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Marine Resource Exploitation and Diversity in Kahikinui, Maui, Hawaii: Bringing Together Multiple Lines of Evidence to Interpret the Past

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ABSTRACT: This paper presents information from an ecological marine faunal survey conducted in the traditional district of Kahikinui, Maui, Hawaii. The survey documented coastal environments throughout the district and described the faunal diversity and abundance of vertebrates and invertebrates. These modern data are used as a comparative base for zooarchaeological data, and to identify areas that were potentially useful to Hawaiians for fishing and collecting in the past. Comparative analysis of zooarchaeological remains from Kahikinui demonstrates that considerable variability exists among social groups in regard to strategies of animal exploitation; elites had a specialized subsistence strategy while commoners maintained a more generalized strategy. Both groups targeted specific marine resources that are still available in Kahikinui. Elites located their largest coastal chiefly household and ritual complex in an area with great faunal diversity and abundance, and with a well-developed bay, providing easy access to the sea, while commoners lived in more marginal areas. Differences in consumption patterns between elites and commoners can be explored through an ecological framework and explained by combining multiple lines of evidence – modern ecological, ethnographic, and archeological. This paper focuses on the ecological survey and the use of ethnographic data to explain differences in subsistence patterns.

KEYWORDS: KAHIKINUI, HAWAII, ZOOARCHAEOLOGY, MARINE EXPLOITATION, ETHNOARCHAEOLOGY

RESUMEN: Este trabajo presenta la información recolectada en un estudio de la fauna marina realizado en el distrito de Kahikinui en Maui, islas Hawaii. Dicho sondeo documenta los medios ambientes costeros de la zona, al tiempo que describe la diversidad de fauna de vertebrados e invertebrados. Dichos datos han sido utilizados como base comparativa de un análisis zooarqueológico donde poder identificar las áreas de pesca y recolección que pudieron haber sido utilizados por los hawaianos que en el pasado ocuparon la zona. El análisis comparativo de Kahikinui evidencia que existieron variaciones considerables entre distintos grupos sociales en lo que a estrategias de explotación animal se refiere. De este modo, las elites exhibían una estrategia de subsistencia especializada, en tanto que el resto de la población desarrolló estrategias más generalizadas. Ambos grupos utilizaban recursos que todavía se encuentran en Kahikinui. Las élites ubicaron sus complejos hogareños y de ritual en áreas con gran diversidad y abundancia de fauna, en una bahía que proveía fácil acceso al mar. La variación en los patrones de consumo entre las élites y el pueblo puede ser examinada a través de un marco ecológico y explicado mediante la combinación de varias fuentes de evidencia, incluyendo las ecológicas, etnográficas, y arqueológicas. A partir del análisis de biotas recientes este trabajo usa los datos etnográficos para generar explicaciones a las variaciones detectadas en los patrones de subsistencia.

PALABRAS CLAVE: KAHIKINUI, ISLAS HAWAII, ZOOARQUEOLOGÍA, EXPLOTACIÓN MARINA, ETNOARQUEOLOGÍA

INTRODUCTION

Human strategies of marine resource exploitation in the tropics have long been of interest to anthropologists and archaeologists alike. In an effort to understand how prehistoric peoples lived in and used these diverse environments, archaeologists have frequently relied upon zooarchaeological materials and the artifactual remains of fishing technologies. But we can understand marine exploitation strategies much better if we combine such archaeological data with additional lines of evidence, such as ethnographic records and information from modern ecological surveys.

In this paper I discuss a marine ecological survey in the traditional district of Kahikinui, East Maui, Hawaii, which I use as a comparative base to understand zooarchaeological data from this region. I draw interpretations of prehistoric behaviors from ecological and zooarchaeological data and expand upon these with ethnographic accounts. In this framework, we can view marine exploitation patterns both as a response to the local environment and, perhaps more importantly, as a reflection of social constraints (rank-based access to resources) that have been documented ethnographically and archaeologically.

Because a strictly ecological outlook fails to account adequately for differences in the zooarchaeological assemblages from Kahikinui, a more holistic position is necessary – one that weighs the social environment in association with the natural environment. This analysis demonstrates that inter-assemblage variability can be attributed to both ecological and social factors, and enriched through comparison with ethnographic records.

The Setting

Kahikinui comprises a large expanse of geologically youthful volcanic substrates. This leeward landscape exhibits little surface weathering and is thus a relatively marginal, arid lava terrain (Stock *et al.*, 2003). Geographically, the district, or *moku*, spans from the southwestern slopes of the dormant volcano Haleakala to the shore (Figure 1). The rugged coastline, which lacks a fringing reef, is largely made up of sea cliffs that range in height from 1 m to over 50 m. The coastal strip, where the survey was carried out, is approximately 200-350 m wide, stretching inland from the shore. Site density here is high, with occupation definitely associated with marine exploitation. From land, access to the sea is restricted to the few areas where basalt cobble beaches occur in protected bays. Archaeological sites are frequently clustered around such bays and beaches.

The 'Alenuihaha Channel, known for strong currents (near-shore tidal and surface currents) and rough seas, runs parallel to the Kahikinui shore, between Maui and the north end of the Big Island or Hawai'i. Wind and waves pound the coast year round; Kona storm waves ranging from 3 to 5 m are common in late winter and early spring (although potentially present all year), while southern swells hit in the summer and early autumn with waves from 0.5 to 1.25 m (Armstrong, 1983). Such conditions must have made fishing from canoes and collecting along the littoral zone very difficult at times for the Kahikinui's prehistoric inhabitants, who gained much of their dietary protein from the sea.

