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Prehistoric Animal Exploitation, Environmental Change, and Emergent Complexity on Santa Cruz Island, California

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Abstract. The prehistoric Native American inhabitants of Santa Cruz Island had unusually complex economic and political organization, and environmental change has been postulated as a stimulus for this complexity. Analysis of animal remains from 4 prehistoric middens on Santa Cruz Island yields information on economy and palaeoenvironment, and demonstrates a marine-oriented economy that included mollusks, fish, marine mammals, birds, and terrestrial mammals. Although the overall composition of the assemblage changed over time, fish and shellfish remains are the most abundant fauna in these archaeological sites. The abundance of marine mammals decreased through time, and terrestrial mammals were a minor component of the faunal assemblage. Analysis of fish taxa identified from otoliths yields information about habitats exploited and local marine ecosystems.

Keywords: Chumash Indians; midden; chiefdom; otolith; El Niño-Southern Oscillation.

Introduction

The Chumash Indians of southern California were one of the most complex hunting and gathering groups in North America, exhibiting a variety of characteristics typical of simple chiefdoms, including regional religious and economic integration, craft specialization, high population density, hereditary chiefs, and capital villages (Landberg 1965; King 1976; Johnson 1988). The nature and timing of emergent complexity in the Santa Barbara region is a topic of some controversy. King (1981, 1990) suggested that political differentiation occurred at the end of the Early Period (before 1400 B.C.) and that further economic changes occurred in the Late Period, after A.D. 1100. Most researchers believe the development of complexity occurred after A.D. 1100 (King 1982; Martz 1984; Arnold 1992). Arnold's (1987, 1992) research on Santa Cruz Island suggests that chiefdom-level economic organization developed approximately A.D. 1150–1200 as part of a complex set of economic responses to environmental changes that occurring at that time. The conditions of emergent complexity included high regional population density, reliance on marine resources, and environmental change. This research is an analysis of faunal remains from archaeological sites from the appropriate time periods. If changes in economic organization and climate took place at that time, faunal remains should show evidence of these changes.

Although most researchers believe that simple chiefdom-level complexity is a late prehistoric phenomenon, the *conditions* of emergent complexity developed over a long period of time. Archaeological data suggest increasing population size and density over time (Glassow et al.1988; Lambert and Walker 1991), but few good estimates of population parameters exist. Certainly the Chumash had high population density at European contact (Brown 1967; Johnson 1988). Brown (1967), using historic and mission register data, estimated the contact-period population for the Chumash area to be approximately 15,000. Much of this population was concentrated along the mainland coast, although fairly large villages existed on the Channel Island coasts and in the Santa Ynez Valley (King 1975) as well. Keeley (1988) noted that estimates of population density for the coastal region at historic contact were considerably higher than other complex hunter-gatherer groups, approaching 22 persons per sq mi.

Around A.D. 1150–1300, significant environmental changes in southern California included a prolonged period of increased sea surface temperature (Pisias 1978, 1979; Arnold and Tissot 1993) and some significant droughts (Larson et al. 1989). These climatic changes probably had severe impacts on marine ecology and the availability of resources consumed by Native Americans. Physical anthropology provides evidence of nutritional stress and interpersonal violence just prior to the Transitional period, the time of prolonged warm water (Lambert and Walker 1991). The health of people in the region generally declined prior to this period. Periosteal lesions, which are indicators of trauma, pathogens, or nutritional deficiencies, became more common. *Cribra orbitalia*, which indicates childhood anemia, was also common.

Technological changes, including the introduction of the bow and arrow and the development of the plank canoe, had impacts on society. The bow and arrow became widespread in western North America after A.D. 500 (Blitz 1988; Lambert and Walker 1991; Maschner 1991), and some people believe the impact of this technological change on interpersonal relations was profound. Lambert and Walker (1991) have demonstrated that arrow wounds in prehistoric skeletons from the Santa Barbara Channel were increasingly common during the prehistoric period up to and during the Transitional period, and there is other evidence of violence in cranial injuries, suggesting that interpersonal violence was common. Health improved and evidence of violence decreased after the start of the Late period.

Other technological innovations occurred at this time as well. Plank canoes were invented or became more common after A.D. 500 (Hudson et al. 1978), and other fishing technology was common by the Transitional period. Arnold (1987, 1991, 1992) and Arnold and Munns (1993) have demonstrated a dramatic increase in craft activities during the transition from the Middle to Late periods. Chert microdrill production increased dramatically on the eastern portion of Santa Cruz Island, and access to the chert quarries became more restricted. Shell bead manufacturing increased at a rapid rate at sites on the west end of Santa Cruz Island and virtually ceased at other sites in the Santa Barbara region. Mortuary data from several mainland archaeological sites indicate status differentiation by the Late period (King 1969, 1982; Martz 1984, 1992).

In sum, these various sources of information indicate significant changes in economic and political organization during the Transitional period, and regional reorganization of this scale is sure to affect all aspects of the economy, including the subsistence economy. By examining faunal remains, we can gain insight into overall economic organization, ecological adaptations, and palaeoenvironmental conditions. The coincidence of these changes and an extended period of warm water has led several researchers (Walker 1989; Arnold 1991, 1992, 1993; Colten 1993) to suggest that this environmental change was important in the development of social complexity in the region. Arnold (1993) has emphasized that unstable environmental conditions may have presented opportunities for aspiring elites to take control of productive labor for their own benefits. Whether the organizational changes during the Middle to Late transition were based on functional or political motivations is unclear, but faunal data, reflecting both economy and environment, have great potential to address this issue. I believe that the nature of the emergence of complexity in this region, the timing of the transition in relation to environmental conditions, the effects on health, and the faunal data all suggest that the change had an adaptive component. The political aspirations of individuals or groups also may have played a significant role in cultural evolution in the prehistoric society of the Santa Barbara Channel.

