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Late Holocene Logistical and Residential Settlement in Interior Santa Rosa Island, California: A Comparative Analysis of Four Rockshelter Sites

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Abstract

California's northern Channel Islands (NCI) are recognized by archaeologists for the highly complex, maritime Indigenous cultures that inhabited the islands at the time of Spanish contact. On Santa Rosa Island (SRI), the second largest of the NCI, numerous coastal sites have been studied extensively with respect to the subsistence-settlement system, while the role of interior sites within those systems has received less attention. Throughout the late Holocene (3350 cal BP– Present) interior settlement included small encampments, in many cases for logistical forays to the interior for terrestrial resources. This was particularly the case with sites occupied during the late Middle Period (1300 – 800 BP) and Middle to Late Period Transition (MLT; 800 – 650 BP), which coincided with a period of severe and persistent droughts interspersed with wetter and more mild periods (the Medieval Climatic Anomaly, MCA, 1150–800 cal BP). In other cases, some small sites represent smaller residential bases, a pattern that becomes more prevalent after the time of Spanish contact (408 cal BP) when Indigenous populations had declined. In this thesis, I examine the faunal records from four interior rockshelter sites within the context of late Holocene settlement systems on SRI to investigate how environmental and cultural factors may have contributed to the choices people made regarding how and where to settle, specifically the severe droughts of the MCA and the social effects of Spanish contact.

In this thesis, I test two primary hypotheses that were formulated from the perspective of the Diet Breadth and Central Place Foraging (CPF) models from Human Behavioral Ecology (HBE). To test each hypothesis, I use four lines of evidence: radiometric dating (radiocarbon), faunal analysis (primarily marine fauna), stable isotopic data from *Mytilus californianus* shell, and geospatial analysis (Euclidian distance and Hot

Spot analysis). The first hypothesis is that during the late Middle Period and MLT, settlement was likely influenced by drought conditions of the MCA, in part reflecting seasonal, short-term occupation during dry periods. The second hypothesis is that after Spanish contact, interior settlement at rockshelters reflects a more substantial or permanent settlement system for small population groups.

The results of faunal analysis revealed that differences in the diversity and density of the faunal assemblages distinguishes the sites from one another, with the late Middle Period/MLT sites having less diversity and density than the post-contact period sites. The late Middle Period/MLT sites are consistent with CPF while the post-contact period sites violate the expectations of the model, suggesting they are residential sites instead of special-purpose sites. The seasonality studies for the sites indicate that one of the sites pertaining to the late Middle Period/MLT was occupied during the summer drought months, while this pattern was not observed at post-contact period sites. Finally, the geospatial analysis suggests that the sites are more likely to be in “hot spots” of resilient water sources, as well as closer to water sources, than are randomized points. Understanding the purpose of settlement at these interior sites during the late Holocene is essential to a complete picture of how people made decisions regarding environmental and cultural events on SRI, which can be extended to understanding similar choices people face in Mediterranean environments generally.

Acknowledgements

One and a half semesters into my master's program at UNR, humanity was hit with a global pandemic. Not having access to the resources on campus, especially the people, was a challenging part of adjusting to COVID-19 as a new graduate student. Despite these setbacks, I've pushed through incrementally, continually learning about my motivation, how to set boundaries, and exactly what I need to work optimally. I'm happy to have had these lessons engrained in me as we adjust to life where we can once again wander freely and interact with one another in person.

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Chapter 1: Introduction

Many factors can influence hunter-gatherer mobility and settlement, including environmental change, culture contact, and conflict, among many others (Alvard 2006; Boese et al. 2020). Faunal remains and spatial data from archaeological sites are useful for interpreting the decisions people made in the past regarding settlement by identifying diachronic changes in settlement intensity and location. These data can then be applied to broader questions regarding decisions about spatial organization in the face of climate change and cultural contact (Balasse 2002; Perry and Glassow 2015; Winterhalder et al. 2010). The Northern Channel Islands (NCI), which include Santa Cruz, Santa Rosa, San Miguel, and Anacapa Islands, offer a unique opportunity to study past human settlement because of their discreteness and well-preserved archaeological deposits (Glassow et al. 2010).

Occupants of regions with Mediterranean climates like coastal southern California make decisions about subsistence and settlement in relation to seasonal resource availability, particularly fresh water and botanical resources, despite the biota of these regions being distinct (Jazwa and Jazwa 2021; Jazwa et al. 2016a; Thakar 2014). For example, subsistence practices revolving around surplus storage to compensate for interannual variability in critical resources are a commonality between the Chumash and Aegean cultures of the Mediterranean (Jazwa and Jazwa 2020). The seasonal availability of critical terrestrial resources, particularly fresh water, is especially pronounced on the NCI because there is less space available to form large watersheds (Power and Rudolph 2018). The settlement decisions hunter-gather people who inhabited the NCI were influenced, in part, by these differences in critical resource distribution (Kelly 2001).

It is not possible to fully understand archaeological settlement patterns in island contexts without considering island interior sites. Recent work has focused on understanding the role of interior sites in patterns of island occupation (Gill 2015; Jazwa et al. 2015; Perry and Glassow 2015; Thakar 2015). This includes questions about whether territorial settlement patterns that became more prevalent on the NCI during the MCA (1150 – 600 cal BP; Jones and Schwitalla) extended into island interiors. However, many of these interior sites remain unexamined, primarily because archaeological research on the NCI has focused on coastal sites, but also because interior sites tend to be small. The importance of small sites has been recognized in the context of greater settlement-subsistence systems in archaeology (e.g., Jochim 1991, Perry and Glassow 2015). Furthermore, ascertaining the specific purpose of these sites is often overlooked because their assemblages are deceptively similar.

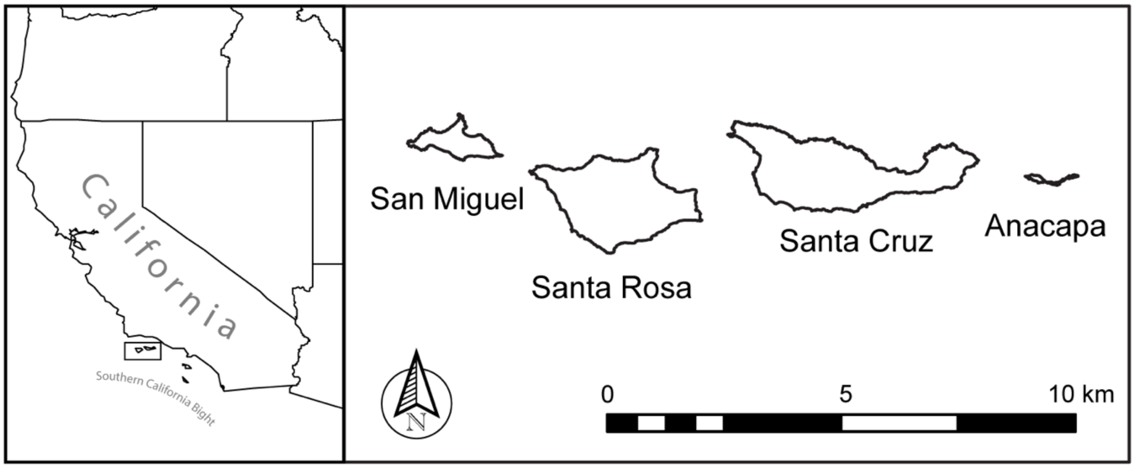
In this study, we examine four small late Holocene rockshelter sites from the interior of Santa Rosa Island (SRI) to identify distinct settlement patterns and how they correspond to different choices hunter-gatherers made in the past. We use faunal analysis, isotopic data, and geospatial data to demonstrate that while late Holocene interior settlement on the NCI is generally characterized by small, ephemeral sites, there are still differences among them. Two patterns emerge after this analysis. The first pattern is for those sites dating to the late Middle Period (1300 – 800 BP) and Middle to Late Period Transition (MLT; 800 – 650 BP). These sites are more ephemeral and may represent a response to the drought periods of the MCA, as small groups of people made logistical forays to the interior as they tried to obtain water from resilient water sources at higher elevations. The second is a reorganization of a more permanent residential settlement.

This reorganization may have been the result of expanding population density after the MLT, or as a response to colonial encroachment. This study demonstrates that even with limited data, it is possible to make distinctions among small sites. Understanding these patterns on SRI and the NCI in general would be beneficial for fully understanding how people made decisions regarding environmental and cultural events through time in regions with Mediterranean climates throughout the world, as well as indigenous response to colonialism worldwide.

Chapter 2: Background

The Channel Islands of southern California are an eight-island archipelago located in the Southern California Bight, a 426-mile-long concave bend in the California coastline stretching from Point Conception in Santa Barbara County, California to Puenta Colonet in Baja California (SCCWRP 2020). The islands are typically divided into two groups: the NCI, consisting of San Miguel (SMI), SRI, Santa Cruz (SCrI), and Anacapa (ANI); and the southern Channel Islands, consisting of Santa Catalina, Santa Barbara, San Clemente, and San Nicolas (Figure 1). The Channel Islands are renowned by scientists, resource managers, and the public for their rich and diverse marine ecosystems as well as their many unique endemic island species, earning them the moniker "the North American Galapagos" (Junak et al. 2007; Laverty 2020; Rick et al. 2005).

Figure 2.1. Location of the Northern Channel Islands and the Southern California Bight.



The NCI are within the ancestral territory of the Chumash, who prior to European colonization, inhabited present-day Santa Barbara, Ventura, and San Luis Obispo counties. Laverty (2020) estimates that around three thousand Chumash lived on the islands, while the mainland population was upwards of twenty-five thousand individuals. Archaeological evidence indicates that the NCI have been occupied since at least the terminal Pleistocene (11,700 cal BP; Erlandson et al. 2007; Johnson et al. 2002) and have played a central role in shifting paradigms regarding the peopling of the Americas within the last 25 years (Erlandson 2007; Johnson 2002; Johnson et al. 2012; Kemp et al. 2012; O'Rourke and Raff 2010). Braje et al. (2010) describe NCI archaeological deposits as "among the most valuable in North America, if not the world… [with] the potential to inform on aspects of prehistory and history that cannot be adequately revealed through archaeological research on the mainland." In part, this is because of unique and fortunate circumstances particular to the NCI. Burrowing rodents are absent from the islands, leaving most stratigraphic contexts undisturbed, which is a rarity on mainland California (Erlandson 1984; Kennett 2005). Additionally, the NCI have escaped the development common on the mainland, preventing the destruction of archaeological deposits.

2.1 Ethnographic and Historical Background

The Chumash are well-known for their complex chiefdom, use of shell bead currency, circumscribed territories, and specialized craft industries (Arnold 1992, 1995, 2001a, 2001b; Arnold and Munns 1994). At the time of historic contact, the Island Chumash primarily lived in large coastal villages governed by chiefs and were politically and economically intertwined with the communities on the mainland and beyond (Arnold 2001b; Johnson 1988; Kennett 2005). They were heavily dependent upon fishing and produced a variety of crafts with which to trade with the mainland, particularly *Olivella biplicata* shell beads (Arnold and Munns 1994; King 1990). This level of complexity may have developed in part because the Chumash have been ensconced in the Santa Barbara Channel for an exceptionally long time. Several lines of evidence allude to this. First, the

Chumash are genetically distinct from their neighbors, even in an area as diverse as Indigenous California (Johnson and Lorenz 2006; Johnson et al. 2012). They bear several unique genetic markers of demonstrable antiquity in the Americas, including a rare subgroup of mitochondrial DNA Haplotype D. This subgroup, D4h3a, characterizes a founding haplotype within Haplogroup D that is consistent with the Coastal Migration Theory of the initial peopling of the Americas (Johnson et al. 2006; Johnson et al. 2012; Kemp et al. 2012; O'Rourke and Raff 2010). Finally, the Chumash language is an isolate, meaning that it is lexically distant from neighboring language groups (Golla 2011).

2.1.1 *Chumash Oral History and Cosmology*

The Chumash oral histories that have been formally documented are fragmentary (Blackburn 1975; Hudson and Underhay 1978). In their translation of J.P. Harrington's notes of accounts from Chumash elders, Blackburn and Underhay (1978) observe that there was no explicit statement regarding how the universe was created. It may be that such an explanatory account for the cosmos is unnecessary in Chumash philosophy and worldview. This makes sense given that the Chumash perspective on life and the afterlife as an endlessly recurring cycle of reincarnation, in which matter is neither created nor destroyed (Hudson and Underhay 1978).

2.1.2 *Ethnohistory*

Early ethnographic characterizations of the Chumash are based primarily on descriptions in historical documents by European explorers and colonists. These records are fragmentary and somewhat unreliable because they were usually recorded during first encounters and very brief interviews (Johnson 2001; Kennett 2005). The Channel Islands were among the first points of contact between the earliest Spanish explorers and the Indigenous cultures of the Americas. The Juan Rodríguez Cabrillo Expedition arrived on the southern California coast and first contacted the Chumash in AD 1542 (Chiles 2015; Laverty 2020). Cabrillo mentioned two large provinces that existed in the Santa Barbara Channel region, *Xucu* and *Xexo*, one of which was ruled by a woman (Hudson and Underhay 1978). After the Cabrillo expedition, the Sebastián Vizcaíno expedition was next to visit the islands in December 1602. This trip produced the most extensive record of colonial contact with Chumash Islanders (Glassow et al. 2010). It is apparent in these accounts that the island Chumash had gotten word that the Vizcaíno expedition was on the way before they arrived, probably from the Tongva of Santa Catalina Island to the south (Glassow et al. 2010; Brown 2001).

Ethnohistory from the Mission Period (1769–1822; Glassow et al. 2010) has the benefit of using mission registers that contain useful demographic data including personal names, kinship relationships, island *ranchería* (village) names, geographic clues regarding village locations, and the chronological context of Chumash islanders' incorporation into mission populations. Archaeologists, ethnologists, and historians have used these data to better understand the aspects of Island Chumash life, namely settlement patterns, economy, and sociopolitics (Glassow et al. 2010; Johnson 1988; Johnson 1993; Johnson 2001). Juan Esteban Pico (1841–1901), a member of Mission San Buenaventura's community of Island Chumash descent, did invaluable work listing and describing the locations of *rancherías* on each island. Pico gave very specific locations of the largest *rancherías* on each of the two largest islands, then described the relative position of the other *rancherías* moving counterclockwise around the islands. His notes have been critical for reconstructing settlement geography patterns in Chumash archaeology (Glassow et al. 2010; Kennett 2005; King 1990).

2.1.3 *Ethnography*

Aside from the historical mission record data, what we know about Island Chumash social organization comes from early twentieth century ethnographic accounts of elders compiled by linguist and ethnologist John P. Harrington. His work from 1912 to 1918 resulted in a formalized ethnography that detailed social and economic pursuits within Chumash communities. Harrington's consultant Fernando Librado Kitsepawit (1835–1915) provided most of the information we know about Island Chumash sociopolitical organization (Johnson 2001). Librado had known many people who came from the islands when he was growing up in a Mission Indian Community at San Buenaventura, and his father had been born on SCrI (Johnson 1988, 2001). Librado provided information regarding sociopolitical organization and kinship on the NCI, including that the *rancherías* on the island each had a *capitán* (chief) and that the *capitán* of the *rancheía* Liyam on SCrI was the *paqwot* (chief of the NCI). Reconstruction of family linages of the *paqwot* Kamuliyatset indicates that he had a patrilocal post-marital residence, in contrast to most islanders who were matrilocal after marriage, and that this was a similar pattern to the mainland (Johnson 1988; 2001). Other political roles include '*alchuklash* (shaman and healer) as well as a *tomol* brotherhood society. Librado mentioned an elite group called "the Twenty," an intervillage political and ceremonial council with mythic origins, related to the mainland '*antap* society. Much like the '*antap*, Harrington’s notes describe the Twenty as ritualists with somewhat supernatural qualities. Librado also provided information regarding craft activities and ceremonial roles for islanders in post-Mission times. Librado gave scant notes regarding the activities and roles of island women (probably because he was male and an orphan), but what was recorded details the use of traditional material culture items, including roasting hearths, fox skin robes, shell beads, and sore throat medicine. Glimpses of women’s roles in society include shell bead money manufacture, making offerings to the sea, and as shamans or healers (Johnson 2001).

2.1.4 *Relocation and Missionization*

The final days of island society were brought about by pressure from religious missionaries and brute force on the part of Spanish colonists and foreign fur traders (Chiles 2015). Russian and American fur traders came with Alaskan Aleut and Native Hawaiian mercenary hunters to harvest sea otter from the NCI. Caught between the depredations of the sea otter hunters and mounting pressure from the Spanish missionaries, most of the remaining Island Chumash left for the mainland missions in 1812 after a huge earthquake hit the area (Chiles 2015). Between 1814 and 1816, large numbers of Chumash Islanders were moved to the mainland missions. Like their mainland kin, they were converted to Christianity and forced into labor. The islanders were not readily accepted into the established Chumash communities in the missions. The mainland Chumash communities had been acculturated to Spanish lifeways for 30 years at that point. Cultural differences including linguistic distinctiveness (island and mainland Chumash languages were not mutually intelligible) encouraged the mainlanders to be culturally chauvinistic towards the islanders (Johnson 2001). However, the ostracism and general trauma of the missionization process seemed to only galvanize island culture, and the island Chumash established their own communities that helped them maintain their own distinct subsistence and ritual practices (Laverty 2020). Based on mission record and radiocarbon data, the majority of Island Chumash villages were likely abandoned by 1822 (Glassow et al. 2010; Kennett 2005).

2.1.5 *Ranching Period and National Park Service*

The historical trajectories of the NCI are similar after the Chumash were moved to the mainland missions. They were primarily visited for fishing (particularly abalone), sealing, and fur trade well into the 20th century (Chiles 2015). Each of the islands (except for Anacapa) went through a series of ownership and land grants dependent on the government of the day: Spanish land grants, followed by Mexican ranchos, and finally Anglo ranches (Chiles 2015). Agricultural development on the islands largely consisted of ranching, and was most successful on Santa Cruz and Santa Rosa, where the remains of these ranches are important parts of the historic landscape (Glassow et al. 2010). Late nineteenth and early twentieth century ranching led to the dispersal of ungulates (cattle, sheep, goats, mule deer, and Roosevelt elk, among others) into the island ecosystems that had not supported large herbivores since the Pleistocene (i.e., *Mammuthus exilis*). This substantially altered the terrestrial island ecosystems, reducing plant populations, changing vegetation regimes, and causing mass erosion (Braje et al. 2019; Gill et al. 2019; Junak et al. 2007).

Today, most of the NCI are administered by the National Park Service (NPS). The origins of the park extend back to the establishment of Channel Islands National Monument in 1938, which encompassed only Santa Barbara and Anacapa Islands. Since the establishment of Channel Islands National Park in 1980, SRI and portions of SCrI were gradually incorporated. Today, ANA, SMI, SRI, and Santa Barbara Island are all managed by the NPS. Approximately 30% of SCrI is administered by the National Park Service, while 70% is owned and managed by the Nature Conservancy, a private company.

2.2 Environmental Overview and Context

2.2.1 *Physiography and Geology*

Geologically, the NCI form the southern margin of the east-west trending Transverse Ranges and are part of an extensive regional anticline stretching across the Santa Barbara Channel to the Santa Monica Mountains on the mainland (Atwater 1998). As part of the transverse range system, the NCI are related to the “Big Bend” in the San Andreas fault system. The islands are essentially the tops of mountains made by the compression and deformation of several tectonic blocks in the “Big Bend” that started in the Miocene (Mount 2013). In the Pleistocene (before 10,000 cal BP; Erlandson and Colton 1991), when sea levels were about 400 feet lower than today, the four NCI were connected into a large island called Santarosae. The nearest point of Santarosae was about seven kilometers from the mainland (Gusick and Erlandson 2019). The relatively long geographic isolation of the NCI from the mainland has resulted in many endemic pygmy species, such as the now extinct pygmy mammoth (*Mammuthus exilis*) and the housecat-sized island fox (*Urocyon littoralis*). The islands themselves are constantly evolving geomorphically, especially by wave action and wind that erodes their shorelines and shrinks their footprints through weathering, mass wasting, and localized fluvial and aeolian erosion (Mount 2013). The intensity and location of these geomorphic processes have varied through time because of fluctuating climate and sea level, and from the long-term impacts of ranching. Coastal erosion continues to affect numerous coastal archaeological sites on the NCI (Jazwa and Johnson 2018). The continuing uplift of the islands and fluctuating sea level caused by glacial advances and retreats indicates that there is evidence on the islands of ancient shorelines at different elevations. The rise in sea level over the last 10,000 years has caused many of the ancient shorelines to be lost to marine transgression (Gusick and Erlandson 2019).

