



Contextualizing Late Holocene Subsistence Change on California's Northern Channel Islands: A Middle Period Case Study from Santa Cruz Island

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ABSTRACT

The complex relationship between sociopolitical complexity, natural climatic change, and subsistence strategies on California's Northern Channel Islands has long been a topic of archaeological inquiry. One period of particular interest to researchers is the Middle-to-Late Period Transition (MLT, 800–650 cal BP), during which Chumash hierarchical sociopolitical organization is thought to have solidified. Multiple models of sociopolitical change have been proposed, all of which acknowledge the relationship between growing populations, shifting dietary patterns, climatic events, and sociopolitical structure. Considerable debate remains, with some pointing to the importance of events during the late Middle Period (~1,500–800 cal BP) or earlier. While these models partly rely on dietary data from late Middle, MLT, and Late Period (650 cal BP–AD 1542) archaeological sites, research at late Middle Period sites has often been more limited than work at later sites, leaving an imbalance in our understanding of subsistence shifts and changing cultural and environmental dynamics. Here, we present faunal and dietary data from two well-dated Middle Period sites on *Limuw* (Santa Cruz Island) that document an intensification of finfishing in the Middle Period, supporting models that see the evolution of Island Chumash complexity as a more gradual phenomenon.

RESUMEN

La relación entre la complejidad sociopolítica, el cambio climático natural y las estrategias de subsistencia en las Islas del Canal del Norte de California ha sido durante mucho tiempo un tema de investigación arqueológica. Un período de particular interés para los investigadores es la Transición del Período Medio al Tardío (MLT, 800–650 cal BP), durante el cual se cree que se solidificó la organización sociopolítica jerárquica de Chumash. Se han propuesto múltiples modelos de cambio sociopolítico, todos los cuales reconocen la relación entre poblaciones en crecimiento, patrones dietéticos cambiantes,

eventos climáticos y estructura sociopolítica. Sigue existiendo un debate considerable y algunos señalan la importancia de los acontecimientos ocurridos a finales del Período Medio (~1,500–800 cal BP) o antes. Si bien estos modelos se basan en parte en datos dietéticos de sitios arqueológicos del Período Medio Tardío, MLT y Tardío (650 cal BP–AD 1542), la investigación en sitios del Período Medio Tardío a menudo ha sido más limitada que el trabajo en sitios posteriores, lo que deja un desequilibrio en nuestra comprensión de los cambios de subsistencia y de las dinámicas culturales y ambientales cambiantes. Aquí, presentamos datos sobre fauna y dieta de dos sitios bien fechados del Período Medio en *Limuw* (Isla Santa Cruz) que documentan una intensificación de la pesca con aletas en el Período Medio, respaldando modelos que ven la evolución de la isla Chumash. La complejidad como un fenómeno más gradual.

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The relationships between sociopolitical complexity, natural climate change, and human subsistence strategies have long been an important line of inquiry for archaeologists working on California's Northern Channel Islands (NCI). Of particular interest has been the Middle-to-Late Transition (MLT, 800–650 cal BP), a period of hypothesized climatic change and the interval during which Chumash hierarchical sociopolitical organization is thought to have solidified (Arnold 1992, 2001a, 2001b; Kennett 2005). The MLT was proposed by Arnold (1992) as a time during which natural environmental shifts spurred island populations to congregate into large coastal villages, with finfishing (e.g., Actinopterygii and Elasmobranchii) becoming the most important protein contributor to island economies and for social hierarchies to develop.

Kennett (2005; Kennett and Kennett 2000) built on Arnold's (1992) model and argued that prolonged drought events, along with cooler sea surface temperatures, prompted communities to coalesce near reliable freshwater sources in large coastal villages and to shift their protein diets away from a primarily shellfish protein diet to finfish, highlighting important changes that began some 500 years earlier during the late Middle Period. High population densities, limited fresh water, and competition resulted in increased interpersonal violence, declines in human health signatures, and a heavy reliance on nearshore and kelp forest fish (Erlandson and Jones 2002; Lambert and Walker 1991). As an outgrowth of these settlement and subsistence shifts, the emergence of institutionalized hierarchies developed rapidly and were necessary to control densely populated coastal villages as well as to regulate resource use.

In an alternative view, Gamble (2008) and King (1990; also see Erlandson and Rick 2002) view the rise of sociopolitical complexity on the NCI as a more gradual process, developing as a reaction to long-term environmental events and the steady increase in human population densities. The MLT, then, was not marked by the sudden and rapid onset of sociocultural and economic shifts, but rather a continuation of millennia of change that resulted in the classic complex, maritime hunter-gatherer Chumash society encountered by the Spanish in AD 1542.

Both models are similar in that they identify a strong relationship between rising populations, shifting dietary patterns, climatic events, and sociopolitical structure that resulted in institutional hierarchies and an islander protein economy focused on finfishing by the Late Period (650 cal BP–AD 1542). The models differ, however, in timing and scale. When these models were first developed and debated, they were built with few Middle Period (2,400–800 cal BP) island archaeological sites that were excavated, analyzed, and well-dated that could help contextualize the relative reliance on shellfishing compared to finfishing immediately prior to the MLT. Arnold (1992, 2001a, 2001b) and Kennett (2005) had relatively few datasets available from Middle Period sites when they developed their model of rapid shifts linked to sudden climatic change, and King (1990) and Gamble (2008) focused more on longer-term trajectories and changes in material culture indicators of status and the rise of sociopolitical elites.

In recent years, a variety of Middle Period sites has been excavated, the analysis of which has added to our view of sociopolitical and economic shifts during the MLT and Late Period (Braje 2010; Braje et al. 2007; Jazwa et al. 2019; Jazwa, Joslin, and Kennett 2020; Jazwa, Kennett, and Hanson 2012; Perry and Glassow 2015; Rick 2007; Thakar 2014). We add to these data by presenting zooarchaeological data from two late Middle Period archaeological sites on southwestern *Limuw* (Santa Cruz Island). Both sites, CA-SCRI-475 and CA-SCRI-890, are dense shell midden deposits exposed along eroding sea cliffs and offer a window into Chumash foraging strategies immediately prior to dramatic climatic changes and the rise of sociopolitical complexity.

