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An Ecological Model for the Emergence of Institutionalized Social Hierarchies on California's Northern Channel Islands

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ONE OF THE central questions in anthropological archaeology is how and why institutionalized social hierarchies evident in ranked societies and chiefdoms developed independently in multiple locations around the world during the Holocene (Feinman and Manzanilla 2000; Flannery 1998). Status competition and social inequality exist in all human groups, regardless of size or mode of production (Fried 1967; Boehm 2000; Diehl 2000). However, archaeological evidence for significant and institutionalized intragroup differences in status and wealth are confined to the last 13,000 years, well after the first evidence for anatomically modern humans in Africa (ca. 150,000 years ago) and their subsequent appearance throughout much of the Old and New Worlds (Klein 2004). The preponderance of archaeological evidence suggests that for the majority of human history groups remained small, occupied relatively large territories at low densities, and moved periodically to adapt to spatial and temporal fluctuations in resources. The record also indicates that group fissioning, environmental infilling, and emigration to diverse habitats were generally favored over localized increases in group size and density or other forms of intensification. Under these conditions, institutionalized hereditary leadership and significant differences in status and wealth rarely emerged or persisted.

Archaeological evidence for ranked societies is often found in conjunction with clear indications of localized population aggregation, economic intensification, and territorial circumscription (Blake and Clark 1999; Carneiro 1970; Clark and Blake 1994; Hayden 1981). In some instances, ranking follows heightened commitment to agriculture (Price and Gebauer 1995), but similar developments occurred among hunter-gatherers in areas where wild resources are concentrated, such as in marine and other aquatic habitats (Erlandson 2001; Kennett 2005; Pálsson 1988; Yesner 1980). In these contexts, certain group members were able to acquire greater wealth and status by (1) manipulating economic, social, and political relationships to their own benefit (Earle 1987); (2) controlling the flow of exotic goods used to signal status (Flannery 1972); (3) monopolizing the labor of other group members (Earle 1987; Arnold 2001); and (4) creating ideologies

that justified the uneven distribution of wealth and power (Earle 1987, 1997). The fundamental paradox in such developments is why a majority of group members would cooperate with individuals who ultimately wanted to subordinate and exploit them (Boone 1992).

In this chapter, we develop a multivariate model for the emergence of institutionalized social hierarchies using the broad framework of human behavioral ecology (HBE; Winterhalder and Smith 1992, 2000; Winterhalder and Kennett 2006) and a case study from California's Northern Channel Islands.

AN ECOLOGICAL MODEL FOR THE EMERGENCE OF INSTITUTIONALIZED SOCIAL HIERARCHIES

The origin of institutionalized social hierarchies in ranked societies presents an interesting evolutionary question. HBE generally assumes that decision-making mechanisms are designed by natural selection to lead to fitness-maximizing choices on the part of individuals. In societies with institutionalized social hierarchies, a small number of people receive more than their share of tangible social, political, and economic advantages at the expense of others in the group who are relatively disadvantaged. Temporary, localized discrepancies in status and wealth might arise from shifting relative advantage in the context of individual and lineage-based competition. Societal agreements to establish these advantages in institutions of inequality are the problem. It is relatively easy to understand how positions of power in a group result from individuals pursuing their own self-interests (Clark and Blake 1994). Why group members would cooperate with people who want to subordinate and exploit them is more difficult to comprehend from an evolutionary perspective.

The foundations of institutionalized social hierarchies are competition-based domination and submission behaviors that are evident in all human groups, including egalitarian foragers (Boehm 2000; Diehl 2000). These behaviors are shared by the African great apes, a pattern that strongly suggests that they were present in a common ancestor (Boehm 2000). As is true with our closest living ancestors (Wrangham 1987; Wrangham and Peterson 1996), these behaviors are most evident in males but are also present, perhaps with different outward manifestations, in females (Boehm 2000). In addition to sex- and age-based social hierarchies, positions of dominance in small-scale egalitarian societies can result from varied hunting prowess or leadership/decision-making qualities (Hawkes 1991). Inherited status or the historical prominence of a lineage can also influence dominance (Diehl 2000), but by definition, prominent social positions in egalitarian societies are not based solely or even primarily on such criteria.

Positions of dominance in a group are not simply a product of hunting prowess or leadership qualities; they depend on the social networks supporting these individuals. Small-scale societies often are composed of subgroup coalitions of hierarchically organized males and females. The cohesion of these groups is fluid and depends on degree of kin relatedness and socioeconomic relationships negotiated among individuals with differing reproductive, social and political agendas. Unequal distributions of resources may be tolerated by closely related individuals, but more distant relatives generally require more tangible incentives to remain loyal. These individual social relationships may provide a means of distributing resources more evenly within a group, but they also can create a form of social debt susceptible to being appropriated by dominant members at critical times. Conversely, the fluid composition of competing coalitions can also serve to suppress domination by one group member (Boehm 2000, 32), a practice evident in many egalitarian societies (Boehm 1993, 2000; Diehl 2000; Erdal and Whiten 1994).

Reproductive skew models provide a framework for tracking the social aspects of group formation and fissure (Summers 2005). They consider the complex relationships between dominant and subordinate members in terms of yield to effort within the group and similar opportunities available through emigration

to a new habitat, in short, through the social realities of group formation. Competition for resources (economic and reproductive) ultimately results in intragroup hierarchies composed of dominant and subordinate members. Dominants emerge through monopolization of economic opportunities, as argued by Boone (1992); subordinate members, by definition, have fewer reproductive and economic opportunities locally and must weigh the costs and benefits of remaining in the group or moving into an adjacent habitat, on their own or as members of other groups. Under these conditions a series of transactions occur between members of the group. Dominant members forcibly eject subordinates, allow them to remain with the group, or may provide economic or reproductive incentives to retain their membership, for various purposes (e.g., economic or defensive). In the same way, subordinates may restrain themselves from claiming their full reproductive or economic share to avoid conflict or eviction from the group.

The most realistic models see these transactions as a tug of war between group members that have limited but differential control over the reproductive and economic resources of the group. If groups are highly circumscribed socially or environmentally (ecological constraints are high), subordinates are more likely to stay with the group even if they are disadvantaged economically or reproductively. The staying incentive for subordinates is proportional to these ecological constraints and dominant members of the group are expected to distribute resources at the minimum level necessary to retain subordinate members.

