It is not possible to determine the nature or the extent of the bias, or correct for it, until the sample size is enlarged through additional work. No specific sample size ensures adequate representation, but small samples are particularly likely to be unrepresentative and to skew the importance of one taxon relative to others (Grayson, 1981; Lyman and Ames, 2004). The materials from each of the sites reported here represent a limited view of animal use and should not be seen as accurately representing all of the diverse activities that might have occurred at each site.

To summarize the data, MNI and biomass estimates are placed into categories defined by vertebrate class, husbandry practices, and other characteristics important to the interpretation of human behavior. This is done in order to contrast the percentages of various groups of taxa in the collection. Only biomass estimates for those taxa for which MNI also is estimated are included in these summaries. Using tables 4.6 and 4.8 as examples, biomass for seatrout (*Cynoscion* spp.) is included in table 4.8 but biomass estimates for drums (Sciaenidae) or spotted seatrout (*C. nebulosus*) are not. Several categories of animals are defined. These include: domestic mammals, domestic birds, deer, other wild mammals, wild birds, turtles/alligators, sharks, rays, ray-finned (bony) fishes, and commensal taxa. The term *fishes* is used throughout this volume to refer to both cartilaginous (Chondrichthyes) and ray-finned (Actinopterygii, formerly Osteichthyes) fishes.

In this study, the commensal category includes wild animals associated with human-built environments as well as pets and work animals (table A.2). The classification was originally developed for the study of materials from St. Augustine because Spaniards claimed to have eaten grass, snakes, rats, and vermin in addition to the leather from sandals, doublets, and sword belts (A.G.I., *Justicia* 1001, No. 2, R. 5, 1568). At another time they claimed to have eaten herbs, fish, and other scum and vermin (Licentiate Gamboa, Madrid, Feb. 4, 1573, A.G.I., *Patronato* 179, No. 5, R. 5, in Connor, 1925: 98–99). These claims needed to be tested objectively, which meant that *vermin* had to be treated in the same way as all other animal resources. The category of commensal taxa includes those animals which Spaniards referred to as scum and vermin and other animals which also seemed unlikely ingredients of their cuisine, such as cats (*Felis catus*) and dogs. Years of testing Spanish claims that they consumed scum and vermin have produced no evidence that they actually did so (Reitz, 1985, 1990, 1991, 1992a, 1992b, 1992c, 1993a, 1994a, 1994b; Reitz and Brown, 1984; Reitz and Cumbaa, 1983; Reitz and Scarry, 1985). It is far more likely that this is a cultural statement about the unfamiliar and socially unsuitable foods that formed the basis of the daily fare of Spaniards in Spanish Florida. Brief moments of privation, such as after a hurricane or privateer raid, may have forced both Spaniards and Native Americans to resort to starvation foods, but archaeological methods are rarely capable of isolating faunal remains associated with events of such short duration.

Although all or most commensal animals probably were not part of the diet, many are associated with disturbed habitats and stored foods typical of human residences. Commensal taxa are commonly identified in faunal assemblages from Spanish Florida, but are typically present in low numbers, (e.g., tables 3.4 and 6.16). Those few cases in which commensal taxa are abundant require special consideration (e.g., tables 3.4, 4.7, 4.8, 5.2, and 6.17), often signaling the presence of stored foods and places with quiet, dark corners. Insectivores and rodents might have been attracted to loosened soil, bushy areas, gardens, or stored foods. Snakes (Colubridae, Viperidae) may well have been attracted to house areas by these small mammals as well as by frogs and toads (Anura). The wild bird

TABLE A.2
Vertebrate Taxa Interpreted as Commensal

Scientific name	Vernacular name
Soricidae	Shrew family
Blarina carolinensis	Short-tailed shrew
Scalopus aquaticus	Mole
Sigmodontinae	New World mouse and rat
Oryzomys palustris	Rice rat
Peromyscus spp.	Mouse
Rattus spp.	Old World rat
Rattus norvegicus	Norway rat
Rattus rattus	Black rat
Mus musculus	House mouse
Sigmodon hispidus	Hispid cotton rat
Canidae	Dog family
Canis familiaris	Domestic dog
Felis catus	Domestic cat
Equus spp.	Horse, donkey, or mule
Anolis carolinensis	Green anole
Sceloporus sp.	Spiny lizard
Ophisaurus spp.	Glass lizard
Serpentes	Indeterminate snake
Colubridae	Nonvenomous snake family
Coluber constrictor	Racer
Elaphe spp.	Rat snake
Heterodon spp.	Hognose snake
Masticophis spp.	Coachwhip
Nerodia spp.	Water snake
Thamnophis spp.	Garter or ribbon snake
Viperidae	Pit viper family
Agkistrodon piscivorous	Cottonmouth
Crotalus sp.	Rattlesnake
Sistrurus miliarius	Pygmy rattlesnake
Anura	Indeterminate frog and toad
Amphiuma spp.	Amphiuma
Siren spp.	Siren
Ambystoma spp.	Mole salamander
Notophthalmus viridescens	Eastern newt
Plethodon glutinosus	Slimy salamander
Scaphiopus holbrookii	Spadefoot toad
Bufo/*Rana* spp.	Toad or frog
Bufo spp.	Toad
Hyla spp.	Tree frog
Ranidae	True frog family
Rana spp.	Frog

category includes small birds (e.g., *Quiscalus ossifragus*, Muscicapidae, Mimidae, *Cardinalis cardinalis*) that might have been commensal instead of food items, though they are included among the food items in this study. Some of the other wild animals interpreted as food items, such as opossums (*Didelphis virginiana*), rabbits (*Sylvilagus* spp.), squirrels (*Sciurus* spp.), and raccoons (*Procyon lotor*), also could have been commensal instead of food. They are included among the food resources because of the long tradition of consuming these animals in many parts of the Americas. It is possible that dogs, cats, and horses (*Equus caballus*) or donkeys (*E. asinus*) were eaten, but it is more likely that they were pets, mousers, guard dogs, pack animals, or feral/wild and not part of a subsistence regime.

Burrowing animals in these collections (e.g., moles [*Scalopus aquaticus*] and gopher tortoises [*Gopherus polyphemus*]) raise another issue. It is unclear how these burrowing animals become incorporated into each collection. They could be contemporaneous with the context within which they are found, or they could be intrusions, burrowing through the temporal sequence and dying, essentially out of context. For the purposes of this study, it is assumed that they are contemporaneous but their presence reminds us that bioturbation occurs at all archaeological sites.

The presence or absence of elements in an archaeological sample may provide information on butchering practices, transportation decisions, redistribution systems, and other site formation processes (Lyman, 1982, 1984, 1994; Reitz and Wing, 2008: 213–232). The mammalian elements represented in each collection are summarized into categories by body parts. The head category includes all material from specimens associated with the cranium and mandible. The presence of head elements at a site may indicate either the consumption of brain or tongue, or the discard of unused refuse. The vertebra/rib/sternum category includes the atlas, axis, cervical, thoracic, lumbar, and caudal vertebrae, but not the sacral vertebrae. The forequarter category contains the scapula, humerus, ulna, and radius. Forefoot includes carpals and metacarpals, elements that do not contain much meat and may be evidence of nearby slaughter, skinning refuse, use of the feet for broth, or a cache of material from which tools or ornaments would eventually be made. The hindquarter category includes the innominate, sacrum, femur, and tibia. Hindfoot includes the tarsals and metatarsals. The foot category contains specimens identified only as metapodials and phalanges that could not be assigned to other categories. The element data for deer are further summarized into head, body, and foot categories. The body category includes vertebra, ribs, sternum, forequarters, and hindquarters; foot includes elements classified as forefoot, hindfoot, and foot.

Figures showing pig, deer, and cattle (*Bos taurus*) specimens identified in each collection are provided in some cases. The numbers indicate the number of specimens from that portion of the deer skeleton present in that context. The shading of the atlas and axis is accurate, but the location of the other vertebrae as well as of ribs is not exact. The last lumbar location is used to indicate otherwise unidentifiable vertebrae rather than lumbar vertebrae. Sesamoids, distal metapodial specimens, and phalanges are entered on the right hindfoot. This does not mean they are from the right hindfoot, but instead means the quarter is unknown.

A logged ratio diagram is used to clarify which portions of the deer skeleton were transported from the kill or butchery site to the archaeological site (Reitz et al., 2006; Reitz and Wing, 2008: 223–224; Simpson, 1941). The archaeological specimens are compared to the distribution of elements in a standard deer skeleton. The standard distribution is calculated from the number of elements found in a complete deer skeleton organized into the same anatomical categories described above (see table 5.5 for an example). This permits comparison of the specimen count for each element type in the archaeological collection with the number of those same elements in an unmodified deer skeleton. The formula is:

$$d = \log_e X - \log_e Y$$

where d is the logged ratio, X is the percentage of that element category in the archaeological sample, and Y is the percentage of that element category in a standard deer. In order to compare the archaeological data with the standard deer, the archaeological percentages for each element category are converted into logarithms and the log value of this same element category for the standard deer is subtracted from the archaeological value. In the accompanying

figures the resulting value (*d*) is plotted against the standard represented by a vertical line. Although the archaeological percentages are derived from specimen counts (NISP) and the percentages for the standard are derived from the number of elements, the relationship in the ratio diagram is similar to that found in unmodified histograms.

Selectivity in transportation and access to portions of a deer carcass can be explored in terms of the food utility value of portions of the deer carcass using a modified food utility index (FUI). Following James Purdue and his colleagues (Purdue et al., 1989), deer skeletal elements are assigned to categories by potential meat, marrow, and bone grease yield (Reitz and Wing, 2008: 228–230). The food utility categories are low (<1000 FUI), medium (1000–3000 FUI), and high (>3000 FUI). Some elements do not have a food utility value or are otherwise problematic for this application; consequently, the total number of specimens used in this application is smaller than the total deer NISP in each archaeological collection and the number of elements present in the standard deer skeleton. For example, though 229 deer specimens are present in the collection from the church, only 216 of these are used in the food utility study (tables 5.5 and 5.6). Although there are 264 elements in a standard deer skeleton, only 222 are used in the food utility study.

Modifications to specimens can indicate butchering methods as well as site formation processes (Reitz and Wing, 2008: 123–143, 242–244). Modifications are classified as cuts, clean-cuts, hacks, burns, calcined, worked, rodent or carnivore gnawed, and weathered. Worked specimens are discussed in more detail by site (see chaps. 4–6, appendix D). Cuts are small incisions across the surface of specimens. These marks were probably made by a knife as meat was removed from elements before or after cooking. Cuts might also result from attempts to disarticulate the carcass at joints. Some marks that appear to be made by human tools may actually be abrasions occurring after the specimens were discarded (Shipman and Rose, 1983), but distinguishing between these sources of small cuts requires access to higher powered magnification than was available during this study. Clean-cut marks are indications of either hacking or sawing. Although specimens from the collections analyzed for this study lack the diagnostic serrations that would indicate sawing, a close examination suggests that modifications identified as clean-cut are probably saw cuts. Hack marks closely resemble cut marks in their shape and irregularity but are deeper and wider. They may indicate use of a cleaver or hatchet rather than a knife to dismember carcasses. A large chopping tool would produce more bone splinters and probably larger cuts of meat than would be produced by a knife.

Burned specimens are exposed to fire, intentionally or unintentionally, as meat is cooked or after the meat is removed, such as might happen when trash is burned or the structure itself burns down. Calcination is the result of two processes. Burning at extreme temperatures (≥ 600°C) can cause calcination and is usually indicated by white or blue-gray discoloration (Lyman, 1994: 385–386). Calcination can also occur by leaching of calcite. Both types of calcination occurred in these assemblages (see appendix D), but no attempt was made to distinguish between them. Experimental studies indicate that color is a poor indicator of the cause of modification because: (1) it is difficult to precisely describe color variations; and (2) other diagenetic factors might alter bone color (Lyman, 1994: 385).

Weathering and gnawing indicate that some specimens were not immediately buried after disposal. Although burial would not insure an absence of weathering and gnawing, exposure for any length of time subjects specimens to weathering and might increase the amount and degree of gnawing. Gnawing by rodents and, particularly, by carnivores results in the displacement or loss of an unknown quantity of faunal material from the archaeological record. Gnawing carnivores include opossums, dogs, foxes (*Urocyon cinereoargenteus*), raccoons, and cats.

Estimates of the relative ages of deer at death are based on the degree of epiphyseal fusion for diagnostic elements and dental characteristics such as eruption sequences and tooth wear (Reitz and Wing, 2008: 72). The area of growth between the shaft (diaphysis) and the proximal or distal ends of an element (the epiphysis) is not fused when animals are young. The interface line fuses when growth is complete. Although environmental factors influence the age at which fusion is complete (Maltby, 1982; Watson, 1978), elements fuse in a regular temporal sequence (Gilbert, 1980; Purdue, 1983; Schmid, 1972; Silver, 1963). During analysis, fused and unfused specimens are recorded according to whether

fusion occurs early in life, during the months just prior to achieving adult status, or somewhere in the middle. This is most informative for unfused specimens that fuse in the first year or so of life and for fused specimens that complete growth at 3 or 4 years of age. Intermediate specimens are more difficult to interpret. An element that fuses by 12 months of age and is found fused archaeologically could be from an animal that died immediately after fusion was complete or any time thereafter. The ambiguity inherent in age grouping is reduced somewhat by recording each specimen under the oldest category possible. In summarizing these data, juveniles are considered to be animals that died before 20 months of age, subadults are ones that died prior to 26–29 months of age, and adults died after 26–42 months of age. Occasionally the age of the individual cannot be estimated even though paired specimens clearly indicate the presence of the individual. These indeterminate individuals were probably at least 20 months of age when they died. In some cases, tooth eruption sequence is used to estimate the age of juvenile individuals (Severinghaus, 1949).

The approximate age of death for deer may be an indication of seasonal hunting strategies in many areas, though on the Georgia coast this is not necessarily the case (Johns et al., 1977; Lueth, 1968; Miller, 1989; Osborn, 1976; Payne et al. 1967; Richter and Labisky, 1985; Warren et al., 1990). The breeding season for deer in Georgia is asynchronous, ranging from November to February, and the gestation period is 196 to 203 days (Golley, 1962: 201). Fawns, therefore, may be born anytime over a five month period between April and August. In a hypothetical case, a fawn conceived in November might be born in April and killed sometime before its 12th month of life the following April. Another fawn conceived in February might be born in August and killed sometime before its 12th month the following August. Obviously the recovery of an unfused distal humerus, an element which fuses at about 12 months of age, does not indicate an exclusively spring or summer kill. Even the recovery of an unshed antler may not indicate a November–February death because the specimen may have been curated for later use as a tool.

The sex of animals is an important indicator of animal use, even though few osteological indicators of sex exist. Males are indicated by the presence of spurs on the tarsometatarsus of chickens (*Gallus gallus*), antlers in deer, and large canine teeth for pigs. Females can be determined based on the absence of such features as spurs and antlers, or the presence of small canines. Female birds may be recognized by medullary bone, a calcium deposit associated with egg laying (Rick, 1975). Unfortunately, clear signs of the animal's sex are not always present in an archaeological sample. Another approach is to compare measurements of identified specimens for evidence that an element falls into either a male or female size range. In the case of deer, the presence of an antler could indicate that one of the individuals was a male. A shed antler is not considered evidence that a male animal actually was hunted. Nor are shed antlers considered when estimating MNI because they can be collected by people after being shed. For this reason only unshed antlers can be used as evidence of season of death or the slaughter of male animals.

One method of assessing variety and degree of specialization is to measure the richness, diversity, and equitability of the species in a collection (Hardesty, 1975; Reitz and Wing, 2008: 245–247). Richness, as used in this study, is the number of taxa for which MNI is estimated. Diversity measures the number of species used. Equitability measures the degree of dependence on the utilized resources and the effective variety of species used at the site based on the even, or uneven, use of individual species. These indices allow discussion of food habits in terms of the variety of animals used at the site (richness or diversity) and the equitability (evenness) with which species were utilized.

To measure diversity, the Shannon-Weaver Index (Shannon and Weaver, 1949: 14) is used, and the Sheldon Index (Sheldon, 1969) is used to measure equitability. The formula for diversity is:

$$H' = -\Sigma\,(p_i)\,(\log_e p_i)$$

where p_i is the number of *i*th species divided by the sample size (Pielou, 1966; Shannon and Weaver, 1949: 14). p_i is actually the evenness component because the Shannon-Weaver Index measures both the number of species used and how much each was used.

Equitability is calculated using the formula:

$$V' = H'/\log_e S$$

where H' is the diversity index and $\log_e S$ is the natural log of the number of observed species

(Pielou, 1966; Sheldon, 1969).

Diversity increases as both the number of species and the equitability of species use increase. A diversity index of 4.99 is a high value. A sample with many species identified and in which the number of individuals slowly declines from most abundant to least abundant will be high in diversity. Diversity can be increased by adding a new taxon to the list, but if another individual of a taxon that is already present is added to the list, diversity decreases. A low diversity can be obtained either by having few species or by having a low equitability, where one species is considerably more abundant than others. A low equitability value indicates that one species was more heavily used than other species in the sample. A high equitability index, approaching 1.0, indicates an even distribution of species in the sample.