2.2.2 *General Climate and Seasonality*

The Köppen climate classification characterizes the NCI as “Csb” (Beck et al. 2018). These climates are often called Mediterranean, and generally have dry summers (approximately May–October) and mild, wet winters (approximately November–April; Erlandson et al. 2019; Kennett 2005). The climate of the islands is highly maritime, which means that both winter and summer temperature extremes are moderated by the moist ocean air with generally high nighttime humidity and frequent fog (Fischer et al. 2009). In addition to latitude, the size of an island and its location relative to the local wind and water currents are the factors influencing ambient temperature (Junak et al. 2007). December through March are the coolest months and July through October are the hottest months. In general, the surrounding oceanic currents result in a natural gradient in

Sea Surface Temperature (SST) around the islands that generally ranges from cool to warm, west to east (Gill and Hoppa 2016). This gradient occurs as the cold California current sweeps southward from Point Conception through the Santa Barbara Channel on the northern side of the islands, forming a counterclockwise eddy as it meets the warm Southern California Countercurrent, which largely flows to the southern side of the islands (Junak et al. 2007).

Seasonal fluctuations in temperature and moisture affect the distribution and availability of terrestrial and marine biota and fresh water. Most rainfall occurs from late fall to early spring, and the rest of the year is generally dry and susceptible to drought. The distribution and productivity of terrestrial plant communities on the islands are highly dependent upon seasonal rainfall and fog inundation (Junak et al. 2007). In general, most plant taxa from the NCI in the ethnobotanical record produce useful or edible parts from spring through fall (e.g., edible seeds, fruits, nuts, stems, leaves, rhizomes) while some (e.g., geophytes) are available year-round (Erlandson et al. 2019; Gill and Hoppa 2016; Gill et al. 2019). *Brodiaea* spp. corms in particular have been recognized as a dietary staple that was available as a food source year-round (Gill 2015; Gill and Hoppa 2016; Gill et al. 2019).

Marine resources also vary by season on the NCI. Elephant seals visit rookeries on San Miguel to breed during in the winter while female elephant seals return in the summer months to molt (Kennett 2005). Many types of schooling fish enter the Santa Barbara Channel during the summer season, including sardines (*Sardinops caeruleus*), yellowtail (Seriola dorsalis), and bonito (*Sarda lineolata*; Kennett 2005). Some species of sea mammals, like the harbor seal (*Phoca vitulina*) and sea lion (*Zalophus californianus*) are present throughout the year but breed in rookeries on the islands during the summer (Delong and Melin 2000). Shellfish such as the California mussel (*Mytilus californianus*) and red abalone (*Haliotis rufescens*) are plentiful and accessible year-round in the rocky intertidal zone (Erlandson 1994; Kennett 2005). Kelp and seaweed are available throughout the year, as are kelp-bed and rocky shore fish (Erlandson et al. 2019; Kennett 2005).

2.2.3 *El Niño Southern Oscillation (ENSO) Cycle*

Located on the margins of the central equatorial Pacific, the NCI are affected by the periodic environmental changes and subsequent impacts of El Niño/Southern Oscillation (ENSO). ENSO climatic anomalies are driven by major oceanic and atmospheric changes in the equatorial Pacific and occur every 2 to 7 years. In the Santa Barbara Channel region, El Niño events typically increase precipitation and SST, whereas during La Niña intervals (the opposite phase of the ENSO cycle) drought is more common, terrestrial productivity is lower, but marine productivity is higher (Kennett 2005). During El Niño years, SST along the central and southern California coast are elevated throughout the annual cycle. In these conditions, the upwelling of cool, nutrient-rich water is reduced and causes overall decreases in marine productivity. Shifts in SST also disrupt kelp growth, which triggers a trophic cascade that results in many ecological imbalances, such as high mortality rates in California sea lion and fur seal pups because females cannot eat enough to maintain lactation (Dayton et al. 1992; DeLong and Melin 2000; Ono et al. 1993). These changes in marine productivity also affect many types of marine species favored by people on the NCI, such as mollusks and nearshore fish

(Kennett 2005). For example, red abalone, which prefer cooler waters, are prolific in middle Holocene deposits (7,000 – 3,350 cal BP; Erlandson and Colton 1991) on the NCI and may represent periods of cool SST related to La Niña ENSO cycles (Glassow et al. 2012; Kennett et al. 2007; Jazwa et al. 2015).

2.2.4 *Hydrology*

The majority of rainfall (95%) on the NCI occurs during the winter between November and April with January and February being the rainiest months (45% of average totals; Kennett 2005). The rest of the year is generally dry and susceptible to periodic drought. The summer dry season is ameliorated somewhat by frequent fog or low clouds (Fischer 2007; Fischer et al. 2009; Junak et al. 2007). Mean annual precipitation ranges is about 35 cm (14 inches) per year among the NCI, although this varies greatly depending on topography and the annual climate cycle (i.e., ENSO; Kennett 2005). Southern California shows more relative year-to-year variation in winter precipitation than anywhere else in the United States, ranging from 20 cm (8 inches) to 100 cm (40 inches) annually (Power and Rudolph 2018).

The physiography of the islands, including geology, vegetation cover, and topography, directly affects precipitation and fog patterns (Gill et al. 2019; Jazwa et al. 2016a; Junak et al. 2007). In general, the larger and more mountainous islands are relatively well-watered. SCrI and SRI have topography that sustain several perennial watersheds, while fresh water is more restricted on the smaller islands of ANA and SMI. In general, the flow of most streams and springs on the islands are intermittent, with only a few perennial water sources on each island (Kennett 2005). The most reliable watersheds on SRI are located on its north coast. Lobo Canyon, Cañada Verde, Arlington Canyon, and Cañada Tecolote provide perennial streams that continue to flow even during severe drought years (Jazwa et al. 2016a). Water availability on the island also appears to be tied to the amount of vegetation on the island, with additional springs appearing when vegetation is most abundant (Kennett 2005). This phenomenon is likely related to fog inundation (Gill et al. 2019).

Although somewhat understudied, fog drip is likely a significant contributor to fresh water availability on the NCI during the summer months when dense fog forms because of the large differential between SSTs and air temperature (Gill et al. 2019; Jazwa et al. 2016a). For example, measurements of fog drip precipitation on San Miguel Island in 1995 reached as much as 136 liters per square meter in the month of August (Estberg 2001; Fisher and Still 2007). The integrated hydrologic model of SRI developed by Jazwa et al. (2016a) demonstrated that fog inundation was a necessary addition to island hydrology, as all the island drainages would go dry without its contribution. Plants play a major role in helping recharge groundwater supplies by “combing” moisture from fog and depositing it into the ground during the summer months (Fischer et al. 2009; Gill 2015). This phenomenon has increased as endemic vegetation recovers on the islands. For example, since the eradication of invasive ungulates, several previously unknown springs have been identified on San Miguel Island and several freshwater marshes with willows and cattails have also reappeared (Erlandson et al. 2019).

2.2.5 *Island Biogeography*

The Channel Islands are well known for their unique island biogeography, including rich and diverse marine life as well as more than 1000 endemic terrestrial plants and animals (Mount 2013). The evolutionary processes that are common for island life, including niche shifts or dwarfism, make biotic resources highly localized and patchy (Junak et al. 2007; Rick et al. 2005). Island size, distance from the mainland, time of isolation, geologic substrate, and diversity of habitats affects biological diversity (Junak et al. 2007; Keegan and Diamond 1987). The larger islands (i.e., SCrI and SRI) have the greatest diversity of habitats on the NCI (Junak et al. 2007). The local variation in ecosystems has influenced the nature of human settlement and subsistence through time, with the larger and more diverse islands attracting larger human populations.

The diminutive Channel Island fox (*Urocyon littoralis*), the size of a housecat, is the largest terrestrial mammal native to the Channel Islands. The fox likely evolved from the mainland grey fox in situ on the NCI during Pleistocene and it is likely that human beings brought foxes to the Southern Channel Islands sometime during the Holocene (Vellanoweth 1998). There are only three other endemic terrestrial mammals on the NCI: the island deer mouse (*Peromyscus maniculatus*), the western harvest mouse (*Reithrodontomys megalotis*), and the island spotted skunk (*Spilogale gracilis var. amphialus*). The island plant communities of the NCI are similar to those on the California mainland, but they tend to be dominated by island endemics and are unique associations (Junak et al. 2007). Island plant communities are highly dependent on variation in topography and geology, as well as groundwater availability and wind exposure. In Table 1, I have provided a simplified version of the typical vegetation communities on the NCI, adapted from Junak et al. (2007). Historical overgrazing has also significantly changed terrestrial island landscapes from pre-colonial conditions. As island vegetation recovers from the removal of non-native herbivores, we are just beginning to see just how verdant the islands may have been in the past (Gill et al. 2019). However, we must be cautious to not project modern conditions into the past by assuming that these recovering plant communities are representative of the period before Spanish contact.

Table 2.1. Generalized Plant Associations and characteristic species (adapted from Junak et al. 2007).

Generalized Plant Association	Characteristic Species	Common Physiography for Habitat
Scrub vegetation	*Baccharis pilularis, Lupinus albifrons, Lycium californicum, Opuntia* spp., *Artemesia californica, Coreopsis gigantea*	South and east-facing slopes of drainages
Island chaparral	*Quercus pacifica, Isocoma menziesii, Heteromeles arbutifolia*	North facing slopes
Mixed woodland	*Quercus agrifolia, Prunis ilicifolia, Quercus tomentella*	Sheltered valleys and drainages
Riparian	*Salix lasiolepis, juncus phaeocephala, Centaurea melitensis, Agrostis viridis*	Coastlines, drainage bottoms
Conifer forest	*Pinus torreyana, Pinus muricata*	North coast of SRI (*torreyana*); sheltered valleys (*muricata*)

The marine environments of the NCI are highly productive because of the cold California Current and seasonal upwelling (Kennett 2005, Rick et al. 2005). Like their terrestrial counterparts, the offshore habitats of each island are unique and localized because their geographic position along the coast is linked to temperature variations and regional ocean circulation, which in turn affects marine productivity (Engle 1993, 1994). The Channel Islands are dense and productive rookeries for many pinniped species (Moody 2009). Archaeological evidence indicates that six marine mammal species were hunted on the NCI: the northern elephant seal (*Mirounga angustirostris*), California sea lions (*Zalophus californianus*), northern fur seals (*Callorhinus ursinus*), harbor seals (*Phoca vitulina*), sea otter (*Enhydra lutris*), and southern fur seals (*Arctocephalus townsendi*). These data also indicate that southern fur seals were also more common on the NCI earlier in the Holocene than they are today (Walker et al. 2000). The islands also have vast stretches of rocky shorelines that support tidepools and nearshore coastal habitats. The rocky intertidal zone supports numerous mollusk species, particularly California mussels (*Mytilus californianus*), a dietary staple of Indigenous coastal California (Bettinger and Malhi 1997). *Olivella biplicata,* culturally significant for its shell, are also found in island beach habitats (Hudson and Blackburn 1980:149; Kennett 2005). Although ethnographic evidence is scant, it is very likely that people used the prolific kelp, algae, and marine plant communities around the NCI for subsistence and medicine (Ainis et al. 2019).

2.3 Paleoenvironment

The Holocene (11,700 cal BP – Present) paleoclimate record of the Santa Barbara Channel is comprehensive because the Santa Barbara Basin has exceptionally well-preserved varved marine sediments (Heusser 1978; Kennett and Kennett 2000; Pisias 1978). The laminae are excellent archives of environmental change in coastal California environments and include data such as marine biota, pollen, and other terrestrial materials carried by fluvial and aeolian processes that become trapped in marine sediment over time (Heusser and Sirocko 1997). The Santa Barbara regional record indicates that environments fluctuated throughout the Holocene and seem to be tied to broader climatic changes in western North America (Whitlock and Bartlein 1997). Ernest Antevs (1955) established the baseline climate history for western North America using pluvial lake core data from the Great Basin. Antevs’ climatic sequence posited two cool and wet climatic cycles (the Anathermal, 10,000– 7,000 cal BP; and the Medithermal, 4,500 cal BP to present) bisected by a warm and dry interval (Altithermal, 7,000–4,500 cal BP). These periods roughly coincide with the early, middle, and late Holocene. Antev’s sequence is still generally accurate for the Great Basin and western North America (Madsen and Rhode 1990; Thompson 1992). Abundant paleoclimate research since Antevs has provided more nuance for the general sequence in southern California (e.g., Colton and Liu 1994; C.J. Heusser et al. 1985; L.E. Heusser 1978, 1995; Heusser and Siracko 1997; Junak et al. 2007; Kennett and Ingram 1995; Kennett and Kennett 2000; Raab et al. 1995; Stine 1994).

2.3.1 *Terrestrial Data*

Researchers have used palynomorph data to characterize the paleoclimate of the Santa Barbara Channel from the Pleistocene through the Holocene (Colton and Liu 1994; L.E. Heusser 1978, 1995; Heusser and Siracko 1997). According to these data, starting around 160 kya, the vegetation and climate of southwestern California can be generalized by oscillations in oak woodland (*Quercus* spp.) and conifer forests (*Pinus* spp.) that pertain to warm and cool periods, respectively (L.E. Heusser 1995; Heusser and Siracko 1997). During the last glacial, conifer species dominated the area, and there were several high-amplitude *Pinus* pollen events at the end of the Last Glacial Maximum (approximately 12.1 kya; Heusser and Siracko 1997). These increases in *Pinus* pollen coincide with an overall reduction in pollen and as well as an increase in charcoal. This pattern likely represents ENSO cycle-related wet winter rain events after hot, dry, and wildfire-prone summer droughts (Heusser and Siracko 1997). These ENSO events continue to appear in the pollen record at approximate 1000 year-intervals as the climate continued to make several broader shifts through the Holocene.

The Holocene pollen record indicates five general shifts in climate. From approximately 12,000 – 7,800 cal BP, the Santa Barbara Channel was more mesic, exemplified by the proliferation of upland coniferous species like *Pinus muricata* (L.E. Heusser 1978; Junak et al. 2007). From 7,800 – 5,700 cal BP, conditions dried out, and the coniferous species were succeeded by cismontane communities represented by *Quercus* species and members of the *Compositae* (formerly *Asteraceae*) family. The xeric chaparral and coastal sage scrub associations that are prevalent today first appeared in the Santa Barbara Channel around 5,700 cal BP (L.E. Heusser 1978). Analysis of pollen cores from SRI indicate that the interval between 5200–3250 cal BP was even more arid, indicated by an increase in the xerophilic phyla *Ambrosia* and *Chenopodium*, followed by a generally wet phase lasting until 150 cal BP (AD 1800), evinced by higher carbonate and sedge pollen values (Colton and Liu 1994).

2.3.2 *Oceanographic Data*

Analyzing stable oxygen isotopes ($\delta^{18}O$) in marine organism carbonate is a powerful tool for reconstructing oscillations in paleo-SST (e.g., Friddell et al. 2003; Jew et al. 2013; Kennett and Ingram 1995). SST is a barometer for many different measures of environmental productivity along the California coast, especially ocean upwelling (Moody 2009). Using $\delta^{18}O$ from foraminifera in marine varves, Kennett and Ingram

(1995) reconstructed high-resolution patterns in SST through time in the Santa Barbara Channel. They determined that the past 20,000 years of climate and oceanographic change in the Santa Barbara Basin appear to be synchronous with the main ocean-climate fluctuations of the North Atlantic region. This pattern is an oscillating and gradual warming SST trend since the Pleistocene, with rising sea levels. Jew et al. (2013, 2014) used archaeological *Mytilus californianus* shells from San Miguel and Santa Rosa Islands to characterize early Holocene SST, which was about 2°C cooler than current SST in the early Holocene (~8,000 kya), followed by a period of warm SST from 8,500–7,500 cal BP. Friddell et al. (2003) used foraminifera records to reconstruct middle Holocene climatic events. They showed that the middle Holocene as a whole was the warmest interval of the current interglacial and was characterized by decadal- to centennial-scale climatic variability and potentially more intense ENSO warm events. Kennett and Kennett (2000) developed a high-resolution (25–50 year scale) marine climate sequence for the Santa Barbara Basin using foraminifera. These data indicate that the Holocene is characterized by millennial-scale warm and cool oscillations in SST, with increasing instability starting late in the middle Holocene, especially after 5,500 cal BP.

There has been some debate about the SST in the late Holocene around the NCI and its role as a catalyst in rapid cultural change during the Middle to Late Transition (MLT; 800 – 650 cal BP; Arnold 2001b). Pisias's (1978) climate record of radiolarian assemblages from the Santa Barbara Basin suggested that between 1850–650 cal BP, SST was 18°C on average, and reached a high of 21°C between 800–650 cal BP. Based on this, Arnold (1992) argued that this was disruptive to regional marine ecosystems that resulted in hardship and social disruption for the Chumash people. Arnold (1992) and

Arnold and Tissot (1993) substantiated this perspective with a growth study of black abalone in archaeological assemblages from this period. This perspective has been challenged by other researchers who attest that there is little evidence for marine resource scarcity during this period (Kennett and Kennett 2000; Raab et al. 1995, 1997; Raab and Larsen 1997). Based on higher resolution data than that which Pisias (1978) used, Kennett and Kennett (2000) determined that average SST fluctuated between 9 and 15°C during the late Holocene. There are three general climatic phases. Between 3000–1500 cal BP, SST was generally warm and stable. Between 1500–650 cal BP was one of the coldest and most unstable marine intervals of the Holocene. While SST was cold, the terrestrial environment was also very arid. After 650 cal BP, SST warmed slightly and stabilized.

Figure 2.2. Generalized terrestrial and oceanographic paleoclimate sequence for the NCI.

Terrestrial (Pollen) (Colton and Liu 1994; Heusser 1978)		**Oceanographic (SST)** (Friddell et al. 2003; Jew et al. 2013, 2014; Kennett and Kennett 2000; Pisias 1978)	
Date	**Character**	**Date**	**Character**
12,000 – 7,800 cal BP	• Mesic (e.g., *Pinus muricata*).	8000 – 7,800 cal BP	• Cool; ~2°C less than today.
7,800 – 5,700 cal BP	• Xeric (e.g., *Quercus* spp.; *Compositae* spp.).	7,800 – 5,400 cal BP	• Warm; ~3-4°C rise in SST.
5,200 – 3,250 cal BP	• Very Xeric (e.g., *Ambrosia* spp.; *Chenopodium* spp.) • Today's chaparral and sage scrub communities become established.	5,200 – 3,600 cal BP	• Warmest period; sharp rise (>2°C) in SST. • ENSO intensifies.
		3,600 – 1,500 cal BP	• SST cools and stabilizes • ENSO decreases
3,250 – 150 cal BP	• Relatively more mesic, but drier than the early Holocene (e.g., Sedge pollen, carbonate).	1,500 – 650 BP	• SST cold and unstable • ENSO decreases
150 BP – Present	• Xeric (e.g., *Ambrosia* spp.; Chapparal and sage scrub).	650 BP – Present	• SST warms and stabilizes • ENSO decreases

2.3.3 The Medieval Climatic Anomaly (1150–600 cal BP)

In the mid-20th century, climate researchers identified a post-glacial warm period that roughly overlapped with the European Middle Ages (c. 950 – 400 cal BP) that they dubbed the Medieval Warm Period (WMP; Lamb 1965). While some had considered the effects of the MWP in American Southwest (Moratto et al. 1978; Moratto 1984), Stine (1994) recognized that the WMP was associated with two extremely severe and prolonged droughts in the eastern Sierra Nevada from 1038–838 cal BP and 740–600 cal BP. Archaeologists generalize this time period and typically cite what is now called the MCA as existing from 1150–600 cal BP (e.g., Jones et al. 2004; Jones and Schwitalla 2008; Raab and Larson 1997). Later research from northern California, Nevada, and New Mexico indicates that there were multiple droughts during Stine's original time frame that were interspersed with pluvial periods (Benson et al. 2002; Benson et al. 2007; Cook et al. 2015).

On the NCI, the MCA is roughly coincident with demographic decline, a disruption in settlement patterns, and rapid sociopolitical change (Arnold 1992; Jazwa and Rosencrance 2019; Jazwa et al. 2019; Jones and Schwitalla 2008; Kennett 2005). These effects are all likely related to the drought conditions during the MCA, which caused a decline in terrestrial resources and the availability of fresh water both on the NCI and the mainland (Jones and Schwitalla 2008; Jazwa and Rosencrance 2019; Raab and Larsen 1997). Archaeologically, there is evidence of territorial buffer zones being established around existing settlements on SRI, and that the most productive habitats on were depopulated if they were near to other productive habitats (Jazwa et a. 2019). There is an increase in arrow points in the interior Pocket Field region on western SRI that may indicate increasing conflict and territoriality (Jazwa and Rosencrance 2019; Kennett et al. 2013). On San Clemente Island, there was an apparent depopulation during the MCA, and the sites recorded during this period are generally located near resilient water sources (Yatsko 2000). There are noted shifts in subsistence coincident with the MCA, including a general increased reliance on fish (Arnold 1992; Kennett 2005), and a decrease in the frequency of groundstone in the Pocket Field (Jazwa and Rosencrance 2019). The Middle-Late Transition (MLT; 800–650 cal BP; Figure 3; Arnold 2001), a period of rapid cultural change on the NCI, is coincident with one of the most significant droughts of the MCA (Benson et al. 2007; Jazwa and Rosencrance 2019). During this time, there were dramatic increases in bead production, trade, and sociopolitical complexity on the NCI and in the Santa Barbara Channel (Arnold 1992; Jones and Schwitalla 2008).