How might this play out in practice? Archaeological evidence for institutionalized social inequality often parallels evidence for localized increases in group size. Population increase at the local level, due to immigration, inherent growth, or environmental change (e.g., sea level rise), invariably stimulates competition and differential access to resources. Given the fitness maximizing assumption of HBE, the first-order prediction is that the oldest and largest

lineages at any location control the most productive resource patches (e.g., agricultural lands or oak groves). Control of such resources can also result from usurpation due to realignment of competitive factions of subordinate group members. Regardless, competition for localized and limited resources will result in differential access to the best resource patches within a habitat or territory. As access to resources diminishes for some group members, increasingly disenfranchised individuals appraise the costs and benefits of local group membership relative to alternatives as emigrants.

The ideal free distribution (IFD), a model drawn from population ecology (Sutherland 1996), provides a useful framework for considering the changing set of ecological circumstances within which individual decision making takes place. In this model, settlement locations or habitats are ranked by their suitability, a quality measure related to the overall productivity of the resource habitat and, by extension, the fitness of the initial occupants (see Shennan 2007; Winterhalder and Kennett 2006). Habitat suitability is density-dependent; it declines with increasing population density due to exploitation. The model predicts that colonizing people will locate first in the best habitats available (figure 20.1A). As population grows, suitability in this habitat drops due to density-dependent resource depletion or interference arising from competition. When density-sensitive suitability is diminished to a level equal to that of the second-ranked resource patch, further population growth will be divided between them. Individuals relocate to their advantage, reaching an equilibrium distribution of population over habitats when the suitability of marginal habitats is the same. When this is the case, no individual has an ecological or economic incentive to relocate.

An important variant of this model allows for an Allee effect, in which initial increases in the population cause habitat suitability to improve, as a founding group is able to take advantages of economies of scale (figure 20.1B; see Kennett, Anderson, and Winterhalder 2006). Sociality and communication, a highly developed
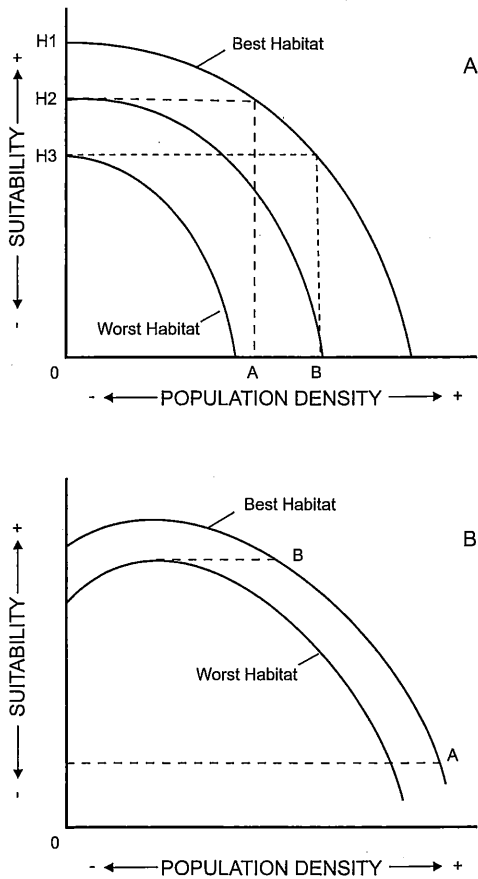
FIGURE 20.1 A, the ideal free distribution 5; B, Allee's principle (after Fretwell and Lucas 1970, 24; Sutherland 1996).

ate numbers or densities in the lower-ranked habitats. This makes intuitive sense: by garnering disproportionate resources in the best habitats, the better competitors push inferior ones more rapidly into habitats of lesser suitability. In many empirical studies, the IFD serves as a null hypothesis, against which one can measure the effects of interference competition and unequal resource access (Sutherland 1996).

Whatever form they take, the IFD and IDD models show how an incremental quantitative change in one variable (e.g., population size) results in other testable quantitative and qualitative behavioral predictions (e.g., expansion of populations into increasingly less suitable habitats). As with most HBE models, there are few limits on what kinds of variables one might accommodate in using the IFD to generate hypotheses. For instance, climate change might shift the relative suitability (vertical position, thus relative ranking) of the curves. Habitats or subsistence practices highly susceptible to density-dependent degradation will have steep downward slopes; those that generally are not so sensitive to population density will have more shallow slopes. Economies of scale in subsistence or related practices may cause the slope of the curve to be positive through some part of their range.

The decision by an individual or subgroup to leave or fission from their parent community depends on the risks of staying, costs of moving, the likely success of relocating, and the relative advantages of their alternative settlement location. Relative advantage is dependent on the availability and suitability of adjacent habitats and the behavior of other groups in the area. Localized population increase, from endogenous growth or in-migration, followed by community fission results in environmental infilling and the occupation of increasingly marginal zones (environmental packing; Binford 1968, 1983). Localized decreases in habitat suitability due to depletion or interference will precipitate group fission and emigration until most habitable areas are occupied. People may live in large groups, even under severely disadvantaged conditions, if they are circumscribed environmentally,

division of labor, and an ability to implement group-dependent technologies such as weirs or irrigation systems suggest that Allee effects will be common in human settlement.

The ideal despotic distribution (IDD) is a variant of the IFD. It allows for individuals with different competitive abilities, highlighting competition and the possibility of differential access to resources within and among groups. If interference arises among competitors of unequal abilities, or if by establishing territories superior competitors or competing groups can protect themselves from density-dependent habitat deterioration by defending better resource opportunities, then the inferior competitors and those without territories are pushed to poorer habitats. Compared to the IFD, a despotic distribution will equilibrate with disproportion-

Niwoyomi

Tugan

Nimikilkil

Niaqla

Silimihl

Hichimin

San Miguel Island

Qshiwqshiw

Nawani

Nilal'uy

He'lewashkuy

Santa Rosa Island

L'akayamu

Ch'oloshush

L'alale?

