UNIVERSITY OF CALIFORNIA, SANTA CRUZ

AN ECO-ARCHAEOLOGICAL STUDY OF INDIGENOUS CLAM BED MANAGEMENT AT COLONIAL PERIOD TOMS POINT (CA-MRN-202), TOMALES BAY, CALIFORNIA

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in

ANTHROPOLOGY

by

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Abstract: Current archaeological research suggests that Native people employed novel and creative ways to negotiate waves of colonialism since the late 16th century and continued to manage landscapes outside of colonial administration. By examining the material residues of "hinterland" non-state spaces, this eco-archaeological project seeks to further understand how indigenous people resisted colonialism while maintaining their connections to important resources on the landscape. In this paper I discuss the results of the analysis of three datasets: 1) ethnographic, 2) shell morphometrics and 3) radiocarbon are used to explore the possibility of indigenous shellfish management by Coast Miwok who lived at worked at Toms Point (CA-MRN-202), a nineteenth-century trading post in north Tomales Bay region. In addition to investigating the overall persistence of traditional resource collection, we discuss the relevance that archaeological data has for future restoration and historical ecological projects that aim to integrate Traditional Ecological Knowledge (TEK) and collaborate with indigenous communities.

Keywords: Indigenous Archaeology, Coast Miwok, Traditional Resource Management, Historical Ecology, Morphometric Analyis

Preface

When you're an undergrad studying archaeology, opportunities to apply the theories we learn in the classroom to fieldwork are few. I recently had such an opportunity to climb out of the anthropological armchair and jump into Marin County and the world of Coast Miwok people who, in the 18th and 19th century, confronted four different surges of colonization. Rather than tell the age-old story of Native American culture loss and village abandonment, however, Drs. Tsim Schneider (UC Santa Cruz) and Lee Panich (Santa Clara University) are researching instances of change, as well as refuge, resiliency, and economic opportunity for Coast Miwok people. In the summer of 2016, Schneider and Panich led a team of graduate and undergraduate archaeologists into the field to explore the local political economy and landscape use by employing minimally-invasive excavation techniques such as surface collection, auger sampling and Ground Penetrating Radar. Here, scattered about the now-shrubby landscape, we searched for the material remains of indigenous power structures, social organization, and traditional resource use during a time more often understood as a time when Native people fully adopted European and American ways.

After fieldwork at Tomales Bay came to a close, my experience that I gathered as a research assistant for a collaborative restoration ecology project that is reestablishing ethnobotanically important wildflowers in Pinnacles National Park grasslands greatly influenced my eagerness to apply similar multidisciplinary studies to other ecological contexts and add to the new generation of research that spans across academic platforms

and operates with multiple stakeholders to answer environmental issues.

Dr. Schneider introduced me to article from *News From Native California* that discussed the disappearance of "clam gardens" in Tomales Bay during the mid 20th century. The article noted that the extirpation of native clam varieties and relict beds may have been caused by removing indigenous tending practices and introducing commercially competitive shellfish varieties. From this article, I was interested in addressing the overlooked realm of intertidal Resource Management (Lepofsky et al 2015) in California, which is usually plant-based for a variety of ecological and intellectual reasons. The eco-artifact assemblage from Toms Point provided just the opportunity to explore the possibility of clam bed management by Coast Miwok living outside the missions and also evaluate the visibility of shellfish management in the archaeological record.

First and foremost, I would like to thank Tsim Schneider for his unwavering support and guidance at all stages of this research. His counsel generated an exceptional undergraduate learning experience as well as the opportunity to present this research at an archaeology conference (Society of California Archaeology). I also would like to thank the Fred Keeley Coastal Sustainability Scholarship for graciously funding an excellent three weeks of field research, laboratory studies and attendance fees to the Society of California Archaeology annual conference to share my research. I would also like to extend acknowledgment to Dr. Kerstin Wasson from the Elkhorn Slough Ecological Reserve who helped me get ahold of much-needed modern clamshells that were needed

to build a statistical formula. Dr. Lars Fehren-Schmitz, and his Anthropology 195 was also instrumental in helping with the structure and mechanics of this paper. Reed Kenny, a great friend and undergraduate ecologist greatly assisted me with my statistics and regression building. Finally, I would thankfully acknowledge the Federated Indians of Graton Rancheria for allowing me to study aspects of their ancestral landscapes that are sacred, sensitive and private.

Introduction

Current archaeological research suggests that Native people continued to traditionally use landscapes around the Spanish mission systems in California, contrary to assumptions about cultural loss, village abandonment and limited opportunity (Lightfoot 2005, 2014; Milliken 2005; Panich and Schneider 2015, Schneider 2015). In addition, a slew of recent studies has unraveled the intricate and novel strategies that indigenous

people have employed to bolster, enhance, and manage territorial resources to increase stability and biomass yields (Anderson 2005; Campbell and Braje 2015; Cannon and Burchell 2008; Groesbeck et al 2014; Lepofsky et al 2015; Lepofsky and Caldwell 2013; Lightfoot et al 2013; Lightfoot and Parris 2009; Singh and McKechnie 2015). Using an archaeological site from Tomales Bay, California, this study explores the possibility of intertidal resource management by Coast Miwok Indians who continued to access and use their ancestral landscape by employing traditionally structured cultural practices.

By studying hinterland sites and the archaeology of colonialism from an "outside-in" perspective, this project seeks to understand ways in which indigenous people resisted colonialism while maintaining their connections to important resources on the landscape. The hypothesis I consider states that <u>if indigenous people continued to inhabit non-state landscapes, then evidence for traditional resource management should be recognizable in the archaeological record.</u> To test my hypothesis, I examine three lines of evidence: (1) ethnographic data on Coast Miwok intertidal resource and shellfishing practices, (2) archaeomalacological analysis of marine remains as well as developing an allometeric regression to estimate the total size of Pacific Gaper Clam (*Tresus nutallii*) shell fragments from Toms Point (CA-MRN-202) and (3) review 9 AMS (Accelerated Mass Spectometry) measurements that include . Our research compares these multiple streams of evidence to trace changes in clam morphology through time as a proxy for possible resource management at Toms Point and offer empirical evidence that supports our thesis.