Marine Ecology and the El Niño-Southern Oscillation

The marine environment, and the kelp-bed community in particular, was an important source of food for prehistoric Santa Cruz Islanders, and an understanding of kelp-bed ecology is necessary to understand prehistoric subsistence on the island. The ecology of giant kelp forests is complex and influenced by many variables, including substratum composition, sedimentation and soil movement, light, water motion, water temperature, available nutrients, salinity, and grazing by animals (Foster and Schiel 1985). There are narrow limits to various abiotic factors within which kelp can survive, sea temperature being the most important. The kelp community supports a variety of animal forms of interest to hunter-gatherers, including mollusks, crustaceans, fish, birds, and mammals. Factors that affect micro-organisms also impact higher trophic levels, including human predators.

About A.D. 1150–1250 an extended period of elevated sea-surface temperature occurred in the Santa Barbara Basin (Pisias 1978; Arnold and Tissot 1993). Analysis of the effects of this event on the marine ecosystem can be aided by comparison to modern El Niño-Southern Oscillation (ENSO) events. Although the event in question differs from historically studied ENSO events, the impacts of elevated sea temperature on local marine ecology may shed light on this past event. These events include a variety of short-term phenomena that adversely affect kelp-bed communities and associated fauna, notably a significant rise in sea temperature, lowering of the thermocline, higher sea levels, severe storms, and increased rainfall that could increase sedimentation from the adjacent mainland (Glynn 1988; Open University 1989; Hansen 1990). These events are of relatively short duration, and normal conditions usually return within 1 or 2 years. Although the primary atmospheric mechanisms of the ENSO occur in the southern hemisphere, their influence is felt worldwide. For example, Andrade and Sellers (1988) have reported a strong positive correlation between ENSO events and precipitation in the American Southwest.

The impacts of El Niño events on kelp-bed communities and associated fauna during recent events are well documented (Barber and Chavez 1983, 1986; Tegner and Dayton 1987; Glynn 1988, 1990). Recent research on the biological consequences of El Niño events has demonstrated that populations of pinnipeds (Trillmich and Limberger 1985; Limberger 1990; Trillmich and Ono 1991), birds (Schreiber and Schreiber 1984, 1989), and fish (Schoener and Fluharty 1985) exhibit significant disruptions in reproduction, high mortality, and anomalous geographical distributions. Some animals cease to reproduce during El Niño events, die of starvation, or migrate far beyond their normal ranges. The effects of these disruptions of animal populations can extend beyond the duration of the warm-water event. The warm-water cycle

that occurred around A.D. 1150–1250 was an event of much longer duration than recently observed El Niño events. It likely had significant impacts on the marine ecosystem and human foragers. Although a thorough review of the ecological impacts of ENSOs is beyond the scope of this paper, much of this literature has been summarized elsewhere (Colten 1993). Interestingly, there are some indications that the period around A.D. 1100 to 1300 was a time of worldwide climate change (for a summary of some relevant literature, see Colten 1993).

The Archaeological Data

The archaeological material used in this analysis was collected by Jeanne Arnold of the University of California, Los Angeles, from 1988 through 1990 from sites on western Santa Cruz Island (Arnold 1992). Eleven sites were initially sampled through a combination of systematic surface collection and sub-surface auger testing. After analysis of this material, Arnold selected 4 sites for more detailed study. Sites were selected for their potential to yield information about shell bead manufacturing and subsistence from the Middle-to-Late periods, including the Middle-to-Late transition. These sites are SCRI-330, near Forney's Cove; SCRI-191, near Christy Beach; SCRI-474, at Posa Creek; and SCRI-192, at Morse Point (Fig. 1). At each site, several contiguous 1- x 1-m units were excavated with trowels. Initial units were excavated in 5-cm arbitrary levels. On the basis of these excavations, in some cases additional units were excavated in cultural levels. All excavated material was screened over 1/8-in. mesh metal screens, and all residue later sorted into midden constituents in laboratories either on the island or at the Institute of Archaeology at University of California, Los Angeles. Column samples were collected from each excavation unit and later processed through a flotation system to recover macrobotanical remains, which are currently being analyzed (Gumerman 1991). All of the "heavy fraction" materials from the columns have been sorted into constituent categories. Data complementing my analysis of the mammal and bird bones were provided by: detailed analysis of shellfish from one excavation unit at SCRI-191 (Stevenson 1989), separate analyses of fish remains from column samples (Johnson 1993), and fish otoliths from excavation levels.

A combination of stratigraphic control, diagnostic artifacts, and numerous radiocarbon dates provides superb chronological control for these archaeological materials. Sites on Santa Cruz Island exhibit excellent stratification because there are no burrowing animals on the island, and archaeological sites are rarely disturbed by modern development or non-scientific collecting. Discrete strata from all 4 sites have been dated with a suite of more than 20 radiocarbon analyses conducted on charcoal samples (Arnold 1992). Analysis of microblades (Arnold 1987), beads, and bead making detritus (Arnold and Munns 1993) indicate that these artifacts are chronologically diagnostic for Santa Cruz Island, further refining the chronology.