2.4 Archaeological Background

Archaeologists have developed several chronological sequences for the Santa Barbara Channel region. King's (1982, 1990) sequence is widely used, it is functionalist, and it reflects change in economic and socio-political organization as opposed to subsistence and technology. Based on excavations from SCrI and calibrated radiocarbon dates, Arnold (2001) refined King's chronology for the Middle and Late Periods. She placed the start of the Late Period at 650 cal BP and defined a new period of rapid cultural change she calls the MLT. Erlandson and Colton (1991) developed a chronology that is based on geologic sequences (i.e., Pleistocene and Holocene). A comparison of Erlandson and Colton's (1991) sequence and Arnold's culture history sequence is listed below (Table 2). I will reference Arnold's sequence in this thesis when discussing cultural events, while I will use Erlandson and Colton when discussing broader environmental events.

Figure 2.3. Archaeological sequences of the Santa Barbara Channel region used in this thesis.

<table>
<tr><th colspan="2">Erlandson and Colton 1991</th><th colspan="3">Arnold 2001a</th></tr>
<tr><th>Time Period</th><th>Cal BP</th><th>Time Period</th><th>AD/BC</th><th>Cal BP**</th></tr>
<tr><td>Early Holocene</td><td>11,700 – 7,000</td><td>Early Holocene</td><td>8000 – 5500 BC</td><td>9950 – 7450</td></tr>
<tr><td>Middle Holocene</td><td>7,000 – 3,350</td><td rowspan="2">Early Period</td><td rowspan="2">5500 – 600 BC</td><td rowspan="2">7450 - 2550</td></tr>
<tr><td rowspan="5">Late Holocene</td><td rowspan="5">3,350 – present</td></tr>
<tr><td>Middle Period</td><td>600 BC – AD 1150</td><td>2,550 – 800</td></tr>
<tr><td>Middle/Late Transition</td><td>AD 1150 – 1300</td><td>800 – 650</td></tr>
<tr><td>Late Period</td><td>AD 1300 – 1782</td><td>650 – 168</td></tr>
<tr><td>Historic</td><td>AD 1782+</td><td>168 +</td></tr>
</table>

** Adjusted by subtracting AD from 1950 and adding 1950 to dates in BC.

2.4.1 *Terminal Pleistocene (pre-11,700 cal BP) and Early Holocene (11,700–7,000 cal BP)*

Sites dated to the terminal Pleistocene-early Holocene are more abundant on the NCI than any other area of comparable size in North America, although this may be the product of focused research there (Glassow et al. 2010; Rick et al. 2005). Several terminal Pleistocene sites occur on SRI, SCrI, and SMI; Daisy Cave is a well-known site on SMI with a terminal Pleistocene deposit (12,300 cal BP; Erlandson et al. 1996). Early Holocene sites are far more prolific, with over 90 sites with well-dated contexts occurring on the NCI (Erlandson et al. 2020; Gusick and Erlandson 2019). Faunal assemblages from sites dating to this time tend to be shell midden sites with diverse faunal assemblages. Artifact assemblages consist of cores, flake tools (including eccentric crescents and contracting stemmed points), *Olivella* shell beads, bone gorges, abalone pry bars, digging stick weights, and fiber artifacts (e.g., cordage and basket fragments) made from sea grass (Connolly et al. 1995; Erlandson et al. 1996; Kennett 2005; Rick et al. 2005). These assemblages are generally indicative of short-term occupation, although some (e.g., Daisy Cave) are likely the result of more intense occupation (Erlandson et al. 1996; Rick et al. 2005).

2.4.2 *Middle Holocene (7,000 – 3,350 cal BP)*

By the middle Holocene, it is evident that economic and social patterns seen in the record at the end of the early Holocene were still in place, and population size had grown substantially, evidenced by site complexity and the sheer number of middle Holocene sites (when Kennett published in 2005, that number was 58 sites). For heuristic purposes, Kennett (2005) grouped middle Holocene sites into four categories: primary villages, secondary villages, interior residences, and logistical encampments. Primary villages were clearly occupied for extended periods of time, and have significant deposits associated with them, such as cemeteries and deep, stratified middens. Analysis of middens from primary villages has given us demographic data through inference. For example, faunal evidence from CA-SRI-147 on SRI showed significant impacts to nearshore ecosystems that were likely the result of growing human populations and depletion of resources during the middle Holocene (Braje et al. 2007). Secondary villages are similar to primary villages, but they have less substantial midden components and lack cemeteries. Interior residences are smaller than primary or secondary villages and tend to be positioned on ridges and low-lying hills. The deposits from these sites suggest repeated or more residential use, and they are most likely the result of temporary encampments devoted to harvesting terrestrial resources (Braje et al. 2007; Clifford 2001; Perry and Glassow 2015). Their placement on top of ridges and hilltops might be strategic positioning for defensibility of economic plant resources (Clifford 2001). The fourth type of site identified by Kennett was logistical encampments, which are sites that suggest special purpose activities, typically related to subsistence and resource acquisition far from a village site.

2.4.3 *Late Holocene (3,350–Present)*

The late Holocene on the NCI is best characterized by substantial population growth and demographic expansion to areas that did not previously have evidence of permanent settlement at the beginning of the late Holocene, along with several other cultural phenomena related to these changes (Kennett 2005; Winterhalder et al. 2010; Jazwa et al. 2016b, 2019). Throughout the late Holocene, there is a general increase in fish bone at coastal village and fishing sites, suggesting a shift in subsistence strategies (Jazwa et al. 2019, 2020). There was a short-term increase in radiocarbon dates (interpreted as demographic expansion) on the NCI around 1300 BP that may have been related to climatic amelioration (Figure 2; Jazwa et al., 2016a; Kennett 2005). These patterns mirror larger late Holocene cultural patterns of demographic expansion in the southern California region (Braje et al. 2007; Kennett 2005; Kennett and Kennett 2000; Rick 2004). This was followed by a decrease in the number of sites from about 1150–600 cal BP, which is roughly coincident with the MCA (Jazwa and Rosencrance 2019; Kennett 2005). The MLT (Figure 3) is roughly coincident with the end of the MCA and is associated with accelerated social change and technological development (Arnold, 1991, 1992, 2001; Raab and Larson 1997; Kennett 2005). During this period, there were changes in subsistence patterns, including an expansion of fishing strategies that included pelagic (deep-sea) fish. *Olivella* bead craft specialization took off and there were major technological developments, such as the development of the single-piece shell fishhook, which may be related to pelagic fishing (Arnold 1992; Braje et al. 2007; Kennett 2005; Rick et al. 2005). Following this, during the Late Period (650–168 cal BP; Arnold 2001a; Figure 3) population continued to grow and congregate in large, coastal villages that were present at contact (Arnold 2001a; Kennett 2005). After Spanish contact, population declined (Laverty 2020).

Although the Island Chumash first interacted with Cabrillo in 408 cal BP (AD 1542), it was not until the mission period that there were marked differences in the archaeological record (Arnold 2001; Glassow et al. 2010; King 1990). Nevertheless, Spanish artifacts, such as glass trade beads and iron needles, have been found at archaeological sites postdating this time, and the islanders were clearly aware of the Spanish presence in California (Glassow et al 2010). In this thesis, I use the term “post-contact” to describe this period. Contact, *sensu* Silliman (2005:205), “does not mean the advent of agency [for Indigenous people], but rather an alteration of its expression.” It is common practice in U.S. archaeology to categorize sites within a prehistoric-protohistoric-historic triad (Panich and Schneider 2019). However, temporal classifications like “historical” can still unwittingly erase long-term cultural trajectories.

Therefore, I have chosen language that highlights that the processes of colonization continue today, and that the Indigenous people whose ancestors we study are still present (Tuhiwai Smith 2012). Furthermore, the use of the term prehistoric to identify Indigenous assemblages implies that only written documents count as legitimate “history”, assumes that Indigenous Peoples were not documenting history until they came into contact with Europeans, and inherently invalidates the ways in which Indigenous peoples recorded their own histories (Yonging 2018). Archaeology has a long way to go before we can consider it decolonized (Schneider and Hayes 2020), but the incremental work we all do will bring result in a more powerful research tool from which Indigenous people and all people can benefit (Atalay 2006).

2.5 Present Study: Specific Background

2.5.1 *SRI Rockshelters*

This study focuses on four small rockshelter sites on the northern half of SRI and how they fit into the subsistence-settlement systems of that island (see Figure 4). Jazwa (2012, 2014) recorded 16 small rockshelter sites on the north and east end of SRI during survey and excavation projects in 2012 and 2013, four of which are the sites in this study. In the areas surveyed, rockshelters are most prevalent in Cow (n=7) and Lobos (n=6) canyons, while Soledad, Tecolote, and Upper Cherry canyons each had one rockshelter site. The assemblages at these sites are generally small lenses of shell midden, although some had more substantial deposits and artifacts, such as sandstone bowl fragments and groundstone. Earlier surveys from the 1990s also located several rockshelters in La Jolla

Vieja Canyon (unpublished site records). Kennett also located several rockshelters in Cañada Verde (unpublished site records).

CA-SRI-147 is a prominent site that contains a series of caves and rock shelters in La Jolla Vieja Canyon on the south side of SRI (Braje et al. 2007; Orr 1968). The rockshelters contain archaeological materials, habitation debris, numerous human burials, and the only known petroglyphs on SRI. The site has a remarkably long occupational sequence that spans from the early Holocene (7,300 cal BP) through the late Holocene (350 cal BP). There is a general decline in the size of California mussel shell size over time as well as an increase in species diversity from faunal assemblages at the site, which reflects dynamic human-environment interactions revolving around population growth and anthropogenic impacts to the environment, climate change, and ecological reorganization (Braje et al. 2007).

2.5.2 *Interior Settlement Patterns on SRI and the NCI*

While this study focuses specifically on SRI, it is beneficial to first review the research regarding settlement systems on the NCI for context. Archaeological research on the NCI has tended to focus to the large, complex sites along the coast (Arnold 1992, 1995; Erlandson and Rick 2002; Kennett 2005; Kennett and Conlee 2002; King 1990; Orr 1968). While attention has been paid to interior settlement on the NCI in the past (e.g., Highland Culture, Orr 1968), recent research has focused more explicitly on interior sites and how they integrate with broader settlement patterns on the NCI (e.g., Gill 2015; Hoppa 2017; Jazwa and Rosencrance 2019; Perry and Glassow 2015; Thakar 2014).

Interior settlement is generally defined as sites located on and above the upper marine terraces on the islands (Jazwa and Rosencrance 2019; Kennett 2005; Orr 1968).

The attention given to interior settlement is related in part to recent research that explores the dietary importance of terrestrial resources for Indigenous populations (Gill 2015; Gill et al. 2021; Hoppa 2014, 2017; Gill and Hoppa 2016; Thakar 2014), because paleo-subsistence research on the NCI has traditionally focused primarily on marine resources (Arnold 1992; Braje et al. 2007; Erlandson et al. 2009; Kennett 2005). Other terrestrial resources undoubtedly attracted people to the island interiors include toolstone and fuelwood for fire (Gill 2015; Perry and Glassow 2015). Fresh water in particular is an essential resource that is most reliably available on the island interiors, especially during the dry season and periodic droughts (Jazwa et al. 2016a). In their overview of interior site occupation on SCrI, Perry and Glassow (2015:201) connected one late Holocene interior site—CA-SCrI-647—to a fresh water source in the form of reliable seep and fog capture on local vegetation.

Interior site size and complexity varies throughout time on the NCI. During the middle Holocene, there is evidence for interior residential bases that appear to have been used repeatedly. CA-SRI-50 is the best example of such an interior residential base on SRI (Jazwa et al. 2015). The site is located between Dry Canyon and Cañada Verde, approximately 4 km from the coast. Its shellfish faunal assemblage is similar to coastal residential bases in density, but it is comprised primarily of *Mytilus californianus* (California mussel). Jazwa et al. (2015) analyzed midden assemblages from this site using Central Place Foraging (CPF) to network this site with local coastal residential bases and red abalone special purpose sites.

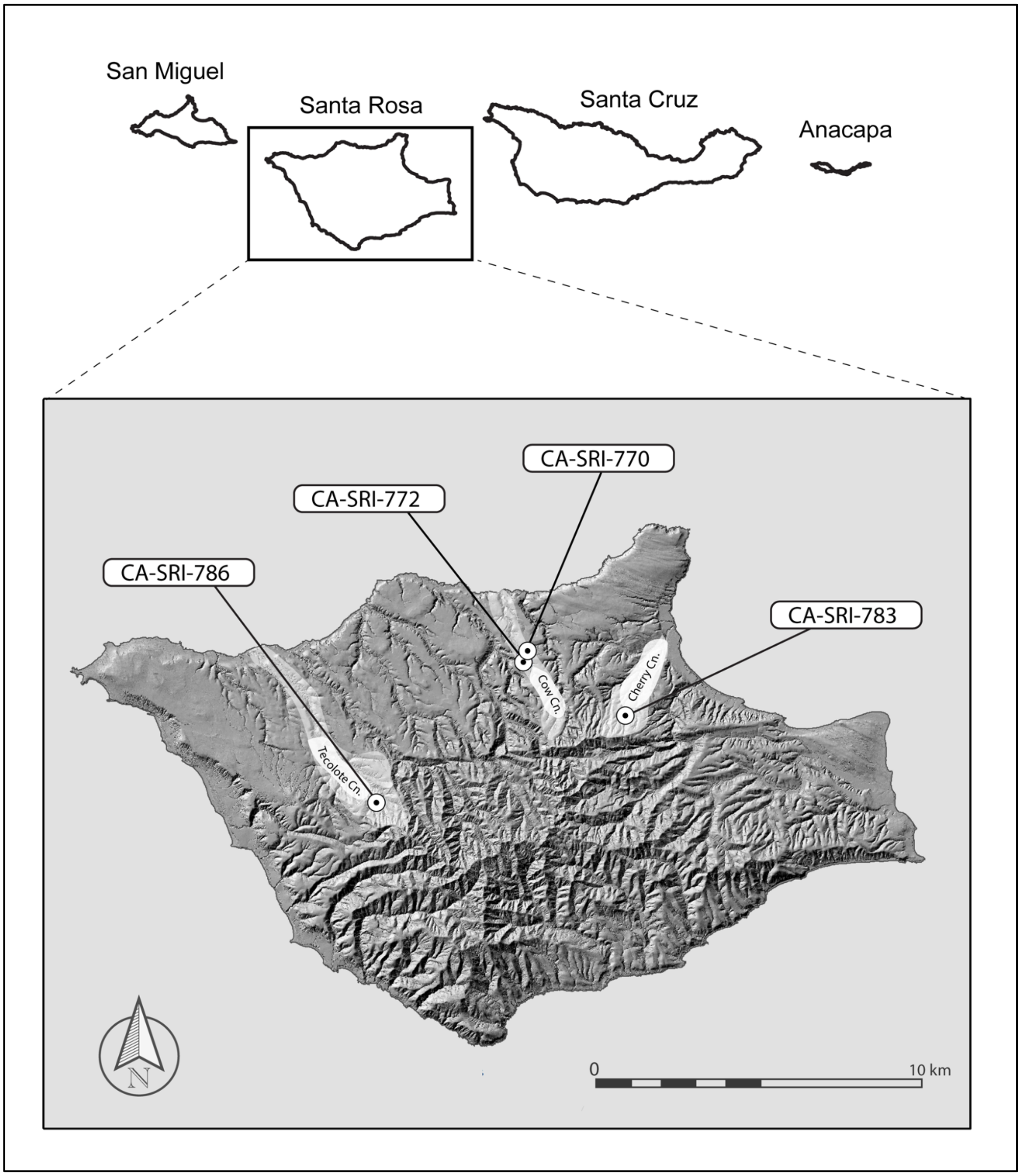
More recently, Jazwa and Rosencrance (2019) assess the chronology, distribution, and contents of 111 sites in Pocket Field on interior SRI. There appears to be two primary periods of habitation in this area. The first episode dates to the terminal-Pleistocene/early-Holocene (before 7550 cal BP) and the other to the late Holocene (3600–168 cal BP), although there is limited evidence of habitation during the middle Holocene. Approximately 30% of sites that were recorded in Pocket Field (34 sites) are residential sites, while another 52 sites contained low-density midden. Groundstone is prevalent in the Pocket Field, but there is a decrease in its abundance through the late Holocene. Pocket Field was more intensely occupied during the MLT in particular. This is possibly because the area allowed for greater access to fog water during this period. The highest density of dated sites occurred during the Late Period.

2.5.3 *Study Sites*

Previous studies have verified that people were going to the interior of SRI for terrestrial resources, including fresh water (Jazwa and Rosencrance 2019; Jazwa et al. 2015). Some of these sites were very likely residential bases, but many are small and ephemeral, and their exact purpose is unclear. While small sites tend to receive less attention because they may offer a limited diachronic perspective, they are nevertheless fundamental for understanding entire subsistence settlement systems (Binford 1980; Butzer 1982; Kennett 2005). Some researchers who study settlement patterns on the NCI (e.g., Arnold and Martin 2014; Kennett 2005; Perry and Glassow 2015) propose that ephemeral late Holocene sites are the product of targeted, logistical forays for terrestrial resources. In this study, I will examine the faunal assemblages from four of these small sites on the north side of SRI to evaluate their logistical function so that we may better understand how they integrate into larger settlement patterns.

The sites in my study were recorded as part of an archaeological survey project led by Christopher Jazwa on SRI during summer and fall of 2012 and 2013 (Jazwa 2012, 2014). The goal of this project was to survey the coastal terrace on the northern side of the island, including drainage bottoms. The sites in my study are located in Upper Cherry Canyon (CA-SRI-783), Tecolote Canyon (CA-SRI-786), and Cow Canyon (CA-SRI-770, CA-SRI-772; Figure 2.4).

Figure 2.4. Location of rockshelters in this study. Drainages are highlighted and labeled.



CA-SRI-770

This site is a large sandstone rockshelter with small midden component located in a small side branch of Cow Canyon that extends east from the main canyon. It is visible from a long distance to the north. There is a dry waterfall in the middle of the site that is likely seasonally active. It is easily accessible from the base of Cow Canyon or from the terrace above the site. The rockshelter is heavily eroded, with the sand from the walls and ceiling covering the shelter floor. The midden layers are intact in parts with the potential that it was occupied repeatedly. A 25 cm x 25 cm column sample was excavated to a depth of 83 cm below datum in August 2019 by Jazwa, Tyler Molter, Richard-Patrick Cromwell, and Gilbert Unzueta. Much of the depth of this unit was sand overburden from the rockshelter walls.

CA-SRI-772

This site is a small rockshelter site with a dense midden near the top of the western wall of Cow Canyon, intervisible from CA-SRI-770. It is more readily accessible from above than below. There is a dense midden layer at the base of the rockshelter and midden is spilling out of it and down into a streambed below. This rockshelter differs from most others in Cow Canyon in that it is made of volcanic bedrock rather than sandstone. The cave is therefore not eroding as quickly, and the midden is not as deeply buried. A 25 cm x 50 cm column sample was excavated to a depth of 37 cm below surface in August 2019 by Jazwa, Kirk Schmidt, Jennifer Mak, Alan Salazar, and me.

CA-SRI-783

This is a cave site near Black Mountain in one of the branches of the top of Cherry Canyon. It is accessed most readily from the ridgeline above. It has a diverse assemblage that includes shell, fish, bird, lithics, *Olivella* beads, and groundstone. The midden is dense and eroding down the slope in front of the rockshelter. There is a large viewshed from the cave that extends all the way to the plateau above Carrington Point to the north and Skunk Point to the east. It is in a steep drainage, that likely is wet only occasionally. A 25 cm x 50 cm column sample was excavated to a depth of 54 cm below surface in August 2019 by Jazwa, Molter, Cromwell, and Unzueta.

CA-SRI-786

This is a large rockshelter, shell midden, and lithic scatter site approximately 200 m from the head of Tecolote Canyon. It is located at the base of an ephemeral waterfall and there is a small depression in front of the shelter where water likely accumulates seasonally. This location is challenging to reach from any direction, but can be reached from the terrace above or by walking up the drainage. The rockshelter is in volcanic bedrock rather than sandstone, so interior erosion does not obscure the midden with sediment. There is a low-density shell midden with a light lithic scatter interspersed. Stratigraphy is visible below the rockshelter because of erosion. A 25 cm x 25 cm column was excavated to a depth of 60 cm below datum in August 2019 by Jazwa, Molter, Cromwell, and Unzueta.

Chapter 3: Theoretical Background

In hunter-gatherer archaeology, reconstructing settlement patterns is foundational to help researchers formulate and test hypotheses regarding the decisions people made in the past, including how to respond to climate change or how to mitigate social conflict (Bird and O'Connell 2006; Kennett 2005; Winterhalder and Smith 2000). For hunter-gatherer groups, decisions regarding mobility and settlement are foundational to most activities, be they individual or group. Mobility is first and foremost important for subsistence activities, whereby individuals and groups mitigate spatial and temporal variation in critical resource distribution, particularly water and food (Jazwa et al. 2015; Jazwa et al. 2016a; Perry and Glassow 2015). Raw material collection, material conveyance, and trade also necessitate strategic mobility (Alvard 2006; Beck et al. 2002; Kelly et al. 2006). Hunter-gatherers move and settle for social purposes as well, including social networking, information exchange, political interactions, and searching for mates (Kelly 2007; Murdock 1967; Robinson and Weinhold 2016). Collectively, these activities form settlement systems, all of which produce cultural residues that archaeologists might find in the record.