The material consequences of Coast Miwok interaction with intertidal habitats, this study addresses three main themes that suggest that indigenous groups associated with Toms Point, a colonial period (1769-1849) trading post: 1) exerted a degree of socioeconomic autonomy during a “time of little choice” by resisting colonialism and maintaining their connections to important resources from the land and seascape, 2) possibly extended similar terrestrial plant resource management (resource enhancement) to littoral contexts (3) leaves us recoverable knowledge that can be used to inform and react to contemporary problems in fields such as habitat restoration (Singh and McKechnie 2015), anthropogenic change of marine ecosystem (Erlandson and Rick 2010), intertidal productivity, mitigate sea-level rise in sensitive intertidal &wetland areas (NOAA 2015, Orff 2015) and help descendant Coast Miwok communities that are seeking to reengage with clam bed management and heal from the colonization process (Groesbeck et al; Lepofsky and Caldwell 2013).

Background

Environmental Site Description

Toms Point is a peninsula bluff that tacks out near the mouth of Tomales Bay. This sandy promontory is flanked with tidal wetlands and pockets salt marshes. Situated at approximately 38°13'0.46"N , 122°57'5.93"W, with a peak altitude of 112 feet, Toms Point gives sweeping vantage of this twelve-mile long, linear body of water lays atop of the San Andreas Fault line. The eastern shoreline of Tomales Bay (where Toms Point is) is best characterized as dry and grassy while its western shore is lush and forested (Avery

2009). The Tomales Bay region is dominated by undulating grassland that supports robust dairy operations of west Petaluma. At Toms Point, Coyote Brush (*Bacharris pilularis)*, Rushes (Juncaceae*)*, Sedges (Cyperaceae), Tree Lupine (*Lupinus arboreus)* and Deergrass (*Muhlenbergia rigens*) (The Jepson Manual, Eflora 2017) may be found in abundance in the loamy sand.

The intertidal productivity of Tomales Bay is illustrated by its ability to supply 1/5th of California's oyster crop and also being one of the scientifically studied bodies of water on the Pacific Coast (Avery 2009). A plethora of shell-producing mollusks fill the intertidal zones of Tomales Bay: 10 species of clam, 4 of abalone and a variety of mussels*,* oysters, chitons, snails and limpets. In addition to shellfish; otter, turtle, halibut, sturgeon, smelt, bass, salmon and eel in the littoral waters of Tomales Bay. In short, the Tomales Bay region is known for abundant waterfowl, deer, Bishop pine groves, scenic pastures, commercial shellfisheries, and recreational clamming.

Aerial photograph of Toms Point, Tomales Bay, California from Audobon Canyon Ranch website. Photo by Jeanne Wirka

It wasn't until the year 1912 that San Francisco owned oyster companies moved to Tomales Bay in search of fresh, mercury free waters (Avery 2008). An article about Tomales Bay's relict "clam gardens" by baker (1992) highlights some of the State's earliest attempts at "conservation" just before World War II. On one hand, they sought to push *Sierra Club* style agendas that aimed to protect pristine natural resources by removing human disturbance while on the other hand, supporting a booming commercial shellfish industry that was built on non-local varieties. Through this combination of state and privte action, the clam beds of Tomales bay saw the dissapearence of a few native clam varieties. Although further research is needed to explore Baker's (1992) argument, it is not hard to imagine that the extirpation of local varieties may be linked to underharvesting, removal of human disturbance regimes and the introduction of exotic species from clumsy resource management policies.

Tomales Bay Disturbances

The introduction of the Pacific Oyster (*Crassostrea gigas)* is almost 6 times larger than California's native Olympia Oyster (*Ostrea lurida).* The commercial appeal of the Japanese giants (Pacific Oysters) has made it ubiquitous with modern oyster farming which inevitably escape pens and outcompete native bivalves. Tomales Bay has been addressing significant changes to water quality due to dairy runoff. Loads of fertilizer, sediment, and mammal excrement alters the chemistry of bay water and the health of filter-feeding mollusks, especially bivalves. The handful of human-driven changes and disturbances have arguably impacted our ability to fully understand historic clam beds

and the long record of indigenous intertidal resource management. As I describe in the remainder of this paper, I seek to explore exactly these issues.

Archaeological Site Description

The archaeological components of Tomales Bay has received spotty coverage at best. While Tomales Bay has produced one of the earliest sites in California (McClure site) and nearly 600 recorded other cultural resource sites throughout the county, we still know very little about the Coast Miwok before European contact. The Coast Miwok, a Penutian-speaking semi-sedentary resource-collecting group have shaped their relationship with Tomales Bay through 4000 years of interaction through channels of subsistence and sociality. In historic times, the strategic location may have served as an excellent stopover for merchant ship traffic, travelers, and locals to haggle and exchange valued media.

Integral to many coastally adapted groups, shellfishing was, and remained an important resource governing activity for a variety of reasons: social, economic, utility, and of course dietary. Although the archaeology has been sparse until recently, Toms Point holds the archaeological residuals from both historic and prehistoric contexts, adding to the significance of using this site as an arena for evaluating autonomy, resource management, and resistance during the process of colonialism.

A battery of historical sources document the presence of Miwok inhabitants at "Toms Point" (CA-MRN-201, 202, 363) raised interesting questions about indigenous resistance to colonialism and continuity during a time characterized by abandonment and

loss. Between 2015 and 2016, Drs. Schneider and Panich have launched a broad-spectrum investigation of Toms Point, hoping to shed light on how an ethnographically recorded Miwok village near the entrance of the Bay that was used before and throughout the mission, Mexican, and into the American period. Using geophysical surveys, surface collections and sub-surface testing calibrated by historical documents, the archeological team explored the ways that Coast Miwok exercised autonomy through restructuring economic relationships and perpetuating patterns of land use within ancestral and non-state spaces.