The faunal data analyzed for this research are derived from 75 levels from 6 excavation units at the 4 sites listed above. Earlier analyses of these faunal collections (Colten 1991, 1993) indicate an extremely high density of bone per m^3, excellent preservation, and a reasonable percentage of identifiable material. The samples I have analyzed

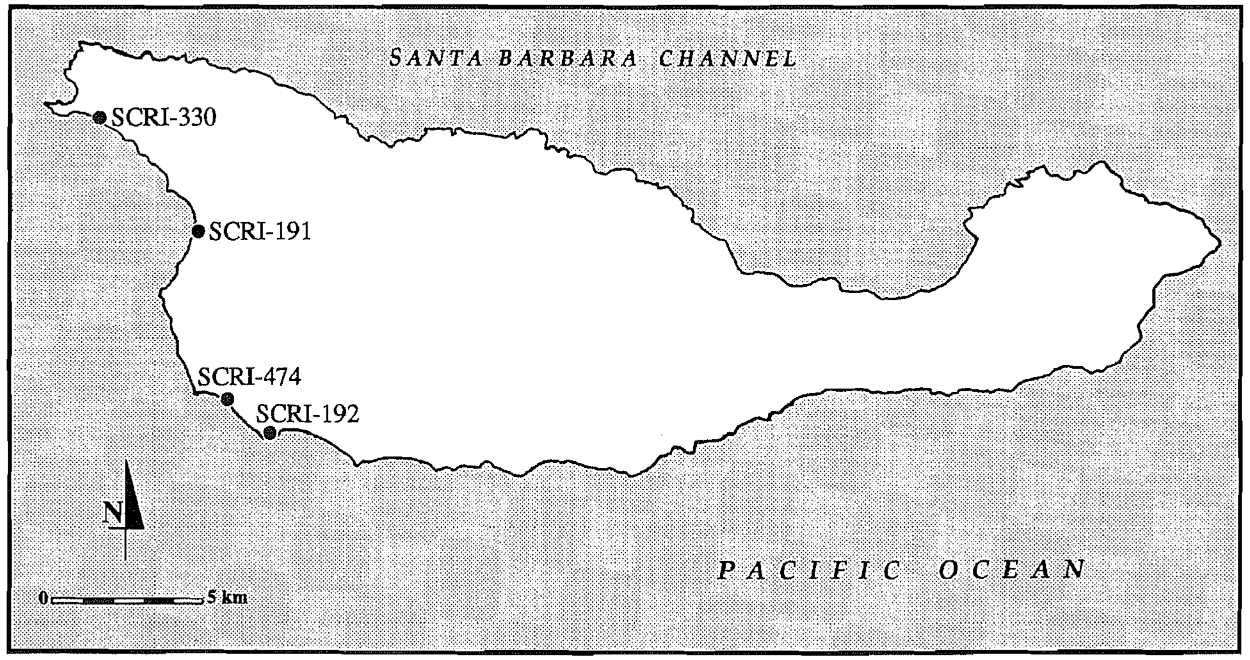

Figure 1. Archaeological site locations on Santa Cruz Island.

Table 1. Non-fish fauna, all sites.

Taxonomic category	Common name	NISP	Weight (g)
Birds			
Aechmophorus occidentalis	Grebe–western	1	0.50
Anas crecca	Duck–green-winged teal	1	0.17
Anas platyrynchos	Duck–mallard	6	4.39
Anas sp.	Duck–undifferentiated	16	4.49
Anser albifrons	Goose–white-fronted	3	5.98
Anser caerulescens	Goose–snow	1	8.49
Anseriformes	Goose–undifferentiated	1	1.66
Aves	Bird–undifferentiated	1,762	277.99
Aves–large	Large bird	1	0.67
Brachyramphos hypoleucus	Murrelet–Xantus	1	0.02
Cepphus columba	Pigeon guillemot	1	0.62
Chen hyperborea	Goose–snow	2	3.08
Diomedea sp.	Albatross–undifferentiated	3	7.94
Gavia sp.	Loon–undifferentiated	1	0.75
Larus californicus	Gull–California	7	8.13
Larus glaucescens	Gull–glaucous-winged	1	0.97
Larus heermanni	Gull–Heermann's	2	0.59
Larus occidentalis	Gull–western	5	6.04
Larus sp.	Gull–undifferentiated	4	3.26
Melanitta fusca deglandi	Scoter–white-winged	2	3.49
Melanitta sp.	Scoter–undifferentiated	1	0.22
Mergus serrator	Merganser–common	1	0.81
Pandion haliaetus	Osprey	2	0.81
Passeriforme	Bird–songbird	22	0.63
Pelecanus californicus	Pelican–California brown	1	3.49
Pelecanus sp.	Pelican–undifferentiated	35	33.18
Phalacrocorax auritus	Cormorant–double-crested	392	415.55
Phalacrocorax pelagicus	Cormorant–pelagic	4	1.93
Phalacrocorax penicillatus	Cormorant–Brandt's	27	19.55
Phalacrocorax sp.	Cormorant–undifferentiated	8	5.20
Podiceps nigricollis	Grebe–eared	1	0.37
Ptychoramphus aleuticus	Auklet–Cassin's	2	0.26
Zenaida macroura	Dove–mourning	2	0.39
	Subtotals	2,319	821.62
Terrestrial mammals			
Artiodactyla	Ungulate–undifferentiated	1	1.18
Canis familiaris	Dog	18	72.43
Felis catus	Cat–domestic	2	0.29
Mammalia–terrestrial	Mammal–terrestrial	109	127.95
Odocoileus hemionus	Deer–mule	18	83.07
Peromyscus sp.	Mouse	136	3.36
Spilogale putorius	Skunk–spotted	1	0.35
Urocyon littoralis	Fox–island	26	9.83
	Subtotals	311	298.46

Table 1 (continued).

