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Importance of small-scale paleo-oceanographic conditions to interpret changes in size of California mussel (*Mytilus californianus*). Late Holocene, Santa Cruz island, California

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ABSTRACT

Several authors have highlighted the difficulties in disentangling human from natural effects when studying shellfish foraging strategies and archeo-malacogical records. In coastal settings, one of the reasons for this difficulty is the lack of understanding of small-scale oceanographic conditions and their influence on coastal and marine species used by people in the past. The present study evaluated the influence of environmental conditions on shellfish harvesting during the Late Holocene around Santa Cruz Island (Southern California) considering small-scale nearshore oceanographic variability around the Island and its effect on *M. californianus* (main shellfish species exploited through prehistory along the coast of California). Fluctuations in size and abundance of *M. californianus* shells through time and local past sea surface temperature (SST) values from oxygen isotope analysis of mussel shells are correlated throughout the stratigraphy of two shell midden sites (2200–500 cal B.P.) nearby coasts with different paleo-oceanographic characteristics.

Despite the fact that human harvesting seems to have been the main force shaping length and availability of *M. californianus*, no clear evidence of human pressure was found on archaeological mussel assemblages. Results also show that fluctuations in regional SST records (Santa Barbara Basin marine core) do not represent local SST variations (oxygen isotope analyses on mussel shells), especially if the archaeological site is located on a coast exposed to strong and consistent upwelling activity.

By re-evaluating human impact on mussel beds during the Late Holocene around Santa Cruz Island, the research presented here demonstrates the importance of considering small-scale nearshore oceanography for understanding the archaeological evidence of prehistoric human foraging on important intertidal shellfish species.

1. Introduction

Several authors have highlighted the difficulties in disentangling human from natural effects in understanding shellfish foraging strategies reflected in archeo-malacological records (e.g. Erlandson, 2001; Mannino and Thomas, 2002; Jerardino, 2012). One of the reasons for this difficulty is the lack of proper methodological approaches to understand and reconstruct natural conditions, and the way they influenced coastal and marine species used by people in the past. Oceanographic characteristics of coastal settings are spatially heterogeneous (Broitman et al., 2005; Blanchette et al., 2006; Blanchette and Gaines, 2007) and the omission of small-scale variations may obscure the understanding of interactions between human adaptation and local coastal environment and marine resource use through time.

A rich archaeological record and biological diversity makes Santa Cruz Island, one of California's northern Channel Islands, an ideal setting to answer research questions about human-environment interactions (Fig. 1). Hundreds of archaeological sites cover the island's coastline, primarily identified by dense shell midden deposits that date from the Terminal Pleistocene to Historic times (e.g. Glassow, 2010). In addition, a high-resolution nearshore oceanographic conditions and ecological datasets have been compiled over more than 10 years from intertidal study sites around the Island (SWAT http://cbsurveys.ucsc.edu/index.html).

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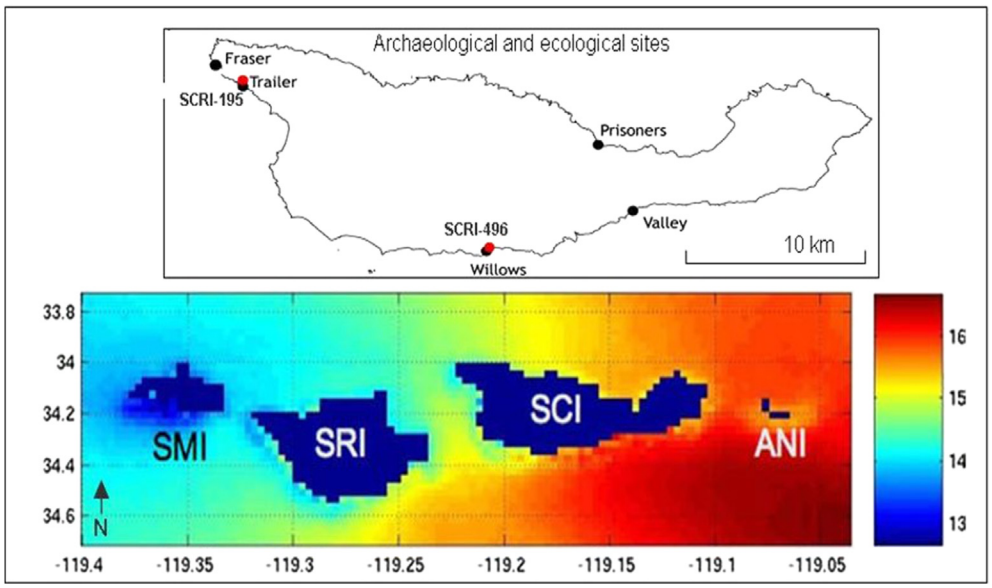

