Flexible Strategies for Resource Defense on the Northern Channel Islands of California: An Agent-Based Model

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Territorial behavior and the protection of economically valuable resources is undeniably an important component of human social life (a territory being defined as an area or region that is used and/or controlled exclusively by an individual or group of people; see Dyson-Hudson and Smith 1978; Cashdan 1992). Most ethnographically recorded foragers and agriculturalists acknowledge spatial boundaries of some kind (Kelly 1995), but individuals and groups differ greatly in how they delineate, protect, and share access to land and subsistence resources. Clearly demarcated territorial boundaries are likely to be defended vigorously against intrusion at the cost of injury or even death. Ill-defined boundaries, however, may be maintained through mutual avoidance or more subtle social solutions. Describing and explaining these sorts of differences in human territoriality has preoccupied anthropologists and archaeologists interested in the spatial organization of human groups for decades (Radcliffe-Brown 1952; Steward 1955; Service 1962; Dyson-Hudson and Smith 1978; Thomas 1981; Cashdan 1983, 1992; Layton 1986; Rosenberg 1990, 1998; Smith and Boyd 1990; Steffan 1991; Kelly 1995; Adler 1996; Eerkens 1999; Gartner 1999; Hayden 2000), and the explication and understanding of the types of pressures that account for human territorial organization remains some of the most interesting and controversial research within the discipline (Rosenberg 1998; Hayden 2000).

In this chapter, we examine the emergence and character of territorial behavior during the Middle Holocene (7500–3000 BP) on the
Northern Channel Islands of California (see Figure 2.1). Settlement patterns during this time suggest strategic movement of at least a segment of the population from coastal villages to small interior hilltop and ridgeline residences that appear to have been used periodically, possibly seasonally. We are particularly interested in the seemingly defensive nature of interior hilltop settlements that date to this interval. The spatial distribution of these sites along with the makeup of artifact/faunal assemblages suggest that they were used as seasonal encampments for seed and tuber collecting. This activity in itself, however, does not seem to explain the location of these sites, given their exposure to the elements (e.g., wind) and their relative distance from potable water and heavily utilized marine resources in comparison to other potential inland settlement locations that appear to be unused during this interval. Given this, we argue that any explanation for the location of these settlements must look beyond basic geographic and subsistence considerations and take into account the social dynamics shaping this settlement strategy.

Figure 2.1. Map of the Northern Channel Islands and the adjacent mainland (drafted by C. Kantner).

Based on the patchy and somewhat unpredictable nature of plant productivity on the Northern Channel Islands, we argue that this pattern of inland settlement represents a flexible strategy that served to balance resource procurement and defendability. Semipermanent, highly visible hilltop settlements within commonslands functioned to maximize access to plant resources, while lessening the costs of year-round defense of clearly demarcated territories. Flexible strategies for defending resources have been documented in a number of different animal species (Davies 1976, 1978; Cashdan 1992; Mason 1996; Dearborn 1998), and in a variety of ethnographically recorded hunter-gatherer societies (Thomas 1981; Andrews 1994; Kelly 1995). Flexibility is usually employed when resources are periodically and somewhat predictably available at a location that is not suited for permanent year-round occupation. The concept of ‘economic defendability’ helps predict whether a resource patch is worth protecting on a periodic, possibly seasonal, basis. Resources are considered economically defendable if the benefits of maintaining exclusive access to them outweigh the costs of doing so (Brown 1964). From this baseline, then, the abundance, distribution, and temporal nature of resources can be used to predict territorial behavior in a wide variety of animal species, including humans (Dyson-Hudson and Smith 1978). Territorial behavior, however, is also conditioned by the presence or absence of other competing, or at least coexisting individuals and groups. In exploring this dynamic, we turn to agent-based models drawn from evolutionary game theory (Maynard Smith and Price 1973; Maynard Smith 1974, 1982; Axelrod and Hamilton 1981; Smith and Winterhalder 1992). To evaluate these behaviors through time, both the concept of economic defendability and models drawn from evolutionary game theory will be presented within the context of a broader Darwinian-based framework of behavioral ecology (Davies and Krebs 1978; Bettinger 1991; Smith and Winterhalder 1992; Kelly 1995; Boone and Smith 1998; Broughton and O’Connell 1999).

THEORETICAL FRAMEWORK

First developed in the field of evolutionary biology, behavioral (or evolutionary) ecology is “the application of natural selection theory to the study of adaptation and biological design in an ecological setting” (Winterhalder and Smith 1992:5). It focuses then, on the interactions
between ecological variables and their role in the development of specific adaptations (Broughton and O'Connell 1999:153). In keeping with their Darwinian baseline, behavioral ecologists see the costs and benefits of behavior as being best understood in terms of genetic fitness (Bettinger 1991:154). This is not to say that behavior is necessarily linked to an organism's genetic makeup in any direct sense, but, as Bettinger (1991:154) puts it:

Any specific behavior should have the effect of increasing the likelihood that some or all of the genes of an individual will be passed on to another individual... If behavioral variability (whether its source, i.e., genetic or otherwise) results in differential genetic fitness and if such behaviors (again regardless of source) are transferable from one individual to another, then this transfer necessarily carries with it the implication of genetic fitness.

