EXAMINING CHANGE, PERSISTENCE, AND VARIATION IN THE ROLE OF INVERTEBRATE FAUNA IN MISSION-ERA GUALE FOODWAYS ON ST. CATHERINES ISLAND, GA

by

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ABSTRACT

This thesis is an analysis of invertebrate fauna from Mission-era (ca. AD 1565-1680) shell middens on St. Catherines Island, Georgia, which contributes to archaeological inquiries into population aggregation, community organization, and indigenous foodways at Pueblo Santa Catalina de Guale. Zooarchaeological and stable isotope analyses of bulk samples of shell midden matrix from five Mission-era residential neighborhoods at Pueblo Santa Catalina de Guale are used to explore invertebrate animal use, season of capture, and habitat exploitation. The summed Mission-era results are contrasted with similar data from the pre-Hispanic Irene Period (AD 1300-1580) (Bergh 2012) on St. Catherines to assess change and continuity in shellfishing practices during missionization. Reduced reliance on eastern oysters (*Crassostrea virginica*) relative to other mollusks, increased seasonal restriction in oyster collection, and increased intra-site variability in animal use on St. Catherines Island were indirect consequences of Spanish colonialism. The assemblages from each Mission-era neighborhood are compared to one another and considered in combination with previous vertebrate faunal (Reitz and Duke 2008, Reitz et al. 2010, Reitz 2016) analyses to closely examine intra-site variability. Population aggregation of towns from along the coast at Pueblo Santa Catalina created a pluralistic indigenous community with multiple culinary communities of practice. This is linked to increased variation in vertebrate and invertebrate animal use from the Irene Period at Meeting House Field (Bergh 2012) into the Mission era at Pueblo Santa Catalina de Guale.

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1. INTRODUCTION

Along the Georgia Bight, a stretch of coastline extending from Cape Fear, NC, to Cape Canaveral, FL, the past habitations of indigenous peoples are often evidenced by shell middens. A midden is an accumulation of human refuse that may include shell, bone, charred plant remains, fragments of pottery, remnants of stone tools, and all manner of quotidian debris. In coastal areas around the world, middens are often brimming with shell. Depending on the rate of deposition and various taphonomic factors, shell deposits can withstand the passage of millennia (Claassen 1998). The high calcium carbonate content of these exoskeletal elements neutralizes acids in surrounding soils which would normally have deleterious effects on archaeological materials, improving the preservation of midden contents.

The many shell middens which accumulated in the village, or *pueblo*, surrounding the Mission Santa Catalina de Guale preserve a record of indigenous life and foodways during the sixteenth and seventeenth centuries. The site of the mission, St. Catherines Island, was among the earliest Spanish attempts to missionize native peoples in the contemporary United States. Missionary presence on the island began in AD 1565 and endured, apart from interludes following early Jesuit failures in the area and the Guale Uprising of 1597, until AD 1680 when the Mission de Santa Catalina and its residents were relocated to Sapelo Island (Blair 2015). Guale interaction with Spanish missionaries permanently altered traditional political, social, and subsistence practices.

The missionization of La Florida was long considered less disruptive or transformative for the indigenous population than for other Spanish territories in the Americas. This was due to the perceived sedentism of the agricultural chiefdoms residing in the Southeast, which theoretically posed fewer logistical challenges than more mobile, dispersed populations elsewhere whom the Spanish actively congregated into more centralized, exploitable settlements. There are bioarchaeological (Stojanowski 2005, 2010, 2013), ethnohistoric (Worth 1999a, 2013) and ceramic data (Blair 2015) to suggest population aggregation in La Florida and specifically on St. Catherines Island. Displacement and migration due to colonial interferences transformed the social configuration of this area. Missionization molded the politics and ethnic makeup of the island through population aggregation and by attempting to disrupt traditional power structures, altering patterns of lineal descent, and imposing European values not only in the religious domain, but also on secular institutions such as marriage (Blair and Thomas 2014).

Archaeological investigations targeting Mission-era remains on St. Catherines Island have included extensive excavations of the Mission de Santa Catalina de Guale compound (9Li274) and the most immediate residential areas (Thomas 2008b). There are five known Mission-era neighborhoods on St. Catherines Island: 9Li210, Pueblo North (9Li2117), Pueblo East, Wamassee Head (9Li13), and Fallen Tree (9Li8). These sectors have been interpreted as aggregated populations from other mission and non-mission communities, however this can prove challenging to detect in the archaeological record due to the relative homogeneity of material culture. The communities which were recorded aggregating to St. Catherines, such as the population of the Mission San Diego de Satuache, shared linguistic and cultural heritage under the umbrella of Guale society. Parsing these potential distinctions between aggregated communities requires a fine-grained analysis of artifact assemblages, such as Blair's (2015) ceramic analysis of pueblo pottery which found evidence of multiple communities of potters creating vessels in the Pueblo Santa Catalina.

Another productive avenue for investigating variation and social organization in the pueblo is through foodways. Foodways encompass the many interconnected social, cultural, and economic factors which relate to obtaining, processing, preparing, and consuming food. Food is entwined with numerous aspects of identity including ethnicity, gender, status, and religion and it plays an important role in the establishment of social solidarity or differentiation. Diet acts to build and negotiate group and individual identity on multiple levels, defining cultures, differentiating between group and self, and marking social strata (Twiss 2007).

In their 2010 study of vertebrate fauna from the pueblo, Reitz et al. found remarkable intra-site variation in vertebrate animal use at the Pueblo Santa Catalina de Guale. The authors cautioned that “without zooarchaeological data from marine invertebrates such as oysters (*Crassostrea virginica*) and clams (*Mercenaria spp.*), the contribution of the full range of estuarine biomass to the diets of the pre-Hispanic and First Spanish periods cannot be assessed” (Reitz et al. 2010: 148-149). The first part of this undertaking has been completed with the invertebrate faunal analysis of late pre-contact assemblages (Bergh 2012), and this project supplies a depiction of post-contact continuity and change in invertebrate animal use on St. Catherines heretofore absent from the discussion.

After obtaining samples from shell middens in each residential locality in the pueblo, I focused first on identifying and quantifying the species present. I looked closely at the most abundant species, eastern oysters (*Crassostrea virginica*), and used characteristics of their shape and chemistry to infer the habitats and seasons in which they were gathered through morphometric and oxygen stable isotope analysis. The resulting information was examined closely to parse apart internal dissimilarities and contrast it with data predating European interference.

Schlerochronological analysis has been conducted on three of the Mission-era sites to determine seasonal occupation: Fallen Tree (9Li8), Wamassee Head (9Li13), and 9Li210. Sclerochronology is a technique which utilizes the accretionary growth bands of skeletal materials, most often mollusk shell, to create time-sequence data sets with the use of incremental growth analysis, geochemical analysis, or a combination thereof (Andrus 2011). Growth band analysis of *Mercenaria* from Wamassee Head and 9Li210 has shown that all four incremental stages were represented, meaning clams were harvested year-round. Shell from Fallen Tree indicated the neighborhood was occupied from the late summer into late fall (O'Brien and Thomas 2008). This data is a useful starting point for understanding the nature of occupation at each of the Mission pueblo neighborhoods. The isotopic analysis conducted in this project will provide additional information about season of capture for shell from all five mission-era neighborhoods.

By measuring the oxygen isotope composition of growth bands in hard tissues such as shell, the ambient water conditions at the time of death can be estimated. The relationship between oxygen isotopes and water temperature have been well studied and proven consistent within species, and the conditions reflected by the levels of oxygen isotopes can be interpreted as the season of capture (Andrus and Crowe 2000, 2008). Measures of oxygen isotopes have also been used to look at environments of origin for oyster samples from Sapelo Island (Andrus and Thompson 2011b). The use of stable isotope analysis on samples from St. Catherines will assist in the comparison of assemblages between neighborhoods, exposing potential differences in shellfish sourcing and seasonal activity.

Shell morphology can provide information about environmental conditions, specific habitat characteristics, and anthropogenic pressures. The morphology of an individual oyster is dependent upon numerous factors, including the type of substrate on which it develops and the density of surrounding oysters. One method of determining the environmental origins of is morphometric analysis of shell shape, based on such measurements as height-length ratio (HLR). HLR has a dependable correspondence to the environmental origins of oysters and can be used to classify them as sand, bed, channel, or reef (Kent 1992). HLR will be a useful metric for observing change in the types of habitats being exploited for shellfish collection between the Irene Period (AD 1300-1580) and Mission era on St. Catherines.

There is evidence to suggest that indigenous peoples along the Georgia coast practiced some degree of ecological stewardship through sustainable shellfish harvesting practices (Andrus and Thompson 2011, Bergh 2012, Lulewicz 2017). Mollusks are unique in that they blend nutritional values generally associated with animal resources with the stability and manipulability of plant resources. The cultivation or “gardening” of mussels has been documented among pre-contact Native American groups in California (Whittaker 2008). While this has not been proposed as a systematic practice in the Southeast, the very act of selectively harvesting oysters and other shellfish can encourage their growth (Thomas 2008c).

Whether or not groups were able to continue gathering from a wide range of oyster communities and mitigating selective pressures to maintain estuarine health during the Mission era, when their lifeways faced disruption, has not been fully explored. Vertebrate fauna excavated from the Pueblo Santa Catalina de Guale show that vertebrate components of Guale foodways shifted from the Irene Period into the Mission era, becoming more terrestrially focused (Reitz et al. 2010). This poses two important questions which I attempt to address in this thesis.

First, did shellfish, which contributed substantially to the diet prior to Spanish contact, undergo similar shifts during missionization? Second, given the sociopolitical context of missionization and population aggregation, did the various social groupings in the pluralistic pueblo community utilize available resources such as shellfish differentially during this time?

In the following chapter, I provide historical, archaeological, and theoretical context for this project. In Chapter 3, I detail the methods used in this study. I describe and justify the excavation and sampling strategies, zooarchaeological sorting and identification procedures, morphological metrics, and stable isotope analyses used to analyze invertebrate assemblages from Pueblo Santa Catalina de Guale. I present the results of these analyses in chapters 4 and 5, which focus on diachronic and synchronic variation respectively. Finally, in Chapter 6 I end the thesis with a discussion of these data, their implications, limitations, and future directions. This research will contribute to our understanding of how social groupings in the Pueblo Santa Catalina related to one another and dealt with missionization, and also to the growing body of knowledge about how traditional indigenous foodways were negotiated in colonial contexts.

2. BACKGROUND AND THEORY

The shell middens surrounding the site of the Mission Santa Catalina de Guale accumulated during a particularly tumultuous time, when regional social dynamics, community organization, political leadership, and traditions underwent profound transformation. During the sixteenth and seventeenth centuries, social groupings throughout the coastal Southeast were driven into uncharted proximity, forced to renegotiate their relationship to one another under the harsh reality of missionization. Here, I position St. Catherines Island within the context of Spanish colonialism and summarize the archaeology of Mission and Pueblo Santa Catalina de Guale. I also construct a theoretical framework that draws upon ideas of ethnogenesis and communities of practice to consider what Mission-era foodways may reflect about social relations and residential configuration within the Pueblo. This will act as the groundwork for examining the ways in which these circumstances affected the ability of people to continue a deeply rooted practice, shellfishing, and how potential continuity or change can inform our understanding of mission-era life.

Natural and Cultural History of St. Catherines Island

St. Catherines Island is one of 15 barrier islands dotting the Atlantic coast of southeast Georgia; it sits six kilometers east of mainland Liberty County across a richly biodiverse expanse of salt marshes (Figure 1). The island is around five kilometers at its widest point and extends 16 kilometers north to south between St. Catherines Sound and Sapelo Sound. The island's core, which accounts for a third of the existing landform, was created during the Pleistocene during the Silver Bluff shoreline formation (Reitz et al. 2008). The Holocene dunes which comprise the other two thirds of the island began to accumulate around 4000-5000 years ago, creating its tidal marshes and the beach ridges on its seaward side.

The estuaries surrounding St. Catherines Island provide excellent habitat for a variety of organisms. Indications of substantial shellfishing on the Georgia coast appear in the archaeological record around 3000 cal. BC (Thomas 2014). The abundant plant and animal resources of St. Catherine's aquatic and terrestrial landscapes attracted people to its shores shortly after the island became habitable. The first evidence of lasting occupation appears during the Late Archaic period (3000-1000 cal. BC), marking the beginning of St. Catherine's 4000-year human history (Thomas 2008a). The most dominant taxon in shell formations, from Late Archaic shell rings to Mississippian household middens, is the Eastern Oyster *(Crassostrea virginica).* These bivalves inhabit the intertidal zone and encourage the health of estuarine ecosystems by filtering the water and providing important physical infrastructure. The shells of dead oysters create additional substrate for live oysters and offer shelter to a variety of other invertebrates and fish. Oysters and other mollusks combine the nutritional characteristics of animal resources while being more reliable and easily exploited (Crook 1992). Mollusks were among the suite of resources which created a plentiful environment in which the coastal population grew, social stratification became more pronounced, and hereditary leadership positions emerged (cal. AD 800) (Thomas 2008a).

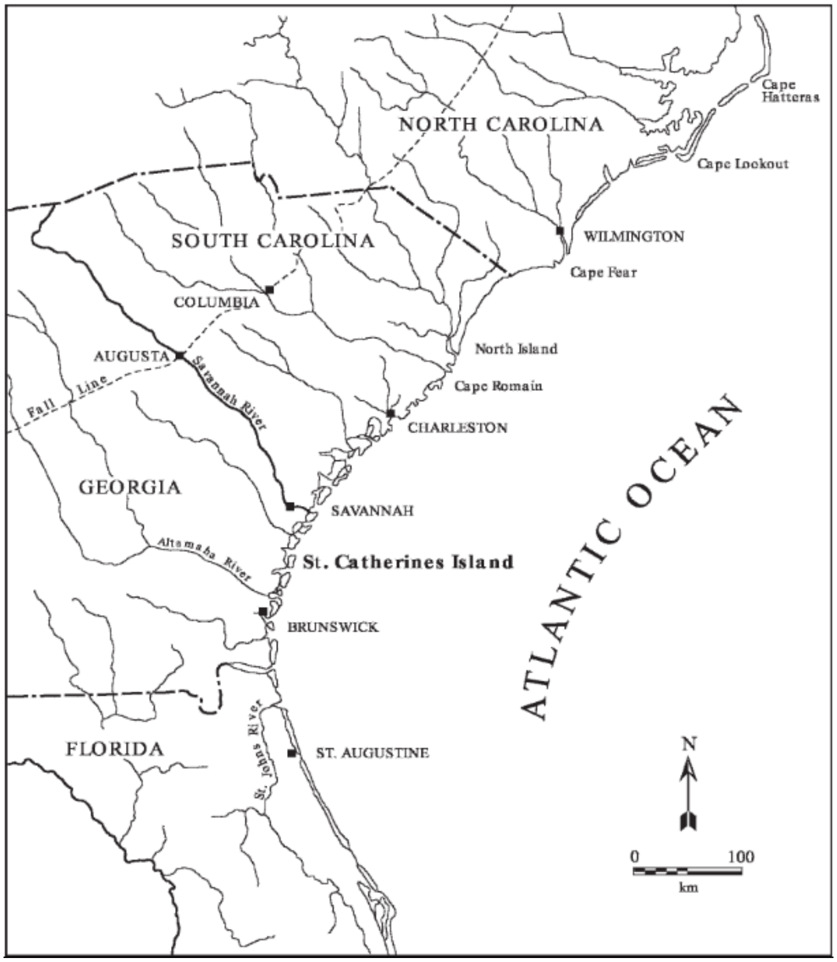


Figure 1. The location of St. Catherines Island, GA (Thomas 2008a:10, Figure 1.1). Reproduced courtesy of the Division of Anthropology, American Museum of Natural History.

By the Irene Period (cal. AD 1300-1580) the Guale were dispersed among 50 or so communities between the Altamaha and Ogeechee Rivers along the Georgia coast and its barrier islands. Based on the written accounts of European explorers during the 1520s, at least 3,000 Guale individuals are estimated to have inhabited this area prior to colonization (Worth 2004). Several constituent Guale chiefdoms formed the basis of a two-tiered political system, in which each chiefdom was ruled by a *mico*, who were collectively presided over by the *mico mayor* (Jones 1978, Thomas 2008b, Blair 2015). Guale commoners were distinguished from classes of elites, healers, and war captains (Francis and Kole 2011). The matrilineally reckoned *micos* concentrated control amongst the elite class by creating ideologies which legitimized their status and justified the regulation of human labor (Blair and Thomas 2014).

A combination of hunting, fishing, gathering, and farming sustained the Irene Period Guale. The intensity of pre-Hispanic Guale agricultural activities has been the subject of lengthy scholarly debate (see Jones 1978, Larson 1980, Crook 1986, Thomas 1987, Worth 1999a, Saunders 2000, 2002, Ruhl 2003, Keene 2004, Thomas 2008, Thomas 2012, Crook 2012). Researchers disagree whether maize was an essential or incidental part of Guale subsistence and how this effected their mobility. The Late Mississippian Guale have been depicted as a semisedentary population with mixed subsistence strategies and limited maize agriculture (Larson 1980, Crook 1986, 2004), and alternately as sedentary agriculturalists who supplemented their maize yields with marine and mast resources (Jones 1978, Worth 1999a, Keene 2004, Thomas 2008c).

Early Jesuit accounts described the Guale as seasonally mobile and primarily dependent on wild resources. Fray Rogel, who worked at the missions of Santa Elena and Orista, reported to Governor Pedro Menendez de Aviles that the local populations abandoned him during the acorn season to harvest and process mast resources (Jones 1978). Rogel spent eleven months among the Guale and blamed the botched Jesuit attempts at missionizing the local populations on the infertility of local soils and an inability to settle the highly mobile Indians into a sedentary lifestyle (Thomas 1990). Worth (1999a) has suggested that these claims may reflect emergency subsistence strategies employed in the face of the severe, prolonged regional drought reflected in the paleoclimatic data. Alternately, the Guale may have simply been actively avoiding contact with Jesuit missionaries (Jones 1978).

Direct evidence for maize cultivation is inconclusive, as early research strategies on St. Catherines neglected to adequately sample the paleoethnobotanical record (Thomas 2010). Bioarchaeologically, there is no evidence for maize consumption on the island prior to AD 1300, but ^{13}C isotope ratios and increased dental caries suggest it became part of the diet during the Irene Period (Larsen and Thomas 1982, Larsen et al. 1991, Schoeninger et al. 1990, Thomas 2008c). In reviewing the literature surrounding the "Guale Problem," Thomas (2008c) concluded there is convincing evidence that maize was grown in sizeable quantities prior to and during the contact era. Single-season sites on St. Catherines are rare; seasonality estimates for Irene period sites indicate that the majority were occupied for three or four seasons of the year. Thomas cites the ethnohistorical evidence as discussed by Worth (1999a), that quantities of corn recorded by the Spanish during the Mission-era suggests a deep familiarity with maize agriculture. Additionally, the skeletal evidence presented by Larsen and his colleagues shows that maize was a significant pre-contact dietary component.

Skeletal evidence also shows declines in health, nutrition, and population numbers following Spanish colonization of La Florida (Larsen 2001, Larsen et al. 1990, 1992, 2001, 2002, Stojanowski 2005, 2010, 2013). Stable isotope analysis of human remains from Mission-era cemeteries have demonstrated reduced reliance on marine resources during the Mission era in comparison with samples from pre-Hispanic populations (Larsen 2001; Larsen et al. 2001). Human remains from the Georgia coast dating to the First Spanish Period display less negative ^{13}C and less positive ^{15}N than remains from the Late Mississippian (Larsen 2001), suggesting residents were consuming more maize and less marine foods. Analysis of skeletal populations from across la Florida have indicated slight variability within broadly similar patterns. Isotopic ratios collected from cemeteries on St. Catherines suggest that later populations were cultivating maize more intensely than neighboring inland groups following the establishment of the Mission Santa Catalina de Guale (Larsen et al. 2001). The enamel defects and isotopic data from tooth dentin belonging to individuals interred in the mission cemetery have shown that this increase in maize consumption resulted in nutrient deficiencies upon weaning (Garland et al. 2018).

History of the Mission Santa Catalina de Guale

Ultimately, these deleterious effects upon the physical, societal, and cultural wellbeing of peoples in La Florida can be traced back to AD 1513, when the Spanish first made landfall on the Atlantic coast of Florida. In the years that followed, more than a dozen conquistadors journeyed into the interior only to be disappointed by the lack of precious minerals. As the empire expanded, the strategic importance of the southeast became apparent. In 1565, King Phillip II directed Pedro Menendez de Aviles to establish a foothold in the region to protect treasure-laden Spanish fleets sailing northward up the Atlantic Coast.

Menendez's founding of San Augustine and Santa Elena marked the birth of La Florida (Francis and Kole 2011, Worth 2014). The Spanish monarchy and the Catholic church were closely intertwined during the sixteenth and seventeenth centuries, and Spain's colonization of the Americas was a combined effort undertaken by religious and secular authorities. This is especially true in the southeastern United States, where missions have been characterized as a core element of Spanish colonization (Schneider and Panich 2014). Menendez was contractually obligated to bring along friars from the religious order of his choosing so they could immediately begin conversion efforts to groom obedient Christian subjects (Francis and Kole 2011). Supported by royal stipends, clergymen established missions across the landscape and were instrumental in expanding colonial jurisdiction into the hinterlands of the Florida provinces.

Spanish presence on St. Catherines began in 1566 when Governor Menendez visited the island and stationed twenty soldiers and a missionary at the newly established outpost (Worth 2009a). Throughout La Florida, Catholic friars were integrated into existing political hierarchies where they could advance the parallel agendas of the Spanish church and crown. Missionaries worked to alter indigenous religious practices, social behaviors, and reorient the agrarian focus of indigenous groups across the region to benefit the economies of the mission system and the colonial government (Blair and Thomas 2014). Alliances with these Europeans opened access to exotic trade goods and military backing which helped cement power for the Guale, Timucua, and Mocama elite within their own communities and among neighboring groups. Spanish soldiers acted as agents of the *sabana* and *repartimiento* systems, ensuring that indigenous leaders fulfilled their sworn obligations of loyalty, trade, defense, and conversion by routinely compensating them with gifts (Bushnell 1994). The resulting political situation in La Florida was a modified paramount chiefdom, characterized by factionalism and predictable cycles of instability, in which the Spanish had reinforced traditional tributary exchange programs (Blair and Thomas 2014).

Several rounds of missionary efforts took place on St. Catherines during the sixteenth century. The first friar temporarily stationed on St. Catherines by Mendez was followed by a failed Jesuit attempt to establish a mission at the town of Guale between 1568-1570 (Worth 2004). There was a brief attempt made by the Franciscans to replace the Jesuits between 1574-1575, but the friars left La Florida due to disagreements with Governor Diego de Velasco (Lyons 1992, Blair 2015). Though it is poorly documented, it is believed that Theatine friars also established residences in the towns of Guale and Orista during the 1570s. Franciscan missionization of La Florida intensified in 1587, with Fray Alonso de Reynoso enlisted the help of nine other friars to undertake a "spiritual conquest" of the region (Francis and Kole: 32). In 1595, six missionaries were sent into the Guale province, and Mission Santa Catalina de Guale was constructed on St. Catherines Island.

After the new governor Pedro Menéndez de Marqués convinced Spain's monarch to abandon Santa Elena in 1597 to consolidate Spanish forces at a single garrison, making St. Augustine the capital, Mission Santa Catalina became the primary northern outpost of La Florida (Thomas 1987, Francis and Kole 2011). Later that same year, Guale rebels killed five friars stationed in the Guale province and destroyed their mission compounds, including the two friars residing at Mission Santa Catalina. The Guale Uprising of 1597 has long existed in the historical consciousness as "Juanillo's Rebellion", so-named for the scorned heir to the Guale *mico mayor* who supposedly led the revolt in response to friars' attempts to ban polygamy and prevent him from inheriting his title. This version of events is largely based on a second-hand chronicle of the rebellion, the *Account of the Martyrs in the Provinces of La Florida* by Fray Luis Gerónimo de Oré (1619), and newer interpretations tend to emphasize the role of Guale factionalism. Francis and Kole (2011) have pointed out that the revolt included an attack led by don Domingo of Asao on the Native American residents of Mission San Pedro, not the mission friars. Internal Guale factionalism and competition with the neighboring chiefdoms of Orista and Mocama may have been an equal, or even stronger, catalyst for the violence that occurred in 1597 than anti-Catholic sentiment (Blair and Thomas 2014).

Nearly a decade passed before four new missions were constructed and missionaries were redistributed throughout the Guale province in 1606 (Francis and Kole 2011). Mission Santa Catalina was rebuilt during this time when new friars were dispatched to St. Catherines (Worth 2009). Seventeenth century La Florida was characterized by aggregation and reorganization of mission populations. Across the Americas, the Spanish empire enforced policies of *congregación* and *reducción,* whereby dispersed peoples were congregated to a centralized area. *Reducción* referred specifically to the *congregación* of semisedentary groups (Bushnell 1994). Within La Florida, bioarchaeological studies of mission cemeteries reveal information about increased migration, aggregation, and localized demographic collapse. (Stojanowski 2005). “Population loss within the context of massive epidemics and the stresses of the draft labor system resulted in increasingly dysfunctional aboriginal societies, and whether by Spanish or Indian intent (and probably by a combination of both), settlement systems became increasingly centralized” (Worth 1995: 13).

One incidence of aggregation to St. Catherines occurred between 1663 and 1666 following intense slave raiding to the north by British allied Westos, when Mission San Diego de Satuache was displaced and combined with Mission Santa Catalina (Worth 1995, 2009). Resettlement of Satuache residents was so well-documented due to the association with Mission San Diego, but there were likely more communities from *visitas* and pagan villages who joined Mission Santa Catalina during its tenure on St. Catherines Island. Archaeological evidence suggests the presence of at least five distinct residential areas and multiple communities of potters (Blair 2015) which probably reflect aggregated populations. Cemetery populations on St. Catherines and Amelia Island, where the mission would later relocate, appear genetically more subdivided than precontact populations, supporting the idea that aggregation increased during the mission era. Stojanowski suggests that this excess of genetic diversity may be explained by a cycle in which local populations aggregate to missions, mortality increases and out-migration stress populations leading to decline, and new groups are brought to the mission via *congregación* (2010:147).

Traumatized by a violent Westo attack and facing deepening instability, St. Catherines was abandoned in 1680. Residents relocated to Sapelo Island, joining the aggregated San Joseph and Santa Clara population. Shortly thereafter in 1683 these communities collectively retreated southward to the abandoned site of Mission Santa Maria on Amelia Island, in present-day Florida. In his studies of biodistance within the cemetery at Mission Santa Catalina de Guale de Santa Maria on Amelia Island, Stojanowski (2013) found a complex mixture of individuals from differing political and ethnic groups throughout Spanish Florida. By the early eighteenth century, British encroachment continued to reduce Spanish territory and destabilize the region causing disease, slave-raiding, and out-migration to indigenous confederations such as the Yamasee to severely reduce the number of Spanish-allied mission Indians. By this point, records suggest there were no more than 400 individuals from the Guale and Mocama provinces remaining in the settlements surrounding St. Augustine to which they had been confined. In 1763, the last Spanish officials abandoned La Florida and made their final retreat to Cuba (Worth 1995, 1998, 2004).

Archaeology of the Mission and Pueblo Santa Catalina de Guale

The reconstruction of this complex history has required painstaking work on behalf of ethnohistorians and archaeologists. Archaeological research on St. Catherines Island began in the late nineteenth century with the work of Charles Colcock Jones Jr. and extensive excavations conducted by Clarence Bloomfield Moore (Moore 1897). St. Catherines Island has been held in trust by the Edward John Noble Foundation since 1943, which has protected it from residential and commercial developments and fostered partnerships with various research institutions to explore the island’s natural and cultural history. Locating Mission Santa Catalina de Guale was a consequential prospect to the both the foundation and the broader archaeological community. As a result, many archaeologists, including Lewis Larson (Larson 1952, 1953), John W. Griffin

(Griffin 1965), and Joseph Caldwell (Caldwell 1971), sought to verify its whereabouts. The abundance of Mission-era ceramics discovered by Larson while excavating in the Wamassee Head area led him and his fellow investigators to correctly consider it the most likely location for the mission, but definitive evidence of mission structures eluded them.

Finally, after spending more than five years developing and executing a plan to pinpoint Mission Santa Catalina de Guale, David Hurst Thomas and a crew of archaeologists from the American Museum of Natural History successfully relocated the site in 1981. The historic Spanish documents had proven unhelpful due to the frequent movement of towns and missions, which often retained their names despite geographic shifts. Shifting strategies in 1977, the team undertook a 20 percent survey of the island with the intention of better understanding the archaeological record throughout all time periods and narrowing their search for the mission. Results of small-scale test excavations found the majority of olive jar and majolica sherds clustered near the Wamassee Creek drainage, confirming the suspicions of earlier researchers about the location of Mission Santa Catalina. Systematic auger tests further narrowed the search area to a 1-hectare block, and magnetometry, soil resistivity, and ground-penetrating radar were used to locate structures and guide excavations within the mission compound (Thomas 1987, 2008a).

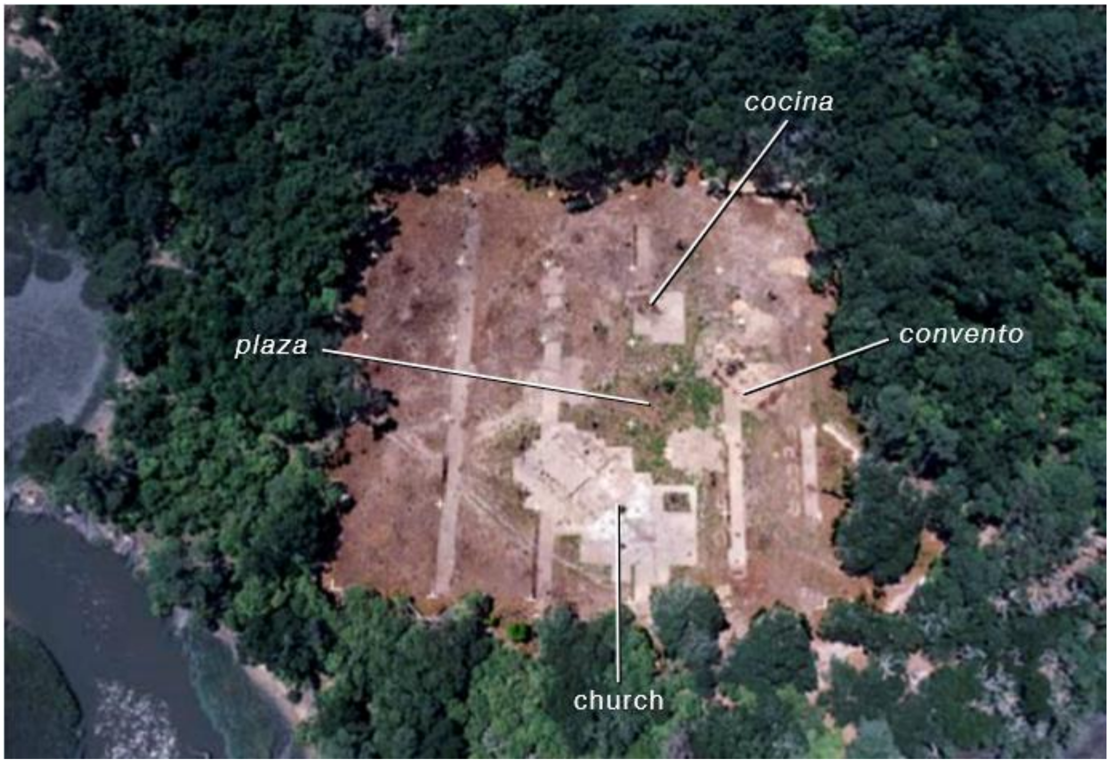


Figure 2. Aerial photograph of Mission Santa Catalina de Guale compound in Quad IV, oriented with true north at the top of the image (Thomas 2009: 24, Figure 3.1). Reproduced courtesy of the Division of Anthropology, American Museum of Natural History.

Excavations on St. Catherines from 1981 until 1990 were focused almost exclusively on the mission compound. While Thomas oversaw the structural excavations of Mission Santa Catalina (9Li274), bioarcheologist Clark Spencer Larsen was responsible for excavating the associated cemetery (Thomas 2008a). Larsen and his colleagues disinterred 431 individuals buried in a manner which blended Catholic and Guale mortuary traditions. Among the grave goods were nearly 70,000 beads, other items of personal adornment such as medallions and rings, mirrors, crucifixes, rosaries, shroud pins, shell gorgets, chunkey stones, ceramics, and projectile points (Larsen 1990). In 1990, the scope of excavations was expanded to include the indigenous pueblo surrounding the mission. Research in the decades since has revealed five distinct Mission-era pueblo neighborhoods on St. Catherines Island: 9Li210, Pueblo North

(9Li2117), Pueblo East, Wamassee Head (9Li13), and Fallen Tree (9Li8) (Blair 2015) shown in figure 3. Elizabeth Reitz and her students at the University of Georgia have completed extensive zooarchaeological analysis of vertebrate fauna from the mission pueblo (Reitz 2008, Reitz and Dukes 2008, Reitz et al. 2010, Reitz 2016).