Mashchal

Kaxas

Shawa

Liyam

Lu'upsh

Swaxil

Nanawani

Anacapa Island

Santa Cruz Island

N
W — E
S

0   10   20
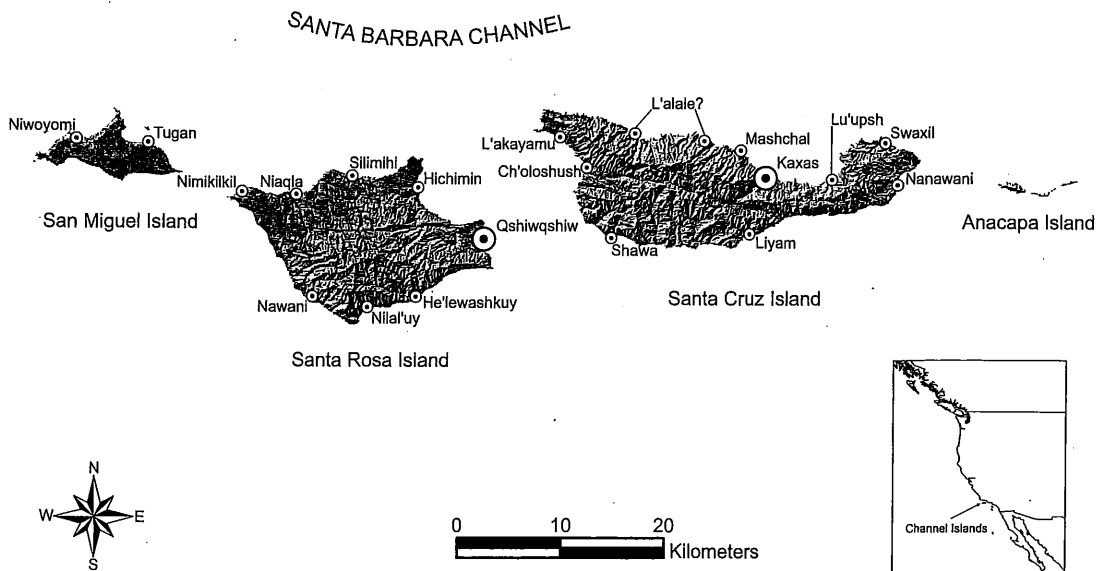Kilometers

Channel Islands

FIGURE 20.2 Map of the California's Northern Channel Islands showing known historic Chumash communities (see Kennett 2005 for details).

demographically, or socially (Carneiro 1970, 1978). Circumscription includes social boundaries maintained by the threat of violence from adjacent communities, real or perceived. Socialization for fear of others is a common form of coercion used to manipulate subordinate members of a group (Kantner 1999; Lekson 2002), and it can be used to reduce the attractiveness of settlement locations. Subordination to members of a group may be the best alternative. Ideological manipulation can also play an important role in the perception of the costs and benefits of staying with the group, while being subjugated and exploited by others (Earle 1987).

A CASE STUDY FROM CALIFORNIA'S NORTHERN CHANNEL ISLANDS

As a first test of this general model, we turn to the Late Holocene archaeological and ethnohistoric records on California's Northern Channel Islands (figure 20.2). Erlandson (1997) and Erlandson and Rick (2002) have argued that population growth, technological innovations, and intensification during the Early and Middle Holocene set the stage for the development of cultural complex-

ity during the Late Holocene in the Santa Barbara Channel region. They believe that technological and other cultural changes in the area generally accelerated through time, especially after about three thousand to four thousand years ago when, they argue, local populations reached a state of territorial circumscription. A variety of data also suggest that the Island Chumash and their ancestors had significant impacts on nearshore marine ecosystems during the Early and Middle Holocene (Erlandson et al. 2005; Kennett 2005; Rick, Kennett, and Erlandson 2005; Walker et al. 2002), leading to measures (intensification, extensification, resource switching, etc.) designed to maintain or increase the yields of local fisheries.

An estimated three thousand people lived on the Northern Channel Islands at historic contact (1542 CE), occupying at least twenty-two villages varying in size and sociopolitical importance (Johnson 1982, 1993; Kennett 2005). The locations of many of these villages were described by Chumash informants (Johnson 1982), and archaeological work substantiates their existence (Arnold 1990; Johnson 1993; Kennett 2005; Kennett et al. 2000; Kroeber 1925). Ethnohistoric records suggest that the

Island Chumash were organized primarily at the village level—economically and politically—and that some of these communities were governed by hereditary leaders or chiefs (Johnson 2000; Kennett 2005).

A more limited number of ethnohistoric accounts suggest the periodic integration of island communities under one or two influential hereditary chiefs (Johnson 1988, 2000). On the northeastern end of Santa Cruz Island at Prisoner's Harbor, the village of Kaxas was well positioned to be an important economic center, a natural ,port of trade between the islands and the mainland. The village of Qshiwqshiw, situated at the mouth of Old Ranch Canyon on Santa Rosa, was also a natural geographic center for the outer islands (Johnson 1993). Mission records suggest that Kaxas was the second-largest village on Santa Cruz and an important economic and political center (Johnson 1982, 1993). Historically, at least one chief lived in this village. Likewise, baptismal records suggest that Qshiwqshiw was one of the larger communities on the outer islands of Santa Rosa and San Miguel and that it had at least four chiefs in residence historically (Johnson 1993). It was also an important center for manufacturing plank canoes (Brown 1967, 16)—watercraft with great economic, social, and political value (Arnold 1995).

When and how ascribed status or institutionalized social hierarchies evident at historic contact first emerged on the islands is open to debate. The evolutionary scenarios put forward emphasize gradual or punctuated mechanisms to varying degrees (Arnold 1987, 2001; Erlandson and Rick 2002; Kennett and Kennett 2000; Kennett 2005; King 1990; Martz 1984; Raab and Larson 1997). At issue are some of the most basic facts, as well as causal mechanisms. We offer the environmental, demographic, and sociopolitical predictions of the IFD/IDD model as a framework to explore potential causal mechanisms and the existing archaeological data with the idea of establishing predictions to be tested with future work.

As a starting point, we employ a Geographic Information System (GIS) to rank the suitability of potential coastal village locations on the Northern Channel Islands based on environmental variables that we argue to be good indicators of habitat suitability. The variables include watershed size, coastline type, and kelp forest distribution. We then compare the character of Late Holocene demographic expansion against the ranked suitability of these habitats as a first test of the IFD/IDD model. Of the various possible hypotheses, we provide a qualitative test of two predictions: (1) habitats will be initially occupied in descending rank order of their measured suitability; and (2) social stratification will be coincident with saturation of viable habitat locations, indicative of heavy exploitation and steep declines in suitability across all occupied areas. Saturation of all but the lowest-ranked habitats will parallel the emergence of institutionalized social hierarchies.