Or in other words, from the point of view of evolutionary ecology, behaviors are as much a part of the variation of the phenotype as its genetic makeup (again, whether this behavior is directly genetically controlled or not), and therefore is an important aspect of the overall fitness of an organism (Bettinger 1991; Winterhalder and Smith 1992; Boone and Smith 1998).

In applying this approach, behavioral ecologists structure their inquiries around predictive models of behavioral optimality (Bettinger 1991; Smith and Winterhalder 1992; Boone and Smith 1998; Broughton and O'Connell 1999; Winterhalder and Smith 2000). This approach requires hypotheses regarding the relative fitness (in a Darwinian sense) for the behavior(s) being studied and alternate behavioral strategies (including constraints limiting the field of strategies), as well as the costs and benefits associated with each strategy and the currencies by which these costs and benefits are to be measured (Broughton and O'Connell 1999:153–154). Energetic efficiency is one proximate measurement of fitness for an organism, with the underlying assumption being that the behavioral strategies that are the most efficient will ultimately enhance the overall fitness (i.e., genetic fitness) of their practitioners.

Though it has been implied thus far, it should be explicitly stated that, in keeping with their Darwinian baseline, behavioral ecologists view the individual as being the level at which selection takes place (Smith and Winterhalder 1992; Kelly 1995; Kantner 1996; Nettle 1997; Boone and Smith 1998). A variety of agent-based approaches have been shown to effectively elucidate the fundamental processes underlying individual decision making and the evolution of complex adaptive systems (Axelrod 1997; Kohler and Gumerman 2000). In particular, evolutionary ecologists adhere to the concept of "methodological individualism," where the properties of groups (populations, social institutions, economies, cultures, etc.) are viewed as being the outcome of the actions of their individual members (Smith and Winterhalder 1992:39).

Economic Defendability

Economic defendability is a concept that was developed in the field of evolutionary biology to explain the costs of defending resources versus the benefits of having sole access to them (Brown 1964; Cashdan 1992; Kelly 1995). The propensity of an individual to defend a resource is often dependent on the distribution and predictability of the resource. Resources are economically defendable if the benefits for controlling them exceed the costs of defense. If a resource is sparsely distributed across the landscape and temporally unpredictable, the costs of defending it will likely offset the gains made in defense. As resource density and predictability increase, so does the likelihood that they will be defended (Kelly 1995).

Based on the concept of economic defendability, Dyson-Hudson and Smith (1978) outlined a model of territorial behavior in human groups where resource density and predictability were used to forecast territorial behavior. In this model, it is predicted that when resource density and predictability are low and the costs of defending a territory exceed the benefits of doing so, human groups will be both dispersed and highly mobile (see Figure 2.2). If resource density is high, but unpredictable, territories will shift in response to unpredictably high yields. When resource density is low but predictability is high, a "passive territorial" strategy is often maintained, that is, a group will occupy a defined range where resource availability and predictability is sufficient enough so that people do not have to move beyond the boundary of their territory. Finally, high resource density and predictability promotes territoriality because the costs of defending the resources are less than the benefits of doing so. Using ethnographic data from Native American and African groups, Dyson-Hudson and
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From Dyson-Hudson and Smith (1978)

**Figure 2.2.** Ecological model predicting territorial behavior among human foragers based on the spatial and temporal distribution of resources.

Smith (1978) provide empirical evidence that, for the most part, correlates with their prediction that resource density and predictability are generally correlated with human territorial behavior.

Of course, the costs of defending resources that are unpredictable will often exceed the benefits of doing so (Cashdan 1992). However, if highly productive or nutritionally important resources become available seasonally, more flexible strategies of defense may be favored evolutionarily (Davies 1976, 1978; Davies and Houston 1984; da Silva, Woodroffe, and Macdonald 1993). A number of animal species respond to changes in the availability of resources. For instance, spotted hyenas (*Crocuta crocuta*) are territorial when food is abundant and predictable, but wander over large areas when food is only seasonally available (Kruuk 1972). Similar behavioral strategies have been identified in a number of bird species, including pied wagtails (*Motacilla alba*) and rufous-tailed hummingbirds (*Amazilia tzacatl*), in that individuals are extremely territorial when resources are dense and predictable, but for-

...widely in larger groups when food is patchy and unpredictable (Davies 1976; Dearborn 1998). In human groups, individuals may tolerate the intrusion of other people into their range during times when resources are not available, but defend them when food is abundant and predictable. For instance, ethnographic accounts demonstrate that the Reese River Shoshone were more territorial during winter months when they moved to encampments close to high altitude pinyon pine stands (Thomas 1981). Likewise, Andrews (1994) has argued that the Akitlmut in southwestern Alaska defended river bottlenecks twice a year when large numbers of white fish and pike were spawning and easily captured (also see Kelly 1995). In both cases, people responded to seasonal increases in resources with transitory territorial behavior.