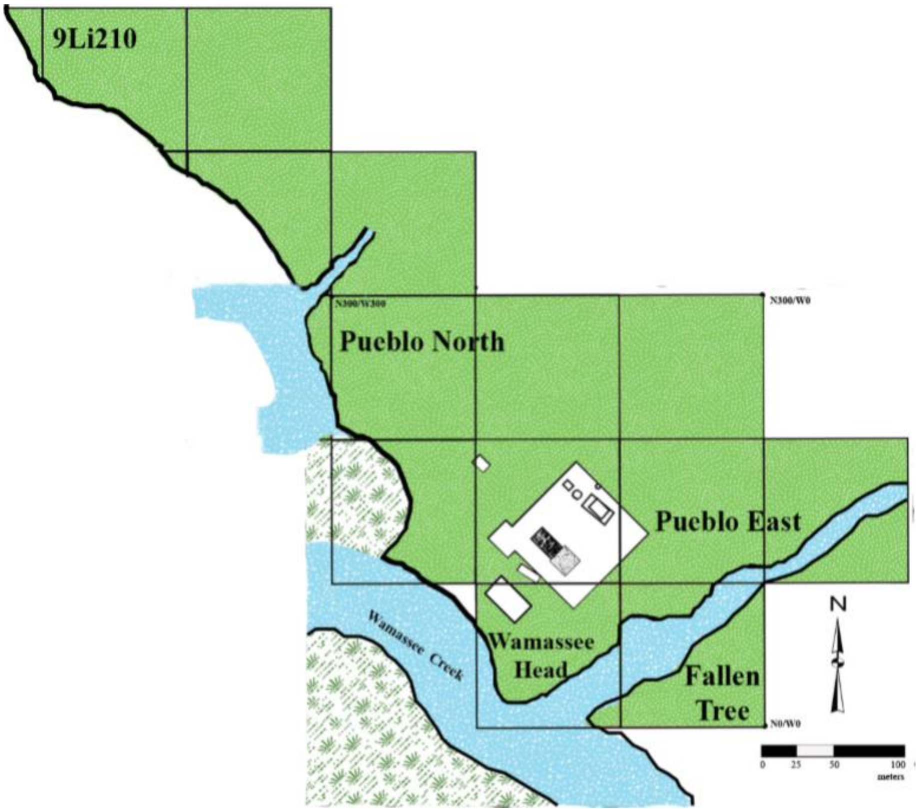


Figure 3. Map of Mission Santa Catalina de Guale Pueblo neighborhoods (Blair 2015:77 figure 5.1). Reproduced courtesy of Elliot Blair.

Zooarchaeological and paleoethnobotanical investigations across La Florida suggest that colonization did not severely alter the constituent components of indigenous diets, although there is evidence that diets became more regionally homogenized and dependent on maize (Stojanowski 2010). The mission economy relied heavily on indigenous manpower through the *repartimiento* system of labor conscription and via tribute. The resident friars of Spanish missions depended on local inhabitants to produce maize and white-tailed deer, not only to sustain their own populations but also to support the *presidio*. Military forces from St. Augustine and Santa Elena consistently harassed the Guale and demanded tributes of food (Jones 1978). As noted by Bushnell (1994), when the stores of maize became low in 1680, Governor Cabrera ordered "all the *caciques* and *mandadores* of the pueblos to see to the planting and working and harvesting of the maize and beans, letting no one during that season, regardless of estate or quality, occupy himself with fishing or hunting or other activities" (149).

Early attempts to recreate Iberian foodways in La Florida largely failed (Ruhl 1997). Mutton was the meat of choice among sixteenth century Spaniards, but sheep were not well-suited to the climate of La Florida, and their flocks dwindled and died. Other Eurasian introductions saw varying degrees of success, but never supplanted locally available flora and fauna for Native Americans, especially in the hinterlands. Wheat was principal among the cereal grains transported with Menendez's initial expedition into La Florida, an especially important element for recreating the Iberian lifestyle for the more than 600 soldiers and settlers who also made the journey. Spanish residents of St. Augustine were more successful than friars and soldiers in outlying areas at growing Old World fruits and vegetables (Reitz and Scarry 1990) except in certain cases such as Mission San Luis de Talimali in the Apalachee province, where domestic mammals contributed almost all biomass within Spanish contexts (Reitz 1993). Cattle ranches and wheat cultivation succeeded more readily in the fertile soils of Apalachee than in other provinces, and Apalachee became an important source of beef, tallow, and hides for St. Augustine and the Caribbean (Reitz 1993, Scarry 1993).

The most common location for the recovery of wheat in the botanical record of missions during this time is in storage areas associated with churches. At Mission de Santa Catalina, wheat grains were uncommon in most contexts including the *cocina*, however, thousands of specimens were recovered from the *iglesia*. This pattern may result from the role of wheat flour in the preparation of Eucharist wafers or the elevated status of the friars who preferred breads of wheat to those of maize (Ruhl 1997). At Baptizing Spring, the site of Mission San Augstín de Urica, some indigenous households consumed Old World domesticates such as pigs, cows, and peaches though they “did not appear to have been important” (Loucks 1993: 206). At San Joseph de Sapala, maize kernels were the most frequently recovered botanical remains from mission era contexts. Wild foods appear to have remained an important part of the diet, however, with approximately 150 fragments of carbonized fungi being excavated from a single unit level. Also present in smaller quantities were chenopod, wild grapes, peppergrass, boneset, and other grasses (Moore and Jeffries 2014). Plant remains excavated from a council house at San Luis de Talimali were dominated by indigenous cultigens but also included yaupon holly (used to make a ritual beverage known as black drink), and small amounts of introduced seeds from wheat, peach, and watermelon (Scarry 1993).

Botanical remains from Fallen Tree (9Li8) on St. Catherines included maize, chenopod, and peach. Peaches were the only European plant domesticate represented in the residential area, and the emphasis seems to be on indigenous cultigens (May et al. 2008). When comparing vertebrate faunal assemblages from Meeting House Field, an Irene period village on St. Catherines, to those from the Pueblo Santa Catalina, Reitz and Dukes (2008) found increased presence of field predators such as opossum, rabbits, squirrels, racoons, and deer which may be tied to more intense agricultural developments. Overhunting of deer may be evidenced by the increase of young deer from 25% of individuals from Meeting House Field to over half of those recovered from Fallen Tree. Fishing declined, and the incidence of turtles plummet from the

Irene Period. European livestock were modestly incorporated into the diet, reflected by small amounts pig remains (Reitz and Dukes 2008).

Reitz et al. found there was nearly as much variability in animal use between the different Pueblo Santa Catalina de Guale neighborhoods as there is between the Irene Period and Mission era assemblages, which they consider the most significant outcome of the study. These results suggested “these sectors were used: (1) as different activity areas; (2) at different times; (3) by distinct ethnic or social groups; and/or (4) by people with different relationships with the Spanish personnel stationed at the mission” (2010: 134). These possibilities are not mutually exclusive, however neither temporal nor functional differences alone are likely to explain the full extent of variation. The possibility that these neighborhoods represent distinct social groups has found further support in Blair’s (2015) fine-grained analysis of ceramic production and consumption at Pueblo Santa Catalina, which provided consequential data on intra-community variation.

In Blair’s study, the observed morphological differences of grit inclusions in ceramic sherds indicated that communities of potters in the northern neighborhoods of 9Li210 and Pueblo North used a technique to prepare this temper which differed from other pueblo potters. The ceramic assemblage from 9Li210 was especially distinctive, with far higher ratios of plain to stamped wares and well executed line block stamping with fewer instances of the over-stamping common in other neighborhoods. These characteristics bear striking similarity to assemblages from Pine Harbor and Harris Neck on the mainland, and Blair suggests this may be evidence of an undocumented incident of aggregation to St. Catherines. The complicated firing techniques used to produce ceramics at 9Li210 and Pueblo East, evidenced by complex firing cores and more carbon retention in a high percentage of sherds, may be evidence of ties between the two neighborhoods. While not certain, this could potentially connect Pueblo East to the community which aggregated from Mission San Diego de Satuache and 9Li210 to an earlier migration.

Following his analyses of ceramic and glass bead assemblages from the Pueblo, Blair called for invertebrate analysis of mission-era assemblages in order to measure changes in shellfishing related to missionization and the associated agricultural reorientation, and to explore how foodways varied between neighborhoods (2015: 192-193). Analysis of invertebrate fauna have been conducted for Irene Period sites on St. Catherines (Bergh 2012), however there have been no comparable studies the Mission era. Reitz et al. (2010) have made similar remarks about the potential importance of incorporating invertebrate data into the conversation about mission-era foodways. The authors mention that other biological and geochemical techniques should be combined with traditional zooarchaeological methods in future research, and that stable isotope analysis on the incremental growth structures of mollusks should become routine (2010:199). This project attempts to address this gap in the data, and better our understanding of mission-era foodways and their relationship to the social reorganization and culture change prompted by missionization.

Theoretical Framework

In order to address questions concerning the effects of colonialism, it is important to understand previous and current approaches to colonial archaeology. Colonial encounters have attracted the attention of archaeologists for over a century for their utility as microcosms of cultural change and the complex dynamics of identity. A multitude of theoretical concepts have been used to understand how cultures persist and transform in the context of colonialism. Among the earliest and most pervasive of these were acculturation models, which many have critiqued for denying the agency of subjugated populations. The following theoretical overview contextualizes my approach, explaining how ethnogenesis differs from other models of culture change and how the concept of communities of practice provides a basis for understanding past foodways as a product of community-based learning and an expression of local identity.

Historical Approaches to Theorizing Culture Change

Through much of the twentieth century, acculturation was the dominant framework for conceptualizing the culture change experienced by colonized populations around the globe in response to European expansion. Cusick (2015) has emphasized that "acculturation" never embodied a unified definition, concept, or approach. However, he maintains that there were several shared assumptions that underpinned most discussions of acculturation. As a term it was broadly used to describe the loss of traditional lifeways with the adoption of European technologies, ideas, styles, and customs. Methodologies often resembled those outlined by Quimby and Spoehr (1951) in which artifacts were categorized as "introduced" or "native" based on their form, materials, and manner of production, before being quantified to calculate the degree of acculturation in a given assemblage. As early as Redfield et al.'s (1935) definition it was acknowledged that acculturation encompassed "changes in the original cultural patterns of *either or both groups*" (149, emphasis added). This being said, the majority of acculturation models were unidirectional and the transmission of cultural traits was heavily weighted in favor of "dominant" colonizers.

On this basis it was presumed that the duration and intensity of the interaction between groups directly correlated with the degree of culture change, which Worth (2006) has contradicted with his studies of the Timucua during Spanish colonization. Worth points out that the degree to which individual Native American households in La Florida adopted Spanish goods and practices varied greatly and did not reflect a one-to-one relationship to overarching social, economic, or political change. Lightfoot (1995) has made similar observations and has critiqued acculturation models for portraying subjugated populations as passive recipients of change.

Alternative Frameworks and the Advantages of Ethnogenesis

Many different frameworks for theorizing culture contact situations have emerged as alternatives to acculturation, such as transculturation, creolization, and hybridity. None of these have the capacity to predict or explain the outcomes of colonialism in all instances, because every encounter was comprised of distinct communities which were uniquely situated in their own historical and sociopolitical contexts. A common strain among these is acknowledging the interdependence of all social groups involved in colonial exchanges and restoring agency to subordinate populations despite the asymmetrical relations of power. Beginning with her studies of Californios (2005, 2008) Voss has popularized ethnogenesis in culture contact studies as one way to conceive of the emergence or transformation of ethnic identities. Ethnogenesis differs from acculturation models because it represents "the unpredictable outcome of practical strategies and tactics and of cultural creativity, rather than a predicable process driven by external stimuli" (Voss 2008: 33).

Ethnogenesis emphasizes cultural persistence in addition to transformation and recognizes that these are not inherently dichotomous; there is a dialectical relationship between change and continuity (Voss 2015). One outgrowth of ethnogenesis which attempts to encompass the full cycle of historical processes which ethnic identities undergo is the concept of "ethnomorphisis," which encompasses their formation, maintenance, and disappearance (Hu 2013). Voss has said that ethnogenesis models "apply best to those situations in which prior modes of identification are transformed and replaced by new identity practices" (2015: 659) and lists aggregation and fusion as processes characteristic of ethnogenesis. I believe that Guale entanglement with the Spanish can be best understood as part of a rapid, multiscalar cycle of ethnomorphisis during the sixteenth and seventeenth centuries, which involved all the indigenous chiefdoms of La Florida.

The very ethnonym "Guale" was a Hispanicization of an unknown prior epithet, and the social, religious, and political reconfiguration which resulted from missionization permanently transformed the Guale's preexisting ethnic identity. Through the course of Spanish colonization, Guale communities throughout the province experienced fission and fusion with dissenters fleeing to the interior and joining the Yamassee (Francis and Kole 2011, Worth 1999a) and mission authorities frequently relocating mission populations. Bioarchaeological studies of ethnogenesis in Spanish Florida have provided biological evidence of the ways in which colonization altered intertribal networks and relationships. Stojanowski's (2010) measurements of biodistance reveal that sixteenth century mission communities were less biologically integrated, but with increased aggregation as a part of the slow retreat down the coast, the Native Americans of La Florida were essentially a single biological population by the end of the mission period in the late seventeenth century. The aftermath of Spanish colonization following their evacuation of the Southeast did not only result in Guale nomocide, but in the genesis of new tribal identities such as the Yamassee (Worth 1999b) and Seminole (Weisman 2007).

Bridging the Gap: Food, Identity, and Communities of Practice

By studying the debris of everyday life at the household or site level, we can gain knowledge about how these broader processes affected daily practices. When outlining practice theory, Bourdieu made clear that the household is the prime location for observing habitus, the "durable, transposable dispositions which functions as the generative basis of structured, objectively unified practices" (Bourdieu 1984: vii). According to Bourdieu, the whole suite of practices involved in obtaining, storing, and preparing food is exemplary of habitus, as it reinforces social rules within daily practices, where they are transmitted to broader society and reflected back again (Bourdieu 1984).

Foodways are useful for observing temporal change because they represent a nexus of environmental context, biological needs, and a suite of culturally contingent values and traditions. Hastorf and Weismantel (2007) summed up this complexity, calling food “a means for communicating a highly condensed set of profound statements about ecology, biology, and economy, as well as about the political, cultural, and religious systems of a given society” (308). Food plays an important role in the establishment of social solidarity or differentiation; it is key to building and negotiating group and individual identity on multiple levels: defining cultures, differentiating between group and self, and marking social strata (Twiss 2007). While culinary traditions might serve to unite a social group under a shared identity, there are subtle differences between the foodways of different communities which relate to their educational lineages.

There is a vast body of practical and cultural knowledge entwined in foodways. The way in which an individual learns about food production, procurement, processing, preparation, and consumption depend on their social, cultural, and economic circumstances. Culinary knowledge may then exist within communities of practice in the same way the conveyance of lithic and ceramic technological knowledge has been viewed to exist. A community of practice typically describes a group of people who share the same craft and are connected through a social network of situated learning which may involve shared identity and participation in a group, kinship ties, and apprenticeships or mentored relationships. The concept originated in cognitive anthropology (Lave and Wenger 1991), however it has found great utility among archaeologists. While communities of practice are usually discussed in terms of production, such as Blair’s (2015) study of pottery manufacture in Pueblo Santa Catalina de Guale, it has also been used to understand patterns of consumption, as with glass trade beads on St. Catherines Island.

Barbara Mills (2016) has utilized these concepts when examining archaeological foodways, describing constellated networks of culinary communities of practice. Mill's application of communities of practice draws on De Certeau's (1988) assertions that cooking and consumption are relations of power which are strategically used. This seems especially pertinent to St. Catherines Island, where Spanish missionaries were forced to make concessions about their diets and consume indigenous ingredients. Foodways at the household level may have been an avenue for cultural continuity and identity maintenance for the Guale both as non-Spanish and even as distinct towns following relocation and aggregation. The fact that documents recording the movement of these communities show that they continued to retain the name of their town of origin, and archaeologically it appears that they resided in distinct neighborhoods, suggests they also maintained that local identity and that food-related knowledge may have continued to be transmitted within these town-specific social networks.

Considering differential patterns of food consumption in the Pueblo Santa Catalina de Guale as evidence of culinary communities of practice helps connect the data presented in chapters four and five of this text to broader conversations regarding missionization and population aggregation. In the final three chapters of this thesis I will examine how indigenous shellfishing practices both changed and persisted in the context of geographic displacement, reorganization of the social landscape, threats of violence, conversion, political tensions, and participation in the mission economy.

Chapter Summary

The colonization of La Florida had direct and indirect implications for indigenous diets. Along the Georgia coast, the colonial agenda shifted the ratios of wild versus domesticated plants and deemphasized marine resources in favor of terrestrial ones. By altering the social and political environment, population aggregation around Spanish missions further complicated the production and reproduction of indigenous foodways. The Mission-era residents of St. Catherines Island consumed more maize and white-tailed deer than their predecessors in the Irene Period, and ate fewer vertebrate estuarine animals such as turtles and fish (Reitz and Dukes 2008, Reitz et al. 2010). Given the importance of oysters, clams, stout tagelus, and other mollusks within Guale cuisine, the lack of invertebrate faunal analysis from Mission pueblo assemblages has limited our ability to understand the full breadth of dietary change during this period. In the following chapter, I explain the methods used to characterize shell midden assemblages from all five Pueblo Santa Catalina sectors to assess intra-community variation and diachronic changes in shellfish consumption.

3. METHODS

Samples of invertebrate fauna from the indigenous pueblo surrounding Mission Santa Catalina were collected for two primary purposes: 1) to enable diachronic comparison with earlier Irene Period shell middens on St. Catherines Island to broadly examine the effects of missionization on local foodways, and 2) to explore synchronic variation in foodways and resource utilization in the mission pueblo resulting from the confluence of aggregated peoples and their associated culinary communities of practice. This chapter describes the excavation and sampling strategies, the zooarchaeological species identification and quantification procedures, and the methods of morphological and stable isotope analysis used to assess oyster-harvesting practices. Bulk samples were analyzed from shell middens in each of the five known Pueblo Santa Catalina neighborhoods: Fallen Tree (9Li8), Wamassee Head (9Li13), Pueblo North (9Li2117), Pueblo East, and 9Li210. The summed results of the zooarchaeological and chemical analysis of Mission-era shell middens are presented and contrasted with pre-contact datasets in chapter four, and the results of intra-site analysis and variation is discussed in chapter five.

Field Methods

In May of 2018, a crew of students from the University of Alabama excavated three 1x1 meter units in three neighborhoods of Pueblo Santa Catalina de Guale at Wamassee Head (9Li13), Pueblo East, and 9Li210. The locations of these units were chosen for their proximity to previous test units which had relatively dated the middens to the Mission period and that had been sampled in previous ceramic and vertebrate zooarchaeological analyses. Previously excavated bulk samples from Pueblo North and Fallen Tree (9Li8) were provided by the American Museum of Natural History to be included in these analyses. The sampling strategy for collecting bulk samples of invertebrates mirrored Sarah Bergh's (2012) intensive zooarchaeological analysis of Mississippian Period shell middens on St. Catherines Island. In maintaining sampling and analytical strategies consistent with Bergh, I hoped to foster the best possible conditions for observing diachronic change between time periods.

The 1x1 meter units were excavated in arbitrary 10 cm levels through the vertical extent of the midden deposits. Forty-liter bulk samples of shell and the surrounding midden matrix were collected from the full vertical and horizontal extent of each level. Bergh (2012) rationalized 40-liter bulk samples collected in this manner as a compromise between collecting column samples, which disadvantage large vertebrate remains and represent only a small portion of the midden assemblage, and studying all materials from a 1 m^2 unit, for which neither the time needed to analyze these materials and the space required to store them in perpetuity are feasible. This sampling strategy resulted in the collection of comparable vertebrate samples, which were not analyzed in this study but will be available for future research. After 40-liter bulk and 10-liter flotation samples were collected from each level, the remaining soil was first dry screened at 1/8" to reduce volume, bagged, and then wet screened at 1/8" to improve the recovery of small artifacts such as glass beads. All 40-liter bulk samples were reduced in the field via wet screening into 1/2", 1/4", 1/8", and 1/16" fractions.

Fallen Tree (9Li8)

Fallen Tree is separated from the Mission compound by a small freshwater tributary of Wamassee Creek, making it the southernmost neighborhood of the Pueblo Santa Catalina de

Guale. This neighborhood was included in both Lewis Larson and Joseph Caldwell's excavations during their respective searches for Mission Santa Catalina, revealing an array of historic artifacts and structural remains. Larson's block excavation at Fallen Tree uncovered Spanish olive jar and majolica, iron artifacts, glass beads, carbonized peach pit fragments and other Spanish-introduced materials along with many late precontact indigenous ceramic sherds (May 2008). Fallen Tree was sampled in the American Museum of Natural History's systematic test pit survey in 1980 and additional units were excavated by Alan May in 1983 following the discovery and excavation of the Mission Santa Catalina compound. The resulting material culture from these excavations, predominantly comprised of artifacts of aboriginal manufacture but also including those produced by Europeans, provided further evidence of a mission-era indigenous occupation of this area.

Figure 4. The AMNH Operation 10A excavation block at -40 cm below datum, oriented with west at the top of the image. F(2013)23 is shown on the southern end of the block. Photograph

by Nicholas Triozzi, reproduced courtesy of the Division of Anthropology, American Museum of Natural History.

In 2013 the American Museum of Natural History opened a large excavation block consisting of 35 1 x 1 m units (Operation 10) adjacent to Alan May's Block B at Fallen Tree (Semon et al. 2017). In May of 2017, a combined crew of archaeologists from the University of Alabama and the American Museum of Natural History revisited Operation 10 to map and excavate features previously noted in 2013. One of these features, F(FT 2013) 23, was a shell deposit along the southern margin of the excavation block. The exposed layer of shell extended horizontally across several square meters and extended southward beyond the excavation area. Shell was primarily contained within one 10cm level at a depth of 40-50 cm. 40-liter bulk samples of shell were collected from each 1 x 1 m grid unit resting entirely within the boundary of the feature, and those units bisected by the feature were combined as needed. This ultimately yielded five 40-liter bulk samples which represent the Fallen Tree neighborhood in the shell midden analysis discussed in chapters four and five.

Wamassee Head (9Li13)

The Wamassee Head neighborhood is located north of Fallen Tree across the freshwater creek, just southwest of the mission compound. As with Fallen Tree, Wamassee Head was also subject to the investigations of Joseph Caldwell, at which time the two sites were often lumped together under the same moniker of Wamassee Head (Blair 2015). During the May 2018 field season the University of Alabama crew placed one 1 x 1 m unit into Midden D in Quad II at Wamassee Head (9Li13). The location of this unit, N56 E735, was selected based on the position of previous excavations into Midden D. The unit was situated directly to the southwest of the 10 x 10 ft unit dug by Joseph Caldwell and northeast from the previous AMNH 1x1 m unit, 208D (fig. 5). For N56 E735, the N100 E700 marker served as our datum for plotting coordinates and measuring depths. This unit was excavated in 10 cm arbitrary levels until 60 centimeters below datum (cmbd). A split spoon at 60 cmbd showed that sterile soil had not yet been reached, but the vertical extent of the mission-era shell midden had concluded. Supplementary oyster and clam samples were collected from each level during water screening.

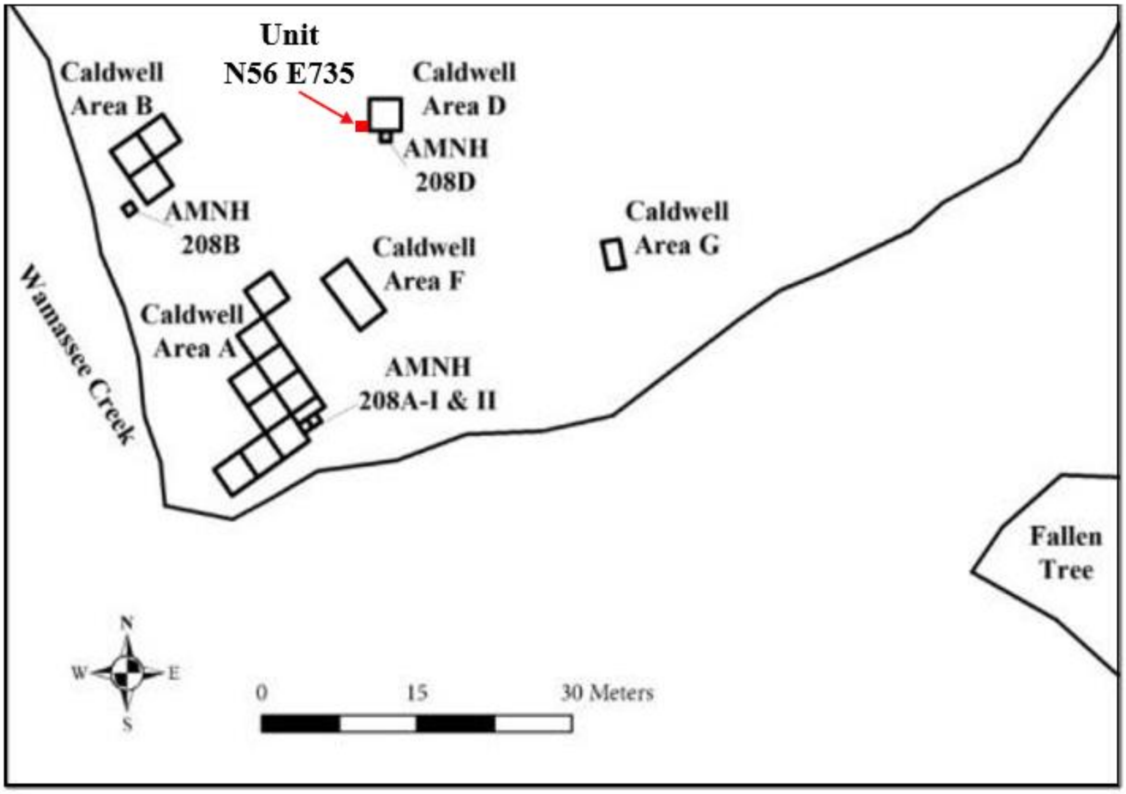


Figure 5. Map of excavations at Wamassee Head (9Li210) (Blair 2015:82, figure 5.4). Reproduced courtesy of Elliot Blair, modified to show N56 E735 in red.

Based on the stratigraphy observed in the profile and the presence of a possible Deptford ceramic near the surface, excavators believe the first level included backfill soils from one of the adjacent units. The midden was comprised of dark brown-black sand mixed with intact and fragmentary mollusk valves, primarily oyster (fig. 6). Small amounts of vertebrate fauna and carbonized botanical materials, including a fragment of peach pit and maize cob, were also present. The midden contained many ceramic sherds which were primarily Altamaha in design. Several shell and glass beads were recovered from unit N56 E735 during water screening.

Figure 6. North profile of unit N56 E735 in Wamassee Head (9Li13) at a depth of 60cm below datum. Photograph by Cayla Colclasure.

Pueblo East

The residential area east of the Mission compound is known as Pueblo East, and as of May 2019 this area has not been designated a state archaeological site number. Pueblo East was also included in Caldwell's 1969 excavations and was tested by David Hurst Thomas's crew from the American Museum of Natural History. In May of 2018 the University of Alabama crew placed a 1 x 1 unit into midden III-A at Pueblo East. The unit, N135 E844, was oriented directly to the north of a previously excavated 2x2 m unit, N134 W56 (fig. 7). As with the unit at 9Li13, the N100 E700 marker served as our datum for plotting these coordinates and measuring depths.

This unit was excavated in 10 cm arbitrary levels until 70 cmbd after the vertical extent of the midden had been fully excavated. Supplementary oyster and clam samples were collected from each level during water screening.

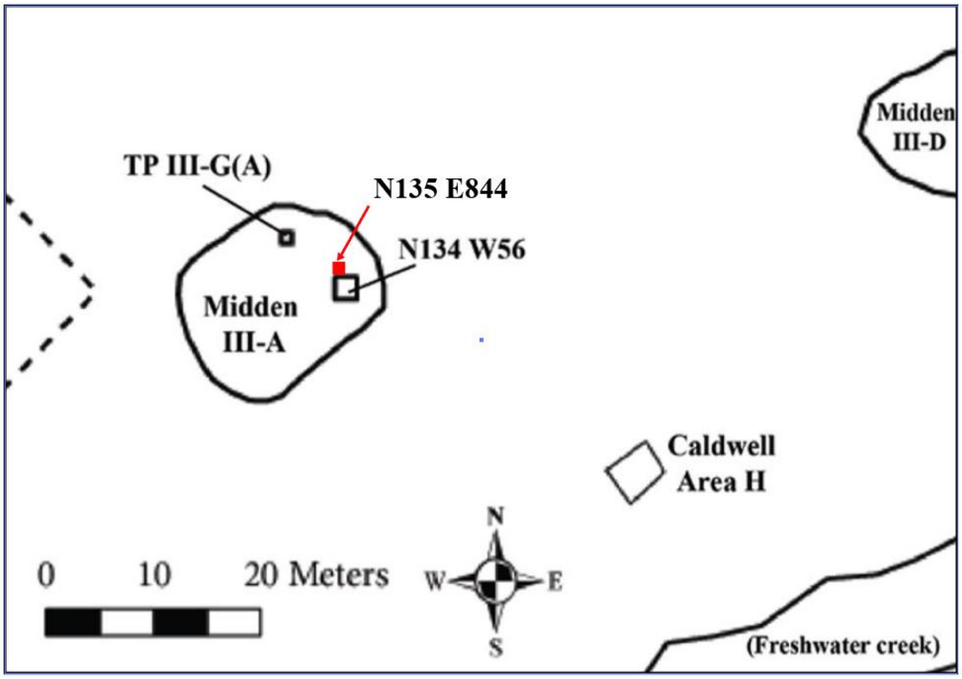


Figure 7: Map of excavations at Pueblo East (Blair 2015:87, figure 5.9). Reproduced courtesy of Elliot Blair, modified to show N135 E844 in red.

Unit N135 E844 was comprised of dark brown soils mixed with intact and fragmentary mollusk valves, which were primarily oyster but also contained an abundance of fragmentary stout tagelus and ribbed mussel (fig. 8). Several intact clam shells were mapped and reserved as a ^{14}C samples from levels 1-3. Vertebrate fauna was also present, among which were several deer vertebra, as were botanicals, including several carbonized cane pieces. Numerous ceramic sherds were recovered from this unit, including Altamaha, Mission red film, and olive jar. A metal fragment from an iron spike and several shell and glass beads were also discovered during water screening.

Figure 8: North profile of unit N135 E844 in Pueblo East at a depth of 60cm below datum. Photograph by Amber Daum.

Pueblo North (9Li2117)

The neighborhood designated as Pueblo North (9Li2117) contains portions of Quads IV, XX, and XXI in the area northwest of the Mission Santa Catalina compound. This pueblo sector has been the site of many excavations over the years, the earliest of which were conducted by the American Museum of Natural History in the 1990s to investigate geophysical anomalies. These test units led to subsequent excavations including that of an indigenous dwelling labelled "structure five." Subsequent AMNH excavations in the Pueblo North area produced many shell samples which were made available to the author for the purposes of this analysis.

The first set of samples originated from the 1x1 m unit VII excavated in Pueblo North by an AMNH field crew in 2005. Unit VII contained a 20 cm thick lens of shell intermixed with dark brown sandy soils. Altamaha ceramics and glass beads were recovered from within the shell deposit. 10-L samples were collected from each 10 cm level. During a 2012 excavation as part of Operation 2B, the AMNH uncovered another portion of the same midden present in unit VII, consisting of F(2012)152, a crushed shell lens above F(2012)136, which yielded the other samples included in this study. F(2012)136 consisted of a dense deposit of crushed shell including a few intact oysters surrounded by a matrix of dark to grayish-brown sandy soils. Altamaha, Spanish red film, olive jar, and majolica sherds were excavated from the immediate area. F(2012)136 spanned 4 1x1 m units within the excavation block. Because this midden feature contained lenses of whole shells, it was excavated at times in either 5 or 10 cm levels as an attempt to follow natural levels. 10-liter samples of midden matrix were collected from each of these levels, which were utilized in this analysis.

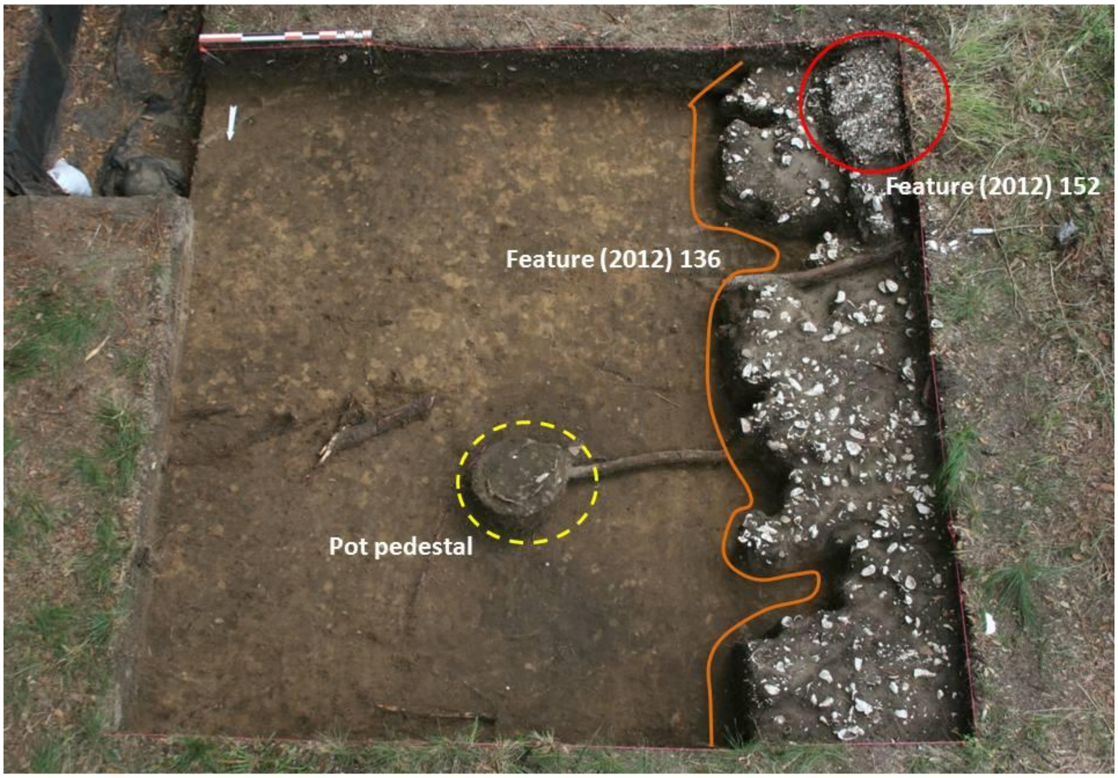


Fig 9. An overhead view of F(2012)152 and F(2012)136. Photograph by Nicholas Triozzi, reproduced courtesy of the Division of Anthropology, American Museum of Natural History

9Li210

9Li210 rests approximately 500 meters north of the main Mission Santa Catalina compound. The site was identified during the 1970s AMNH transect surveys, but the Mission-era component of this site was not initially recognized. Despite the scarcity of post-contact artifacts in 9Li210, it has since been demonstrated that the ceramic assemblage is primarily Altamaha (Thomas 2008) and Blair (2015) has suggested that 9Li210 represents a very early occupation during the Mission period. In May of 2018, a crew from the University of Alabama placed a 1 x 1 m unit on the highest visible point of a midden deposit, northwest of the 1 x 1 m unit previously excavated by the AMNH (fig. 10). This midden had been tested during David Hurst Thomas's transect surveys on the island (Thomas 2008). This unit was excavated in 10 cm arbitrary levels until sterile soil was found 90 centimeters below surface. Forty-liter bulk and 10-liter botanical samples were collected from each 10 cm level. The remaining soil from each level was reduced via dry screening at 1/8" and bagged, then later water screened at 1/8". Supplementary oyster and clam samples were collected from each level during water screening.