Diversity and equitability are estimated for both MNI and biomass. In the case of MNI, estimates of individuals are taken directly from the species lists. Biomass represents a different problem because it is estimated for more taxonomic levels than is MNI. It is important to quantify biomass diversity and equitability using the same taxonomic units used for MNI. For this reason, only biomass estimates for those taxa for which MNI is estimated are used in the biomass diversity and equitability calculations. This ensures that when biomass and MNI diversity and equitability results are compared, the same sample universes are used.

Daniel Pauly and his colleagues (Pauly et al., 1998; Pauly et al., 2000) argue that significant changes in the structure of the marine food web occurred during the last half of the 20th century. They assign the marine animals that were part of the 20th-century fishery to trophic levels ranging between one and five based on the degree to which consumers feed directly on producers. Primary producers and detritus are at the base of the food chain, a trophic level of one. Zooplankton, benthic herbivores, and detritivores occupy the second trophic level. Carnivores occupy trophic levels three to five. When Pauly and his colleagues (Pauly et al., 1998) examine trophic-level use by the marine fishery in the region that includes the Georgia Bight, they report that a peak occurred in the mean trophic level in 1970 and was followed by a sharp decline. Such a peak was presumed to be an historic high, but studies of archaeological remains from the Georgia Bight show that, historically, fishing regularly occurred at even higher levels (e.g., Quitmyer and Reitz, 2006; Reitz, 2004).

To examine this issue, zooarchaeological and modern data are assigned to trophic levels using the method of Pauly and Christensen (1995) as adapted by Reitz (2004). Mean trophic level (*TL)* is estimated by combining modern trophic-level assignments with MNI and allometric estimates of biomass in the zooarchaeological assemblage for the same taxa. Modern trophic-level data are obtained from FishBase 98 (Froese and Pauly, 1998). When the identifications in the archaeological data, the modern fishery data, or FishBase 98 are insufficiently precise, the trophic level for the closest taxonomic category is used. In cases where the zooarchaeological taxonomic identification is not in FishBase 98, the trophic level for the closest taxonomic category is used. The formula:

$$TL_i = \sum (TL_{ij})\,(Biomass_{ij}) / \sum Biomass_i$$

estimates the mean trophic level for the time period (TL_i). The trophic level (TL_{ij}) of each taxon (*j*) for the time period (*i*) is multiplied by the estimated $Biomass_{ij}$ of the taxon (*j*) for the time period (*i*). The sum of these products is divided by the summed biomass for the time period ($Biomass_i$). This formula estimates the mean trophic level for each assemblage. MNI may be used instead of biomass in this formula. This same formula also can be used to estimate the relative contribution of each individual trophic level.

Because fish growth is indeterminate, trophic level, body size, preferred habitat, and feeding habits change as an individual fish matures (Reitz, 2004; Reitz and Wing, 2008: 137, 266–272). A mullet, for example, might have been only 4 or 5 cm in total length when it was captured or it might have been 30 or 40 cm. Simply identifying a mullet in a sample does not tell us the size of the animal. Looking for cultural changes in the use of small-bodied or large-bodied animals is difficult in fishes (and other taxa with indeterminate growth) because smaller-bodied young mature into larger-bodied adults. Sometimes this size difference is reflected in measurements such as those used to estimate total length for Atlantic croakers (*Micropogonias undulatus*) from otoliths in the Fountain of Youth assemblage (Hales and Reitz, 1992). This study found that growth and reproductive habits of croakers changed over

time, with a shift toward smaller croakers.

Although measurements are important in assessing the size range of animals captured at a specific time and place, measurements are not available in sufficient detail for many of the fishes in these collections. To compensate for this problem, the fish taxa identified are sorted into small- or large-bodied categories (table A.3). Small fishes are those taxa whose adult sizes are generally less than 25 cm today. This classification does not necessarily mean that a specific individual fish was either small or large in the collection. Without measurements and body size estimates for all fishes at all sites, it is not possible to know which specific individuals were large or small.

As fishes grow from small size to large size, the appropriate capture technology changes. Small fingerling mullets, for example, might be taken in shallow weedy areas with a basketry scoop or a small dip net. Large mullets, however, might be taken with cast nets from the surf zone or weirs in larger tidal streams. Regrettably, very little archaeological evidence for fishing technology has been recovered from the southern Georgia Bight. Thus, technology is reduced to a hypothetical dichotomy between mass-capture techniques on the one hand and individual-capture techniques on the other: poisons, nets, traps, scoops, or weirs visualized as mass-capture techniques and leisters or a gorge or hook as individual-capture devices (table A.3).

The classification is based in large part on personal observation and on sources such as Michael Dahlberg (1975) and Sydney Johnson et al. (1974; see also DEIS, 1978; Miller and Jorgenson, 1969). Some individuals of all taxa could be taken either en masse or individually; there is considerable overlap in the behavior and capture technology of many of these fishes. We have observed, for example, small sharks captured with seine nets, gars taken with nets, sea catfishes taken with either nets or hooks, and mullets taken with hooks. Some fishes, however, are more vulnerable to mass-capture techniques regardless of body size and others are more likely to be taken individually.

The body size of each fish is a more appropriate measure of capture technology than is a classification based on taxonomy, of course. It is hoped that eventually adequate measurements will be available to refine this aspect of the study. It is likely that the ability to capture a particular fish taxon, using a variety of methods, from several different locations, during more than one part of the seasonal or tidal cycle are important criteria in determining whether a fish species is one of the suite of taxa common in Georgia Bight collections. It is very clear from the review in chapters 3 and 4 that fishes with very specific seasonality, habit, and habitat requirements were not captured by pre-Hispanic or Spanish fishing strategies.

We also note that small members of taxa that eventually grow to large size may be discriminated against by use of a large screen size during excavation, leaving the false impression that only large-bodied members of a species were used.

Ubiquity refers to the frequency with which a taxon is present in a group of collections. Ubiquity is estimated by dividing the number of collections in which a taxon or a group of taxa is identified by the total number of collections included in the study. To estimate ubiquity, only those taxa for which MNI is estimated are considered. These are the same taxa used to estimate a collection's richness. Thus, the ubiquity of flounder (*Paralichthys* spp.) reported in chapter 3 (91%) is estimated by dividing the number of collections in which flounders are identified ($N = 10$) by the total number of sites in the study ($N = 11$).

MATERIALS: ST. FRANCIS BARRACKS/ CONVENTO DE SAN FRANCISCO (SA 42A)

The St. Francis Barracks site (SA 42A), in St. Augustine, was the location of the Convento de San Francisco during the First Spanish period (fig. 4.2; K. Hoffman, 1990, 1993). The Convento was founded in 1592, burned in 1599, rebuilt by 1603, remodeled in 1610, burned again in 1702, and rebuilt in 1750. During this time, it served as the seat from which the extensive Franciscan mission system of Spanish Florida was administered. In the mid-17th century, as many as 40 missionaries were attached to the Convento, though probably only a few administrators and staff actually lived on the property (K. Hoffman, 1993). The Convento was abandoned by the Franciscans, along with other missions in the Spanish Florida mission chain, at the beginning of the brief British period (1763–1783). During the subsequent Second Spanish period, Franciscan friars reoccupied the Convento between 1786 and 1792, but were

TABLE A.3
Characteristics of Fish Taxa in the Collections

Scientific name	Vernacular name	Body size	Capture method	Trophic level
Squaliformes	Cartilaginous fishes	Large or unclassified	Individual	3.6
Chondrichthyes	Cartilaginous fishes	Large or unclassified	Individual	3.6
Ginglymostoma cirratum	Nurse shark	Large or unclassified	Individual	3.8
Carcharias (Odontaspis) taurus	Sand tiger shark	Large or unclassified	Individual	4.5
Lamnidae	Mackerel shark family	Large or unclassified	Individual	3.8
Carcharhinidae	Requiem shark family	Large or unclassified	Individual	4.0
Carcharhinus spp.	Requiem shark	Large or unclassified	Individual	4.0
Galeocerdo cuvier	Tiger shark	Large or unclassified	Individual	4.5
Rhizoprionodon terraenovae	Sharpnose shark	Large or unclassified	Individual	4.3
Sphyrnidae	Hammerhead shark family	Large or unclassified	Individual	3.6
Sphyrna sp.	Hammerhead shark	Large or unclassified	Individual	3.6
Pristis pectinata	Smalltooth sawfish	Large or unclassified	Individual	3.6
Rajiformes	Skates and rays	Large or unclassified	Individual	3.5
Dasyatidae	Whiptail stingray family	Large or unclassified	Individual	3.5
Dasyatus spp.	Whiptail stingray	Large or unclassified	Individual	3.5
Myliobatidae	Eagle ray family	Large or unclassified	Individual	3.5
Acipenser spp.	Sturgeon	Large or unclassified	Individual	3.6
Lepisosteus spp.	Gar	Large or unclassified	Individual	—
Amia calva	Bowfin	Large or unclassified	Individual	—
Elops saurus	Ladyfish	Small	Mass	3.0
Clupeidae	Herring family	Small	Mass	2.6
Brevoortia spp.	Menhaden	Small	Mass	2.8
Ictaluridae	Freshwater catfish family	Large or unclassified	Individual	2.6
Ariidae	Sea catfish family	Large or unclassified	Mass	3.2
Ariopsis felis	Hardhead catfish	Large or unclassified	Mass	3.5
Bagre marinus	Gafftopsail catfish	Large or unclassified	Mass	3.2
Esox spp.	Pickerel	Small	Mass	4.1
Opsanus spp.	Toadfish	Small	Individual	3.5
Cyprinodontidae/*Fundulus* spp.	Killifishes	Small	Mass	—
Centropomus sp.	Snook	Large or unclassified	Individual	3.5
Serranidae	Sea bass family	Large or unclassified	Individual	3.5
Centropristis spp.	Sea bass	Small	Mass	3.5
Epinephelus spp.	Grouper	Large or unclassified	Individual	3.9
Micropterus salmoides	Largemouth bass	Large or unclassified	Individual	3.7
Pomatomus saltatrix	Bluefish	Large or unclassified	Individual	3.3
Carangidae	Jack family	Large or unclassified	Individual	3.3
Caranx hippos	Crevalle jack	Large or unclassified	Individual	3.8
Chloroscombrus chrysurus	Atlantic bumper	Small	Mass	3.3
Lutjanus spp.	Snapper	Large or unclassified	Individual	4.6
Lobotes surinamensis	Atlantic tripletail	Large or unclassified	Individual	—
Haemulidae	Grunt family	Large or unclassified	Individual	3.5
Archosargus probatocephalus	Sheepshead	Large or unclassified	Individual	3.4
Sciaenidae	Drum family	Large or unclassified	Individual	3.3
Bairdiella chrysoura	Silver perch	Small	Mass	3.3

TABLE A.3 — (*Continued*)

Scientific name	Vernacular name	Body size	Capture method	Trophic level
Cynoscion spp.	Seatrout	Large or unclassified	Mass	3.4
Larimus fasciatus	Banded drum	Small	Mass	3.3
Leiostomus xanthurus	Spot	Small	Mass	3.4
Menticirrhus spp.	Kingfish	Large or unclassified	Individual	3.4
Micropogonias undulatus	Atlantic croaker	Large or unclassified	Mass	3.3
Pogonias cromis	Black drum	Large or unclassified	Individual	3.4
Sciaenops ocellatus	Red drum	Large or unclassified	Individual	3.4
Stellifer lanceolatus	Star drum	Small	Mass	3.3
Eleotridae	Sleeper family	Small	Mass	2.1
Chaetodipterus faber	Atlantic spadefish	Small	Individual	3.3
Sphyraena barracuda	Barracuda	Large or unclassified	Individual	4.5
Mugil spp.	Mullet	Large or unclassified	Mass	2.1
Trichiurus lepturus	Atlantic cutlassfish	Small	Individual	3.8
Peprilus spp.	Butterfish	Small	Mass	3.3
Paralichthys spp.	Flounder	Large or unclassified	Individual	3.5
Trinectes spp.	Sole	Large or unclassified	Individual	3.0
Diodon hystrix	Porcupinefish	Large or unclassified	Mass	3.2

replaced by Spanish soldiers after 1792 until the end of Spanish administration in 1821. From an archaeological perspective, the Second Spanish period is the least-studied and least-understood period of the Spanish administration in Florida.

Fieldwork at St. Francis Barracks was conducted in 1988 by Kathleen Hoffman under the direction of Kathleen Deagan, both of the Florida Museum of Natural History (K. Hoffman, 1993). During excavation, faunal materials were recovered using flotation. This fine-screen recovery technique was designed to ensure that small fishes were collected from the site if present.

The faunal remains studied were from three temporal components: the late 16th century/early 17th century (ca. 1600), the mid-17th century (ca. 1650), and the Second Spanish period (1786–1821). The ca. 1600 component includes materials from a trash pit and a well construction pit (Feature 30) dug prior to 1599. The ca. 1650 component includes faunal materials from four large post pits, a builder's trench, a barrel well (Feature 31), two trash pits, and a possible well construction pit. Although the cloister for which the post pits were dug was built prior to 1600, the fill was probably deposited after the monastery was rebuilt in the early 17th century. The Second Spanish period component consists of materials from miscellaneous pits and post-molds. In estimating MNI, faunal materials recovered from each temporal component were considered discrete analytical units, with further subdivisions based on archaeological evidence. The vertebrate materials from St. Frances Barracks were identified by Gwyneth Duncan and Jennifer Freer with the assistance of Elizabeth Misner and Daniel Weinand. A list of the samples analyzed is included in the study report (Reitz, 1992c).

MATERIALS: MISSION SANTA CATALINA DE GUALE (9Li13)

Mission Santa Catalina de Guale was founded on St. Catherines Island in the early 1580s (fig. 5.1; Thomas, 1987: 143–150, 1993a: 16–19; see chap. 2). It became the principal northern mission on the Atlantic coast in 1587 when Spanish outposts further north, such as Santa Elena, were abandoned. The mission itself was abandoned in 1597 during the Guale Rebellion. It was reoccupied and rebuilt around 1609. Santa Catalina de Guale was one of a series of missions

operating on the sea islands and adjacent mainland for most of the 17th century. In 1680, a Yamassee attack on the mission resulted in its abandonment. The mission was moved further south along the coast, first to Sapelo Island, then to Amelia Island, and eventually to St. Augustine (Saunders, 2009). There Guale and other refugees made a substantial contribution to the material culture of the town (Deagan, 1993, 2009; Waters, 2009). Although the faunal remains recovered from the mission compound could be from either the 16th- or the 17th-century occupation, they are interpreted here as representing 17th-century vertebrate use by Spaniards at the mission. It is also likely that some, if not most, of the people living within the mission compound were not Spanish friars. Some soldiers were stationed at the mission and some Native Americans probably lived inside the compound as well.

Although the approximate location of Mission Santa Catalina de Guale had been known for many years, it was David Hurst Thomas of the American Museum of Natural History who first confirmed the identity of the mission and began a systematic survey and excavation program (Thomas, 1993b, 2008b: 525–601; see chap. 2). The transect survey initiated in 1977 indicated that the mission was near Wamassee Creek on St. Catherines Island and this location became the focus of study in 1980. The temporary site number AMNH208 was assigned to the area where the mission was thought to be. Preliminary work included excavating a series of test pits as well as sampling with augers and remote sensing devices. Beginning in 1982, four areas of the mission compound were subjected to intensive excavation. These areas are known as Structure 1, the iglesia or church (this also includes Str1NWC); Structure 2, the cocina or kitchen; Structure 2/4, the garden and well between Structures 2 and 4; and Structure 4, the convento or friary. Structures 2, 2/4 (garden and well), and 4 are jointly known as the Eastern Plaza Complex. Prior to October 1987, recovery was almost always through dry 3.18 mm (1/8-inch) mesh screen with 6.35 mm mesh (1/4-inch) used occasionally. Beginning with the October 1987 excavation season, recovery methods included water-screening and flotation.

Only those materials excavated between 1982 and 1989 from the church, cocina, garden/well, and friary are reported in chapter 5. Vertebrate faunal remains recovered by Joseph Caldwell between 1969 and 1971, from what subsequently proved to be the mission, are reported elsewhere (Reitz, 1990, 2008). None of the samples designated as simply Quad I, Quad II, Quad III, Quad IV, Test Trench, Kings New Ground, or Wamassee are included in chapter 5.

To manage the large number of zooarchaeological samples from the mission compound, a separate accession number was given to each excavated area (Structures 1, 2, 2/4 [garden and well], and 4) and code numbers were assigned to each sample within an accession. Structure 2 and Structure 2/4 (garden and well) materials excavated prior to October 1987 are Accession #99. Structure 2 and Structure 2/4 (garden and well) materials excavated after 1987 are Accession #107. Structure 4 materials excavated after 1987 are Accession #108. Structure 1 materials excavated after 1987 are Accession #128. Lastly, the northwest corner of Structure 1 (Str1NWC) materials are Accession #131. The accession number appears as part of a unique eight-digit number assigned to each taxon in each sample during the study (Reitz and Wing, 2008: 159). A code number was assigned to each sample within each accession so that all data from the same accessioned sample have the same code number. A list of these code numbers is provided in the original report (Reitz and Duncan, 1993).