Starting with processual archaeology in the 1960s (e.g., Binford 1980; Butzer 1982), archaeologists have used anthropological case-studies of modern hunter-gatherer groups to better understand the rationale behind their mobility subsistence systems and the material products of those systems (Binford 1980; O'Connell and Bird 2006). Dichotomous typologies have proven to be useful heuristic tools for understanding ranges of variation in hunter-gatherer behavior (Jochim 1991). These dichotomies express how hunter-gatherers make decisions regarding environmental fluctuations and resource abundance through social organization tactics including mobility, sedentism, and food storage (Bettinger and Baumhoff 1982; Keeley 1988; Testart et al. 1982; Woodburn 1982). During his fieldwork among the Inuit people of central Alaska, Binford (1980) developed a dichotomous typology for hunter-gatherer mobility that I use in this study: residential and logistical mobility. Residential movement is the movement of all members of a residential base from one locality to another. In this scenario, people are considered foragers who map on to resources, and follow resources (food, water, raw material, etc.) from one locale to another. The second concept is logistical movement, which entails the movement of specially organized task groups on temporary excursions from a main residential base, who collect food and bring it back to a main residential camp. Although dichotomous in theory, these concepts are not absolute categories and may overlap in many cases.

3.1 Seasonal Mobility

Environmental fluctuations and their predictability are highly influential on hunter-gatherer settlement patterns (Jochim 1991; Kelly 1988). In regions with cool, wet winters and warm, arid summers like the NCI, seasonal fluctuations in food resources and fresh water availability are primary factors for movement and reorganization of settlements (e.g., Balase and Ambrose 2002; Berger et al. 2016; Jazwa and Jazwa 2021; Stiner and Munro 2011). Therefore, being able to identify the season in which a site was used is helpful to reconstruct settlement patterns in these types of environments. Seasonality studies involve identifying data sets that can be directly connected to the duration and nature of site use. This includes seasonality inferences from palaeobotanical remains (Gill 2015; Greenway 2004; Joslin et al. 2006; Thakar 2014), feature and structure remains (Gill 2015), tool assemblage diversity (Dow and Reed 2015), remains of migrating animal species (Walker and Craig 1979), and other changes in the skeletons and teeth of animals that may be related to age and seasonality (Broughton 1994; Winters 1969). Understanding site seasonality gives us a temporal perspective on settlement patterns, which is necessary for fully understanding hunter-gatherer behavior. Many studies exist on the NCI connecting past settlement patterns to seasonal resource fluctuation (e.g., Jazwa and Kennett 2016; Jazwa et al. 2015; Jew et al. 2013, 2014; Kennett 1998).

Climate change has affected seasonal variability in the past, which we can track through patterns of settlement in the archaeological record. For example, seasons might shift earlier or later depending on environmental inputs, which in turn have effects on effective moisture and primary production. These seasonal shifts are recorded in various environmental proxies. For example, Heusser et al. (1985) used surface samples of modern pollen to estimate trans-Holocene temperature and precipitation values for southern Alaska, the Olympic Peninsula in Washington, and the Coast Mountains of British Columbia. They found that the quantified mean July temperature and annual precipitation estimates for these three areas were synchronously variable through the Holocene, implying that seasonal duration and intensity was also variable. Heusser and Sirocko (1997) conducted similar research in southern California and found a succession of brief (<200 year) massive precipitation events that occurred at the end of the Pleistocene into the early Holocene. They correlate these events with synchronous monsoonal events in the northern Indian Ocean that are likely past tele-connected ENSO events. These cycles stop in the early Holocene and suggest an amelioration in seasonal intensity and climate. Studies connecting past climatic and seasonal variation have been conducted on the NCI. For example, Arnold (1992) used Pisias's (1978) climate record of radiolarian assemblages to attribute the MLT cultural change (including changes in settlement patterns) to shifts in SST and consequent disruptions in marine ecosystem productivity. Arnold and Tissot (1993) substantiated this perspective with a growth study of black abalone in MLT archaeological assemblages. Although later studies have challenged this perspective (Kennett and Kennett 2000), this study remains a good example of connecting climatic and seasonal shifts to social change.

3.2 Human Behavioral Ecology

HBE is a well-established and effective theoretical approach for exploring individual decision-making in the archaeological record (e.g., Bettinger and Baumhoff 1982; Jazwa 2015; Kennett 2005; Thakar 2014). While one of the goals of archaeology is to reconstruct human behavior from archaeological residues, HBE uses heuristic models that account for the behavior as reconstructed (Bird and O'Connell 2006). In other words, we can formulate specific hypotheses about individual behavior and then systematically test the associated predictions using the archaeological record. HBE applies the principles of evolutionary ecology and optimization to the study of human behavior, life history, and morphology to understand why certain patterns of behavior arrive and persist (Bird and O'Connell 2006; Winterhalder 1986; Winterhalder and Smith 2000). From an evolutionary perspective, humans are subject to natural selection and will seek out adaptive ecological strategies that promote Darwinian fitness (Borgerhoff Mulder and Schacht 2012). A behavior is adaptive when it enhances an individual's inclusive fitness, defined most generally as its propensity to survive and reproduce. Assuming that people will choose to act optimally according to evolutionary principles, deviations from model predictions provide a starting point from which to learn about human populations (Bird and O'Connell 2006). In this study, my hypotheses and expectations are influenced by major components of two HBE models. The first is Diet Breadth, with explores individual choices made regarding subsistence resources and their availability over time (e.g., Braje et al. 2007). The second is Central Place Foraging, which helps explain site formation processes, including decisions regarding resource field processing, mobility, and sedentism (e.g., Jazwa et al. 2015).

3.2.1 *Diet Breadth*

Diet Breadth is part of a set of models from evolutionary ecology known as Optimal Foraging Theory (OFT; Bird and O'Connell 2006). These are some of the most widely used models in HBE (e.g., Bettinger and Baumhoff 1982; Braje 2012; Erlandson 1988; Erlandson et al. 1999; Nettle et al. 2013; Simms 1987). OFT models help develop predictions regarding how an individual makes decisions when searching for food in its environment (e.g., MacAurthur and Pianka 1966). Diet breadth investigates how an individual will optimize its intake of various food or prey under changing environmental circumstances (Charnov 1974). Prey items are equated with a currency—in this case calories—so that they can be ranked according to their value. Value is determined by the difference between the benefit (i.e., caloric return) and the cost of including a prey item in the diet. Cost is determined by several factors, including the likelihood of encountering prey, the cost of pursuit, and the cost of processing the prey. A forager's diet will be broad (incorporating a wide variety of prey) or narrow (focusing on a few prey items) depending on how long it takes to find, harvest, and process each food resource. Diet breadth therefore correlates to environmental productivity and tends to increase as environments are exploited to the point of resource depression (Charnov et al. 1976).

Applied to HBE, the diet breadth model formalizes the assumption that humans will make economically and socially informed decisions regarding resource use based on long-term interactions with their environments. These decisions have implications for settlement patterns. For example, as higher-ranked resources become depleted around a residential base, foraging efficiency declines. This will result in foragers either increasing their diet breadth, moving their home base, or some combination thereof (e.g., Braje et al. 2007). Increasing diet diversity may also signal the initiation of intensification processes. Intensification tends to promote greater sedentism by investment in food processing and storage (Bettinger 1991), or by intensifying other extractive activities, as was the case on the NCI (i.e., Olivella shell bead production; Arnold 2001). There are many ways to determine diet breadth from the archaeological record, including diversity analysis of faunal (e.g., Jazwa and Kennett 2016) and botanical (Gill 2015; Thakar 2014) components of site assemblages.

3.3.2 *Central Place Foraging*

The Central Place Foraging (CPF) model is used to investigate the choices an individual faces regarding collecting, processing, and transporting selected resources to a central place (Barlow and Metcalfe 1996; Burger et al. 2005; Lupo 2001; Orians and Pearson 1979). CPF models both how individuals might optimize foraging with respect to a home base (e.g., Bettinger et al. 1997) and how foragers may locate a central place with regard to resource distribution (e.g., Zeanah 2004). Optimal decisions are sensitive to the size and utility (i.e., energetic benefit after processing) of a resource, the time required for processing, the ratio of edible components of a resource compared to its inedible components (e.g., ratio of nut meat to shell), and transport distance from collection sites back to the residential base (Barlow and Metcalfe 1996; Bliege Bird and Bird 1997; Jazwa et al. 2015).

CPF is helpful for understanding archaeological site formation processes through the lens of resource selection, processing, and transport decisions, which can help to interpret past decisions regarding mobility and settlement strategies. Archaeological assemblage data are analyzed to see how they reflect the field processing decisions that are part of a larger resource procurement strategy. For example, the farther away from the central place the procurement site is, the more appealing it is for foragers to expend energy and time to process a resource in the field, thereby increasing its utility, before returning to their central place (Metcalfe and Barlow 1992). To illustrate, in their fieldwork with the Meriam in coastal Australia, Bleige Bird and Bird (1997) found that some taxa were over-represented in residential deposits relative to their dietary importance, whereas high-energy yield taxa that were easy to process were more likely to be under-represented because these taxa were more likely to be processed prior to transportation. If we were to look at this midden archaeologically, the under-representation of a species may lead us to incorrectly underestimate the importance of a given species in the diet of the people from that site, while over-representing the importance of that species at another. Jazwa et al. (2015) used CPF to demonstrate that during the middle Holocene, *H. rufescens* was more likely to be preferentially processed (i.e., shucked) on the coast whereas *M. californianus* was more likely to be transported to sites in the island interior as long as they were farther than the threshold distance. They based this on decisions regarding travel thresholds for field processing (Bettinger et al. 1997; Jazwa et al. 2015). A travel threshold is the point at which an individual would decide to preferentially process a prey item in the field rather than collect it whole to bring back to the home base. In the case of the NCI, large-bodied shellfish prey, such as *H. rufescens*, are most often found in coastal midden assemblages because they have a low field processing travel threshold.

Chapter 4: Hypotheses and Expectations

By the late Holocene, most of the settlement across the NCI had concentrated into large, multi-family coastal villages containing rich artifact and faunal assemblages and residential structures, evinced in the record by surface house depression features (Gill 2015; Kennett 2005; Perry and Glassow 2015; Rick et al. 2005; Jazwa and Jazwa 2021). The large interior residential bases from the middle Holocene appear to have been used less frequently during this time (e.g., Gill 2015; Thakar 2014). By and large, late Holocene interior sites on the NCI are characteristically small and ephemeral (Kennett 2005; Rick et al. 2005). The nature of these site assemblages, contrasted with large residential bases with substantial deposits, likely represent logistical encampments or short-term residential bases (Kennett 2005; Jazwa and Rosencrance 2019). This study will add data to previous comparative analyses of interior site assemblages (e.g., Jazwa and Rosencrance 2019) to better understand their function within the late Holocene settlement systems on SRI.

The objective of this thesis is to investigate why there is an apparent shift in interior settlement during the late Holocene on SRI during two time periods: the late Middle Period/MLT and after Spanish contact. The extreme droughts of the MCA overlap with the first period and I argue likely influenced the settlement patterns of the time, although other factors also influenced settlement decisions during this period. During the second period, I propose that Spanish contact was the most probable factor influencing settlement decisions, although other factors likely also influenced settlement. I have two primary hypotheses, one associated with each of the time periods indicated in this study. During the late Middle Period/MLT, settlement along the California coast and Channel Islands was very likely influenced by persistent droughts (Raab and Larsen

1997; Yatsko 2000). Consistent with this interpretation, the first hypothesis is that **people moved to the island interior seasonally in small populations during the late Middle Period/MLT, at times in response to extreme MCA droughts, as they tried to obtain water from resilient springs and/or fog condensation at higher elevations**. Therefore, the sites corresponding to the late Middle Period/MLT (CA-SRI-770, CA-SRI-786, and the late Middle Period/MLT component of CA-SRI-783) should reflect a settlement pattern of temporary occupation specifically during the summer drought months (May through October; Erlandson et al. 2019; Kennett 2005). This pattern could have been the result of people going to the interior to collect fresh water from more reliable sources (including springs and fog zones) as drainage bottom-water sources became increasingly unreliable during the MCA mega-droughts (Jazwa et al. 2016a; Perry and Glassow 2015). Several expectations follow from this hypothesis: (1) the faunal and cultural assemblages should have relatively low diversity and density compared to the later sites, which is representative of shorter periods of occupation (Jazwa 2015); (2) artifacts including *Olivella* shell beads, lithics, and groundstone should be rare or absent at these sites; (3) the $\delta^{18}O$ profiles of *Mytilus californianus* shells from these sites should correspond to seasons that are dry but have consistent overnight fog drip (May through October; Erlandson et al. 2019; Kennett 2005); (4) these sites should be in proximity to known resilient water sources on the interior of SRI, which were identified during a multi-year reconnaissance of surface hydrology during the extreme drought of 2014 – 2016 (Power and Rudolph 2018).

After Spanish contact, interior settlement was likely influenced by culture contact with explorers. Rather than moving to the interior with the primary purpose of collecting terrestrial resources, settlement decisions may have been made for other reasons, including protection or to monitor the coastline. Therefore, my second hypothesis is that **after contact, interior settlement at rockshelters reflects a more substantial or permanent settlement system for small population groups.** Therefore, the sites corresponding to this period (CA-SRI-772 and CA-SRI-783) should reflect a settlement pattern that is more residential in nature, perhaps as small groups avoided contact with colonists arriving by boats on the coast. Several expectations follow from this hypothesis: (5) the site assemblages should have higher diversity and density of cultural materials than that of the late Middle/MLT sites; (6) these sites should contain artifacts that are typically associated with residential sites, including *Olivella* shell beads, lithics, and groundstone; (7) the $\delta^{18}O$ profiles of *Mytilus californianus* shells from these sites should reflect a pattern of year-round habitation; and (8) because this was not during a relatively dry period, settlement locations should be less influenced by proximity to fresh water sources, and instead other factors like viewshed should be more important. In sum, these sites should reflect residential patterns of habitation, albeit less dense than contemporaneous coastal sites.

Chapter 5: Methods

5.1 Site Excavation and Chronometric Dating

All four sites investigated in this thesis were recorded in 2012 by teams of four crew members led by Christopher Jazwa as a part of a systematic survey of interior drainages on Santa Rosa Island. They were revisited and excavated in August 2019. Unit sizes were determined by the structure of the site. CA-SRI-770 and -786 contained eroding escarpments with exposed midden lenses. They were excavated as 25 x 25 cm column samples. CA-SRI-772 and -783 do not contain exposed lenses, so they were excavated from the surface. They were 25 x 50 cm column samples for allow for excavation to deeper levels. All materials larger than 1/8” were kept, with soil that passed through the screen kept in entirety for the 25 x 25 cm units and for the western half of the 25 x 50 cm units. Excavation of all sites was done in 10 cm arbitrary levels, with materials from clearly distinct strata separated. While deposits from CA-SRI-772 and -783 were exposed on the surface, those from CA-SRI-770 and -786 were buried under a lens of sediment. Material was sorted through 1/2-inch and 1/8-inch screens in the field, with each bagged separately to prevent damage during transportation.

Jazwa et al. (2016) obtained AMS dates from *Mytilus californianus* shells from all four sites, the results of which will be applied to this study. These samples were collected during the initial survey either from deposits exposed on the floor of the rockshelter or from exposed lenses. In this study, I obtained additional dates from CA-SRI-772 and -783 from samples collected during excavation. Because CA-SRI-770 and -786 are narrow lenses, they were each represented by a single date. All radiocarbon samples were manually and chemically cleaned at the UNR Human Paleoecology and Archaeometry Laboratory. Whole shells were then sonicated in deionized water to remove dirt and subjected to a 50% HCl etch to remove contaminants. Approximately 30 mg of powder was drilled from along the growth axis, which was subjected to a further 10% HCl etch. Samples were then hydrolyzed under vacuum using phosphoric acid. Carbon dioxide was separated from non-condensable gases and submitted to the Penn State AMS Laboratory for graphitization and measurement.

5.2 Midden Analysis

The midden from each unit was sorted through 1/2-inch, 1/4-inch, and 1/8-inch mesh screens and bagged separately. For each level, the 1/2-inch material, a 100-gram subsample of 1/4-inch material, and a 15-gram subsample of 1/8-inch material was completely sorted, separating taxa of shellfish and faunal constituents and other distinct cultural materials. Subsampling in this way has previously been used to estimate the weight contributions of major constituents for each excavation level (Jazwa et al. 2012, 2013, 2016; Kennett 1998; Braje et al. 2007). The remaining 1/4-inch and 1/8-inch material was partially sorted using the "Powersort" method following Kennett (1998). The material extracted during the Powersort was formal artifacts, *Mytilus* hinge fragments, bone, asphaltum, charcoal, lithics, and *Olivella biplicata*. Complete and fragmented *Olivella* shells were included in the Powersort because it was not a dietary species and therefore likely to be bead detritus (Bennyhoff and Hughes 1987; King 1990; Arnold and Munns 1994). All data were compiled by excavation level. Since excavation levels varied in size because of the two different column sample widths and because stratigraphically distinct materials were separated, they are not uniform in volume. All faunal data were therefore normalized to a volume of one cubic meter. The data from each unit were also combined for each component and normalized again to one cubic meter.

I used measures of shellfish assemblage diversity and density to characterize midden from each site, as shellfish make up the bulk of faunal remains in each midden (Braje et al. 2007; Jazwa 2015). Changes in shellfish taxonomic diversity were estimated using the Shannon-Weaver function as described by Reitz and Wing (1999:235). I also calculated Shannon-Weaver diversity values for the entire shellfish assemblage of each site, which I then use to compare my sites to others on northern SRI. As discussed by Reitz and Wing (1999), the Shannon-Weaver function is as follows:

$$H' = -\sum p_i * \ln(p_i)$$

In this case, p_i is the proportion of each shellfish taxon per level or site.

5.3 Seasonality and Isotope Ecology

I estimated site seasonality from $\delta^{18}O$ measurements of *Mytilus californianus* shells from three sites pertaining to both periods to infer site use: CA-SRI-770 (late Middle), CA-SRI-772 (post-contact), and CA-SRI-783 (post-contact component). CA-SRI-786 lacked sufficient *Mytilus californianus* shells with terminal growth for analysis. Estimating the seasonality of mollusk harvest (and associated site occupation) using stable oxygen isotopic measurements ($\delta^{18}O$) from marine shell carbonate is a well-established method for tracing past SST and seasonal variation (Jones and Kennett 1999).

Initially used in paleoenvironmental reconstruction (Epstein et al. 1953; Killingley and Berger 1979), this technique works on the premise that the $\delta^{18}O$ ratios in shell (both marine and freshwater) are influenced by the physical and chemical environment of their growth, particularly Sea Surface Temperature (SST) and salinity. In the context of the open ocean with minimal terrestrial water input, as on the NCI, I can assume constant salinity (and therefore ambient $\delta^{18}O$). The oxygen isotopic ratios in marine shells are therefore dependent on the ambient SST at the time the shell carbonate for a mollusk is forming, and the final growth increment of mollusk shell represents the water temperature at the time it was harvested. This technique has been used widely (Loftus et al. 2019) and has a rich history on the California coast using *Mytilus californianus* shell (Glassow et al. 1994; Jones et al. 2008; Jones and Kennett 1999).

The process of determining the season of harvest from marine shell carbonate has two steps. First, we estimate the range of SST from the $\delta^{18}O$ measurements from the shell carbonate for shells sampled enough to encompass a whole year of variation. This is done by taking a full profile of two shells from each site. This was used to modify the annual water temperature pattern obtained from modern measurement data from 1981–1992 collected by J. Engle (Jazwa et al. 2015). This entailed drilling 20 carbonate samples at 2 mm increments along the growth axis using a 0.5 mm dental drill. Second, we estimate season of harvest from the $\delta^{18}O$ in the terminal growth band and several additional growth bands of a shell. For this step, I collected five carbonate samples from each of 18 other mussel shells from each site. Like the full profile, these samples were collected along the growth axis at 2 mm intervals. The terminal growth band was sampled using the side of the drill bit along the edge.

The resulting samples were sent to Yale Analytical and Stable Isotope Center (YASIC) for analysis. A total of 324 samples were analyzed. After the δ^{18}O values for the samples were determined, I estimated SST at the time of carbonate deposition using an equation for calcite established by Horibe and Oba (1972):

$$t°\mathrm{C} = 17.04 - 4.34(\delta c - \delta w) + 0.16(\delta c - \delta w)^2$$

This equation was modified from the original equation from Epstein et al. (1953), where δc is the measured δ^{18}O value from the sample. Following Jazwa et al. (2015), I use an island-wide average .26‰ for δw, the δ^{18}O of ambient seawater obtained from 28 seawater samples around the coast of Santa Rosa Island. The individual measurements can be referenced in Appendix B.