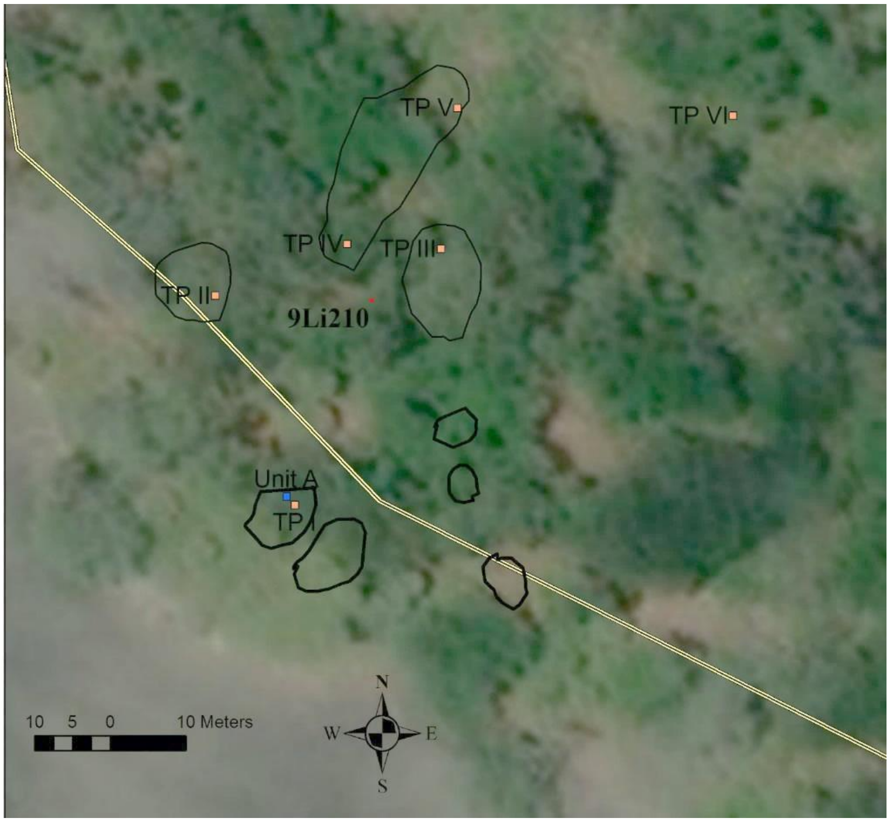


Figure 10. Map of 9Li210 showing Unit A in blue. Reproduced courtesy of Elliot Blair.

Unit A consisted of nine levels; based upon differences in the composition of the midden matrix, ceramics, and the morphology of the oyster valves present, this unit contained two potential cultural horizons (fig. 11). Levels 1-5 contained an extremely dense matrix of shell with a small amount of black sand rich in organic material. These levels included numerous grit tempered Altamaha ceramics. Invertebrate specimens from levels 1-5 were very well preserved. The midden included large amounts of intact and fragmented oyster valves as well as fragmented clam, stout tagelus, and ribbed mussel. An intact clam shell was mapped and reserved as a ^{14}C sample from level 2. In levels 6 and 7, shell remained dense, but these levels included a much higher proportion of crushed and burnt shell fragments. Several clay tempered ceramics were found in levels 6 and 7. Another intact clam shell was mapped and reserved as a ^{14}C sample from level 7. Soils from level 8 were light brown and mottled with lighter sands. The diversity of species and density of shell in level 8 lessened considerably. One large Refuge plain sherd was found in level 8. Level 9 produced no artifacts. The light brown mottled sand quickly terminated in level 9, and soils were sterile in the final 8 cm. Overall, this unit produced relatively large amounts of vertebrate fauna. Several shell and glass beads were recovered during water screening.

Figure 11. North profile of Unit A in 9Li210 at a depth of 90 cm below surface. Photograph by Cayla Colclasure.

Species Identification & Quantification

Once all bulk samples had been reduced via water screening in the field to 1/2”, 1/4”, 1/8”, and 1/16” fractions, they were dried in the sun, bagged, and transported to the University of Alabama for analysis. Species identification and quantification were conducted for invertebrates in the 1/2”, 1/4”, and 1/8” fractions. Vertebrate remains were separated and reserved for future study along with all material culture. All invertebrates were sorted and identified to the most specific taxonomic level possible following standard zooarchaeological procedures (Reitz and Wing 2008). Reference images from the Florida Museum of Natural History's Environmental Archaeology Specimen Image Database as well as modern and archaeological comparative specimens were used to aid identification.

Sorting procedures were modeled after Quitmyer (1985) and Bergh (2012) to facilitate the comparison of existing invertebrate datasets with the results of Mission-era midden analysis. Oysters are the dominant component of all midden samples analyzed, and to avoid overrepresenting their contribution only broken valves with identifiable hinge elements were categorized as oyster. Intact left and right oyster valves were counted and bagged separately for further analysis. Oyster fragments with hinge elements were counted and weighed. Oyster fragments without hinge elements were included with other fragments lacking identifiable landmarks in the general 'Mollusca' category.

The procedure followed for oysters would underrepresent mussels, clams, and stout tagelus, so all other bivalve fragments were recorded regardless of the presence of hinge elements. Clam valve fragments were both counted and weighed. Mussel and stout tagelus, are especially susceptible to mechanical damage and as such they were weighed but not counted, as the fragility of specimens could not yield a reliable NISP. Whelk were rare in the samples analyzed, but as they typically break into identifiable fragments, all whelks were recorded regardless of completeness. Other gastropods intact enough for identification, usually those with the presence of the apex and aperture, were sorted, counted, and weighed. Identifiable crab fragments were typically limited to claw elements, which were counted and weighed. Remains which were indeterminant as vertebrate or invertebrate were usually so finely fragmented that they were discarded with root matter and other debris. All other indeterminate shell remains were categorized and weighed as 'Mollusca.'

All taxa were weighed in grams. Any modifications which may indicate processing or preparation methods of oyster valves and fragments such as evidence of burning, cracking, or hammering were noted but rarely apparent. Evidence of epibionts, encrusting organisms living on the surface of mollusk valves, were also noted. Analysis of the 40-liter bulk samples from the Pueblo Santa Catalina de Guale resulted in the following categories: Arks (*Anadara sp*.) Barnacles (*Balanus sp*.), Boonea (*Odostomia sp*.), Candes barrel bubbles (*Acteocina candei*), Eastern Oysters (*Crassostrea virginica*), Crabs (Brachyura), Hard Clams (*Mercenaria spp.*), Knobbed Whelks (*Busycon carica*), Terrestrial Snails (Polygyridae), Wolf Snails (*Euglandia sp*.), Marsh Snails (*Melampus bidentatus*), Marsh Periwinkles (*Littorina irrorate*), Oyster Drills (*Urosalpinx sp*.), Ribbed Mussels (*Geukensia demissa*), Stout Tagelus (*Tagelus plebeius*), indeterminate gastropods (Gastropoda), and indeterminate mollusks (Mollusca).

Secondary Zooarchaeological Measures

Several secondary data estimates were calculated based on the primary data amassed during the identification and quantification process. These were useful in both the diachronic and synchronic comparison of midden assemblages, and the metrics chosen were those most relevant to my primary goal of assessing difference in Guale collection practices. Specimen weight, number of individual specimens (NISP), and minimum numbers of individuals (MNI) are all commonly used metrics for comparing the relative abundance of taxa in archaeological collections (Reitz and Wing 2008) and were obtained for taxa from Pueblo Santa Catalina de Guale (PSCDG) whenever possible. Biomass estimates were calculated to discuss dietary contribution, and richness, diversity, and equitability were used to discuss niche breadth.

The number of individual specimens (NISP) is primary data which provides a foundation for secondary data estimates such as MNI; NISP simply refers to the total number of whole specimens and fragments counted during sorting. The minimum number of individuals (MNI) is an estimate based on the lowest possible number of organisms which would be required to account for all skeletal elements (or exoskeletal elements) of a particular species present at a site (Shotwell 1955:330). MNI relies on the number and identifiability of fragments which are inevitably affected by site formation processes, sampling techniques, and laboratory procedures (Reitz and Wing 2008). MNI is a conservative estimate which does not necessarily reflect the actual number of individuals who contributed to an assemblage, however it is a useful analytical tool for cross-species comparison.

MNI is normally based on paired elements, however barnacles are an exception. A barnacle’s shell is comprised of a base, six immobile plates, and several mobile plates collectively referred to as the operculum. The scota and terga which comprise the operculum were included in the NISP for barnacles, but not in MNI estimates. To calculate the MNI of barnacles in these samples, the number of immobile plates was divided by six and added to the number of whole individuals (Bergh 2012). Given the symmetry of bivalves and the fact that identified oyster specimens were limited to those with hinge elements, the number of fragments and oyster larvae, or spat, were divided by two and added to the total number of the more abundant side (left or right) counted among the intact valves. For clams, hinged elements were sided and the more abundant side became the MNI, but as hinged elements were rare, the clam MNI presented here likely underestimates the true number of individuals. As only intact specimens were identifiable for small gastropods such as terrestrial snails and boonea, the MNI is the same as the NISP. For whelks and periwinkles, MNI was based on intact specimens and the minimum number of individuals required to account for singular elements such as the apex. MNI is not provided for stout tagelus, ribbed mussel, or crab as shell fragments were either too fragile (tagelus and mussel) to obtain a meaningful NISP or the elements were not definitively symmetrical enough (crab) to estimate individuals.

There are several methods for assessing the amount of meat a given animal may have provided based on its skeletal or exoskeletal elements. For this analysis, allometry and specimen weight was used to create these estimates. The relationship between shell weight and soft tissue is expressed as:

$$Y = aX^b$$

(Simpson et al. 1960:397). Here, Y is the biomass or quantity of meat, X is the specimen weight, b is the constant of allometry, and a is the Y-intercept of a log-log plot based on least squares regression and the best fit line (Reitz et al. 1987; Reitz and Wing 2008: 238-239). Biomass was not estimated for barnacles, as there is no Allometric formula available for them. The values of a and b for each species are listed in Appendix C and are drawn from calculations based on data at the Florida Museum of Natural History and the Georgia Museum of Natural History (Quitmyer 1985, Reitz et al. 2010, Bergh 2012).

Discussing food collection and consumption habits requires a way to determine the number and variety of species used at a site, as well as the comparative evenness with which these species were used. Sample richness is the number of species which are present in a sample. Diversity measures the heterogeneity of a faunal assemblage and the relative importance of species present. Equitability describes the evenness with which species were used. The Shannon-Weaver Index (Shannon and Weaver 1949:14) measures the number of species used as well as how much each species was used. The following formula for the Shannon-Weaver Index was used to measure diversity:

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

Where p_i stands for the number of *i*th species, divided by the sample size (Shannon and Weaver 1949:14). By this index, diversity is measured on a scale of zero to five, with lower values indicating lower diversity. Diversity increases with species richness and equitability within a collection. Low diversity can be a result of the utilization of a limited number of taxa or a low equitability among those species. Equitability was measured using the Sheldon Index by the formula:

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

Where H' is the Shannon Weaver Diversity Index and $\log_e S$ is the natural log of the number of taxa for which the measure of relative abundance was calculated (Sheldon 1969). Equitability is measured from zero to one. High equitability reflects an even distribution of species along a normal curve, where there are a few abundant species, an average number of common ones, and a large number of rare species. Lower equitability is a result of select species being used disproportionately to others. Diversity and equitability characterize differences in animal use which may assist the archaeologist in distinguishing various ethnic or social groups (Reitz and Wing 2008). Species considered commensal, those which likely entered the assemblage incidentally through commensality with humans or prey animals, were not included in estimates of diversity and equitability. These include terrestrial snails (Polygridae) which are drawn to shell middens as a calcium resource, small predatory gastropods such as boonea (*Odostomia spp*.) and oyster drills (*Urosalpinx spp*.), and rare gastropods such as wolf snails

(*Euglandia sp*.) and marsh snails (*Melampus bidentatus*). While barnacles were probably also commensal, their prevalence may suggest that, intentionally or not, they may have contributed modestly to the diet if they were boiled with other shellfish. They were not included in these secondary measures, however, as their biomass could not be calculated.

The Similarity Index compares relative abundance of various components between assemblages, and is expressed by the following formula:

$$P = S \text{ minimum } (P_{1i}, P_{2i})$$

Where P is the percentage similarity between samples 1 and 2, P_{1i} is the percent of species is sample 1, and P_{2i} is the percent of species in sample 2. Percentages of taxa, in this case based on percent of total biomass, are compared and the smaller percentage of each taxa from either collection is selected. The smaller percentages are then added together to produce the similarity (Reitz and Wing 2008). Greater similarity between assemblages is reflected by a higher resulting percentage. Sample size and taxonomic diversity have little effect on the results of the percentage similarity coefficient (Krebs 1989). In calculating similarity, I excluded species which were not common between the assemblages being compared and those which contributed only negligibly to biomass. This list was therefore limited to eastern oysters, ribbed mussels, hard clams, knobbed whelk, crabs, and stout tagelus.

Oyster Measurements

As discussed in Chapter 2, oysters are a key component of estuarine ecosystems and have been essential to coastal indigenous lifeways. The size and shape of an Eastern oyster (*Crassostrea virginica*) may vary based on age and the characteristics of the oyster community from which it originates. Oyster larvae can settle on several kinds of substrate, and morphology is highly variable and may be rounder or more elongate depending upon developmental conditions (Kent 1991). Human predation can create selective pressures for an oyster population which affect normal growth patterns. The degree of sustainability in harvesting practices can affect mean height throughout time. Discussions of oyster paleoecology based on morphometric analyses have been used to look at changes in climate and human subsistence practices for many coastal sites (e.g. Dame 2009, Milner 2013, Rick et al. 2016, Savarese et al. 2016, Lulewicz 2017).

Most commonly, decreasing shell height from the deepest levels to the top of a deposit have been interpreted as an increase in shellfishing activity that impacts natural growth curves. However, as Lulewicz points out “If Native populations were active managers of their surrounding oyster ecosystem, we would expect oyster size to either remain constant or increase throughout time” (2017:287). Oyster shape can be an important indicator of population density and microecological conditions. According to Kent (1992), an oyster with an elongated form and therefore a higher surface area to volume ratio, will have to produce more shell material than an oyster which has the same volume of soft tissue but a lower height-length ratio. This elongate form is favorable, however, in environments such as densely clustered oyster beds where the only possible directionality of growth is along the ventral edge.

The most common method of conducting morphometric analysis on oyster shell is height-length ratio (HLR), which is the height of an intact valve divided by its length. Calculating the HLR of oyster samples is the simplest way for morphometric differences in shell shape to be quantified and statistically analyzed. The height measures the longer dorsal-ventral dimension of an oyster valve while length is defined by the maximum anterior-posterior dimension of each specimen (Gunter 1938, Kent 1992).

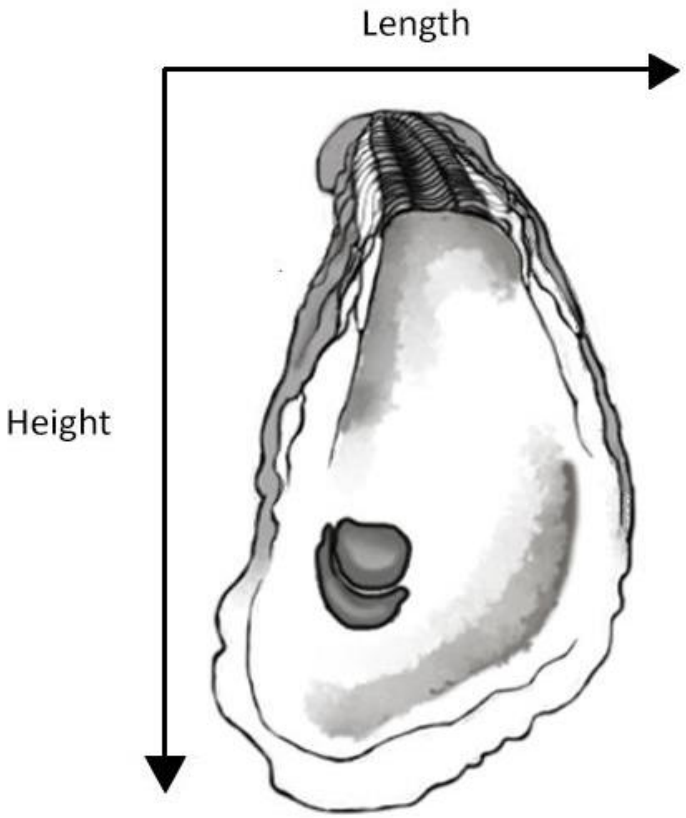


Figure 12. Diagram of a left oyster valve showing the orientation of height and length.

Up to 80 intact left oyster valves from every bulk sample were measured to ascertain mean height-length ratios. If there were fewer than 80 suitable left valves, all intact specimens were measured. For bulk samples with more than 80 left valves, specimens were sampled by being pulled from a bag at random. Each oyster was weighed following measurement, and any evidence of epibiont activity, human modification, or attachment scars were documented. Digital calipers were used to measure the shells to the nearest .01 mm. In total, the height-length ratios of over 1,200 left oyster valves from the Pueblo Santa Catalina de Guale were recorded. These measurements are reported in Appendix B.

Stable Isotope Analysis

The final metric used for comparing variation in oyster harvesting practices was oxygen stable isotope ratios. Studies of mollusk seasonality at pre-contact sites in the Southeast suggest that for many coastal populations, shellfishing was a year-round activity (Andrus and Crowe 2008, Bergh 2012, Cannerozzi 2012, Jones et al. 2012, Quitmyer 1997, 2012, Russo and Saunders 2008). One possible outcome predicted as a result of missionization on St. Catherines Island was a shift towards a more seasonal reliance on marine resources as a supplement when terrestrial resources became scarce. Ambient water conditions at the time of death, indicating season of harvest, can be estimated by looking at the chemical composition of incremental growth bands in hard tissues such as shell. For this project, stable isotope analysis was used to gather evidence of the seasonality of *Crassostrea virginica* to investigate whether there was a significant temporal shift in harvesting practices and examine potential synchronic variation in the Pueblo Santa Catalina.

The relationship between oxygen isotopes ($\delta^{18}O$) and water temperature has been studied extensively and proven consistent within species, and the conditions reflected by the $\delta^{18}O$ ratios can be interpreted as the season of capture (Andrus and Crowe 2000, 2008). According to Shackleton (1973), for each rise in temperature by 1 ^{o}C, $\delta^{18}O$ will fall ~0.2‰, assuming that temperature is the only significant variable. Death during the warm season is thusly indicated by a relatively negative delta value, and the cool season by a relatively positive one. In reality, the oxygen isotope composition of the water in which the oyster grew is also a variable that partially determines shell $\delta^{18}O$ values, this temperature alone is rarely the sole determinant of shell $\delta^{18}O$ oscillations. Because $\delta^{18}O$ of water co-varies with salinity, the absolute values of shell $\delta^{18}O$ profiles can give insight into the salinity of the habitat in which the shells grew. This has been applied to shell samples from the Sapelo Island Shell Ring to look at the types of habitats being exploited archaeologically (Andrus and Thompson 2011).

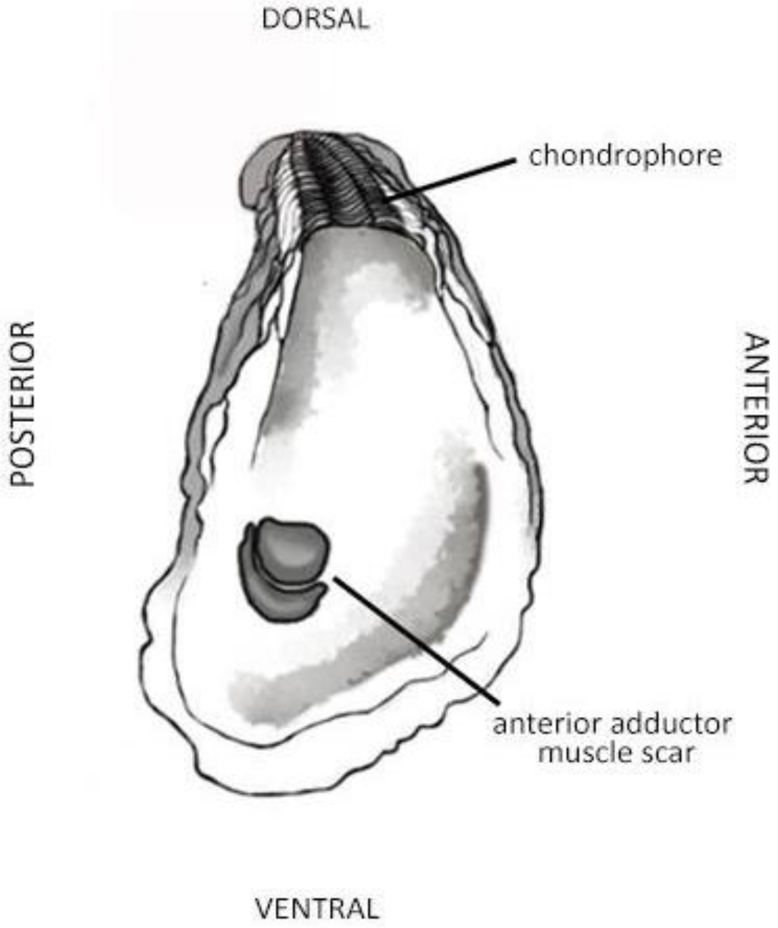


Figure 13. Diagram of a left oyster valve showing relevant structures and anatomical directions. Redrafted from Kent 1992:10 figure 2.

Five intact left valves of *Crassostrea virginica* were sampled from each Mission-era neighborhood for oxygen stable isotope analysis, 25 valves in all, with preference given to those that exhibited the highest quality of preservation and which had umbos with angles favorable for bisection. Only left valves were sampled to avoid possible redundancy. Any valves with evidence of epibiont activity on their interior surfaces were discarded, as this indicates the specimen was deceased when harvested. Selected valves were bisected along the dorsal-ventral axis through the chondrophore using a manual wet tile saw. *Crassostrea virginica* precipitates two types of growth bands: light and dark. Dark growth bands are produced when the oyster experiences stress and are often interpreted as winter growth bands in areas with seasonality similar to the Georgia Bight (e.g. Zimmt et al. 2019) The half with clearer visual distinction of growth band increments was chosen for slide preparation.

The chosen half of the valve was trimmed along the anterior-posterior axis to achieve a segment which would fit the microscope slides. The bisected, trimmed valve segments were then allowed to dry and mounted on glass slides using Crystalbond thermal adhesive. These were cut a final time to produce approximately centimeter-thick thick-sections of the umbone regions using an automatic circular saw. All calcium carbonate sample collection was conducted in the Alabama Stable Isotopes Laboratory. An ESI/New Wave computer-controlled micromill system was used to drill calcium carbonate samples from each thick-section of shell. The number of samples varied depending on the size and distribution of growth bands. Oyster shell contains two varieties of calcium carbonate, calcite and aragonite, each with unique fractionation during acid digestion, thus should not be mixed in isotope analyses. Therefore, aragonite (present near muscle attachment surfaces) was avoided during the micromilling process and only calcitic areas were sampled. For each shell, I collected approximately 20 samples extending past the second most-recent winter growth band to capture at least one full cycle of seasonal fluctuation. Contiguous transects were plotted following ontogeny and drilled individually with care taken to avoid contamination. Intermediate sample transects were interpolated using ESI/New Wave micromilling software to maintain consistent distances between pathways.

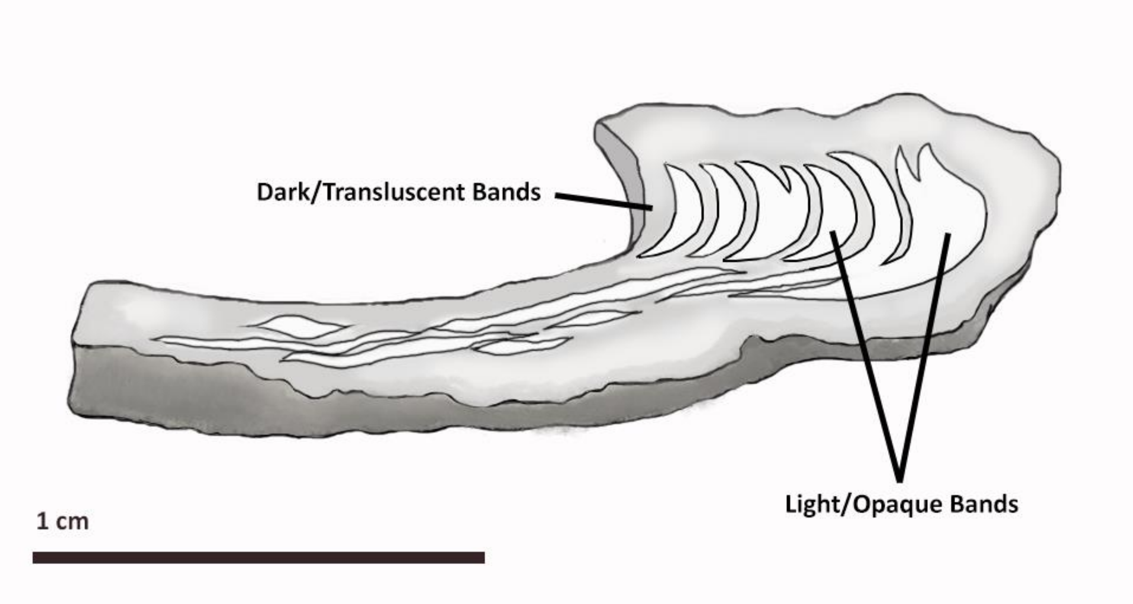


Fig 14. Diagram of a *Crassostrea virginica* thick section showing growth bands. Redrafted from Andrus 2012:126, figure 6.3.

I weighed the ensuing carbonate powder in high mass resolution microbalance, with an accepted sample weight range of 45-105 µg. Each carbonate sample was then sealed in a 4.5 ml borosilicate vial, flushed with ultra-pure helium, and acidified at 50° C with orthophosphoric acid in a Thermo GasBench II to produce CO^2 for gas chromatography and mass spectrometry. Samples were analyzed in a Thermo Delta V Plus isotope ratio mass spectrometer. Data was processed using IsoDat software and calibrated using IAEA-603. Fifteen calcium carbonate standards were included with each batch of samples, and the data from these was used to monitor any mechanical fluctuations and build corrections for drift or beam size effect. Analytical precison for $\delta^{13}C$ averaged ±.05% and ranged from ±.03% to ±.07%. Analytical precision for $\delta^{18}O$ averaged ±.14% and ranged from ±.06% to ±.27%. The data reported in Appendix D are relative to Vienna Pee Dee belemnite (VPDB) in parts per mil (‰).

Samples which did not produce a sinusoidal curve when plotted, believed to represent a full seasonal cycle, were sampled additionally until one was achieved. This can occur due to variation in the speed of growth due to age and environmental conditions of oyster specimens. The ambient water temperatures and inferred seasonality indicated by the resulting $\delta^{18}O$ ratios are discussed in chapters 4 and 5. These data were also used to broadly estimate ambient water salinity, which covaries with $\delta^{18}O$ ratios and can provide habitat information based on the brackishness of the waters where the oysters were harvested (Andrus and Thompson 2011).

Chapter Summary

In order to understand the relevancy of invertebrate species to Mission-era Guale foodways and observe variation and temporal change in shellfishing practices, I assessed the taxonomic composition of midden assemblages, measured the morphology of oyster valves, and conducted stable isotope analysis on oyster samples from each neighborhood of the Pueblo Santa Catalina de Guale. Oysters were by far the most abundant taxa in all midden assemblages analyzed and had the best potential for providing additional information about their habitats of origin given their growth plasticity. Oyster morphology provided information about the predation and habitat exploitation, while stable oxygen isotope analysis provided a way to assess the seasonality of oyster collection.

In the following chapters, these lines of evidence will be woven together and considered in combination with what is known about pre-contact foodways, contemporary vertebrate animal consumption, and the material evidence for population aggregation within the Pueblo Santa Catalina de Guale. The effects of Spanish missionization on marine subsistence will be discussed at two scales: broadly for the entire indigenous population of St. Catherines Island before and after Spanish contact, and between subpopulations represented by the different pueblo neighborhoods during the brief but tumultuous tenure of the Mission Santa Catalina.

4. ASSESSING THE EFFECTS OF MISSIONIZATION ON ST. CATHERINES ISLAND THROUGH A DIACHRONIC COMPARISON OF SHELLFISHING PRACTICES

In the millennia that passed between the earliest evidence of animal use around 3000 BC and the onset of Spanish colonization in the 1500s, the foodways of coastal Georgia are characterized by remarkable consistency (Reitz 2014). Though the archaeological record shows fluctuations in animal use through time to accommodate environmental and cultural shifts, marine organisms remain essential notwithstanding eventual population growth, social stratification, and introduction of domesticated crops (Reitz and Quitmyer 1988, Reitz 1990). Despite the resilience exhibited by coastal peoples and the estuarine habitats which helped nourish them, Spanish colonialism sparked a degree of rapid change, reorganization, and instability which shook the foundations of indigenous societies. Determining the effects of missionization upon indigenous foodways, among the most essential daily strategies for biological and cultural survival, may help us better understand the lived experience of sixteenth and seventeenth century people at Pueblo Santa Catalina de Guale.

In this chapter, I present the results of my invertebrate zooarchaeological and stable isotope analyses from a diachronic perspective. I discuss how both the summed Pueblo Santa Catalina invertebrate collection and the varying samples from the five neighborhoods therein compare to those from Irene Period sites on St. Catherines Island. Changes in shellfishing are examined in terms of relative abundance of taxa, oyster morphology, and seasonality. These data are considered in conjunction with the vertebrate zooarchaeology of Pueblo Santa Catalina to present an integrated interpretation of how the Guale adjusted their foodways during the Mission era. The divergent strategies of pluralistic Pueblo inhabitants are looked at more closely in Chapter 5.

Pre-contact Subsistence

The excavation of a Wilmington Period, AD 350-800 (Thomas 2008b), component underlying the mission-era midden at 9Li210 offered a temporal point of comparison in the same geographic locale. The Wilmington Period is represented here by levels 6-9 of unit A at 9Li210. This 44.40 kg sample contained at least 4582 individuals, of which 86% were eastern oyster. Oysters provided nearly 69% of biomass, followed by stout tagelus at 27%, and hard clams at 3%. The species diversity of this assemblage is 0.78 and the equitability is 0.34. While this sample size is small, it offers an interesting opportunity to compare how people at 9Li210 differentially utilized invertebrate species at different points in time. The similarity index of this Wilmington Period component to the Mission era component of 9Li210 is 89.56%.

Table 1

Wilmington Period 9Li210 Invertebrate Species List

Taxa	NISP	MNI	% MNI	Weight, g	Biomass, kg	% Biomass
Mollusca	---	---	---	7762.77	---	---
Balanus sp.	199	39	0.852%	17.67	---	---
Crassostrea virginica	5962	3945	86.173%	34400.25	4.275	68.65%
Brachyura	3	---	---	0.50	0.006	0.0889%
Geukensia demissa	---	---	---	354.18	0.066	1.0603%
Littorina irrorata	37	35	0.765%	12.51	0.005	0.0789%
Euglandia spp.	1	1	0.022%	0.10	0.000083	0.0013%
Mercenaria mercenaria	198	23	0.502%	919.91	0.193	3.0999%
Odostomia spp.	108	108	2.359%	0.58	0.000419	0.0067%

Polygridae	427	427	9.327%	15.75	0.008742	0.1404%
Tagelus plebius	---	---	---	918.61	1.673	26.8707%
TOTAL:	6935	4578	100.000%	44402.83	6.227	100.00%

The collection primarily used for diachronic comparison with the Pueblo Santa Catalina is from Early and Late Irene Period occupations at the Meeting House Field (9Li21) site on St. Catherines Island. The use of variable screen sizes limited early research into Irene Period subsistence on St. Catherines, and invertebrates were often excluded from analysis. As a result, the importance of deer, sea catfishes, and pond turtles were overemphasized (Reitz 2008, Reitz and Dukes 2008). Bergh's (2012) study shows that people were exploiting the salt marshes and adjacent habitats to focus on small, mass-capture fishes and mollusks. At Meeting House Field, oysters provided 80% of biomass and mussels, tagelus, and clams provided a combined 16%. The only other taxa to provide over 0.5% of biomass were pond turtles, sea catfishes, drums, and deer. When the invertebrates are isolated, the diversity of species is very low at .55, as is the equitability at .19.