Taxonomic category	Common name	NISP	Weight (g)
Mammals			
Carnivora	Carnivore	7	3.42
Mammalia	Mammal–unidentified	6,416	2,688.10
	Subtotals	6,423	2,691.52
Reptiles			
Chelonia sp.	Turtle–green sea	2	2.14
Clemmys marmorata	Turtle–western pond	1	1.42
Pituophis melanolecus	Gopher snake	4	0.09
	Subtotals	7	3.65
Marine mammals			
Arctocephalus townsendi	Fur seal–Guadalupe	48	884.76
Callorhinus ursinus	Fur seal–northern	1	36.14
Cetacea	Whales and dolphins	27	656.13
Cetacea-large	Whales and dolphins–large	99	176.50
Delphinidae	Dolphin/porpoise	31	70.19
Delphinus delphis	Dolphin–common	1	11.94
Enhydra lutris	Otter–sea	263	720.29
Fur seal	Fur seal–undifferentiated	31	243.25
Fur seal–small	Small fur seal	1	44.05
Globicephala macrorhynchus	Short-finned pilot whale	1	14.36
Lagenorhynchus obliquidens	Pacific white-sided dolphin	2	35.33
Mammalia–marine	Marine mammal–undifferentiated	2,105	788.72
Otariidae	Sea lion and fur seal	689	1,937.49
Otariidae-large	Eared seal–large	9	143.65
Otariidae-small	Eared seal–small	36	272.96
Phoca vitulina	Seal–harbor	17	166.42
Phocidae	Seal–earless seal–undifferentiated	2	0.75
Pinnipedia	Sea lion and all seals	59	119.27
Pinnipedia–large	Large pinniped	2	13.61
Tursiops truncata	Dolphin–bottlenose	2	7.63
Zalophus californianus	Sea lion–California	1	1.11
	Subtotals	3,427	6,344.55
	Grand totals	12,487	10,159.80

include 12,487 bird, mammal, and reptile bones or bone fragments weighing a total of 10,159.8 grams and representing 67 different taxonomic categories, ranging in specificity from genus and species to order (Table 1). As is typical of archaeologically derived faunal assemblages, many specimens (approximately 83%) were too fragmented to classify beyond the categories of bird, terrestrial mammal, mammal, or marine mammal. Although a significant portion of the assemblage (about 50% by count and 25% by weight) has been classified as undifferentiated mammal, there is very little terrestrial mammal in the assemblage, and most of the undifferentiated mammal is therefore probably marine mammal.

Archaeological Assemblage Composition

In order to quantify the overall assemblage composition and to assess changes through time, I have calculated meat weight estimates for broad classes of fauna for the 4 sites on the west end of Santa Cruz Island. I have used the bone weight method (Ziegler 1973) for estimating meat weight, multiplying the bulk weight of bone or shell by an empirically derived conversion factor (Erlandson 1988; Glassow and Wilcoxon 1988). Although there are significant problems with this method (Casteel 1978; Lyman 1979; Grayson 1984), it is the only method for estimating the relative contributions of both vertebrates and invertebrates and for providing a general sense of the overall assemblage. In more detailed analyses of specific classes of fauna, other methods are more appropriate (Colten 1993). Figure 2 shows the relative contributions of fish, marine mammal, terrestrial mammal, undifferentiated mammal, bird, and shell to the composition of the entire assemblage, including data from all 4 sites. Figure 3 shows the same information for 4 time periods: Middle, Transitional, Late, and Historic. The general pattern is that the importance of marine mammals and shellfish decreases through time, and the dietary contribution of fish increases through time. As might be expected, there is some intersite variability in this pattern (Colten 1993).

Fish Data

Fish otoliths, or ear bones, are highly diagnostic and can be identified to the species level in most cases. A total of 1,754 otoliths representing 82 species were identified (by Richard Huddleston) from 53 of the 75 excavation levels considered here. These otoliths were collected during field screening and lab sorting and provide a detailed description of the taxa present (Table 2). Not all otoliths were classified to side, so it is not possible to consider Minimum Number of Individuals for this class of fauna in this analysis. The fish assemblage from all 4 sites is dominated by various species of rockfish (*Sebastes* sp.) and several varieties of surfperch (Embiotocidae) (Table 3).

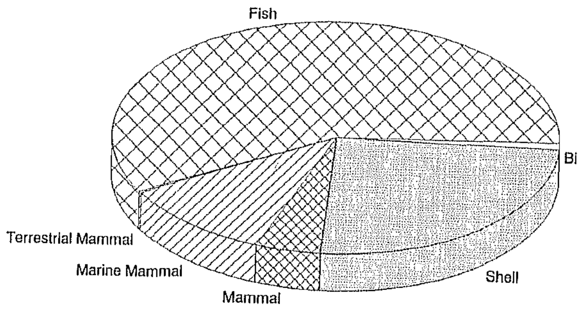

Figure 2. Estimated meat weight for the archaeological assemblage.