In addition, Arnold's (1992) model was developed from her excavations of a series of Late Holocene Chumash villages on Santa Cruz Island (CA-SCRI-191, CA-SCRI-192, CA-SCRI-240, CA-SCRI-328, CA-SCRI-330, and CA-SCRI-474) on the west end of *Limuw*, not far from CA-SCRI-475 and CA-SCRI-890, making these sites especially relevant for evaluating past subsistence and technological changes. Despite significant interest and important research on this time period, questions persist about the types of shellfish people were gathering and the relative importance of various animal categories through time. We seek to fill this gap through our

analyses of shellfish and other faunal constituents from Late Holocene *Limuw* and a synthesis of data from throughout the NCI.

Environmental and Cultural Background

Limuw is the largest and most ecologically diverse of the Northern Channel Islands. Located ~30 km off the mainland California coast, it is 35 km long and 10 km wide with an area of 249 km² (Figure 1; Schoenner, Feldmeth, and Emerson 1999). It is the most topographically rugged and geographically diverse of the NCI, hosting multiple habitat types that support an abundance of both terrestrial and marine resources as well as year-round freshwater sources. With roughly 480 native plant species and five additional plant communities found exclusively on the island, *Limuw* boasts the richest flora of all the Channel Islands (Schoenner, Feldmeth, and Emerson 1999), including abundant geophytes, oaks, and other plant foods (Gill et al. 2019). Rocky intertidal, sandy beaches, kelp forests, and other nearshore habitats provided a diverse array of potential subsistence resources that supported human population on the island for at least 13,000 years.

The cultural history of the NCI is as rich and complex as its natural history, supporting human populations continuously throughout the Holocene. The Island Chumash and their predecessors were maritime hunter-gatherers, who harvested both marine and terrestrial resources from a variety of ecosystems. The islands have yielded some of the earliest evidence for human occupation in the New World. Human skeletal remains

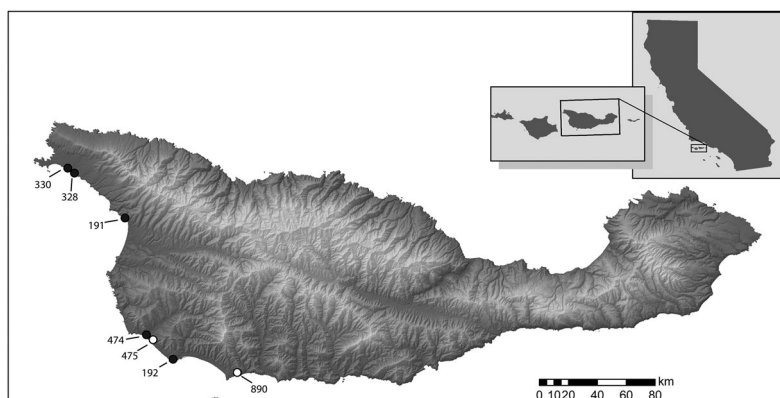


Figure 1. Map of the southern California coast, the Northern Channel Islands, and the archaeological sites discussed in this article. Dark circles are sites excavated and analyzed by Arnold (1992, 1995, 2001a, 2001b), on which many of the changes of the MLT and Late Period were first identified. Light circles are the two Middle Period sites (CA-SCRI-475 and CA-SCRI-890) presented in this study.

from Arlington Springs on Santa Rosa Island (~13,000 cal BP) and shell midden deposits on eastern San Miguel Island (~12,240 cal BP) and north-western Santa Rosa Island (~12,010 cal BP) date human occupation to the terminal Pleistocene (Erlandson et al. 1996, 2011; Johnson et al. 2002).

Only a handful of archaeological sites dated to this interval has been excavated, making it difficult to categorize Paleo coastal subsistence strategies (Gusick and Erlandson 2019). We do know, however, that these earliest island foragers collected a variety of shellfish and geophytes, fished nearshore and kelp forest habitats, and engaged in marine mammal and bird hunting (Erlandson et al. 2011; Gill et al. 2021; Gusick and Erlandson 2019; Hofman et al. 2018).

Throughout the Holocene, subsistence strategies diversified and new sociopolitical and economic systems emerged as island populations increased. Zooarchaeological data from a variety of Early Holocene sites indicate very early and sophisticated nearshore finfishing, shellfish collecting, and a heavily maritime protein diet (Rick, Erlandson, and Vellanoweth 2001; Vellanoweth et al. 2003). During the Middle Holocene (7,500-3,500 cal BP), there is evidence for increasing sedentism, a variety of new subsistence technologies, the expansion of long-distance trading networks, and early subsistence intensification (Braje 2010; Braje, Erlandson, and Rick 2021; Kennett 2005; Rick et al. 2005).

It was not until the Late Holocene, however, that the Island Chumash saw a dramatic increase in economic and political complexity. By first European contact in AD 1542, the Chumash were hierarchically organized, complex hunter-gatherers, supporting large sedentary populations through a mixture of diverse subsistence strategies, innovative maritime hunting technologies, intensive economic (purple olive snail [*Callianax biplicata*] beads) exchange networks, and chief-level political organization.

Climatic, Social, Technological, and Dietary Change During the Late Holocene

The Late Holocene (3,500 cal BP-AD 1542) on the NCI was one of the coldest, most unstable marine climatic intervals of the last 10,000 years and the period when institutionalized hierarchical sociopolitical systems solidified (Figure 2; Jazwa et al. 2019; Kennett 2005; Kennett and Ingram 1995; Kennett and Kennett 2000; Kennett et al. 2007). Short-term climatic variability, such as fluctuations in upwelling and the impacts of El Niño/Southern Oscillation (ENSO) events, affected the productivity and availability of marine resources, causing shifts in the dietary importance of certain taxa. Warmer water intervals occurred between 2,900 and 1,500 cal BP, along with general warming trends from 500 years ago to the present.

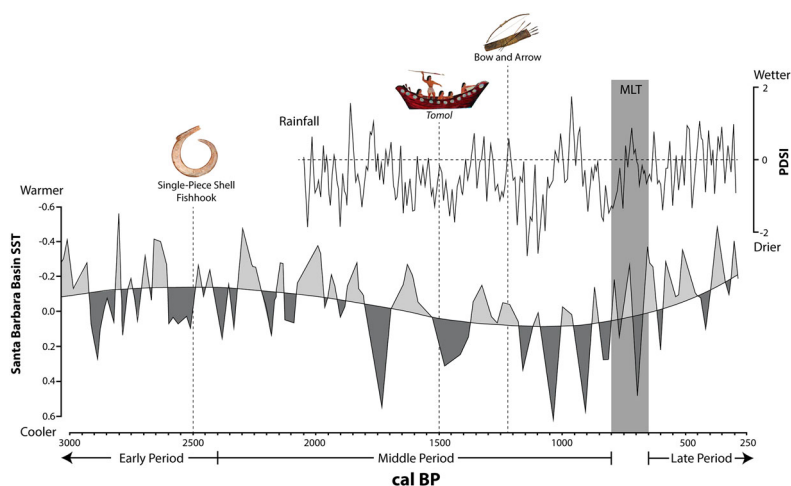


Figure 2. Late Holocene climatic patterns and some important technological innovations identified on the California NCI (following Jazwa et al. 2019). Sea surface temperature fluctuations are derived from Kennett and Kennett (2000) and rainfall fluctuations are from the Cook and Krusic (2004) Palmer Drought Severity Index (PDSI).