The moku is divided by eight traditional political subdivisions (*ahupua'a*) that run from the uplands, high on the western slopes of the Haleakala, to the sea (the ahupua'a are named in Figure 1). Each of the ahupua'a exhibits a slightly varied ecological character that can best be described in terms of zones. Intra-ahupua'a natural environmental variation can be striking at times; for example, Haleakala's volcanic eruptions have produced isolated flows that cover certain areas but leave adjacent sediment patches exposed; thus relatively fresh lava may abut much older volcanic sediments. This geomorphic variability undoubtedly affects faunal composition, as is discussed below. This paper focuses on new data obtained from a faunal survey of the district's coastal zone; note that the overall environment has been described elsewhere (Kirch & Van Gilder, 1996; Kirch, 1997; Stock *et al.*, 2003). The survey characterized the district's marine environmental variation, thus supporting the idea that neither the moku nor the ahupua'a should be thought of as homogenous environmental units.

Goals of the Study

Over time numerous natural and human-induced local changes have occurred, so that the landscape that exists today is probably a very different natural environment from what the prehistoric Hawaiian inhabitants of Kahikinui experienced (Hawaiian settlement occurred from about

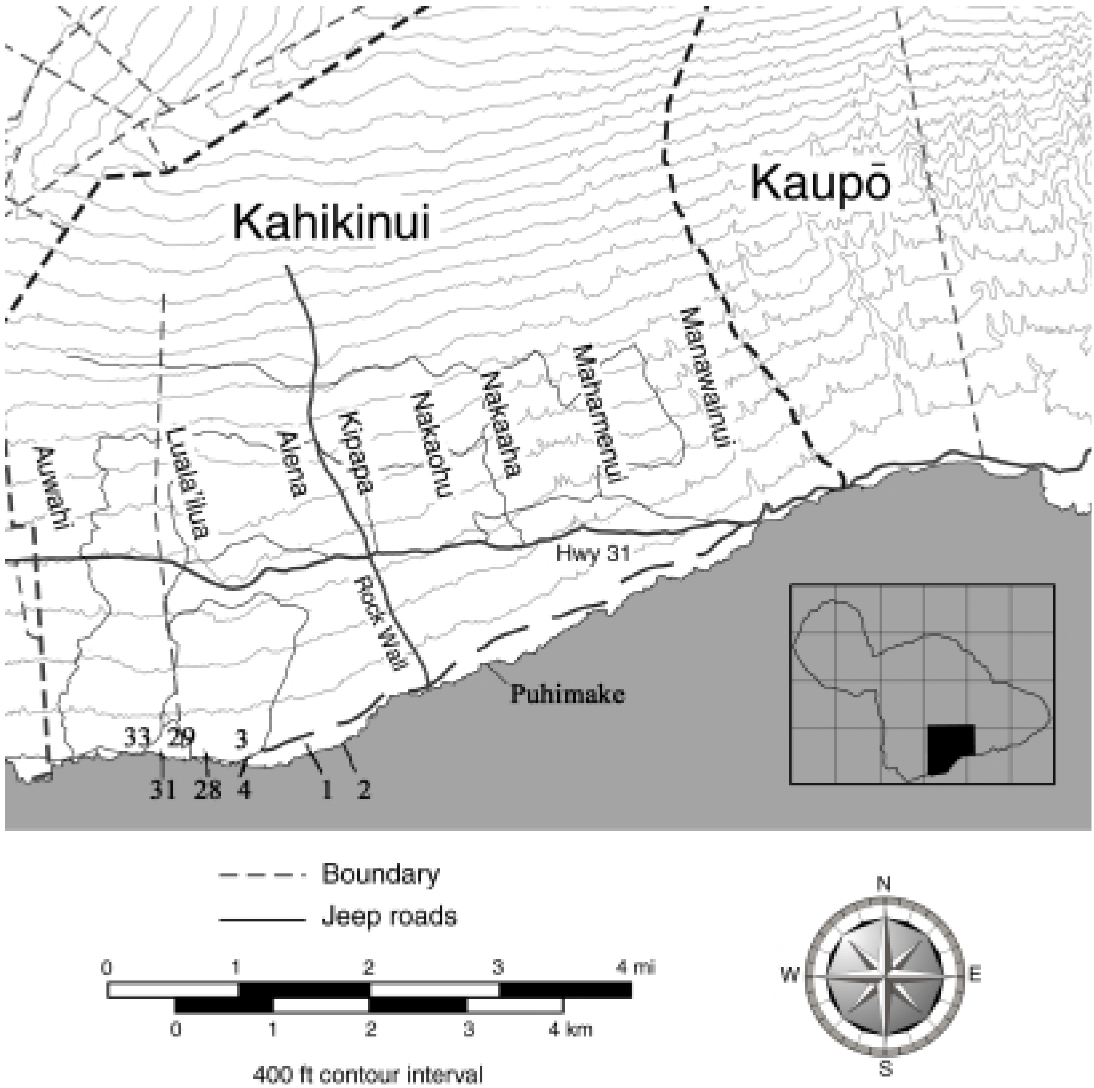

FIGURE 1
Map of the district of Kahikinui, Maui Island, showing the locations of the ahupua'a, and survey zones discussed in this paper.