5.4 Geospatial Analysis

5.4.1 Optimized Hot Spot Analysis

I used ESRI Geographic Information System (GIS) spatial statistics to determine zones of the most resilient water sources on the island. I first determined the location of drought-resilient water sources using GIS data of surface water observations from Channel Islands National Park. These data were taken by the NPS during a survey of available surface water on SRI from the drought period lasting from 2014 – 2016 (Power and Rudolph 2018). I ranked three types of point data collected by the project. Points representing resilient water sources most likely to be used for drinking water were ranked in a numeric field with three categories: springs (3), seeps (2), and ponds (1). I then used the ESRI tool Optimized Hotspot Analysis to identify locations of statistically significant hot spots and cold spots in this data. Optimized Hot Spot Analysis uses vectors to identify and aggregate points of occurrence into polygons or converging points that are in proximity to one another based on a calculated distance. The analysis groups features when similar high (hot) or low (cold) values are found in a cluster. I then used the IDW Interpolation tool to rasterize point data generated by the Optimized Hot Spot Analysis tool, thereby creating an overlay of zones that should have the most attractive water sources on SRI during the drought episodes of the MCA.

Hot Spot Analysis identifies the statistical probability that point data should be clustered compared to a random distribution of events (Mitchell 2005). When examining point patterns, the density of points within a defined area is compared against a complete spatial randomness model, which describes a process in which point events occur completely at random. Many statistical tests begin with identifying a null hypothesis. For geostatistics, the null hypothesis is Complete Spatial Randomness (CSR). This can be for the features themselves or for the values associated with those features. CSR generates z-scores and p-values to determine if a null hypothesis can be accepted or rejected. To categorize the data, one must make a subjective judgement regarding what degree of risk is acceptable. For my analysis, I chose intervals of 90, 95, and 99 percent confidence intervals. The z-score is a probability that the observed spatial pattern was created by some sort of random process. When the z-score is small, it means that it is very unlikely that the observed spatial pattern is the result of a random process. Thus, the null hypothesis can be rejected. The p-value is a standard deviation. When a very high or very low z-score is associated with a small p-value, it indicates that the spatial patterning is unlikely to reflect the CSR or null hypothesis. I mapped the areas based on the probability that the data should be clustered based on their rank. Areas that have a 99% confidence rating that they are significantly clustered. It is in these areas that resilient water sources are likely to be collected, and therefore, more attractive to people seeking out fresh water. Areas that are identified as “cold spots” are unlikely to exhibit any sort of clustering.

5.4.2. Euclidean Distance Analysis

I also analyzed the probability that the sites in this study were located closer to resilient water sources (as defined above) compared to a set of randomized points. I calculated Euclidean distance from three categories of sites to the resilient water sources: 1) thesis rockshelter sites; 2) all recorded sites on SRI (n=1041); and 3) a set of randomized points generated for a polygon of SRI (n=800). I then gave these data to Christopher Morgan who tested for normality by generating histograms and running significance tests for normality using IBM SPSS 28. The significance for all tests was 0.05. We then ran the Mann-Whitney and the Wilcoxon-Ranked Signed tests to determine significant differences in the lengths of the three data sets to resilient water sources.

Chapter 6: Results

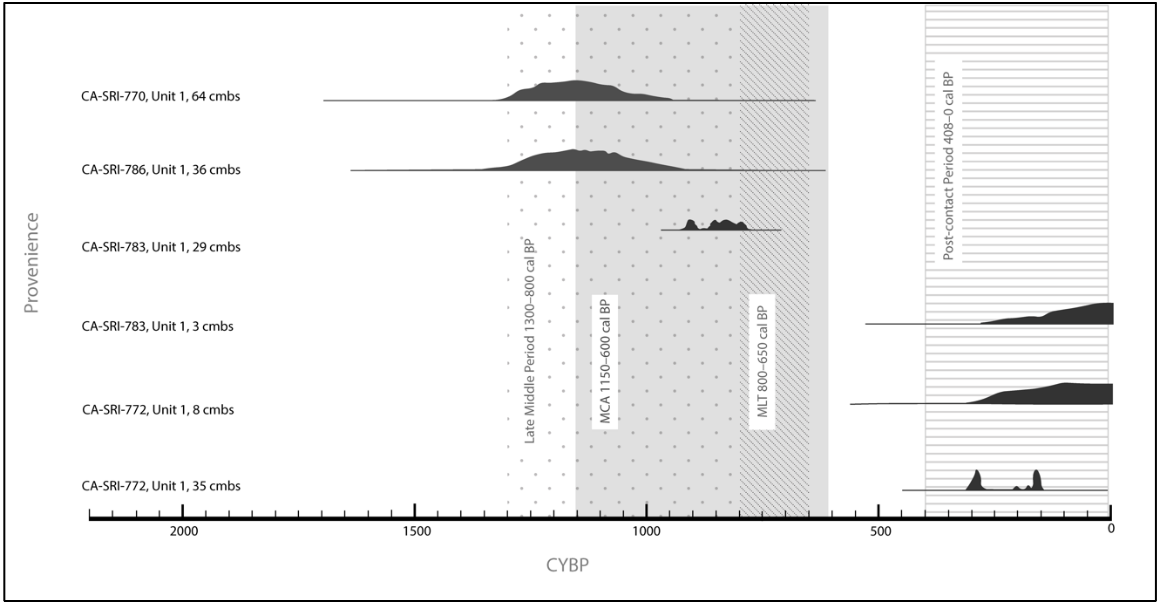
6.1 *Site Chronology*

Radiocarbon dates suggest that occupation of the sites in this project are divided between two periods: the late Middle/MLT and the post-contact period. Approximately half of the 95% probability date range for the dates from CA-SRI-770 and CA-SRI-786 is within the MCA (Table 6.1, Figure 6.1). Two radiocarbon samples were taken from CA-SRI-772. Both samples post-date the period of contact (Table 6.1). CA-SRI-783 spans both the late Middle/MLT and the post-contact period, so I split the midden assemblage from this site into two periods for analysis: CA-SRI-783 (late Middle/MLT) and CA-SRI-783 (post-contact; Figure 6.1). Four of the six samples are from marine shell and therefore were calibrated using the Marine20 calibration curve (Heaton et al. 2020). For these samples, I used variable delta R values for the Santa Barbara Basin that have been updated for the new calibration curve (Hendy et al. 2013; Sean Hixon, Brendan Culleton, and Douglas Kennett, personal communication 2021). The two charcoal samples were calibrated using IntCal20 (Reimer et al. 2020).

Table 6.1. Radiocarbon data for sites in this study. All samples were calibrated using OxCal 4.4 (Bronk Ramsey 2021).

Provenience	**Material**	**Lab Number**	**^{14}C age (BP)**	**±**	**ΔR**	**ΔR Error**	**95.4% cal BP**
CA-SRI-770, Unit 1, 64 cmbs	*Mytilus californianus*	UCIAMS-116214	1685	15	-77	71	1330 – 950
CA-SRI-786, Unit 1, 36 cmbs	*Mytilus californianus*	UCIAMS-115033	1670	15	-74	71	1310 – 940
CA-SRI-783, Unit 1, 29 cmbs	Charcoal	PSUAMS-6858	965	20	N/A	N/A	925 – 795
CA-SRI-783, Unit 1, 3 cmbs	*Mytilus californianus*	PSUAMS-6883	715	15	142	77	240 – 0
CA-SRI-772, Unit 1, 8 cmbs	*Mytilus californianus*	UCIAMS-116215	770	15	131	74	270 – 0
CA-SRI-772, Unit 1, 35 cmbs	Charcoal	PSUAMS-6857	225	20	N/A	N/A	305 – 0

Figure 6.1. Radiocarbon sequence for sites in this thesis. The dotted area represents the late Middle Period (1300-800 cal BP), the area with diagonal lines represents the MLT (800-650 cal BP), the solid grey area represents the MCA (1500-600 cal BP), and the area with horizontal lines represents the period after contact (408-0 cal BP).



6.2 *Midden Analysis*

As with most sites on the NCI, shellfish make up the bulk of the midden assemblages in this study by measured weight, between 94.6–99.7% of the assemblage for each site (Table 6.2; Figure 6.2). Fish is the next most common faunal constituent (other than shellfish) and comprises 5% of the assemblage at CA-SRI-786. Sea mammal and small mammal (i.e., rodent taxa) remains make up the remaining portions of the faunal assemblage. Since these are rockshelter sites, I assume that the rodent bone was from natural sources and not deposited by humans. Based on radiocarbon and assemblage data, I split CA-SRI-783 into two components for midden analysis. Based on the radiocarbon date from 29 cmbs (925–795 cal BP; Table 6.1, Figure 6.1), I analyzed the midden data for changes in composition. Because levels 0–10, 10–20, and 20–30 cmbs had a similar faunal composition and levels 30–40 and 40–54 cmbs were more alike, I am designating the midden from 0–30 cmbs as pertaining to the post-contact period, whereas

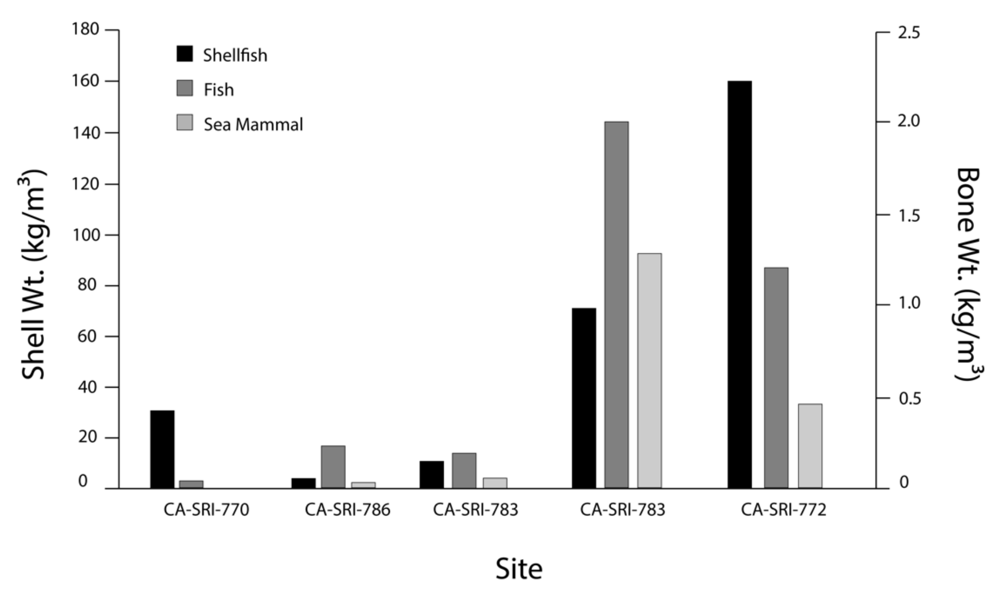
30–54 cmbs pertains to the late Middle/MLT. I also excluded the top level of CA-SRI-770 (8 – 44 cmbs) because it was overburden with negligible midden constituents. The weight values that I used in this analysis have been normalized to a volume of one cubic meter.

Table 6.2. Total weight (corrected to grams per cubic meter) and percentage of faunal constituents per unit.

Site	**CA-SRI-770**		**CA-SRI-786**		**CA-SRI-783**		**CA-SRI-783**		**CA-SRI-772**	
Period	**Late Middle**		**Late Middle**		**Late Middle/MLT**		**Post-contact**		**Post-contact**	
	Wt (g/m^3)	**Wt %**	**Wt (g/m^3)**	**Wt %**	**Wt (g/m^3)**	**Wt %**	**Wt (g/m^3)**	**Wt %**	**Wt (g/m^3)**	**Wt %**
Shellfish	31,012.2	99.7	4,140.5	94.6	11,802.3	97.4	71,085.0	95.4	159,721.7	98.8
Fish Bone	28.9	0.1	218.3	5.0	196.0	1.620	1,994.4	2.7	1,203.4	0.7
Sea Mammal Bone	0.0	0.0	18.3	0.4	43.7	0.4	1,290.7	1.73	455.4	0.3
Small Mammal Bone	61.3	0.2	0.3	0.01	74.3	0.6	108.5	0.2	241.9	0.2
Total Weight	31,102.3	100	4,377.3	100	12,116.3	100	74,478.6	100	161,622.4	100

By weight, it appears that the faunal constituents from the sites dating to the late Middle/MLT sites are less dense than the post-contact period sites. All sites exhibit greater quantities of fish bone than sea mammal bone (Table 6.2; Figure 6.2).

Figure 6.2 Graph of faunal assemblage weight by category: shell, fish bone, and sea mammal bone.
Shell weight (kg/m^3) is graphed according to the left y-axis,
while fish and sea mammal bone weight (kg/m^3) are graphed according to the right y-axis.



6.2.1 *Shellfish*

The most abundant species in the shellfish assemblages were *Mytilus californianus*, *Septifer bifurcatus*, *Haliotis* spp. (primarily *Haliotis cracherodii*), *Strongylocentrotus purpuratus, Chiton* spp. (the sum of *Ischnochiton conspicuus*, *Cryptochiton stellerii*, and unidentified chiton species from each site)*, Cancer* spp.*, Olivella biplicata, Tegula* spp. (the sum of *Tegula funebralis* and other *Tegula* species from each site)*, Pollicipes polymerus,* and small Limpet spp. (Table 6.3). *Mytilus* is the most abundant taxa and makes up between 58.1 and 87.3% of the shellfish assemblage. *Septifer* is the next most common and comprises 20.9% of the assemblage from CA-SRI-770 and 14.4% of CA-SRI-772 (Table 6.3). The remaining shellfish taxa make up smaller portions of those assemblages (see Appendix A.1 for full faunal tables from each excavation unit).

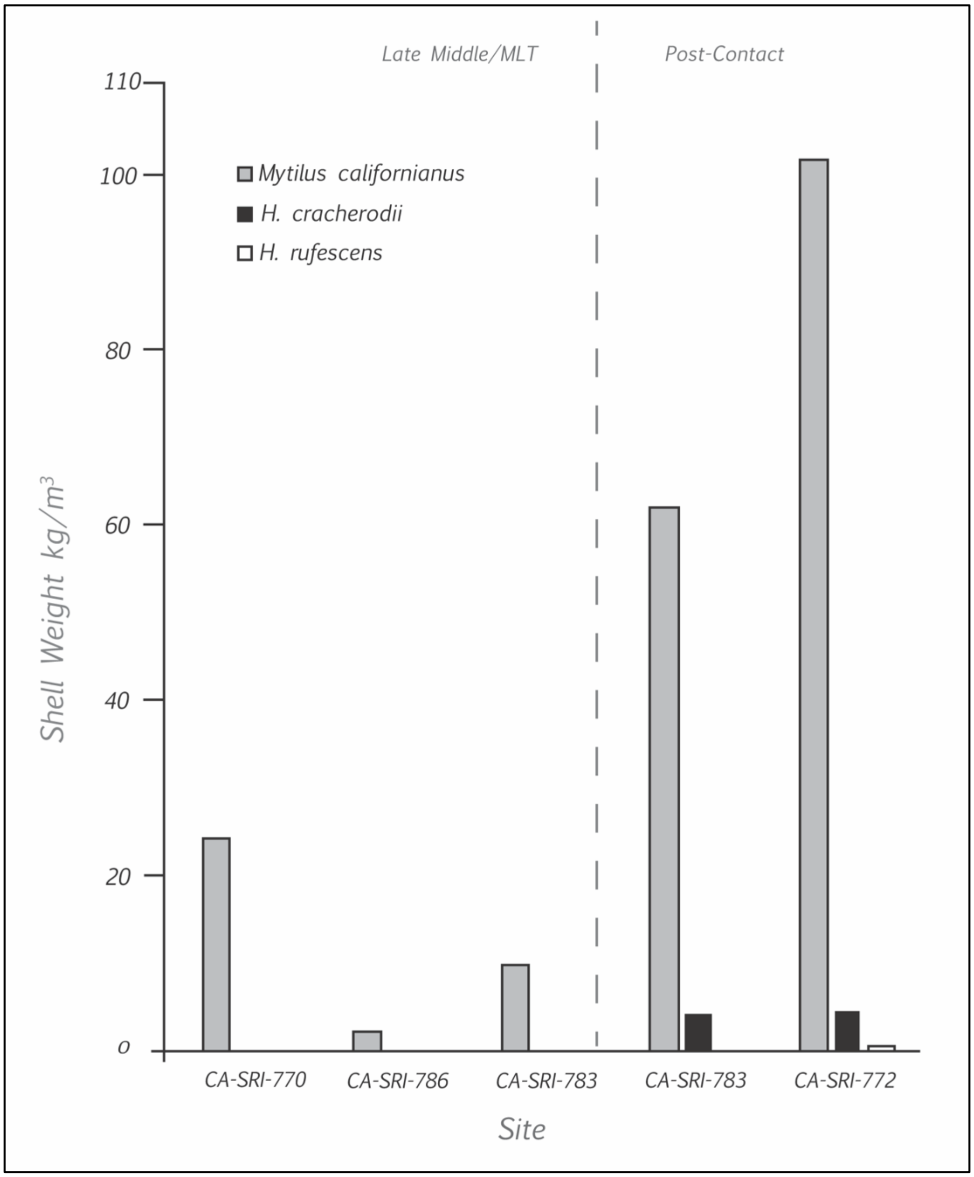
I excluded *Balanus* spp. and *Helix* spp. from diversity analysis because they are unlikely to be subsistence remains. Although in some contexts, *Balanus* spp. were likely eaten by coastal populations (Moss and Erlandson 2010), I assume that since the individuals are small, they are unlikely to have been dietary in this context and instead they were probably riders on other mollusk shells. *Helix* spp. are terrestrial and occur naturally in sandy soils on the NCI. Finally, because *H. cracherodii* was the only identifiable *Haliotis* taxon in every unit except for CA-SRI-772, I counted all *Haliotis* nacre as contributing to *H. cracherodii* weight those units. In CA-SRI-772, I proportionally split the nacre values according to the ratio of identified *H. cracherodii* to *H. rufescens*.

Table 6.3. Summary of analysis for prominent shellfish taxa. Table includes the Shannon-Weaver diversity function for shellfish taxa, shell weight (corrected to grams per cubic meter), and percent of shell weight.

Site Number	***CA-SRI-770***		***CA-SRI-786***		***CA-SRI-783***		***CA-SRI-783***		***CA-SRI-772***	
Site Type	**Late Middle**		**Late Middle**		**Late Middle/MLT**		**Post-contact**		**Post-contact**	
Shell Diversity	**0.54**		**1.57**		**0.77**		**0.60**		**1.16**	
Taxon	**Wt (g/m^3)**	**% Wt**	**Wt (g/m^3)**	**% Wt**	**Wt (g/m^3)**	**% Wt**	**Wt (g/m^3)**	**% Wt**	**Wt (g/m^3)**	**% Wt**
Mytilus californianus	24,436.6	79	2,407.0	58	10,052.9	85.2	62,049.2	87.3	101,918.4	64
Septifer bifurcatus	6,476.5	21	341.5	8	198.8	1.7	1,137.6	1.6	23,408.0	15
Haliotis cracherodii	0	0	149.5	4	0	0	4,104.3	5.8	4,824.4	3
Haliotis rufescens	0	0	0	0	0	0	0	0	509.4	0
Strongylocentrotus purpuratus	0	0	252.8	6	3.7	0.0	0	0	21,889.4	14
Chiton spp.	22.2	0	0	0	79.6	0.7	0	0	1,193.1	1
Cancer spp.	0	0	0	0	0	0	470.6	7	1,276.5	1
Olivella biplicata	0	0	0	0	180.9	1.5	776.5	1.1	973.1	0.6
Tegula spp.	0	0	411.3	10	0	0	0	0	0.0	0
Pollicipes polymerus	8.4	0.3	0	0	0	0	0	0	0.0	0
Limpet sp.	13.3	0.4	0	0	0	0	0	0	0.0	0

The faunal record from these sites is largely consistent with the observations by Jazwa et al. (2015) for transportation of *Mytilus* and *Haliotis* shell on SRI during the middle Holocene. Based on an experimental study and calculations of a field processing CPF model, they indicate that *Haliotis rufescens* shell should not be transported more than 1.81 km by foot among seasonally mobile populations. All four of the sites investigated here are further from the coast than that threshold distance, with CA-SRI-770 at 2.1 km, CA-SRI-772 at 2.3 km, CA-SRI-783 at 2.5 km, and CA-SRI-786 at 4.1 km. Here, we find that *Haliotis cracherodii* is uncommon and *Haliotis rufescens* is absent from the late Middle/MLT assemblages (Figure 6.3). After contact, when people are more sedentary in the interior, *Haliotis cracherodii* increases in prominence at these interior rockshelter sites.

Figure 6.3. Shell weight density (kg/m^3) of *Mytilus californianus*, *Haliotis cracherodii*, and *Haliotis rufescens*.