These intervals drove periods of lower marine productivity between 2800 and 1000 cal BP (Kennett 2005), although it is not clear if or how these affected the Island Chumash. Several lines of evidence indicate dry conditions during the Late Holocene, particularly between 2300 and 1500 cal BP and again after 500 cal BP (Jones et al. 1999; Kennett 2005; Raab and Larson 1997), which were exacerbated by megadroughts during the Medieval Climatic Anomaly (MCA) (1,150-600 cal BP). These droughts may have reduced the number of permanent freshwater sources on the NCI and led to the aggregation of some Island Chumash communities.

Significant demographic and settlement changes occurred during the Late Holocene and solidified during the MLT (Arnold 1992). While it is difficult to estimate human populations on the NCI, there is evidence for steady population growth from the Early to Late Holocene, with more rapid demographic increases occurring around 1,300 cal BP (Erlandson and Rick 2002; Kennett 2005). This growth is evidenced by larger numbers of coastal villages after 3,000 cal BP and an increase in the number of site components dated to the Late Holocene (Erlandson et al. 2001).

However, the exact timing of population growth and its relationship to changes in subsistence strategies, technological innovations, and the rise of sociopolitical complexity is not well understood. Rising island

populations may have forced islanders to develop new technologies, diversify dietary strategies, and develop hierarchies to regulate resources or these sociocultural and economic developments may have come first, allowing populations to increase further. More demographic data are necessary to understand these complex interrelationships.

New sociopolitical and economic systems were established during the Late Holocene, characterized by village-level economic and political organization, governed by hereditary chiefs (Gamble 1995; Kennett 2005). Archaeological data document significant cultural changes, including economic intensification, increased violence, and the control of island resources by certain communities and/or individuals (Arnold 1987, 1992, 2001a, 2001b; Kennett and Kennett 2000). Status differentiation, craft specialization, and ritual behavior are all cultural hallmarks of the Late Holocene and Late Period (Arnold 2001a; Arnold and Graesch 2001, 2004; Erlandson and Jones 2002; Glassow 1996; Glassow et al. 2007; Kennett 2005; Pletka 2001; Rick 2007; 2011; Rick et al. 2005). Major technological advances also occurred during the latter half of the Late Holocene, including the development of circular shell fishhooks, the plank canoe, purple olive snail cup beads, net weights, contracting stem points, harpoons, and the bow and arrow (Arnold 1995; Braje, Erlandson, and Rick 2021; Gamble 2002; Glassow 1996; Rick et al. 2002).

Regional trade and exchange on the NCI surged during the Late Holocene. Excavations at large coastal village sites have yielded increasing numbers of formal artifacts manufactured from non-local materials (e.g., fused shale, obsidian, serpentine) (Kennett 2005). Islanders exchanged fish, shell beads, sea otter pelts, and other items for terrestrial food resources such as acorns and seeds, and nonfood items such as deer bone and baskets (Arnold 1992; Kennett 2005; King 1990; Rick 2007). A notable increase in shell bead production occurred between 1,300 and 850 cal BP on the islands and peaked between 650 and 200 cal BP (Kennett 2005; Kennett and Conlee 2002). *Callianax biplicata* shell cup beads became the most important island exchange item (often referred to as “money beads”) and were traded throughout the western United States and into northern Mexico (Bennyhoff and Hughes 1987; King 1990).

On *Limuw*, dense accumulations of shell bead production detritus in late Middle and Late period sites demonstrate intensive cross-channel trade networks. The most intensive production of beads has been recorded on the west end of *Limuw*, where sandy beaches provide an abundance of these small gastropods, although sites on Santa Rosa and San Miguel islands also contain evidence of significant bead production (Arnold 1987; Arnold and Munns 1994; Kennett 2005; Rick 2007). Chert microliths used in bead manufacturing were produced primarily on the east end of

Limuw, where high-quality chert outcrops provided raw material (Arnold 1987; Arnold, Preziosi, and Shattuck 2001; Kennett 2005).

Environmental fluctuations and shifts in the availability of marine resources occurred throughout the Late Holocene. The Island Chumash developed new economic and dietary strategies to counteract shifts in resource availability, while sustaining large island populations (Braje 2010; Braje, Erlandson, and Rick 2021; Erlandson, Rick, and Braje 2009). Diversification and intensification of marine resources are evident in the archaeological record throughout the Holocene, with measurable increases in fish and sea mammal remains through time, a diversification of shellfish taxa to include more low-ranked species, and the introduction of new fishing and marine mammal hunting technologies (e.g., redwood plank canoe, single-piece fishhooks) (Braje et al. 2007; Kennett 2005; Rick et al. 2005). In addition, recent research of paleoethnobotanical remains from archaeological sites spanning the Holocene demonstrate that geophytes were super abundant and provided a stable carbo/caloric foundation for the Island Chumash – something not recognized by earlier models defined primarily on assumptions of resource scarcity and stress (see Gill et al. 2019, 2021; Gill, Fauvelle, and Erlandson 2019).

Site Setting and Methods: CA-SCRI-475 and CA-SCRI-890

To contextualize the degree of subsistence shifts during the MLT, we excavated two Middle Period sites on southwestern *Limuw*, CA-SCRI-475 and CA-SCRI-890. These sites were occupied immediately prior to the dramatic economic, cultural, and climatic changes first identified by Arnold (1992, 1995, 2001a, 2001b) during the MLT at a series of Chumash villages on western *Limuw* (CA-SCRI-191, CA-SCRI-192, CA-SCRI-240, CA-SCRI-328, CA-SCRI-330, CA-SCRI-474). CA-SCRI-475 and CA-SCRI-890 are positioned on the southwestern coast in an environmentally rich area, characterized by long stretches of sandy beaches, productive rocky intertidal zones, kelp forest, and freshwater seeps.