The vertebrate materials from Mission Santa Catalina de Guale were identified by Nanny Carder, Gwyneth Duncan, Jennifer Freer, Kevin Roe, David Varricchio, and Karen Wood. They were assisted by Lori Taylor, Meg Kollock, Thomas Pluckhan, Kathleen Reichart, and Emmett Walsh. Valerie Johnston did the final check of the computerized data and inventory files.

In estimating MNI, faunal materials recovered from the church (Structure 1) and the Eastern Plaza Complex were considered two discrete analytical units. All materials within Structure 1 were considered part of a single analytical unit as were all materials within the Eastern Plaza Complex. This means that when MNI was estimated for the Eastern Plaza Complex, data from the cocina (Structure 2), the garden/well (Structure 2/4), and the friary (Structure 4) were combined analytically. NISP, MNI, and specimen weight for Structure 2, Structure 4, and the area in between (2/4 or garden) are provided in appendix C. A list of the samples studied is included in the study report (Reitz and Duncan, 1993).

Materials from Structure 1W were recovered from the western side of the Plaza Complex. At the time of the original study, materials from Structure 1W were not clearly affiliated with either the church or the Eastern Plaza Complex. For this reason, the data from this area are not included in chapter 5 nor are they included in the studies reported in appendices D and E.

MATERIALS: PUEBLO SANTA CATALINA DE GUALE (9Li8)

The data reported in chapter 6 are from two sectors within Pueblo Santa Catalina de Guale designated Pueblos South (II) and North (IV) (fig. 5.1). The pueblo was given a temporary designation of AMNH441 during the transect survey (Reitz and Dukes, 2008; Thomas, 1987, 2008b: 579–580; see chap. 2). Pueblos South and North are located approximately 50 m from Fallen Tree (May, 2008), which is a sector in the pueblo reported previously (Reitz and Dukes, 2008). Fallen Tree, Pueblo South, and Pueblo North are all sectors in the same Guale village, with each designation indicating their location in the archaeological grid (see chap. 2). Fallen Tree is separated from the rest of the pueblo by a freshwater creek. Vertebrate remains from Pueblo Santa Catalina de Guale were identified by C. Fred T. Andrus and Daniel Weinand.

Faunal remains from Fallen Tree were recovered using 6.35 mm mesh (1/4-inch) by Thomas in 1980 and using 3.18 mm mesh (1/8-inch) by Alan May in 1983 (May, 2008; Reitz, 2008; Reitz and Dukes, 2008). The faunal data from that portion of the pueblo are reported elsewhere (Reitz and Dukes, 2008) and summarized in this monograph.

Auger testing of Pueblo South and Pueblo North sectors in 1990 and 1991 and excavations in 1992–1993 were conducted by Joe Jimenez under the direction of Thomas. Animal remains from these two sectors were recovered by sieving through 3.18 mm (1/8-inch) mesh. MNI is estimated separately for the two sectors, with observations from units and levels within each sector combined.

MATERIALS: AUGER SURVEY AND MISCELLANEOUS CONTEXTS

Faunal data also are available from a power auger survey, trenching of the general mission area, as well as miscellaneous excavation units inside the mission compound (fig. 5.1; Thomas, 1987: 110–116). A 3.18 mm (1/8-inch) mesh was used to screen these materials. The mission and pueblo were occupied throughout the 17th century; therefore, the auger and miscellaneous context data are interpreted as evidence of general subsistence activities (commensal animals notwithstanding) during the 17th century.

An intrasite sampling program was initiated in 1980 to define the boundaries of the Santa Catalina de Guale site. Auger testing was performed across the entire mission area covering what subsequently proved to be both the Mission and Pueblo Santa Catalina de Guale (Thomas, 1987: 114–116). Although some pueblo contexts are included in the auger assemblage, most of the samples are from mission contexts in Quad IV and the trench materials were recovered from the mission area of Quad IV, as well, in 1984.

Animal remains from the miscellaneous excavation unit contexts (referred to elsewhere as "Uncombined samples;" see appendices D and E; Pavao and Reitz, 1998) are primarily from Quad IV, but include some materials from Quads II and III (Thomas, 1987: 112–115, 143). The Quad IV animal remains are primarily from units in and around the church (Structure 1) and cocina (Structure 2), but some materials are associated with the friary (Structure 4).

MNI was estimated separately for the auger survey assemblage and the miscellaneous context assemblage to allow for a comparison between the two. A list of the samples studied is included in the study reports (Dukes, 1993; Pavao and Reitz, 1998; Weinand, 1997; Weinand and Reitz, 1995). Identifications of the faunal materials from the auger survey and miscellaneous contexts were made by Alana Lynch, Charlene Keck, and Barnet Pavao-Zuckerman.

APPENDIX B

THE NATURAL HISTORY OF THE SOUTHERN GEORGIA BIGHT AND THE CAROLINA PROVINCE

The geographical focus of this monograph is on the tidewater reaches of the Atlantic coast that include the sea islands and adjacent mainland of the Georgia Bight (fig. 1.2; Reitz et al., 2008). The Georgia Bight is a large embayment extending along the southeastern Atlantic coast of the United States from Cape Fear, North Carolina to Cape Canaveral, Florida (Frey and Howard, 1986; Hubbard et al., 1979). Our focus is on the southern portion of the Georgia Bight between St. Catherines Island and St. Augustine. St. Catherines Island is one of the largest islands in a series of barrier or sea islands separating the inshore and offshore waters of the western Atlantic from a system of tidal creeks, sounds, and salt marshes lying between the sea islands and the mainland. Tidal forces influence estuarine waters with highly variable ranges in temperature, salinity, turbidity, and other biogeophysical characteristics. At the southern end of this region, St. Augustine lies behind Anastasia Island, a much smaller barrier island and one of the last in the chain.

The geological and natural history of this region, and of St. Catherines Island in particular, are reviewed in more detail elsewhere (Johnson et al., 1974; Linsley et al., 2008; Reitz, 1988; Reitz et al., 2008; Thomas, 2008a: 42–47; Thomas et al., 2008). Highlights of those reviews are provided here in order to define terminology used in this monograph, but for a more detailed description of this area the reader is referred to Sydney Johnson et al. (1974).

In addition to the inherent, diachronic environmental complexity of the southern Georgia Bight, synchronic changes in mean sea level, marsh configuration, and island evolution are additional components of life in the region (e.g., Linsley et al., 2008; Thomas, 2008a: 42–47; Thomas et al., 2008). The evolution of estuaries and islands is a product of long-term isostatic and eustatic sea-level changes, sedimentation, distance from fluvial sources, shoreline configurations, littoral drift, aeolian sand accumulation rates, storm processes, and the migration of tidal inlets (DePratter and Howard, 1981; Dolan et al., 1980; Liu, 2004; Oertel, 1979). Island evolution and sea-level rise and fall are well-known for this area but, with few exceptions, details for specific locations within the Georgia Bight are generally unavailable (DePratter and Howard, 1981; Linsley et al., 2008; Thomas et al., 2008). Changes in sea level, particularly those associated with other biogeophysical characteristics, are important forcing mechanisms in this area.

THE ATLANTIC COASTAL PLAIN AND THE GEORGIA BIGHT

The mainland portion of this region, the Atlantic coastal plain, is a low, flat region consisting of well-drained, gently rolling hills and poorly drained flatwoods (Shelford, 1974: 57–88; Wharton, 1977). The coastal plain extends from the Fall Line, the old Mesozoic shoreline marked by a line of sand hills, east to the Atlantic Ocean and southwest to the Gulf of Mexico (fig. 1.2; Johnson et al., 1974: 3). The coastal plain in Georgia is as much as 300 km wide. The sediments are of marine origin and soils have low native fertility due to excessive leaching. The lower coastal plain is a tidewater

zone that includes the mainland portions of coastal rivers influenced by tides as well as the lower reaches of estuaries and their associated salt marshes and islands. The portion of the lower coastal plain that experiences tidal flow and brackish waters is referred to as the coastal zone (Wharton, 1977: 60).

The coastal plain also is referred to as the Pine Barrens sector (Larson, 1980: 35). On well-drained soils the dominant plant species are long-leaf pine (*Pinus palustris*), loblolly pine, (*P. taeda*), and several species of oak (*Quercus* spp.). On poorly drained soils the dominant species are long-leaf pine *(P. palustris*) and slash pine (*P. elliottii*) with a dense ground cover of saw palmetto (*Serenoa repens*), gallberry (*Ilex* spp.), and wire-grass (*Aristida stricta*). These plants are adapted to a humid subtropical climate of mild winters, hot summers, high rainfall, and frequent ground fires.

Other plant communities are found on the coastal plain. The Southern Mixed Hardwood community includes live oak (*Q. virginiana*), laurel oak (*Q. laurifolia*), sweet gum (*Liquidambar styraciflua*), magnolia (*Magnolia grandiflora*), red bay (*Persea borbonia*), pignut hickory (*Carya glabra*), and cabbage palm (*Sabal palmetto*). Hardwood communities border the numerous freshwater streams, floodplain swamps, and low, fertile areas near the coast. Wooded swamps composed principally of cypress (*Taxodium ascendens*), gum (*Nyssa* spp.), and red maple (*Acer rubrum*) are found adjacent to ponds and lakes as well as along sluggish, meandering streams.

St. Catherines Island shares similar Pleistocene and Holocene histories and physiographic characteristics with neighboring sea and marsh islands (Frey and Howard, 1986; Hayden and Dolan, 1979; Hoyt, 1967; Hoyt and Hails, 1967; Johnson et al., 1974: 11; Linsley et al., 2008; Wenner et al., 1979; Wenner et al., 1980). The island consists of Pleistocene barrier remnants and active Holocene beaches. Today, the estuary that separates St. Catherines Island from the landward marsh islands to the west is approximately 6 km wide. St. Catherines Island itself is approximately 16.4 km long north to south, 5.5 km wide at its widest point, and its maximum elevation is about 6 m above mean low tide (Thomas, 2008a: table 11.3). The major plant communities are maritime oak forests and pine forests. Oak forests are dominated by live oak associated with cabbage palm and a low, woody understory. Pine forests occupy the better-drained portions of the island (Johnson et al., 1974: 49) and low, sandy beaches border the seaward edge.

Michael Dahlberg (1975: 4–10) defines two major marine habitats in the Georgia Bight: the offshore zone and the inshore zone. The offshore zone encompasses the broad, shallow continental shelf that lies east of the sea island beaches. There is little evidence that the offshore zone was used for subsistence-related activities before or during the First Spanish period (Reitz et al., 2009; see chap. 3). The inshore zone includes the waters immediately bordering the beaches on the seaward side of the islands and the estuaries between the islands and the mainland.

Estuaries are characterized by mud flats, oyster bars, salt marshes, mazes of tidal creeks, and deep sounds fed by rivers that drain the adjacent mainland. Although protected from the ocean by the sea islands, estuaries are subject to regular tidal fluctuation through the inlets 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 with a range of 1 m to 3 m during the spring (Howard and Frey, 1985; Hubbard et al., 1979; Schelske and Odum, 1961). A spring high tide may produce a 50% increase over mean tide level (Frey and Howard, 1986). The inlets and marshes in Georgia experience the largest tidal ranges in the Georgia Bight because the back bay area is larger and more complex than those in South Carolina or Florida (Hubbard et al., 1979).

Estuaries are divided into upper, middle, and lower reaches based on a salinity gradient (Dahlberg, 1972). Due to storms, freshwater drainage, tidal action, offshore currents, and geographical features, the temperature, salinity, dissolved oxygen, turbidity, and suspended nutrients in estuarine waters are highly variable; thus these divisions lack distinct boundaries (Hackney et al., 1976; Johnson et al., 1974: 86–94). The salinity gradient is greater in estuaries associated with rivers such as the Altamaha River than in estuaries into which major rivers do not flow (Frey and Howard, 1986). Salinity is highly variable depending on location within each estuary (Dahlberg, 1972). The upper reaches of estuaries (farther from the open sea) have the lowest salinity, with ranges between 0.3 to 18.7 ppt and the middle reaches have a range of 11.7 to 29.0 ppt (Dahlberg, 1972). During

years of drought upstream, high-salinity waters and associated organisms may be found as far as 40 km inland (Frey and Howard, 1986). Likewise, when the flow of freshwater is particular strong, for example during floods, low-salinity waters and organisms may be found far out into the estuaries. Because of the low and fluctuating salinity levels in estuaries, they are ecological barriers that protect developing fish and shellfish from the diverse array of predators found in the inshore and offshore zones beyond the sea islands (Weinstein, 1979). For this reason, estuaries are important nursery grounds for fishes and shellfishes.

ANIMALS OF THE CAROLINA PROVINCE

The marine waters between Cape Hatteras or Cape Fear, North Carolina, and Anastasia Island or Cape Canaveral, Florida, form a transitional biogeographical province between the tropical fauna of the Caribbean and the temperate fauna of the Middle Atlantic (Briggs, 1974: 214–218; Ekman, 1953: 46–49). This area is known as the Carolina province and corresponds along most of its length with the Georgia Bight. Although species abundance may fluctuate from one season to another, individuals of many species are found inshore throughout the year. Seasonal variations in some species correlate with salinity rather than temperature, both of which can change dramatically at any given location within just a few hours (Hackney et al., 1976). More species may be present in such fluctuating environments than in stable ones (Hackney et al., 1976). There is a gradual change in fish species abundance from the northern end of the Carolina province to the southern end, but species composition remains the same throughout (Bearden, 1961; Dahlberg, 1972; Freeman and Walford, 1976; Mahood et al., 1974). Although some variation in Native American and Spanish fishing strategies might have occurred within the Carolina province, the differences would not have been as great as those between the Carolina province and the Middle Atlantic province to the north or the Caribbean province to the south.

Marine vertebrates typical of archaeological sites in the region are primarily members of the sea catfish (Ariidae) and drum (Sciaenidae) families but also include sharks and rays (Chondrichthyes), gars (*Lepisosteus* spp.), sheepsheads (*Archosargus probatocephalus*), mullets (*Mugil* spp.), and flounders (Pleuronectiformes). The term *fishes* is used throughout this monograph to refer to both cartilaginous and ray-finned (formerly bony) fishes. The fishes prominent in native and immigrant diets are described in greater detail below.

Cartilaginous sharks and rays are frequent in inshore waters and in archaeological collections. Most sharks are found only during the warm months of the year. Sharks are more common along beaches and in the lower reaches of estuaries than in middle or upper reaches (Dahlberg, 1972). Rays are found in a variety of salinity conditions and are present in estuaries either year-round or only during warm months, depending on the species (Dahlberg, 1975: 28–31; DEIS, 1978: D426).

Gars are primarily freshwater fishes and are found year-round throughout Florida and Georgia. One member of this family also is found in estuaries. Longnose gars (*Lepisosteus osseus*) are sometimes observed in estuarine waters, especially in stream mid-channels just below the surface. They are air-breathers and thus must surface at intervals to breathe. This carnivore forms large schools. Gars today are often captured in nets and trawls and are considered pests by fishermen because they damage nets and have no commercial value (Manooch, 1984: 32–33).

Sea catfishes are very common in the estuarine environment. The hardhead catfish (*Ariopsis* [*Arius*] *felis*) is more common than the larger gafftopsail (*Bagre marinus*) and tolerates a greater range of salinities than does the gafftopsail. Sea catfishes are present in the inshore area year-round, though most leave briefly during periods of cold weather for deeper waters where temperatures are more stable and warmer (Dahlberg, 1972). Both the hardhead and the gafftopsail are bottom feeders, living as scavengers, but at night they may rise to the surface in large numbers to feed (McLane 1955: 104). They also are attracted to refuse dumped into the bay.

Sheepsheads are common, year-round residents of the inshore area. They are gregarious, clustering near the bottom around jetties and pilings where they feed on invertebrates.

Members of the drum family are common in coastal habitats and often are the most common vertebrate forms in archaeological sites. Silver perches (*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 than inside bays. Weakfishes (*C. regalis*) may leave estuaries during cold months of the year (Dahlberg, 1972) but spawn inshore (Powles and Stender, 1978). Spots (*Leisotomus xanthurus*), found in the inner bay during warm months, spawn offshore during the winter months (Powles and Stender, 1978). The Atlantic croaker (*Micropogonias undulatus*) is a common drum found throughout the coastal habitat in the warmer months. Adults leave the estuary to spawn offshore in the cool months 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. Red drums spawn in coastal waters near shore (Powles and Stender, 1978) but otherwise are present inshore year-round. Star drums (*Stellifer lanceolatus*) are small drums that are found in greatest numbers in the summer and fall.

Mullets and flounders are also part of the estuarine fauna. Mullets are herbivorous fishes with small mouths. Due to their herbivorous habits, they rarely take hooks. Large schools of mullets occur throughout the inshore area and in brackish waters. By day, schooling mullets are active in the mid-channels of bays and larger tidal creeks. They frequently follow tides into smaller creeks. Roe or striped mullets (*Mugil cephalus*) spawn along beaches from September through April and are considered, along with gafftopsail catfishes, whitings, and croakers, to be one of *the* surf fishes. White mullets (*M. curema*) spawn between March and September and prefer waters with higher salinity (Dahlberg, 1972). Many of the young, small mullets are found in shallow, brackish waters though adults prefer slightly deeper, more stable conditions. Adults, depending on the species, may be present throughout the year, but when temperatures drop below 7°C, even striped mullets seek warmer waters (Dahlberg, 1972). Flounders are bottom-dwelling carnivores that are active over mud flats where they actively feed at night. Flounders may be present throughout the year depending on the species.