1500-1860 AD). Nevertheless, a baseline is needed from which to compare the archaeological and historical evidence. Archaeological data together with initial observations of the geologically youthful coastline led to an assumption that the southeast Maui coastline, and Kahikinui in particular, had low marine resource productivity (Handy *et al.*, 1972; Kirch, 1997; O'Day, 2001). Clearly, more fine-grained ecological data from the modern environment was needed to substantiate that deduction.

To create such a comparative base, P. O'Day and I conducted environmental and marine surveys of the district's coastline in the summer of 1999. The goal of the study was to characterize and describe the overall diversity of the marine environments throughout the moku, and to estimate marine vertebrate and invertebrate faunal diversity and abundance. The resulting information is useful for examining the association between archaeological coastal settlements, habitat type, and available resources, and for generating hypotheses about how and where marine resources were collected and regulated prehistorically.

METHODS

Marine Survey

After we carried out an initial reconnaissance survey of the entire Kahikinui coastline, we created a standardized form to characterize sections according to marine environmental zones. I define “coastline” and “coastal region” to mean the sea and land area bordering the shoreline, and more or less limited in a seaward direction to the littoral (and in some cases the inshore) water mass. In a landward direction it includes the beach zone to the top of the first major change encountered in topographic structure. I define “environmental zone” here as an area where the general landforms, substrate, and plant and animal inhabitants are uniform in character.

Using our standardized form, we surveyed the coastline by walking parallel to the water's edge and documenting significant changes in geological landforms. We identified major changes as the transitions from one zone or microenvironment to another. For example, a large isolated bay or basalt beach flanked by cliffs was characterized as a single environmental zone. Each zone was assigned an arbitrary number for reference and its extent was measured and plotted on the U.S. Geological Survey (USGS) map and on air photos. All nearby archaeological sites were noted. The zone was then described in writing, and general features on the landscape were indicated. Notable features included tide pools, splash pools, bays, cliffs, basalt beaches, boulders, blow holes, surge channels, salt flats, lava pinnacles, the extent and degree of flow slope, the presence and character of existing sediment, the type of lava present and its state of degradation, standard boulder size, the presence and type of marine and terrestrial vegetation, the presence of coral, and the possibility of sea access from the land. As the zones were surveyed, we also identified and recorded the animals inhabiting the area. Finally, we took a photo of each zone.

We made faunal identifications using field guides (Tinker, 1978; Kay, 1979; Hoover, 1999; Randall, 1999) and wrote up the environmental descriptions. Both P. O'Day and I have training and field experience in biological methods and fisheries science, and hold interdisciplinary graduate degrees in anthropology and fisheries biology or zoology. P. O'Day has five years of experience directing field research at the University of Florida Department of Fisheries Biology and Aquatic Sciences. Additionally, we have studied, collected, and analyzed modern and archaeological, tropical and subtropical fishes and invertebrates from the Pacific Islands for over seven years.

We identified 34 environmental zones within the district. Nine littoral transects were completed, following ecological procedures from Krebs (1999). Although environmental zones were described along the entire coastal strip, unfavorable weather, limited time, and the difficult terrain (many high cliffs with steep drop-offs) made it impossible for us to conduct littoral surveys in all of the environmental zones. The transects were located in the western ahupua'a of Alena, Lualailua, and Auwahi, where the littoral zone and associated tide pools are accessible and developed enough to have invertebrate and/or vertebrate inhabitants. The transects, designed to give a quantitative assessment of the littoral zone inhabitants, measured 10 m by 2 m; they were positioned randomly within zones, cutting across the littoral region in each area (i.e., perpendicular to the shore). All animals inside each transect were identified, counted, and measured. Additional observations on corals, seaweeds, and other flora were also recorded. The location of each littoral transect was plotted on the USGS map and air photos, and a photograph was taken.

Two subtidal transects were conducted in addition to five subtidal reconnaissance surveys of near-shore environments. Because these surveys were undertaken only in areas where the water could be reached safely from land, all were conducted in sheltered bays. Like the littoral transects, these transects measured 10 m by 2 m; they were positioned randomly in the outer regions of each bay. Using snorkel and dive equipment one of us swam along the transect (marked by weighted lines on the bottom) or floated above it for 15 minutes identifying, counting, and estimating the size of all of the fish and invertebrates inside the transect, and recording the information on a waterproof slate. The second swimmer similarly recorded fishes outside the transect and, in addition, any other useful qualitative information (such as the nature of the subsurface area, the relative slope, and the patchiness and character of the reef). Reconnaissance water surveys were conducted more informally, by snorkeling into areas and recording the marine life observed during 15-minute intervals.

Niche Width Measures

In this study I applied the Shannon-Wiener measure of niche breadth or diversity to the ecological data from the selected Kahikinui zones in order to measure the degree of abundance and variation found in each environment. The measure quantitatively characterizes the variety of animals identified within transects and the relative importance or abundance of the species present. Niche breadth is measured by observing the distribution of individual organisms within a set of resource states. The formula used is (following Krebs, 1999: 463):

$$H' = - \Sigma (p_i) (\log_e p_i)$$

where H' is the information content of the sample and p_i is the relative abundance of individuals or resources for each taxon in the transect. Niche breadth is calculated on the basis of individuals. Since this diversity measure ranges from 0 to •, it can be standardized on a scale from 0-1 by using an evenness or equitability measure, V'. Equitability indicates the evenness, or distribution, of species or animal resources. The equitability formula used is (following Reitz & Wing, 1999):

$$V' = H'/ \log_e S$$

where H' is the Shannon-Wiener function and S is the number of taxa present. Both diversity and equitability indices were calculated on the basis of the number of individuals documented for vertebrate and invertebrate faunas within each littoral transect.