The environment, however, is not the only factor in determining territoriality. The presence or absence of other people make certain resource patches (clumps) more or less attractive. Individuals entering an environment that is occupied by other people may choose a less desirable place to settle in order to avoid overcrowding or competition at prime locations. Many hunter-gatherers also relocate their villages during the year within an established range or territory. Individuals must decide if they will defend this region against outsiders or allow people to forage in different parts of the area. In other words, population-dependent demands for resources can alter the payoff structure when people are making decisions about resource and territorial defense (Kelly 1995). Evolutionary game theory, we feel, offers a productive approach for examining these sorts of interpersonal (and group) dynamics.

**Evolutionary Game Theory**

Game theory originally emerged in the field of economics to explain rational decision making (von Neuman and Morgenstern 1944), but has more recently been adopted by evolutionary biologists to better understand competitive and cooperative relationships in a variety of animal species (Maynard Smith 1982). In the field of anthropology, evolutionary game theory is one of a suite of approaches being explored with the resurgence of neo-Darwinian theory (Smith and Winterhalder 1992). This approach has been used to explore problems of collective action such as sharing and exchange (Hawkes 1992; Nettle and Dunbar 1997),
Game theory is an agent-based approach for modeling why individuals make certain behavioral decisions in cooperative and competitive relationships. It is well suited for exploring the nature of resource defense and territoriality, because the most successful strategies are often dependent on how other actors are behaving. Fundamentally, the approach is grounded in the concept of methodological individualism (Winterhalder and Smith 1992). Proponents of methodological individualism argue that the actions of individuals, rather than groups, explain higher orders of social aggregates such as social institutions and economic systems (Winterhalder and Smith 1992; Nettle and Dunbar 1997). From this perspective, individuals are considered fundamentally rational and driven by self-interest, however, nonrational behavior can also be accommodated by the model (Winterhalder and Smith 1992). Proponents of this approach argue that behavioral strategies are phenotypic expressions and subject to natural selection (Smith and Winterhalder 1992). Within a given context, strategies are assigned a certain payoff. In evolutionary game theory, biological fitness (e.g., number of surviving offspring) is often given primacy, but proximate economic factors may also be considered.

**An Evolutionary Model of Resource Defense and Territoriality**

One evolutionary game for modeling contests for resources or territories is the Hawk–Dove game (Maynard Smith 1982; in classical game theory the same payoff structure can be found in the game of chicken—see Binmore 1992). In the Hawk–Dove game, two individuals compete for access to a resource or territory using one of two strategies: Hawk or Dove (Smith and Winterhalder 1992). Tactically, a Hawk will always fight aggressively to maintain access to a resource or a territory until severe injury or death. A Dove will display vigorously to protect a resource or a territory, but will back down if confrontation with a Hawk escalates. Doves will share a resource or territory with another individual using the Dove strategy. Considering the value (V) of the resource or territory being contested and the cost (C) of defending or gaining access to it, adds a dimension of realism—the Hawk–Dove game (see Figure 2.3). In this example, the value of the resource or the territory being contested is equal to 200 points. The cost (C) incurred fighting and losing access to the resource is 300 points, because it is assumed that a violent Hawk versus Hawk confrontation will result in an overall decrease in fitness for theloser (e.g., reduced ability to forage, attract mates, escape predators, survive disease). In this context, the individuals who give up (play Dove) gain and lose nothing (0). The payoff structure expressed in Figure 2.3B assumes that when two Hawks contest they have an equal (0.5) probability of winning [(100/2) + (−300/2) = −100]. When a Hawk and Dove contest for access to a resource, the Hawk strategy will always win out. However, in a large population, the costs associated with two Hawks meeting (300) precludes the dominance of the Hawk strategy. Maynard Smith (1982) shows mathematically that through evolutionary time the optimal strategy is to play Hawk half the time and Dove the other half.