Landscape Management Approaches

Ecological approaches to archaeology stemming from the 1960's have been criticized as colonialist in practice, viewing culture change as a response to external factors and limited by ecological thresholds. Anthropologists like Harry Laurandos, Florence Shipek and Thomas Blackburn rejected theoretical models that placed environmental change as the ultimate mechanism of cultural evolution, and proposed that indigenous peoples were cognizant actors in shaping "natural" environments and had profound effects on localized ecological structures and cultural behaviors (Lightfoot and Parrish 2009; McNiven and Russell 2005). Landscape management frameworks are particular interesting when

Such approaches are not without controversy, but can provide us a framework to analyze the extent that social and natural systems provided services for one another. Social organization, subsistence and material choices have resulted in landscapes that are

more the result of human chores rather than "natural" processes. Archaeologists like William Hildebrandt, Terry Jones, Katherine Bradford, and Mark Raab has pointed to instances that coastal Californian groups exhausted and overexploited resources through intensification (Anderson 2005; Lightfoot and Parrish 2009). Cases like this are important for archaeologists who continue to apply traditional resource management frameworks which fall usually on two ends of a spectrum: prehistoric Californians are understood as complex resource managers who precipitated favorable habitats through spiritual and subsistence regimes or they are understood as populations that exhibited precarious and often turbulent livelihoods that are marked by political instability, famine, and resource intensification (Lightfoot and Parrish 2009: 89). The binary approach to anthropogenic ecosystems is the result of diverse theoretical approaches, academic background, and interdisciplinary practice which in turn, are changing every day as techniques and principles evolve. This study follows a framework that invites a disentanglement of social, ecological, and subsistence systems to understand the degree that Coast Miwok cultural patterns influenced the form/state/composition of localized intertidal habitats.

Indigenous Landscapes Approaches

Archaeomalacology

Shell-bearing mollusks have been used by humans as material, energy and information for millennia (Claasen 1998). Some of the earliest evidence of shell use dates to at least 300,000 years ago, but early sites like this are often archaeologically scarce to due sea level stabilization during the Holocene. Shell used as tools, jeweley, building

material, fertilizer, medicine, pottery temper, money, tweezers and for a suite of ceremonial purposes. Archaeologist have looked at the accumilations of shell use (shell middens) as reservoirs of knowledge that lets us study paleoenvironmental and dietary reconstructions, cultural history, social organization, settlement patterns and site formation (Claasen 1998).

The importance of shellfish in non-industrial economies has been debated for decades. Some have argued (Claasen 1998; Erlandson 1988) that shellfish was a viable substitute or, "alternative" to terrestrial resoruces. Primarily from a protein perspective, plant-based economies may near the coast may have relied on shellfish as dietary staples, and under prime shellfish ecolological and social conditions, influence settlement patterns and food choices (Erlandson 1988).

Methods and Materials

Archaeological and AMS Samples

All archaeological samples used in this study were collected from Toms Point, Tomales Bay, California (CA-MRN-202) from 2015 and 2016 field seasons led by Drs. Tsim Schneider and Lee Panich. Artifacts were captured using 1/16 inch/ 1.58 (mm) soil sieve, hand trowels and geology picks when within clayey substrate. Shellfish analysis was narrowed to two subsamples: excavation units "E5" (1001N/1005E) and "E3"

(1003N/1007E) from MRN-202 for this study. 14C measurements were acquired from unit "E5" from 30-40 cm, 40-50 cm depths, and from "E3" from depths 30-40 cm, 40-50 cm, and 60-70 cm. All 14C samples were photographed, weighed and prepared by myself and measured by AMSDirect with a NEC Pelletron 500 kV AMS. The purpose of obtaining Carbon-14 measurements will be to identify age ranges associated with observed patterns of change in the shell artifact assemblage.

Zooarchaeological Procedure

Marine invertebrate samples were studied in three phases: identification, analysis, and interpretation (Reitz and Wing 1998). Shell specimens from excavation units "E5" and "E3" were weighed, counted, and measured. Minimun Number of Individuals (MNI) calculations were obtained by counting Non-Repetitive Elements (NRE) for bivalves and gastropods outlined in Claasen (1998). Furthermore, *Tresus nutalli, Saxidomus nutalli and Leukoma staminea* were submitted to additional measurements to explore an allometric relationship between umbo dimensions and total valve length. All specimens will be identified to closest taxa using relevant field identification guides (Keen and Coan 1974; McLean 1969; Smith and Carlton 1967) and a comparative collection developed by myself and donated to UCSC's Anthropology Department labs.

Measurement Criteria for Regressions

Bivalve umbones (hinge, or area where shell valves articulate) are important for archaomalacogy for a variety of reasons: they offer a reliable count for quantifying non-repetitive elements within a dataset, they are mechanically robust thus preserving well in

archaeological contexts, and more recently, has offered researchers a method for estimating the mean size of harvested shellfish. Clam (and many bivalve taxa) umbones are the sites for oldest shell growth. Sihgn and McKechnie (2015) indicate that despite the potential for growth variation between habitats, umbo allometry is a statistically strong principle to base size estimation on. All umbone measurements were obtained using Champion series digital calipers and Ohaus scientific scale. The height, width, length of clam hinges were recorded was three times respectively, and averaged to help compensate for human error. Umbones with less than 50% of landmarks present (due to taphonomic degradation) were excluded from regression measurements.

Allometric and Morphometric Regressions

Following previously published regression methods to archaeological *Mytilus californianus* specimens (Cambell and Braje 2015; Singh and McKechnie 2015), this study will apply similar techniques to a prolific heterodont clam species: Pacific Gaper Clam (*Tresus nutallii).* Morphometric landmarks on umbo fragments were measured and submitted to regressions based on modern clamshell in order to estimate total length. Umbo length, width, and height will be assigned to x-variable, while total length will be assigned to y-variable. 30 complete modern clam of species from Elkhorn Slough Ecological Reserve and 5 from Tomales Bay will be used to establish regression baselines.