CA-SCRI-475 is a large shell midden located on the east side of the mouth of Pozo Creek on a marine terrace overlooking Pozo Beach (Figure 3). The site was recorded by Jeanne Arnold and colleagues in 1988, who estimated its size as at least 70 × 75 m and its maximum depth at 1.9 m. At least five house depressions are visible on the site surface and dense shell midden deposits are actively eroding from sea cliff exposures along the southern site margin. After recording CA-SCRI-475, Arnold obtained a few auger samples from the deposits, presumably related to her more extensive work at the large village of CA-SCRI-474 across Pozo Creek. To our knowledge, no data from Arnold's samples at CA-SCRI-475 have been reported (see Braje et al. 2010).



Figure 3. Top: Photograph of the sea cliff exposure and dense shell midden deposits at CA-SCRI-475 prior to excavation. Bottom: Overview photograph of the location of CA-SCRI-890.

CA-SCRI-890 is a large village site situated on a low marine terrace near Malva Real, just east of Punta Arena. Recorded by Erlandson and Gill in 2013, the site consists of a large, dense shell midden deposit roughly 100 × 150 m in size with at least 11 house pit depressions and an additional

four possible house pits visible on the site surface. The southern margin of the shell midden is exposed in an actively eroding sea cliff, where we also noted evidence of relatively recent looting.

We visited CA-SCRI-475 and CA-SCRI-890 in 2013 as part of a rapid archaeological assessment of *Limuw* archaeological sites threatened by sea level rise and marine erosion. At each site, we excavated a single column sample (consisting of 20 × 20 cm samples) from eroding sea cliff exposures (Figure 2), using arbitrary 10-cm levels and natural stratigraphic breaks when possible. All excavated materials were dry field-screened over 1/16-inch mesh and returned to San Diego State University's Environmental Anthropology and Archaeology Laboratory for detailed zooarchaeological analysis. Single piece, small shell fragments from excavation units were submitted for high-precision accelerator mass spectrometry (AMS) radiocarbon dating for both sites.

Laboratory analyses were conducted by trained graduate and undergraduate students from spring 2014 to fall 2015. All shellfish remains from 1/4-inch and 1/8-inch screen residuals were identified to the most specific taxonomic level possible, using a conservative approach (Moss 1989). The remaining 1/16-inch residuals were "fast-sorted" for diagnostic materials such as shell beads and other artifacts. The remaining faunal material was sorted by class (fish, land mammal, sea mammal, and undifferentiated bone) and weighed. We focused on shellfish to help fill gaps in Late Holocene shellfish data from Santa Cruz Island and to better document human interactions with local nearshore communities. Minimum number of individuals (MNI) was recorded for shellfish taxa when possible (Glassow 2000; Mason, Peterson, and Tiffany 1998). Meat-yield conversion formulas were applied to calculate the approximate amount of edible meat represented by major faunal taxa following Braje (2010), Erlandson (1994), and Glassow and Wilcoxon (1988).

While it is important to understand the importance of shellfish relative to other faunal categories (e.g., fish, sea mammal), it can be difficult to quantify shellfish abundance compared to vertebrate remains because of preservation biases (see Butler and Campbell 2004). Additionally, dietary reconstructions based on meat multipliers are subject to a variety of methodological, sampling, and taphonomic biases (Erlandson 1994; Gifford-Gonzalez and Hildebrandt 2012; Mason, Peterson, and Tiffany 1998; Moss 1989). However, other zooarchaeological measures (e.g., number of identified specimens [NISP], non-repetitive elements [NRE], biomass, and MNI) pose methodological challenges, particularly when comparing across animal categories (e.g., fish versus shellfish) (Glassow 1996).

Because of these challenges, we present NISP and MNI data for all faunal categories in this article. We use meat weights to compare between different animal categories and acknowledge the methodological

challenges associated with this method. Without this data transformation, however, the relative dietary importance of finfish is often obscured as shellfish remains normally constitute the vast majority of the total weight of the faunal sample at NCI archaeological sites (Kennett 2005). Although the overall dietary importance of shellfish tends to decline throughout the Holocene, shellfish harvesting tends to intensify alongside growing human populations (see Braje, Rick, and Erlandson 2012).

Published dietary data spanning the Early, Middle, MLT, and Late periods of the Late Holocene were compiled to contextualize the dietary patterns identified at CA-SCRI-475 and CA-SCRI-890. While zooarchaeological data are reported in different ways by NCI archaeologists, we focused on well-dated Late Holocene sites with at least 1 kg of faunal materials reported. We then compiled the total grams of shellfish and fish from each site or site component and converted these to edible meat estimates using standard meat weight conversions for the Santa Barbara Channel region (see Braje 2010; Rick 2007).

Results

Seven AMS radiocarbon dates from well-preserved shell fragments were obtained from CA-SCRI-475 ($n = 5$) and CA-SCRI-890 ($n = 2$) (Table 1). The dates all fall squarely into the Middle Period over a relatively tight time frame. The radiocarbon chronology suggests that CA-SCRI-475 was occupied from approximately 2,890–740 cal BP and CA-SCRI-890 from roughly 1,470–700 cal BP, at the two-sigma age range. These age ranges suggest that Island Chumash occupation of both sites may have continued into the early MLT Period (800–650 cal BP), although it is statistically

Table 1. Radiocarbon Dates from CA-SCRI-475 and CA-SCRI-890.

Site CA-	Provenience	Material	Lab # (DAMS-)	14C Age	Age Range, 1 sigma (cal BP)	Age Range, 2 sigma (cal BP)
SCRI-475	Stratum 1A, 13 cm below surface	California Mussel	5093	1,728 ± 24	1,130–870	1,240–740
SCRI-475	Stratum 1B, 42 cm below surface	California Mussel	5088	1,732 ± 22	1,140–875	1,250–750
SCRI-475	Stratum 2, 62 cm below surface	California Mussel	5090	1,744 ± 26	1,150–890	1,260–760
SCRI-475	Stratum 3, 79 cm below surface	Black Abalone	5092	2,090 ± 25	1,500–1,250	1,630–1,100
SCRI-475	Base of deposit	Marine Shell	3980	3,142 ± 26	2,760–2,465	2,890–2,320
SCRI-890	Stratum 1, 10 cm below surface	California Mussel	5098	1,692 ± 31	1,080–810	1,210–700
SCRI-890	Stratum 1, 80 cm below surface	California Mussel	5094	1,952 ± 23	1,340–1,090	1,470–960

Note: Radiocarbon dates were calibrated using CALIB 8.2 with a delta-R of 128 ± 104.

possible that both sites were abandoned somewhat earlier. Either way, occupation of the two predominantly Middle Period sites seems to have ended by the beginning or early stages of the MLT Period. The dates from CA-SCRI-475 overlap with the large house pit village of CA-SCRI-474 across Pozo Creek, however, where Arnold (2001a) documented a continued Island Chumash occupation spanning the MLT Period.