NORTHERN CHANNEL ISLANDS GIS

All of the archaeological and environmental coverages were created using ESRI's ArcMap and integrated with existing geographic data sets for the Northern Channel Islands (see Kennett 1998, 2005). Primary village locations were identified as sites clearly occupied for extended periods of time, serving as central places for a variety of economic and social activities. We estimate the environmental suitability of forty-six potential village locations contingent on (1) area of watershed; (2) length of adjacent coastline, in three categories—cliffs, sandy beaches, and rocky intertidal; and (3) area of nearby offshore kelp forest habitat. Examples of high- and low-ranked village locations are shown in figure 20.3; we explain and justify these suitability measures below.

WATERSHED SIZE One of the essential and more restricted resources on these islands, particularly on the smaller islands of Anacapa and San Miguel, is drinking water (Kennett 2005). In the absence of instrumental records for the flow of island streams, we use watershed size as a proxy for the availability of fresh water at each of the forty-six drainage mouths. Watersheds on
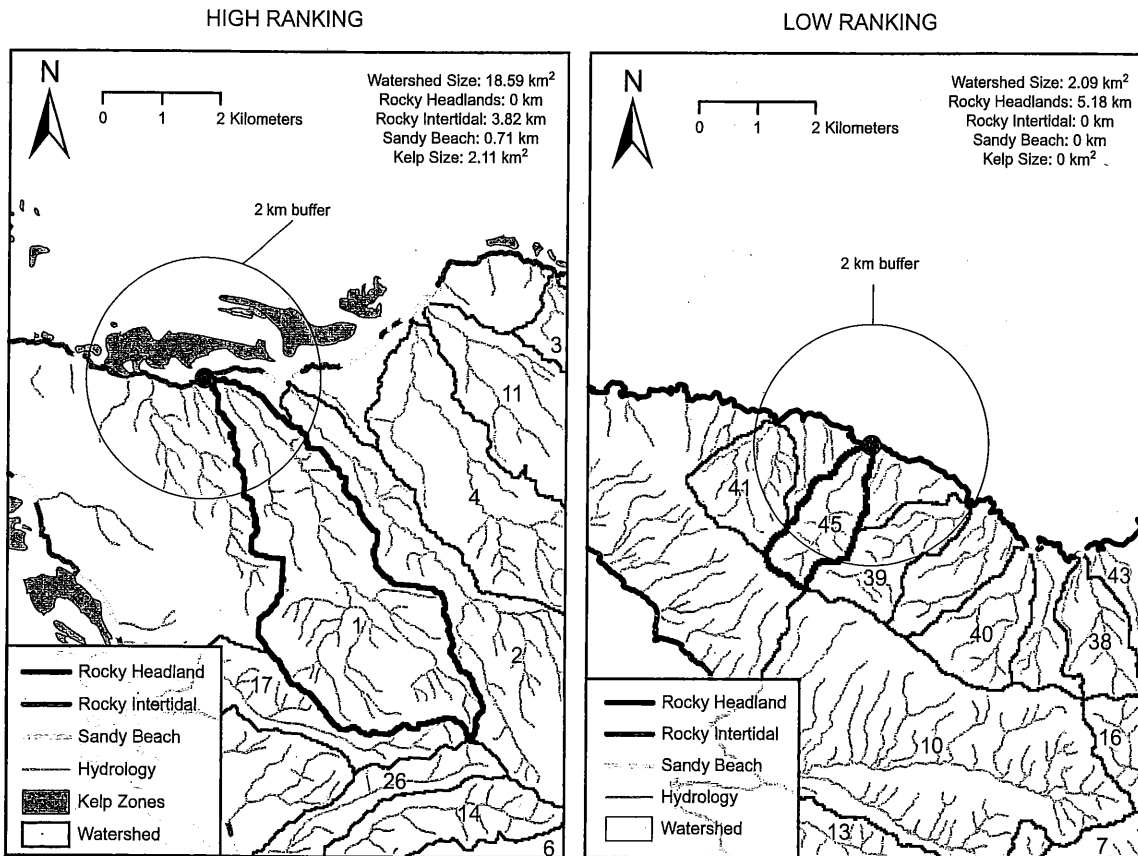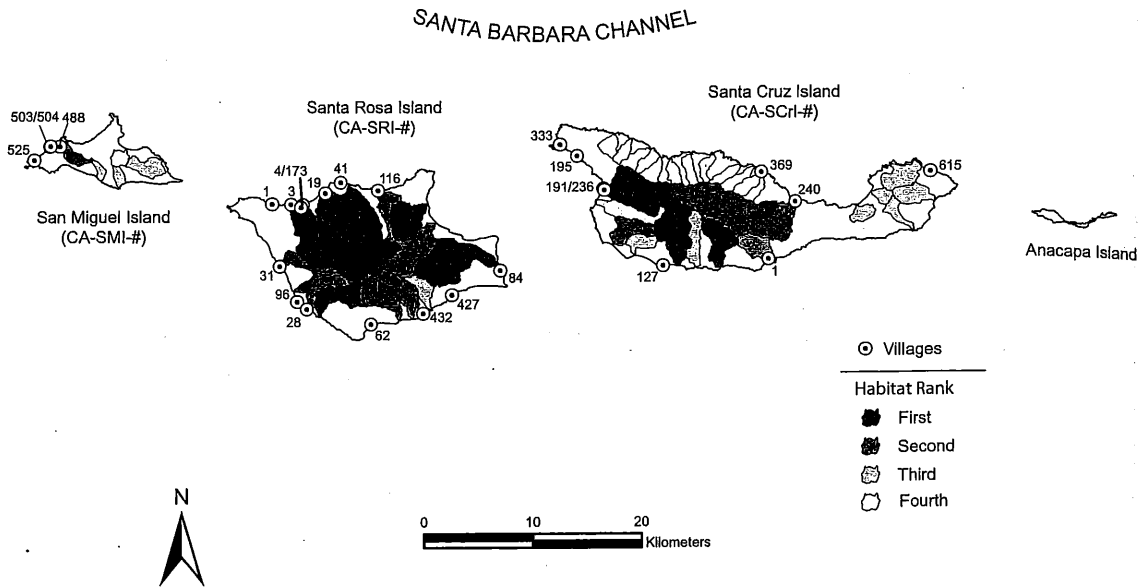
FIGURE 20.3 Examples of first- (good) and fourth- (bad) ranked village locations on the Northern Channel Islands.

the islands were defined using ArcMap, a digital elevation model for these islands (DEM, 30 meters), and ESRI's grid function for hydrological analysis. The character and extent of watersheds was then verified using color digital aerial photographs (1.5-meter resolution; see Kennett 1998). Drainage size is more heavily weighted (50 percent) in our overall assessment of suitability than other features, based on the importance of drinking water and the added value and importance of terrestrial plant foods and trees—relatively limited resources in these insular environments.