Table 2

Bergh (2012) Early and Late Irene Meeting House Field Invertebrate Species List

Taxa		NISP	MNI	%	Wt, g.	Biomass, g
Mollusca	Indeterminate mollusks	---	---	---	276832	---
Lampsilis dolabraeformis	Altamaha pocketbook	1	1	0.001%	1.253	1.21
Arcidae	Arks	1	1	0.001%	0.294	0.02
Anadara ovalis	Blood Ark	1	1	0.001%	0.021	0.0007
Geukensia demissa	Ribbed mussel	14929	3452	2.837%	16474.37	2186.55
Crassostrea virginica	Eastern oyster	195874	103571	85.108%	714351.2	87116.27

Veneroida	Tellins and surf clams	43	22	0.018%	0.598	1.1
Dinocardium robustum	Atlantic giant cockle	2	1	0.001%	4.06	2.7
Cardiidae	Cockles	3	3	0.002%	3.612	3.51
Tagelus plebius	Stout tagelus	5069	2303	1.892%	5571.852	10151.92
Mercenaria mercenaria	Hard clam	2064	101	0.083%	5588.378	1109.62
Gastropoda	Gastropods	890	890	0.731%	8.118	5.68
Melampus bidentatus	Eastern melampus	25	25	0.021%	0.837	0.66
***Crepidula* spp.**	Slipper snails	31	31	0.025%	1.9	1.4
Littorina irrorata	Marsh periwinkle	111	111	0.091%	50.555	20.94
Polygridae	Terrestrial snails	5179	5179	4.256%	212.702	115.69
***Polygra* spp.**	Terrestrial snails	314	314	0.258%	10.553	6.81
Succineidae	Amber snails	97	97	0.080%	1.296	0.97
***Euglandina* spp.**	Wolf snails	21	21	0.017%	5.635	3.83
Zonitidae	Glass snails	904	904	0.743%	10.092	6.79
Acteocina candei	Cande's barrel bubble	1	1	0.001%	0.027	0.02
Prunum apicinum	Common Atlantic marginella	1	1	0.001%	0.13	0.11
Melongenidae	Whelks	83	---	---	103.844	52.75
Busycon carica	Knobbed whelk	10	8	0.007%	490.537	166.51
Busycoptycus canaliculatus	Channeled whelk	1	1	0.001%	0.654	0.04
Eupleura caudata	Thick-lipped drill	1	1	0.001%	0.173	0.14
***Urosalpinx* spp.**	Oyster drill	10	10	0.008%	8.631	5.48

Nassarius obsoletus	Eastern mudsnail	110	110	0.090%	40.152	17.18
***Olivella* spp.**	Olives	19	19	0.016%	1.043	0.72
Decapoda	Crabs	1310	---	---	57.579	377.47
Brachyura	Crabs	9	---	---	0.635	6.73
Callinectes sapidus	Eastern blue crab	87	11	0.009%	50.433	189.35
***Menippe* spp.**	Stone crabs	12	6	0.005%	2.334	24.23
***Balanus* spp.**	Barnacles	27572	4498	3.696%	2343.585	---
Total		254785	121694	100.000%	1022229	101576.4

In comparing the early and late Irene components, Bergh found that vertebrates were somewhat more important in the diet of early Irene residents. Clams and tagelus, which can live in their own beds apart from oysters and prefer low intertidal or subtidal areas, were exploited with a marginally higher frequency during the early Irene. She argued that oyster beds were a target habitat for Irene Period residents. Oyster beds are home to other bivalves such as clams and mussels, commensal taxa such as barnacles and oyster drills, and are frequented by crabs and whelks that prey on stationary mollusks. While many of the bony and cartilaginous fish present in Irene Period samples may have been found throughout the estuarine system, they would also have been readily available near oyster reefs.

Mission-era Subsistence on St. Catherines Island

Reitz and Duke’s investigation of animal use among the mission-era Guale on St. Catherines Island led them to believe that residents “combined their traditional subsistence practices with some aspects of Spanish animal use to create a new system that continued to rely on locally available estuarine resources but emphasized local terrestrial resources” (2008: 798).

Whereas turtle meat contributed nearly as much to the diet of Irene Period residents as venison, the percent of biomass offered by white-tailed deer increased from 40-47% at Meeting House Field to 89% at Fallen Tree. Diversity based on biomass was low at Fallen Tree due to the prevalence of deer, however the remaining non-deer vertebrate species became more diverse; additional species were used with less intensity than during the Irene Period. Opossum, rabbits, squirrels, and racoons may have been drawn to the food source provided by larger agricultural fields during the Mission era, creating a situation where it was more feasible for Pueblo residents to trap these field predators than collect as many estuarine fish and reptiles (Reitz and Dukes 2008).

The invertebrate assemblage from Pueblo Santa Catalina de Guale included bulk samples of shell midden matrix from five neighborhoods, however the summed results are biased toward patterns of invertebrate use in 9Li210, where the mission-era component comprises 45% of the total shell weight for all neighborhoods. Sample volumes and locales are reported in Appendix A. Samples from levels 6-9 of the test unit in 9Li210 are excluded from discussions of mission-era invertebrate use, as these levels included clay-tempered Wilmington Period pottery.

As described in Chapter 3, biomass calculations were based on shell weight. It is important to note that the estimated biomass weight reflects only the soft tissue of the taxa, not the live weight. Biomass based on allometry avoids many of the shortcomings of specimen weight, NISP, and MNI, though it is not without its faults. Given the morphological variation in Eastern oysters, producing the same amount of soft tissue requires different amounts of hard tissue depending on the degree of elongation (Kent 1992). Additionally, not all oyster valves which are deposited in a midden came from viable, live oysters. Given the nature of cementation in oyster reefs, the exoskeletons of dead organisms are frequent in harvests. Oyster biomass, therefore, assumes both a more regular growth pattern than that which likely occurred, and that all specimens were live collections and contributed meat to the diet. Crustaceans were almost certainly underrepresented due to the fragility of their exoskeletons. Shrimp are also not well suited to preservation, and no elements were recovered from the 1/2", 1/4", or 1/8" fractions. The most likely location for shrimp remains such as mandibles, the 1/16" fraction, has not yet been analyzed.

Results of Mission-era Invertebrate Analysis

The percentage of biomass provided by eastern oysters sharply declines from 86% of invertebrate biomass during the Irene Period at Meeting House Field to 66.89% in Pueblo Santa Catalina. Stout tagelus are the other main source of biomass at 26%, up from 10%. When neighborhood assemblages are examined separately, oyster contribution ranged from 47% at Pueblo East to over 77% at 9Li210. Species richness within the middens appears to decrease during the Mission era as well although this is likely due to sample size; 31 invertebrate taxa were reported from Meeting House Field, whereas only 14 were recorded in the Pueblo Santa Catalina. Site-wide sample sizes were much larger for the Irene Period analysis, which probably accounts for most of the discrepancy in richness, as the likelihood that rare taxa will be included increases with the sample size until the point of diminishing returns is reached. Many of the taxa absent from the Pueblo are small marine bivalves and terrestrial snail species which only marginally represented at Meeting House Field.

Table 3

Pueblo Santa Catalina de Guale Invertebrate Species List

Taxa	NISP	MNI	Weight, g	Biomass, kg	% Biomass

Mollusca	Indeterminate mollusks	---	---	48046.83	---	---
Anadara spp.	Arks	12	2	2.89	0.00033	0.0017%
Balanus spp.	Barnacles	3077	668	477.95	---	---
Busycon carica	Knobbed whelk	11	8	264.00	0.082	0.4095%
Crassostrea virginica	Eastern oyster	25527	13460	111813.51	13.412	66.89%
Decapoda	Crabs	67	---	7.97	0.054	0.2673%
Gastropoda	Gastropods	3	3	0.11	0.000091	0.0005%
Geukensia demissa	Ribbed mussel	---	---	3723.95	0.434	2.1627%
Littorina irrorata	Marsh periwinkle	106	99	39.58	0.015	0.0723%
Melampus bidentatus	Eastern melampus	2	2	0.50	0.000366	0.0018%
Mercenaria mercenaria	Hard clams	1964	61	4155.97	0.797	3.9731%
Odostomia spp.	Boonea	344	344	9.88	0.005692	0.0284%
Polygridae	Terrestrial snails	1950	1950	53.21	0.026793	0.1336%
Tagelus plebius	Stout tagelus	---	---	2901.53	5.224	26.0568%
Urosalpinx sp.	Oyster drills	2	2	0.06	0.000052	0.0003%
TOTAL:		33065	16599	171497.94	20.049999	100.00%

Species diversity for the Pueblo Santa Catalina assemblage measured by the Shannon-Weaver Index is 0.87, and the equitability of species is 0.39. Species equitability is low because a small minority of species supply the majority of biomass. Diversity in an assemblage may be low when a small number of species are represented or if the equitability of those species reflects disproportionate utilization, both of which are the case within the Pueblo. The similarity coefficient of Meeting House Field and Pueblo Santa Catalina de Guale is 76.35%. When broken down by neighborhood, similarity to Meeting House Field ranged from 56.39-89.56%. Pueblo East was the least similar to Meeting House Field, and 9Li210 was most similar. These differences and their implications will be discussed further at the end of the chapter.

Oyster Morphology

The mean height-length ratio of all mission-era samples from the Pueblo was 2.18, which is significantly different (p=.05) than the average HLR from the Irene Period, 1.85. As is the mean height for left oyster valves, which increases from 78.08 mm during the Irene to 81.21 mm during the Mission era. All mission-era oyster measurements are reported in Appendix B. Mean height ranged from 55.98 mm at Fallen Tree to 93.5 at 9Li210. By the classification system laid out by Kent (1992), Irene Period oysters fall into the “bed” range below 2.0, associated with oysters growing in looser clusters on softer substrates. Mission era oysters overall appear to be “reef” oysters from more densely packed intertidal environments growing upon firmer substrates.

As with the similarities and relative abundance of species, however, there is variability in mean HLR within the Pueblo. 9Li210 supplied the most intact valves to the morphometric analysis and the summed results are biased towards the primarily elongated oyster type represented in this neighborhood. Average HLR varied from 1.71-2.18 within the pueblo; figure 16 shows the mean HLR’s of each individual sector. Oysters from Wamassee Head, Pueblo East, and 9Li210 show a trend towards a more elongated form, and those from Fallen Tree, Pueblo North have a higher percentage of more rounded “bed” oysters. Aside from Fallen Tree, where the sample size of intact valves was smallest, there is evidence that multiple oyster community types were exploited at each location.

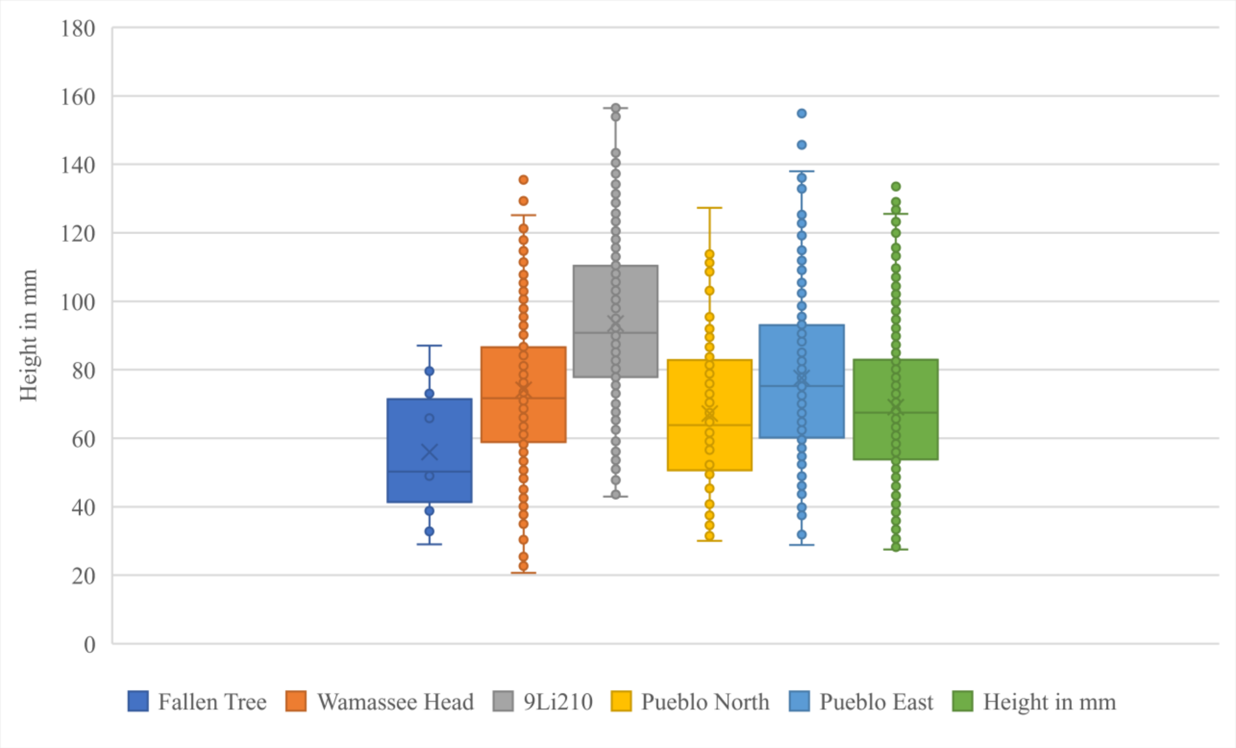


Figure 15. A box and whisker plot of oyster valve height in mm for Meeting House Field and all Pueblo Santa Catalina de Guale neighborhoods.

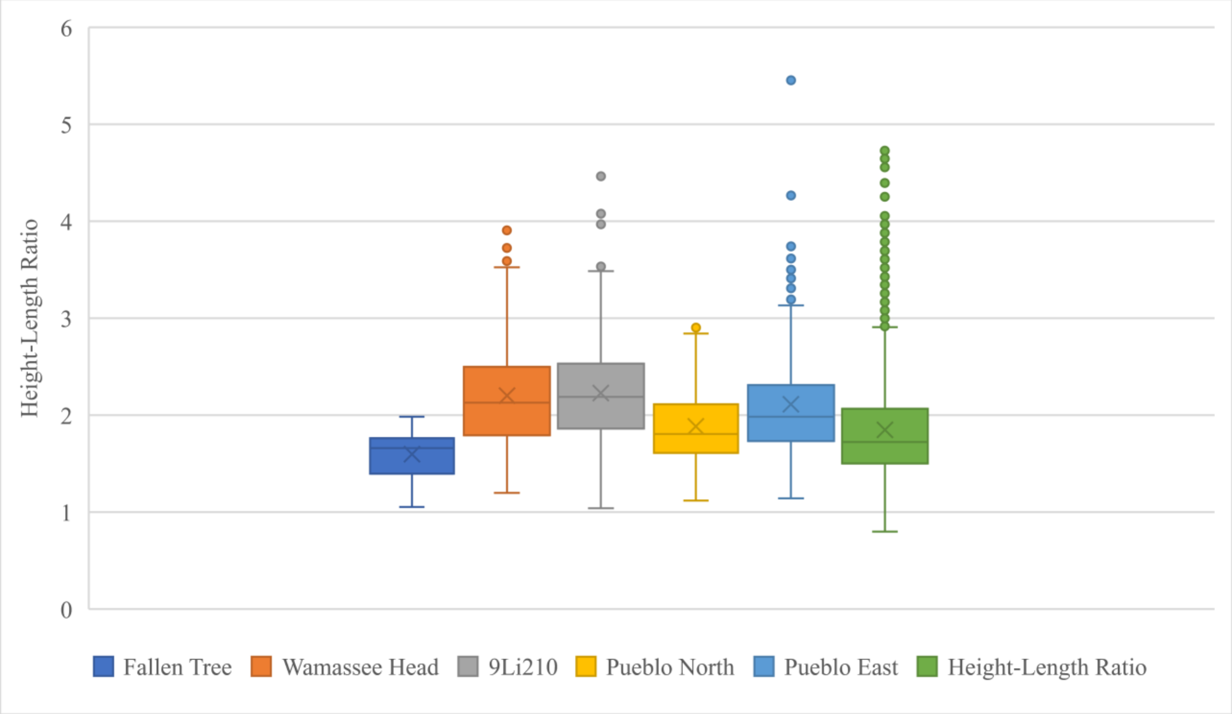


Figure 16. A box and whisker plot of oyster valve height-length ratio for Meeting House Field and all Pueblo Santa Catalina de Guale neighborhoods.

Changes in Seasonality

Across the coastal Southeast, there is evidence for indigenous peoples exploiting shellfish during all seasons, with an emphasis on winter and spring. The hard clam or northern quahog (*Mercenaria mercenaria*) has historically found more utility among archaeologists as an indicator of seasonality due to their distinct seasonal growth bands. Of 26 temporally variable sites along the southeastern Atlantic coast analyzed by Quitmyer et al. (1997), all contained hard clams which were harvested specifically in winter and early spring. Three shell rings from the Late Archaic, including the Cannon's Point Shell Ring on St. Simon's Island, GA, and the St. Catherines and McQueen Shell Rings on St. Catherines Island had a clear winter/spring pattern for hard clam collection (Jones et al. 2012). While the sample size of Eastern oysters from the St. Catherines Shell Ring reported by Cannerozzi (2012) is too small to be conclusive (N=4), she also found variability in season of capture. There are some exceptions to this pattern, such as at Graveline Mound, a Late Woodland Period platform mound on the Gulf coast of Mississippi, where Blitz et al. (2014) found that 72% of marsh clams (*Rangia cuneata*) and Eastern oysters (*Crassostrea virginica*) sampled for stable isotope analysis were harvested in the spring and summer. The authors mention that the midden at Graveline Mound appeared to have been rapidly deposited and may reflect a short interval of shellfish collection and consumption.

Growth increment analysis in clams from Meeting House Field and Back Creek village on St. Catherines Island included clams harvested during all seasons, with the most common seasons represented being winter and spring (Russo and Saunders 2008, Bergh 2012). Russo used measurements of impressed odostomes (*Boonea impressa*), parasitic gastoropods which prey on oysters, as a proxy for oyster season of capture at Meeting House Field. He found a trend toward cooler months, with summer and fall as secondary harvesting seasons (Russo 1991). In one study, 67% of Early Irene clams and 66% of Late Irene clams ended in opaque growth bands which are associated with cold weather growth (Bergh 2012). By comparison, 84% of oysters sampled from the Pueblo Santa Catalina de Guale for oxygen stable isotope analysis indicated death during winter or early spring. Following Andrus and Crowe (2008), seasonal oscillation in δ^{18}O values can be divided into three portions, where the upper 1/3 is interpreted as the coldest time of year, the lower 1/3 is associated with summer, and the middle 1/3 denotes transitional seasons which are interpreted as spring or fall depending upon whether the trend of the line is positive or negative. Of the 25 left oyster valves sampled from the Pueblo Santa Catalina de Guale for oxygen stable isotope analysis, only one exhibited δ^{18}O values which indicated that it was captured during the warmest part of the year. One complication is that the two primary datasets being compared are based on different species, hard clams (Russo and Saunders 2008, Bergh 2012, Quitmyer and Jones 2012) and *Boonea impressa* (Russo 1991) for Meeting House Field and eastern oysters for Pueblo Santa Catalina. Overall, the Pueblo sample's seasonality suggests that shellfish collection was further constricted to cold weather.

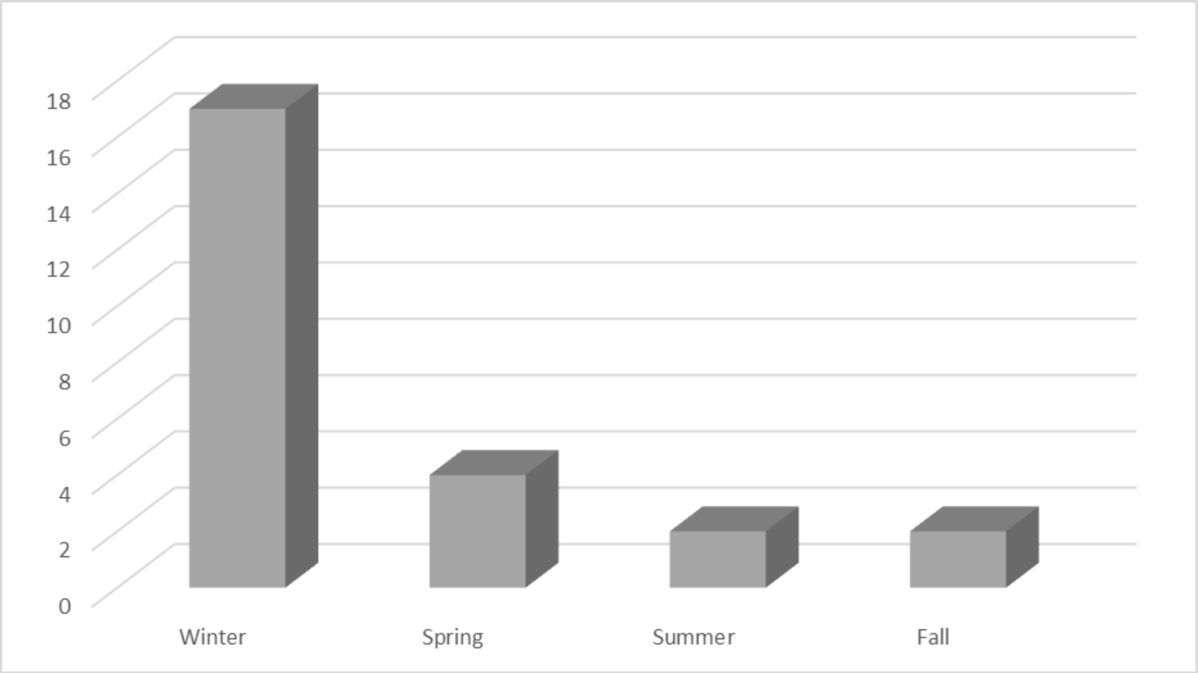


Figure 17. Season of Capture for Crassostrea virginica at Pueblo Santa Catalina de Guale. The y-axis is the number of individual valves categorized by season (x-axis).

Ambient Water Salinity based on Stable Oxygen Isotopes

While the sinusoidal profile of $\delta^{18}O$ correlates to seasonal temperature fluctuations, isotopic data can also provide information about the habitat in which the mollusk developed. Andrus and Thompson (2011) have shown that water temperature and salinity covary reliably enough along the Georgia Bight that the range of absolute $\delta^{18}O$ values can provide information about the brackishness of ambient waters. In effect, the more negative the ^{18}O value, the less saline the water. Figure 18 shows the median and range of $\delta^{18}O$ for all 25 individual oysters from Pueblo Santa Catalina. Median $\delta^{18}O$ values ranged from -1.42 to 1.0.

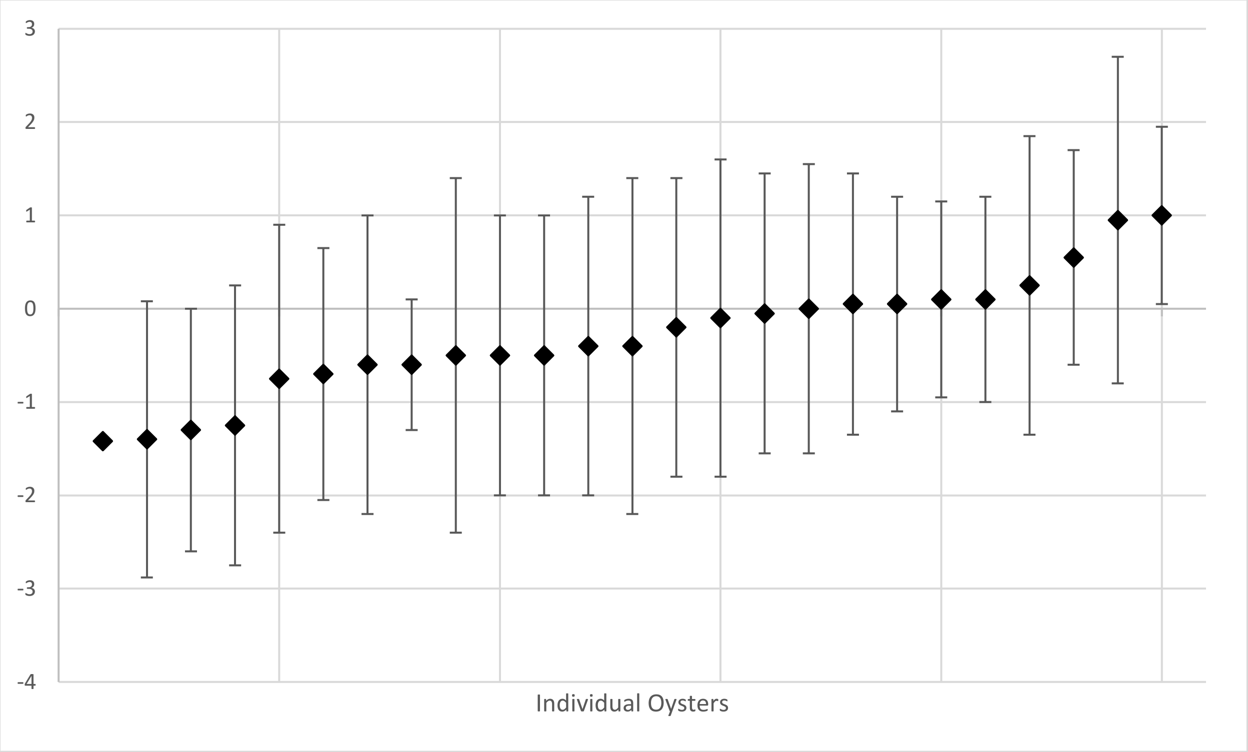


Figure 18. Median δ^{18}O values (black diamonds) and ranges (vertical bars) for all analyzed oysters. X-axis are sample valves plotted from most negative to most positive. Y-axis is δ^{18}O in parts per mil (%) expressed relative to VPDB. Modelled after Thompson and Andrus (2011).

On Sapelo Island, south of St. Catherines, Andrus and Thompson (2011) found that salinity profiles based on oxygen isotope schlerochronology of hard clams and eastern oysters exhibited evidence that shellfish were gathered from diverse locales throughout the estuarine system surrounding Sapelo during the Late Archaic. As there is evidence of overexploitation of mollusks in nearby pre-contact sites (Quitmyer 1985, Quitmyer and Jones 2000), the authors argue that harvesting from a broad range of salinities may have been part of a harvesting strategy based on resource management (Andrus and Thompson 2011). Immediately north of St. Catherines on Ossabaw Island, Lulewicz (2017) found that even during the Irene Period when population size was greatest on the Georgia coast (DePratter and Howard 1981), there was relative stability in oyster valve height. She makes a similar suggestion that the indigenous population of Ossabaw were actively managing reefs to avoid the negative effects of overexploitation.

The oxygen isotope values shown in figure 18 suggest the sample of Pueblo oysters come from more saline environments than those observed by Andrus and Thompson (2011) on Sapelo Island. This may have to do with the influx of freshwater Sapelo receives from the nearby Altamaha River. These results also reflect oyster harvesting from a broad range of estuarine salinities during the Mission era. While people may have had limited opportunity to shellfish during warmer months, based on the salinity and HLR ranges it seems that during colder months people were conscious of sustainably and harvested from a variety of community types in different locations. As I will discuss more in Chapter 5, this is especially true at 9Li210. More work is needed to compare the specific salinities reflected by these $\delta^{18}O$ values to measurements of salinity in estuarine environments on St. Catherines. Given their critical role in overall estuarine health, mitigating the effects of human predation on oyster communities would have improved the availability of many other associated organisms.

Discussion and Summary

The assemblage from Pueblo Santa Catalina de Guale is more dissimilar to Meeting House Field and other late pre-contact invertebrate assemblages than what is typically observed in inter-site variation. Reduction in species richness was likely an effect of differential sample sizes, but the decline in the frequency of oysters in relation to other invertebrate taxa is substantial. In some neighborhoods, oysters were nearly equaled by other taxa such as tagelus in terms of biomass. As the Eastern oyster had historically been one of the most significant sources of meat weight among all animals, and by far the most predominant among invertebrates, this may be an effect of diminished shellfishing more generally. While intensity is difficult to pinpoint given the likelihood of established traditions aimed at sustainability, shellfish exploitation became less consistent in the context of Pueblo Santa Catalina de Guale.

While oysters remain the most prevalent species in the pueblo neighborhoods, the percentage of individuals and biomass they represent decreases from the Irene Period to the Mission era. Consistent with patterns from the area during earlier time periods, oysters were harvested from a broad range of salinities. The pre-Hispanic evidence on St. Catherines and throughout the region suggests that collection of clams, and possibly other shellfish, was already most intense during cooler weather. This trend intensifies during the Mission era, potentially as a result of increased agricultural and terrestrial hunting activities during the warmer months. Patterns of food consumption on St. Catherines Island during the tenure of Mission Santa Catalina de Guale were complex, and the assemblages from each neighborhood reflect the differential suite of practices and reactions to missionization. The following chapter will take a closer look at the intra-site variability within the mission-era collection.

5. INTRA-SITE VARIABILITY OF INVERTEBRATE ASSEMBLAGES AT PUEBLO SANTA CATALINA DE GUALE

In the previous chapter, I examined diachronic change on St. Catherines Island by comparing Irene Period faunal assemblages to the summed results from Pueblo Santa Catalina de Guale. This chapter delves into variation within the Pueblo; I compare the taxonomic breakdown of each assemblage, provide results of the morphological analysis of oysters, and include results of isotope analysis at the neighborhood level. The sociopolitical context of the sixteenth and seventeenth centuries resulted in discrete town populations forming pluralistic communities around Spanish missions, which is reflected in the nuanced material culture at Pueblo Santa Catalina de Guale (Reitz et al. 2010, Blair 2015). Invertebrate faunal assemblages also exhibit noteworthy distinctions that may provide further information about how foodways functioned to maintain group identities and a subdivided social organization during the Mission era. These results are considered here in conjunction with relevant studies into mission-era subsistence, and the chapter ends with a summary of intra-site variability.

Fallen Tree 9Li8

Zooarchaeological Characterization of Fallen Tree

The sample from Fallen Tree (9Li8) included 2,216 individuals weighing 99.26 kg. Twelve taxa were identified. Eastern oysters (*Crassostrea virginica*) comprised 89.79% of individuals, of which 7.59% were represented by spat. Commensal taxa such as terrestrial snails, barnacles, and odostomes constitute a combined 7.08% of individuals. Due to the robusticity of their shells, oysters are favorably biased within measures of specimen weight and MNI. However, when biomass was calculated for all possible taxa, oysters are still estimated to have supplied over half of the meat weight from invertebrates at 54.22%. Stout tagelus (*Tagelus plebius*) contributed another 28.45% of biomass, and hard clams (*Mercenaria mercenaria*) represented 13.91%. Of all the pueblo neighborhoods, hard clam was most prevalent at Fallen Tree.

Table 4

Fallen Tree (9Li8) Invertebrate Species List

Taxa	NISP	MNI	% MNI	Weight, g	Biomass, g	% Biomass
Mollusca	---	---	---	4788.93	---	---
Geukensia demissa	---	---	---	121.99	28.12285353	2.76%
Crassostrea virginica	1529	774	89.90%	4177.48	552.4423879	54.24%
Tagelus plebius	---	---	---	156.36	289.8574086	28.46%
Mercenaria spp.	459	9	1.05%	661.68	141.7128158	13.91%
Gastropoda	1	1	0.12%	0.03	0.027475876	0.00%
Littorina irrorata	15	15	1.74%	4.21	1.765327028	0.17%
Busycon carica	1	1	0.12%	1.08	0.809237416	0.08%
Brachyura	4	---	---	0.3	3.641157197	0.36%
Balanus spp.	167	28	3.25%	12.49	---	---
Odostomia	11	11	1.28%	0.11	0.090799043	0.01%
Anadara sp.	7	1	0.12%	1.4	0.135269151	0.01%
Polygridae	21	21	2.44%	0.38	0.000284	0.00%
Total	2215	861	97.56%	9926.44	1018.604732	100.00%

When calculating the diversity within the Fallen Tree assemblage based upon biomass, which included all taxa except barnacles (*Balanus sp.*) and indeterminate mollusks (Mollusca), the site's Shannon-Weaver index was 1.05. While low, this score falls on the higher end of diversity within the pueblo. The equitability of invertebrate species at Fallen Tree was 0.44, which is moderately low. Fallen Tree was among the neighborhood assemblages which varied most greatly from Meeting House Field, with a similarity coefficient of 63.65%.

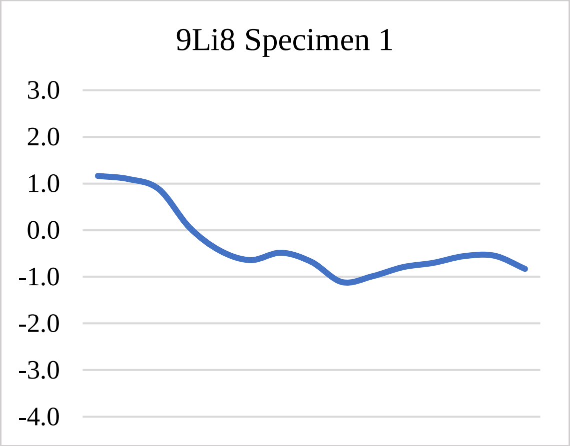
Oyster Morphology at Fallen Tree (9Li8)

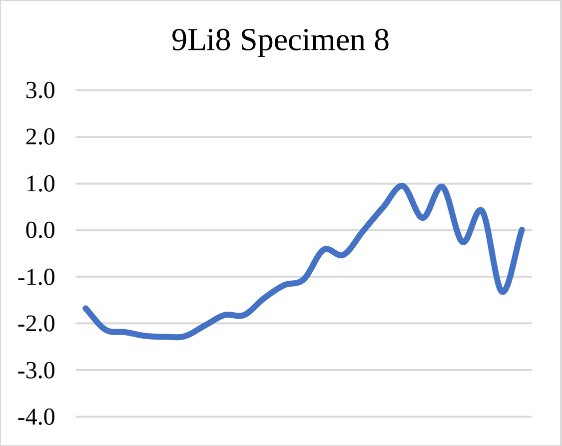
Fallen Tree had the fewest intact oyster valves; only 12 were suitable for measurement. Height ranged from 29.04-87.08 mm, and eight-length ratio ranged from 1.05-1.98. The mean height was 55.98 mm, and the average HLR was 1.71. Of the entire Pueblo, Fallen Tree had the lowest means and ranges for both metrics, which may be due in part to the small sample size. Kent (1992) classifies oysters with height-length ratios between 1.3 and 2.0 as “bed” oysters, which most frequently grow on mixed, muddy sand and occur singly or in clusters, as opposed to “reef” oysters which occur on harder substrates in more densely-packed intertidal environments. Oysters may settle on any substrate strong enough to support their weight, and larvae will sometimes form new clusters in soft sediment. The shorter height of the oysters at Fallen Tree combined with a rounder morphology may indicate that a smaller, younger oyster community was harvested from. These softer substrates would also provide better habitat for shallowly burrowing clams, which contribute 14% of biomass at Fallen Tree.

Stable Isotope Analysis at Fallen Tree (9Li8)

O’Brien and Thomas’s (2008) visual analysis of molluscan incremental growth sequences found that 52% of hard clams sampled from Fallen Tree (N=25) were harvested during the summer and fall, 24% were harvested during winter, and 24% were too fast-growing for season-of-capture to be reliably determined. Figure 19 shows the plotted $\delta^{18}O$ values from each eastern oyster specimen sampled for oxygen stable isotope analysis, with the most recent growth oriented to the right. Among the oyster valves subsampled from Fallen Tree, the most recent growth for specimens 15, 18, and 23 terminated in the upper third of their δ^{18}O ranges, indicating cold weather season of capture. Sudden fluctuations in temperature or salinity during the cool season appear to have been experienced by specimen 8; samples milled very compactly from fast growing shells can sometimes capture more detailed weather patterns (Andrus, personal communication 2018).