The invertebrates found in archaeological sites in the Carolina province are those from shallow, estuarine waters in marshes and oyster beds, as well as from sandy bottoms and mud flats. These invertebrates include shrimp (*Penaeus* spp.), Atlantic ribbed mussels (*Geukensia demissa*), oysters (*Crassostrea virginica*), stout tagelus (*Tagelus plebeius*), Carolina marsh clams *(Polymesoda caroliniana*), hard clams (*Mercenaria* spp.), marsh periwinkles (*Littorina irrorata*), whelks (*Busycon* spp.), and eastern mudsnails (*Ilynassa obsoleta*).

Many of the mammals and birds in this area are closely affiliated with salt marshes, tidal creeks, and wetlands. Opossums (*Didelphis virginiana*) and raccoons (*Procyon lotor*) are omnivorous, primarily nocturnal, mammals found in a variety of habitats, usually near water. Both forage in coastal marshes. Rabbits (*Sylvilagus* spp.) are crepuscular vegetarians usually found in low-lying damp areas. Squirrels (*Sciurus* spp.) are active diurnal feeders usually found near trees in forests or bottom lands. White-tailed deer (*Odocoileus virginianus*) feed in forest edge settings but also graze in salt marshes. They are most active at dawn and dusk. Abundant deer were cited as evidence for the bounty of the Americas by English settlers in New England (Anderson, 1971: 79). Deer may have been considered prestigious by Spanish colonists as well, especially those born in Spain where hunting was restricted to the nobility (Townsend, 1814: 370–371; see also Pluskowski, 2007; R. Thomas, 2007). Deer were absent from Caribbean islands, so colonists coming from Caribbean posts might have been impressed by deer in Spanish Florida. Turkeys (*Meleagris gallopavo*) are found in the terrestrial environment, but often are associated with damp, swampy locations. Herons (Ardeidae), ducks (Anatidae), and rails (Rallidae) are found almost exclusively in aquatic locations. Most of these animals, including some of the birds, raid gardens and forage in fields. Some also raid food stores and trash deposits.

Reptiles are the most diverse class of animals in terms of habits and habitat preferences. Snapping turtles (*Chelydra serpentina*), musk turtles (Kinosternidae), pond turtles (Emydidae), and softshell turtles (*Apalone ferox*) are common freshwater turtles, and some are found in estuarine waters, as are alligators (*Alligator mississippiensis*). Alligators also frequent seaward beaches. Diamondback terrapins (*Malaclemys*

terrapin) are particularly prominent among the salt marsh animals. Box turtles (*Terrapene carolina*) are small emydid turtles found in open woodlands near quiet bodies of water. During nesting season, turtles also are found on land. Gopher tortoises (*Gopherus polyphemus*) build extensive burrows in the dry, sandy soils of the dunes that border the seaward edge of the coastal mainland and some sea islands (Franz and Quitmyer, 2005). Sea turtles (Cheloniidae) nest on the seaward side of the sea islands during the summer and feed in the estuaries.

EURASIAN ANIMALS

Important additional animal resources were introduced to the Americas as part of the Columbian Exchange (Crosby, 1972, 1986; see appendix A for a discussion of the taxonomy of domestic animals). Prior to that time, dogs (*Canis familiaris*) were the only domestic animals in what later became Spanish Florida. Colonists brought with them a suite of domestic animals, including cats (*Felis catus*), donkeys (*E. asinus*), horses (*Equus caballus*), pigs (*Sus scrofa*), cattle (*Bos taurus*), goats (*Capra hircus*), sheep (*Ovis aries*), and chickens (*Gallus gallus*). It is common to refer to these animals as "European" but, in fact, they were all domesticated in Asia or Africa and introduced into Europe during the Neolithic period (Reitz, 1992a; Reitz and Wing, 2008: 291–292). This suite of animals, therefore, shares a common pioneer heritage. In order to reinforce the pioneer ancestry of these animals, we refer to this suite as "Eurasian" or "European-introduced" rather than as "European."

As people transplanted these animals into many novel environmental settings, the animals adapted to changes in animal husbandry strategies and feeding opportunities with various degrees of success (e.g., Gifford-Gonzalez and Sunseri, 2007). This success was, in part, related to forage quality and quantity, heat, humidity, diseases, and predators in each setting. In Spanish Florida, the primary husbandry strategy was to turn these animals loose to fend for themselves (Reitz, 1992a; Reitz and McEwan, 1995). Some animals were able to survive under this regime and others were not. Pigs, cattle, sheep, goats, and chickens all had unique biological requirements that enabled or discouraged their success in each colonial setting (e.g., Dahl and Hjort, 1976; Williamson and Payne, 1978). Pigs and, eventually, cattle appear to have flourished in the warm, subtropical setting of Spanish Florida; sheep and goats did not (Reitz, 1992a).

Spanish Florida was colonized very early with animals that were either from the Mediterranean climate of the Iberian Peninsula, the arid Canary Islands, or the tropical Caribbean archipelago (Deagan and Reitz, 1995; Reitz, 1992a). The Caribbean archipelago offered a unique experience that is reviewed at length elsewhere (Deagan and Reitz, 1995). None of these settings prepared Eurasian animals for their encounter with Florida. These immigrant animals flourished in colonial settings only to the extent that their biological requirements were met. High temperatures and humidity, poor-quality graze, human and nonhuman predators, mineral deficiencies, screwworm, fever ticks, competition from deer, and inexperienced herders were among the hurdles Eurasian animals had to overcome in Spanish Florida.

Many animals failed to thrive, though a reliable suite of livestock emerged after a period of time. The success of these animals was different in each colonial setting of the Spanish Americas and probably explains, to a great extent, the different outcomes as colonists endeavored to develop viable industries in meats, hides, and other animal by-products in each location.

Free-ranging, feral, or wild pigs are resourceful and dangerous animals (Gray, 1933: 206). Under such circumstances, they are nocturnal and gregarious. They prefer moist bottomlands where they feed on seeds, roots, fruits, nuts, mushrooms, snakes, larvae, worms, eggs, carrion, mice, and small mammals. Their introduction to the Georgia Bight almost certainly is associated with increased predation on sea turtle eggs (Ernst and Barbour 1972: 237). Pigs gain weight rapidly and store 35% of the calories they consume (Towne and Wentworth, 1950: 7–8). Their reproductive rate is also high. Pigs frequently raid fields and gardens, and also eat kitchen refuse and feces. Confining pigs and otherwise keeping them out of gardens can be a challenge. For example, Cáceres (1574) observed 50 wild and skinny pigs running loose in St. Augustine. Many of the pigs in Spanish Florida assemblages were probably hunted rather than raised in the traditional domestic sense. Native farmers finding pigs raiding their gardens and fields likely shot them.

Cattle in parts of Spain were tough, resourceful, and adapted to hot, open range environments

where pasturage was low in nutrients and scarce. These cattle became the criollos of the Spanish Americas (Rouse, 1973: 364-374, 1977: 14). Cattle initially had some difficulty adapting to Spanish Florida, but eventually flourished, especially in Apalachee province (Hann, 1986b: 200). Early accounts describe the soils and climate of Apalachee as rich compared to conditions in Timucua and Guale provinces. The cattle of Spanish Florida were considered superior to cattle in the English Carolinas and cattle rustling was a common complaint made against the Carolina colonists and their allies by missionaries and ranchers of 17th-century Spanish Florida (Arnade, 1961; Bushnell, 1978b; Griñán, 1757; Hann, 1986b: 200). The reported superiority of the Spanish cattle was not simply hyperbole. Spanish Florida cattle were larger than cattle in the English town of Charleston (fig. 1.2), though about half the size of their probable Caribbean ancestors (Reitz and Ruff, 1994). Annual cattle roundups were conducted following a tradition in parts of Spain where cattle were raised for meat and hides rather than for their labor (Bishko, 1952; Rouse, 1977: 3). In the 17th and 18th centuries, there was some demand for cheese and milk in Spanish Florida (Boyd et al., 1951: 25; Harman, 1969: 83–88). Cattle also raid fields and gardens (Cáceres, 1574; García, 1902: 206), and their management would have been a challenge to farmers unaccustomed to building corrals to keep cattle in or fencing the fields to keep them out.

Sheep and goats were not successful in Spanish Florida. Pedro Menéndez de Aviles brought sheep and goats with him when he established the colony (Lyon, 1976: 183, 1977), but these animals did not thrive (Cáceres, 1574). Colonists in later years in Spanish Florida particularly disliked sheep because they did not defend themselves against wild dogs and wolves and would not reproduce freely (Thompson, 1942: 211). As the preferred animal husbandry technique was to turn animals loose, these were obvious drawbacks. These deficiencies also were compounded by biological constraints; for example, male sheep are sterile for about a year after being transferred from a temperate to a tropical setting, and do not breed well thereafter (Williamson and Payne, 1978: 19). Goats fared better than sheep because they would defend themselves against carnivores (Bonner, 1964).

Chickens are often cited as animals that should be common in Spanish and Native American contexts. Predators such as opossums, raccoons, dogs, foxes (*Urocyon cinereoargenteus*), raptors, and snakes take a heavy toll on chickens and their eggs, however. Free-ranging chickens roost 6 to 15 m above the ground and nest in out-of-the-way places. Such behaviors do not facilitate catching chickens or collecting their eggs. It is possible that chickens are underrepresented in zooarchaeological collections if eggs were the primary product used, but it is more likely that eggs and chickens were seldom used. Without year-round lighting, most hens lay eggs only in the summer when daylight is plentiful. Chickens can be kept close by feeding them table scraps and Spaniards even fed them shellfish (Cáceres, 1574). The people most likely to have fed and protected chickens as part of a daily routine were friars, and it is in their trash deposits that we find chickens to be more common. Chickens were very expensive in St. Augustine, costing at one time as much as 8 to 10 reales (Geiger, 1937), so it could be that chickens were a status marker for the religious elite in Spanish Florida.

Colonists also were accompanied by some nondomesticated animals. Chief among these were Eurasian members of the Muridae subfamily Murinae: the house mouse (*Mus musculus*), the Norway rat (*Rattus norvegicus*), and the black rat (*R. rattus*). These rodents joined preexisting and vibrant members of the Muridae subfamily Sigmodontinae that are indigenous to the region.

APPENDIX C

SPECIES LISTS FOR THE COCINA (STRUCTURE 2), GARDEN/WELL (STRUCTURE 2/4), AND THE FRIARY (STRUCTURE 4) AT MISSION SANTA CATALINA DE GUALE

These structures are part of the Eastern Plaza Complex. Although an estimate of Minimum Number of Individuals (MNI) is provided for each structure, MNI was recalculated for the Eastern Plaza Complex using the minimum distinction method that is reported in chapter 5. Common names are provided in the Eastern Plaza Complex species list (table 5.9).

TABLE C.1
Mission Santa Catalina de Guale: the Cocina (Structure 2) Species List

Taxa	NISP	MNI	Wt. (g)
Indeterminate mammal	12290	—	5930.66
Blarina carolinensis	1	1	0.04
Scalopus aquaticus	19	3	0.88
Sylvilagus spp.	86	5	31.63
Sylvilagus cf. *aquaticus*	2	—	0.97
Sciurus spp.	191	5	31.25
Sciurus carolinensis	33	—	5.47
Sciurus niger	1	—	1.1
Sigmodontinae	7	—	0.13
Oryzomys palustris	2	1	0.12
Peromyscus sp.	1	1	0.02
Indeterminate carnivore	2	—	0.24
Canis familiaris	18	1	8.57
Procyon lotor	60	4	69.58
Felis catus	1	1	0.01
Artiodactyla	828	—	1490.17
Sus scrofa	212	5	783.78
Odocoileus virginianus	1122	26	7002.31
Indeterminate bird	2799	—	352.111
Ardea herodias	2	1	0.78
Casmerodius albus	1	1	1.08
Mycteria americana	3	1	10.47
Anatidae	2	—	4.34
Branta canadensis	3	1	1.05
Phasianidae	52	—	6.62

TABLE C.1 — (*Continued*)

Taxa	NISP	MNI	Wt. (g)
Gallus gallus	1098	24	494.87
Rallus sp.	1	1	0.21
Grus canadensis	2	1	6.7
Passeriformes	3	—	0.06
Muscicapidae	1	1	6.73
Mimidae	1	1	0.2
Emberizidae	1	—	0.05
Cardinalis cardinalis	1	1	0.05
Alligator mississippiensis	1	1	7.07
Indeterminate turtle	642	—	161.781
Chelydra serpentina	1	1	0.23
Kinosternon spp.	25	2	5.29
Emydidae	68	—	27.08
Deirochelys reticularia	1	1	0.41
Malaclemys terrapin	483	10	525.93
Terrapene carolina	1	1	1.31
Gopherus polyphemus	1	1	1.2
Indeterminate lizard	5	—	0.21
cf. *Ophisaurus* spp.	44	1	0.66
Indeterminate snake	3	—	0.05
Colubridae	24	1	0.95
Indeterminate toad/frog	73	—	2.85
Scaphiopus holbrookii	7	2	0.33
Bufo spp.	39	4	6.48
Rana spp.	6	1	0.11
Odontaspis taurus	1	1	0.11
Carcharhinidae	2	—	0.62
Galeocerdo cuvier	2	1	0.7
Squaliformes	2	—	1.27
Rajiformes	1	—	0.01
Dasyatis spp.	19	1	0.55
Indeterminate fish	9784	—	256.139
Siluriformes	131	—	9.56
Ariidae	259	—	26.031
Ariopsis felis	533	24	85.73
Bagre marinus	139	4	51.11
Sciaenidae	11	—	3.02
Bairdiella chrysoura	3	1	0.32
Cynoscion spp.	19	3	3.0
Cynoscion nebulosus	40	—	4.58
Pogonias cromis	75	3	30.23
Sciaenops ocellatus	13	3	14.14
Stellifer lanceolatus	1	1	0.1
cf. *Mugil* spp.	10	—	0.025
Mugil spp.	646	18	41.531
Paralichthys spp.	13	1	5.29
Indeterminate vertebrate	—	—	1468.943
Total	31974	173	18987.201

TABLE C.2
Mission Santa Catalina de Guale: the Garden and Well (Structure 2/4) Species List

Taxa	NISP	MNI	Wt. (g)
Indeterminate mammal	3440	—	964.185
Scalopus aquaticus	1	1	0.01
Homo sapiens	3	1	0.64
Sylvilagus spp.	2	1	0.96
Sciurus sp.	1	1	0.5
Procyon lotor	1	1	8.15
Artiodactyla	59	—	54.05
Sus scrofa	64	3	169.49
Odocoileus virginianus	216	5	758.62
Indeterminate bird	52	—	8.963
Gallus gallus	18	3	11.93
Columbidae	1	1	0.13
Emberizidae	1	1	0.001
Indeterminate turtle	122	—	20.764
Kinosternidae	1	1	0.07
Emydidae	15	—	8.4
Malaclemys terrapin	108	2	70.4
Indeterminate toad/frog	2	1	0.06
Chondrichthyes	1	—	0.01
Carcharhinidae	1	1	0.1
Indeterminate fish	1228	—	23.273
Siluriformes	25	—	2.17
Ariidae	106	—	6.847
Ariopsis felis	96	8	16.227
Bagre marinus	23	3	5.09
Perciformes	1	—	0.02
Archosargus probatocephalus	1	1	0.09
Sciaenidae	1	—	0.01
Cynoscion spp.	7	2	0.95
Pogonias cromis	13	1	1.67
Sciaenops ocellatus	5	2	2.46
Mugil spp.	85	3	3.838
Indeterminate vertebrate	—	—	124.225
Total	5700	43	2264.303

TABLE C.3
Mission Santa Catalina de Guale: the Friary (Structure 4) Species List

Taxa	NISP	MNI	Wt. (g)
Indeterminate mammal	2982	—	967.6
Sylvilagus spp.	10	1	2.16
Indeterminate rodent	3	—	0.25
Sciurus carolinensis	2	2	1.15
Sigmodontinae	5	—	0.17
Peromyscus spp.	2	1	0.33
Cetacea	1	—	251.8
Delphinidae	8	1	87.2
Procyon lotor	75	1	91.56
Artiodactyla	32	—	37.69
Sus scrofa	425	2	287.95
Odocoileus virginianus	265	6	1213.21
Indeterminate bird	271	—	36.471
Butorides striatus	1	1	0.7
Anas sp.	1	1	0.7
Gallus gallus	27	4	26.04
Corvus ossifragus	1	1	0.25
Emberizidae	2	1	0.3
Indeterminate turtle	272	—	37.77
Kinosternon subrubrum	1	1	0.1
Emydidae	3	—	1.05
Malaclemys terrapin	134	7	74.58
Colubridae	3	1	0.3
Indeterminate toad/frog	4	—	0.4
Scaphiopus holbrookii	1	1	0.1
Bufo spp.	11	2	1.1
Rana sp.	1	1	0.1
Chondrichthyes	1	—	0.04
cf. Lamnidae	3	1	1.02
Carcharhinidae	2	—	0.301
Carcharhinus sp.	1	1	0.35
Rajiformes	1	1	0.03
Indeterminate fish	652	—	29.538
Lepisosteus spp.	6	1	2.29
Siluriformes	20	—	3.2
Ariidae	37	—	4.052
Ariopsis felis	168	11	29.36
Bagre marinus	15	2	4.3
Perciformes	6	—	0.4
Archosargus probatocephalus	4	1	0.49
Sciaenidae	3	—	6.8
Cynoscion spp.	6	1	0.491
Pogonias cromis	19	1	3.17
Mugil spp.	44	1	3.12
Paralichthys sp.	1	1	0.1
Indeterminate vertebrate	—	—	50.681
Total	5532	57	3260.764

APPENDIX D

VERTEBRATE FAUNA FROM THE AUGER SURVEY AND MISCELLANEOUS CONTEXT ASSEMBLAGES

Vertebrate fauna from Santa Catalina de Guale were collected using several different excavation strategies over the past three decades (see chap. 2). Prior to formal excavations, an extensive intrasite auger survey and trench testing program was conducted (fig. 5.1; Thomas, 1987: 108–117). The goals of the survey and testing program were to locate and define the boundaries of Mission Santa Catalina de Guale. Once the mission compound was broadly defined, additional miscellaneous units were excavated to refine the survey results. Subsequently, the focus of the project turned to the church (Structure 1) and Eastern Plaza Complex (Structures 2, 2/4, and 4).