SHORELINE TYPE The shoreline surrounding each of the Northern Channel Islands consists of rocky sea cliffs, sandy beaches, and rocky intertidal habitats.[1] Rocky sea cliffs are relatively inaccessible and had limited economic value for prehistoric inhabitants of these islands.

They only figure into our measure of suitability by reducing the extent of sandy beach and rocky intertidal habitats within two kilometers of the mouths of the forty-six potential village locations. We consider the succession of rocky intertidal habitats (upper, middle, and lower) and the associated tide pools to have greatest economic potential due to the broad range of easily collected marine organisms that occupy them (see de Boer et al. 2002; Kennett 2005; Schoenherr, Feldmeth, and Emerson 1999). We assign this feature a 30 percent contribution to overall suitability. A digital map of these shoreline types was created using a combination of coastal surveys and aerial photography, and the length of each shoreline type was recorded within a two-kilometer stretch on each side of the mouth of each of the forty-six ranked drainages.

A

Santa Cruz Island
(CA-SCrl-#)

Santa Rosa Island
(CA-SRI-#)

San Miguel Island
(CA-SMI-#)

503/504 488
525

333
195
191/236
369
240
615

4/173 41
1 3 19 116
31
96 427
28 62 432 84
127 1

Anacapa Island

N

0   10   20
Kilometers

⊙ Villages

Habitat Rank
🕷 First
🕷 Second
🏵 Third
⬡ Fourth

B.

Santa Cruz Island
(CA-SCrl-#)

Santa Rosa Island
(CA-SRI-#)

San Miguel Island
(CA-SMI-#)

503/504 485
470
525 468
528 161/163
602 510 492

6/165 41 40
15 2 116
60
166 77
88
87
85
31 84
28/97/98 427
62 130/131 432

333
328/330
195
191/236/257
436
434
145
474/475 240 306 392
192 127 1 495
423/507
504/505
506

Anacapa Island

N

0   10   20
Kilometers

⊙ Villages

Habitat Rank
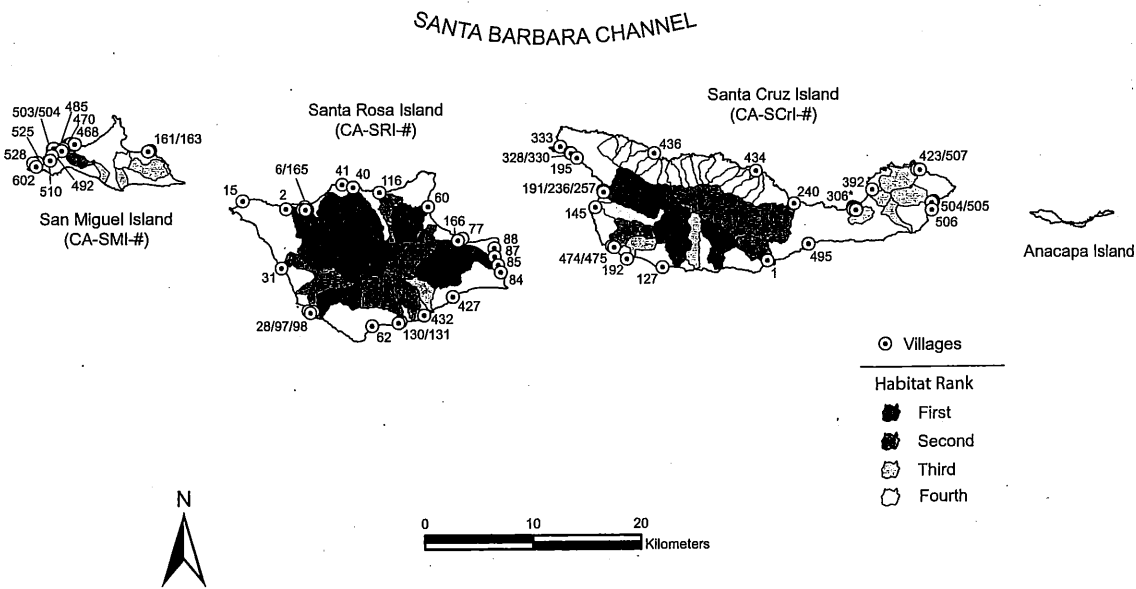🕷 First
🕷 Second
🏵 Third
⬡ Fourth

FIGURE 20.4 Geographic distribution of first-, second-, third-, and fourth-ranked village locations compared with known settlements dating to between (A) 3,000 and 1,500 BP and (B) 1,500 and 250 BP.

KELP FORESTS Patches of giant (*Macrocystis pyrifera*) and bull (*Nereocystis* spp.) kelp forests fringe each of the Northern Channel Islands, providing a three-dimensional habitat that supports a wide range of marine organisms (Kinlan, Graham, and Erlandson 2005). The distribution of kelp is dependent on favored rocky reef substrates in shallow water habitats (<25–28 meters) and, depending on the character and depth of the substrate, can be restricted to

nearshore or extend well offshore (Engle 1993). This marine plant grows quickly to great lengths (60 meters) and creates a dense canopy on the water surface that provides food and shelter for fishes, invertebrates, and sea mammals (e.g., sea otters—*Enhydra lutris*—and harbor seals—*Phoca vitulina*; Schoenherr et al. 1999, 101). We estimated the lateral extent of kelp based on forest surveys (1980–1988 and summer of 1989), by combining color digital aerial photographs showing kelp canopy (1.5 meters), with the 25-meter isobath surrounding each of the islands thought to be a good predictor of the maximum aerial extent of kelp forests (Kinlan et al. 2005, 134). The contribution of kelp forest area to overall suitability of coastal village locations, based on its lateral extent within a two-kilometer radius of each drainage mouth, was estimated at 20 percent.