RESULTS

Niche Width Measures and Environmental Characterization

The survey data indicate that the areas with the most abundant and diverse marine fauna are in the ahupua'a of Lualailua and Auwahi, at the western end of the moku. Tables 1 and 2 present littoral and subtidal survey data; Appendix 1 gives a modern species list with common names. When multiple littoral or subtidal transects were conducted in a single zone, the transect was designated with both the zone number and the letter, for example "31a." Note that the transects in Table 1, labeled "3 Lualailua-Alena" and "3b L-A" were positioned in different locations within a single zone; zone 3 lies on the boarder of the ahupua'a of Lualailua and Alena, where the transition from one ahupua'a to the next is undetermined.

The two westernmost ahupua'a have well-developed tide pools with a series of microhabitats, as reflected in the high faunal densities and animal variation (see zones 4, 28, 29, 30, 31, 32, and 33 in Tables 1 and 2). In addition, Lualailua and Auwahi both have several bays and beaches from which the sea is easily accessible from land. These areas stand in contrast to the long tracts of coastline that provide few places to reach the littoral zone and the sea.

Calculations of niche breadth and equitability are presented in Table 1; these measures indicate that the littoral zones with the greatest relative diversity of vertebrate and invertebrate fauna and the highest equitability include the following: zone 29 (H' = 1.795, V' = 0.722); zone 31 (H' = 1.885, V' = 0.969); and zone 33 (H' = 1.539, V' = 0.568). All these zones are in Lualailua and Auwahi, indicating that both littoral faunal diversity and equitability are higher in the westernmost ahupua'a. Moving east from this area, the diversity decreases and equitability is lower, indicating a more uneven distribution of taxa.

Six of the seven subtidal transects were conducted in Lualailua and Auwahi (Table 2). A single transect was located in Mahamenui, at the eastern end of the moku. The reconnaissance surveys (in zones 25, 31a, 31b, 32, and 33a) and transects (zones 30 and 33b) were located in different areas, even when they were positioned within a single zone (for example, transects 33a and 33b were located in different parts of the large bay in zone 33). A suite of common near-shore invertebrates including sea cucumbers and sea urchins were identified in these surveys. Virtually all the bony fishes documented in the subtidal transects were small near-shore herbivores and omnivores (the average total length was 25 cm, with lengths ranging from 5 to 50 cm). The most commonly identified bony fishes included species in the families

Taxon	Zone and Number																	
	1 Alena		2 Alena		3 Lualailua-Alena		3b L-A		4 Lualailua		28 Lualailua		29 Lualailua		31 Lualailua		33 Auwahi	
	count	L	count	L	count	L	count	L	count	L	count	L	count	L	count	L	count	L
Aiptasia pulchella			4	3,2	2	2,5	5	2,5			1	1,7					3	2
Unidentified anemone											6	2						
Cellana exarata			6	2,4					3	4	12	1	8	3,2			102	2,8
Cellana sandwicensis													1	2,9			1	0,35
Nerita picea	17	1,2	703	0,7	7	0,7	361	1	10	1			29	1,2			15	1,3
Littorina pintado	946	0,95	400	0,4	77	0,8	120	0,6	121	0,4	425	1	7	1,1			4	0,1
Nodilittorina picta	60	0,75			37	0,2	134	0,3	42	0,2	495	0,4	35	0,3			43	0,6
Cypraea caputserpentis											4	3,3						
Cypraea mauritiana													1	5,3				
Drupa ricina							3	1,9			9	2	7	2,1	2	13	2	2,8
Morula granulata	2	2,1					8	1,2	11	1	2	1,5	2	1,8			2	2,1
Cantharus sp.							2	2,5			2	1,5						
Smaragdinella calyculata			30	2,3														
Isognomon sp.					30	1,4	13	1	2	1,5								
Isognomon californicum	7	1,3	42	1,8														
Colobocentrotus atratus																	1	2
Echinometra oblonga			17	1,5					1	3,5	3	2,5			2	40	5	3,1
Echinometra mathaei			7	1,3									1	3,7				
Actinopyga mauritiana									1	15					1	100		
Holothuria atra															2	195		
Holothuria whitmaei															2	170	1	6
Diogenidae	15	1,5	2	1,5	1	1,4	1	1,4	25	1,4	43	1,8	2	1,6				
Grapsidae											1	2,7						
Grapsus tenuicrustatus	5	11							2	9								
Chromis sp.																	2	4
Thalassoma sp.																	3	8
Kuhila sandvicensis															1	100		
Blenniidae	10	4			3	5,5	5	4,5	5	3	29	2,5	3	4,2	3	75		
Entomacrodus marmoratus			2	6,5														
Acanthurus triostegus													2	4			7	32
Diversity (H')	0,505		1,046		1,308		1,223		1,455		1,162		1,795		1,885		1,539	
Equitability (V')	0,243		0,454		0,672		0,531		0,607		0,44		0,722		0,969		0,568	

TABLE 1

Littoral survey data from Kahikinui, Maui, Hawaii, ahupua'a, zone number, and species list indicated, taxon count and average total length (L, in cm) given.