6.2.2 *Cultural Assemblage*

The presence or absence of artifacts related to *Olivella* shell bead making (i.e., chert microblades and *Olivella* beads) is a distinguishing element between the late Middle/MLT and post-contact period sites. They are present at the post-contact period sites, while they are absent from the late Middle/MLT sites (Table 6.4). *Olivella* shell debris follows a similar pattern. It is largely absent from the late Middle/MLT sites, except for the late Middle/MLT component of CA-SRI-783 (Table 6.4). This may be the result of my splitting the site by excavated levels, as level 20–30 cmbs may represent a transition between late Middle/MLT and post-contact period occupation at CA-SRI-783. Groundstone is similar to *Olivella* debris in distribution. It occurs in higher frequencies in the post-contact period sites, while it is absent from the late Middle/MLT sites except for the late Middle/MLT component of CA-SRI-783 (n=1; Table 6.4).

Table 6.4. *Olivella* shell beads, microblades, *Olivella* shell debris, and groundstone by site. Beads, microblades, and groundstone are given by count, *Olivella* debris is given by weight (g/m^3).

Site	**Period**	**Olivella Shell Beads**	**Microblades**	**Olivella Shell** (g/m^3)	**Groundstone**
CA-SRI-770	Late Middle	n=0	n=0	0	n=0
CA-SRI-786	Late Middle	n=0	n=0	0	n=0
CA-SRI-783	Late Middle/MLT	n=0	n=0	180.9	n=1
CA-SRI-783	Post-contact	n=5	n=6	776.5	n=4
CA-SRI-772	Post-contact	n=4	n=2	973.1	n=2

6.3 *Seasonality and Isotope Ecology*

To estimate season of harvest for the selected shells from each site, I superimposed the $\delta^{18}O$ data for the seasonal profile shells (Table 6.5) on the calibrated SST curve for the site (Figures 6.4, 6.5, 6.6). Measurements that were clearly erroneous (likely because of apatite and carbonate mixing) were omitted. Additionally, some samples that I drilled were too small to obtain a sufficient $\delta^{18}O$ reading, so shells that were missing too many values near the terminal growth band were also omitted. When the terminal growth band was erroneous, I extended the shell graph in the direction of growth. The distance between each sample is 2 mm, which represents approximately one month of deposition (Jones and Richman 1995:40), although this can be variable depending on the size of the shell, season, and placement in the water column (Coe and Fox 1942; Jazwa et al. 2020). Of the three sites sampled, it appears that CA-SRI-770 (Figure 6.4) has a pattern of mussel harvesting and therefore occupation during the drier months of the year, from summer through early winter (July – December). CA-SRI-772 (Figure 6.5) appear to have evidence for mussel harvesting throughout the year, while CA-SRI-783 (post-contact; Figure 6.6) appears to have a seasonal signature pertaining to the winter and early summer. However, the dates for CA-SRI-783 may be somewhat misleading, because there are fewer samples from this site, as a number of the $\delta^{18}O$ samples collected were too small to obtain measurements.

Table 6.5. Isotope $\delta^{18}O$ values and SST for each full shell profile.

Site	Unit	Level (cmbs)	$\delta^{18}O$			SST °C		
			Min	Max	Mean	Min	Max	Mean
CA-SRI-770	1	60 - 70	0.09	1.07	0.65	12.55	16.65	14.31
CA-SRI-772	1	10 - 20	-0.07	1.12	0.66	11.28	16.23	13.19
CA-SRI-772	1	10 - 20	-0.24	1.03	0.41	11.67	16.95	14.22
CA-SRI-783	1	0 - 10	0.42	1.26	0.92	10.67	14.19	12.10
CA-SRI-783	1	0 - 10	0.05	0.99	0.57	11.80	15.73	13.56

Figure 6.4. Seasonal profile for CA-SRI-770 (late Middle).
Seasonality data suggests preferential harvesting *Mytilus* in the summer and fall months.

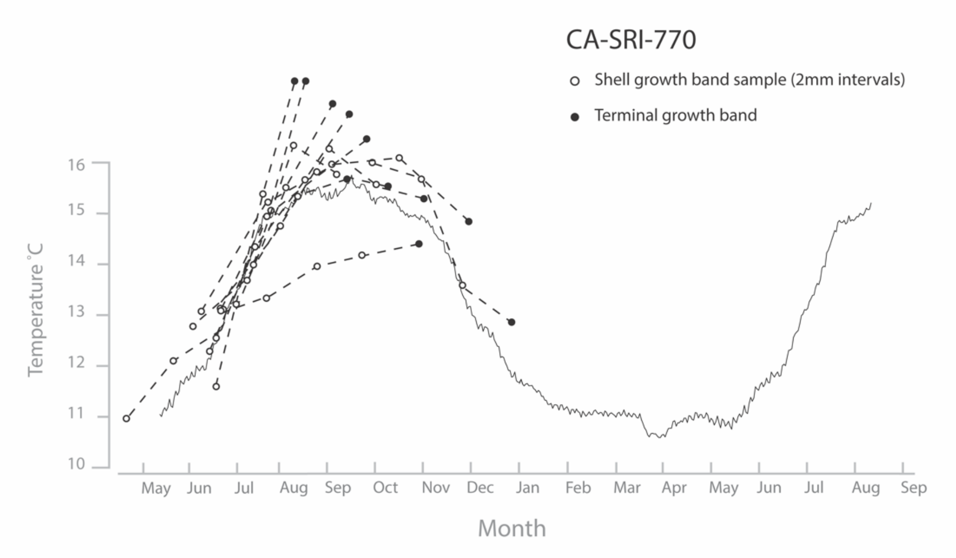


Figure 6.5. Seasonal profile for CA-SRI-772 (post-contact).
Seasonality data suggests occupation from fall through summer.

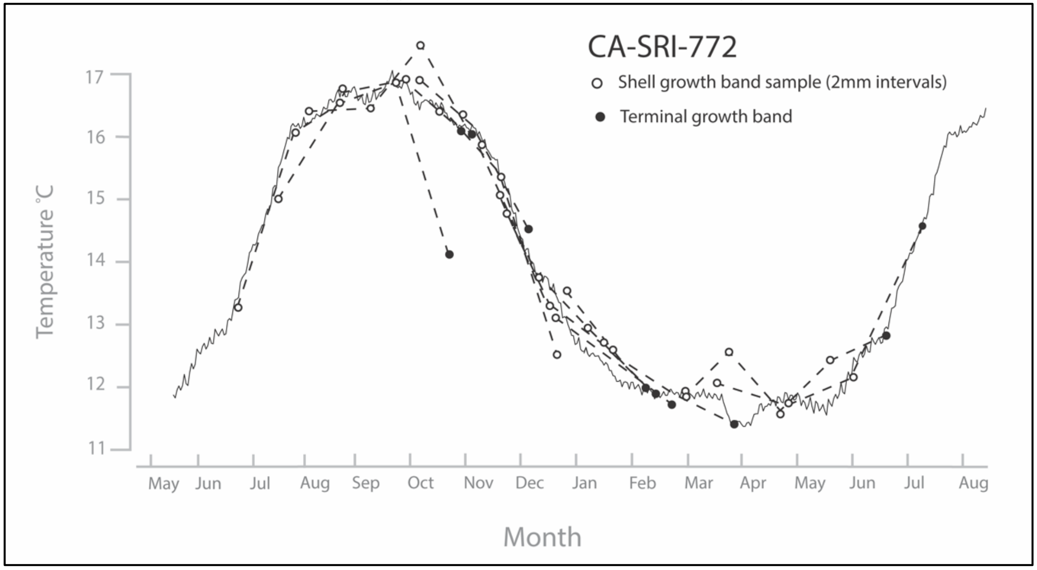
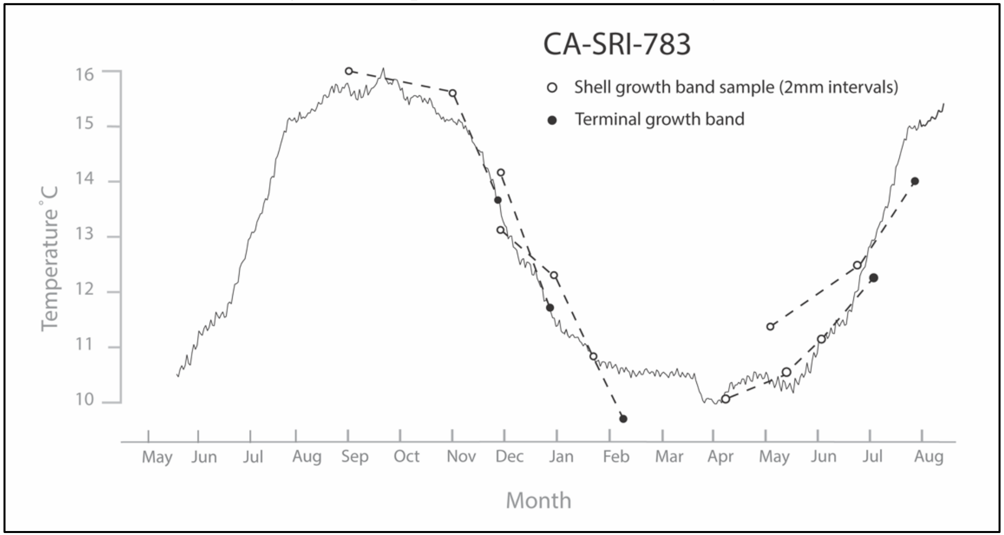


Figure 6.6. Seasonal profile for CA-SRI-783 (post-contact).
Seasonality data occupation in the winter and early summer.



6.4 Geospatial Analysis

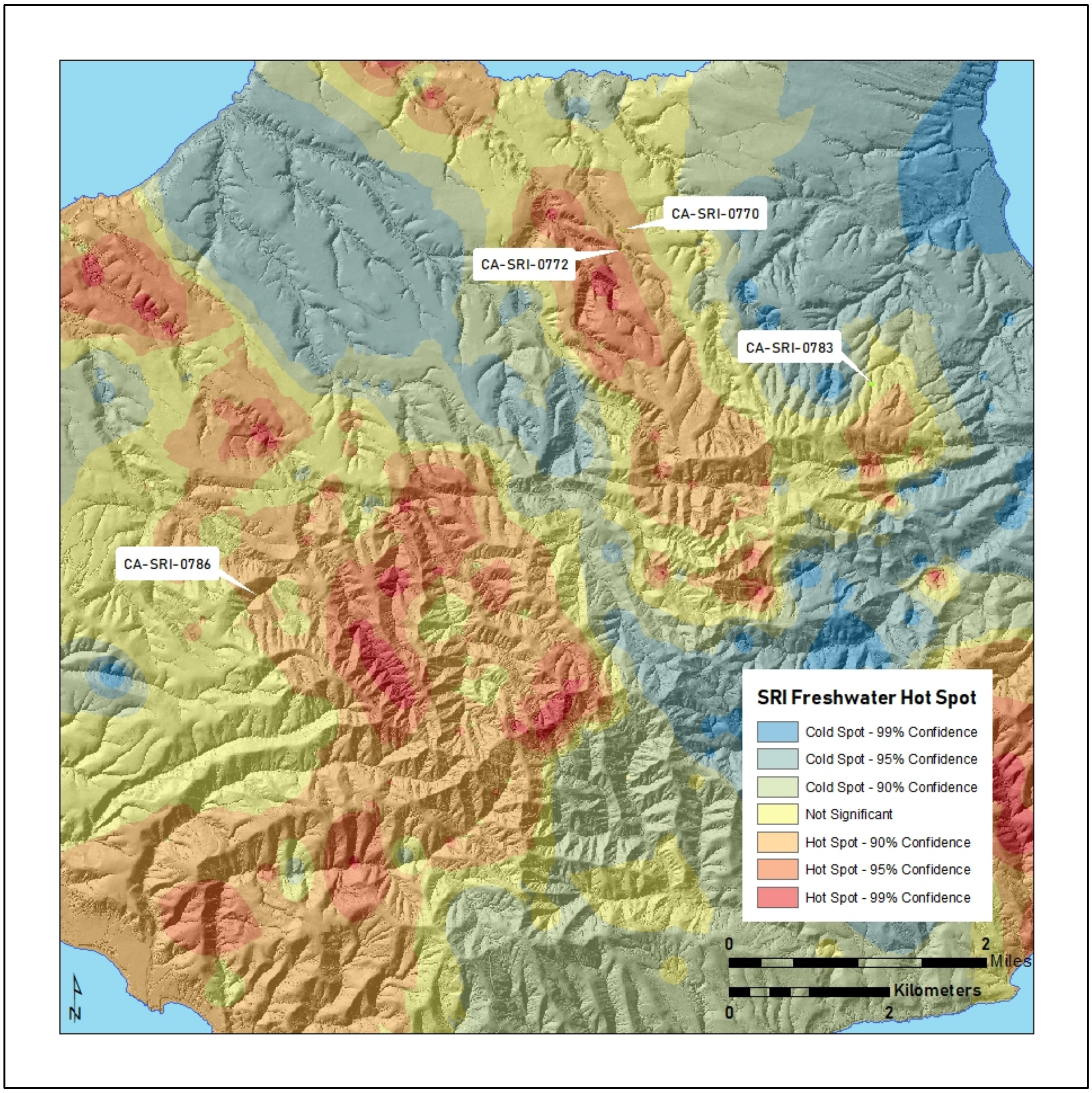
6.4.1 Optimized Hot Spot Analysis

I conducted a Hot Spot analysis to generate a map based on the point data of resilient water sources on SRI (Figure 6.7). In this analysis, I am assuming that because the hot spot zones are more likely to have a higher concentration of resilient fresh water sources, then these zones would have been attractive to people seeking out fresh water. The four sites in this study are distributed in different zones (Table 6.6). CA-SRI-772 is located within the 95% confidence zone, while CA-SRI-770 and CA-SRI-786 are in the 90% confidence zone. Although CA-SRI-783 is not in a hot spot zone, it is not in a cold zone, and it is only 0.4 km from a 90% confidence zone. Not surprisingly, the hot spot areas cluster around significant topography, as there is a positive correlation between orography and precipitation on the NCI.

Table 6.6. Spatial distribution of sites in hot spot zones and their time period designation.

Site	Period	Hot Spot Likelihood
CA-SRI-770	Late Middle	90% Confidence
CA-SRI-786	Late Middle	90% Confidence
CA-SRI-783	Late Middle/MLT	Not significant
CA-SRI-783	Post-contact	Not significant
CA-SRI-772	Post-contact	95% Confidence

Figure 6.7. Optimized Hot Spot analysis of water sources on SRI.
The site label leader lines indicate site location.



6.4.2. Euclidean Distance Analysis

The test for normality indicated that the rockshelter sites data set was normal, although this is likely because of the small sample size, while the random points and all sites were not normal. Because of this, we used a non-parametric alternative to a t-test, the Mann-Whitney test (U), which runs off comparing median ranks, rather than means.

Using this test and the Wilcoxon-Signed Rank test (W), we compared the different data sets (Table 6.7).

Table 6.7. Statistical Analysis of Euclidian Distance

	Mann-Whitney (U)	**Wilcoxon-Signed Rank (W)**	**Z-Score**	**P-Score**	**Reject Null Hypothesis?**
Rockshelter Sites vs. **All Sites**	1693	1703	-0.640	0.522	No
Rockshelter Sites vs. **Random Points (Null Hypothesis)**	585	595	-2.191	0.028	Yes
All Sites vs. **Random Points (Null Hypothesis)**	281743.5	822023.5	-11.857	<0.001	Yes

A Mann-Whitney test indicates that distances from rockshelters to observed water versus distances from all recorded SRI sites to observed surface water are not significant (U = 10.5, P =.522). To double-check this measure, we used a Wilcoxon-Signed Rank test, which also indicates that distances from rockshelters to observed water versus distances from all recorded SRI sites to observed surface water are not significant (Z = -.087, P =.941). A Mann-Whitney test indicates that distances from rockshelters to observed water versus distances from random points to observed surface water are significant (U = 585, P =.028). The same held true for a Mann-Whitney test of all sites to observed water versus random points to observed water (U=281,743.5, P=<0.001).

This indicates that there is a significant difference in the distance of rockshelter sites as well as all sites on SRI to water, compared to randomized points. While there is a problem of sample size for the study sites, the data still indicate that these sites are significantly closer to water. However, that the large sample of all SRI sites is significantly close to water, compared to the null hypothesis, suggests that archaeological sites on SRI have a connection to resilient water sources.

Chapter 7: Discussion and Conclusion

Based on chronometric dating, comparative faunal analysis, isotopic data, and spatial statistics, I argue that the four interior rockshelter sites in this study reflect two distinct settlement patterns. Specifically, the sites dating to the late Middle Period/MLT reflect a seasonal or logistical settlement pattern, while the sites dating after Spanish contact reflect a small group residential pattern of habitation. In the following discussion, I will first review my hypotheses and expectations considering the data from the previous chapter. Then, I will discuss the broader implications for these patterns within late Holocene settlement on SRI and the NCI. I will conclude with a discussion regarding how these patterns fit into the bigger picture of mobility and human-environment interactions.

7.1 Late Middle Period/MLT Rockshelter Sites

Although there is evidence for occupation of rockshelter sites on Santa Rosa Island that clearly predate the MCA, these sites are limited. To date, only CA-SRI-147 (Braje et al. 2007), CA-SRI-220 (C. Jazwa, personal communication 2021), and CA-SRI-381 (C. Jazwa and D. McKenzie, personal communication 2021) have radiocarbon dates clearly predating this period. Of these, only CA-SRI-147 is in the island interior. It appears that there was an expansion in the use of rockshelter sites during the late Middle Period/MLT, which I suggest may have been associated with the droughts that occurred during the MCA. My first hypothesis focused on distinguishing characteristics of these rockshelter sites. I proposed that **people moved to the island interior seasonally in small populations during the late Middle Period/MLT, at times in response to extreme MCA droughts to obtain water from resilient springs and/or fog**

condensation at higher elevations. I had four expectations that followed this hypothesis (Table 7.1). The data largely support this hypothesis.

Table 7.1. First hypothesis expectations and assessments following faunal, isotopic, and GIS analysis.

Expectation	**Description**	**Result**	**Notes**
1	Low diversity and density compared to the later sites; Rockshelter sites will have lower overall diversity and density than coastal habitation sites.	Partially supported	Late Middle/MLT sites had low density but similar diversity. Rockshelter sites have lower diversity, but some have similar density to coastal sites.
2	Formal artifacts should be rare or absent at these sites	Supported	CA-SRI-770 has no formal artifacts. CA-SRI-783 and CA-SRI-786 have very few formal artifacts.
3	Seasonality should correspond to dry season (May through October)	Supported	Seasonality data primarily cluster July through October.
4	Sites should be in proximity to resilient water sources	Mostly supported	CA-SRI-770 and CA-SRI-786 are within 90% confidence zone (hot spot) for resilient water sources. CA-SRI-783 is ~0.4 km from a hot spot. Rockshelter sites are significantly closer to water sources than are random points (Euclidean Distance).

The first expectation is derived from the diet breadth model. I expected that the faunal and cultural assemblages from the rockshelter sites would have lower overall density and diversity than known residential sites (i.e., primary habitation sites) from the coast, but that the late Middle/MLT sites should have even lower diversity and density compared to the post-contact period sites. This expectation was partially supported. First, an average of the diversity assemblages from the rockshelter sites in my study is 0.9 (Table 7.2). This is lower than the overall average diversity for coastal residential sites (from Jazwa et al. 2016b), which is 1.5 (Table 7.2). This expectation is not supported between the two rockshelter types, however, which have near identical diversity measures. The late Middle/MLT sites have an average diversity of 1.0 while the post-contact period sites have a diversity of 0.9. A comparison of midden density from these sites was mixed. By a simple comparison of the descriptions of the midden at these sites, all of the coastal sites have high density, while the post-contact period rockshelter sites also have high density. However, most of the late Middle/MLT sites in this study are low density (except for CA-SRI-783). By shell and bone weight, the largest late Middle/MLT assemblage (CA-SRI-770) is less than half of the smallest post-contact period assemblage (CA-SRI-783). Therefore, overall faunal density appears to be the distinguishing factor between the two site categories in this study, while diversity measures are similar. Assemblage diversity did not prove to be a distinguishing factor between the late Middle/MLT and post-contact period sites. For example, CA-SRI-786 has the highest overall diversity, but the lowest overall density (Table 7.2).

Table 7.2. Comparison of overall midden density and shellfish diversity between coastal residential and the rockshelter sites in this study.

Site	Site Type	Drainage	Midden Density	Shell Diversity	Reference
CA-SRI-19, Unit 2	Coastal	Soledad/Dry	High	1.8**	Jazwa et al. 2016b
CA-SRI-115	Coastal	Cow/Lobos	High	0.8**	Jazwa et al. 2016b
CA-SRI-31	Coastal	Bee	High	1.7**	Jazwa et al. 2016b
CA-SRI-313	Coastal	Bee	High	1.9**	Jazwa et al. 2016b
CA-SRI-770 (Late Middle)	Interior Rockshelter	Cow	Low*	0.5	This study
CA-SRI-772 (Post-contact)	Interior Rockshelter	Cow	High*	1.2	This study
CA-SRI-783 (Late Middle/MLT)	Interior Rockshelter	Upper Cherry	High*	0.8	This study
CA-SRI-783 (Post-contact)	Interior Rockshelter	Upper Cherry	High*	0.6	This study
CA-SRI-786 (Late Middle)	Interior Rockshelter	Tecolote	Low*	1.6	This study

*Descriptions taken from unpublished site records on file with Channel Islands National Park.