While archaeological materials from these column samples consist primarily of shellfish and animal bone, a small number of artifacts were discovered. Artifacts recovered from CA-SCRI-475 and CA-SCRI-890 reflect a maritime economy focused on maritime foraging and the production and exchange of *Callianax biplicata* beads. A total of 1,026 artifacts was recovered from excavations at CA-SCRI-475, 960 of which consist of chipped stone artifacts. The vast majority of these were classified as debitage and waste debris, but two chert microdrill fragments were also identified, likely used for the production of shell beads.

Chipped stone materials consist primarily of local chert and metavolcanics, although six obsidian flakes were found and represent island-mainland exchange, with the nearest obsidian source located ~250 km to the interior at Obsidian Butte (Gill et al. 2019). Two nearly complete J-shaped California mussel shell fishhooks and one smaller fragment were recovered from CA-SCRI-475, along with one complete J-shaped abalone fishhook and 56 *Callianax biplicata* beads (Figure 4). Fifty-four of the specimens are wall beads, with two spire-removed beads. Three bone gorge fragments were also identified, along with one bone awl fragment. Red ochre fragments ($n = 50$), likely used as pigment, were recovered from the sample as well.

Excavations at CA-SCRI-890 yielded a total of 472 artifacts. The largest artifact class is chipped stone ($n = 450$), which, like CA-SCRI-475, consists mostly of local cherts and metavolcanics. One complete metavolcanic drill and one chert drill tip were identified in the sample, along with one chert core. Shell artifacts include three California mussel J-shaped fishhook fragments and 11 *Callianax biplicata* beads, 10 wall beads, and one spire-removed. One cylindrical soapstone bead was also present in the sample, along with one California mussel bead and one bone bead, likely crafted from a sea mammal vertebra. Four tarring pebbles, one pestle fragment, and one red ochre fragment were also recovered at CA-SCRI-890.

Zooarchaeological analysis of column samples from CA-SCRI-475 and CA-SCRI-890, by weight, are dominated by shellfish remains, comprising 95.2% and 94.9% of the total assemblage, respectively (Tables 2 and 3). California mussel shell dominates the shellfish assemblages by weight, followed by much smaller amounts of other highly ranked intertidal shellfish species such as sea urchin and black abalone (see Braje et al. 2007). Fish



Figure 4. Selected Middle Period artifacts recovered from excavations at CA-SCRI-475 and CA-SCRI-890: (A) J-shaped shell fishhooks from CA-SCRI-475 (top row) and CA-SCRI-890 (bottom row); (B) bone tools from CA-SCRI-475; and (C) bone (left) and soapstone (right) beads from CA-SCRI-890. Photographs by S. Duncan.

bone contributes only 3.5% of the total faunal weight at CA-SCRI-475 and 3.1% at CA-SCRI-890, with sea mammal bone contributing 1.1% and 2.0%, respectively.

Meat weight conversions suggest a much greater reliance on vertebrate proteins at both CA-SCRI-475 and CA-SCRI-890. These conversions are important as they help assess the shift towards more intensive finfishing and the declining dietary contribution of shellfish harvesting during the Late Holocene. Meat weight multipliers follow those reported by other

Table 2. Faunal Data from Excavations at CA-SCRI-475.

	Weight (g)	Weight %	Meat Weight (g)	Meat (%)
California Mussel	18380.5	70.2	5477.4	13.5
Black Abalone	750.2	2.9	708.2	1.7
Red Abalone	32.7	0.1	44.5	0.1
Abalone undiff	166.6	0.6	191.9	0.5
Platform Mussel	135.2	0.5	49.2	0.1
Black Turban Snail	123.8	0.5	45.2	0.1
Purple Olive Snail	132	0.5	-	-
Sea Urchin	3095.8	11.8	1804.9	4.4
Acorn Barnacle	942.6	3.6	-	-
Gooseneck Barnacle	90.4	0.3	-	-
Chiton	330.6	1.3	380.2	0.9
Worm Shell	53.8	0.2	-	-
Limpets undiff	84.5	0.3	-	-
Crab	196.3	0.7	-	-
Shell undiff	165.3	0.6	-	-
Nacre	221.6	0.8	160.4	0.4
Gastropods undiff	11.8	<0.1	-	-
Slipper Shell	1.5	<0.1	-	-
Wavy Turban	6.7	<0.1	-	-
Giant Pacific Chiton	23.4	0.1	-	-
Brown Turban	5.4	<0.1	-	-
Jewel Box	0.3	<0.1	-	-
Shellfish Subtotal	24972.5	95.2	8861.7	21.8
Fish Bone	905.7	3.5	25087.1	61.8
Sea Mammal Bone	275.4	1.1	6664.2	16.4
Land Mammal Bone	4.8	<0.1	-	-
Bird Bone	17.4	<0.1	-	-
Vertebrate Subtotal	1203.3	4.5	31751.3	78.2
Total	26175.8	100	40613	100

Note: Overall dietary contribution is based on meat weight conversions that include shellfish, fish, sea mammals, and bird bone (see Braje 2010; Erlandson 1994; Glassow and Wilcoxon 1988; Rick 2007).

Channel Island archaeologists for major dietary taxa. Dietary reconstructions suggest a heavy reliance on fish at both sites, providing 61.8% of the meat yield at CA-SCRI-475 and 51.7% at CA-SCRI-890. Sea mammals provided estimated meat yields of 16.4% at CA-SCRI-475 and 28.3% at CA-SCRI-890. Rocky intertidal shellfish provided 21.8% and 19.9%, respectively, with California mussel as the largest single contributor at 13.5% and 11.3%.

To place dietary strategies at CA-SCRI-475 and CA-SCRI-890 into a broader temporal context, we compiled faunal data available from Late Holocene sites across the NCI. We only considered sites that produced 1 kg or more of faunal material from subsurface excavations. Due to differences in reporting and challenges converting data to g/m³ (volumetric reporting is not always available), we compiled the total shellfish remains (g) and fish bone (g) from each site (Table 4). These data were then converted to meat yields, but due to the lack of consistent reporting of shellfish species or genera at each site, we used a standard shellfish multiplier of 0.724 and 24.2 for fish (Jazwa et al. 2019). Including the two sites

Table 3. Faunal Data from Excavations at CA-SCRI-890.

