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Central place foraging and shellfish processing on California's Northern Channel Islands

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ABSTRACT

We use a central place forager model for shellfish processing to understand Middle Holocene (7550–3600 cal BP) human settlement patterns on California's Northern Channel Islands. This period was associated with increasing sedentism and special purpose sites. We examine the processing and transport costs of two high-ranked shellfish species collected during the Middle Holocene, red abalone (*Haliotis rufescens*) and California mussel (*Mytilus californianus*), and how these costs influence archaeological assemblages at coastal and interior settlements. Experimental data and the biology of these species suggest that red abalones are less likely than mussels to be transported long distances (~2 km) without field processing. Consistent with these expectations, coastal red abalone midden sites (CA-SRI-109 and -338) are dominated by large red abalone shells and California mussels are most abundant at contemporaneous inland sites (e.g., CA-SRI-50). Large coastal settlement sites (CA-SRI-5, -19, -116, and -821) had the highest overall shellfish diversity. A stable oxygen isotope study suggests that special purpose sites were occupied seasonally and large coastal settlements were more likely to be inhabited year-round. Our study suggests that transportation and processing costs of food resources were important variables in the development of early hunter–gatherer settlement patterns.

1. Introduction

Among human populations, there is a fundamental trade-off between sedentism and access to diverse environmental resources. Decisions must be made about mobility, investments in transportation, which resources to prioritize, and scheduling of resource procurement activities (e.g., Bettinger, 1991, 2009; Metcalfe and Barlow, 1992; Smith and Winterhalder, 1992; Madsen, 1993; Barlow and Metcalfe, 1996; Bettinger et al., 1997; Bird and Bliege Bird, 1997; Madsen and Schmitt, 1998; Winterhalder and Smith, 2000; Nagaoka, 2002; Cannon, 2003; Bird and O'Connell, 2006; Kennett et al., 2009; Winterhalder et al., 2010). Among modern industrial populations, efficient forms of long-distance transportation and refrigeration allow people to be almost exclusively sedentary while maintaining access to a broad range of resources. Among hunter–gatherer populations, seasonal and long-term mobility and the conditions in which certain resources are collected and transported back to residential bases are much more variable and related to a series of environmental and social factors. Changes in population size or density, sea level rise, seasonal water availability, distribution of food resources, and weather patterns all play a role in shaping settlement systems. Human Behavioral Ecology (HBE) is an effective approach for exploring the decisions that people make about settlement location, mobility, and resource acquisition because it allows for models that can be tested with archaeological data (e.g., Smith, 1983; Stephens and Krebs, 1986; Madsen, 1993; Bird and O'Connell, 2006).

One model of particular use for understanding early settlement systems is the central place forager model (Bettinger, 1991). This model predicts that when collecting a resource, decisions about whether to field process prior to transportation back to a central location should be made to maximize energetic and other returns (e.g., Charnov, 1976; Smith, 1983: 631–634; Ugan et al., 2003; Burger et al., 2005; Metcalfe and Barlow, 1992; Barlow and Metcalfe, 1996; Bird and Bliege Bird, 1997; Cannon, 2003; Bettinger et al., 1997). These decisions become necessary when people occupy one location and must travel substantial distances to collect resources not available locally. This, in turn, can lead to the development of regional settlement systems that include special purpose sites (e.g., Binford, 1980). Decisions about shellfish processing have been addressed in coastal environments such as the South Pacific to understand fundamental questions about

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human subsistence (e.g., Bird et al., 2002; Thomas, 2007; Codding et al., 2014). Patterns of shellfish remains in archaeological contexts also can provide important information about population size and movement during the initial colonization of new locations (see Codding et al., 2014).

In this paper, we use a central place forager model to understand the distribution of permanent and special purpose sites on Santa Rosa Island, California, during the Middle Holocene (~7550–3600 cal BP). At this time, people collected shellfish from special purpose coastal sites for transport back to permanent coastal settlements or interior residential bases. The faunal record supports a field processing model in which red abalones (*Haliotis rufescens*) are preferentially processed at or near collection sites because they are easily removed from their heavy shells. California mussels (*Mytilus californianus*) were transported unprocessed because their shells are lighter and more time consuming to remove, and because the meat preserves better in the shell. This model describes a settlement system in which decisions about where to establish a central base, seasonal movement, and patterns of field processing are made to take advantage of disparate resources across the landscape. It helps explain differing archaeological assemblages between sites that were likely seasonally occupied by the same groups of people.