Warm spells are common in Georgia winters, and applying a moving average for Specimen 8 supported the interpretation of this individual was captured during the cooler portion of the year. Specimen 1 was among only three valves from the entire pueblo whose recent growth exhibited low δ^{18}O values suggesting that they were collected during warmer months, and it was the only one firmly classified as a summer capture with δ^{18}O values terminating in the lower 1/3 of the range. Season of capture estimates assume that the organism was alive until collection. Sampling strategies avoided shells with any evidence of postmortem harvest, however it is possible that dead shells were collected incidentally in a cluster with live oysters. Median δ^{18}O for individual specimens ranged from -1.3 to -0.4, which corresponds to less brackish waters.





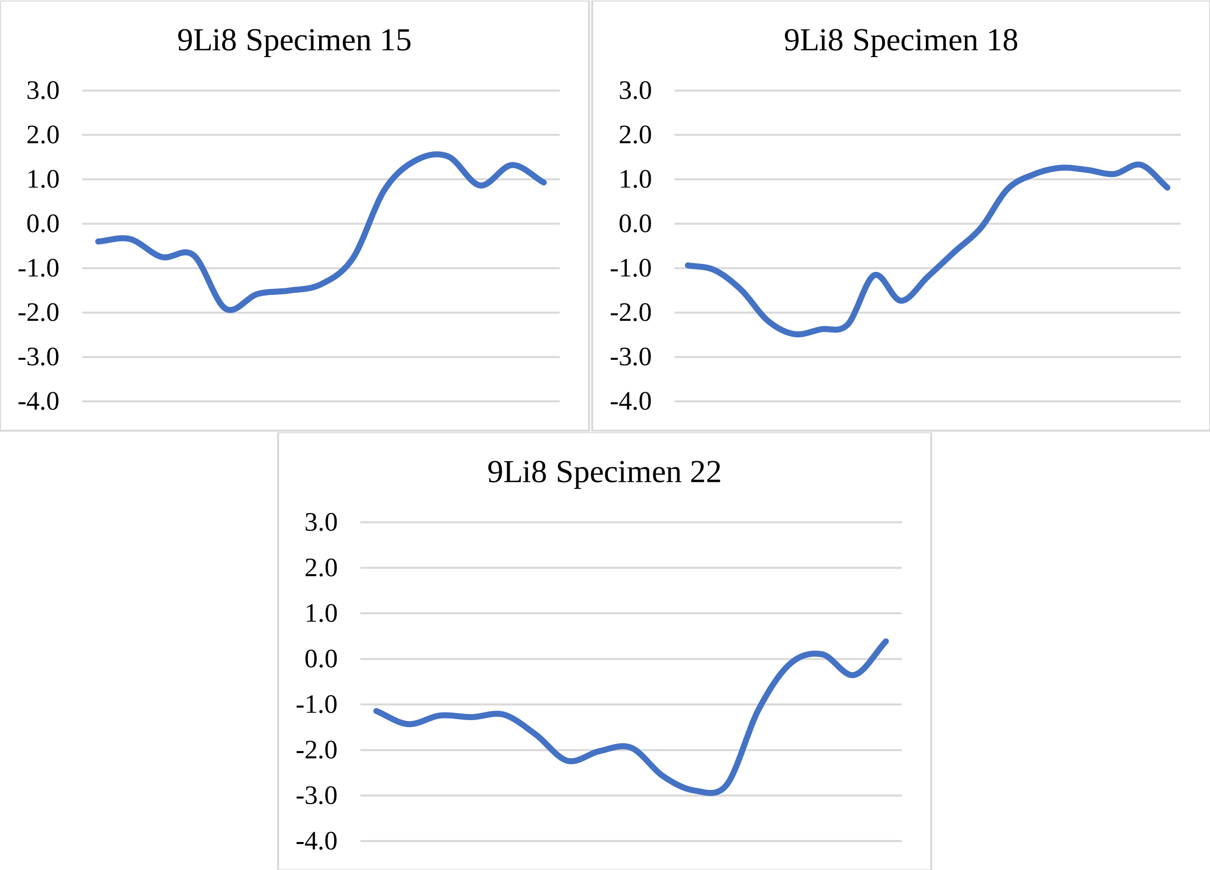


Figure 19. 9Li8 isotopic values by increment, from oldest to most recently precipitated (X-axis) by δ^{18}O (% VPDB) (Y-axis)

Discussion and Summary of Fallen Tree (9Li8)

Previous examinations of the botanical and zooarchaeological record at Fallen Tree have suggested that old world ingredients were modestly incorporated into the diet, but emphasis remained on native resources. Domesticated animals included at least two pigs (*Sus scrofa*) and one chicken (*Gallus gallus*) in the vertebrate assemblage, which contributed about 5% to biomass. Deer and other wild mammals made up 89% of vertebrate biomass (Reitz and Dukes 2008). Botanical samples from Fallen Tree included wild foods such as mast nutshell, indigenous crops, and peach pits. The emphasis was on native cultigens, especially maize (May 2008). Oysters are harvested less frequently in relation to other invertebrates than during previous time periods on St. Catherines. Fallen Tree had the highest equitability of species, in part because eastern oysters, hard clams, and stout tagelus all contributed substantially to biomass. The stable isotope analysis reported here provides direct evidence for oyster collection during winter, spring, and summer at Fallen Tree.

Wamassee Head (9Li13)

Zooarchaeological Characterization of Wamassee Head

The invertebrate bulk sample from Wamassee Head weighed nearly 33 kg and included at least 4,192 individuals. 12 taxa were identified. Eastern oysters (*Crassostrea virginica*) made up 86.31% of estimated individuals, and 8.03% of those oyster specimens were classified as spat. 12.15% of individuals consist of commensal invertebrates. 59.29% of the sample biomass comes from oysters, 27.02% from stout tagelus (*Tagelus plebius*), 6.35% from ribbed mussel (*Guekensia demissa*), and 4.92% from hard clams (*Mercenaria mercenaria*). The ratios of taxonomic contribution to biomass at Wamassee Head were similar to those from Fallen Tree, with higher numbers of ribbed mussel and fewer hard clams. The Wamassee Head assemblage is 68.65% similar to Meeting House Field. The Shannon-Weaver diversity index for the Wamassee Head invertebrate assemblage was 1.09, and the equitability of taxa was 0.46. While Wamassee Head had the highest diversity and equitability within the Pueblo, the diversity remains a very low score overall.

Table 5

Wamassee Head (9Li13) Invertebrate Species List

Taxa	NISP	MNI	% MNI	Weight, g	Biomass, g	% Biomass
Mollusca	---	---	---	12795.9	---	---
Balanus spp.	651	129	3.08%	77.87	---	---
Busycon carica	3	2	0.05%	152.9	51.86833268	1.88%

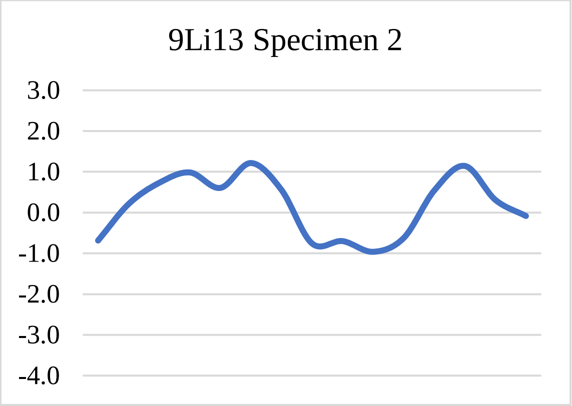
Crassostrea virginica	7225	3618	86.31%	17565.62	1636.17247	59.29%
Brachyura	1	---	---	0.01	0.223872114	0.01%
Gastropoda	1	1	0.02%	0.01	0.01	0.00%
Geukensia demissa	---	---	---	1200.2	175.1470786	6.35%
Littorina irrorata	48	48	1.15%	22.2	8.425036603	0.31%
Mercenaria mercenaria	353	14	0.33%	632.02	135.7334764	4.92%
Odostomia	64	64	1.53%	0.09	0.075492379	0.00%
Polygridae	314	314	7.49%	10.43	5.981657794	0.22%
Tagelus plebius	---	---	---	406.12	745.7063371	27.02%
Urosalpinx spp.	2	2	0.05%	0.06	0.051987526	0.00%
Total	8662	4192	100.00%	32863.43	2759.395741	100.00%

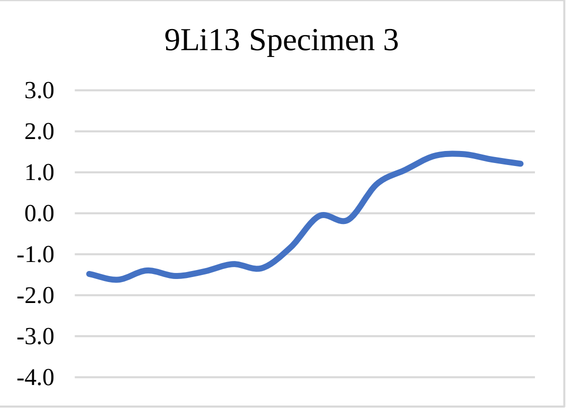
Oyster Morphology at Wamassee Head (9Li13)

Three hundred thirty-seven intact left oyster valves were subsampled from Wamassee Head for morphological analysis. Height ranged from 20.70-136.42 mm, and height-length ratio ranged from 1.20-3.91. The mean height for this sample was 74.10 mm, and the average HLR was 2.20. These oysters fall within Kent's (1992) categorical range for "reef" oysters, suggesting they were harvested primarily from more densely-packed intertidal oyster communities. As I will discuss, Wamassee Head, Pueblo North, and Pueblo East all had similar mean valve heights, but Wamassee Head had the highest mean HLR in the pueblo. The broad range of height-length ratios may suggest that the residents of Wamassee Head exploited multiple kinds of oyster communities throughout the depositional period of this midden.

Stable Isotope Analysis at Wamassee Head (9Li13)

All four incremental growth sequences were represented in a previous schlerochronological study of hard clams (*Mercenaria mercenaria*) at Wamassee Head (9Li13) suggesting that clams were harvested year-round at various points in the neighborhood's approximately century-long occupation. Out of the 40 clam shells thin sectioned for this analysis, 45% were harvested during the winter, 30% during spring, and 25% between approximately March and mid-May (O'Brien and Thomas 2008). The sinusoidal curves produced by plotting δ^{18}O values in figure 20 show seasonal fluctuations in ambient water temperature. Median δ^{18}O for individual specimens ranged from 0.3 to -1.3. Sampling of specimens 2 and 4 probably captured more than one year's growth for each oyster, as evidenced by multiple peaks in δ^{18}O values. Specimens 3, 4, and 6 terminate in high δ^{18}O values, indicating cold weather seasons of capture. Specimen 2 is intermediate, possibly signifying a spring harvest. Along with Fallen Tree Specimen 1, Wamassee Head Specimen 5 is one of only 2 oysters out of the 25 sampled from the Pueblo which terminate in the lower 1/3 of their individual δ^{18}O spectrums, indicating a summer or early fall warm-weather harvest. Both the range of HLRs and estimated season of capture indicate variability in oyster harvesting practices in the Wamassee Head neighborhood.





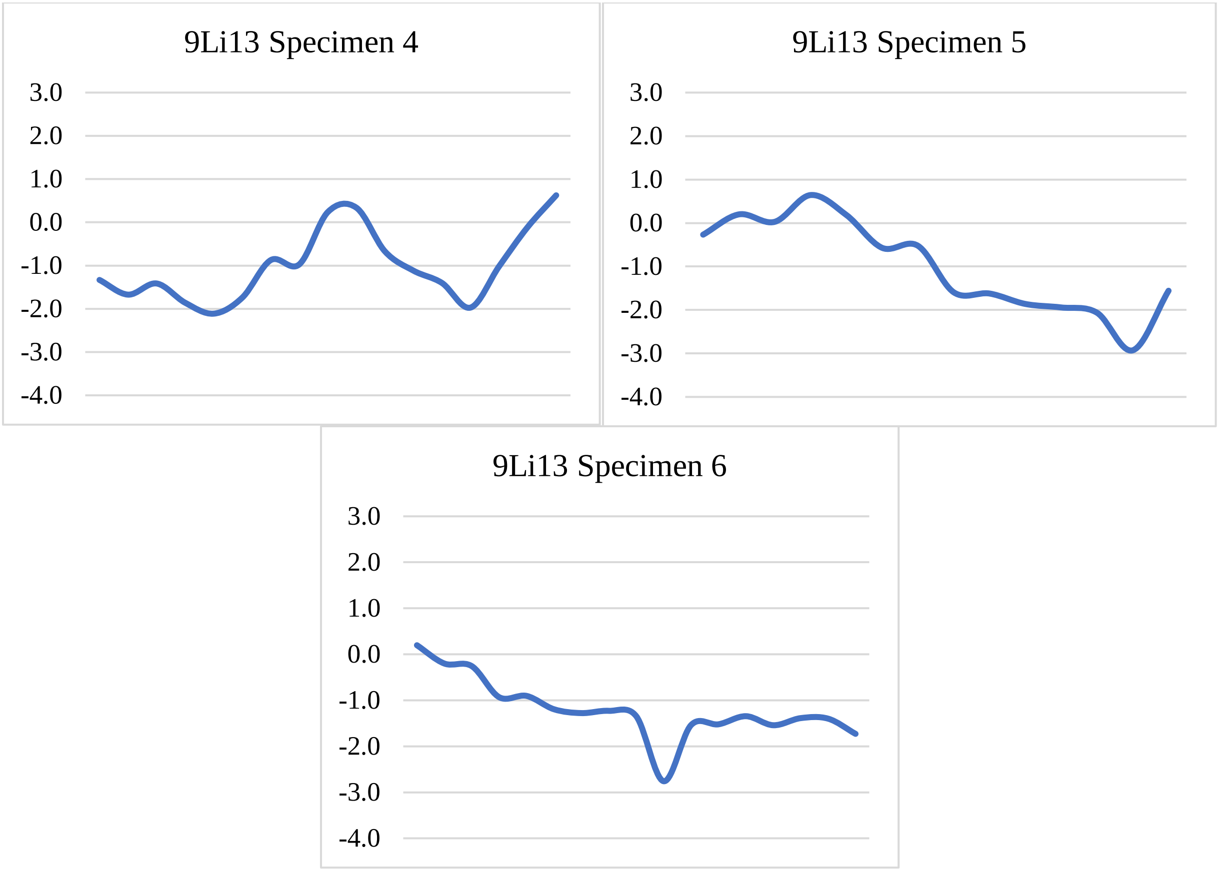


Figure 20. 9Li13 isotopic values by increment, from oldest to most recently precipitated (X-axis) by $\delta^{18}O$ (% VPDB) (Y-axis)

Discussion and Summary of Wamassee Head 9Li13

The vertebrate zooarchaeological assemblage from Wamassee Head, referred to by Reitz et al. (2010) as Pueblo South, contained two old world specimens, wild mammals, wild birds, deer, and estuarine reptiles such as turtles, terrapins, and a skeletal element of one alligator. Pigs and chickens contributed a combined 9% of biomass, fishes 8%, and deer 73.4%. Oysters contribute around 60% of biomass, which is lower than most pre-contact assemblages. Wamassee Head was among the sectors most dissimilar to Meeting House Field. Oysters may have been harvested less strategically during the mission-era; they were harvested during at least three seasons and appear to come from a wide range of community types and salinity ranges.

9Li210

Zooarchaeological Characterization of 9Li210

Seven thousand seventy-three individuals are estimated in the 220,727.69 g sample from 9Li210. Eleven taxa were identified. Of these, 77.69% of estimated individuals were eastern oysters. Oyster spat supplied 13% of oyster specimens. Commensal taxa comprised 22% of individuals. Oysters comprised 77.7% of the invertebrate biomass. While oysters are the most dominant taxa by all metrics between the pueblo neighborhoods, it is most prevalent at 9Li210. The only other taxa which contributes considerably to biomass is stout tagelus at 17%. The Shannon-Weaver diversity index for 9Li210 was 0.72 and the equitability score was 0.29, which are the lowest values for each within the pueblo. This is unsurprising given the ratio of oysters to all other taxa. The 9Li210 mission-era assemblage had a similarity coefficient of 87.13% when compared to Meeting House Field, and of 89.56% as compared to the underlying Wilmington Period assemblage.

Table 6

Mission-era 9Li210 Invertebrate Species List

Taxa	NISP	MNI	% MNI	Weight, g	Biomass, kg	% Biomass
Mollusca	---	---	---	14964.60	---	---
Balanus sp.	1248	316	4.345%	259.13	---	---
Busycon carica	3	1	0.014%	0.38	0.0003	0.0033%
Crassostrea virginica	10224	5650	77.685%	58546.80	7.16023027	77.70%
Brachyura	57	---	---	7.15	0.049	0.5321%
Geukensia demissa	---	---	---	1255.29	0.182	1.9716%
Littorina irrorata	14	13	0.179%	2.88	0.001	0.013%
Melampus bidentatus	2	2	0.027%	0.50	0.000366	0.0040%
Mercenaria spp.	414	17	0.234%	1213.37	0.250	2.7174%

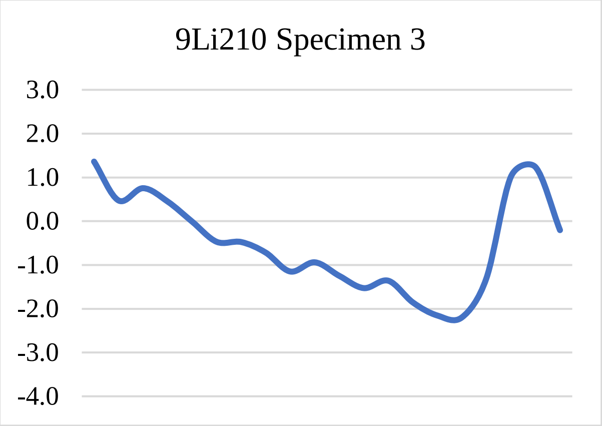
Odostomia sp.	129	129	1.774%	1.00	0.000692	0.0075%
Polygridae	1145	1145	15.743%	39.90	0.020559	0.2231%
Tagelus plebius	---	---	---	850.47	1.550	16.8234%
TOTAL:	13236	7273	100.000%	77141.47	9.21473724	100.00%

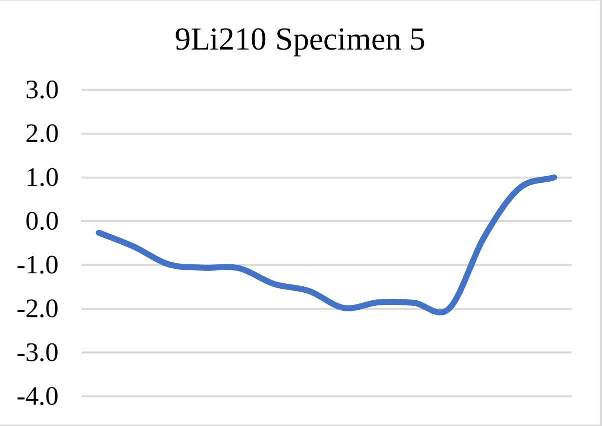
Oyster Morphology at 9Li210

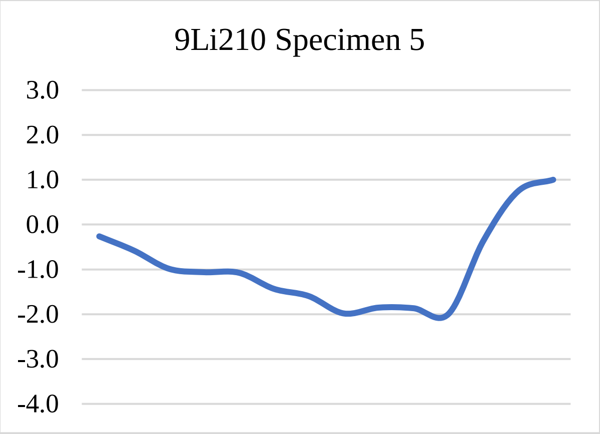
Unit A in the 9Li210 neighborhood was the only midden included in this sample to have more than one depositional period marked by separate cultural horizons. Four hundred intact left valves were measured from the Mission-era component, and 244 from the Wilmington Period assemblage. There are significant differences between the average height and HLR of oyster valves from the upper and lower levels of Unit A. Mean oyster height for the earlier component falls within a narrow range. Height is greater during the later Mission-era component, and it gradually increases as it moves upward stratigraphically. Average height-length ratios for levels six through nine all fall within the 1.3- 2.0 range for “bed” oysters, and all average height length ratios for the upper five levels measure above 2.0 and are likely “reef” oysters. It is likely that these differences in HLR between the two components reflect the exploitation of different habitat types on the landscape at different rates during the two periods. Though the volume of shell present in the mission-era component is higher, the morphology of these oysters seems to suggest that they were being harvested from an oyster population which was densely clustered, greater in height, and may have been from a less consistently harvested location.

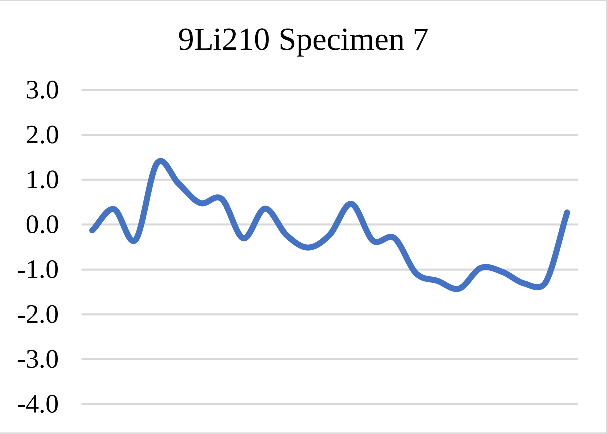
Stable Isotope Analysis at 9Li210

Figure 21 shows the plotted oxygen isotope data for the 5 valves sampled from 9Li210. Previous investigations into the seasonality of resource use at 9Li210 found that hard clams were harvested during all four seasons. 38% of hard clams (N=13) were harvested during winter, 23% during spring, and 23% during summer. The remaining clams were too fast-growing to be assigned a season-of-capture (O'Brien and Thomas 2008). Median δ^{18}O values ranged from -0.8 to -1.9. The δ^{18}O values for the most recent growth of specimens 4, 5, and 10 fell within the highest 1/3 of the δ^{18}O ranges for each specimen, indicating winter harvest. Specimen 3 has ending δ^{18}O values suggest it was captured during the spring. The plotted values for specimen 10 did not quite produce a satisfactory sinusoidal curve despite adequate sampling, however it is cautiously interpreted as a fall harvest.









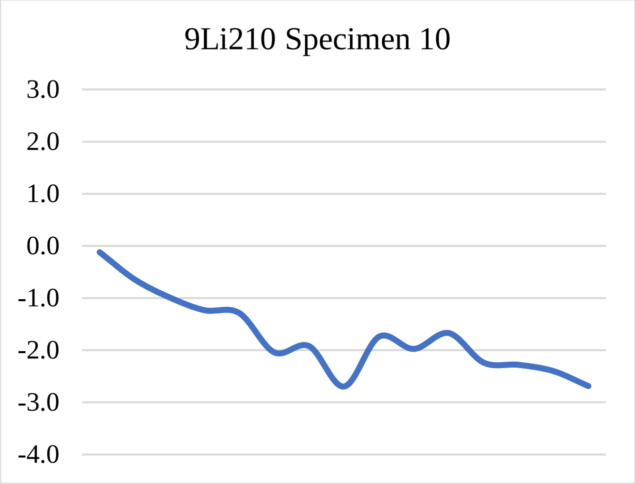


Figure 21. 9Li210 isotopic values by increment, from oldest to most recently precipitated (X-axis) by $\delta^{18}O$ (% VPDB) (Y-axis)

Discussion and Summary of 9Li210

Analysis of vertebrate remains from 9Li210 excavated in the 1977 island-wide transect survey was conducted in the 1980s, however it was not included in subsequent publications regarding the archaeology of the mission pueblo due concerns about the timing of 9Li210's occupation (Reitz 2016). A post-1580 occupation is indicated by the complete lack of Irene complicated-stamped wares; however, it remains unclear where 9Li210 fits sequentially within the Mission era. In Blair's (2015) analysis of Pueblo Santa Catalina pottery he found the assemblage from 9Li210 to be the most distinctive with far higher ratios of plain to stamped wares, complex firing cores, and a hint towards finer lands and grooves. He proposed two possible explanations: that 9Li210 was an early, undocumented incidence of aggregation, and/or a post A.D. 1580 pre-AD 1605 occupation (2015: 138).

The vertebrate assemblage at 9Li210, analyzed at the University of Georgia by Gwyneth Duncan, had more in common with mission-era pueblo sectors than it did with the Irene Period site Meeting House Field. As with Fallen Tree, Wamassee Head, and Pueblo North, bony fishes dominated MNI and venison provided the most biomass. White-tailed deer comprised 18.2% of individuals and 78.9% of biomass followed by bony fishes at 36.4% of individuals and 13.1% of biomass. Turtles and other wild mammals were also present, but notably absent were any introduced domesticates. Reitz suggested that the absence of Eurasian vertebrates at 9Li210 "may be evidence that this sector was occupied very early in the Mission period or by a group that was marginal to mission life with restricted access, or strong resistance to, introduced livestock" (2016: 4).

The assemblage at 9Li210 is characterized by an abundance of large, elongated reef oysters harvested during cold and intermediate seasons, with smaller amounts of stout tagelus and minor meat weight contributions from hard clams and ribbed mussels. The pattern of invertebrate use presented above is consistent with a community which practiced food procurement strategies which more closely resembled pre-Hispanic subsistence than other Mission-era pueblo residents. Interestingly, the ratios of invertebrate biomass contribution are nearly identical between 9Li210 and Pueblo North, as shown by a similarity coefficient of 95.33%.

Pueblo North (9Li2117)

Zooarchaeological Characterization of Pueblo North

Bulk samples from Pueblo North (9Li2117) included 922 individuals weighing 17930.57 g. Eleven taxa were identified. Eastern oysters represent 91% of all identified individuals and 73.17% of biomass. 3.22% of oyster specimens were classified as spat. The only other taxa to contribute more than 5% of invertebrate biomass was stout tagelus at 19%. Commensal taxa made up 7.7% of individuals. Tagelus The Shannon-Weaver diversity index was 0.84 and the equitability score was 0.36. The similarity coefficient between Pueblo North and Meeting House Field was 85.73%, parallel to that of 9Li210.

Table 7

Pueblo North (9Li2117) Invertebrate Species List

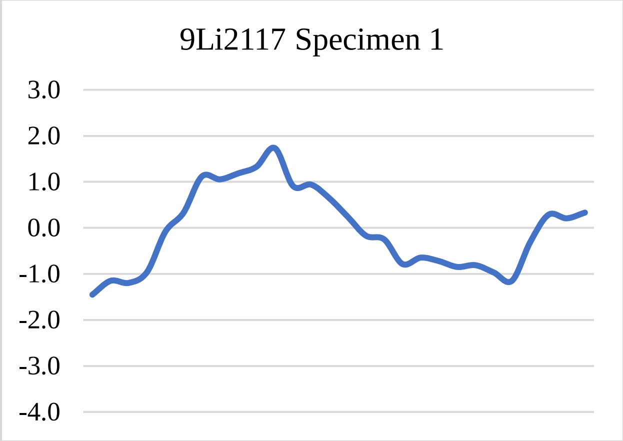
Taxa	NISP	MNI	%	Weight, g	Biomass, g	% Biomass
Mollusca	---	---	---	5047.6	---	---
Geukensia demissa	---	---	---	244.45	49.04017748	2.32%
Crassostrea virginica	1555	839	90.90%	12068.2	1545.942096	73.17%
Tagelus plebius	---	---	---	217.24	401.3935562	19.00%
Mercenaria mercenaria	151	5	0.54%	327.64	73.19359897	3.46%
Gastropoda	1	1	0.11%	0.07	0.059908742	0.00%
Littorina irrorata	4	4	0.43%	1.8	0.794248046	0.04%
Polygridae	30	30	3.25%	0.92	0.640744373	0.03%
Busycon carica	3	3	0.33%	105.84	38.080782	1.80%
Brachyura	3	---	---	0.29	3.541329672	0.17%
Balanus spp.	221	40	4.33%	21.76	---	---
Odostomia	1	1	0.11%	0.01	0.01	0.00%
Total	1969	923	100.00%	18035.82	2112.696442	100.00%

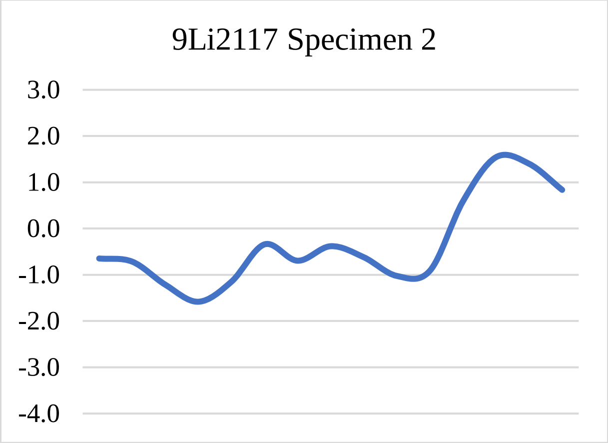
Oyster Morphology at Pueblo North (9Li2117)

Measurements were taken from 105 intact left oyster valves from Pueblo North. Height ranged from 30.09-127.27 mm, and HLR ranged from 1.12-2.96. The mean height was 67.18 and the average HLR was 1.88. Along with Fallen Tree, the average HLR for Pueblo North suggests this sample most closely reflects “bed” oysters from clusters on mixed, muddy sand. While the taxonomic ratios between 9Li210 and Pueblo North are very similar, it appears that different oyster community types are being exploited.

Stable Isotope Analysis at Pueblo North (9Li2117)

There have been no previous studies of seasonality at Pueblo North. As with 9Li210, $\delta^{18}O$ values fell within a narrower range than other neighborhoods. Median $\delta^{18}O$ values from Pueblo North oyster specimens ranged from -0.8 to 0.8. Of the five oyster specimens sampled from Pueblo North, the most recent growth of Specimen 4 shows the highest $\delta^{18}O$ in each organism's plotted range of $\delta^{18}O$ values. These were very likely harvested during the coolest part of the year. Narrow, densely packed growth bands on Specimen 3 may indicate that this was a fast-growing oyster, and some of the oscillations within the data may reflect weather. The most recent $\delta^{18}O$ values for Specimen 1 are intermediate, showing an abbreviated increase following the lowest $\delta^{18}O$ within this specimen's sinusoidal curve, and may indicate that this oyster was captured during the fall.


9Li2117 Specimen 1


9Li2117 Specimen 2

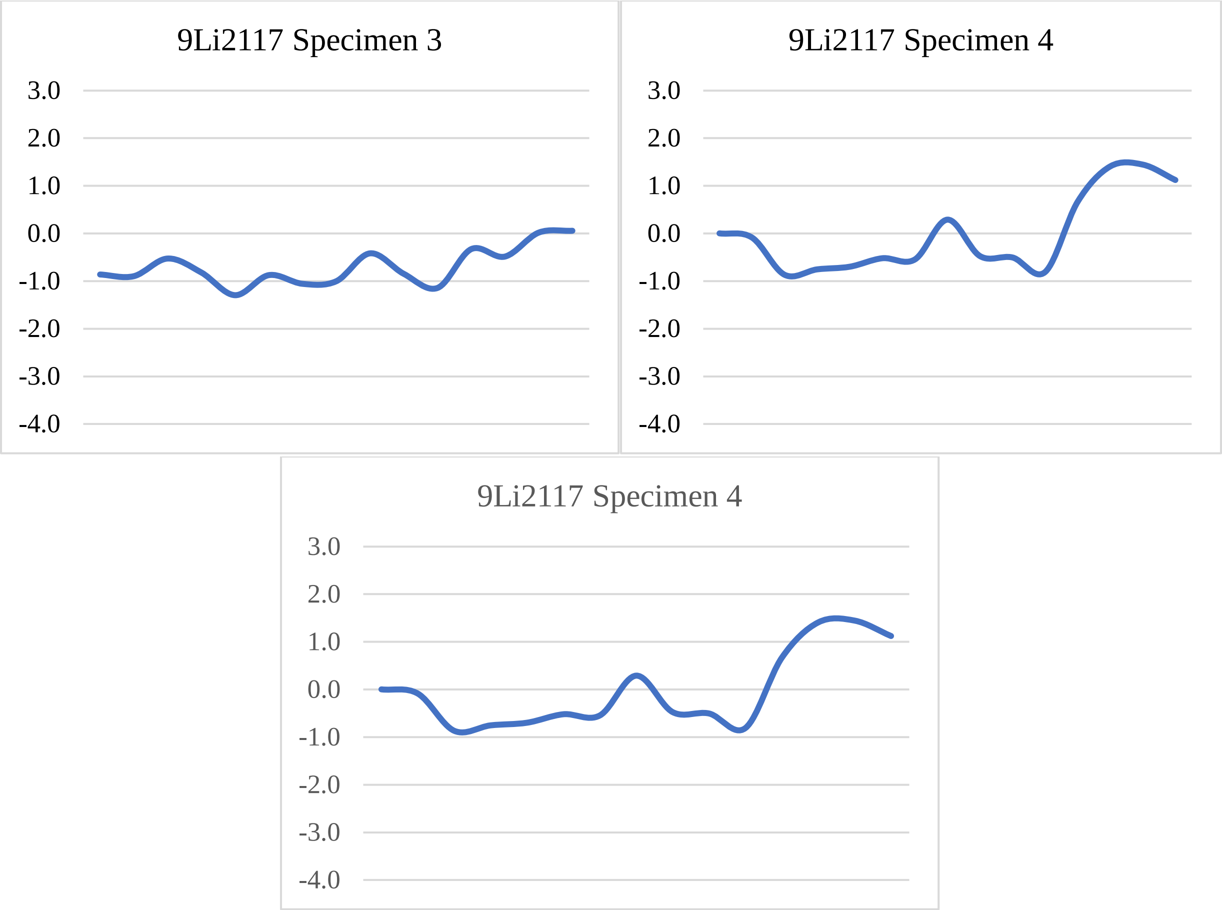


Figure 22. 9Li2117 isotopic values by increment, from oldest to most recently precipitated (X-axis) by δ^{18}O (% VPDB) (Y-axis)

Discussion and Summary of Pueblo North

Reitz et al (2010) found a single pig, contributing 3% to biomass, was the only Eurasian domestic animal in the Pueblo North vertebrate assemblage. Deer contribute 82.5% of vertebrate biomass. Sharks, rays, and fishes contribute another 6.4%, and turtles provide 3.3%. Over 92% of invertebrate biomass was supplied by only two taxa. Throughout all time periods on the Georgia Bight, when large sample sizes pass the point of diminishing returns, high species richness and low equitability are typical of invertebrate assemblages. Many taxa may be present, but there are a limited number which contribute significant amounts of meat weight. Pueblo North is a drastic example of this, as residents seem to have targeted a few select animal species.