Faunal remains were recovered during all of the preliminary tests. Because materials from the auger survey, trench testing, and miscellaneous excavation units were recovered prior to the extensive excavations inside the mission compound and within Pueblo Santa Catalina de Guale, these materials cannot be associated specifically with the church, the Plaza Complex, or the pueblo. Therefore, the auger survey, trench testing, and miscellaneous excavation units are not included in the studies reported in chapters 5 and 6.

Materials from the auger survey, trench testing, and miscellaneous units provide the opportunity to explore the effect of sampling methodology on interpretations of human subsistence behavior. In this appendix, the auger survey and trench testing assemblage is compared to the miscellaneous excavation assemblage to determine whether either sampling strategy reflects the patterns observed in the much larger Santa Catalina de Guale assemblages.

METHODS

The excavations that produced the vertebrate samples reported here were conducted in the 1980s (Thomas, 1987: 111–116; see chap. 2 and appendix A). These materials are treated separately because they extend beyond the bounds of the mission compound and pueblo reported in chapters 5 and 6 and because the methods used to recover these materials were different from those used during the more extensive excavations of the mission compound and pueblo. Details of the intrasite sampling program are reviewed in appendix A. (Also see appendix A for a discussion of commensal taxa and the other zooarchaeological methods used in this study.)

The materials reported here were recovered during auger and trench testing, and from miscellaneous excavation units. Intrasite auger tests were made across the entire site, covering what subsequently proved to be both Mission and Pueblo Santa Catalina de Guale (Thomas, 1987: 112–116, 143). Although some pueblo contexts are included in the auger assemblage, most of the samples are from Spanish contexts in Quad IV. The trench materials were excavated from the mission area of Quad IV in 1984. The auger survey and trench test materials are referred to as the *auger survey assemblage* hereafter.

The materials from the miscellaneous excavation unit contexts (referred to by Pavao and Reitz [1998] as "Uncombined samples") were excavated primarily from Quad IV, but include some animal remains from Quads II and III (Thomas, 1987: 112–115, 143). The Quad

IV animal remains are primarily from units in and around the church (Structure 1) and cocina (Structure 2), but some materials are from near and inside the friary (Structure 4).

The mission compound and pueblo were occupied during most of the 17th century. Therefore, the auger and miscellaneous contexts data are interpreted as evidence of general subsistence activities by Spanish and Guale residents during the 17th century, infiltrated by commensal animals.

RESULTS: AUGER SURVEY ASSEMBLAGE

The auger survey assemblage is small. It contains 754 specimens (NISP), the remains of an estimated 15 Minimum Number of Individuals (MNI), and weighs 731.63 g (table D.1). MNI is estimated for 13 taxa. Noncommensal, domesticated taxa are represented by a single pig (*Sus scrofa*). White-tailed deer (*Odocoileus virginianus*) contributes a significant amount of biomass, though the remains of only one deer are present. Fishes are well-represented in the auger survey assemblage, contributing 27% of the individuals; however, they are responsible for only 2% of the biomass (table D.2). An unusual aspect of this assemblage is the presence of a freshwater bowfin (*Amia calva*). Commensal taxa, consisting of two, almost-complete, dog (*Canis familiaris*) burials and a non-venomous snake (Colubridae), constitute 20% of the individuals in the auger survey assemblage and 46% of the biomass. The MNI diversity of the assemblage is moderate ($H' = 2.523$) and the assemblage is highly equitable ($V' = 0.984$).

In terms of both MNI and biomass, dog dominates the assemblage. An almost complete dog skeleton was recovered from Unit 200N 195W in Quad IV, the mission compound. A second dog burial was found at 60N 20W in Quad XX, immediately west of the mission compound. It is not known if these dogs are from an indigenous or a Eurasian breed.

Evidence for carcass transport and age at death is limited in the auger survey assemblage and there is no evidence for the sex of any taxon. Four pig specimens were recovered (table D.3). Three of these specimens are tooth fragments and the fourth is a distal humerus fragment. Age could not be estimated for the pig individual. A wide range of deer elements is represented, despite the taxon's low specimen count (fig. D.1). Over a third (NISP = 18) of the deer specimens are tooth fragments; however, the deer specimens suggest a fairly high degree of skeletal completeness, with specimens recovered from all portions of the skeleton. The deer individual was an adult at the time of death (table D.4).

Modifications in the assemblage are primarily attributable to weathering and burning (table D.5). Modifications are observed on 18% of specimens (NISP = 135) identified at some level other than Indeterminate vertebrate, and 32 of the Indeterminate vertebrate specimens also are modified. Weathering was noted on 102 specimens and 58 specimens are burned. No decorative or worked specimens are present, though three specimens were grooved and snapped for an unknown purpose.

RESULTS: MISCELLANEOUS CONTEXT ASSEMBLAGE

The miscellaneous assemblage includes 7732 specimens (NISP), weighing 6200.86 g, and contains the remains of an estimated minimum of 80 individuals (table D.6). MNI is estimated for 43 taxa. Four domestic animals are present in the assemblage: a possible horse (cf. *Equus caballus*), pigs, a cow (*Bos taurus*), and chickens (*Gallus gallus*). Deer dominate the miscellaneous assemblage both in terms of MNI and biomass (table D.7). The highest MNI is contributed by deer followed by hardhead catfish (*Ariopsis felis*). Fishes are well-represented, contributing 31% of the individuals though only 3% of the biomass. An unusual aspect of this assemblage is the presence of three freshwater fishes (*Amia calva*, *Lepomis* spp., and *Micropterus salmoides*). One alligator (*Alligator mississippiensis*) tooth is present. Commensal taxa represent 14% of the individuals and include one almost complete dog burial. The dog burial was recovered from Feature 207 in the mission compound (Quad IV). Other dog remains are present in the assemblage, though they are not sufficiently complete to characterize them as purposeful burials. The ancestry of these dogs is unknown. The MNI diversity of the miscellaneous assemblage is high ($H' = 3.338$) and highly equitable ($V' = 0.887$).

A wide range of elements is represented in the miscellaneous assemblage (table D.8). The majority of pig specimens are from the head, including 138 tooth fragments (fig. D.2). More than half (NISP = 356) of the deer specimens

TABLE D.1
Mission Santa Catalina de Guale: Auger Survey Species List

			MNI			
Scientific name	Vernacular name	NISP	No.	%	Wt (g)	Biomass (kg)
Indeterminate mammal		308	—	—	202.8	0.324
Sylvilagus sp.	Rabbit	1	1	6.7	0.36	0.003
Canis familiaris	Domestic dog	291	2	13.3	286.28	0.358
Procyon lotor	Raccoon	7	1	6.7	2.45	0.015
Mustela vison	Mink	1	1	6.7	0.6	0.005
Artiodactyla	Even-toed ungulate	17	—	—	18.95	0.075
Sus scrofa	Pig	4	1	6.7	10.81	0.049
Odocoileus virginianus	White-tailed deer	50	1	6.7	131.54	0.267
Indeterminate bird		8	—	—	3.35	0.019
Phalacrocorax auritus	Double-crested cormorant	4	1	6.7	3.51	0.020
Accipitridae	Hawks and eagles	1	1	6.7	0.59	0.004
Indeterminate turtle		29	—	—	9.53	0.044
Emydidae	Pond turtles	1	—	—	0.1	0.001
Malaclemys terrapin	Diamondback terrapin	8	1	6.7	12.02	0.053
Colubridae	Nonvenomous snakes	1	1	6.7	0.1	0.001
Indeterminate fish		8	—	—	0.85	0.006
Amia calva	Bowfin	1	1	6.7	0.09	0.001
Ariopsis felis	Hardhead catfish	13	2	13.3	1.96	0.012
Bagre marinus	Gafftopsail catfish	1	1	6.7	0.1	0.001
Indeterminate vertebrate		—	—	—	45.64	—
Total		754	15		731.63	1.258

TABLE D.2
Mission Santa Catalina de Guale: Auger Survey Summary

	MNI		Biomass	
	No.	%	kg	%
Domestic mammals	1	6.7	0.049	6.2
Domestic birds	—	—	—	—
Deer	1	6.7	0.267	33.8
Other wild mammals	3	20.0	0.023	2.9
Wild birds	2	13.3	0.024	3.0
Turtles	1	6.7	0.053	6.7
Sharks, rays, & fishes	4	26.7	0.014	1.8
Commensal taxa	3	20.0	0.359	45.5
Total	15		0.789	

TABLE D.3
Mission Santa Catalina de Guale: Auger Survey Summary of Elements

Skeletal elements	Pig	Deer
Head	3	23
Vertebra/rib/sternum	—	6
Forequarter	1	7
Forefoot	—	3
Foot	—	6
Hindfoot	—	2
Hindquarter	—	3
Total	4	50

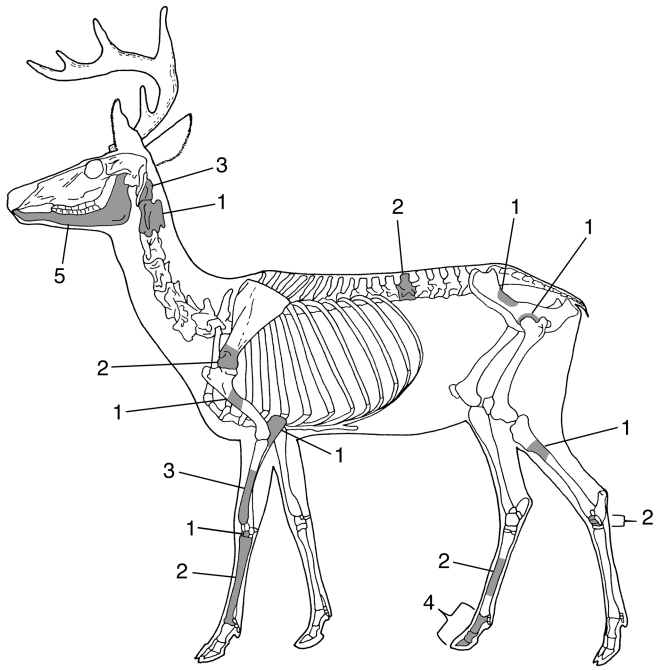

Fig. D.1. Santa Catalina de Guale deer elements from auger survey. NISP = 50 (18 loose teeth not shown). The numbers indicate the number of specimens from that portion of the deer skeleton.

TABLE D.4
Mission Santa Catalina de Guale: Auger Survey Deer Epiphyseal Fusion

Skeletal elements	Unfused	Fused	Total
Early fusing			
Humerus, distal	—	—	—
Scapula, distal	—	1	1
Radius, proximal	—	—	—
Acetabulum	—	1	1
Metapodials, proximal	—	—	—
1st/2nd phalanx, proximal	—	2	2
Middle fusing			
Tibia, distal	—	—	—
Calcaneus, proximal	—	—	—
Metapodials, distal	—	1	1
Late fusing			
Humerus, proximal	—	—	—
Radius, distal	1	—	1
Ulna, proximal	—	—	—
Ulna, distal	—	—	—
Femur, proximal	—	—	—
Femur, distal	—	—	—
Tibia, proximal	—	—	—
Total	1	5	6

are tooth fragments and 22% of the deer specimens are from the forefoot, hindfoot, and foot portions of the skeleton (fig. D.3). Three tooth fragments from a single cow individual also are present. The possible horse is identified from an incisor fragment.

There is some evidence for age at death in the miscellaneous assemblage, but no evidence for the sex of any of the individuals. At least one of the four pig individuals was a subadult at the time of death and the other three were of indeterminate age (table D.9). At least one deer was a juvenile and at least three were adults when they died (table D.10). The age of the cow cannot be estimated. The age of the possible horse is indeterminate.

Modifications in the miscellaneous assemblage are primarily attributable to burning (table D.11). A total of 3958 specimens are burned, comprising over 96% of the modifications. Modifications are observed on 14% of specimens (NISP = 1119) identified at some level other than Indeterminate vertebrate, and 3012 of the Indeterminate vertebrate specimens also are modified.

COMPARING THE ASSEMBLAGES

Comparing the auger survey assemblage with the miscellaneous context assemblage reveals many similarities despite differences in sampling strategies. Both assemblages support similar interpretations of human subsistence behavior at Santa Catalina de Guale. Further, the subsistence strategy indicated by the auger survey and miscellaneous assemblages is very similar to that suggested by the much larger assemblages from Santa Catalina de Guale reported in chapters 5 and 6. All of these assemblages support the interpretation that the exploitation strategy emphasized deer as a source of animal nutrients with frequent use of fishes, particularly hardhead catfishes.

Although the assemblages are broadly similar, several important differences between the auger survey assemblage and the miscellaneous context assemblage must be acknowledged. The greatest difference between the two is in the representation of commensal taxa. Commensal taxa constitute 20% of the individuals in the auger survey assemblage and 14% of the miscellaneous assemblage individuals. This difference is due to the recovery of two dog burials in the otherwise small auger survey assemblage, compared to the recovery of 10 different commensal taxa in the much larger miscellaneous context assemblage.

Wild mammals are well-represented in both the auger survey assemblage and the miscellaneous context assemblage, but birds are rare. Deer contributed the highest percentage of noncommensal biomass in both assemblages, confirming that the occupants of Santa Catalina

TABLE D.5
Mission Santa Catalina de Guale: Auger Survey Modifications

Taxa	Cut	Burned	Worked	C.-gnawed[a]	Weathered
Indeterminate mammal	—	15	3	3	100
Artiodactyl	—	2	—	—	—
Pig	1	—	—	—	—
Deer	—	2	—	—	2
Indeterminate turtle	—	4	—	—	—
Diamondback terrapin	—	1	—	—	—
Hardhead catfish	—	2	—	—	—
Indeterminate vertebrate	—	32	—	—	—
Total	1	58	3	3	102

[a] Key to abbreviation: C.-gnawed, carnivore-gnawed.