Fig. 1. Map of Santa Cruz Island with ecological and archaeological sites and long-term mean SST (Advanced Very High Resolution Radiometer (AVHRR) from 1997 to 2002) around San Miguel Island (SMI), Santa Rosa Island (SRI), Santa Cruz Island (SCI) and Anacapa Islands (ANI). Modified from Blanchette et al., 2006:691. The color bar on the right shows temperature in °C.(For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.).

These two types of data provide a great scenario to study small-scale oceanographic conditions and their influence on coastal and marine species used by people in the past.

The Late Holocene (3000–200 B.P.) on the northern Channel Islands is a period of important cultural development, technological innovation, intensification of fishing, increased territoriality, craft specialization, expansion of trade networks, and higher sociopolitical complexity (Arnold, 2001; Munns and Arnold, 2002; Kennett, 2005). The archaeological record during this time around Santa Cruz Island provides evidence of population growth, with numerous archaeological sites and the establishment of primary villages on the island's coast (e.g., Arnold, 2001; Erlandson and Jones, 2002; Kennett, 2005). This period is also described as an epoch of environmental instability, with episodes of extremely dry conditions (Kennett and Kennett, 2000). Within this environmental context, a decrease in residential mobility and an overall reduction in foraging range has been identified, which may have put more pressure on the exploitation of particular resources as people filled the coastal landscape and competed for nearshore resources (see Glassow, 1993; Kennett, 2005).

Various researchers have addressed the question about how much of the observed variation in archaeo-malacological assemblages (especially *Mytilus californianus*) around the northern Channel Islands is due to fluctuations in past environmental conditions or human predation (for examples, Kennett and Kennett, 2000; Arnold, 2001; Kennett et al., 2007; Braje et al., 2012; Glassow et al., 2012). Scholars have argued that the increase in human population and spatial circumscription on the northern Channel Islands during the Late Holocene (3000–200 B.P.) had some effect on intertidal habitat suitability (Arnold, 2001, 2004; Erlandson and Jones, 2002; Kennett et al., 2009; Winterhalder et al., 2010) with shellfish harvesting decisions more influenced by foraging pressure than environmental conditions (Braje et al., 2012). Several sources of evidence have been used to infer this decreasing environmental influence (Glassow, 1993; Braje et al., 2007, 2011; Erlandson et al., 2008); for example a general decline through time in size and abundance of *M. californianus* shells and the decreasing correlation through time between these changes and regional past SST and marine productivity recorded in a marine sediment core from the Santa Barbara Basin, California (Kennett and Kennett, 2000; Kennett et al., 2007).

The research done around the Channel Islands, supported by a regional approach to the relationship though time between changes in archaeological shellfish assemblages and past SST, has been an important contribution to the understanding of general patterns of human-environment interactions along the California coast and beyond (e.g. Rick et al., 2006; Braje et al., 2007, 2012; Kennett et al., 2007; Erlandson et al., 2008). Nonetheless, the complexity of oceanographic dynamics and their effect on *M. californianus*, the main intertidal shellfish species exploited through prehistory along the coast of California, have not yet been addressed.

The proposal of lessening influence of environmental conditions on shellfish harvesting around the northern Channel Islands during the Late Holocene is based on a rich body of archaeological data but has never been evaluated using small-scale oceanographic and ecological data to assess local past intertidal habitat productivity and to evaluate human impact on these habitats. The absence of this approach has two main issues: the use of regional past SST records as a correlate of past local nearshore SST and the omission of the differential effect of marine productivity on intertidal shellfish species.

In the present study, in order to evaluate the influence of small-scale oceanographic conditions on *M. californianus* during the Late Holocene, fluctuations in size and abundance of *M. californianus* shells through time and possible correlation with local past SST values from oxygen isotope analysis on mussel shells are studied throughout the stratigraphy of two shell midden sites (2200–500 cal B.P.). This paper discusses the lessening influence of environmental conditions on shellfish harvesting around the northern Channel Islands during the Late Holocene with a case study from Santa Cruz Island, considering small-scale nearshore oceanographic variability and its effect on *M. californianus* intertidal beds.

1.1. Effect of human harvesting on shellfish species

Evidence of the effects of human harvesting on modern intertidal shellfish species comes initially from ecological studies

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