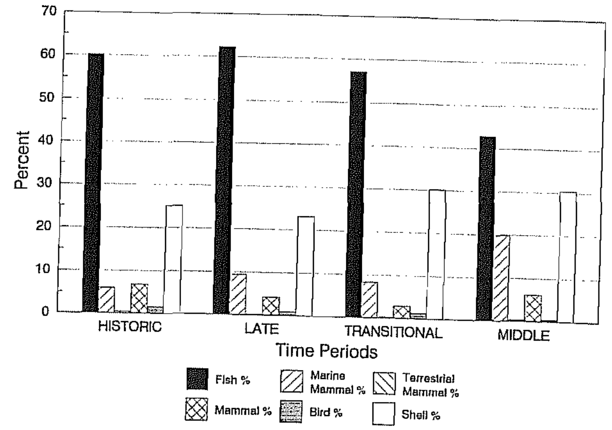

Figure 3. Estimated meat weight by time period.

Table 2. Rockfish and surfperch abundance.

Site and time period	Rockfish (%)	Surfperch (%)
SCRI-191		
Late Period	69.38	23.75
Transitional Period	65.96	29.25
Middle Period	50.92	44.44
SCRI-192		
Historic Period	85.14	12.16
Late Period	92.13	6.23
SCRI-330		
Historic Period[1]	94.44	5.5
Late Period	89.23	7.69
SCRI-474		
Transitional Period[1]	92.86	7.14
Middle Period	74.67	22.70

[1] Represents only one excavation level.

Table 3. Fish taxa by time period (number of identified specimens for otoliths).

Taxon	Common name	Mid	Trans	Late	Hist	Total
Amphistichus argenteus	Barred surfperch	2	2	1	0	5
Amphistichus koelzi	Calico surfperch	0	0	1	0	1
Anoploma fimbrina	Sablefish	0	0	1	0	1
Atherinops affinis	Topsmelt	1	0	0	0	1
Atractoscion nobilis	White seabass	2	1	1	0	4
Brachyistius frenatus	Kelp surfperch	2	2	0	0	4
Caulotatilus princeps	Ocean whitefish	0	1	0	0	1
Chilara taylori	Spotted cusk-eel	0	0	2	0	2
Cymatogaster aggregata	Shiner surfperch	0	0	1	0	1
Embiotoca jacksoni	Black surfperch	55	26	40	6	127
Embiotoca lateralis	Striped surfperch	3	1	0	0	4
Embiotocidae	Surfperch family	2	1	7	0	10
Genyonemus lineatus	White croaker	0	0	1	0	1
Girella nigricans	Opaleye	0	0	1	0	1
Hermosilla azurea	Zebraperch	1	0	0	0	1
Hippoglossus stenolepis	Pacific halibut	0	0	0	1	1
Hyperprosopon anale	Spotfin surfperch	1	1	3	0	5
Hyperprosopon argenteum	Walleye surfperch	31	5	8	1	45
Hyperprosopon ellipticum	Silver surfperch	3	2	2	0	7
Hypsurus caryi	Rainbow surfperch	4	7	14	1	26
Merluccius productus	Pacific hake	1	0	0	0	1
Micrometrus minimus	Dwarf surfperch	0	0	1	0	1
Paralabrax clathratus	Kelpbass	0	1	0	0	1
Paralichthys californicus	California halibut	0	1	2	0	3
Parophrys vetulus	English sole	0	0	2	0	2
Phanerodon atripes	Sharpnose surfperch	0	0	1	0	1
Phanerodon furcatus	White surfperch	4	2	3	0	9
Pleuronichthys ritteri	Spotted turbot	0	0	2	0	2
Porichthys notatus	Plainfin midshipman	2	0	0	0	2
Rhacochilus toxotes	Rubberlip surfperch	6	1	3	1	11

Table 3 (continued).

Taxon	Common name	Mid	Trans	Late	Hist	Total
Rhacochilus vacca	Pile surgperch	4	2	8	2	16
S. alutus	Pacific Ocean perch	0	0	2	0	2
S. atrovirens	Kelp rockfish	10	2	10	1	23
S. auriculatus	Brown rockfish	2	5	13	1	21
S. babcocki	Redbanded rockfish	0	1	5	0	6
S. carnatus	Gopher rockfish	0	0	7	0	7
S. chlorostictus	Greenspotted rockfish	0	0	8	0	8
S. chrysomelus	Black-and-yellow rockfish	0	0	2	0	2
S. constellatus	Starry rockfish	3	1	7	0	11
S. crameri	Darkblotched rockfish	1	0	14	3	18
S. dalli	Calico rockfish	1	9	2	0	12
S. diploproa	Splitnose rockfish	2	0	3	0	5
S. elongatus	Greenstriped rockfish	3	4	15	0	22
S. entomelas	Widow rockfish	5	3	15	4	27
S. eos	Pink rockfish	0	0	4	0	4
S. flavidus	Yellowtail rockfish	17	13	30	3	63
S. gilli	Bronzespotted rockfish	2	0	3	0	5
S. goodei	Chilipepper	72	9	187	15	283
S. helvomaculatus	Rosethorn rockfish	0	1	3	0	4
S. hopkinsi	Squarespot rockfish	1	0	4	0	5
S. jordani	Shortbelly rockfish	0	5	13	0	18
S. levis	Cowcod	0	1	3	3	7
S. macdonaldi	Mexican rockfish	4	3	19	0	26
S. maliger	Quillback rockfish	2	0	6	0	8
S. melanops	Black rockfish	1	0	1	0	2
S. melanostomus	Blackgill rockfish	0	0	2	6	8
S. miniatus	Vermillion rockfish	10	16	50	5	81
S. mystinus	Blue rockfish	2	0	4	0	6
S. ovalis	Speckled rockfish	3	1	5	0	9
S. paucispinis	Bocaccio	11	9	25	2	47

Table 3 (continued).