Shell umbones preserve remarkably well in comparison to other parts of shell, such as margins, and actual complete valves. This problem of preservation is well known

to coastal archaeologists, and has been approached by a series of different approach ranging from umbo angle, size class, shell/meat ratios, and more recently, regression equations to classify harvesting profiles. My proposed measurements will be derived from Singh and McKecknie (2015) and Campbell and Braje (2015) work on *Mytilus californianus,* performing a sound attempt at implementing morphometric regression formulas to estimate shell size, and thus, deriving significant conclusions on seasonality, settlement patterns, and human/ecological interactions. Moreover, these approaches may prove valuable for fishery managers who seek to better understand historical population dynamics and also for descendant communities who seek to use archaeological information on prehistoric subsistence patterns to inform contemporary health issues like diabetes and heart disease.

Ethnographic and Historic Data

Ethnographic field notes published by Isabel Kelly (edited by Collier and Thalman 2003) was referenced for 3 reasons: (1) to target ethnographically important clam species, (2) highlight intertidal resource harvesting strategies and (3) interpret the social structures in place that regulated, filtered, and governed access to intertidal resource locales. In addition, Lightfoot and Parrish (2009) was referred to for general synthesis of Coast Miwok shellfish use and subsistence strategies.

Morphometric Analysis on Pacific Gaper-clam (*Tresus nutalli*) from CA-MRN-202

Introduction

Tracking changes in the sizes of different faunal shell and bone elements within zooarchaeological assemblages over time is one approach to evaluate how the environment has changed and also understand the influence that social systems impress on localized habitats (Campbell and Braje 2015; Cannon and Burchell 2008; Singh and McKechnie 2015). From coastal shellmound sites archaeologists typically recover large quantities of shellfish remains – including gastropod fragments and the umbones and valve fragments of bivalves – all of which reflect past harvesting activities and processing, consumption, and disposal behaviors (Claasen 1998; Reitz and Wing 2008). Examining the size of clams from archaeological contexts also reflect important changes in resource stability, management, as well as intensification and over-exploitation. Such developments are important proxies for understanding changes in Native American communities, particularly those contending with the dramatic effects of colonialism. Following recent interdisciplinary efforts to develop statistically reliable measures for estimating the total size of fragmented bivalve shells collected from coastal shell middens western North America, I apply similar allometric techniques to a sample of archaeological clam shell umbones from site CA-MRN-202 (Tomales Bay, California). For this study, I measured modern *Tresus nuttalli* valves to (1) evaluate the efficacy of using modern whole clam valves for predicting valve size from fragmented archaeological specimens and (2) estimate changes in the size of past clams through time.

Background

The careful analysis of marine carbonate exoskeletons may bear greatly on a suite of information that will benefit both the archaeologist and the ecologists. Morphometric regression is a method that examines growth shape changes in one measurable trait in relation to another (Campbell and Braje 2015; Reitz and Wing 2008:66). Such methods are established on biological principles of allometry and isometry which have been shown to have both positive and negative growth relationships in bivalve taxon (Singh et al. 2015). The application of such techniques to molluscan organisms has be fiercely debated in an Singh et al. (2015) addendum that highlights the theoretical battleground that archaeologists and zoologists find themselves in. Nonetheless, zooarchaeologists have pushed for low-cost, practical methods that can convert substantial amounts of fragmented shell into insight about coastal economies, as well as remaining valid for multi-disciplinary platforms.

Methods and Materials

Modern Gaper clam shells collected from the intertidal surface this past year from Elkhorn Slough Reserve (Monterey/Santa Cruz County; n= 30) and Sand Point (Marin County; n=5) were cataloged and measured. Clam shells from Elkhorn Slough were returned to be re-integrated into native Oyster (*Ostrea lurida*) restoration experiments. Clamshell umbones (length, width, and height) and total valve lengths (TL) were measured three times to obtain averages to cushion human errors. Total length (TL) ranged from a maximum of 178.6 mm to a minimum of 98 mm, with an average shell length 128 mm. Archaeological *Tresus nutalli* umbones (n=27) that had preserved

dentition (more that 50% visible) from units “E5” and “E3” of CA-MRN-202 were then cataloged and measured. Using digital calipers the length, width, and height measurements of each archaeological umbo was recorded three times as well.

Measurement criteria were adapted from Campbell and Braje (2015) to collect metric data from a characteristic feature of the *Tresus* genus: the presence of a distinct chondrophore and posterior and anterior lateral teeth on the inside of the hinge plate. To obtain umbo “length” in regards to the long axis of clam (posterior to anterior), calipers were placed at end of each lateral tooth, before the start of the “plate”. “Width” was measured along the margin/umbo axis by placing calipers at the apex of umbo and the outermost lip of chondrophore. Umbo height was negotiated by placing an arbitrary 10 mm mark with colored pencil vertically from umbo apex (along outside of shell). Umbo was then placed ventral side down on flat surface and measured from arbitrary 10 mm mark to where umbo makes contact with surface. The intricacies involved with working with mussel umbo height has been shown to lower r-value during statistical analysis (Campbell and Braje 2015).

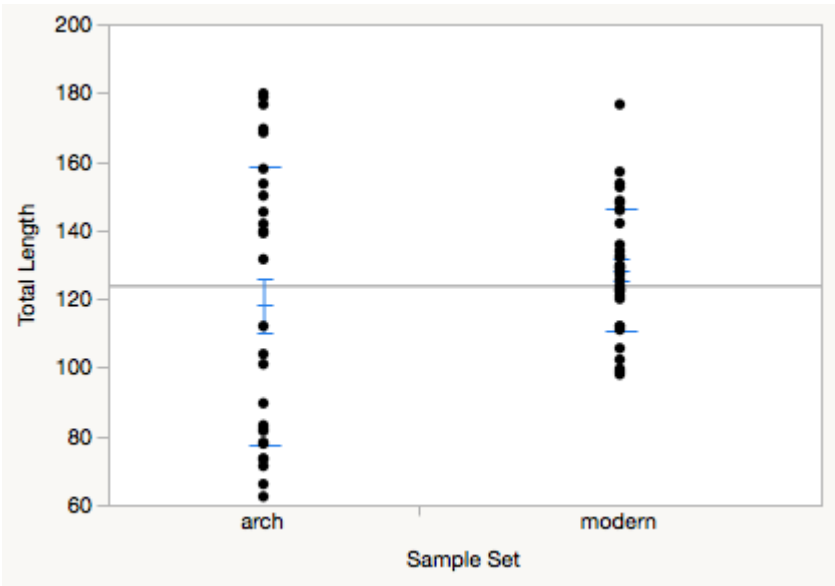
Bivariate regression formulae were built with JMP and Excel software. Modern umbo dimensions (L, W, H) were fitted to total lengths to create y-intercept equations which were then appended to archaeological umbo measurements.