Acanthuridae (surgeonfishes), Chaetodontidae (butterflyfishes), Labridae (wrasses), Pomacentridae (damselfishes), and Balistidae (triggerfishes). Only three pelagic individuals were identified; these carangids (jacks) were documented in the Lualailua transects. The Mahamenui transect contained fewer species overall and less diversity than the Lualailua and Auwahi transects.

Although quantitative littoral transects were not conducted along the coast of Kipapa and Nakaohu, the ahupua'a where the most intensive archaeological excavation has focused (see Kirch & Van Gilder, 1996; Kirch, 1997), the marine survey produced useful qualitative information. Few areas of rich marine resources that were easily accessible from shore were found in these areas (Table 3). Beginning on the western end, with Kipapa, the coastline is made up of degraded and weathered volcanic sediments sloping to the sea. Tide pools, surge channels, and salt flats dot the shoreline. The littoral zone is inhabited by rock-boring urchins (*Echinometra* spp.), black foot *opihi* or limpets (*Cellana exarata*), periwinkles (*Littorina* spp.), thin-shelled rock crabs (*Grapsus tenuicrustatus*), juvenile surgeonfish (*Acanthurus* spp.), and juvenile Hawaiian flagtails or *aholehole* (*Kuhlia sandvicensis*).

Traveling east, into the ahupua'a of Nakaohu, one encounters a large temple site, M11. After this point the seaward slope becomes more pronounced and eventually turns to cliffs in some areas; here the sea is totally inaccessible by land. On the west side of Nakaohu is Puhimake Bay, which lies just seaward of the Nakaohu Kai household complex (the sites and associated zooarchaeological assemblages are described in Kirch & O'Day, 2003; see Figure 1). This is a fairly large bay with steep cliffs that drop abruptly to the water's edge. Below is a small, waterworn, basalt cobble beach, flanked on both sides by moderate-sized tide pools and a surge channel on the west. Puhimake is accessible only from the eastern end of the cliff line, though entry from a boat would be preferable on a calm day. The bay and deeper waters just outside the mouth are fishing spots still used today by locals who

Taxon	Zone and Number													
	25 Mahamenui		30 Lualailua		31a Lualailua		31b Lualailua		32 Lualailua		33a Auwahi		33b Auwahi	
	count	L	count	L	count	L	count	L	count	L	count	L	count	L
Cephea cephea													1	14
Colobocentrotus atratus					23	3,5								
Echinometra mathaei			1	2										
Echinothrix diadema					1	13					3	12		
Hetrocentrotus mammillatus											3	13		
Actinopyga mauritiana					4	18					1	15		
Holothuria sp.					6	25								
Myripristis sp.					2	15								
Kuhila sandvicensis	6	10												
Paracirrhites arcatus													2	12
Cirrhitus pinnulatus											2	15		
Carangoides orthogrammus			1	50			1	70						
Caranx melampygus							P							
Parupeneus cyclostomus			1	30										
Parupeneus multifasciatus	3	15												
Parupeneus bifasciatus											1	30		
Kyphosus sp.							P							
Chaetodon sp.			10	20										
Chaetodon auriga									8	20				
Chaetodon lunula									2	20				
Chaetodon miliaris									3	14	3	15		
Chaetodon multicinctus	2	12												
Forcipiger longirostris									6	12				
Chromis agillis					5	5								
Chromis hanui			1	8										
Chromis ovalis			6	6										
Stegastes gregory													3	10
Stegastes fasciolatus	>20	12												
Coris flavovittata			1	24	3	16								
Coris venusta													4	10
Gomphosus varius											2	20		
Labroides phthirophagus			7	7	8	8								
Thalassoma duperrey	1	22			2	23	P						6	18
Pseudocheilinus sp.													3	6
Scarus sp.											3	45		
Cirripectes obscurus					20	8								
Acanthurus sp.			10	18										
Acanthurus achilles					3	18			10	25	2	25		
Acanthurus guttatus							P		4	20				
Acanthurus leucopareius									5	20				

TABLE 2

Subtidal survey data from Kahikinui, Maui, Hawaii, ahupua'a, zone number, and species list indicated. Note that sine data from reconnaissance transects indicate the presence (P) of a species rather than a count.

fish from boats, using hook and line, and spears. Six green sea turtles (*Chelonia mydas*) and a dozen parrotfish (Scaridae) were identified in the bay during the survey. Sterling (1998: 202) discusses an ancient fishing ground where the water is 36.5 m deep; from the description, it appears to be located just offshore from Puhimake Bay (zone 18).

Toward the eastern end of Nakaohu, an area primarily of basalt lava flows forms shelves, sloping toward the sea. The shelves drop off abruptly at a cliff line along the water's edge. Within this area are numerous tide pools, mostly small (about 2 m by 2 m or less, and under 0.2 m deep) and relatively undeveloped (i.e., with few inhabitants and little variation in fauna); each typically supports a community of a few hundred *Littorina*, about a dozen *Grapsus tenuicrustatus*, fewer than 20 limpets (*Cellana exarata* and *Cellana sandwicensis*), and between two and six juvenile *Acanthurus*. The larger, more developed tide pools contain abundant and diverse fauna; these pools are generally deeper and larger in diameter, containing about four times as much animal life as the small, shallow tide pools. The far eastern end of Nakaohu has more well-developed tide pools (typically more than 2 m by 2 m and over 0.2 m deep), where various small reef fish were identified [*Kuhlia sandvicensis*, Chaetodontidae, Labridae, and blennies (Blenniidae)].

