UPDATING PREHISTORIC MARITIME SUBSISTENCE AT LITTLE HARBOR, SANTA CATALINA ISLAND, CALIFORNIA

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ABSTRACT

A chronologically controlled synthesis of marine mammal remains recovered from three archaeological excavations at Little Harbor, Santa Catalina Island (CA-SCAI-17), reveals a striking pattern of intensive reliance on dolphin throughout the Holocene, climaxing in the Middle Holocene and followed by a precipitous decline in use of all marine mammals during the Late Holocene. Although dolphin has traditionally been considered low-ranked prey, the quantity of dolphin bone exceeds that of the more readily accessible and traditionally higher ranked pinnipeds during the entire time of site occupation. These data necessitate reassessment of currently accepted optimal foraging patterns of the early island people and present a new interpretation of the California maritime adaptation. While capture technology for these cetaceans remains enigmatic, several Pacific Island cultures in which dolphin were intensively exploited as highly ranked prey are reviewed as possible analogs to Little Harbor.

Keywords: Little Harbor, Santa Catalina Island, maritime subsistence, dolphin hunting.

INTRODUCTION

California archaeology today is increasingly focused on the prehistoric maritime adaptation of coastal California and the paleoclimatological environment which sculpted and sustained this adaptation. Numerous archaeofaunal assemblages from mainland coastal sites and the four Northern Channel Islands (Santa Cruz, Anacapa, San Miguel, and Santa Rosa) are described within diverse theoretical contexts, from fluctuating environmental conditions, population demographics, and changes in subsistence patterns to resultant cultural changes (e.g., Jones 1991; Arnold 1992; Arnold and Tissot 1993; Colten 1993, 1995; Glassow 1993, 1997; Broughton 1994; Jones and Hildebrandt 1995; Jones and Waugh 1995).

Typically these studies focus on shellfish, fish, and migratory pinnipeds, all considered the foundation resources of the maritime adaptation, especially on islands where terrestrial mammals are rare or absent (e.g., Erlandson 1988a 1988b, 1991; Glassow and Wilcoxon 1988; Colten 1991; Glassow 1992, 1993, 1996; Bowser 1993). In terms of mammalian protein, pinnipeds are consistently deemed the highest ranked prey. They provide large quantities of meat and fat calories and can be taken on land, especially females and juveniles basking in their rookeries (Colten 1993, 1995; Glassow 1993, 1997; Jones and Hildebrandt 1995). Emergent paleoclimatological data are frequently applied as context for the interactions of the early coastal people with their natural world and its marine resources (e.g., Pisias 1978, 1979; Larson et al. 1989; Carbone 1991; Stine 1994; Kennett 1998).

For the three Southern Channel Islands (San Nicolas, San Clemente, and Santa Catalina), scientifically gathered and analyzed archaeological data are less abundant, partly because San Nicolas and San Clemente Islands are military preserves, and Santa Catalina is privately owned and has been extensively developed. Only a few sites on the southern islands have been described in sufficient detail or with adequate chronological control to address questions of human ecology or the maritime adaptation in this region. As examples: the mammals and birds from the Thousand Springs Site (CA-SNI-11) on San Nicolas Island are described in a human ecological context by Bleitz-Sanburg (1987), and the dietary constituents of Eel Point on San Clemente Island (CA-SCLI-43) are documented with nearly 9,000 years of fine-grained chronological control and with reference to ecological and environmental factors (Raab and Yatsko 1992; Porcasi 1995; Raab et al. 1998).

Those two sites aside, what may prove to be one of the most important and unique maritime sites in the Southern Channel Islands from a subsistence point of view—the Little Harbor site on Santa Catalina Island (CA-SCAI-17)—is yet to be fully described even though it was the focus of a seminal ecological interpretation of the California maritime adaptation (Meighan 1959). Little Harbor has been excavated twice (in 1973 and 1991) since Meighan's report was published, but only small portions of data have been published. This paper presents a synthesized analysis of the mammalian archaeofaunas from these Little Harbor excavations with trans-Holocene chronological control. Emerging from these data is an entirely different prehistoric lifeway than previously recognized on the southern California islands.