	Weight (g)	Weight %	Meat Weight (g)	Meat (%)
California Mussel	3538.4	63.8	1054.5	11.3
Black Abalone	229.5	4.1	216.6	2.3
Red Abalone	19.2	0.3	25	0.3
Abalone undiff	43	0.8	49.5	0.5
Platform Mussel	68.7	1.2	25	0.3
Black Turban Snail	57.3	1.0	20.9	0.2
Olivella	59.8	1.1	-	-
Sea Urchin	488.7	8.8	284.9	3.1
Acorn Barnacle	303.5	5.5	-	-
Gooseneck Barnacle	40.7	0.7	-	-
Chiton	25.9	0.5	-	-
Worm Shell	6.0	0.1	-	-
Limpets	15.7	0.3	-	-
Crab	25.6	0.5	-	-
Shell undiff	89.7	1.6	-	-
Clam	0.9	<0.1	-	-
Nacre	249.2	4.5	180.4	1.9
Gastropods undiff	2.9	0.1	-	-
Slipper Shell	0.9	<0.1	-	-
Trivia	0.3	<0.1	-	-
Shellfish Subtotal	5265.9	94.9	1856.8	19.9
Fish Bone	173.9	3.1	4817.9	51.7
Sea Mammal Bone	108.9	2.0	2636.1	28.3
Vertebrate Subtotal	282.8	5.1	7454.0	80.1
Total	5548.7	100	9310.8	100

Note: Overall dietary contribution is based on meat weight conversions that include shellfish, fish, sea mammals, and bird bone (see Braje 2010; Erlandson 1994; Glassow and Wilcoxon 1988; Rick 2007).

described here, our metanalysis included 27 Late Holocene sites with 42 discrete components: seven sites and 10 site components from *Limuw*, 11 sites and 19 site components from *Wi'ma* (Santa Rosa Island), and nine sites and 13 site components from *Tuqan* (San Miguel Island) (Figure 5).

These NCI-wide data generally confirm that finfishing becomes more central to the protein diets of Channel Islanders during the Late Holocene, with shellfish contributing less to the diet through time. During the Early Period of the Late Holocene and the earliest Middle Period, protein diets are generally dominated by shellfish. A shift becomes evident after about 1,300 cal BP, however, as finfishing becomes more central to Island Chumash diets. This shift becomes even more pronounced in the MLT and Late periods, when faunal data from the vast majority of archaeological sites suggest that finfishing contributed 60% or more of the protein to Island Chumash diets.

Discussion and Conclusions

The MLT was a time of pronounced environmental fluctuation, which many Channel Island archaeologists argue helped spur the rise of sociopolitical

Table 4. Summary table of shellfish versus fish remains from published sources of late holocene archaeological sites from across the Northern Channel Islands.

Site CA-	Provenience	Age (cal BP)	Time Period	Shellfish		Fish Bone		Total g	Shellfish Meat		Fish Meat		References
				g	%	g	%		(Wt)	%	(Wt)	%	
SCRI-801	Unit 12N-OE	3350–3000	Early	8063.2	100.0	0.9	0.0	8064.1	5837.8	99.6	21.8	0.4	Perry and Glassow 2015
SRI-31	Unit 2, 10–25 cm	3190–2910	Early	1358.0	96.0	57.1	4.0	1415.1	983.2	41.6	1381.8	58.4	Kennett 2005
SMI-87	West Unit, all levels	3200–2860	Early	19326.5	99.6	69.8	0.4	19396.3	13992.4	89.2	1689.2	10.8	Rick 2007
SMI-87	East Unit, all levels	2860–2340	Early	17492.8	99.9	17.0	0.1	17509.8	12664.8	96.9	411.4	3.1	Rick 2007
SRI-147	Column Sample, 60–70 cm	2660–2440	Early	1236.5	99.9	1.2	0.1	1237.7	895.2	96.9	29.0	3.1	Braje et al. 2007
SRI-41	Unit 1, 20–30 cm	2280–2070	Middle	1329.3	95.0	69.5	5.0	1398.8	962.4	36.4	1681.9	63.6	Kennett 2005
SCRI-475	Column 1	2890–2740	Middle	24972.5	96.5	905.7	3.5	25878.2	18080.1	45.2	21917.9	54.8	This Study
SCRI-236	Levels 17–20	~1535	Middle	37755.0	99.6	167.5	0.4	37922.5	27334.6	87.1	4053.5	12.9	Thakar 2014
SRI-31	Column Sample	1680–1350	Middle	5561.6	96.8	184.1	3.2	5745.7	4026.6	47.5	4455.2	52.5	Jazwa, Kennett, and Hanson 2012
SCRI-823	Level 5	~1420	Middle	4784.0	98.7	61.6	1.3	4845.6	3463.6	69.9	1490.7	30.1	Thakar 2014
SMI-628	Column 1, Lv. 1	1480–1300	Middle	3515.1	99.0	35.4	1.0	3550.5	2544.9	74.8	856.7	25.2	Braje 2010
SMI-492	N Profile, Str 9	1360–1240	Middle	1349.3	81.8	300.0	18.2	1649.3	976.9	11.9	7260.0	88.1	Kennett 2005
SCRI-236	Levels 15–16	~1235	Middle	5647.0	99.5	27.3	0.5	5674.3	4088.4	86.1	660.7	13.9	Thakar 2014
SRI-130	Unit 1, 7–44 cm	1310–1150	Middle	1836.1	99.0	17.9	1.0	1854.0	1329.3	75.4	433.2	24.6	Kennett 2005
SRI-41	Unit 1, 0–10 cm	1260–1130	Middle	1017.2	98.2	18.8	1.8	1036.0	736.5	61.8	455.0	38.2	Kennett 2005
SMI-510	N Profile, Str 6, 89–97 cm	1260–1110	Middle	1598.0	97.7	38.0	2.3	1636.0	1157.0	55.7	919.6	44.3	Kennett 2005
SMI-232	Columns 1 and 2	1290–1070	Middle	15924.9	88.3	2104.9	11.7	18029.8	11529.6	18.5	50938.6	81.5	Braje 2010
SMI-481	Unit 1	1260–1920	Middle	14128.1	94.9	759.1	5.1	14887.2	10228.7	35.8	18370.2	64.2	Rick 2007
SRI-15	Unit 1, St. C-H, 65–135 cm	1265–1930	Middle	6344.2	91.1	619.1	8.9	6963.3	4593.2	23.5	14982.2	76.5	Jazwa, Kennett, and Hanson 2012
SMI-468	Unit 2, Str III	1150–1040	Middle	2911.7	96.2	115.3	3.8	3027.0	2108.1	43.0	2790.3	57.0	Rick 2007
SCRI-823	Levels 3–4 & Feature 1	~1140	Middle	26277.0	99.3	176.2	0.7	26453.2	19024.5	81.7	4264.0	18.3	Thakar 2014
SCRI-890	Column 1	1470–1700	Middle	5265.9	96.8	173.7	3.2	5439.6	3812.5	47.6	4203.5	52.4	This Study
SRI-2	Unit 2, Str 3	1030–880	Middle	2418.7	95.8	106.1	4.2	2524.8	1751.1	40.5	2567.6	59.5	Rick 2011
SCRI-647	Augers	950–700	MLT	5456.5	94.7	307.1	5.3	5763.6	3950.5	34.7	7431.8	65.3	Perry and Glassow 2015
SMI-468	Unit 1	910–720	MLT	15278.3	96.4	566.7	3.6	15845.0	11061.5	44.6	13714.1	55.4	Rick 2007
SRI-15	Unit 1, St. A & B, 0–30 cm	880–560	MLT	1917.8	92.3	160.4	7.7	2078.2	1388.5	26.3	3881.7	73.7	Jazwa, Kennett, and Hanson 2012
SRI-97	Unit 1 30–100 cm	795–555	MLT/Late	3992.6	95.2	201.5	4.8	4194.1	2890.6	37.2	4876.3	62.8	Jazwa et al. 2019