The Hawk–Dove contest is a symmetrical game that assumes that each individual has the same potential for maintaining access to a resource (Maynard Smith 1982; Boone 1992). Asymmetrical games assume that the resource holding potential differs for owners and intruders. Individuals who already hold a resource have the defensive advantage over the intruder. Consider the Hawk–Dove–Bourgeois game where two individuals, an owner and intruder, are contesting for a resource (Figure 2.4A). In this game, the owner is the first individual to establish an encampment next to the resource being contested. Each contestant can use one of three strategies: Hawk, Dove, or Bourgeois. As already described, a Hawk will fight for the resource until injured or the opponent gives up. A Dove retreats as the contest escalates. The Bourgeois strategy is to play Hawk if the resource is currently owned and Dove if it is not. Assuming that the contestants are resource owners half the time and that V < C, the Bourgeois strategy always does better than Hawk or Dove and is the optimal strategy (see Figure 2.4B; Maynard Smith 1982).

The Bourgeois strategy is expected to do well in regions where populations are dispersed and resource availability is high relative to population levels (see Kantner 1999). In other words, when the loser of a contest has a viable alternative elsewhere, this strategy will be dominant. Competition for resources—driven by population growth, overall
Figure 2.3. *Hawk–Dove* game used by evolutionary ecologists to model contests for resources (after Winterhalder and Smith 1992). In this example, the value (V) of the resource or territory being contested is equal to 100. The cost (C) incurred fighting and losing access to the resource is 50 points. In this game, individuals who give up (Doves) gain and lose nothing (0). Hawks always contest, while Doves never do.

Figure 2.4. Asymmetrical *Hawk–Dove–Bourgeois* Game. The payoff structure for contests between Hawks and Doves are the same as in Figure 2.3. This game assumes that individuals using the Bourgeois strategy play Hawk if they are the owner and Dove if they are the intruder. Assuming that players are resource owners half the time, the Bourgeois Strategy always does better than Hawk or Dove (adapted from Maynard Smith 1982; used with the permission of Cambridge University Press).
decrease in resource abundance, or other factors—will increase the benefits of Hawklike strategies and territorial behavior. The benefits of taking and defending a resource should also favor more competitive, Hawklike, behavioral strategies or more innovative cooperative ones.

THE NORTHERN CHANNEL ISLANDS: AN ARCHAEOLOGICAL EXAMPLE

The Northern Channel Islands of California present an excellent opportunity for exploring the long-term dynamics of spatial patterning in the archaeological record and the implication of these changes for understanding the evolutionary ecology of human territorial behavior. Islands inherently provide a bounded space where the residues of past human behavior, such as territoriality, can be explored effectively (Kirch 1986). In addition, the archaeological data on the Northern Channel Islands is the best preserved in California owing to the dearth of burrowing animals and urban development (Glassow 1980). The islands also have an extremely long period of continuous occupation stretching back at least to the Terminal Pleistocene (Erlanson 1994; Erlandson et al. 1996; Erlandson, Tveskov, Kennett, and Ingram 1996; Kennett 1998), further enhancing our ability to understand the nature and tempo of culture change.

Located off the coast of present-day Santa Barbara and Ventura Counties in Southern California, the Northern Channel Islands (Anacapa, Santa Cruz, Santa Rosa, and San Miguel) are a continuation of the Santa Monica Mountains, extending east–west for approximately 88 km along the southern margin of the Santa Barbara Channel (see Figure 2.5). The islands range in size from 2 km² (Anacapa) to 249 km² (Santa Cruz) and maximum elevations do not exceed 753 m. Each of the islands is distinct topographically: Anacapa is dominated by generally inaccessible rocky cliffs, Santa Cruz by rugged mountainous terrain, and Santa Rosa and San Miguel with smaller mountain ranges, rolling hills, and dune fields. Though all of the islands feature perennial water sources in the form of streams and/or springs and seeps, water availability is limited and unevenly distributed across the landscape, with much of it concentrated in the larger drainages on the northern shores of the islands (Kennett 1998).
Though much environmental variation exists between the islands, all of them are surrounded by rich marine environments hosting a variety of valuable resources that certainly would have been worth defending prehistorically. Due to the Santa Barbara Channel's unique geographic position, the Northern Channel Islands lie near the middle of one of the world's most productive fisheries (Kennett 1998:90). The reasons for this area's high marine productivity are complex, but are ultimately centered around the islands' proximity to the cold, nutrient-rich, California current (Engle 1993, 1994; Kennett 1998). Although the marine resources of the Northern Channel Islands are abundant, the nature, availability, and accessibility of these resources vary, often quite markedly, between islands. Each of the islands has a distinct character that results from its geographic position along the coast, the physical characteristics unique to each island, and its proximity to the California current (Engle 1993, 1994). Spatial variation in sea-surface temperatures and marine productivity are directly related to the complexity of oceanographic circulation in the region (Frobose 1992; Browne 1994; Kennett, Ingram, Erlandsen, and Walker 1997). The distribution and composition of algae, kelp, benthic biota, shellfish, fish, and sea mammals for each island also reflect this complexity (Neushul, Clarke, and Brown 1967; Murray, Littler, and Abbott 1980; Seapy and Littler 1980; Engel 1993, 1994; Stewart, Yochem, DeLong, and Antonelis 1993). Intertidal and fish resources are extremely rich around all of the islands and the cool waters surrounding San Miguel Island support the largest modern sea mammal rookery on the west coast of North America (Stewart et al. 1993). Most marine resources exploited prehistorically were available throughout the year.