Pueblo East

Zooarchaeological Characterization of Pueblo East

No prior seasonality estimates have been published for Pueblo East. The Pueblo East invertebrate assemblage weighed 33.53 kg in total. 11 taxa were identified. Of the 3,351 estimated individuals, 76.96% were eastern oyster. 10.07% of oyster specimens were classified as spat. Nearly 22% of the estimated MNI is comprised of commensal taxa. Stout tagelus (*Tagelus plebius*) was more prevalent at Pueblo East than any other pueblo neighborhood and made a comparable contribution to oysters in terms of biomass at 44.47%. Pueblo East varied the most of any Pueblo sector from the Meeting House Field assemblage, with a similarity coefficient of only 56.39%. The Shannon-Weaver index for Pueblo East was 0.99, and the equitability score was 0.43.

Table 8

Pueblo East Invertebrate Species List

Taxa	NISP	MNI	%	Weight, g	Biomass, g	% Biomass
Mollusca	---	---	---	10449.8	---	---
Geukensia demissa	---	---	---	902.02	139.371166	2.69%
Crassostrea virginica	4994	2579	76.96%	19455.41	2456.796446	47.34%
Tagelus plebius	---	---	---	1271.34	2307.911198	44.47%
Mercenaria spp.	587	16	0.48%	1321.26	271.4744676	5.23%
Littorina irrorata	25	19	0.57%	8.49	3.413290321	0.07%
Polygridae	440	440	13.13%	1.58	1.053815349	0.02%
Busycon carica	1	1	0.03%	3.8	2.328188936	0.04%

Brachyura	2	---	---	0.22	2.426771391	0.05%
Balanus spp.	790	155	4.63%	106.7	---	---
Anadara sp.	5	2	0.06%	1.49	0.1461339	0.00%
Odostomia	139	139	4.15%	8.67	5.046352336	0.10%
Total	6983	3351	100.00%	33530.78	5189.96783	100.00%

Oyster Morphology at Pueblo East

The height, length, and other characteristics of 205 intact left oyster valves were measured from Pueblo East. Oyster height ranged from 28.86-154.86 mm and the mean height was 77.56. The HLR ranged from 1.14-5.45, and the average was 2.11. Along with Wamassee Head, this suggests the majority of oysters from Pueblo East were more elongated "reef" oysters, from denser oyster communities formed on hard substrates. However, the broad range of HLRs in this sample suggest that multiple oyster community types were probably exploited at Pueblo East.

Stable Isotope Analysis at Pueblo East

The δ^{18}O values for three of the five oysters sampled from Pueblo East terminate at the highest end of the range for δ^{18}O values in each specimen, strongly suggesting that they were collected during the winter. The other two specimens terminated in intermediate values which still trend higher, suggesting cool weather, perhaps reflecting an early spring harvest. Pueblo East was the only neighborhood where the δ^{18}O values had a mean and median above zero. The δ^{18}O values for specimens 6 and 7 were entirely positive, which suggests a high ambient water salinity. Further calculations need to be performed to estimate the exact salinity these represent so that the possible harvesting location can be determined, however salinity values in this range *may* indicate that these oysters were collected from McQueen’s Inlet or some other intertidal creek nearer the Island’s seaward side.

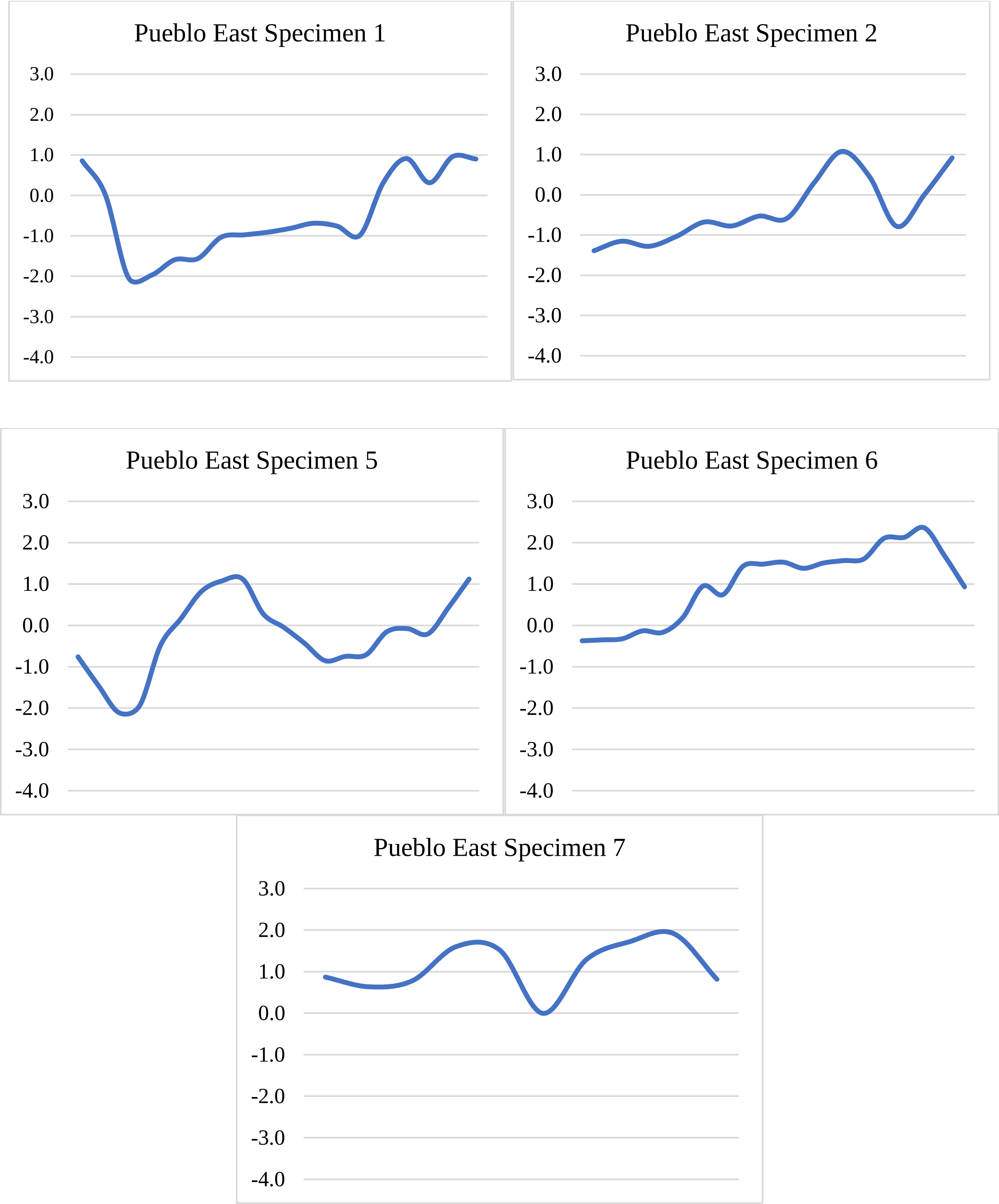


Figure 23. Pueblo East isotopic values by increment, from oldest to most recently precipitated (X-axis) by δ^{18}O (% VPDB) (Y-axis)

Discussion and Summary of Pueblo East

Tagelus prefer to inhabit the more stable and protected intertidal habitats and are most successful in low intertidal or shallow subtidal areas (Holland and Dean 1977). They are present in their highest densities in muddy sands with high organic content (Lomovasky et al. 2018). Where there is suitable substrate these creatures burrow vertically, building permanent passageways more than 50-70 cm deep (Ramasamy 2018). Tagelus probably required more effort to obtain than oysters, which are permanently cemented to the substrate, or than clams, which burrow shallowly into soft mud. Stout tagelus are pressure sensitive, and when the sands near their burrows are compacted, they travel deeper for protection. To gather them, the entrance to their burrow must be identified, their depth estimated, and a digging implement used to excavate the organism. Once a colony has been located, one of the most efficient ways to collect tagelus is to dig a deep trench where individuals can then be excavated from the profile (Quitmyer, personal communication 2019).

While tagelus are also present in all neighborhoods, apart from Pueblo East they offer far less biomass than oysters. In these instances, the ratio may suggest tagelus were harvested from the firmer substrates of the same intertidal creek areas the oysters were gathered from. Given the prevalence of stout tagelus at Pueblo East, it seems likely that these mollusks were being specifically targeted by collectors. Oysters present in the assemblage have similar ranges in height and height-length ratio to other neighborhoods, which does not suggest that tagelus would have served as an alternative in the face of resource depletion. Given the effort required to harvest the amount of tagelus recovered from Pueblo East, tagelus may have played a more important role in this community’s cuisine. Higher rates of tagelus exploitation in this neighborhood could be tied to ideas of taste and preference within this particular culinary community of practice.

Discussion and Summary of Intra-Site Variation in Pueblo Santa Catalina de Guale

Vertebrate and invertebrate assemblages from Pubelo Santa Catalina de Guale cannot be directly compared due to differential sampling strategies. When considering these datasets together, however, it becomes evident that mission-era residents were consuming more venison and other wild terrestrial mammals than their predecessors, and fewer oysters relative to other invertebrates. There is considerable intra-site variation between pueblo sectors, and some show greater difference to the pre-Hispanic Irene period than others (figure 24).

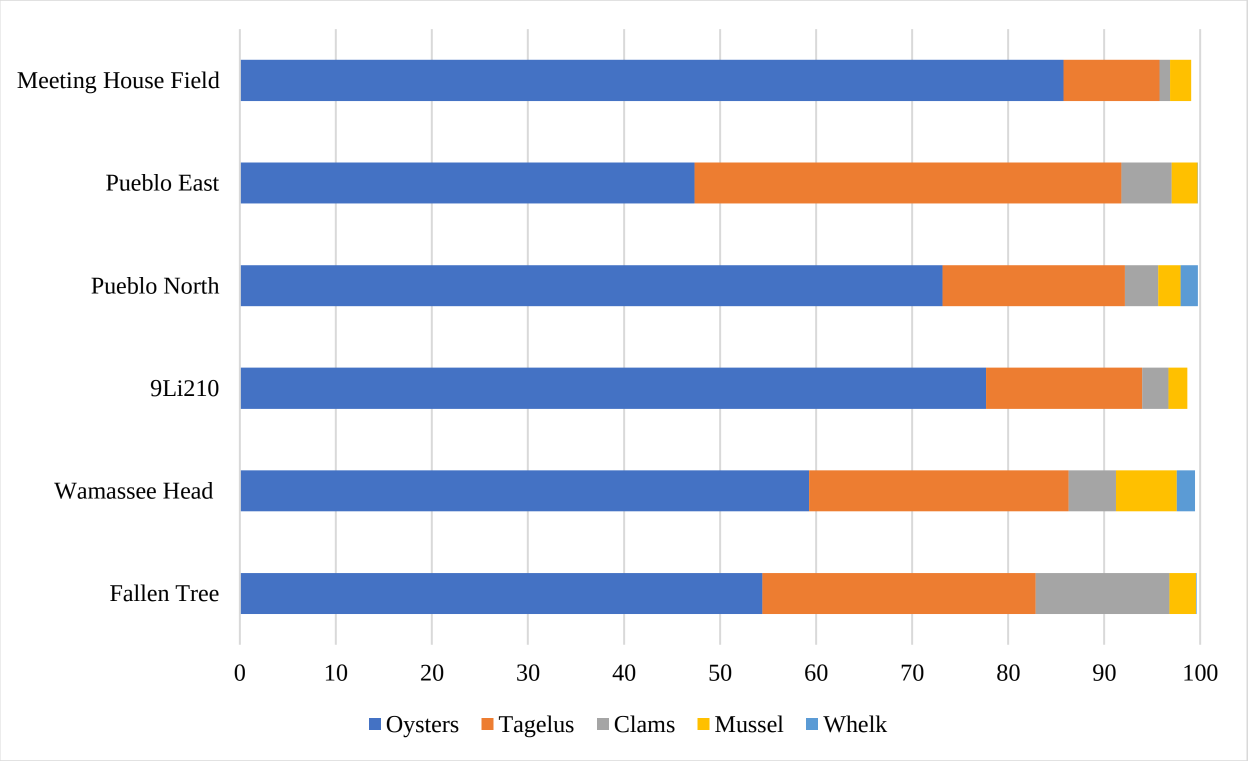


Figure 24. Species by percent of total invertebrate biomass at Meeting House Field and the five Pueblo Santa Catalina de Guale neighborhoods.

Researchers have speculated that 9Li210 may represent an early occupation in the Pueblo based on the absence of Eurasian vertebrates (Reitz 2016) and ceramic characteristics (Blair 2015). Oysters are the most predominate at 9Li210 and Pueblo North, and these have the highest similarity to the Meeting House Field assemblage. These neighborhoods most closely resemble pre-Hispanic invertebrate use more broadly, which may reflect early temporal occupation, a differential relationship to Mission Santa Catalina, or a culinary community of practice specific to the residents of these northernmost neighborhoods. Fallen Tree and Wamassee Head are both dissimilar to earlier assemblages but share a similarity coefficient to one another of 89.32%. Pueblo East has a similar rate of difference from the Irene Period as Fallen Tree and Wamassee Head but has a distinct pattern of invertebrate use which differs from its fellow neighborhoods.

The data presented in this chapter seem to reflect the presence of at least three culinary communities of practice in the pueblo. Neighborhoods which appear to share the same or very similar culinary communities of practice such as 9Li210 and Pueblo North or Fallen Tree and Wamassee Head may be contemporaneous, more closely affiliated social groupings or separate temporal habitations by members belonging to the same social grouping. The presence of multiple coexisting social groupings within one small community is a possible result of mission-sponsored *congregación* or migration in response to increased violence and instability in the region. How the intra-site variability reported in this chapter relate to the sociopolitical context of missionization and population aggregation will be further explored in Chapter 6.

6. DISCUSSION AND CONCLUSIONS

I outlined in Chapter 2 the historical and archaeological context of Mission and Pueblo Santa Catalina de Guale. Our understanding of sixteenth and seventeenth century indigenous diets on St. Catherines Island have largely been based on bioarchaeological data and analysis of vertebrate faunal assemblages. This project sought to supplement existing information with a detailed analysis of invertebrate fauna, which were an abundant and accessible resource to island residents. Chapter 3 described how samples from Fallen Tree (9Li8), Wamassee Head (9Li13), 9Li210, Pueblo North (9Li2117), and Pueblo East were obtained and analyzed via zooarchaeological and stable isotopic methods. Assemblages were sorted, identified, and quantified following standard zooarchaeological procedures (Reitz and Wing 2008). Oyster valves were sampled for further analysis of their morphology and geochemistry. Results of these analyses are reported and compared with pre-contact invertebrate data in Chapter 4. The complex intra-site variability of Pueblo Santa Catalina is detailed in Chapter 5. In this final chapter, I will discuss the limitations of this study, my interpretations of the results, and relevant possibilities for future research.

Limitations

While excavation and bulk sampling strategies were consistent between Wamassee Head (9Li13), 9Li210, and Pueblo East, there was some variation in how samples were collected from Fallen Tree (9Li8) and Pueblo North (9Li2117). I believe that these samples are comparably representative of their middens of origin, however I cannot rule out the possibility that some characteristics of their datasets are result of these discrepancies. Furthermore, without additional testing of more middens within the same neighborhoods at Pueblo Santa Catalina de Guale, it is impossible to be certain whether the differences in their invertebrate assemblages are representative of neighborhood groupings or more prominent at the individual household level.

Due to the nature of cementation in oyster clusters and reefs, dead oyster valves are often included in harvests. The potential implications of this upon my research are twofold and may have effected season of capture estimates and biomass calculations. While any valves showing evidence of interior epibiont activity were not sampled for stable isotope analysis for this reason, death prior to capture is not always evident and there is no way to be certain that all valves included belonged to organisms alive at the time of collection. At the King's Bay site on the Georgia mainland, Quitmyer (1985) argued in favor of using only 82.62% of shell weight when calculating biomass for oysters, as this is the typical percentage of an oyster colony by weight believed to support living tissue (37). I did not take similar precautions, as I was striving to create a good basis of comparison with Irene Period samples (Bergh 2012) collected on the island. Another potential limitation on the precision of season-of-capture estimates is the tendency of many mollusks to cease growing during parts of the year (Andrus 2012). Shell volume is also extremely variable, and in order to produce the same amount of soft tissue, organisms with a more elongated form must precipitate more hard tissue (Kent 1992). This is to say that simply using allometric regression of shell weight may overemphasize the actual meat weight of oysters.

Discussion and Conclusions

Despite the reorientation of subsistence activities during the Mission era, oyster populations do *not* show evidence of overexploitation as a result of collectors having less time to travel outside of their immediate sphere of resources. Based on estimated salinity ranges and oyster morphology, it appears that the people of Pueblo Santa Catalina continue to exploit a broad variety of oyster communities. Increased exploitation of additional resources, namely the abundance of stout tagelus at Pueblo East, may have been part of an alternate strategy to maintain estuarine health and avoid overharvesting oysters under different conditions. It is probable that differential animal consumption was tied to distinct traditions and preferences held by the residents of these aggregated communities.

Overall, oysters contribute considerably less to biomass and estimated individuals to the Pueblo assemblages than they do at Meeting House Field. In fact, this decline upsets a pattern of continuity and stability observed in oyster harvesting since the inception of a fishery in the Georgia Bight (Reitz 2014). Prior to Spanish colonization, there is evidence that shellfish were harvested during all seasons, though the practice was most intense during the winter and early spring. This is largely based on measurements of hard clams, though oysters and impressed odostome oyster proxy have also been used. Oyster collection may have become even more seasonally constrained during the Mission era. Stable oxygen isotope analysis of eastern oysters from each pueblo neighborhood found an intensification of the cool-weather trend, with the season of capture for only 1 valve estimated to have been during the summer. 84% were categorized as winter oysters based on δ^{18}O values in the upper 1/3 of their range immediately prior to death.

It is unclear to what extent the seasonality of gathering hard clams and eastern oysters may have differed for native peoples, which could have important implications for my interpretation of increased seasonal constriction during the Mission era. Claassen (1986) reviewed studies of shellfish seasonality at 94 sites in the southeastern United States and concluded that humans exploit mollusks most intensely during the period of most rapid growth specific to each species. For hard clams (*Mercenaria spp.*), the period of most rapid growth is November through April (Claassen 1986), but growth rates are more variable for eastern oysters (*Crassostrea virginica*) (Andrus 2012). No hard clams were sampled in this study for season-of-capture determination, however as previously mentioned O'Brien and Thomas did a study of visible growth increments on the species from Fallen Tree, Wamassee Head, and 9Li210. They found that 53% of hard clams with adequate growth banding (N=70) terminated in winter or early spring growth increments. This is lower than the 67% of hard clams sampled for sclerochronological analysis from the Irene Period site Meeting House Field which terminated in winter and early spring growth (Bergh 2012). Oxygen stable isotope analysis of eastern oysters from the Irene Period would ensure that the changes in seasonality are not a product of differential exploitation of species.

Oysters and clams may not have been as important as a resource during the summer following missionization if pueblo residents were more concerned with producing resources which had been commodified in the colonial economy such as maize and deer hides. The warmer seasons are more labor-intensive for maize agriculture, and it may have been less pragmatic to shellfish during these critical months. The *repartimiento* system of drafted labor may have reduced the population present of the island to participate in such food procurement. It is unclear whether shellfishing was a gendered activity among the Guale, as it is interpreted in many parts of the world (Claassen 1991, Crook 1992), but if this were the case and women were drawn away from shellfishing to fill roles vacated by men entwined in *repartimiento*, this too could affect the seasonality and intensity of invertebrate animal use. Additionally, if the role of mollusks in the diet had been diminished by the colonial agenda and its terrestrial priorities, shellfish may have been utilized on a basis of necessity when stores of maize dwindled.

Future Directions

The degree to which intra-site variation may be temporal in nature cannot be determined with the current understanding of occupational periods for the mission-era. Increased chronological controls for mission-era neighborhoods would be beneficial for comparisons of all classes of artifact assemblages. Additional stable isotope analyses of hard clams and stout tagelus from the Mission era, and eastern oysters from the Irene Period would help confirm or deny whether the seasonality of various molluscan species was consistent or not. Most importantly, no discussion of foodways is complete without consideration of plant consumption. Analysis of botanical samples gathered systematically from the various neighborhoods of Pueblo Santa Catalina de Guale would improve our understanding of diachronic change, mission-era foodways, and intra-site variation.

Conclusions

Change does not need to be dramatic in order to be meaningful, nor is change dichotomous to continuity. Concepts of ethnogenesis (Voss 2015) and ethnomorphosis (Hu 2013) emphasize cultural persistence in addition to transformation and recognize that these are not inherently oppositional; there is a dialectical relationship between change and continuity. Continuation of food traditions, crucial to the maintenance of an individual’s many nested identities, were manifested and modified in a variety of ways at Pueblo Santa Catalina de Guale. Though few introduced plants and animals were incorporated into indigenous diets, foodways are much more than a suite of ingredients. The layered social, cultural, and political situation in this missionized community shifted deeply rooted traditions and had many consequences for indigenous diets, some intended and others inadvertent.

Shellfishing strategies became less focused on eastern oysters during the Mission era, which decrease in their contributions to invertebrate biomass when compared with the Irene Period. Three or more potential culinary communities of practice, formed through knowledge transmission within established social networks of situated learning, were in action at the Pueblo Santa Catalina de Guale. Though Mission-era residents of St. Catherines Island were still consuming primarily the same locally available, native ingredients which had been eaten in this location since its peopling, they were doing so in a manner that reflects a diversification of influences. Demands for tributes of labor and maize from Spanish officials in St. Augustine, missionary efforts by resident Franciscan friars, and differing culinary communities of practice among disparate, aggregated town populations all contributed to the high degree of intra-site variability at Pueblo Santa Catalina de Guale.

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APPENDIX A. SAMPLES AND PROVENIENCES

Site #	Bag #	Unit	Feature	Level	Volume, L
9Li8	44476	S4 E820/ S3 E820	F(2013)23	2	40
9Li8	44477	S5 E821/ S4 E821	F(2013)24	2	40
9Li8	44479	S4 E822/ S3 E822	F(2013)25	2	40
9Li8	44475	S5 E820	F(2013)26	2	40
9Li8	44478	S5 E822	F(2013)27	2	40
9Li13	45567	N56 E735		1	40
9Li13	45566	N56 E735		2	40
9Li13	45565	N56 E735		3	40
9Li13	45563	N56 E735		4	40
9Li13	45564	N56 E735		5	40
9Li210	45644	A		1	40
9Li210	45674	A		2	40
9Li210	45676	A		3	40
9Li210	45677	A		4	40
9Li210	45678	A		5	40
9Li210	45679	A		6	40
9Li210	45680	A		7	40
9Li210	45681	A		8	40
9Li210	45682	A		9	40
9Li2117	164	VII		0-10 cm	10
9Li2117	172	VII		10-20 cm	10
9Li2117	203	VII		20-30 cm	10
9Li2117	238	VII		30-40 cm	10
9Li2117	25645		F(2012)152	10-15 cm	10
9Li2117	25650		F(2012)152	15-20 cm	10
9Li2117	25654		F(2012)152	20-25 cm	10
9Li2117	25658		F(2012)152	25-30 cm	10
9Li2117	25658	N217 E617	F(2012)136	25-30 cm	10
9Li2117	25673	N217 E617	F(2012)136	30-35 cm	10
9Li2117	25475	N218 E617	F(2012)136	30-35 cm	10
9Li2117	25510	N219 E617	F(2012)136	25-30 cm	10
9Li2117	25519	N219 E617	F(2012)136	30-35 cm	10
9Li2117	25577	N219 E617	F(2012)136	35-45 cm	10
9Li2117	25573	N220 E617		31-40 cm	10
PSCDGE	45532	N135 E844		1	40
PSCDGE	45586	N135 E844		2	40

PSCDGE	45591	N135 E844		3	40
PSCDGE	45595	N135 E844		4	40
PSCDGE	45598	N135 E844		5	40
PSCDGE	45601	N135 E844		6	40

APPENDIX B. OYSTER MEASUREMENTS

Site #	Unit	Level	Feature	Height, mm	Length, mm
9Li8	S4 E820/ S3 E820	2	F(2013)23	87.08	53.52
9Li8	S4 E820/ S3 E820	2	F(2013)23	66.52	37.5
9Li8	S4 E820/ S3 E820	2	F(2013)23	79.57	40.15
9Li8	S4 E820/ S3 E820	2	F(2013)23	50.3	36.61
9Li8	S4 E820/ S3 E820	2	F(2013)23	32.85	31.16
9Li8	S4 E820/ S3 E820	2	F(2013)23	73.05	44.64
9Li8	S4 E820/ S3 E820	2	F(2013)23	29.04	23.67
9Li8	S4 E820/ S3 E820	2	F(2013)23	50.16	34.28
9Li8	S4 E820/ S3 E820	2	F(2013)23	49.48	28.71
9Li8	S4 E822/ S3 E822	2	F(2013)23	38.84	22.42
9Li8	S5 E821/ S4 E821	2	F(2013)23	65.89	34.8
9Li8	S5 E822	2	F(2013)23	48.98	29.09
9Li13	N56 E735	1		44.79	24.64
9Li13	N56 E735	1		84.72	49.05
9Li13	N56 E735	1		73.46	39.04
9Li13	N56 E735	1		51.31	27.58
9Li13	N56 E735	1		107.88	41.35
9Li13	N56 E735	1		70.16	41.69
9Li13	N56 E735	1		56.22	19.69
9Li13	N56 E735	1		90.94	39.72
9Li13	N56 E735	1		85.21	34.17
9Li13	N56 E735	1		84.39	44.79
9Li13	N56 E735	1		85.46	26.68
9Li13	N56 E735	1		68.85	32.93
9Li13	N56 E735	1		63.46	37.59
9Li13	N56 E735	1		92.86	34.18
9Li13	N56 E735	1		73.78	41.09
9Li13	N56 E735	1		82.55	25.16
9Li13	N56 E735	1		101.35	42.32
9Li13	N56 E735	1		71.64	37.43
9Li13	N56 E735	1		104.09	37.35
9Li13	N56 E735	1		74	31.14
9Li13	N56 E735	1		84.66	34.45
9Li13	N56 E735	1		86.35	52.97
9Li13	N56 E735	1		56.04	31.96
9Li13	N56 E735	1		41.85	23.03

9Li13	N56 E735	1		94.39	47.65
9Li13	N56 E735	1		69.88	24.92
9Li13	N56 E735	1		67.04	40.23
9Li13	N56 E735	1		109.82	55.68
9Li13	N56 E735	1		69.39	37.83
9Li13	N56 E735	1		67.58	35.4
9Li13	N56 E735	1		107.93	34.06
9Li13	N56 E735	1		129.32	38.68
9Li13	N56 E735	1		109.33	40.46
9Li13	N56 E735	1		54.08	35.22
9Li13	N56 E735	1		81.54	48.58
9Li13	N56 E735	1		51.13	39.32
9Li13	N56 E735	1		66.45	41.01
9Li13	N56 E735	1		67.92	37.85
9Li13	N56 E735	1		82.19	42.66
9Li13	N56 E735	1		72.58	36.62
9Li13	N56 E735	1		120.19	56.75
9Li13	N56 E735	1		49.54	20.3
9Li13	N56 E735	1		101.83	40.64
9Li13	N56 E735	1		66.81	27.75
9Li13	N56 E735	1		94.91	35.43
9Li13	N56 E735	1		73.74	46.4
9Li13	N56 E735	1		73.89	29.21
9Li13	N56 E735	1		96.58	38.51
9Li13	N56 E735	1		115.43	37.85
9Li13	N56 E735	1		118.94	35.57
9Li13	N56 E735	1		36.81	15.12
9Li13	N56 E735	1		95.96	40.51
9Li13	N56 E735	1		70.81	31.52
9Li13	N56 E735	1		94.62	34.21
9Li13	N56 E735	1		63.91	24.47
9Li13	N56 E735	1		48.27	29.83
9Li13	N56 E735	1		74.05	34.25
9Li13	N56 E735	1		99.69	48.44
9Li13	N56 E735	1		56.81	28.48
9Li13	N56 E735	1		64.8	28.21
9Li13	N56 E735	1		51.34	29.66
9Li13	N56 E735	1		66.22	40.17
9Li13	N56 E735	1		86.94	37.62
9Li13	N56 E735	1		38.88	24.61
9Li13	N56 E735	1		64.83	27.88
9Li13	N56 E735	1		88.84	38.31
9Li13	N56 E735	2		88.84	36.07
9Li13	N56 E735	2		72.67	43.36

9Li13	N56 E735	2		103.74	48.38
9Li13	N56 E735	2		69.06	34.73
9Li13	N56 E735	2		85.2	38.37
9Li13	N56 E735	2		86.3	43.53
9Li13	N56 E735	2		85.6	38.6
9Li13	N56 E735	2		93.57	44.21
9Li13	N56 E735	2		78.72	33.26
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9Li13	N56 E735	2		99.08	33.72
9Li13	N56 E735	2		80.52	49.74
9Li13	N56 E735	2		91.06	47.82
9Li13	N56 E735	2		100.63	37.13
9Li13	N56 E735	2		103.89	44.81
9Li13	N56 E735	2		71.62	31.69
9Li13	N56 E735	2		74.25	29.99
9Li13	N56 E735	2		107.81	38.3
9Li13	N56 E735	2		87.81	38.89
9Li13	N56 E735	2		68.73	43.68
9Li13	N56 E735	2		75.54	41.26
9Li13	N56 E735	2		69.38	36.16
9Li13	N56 E735	2		66.35	33.57
9Li13	N56 E735	2		106.86	34.16
9Li13	N56 E735	2		60.12	31.27
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9Li13	N56 E735	2		75.1	31.91
9Li13	N56 E735	2		54.85	29.99
9Li13	N56 E735	2		57.84	25.76
9Li13	N56 E735	2		44.53	24.89
9Li13	N56 E735	2		59.02	41.3
9Li13	N56 E735	2		67.14	35.15
9Li13	N56 E735	2		80.82	29.83
9Li13	N56 E735	2		46.48	38.26
9Li13	N56 E735	2		99.89	34.76
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9Li13	N56 E735	2		50.66	34.7
9Li13	N56 E735	2		46.28	24.1
9Li13	N56 E735	2		52.19	29.37
9Li13	N56 E735	2		40.99	25.62
9Li13	N56 E735	2		78.74	37.88
9Li13	N56 E735	2		48.24	33.34
9Li13	N56 E735	2		46.65	30.69
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9Li13	N56 E735	2		81.1	37.68
9Li13	N56 E735	2		53.87	31.66

9Li13	N56 E735	2		58.62	37.53
9Li13	N56 E735	2		67.91	31.89
9Li13	N56 E735	2		80.07	32.13
9Li13	N56 E735	2		70.86	32.98
9Li13	N56 E735	2		69.16	34.81
9Li13	N56 E735	2		59.71	34.5
9Li13	N56 E735	3		84.54	43.46
9Li13	N56 E735	3		101.58	67.29
9Li13	N56 E735	3		102.68	34.04
9Li13	N56 E735	3		99.48	58.07
9Li13	N56 E735	3		67.31	30.48
9Li13	N56 E735	3		129.58	37.7
9Li13	N56 E735	3		61.16	31.72
9Li13	N56 E735	3		68.02	39.06
9Li13	N56 E735	3		71.93	40.33
9Li13	N56 E735	3		58.28	32.18
9Li13	N56 E735	3		77.13	51.77
9Li13	N56 E735	3		85.32	51.01
9Li13	N56 E735	3		58.8	33.84
9Li13	N56 E735	3		81.85	36.07
9Li13	N56 E735	3		82.72	37.29
9Li13	N56 E735	3		43.74	21.67
9Li13	N56 E735	3		99.33	49.79
9Li13	N56 E735	3		66.95	31.26
9Li13	N56 E735	3		70.56	40.84
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9Li13	N56 E735	3		93.44	44.91
9Li13	N56 E735	3		71.02	38.4
9Li13	N56 E735	3		40.06	27.42
9Li13	N56 E735	3		80.09	31.2
9Li13	N56 E735	3		68.79	40.12
9Li13	N56 E735	3		97.52	42.05
9Li13	N56 E735	3		99.13	42.57
9Li13	N56 E735	3		54.74	32.18
9Li13	N56 E735	3		42.62	26.37
9Li13	N56 E735	3		42.55	26.88
9Li13	N56 E735	3		117.86	39.69

9Li13	N56 E735	3		53.33	25.65
9Li13	N56 E735	3		38.74	23.63
9Li13	N56 E735	3		51.28	17.62
9Li13	N56 E735	3		38.7	19.79
9Li13	N56 E735	3		80.57	26.33
9Li13	N56 E735	3		107.96	45.71
9Li13	N56 E735	3		42.62	34.73
9Li13	N56 E735	3		39	17.14
9Li13	N56 E735	3		37.68	20.93
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9Li13	N56 E735	3		78.63	47.43
9Li13	N56 E735	3		80.1	37.92
9Li13	N56 E735	3		90.77	36.66
9Li13	N56 E735	3		25.42	11.99
9Li13	N56 E735	3		100.61	43.65
9Li13	N56 E735	3		84.6	45.47
9Li13	N56 E735	3		66.79	36.3
9Li13	N56 E735	3		31.16	9.03
9Li13	N56 E735	3		42.88	31.68
9Li13	N56 E735	3		30.69	19.52
9Li13	N56 E735	3		20.7	12.84
9Li13	N56 E735	4		90.2	40.16
9Li13	N56 E735	4		70.78	29.95
9Li13	N56 E735	4		94.03	42.44
9Li13	N56 E735	4		112.28	37.87
9Li13	N56 E735	4		67.07	37.42
9Li13	N56 E735	4		119.65	34.28
9Li13	N56 E735	4		77.45	36.77
9Li13	N56 E735	4		84.82	33.36
9Li13	N56 E735	4		136.42	36.17
9Li13	N56 E735	4		55.91	32.05
9Li13	N56 E735	4		51.82	33.63
9Li13	N56 E735	4		59.11	26.97
9Li13	N56 E735	4		100.59	43.37
9Li13	N56 E735	4		64.58	34.11
9Li13	N56 E735	4		111.43	37.86
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9Li13	N56 E735	4		68.89	31
9Li13	N56 E735	4		91.97	40.05
9Li13	N56 E735	4		51.14	25.31
9Li13	N56 E735	4		61.53	31.77
9Li13	N56 E735	4		85.37	31.42
9Li13	N56 E735	4		75.3	35.63