MATERIALS AND METHODS

The Faunal Collections

The complete mammalian faunal collections from the 1973 and 1991 excavations at Little Harbor were identified using comparative specimens at the UCLA Zooarchaeology Laboratory, the UCLA Dickey Biological Collection, and the Los Angeles County Museum of Natural History. The 1953 to 1955 data are derived from Meighan (1959). The faunal assemblage is presented in terms of the Number of Identified Specimens (NISP), the NISP per cubic meter of excavated matrix, and the relative proportions (percentages) of marine mammal categories within a trans-Holocene timeframe. Because the mammalian collection is almost exclusively marine mammal, unidentified mammal bone is added to the identified marine mammal categories based on the proportional representations of the identified bones in each provenience.

Chronological Structure of the Analysis

To construct a temporal framework for this analysis (Table 1), three major periods of the Holocene, Early (8000 to 4650 BC), Middle (4650 to 1350 BC), and Late (1350 BC to 1500 AD) are established consistent with Erlandson (1997). The Little Harbor radiocarbon dates (and the Components [Raab et al. 1995:293], Natural Levels, and Layers [Meighan 1959] they represent) are then crossdated into these periods. To include stratigraphically intervening deposits for which no radiocarbon evidence is available and to differentiate between deposits identified as separate cultural entities but whose dates overlap other components (e.g., Component 4), two undated periods; i.e., the Undated Early/Middle (UE/M) and Undated Middle/Late (UM/L), are interposed between the dated periods. The stratigraphic position of these undated deposits between dated materials allows for relative temporal placement of all recovered materials.

While integrity of site stratigraphy has been questioned (Arnold et al. 1997), both Meighan (1959) and Raab et al. (1995) found that pothunting and erosional disturbance was limited to the upper 30 cm of the site. My analysis of the 1973 and 1991 faunal collections (more than 20,000 specimens from 34 screened units) yielded only 17 squirrel bones, no gopher bones, no rodent burrows, or other sources of bioturbation. Therefore, I concur that the primary cultural deposit between 30 and 65 cm is relatively undisturbed.

The Little Harbor Site

Santa Catalina Island is located 42 km southwest of Los Angeles Harbor, is the second largest of the California Channel Islands, and is the largest of the southern group. It is 34 km long and 13 km wide at its maximum, and is nearly bisected by a narrow isthmus about 1 km wide. The Little Harbor site caps a gently sloped headland towering hundreds of feet above a narrow embayment on the seaward coast of the island (Figure 1). A nearly vertical cliff overlooks the beach and surf below. The submarine Catalina Canyon thrusts directly into the bay at the base of the cliff.

Little Harbor contains an extremely dense midden measuring approximately 60 by 120 m. A well-defined, dark ashy deposit begins about 20 or 30 cm below the present surface and transitions into a clay basal stratum at

Table 1. Crossdating the stratigraphy at Little Harbor (Volumes are from 1973/1991 excavations only.)

Period/ Volume	^{14}C Dates[a]	1995 (Raab et al.) Components	1973 UCLA Natural Levels	1959 (Meighan) Layers[b]
Late 0.6 m^3	AD 1022 (956-1070) UCLA-1880A	5	--	2/3
	AD 657 (617-681) BETA-47276	4	--	2/3
UM/L 8.1 m^3	2384 BC (3922-4335) MEIGHAN-434	3	1	--
Middle 9.0 m^3	3172 BC (3028-3320) BETA-47277 THROUGH 3943 BC (3799-3967) BETA-47272	2	2	4
UE/M 4.2 m^3	--	--	3/4	--
Early 0.1 m^3	5704 BC (5579-5947) BETA-47278	1	--	--

[a] From Raab et al. (1995) cal. Years BC/AD, mean dates with corresponding 1-sigma intercepts in parentheses.

[b] Layer 1 was clay overwash. Layer 5 was noncultural subsoil.