Throughout time, shellfish was the most consistent staple of the islander's diets (Glassow 1980; Kennett 1998), but these invertebrates were particularly important to islanders during the Middle Holocene (Glassow 1993a). The main areas for the procurement of these resources are to be found in the islands' abundant rocky intertidal zones, which traditionally have supported large colonies of black and red abalone (Halichondria cracherodii and Haliotis rufescens, respectively) and California mussels (Mytilus californianus), as well as other useful shellfish species (Glassow 1980; Kennett 1998:96). Though these zones are found to some extent on most areas of the islands, they are generally more abundant on their northern shores due to the greater density of rocky intertidal habitats (Kennett 1998:96–100). Fishing, though overall the less important resource procurement strategy in comparison to shellfish collecting, did increase in importance through time on the Northern Channel Islands and seems to have played a strong supporting role in the makeup of the islanders' diet during the Middle Holocene (Landberg 1965; Glassow 1980; Kennett 1998).

In comparison to their marine resources, the Northern Channel Islands are quite depauperate terrestrially, as there are no large land-based mammals native to the islands, and their flora is restricted to only a fraction of the species found on the adjacent mainland (Timbrook 1993). The islands do, however, contain a number of plant resources that would have been useful to prehistoric populations. Roots, tubers, and seeds were undoubtedly the most important terrestrial food resources for the islanders and occur mostly during the summer months (May through August) in the islands' grassland, coastal sagebrush, and woodland communities (Philbrick and Haller 1977; Philbrick 1980; Jones, Junak, and Paul 1993; Timbrook 1993; Junak, Ayers, Scott, Wilken, and Young 1995). Acorns and pine nuts also played a role in the islander's diets, being available between October and December on Santa Cruz and Santa Rosa Islands. The distribution and productivity of these plant communities varies greatly and are related to the size and topographic relief of each island, local differences in seasonal rainfall, hydrology, substrate permeability, and the chemical and erosional qualities of the soil (Junak et al. 1995; Kennett 1998).

Although the resource base of Southern California has traditionally been characterized as abundant and stable, recent studies show that at least the latter part of the picture is simply not true. Environmental conditions have actually been in a constant state of flux throughout the Holocene (Kennett 1998; Kennett and Kennett 2000; Kennett, Kennett, and Erlandson in press). These long-term environmental fluctuations are evident in a number of proxy records for the Santa Barbara Channel region (Heusser 1978; Pisias 1978, 1979; Arnold and Tissot 1993; Cole and Liu 1994; Kennett and Ingram 1995a, 1995b; Ingram and Kennett 1995; Behl and Kennett 1996; Kennett 1998; Kennett and Kennett 2000) and no doubt the short-term climatic variability visible historically (i.e., El Niño/drought cycles) occurred throughout much of the Holocene, superimposed on long-term climatic cycles. Environmental conditions in general seem to have been particularly unstable after 5000 BP (Kennett 1998; Kennett et al. in press). Both long- and short-term climatic fluctuations undoubtedly had the potential to markedly alter both the nature and the productivity of the area's resource base.
Flexible Strategies for Resource Defense on the Northern Channel Islands

Middle Holocene Settlement Dynamics

Archaeological records on the Northern Channel Islands provide some of the best evidence for human occupation along the west coast of North America between 12,500 and 7500 BP (Erlanson 1994; Erlanson, Kennett et al. 1996; Erlanson, Tvekslov et al. 1996; Kennett 1998; Erlanson, Rick, Vellanoweth, and Kennett 1999). Most of the early sites are located on the northern coasts of San Miguel and Santa Rosa, but the number of sites is relatively small and the dominant settlement and subsistence strategies are difficult to define. Almost all the early sites are relatively small and it is possible that the islands were occupied only sporadically during this interval (Kennett 1998). Human settlements proliferated on San Miguel, Santa Rosa, and Santa Cruz after 7500 BP and the islands appear to have been occupied permanently after this time (Erlanson 1997a, 1997b; Kennett 1998).

By the Middle Holocene (7500–3000 BP) settlement strategies appear to have been semisedentary in nature on the Northern Channel Islands. Population densities were relatively low and periodic movement between coastal and interior habitats suggests the complementary use of marine and plant resources. Large coastal sites, consisting primarily of red abalone and California mussel shells, are generally associated with long stretches of rocky coast and perennial streams on the larger islands. Relatively diverse tool assemblages and cemeteries at these sites suggest a certain degree of sedentism, but the presence of substantial interior midden and temporary encampments along the coast indicate that these people were not fully sedentary. Shellfish harvesting profiles (δ18O) for a sample of residential bases (coastal and interior) and temporary camps on Santa Rosa and Santa Cruz islands provide additional evidence for some residential mobility (Kennett 1998). Settlement and subsistence strategies appear to have been relatively stable throughout the Middle Holocene (7000 to 3000 BP).