TABLE D.6
Mission Santa Catalina de Guale: Miscellaneous Contexts Species List

			MNI			
Scientific name	Vernacular name	NISP	No.	%	Wt (g)	Biomass (kg)
Indeterminate mammal		3019	—	—	1810.73	24.426
Talpidae	Moles	1	—	—	0.03	0.001
Scalopus aquaticus	Mole	1	1	1.3	0.07	0.002
Homo sapiens	Human	13	—	—	7.33	—
Sylvilagus spp.	Rabbit	31	4	5.0	9.26	0.199
Indeterminate rodent		4	—	—	0.11	0.004
Sciuridae	Squirrels	3	—	—	0.04	0.002
Sciurus spp.	Squirrel	2	1	1.3	0.05	0.002
Geomys pinetis	Pocket gopher	1	1	1.3	0.1	0.003
Sigmodontinae	New World mice and rats	1	—	—	0.03	0.001
Oryzomys palustris	Rice rat	1	1	1.3	0.03	0.001
Peromyscus sp.	Mouse	1	1	1.3	0.01	0.0004
Indeterminate carnivore		1	—	—	0.19	0.006
Canis spp.		14	—	—	4.61	0.104
Canis familiaris	Domestic dog	214	1	1.3	339.06	8.282
Procyon lotor	Raccoon	66	6	7.5	30.77	0.601
cf. *Equus caballus*	Possible horse	1	1	1.3	2.03	0.050
Artiodactyla	Even-toed ungulate	219	—	—	190.86	3.158
Sus scrofa	Pig	162	4	5.0	185.95	3.003
Odocoileus virginianus	White-tailed deer	645	12	15.0	1828.76	23.893
Bos taurus	Cow	3	1	1.3	34.19	0.632
Indeterminate bird		72	—	—	7.18	0.156
Ardea herodias	Great blue heron	2	1	1.3	0.81	0.017
Anas spp.	Dabbling duck	2	—	—	1.78	0.035
Anas platyrhynchos	Mallard	1	1	1.3	1.03	0.021
Gallus gallus	Domestic chicken	20	2	2.5	6.26	0.108
Meleagris gallopavo	Turkey	2	1	1.3	1.01	0.021
Rallus longirostris	Clapper rail	1	1	1.3	0.15	0.004
Passeriformes	Song birds	1	—	—	0.02	0.001
Corvus sp.	Crow	1	1	1.3	0.08	0.013
Cardinalis cardinalis	Northern cardinal	1	1	1.3	0.01	0.0003
Indeterminate reptile		2	—	—	0.13	—
Alligator mississippiensis	American alligator	1	1	1.3	0.06	—
Indeterminate turtle		227	—	—	53.1	0.461
Kinosternidae	Mud/musk turtles	5	1	1.3	1.35	0.039
Emydidae	Pond turtles	56	—	—	30.27	0.310
Graptemys spp.	Map turtle	2	1	1.3	0.74	0.026
Malaclemys terrapin	Diamondback terrapin	13	2	2.5	9.57	0.195
Terrapene carolina	Box turtle	1	1	1.3	0.23	0.012
Trachemys scripta	Common slider	3	1	1.3	1.99	0.050
Indeterminate lizard		2	1	1.3	0.03	—
Indeterminate snake		53	—	—	3.31	0.046
Colubridae	Nonvenomous snakes	8	—	—	0.66	0.010
Nerodia sp.	Water snake	1	1	1.3	0.1	0.001
Viperidae	Pit vipers	1	1	1.3	0.03	0.0004
Indeterminate salamander		2	—	—	0.05	—

TABLE D.6 — (*Continued*)

			MNI			
Scientific name	Vernacular name	NISP	No.	%	Wt (g)	Biomass (kg)
Indeterminate toad/frog		62	—	—	2.47	—
Scaphiopus holbrookii	Eastern spadefoot toad	15	2	2.5	0.45	—
Ranidae	True frogs	1	1	1.3	0.01	—
Chondrichthyes	Cartilaginous fishes	13	1	1.3	1.42	0.170
Indeterminate fish		2361	—	—	48.15	0.684
Lepisosteus spp.	Gar	9	1	1.3	0.87	0.027
Amia calva	Bowfin	3	1	1.3	0.21	0.011
Siluriformes	Catfishes	71	—	—	6.86	0.124
Ariidae	Sea catfish	23	—	—	6.58	0.120
Ariopsis felis	Hardhead catfish	143	10	12.5	26.47	0.468
Bagre marinus	Gafftopsail catfish	42	2	2.5	7.74	0.140
Morone saxatilis	Striped bass	3	1	1.3	1.0	0.028
Centrarchidae	Sunfishes	2	—	—	0.07	0.002
Lepomis spp.	Sunfish	2	1	1.3	0.01	0.0004
Micropterus salmoides	Largemouth bass	2	1	1.3	0.05	0.001
Archosargus probatocephalus	Sheepshead	7	1	1.3	0.42	0.007
Sciaenidae	Drums	3	—	—	9.31	0.203
Cynoscion sp.	Seatrout	1	1	1.3	0.11	0.008
Pogonias cromis	Black drum	1	1	1.3	5.05	0.129
Sciaenops ocellatus	Red drum	4	1	1.3	1.46	0.052
Mugil spp.	Mullet	81	3	3.8	3.1	0.074
Indeterminate vertebrate		—	—	—	1514.78	—
Total		7732	80		6200.75	68.146

TABLE D.7
Mission Santa Catalina de Guale: Miscellaneous Contexts Summary

	MNI		Biomass	
	No.	%	kg	%
Domestic mammals	5	6.3	3.635	9.5
Domestic birds	2	2.5	0.108	0.3
Deer	12	15.0	23.893	62.2
Other wild mammals	12	15.0	0.802	2.1
Wild birds	6	7.5	0.076	0.2
Turtles/alligators	7	8.8	0.322	0.8
Sharks, rays, & fishes	25	31.3	1.114	2.9
Commensal taxa	11	13.8	8.3398	21.7
Total	80		38.292	

TABLE D.8
Mission Santa Catalina de Guale: Miscellaneous Contexts Summary of Elements

Skeletal elements	Pig	Deer	Cow
Head	153	390	3
Vertebra/rib/sternum	—	15	—
Forequarter	2	37	—
Forefoot	—	29	—
Foot	4	47	—
Hindfoot	3	69	—
Hindquarter	—	58	—
Total	162	645	3

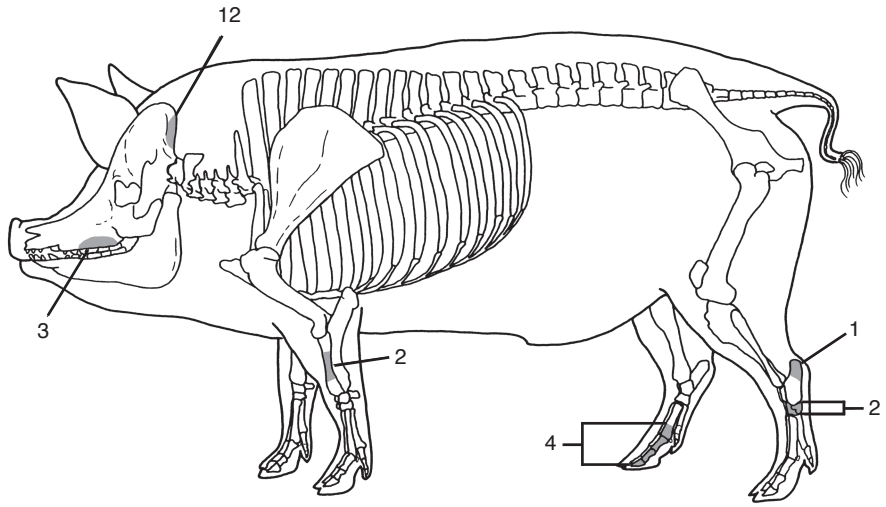

Fig. D.2. Santa Catalina de Guale pig elements from miscellaneous contexts. NISP = 162 (138 teeth not shown). The numbers indicate the number of specimens from that portion of the pig skeleton.

de Guale relied heavily on this species as a source of food and raw materials. Although the remains of several domestic animals are present in both assemblages, they contributed little meat to the diet. Eurasian domestic animals are more common in the miscellaneous assemblage than in the auger survey assemblage due to the presence of four pigs, a cow, and two chickens in the miscellaneous assemblage. The cow specimens from the miscellaneous contexts are the only evidence that cattle were present at Santa Catalina de Guale. The only clearly Eurasian domestic animal in the auger survey assemblage is a pig. These findings suggest that pigs, cattle, and chickens were consumed occasionally, but not often. In addition to these domestic meat sources, these samples provide the only evidence of horse or donkey at the mission. It appears that wild birds contributed very little to the diet.

Some of the reptiles in both the auger survey assemblage and the miscellaneous context assemblage were included in the diet at Santa Catalina de Guale, though most of the reptiles and the amphibians are considered commensal animals in this study. Certainly, alligators could have been used as food, though the presence of a single tooth is inconclusive evidence that this particular animal was eaten. The tooth could have

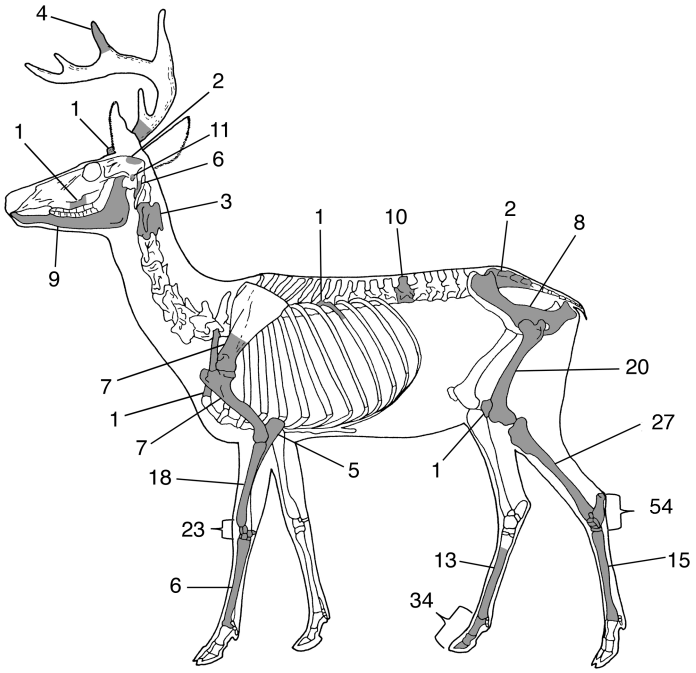

Fig. D.3. Santa Catalina de Guale deer elements from miscellaneous contexts. NISP = 645 (356 teeth not shown). The numbers indicate the number of specimens from that portion of the deer skeleton.

TABLE D.9
Mission Santa Catalina de Guale: Miscellaneous Contexts Pig Epiphyseal Fusion

Skeletal elements	Unfused	Fused	Total
Early fusing			
Humerus, distal	—	—	—
Scapula, distal	—	—	—
Radius, proximal	—	—	—
Acetabulum	—	—	—
Metapodials, proximal	—	—	—
1st/2nd phalanx, proximal	—	—	—
Middle fusing			
Tibia, distal	—	—	—
Calcaneus, proximal	1	—	1
Metapodials, distal	1	—	1
Late fusing			
Humerus, proximal	—	—	—
Radius, distal	—	—	—
Ulna, proximal	—	—	—
Ulna, distal	—	—	—
Femur, proximal	—	—	—
Femur, distal	—	—	—
Tibia, proximal	—	—	—
Total	2	—	2

TABLE D.10
Mission Santa Catalina de Guale: Miscellaneous Contexts Deer Epiphyseal Fusion

Skeletal elements	Unfused	Fused	Total
Early fusing			
Humerus, distal	—	3	3
Scapula, distal	—	5	5
Radius, proximal	—	7	7
Acetabulum	—	4	4
Metapodials, proximal	—	4	4
1st/2nd phalanx, proximal	—	10	10
Middle fusing			
Tibia, distal	2	4	6
Calcaneus, proximal	5	6	11
Metapodials, distal	1	2	3
Late fusing			
Humerus, proximal	1	—	1
Radius, distal	1	5	6
Ulna, proximal	—	—	—
Ulna, distal	—	—	—
Femur, proximal	—	1	1
Femur, distal	2	—	2
Tibia, proximal	—	5	5
Total	12	56	68

been kept as a curio or the animal could have been used for its commercially valuable hide. Diamondback terrapins (*Malaclemys terrapin*) in the assemblage represent a continuation of a pre-Hispanic tradition emphasizing this estuarine turtle. Lizards (Indeterminate lizard) and snakes (Colubridae, *Nerodia* spp., Viperidae) could be commensal taxa, but, as discussed in appendix A, these reptiles also might have been consumed.

The highest MNI percentages in the auger survey assemblage and the miscellaneous context assemblage are contributed by fishes, though they provide very little biomass. It is well-known that screening can lead to incomplete recovery of fishes, particularly when larger-sized screen mesh is used (see figs. 3.2 and 3.3). In addition, the entire fish might have been consumed by people, dogs, cats, pigs, chickens and other scavengers (e.g., Kent, 1981; Wheeler and Jones, 1989: 69–75). In any case, the high number of fish individuals suggests some use of estuarine ecosystems as sources of animal nutrients. None of the freshwater fishes identified in these two assemblages are present in the Irene-period Meeting House Field assemblage or in the 17th-century Plaza Complex and pueblo assemblages reported in chapters 5 and 6. These auger survey and miscellaneous context assemblages provide the only record that freshwater habitats were used, expanding our knowledge of the subsistence base and ecology of the island. The three freshwater fishes provide evidence that freshwater habitats were present on the island during this time period and were sufficiently stable and large to support such animals even during the prolonged drought.

The small number of specimens in the auger survey and miscellaneous assemblages for which age could be estimated prohibits any conclusions regarding differential use of animals by the inhabitants of Santa Catalina de Guale based on age cohorts.

The three dog burials offer special insight into domestic life at Santa Catalina de Guale. DNA analysis of these remains might clarify the ancestry of these animals but was not performed during this study. The skeletal completeness of each of these individuals indicates intentional burial. No human modifications were noted

on the dog specimens, though one specimen was gnawed by a carnivore. Given the lack of butchering evidence and the high degree of skeletal completeness, it is unlikely that these dogs were eaten. The intentional burials suggest that these animals played important roles at the mission, perhaps providing protection and/or companionship. The recovery of these burials emphasizes the importance of excavating nonstructural locations in order to understand a fuller range of human and animal associations beyond those associated with buildings.

The wide scope of the auger survey and miscellaneous context assemblages enables us to conclude that the results summarized in chapters 5 and 6 broadly characterize diet and exploitation strategies throughout the mission compound and pueblo. Both the auger survey and miscellaneous context assemblages verify the results of excavations focused on the church, the Plaza Complex, and the pueblo. These results reveal a heavy emphasis on deer and use of the surrounding marsh and estuarine environments. They support the conclusion that the subsistence strategy employed at Santa Catalina de Guale relied more on locally available wild sources of animal nutrients than on domesticated livestock. To the extent that Spaniards were accustomed to consuming large amounts of meat from domestic sources, they adapted to their new environment by substantially altering their traditional subsistence patterns. The Guale people continued their traditional strategy with comparatively minor changes.

TABLE D.11
Mission Santa Catalina de Guale: Miscellaneous Contexts Modifications[a]

Taxa	Cut	Hacked	Burned	Calcined	R.-gnawed	C.-gnawed	Weathered
Indeterminate mammal	4	1	829	41	1	5	—
Mole	—	—	1	—	—	—	—
Human	—	—	1	—	—	—	—
Rabbit	—	—	1	—	—	—	—
Domestic dog	—	—	—	—	—	6	—
Artiodactyl	1	—	27	1	—	—	2
Pig	—	—	26	—	—	—	1
Deer	9	5	34	—	1	1	6
Indeterminate bird	—	—	2	—	—	—	—
Great blue heron	—	—	2	—	—	—	—
Dabbling duck	—	—	—	—	—	—	1
Chicken	—	—	1	—	—	—	—
Clapper rail	—	—	1	—	—	—	—
Indeterminate turtle	—	1	17	2	—	—	—
Mud/musk turtles	—	—	1	—	—	—	—
Indeterminate snake	—	—	3	—	—	—	—
Indeterminate frog/toad	—	—	1	—	—	—	—
Cartilaginous fishes	—	—	1	—	—	—	—
Indeterminate fish	—	—	64	2	—	—	—
Catfishes	—	—	3	—	—	—	—
Sea catfishes	—	—	1	—	—	—	—
Hardhead catfish	—	—	9	—	—	—	—
Gafftopsail catfish	—	—	1	—	—	—	—
Mullet	—	—	2	—	—	—	—
Indeterminate vertebrate	1	—	2930	81	—	—	—
Total	15	7	3958	127	2	12	10

[a] Key to abbreviations: R.-gnawed, rodent-gnawed; C.-gnawed, carnivore-gnawed.

Some aspects of the auger survey and miscellaneous assemblages alter the interpretation of daily life, diet, and exploitation strategies at Santa Catalina de Guale. Chief among these alterations is the addition of cattle to the list of Eurasian animals at the mission. That there are only three cattle specimens out of 70,324 specimens and only one cow individual out of 510 individuals clearly indicates that these animals were rare. Nonetheless, they were present on the island. Both pigs and cattle undoubtedly initiated environmental damage associated with their presence on the sea islands. The dog burials suggest that some dogs were sufficiently valued to be intentionally buried. Perhaps they were used to herd and protect livestock, or to protect the mission and fields from human and animal predation. They also may have been valued pets or hunting companions. The presence of freshwater fishes raises the possibility that freshwater sources on the island were sufficient to sustain freshwater fishes such as bowfin in the 17th century.

CONCLUSIONS

This review of the auger survey and miscellaneous assemblages shows that sampling strategies such as these may yield results that are similar to those from large-scale excavations focused on a few activity areas. Broad-scale, intrasite sampling surveys also provide information unavailable from focused excavations. Survey data confirm the overall conclusions concerning human diet and exploitation strategies that are based on the focused excavations at Santa Catalina de Guale. The auger survey and miscellaneous assemblages, however, expand our interpretations of diet and exploitation strategies at Santa Catalina de Guale. Comparison of the auger survey and miscellaneous assemblages with the larger mission compound and pueblo assemblages demonstrates the importance of a research design that combines sampling diverse activity areas with focused excavations of some activity areas. The comparison also shows the importance of excavating activity areas that are not associated with structures.

APPENDIX E

ASSESSING DENSITY-MEDIATED ATTRITION IN WHITE-TAILED DEER REMAINS

The broad-scale sample of activity areas at Santa Catalina de Guale offered by the auger survey and miscellaneous assemblages reported in appendix D present an opportunity to construct and test hypotheses associating density-mediated attrition with butchering strategies, transportation decisions, and redistribution mechanisms. The results of this analysis are intended as a proxy measure of the degree of density-mediated taphonomic attrition throughout Santa Catalina de Guale. This taphonomic study reveals that density mediation played a role in the formation of the Santa Catalina de Guale assemblage, as did removal of bone by scavengers. The research also suggests that some differential transportation and redistribution occurred at the mission.