(Continued)

Table 4. Continued.

Site CA-	Provenience	Age (cal BP)	Time Period	Shellfish		Fish Bone		Total g	Shellfish Meat		Fish Meat		References
				g	%	g	%		(Wt)	%	(Wt)	%	
SRI-85	Unit 1, 70–80 cm	660–540	Late	1250.9	91.5	115.9	8.5	1366.8	905.7	24.4	2804.8	75.6	Kennett 2005
SCRI-747	Column Sample	650–500	Late	2955.7	98.8	37.2	1.2	2992.9	2139.9	70.4	900.2	29.6	Perry and Glassow 2015
SRI-15	Unit 2	670–380	Late	3220.0	90.9	323.4	9.1	3543.4	2331.3	23.0	7826.3	77.0	Jazwa, Kennett, and Hanson 2012
SRI-2	Unit 2, Str 2	480–410	Late	3809.4	86.4	600.6	13.6	4410.0	2758.0	15.9	14534.5	84.1	Rick 2011
SMI-481	East Dune, Bulk Sample	470–380	Late	4010.0	92.0	349.8	8.0	4359.8	2903.2	25.5	8466.1	74.5	This Paper
SMI-470	Unit 1, Bulk Sample	460–260	Late	8779.3	93.9	568.4	6.1	9347.7	6356.2	31.6	13755.3	68.4	Rick 2007
SRI-2	Unit 2, Str 1	320–230	Late	10573.0	96.8	344.6	3.2	10917.6	7654.9	47.9	8339.3	52.1	Rick 2011
SRI-333	Unit 1, 0–50 cm	380–140	Late	3707.9	96.1	152.4	3.9	3860.3	2684.5	42.1	3688.1	57.9	Jazwa et al. 2019
SMI-163	Unit 1	270–250	Late	1652.3	99.1	15.5	0.9	1667.8	1196.3	76.1	375.1	23.9	Rick 2007
SMI-163	Unit 2	320–150	Late	87929.2	95.3	4300.0	4.7	92229.2	63660.7	38.0	104060.0	62.0	Rick 2007
SRI-60	Unit 1, 40–50 cm	300–150	Late	1658.2	97.9	35.4	2.1	1693.6	1200.5	58.4	856.7	41.6	Kennett 2005
SRI-40	Unit 1, 60–70 cm	300–150	Late	3099.4	89.9	347.8	10.1	3447.2	2244.0	21.0	8416.8	79.0	Kennett 2005
SRI-97	Unit 1, 0–30 cm	310–135	Late	2085.6	81.2	483.8	18.8	2569.4	1510.0	11.4	11708.0	88.6	Jazwa et al. 2019
SRI-2	Unit 1	260–150	Late	35913.1	98.5	563.5	1.5	36476.6	26001.1	65.6	13636.7	34.4	Rick 2011
SCRI-801	Unit 12N-0E	250–150	Late	615.6	85.0	108.3	15.0	723.9	445.7	14.5	2620.9	85.5	Perry and Glassow 2015

Notes: Site ages are reported in the same fashion as the original published source. Shellfish remains and fish bone weights (g) and percentages are reported, along with shellfish and fish meat weights, using a standard shellfish multiplier of 0.724 and 24.2 for fish (see Jazwa et al. 2019). Only sites with at least 1 kg of fauna data reported were included.

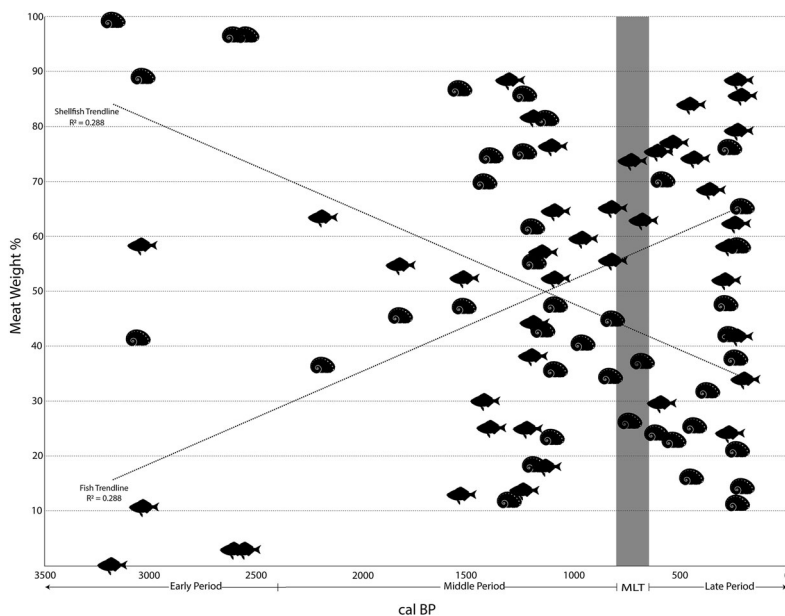


Figure 5. Graph depicting meat weight percentages of fish versus shellfish at Late Holocene archaeological sites from the Northern Channel Islands. Shellfish percentages are depicted by an abalone symbol and fish percentages by a surfperch symbol. Given the larger sample size from after 1,500 cal BP, the trendline is likely influenced somewhat by this less amount of data from prior to 1,500 cal BP.

complexity (e.g., Arnold 1992, 1995; Kennett 2005; Rick 2007; 2011). During this interval, already dry and unstable environmental conditions were marked by extended megadroughts during the MCA (1,150–600 cal BP), along with cool sea surface temperatures and high marine productivity.