These environmental quality proxies are listed in table 20.1 along with the weighted overall suitability measure for each potential village location. The spatial distribution of first- (1–11), second, (12–22), third- (23–34), and fourth- (35–46) ranked village locations are shown as watershed outlines in figure 20.4. It is not surprising that the larger islands of Santa Rosa and Santa Cruz have a high number of first- and second-ranked village locations, given the larger size of their drainages, many of which provide a perennial source of drinking water and a greater diversity of edible or utilitarian plants and trees. Of these two islands, Santa Rosa has the largest number of first-ranked village locations. A majority of these occur on its northern side, but first- and second-ranked locations also occur along the southern and eastern coasts. The high concentration of first- and second-ranked village locations on Santa Rosa is a product of big watersheds, long stretches of rocky intertidal habitat, and laterally extensive, offshore kelp forests. First- and second-ranked village locations on Santa Cruz occur on the southern and western coasts, except for a second-ranked village location on its northern side at Prisoner's Harbor (see CA-SCrI-240). The highest-ranked (second-tier) village location on

the smaller island of San Miguel occurs on its northwestern side, with the remaining village locations of third and fourth rank. Third-ranked village locations also occur on the eastern end of Santa Cruz, and the highest concentration of fourth-ranked locations occurs along the northern coast, a product of small drainage size and the predominance of inaccessible coastal sea cliffs along with a lack of substantial kelp forests.

DEMOGRAPHIC EXPANSION AND THE EMERGENCE OF INSTITUTIONALIZED SOCIAL HIERARCHIES

The IFD model predicts that the highest-ranked habitats will be occupied first and most persistently through time, with secondary and tertiary habitats settled later in time, and perhaps also with lesser permanence. The despotic variant of the model (IDD) predicts that as local competition increases and certain individuals hoard access to resources, other individuals will opt out of the group and settle secondary and tertiary locations as long as the benefits of doing so outweigh those of remaining in the parental group. Of course, the benefits of staying in a group, even with greater subjugation, increase as secondary and tertiary habitats become saturated. It is under these environmental and social conditions that we predict the first evidence for institutionalized social hierarchies. We limit our analysis here to villages dating to the Late Holocene (3,000–200 BP), breaking them into two periods: those dating to between 3,000 and 1,500 BP (figure 20.4A) and to sites dating to between 1,500 and 200 BP (figure 20.4B).

The distribution of settlements between 3,000 and 1,500 BP is a continuation of demographic trends evident on the Northern Channel Islands during the Middle Holocene (7,500–3,000 BP; Kennett 2005). The largest villages were located on the north coast of Santa Rosa in the region of the highest-ranked habitats. Most of the Middle Holocene village complexes on northern Santa Rosa (CA-SRI-1,3, 4 at the mouth of Arlington Canyon and CA-SRI-41

TABLE 20.1. *Environmental Parameters Used to Rank Coastal Village Locations*

DRAINAGE NAME	DRAINAGE SIZE		ROCKY INTERTIDAL		SANDY BEACH		ROCKY HEADLANDS		KELP BED DENSITY		WEIGHTED SCORE	RANK
	KM²	RANK	KM	RANK	KM	RANK	KM	RANK	KM²	RANK		
Cañada Tecolote	12.14	7	3.82	3	0.71	36	0.00	40	1.70	3	6.65	1
Arlington Canyon	11.93	8	2.87	6	1.54	29	0.00	40	1.46	8	8.45	2
Cañada Soledad	12.28	6	2.57	14	1.95	17	0.21	36	0.67	14	10.15	4
Water Canyon	12.28	5	0.57	33	2.55	8	1.21	22	0.95	13	14.75	12
Ranch Canyon	8.84	11	2.58	13	1.90	19	0.00	40	1.38	10	11.85	5
Old Ranch Canyon	18.59	2	1.46	26	2.98	6	0.00	40	0.12	26	13	8
Unnamed (China Camp 1)	7.36	14	2.73	10	2.10	16	0.00	40	1.13	11	12.45	6
Cañada Christi	18.10	3	1.57	24	2.46	12	0.94	24	0.11	27	13.35	10
Cañada Verde	11.83	9	4.30	1	0.30	39	0.56	28	0.43	20	9.75	3
Laguna Canyon	12.55	4	2.37	16	1.58	27	0.80	26	0.04	30	12.65	7
Dry Canyon	6.84	15	2.66	11	1.95	17	0.21	36	0.55	18	14.35	11
Willows Canyon	7.97	12	2.83	7	1.77	20	0.14	38	0.06	28	13.3	9
Unnamed (Bee Rock)	3.79	25	1.95	17	2.49	10	0.00	40	1.86	1	18.25	17
Jolla Vieja Canyon	9.31	10	1.18	28	1.43	30	1.84	18	0.58	17	17.45	15
Unnamed (China Camp 2)	4.83	22	2.56	15	2.47	11	0.00	40	1.44	9	17.4	14
Cañada de los Sauces	6.20	17	2.74	9	2.44	13	0.21	35	0.25	23	15.3	13
Cañada de la Calera (1)	34.35	1	0.00	37	1.70	24	3.00	14	0.03	35	18.05	16
Pozo Canyon	6.45	16	1.10	31	3.27	2	0.29	34	0.42	21	20.55	23
Wreck Canyon	7.44	13	1.14	30	1.36	31	2.21	16	0.61	16	19.45	19
Unnamed (Cluster Point)	2.81	28	1.34	27	3.17	3	0.00	40	1.77	2	22.55	26
Otter Creek	2.61	34	3.88	2	1.70	25	0.00	40	1.47	7	19.9	21