All archaeological assemblages are subject to biological, chemical, and physical processes that add to, subtract from, or rearrange the original buried assemblage (Lyman, 1994). These taphonomic processes occur before, during, and after the specimens are buried, as well as during excavation. As a result, much of the originally deposited assemblage does not become part of the studied assemblage. The destruction of organic material by human and nonhuman taphonomic processes is mediated by the ability of specific parts of the skeleton to resist physical and chemical degradation. Skeletal portions with higher bone mineral densities tend to survive longer than those that are less dense.

Density-mediated attrition is a process that affects all zooarchaeological assemblages, but often it is not clear whether patterns observed in the archaeological record, such as the absence of certain skeletal portions, are the result of in situ density-mediated destruction or selective human behavior. Determining the degree to which skeletal remains with varying bone densities have survived in an assemblage can help identify patterns that are the result of factors independent of human agency. The low representation of skeletal element portions that are particularly susceptible to chemical and physical impacts may suggest nonhuman in situ destruction. However, the observation that animal remains have undergone density-mediated attrition does not entirely rule out human behavior as the primary taphonomic agent. Many human activities involving animal carcasses, including butchering, transportation, and redistribution, can be density-mediated. When skeletal recovery patterns do *not* reflect density-mediated attrition, alternate explanations, such as human behavior, can be explored.

Bone density can be measured using photondensitometry (Kreutzer, 1992; Lam, 2005; Lyman et al., 1992; Stahl, 1999). Photondensitometers are widely available in medical clinics and hospitals for diagnosing and tracking osteoporosis in humans. The first effort to directly measure bone mineral density using a bone densitometer was R. Lee Lyman's assay of artiodactyl skeletons, including deer (*Odocoileus* spp.; Lyman, 1984, 1994: 240–241). Since the 1980s, dozens of bone density analyses have been completed. Bone density varies among species, between individuals in the same species, within a single individual's skeleton, and across a single skeletal element. Patterns of bone density are shaped by

locomotor behavior, functional biomechanics, and phylogeny. Density patterns are affected by characteristics of the individual organism, such as age, sex, and health.

METHODS

In the following study, bone density values published by Lyman (1994: 240–241) are applied to the white-tailed deer (*O. virginianus*) specimens identified in the auger survey and miscellaneous context assemblages from Santa Catalina de Guale (see appendix D). The materials assessed for density-mediated attritional processes were recovered during initial testing of Santa Catalina de Guale conducted in the 1980s, prior to extensive excavations in the mission compound and associated pueblo (Thomas, 1987: 112–116; see appendix D). A description of these assemblages and species lists for each are provided in appendix D and a list of the samples assessed for density-mediated attrition is available elsewhere (Pavao and Reitz, 1998).

White-tailed deer specimens were selected for this study for two important reasons: (1) this species is the most common mammal in the Santa Catalina de Guale zooarchaeological assemblages; and (2) this animal may have played a role in tithes, trade, and tribute between Guale hunters, the St. Catherine's mission, and St. Augustine. Delineating skeletal element recovery patterns consistent with density-mediated attritional processes is critical to teasing out skeletal patterns resulting from human butchery and transport decisions made in the context of provisioning colonial authorities with deer meat, hides, and other products. A total of 695 deer specimens were identified in the auger survey and miscellaneous context assemblages (see figs. D.1 and D.3). Ribs and vertebrae from pigs (*Sus scrofa*), deer, and caprines (Caprinae, goats [*Capra hircus*], and sheep [*Ovis aries*]) are notoriously difficult to differentiate. Because of this problem, ribs and vertebrae are excluded from the following analysis.

Bone mineral density as measured through photondensitometry is expressed as grams of bone mineral (hydroxyapatite) per cm^3 (g/cm^3) (Lyman, 1984). This measurement of bone mineral density is also referred to as volumetric, or volume, density (VD). As observed above, bone mineral density varies significantly across an individual skeletal element. For example, mid-shaft portions of long bone elements tend to exhibit higher bone mineral density than the proximal or distal ends of these elements. To account for variation in bone mineral density across individual skeletal elements, most assays of bone mineral density employ cross-sectional "scan sites" across which bone mineral density is measured. These scan sites are generally 1 to 3 mm in width, at right angles to the longest axis of the element. Each scan site is a three-dimensional "slice" of the element that generally corresponds to a key diagnostic skeletal landmark such as a muscle attachment or epiphyseal line. Locating scan sites on or near osteological landmarks allows for replicability of scan-site placement. In addition, when detailed descriptions of the skeletal portions recovered are available, these data are easily converted into scan-site codes to allow for comparison of skeletal portions and bone mineral density values.

Human actors, however, make transport decisions based on carcass portions, whole elements, or portions of elements, not on scan sites. In recognition that scan sites are archaeological tools, and also to simplify presentation, scan-site data from Lyman (1984) are used to derive aggregate bone mineral densities for skeletal portions (such as the proximal femur and distal humerus) by averaging Lyman's scan-site values for that skeletal portion. For example, the volume density listed for the proximal femur (pF) in table E.1 is an averaged bone mineral density of scan sites FE1, FE2, and FE3 in Lyman's (1984) scan-site nomenclature.

Estimating bone loss due to density-mediated attritional processes requires comparing the archaeologically recovered assemblage with the assemblage that was originally deposited at the site. While the archaeological assemblage is known, the originally deposited assemblage must be reconstructed based on the observable characteristics of the archaeologically recovered assemblage. One approach to reconstructing the originally deposited assemblage is to estimate the frequencies of skeletal portions that would be expected to survive if the only taphonomic process acting on the assemblages was attrition mediated by bone mineral density, using the following formula:

$$expected\ frequency = (MNE_{element\ portion})(freq_{element\ portion/individual})(VD_{element\ portion})$$

In the above formula, $MNE_{element\ portion}$ represents an estimate of the minimum number of a given element portion (such as proximal femur) in the sample. In this analysis, the estimation of MNE takes into account bone fragment overlap and other characteristics such as fusion status (see appendix A for a discussion of skeletal fusion), sex, and size, when observed. The $freq_{element\ portion/individual}$ represents the frequency of the above element portion in the living animal. For example, each deer skeleton contains two femora. In the above formula, $VD_{element\ portion}$ is the bone mineral density (expressed as g/cm^3), of that element portion. As stated above, when a skeletal element portion includes more than one scan site (such as in the proximal humerus), an average of all scan sites within that element portion is used.

The percent expected frequency of each element portion is then compared to percent survivorship (the observed frequency) of that same element portion. Where these values differ, a pattern inconsistent with density-mediated attrition is indicated and other cultural or taphonomic explanations must be sought. Pearson's r is used to test correlations between the observed and expected data. A positive correlation between observed and expected element portion frequencies, however, does not necessarily mean that the assemblage is density mediated. There is a weak negative correlation between deer bone mineral density values and several indices of meat utility, meaning that high meat utility specimens tend to be those with lower bone mineral density (Lyman, 1985: 258–259; 1994). As a result, reverse utility strategies (see Lyman, 1994: 228) can mimic the effect of density-mediated attrition. Reverse utility curves are likely to be found at primary butchery sites where high utility (lower density) carcass portions are removed for transport to the place of consumption, and only low utility (high density) portions remain. Because of the problem

TABLE E.1
Bone Density Application: Auger Survey and Miscellaneous Contexts Assemblages[a]

Skeletal portion	Observed MNE	Frequency in skeleton	Volume density (avg.)	Expected MNE
Sacrum (SC)	—	1	0.175	1.575
Sternum (ST)	1	1	0.22	1.98
Proximal humerus (pH)	2	2	0.245	4.41
Acetabulum (AC)	4	2	0.27	4.86
Proximal tibia (pTI)	6	2	0.31	5.58
Distal femur (dF)	11	2	0.325	5.85
Scapula (SP)	7	2	0.34	6.12
Proximal femur (pF)	2	2	0.367	6.606
Proximal ulna (pU)	5	2	0.375	6.75
Distal radius (dR)	8	2	0.405	7.29
Distal ulna (dU)	—	2	0.44	7.92
Calcaneus (CA)	12	2	0.488	8.784
Distal tibia (dTI)	8	2	0.505	9.09
Distal humerus (dH)	5	2	0.51	9.18
Dentary (DN)	3	2	0.511	9.198
Proximal radius (pR)	7	2	0.52	9.36
Astragalus (AS)	17	2	0.557	10.026
Metatarsus (MT)	14	2	0.578	10.404
Metacarpus (MC)	7	2	0.592	10.656
Third phalanx (P3)	7	8	0.25	18.0
Second phalanx (P2)	8	8	0.293	21.096
First phalanx (P1)	12	8	0.45	32.4

[a] Skeletal portion and scan site abbreviations follow Lyman (1984, 1994: 240–241).

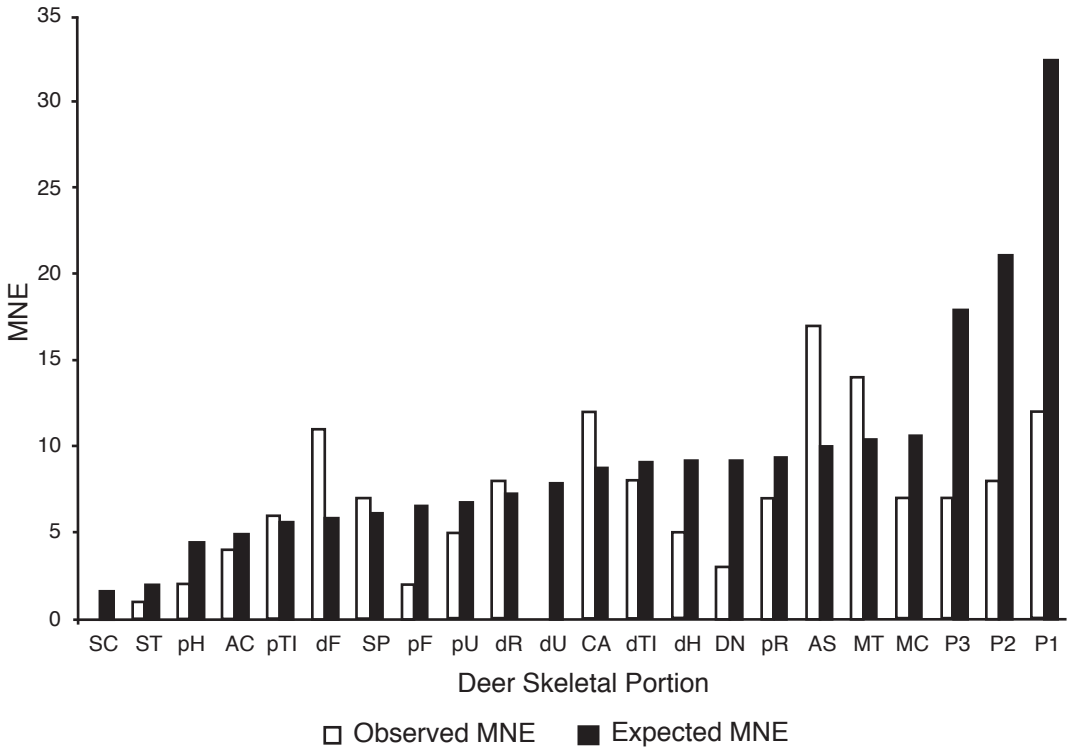

Fig. E.1. Auger survey and miscellaneous context assemblages: observed and expected deer skeletal portions expressed as minimum number of elements (MNE). See table E.1 for key to abbreviations.

of equifinality, in which different processes may produce similar outcomes, detailed examination of recoveries of individual element portions is needed to identify human transport behaviors in zooarchaeological assemblages.

RESULTS: BONE DENSITY

Excluding ribs and vertebrae, the total MNE in the assemblage is 146. A positive relationship is found between the observed and expected skeletal element portion frequencies (Pearson's $r = 0.45$). The observed and expected scan-site frequencies reveal a few discrepancies (fig. E.1). Upper limb elements, including humeri and proximal femora, exhibit a lower-than-expected survivorship, as do mandibles, metacarpals, and phalanges. At the same time, the observed frequencies of the distal femur, astragalus, calcaneus, and metatarsus are higher than expected.

INTERPRETING THE RESULTS

These results suggest that density-mediated attrition played a role in the formation of the Santa Catalina de Guale deer assemblage. As explained above, however, processes such as reverse utility strategies can mimic the results of density-mediated attrition; therefore, close examination of specific patterns in skeletal portion recovery is necessary.

The lower than expected recovery of long bones associated with meaty portions of the deer carcass, such as the humerus and proximal femur, could reflect butchering and transportation decisions (fig. E.1). Meat may have been deboned at the kill or butchery site to reduce transportation costs and to enhance drying, smoking, or some other preservation process. Another possibility

is that breakage of limb elements to extract marrow reduced many portions of the skeleton to unidentifiable pieces. The absence of great numbers of Indeterminate mammal remains in assemblages from the site, however, suggests that the latter interpretation does not hold true at Santa Catalina de Guale.

The underrepresentation of mandibles, metacarpal specimens, and phalanges may be attributable to butchering practices (fig. E.1). These low meat-utility elements may have been left behind at the kill site. Closer examination of the mandible assemblage, however, suggests that the low frequency of these elements is, in fact, due to fragmentation. Although 14 mandible fragments were recovered, none were sufficiently complete to indicate the presence of more than one MNE for the mandible. Further, the large number of loose tooth fragments (NISP = 374) in the assemblage indicates that, in contrast to the MNE estimate, multiple mandibles and crania were present in the mission assemblage. Crania contain very little meat, though brains are relished in some cuisines. Brain tissue is a common tanning agent and may have been brought back to the mission for use in hide-processing activities.

The low frequency of metacarpal specimens is surprising given that metatarsal specimens appear at greater than expected frequencies (fig. E.1). The metatarsus is longer than the metacarpus and has a more square or flatter shape that is more amenable to tool manufacture, though the anterior groove may require more work to remove. In some medieval English contexts, deer bone flutes made from metatarsals are almost all from high-status sites (Leaf, 2007: 15–16), suggesting the range of valued objects that might be made from metatarsals. Metatarsals may have been preferentially selected for transport to the mission compound. The recovery of a grooved and snapped deer metatarsus specimen in the Eastern Plaza Complex assemblage (see chap. 5) provides some support for this hypothesis.

The archaeological recovery of phalanges is highly variable. Phalanges are commonly used in the manufacture of bone tools, such as fish hooks or gorges, and often accompany hides as "riders" (Perkins and Daly, 1968). Because their meat utility is low, however, phalanges are often left behind at kill sites. This explanation may apply to the Santa Catalina materials, in which phalanges are present in lower than expected frequencies (fig. E.1). Alternatively, perhaps phalanges did accompany hides, but the hides were processed outside of the excavated area or sent elsewhere with the phalanges still attached.

Human agents were not the only taphonomic factors affecting animal remains in the auger and miscellaneous context samples. The presence of rodent gnawing, carnivore gnawing, and weathering indicates that the assemblage experienced some loss due to biological and physical agents (tables D.5 and D.11). These processes likely were responsible for removing, destroying, or rendering unidentifiable an unknowable quantity of animal remains. The presence of burrowing animals such as moles (*Scalopus aquaticus*) and pocket gophers (*Geomys pinetis*) in the auger survey and miscellaneous context assemblages reminds us that bioturbation displaces buried artifacts.

CONCLUSIONS

The density study of deer samples from the auger survey and miscellaneous contexts assemblages reveals that density-mediated attrition played a role in the formation of the Santa Catalina de Guale faunal assemblage. Given this evidence, caution should be used in interpreting the role of human behavior in shaping skeletal portion frequencies in the assemblage as a whole. The density study also reveals some patterns that diverge from a density-mediated pattern and may suggest human butchering, transportation, and redistribution decisions. It appears that meaty portions were brought into the mission compound off the bone, or that these elements were further processed, such as for marrow extraction, rendering them unidentifiable. In addition, many elements from the foot may have been left at kill or butchering sites, whereas some elements, such as the metatarsus, may have been brought into the mission compound for use as raw materials in tool manufacture.

APPENDIX F

MEASUREMENTS FROM CONVENTO DE SAN FRANCISCO, MISSION SANTA CATALINA DE GUALE, PUEBLO SANTA CATALINA DE GUALE (SOUTH AND NORTH), AND SANTA CATALINA DE GUALE AUGER SURVEY AND MISCELLANEOUS CONTEXTS

Mammal and bird dimensions follow the guidelines published by Angela von den Dreisch (1976). The fish dimensions are the anterior centrum width of the fish atlas and the greatest length of fish otoliths (tables F.1, F.2, F.3, and F.4).