Not long after the introduction of the single-piece shell fishhooks (ca. 2,500 cal BP; Rick et al. 2002), the *tomol* (ca. 1,500 cal BP; Arnold 2001b), and the bow and arrow (ca. 1,225 cal BP; Kennett et al. 2013), the Island Chumash coalesced into large coastal villages near reliable freshwater sources and with extensive viewsheds (Kennett 2005). They focused increasingly on finfishing, dramatically increased their production of shell money beads, and intensified island-mainland trade networks. Bioarchaeological studies show evidence for increased levels of nutritional stress and disease, along with declines in stature, possibly caused by population aggregations and polluted water sources (Lambert 1994). The MCA is also the interval during which projectile point injuries and other evidence for interpersonal violence are most common (Lambert 1994), suggesting that population aggregations and the rise of a chiefly elite may have increased social stress and intergroup competition.

These channel-wide reconstructions, however, were built on faunal and artifactual data from Late Period (650-200 cal BP) and MLT archaeological sites, with only limited late Middle Period data. These models were also developed at a time when archaeologists viewed the Channel Islands as relatively marginal compared to the mainland, with limited plant food resources and fresh water. Both these assumptions have been questioned recently based on a combination of archaeobotanical data and the post-grazing era recovery of island plant communities and hydrology (see Gill, Fauvelle, and Erlandson 2019).

Available MLT faunal data do support an expanding diet breadth, declines in the size of highly ranked shellfish, and an increased emphasis on fishing (e.g., Braje 2010; Colten 2001; Erlandson and Jones 2002; Jazwa, Kennett, and Hanson 2012; Jazwa, Joslin, and Kennett 2020; Jazwa et al. 2019; Kennett 2005; Perry and Glassow 2015; Pletka 2001; Rick 2007; 2011). Less known are the strategies employed during the Middle Period build-up to MLT cultural shifts, especially on western *Limuw* where Arnold (1992; 1995; 2001a; 2001b) first identified the social, economic, and political importance of the MLT for the Chumash. Middle Period zooarchaeological data from CA-SCRI-475 and CA-SCRI-890 provide a rare opportunity to fill this gap.

Compared to Early Period Late Holocene sites on *Limuw*, subsistence strategies during the late Middle Period at CA-SCRI-475 and CA-SCRI-890 demonstrate an increased reliance on fish that precedes the intensified finfishing of the MLT and Late periods, identified by many NCI archaeologists (e.g., Arnold 1992, 1995, 2001a, 2001b; Braje 2010; Jazwa, Kennett, and Hanson 2012; Jazwa, Joslin, and Kennett 2020; Jazwa et al. 2019; Kennett 2005; Perry and Glassow 2015; Rick 2007). The increased reliance on fishing at CA-SCRI-475 and CA-SCRI-890 represents a significant increase from nearly all Early Period sites on the Channel Islands and offers a transition to the intensive finfishing economies of the MLT and Late periods, where shell middens often contain dense accumulations of fish bone. Kennett (2005, 190–191), for example, found that edible fish meat contributed over 81% to the meat weight of island foragers across 17 discrete occupations from the three largest NCI, except for one *Tuqan* site at 66% and one site on *Wi'ma* at 64%. Overall, subsistence strategies at CA-SCRI-475 and CA-SCRI-890 follow channel-wide trends in Late Holocene subsistence (i.e., increased pressure on high-ranked shellfish, intensified fishing practices, and more diversified economies) and suggest that the Middle Period was a time of subsistence transition that previewed the substantial changes to come during the MLT and Late periods.

Rather than a sudden and dramatic change at ~800 cal BP, the finfishing-intensive economies typical of the MLT and Late periods were already in place at several sites across the NCI, especially after about

1,500 cal BP (see [Figure 5](#)). This was probably facilitated by new technologies such as single-piece shell fishhooks and the *tomol* that were first used during the Middle Period, as well as gradual changes in subsistence, technology, and sociopolitical organization that fully emerged during the Late Period (see [King 1990](#); [Gamble 2002](#); [2008](#); [Glassow 1996](#)). More definitive answers likely will require additional data from a variety of Middle Period archaeological sites across the NCI to further contextualize the scale and timing of subsistence shifts.

It is possible that differential subsistence strategies occurred between islands and that the larger channel-wide patterning obscures localized strategies developed to combat the social and environmental challenges of the Late Holocene. Across the islands, the Chumash Islanders likely developed localized strategies to combat shifting resource availability. For example, *Limuw* islanders seem to have increased shell bead production and mainland-island trade (see [Kennett 2005](#), 204–205), *Wi'ma* islanders diversified shellfish harvesting and scaled up trade (but not to the level of *Limuw* islanders; see [Kennett 2005](#), 204–205), and *Tuqan* islanders intensified sea mammal hunting (see [Braje 2010](#); [Rick 2007](#)).

Additional archaeological data across the Late Holocene can help elucidate these localized patterns and better explain Channel Island strategies for dealing with the natural and cultural challenges of the Late Holocene. It seems likely that the Island Chumash leveraged trade and subsistence resources differently between islands through time, and archaeologists need to take a localized and nuanced approach to modeling the rise of sociopolitical hierarchies during the Late Holocene.

Finally, we note that models of rapid and dramatic cultural changes caused by abrupt shifts in climate or marine productivity were developed when most archaeologists believed the Channel Islands were marginal and resource limited. With this marginality now in question, it seems less likely that the environmental fluctuations characteristic of the Late Holocene had major effects on the Island Chumash, who regularly dealt with droughts, ENSO events, and changes in marine productivity over the millennia. Moving forward, it may be more productive to look more closely at the resource abundance and internal cultural mechanisms that led to the florescence of cultural complexity, technological innovation, and artistic expression among the maritime Chumash.

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