Three primary Middle Holocene settlement types have been identified on the Northern Channel Islands: large coastal sites, interior residential middens, and temporary camps (see Figure 2.5). Large coastal sites appear to have been the primary residential loci, continually occupied and reoccupied throughout the Middle Holocene. They were generally situated on long stretches of rocky coastline close to freshwater (Kennett 1998). No domestic features (house floors, pits, etc.) have been identified at these sites but the tool assemblages at these locations are relatively diverse and the presence of cemeteries at some coastal sites indicates a certain degree of sedentism (Orr 1968; Kennett 1998).

Interior residential middens, contemporary with the large Middle Holocene coastal residences, are the most common settlement type on Santa Cruz, Santa Rosa, and San Miguel islands (see Figure 2.5; see also Kennett 1998 for radiocarbon dates). Midden deposits dating to this time have been recorded in the bottoms of drainages, but the vast majority of interior residential middens are positioned on hilltops or ridgelines. Over 200 hilltop/ridgeline settlements have been recorded on Santa Rosa and Santa Cruz alone (Kennett 1998). Interior hilltop/ridgeline settlements are substantially smaller than contemporary residential middens on the coast, averaging 1,525 m² and ranging from 20 to 6,800 m². Many of these are situated on the leeward side of ridgelines and hilltops, slightly protected from the prevailing northwesterly wind that batters the Northern Channel Islands. These sites are located between 0.7 and 4.85 km from the coast, all within two hours walking distance from the rocky intertidal zone. Faunal assemblages are comparable to coastal villages, but California mussel shells are more common than abalone at the interior locations. Stemmed dart points, utilized flakes, groundstone tools (mortars and pestles), and digging stick weights have also been recovered from these sites (Kennett 1998; Clifford 2001).

A large number of temporary camps have also been identified along the coast of the Northern Channel Islands, including several cave sites (see Figure 2.5; Glassow 1993b; Erlanson, Kennett et al. 1996; Kennett 1998; Vellanoweth, Rick, and Erlanson 2000). Many of the open sites are distinctive, thin layers of red abalone shells, many of which date to between 7500 and 3000 BP. Glassow (1993b; also see Glassow, Kennett, and Wilcoxon 1994) first noted that middens with large quantities of red abalone shells consistently dated to this period. Faunal and artifact diversity are limited at these sites suggesting occupation for short periods of time, possibly to collect and process red abalone. Seasonality studies substantiate that these sites were not permanently occupied (Kennett 1998).

In summary, the location of Middle Holocene settlements in rocky coastal areas and in the interior of each island suggests complementary use of shellfish and plant resources. Fish, sea mammal, and bird bones are all found in residential middens of Middle Holocene age, but
abalone and California mussel shells are the most abundant midden constituents. Quantitative midden constituent data from all types of sites on the Northern Channel Islands indicate that shellfish provided the primary meat source during the Middle Holocene (Glasgow 1993a; Kennett 1998; Vellanoweth et al. 2000; Clifford 2001). The position of Middle Holocene interior sites suggests the strategic use of coastal sagebrush and grassland communities (Kennett 1998). The importance of grasses and sagebrush during the Middle Holocene is supported by the presence of milling equipment and digging stick weights at these locations and independently with osteological and isotopic data (Walker and DeNiro 1986; Walker and Erlandson 1986; Goldberg 1993). These subsistence-settlement strategies persisted throughout the Middle Holocene.

**DISCUSSION**

Based on the available data, Middle Holocene (7500–3000 BP) settlement strategies on the Northern Channel Islands were characterized by periodic movements of people between large semipermanent coastal and interior hilltop locations. The large coastal settlements were established in optimal locations to maximize access to long stretches of rocky coast and freshwater sources. The small number of large coastal settlements dating to this time suggest that population levels were low relative to later time periods. The original occupants of optimal coastal locations undoubtedly used Hawklike strategies to control access to resources. Once access to certain areas was restricted by current occupation, contests for resources were asymmetrical: intruders challenging the control established by earlier occupants. In this context, game theory predicts that the Bourgeois strategy would be the best and unbeatable strategy as long as other viable locations were available on the islands. For example, Hawklike strategies were probably first employed to establish control over unused resources or settlement locations, but later settlements would have been established elsewhere if prime locations were already in use (Dove-like strategy). The absence of settlements at many viable coastal locations suggests that populations were low on the islands for much of the Middle Holocene.