Taxon	Common name	Mid	Trans	Late	Hist	Total
S. phillipsi	Chameleon rockfish	4	0	5	0	9
S. pinniger	Canary rockfish	3	6	27	3	39
S. rastrelliger	Grass rockfish	0	1	2	0	3
S. rosaceus	Rosy rockfish	1	0	3	0	4
S. ruberrimus	Yelloweye rockfish	5	4	11	1	21
S. rubrivinctus	Flag rockfish	0	1	3	0	4
S. rufus	Bank rockfish	1	0	7	7	15
S. saxicola	Stripetail rockfish	1	0	1	0	2
S. semicinctus	Halfbranded rockfish	0	0	2	0	2
S. serranoides	Olive rockfish	4	1	14	1	20
S. serriceps	Treefish	1	0	0	0	1
S. serriceps cf.	Treefish cf.	0	0	1	0	1
S. simulator	Pinknose rockfish	0	0	3	0	3
S. simulator cf.	Pinknose rockfish cf.	0	0	1	0	1
S. umbrosus	Honeycomb rockfish	1	2	3	0	6
S. vexillaris	Whitebelly rockfish	2	0	4	1	7
S. zacentrus	Sharpchin rockfish	0	0	0	1	1
Scorpaena guttata	California scorpionfish	1	0	0	0	1
Sebastes sp.	Rockfish undifferentiated	106	39	355	40	540
Sebastolobus alascanus	Shortspine thornyhead	0	0	1	0	1
Semicossyphus pulcher	California sheephead	1	0	1	0	2
Seriphus politus	Queenfish	0	0	1	0	1
Sphyraena argentea	California barracuda	1	7	13	0	21
Thunnus alalunga	Albacore	1	0	0	0	1
Trachurus symmetricus	Jackmackerel	3	1	3	1	8
Zaniolepis frenata	Shortspine combfish	0	0	1	0	1
Unidentified teleostei	Boney fish undif.	0	1	1	0	2
Totals		412	202	1,030	110	1,754

The rockfish are the most prominent genus present, constituting between 50 and 94% of the identified otoliths. Surfperch range between 5 and 44% of the identified otoliths in the various analytical units. At 3 of the sites (excluding SCRI-192), rockfish became more important and surfperch less important through time. Rockfish are primarily rocky substrate species and surfperch are primarily sandy substrate species. SCRI-191 and SCRI-474 have greater proportions of surfperch than the other 2 sites. Both of these sites are next to sand beaches; the composition of their fish assemblages probably reflects local environmental conditions. Both of these sites have Middle and Transitional period levels, so there could also be a temporal aspect to the composition of the fish assemblages. The clear reduction in importance of surfperch through time at SCRI-191 supports this explanation.

Fish are temperature sensitive, and their remains can provide information on palaeoenvironment as well as diet. As discussed earlier, during modern warm-water events, giant kelp forests (*Macrocystis* sp.) are often adversely affected by decreased nutrients and storm activity. If there were a significant reduction or an absence of kelp-bed fish in the Transitional period archaeological samples, it might indicate a change in environmental conditions during that time period. Of the 82 distinct fish taxa identified from otoliths in these assemblages, only 4 are considered to be exclusively kelp-bed varieties: white seabass, kelpbass, pile surfperch, and California sheephead. None of these taxa is common in the assemblages of identified otoliths, but 3 of them (pile surfperch, 2 otoliths; white seabass, 1 otolith; and kelpbass, 1 otolith) were recovered from Transitional period levels at SCRI-191. This is about 2% of the otoliths recovered from Transitional levels at SCRI-191. Remains of kelp surfperch, common in kelp beds today, were also recovered from Transitional period levels (2 otoliths from Transitional period levels at SCRI-191).

The overall fish assemblage is similar to what might be found in waters around Santa Cruz Island today, with only 2 indicators of unusual water conditions (A. Ebeling 1993, pers. comm.). *Hermosilla azurea*, or zebraperch, is only found in the Santa Barbara Channel in modern times during El Niño events. The single otolith of this species was recovered from the Middle period levels of SCRI-474. *Hippoglossus stenolepis*, Pacific halibut, is extremely rare in the Santa Barbara Channel today, preferring the cold waters near Alaska. One otolith of this cold-water species was recovered from the Transitional levels of SCRI-191. These data suggest that kelp-bed species were not completely eliminated by changing climatic conditions, at least in the area exploited by the Transitional period inhabitants of SCRI-191. However, only very small numbers of these species were recovered. Even if kelp beds were adversely impacted by temperature change, a few of these fish might remain in the area, so these data do not constitute conclusive evidence that kelp beds were unaffected by sea temperature change.

Table 4. Fish species by range[1] and fish taxonomic diversity.[2]

Time period	% South	% North	% Transitional	Diversity
Historic	0.0	5.7	94.3	0.91
Late	3.8	5.6	90.7	0.90
Transitional	6.2	8.1	85.7	0.94
Middle	2.6	6.6	90.8	0.89

[1] Percentage of fish that could be classified to range.
[2] Simpson's Index of Diversity.