Results

Table 1: Summary of measurement selection and regression equations developed when fitted against known total length values.

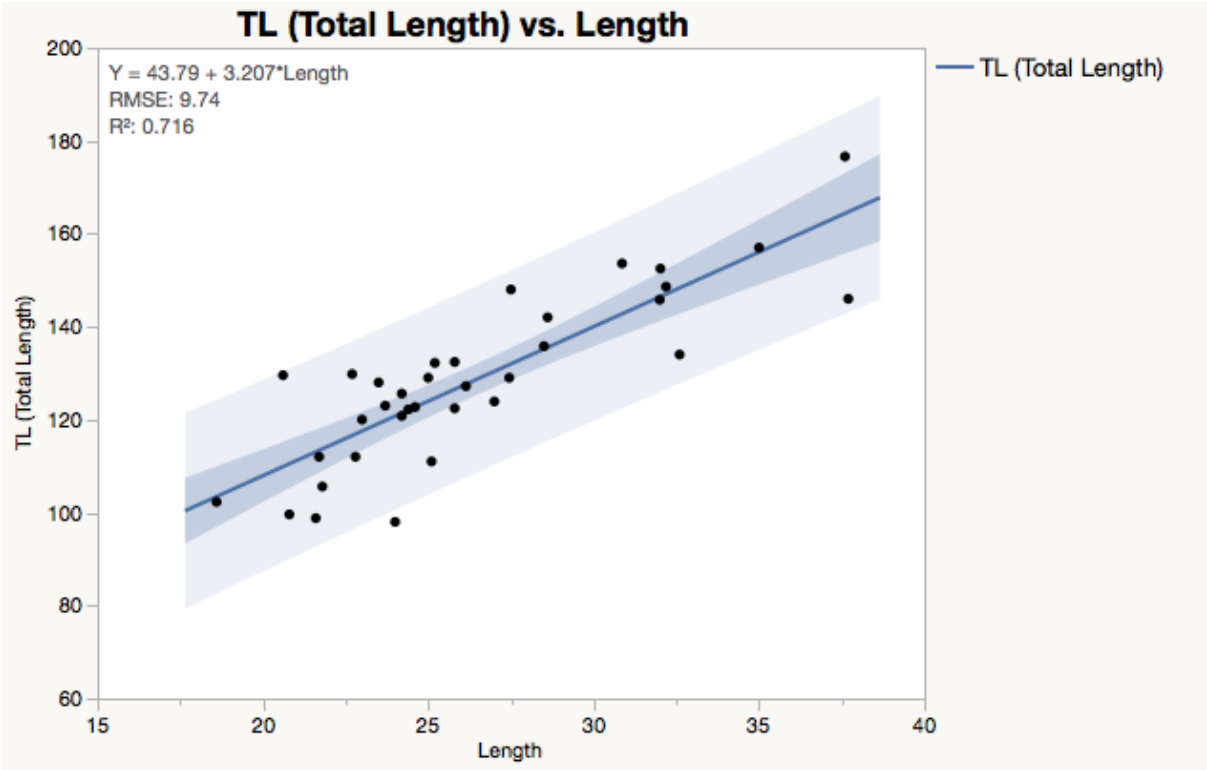
Umbo Measurement	Regression Equation	R-Square Value	P-Value
Length	y= 43.78818x + 3.2072572	.716	<.05
Width	y= 58.603706 + 4.6145696	.523	<.05
Height	y= 53.795065 + 6.6870353	.214	=.005

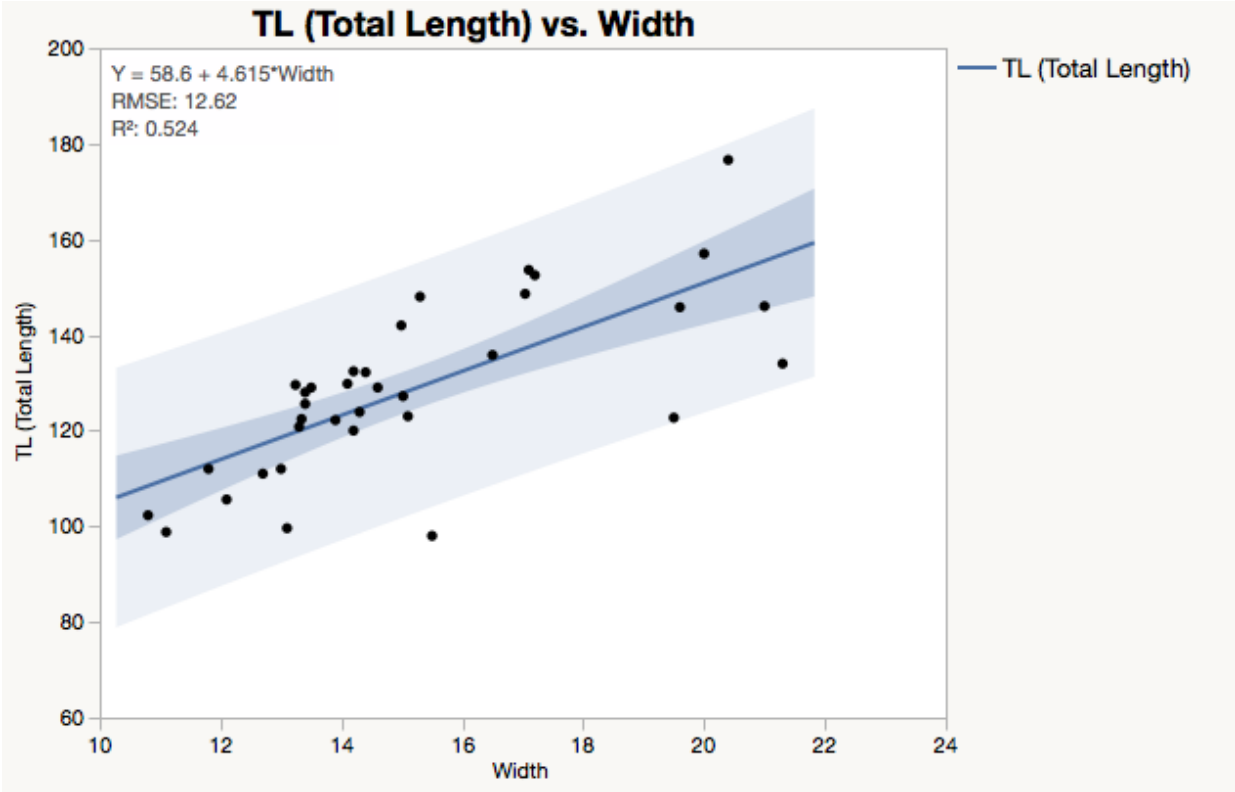
A One way analysis of Total lengths and sample set. Modern sizes range between 178 mm and 98 mm. Archaeological estimates range between 208.5 mm and minimum of 62.4 mm.