9Li13	N56 E735	4		91.25	30.13
9Li13	N56 E735	4		97.38	32.61
9Li13	N56 E735	4		22.67	18.91
9Li13	N56 E735	4		34.93	26.65
9Li13	N56 E735	4		88.29	27.64
9Li13	N56 E735	4		73.32	30.66
9Li13	N56 E735	4		112.14	49.02
9Li13	N56 E735	4		112.91	29.86
9Li13	N56 E735	4		57.52	39.72
9Li13	N56 E735	4		82.13	30.26
9Li13	N56 E735	4		97.84	42.13
9Li13	N56 E735	4		61.06	32.03
9Li13	N56 E735	4		65.31	35.12
9Li13	N56 E735	4		79.16	47.31
9Li13	N56 E735	4		78.43	37.28
9Li13	N56 E735	4		130.41	40.32
9Li13	N56 E735	4		69.35	31.32
9Li13	N56 E735	4		103.46	39.38
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9Li13	N56 E735	4		84.22	33.58
9Li13	N56 E735	4		63.72	28.96
9Li13	N56 E735	4		102.89	29.18
9Li13	N56 E735	4		83.39	32.49
9Li13	N56 E735	4		72.88	35.61
9Li13	N56 E735	4		68.15	34.83
9Li13	N56 E735	4		72.63	33.82
9Li13	N56 E735	4		78.04	27.73
9Li13	N56 E735	4		70.34	29.72
9Li13	N56 E735	4		79.32	40.36
9Li13	N56 E735	4		68.38	33.67
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9Li13	N56 E735	4		76.66	45.9
9Li13	N56 E735	4		90.65	28.09
9Li13	N56 E735	4		52.93	19.64
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9Li13	N56 E735	4		64.72	32.39
9Li13	N56 E735	4		79.69	50.98
9Li13	N56 E735	4		36.97	20.83
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9Li13	N56 E735	4		63.12	39.94
9Li13	N56 E735	4		63.72	33.76

9Li13	N56 E735	4		91.03	33.68
9Li13	N56 E735	4		48.95	23.64
9Li13	N56 E735	4		77.23	36.31
9Li13	N56 E735	4		81.55	37.75
9Li13	N56 E735	4		105.36	35.93
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9Li13	N56 E735	4		67.28	41.51
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9Li13	N56 E735	4		73.83	30.64
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9Li13	N56 E735	5		59.82	24.15
9Li13	N56 E735	5		55.92	33.69
9Li13	N56 E735	5		78.25	30.58
9Li13	N56 E735	5		71.48	32.5
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9Li13	N56 E735	5		51.99	25.35
9Li13	N56 E735	5		30.33	22.24
9Li13	N56 E735	5		40.45	18.84
9Li13	N56 E735	5		45.04	32.88
9Li13	N56 E735	5		74.43	27.82
9Li13	N56 E735	5		51.79	24.37
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9Li13	N56 E735	5		95.39	44.01
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9Li13	N56 E735	5		88.42	24.57
9Li13	N56 E735	5		96.71	31.77
9Li13	N56 E735	5		101.7	34.27
9Li13	N56 E735	5		75.6	34.04
9Li13	N56 E735	5		54.99	29.16
9Li13	N56 E735	5		49.8	25.89
9Li13	N56 E735	5		135.48	36.37
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9Li13	N56 E735	5		73.32	36.3
9Li13	N56 E735	5		49.01	22.62
9Li13	N56 E735	5		53.56	32.01
9Li13	N56 E735	5		79.51	35.7
9Li13	N56 E735	5		122.6	38.76
9Li13	N56 E735	5		57.93	29.73
9Li13	N56 E735	5		78.65	31.86

9Li13	N56 E735	5		102.94	45.26
9Li13	N56 E735	5		77.63	28.98
9Li13	N56 E735	5		60.19	30.95
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9Li13	N56 E735	5		69.63	37.99
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9Li13	N56 E735	5		82.32	27.69
9Li13	N56 E735	5		79.88	30.86
9Li13	N56 E735	5		54.34	29.38
9Li13	N56 E735	5		73.35	29.87
9Li13	N56 E735	5		69.83	34.38
9Li13	N56 E735	5		69.79	35.43
9Li13	N56 E735	5		54.54	22.31
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9Li13	N56 E735	5		87.56	30.62
9Li13	N56 E735	5		82.2	32.59
9Li13	N56 E735	5		69.66	37.33
9Li13	N56 E735	5		66.08	32.76
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9Li13	N56 E735	5		64.91	28.16
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9Li13	N56 E735	5		63.87	33.59
9Li13	N56 E735	5		84.5	39.41
9Li13	N56 E735	5		79.84	32.33
9Li13	N56 E735	5		68.29	22.17
9Li13	N56 E735	5		54.88	24.2
9Li13	N56 E735	5		70.3	34.04
9Li13	N56 E735	5		78.62	40.17
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9Li13	N56 E735	5		69.45	32.46
9Li13	N56 E735	5		96.02	32.24

9Li13	N56 E735	5		46.82	30.39
9Li13	N56 E735	5		67.66	30.4
9Li13	N56 E735	5		48.95	26.93
9Li13	N56 E735	5		65.71	29.89
9Li13	N56 E735	5		53.42	21.57
9Li210	A	1		133.04	54.6
9Li210	A	1		127.07	42.15
9Li210	A	1		105.18	52.67
9Li210	A	1		118.34	38.62
9Li210	A	1		139.12	58.43
9Li210	A	1		118.29	47.09
9Li210	A	1		154.73	43.8
9Li210	A	1		105.6	54.55
9Li210	A	1		104	23.3
9Li210	A	1		153.97	43.55
9Li210	A	1		132.79	57.74
9Li210	A	1		94.07	55.6
9Li210	A	1		132.1	40.99
9Li210	A	1		99.99	32.65
9Li210	A	1		97.98	43.83
9Li210	A	1		99.6	44.8
9Li210	A	1		114.8	28.39
9Li210	A	1		98.25	51.24
9Li210	A	1		84.83	53.66
9Li210	A	1		134.16	57.16
9Li210	A	1		87.18	30
9Li210	A	1		88.99	43.69
9Li210	A	1		108.72	40.18
9Li210	A	1		82.04	40.3
9Li210	A	1		82.94	40.02
9Li210	A	1		57.36	34.52
9Li210	A	1		115.88	53.05
9Li210	A	1		110.47	52.42
9Li210	A	1		121.67	48.49
9Li210	A	1		102.71	53.22
9Li210	A	1		101.47	44.74
9Li210	A	1		140.46	51.33
9Li210	A	1		94.99	46.51
9Li210	A	1		131.37	53.89
9Li210	A	1		100.07	39.14
9Li210	A	1		99.67	42.04
9Li210	A	1		81.41	58.93
9Li210	A	1		76.13	46.54
9Li210	A	1		80.58	53.75

9Li210	A	1		67.91	36.4
9Li210	A	1		51.9	39.54
9Li210	A	1		60.51	33
9Li210	A	1		99.78	43.92
9Li210	A	1		90.81	35.64
9Li210	A	1		95.33	42.57
9Li210	A	1		79.73	40.88
9Li210	A	1		83.29	54.65
9Li210	A	1		135.13	50.7
9Li210	A	1		85.55	33.14
9Li210	A	1		86.25	32.07
9Li210	A	1		115.2	49.63
9Li210	A	1		101.3	41.8
9Li210	A	1		83.61	47.68
9Li210	A	1		69.71	32.69
9Li210	A	1		120.51	52.93
9Li210	A	1		110.1	59.04
9Li210	A	1		88.68	39.93
9Li210	A	1		94.02	45.34
9Li210	A	1		82.42	49.09
9Li210	A	1		116.58	48.87
9Li210	A	1		99.19	39.19
9Li210	A	1		94.03	52.93
9Li210	A	1		90.49	40.92
9Li210	A	1		93.28	41.41
9Li210	A	1		86.83	44.93
9Li210	A	1		96.39	43.47
9Li210	A	1		112.54	55.07
9Li210	A	1		84.67	41.26
9Li210	A	1		108.1	49.17
9Li210	A	1		92.35	47.62
9Li210	A	1		84.58	37.95
9Li210	A	1		88.48	36.32
9Li210	A	1		73.82	32.64
9Li210	A	1		75.74	35.84
9Li210	A	1		102.23	53.59
9Li210	A	1		78.42	36.57
9Li210	A	1		96.61	56.75
9Li210	A	1		71.85	33.97
9Li210	A	1		70.94	37.64
9Li210	A	1		82.96	35.98
9Li210	A	2		92.79	63.95
9Li210	A	2		95.65	42.77
9Li210	A	2		124.39	62.18

9Li210	A	2		91.93	46.6
9Li210	A	2		156.44	65.16
9Li210	A	2		127.31	58.57
9Li210	A	2		114.68	43.19
9Li210	A	2		121.59	40.33
9Li210	A	2		122.36	57.85
9Li210	A	2		111.5	54.27
9Li210	A	2		85.91	42.32
9Li210	A	2		112.47	49.72
9Li210	A	2		92.29	59.37
9Li210	A	2		104.19	52.32
9Li210	A	2		114.08	52.05
9Li210	A	2		77.85	49.78
9Li210	A	2		99.6	50.93
9Li210	A	2		115.67	52
9Li210	A	2		131.52	61.5
9Li210	A	2		85.75	43.2
9Li210	A	2		118.12	42.17
9Li210	A	2		144.06	50.81
9Li210	A	2		123.29	56.51
9Li210	A	2		76.78	42.08
9Li210	A	2		96.77	36.18
9Li210	A	2		117.12	38.49
9Li210	A	2		118.09	63.51
9Li210	A	2		86.06	38.98
9Li210	A	2		107.29	40.73
9Li210	A	2		115.9	45.77
9Li210	A	2		105.81	62.99
9Li210	A	2		54.48	32.97
9Li210	A	2		107.61	42.1
9Li210	A	2		95.41	39.9
9Li210	A	2		57.34	32.22
9Li210	A	2		79.06	51.2
9Li210	A	2		82.67	40.49
9Li210	A	2		88.25	37.45
9Li210	A	2		129.1	46.98
9Li210	A	2		128.93	48.88
9Li210	A	2		60.78	28.07
9Li210	A	2		116.79	54.24
9Li210	A	2		92.58	47.69
9Li210	A	2		137.3	61.43
9Li210	A	2		82.41	42.76
9Li210	A	2		156.44	49.56
9Li210	A	2		119.19	62

9Li210	A	2		104.57	39.33
9Li210	A	2		98.6	57.47
9Li210	A	2		109.24	47.41
9Li210	A	2		62.91	28.96
9Li210	A	2		119.59	52.65
9Li210	A	2		59.87	38.49
9Li210	A	2		113.07	57.47
9Li210	A	2		62.91	32.08
9Li210	A	2		107.24	43.46
9Li210	A	2		118.81	50.47
9Li210	A	2		59.25	25.85
9Li210	A	2		62.46	37.44
9Li210	A	2		99.95	46.96
9Li210	A	2		123.43	45.07
9Li210	A	2		49.54	26.47
9Li210	A	2		96.67	46.05
9Li210	A	2		94.18	39.32
9Li210	A	2		110.87	61.1
9Li210	A	2		53.57	25.93
9Li210	A	2		112.37	46.01
9Li210	A	2		82.48	34.06
9Li210	A	2		113.82	42.72
9Li210	A	2		93.4	51.66
9Li210	A	2		80.83	29.4
9Li210	A	2		71.81	41.74
9Li210	A	2		79.76	46.31
9Li210	A	2		82.83	52.29
9Li210	A	2		115.71	45.59
9Li210	A	2		49.33	22.63
9Li210	A	2		77.85	31
9Li210	A	2		128.77	43.09
9Li210	A	2		75.73	43.39
9Li210	A	2		110.81	40.61
9Li210	A	3		130.3	41.44
9Li210	A	3		90.6	40.18
9Li210	A	3		79.78	48.71
9Li210	A	3		119.7	48.21
9Li210	A	3		118.72	47.17
9Li210	A	3		120.33	48.26
9Li210	A	3		87.13	35.95
9Li210	A	3		111.34	38.8
9Li210	A	3		88.09	36.58
9Li210	A	3		87.57	43.88
9Li210	A	3		101.51	39.28

9Li210	A	3		82	37.84
9Li210	A	3		78.72	54.85
9Li210	A	3		126.49	47.06
9Li210	A	3		121.34	36.06
9Li210	A	3		125.63	47.19
9Li210	A	3		114.63	45.41
9Li210	A	3		93.32	53.08
9Li210	A	3		101.63	29.38
9Li210	A	3		121.96	53.34
9Li210	A	3		109.51	39.42
9Li210	A	3		83.63	41.86
9Li210	A	3		104.12	46.88
9Li210	A	3		110.67	53.31
9Li210	A	3		90.43	42.2
9Li210	A	3		122.42	51.61
9Li210	A	3		85.11	49.71
9Li210	A	3		130.01	37.44
9Li210	A	3		78.06	41.26
9Li210	A	3		137.85	38.2
9Li210	A	3		116.83	36.38
9Li210	A	3		83.27	46.32
9Li210	A	3		121.18	51.45
9Li210	A	3		126.63	49.77
9Li210	A	3		81.4	42.36
9Li210	A	3		112.67	51.37
9Li210	A	3		78.88	39.01
9Li210	A	3		109.96	52.96
9Li210	A	3		104.5	40.89
9Li210	A	3		91.41	36.6
9Li210	A	3		54.94	43.96
9Li210	A	3		110.93	46.85
9Li210	A	3		95.35	37.51
9Li210	A	3		94.25	39.56
9Li210	A	3		88.35	36.82
9Li210	A	3		90.79	28.42
9Li210	A	3		96.32	36.73
9Li210	A	3		63.61	36.53
9Li210	A	3		89.21	47.45
9Li210	A	3		85.35	38.93
9Li210	A	3		87.46	32.09
9Li210	A	3		86.33	43.3
9Li210	A	3		104.72	40.73
9Li210	A	3		72.4	32.96
9Li210	A	3		89.16	40.66

9Li210	A	3		77.73	35.18
9Li210	A	3		70.31	42.58
9Li210	A	3		133.15	38.9
9Li210	A	3		87.03	50.67
9Li210	A	3		69.18	36.26
9Li210	A	3		75.46	42
9Li210	A	3		103.82	43.89
9Li210	A	3		126.43	46.29
9Li210	A	3		78.96	34.56
9Li210	A	3		81.11	43.55
9Li210	A	3		56.19	38.85
9Li210	A	3		47.82	32.36
9Li210	A	3		60.62	25.01
9Li210	A	3		45.39	36.47
9Li210	A	3		49.12	24.3
9Li210	A	3		130.38	54.26
9Li210	A	3		143.34	57.83
9Li210	A	3		118.76	56.43
9Li210	A	3		105.34	36.84
9Li210	A	3		111.03	50.8
9Li210	A	3		79.21	43.5
9Li210	A	3		100.53	41.1
9Li210	A	3		120.88	39.36
9Li210	A	3		108.91	54.1
9Li210	A	3		85.87	58.44
9Li210	A	4		119.74	48.9
9Li210	A	4		73.21	46.49
9Li210	A	4		109.1	46.61
9Li210	A	4		91.59	35.63
9Li210	A	4		104.77	38.02
9Li210	A	4		66.22	36.64
9Li210	A	4		80.75	25.23
9Li210	A	4		84.26	49.56
9Li210	A	4		108.12	39.5
9Li210	A	4		103.26	49.91
9Li210	A	4		82.47	44.25
9Li210	A	4		109.76	48.71
9Li210	A	4		95.63	55.12
9Li210	A	4		77.87	39.61
9Li210	A	4		106.54	49.97
9Li210	A	4		107.51	47.86
9Li210	A	4		62.69	30.12
9Li210	A	4		87.61	54.88
9Li210	A	4		79	44.47

9Li210	A	4		76.62	47.09
9Li210	A	4		90.24	40.7
9Li210	A	4		77.35	46.63
9Li210	A	4		72.21	42.68
9Li210	A	4		119.3	38.8
9Li210	A	4		75.06	32.5
9Li210	A	4		71.3	33.23
9Li210	A	4		137.34	45.81
9Li210	A	4		101.06	34.32
9Li210	A	4		68.73	29.61
9Li210	A	4		87.91	41.03
9Li210	A	4		104.24	42.66
9Li210	A	4		85.57	30.96
9Li210	A	4		127.19	45.33
9Li210	A	4		74.18	53.44
9Li210	A	4		125.17	54.57
9Li210	A	4		77.18	38.91
9Li210	A	4		106.73	42.4
9Li210	A	4		56.56	48.54
9Li210	A	4		73.06	37.2
9Li210	A	4		85.21	30.52
9Li210	A	4		142.35	41.51
9Li210	A	4		75.63	28.19
9Li210	A	4		90.1	35.55
9Li210	A	4		109.63	47.23
9Li210	A	4		93.85	41.97
9Li210	A	4		105.6	38.74
9Li210	A	4		91.56	36.23
9Li210	A	4		85.09	37.84
9Li210	A	4		81.25	48.72
9Li210	A	4		100.81	52.98
9Li210	A	4		113.22	35.01
9Li210	A	4		76.33	39.44
9Li210	A	4		76.01	38.44
9Li210	A	4		50.96	20.8
9Li210	A	4		70.06	38.04
9Li210	A	4		85.73	28.92
9Li210	A	4		83.89	42.21
9Li210	A	4		103.93	49.2
9Li210	A	4		119.71	39.79
9Li210	A	4		71.44	30.8
9Li210	A	4		54.81	25.79
9Li210	A	4		43.55	10.97
9Li210	A	4		112.03	47.92

9Li210	A	4		87.42	46.67
9Li210	A	4		117.27	37.91
9Li210	A	4		99.05	43.88
9Li210	A	4		142.36	51.9
9Li210	A	4		89.95	30.85
9Li210	A	4		125.65	53.02
9Li210	A	4		95.79	44.88
9Li210	A	4		104.32	49.67
9Li210	A	4		110.12	37.34
9Li210	A	4		84.01	48.59
9Li210	A	4		87.44	40.48
9Li210	A	4		86.73	28.96
9Li210	A	4		82.02	37.6
9Li210	A	4		93.24	46.11
9Li210	A	4		42.99	41.34
9Li210	A	4		83.36	36.92
9Li210	A	4		82.94	43.65
9Li210	A	5		102.47	40.79
9Li210	A	5		94.66	46.67
9Li210	A	5		96.53	38.97
9Li210	A	5		59.53	39.84
9Li210	A	5		116.06	48.06
9Li210	A	5		101.57	34.4
9Li210	A	5		110.94	38.86
9Li210	A	5		101.06	47.38
9Li210	A	5		103.06	34.66
9Li210	A	5		81.26	45.07
9Li210	A	5		108.97	41.7
9Li210	A	5		67.81	39.88
9Li210	A	5		121.02	41.41
9Li210	A	5		83.42	35.23
9Li210	A	5		76.66	31.18
9Li210	A	5		67.57	30.52
9Li210	A	5		90.8	49.97
9Li210	A	5		112.76	39.8
9Li210	A	5		96.67	57.48
9Li210	A	5		69.42	44.08
9Li210	A	5		116.36	43.27
9Li210	A	5		71.04	37.77
9Li210	A	5		57.23	37.37
9Li210	A	5		86	42.88
9Li210	A	5		83.85	32.14
9Li210	A	5		69.57	43.3
9Li210	A	5		66.56	48.73

9Li210	A	5		70.31	45.03
9Li210	A	5		77.29	38.5
9Li210	A	5		98.15	34.37
9Li210	A	5		83.11	32.94
9Li210	A	5		71.06	38.17
9Li210	A	5		80.42	38.72
9Li210	A	5		69.82	46.82
9Li210	A	5		65.26	40.03
9Li210	A	5		86.61	38.33
9Li210	A	5		67.62	33.13
9Li210	A	5		80.22	43.64
9Li210	A	5		94.34	53.42
9Li210	A	5		60.29	45.75
9Li210	A	5		66.34	38.76
9Li210	A	5		60.92	35.33
9Li210	A	5		63.66	39.35
9Li210	A	5		88.28	42.2
9Li210	A	5		103.06	29.57
9Li210	A	5		67.37	44.35
9Li210	A	5		81.19	38.6
9Li210	A	5		130.01	40.19
9Li210	A	5		85.32	20.92
9Li210	A	5		93.45	33.13
9Li210	A	5		87.79	30.16
9Li210	A	5		54.38	35.84
9Li210	A	5		71.83	51.57
9Li210	A	5		66.6	41.26
9Li210	A	5		73.24	39.84
9Li210	A	5		85.65	47.2
9Li210	A	5		84.99	33.08
9Li210	A	5		62.78	51.42
9Li210	A	5		69.24	37.67
9Li210	A	5		68.64	46.98
9Li210	A	5		56.14	40.34
9Li210	A	5		59.1	40.93
9Li210	A	5		70.63	43.19
9Li210	A	5		93.95	34.28
9Li210	A	5		78.01	40.47
9Li210	A	5		61.15	38.73
9Li210	A	5		80.73	43.74
9Li210	A	5		63.76	46.48
9Li210	A	5		74.88	30.88
9Li210	A	5		111.79	41.56
9Li210	A	5		73.95	35.19

9Li210	A	5		67.55	40.75
9Li210	A	5		86.24	30.92
9Li210	A	5		81.31	35.89
9Li210	A	5		63.93	32.29
9Li210	A	5		62.5	45.53
9Li210	A	5		57.28	42.32
9Li210	A	5		114.32	41.72
9Li210	A	5		67.45	44.28
9Li210	A	5		71.23	35.49
9Li2117	VII			83.52	46.15
9Li2117	VII			71.14	41.9
9Li2117	VII			66.96	32.91
9Li2117	VII			53.09	28.19
9Li2117	VII			80.57	44.61
9Li2117	VII			45.45	22.67
9Li2117	VII			51.38	27.02
9Li2117	VII			97.46	42.34
9Li2117	VII			70.99	28.02
9Li2117	VII			46.57	23.01
9Li2117	VII			39.1	24.32
9Li2117			F(2012)152	57.56	39.03
9Li2117			F(2012)152	103.11	45.51
9Li2117			F(2012)152	62.79	34.43
9Li2117			F(2012)152	76.73	45.1
9Li2117			F(2012)152	57.25	33.83
9Li2117			F(2012)152	50.94	30.81
9Li2117	VII			63.2	26.85
9Li2117	VII			89.5	39.12
9Li2117	VII			73.66	31.51
9Li2117	VII			42.92	17.34
9Li2117	VII			60.32	22.89
9Li2117	VII			61.63	37.45
9Li2117	VII			66.9	34.78
9Li2117	VII			63.39	25.07
9Li2117	VII			85.28	42.46
9Li2117	VII			127.27	45.63
9Li2117	VII			37.44	33.5
9Li2117	VII			50.09	32.77
9Li2117	VII			96.96	39.74
9Li2117	VII			75.92	34.26
9Li2117	VII			92.03	42.92
9Li2117	VII			86.69	39.14
9Li2117	VII			97.13	40.2
9Li2117	VII			62.74	21.19

9Li2117	VII			62.2	41.76
9Li2117	VII			53.8	36.39
9Li2117	VII			35.83	20.12
9Li2117	VII			46.4	37.37
9Li2117	VII			62.37	36.12
9Li2117	VII			79.09	31.38
9Li2117	VII			84.42	43.21
9Li2117	VII			77.94	44.43
9Li2117	VII			49.45	34.39
9Li2117	VII			91.75	46.48
9Li2117	VII			30.09	15.9
9Li2117	VII			33.32	28.05
9Li2117	VII			35.37	21.85
9Li2117	VII			111.23	54.98
9Li2117	VII			58.32	32.8
9Li2117	VII			64.97	38.11
9Li2117	VII			90.76	45.65
9Li2117	VII			61.95	53.1
9Li2117	VII			83.76	37.62
9Li2117	VII			89.95	60.4
9Li2117	VII			76.52	38.82
9Li2117	VII			81.36	48.87
9Li2117	VII			72.96	46.1
9Li2117	VII			108.59	37.31
9Li2117	VII			113.81	40.07
9Li2117	VII			45.78	24.92
9Li2117	VII			72.76	37.31
9Li2117	VII			59.15	46.82
9Li2117	VII			83.09	28.64
9Li2117	VII			46.64	27.15
9Li2117	VII			34.59	22.24
9Li2117	N219 E617		F(2012)136	85.59	36.68
9Li2117	N219 E617		F(2012)136	52.25	37.25
9Li2117	N219 E617		F(2012)136	91.97	46.4
9Li2117	N219 E617		F(2012)136	87.76	38.83
9Li2117	N219 E617		F(2012)136	79.63	42.75
9Li2117	N219 E617		F(2012)136	47.29	30.61
9Li2117	N219 E617		F(2012)136	64.77	31.53
9Li2117	N219 E617		F(2012)136	45.39	21.83
9Li2117	N219 E617		F(2012)136	50.22	40.43
9Li2117	N219 E617		F(2012)136	47.51	17.71
9Li2117			F(2012)152	81.95	46.61
9Li2117			F(2012)152	67.87	36.9
9Li2117	N217 E617		F(2012)136	47.1	34.28

9Li2117	N217 E617		F(2012)136	87.28	46.49
9Li2117	N217 E617		F(2012)136	104.11	64.54
9Li2117	N217 E617		F(2012)136	58.67	37.3
9Li2117	N217 E617		F(2012)136	68.03	37.87
9Li2117	N217 E617		F(2012)136	40.8	23.96
9Li2117	N217 E617		F(2012)136	60.29	34.79
9Li2117	N217 E617		F(2012)136	78.89	44.52
9Li2117	N217 E617		F(2012)136	31.46	18.16
9Li2117	N217 E617		F(2012)136	58.22	32.25
9Li2117	N217 E617		F(2012)136	50.4	39.41
9Li2117	N217 E617		F(2012)136	63.81	34.37
9Li2117	N217 E617		F(2012)136	49.5	33.83
9Li2117	N219 E617		F(2012)136	54.04	37.19
9Li2117	N219 E617		F(2012)136	95.46	40.93
9Li2117	N219 E617		F(2012)136	62.36	38.79
9Li2117	N218 E617		F(2012)136	70.57	43.45
9Li2117	N218 E617		F(2012)136	70.47	41.13
9Li2117	N218 E617		F(2012)136	86.6	46.64
9Li2117	N218 E617		F(2012)136	65.41	44.08
9Li2117	N218 E617		F(2012)136	82.68	47.65
9Li2117	N218 E617		F(2012)136	67.46	41.96
9Li2117	N218 E617		F(2012)136	58.62	33.46
9Li2117	N218 E617		F(2012)136	54.38	24.79
9Li2117	N219 E617		F(2012)137	56.54	46.62
9Li2117	N219 E617		F(2012)138	46.39	22.45
9Li2117	N219 E617		F(2012)139	35.91	20.99
PSCDGE	N135 E844	1		75.07	38.84
PSCDGE	N135 E844	1		114.87	50.17
PSCDGE	N135 E844	1		89.83	42.9
PSCDGE	N135 E844	1		51.23	31.64
PSCDGE	N135 E844	1		73.05	26.55
PSCDGE	N135 E844	1		71.54	37.32
PSCDGE	N135 E844	1		85	38.82
PSCDGE	N135 E844	1		59.57	35.93
PSCDGE	N135 E844	1		67.69	38.87
PSCDGE	N135 E844	1		76.01	49.97
PSCDGE	N135 E844	1		117.12	57.45
PSCDGE	N135 E844	1		97.86	42.78
PSCDGE	N135 E844	1		84.59	50.83
PSCDGE	N135 E844	1		67.89	45.3
PSCDGE	N135 E844	1		70.96	39.53
PSCDGE	N135 E844	1		88.53	55.06
PSCDGE	N135 E844	1		97.75	43.05
PSCDGE	N135 E844	1		48.93	24.07

PSCDGE	N135 E844	1		109.05	48.26
PSCDGE	N135 E844	1		59.19	37.66
PSCDGE	N135 E844	1		57.17	31.76
PSCDGE	N135 E844	1		41.92	23.73
PSCDGE	N135 E844	1		82.59	37.15
PSCDGE	N135 E844	1		43.68	30.64
PSCDGE	N135 E844	1		60.47	32.9
PSCDGE	N135 E844	1		76.53	39.99
PSCDGE	N135 E844	1		28.86	16.24
PSCDGE	N135 E844	1		76.23	34.83
PSCDGE	N135 E844	1		81.79	46.22
PSCDGE	N135 E844	1		96.72	50.75
PSCDGE	N135 E844	1		93.64	49.78
PSCDGE	N135 E844	1		63.74	40.43
PSCDGE	N135 E844	1		82.57	39.75
PSCDGE	N135 E844	1		64.56	42.3
PSCDGE	N135 E844	1		65.98	29.91
PSCDGE	N135 E844	1		54.8	31.16
PSCDGE	N135 E844	2		117.14	39.24
PSCDGE	N135 E844	2		124.62	39.8
PSCDGE	N135 E844	2		122.93	41.55
PSCDGE	N135 E844	2		84.41	37.33
PSCDGE	N135 E844	2		61.62	41.84
PSCDGE	N135 E844	2		80.88	50.53
PSCDGE	N135 E844	2		123.41	28.94
PSCDGE	N135 E844	2		84.62	42.11
PSCDGE	N135 E844	2		92.31	51.92
PSCDGE	N135 E844	2		97.16	43.62
PSCDGE	N135 E844	2		86.59	37.29
PSCDGE	N135 E844	2		97.87	45.38
PSCDGE	N135 E844	2		134.91	36.05
PSCDGE	N135 E844	2		93.29	46.19
PSCDGE	N135 E844	2		95.53	45.57
PSCDGE	N135 E844	2		71.23	39.1
PSCDGE	N135 E844	2		80.7	51.09
PSCDGE	N135 E844	2		96.31	55.22
PSCDGE	N135 E844	2		125.31	22.98
PSCDGE	N135 E844	2		82.82	48.02
PSCDGE	N135 E844	2		88.21	44.44
PSCDGE	N135 E844	2		97.04	40.81
PSCDGE	N135 E844	2		117.11	42.97
PSCDGE	N135 E844	2		90.57	39.12
PSCDGE	N135 E844	2		76.83	27.62
PSCDGE	N135 E844	2		103.35	42.03

PSCDGE	N135 E844	2		67.97	46.3
PSCDGE	N135 E844	2		72.2	36.84
PSCDGE	N135 E844	2		65.15	32.33
PSCDGE	N135 E844	2		75.29	50.19
PSCDGE	N135 E844	2		74.28	30.09
PSCDGE	N135 E844	2		85.2	39.11
PSCDGE	N135 E844	2		75.51	40.38
PSCDGE	N135 E844	2		65.76	33.95
PSCDGE	N135 E844	2		65.43	37.61
PSCDGE	N135 E844	2		74.57	42.81
PSCDGE	N135 E844	2		86.15	43.15
PSCDGE	N135 E844	2		91.45	49.06
PSCDGE	N135 E844	2		97.5	40.65
PSCDGE	N135 E844	2		60.93	40.01
PSCDGE	N135 E844	2		82.93	48.05
PSCDGE	N135 E844	2		58.54	30.33
PSCDGE	N135 E844	2		69.42	36.33
PSCDGE	N135 E844	2		87	40.86
PSCDGE	N135 E844	2		72.49	46.81
PSCDGE	N135 E844	2		66.53	29.79
PSCDGE	N135 E844	2		62.34	38.83
PSCDGE	N135 E844	2		64.77	43.43
PSCDGE	N135 E844	2		56.47	30.66
PSCDGE	N135 E844	2		77.23	39.13
PSCDGE	N135 E844	2		66.63	38.55
PSCDGE	N135 E844	2		46.72	27.27
PSCDGE	N135 E844	2		56.35	44.68
PSCDGE	N135 E844	2		63.56	31.53
PSCDGE	N135 E844	2		48.42	30.24
PSCDGE	N135 E844	2		44.02	21.47
PSCDGE	N135 E844	2		39.83	23.8
PSCDGE	N135 E844	2		38.48	24
PSCDGE	N135 E844	2		44.05	21.33
PSCDGE	N135 E844	2		38.42	21.85
PSCDGE	N135 E844	2		72.25	32.04
PSCDGE	N135 E844	2		70.09	24.91
PSCDGE	N135 E844	2		71.33	42.81
PSCDGE	N135 E844	2		53.31	33.18
PSCDGE	N135 E844	2		51.19	34.82
PSCDGE	N135 E844	2		115.96	33.13
PSCDGE	N135 E844	2		80.14	55.02
PSCDGE	N135 E844	2		95.55	53.1
PSCDGE	N135 E844	2		93.3	49.88
PSCDGE	N135 E844	2		83.51	43.39

PSCDGE	N135 E844	2		125.39	36.75
PSCDGE	N135 E844	2		83.66	38.17
PSCDGE	N135 E844	2		76.58	45.35
PSCDGE	N135 E844	2		102.4	45.31
PSCDGE	N135 E844	2		88.97	44.62
PSCDGE	N135 E844	2		72.04	43
PSCDGE	N135 E844	2		68.63	30.22
PSCDGE	N135 E844	2		56.85	34.15
PSCDGE	N135 E844	2		75.91	30.38
PSCDGE	N135 E844	2		59.91	33.99
PSCDGE	N135 E844	3		121.5	48.01
PSCDGE	N135 E844	3		122.78	39.76
PSCDGE	N135 E844	3		61.82	33.62
PSCDGE	N135 E844	3		80.18	36.07
PSCDGE	N135 E844	3		109.81	44.79
PSCDGE	N135 E844	3		77.69	31.05
PSCDGE	N135 E844	3		136.02	41.12
PSCDGE	N135 E844	3		78.34	27.86
PSCDGE	N135 E844	3		37.45	15.3
PSCDGE	N135 E844	3		107.73	35.37
PSCDGE	N135 E844	3		74.68	26.53
PSCDGE	N135 E844	3		138.01	43.11
PSCDGE	N135 E844	3		124.9	41.3
PSCDGE	N135 E844	3		91.53	51.95
PSCDGE	N135 E844	3		70.83	39.96
PSCDGE	N135 E844	3		98.64	47.12
PSCDGE	N135 E844	3		59.26	27.31
PSCDGE	N135 E844	3		73.29	37.68
PSCDGE	N135 E844	3		82.52	57.08
PSCDGE	N135 E844	3		100.98	41.36
PSCDGE	N135 E844	3		37.51	19.84
PSCDGE	N135 E844	3		71.03	39.94
PSCDGE	N135 E844	3		38.07	20.6
PSCDGE	N135 E844	3		66.76	26.39
PSCDGE	N135 E844	3		45.57	33.34
PSCDGE	N135 E844	3		46.09	22.3
PSCDGE	N135 E844	3		111.87	51.29
PSCDGE	N135 E844	3		56.62	33.07
PSCDGE	N135 E844	3		86.83	30.41
PSCDGE	N135 E844	3		55.94	29.55
PSCDGE	N135 E844	3		65.08	29.06
PSCDGE	N135 E844	3		83.06	39.59
PSCDGE	N135 E844	3		72.73	38.47
PSCDGE	N135 E844	3		56.18	27.8

PSCDGE	N135 E844	3		44.48	17.78
PSCDGE	N135 E844	3		93.31	27.2
PSCDGE	N135 E844	3		33.81	21.69
PSCDGE	N135 E844	3		84.7	37.95
PSCDGE	N135 E844	3		93.17	47.19
PSCDGE	N135 E844	3		79.09	36.52
PSCDGE	N135 E844	3		53.17	32.23
PSCDGE	N135 E844	3		46.58	22.47
PSCDGE	N135 E844	3		96.93	29.69
PSCDGE	N135 E844	3		49.4	32.43
PSCDGE	N135 E844	3		68.66	51.01
PSCDGE	N135 E844	3		70.51	46.2
PSCDGE	N135 E844	3		31.9	15.09
PSCDGE	N135 E844	3		32.52	16.65
PSCDGE	N135 E844	3		57.41	29.74
PSCDGE	N135 E844	3		68.89	38.61
PSCDGE	N135 E844	3		57.31	30.68
PSCDGE	N135 E844	3		39.99	29.37
PSCDGE	N135 E844	3		49.31	23.15
PSCDGE	N135 E844	3		75.26	50.85
PSCDGE	N135 E844	3		54.75	21.38
PSCDGE	N135 E844	3		52.4	23.41
PSCDGE	N135 E844	3		71.29	42.8
PSCDGE	N135 E844	3		96.31	31.26
PSCDGE	N135 E844	3		66.53	23.92
PSCDGE	N135 E844	3		60.22	46.21
PSCDGE	N135 E844	3		37.99	33.31
PSCDGE	N135 E844	3		105.49	33.02
PSCDGE	N135 E844	3		83.45	36.19
PSCDGE	N135 E844	3		58.91	27.89
PSCDGE	N135 E844	3		96.78	47.33
PSCDGE	N135 E844	3		84.27	40.65
PSCDGE	N135 E844	3		120.19	33.25
PSCDGE	N135 E844	3		67.33	36.67
PSCDGE	N135 E844	3		132.86	42.93
PSCDGE	N135 E844	3		96.87	50.31
PSCDGE	N135 E844	3		79.08	46.19
PSCDGE	N135 E844	3		68.75	29.1
PSCDGE	N135 E844	3		65.32	34.47
PSCDGE	N135 E844	3		145.73	51.14
PSCDGE	N135 E844	3		85.45	25.5
PSCDGE	N135 E844	3		109.37	45.59
PSCDGE	N135 E844	3		42.08	18.13
PSCDGE	N135 E844	3		60.21	44.52

PSCDGE	N135 E844	3		62.36	24.3
PSCDGE	N135 E844	3		92.84	54.81
PSCDGE	N135 E844	4		119.23	32.62
PSCDGE	N135 E844	4		86.79	42.07
PSCDGE	N135 E844	4		77.12	43.67
PSCDGE	N135 E844	4		113.71	42.55
PSCDGE	N135 E844	4		154.86	65.44
PSCDGE	N135 E844	4		81.37	37.12
PSCDGE	N135 E844	4		62.67	35.36
PSCDGE	N135 E844	4		47.07	33.78
PSCDGE	N135 E844	4		50.88	25.77

APPENDIX C. BIOMASS REGRESSION FORMULAE

Taxon	N	Slope (b)	Y-intercept (log a)	r^2
Anadara sp.	62	1.24	-1.05	0.83
Busycon carica	16	0.84	-0.12	0.92
Callinectes sapidus	11	0.82	0.99	0.58
Crassostrea virginica	100	0.97	-0.77	0.97
Gastropoda	135	0.92	-0.16	0.89
Geukensia demissa	100	0.8	-0.22	0.86
Littorina irrorata	62	0.94	-0.34	0.97
Mercenaria sp.	40	0.94	-0.5	0.95
Tagelus plebius	46	0.99	0.29	0.95

Note: $Y=aX^b$ where Y is biomass or meat weight, X is bone weight, a is the Y-intercept, and b is the slope. N is the number of observations (Quitmyer and Reitz 2006; Reitz et al. 1987; Reitz and Wing 2008:234-242).