Ethnographic and Ethnohistoric Support

Ethnographic records of Kahikinui from the historic period (primarily from the late 1800s) report important, locally known, named fishing, and salt and seaweed collecting grounds. One such place, Papale, said to be the best in the district, is located immediately east (zone 32) of the chiefly village of Makee in Auwahi (Sterling, 1998: 213; zone 33 on Figure 1). Several named fishing grounds are located offshore of Lualailua ahupua'a (Sterling, 1998: 206).

Moving east through Alena (zones 1 and 2) and Kipapa, the shoreline becomes less weathered, the lava flow is more youthful, and the lava slopes turn into shelves and tide pools where the land meets the sea. Large basalt boulders are scattered about and covered with a mat of seaweed or *limu* and red and brown algae. This area was described in 1967 by Sam Po, a lifelong resident of Honuaula (the moku just west of Kahikinui). Po claimed that this place (including zones 1 and 2) was named "Papa-'ula… if the flats (reef) appeared red it meant the tide was too low and the *limu* had been exposed and was all dry, hence Papa-'ula [red flat]" (Sterling, 1998: 213). *Limu* was probably collected here, as the name implies. Tide pools at Papa-'ula range from small and shallow to deep and well developed. In addition to the typical suite of periwinkles, limpets, and crabs inhabiting the pools, many species of blennies were documented. Shallow, naturally formed salt basins dot the landward side of the littoral zone. These were important prehistorically since salt was traditionally used for preserving and flavoring many foods, especially fish (Buck, 1957). Offshore of Kipapa, coral heads become more abundant (than in Alena), and sea turtles frequent the surf.

DISCUSSION

In sum, the littoral strip in Kipapa and Nakaohu is characterized by a low diversity of commonly occurring fauna, including *Littorina pintado*, *Nodilittorina picta*, *Cellana exarata*, Blenniidae, *Acanthurus* spp., and *Grapsus tenuicrustatus*. These species are also frequently identified from archaeological assemblages (O'Day, 2001; Kirch & O'Day, 2003), and were probably collected prehistorically by women and children, as is the case throughout Polynesia (Titcomb, 1972; Titcomb, 1978; Halapua, 1982; Malm, 1999). Small fish would have been taken with nets, while the invertebrates were collected by hand with the help of sticks to pry the animals off the rocks. Traditional tales warned that gatherers should always keep one eye on the sea; in fact, gathering limpets or *'opihi* was considered so dangerous that it was called the fish of death (*he i'a make*) (Titcomb, 1972). This is certainly the case in Kahikinui, where collecting in the tide pools and along the water's edge can be treacherous because of the wind and breaking waves. Rough conditions make collecting impossible at times.

Fish documented in subtidal surveys (Table 2) include (in decreasing order of abundance) many species of surgeonfish (*Acanthurus nigroris, A. nigrofuscus*, *Naso lituratus*, *Zebrasoma flavescens*), wrasses (*Coris flavovittata*, *Coris venusta*, *Labroides phthirophagus*, and *Thalassoma duper-*

Ahupua'a	Zone	Description	Sea Access	Fauna Present
Nakaohu	17	Lava flow slopes to a drop off along water's edge turning to cliffs (10-25m tall), 22 tide pools (>2x3m and >.2m deep) lie on eastern most shelf area. Numerous basalt boulders (>1x1m) dot area around sea and below cliffs. Two small (about 2x2m) caves located in cliff face. Zone extends 158m by 35-45m. No sediment or coral seen. Seeweed and algae abundant in surge zone.	None from land.	Chaetodon spp., Labridae, Acanthurus triostegus, Blennidae, Cellana exarata, Cellana sandwicensis, Littorina spp., Graspsus tenuicrusatus.
Nakaohu	18	is surrounded by steep cliffs (average 20m tall). A basalt cobble beach lies at the base of the cliffs, along the waters edge. Two tide pools (about 2x3m) and a surge channel flank the beach. No coral, sand or sediment was seen in the zone.	Limited to entry from east.	Scaridae, Chelonia mydas
Kipapa	19	Large area of fairly homogenous coastline (500m x20-40m). Comprised of weathered lava slope to sea, dotted with 65 tide pools, 12 surge channels, and numerous basalt boulders (>1x1m). Tide pools range from 1x2m and .2m deep to 2x5m and .5m deep. Over 20 naturally formed salt basins (average .5x.5m) on slope.	None from land.	Acanthurus triostegus (13cm long), Blennidae, Graspus tenuicrusatus, Littorina spp., Cypraea caputserpentis, Cypraea maculifera.

TABLE 3

Descriptions of environmental zones within Kipapa and Nakaohu ahupua'a based on a marine survey, Kahikinui, Maui, Hawaii.

rey), parrotfishes (*Scarus* spp.), goatfishes (*Parupeneus* spp.), jacks (*Carangoides* spp. and *Caranx melampygus*), triggerfishes or *humuhumu* (*Rhinecanthus rectangulus*), and chubs (*Kyphosus* spp.). These fish could have been collected prehistorically using a variety of methods, as the ethnohistoric record suggests. It is well known among marine biologists that tidal fluctuations, diurnal rhythms, weather, current, spawning behavior, and community interactions all influence the behavior of fish, and subsequently capture techniques. However, certain methods may have been preferred to others for particular species (see, Tinker, 1978; Halapua, 1982; Leach *et al.*, 1997). For example, reef omnivores, herbivores, and planktivores (parrotfish, wrasse, surgeonfish, and triggerfish) could be easily harvested using nets and traps. Near-shore and open-water carnivores, such as jacks and some species of triggerfishes, were likely taken by fishermen using canoes and a hook and hand line. Most of these species could also be taken with a spear or poisoned.