The presence of semipermanent encampments in the interior of the islands during this time also suggests that people were not concerned about losing access to prime coastal locations, another indication that population levels on the islands were relatively low. Undoubtedly, these semipermanent interior settlements were periodically established to maximize access to plant resources. The spatial organization of these interior settlements on the Northern Channel Islands is comparable to the pattern on the Santa Barbara mainland during the Early Holocene (10,000–7500 BP). Many of the residential bascamps on the mainland during this time were located away from the coast on ridges, terraces, and knolls (Erlandson 1994). Rogers (1929) argued that these interior settlement locations provided convenient access to oak groves and other important plant resources. More recently, Moore (1985) has argued that these interior locations were established to maximize access to interior plant and marine/estuarine resources. These settlements have also been interpreted as defensive positions against more aggressive groups in the region (King 1980; Gamble and King 1997). Erlandson (1994) does, however, point out that the settlement record may be biased toward elevated Early Holocene sites because temporary locations along the coast and valley bottoms have been destroyed by sea level rise, coastal erosion, and sedimentation.

In specific regard to the Northern Channel Islands, Orr (1968:99) surmised that these interior settlements were occupied in a more or less permanent fashion during a time of higher rainfall when the interior was dotted with ponds and covered with “a forest of oak, catalina, and elderberry.” Environmental data, however, does not support such a scenario. Regional pollen studies suggest that the Middle Holocene was a period of relative aridity and that a decidedly dry terrestrial climate was firmly established between ~6,000 and 2,000 years ago (Huesser 1978; Davis 1992; Cole and Liu 1994). This suggests a general environment much more conducive to the development of the types of grassland, sage, chaparral, and oak scrubland communities that dominate the Northern Channel Islands today than the lush environment hypothesized by Orr (1968). Though intrusive species have no doubt greatly changed the specific makeup of modern island plant communities, there is still a strong correlation between current grassland- and sagescrub-dominated areas and the locations of these hilltop and ridgeline settlements, with the overwhelming majority being situated in or within close reach of these locations (Kennett 1998).
Although interior sites on the Northern Channel Islands were certainly located in optimal locations to maximize access to plant foods, we argue that this in itself does not explain why these settlements were positioned in elevated areas. Many of these settlements were located far from drinking water and exposed directly to the prevailing northwesterly wind. Plant communities could have just as easily been exploited from valley bottom locations that were more sheltered and closer to freshwater sources. Site visibility in drainage bottoms has probably distorted the record slightly—however, these biases are not as problematic as the Early Holocene record along the mainland coast. Drainages are not as wide and sedimentation rates are not as high on the islands compared to the mainland and many archaeological sites are exposed in river cuts. Indeed, there are Middle Holocene valley bottom sites in the interior of Santa Rosa and Santa Cruz islands (Peterson 1994; Kennett 1998), and it appears that plants were collected from these valley bottom locations in more environmentally marginal areas of these islands (see Figure 2.5; York 1996). However, such sites are relatively rare; most interior settlements dating to this time were positioned on ridges and knolls.

Plant resources on the Northern Channel Islands are generally limited and only available seasonally. The limited nature and dietary importance of these plants would have made them highly desirable and worth defending during certain times of the year. However, as mentioned, plant resources are only desirable if it is certain that they will be available at the time of harvest (Cashdan 1992). One way to ensure this availability is to maintain a well-defined territory. If this strategy is used, large investments of time and energy are needed to monitor territorial boundaries and if the productivity of plant resources is unpredictable spatially, it could be a costly long-term strategy. A more flexible strategy for defending a resource would be to establish an encampment next to it and limit access to other individuals at critical times during the year when the resource is highly productive. We suggest that the elevated nature of the interior sites during the Middle Holocene is evidence for such a flexible strategy of resource defense. For much of the year, resource availability in the interior of the islands was limited. No large land-based mammals were present and seeds, tubers, and acorns were not available. Settlements were focused along the coast of the island and logistical forays to other coastal locations occurred on a regular basis. Interior territorial ranges may have been defined for individual groups, but the boundaries were probably not maintained throughout the year and foraging ranges likely overlapped. When plant resources became seasonally abundant, we argue that individual families shifted their settlements closer to productive plant patches to control their access. The elevated nature of these encampments provided one way of signaling, or advertising, that resource patches were in use. Approaching people were also easily seen from these locations. The benefits of controlling access to plant patches through residence in highly visible and exposed locations appears to have outweighed the travel and transportation associated with being so far away from freshwater and marine resources and at locations that were more exposed to the elements, particularly wind.