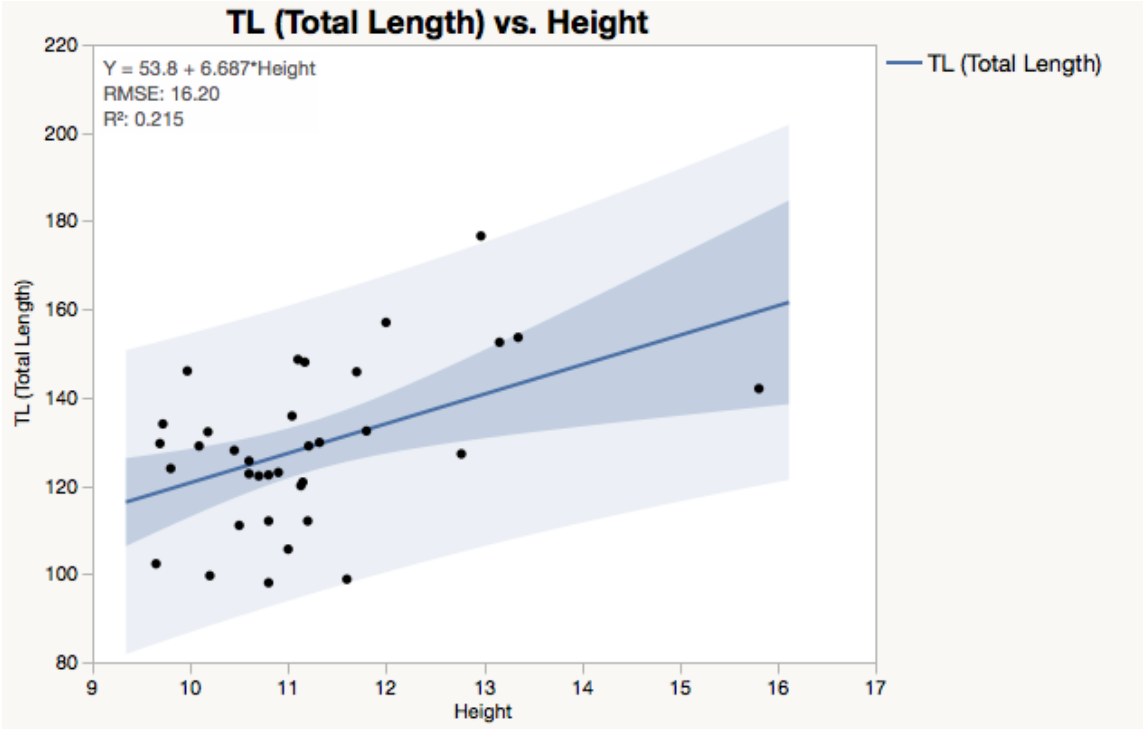


Sample Set	N	Mean	Std Dev	Mean Std Err.	Lower 95%	Upper 95%
archaeological	**27**	**118.077**	**40.5365**	**7.8013**	**102.04**	**134.11**
modern	**35**	**128.485**	**18.0133**	**3.0448**	**122.30**	**134.67**

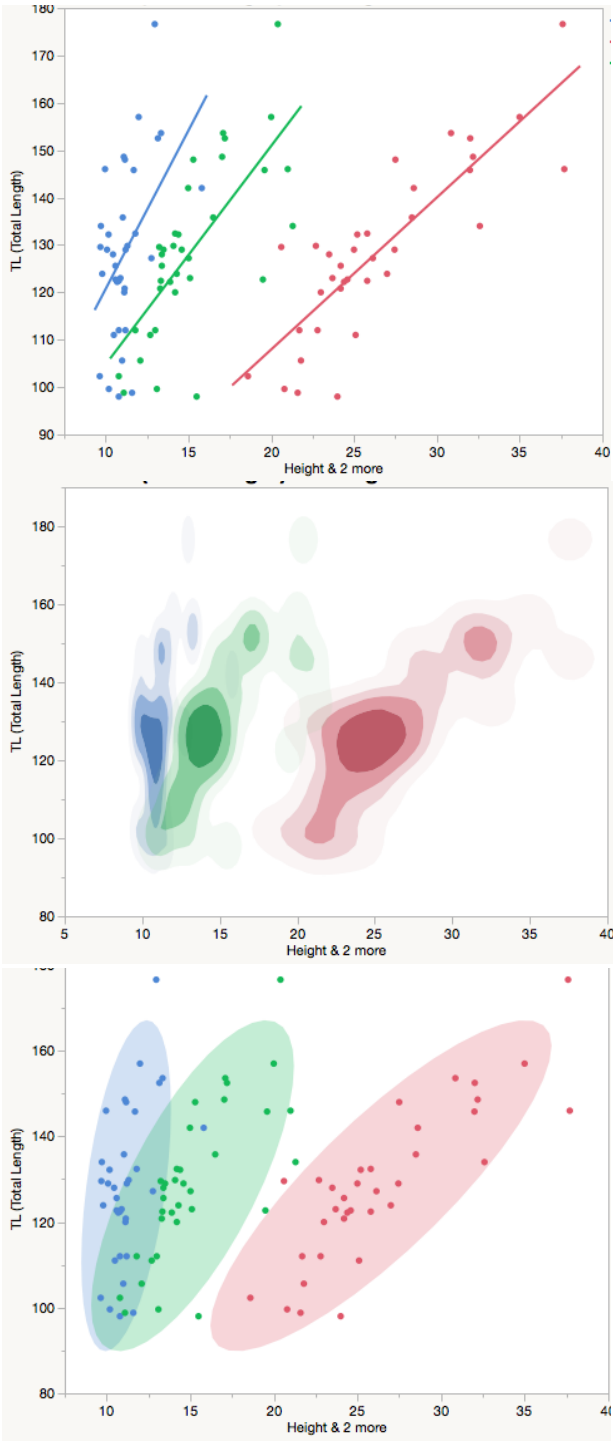
Archaeological umbo Height fitted against allometric regression. With an r value of 0.7, this measure was the most statistically reliable compared to width and height.