Cañada Lobos	4.74	23	2.66	12	0.30	39	1.90	17	0.31	22	20.35	22
San Augustine Canyon	3.62	26	1.68	20	1.72	23	1.48	19	0.43	19	23	27
Smugglers' Canyon	5.13	20	1.89	18	1.76	21	1.29	21	0.03	34	21.55	24
Montañon Canyon	2.78	30	1.17	29	2.35	15	0.89	25	0.98	12	26.25	28
Coches Prietos Canyon	5.39	19	3.11	5	0.92	33	1.45	20	0.00	43	19.1	18
Johnsons Canyon	3.32	27	0.59	32	3.74	1	0.11	39	0.14	25	26.9	29
Alamos Canyon	5.08	21	3.21	4	0.90	34	0.80	26	0.00	43	19.85	20
Willow Canyon	4.63	24	2.82	8	1.68	26	0.32	29	0.00	43	22.15	25
Unnamed (San Miguel South 2)	1.53	45	1.63	22	3.03	4	0.31	33	1.57	6	30.2	31
Scorpion Canyon	6.17	18	0.00	37	0.16	43	5.51	9	0.01	37	27.8	30
Unnamed (China Harbor)	2.63	33	0.00	37	1.76	22	2.69	15	0.17	24	32.3	33
Unnamed (San Miguel South 1)	1.28	46	1.65	21	2.50	9	0.31	30	0.65	15	32	32
Valdez Canyon	2.65	32	0.22	34	0.39	38	5.65	8	0.03	32	32.9	34
Unnamed (Twin Harbors 1)	2.81	29	0.00	37	0.00	44	6.63	1	0.01	39	33.65	35
Nidever Canyon	1.97	44	1.54	25	2.41	14	1.13	23	0.06	29	34.55	36
Orizaba Canyon	2.73	31	0.00	37	0.00	44	6.27	3	0.01	39	34.65	37
Unnamed (Lady's Harbor)	2.36	37	0.00	37	0.87	35	5.31	10	0.03	31	36	38
Unnamed (Trident Cove)	2.21	39	0.22	34	0.70	37	5.73	6	0.03	32	36.35	40
Hazard's Canyon	2.58	35	0.22	34	0.20	42	5.29	11	0.00	43	36.25	39
Unnamed (Dick's Cove)	2.30	38	0.00	37	0.28	41	6.25	4	0.01	39	38	42
Unnamed (Profile Point)	2.55	36	0.00	37	0.00	44	5.66	7	0.00	43	37.75	41
Diablo Canyon	2.09	41	0.00	37	0.94	32	5.85	5	0.01	38	38.9	43
Cañada de la Calera (2)	1.99	43	0.00	37	1.57	28	3.89	13	0.02	36	39.4	44
Unnamed (Twin Harbors 2)	2.04	42	0.00	37	0.00	44	6.57	2	0.01	39	40.15	46
Unnamed (Ruby Rock)	2.09	40	0.00	37	0.00	44	5.18	12	0.00	43	39.75	45

at the mouth of Cañada Verde) continued to be occupied between 3,000 and 1,500 BP. This is also the case at one known village on western Santa Cruz Island (CA-SCrI-333; Wilcoxon 1993; King 1990), a community not positioned directly on one of our ranked village locations, but within the vicinity of the highest-ranked settlement location on that island. Continued use of cemeteries at all of these villages between 3,000 and 1,500 BP indicates a certain degree of settlement continuity at these locations (Kennett 2005; King 1990).

However, it is between 3,000 and 1,500 BP that settlements expanded to many of the other first and second ranked habitats along the coasts of Santa Rosa and Santa Cruz. Likewise, the first definitive evidence for a settled village occurs toward the west end of San Miguel within or near the highest-ranked village location on that island (SMI-488, 503/504). There are also several village sites in unranked locations (CA-SRI-525, SCrI-195, 333). All of these sites are within the vicinity of high-ranked habitats and may be seasonal residences established to exploit specific, nearby resources not accounted for in our model. This is likely the case with CA-SMI-525, a site located near one of the largest breeding colonies of sea mammals on the western coast of North America (Walker et al. 2002). Despite these exceptions, the available archaeological evidence suggests that many second- and third-ranked village locations were not occupied between 3,000 and 1,500 BP, and island-wide population levels appear to be well below what would saturate viable habitats. This of course implies quite slow cumulative population growth through the early portions of the archaeological sequence, something not yet well explained.

By about 1,500–1,300 BP, primary villages were distributed around the perimeters of Santa Rosa and Santa Cruz, and along the north coast of San Miguel (Munns and Arnold 2002; Glassow 1993; Kennett 1998; Kennett and Conlee 2002; figure 20.4B). Many of the first-, second-, and third-tier habitats were occupied by this interval. There appears to be a change in the character and structure of primary villages after

this time that suggests even greater settlement stability. These changes are difficult to quantify because the large-scale excavations needed to better characterize them are sorely lacking. However, primary villages occupied during the latest Holocene (after 1,500–1,300 BP) are generally located on promontories or cliff faces close to springs or near the mouths of perennial streams. Compared with primary village sites dating to between 3,000 and 1,500 BP, these villages tend to be more compact and not as laterally extensive (Kennett 1998).

Evidence for relative stability after this time includes more substantial domestic features, larger and deeper midden deposits, and greater faunal and artifact diversity (see Kennett 2005; Rick 2004). The consolidation of primary villages after about 1,500–1,300 BP also corresponds to some notable changes in the location and structure of cemeteries (King 1990). These newly established cemeteries were often used continuously into the Historic period; supporting data suggest settlement continuity at certain locations between 1,300 and 200 BP. Demographic expansion parallels evidence for decreases in body size in both men and women and evidence for poor health, as indicated by increasing incidences of cribra orbitalia and periosteal lesions in skeletal material through time (Lambert 1994, 1997; figure 20.5).

Several lines of evidence support the idea that the institutionalized social hierarchies evident at historic contact were well established on the islands by the beginning of the Late Period (ca. 650 BP; Arnold 2001; Kennett 2005). Varied interpretations of the available mortuary data suggest that ascribed status differences had emerged by at least this time (Arnold 2001; King 1990). Many of the named historic island communities were occupied by the beginning of this interval, suggesting continuity between the Late and Historic periods. Some of these villages are located in more marginal fourth-tier locations along the north coast of Santa Cruz Island (e.g., CA-SCrI-434, -436).