The marine survey documents some of the intra-ahupua'a environmental diversity found in coastal habitats and in living faunal assemblages. Associated with Kahikinui's microhabitats are potentially important resources such as salt, seaweed, and well-known or easily accessible fishing grounds. Notably, the westernmost ahupua'a of Lualailua and Auwahi exhibit the greatest faunal diversity and evenness. These areas have well-developed bays and tide pools, providing easy access to the sea for collecting and offshore fishing. It is no surprise that Kahikinui's most extensive coastal chiefly household and temple complex, Makee, is located in Auwahi, zone 33 (see Figure 1 and Table 2). The other coastal household complexes are relatively similar in size and composition to each other, and do not appear to correlate with any particular set of resources or habitat types.

The marine survey data indicate that Kahikinui's near-shore waters, though a geologically burgeoning emergent reef, nevertheless show relatively low marine resource diversity and productivity (compared with other areas in Maui and elsewhere in the Pacific). The tide pools, with their small size, low faunal diversity, and few inhabitants, could not have been exploited with much intensity. Ethnohistorical records show that littoral and near-shore exploitation was strictly regulated by chiefs and the elite class (Handy *et al*., 1972; Titcomb, 1972; Titcomb, 1978). Titcomb documents an account from M.K. Pukui regarding fishing taboos in Ka'u, Hawai'i: Pukui says, "The taboo for inshore fishing covered also all the growths in that area, the seaweed, and shellfish, as well as the fish" (Titcomb, 1972: 14). Pukui goes on to describe how regulation and conservation worked:

When the *kahuna* [expert or priest] had examined the inshore area, and noted the condition of the animal and plant growths, and decided that they were ready for use, that is, that the new growth had had a chance to mature and become established, he so reported to the chief of the area, and the chief ended the *tabu*. For several days it remained the right of the chief to have all the sea foods that were gathered, according to his orders, reserved for his use, and that of his household and retinue. After this, a lesser number of days were the privilege of the *konohiki* [headman of an *ahupua'a*]. Following this period the area was declared open (*noa*) to the use of all (Titcomb, 1972: 14).

If this practice was widespread in the islands, as ethnohistoric records indicate, then commoners consumed different types of marine fauna from elites, and possibly smaller individual animals as well. It follows that archaeological assemblages associated with various social classes also differ, in some cases substantially (Kirch & O'Day, 2003). Concentration indices of archaeologically recovered fauna, from six commoner habitation sites (two households) and two elite residences indicate that commoners relied more heavily on the littoral and inshore marine resources, including fish and especially mollusks, than did elites. Commoner households contained abundant shellfish remains; these sites exhibit a broad-based pattern of invertebrate exploitation. For example, 19 more varieties of shellfish were identified in commoner assemblages than in elite contexts. Commoner households contained a high concentration of *Nerita* spp., *Littorina* spp., *Cypraea* spp., and Thaidids. Elite consumption emphasized a more select group of shellfish – especially *Cellana exarata*, a near-shore limpet, and certain species of large *Cypraea* and cones (*Conus* spp.). *Cellana exarata* occurs closer to shore and grows larger than other limpet species common to Kahikinui assemblages (Kay & Magruder, 1977; Kay, 1979).

A final detail, also derived from Titcomb's accounts, is that not all fish were protected. No taboos were imposed on various juvenile fishes that inhabit tide pools, including surgeonfishes (*Acanthurus* spp. and *Naso* spp.), parrotfishes

(*Scarus* spp.), and goatfishes (Mullidae). The frequent occurrence of these fishes is therefore to be expected in archaeological deposits from commoner households, as is supported by zooarchaeological data (O'Day, 2001; Kirch & O'Day, 2003). These points are critical to the understanding of variability between sites – that is, the variability is intricately tied to the social and the physical environments of the former residents.

Analysis of zooarchaeological remains from both commoner and elite households confirms the hypotheses generated from the ethnographic accounts: Overall, bony fish are more highly concentrated in elite sites. The fish remains from elite households contain more groupers (*Epinephelus* sp.), Carangids, and sharks (Carcharhinidae); these remains all represent relatively large carnivorous fish.

While the subtidal surveys provide a view of the faunal makeup in Lualailua and Auwahi, limited sea access to the central and eastern ahupua'a made it impossible to conduct similar surveys there. Thus an adequate representation of near-shore areas used in the past is lacking. Some of the inhabitants of Kahikinui likely used canoes, giving them ready access to the entire coastline and thus to fishing and collecting areas throughout the district. Near-shore and offshore areas were certainly important resources in the past, as indicated by the presence of pelagic and offshore fishes in the archaeological record. Because Kahikinui's leeward shoreline is geologically youthful and supports a burgeoning reef with relatively few top carnivores, it has fairly low inshore marine resource productivity. Although the littoral zone is dotted with many tide pools and bays, few are well developed and most do not contain abundant and varied fauna. Large carnivorous fish would have been important commodities prehistorically, as recorded ethnographically (Buck, 1957; Handy *et al*., 1972); they were reserved for special occasions and for consumption by the ruling classes.