TL (Total Length) vs. Width
Y = 58.6 + 4.615*Width
RMSE: 12.62
R²: 0.524
TL (Total Length)
TL (Total Length)
Width
200
180
160
140
120
100
80
60
10
12
14
16
18
20
22
24


TL (Total Length) vs. Height
Y = 53.8 + 6.687*Height
RMSE: 16.20
R²: 0.215
TL (Total Length)
TL (Total Length)
Height
220
200
180
160
140
120
100
80
9
10
11
12
13
14
15
16
17

Summary of all 3 umbone measurements fitted against regressions. Blue=Height, Green=Width, and Red=Length.



Discussion

Morphometric analysis of archaeological *Tresus nutalli* from Toms Point provides a range of statistical accuracies. In sum, umbo length shows to be the most statistically reliable measurement to estimate total length with an r-value of .71. Umbo width was also statistically significant, but an r-value of .52 raises questions about reliability, but may increase with a larger sample size. Umbo height was a statistically unreliable measure for estimating the size of clam valves from archaeological fragments when fitted to Total Length. Considering these preliminary results, I plan to use umbone lengths to predict the total lengths of archaeologically deposited *Tresus*. These data will then be matched with AMS radiocarbon dates from CA-MRN-202 to help evaluate change through time in local clam populations.

Further study of other morphological landmarks on *Tresus* is warranted. My results mirror the conclusions of Campbell and Braje (2015) who suggest that umbo height is not a reliable measurement for estimating the size of *Mytilus* (mussel) shells. It is also possible that the multi-step process for umbo height measurement may result in more error than usual. Double-blind tests should also be considered for future studies (reference here.. does McKechnie do this?), specifically reducing single-observer error. Degradation of *Tresus* hinge morphology in the archaeological record greatly reduced the amount of samples that I was able to confidently include into this morphometric analysis. In addition, the distal ends of *Tresus* lateral dentition were usually in poor preservation. Due to taphonomic influence on *Tresus* umbo dentition, future efforts should explore the

potential of the chondrophore, a robust obconical projection that remains remarkably preserved in comparison to other hinge teeth landmarks. Since clams have indeterminate growth, age of death and age class can be interpreted from body size and annual growth bands (Cerreto 1988). Quantifying shell weight is widely regarded as inconsistent, unreliable, can misconstrue interpretations (Claasen; Gallegos and Kyle 1998;) Morphometric analysis are limited due to complex variability in growth environment. Some of the earliest attempts at archaeological shell size estimation was based on external growth band features (see Cerreto 1988) but has been criticized for biological inconsistencies in external "annual growth band" counting. Temperature, salinity, oceanography, climate, predation, and water quality play important factors for determining growth rates and can obfuscate size-age based approaches (Singh and McKechnie 2015).

A Summary of 4 AMS Carbon-Fourteen (14C) Measurements from Toms Point (CA-MRN-202)

Introduction

The purpose of this chapter is to review radiocarbon dating approaches in archaeology and summarize the AMS measurements done at this site. The radiocarbon analysis conducted here uses archaeological marine clamshell and size estimation regressions as a proxy to trace clam size through time. Uncalibrated radiocarbon ages were adjusted using localized carbon reservoir correction (Delta-R) rates for Bolinas Bay,

California by (Robinson and Thompson 1981) found in a global Marine Reservoir Correction Database (calib.org/marine):

Latitude	Longitude	ΔR	ΔR Error
-123.0000	37.9000	232	25

Although Bowman (1990) warns of the localized variability of carbon reservoir effect, to date Bolinas Bay is the closest known rate to use for radiocarbon dating in north Tomales Bay. This chapter provides a brief background on radiocarbon dating in archaeology and discusses preliminary AMS results from eco-archaeological materials.

Background

There are two approaches to radiocarbon dating: conventional and Accelerator Mass Spectrometry (AMS). Conventional methods measures the decay of unstable 14C by counting number of electrons emitted per unit time as well as atomic weights while AMS methods detects the unstable:stable carbon ratios directly in the sample (Bowman 1990). Although AMS approaches are more recent, both methods have been instrumental for archaeologists who cannot rely on written records to develop site chronologies. Bowman (1990) argues that even in the historical period, radiocarbon dating can be used to truth historical documents that are subject to inaccuracy and bias (10).

When an organism dies and ceases to absorb 14C a constant rate of decay ensues. Although principles of radioactive decay places the half-life of 14C at 5730 years, absorbtion happens in varying degrees due to atmospheric concentrations, natural

production rates, human activity, and even *in-situ* alteration and contamination along the taphonomic process (Bowman 1990). A more local and critical phenomena to consider is the reservoir effect. Marine carbonate exoskeletons are affected by cyclic upwelling from deeper, more 14C depleted water (Bowman 1990).