In order to evaluate further whether the overall fish assemblage changed during the period of warm water, I have classified all fish taxa identified from otoliths according to their geographic range. Using the Santa Barbara Channel area as the dividing line and range data provided by Miller and Lea (1972), and Eschmeyer, et al. (1983), I classified these fish as either southern, transitional, or northern species. Northern species are those whose ranges were generally north of the channel, southern species are those whose range was generally south of the Channel, and transitional species are those whose range extended north and south of the Channel. Table 4 shows that, although most of the fish otoliths from the warm-water period (Transitional period) have ranges that extend beyond the Santa Barbara Channel, the percentage of otoliths from southern species increased as did the percentage of fish from northern ranges. Furthermore, this taxonomic diversity of the Transitional period levels is greater than that of the other time periods (as calculated using Simpson's index of diversity) (Table 4). These data suggest that the fish population of the Santa Barbara Channel was affected by climatic change during the Transitional period.

Discussion

In sum, it is clear that faunal data can provide information not only on prehistoric diet, but also on palaeoenvironment and the nature of site occupation. In this analysis, archaeozoological data from 4 sites on Santa Cruz Island indicate changing patterns of marine-animal exploitation through time and provide information about palaeoenvironmental conditions. The overall diet changed through time to include greater amounts of fish and decreasing amounts of marine mammals and shellfish. There was some inter-site variability, however, with invertebrates increasing in importance at SCRI-191 (Colten 1993). The fish and shellfish assemblages and the overall composition of the diet indicate changes in water temperature during the Transitional period, approximately A.D. 1150–1300.

The vertebrate faunal assemblage from these sites provides surprisingly little information on prehistoric sea temperature. No single category of data indicates major disruptions to the marine ecology or radical changes in subsistence strategies by the inhabitants of these sites.

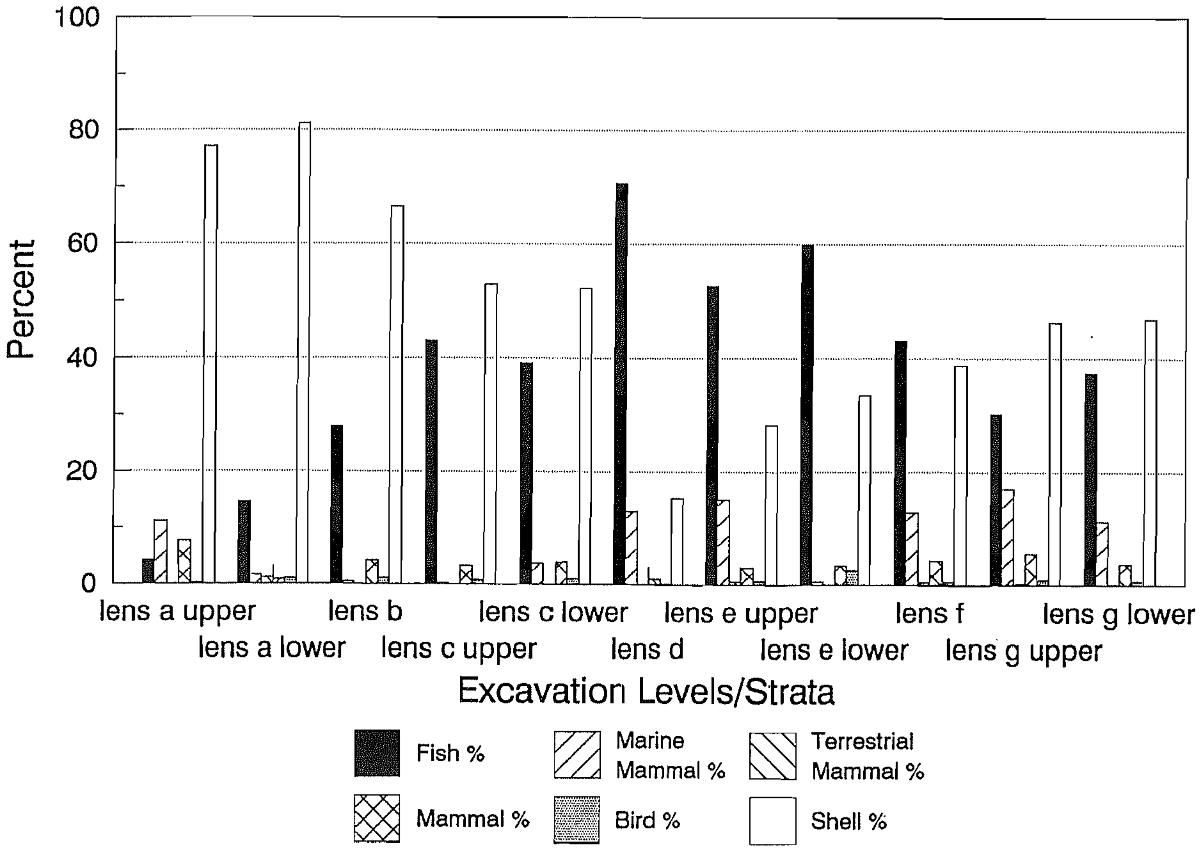

Figure 4. Estimated meat weight by level, SCRI-191, 35s, 2w.

During periods of prolonged sea surface temperature, as identified from other types of data, there were minor changes in the teleost fish assemblage, suggesting changes in prehistoric fish populations. Neither the fish nor the shellfish assemblage indicates any major changes in composition of the faunal assemblage that are clearly related to environmental change.