TABLE F.1
Convento de San Francisco: Measurements

Taxon	Element	Dimension	Measurement, mm
Odocoileus virginianus	Tibia	Bp	54.0
Gallus gallus	Carpometacarpus	Did	6.95
	Femur	Bp	14.6
		Dp	10.2
		Bd	14.8
	Humerus	Bd	7.4
	Radius	Bd	6.5
	Scapula	Dic	10.1, 11.7
	Ulna	Did	7.5
Meleagris gallopavo	Tibiotarsus	Dip	32.8
Archosargus probatocephalus	Atlas	Width	2.6, 5.9
Bairdiella chrysoura	Sagitta	GL	7.75
Cynoscion spp.	Atlas	Width	5.0, 5.8
	Otolith	GL	12.15, 18.2
C. nebulosus	Atlas	Width	4.5
	Otolith	GL	15.2, 19.9
Leiostomus xanthurus	Atlas	Width	5.1
Micropogonias undulatus	Atlas	Width	4.5, 5.2, 5.5
	Otolith	GL	8.8, 9.2, 9.6, 9.7, 9.8, 10.5, 10.7, 11.1, 11.1, 11.6, 12.3, 12.4, 12.6, 12.9, 13.1, 13.9, 14.4, 14.6, 14.7, 14.8, 15.9, 16.5, 17.4, 17.8
Pogonias cromis	Atlas	Width	2.5, 3.9, 10.4
Mugil spp.	Atlas	Width	3.1, 3.8

TABLE F.2
Mission Santa Catalina de Guale: Measurements

Taxon	Element	Dimension	Measurement, mm
Procyon lotor	Tibia	Bd	10.4
		GL	120.9
		SD	7.6
Sus scrofa	Astragalus	GLl	46.4
		GLm	43.1
	Metacarpus III	Bp	17.2
	Tibia epiphysis	Bd	29.1
	2nd phalanx	Bd	12.1, 12.4
		Bp	14.3
		GL	21.5
		SD	11.9
	2nd phalanx epiphysis	Bp	10.5, 14.4
Odocoileus virginianus	Acetabulum	LA	32.3, 34.1, 35.5
	Astragalus	Bd	19.3, 19.7, 21.6, 22.0, 22.3, 22.5, 22.9, 23.0, 23.5
		Dl	18.1, 18.2, 18.7, 19.8, 20.3, 20.5
		Dm	21.6
		GLl	31.7, 32.7, 33.3, 33.8, 36.6, 36.7, 37.5, 37.6
		GLm	31.4, 32.1, 32.5, 33.9, 34.4, 35.3, 35.5
	Calcaneus	GB	22. 0, 22.5, 22.6
		GL	69.2, 71.0, 72.2, 77.5, 82.1
	Cubonavicular	GB	26.15, 26.2, 26.5
	Femur	Bd	48.4
		Bp	47.2, 48.0, 49.1, 52.8
		DC	20.3, 21.2, 22.9, 23.7
	Femur epiphysis	Bd	42.8, 48.9
	Humerus	Bd	30.0, 33.7, 33.9, 34.5, 34.8, 34.8, 35.0, 35.0, 35.7, 36.2, 36.9, 37.5, 37.8, 38.2, 38.5, 38.7, 38.8, 40.0, 40.3
		Bp	44.8, 46.9
		BT	28. 0, 29.2, 30.3, 30.4, 30.4, 30.8, 30.9, 31.1, 31.5, 31.5, 31.8, 31.9, 31.9, 33.1, 33.3, 34.3, 35.1, 35.7
		SD	19.3
	Metacarpus	Bd	25.5, 30.4
		Bp	23.5, 23.7, 24.0, 24.2, 25.4, 26.1
		Dd	16.1
		Dp	17.5
		GL	169.0
	Metatarsus	Bd	26.4
		Bp	23.6
	Radius	Bd	27.6, 28.7, 28.8, 29.0, 29.5, 31.0, 31.7, 33.2, 33.3, 38.2, 40.0
		BFd	24.5, 27.4, 27.4, 28.0, 28.4, 30.4, 30.4
		BFp	29.2, 29.4, 29.8, 30.0, 31.0, 31.9, 32.2, 33.2, 34.9, 35.0
		Bp	30.5, 30.9, 31.5, 31.6, 31.6, 32.2, 33.0, 33.5, 33.8, 35.0, 35.7, 36.3, 36.5
		BT	36.4
	Radius epiphysis	Bd	27.0, 27.0, 27.9, 27.9, 28.3, 28.9

TABLE F.2 — (*Continued*)

Taxon	Element	Dimension	Measurement, mm
		BFd	24.1, 26.3, 26.5, 26.5, 26.5, 26.8
	Scapula	BG	22.9, 25.0, 26.9, 27.2, 29.4, 30.1, 30.3, 30.5, 31.0
		GLP	31.4, 34.1, 35.7, 38.2, 38.2, 41.0, 41.6, 41.6
		LG	24.0, 26.2, 28.3, 29.3, 31.2, 31.5, 31.5, 32.0, 34.0
		SLC	22.5
	Tibia	Bd	27.8, 28.5, 28.5, 28.9, 29.0, 29.6, 29.9, 30.6, 30.9, 31.0, 31.1, 32.0, 32.2, 32.3, 32.5, 32.7, 33.1, 33.4, 33.9, 34.7
		Bp	48.9, 53.5, 53.7
		Dd	21.1, 23.1, 23.1, 23.1, 24.2, 24.2, 24.9, 24.9, 25.3, 25.6, 25.6
		SD	18.0, 20.1, 22.2
	Tibia epiphysis	Bp	45.9, 50.4, 50.5, 51.4
	Ulna	BPC	16.7, 17.9, 18.6, 27.8
		DPA	29.8, 30.6, 34.8, 37.4
		LO	44.8, 45.3, 45.6, 50.0, 52.1
		SDO	26.2, 26.6, 29.2, 32.2, 33.4
	1st phalanx	Bd	9.7, 9.8, 9.9, 10.0, 10.2, 10.3, 10.4, 10.5, 10.6, 10.6, 10.7, 11.2, 11.5, 11.6, 12.0, 12.5, 12.6
		Bp	12.2, 12.4, 12.7, 12.8, 12.9, 13.2, 13.2, 13.3, 13.5, 13.9, 14.2, 14.2, 14.3, 14.7, 14.9, 15.0, 15.6
		GL	37.9, 38.0, 38.1, 38.2, 39.0, 39.5, 41.1, 41.8, 42.3, 42.4, 42.7, 43.0, 44.1, 44.8
		SD	9.2, 9.3, 9.5, 9.6, 9.7, 9.7, 9.8, 9.8, 9.8, 10.0, 10.6, 10.6, 10.8, 11.1, 11.2, 11.5, 11.6
	2nd phalanx	Bd	7.1, 7.7, 8.0, 8.1, 8.1, 8.3, 8.3, 8.6, 8.6, 8.8, 8.9, 8.9, 9.1, 9.2, 9.6, 9.6, 9.7, 9.8, 9.9, 10.0
		Bp	11.0, 11.2, 11.2, 11.3, 11.4, 11.7, 11.8, 12.0, 12.0, 12.1, 13.0, 13.1, 13.2, 13.3, 13.3, 13.3, 13.4, 14.1
		GL	8.1, 23.2, 28.9, 29.2, 30.2, 30.4, 30.4, 30.5, 31.0, 31.2, 31.5, 33.0, 33.1, 33.2, 33.6, 34.1, 34.3, 34.5
		SD	6.8, 8.0, 8.1, 8.2, 8.2, 8.2, 8.2, 8.3, 8.7, 8.8, 8.8, 9.0, 9.0, 9.2, 9.3, 9.3, 9.4, 9.5, 9.7, 10.1, 10.5
	3rd phalanx	DLS	24.4, 28.9, 33.9
		Ld	23.9, 24.8, 30.8
		MBS	8.9, 10.7
Anatidae	Femur	SD	8.25
Branta canadensis	Radius	Bd	10.0
Gallus gallus	Carpometacarpus	Bp	10.1, 10.9, 11.0, 11.0, 11.1, 11.2, 11.3, 11.3, 11.8, 11.9, 12.0, 12.9, 12.9, 13.1, 13.4
		Did	6.3, 6.3, 6.65, 6.7, 6.7, 6.7, 6.8, 7.1, 7.4, 7.8
		GL	33.8, 34.7, 35.6, 37.0, 37.1, 37.2, 40.5, 42.6
		L	32.4, 38.5
	Coracoid	Bb	13.7, 15.3, 17.0
		BF	9.7, 10.2, 10.8, 11.5, 12.6, 12.9
		GL	53.7, 62.2
		Lm	50.8, 58.6
	Femur	Bd	13.8, 14.3, 14.4, 14.45, 14.5, 14.5, 14.6, 15.0, 15.0, 16.6, 17.0, 17.4
		Bp	12.55, 14.4, 15.0, 15.1, 15.5, 15.6, 15.6, 15.7, 15.7, 15.7, 15.8, 15.8, 16.0, 16.0, 16.2, 16.9, 17.6

TABLE F.2 — (*Continued*)

Taxon	Element	Dimension	Measurement, mm
		Dd	13.1, 13.3, 13.9, 14.0, 14.2, 14.5, 14.6, 17.0, 17.7
		Dp	9.0, 9.8, 10.0, 10.0, 10.0, 10.0, 10.4, 10.5, 10.5, 10.8, 10.8, 10.9, 10.9, 11.6, 11.6, 12.2
		GL	75.0, 75.8, 76.0, 76.0, 76.2, 77.8
		Lm	70.3, 70.6, 70.8, 71.0, 71.2, 75.0
		SC	5.9, 6.2, 6.2, 6.3, 6.4, 6.4, 6.5, 6.6
	Humerus	Bd	14.4, 14.6, 14.8, 15.0, 15.2, 15.3, 15.5, 16.9, 17.2, 17.2, 17.7
		Bp	18.5, 19.1, 19.1, 19.2, 19.2, 19.3, 19.9, 19.9, 20.6, 21.5
		GL	70.0, 70.4
		SC	4.9, 5.8, 6.1, 6.4, 6.5
	Radius	Bd	6.1, 6.2, 6.3, 6.4, 6.45, 6.5, 6.5, 6.7, 6.7, 6.7, 6.9, 7.0, 7.2, 7.2, 7.4, 7.5, 7.5, 7.5, 7.7, 7.7
	Scapula	Dic	9.8, 10.0, 10.5, 11.4, 11.5, 11.5, 11.8, 11.8, 12.0, 12.1, 12.2, 12.2, 12.6, 12.6, 12.6, 12.8, 12.9, 12.9, 13.1, 13.1, 14.0, 14.1, 14.8
	Tarsometatarsus	Bd	12.2, 12.3, 12.4, 12.7, 13.1, 13.2, 13.2, 13.4, 13.6, 13.9, 14.9, 15.4, 15.5
		Bp	12.2, 12.2, 12.4, 12.5, 12.5, 12.5, 12.9, 12.9, 12.9, 13.0, 13.0, 13.1, 13.2, 13.3, 13.4, 13.5, 13.5, 13.5, 15.2, 15.9
		GL	74.55
		SC	5.6, 6.0, 6.05, 6.1, 6.2, 6.3
	Tibiotarsus	Bd	9.9, 10.03, 10.4, 10.9, 11.5, 11.5, 12.1, 12.2, 12.2, 12.2, 12.3
		Bp	17.8
		Dd	11.6, 12.4, 12.7, 13.0, 13.5, 13.7, 13.9, 14.5
		Dip	18.4, 18.6, 19.0, 19.5, 20.0, 20.1, 20.3, 20.4, 20.9, 21.4, 21.9, 22.3, 23.4
		GL	115.36
		LA	104.6, 110.69
		SC	5.6, 5.9, 6.0, 6.2, 6.23
	Ulna	Bp	7.8, 8.2, 8.2, 8.4, 8.6, 8.8, 9.1, 9.2, 9.9, 10.1, 10.5
		Did	6.55, 8.6, 8.7, 8.7, 8.8, 9.4, 9.5, 9.9, 10.6, 11.0, 11.1
		Dip	12.3, 12.3, 12.9, 13.0, 13.0, 13.1, 13.4, 14.1, 14.8, 15.0, 15.6
		GL	65.55, 75.0, 78.7
		SC	3.8, 4.0, 4.95
Ariidae	Otolith	GL	11.4, 12.4
Ariopsis felis	Otolith	GL	8.1, 8.8, 10.8
Bagre marinus	Otolith	GL	12.6
Bairdiella chrysoura	Otolith	GL	5.9, 6.8
Cynoscion spp.	Atlas	width	5.0, 9.7
Pogonias cromis	Atlas	width	7.3
Stellifer lanceolatus	Atlas	width	2.59
Mugil spp.	Atlas	width	1.9, 2.1, 2.4, 2.4, 2.8, 3.0, 3.4, 3.6, 3.6, 3.7, 3.8, 3.9, 4.0, 6.6

TABLE F.3
Pueblo Santa Catalina de Guale (South and North): Measurements

Taxon	Element	Dimension	Measurement, mm
Sus scrofa	1st phalanx	Bd	14.9
		Bp	15.4
		GL	36.9
Odocoileus virginianus	Astragalus	GLm	32.2, 33.1
		GLl	35.4, 35.6
		Bd	21.8, 22.6
	Cubonavicular	GB	25.5, 25.7
	Humerus	Bd	36.7
	Intermediate carpal	GB	18.0
	Mandible	#7	78.9, 79.1
		#8	49.6, 49.7
		#9	29.1, 29.4
	Metacarpus	Bp	26.0
	Os malleolare	GB	15.8
	Radius	Bd	31.0, 31.6
	Scapula	GLP	38.3
	Tibia	Bd	30.2
		Dd	22.3
	1st phalanx	Bp	15.5, 15.7
		GL	44.2, 45.4
		Bd	13.0, 13.0, 13.3
	2nd phalanx	Bp	11.8, 12.5, 12.6, 13.4, 14.2
		GL	31.1, 32.1, 32.5, 32.5, 38.2
		GLpe	31.0, 31.6, 32.5, 34.2, 36.4
		Bd	8.5, 8.9, 9.2, 9.3, 9.8
	3rd phalanx	DLS	27.2, 33.8
		Ld	24.8, 31.7

TABLE F.4
Santa Catalina de Guale Auger Survey and Miscellaneous Contexts: Measurements

Taxon	Element	Dimension		Measurement, mm
Canis familiaris	Cranium	#22		16.53, 18.51
		#23		56.29
	Mandible	#3		106.72, 107.32
		#5		91.78
		#20		15.58
Sus scrofa	Upper dP4	GB		7.07
	Upper P1	GB		5.27
	Upper M1	GB		13.41
	Upper M3	GB		14.98, 17.98
Odocoileus virginianus	Astragalus	Bp		20.28, 21.2, 21.49, 23.1, 23.92
		GLl		34.45, 37.63
		GLm		31.43, 31.84, 35.32, 35.48
	Acetabulum	LA		32.19
	Femur	Bp		47.6
	Intermediate carpal	GB		20.26, 20.31
	Lower P2	GB		3.78, 5.31
		GL		12.57, 14.49
	Lower P3	GB		6.55, 6.87, 7.4, 9.37
		GL		17.27, 19.21
	Lower P4	GB		7.96
		GL		21.45
	Lower M1	GB		8.26, 8.4, 8.48, 8.8, 9.0
		GL		13.25, 17.87, 18.16, 19.54, 20.3
	Lower M2	GB		8.84, 9.1, 9.35, 9.65, 9.72, 10.93
		GL		16.10, 19.12, 23.08
	Lower M3	GB		8.69, 8.92, 9.07, 9.7
		GL		21.4, 21.54, 23.59
	Magnum	GB		17.09
	Mandible	#15a		29.6
	Metacarpus	Bp		25.14
	Metatarsus	Bp		22.91
	Os malleolare	GB		16.2
	Radius	Bd		27.59
		Bp		30.35, 35.45
	Scapula	BG		26.03
		GLP		37.61
		LG		28.25
	Tibia	Bd		32.31
	Upper P2	GB		8.47

TABLE F.4 — (*Continued*)

Taxon	Element	Dimension	Measurement, mm
	Upper P3	GB	9.37, 11.69
	Upper P4	GB	11.27, 11.29, 12.7, 12.88
		GL	8.93, 9.35
	Upper M1	GB	13.41, 14.11, 14.31, 16.9
		GL	15.8, 16.6, 16.66, 16.87
	Upper M2	GB	13.91, 13.98, 14.34, 14.38, 15.71, 15.93, 17.6
		GL	17.6, 17.92, 17.93
	Upper M3	GB	14.16, 15.54, 16.58, 17.8
		GL	17.98
	1st phalanx	Bp	11.72, 12.5, 15.31
		Bd	10.1, 11.1, 14.83
		GL	36.2, 43.58, 45.51
	2nd phalanx	Bp	10.3, 11.61
		Bd	8.15, 8.35
		GL	28.88, 29.35
	3rd phalanx	Bp	9.72, 10.24, 14.25
		GL	22.75, 26.72, 29.09
Anas platyrhynchos	Ulna	Did	9.5
Gallus gallus	Coracoid	Bb	16.4
		BF	12.0, 13.0
	Humerus	Bd	14.57
	Tibiotarsus	Bd	15.3
		Dd	15.6
Ariidae	Otolith	GB	7.56, 8.25, 8.42
		GL	8.98, 9.07, 9.23, 9.83, 12.77
Ariopsis felis	Otolith	GB	9.14, 9.4
		GL	9.82, 11.1
Bagre marinus	Otolith	GB	6.6
		GL	7.4