2. Theoretical background

When modeling human subsistence behavior, it is important to consider not only which resources hunter–gatherers choose to exploit, but also how long is spent processing and collecting those resources before transporting them back to a central base. This is often modeled using the marginal value theorem, an optimization model borrowed from biology (Charnov, 1976; Smith, 1983: 631–634; Ugan et al., 2003; Burger et al., 2005), or through the use of utility functions, defined by Metcalfe and Barlow (1992; Barlow and Metcalfe, 1996) as the relationship between the time spent processing and the resulting increase in the utility of the transported load. This model predicts that collectors will spend the amount of time field processing that maximizes the net calories per hour from a resource after traveling to a resource patch, collecting and field processing the resource, and transporting it back to camp (Barlow and Metcalfe, 1996: 355). Metcalfe and Barlow divided the processing of pinyon and pickleweed into steps, for example, with total utility calculated for field processing after each step. They then used this model to predict the degree of field processing of each species based on distance from a base camp (Barlow and Metcalfe, 1996: 358–368). Bettinger et al. (1997) used a similar calculation to model field processing of acorns, arguing that because stages of acorn processing subsequent to drying are disproportionately time consuming, field processing would only be done under extreme circumstances (i.e., one-way travel time greater than 24.95 h), but that field drying was often a preferred strategy. Similarly, Cannon (2003) argued that for large mammal hunting, processing time should increase when more distant resources are being processed. This also occurs when the availability of high-ranked species is depressed and average search time increases.

Shellfish processing differs from that of plants and large mammals in that removing the meat from the shell (shucking) is the only step in the process other than cooking. When collecting shellfish at long distances from a central base, foragers are confronted with the decision to either shuck shellfish in the field or to transport unprocessed shellfish back to their home bases. The benefits to field processing are clear; by removing the shell and, for some species, the guts from the meat, the forager can collect more meat during a single trip because the parts that cannot be consumed do not contribute to the maximum weight that can be carried or the space available in baskets or bags used for transport. In their ethnographic and archaeological study of shellfish collecting among the Merriam Islanders of the eastern Torres Strait in Australia, Bird and Bliege Bird (1997) observed field collection and processing strategies in conjunction with the archaeological record of dietary shellfish species. They found that because of differential field processing and transport, some species were more likely to be over-represented and others under-represented in shellfish assemblages relative to their dietary importance. Using a central place foraging model to predict field processing behaviors, Bird and Bliege Bird (1997) observed consistent relationships between the predictions of their model and observed patterns of transport for five species. They found that resources with high-energy yield (per processing time), such as *Hippopus* and *Tridacna* spp., were likely to be under-represented in residential deposits and low-ranked shellfish (e.g., rocky shore resources) were likely to be over-represented relative to their dietary importance (Bird and Bliege Bird, 1997).

Bettinger et al. (1997) used experimental data for returns on collecting and processing of California mussels obtained by Jones and Richman (1995) to calculate travel thresholds for field processing. Experimental data are available for mussels collected from two environments, pristine and depleted beds, and using two collection strategies, plucking and stripping. Bettinger et al. (1997) calculated these travel thresholds for two load sizes, 15 kg and 36 kg. These were based on the two primary burden basket sizes in the C. Hart Merriam Ethnographic collection at the University of California, Davis. They found that: (1) predicted return rates are higher in depleted beds than pristine ones; (2) plucking is more efficient than stripping; and (3) the one-way travel limit for 15 kg loads is less than the 2 h radius within which most hunter–gatherers confine their daily foraging. Because of this, Bettinger et al. (1997) predicted that field processing of mussels should occur in some cases, namely when the distance to the resources exceeds this travel threshold. For our study, we combine the results from Bettinger et al. (1997) with an experimental study of abalone processing utility to assess differential processing of the two most common shellfish species in Middle Holocene archaeological sites on Santa Rosa Island.

Our central place forager model incorporates three different site types: coastal red abalone middens, coastal settlement sites, and interior residential bases (Fig. 1). We predict that when people seasonally occupied interior residential bases several kilometers from the coast, they occasionally traveled to coastal red abalone sites to collect shellfish. When they did, they preferentially processed red abalones, discarded the shells, and transported the meat to the interior, whereas mussels were more likely to be transported whole and unprocessed (A). When local shellfish resources were depleted at permanent coastal settlement sites, there may have been a similar pattern of field processing abalones that were transported from red abalone sites to permanent sites (B). Additionally, seasonal movement between coastal settlement sites and interior residential bases involved the transportation of shellfish from the coast to the interior and plant foods and other terrestrial resources from the interior to the coast (C). In this model, the three different site types should have distinctive faunal assemblages which reflect their roles in the overall settlement system, including the decisions that people made regarding where to access subsistence resources and whether those resources should be processed prior to transportation.

3. The Middle Holocene on Santa Rosa Island

On California's Northern Channel Islands (NCI), a distinct Middle Holocene settlement pattern developed that included