Methods and Materials

All archaeological shell samples were photographed, weighed and packaged by myself under the supervision of Dr. Schneider. 14C measurements were taken from units "E5" from 30-40 cm, 40-50 cm depths, and from "E3" from depths 30-40 cm, 40-50 cm, and 60-70 cm. The samples were measured by DirectAMS with a NEC Pelletron 500 kV Accelerator Mass Spectrometry with chemically-treated carbonate samples weighing more than 40 mg. Uncalibrated radiocarbon ages were adjusted using the closest known marine carbon reservoir rates conducted by Robinson and Thompson (1981) and plugged into calib.org/marine calibration software using "MARINE13" curve selection.

Results

The following results represent 4 AMS carbonate shell measurements taken from Toms Point (CA-MRN-202). All results have been corrected for isotopic fractionation and calibrated with local ΔR rates from Bolinas Bay, California. Calendric ages and ranges are rounded to the nearest year.

Sample ID	**Unit**	**Depth Below Datum (cm)**	**14C Age (B.P.)**	**2σ (95.4%) Cal Age Ranges**
D-AMS 020861/202-07 (shell)	E3	30-40	814±19	Cal A.D 1659-1825 (Cal B.P. 125-291)

D-AMS 020860/202-06 (shell)	E5	40-50	902 ±20	Cal A.D 1541-1691 (Cal B.P. 259-409)
D-AMS 020862/202-08 (shell)	E3	40-50	968 ±20	Cal A.D 1496-1653 (Cal B.P. 297-454)
D-AMS 020863/202-09 (shell)	E3	60-70	780 ±18	Cal A.D 1679-1875 (Cal B.P. 75-251)

Discussion

The calibrated radiocarbon dates shown indicate that there may be a considerable amount of bioturbation occurring at CA-MRN-202. Rodent tunneling and the sandy stratum are arguably the culprits of this apparent post-depositional stratigraphic mixing. This disturbance complicates my goal to attach shell morphometric regressions to age ranges. Further interpretation and a larger sample size for both radiocarbon and regression datasets may be needed to better test if we can archaeologically see the impacts of human decision-making at this site following a resource management framework.

Ethnographic Observations on Coast Miwok Shellfishing Strategies and Shell Use

Clamming, Money, Ownership and Technology

Several shellfish species are still gathered, and still managed by Native Americans today (Lightfoot and Parrish 2009; Lepofsky et al 2015). Gathering was done all year and at low tide by both men and women with conical burden baskets (Collier and Thalman

1993). A “special stick” was used to both subsurface probe and digging bar for *Tresus nutalli* clams. Clams were roasted, boiled, eaten fresh. Shellfish was often sun driead and stored for winter. Dried shellfish meat was rehydrated with water and recooked before being eaten (Collier and Thalman 2003).

According to Kelly (1978), only Gaper clams were privately owned, while abalone, mussel and Washington beds were accessed by all. She further notes that clam beds were “never sold” but temporary rights were sold to other individuals (even cousins). Clam bed ownership was signaled by placing two large sticks roughly 100 meters apart (Lightfoot and Parrish 2009).

The thick shells of Washington clams (*Saxidomus nutalli)* were highly valued as clam bead money. Clam beads were made by grinding, chipping and drilling: a labor intensive process that produced disk-shaped beads that fueled a robust regional currency used to buy magnesite, obsidian, deer meat and geophytes (Collier and Thalman 1993; Lightfoot and Parrish 2009). Within Coast Miwok tribelets, clam beads were used to purchase ceremonial instruction, compensate dancers and even resolve conflict. For the Coast Miwok, clams transcended dietary importance: it facilitated important social obliagtions; it acted as oil in an engine; it was a material that influences inter-and intraregional interaction; it was linked o social status, power and politics; it was a resource that was highly valued.

Ethnographic Bias and Other work in North America

The limitations of using ethnographic observations to test hypothesis are well

addressed in (Moss 1993). Isabel Kelly, one of the earliest anthropologists to conduct fieldwork with the Coast Miwok in the early 19th century was a product of Kroeberian "salvage ethnography" practice. It very well may be the case that "observing" intertidal management strategies were overlooked in regards to the intellectual interests of the time. A recent handful of studies in the Pacific Northwest has shown that ancient maricultural systems were maintained in order to enhance shellfish harvest yields and facilitate a symbiotic web of social, cultural and economic understandings (Groesbeck at al 2014; Lepofsky et al 2015). Archaeological evidence of tidal flat terracing was shown to improve the productivity of clam populations (Groesbeck et al 2014). Lepofsky et al (2015) bears on multiple streams of evidence to summarize marine and environmental management systems that range from selective harvesting, ownership, tool gauge size, transplanting, habitat construction and harvest timing. Sophisticated ancient intertidal resource management practices in the Pacific Northwest are gaining attention as a viable answer for explaining dense populations, social and cultural complexity outside of classic agricultural definitions.

Conclusion

The central assertion of this paper is that indigenous management of intertidal context in California deserves further study. The importance of coastal resources has been well discussed for prehistoric Californian economies, but usually involves language this addresses questions about resource exploitation, depression and overharvesting. Following current research to seeks to explain how politically-complex semi-sedentary

indigenous Californians managed plant ecosystems to enhance the productivity of food crops, this study takes a resource management approach to evaluate a long standing relationship with intertidal resources may have endured similar subsistence-social regimes such as selective harvesting, clam bed ownership, monetary and dietary importance via a protein perspective.

Today, the end result of Traditional Resource Management (TREM) oriented archaeological investigations have important implications for how we approach long-term plans for landscape management. Anderson (2005) has argued that without integrating such TEK (Traditional Ecological Knowledge) practices, we are in danger of losing scores of resources that embellish our parks, natural habitats, and land reserves. Considering this importance on TEK, archaeological investigation serves as a modality for finding information on how indigenous Californians were able to engender preferred habitat types through the material results of decision making through time.

Next Steps

Rather than solely relying on only one clam shell element to estimate size, Cannon and Burchell (2009) have shown that using clam ventral valve fragments can be thin sectioned to examine incremental growth bands and predict relative age. These techniques may be combined to serve as a robust measure for harvest intensity and intentionality of managing a clam bed population.

The sample size of the regression analysis will be increased to 100 in order to

strengthen statistical estimates. Blind studies using students trained in protocol will also increase the statistical realibility of this regression-based approach.

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