CONCLUSIONS

The social environment imposes constraints that affect human exploitation patterns of animal resources; such constraints may be as important as the local environmental constraints. These limiting factors may become apparent from an ecological perspective when combined with zooarchaeological data and ethnographic records. Elsewhere (O'Day, 2001; Kirch & O'Day, 2003), we studied the differences between two social groups, elites and commoners, and showed a range of behavioral characteristics associated with prehistoric marine resource exploitation in Kahikinui. An ecological framework is needed if we are to understand these differences in quantitative terms, with data organized so that we can compare these areas with other areas within Polynesia; nevertheless the ecological framework fails to adequately explain all the variation, much of which is the result of social and historical factors.

We need to compare archaeological assemblages and environmental data with what we know about how people used, altered, and regulated their environment at the time of European contact. Hawaii's rich ethnographic and historical database provides a wealth of information from which we can gain invaluable insights into the life ways of Hawaiians during the early contact period. We can compare ethnographic descriptions of behavior with archaeological phenomena (archaeological materials) and can tease out the similarities and/or differences. These records also help us to formulate hypotheses that can be explored using archaeological remains and ecological frameworks, such as the way animal resources were used in the past. Zooarchaeological assemblages in Hawaii, and beyond, provide an opportunity for us to explore subtropical prehistoric fishing strategies and resource exploitation. However, we can enrich our interpretations of these assemblages if we combine multiple lines of evidence to create a holistic understanding of the past.

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Taxon	Common Name
Invertebrates	
Cephea cephea	Crowned jellyfish
Aiptasia pulchella	*Glass anemone*
Crustacean	
Diogenidae	Hermit crab
Grapsus tenuicrustatus	Thin shelled rock crab, *a'ma*
Mollusks	
Cellana exarata	Black foot limpet, *opihi*
Cellana sandwicensis	Yellow foot limpet, *opihi*
Nerita picea	Nerite
Littorina pintado	Littorine or periwinkle
Nodilittorina picta	Spotted littorina
Cypraea mauritiana	Cowrie
Drupa ricina	Drupe shell
Morula granulata	Drupe
Cantharus sp.	Whelk
Smaragdinella calyculata	Calyx Bubble Shell
Isognomon californicum	Purse Isognomon
Echinoderms	
Actinopyga mauritiana	White spotted sea cucumber
Holothuria sp.	Sea cucumber
Colobocentrotus atratus	Helmut urchin
Hetrocentrotus mammillatus	Slate pencil sea urchin
Echinometra mathaei	Rock boaring urchin
Echinometra oblonga	Oblong urchin
Echinothrix diadema	Longspined urchin
Vertebrates/Fish	
Myripristis spp.	Soldierfish
Kuhila sandvicensis	Hawaiian flag-tail, *aholehole*
Cirrhitus pinnulatus	Stocky hawkfish
Paracirrhites arcatus	Arc-eye hawkfish
Carangoides orthogrammus	Island jack
Caranx melampygus	Bluefin trevally
Parupeneus bifasciatus	Doublebar goatfish
Parupeneus cyclostomus	Blue goatfish
Parupeneus multifasciatus	Manybar goatfish
Kyphosus sp.	Chub
Chaetodon sp.	Butterflyfish
Chaetodon auriga	Threadfin butterflyfish
Chaetodon lunula	Raccoon butterflyfish
Chaetodon miliaris	Milletseed butterflyfish
Chaetodon multicinctus	Multiband butterflyfish
Chaetodon quadrimaculatus	Fourspot butterflyfish
Forcipiger longirostris	Forcepsfish
Chromis sp.	Damselfish
Chromis agillis	Agile chromis
Chromis hanui	Chocolate-dip chromis
Chromis ovalis	Oval chromis
Stegastes fasciolatus	Pacific gregory
Stegastes gregory	Pacific gregory
Coris flavovittata	Yellow tail coris
Coris venusta	Elegant coris
Gomphosus varius	Bird wrasse
Labroides phthirophagus	Hawaiian cleaner wrasse
Pseudocheilinus sp.	Wrasse
Thalassoma sp.	Wrasse
Thalassoma duperrey	Saddle wrasse
Scarus sp.	Parrotfish
Blenniidae	Blenny
Cirripectes obscurus	Gargantuan blenny
Entomacrodus marmoratus	Blenny
Zanclus cornutus	Morrish idol
Acanthurus sp.	Surgeonfish
Acanthurus achilles	Achilles tang
Acanthurus guttatus	Whitespotted surgeonfish
Acanthurus leucopareius	Whitebar surgeonfish
Acanthurus nigricans	Goldrim surgeonfish
Acanthurus nigrofuscus	Brown surgeonfish
Acanthurus nigroris	Bluelined surgeonfish
Acanthurus olivaceus	Orangeband surgeonfish
Acanthurus triostegus	Convict suergonfish
Ctenochaetus strigosus	Goldring suergonfish
Naso hexacanthus	Sleek unicornfish
Naso lituratus	Orangespine unicornfish
Zebrasoma flavescens	Yellow tang
Melichtyes sp.	Durgon
Rhinecanthus rectangulus	Reef tiggerfish
Sufflamen bursa	Lei tiggerfish
Chelonia mydas	Green sea turtle

APPENDIX 1

Modern species list from Kahikinui, Maui, Hawaii, with common names.