**Diversity for all levels taken as an average of the diversity from shellfish.

Using the perspective of CPF (e.g., Jazwa et al 2015), the low diversity of the assemblages of the interior sites is likely the result of their location on the island interior compared to coastal sites. Jazwa et al. (2015) found similar differences in diversity measures between middle Holocene coastal and interior residential bases. The interior site from that study had a diversity measure of 0.7, while the coastal sites had an average diversity of 1.6 (Table 7.2). The authors identified the location of coastal sites as the reason for the higher diversity in those assemblages, as they reflect local collection, processing, and consumption of a wider diversity of shellfish. Interior sites, on the other hand, have lower shellfish diversity either because of field processing or lower population density (e.g., Jazwa et al. 2015; Thakar 2014). This difference in diversity between interior rockshelter and coastal sites is similar (0.9 and 1.5, respectively; Table 7.2). Therefore, the late Middle/MLT rockshelters in this study likely indicate a subsistence pattern that is indicative of low population density or Central Place Foraging.

My second expectation was that formal artifacts, such as *Olivella* shell beads, groundstone, and flaked stone tools, would be rare or absent at the late Middle/MLT sites because they are typically associated with residential settlement. This expectation was supported by the analyses. The late Middle/MLT site cultural assemblages were very small compared to the post-contact period sites (see **Appendix A2** for cultural assemblage tables). CA-SRI-770 was the only late Middle/MLT site that had no formal artifacts, only charcoal. CA-SRI-786 had charcoal, lithics, and *Olivella* debris, and CA-SRI-783 had charcoal, lithics, *Olivella* debris, and groundstone. However, these materials were in very small quantities. These data therefore support the second expectation for the first hypothesis.

The third expectation for this hypothesis was that the $\delta^{18}O$ profiles of *Mytilus californianus* shells from the late Middle/MLT sites should correspond to seasons that are dry but have consistent overnight fog drip (May through October). The data from also support this expectation. The *Mytilus* from CA-SRI-770 appear to have been harvested primarily between July and October, with three shells harvested in October, December, and January. This is largely consistent with the typical annual dry season in southern California (May through October).

My fourth expectation for this hypothesis was that the late Middle/MLT sites should be in proximity to areas with a high probability for resilient water sources on the interior of SRI. The data largely support this hypothesis. Two of the late Middle/MLT sites, CA-SRI-770 and CA-SRI-786, did occur in areas that had a very high likelihood of having resilient water sources (90% confidence zone). CA-SRI-783, which has components pertaining to both periods, was not within a hot spot for resilient water itself but was only 0.4 km from a 90% confidence zone. None of the sites, however, are located in areas without significant clustering of resilient water sources (i.e., cold spots). Partially supporting this hypothesis, the Euclidean distance analysis indicates that all the rockshelter sites in this thesis are located significantly close to water.

7.2 Post-Contact Rockshelter Sites

Following the droughts of the MCA, the climate ameliorated, and settlement increasingly focused on large coastal village sites (Kennett 2005; Jazwa et al. 2019). After European contact, however, it appears that the use of interior rockshelters changed. My second hypothesis focused on understanding the purpose and characteristics of the post-contact period sites in comparison to the earlier sites and coastal sites. I proposed that **following Spanish contact, interior settlement at rockshelters reflects a more substantial or permanent settlement system for small population groups.** I had four expectations that followed this hypothesis (Table 7.3). The data also largely support this hypothesis.

Table 7.3. Second hypothesis expectations and assessments following faunal, isotopic, and GIS analysis.

Expectation	Description	Result	Notes
5	Site assemblages will have higher diversity and density	Partially Supported	Denser than late Middle/MLT sites in terms of shell and bone.
6	Formal artifacts will be abundant	Supported	Greater density and richness of artifact types, notably groundstone and *Olivella* bead manufacturing.
7	Seasonality should reflect a pattern of year-round habitation	Likely Supported	CA-SRI-772 is year-round. CA-SRI-783 may correspond to the winter and early summer, but more data are needed.
8	Settlement locations will be less influenced by proximity to fresh water sources.	Partially Supported	CA-SRI-772 in "hottest" zone for water of all sites. CA-SRI-783 was not in a "hot spot." Rockshelter sites are significantly closer to water sources than are random points (Euclidean Distance).

My fifth expectation was that the site assemblages from the post-contact period sites would be more diverse and denser than the late Middle/MLT assemblages, which reflects a pattern of residential habitation. As discussed, diversity did not prove to be a distinguishing factor between the late Middle/MLT and post-contact period sites, but it did distinguish these sites from other known coastal residential sites (Table 7.2), which is likely related to their location on the island interior (Table 7.3). The overall faunal density appears to be a distinguishing factor between the two site categories. By shell and bone weight, the post-contact period assemblages were both substantially larger than the late Middle/MLT assemblages. For example, there is a 1000% increase in fish bone between the late Middle/MLT and post-contact period sites, while there is a 3000% increase in sea mammal bone (Table 6.2; Figure 6.2). This difference is likely the result of occupational intensity at these two site categories. The post-contact period sites appear to have a more residential pattern of habitation, which would contribute to an overall denser midden assemblage (Jazwa 2015).

When comparing the shellfish assemblages from the two rockshelter site types, it is apparent that *Haliotis* spp. are more prevalent in the post-contact period sites than the late Middle/MLT sites. This is counter to CPF predictions by Jazwa et al. (2015) that *Haliotis rufescens* shell would be processed (i.e., shucked) if it were to be transported further than 1.81 km. As discussed in the previous chapter, from the perspective of CPF, the sites in this study should have little or no *Haliotis* shell in their assemblages because they are further than 1.81 km from the coast. However, *Haliotis* makes up to 5% of the shellfish assemblages for the post-contact period sites (Table 6.3). The relative abundance of *Haliotis* at the post-contact period sites is therefore indicative of a different type of settlement pattern in which these large shellfish were being taken to the island interior for processing. This also indicates residential habitation (Jazwa et al. 2015).

The sixth expectation was that formal artifacts common in habitation debris would be abundant at the post-contact period sites, relative to the late Middle/MLT sites. The data support this expectation, both in density and richness of artifacts. CA-SRI-772 has 11 categories of artifacts, including cordage, microblades, several types of *Olivella* shell beads, asphaltum, glass trade beads, and groundstone. CA-SRI-783 has 14 categories of artifacts, including five different kinds of Olivella shell beads and a hopper mortar (Figure 7.1). The prevalence of groundstone, and the hopper mortar in particular, suggests that people were intensively processing food at these sites, which is associated with residential habitation. The presence of microblades, *Olivella* shell debris, and shell beads indicates that the people residing at these shelters were making shell beads and were tied into the Late Period shell bead industry that persisted after Spanish contact (Arnold 1985, 1987, 2001a; Arnold and Munns 1994).

Figure 7.1. Hopper mortar from the surface of CA-SRI-783 (likely post-contact). The asphaltum residue would have attached a basket (Photo by C. Jazwa).

My seventh expectation was that the $\delta^{18}O$ profiles of *Mytilus californianus* shells from the post-contact period sites should reflect a pattern of year-round habitation. This expectation was mostly true based on available data. The $\delta^{18}O$ values from CA-SRI-772 is also in accordance with this expectation in that the *Mytilus* appear to have been harvested all year. The post-contact component of CA-SRI-783 diverges from my expectations and appears to have a seasonal signal pertaining to the winter (December through February) and early summer (July). This interpretation is limited, however, because this site had only five shells with enough $\delta^{18}O$ data to determine the season of harvest. In my future work, I will submit additional material from this site for analysis. Regardless, it is evident that the seasonality of this site does not cluster around the summer months like CA-SRI-770.

Finally, the eighth expectation was that for the Optimized Hot Spot Analysis, I expected the post-contact period settlement locations to be less influenced by proximity to fresh water sources than the late Middle/MLT sites. This expectation was partially true. The site within the “hottest” zone for resilient water was CA-SRI-772, with a 95% confidence zone. CA-SRI-783 was not within a hot spot for resilient water, which partially supports this expectation. However, it was only 0.4 km from a 90% confidence zone, and its location could feasibly be related to resilient water sources. Additionally, the Euclidean distance from the rockshelter sites to resilient water sources is significantly closer than are a set of randomized points to water sources. By both measures of geospatial analysis, it appears that the location of the rockshelter sites is related to proximity to water. Finally, the post-contact sites have a more pronounced viewshed of

Bechers Bay compared to the late Middle/MLT sites (C. Jazwa personal communication 2021). This may also have implications for their locations with respect to colonial contact, as good viewshed would have been beneficial for monitoring the coastline.

7.3 Interior Rockshelter Sites in Broader Context on the NCI

While all these sites are interior rockshelter sites, based on the data from this study, they represent two distinct settlement patterns based on choices people made in response to external stimuli. These choices were likely influenced by shifting climatic and cultural inputs. To understand interior settlement in context, we must first look at the commonalities between these sites and how they integrate with late Holocene settlement in general on the NCI. In general, interior occupation sites on the NCI are smaller than coastal residential sites and many appear to have been occupied seasonally (Kennett 2005; Jazwa et al. 2015), but this pattern became more pronounced throughout the late Holocene (Arnold and Martin 2014; Gill 2015; Jazwa and Rosencrance 2019; Thakar 2014). Interior occupation was likely related to obtaining fresh water from interior springs, seeps, and ponds when drainage bottom water dried up (Gill 2015; Jazwa and Rosencrance 2019; Jazwa et al. 2016a; Perry and Glassow 2015). The data from this study support previous characterizations of late Holocene interior settlement on the SRI. The assemblages from these sites have lower shell diversity and density compared to contemporaneous coastal sites on SRI (Table 7.2; Jazwa et al. 2016b). Furthermore, all of these sites are in proximity to hot spots for resilient springs, which indicates that the presence of fresh water may be a significant factor influencing their location.

The late Middle/MLT sites in this study can be distinguished from the later post-contact period sites in that their assemblages are significantly less dense and probably indicate short-term logistical occupation. I argue that settlement is different between these periods because of different environmental and social factors. I argue that the late Middle/MLT settlement pattern was likely influenced by the extreme droughts of the MCA. This characterization is supported by the isotopic signature at CA-SRI-770 pertaining to dry season mussel harvesting, implying occupation during that time of year (July through October). Although CA-SRI-783 (late Middle/MLT levels) and CA-SRI-786 were not tested for seasonality, I speculate that they also have a seasonal signature, given the similarities to the CA-SRI-770 assemblage. Regardless, it is evident that CA-SRI-770 was occupied during the dry season, which may indicate that it (and possibly the other late Middle/MLT sites as well) was related to fresh water collection. During the dry season on SRI, drainage bottom water is especially scarce (Power and Rudolph 2018), and these already dry conditions very likely were exacerbated by the extreme droughts of the MCA (Jazwa et al. 2016b). During such periods, people would have had to collect fresh water from the island interior, where resilient springs, seeps, and ponds, fed by vegetative fog drip, persist during the dry season (Jones et al. 2004; Power and Rudolph 2018).

Starting in the middle Holocene, a period that at times was as dry or drier than the dry periods of the MCA, there is archaeological evidence of water management and storage on the NCI, when asphaltum-sealed water bottles become more abundant (Erlandson et al. 2019). The expansion of settlement into the interior Pocket Field region on SRI (Jazwa and Rosencrance 2019) just after the MLT, a period that coincides with the most extreme drought of the MCA, is also perhaps related to obtaining fresh water from vernal pools and vegetative fog drip. This settlement expansion into the Pocket Field occurred just after apparent population decreases during the MCA, evinced by approximately half of the large coastal villages at the mouths of drainages being abandoned (Jazwa et al. 2016b, 2019; Kennett 1998, 2005; Winterhalder et al. 2010). Other researchers have highlighted the importance of resilient fresh water sources with respect to interior settlement on the NCI. On SCrI, Perry and Glassow (2015) indicate the location of an interior late Holocene site was likely influenced by fresh water accessibility, and Gill (2015) noted pooling spring water year-round at the interior Diablo-Valdez site, even after three years of severe drought.

There are alternative explanations for interior settlement at these late middle/MLT sites. The probabilistic range for these two sites is partially outside the MCA, so it is entirely possible that they were occupied during a time when the climate was more stable. The nature of the site assemblages still indicates that they are associated with logistical settlement. If this is the case, the site locations may be less influenced by water and more so by other terrestrial resources, such as geophytes. Collecting carbohydrate-rich terrestrial resources to supplement a protein and fat rich marine diet was essential for survival on the NCI (e.g., Gill 2015; Gill et al. 2019; Thakar 2014). CA-SRI-770 also overlaps with one of the pluvial events of the MCA (Cook et al. 2015). It may be that wetter conditions contributed to the proliferation of terrestrial resources, such as geophytes, which would have also been attractive to hunter-gatherer populations.

After the MCA, population density at the remaining villages grew and the number of smaller sites on the NCI increased, leading to higher overall populations on the islands than during previous periods (Braje et al. 2010; Erlandson et al. 2011; Jazwa et al. 2019; Thakar 2014). This may have contributed to the formation of smaller interior residential bases, which are evident in the Pocket Field after the MLT (Jazwa and Rosencrance 2019). This shift in residential settlement may also have been influenced by contact with European colonists. In this study, the post-contact period sites appear to reflect a pattern of interior residential habitation similar to the sites found in the Pocket Field. This is further evinced by seasonality data from *Mytilus* at both sites. CA-SRI-772 has a year-round signature, while CA-SRI-783 has a signature pertaining to the winter (December through February) and summer (July). While the seasonality data from CA-SRI-783 are preliminary, they do correspond to seasonality data from an interior residential base on SCrI, CA-SCrI-568 (Thakar 2014). At this site, which was occupied during the late Middle Period, the paleobotanical assemblages suggest a seasonal pattern with longer stays centered around the fall and winter (Thakar 2014). While this pattern does not align with the expectations of the hypotheses in this study, it indicates an avenue for further research regarding the seasonality of late Holocene interior settlement on the NCI more broadly.

These post-contact period assemblages are also characterized by the relative prevalence of *Haliotis* spp. compared to the late Middle/MLT sites. Following existing CPF predictions for field processing *Haliotis rufescens* (Jazwa et al. 2015), all of these sites are outside of the one-way travel threshold for this species (1.81 km). The fact that *Haliotis* was transported into the interior for processing at such a small site suggests that the post-contact period sites were part of a more permanent residential settlement system. Additionally, the small quantities of butchered sea mammal bone at these sites bears a strong resemblance to the faunal assemblages from CA-SCrI-568, a large late Holocene interior residential base (Thakar 2014), and the Sunburst Site, CA-SCrI-813, a Late Period residential base (Gill 2015). The prevalence of sea mammal at these interior sites is also counter to general CPF predictions that large-bodied prey will generally be processed at the kill or collection site (Bettinger 2009). The presence of sea mammal bone at the rockshelters suggests they were processed on site, which is also an indicator of a residential settlement pattern.

Further evidence that the post-contact period sites are habitation sites comes from the artifact assemblages. The sites contain microblades, which are specifically linked to the *Olivella* shell bead industry that took off after the MLT on the NCI (Arnold 1985, 1992, 2001a, 2001b; Arnold and Munns 1994; Munns and Arnold 2002). This industry is linked to increased socioeconomic complexity in the Santa Barbara Channel region (Arnold, 1987, 1992,1995, 2001). Microblades such as those found at the post-contact period sites are typically made from SCrI chert, although they may have been made from local chert sources that have only recently been identified on SRI (Erlandson et al. 2012; Jazwa et al. 2017). Similar assemblages have been found at other late period residential bases in Pocket Field (Jazwa and Rosencrance 2019), the Sunburst Site (CA-SCrI-813), and many coastal residential bases (e.g., Jazwa et al. 2016b).

It is probable that this residential settlement pattern developed earlier than European contact. A similar pattern arose in the Pocket Field just after the MLT (Jazwa and Rosencrance 2019) and may be related to the rapid cultural changes that occurred during this period (Arnold 2001a). During this time, population increased, yet became concentrated in large coastal villages (Jazwa et al. 2019). However, faunal data indicates that the populations of large coastal villages on SRI were still not as dense as they had been prior to the MCA (Jazwa et al. 2019). It may be that the environmental instability during the MCA droughts encouraged cultural changes during the MLT that favored small-group residential settlement on SRI. During the MCA, violence and disease related to resource stress also reached a peak and these shifts in settlement organization might also be explained as some measure to mitigate conflict (e.g., Jazwa et al. 2019). Such defensive settlement organization may have persisted into the post-contact period as it could have been advantageous for mitigating new social threats, such as European colonists.

7.4 Limitations and Future Research

This study has limitations and there are more opportunities to test the hypotheses of this thesis. First, this thesis is limited by the incomplete isotopic data for the *Mytilus* seasonality studies. With these data, we can get a more accurate picture of CA-SRI-783, which had many *Mytilus* shell samples that were too small for δ^{18}O measurements. It would be interesting to compare the complete seasonality data from CA-SRI-783 with CA-SCrI-568, which has a pattern centering around the fall and winter. I have re-drilled these samples and data will be included in a future analysis. It would also be beneficial to test shells from the late Middle/MLT component of CA-SRI-783 to contrast the seasonality from the post-contact period component.

Second, formal viewshed GIS analysis for the sites would be beneficial for testing whether the post-contact period sites are located in places with a strategic advantage relative to the coast, as islanders monitored encounters with European colonists.

Additional analysis to identify areas of fog inundation would be beneficial for identifying "hot spots" for water. Finally, because local lithic sources have been identified on SRI recently (Erlandson et al., 1997, 2008, 2012; Jazwa et al., 2017a) a chert provenance study of the microblades at the post-contact period sites may be of interest for 1) identifying a local chert trade network and/or 2) identifying chert trade between the NCI, which would require chert provenance studies on SCrI as well.

7.5 Conclusion

The four interior rockshelter sites in this study are representative of two distinct types of late Holocene interior settlement on SRI. The first pattern, pertaining to the late Middle Period and MLT, seems to indicate seasonal logistical terrestrial resource collection. During the MCA, it is possible that the terrestrial resource these groups were targeting was fresh water, which is available year-round at higher elevations on SRI. The second pattern pertains to the period following Spanish contact and seems to represent a reorganization to permanent residential settlement of the interior. As is evident in Pocket Field, this reorganization occurred after the MLT and may have been the result of expanding population density, as a response to colonial encroachment, or some combination thereof. Previous research has construed interior sites as a primarily logistical pattern of settlement (e.g., Braje et al. 2007; Kennett 2005). Current research, however, provides more nuance to that view (e.g., Gill 2015; Jazwa and Rosencrance 2019; Thakar 2014). This study makes it more apparent that although many of these smaller sites were logistical, some were probably part of a permanent interior residential settlement system, particularly after the MLT.

The data from the late Middle/MLT site assemblages in this study are beneficial for understanding how hunter-gatherer groups in arid environments mitigate limited fresh water availability. For past hunter-gatherer groups on SRI, the data from this thesis suggest that a solution may have been seasonal residential restructuring focused on water sources. The extensive lenses at these sites indicate that settlement was likely repetitive, and possibly related to resilient water. More data connecting interior sites on the NCI to resilient springs might support this conjecture.

The data gathered from the post-contact period site assemblages in this study might be used to investigate two major cultural events that occurred among the Island Chumash during the end of the late Holocene. The first is how the significant social reorganization that occurred during the MLT (e.g., Arnold 2001a) manifests in settlement patterns. The post-MLT interior settlement patterns from this study and Pocket Field (Jazwa and Rosencrance 2019) both reflect an increase in small residential settlements located in the interior of SRI. The apparent settlement expansion may be related to resource defense and territoriality, which is evident during this period (e.g., Jazwa and Rosencrance 2019; Jazwa et al. 2019). Perhaps these groups were dispersing to avoid territorial disputes over resources. The second major cultural event these small interior residential bases may be related to is European contact, as small groups avoided or monitored the coast where contact occurred.

Regardless, the four sites in this study demonstrate that although late Holocene interior settlement is generally characterized by small, ephemeral sites, there are differences among these sites themselves. While the importance of small sites has been recognized in the context of greater settlement-subsistence systems (e.g., Jochim 1991, Perry and Glassow 2015), they are often overlooked because it can be difficult to glean meaningful information from them. This study demonstrates that even with limited data, it is possible to make distinctions among small sites. Additional studies on the NCI would be beneficial for fully understanding interior occupation, particularly during the late Holocene when small sites most generally comprise interior settlement patterns. Such studies and data would be beneficial for understanding the role of smaller sites in regions with Mediterranean climates throughout the world.