The shellfish assemblage does provide some information on water temperature, suggesting impacts to the diet and to overall marine productivity. First, Arnold and Tissot (1993) found that black abalones exhibited growth patterns typical of modern warm-water conditions during the Transitional period. Second, Stevenson's (1989) data indicate that some invertebrate species (*Astraea undosa* and *Norrisia norrisi*), absent or rare at SCRI-191 during other periods, were present during the warm-water period. Third, the overall composition of the faunal assemblage changed through time at SCRI-191, with shellfish and fish alternating as the most important classes of fauna (Fig. 4). During the occupation represented in lens d, e upper, and e lower, (the warm-water period) fish were far more important than shellfish (Colten 1993). Interestingly, these are the periods of warm water, which suggests that relatively stationary animals such as shellfish were adversely affected by the warm-water event, while the more mobile fish species were able to relocate. In order to obtain adequate animal food, the inhabitants of SCRI-191 caught a higher proportion of fish. After the return to relatively normal, cooler water conditions, shellfish again become the most important class of fauna at this site. Although the taxonomic makeup of the fish and shellfish assemblages changed little throughout the time periods considered in this analysis, changing patterns of broad classes of fauna indicate adaptation to changing environmental conditions.

An alternative explanation for sudden changes in the faunal assemblage is that sites on the island were periodically abandoned or occupied intermittently. Arnold (1991, 1992) has demonstrated that some of the Santa Cruz Island sites were abandoned at the end of the Middle period and identified a hiatus in occupation in the Transitional period by analyzing diagnostic artifacts. This type of intermittent occupation would have impacts on faunal assemblages. For example, long-term exploitation of shellfish beds may have reduced their productivity, creating a need for alternative food sources such as fish. If the site were abandoned even briefly shellfish might recover and provide a greater proportion of the diet for subsequent occupants. The only abrupt change in broad classes of fauna at SCRI-191 occurred between lens d and lens c lower. This change from a fish-dominated assemblage to a shell-dominated assemblage occurred after the hiatus that Arnold identified and would represent temporary abandonment in the early part of the Late period. A single, temporary abandonment of the site would not explain the increasing importance of shellfish throughout the Late period occupation of this site. This pattern might suggest that the site was occupied on an intermittent basis throughout the Late period. It is also possible that site abandonment would be indicated in the absence of warm-water indicators. If sites were abandoned during the most extreme environmental conditions, there would not be an archaeological record of warm-water conditions.

Finally, it is possible that the prehistoric fishers on Santa Cruz Island knew where to find fish, even during adverse climatic conditions. Areas with localized upwelling (i.e., deep marine canyons) would have remained productive, even during warm-water events. Given the importance of deep-water rockfish in these archaeological assemblages, it seems these people were fishing in water deep enough to be below the thermocline, perhaps even in times of warm water.

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Archaeological Settlement Dynamics on the South Side of Santa Cruz Island

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Abstract. Auger probing and limited excavation of 22 archaeological sites in Coches Prietos drainage, on the south shore of Santa Cruz Island, has provided a preliminary look at the dynamics of settlement from the Early period into the period of historic contact. Based on the presence of burials, bead-making detritus, shell density, and site content, nearly all of the sites appear to be habitations, often small, single family occupations. The drainage was occupied from the Early period onward but there was a significant increase in site density at the end of the Middle period, about A.D. 1150–1300, with many small rock shelters initially occupied at this time. These findings are related to various factors that influenced the development of the complex socio-political organization which characterized the Chumash at the time of European contact.

Keywords: Santa Cruz Island; Chumash; Middle period; Late period; settlement patterns; terrestrial resources; marine resources.

Introduction

When the first Spanish explorers arrived off the California coast, they found a thriving population of seafaring people living in large permanent villages on the mainland and on the off-shore islands. The inhabitants of the island were almost entirely marine-adapted hunters and gatherers but, by the time the Spanish arrived, they had developed a complex society with wealth and status differences, hereditary chiefs, manufacturing specialists, inter-village political organizations, and shell bead money. Travelling in large canoes called *Tomols,* made of split log planks drilled and lashed together, their traders and fisher men made trips all up and down the coast and even as far as San Nicolas Island, some 65 mi out to sea. Chumash trade items such as shell beads and pendants have been found as far east as Arizona and New Mexico.

Presented here is a brief summary of some of the results of field work in Coches Prietos drainage, on the south side of Santa Cruz Island (Fig. 1). Twenty-two sites were systematically probed, using a bucket-type auger, and 5 of these also were tested by small unit excavations. The purpose was to try to determine some of the factors that influenced settlement and the development of the complex society on the island by focusing on the patterns found within a single large drainage. I will discuss some of the major factors that influenced settlement dynamics over the island as a whole and within the study area, mainly during the Middle (ca. 1300 B.C.–A.D. 1150) and the Late (A.D. 1150–) periods.

Terrestrial Resources as Settlement Determinants

Subsequent to the demise of the pygmy mammoths in the late Pleistocene, there were no native land mammals of economic significance on the island. Arnold (1991) estimates that terrestrial mammals provided less than 1% of the islander's diet in the middens she examined, and identifiable terrestrial fauna was extremely rare in the Coches Prietos midden samples. Fox, small rodents, and domestic dog provided the only terrestrial meat sources. It is highly unlikely that human settlement patterns would have been significantly affected by distributions of these animals.

Figure 2 shows the present-day distributions of coastal sage scrub, chaparral and oak woodland on the central part of the island. The latter includes stands of poplar, and ironwood mixed in with oak, but does not include isolated ironwood groves. Timbrook (1984) listed 156 plant species recorded as being used in one way or another by the ethno-historic Chumash. Of these, only 91, or 58%, are presently found on Santa Cruz Island. Almost half of the useful plants known to the Chumash were not found on the island, and many of those that were found available only in limited quantities and at widely scattered locations. Island vegetation communities tend to be found in a mosaic of small patches determined by slope, aspect, water and other local physiographic conditions. Large stands of any particular plant are extremely rare.