Given this scenario, game theory predicts that the Bourgeois strategy would be unbeatable through time if other viable plant patches existed elsewhere on the islands. Seasonally, access to productive plant communities would be claimed with Hawklike strategies. Other people would seek carbohydrate rich plants elsewhere rather than intrude on another group's foraging range. Conflict would be minimal as long as other alternatives could be found. This seems to be the case for much of the Middle Holocene. Violent interaction between individuals on the Northern Channel Islands during this time was less common compared with later time periods (Lambert 1994). Dart points are occasionally found imbedded in skeletal material, but the most common form of violent interaction seems to have been sublethal in nature. Walker (1989) has documented a large number of healed cranial fractures from prehistoric populations from Santa Cruz and Santa Rosa islands during the Middle Holocene. This suggests that contests for territory and resources occurred, but were generally not lethal and possibly ceremonial in nature (see Walker 1989; Lambert 1994).

The subsistence-settlement and land tenure strategies described in this chapter were dominant on the Northern Channel Islands for 4,500 years (7500-3000 BP). We argue that the spacing patterns of settlements evident in the archaeological record was a product of an evolutionary stable behavioral strategy that emerged and persisted on the islands in the context of low population densities and only limited competition for resources. There is no archaeological evidence for well-defined territories at this time and the position of semipermanent
interior encampments on hills suggests a flexible strategy for resource defense, whereby patchy and somewhat temporally unpredictable terrestrial plant resources were periodically (seasonally) defended. Evolutionary game theory predicts that the Bourgeois strategy should persist as long as populations remained low and other viable plant resource patches were available when foragers, with conflicting interests, encountered one another. Indeed, the number of interior encampments decreases after 3000 BP as populations increased, more sedentary coastal settlements became densely packed, environmental instability increased, territorial boundaries solidified, and lethal violence intensified (Lambert and Walker 1991; Arnold 1993; Lambert 1994; Kennett 1998; Johnson 2000; Kennett and Kennett 2000).

CONCLUSIONS

Hunter-gatherers practice a variety of resource defense and land tenure strategies. The strategy employed is often dependent on the temporal and spatial distribution of resource patches in a region and the nature of competition for those patches. The principles of economic defendability predict that highly productive resources that are available throughout the year will promulgate rigid territorial strategies, while an unpredictable, patchy resource base will promote dispersed populations and more flexible strategies for resource sharing and defense. In either case, the degree of territorial behavior is heavily dependent on the nature of competition for resources. We argue that evolutionary game theory, particularly the Hawk-Dove-Bourgeois model, provides a firm conceptual framework for exploring the socially determined aspects of territoriality and resource defense in living and prehistoric societies that are often ignored in other models.

Middle Holocene settlement patterns on the Northern Channel Islands, California, suggest a strategy of seasonal movement between coastal and inland hilltop locations. Artifact and faunal assemblages at these elevated inland locations strongly indicate that they were used as residential bases to exploit plant resources on the islands. However, we argue that this in itself does not explain why these residences were positioned on hills and ridges, given their relative distance from both

stable water and marine resources. We suggest that the strategic positioning of interior settlements on hills emerged as a flexible strategy that balanced resource procurement and defendability. Plant resources would have been available only seasonally and due to their limited nature and dietary importance, would have been a highly desirable commodity for island peoples. These plant resources, however, are patchy, spatially variable, and temporally unpredictable, and therefore would have engendered high defense costs. During times of the year when plant resources became available, we hypothesize that individual groups, possibly small family units, shifted their settlements closer to plant-producing areas in order to control access to them. In doing this, groups chose elevated areas where they would be clearly visible to other groups. This would have had the effect of producing seasonally flexible territorial boundaries with low inherent defense costs.

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REFERENCES


Human Impacts on Ancient Environments:
A Case Study from California’s Northern Channel Islands

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Many scholars once viewed hunter-gatherers—and Native Americans in general—as living in relative harmony with nature. For North America, such views have a long history and broad currency among scholars, the media, and the public (see Kretch 1999). More recent models suggest, however, that significant environmental impacts resulted virtually wherever anatomically modern humans (Homo sapiens sapiens) settled, including prominent examples from Australia, the Pacific Islands, and the Americas. Such impacts, including the extinction of many large land animals, may have resulted from direct hunting, deliberate landscape burning, the introduction of exotic species or diseases carried by them, and complex ecological changes associated with the overexploitation or extinction of key animal or plant species.

Such impacts may be visible archaeologically or paleontologically on continental scales (e.g., Martin 1967, 1984; Klein 1992; Flannery 1994, 2001), but data from islands provide some of the most compelling evidence for human impacts on ancient environments (e.g., Kirch 1982; Anderson 1984; Dewar 1984; Olson 1989; Steadman 1989, 1995; Bahn and Flannery 1992; Kirch, Flannery, Steadman, Lamont, and Dawson 1992; Patton 1996; Simmons 1999). As many have noted, the vulnerability of island environments to human impacts makes them ideal places to examine the processes involved in environmental degradation caused by humans, as well as potential solutions developed by human groups to survive such perturbations.