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Appendix A – Midden Data

A.1 – Faunal Data

Taxon	**CA-SRI-770, Unit 1**				
	8-44 cmbs	**44-54 cmbs**	**54-60 cmbs**	**60-70 cmbs**	**70-80 cmbs**
Balanus spp.	0.0	0.0	0.0	0.31	0.0
Chiton sp.	0.0	0.0	0.0	0.50	0.0
Helix spp.	0.5	0.2	0.0	0.0	0.0
Ischnochiton conspicuus	0.6	0.00	0.5	0.0	0.1
Limpet sp.	0.0	0.00	0.0	0.30	0.0
Mytilus californianus	0.0	16.3	230.91	284.59	0.0
Ostrea lurida	0.0	0.0	0.0	0.08	4.3
Pollicipes polymerus	0.0	0.0	0.0	0.18	0.0
Septifer bifurcatus	1.35	4.0	25.38	111.43	0.3
Strongylocentrotus purpuratus	0.02	0.0	0.0	0.00	0.0
Undif. Mammal Bone	0.0	0.0	0.90	0.65	0.2
Fish Jaw (undiff)	0.05	0.2	0.0	0.08	0.0
Total	2.52	20.7	257.69	398.12	4.9

A.1 – Faunal Data

	CA-SRI-772, Unit 1					
Taxon	**0-10 cmbs**	**10-20 cmbs**	**20-30 cmbs**	**30-38 cmbs**	**23-30 cmbs**	**30-39 cmbs**
Acmaea limatula	0.0	0.0	1.1	0.0	0.0	0.0
Balanus spp.	25.66	26.96	33.13	1.38	3.02	0.52
Cancer	0.0	30.66	0.46	0.00	0.00	0.00
Chiton sp.	0.0	0.00	23.75	4.04	1.30	0.00
Crepidula spp.	0.0	0.00	0.24	0.00	0.00	0.00
Cryptochiton stelleri	0.0	5.25	0.00	0.00	0.00	0.00
Fissurella gemmata	0.0	0.1	0.00	0.00	0.00	0.00
Fissurella volcano	0.0	0.00	0.2	0.00	0.00	0.00
Gastropod spp.	0.0	0.00	0.00	0.10	0.00	0.00
Haliotis cracherodii	60.30	21.60	11.81	0.00	7.2	0.00
Haliotis rufescens	8.96	1.70	0.00	0.00	0.00	0.00
Haliotis spp.	0.00	1.30	17.15	0.00	0.00	0.00
Ischnochiton conspicuus	0.00	15.48	1.42	0.00	0.3	0.62
Limpet sp.	0.00	0.00	0.00	0.20	0.43	0.00
Megastraea undosa	0.00	0.00	0.00	0.00	0.00	0.60
Mytilus californianus	769.19	644.40	701.04	159.32	126.02	84.28
Olivella biplicata	4.39	5.80	11.98	1.28	0.00	0.27
Pollicipes polymerus	0.00	0.00	1.74	0.30	2.36	0.62
Septifer bifurcatus	210.88	194.56	152.28	6.00	4.30	2.55
Strongylocentrotus purpuratus	214.28	108.95	172.60	13.40	17.49	6.83
Tegula spp.	2.14	3.84	3.37	0.00	0.00	0.40
Thais emerginata	1.28	0.00	0.00	0.00	0.00	0.00
Sea Mammal Bone Total	0.00	11.10	0.00	0.00	0.00	0.00
Undif. Mammal Bone	2.87	1.20	1	0.83	0.00	0.00
Sebastes sp.	0.00	0.00	0.3	0.00	0.00	0.00
Sheephead Tooth	0.00	0.00	0.00	0.1	0.00	0.00
Otolith (Benthalbella dentata)	0.00	0.12	0.00	0.00	0.00	0.00
Fish Bone (undiff)	9.82	0.30	8.9	6.51	3.18	0.11
Total	1309.76	1073.31	1142.47	193.45	165.61	96.80

A.1 – Faunal Data

	CA-SRI-783, Unit 1					
Taxon	**0-10 cmbs**	**10-20 cmbs**	**20-30 cmbs**	**30-40 cmbs**	**40-50 cmbs**	**50-54 cmbs**
Acmaea sp.	4.8	1.2	0.0	0.0	0.0	0.0
Balanus spp.	36.3	13.0	3.6	0.4	37.7	0.6
Cancer	4.0	13.6	0.0	0.0	0.0	0.0
Gastropod spp.	2.2	0.0	0.0	0.0	0.0	0.0
Haliotis cracherodii	113.4	0.0	1.1	0.0	0.0	0.0
Haliotis spp.	39.0	0.4	0.0	0.0	0.0	0.0
Ischnochiton conspicuus	6.3	0.0	0.0	2.4	0.0	0.0
Mytilus californianus (total)	1323.0	719.9	283.9	187.8	109.3	4.4
Olivella biplicata	11.9	10.0	7.3	2.0	3.2	0.3
Pollicipes polymerus	8.6	2.7	0.0	0.0	0.0	0.0
Septifer bifurcatus (total)	16.3	24.1	2.3	4.9	1.1	0.0
Strongylocentrotus purpuratus	3.7	3.5	0.0	0.0	0.0	0.1
Tegula spp.	8.3	1.1	0.3	0.0	0.0	0.0
Sea Mammal Phalange	0.0	0.0	3.5	1.3	0.0	0.0
Sea Mammal Metatarsal	0.0	0.0	7.4	0.0	0.0	0.0
Sea Mammal C-Vertebra	0.0	0.0	7.3	0.0	0.0	0.0
Sea Mammal Vertebra (juvenile)	0.0	11.6	0.0	0.0	0.0	0.0
Sea Mammal Mandible	0.0	16.1	0.0	0.0	0.0	0.0
Sea Mammal Pelvis	0.0	0.0	2.6	0.0	0.0	0.0
Undif. Mammal Bone	1.7	0.0	0.0	2.1	0.2	0.0
Fish Bone (undiff)	24.4	0.0	17.3	0.0	1.3	0.0
Fish Bone (Total)	0.0	0.0	0.0	4.6	0.0	0.0
Total	1603.9	817.0	336.5	205.4	152.7	5.4

	CA-SRI-786, Unit 1							
Taxon	**0-11 cmbs**	**11-20 cmbs**	**20-25 cmbs**	**25-35 cmbs**	**35-45 cmbs**	**45-55 cmbs**	**55-64 cmbs**	**Wall Clean (0-60 cmbs)**
Acmaea fenestrata	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acmea digitalis	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Acmaea sp.	0.0	0.1	0.1	0.5	0.1	0.0	0.0	0.0
Balanus spp.	1.8	2.9	1.7	1.3	0.6	0.0	0.0	0.0
Cancer	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0
Cryptochiton stelleri	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0
Fissurella gemmata	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Gastropod spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Haliotis cracherodii	0.0	0.2	0.0	5.0	0.0	0.0	0.0	0.0
Haliotis spp.	0.0	0.0	0.0	0.0	0.1	0.7	0.0	0.0
Ischnochiton conspicuus	1.5	2.2	0.4	0.7	0.2	0.0	0.0	0.0
Megastraea undosa	0.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Mytilus californianus (total)	24.5	21.2	12.5	17.5	13.6	6.9	0.1	0.0
Olivella biplicata	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Pollicipes polymerus	0.8	0.8	0.0	0.8	0.6	0.2	0.0	0.0
Septifer bifurcatus (total)	3.6	5.3	0.9	1.5	1.9	0.5	0.0	0.0
Strongylocentrotus purpuratus	1.4	2.2	0.2	0.6	0.9	4.8	0.0	0.0
Tegula spp.	1.9	3.7	1.1	4.5	4.2	1.0	0.0	0.0
Undif. Shell	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Sea Mammal Bone	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Sea mammal sacrum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.4
Land Mammal Bone Undiff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Undif. Mammal Bone	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Fish Bone (undiff)	1.0	2.1	0.4	1.3	2.5	0.6	0.8	0.0
Total	37.3	43.6	17.3	33.7	27.2	15.0	1.0	37.4

A.2 – Cultural Data (All weights are in g)

	CA-SRI-770, Unit 1			
Material	**44 - 54 cmbs**	**54 - 60 cmbs**	**60 - 70 cmbs**	**70 - 80 cmbs**
Charcoal	0.2	0.5	3.97	0.4
Total	0.2	0.5	3.97	0.4

	CA-SRI-772, Unit 1											
	0-10 cmbs		**10-20 cmbs**		**20-30 cmbs**		**30-36 cmbs**		**23-30 cmbs**		**30-39 cmbs**	
Material	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**
Charcoal	98.6	N/A	53.07	N/A	58.85	N/A	17.97	N/A	7.68	N/A	84.50	N/A
Debitage (Metavolcanic)	7	5	23.7	2	0	0	0	0	0	0	0	0
Groundstone	153.7	2	0	0	0	0	0	0	0	0	0	0
Microblade	0.4	2	0	0	0	0	0	0	0	0	0	0
Glass bead	0.1	2	0.15	2	0.3	3	0	0	0	0	0	0
Cordage	0	0	0.5	1	0	0	0	0	0	0	0	0
Asphaltum	0	0	4.5	1	0	0	0	0	0	0	0	0
Small shell bead	0	0	0	0	0.5	1	0	0	0	0	0	0
*Olivella Bead – E3b**	0	0	0	0	0.27	1	0	0	0	0	0	0
*Olivella Bead - C2**	0	0	0	0	0	0	0	0	0	0	0	0
*Bead, Olivella - G**	0	0	0	0	0	0	0	0	0.1	2	0	0
Total	259.9		81.9		59.9		18.0		7.8		84.5	

*Bead types are from Bennyhoff and Hughes 1987

A.2 – Cultural Data (All weights are in g)

CA-SRI-783, Unit 1												
	0-10 cmbs		**10-20 cmbs**		**20-30 cmbs**		**30-40 cmbs**		**40-50 cmbs**		**50-54 cmbs**	
Material	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**
Charcoal	110.5	N/A	79.55	N/A	90.97	N/A	19.45	N/A	31.32	N/A	2.13	N/A
Scraper (Metavolcanic)	0	0	0	0	0	0	0	0	0	0	0	0
Lithics (Metavolcanic)	1.1	3	133.86	3	17.21	9	35.07	11	32.63	29	0.33	1
Microblade	1.0	5	0	0	0.36	1	0	0	0	0	0	0
Groundstone	0	0	3.17	1	129.05	2	2.06	1	0	0	0	0
Awl (Bone)	0.3	1	0.88	1	0	0	0	0	0	0	0	0
Pendant (Steatite)	0	0	0.47	1	0	0	0	0	0	0	0	0
Bead (Abalone)	0	0	0.2	1	0	0	0	0	0	0	0	0
Asphaltum	0	0	0	0	1.43	2	0	0	0	0	0	0
*Olivella bead - K1?**	0	0	0.09	1	0	0	0	0	0	0	0	0
*Olivella bead - H2e**	0	0	0.05	1	0	0	0	0	0	0	0	0
*Olivella bead - H3**	0	0	0.07	1	0	0	0	0	0	0	0	0
*Olivella bead - K3**	0	0	0	0	0.07	0	0	0	0	0	0	0
*Olivella bead - B6**	0	0	0	0	0.03	0	0	0	0	0	0	0
Total	112.8		218.3		239.1		56.6		64.0		2.5	

CA-SRI-786, Unit 1

	0-11 cmbs		11-20 cmbs		20-25 cmbs		25-35 cmbs		35-45 cmbs		45-55 cmbs		55-64 cmbs	
Material	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**	**Wt.**	**Count**
Lithics (metavolcanic)	5.4	2	0	0	0.36	1	0	0	0.3	2	3.38	5	1.7	0
Charcoal	2.45	N/A	2.43	N/A	0.57	N/A	0.51	N/A	1.05	N/A	0.86	N/A	0.13	N/A
Total	7.85		2.43		0.93		0.51		1.35		4.24		2.22	

Appendix B – $\delta^{18}O$ Data

B.1 – Shell profiles to determine season of harvest.

CA-SRI-783, Unit 1, 0-10 cmbs

Band (mm)	$\delta^{18}O$	SST
0	0.71	14.09
2	1.29	11.63
4	0.94	13.11
6	0.78	13.80
8	Sample too small	
0	0.63	14.41
2	Sample too small	
4	0.86	13.46
6	1.02	12.78
8	1.08	12.51
0	Sample too small	
2	Sample too small	
4	0.30	15.78
6	0.45	15.15
8	Sample too small	
0	0.66	14.28
2	Sample too small	
4	Sample too small	
6	-3.08	29.91
8	Sample too small	
0	-0.12	17.55
2	0.43	15.23
4	Sample too small	
6	0.26	15.96
8	0.35	15.57
0	0.88	13.36
2	0.93	13.13
4	0.53	14.84
6	Sample too small	

CA-SRI-772, Unit 1, 10-20 cmbs

Band (mm)	$\delta^{18}O$	SST
0	Sample too small	
2	0.39	15.41
4	0.60	14.51
6	0.74	13.93
8	0.29	15.82
0	0.73	14.00
2	0.34	15.62
4	0.45	15.17
6	0.08	16.72
8	Sample too small	
0	Sample too small	
2	0.83	13.58
4	0.64	14.38
6	0.45	15.17
8	0.01	16.98
0	Sample too small	
2	0.57	14.65
4	0.36	15.56
6	0.40	15.35
8	0.80	13.71
0	Sample too small	
2	0.54	14.79
4	-0.09	17.41
6	-0.35	18.51
8	0.01	16.99
0	Sample too small	
2	0.13	16.48
4	-0.21	17.92
6	0.05	16.82

CA-SRI-770, Unit 1, 60-70 cmbs

Band (mm)	$\delta^{18}O$	SST
0	0.43	15.22
2	-0.01	17.09
4	0.16	16.36
6	0.53	14.82
8	0.37	15.50
0	0.10	16.62
2	0.05	16.85
4	-0.05	17.24
6	Sample too small	
8	0.42	15.27
0	0.33	15.67
2	0.36	15.52
4	0.42	15.30
6	0.54	14.77
8	0.63	14.40
0	0.36	15.52
2	0.07	16.73
4	Sample too small	
6	0.69	14.17
8	0.59	14.56
0	0.07	16.74
2	0.04	16.86
4	-0.15	17.66
6	0.28	15.88
8	0.59	14.59
0	0.26	15.95
2	0.05	16.83
4	0.36	15.54
6	0.82	13.62

8	Sample too small		8	0.06	16.78	8	0.41	15.33
0	Sample too small		0	0.42	15.30	0	0.27	15.93
2	0.88	13.35	2	0.51	14.92	2	0.11	16.57
4	0.45	15.18	4	Sample too small		4	Sample too small	
6	0.93	13.17	6	0.67	14.24	6	0.98	12.96
8	0.36	15.53	8	0.46	15.10	8	Sample too small	
0	1.18	12.11	0	0.60	14.52	0	0.50	14.95
2	Sample too small		2	-0.04	17.20	2	0.03	16.90
4	0.63	14.39	4	0.06	16.79	4	0.52	14.85
6	0.78	13.78	6	0.16	16.35	6	-0.19	17.83
8	-6.77	45.34	8	0.78	13.80	8	0.35	15.58
0	Sample too small		0	Sample too small		0	0.16	16.39
2	0.44	15.22	2	0.89	13.34	2	-0.13	17.58
4	0.78	13.78	4	0.46	15.13	4	-0.10	17.45
6	0.74	13.95	6	0.31	15.76	6	0.10	16.63
8	1.03	12.73	8	0.82	13.63	8	0.56	14.69
0	0.40	15.38	0	0.64	14.36	0	0.07	16.75
2	0.85	13.48	2	0.03	16.93	2	0.41	15.33
4	Sample too small		4	-1.49	23.27	4	0.81	13.65
6	Sample too small		6	0.13	16.49	6	Sample too small	
8	Sample too small		8	0.31	15.73	8	Sample too small	
0	0.60	14.53	0	Sample too small		0	0.53	14.83
2	Sample too small		2	0.53	14.84	2	-0.03	17.17
4	Sample too small		4	0.85	13.48	4	0.49	15.00
6	0.69	14.17	6	0.62	14.44	6	0.64	14.37
8	Sample too small		8	0.69	14.15	8	0.87	13.39
0	1.02	12.77	0	0.78	13.78	0	0.25	16.01
2	Sample too small		2	1.06	12.60	2	0.32	15.70
4	Sample too small		4	1.18	12.12	4	0.39	15.39
6	1.03	12.72	6	1.49	10.80	6	0.27	15.89
8	Sample too small		8	0.60	14.52	8	0.31	15.76
0	0.60	14.55	0	1.01	12.80	0	0.51	14.91
2	Sample too small		2	1.08	12.51	2	0.21	16.15
4	Sample too small		4	1.07	12.56	4	Sample too small	

6	Sample too small	
8	0.28	15.85

6	1.16	12.20
8	1.52	10.69
0	Sample too small	
2	1.14	12.29
4	0.90	13.26
6	Sample too small	
8	1.10	12.45
0	Sample too small	
2	2.16	8.02
4	1.81	9.46
6	1.31	11.55
8	1.03	12.73
0	Sample too small	
2	Sample too small	
4	1.11	12.40
6	1.04	12.71
8	0.61	14.50
0	Sample too small	
2	0.44	15.18
4	Sample too small	
6	0.33	15.67
8	0.29	15.81

6	-0.02	17.13
8	Sample too small	
0	0.04	16.88
	0.11	16.58
4	0.49	14.98
6	0.70	14.11
8	0.29	15.85
0	0.34	15.62
2	1.29	11.65
4	0.45	15.14
6	Sample too small	
8	Sample too small	
0	0.62	14.44
2	0.57	14.68
4	0.29	15.81
6	0.80	13.70
8	0.90	13.26
0	0.64	14.38
2	0.49	14.99
4	0.02	16.94
6	-0.02	17.12
8	-0.17	17.74
0	0.49	15.01
2	0.80	13.71
4	Sample too small	
6	0.59	14.59
8	Sample too small	
0	0.45	15.17
2	Sample too small	
4	0.01	17.00
6	Sample too small	
8	0.24	16.05

B.1 – Shell profiles to determine season of harvest.

CA-SRI-783, Unit 1, 10-20 cmbs

Band (mm)	$\delta^{18}O$	SST
0	1.16	12.18
2	Sample too small	
4	Sample too small	
6	Sample too small	
8	0.85	13.50
0	0.52	14.87
2	Sample too small	
4	0.31	15.76
6	Sample too small	
8	0.27	15.90
0	1.13	12.30
2	Sample too small	
4	0.71	14.08
6	Sample too small	
8	0.12	16.55
0	0.28	15.88
2	0.80	13.68
4	0.24	16.02
6	0.95	13.08
8	1.19	12.05
0	1.19	12.06
2	Sample too small	
4	0.71	14.07
6	0.85	13.50
8	0.71	14.07

B.2 – Full shell profiles to establish seasonal SST.

CA-SRI-783, Unit 1, 0-10 cmbs

Band (mm)	$\delta^{18}O$	SST (ºC)
0	0.96	13.01
2	Sample too small	
4	0.83	13.56
6	1.03	12.73
8	0.42	15.28
10	Sample too small	
12	Sample too small	
14	Sample too small	
16	0.81	13.64
18	Sample too small	
20	0.83	13.57
22	1.03	12.73
24	0.99	12.91
26	1.26	11.76
28	1.15	12.23
30	0.49	14.99
32	1.11	12.38
34	0.94	13.10
36	1.03	12.73

CA-SRI-772, Unit 1, 10-20 cmbs

Band (mm)	$\delta^{18}O$	SST (ºC)
0	1.1	12.4
2	1.0	12.9
4	0.6	14.6
6	0.5	15.1
8	0.3	15.8
10	0.1	16.4
12	-0.1	17.3
14	0.1	16.4
16	0.8	13.7
18	0.8	13.7
20	1.0	12.9
22	1.1	12.4
24	1.0	12.7
26	0.9	13.2
28	1.0	12.7
30	1.0	12.7
32	0.7	14.1
34	0.4	15.5
36	0.1	16.5

CA-SRI-770, Unit 1, 60-70 cmbs

Band (mm)	$\delta^{18}O$	SST (ºC)
0	Sample too small	
2	0.1	16.7
4	0.4	15.2
6	Sample too small	
8	0.7	14.0
10	1.0	12.7
12	1.0	12.9
14	0.7	14.0
16	0.4	15.3
18	0.7	14.2
20	0.7	14.0
22	Sample too small	
24	0.4	15.2
26	0.5	14.9
28	1.1	12.6
30	Sample too small	
32	0.8	13.6
34	0.4	15.3
36	0.4	15.2

B.2 – Full shell profiles to establish seasonal SST.

0	0.58	14.59
2	0.20	16.22
4	0.46	15.12
6	Sample too small	
8	Sample too small	
10	0.40	15.38
12	0.46	15.11
14	Sample too small	
16	0.05	16.81
18	0.94	13.12
20	Sample too small	
22	0.23	16.08
24	Sample too small	
26	0.39	15.41
28	0.99	12.89
30	0.86	13.45
32	0.74	13.97
34	0.89	13.33
36	0.82	13.62

0	1.0	12.8
2	-0.2	18.0
4	0.4	15.5
6	0.4	15.2
8	0.4	15.5
10	0.0	17.0
12	-0.1	17.4
14	0.6	14.5
16		17.0
18	0.6	14.4
20	0.6	14.3
22	0.7	14.2
24	0.4	15.6
26	0.3	16.0
28	Sample too small	
30	0.1	16.4
32	Sample too small	
34	0.6	14.6
36	0.8	13.7