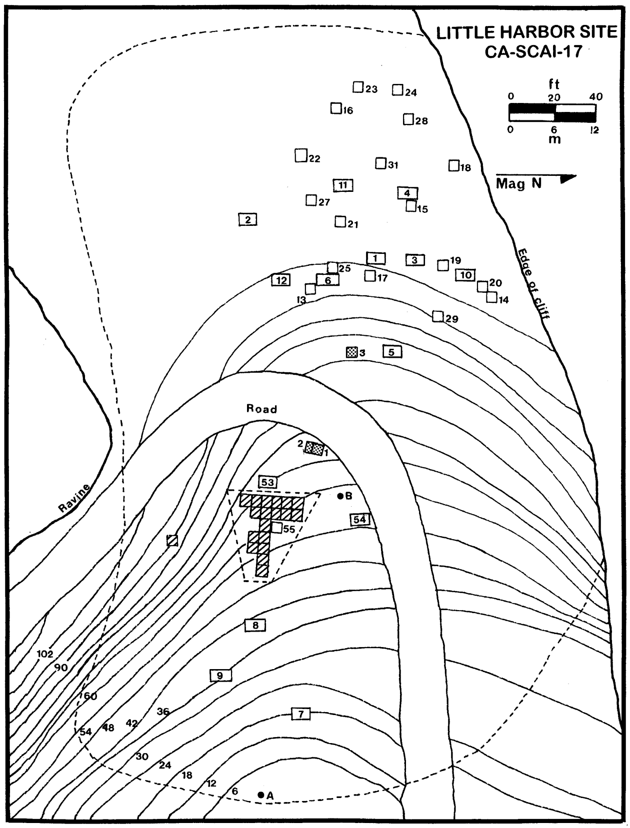

Figure 1. The Little Harbor site (CA-SCAI-17) and excavation units. Crosshatched units are 1953 to 1955 project, open units are 1973 project, and dotted units are 1991 project.

approximately 65 cm below the surface. This midden contains abundant marine shell, mammal, bird, and fish bones as well as lithic artifacts and other cultural materials. Because of the slope of the site and natural erosion over thousands of years, the depths of coeval cultural deposits are variable. In some units the dense midden or even the basal subsoil are found near the surface.

Three Little Harbor Excavations

In 1953 to 1955 a University of California, Los Angeles (UCLA), field school excavated 19 5-ft^2 test units on the upper knoll of the site. A total of 26 yd^3 of midden was excavated in 6-inch levels, yielding numerous artifacts, "innumerable" shells, and more than 6,200 bones and bone fragments (238 bone fragments per cubic yard of midden). The soil matrix was not screened during this project; excavators relied on visual recovery of all materials. Some 25 projectile points and 21 projectile point fragments were recovered, most deemed "large" (Fenenga 1953). Five "Layers" or distinct depositions were identified; Layer 4 being the dense cultural midden. A single radiocarbon date of 3880 ± 250 years before present was derived from the base of Layer 4, dendrocalibrated and corrected by CALIB 3.0.3 (Stuiver and Reimer 1993) to 2384 BC. However, this date remains enigmatic since the charcoal sample was derived from three different portions of the basal midden between 50 and 60 cm deep (Raab et al. 1995:294). The 1953 to 1955 project produced 4037 mammal bones and fragments, 536 (13%) of which were identified to family level. The remainder of the bones appeared to be the same types of animals. The collection was reported as 81% cetacea (primarily dolphins), 16% pinnipeds (seals), and 3% terrestrial mammals. Even though publication of these data in 1959 ushered in ecological interpretation of California's maritime adaptation, the report lacked the quantitative detail and chronological control needed for scientific faunal analysis. Because the proportion of dolphin bone was so extreme, this site has been considered a unique anomaly.

Little Harbor was again explored by a UCLA field school in 1973 under the direction of Nelson Leonard III, but this collection remained unanalyzed and no faunal data were published except a student's analysis of marine shell as a proxy of changes in the marine environment over time (Kaufman 1976). During the 1973 project, 31 units (20.5 m^3) were excavated and screened through 1/8-inch mesh (N. Leonard III, pers. comm. 1997). Most units were located west of the 1953 to 1955 excavation area, dispersed throughout the seaward-projecting cliff; a few were near the 1953 to 1955 units. Units were excavated to varying depths, and data recorded in arbitrary 10-cm levels as well as in four observable "Natural Levels" (NL), of which NL 2 was the rich midden level, corresponding with Meighan's Layer 4.