Institutionalized social hierarchies certainly developed on the Northern Channel Islands
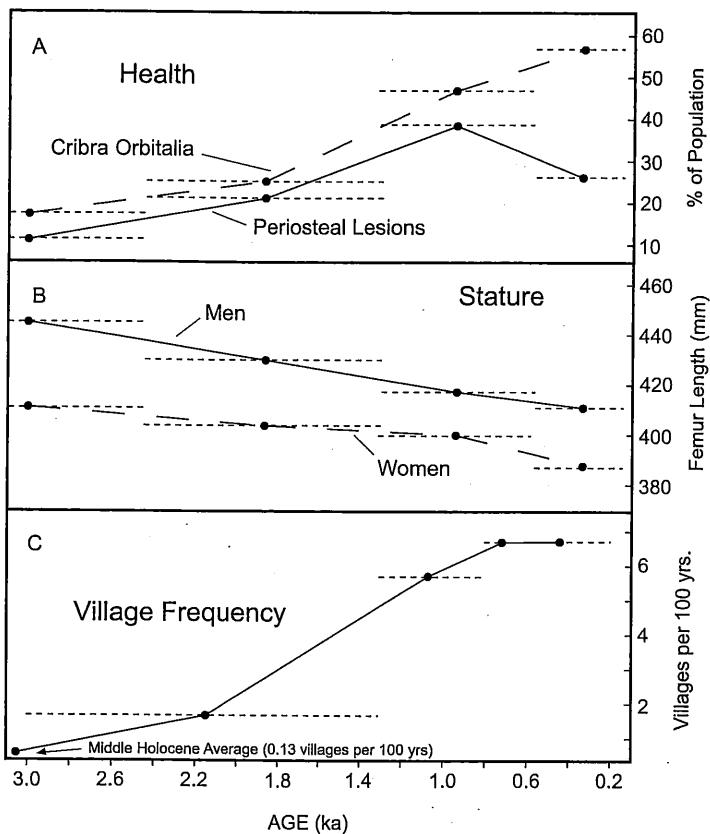
FIGURE 20.5 Demographic trends on the Northern Channel Islands during the last three thousand years. A, Changes in health through time (Lambert 1994); B, changes in body size (stature) through time based on femur length (Lambert 1994); C, number of villages per one hundred years.

prior to 650 BP, but the exact timing is an open question that requires future work. High-status burials in the Santa Barbara Channel region often contain a diverse range of funerary objects, including canoe effigies and plank canoe parts. King (1990) used mortuary data from the Northern Channel Islands to argue for the development of ranked societies and ascribed status by the end of the Early Period (ca. 2,400 BP). The same data have been used more recently to demonstrate that hierarchical social organization developed on these islands later, by about 800 BP (Arnold 2001). In both instances, the raw data needed to evaluate these claims are not presented, and the resolution of this debate awaits a comprehensive analysis of mortuary remains from island contexts, coupled with an ancient DNA study that would allow for the reconstruction of familial relationships and provide the data needed to link wealth and status with heredity.

Although the precise timing for the development of institutionalized social hierarchies on the Northern Channel Islands is unclear, our IFD/IDD model predicts that this occurred sometime between 1,500 and 650 BP. Most first-, second-, and third-ranked habitats on these islands were occupied by this time. Climatic conditions through this interval were generally dry and unstable with a series of severe droughts (Kennett and Kennett 2000; Kennett 2005; Raab and Larson 1997), periodically reducing the overall suitability of all habitats. Potable drinking water was likely unavailable in all fourth- and some third-ranked habitats for much of this interval. Osteological evidence indicates an increase in lethal violence (Lambert 1994), and this further destabilized the social and political milieu. Violence was further exacerbated by the introduction of the bow and arrow between 1,500 and 1,300 BP (Kennett 2005). It is precisely under these conditions—environmental, demographic, and social circumscription—that the IFD/IDD model predicts corporate group formation, asymmetrical access to material and

reproductive resources, and institutionalized social inequality. Additional work on archaeological sites dating to this interval is required to test this prediction.

CONCLUSIONS

Although there is still much to be learned about settlement and demography on the Northern Channel Islands, our analysis suggest that the IFD and IDD models provide a useful framework for predicting when institutionalized social hierarchies would have been favored during the Late Holocene. The predicted first-tier settlement locations on the northern and eastern coasts of Santa Rosa and the western end of Santa Cruz supported primary village locations established during the Middle Holocene. Second-tier settlement locations (e.g., south coasts of Santa Rosa and north coast of San Miguel) that were used logistically during this time do not appear to have been occupied permanently until after 3,000 BP. Under these ecodemographic conditions—favorable habitats for expansion and limited equilibrium impact on overall suitability of all habitats—social hierarchies would not have been favored. The expansion of primary villages to most second-tier settlement locations during the Late Holocene would have been more favorable for their development, particularly after 1,500–1,300 BP when villages were well distributed around the coast of Santa Rosa and Santa Cruz and along the north coast of San Miguel.

Growing populations, intensified resource use, and declines in equilibrium habitat suitability later in the Holocene (after 1,500 BP) would have stimulated competition within and among communities, creating a situation where individuals would have had differential access to key resources. Given unfavorable climatic conditions, we argue that most or all viable habitats were occupied by between 1,500 and 1,300 BP, all of them experiencing the stress of marginal, density-dependent suitability. Due to the lack of viable, unoccupied habitats on the islands (fourth-tier sites or lower) after this time, people

were more likely to accept lower-quality lifestyles—reduced minimal incentives provided by dominants—compared to others in the community, rather than colonizing the most marginal parts of the islands. Of course, this was a gradual process; as viable settlement locations were saturated, continued population growth would increase pressures for social hierarchies within groups. Once intergroup competition and conflict were present, no group could benefit from restricting its population size, thus increasing its vulnerability.

Population increase and demographic expansion were at the core of the cultural changes evident on the islands between 1,500 and 650 BP. Palaeoclimatic data for the region suggests that this interval was highly unstable climatically and that the already dry conditions that prevailed through this period were interrupted by megadroughts that impacted much of southern California (Stine 1994; Kennett and Kennett 2000). Dry conditions further circumscribed populations, and environmental instability stimulated conflict and competition for access to perennial water sources. Larger and more stable settlements emerged on the islands during this period. It is within this context that social hierarchies were favored, and certain individuals were able to control aspects of the political and economic system for their own benefit. The social ranking and hierarchical political structure likely solidified in island Chumash society under these conditions. More detailed study of mortuary remains will be required to determine the exact antiquity of institutionalized social inequality between 1,500 and 600 BP, but Arnold's (2001) estimate of 800 BP is consistent with the predictions of the IFD/IDD model.

NOTE

1. At least one substantial estuary, and an associated suite of resources, also existed at the mouth of Old Ranch Canyon (Eastern Santa Rosa) during the Middle Holocene. It appears to have been largely in-filled in by the Late Holocene (Rick et al. 2005).

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