APPENDIX D. SABLE ISOTOPE DATA

Site	Specimen	Sample	δ^{13}C (‰ VPDB)	δ^{18}O (‰ VPDB)
9Li8	1	9Li8 S1.1	-0.3	-0.8
9Li8	1	9Li8 S1.2	-0.2	-0.5
9Li8	1	9Li8 S1.3	-0.7	-0.6
9Li8	1	9Li8 S1.4	-0.5	-0.7
9Li8	1	9Li8 S1.5	-0.6	-0.8
9Li8	1	9Li8 S1.6	-0.6	-1.0
9Li8	1	9Li8 S1.7	-0.5	-1.1
9Li8	1	9Li8 S1.8	-0.4	-0.7
9Li8	1	9Li8 S1.9	-0.7	-0.5
9Li8	1	9Li8 S1.10	-0.9	-0.6
9Li8	1	9Li8 S1.11	-1.0	-0.4
9Li8	1	9Li8 S1.12	-0.9	0.1
9Li8	1	9Li8 S1.13	-0.6	0.9
9Li8	1	9Li8 S1.14	-0.5	1.1
9Li8	1	9Li8 S1.15	-0.6	1.2
9Li8	8	9Li8 S8.1	-0.7	0.0
9Li8	8	9Li8 S8.2	-1.2	-1.3
9Li8	8	9Li8 S8.3	-0.7	0.4
9Li8	8	9Li8 S8.4	-0.7	-0.3
9Li8	8	9Li8 S8.5	-0.4	0.9
9Li8	8	9Li8 S8.6	-0.7	0.3
9Li8	8	9Li8 S8.7	-0.4	0.9
9Li8	8	9Li8 S8.8	-0.7	0.5
9Li8	8	9Li8 S8.9	-0.9	0.0
9Li8	8	9Li8 S8.10	-0.9	-0.5
9Li8	8	9Li8 S8.11	-1.1	-0.4
9Li8	8	9Li8 S8.12	-1.4	-1.1
9Li8	8	9Li8 S8.13	-1.1	-1.2
9Li8	8	9Li8 S8.14	-1.1	-1.5
9Li8	8	9Li8 S8.15	-1.2	-1.8
9Li8	8	9Li8 S8.16	-1.1	-1.8
9Li8	8	9Li8 S8.17	-1.1	-2.0
9Li8	8	9Li8 S8.18	-1.0	-2.3
9Li8	8	9Li8 S8.19	-1.1	-2.3
9Li8	8	9Li8 S8.20	-1.0	-2.3
9Li8	8	9Li8 S8.21	-1.1	-2.2

9Li8	8	9Li8 S8.22	-0.8	-2.1
9Li8	8	9Li8 S8.23	-0.7	-1.7
9Li8	15	9Li8 S15.1	-0.5	0.9
9Li8	15	9Li8 S15.2	-0.7	1.3
9Li8	15	9Li8 S15.3	-0.9	0.9
9Li8	15	9Li8 S15.4	-0.5	1.5
9Li8	15	9Li8 S15.5	-0.6	1.4
9Li8	15	9Li8 S15.6	-0.9	0.8
9Li8	15	9Li8 S15.7	-0.8	-0.8
9Li8	15	9Li8 S15.8	-1.3	-1.4
9Li8	15	9Li8 S15.9	-1.1	-1.5
9Li8	15	9Li8 S15.10	-1.3	-1.6
9Li8	15	9Li8 S15.11	-1.2	-1.9
9Li8	15	9Li8 S15.12	-0.7	-0.7
9Li8	15	9Li8 S15.13	-1.1	-0.7
9Li8	15	9Li8 S15.14	-1.0	-0.3
9Li8	15	9Li8 S15.15	-1.1	-0.4
9Li8	18	9Li8 S18.1	-1.3	0.8
9Li8	18	9Li8 S18.2	-0.7	1.3
9Li8	18	9Li8 S18.3	-0.7	1.1
9Li8	18	9Li8 S18.4	-0.6	1.2
9Li8	18	9Li8 S18.5	-0.8	1.3
9Li8	18	9Li8 S18.6	-0.9	1.1
9Li8	18	9Li8 S18.7	-1.0	0.8
9Li8	18	9Li8 S18.8	-1.5	-0.1
9Li8	18	9Li8 S18.9	-1.5	-0.6
9Li8	18	9Li8 S18.10	-1.8	-1.2
9Li8	18	9Li8 S18.11	-2.2	-1.7
9Li8	18	9Li8 S18.12	-1.8	-1.2
9Li8	18	9Li8 S18.13	-2.4	-2.3
9Li8	18	9Li8 S18.14	-2.3	-2.4
9Li8	18	9Li8 S18.15	-2.4	-2.5
9Li8	18	9Li8 S18.16	-2.2	-2.2
9Li8	18	9Li8 S18.17	-2.0	-1.5
9Li8	18	9Li8 S18.18	-1.8	-1.0
9Li8	18	9Li8 S18.19	-1.7	-0.9
9Li8	22	9Li8 S22.1	-1.2	0.4
9Li8	22	9Li8 S22.2	-2.0	-0.4
9Li8	22	9Li8 S22.3	-1.3	0.1
9Li8	22	9Li8 S22.4	-1.1	-0.1
9Li8	22	9Li8 S22.5	-1.6	-1.1
9Li8	22	9Li8 S22.6	-1.8	-2.8
9Li8	22	9Li8 S22.7	-1.9	-2.9
9Li8	22	9Li8 S22.8	-2.1	-2.6

9Li8	22	9Li8 S22.9	-1.7	-1.9
9Li8	22	9Li8 S22.10	-2.0	-2.0
9Li8	22	9Li8 S22.11	-2.1	-2.2
9Li8	22	9Li8 S22.12	-1.5	-1.7
9Li8	22	9Li8 S22.13	-1.4	-1.2
9Li8	22	9Li8 S22.14	-1.2	-1.3
9Li8	22	9Li8 S22.15	-1.2	-1.2
9Li8	22	9Li8 S22.16	-1.1	-1.4
9Li8	22	9Li8 S22.17	-1.3	-1.1
9Li13	2	9Li13 S2.1	-1.1	-0.1
9Li13	2	9Li13 S2.2	-1.1	0.3
9Li13	2	9Li13 S2.3	-0.7	1.1
9Li13	2	9Li13 S2.4	-1.1	0.5
9Li13	2	9Li13 S2.5	-1.2	-0.6
9Li13	2	9Li13 S2.6	-1.0	-1.0
9Li13	2	9Li13 S2.7	-1.1	-0.7
9Li13	2	9Li13 S2.8	-1.1	-0.8
9Li13	2	9Li13 S2.9	-0.9	0.6
9Li13	2	9Li13 S2.10	-0.6	1.2
9Li13	2	9Li13 S2.11	-0.5	0.6
9Li13	2	9Li13 S2.12	-0.7	1.0
9Li13	2	9Li13 S2.13	-1.1	0.7
9Li13	2	9Li13 S2.14	-1.3	0.2
9Li13	2	9Li13 S2.15	-1.3	-0.7
9Li13	3	9Li13 S3.1	-0.1	1.2
9Li13	3	9Li13 S3.2	-0.5	1.3
9Li13	3	9Li13 S3.3	-0.6	1.4
9Li13	3	9Li13 S3.4	-0.6	1.4
9Li13	3	9Li13 S3.5	-0.3	1.1
9Li13	3	9Li13 S3.6	-0.7	0.7
9Li13	3	9Li13 S3.7	-0.9	-0.2
9Li13	3	9Li13 S3.8	-0.7	-0.1
9Li13	3	9Li13 S3.9	-1.0	-0.8
9Li13	3	9Li13 S3.10	-0.9	-1.3
9Li13	3	9Li13 S3.11	-1.0	-1.2
9Li13	3	9Li13 S3.12	-0.9	-1.4
9Li13	3	9Li13 S3.13	-0.9	-1.5
9Li13	3	9Li13 S3.14	-0.9	-1.4
9Li13	3	9Li13 S3.15	-1.1	-1.6
9Li13	3	9Li13 S3.16	-0.9	-1.5
9Li13	4	9Li13 S4.1	-1.6	0.6
9Li13	4	9Li13 S4.2	-2.4	-0.1
9Li13	4	9Li13 S4.3	-2.4	-1.0
9Li13	4	9Li13 S4.4	-2.2	-2.0

9Li13	4	9Li13 S4.5	-2.1	-1.4
9Li13	4	9Li13 S4.6	-2.6	-1.1
9Li13	4	9Li13 S4.7	-2.1	-0.7
9Li13	4	9Li13 S4.8	-1.2	0.3
9Li13	4	9Li13 S4.9	-1.4	0.2
9Li13	4	9Li13 S4.10	-1.7	-1.0
9Li13	4	9Li13 S4.11	-2.2	-0.9
9Li13	4	9Li13 S4.12	-2.5	-1.7
9Li13	4	9Li13 S4.13	-2.1	-2.1
9Li13	4	9Li13 S4.14	-1.9	-1.9
9Li13	4	9Li13 S4.15	-1.7	-1.4
9Li13	4	9Li13 S4.16	-1.7	-1.7
9Li13	4	9Li13 S4.17	-1.9	0.1
9Li13	4	9Li13 S4.18	-2.3	-1.3
9Li13	5	9Li13 S5.1	-3.0	-1.6
9Li13	5	9Li13 S5.2	-3.8	-2.9
9Li13	5	9Li13 S5.3	-3.7	-2.1
9Li13	5	9Li13 S5.4	-4.2	-1.9
9Li13	5	9Li13 S5.5	-4.6	-1.9
9Li13	5	9Li13 S5.6	-4.0	-1.6
9Li13	5	9Li13 S5.7	-3.9	-1.6
9Li13	5	9Li13 S5.8	-3.1	-0.5
9Li13	5	9Li13 S5.9	-2.0	-0.6
9Li13	5	9Li13 S5.10	-2.2	0.2
9Li13	5	9Li13 S5.11	-1.6	0.6
9Li13	5	9Li13 S5.12	-2.5	0.0
9Li13	5	9Li13 S5.13	-2.1	0.2
9Li13	5	9Li13 S5.14	-2.7	-0.3
9Li13	6	9Li13 S6.1	-1.3	0.2
9Li13	6	9Li13 S6.2	-1.1	-0.2
9Li13	6	9Li13 S6.3	-1.3	-0.3
9Li13	6	9Li13 S6.4	-1.4	-0.9
9Li13	6	9Li13 S6.5	-1.7	-0.9
9Li13	6	9Li13 S6.6	-1.5	-1.2
9Li13	6	9Li13 S6.7	-1.4	-1.3
9Li13	6	9Li13 S6.8	-1.4	-1.2
9Li13	6	9Li13 S6.9	-1.5	-1.3
9Li13	6	9Li13 S6.10	-1.1	-2.8
9Li13	6	9Li13 S6.11	-1.6	-1.5
9Li13	6	9Li13 S6.12	-1.4	-1.5
9Li13	6	9Li13 S6.13	-1.3	-1.3
9Li13	6	9Li13 S6.14	-1.4	-1.5
9Li13	6	9Li13 S6.15	-1.7	-1.4
9Li13	6	9Li13 S6.16	-1.6	-1.4

9Li13	6	9Li13 S6.17	-1.7	-1.7
9Li210	3	9Li210 S3.1	-1.6	-0.2
9Li210	3	9Li210 S3.2	-0.7	1.2
9Li210	3	9Li210 S3.3	-0.9	1.0
9Li210	3	9Li210 S3.4	-1.5	-1.3
9Li210	3	9Li210 S3.5	-1.6	-2.2
9Li210	3	9Li210 S3.6	-1.6	-2.2
9Li210	3	9Li210 S3.7	-1.7	-1.9
9Li210	3	9Li210 S3.8	-1.6	-1.4
9Li210	3	9Li210 S3.9	-1.8	-1.5
9Li210	3	9Li210 S3.10	-1.5	-1.2
9Li210	3	9Li210 S3.11	-1.4	-0.9
9Li210	3	9Li210 S3.12	-1.3	-1.1
9Li210	3	9Li210 S3.13	-1.0	-0.7
9Li210	3	9Li210 S3.14	-1.2	-0.5
9Li210	3	9Li210 S3.15	-1.2	-0.5
9Li210	3	9Li210 S3.16	-1.0	0.0
9Li210	3	9Li210 S3.17	-1.3	0.4
9Li210	3	9Li210 S3.18	-0.8	0.8
9Li210	3	9Li210 S3.19	-0.9	0.5
9Li210	3	9Li210 S3.20	-0.6	1.4
9Li210	4	9Li210 S4.1	-0.6	0.5
9Li210	4	9Li210 S4.2	-0.7	0.5
9Li210	4	9Li210 S4.3	-1.2	-1.4
9Li210	4	9Li210 S4.4	-1.3	-2.0
9Li210	4	9Li210 S4.5	-1.4	-1.7
9Li210	4	9Li210 S4.6	-1.4	-1.8
9Li210	4	9Li210 S4.7	-1.4	-1.8
9Li210	4	9Li210 S4.8	-1.4	-1.3
9Li210	4	9Li210 S4.9	-1.3	-1.2
9Li210	4	9Li210 S4.10	-1.4	-1.3
9Li210	4	9Li210 S4.11	-1.4	-1.1
9Li210	4	9Li210 S4.12	-1.3	-1.0
9Li210	4	9Li210 S4.13	-1.2	-0.7
9Li210	4	9Li210 S4.14	-1.0	-0.3
9Li210	4	9Li210 S4.15	-0.8	0.0
9Li210	4	9Li210 S4.16	-0.6	0.6
9Li210	4	9Li210 S4.17	-0.6	0.9
9Li210	4	9Li210 S4.18	-0.7	0.8
9Li210	4	9Li210 S4.19	-0.5	1.2
9Li210	4	9Li210 S4.20	-0.8	1.0
9Li210	5	9Li210 S5.1	-1.2	1.0
9Li210	5	9Li210 S5.2	-1.1	0.7
9Li210	5	9Li210 S5.3	-1.4	-0.4

9Li210	5	9Li210 S5.4	-1.7	-2.0
9Li210	5	9Li210 S5.5	-1.7	-1.9
9Li210	5	9Li210 S5.6	-1.6	-1.9
9Li210	5	9Li210 S5.7	-1.7	-2.0
9Li210	5	9Li210 S5.8	-1.6	-1.6
9Li210	5	9Li210 S5.9	-1.7	-1.4
9Li210	5	9Li210 S5.10	-1.5	-1.1
9Li210	5	9Li210 S5.11	-1.3	-1.1
9Li210	5	9Li210 S5.12	-1.2	-1.0
9Li210	5	9Li210 S5.13	-1.4	-0.6
9Li210	5	9Li210 S5.14	-1.1	-0.3
9Li210	7	9Li210 S7.1	-0.9	0.3
9Li210	7	9Li210 S7.2	-1.3	-1.3
9Li210	7	9Li210 S7.3	-1.3	-1.3
9Li210	7	9Li210 S7.4	-1.2	-1.1
9Li210	7	9Li210 S7.5	-1.3	-1.0
9Li210	7	9Li210 S7.6	-1.5	-1.4
9Li210	7	9Li210 S7.7	-1.7	-1.3
9Li210	7	9Li210 S7.8	-1.6	-1.1
9Li210	7	9Li210 S7.9	-1.2	-0.3
9Li210	7	9Li210 S7.10	-1.1	-0.4
9Li210	7	9Li210 S7.11	-1.2	0.5
9Li210	7	9Li210 S7.12	-1.1	-0.2
9Li210	7	9Li210 S7.13	-0.9	-0.5
9Li210	7	9Li210 S7.14	-1.2	-0.2
9Li210	7	9Li210 S7.15	-0.8	0.4
9Li210	7	9Li210 S7.16	-1.0	-0.3
9Li210	7	9Li210 S7.17	-0.8	0.6
9Li210	7	9Li210 S7.18	-0.6	0.5
9Li210	7	9Li210 S7.19	-0.7	0.9
9Li210	7	9Li210 S7.20	-1.0	1.4
9Li210	7	9Li210 S7.21	-1.2	-0.3
9Li210	7	9Li210 S7.22	-1.3	0.3
9Li210	7	9Li210 S7.23	-1.2	-0.1
9Li210	10	9Li210 S10.1	-1.8	-0.1
9Li210	10	9Li210 S10.2	-1.9	-0.6
9Li210	10	9Li210 S10.3	-2.0	-1.0
9Li210	10	9Li210 S10.4	-1.7	-1.2
9Li210	10	9Li210 S10.5	-1.9	-1.3
9Li210	10	9Li210 S10.6	-2.0	-2.0
9Li210	10	9Li210 S10.7	-1.8	-1.9
9Li210	10	9Li210 S10.8	-1.6	-2.7
9Li210	10	9Li210 S10.9	-1.5	-1.7
9Li210	10	9Li210 S10.10	-1.4	-2.0

9Li210	10	9Li210 S10.11	-1.5	-1.7
9Li210	10	9Li210 S10.12	-1.7	-2.2
9Li210	10	9Li210 S10.13	-1.9	-2.3
9Li210	10	9Li210 S10.14	-2.2	-2.4
9Li210	10	9Li210 S10.15	-2.7	-2.7
9Li2117	1	9Li2117 S1.1	-0.2	0.3
9Li2117	1	9Li2117 S1.2	-0.3	0.2
9Li2117	1	9Li2117 S1.3	0.0	0.3
9Li2117	1	9Li2117 S1.4	-0.3	-0.3
9Li2117	1	9Li2117 S1.5	-0.7	-1.1
9Li2117	1	9Li2117 S1.6	-0.7	-1.0
9Li2117	1	9Li2117 S1.7	-0.8	-0.8
9Li2117	1	9Li2117 S1.8	-0.8	-0.8
9Li2117	1	9Li2117 S1.9	-0.8	-0.7
9Li2117	1	9Li2117 S1.10	-0.7	-0.6
9Li2117	1	9Li2117 S1.11	-0.7	-0.8
9Li2117	1	9Li2117 S1.12	-0.7	-0.3
9Li2117	1	9Li2117 S1.13	-0.7	-0.2
9Li2117	1	9Li2117 S1.14	-0.5	0.2
9Li2117	1	9Li2117 S1.15	-0.5	0.6
9Li2117	1	9Li2117 S1.16	-0.6	0.9
9Li2117	1	9Li2117 S1.17	-0.5	0.9
9Li2117	1	9Li2117 S1.18	-0.7	1.7
9Li2117	1	9Li2117 S1.19	-0.4	1.3
9Li2117	1	9Li2117 S1.20	-0.3	1.2
9Li2117	1	9Li2117 S1.21	-0.5	1.1
9Li2117	1	9Li2117 S1.22	-0.4	1.1
9Li2117	1	9Li2117 S1.23	-0.3	0.3
9Li2117	1	9Li2117 S1.24	-0.5	-0.1
9Li2117	1	9Li2117 S1.25	-1.0	-1.0
9Li2117	1	9Li2117 S1.26	-0.7	-1.2
9Li2117	1	9Li2117 S1.27	-0.9	-1.2
9Li2117	1	9Li2117 S1.28	-0.8	-1.5
9Li2117	2	9Li2117 S2.1	-3.2	0.8
9Li2117	2	9Li2117 S2.2	-1.0	1.4
9Li2117	2	9Li2117 S2.3	-1.4	1.5
9Li2117	2	9Li2117 S2.4	-1.2	0.6
9Li2117	2	9Li2117 S2.5	-1.5	-0.9
9Li2117	2	9Li2117 S2.6	-1.2	-1.0
9Li2117	2	9Li2117 S2.7	-1.0	-0.6
9Li2117	2	9Li2117 S2.8	-0.8	-0.4
9Li2117	2	9Li2117 S2.9	-0.7	-0.7
9Li2117	2	9Li2117 S2.10	-0.5	-0.3
9Li2117	2	9Li2117 S2.11	-0.9	-1.1

9Li2117	2	9Li2117 S2.12	-1.0	-1.6
9Li2117	2	9Li2117 S2.13	-1.4	-1.2
9Li2117	2	9Li2117 S2.14	-1.6	-0.7
9Li2117	2	9Li2117 S2.15	-1.8	-0.6
9Li2117	3	9Li2117 S3.1	-0.5	0.1
9Li2117	3	9Li2117 S3.2	-0.5	0.0
9Li2117	3	9Li2117 S3.3	-0.6	-0.5
9Li2117	3	9Li2117 S3.4	-0.5	-0.3
9Li2117	3	9Li2117 S3.5	-0.6	-1.1
9Li2117	3	9Li2117 S3.6	-0.6	-0.8
9Li2117	3	9Li2117 S3.7	-0.4	-0.4
9Li2117	3	9Li2117 S3.8	-0.5	-1.0
9Li2117	3	9Li2117 S3.9	-0.8	-1.1
9Li2117	3	9Li2117 S3.10	-0.6	-0.9
9Li2117	3	9Li2117 S3.11	-0.5	-1.3
9Li2117	3	9Li2117 S3.12	-0.5	-0.8
9Li2117	3	9Li2117 S3.13	-0.5	-0.5
9Li2117	3	9Li2117 S3.14	-0.8	-0.9
9Li2117	3	9Li2117 S3.15	-0.7	-0.9
9Li2117	4	9Li2117 S4.1	-1.0	1.1
9Li2117	4	9Li2117 S4.2	-0.9	1.4
9Li2117	4	9Li2117 S4.3	-1.0	1.4
9Li2117	4	9Li2117 S4.4	-1.1	0.7
9Li2117	4	9Li2117 S4.5	-1.3	-0.8
9Li2117	4	9Li2117 S4.6	-1.0	-0.5
9Li2117	4	9Li2117 S4.7	-0.8	-0.5
9Li2117	4	9Li2117 S4.8	-0.8	0.3
9Li2117	4	9Li2117 S4.9	-0.5	-0.5
9Li2117	4	9Li2117 S4.10	-0.3	-0.5
9Li2117	4	9Li2117 S4.11	-0.6	-0.7
9Li2117	4	9Li2117 S4.12	-0.8	-0.8
9Li2117	4	9Li2117 S4.13	-1.3	-0.9
9Li2117	4	9Li2117 S4.14	-1.1	-0.1
9Li2117	4	9Li2117 S4.15	-1.5	0.0
9Li2117	5	9Li2117 S5.1	-0.6	2.2
9Li2117	5	9Li2117 S5.2	-0.4	2.0
9Li2117	5	9Li2117 S5.3	-0.9	1.7
9Li2117	5	9Li2117 S5.4	-0.9	1.1
9Li2117	5	9Li2117 S5.5	-1.1	0.6
9Li2117	5	9Li2117 S5.6	-1.2	-0.4
9Li2117	5	9Li2117 S5.7	-1.1	-0.5
9Li2117	5	9Li2117 S5.8	-1.2	-0.3
9Li2117	5	9Li2117 S5.9	-1.2	-0.4
9Li2117	5	9Li2117 S5.10	-1.5	-1.2

9Li2117	5	9Li2117 S5.11	-1.8	-1.0
9Li2117	5	9Li2117 S5.12	-1.9	-0.9
9Li2117	5	9Li2117 S5.13	-1.1	0.1
9Li2117	5	9Li2117 S5.14	-0.5	0.9
9Li2117	5	9Li2117 S5.15	-0.1	1.4
9Li2117	5	9Li2117 S5.16	-0.1	1.8
9Li2117	5	9Li2117 S5.17	0.0	2.3
9Li2117	5	9Li2117 S5.18	-0.4	2.3
9Li2117	5	9Li2117 S5.19	-0.5	1.9
9Li2117	5	9Li2117 S5.20	-0.7	0.7
PSCDGE	1	PSCDGE S1.1	-1.0	0.9
PSCDGE	1	PSCDGE S1.2	-1.1	1.0
PSCDGE	1	PSCDGE S1.3	-1.2	0.3
PSCDGE	1	PSCDGE S1.4	-1.2	0.9
PSCDGE	1	PSCDGE S1.5	-1.3	0.3
PSCDGE	1	PSCDGE S1.6	-1.3	-1.0
PSCDGE	1	PSCDGE S1.7	-1.3	-0.8
PSCDGE	1	PSCDGE S1.8	-1.5	-0.7
PSCDGE	1	PSCDGE S1.9	-1.5	-0.8
PSCDGE	1	PSCDGE S1.10	-1.2	-0.9
PSCDGE	1	PSCDGE S1.11	-1.1	-1.0
PSCDGE	1	PSCDGE S1.12	-1.1	-1.0
PSCDGE	1	PSCDGE S1.13	-1.6	-1.6
PSCDGE	1	PSCDGE S1.14	-1.8	-1.6
PSCDGE	1	PSCDGE S1.15	-1.6	-2.0
PSCDGE	1	PSCDGE S1.16	-1.9	-2.0
PSCDGE	1	PSCDGE S1.17	-0.8	0.0
PSCDGE	1	PSCDGE S1.18	-0.5	0.9
PSCDGE	2	PSCDGE S2.1	-1.0	0.9
PSCDGE	2	PSCDGE S2.2	-1.1	0.0
PSCDGE	2	PSCDGE S2.3	-1.4	-0.8
PSCDGE	2	PSCDGE S2.4	-1.1	0.5
PSCDGE	2	PSCDGE S2.5	-1.0	1.1
PSCDGE	2	PSCDGE S2.6	-1.2	0.3
PSCDGE	2	PSCDGE S2.7	-1.3	-0.6
PSCDGE	2	PSCDGE S2.8	-0.9	-0.5
PSCDGE	2	PSCDGE S2.9	-1.0	-0.8
PSCDGE	2	PSCDGE S2.10	-1.1	-0.7
PSCDGE	2	PSCDGE S2.11	-1.1	-1.0
PSCDGE	2	PSCDGE S2.12	-1.3	-1.3
PSCDGE	2	PSCDGE S2.13	-1.2	-1.2
PSCDGE	2	PSCDGE S2.14	-1.2	-1.4
PSCDGE	5	PSCDGE S5.1	-0.4	1.1
PSCDGE	5	PSCDGE S5.2	-0.5	0.4

PSCDGE	5	PSCDGE S5.3	-0.8	-0.2
PSCDGE	5	PSCDGE S5.4	-0.5	-0.1
PSCDGE	5	PSCDGE S5.5	-0.5	-0.2
PSCDGE	5	PSCDGE S5.6	-0.6	-0.7
PSCDGE	5	PSCDGE S5.7	-0.6	-0.7
PSCDGE	5	PSCDGE S5.8	-0.6	-0.9
PSCDGE	5	PSCDGE S5.9	-0.8	-0.4
PSCDGE	5	PSCDGE S5.10	-0.6	0.0
PSCDGE	5	PSCDGE S5.11	-0.5	0.3
PSCDGE	5	PSCDGE S5.12	-0.3	1.1
PSCDGE	5	PSCDGE S5.13	-0.4	1.1
PSCDGE	5	PSCDGE S5.14	-0.6	0.8
PSCDGE	5	PSCDGE S5.15	-0.8	0.2
PSCDGE	5	PSCDGE S5.16	-1.1	-0.5
PSCDGE	5	PSCDGE S5.17	-1.7	-1.9
PSCDGE	5	PSCDGE S5.18	-2.0	-2.1
PSCDGE	5	PSCDGE S5.19	-1.4	-1.5
PSCDGE	5	PSCDGE S5.20	-1.0	-0.8
PSCDGE	6	PSCDGE S6.1	-0.6	0.9
PSCDGE	6	PSCDGE S6.2	-0.3	1.7
PSCDGE	6	PSCDGE S6.3	-0.4	2.4
PSCDGE	6	PSCDGE S6.4	-0.4	2.1
PSCDGE	6	PSCDGE S6.5	-0.5	2.1
PSCDGE	6	PSCDGE S6.6	-0.4	1.6
PSCDGE	6	PSCDGE S6.7	-0.5	1.6
PSCDGE	6	PSCDGE S6.8	-0.7	1.5
PSCDGE	6	PSCDGE S6.9	-0.8	1.4
PSCDGE	6	PSCDGE S6.10	-0.8	1.5
PSCDGE	6	PSCDGE S6.11	-1.0	1.5
PSCDGE	6	PSCDGE S6.12	-1.1	1.4
PSCDGE	6	PSCDGE S6.13	-1.3	0.7
PSCDGE	6	PSCDGE S6.14	-1.2	0.9
PSCDGE	6	PSCDGE S6.15	-1.2	0.2
PSCDGE	6	PSCDGE S6.16	-1.0	-0.2
PSCDGE	6	PSCDGE S6.17	-1.1	-0.1
PSCDGE	6	PSCDGE S6.18	-1.1	-0.3
PSCDGE	6	PSCDGE S6.19	-1.1	-0.4
PSCDGE	6	PSCDGE S6.20	-1.1	-0.4
PSCDGE	7	PSCDGE S7.1	-0.7	0.8
PSCDGE	7	PSCDGE S7.2	-0.5	1.9
PSCDGE	7	PSCDGE S7.3	-0.5	1.7
PSCDGE	7	PSCDGE S7.4	-0.8	1.3
PSCDGE	7	PSCDGE S7.5	-1.0	0.0
PSCDGE	7	PSCDGE S7.6	-0.9	1.5

PSCDGE	7	PSCDGE S7.7	-1.1	1.6
PSCDGE	7	PSCDGE S7.8	-1.2	0.8
PSCDGE	7	PSCDGE S7.9	-1.3	0.6
PSCDGE	7	PSCDGE S7.10	-1.3	0.9