In 1997, I analyzed this collection of 17,929 mammal and bird bone fragments weighing 24,244 g (875 fragments per cubic meter). Of these, 3947 specimens (23.6% of the mammal bone) were identified marine mammals, while 83 specimens (less than 1%) were terrestrial mammals. The remainder of mammal bone was unidentified but was considered to be marine mammal and was quantified with the mammal categories based on the proportions (by NISP) of identified bone. Numerous large biface fragments and projectile points suitable for hunting large mammals were recovered. One Late Holocene date (1022 AD) was obtained from NL 1 and two Middle Holocene dates (3591 and 3336 BC) were obtained from NL 2, all dates from Unit 1 (Kaufman 1976) and corrected and calibrated (Raab et al. 1995:293).

In 1991, California State University, Northridge (CSUN), once again explored this site. This project consisted of three units excavated in arbitary 10-cm levels. A total volume of 1.575 m^3 was excavated and passed through 1/8-inch screen. This yielded 3,298 mammal and bird bone fragments weighing a total of 3,587.18 g (2,094 fragments per cubic meter). Of the total mammalian collection, 623 specimens (22%) were identified marine mammal bone, while 35 specimens (1.2%) were terrestrial mammal (excluding human bone). As in the 1973 project, unidentified mammal bone was quantified in the marine mammal categories in proportions based on NISP of identified bone.

Six additional radiocarbon dates were obtained from various levels of the three units. On the basis of these dates, along with the earlier published dates, Raab et al. (1995:293) describe the chronology of this site and a series of 5 cultural components spanning the Holocene. The richest of these components is Component 2, which corresponds with Layer 4 described by Meighan (1959:386) and NL 2 identified during the 1973 excavation. Based on the average of six radiocarbon dates, an estimated date of 3316 ± 30 BC was established for Component 2. The earliest date derived from the site is 5704 BC (calibrated and corrected), some 3,000 years earlier than Meighan's original date.

Although the entire avian and mammalian faunal collection was identified, only a small portion of the data dealing with dolphin species was published in the context of a disputed paleoclimatic model (Raab et al. 1995). That publication engendered further debate on the nature of trans-Holocene climatological patterns and the possible effects these patterns may have had on the formation of complex cultures in prehistoric coastal California (Arnold et al. 1997; Raab and Larson 1997). Clearly a comprehensive synthesis of the Little Harbor archaeofaunal assemblages with chronological control is timely to join this debate and to provide new data for future research.

RESULTS

Marine Mammal Exploitation Over Time

Table 2 summarizes the combined 1973 and 1991 nonpiscine archaeofaunal assemblage. The 1953 to 1955 collection is not included since it was unscreened and is not quantifiable by provenience. Table 3 lists identified mammal species. Figure 2(A) presents changes in the faunal assemblage over time in terms of simple NISP. Figure 2(B) shows these NISPs controlled by excavated volume of each time period. Because most of the cultural midden is dated to the Middle Holocene and the UM/L, the large volume of matrix of those periods reduces the bone frequency per cubic meter values. Conversely, the lesser volumes assigned to the Early and Late Holocene and the UE/M tend to inflate the bone frequency per cubic meter values of those periods. These inexactitudes are due to sample size bias and the ever-present enigma of depositional rate. However, Raab et al. (1995:294) estimate that Component 2 was deposited during one to three centuries. If that is the case, the deep and dense Component 2 midden reflects a rapid and profound accumulation of marine mammal bone.

While no scientifically sound method is available for determining depositional rate, we can eliminate bias due to sample size by converting data to percentages. Figure 2(C) shows that dolphins were the primary mammalian resource relative to pinnipeds, otters, or larger cetaceans during the entire occupation of Little Harbor. However, there was a moderate increase in pinnipeds relative to dolphins during the Middle Holocene, after which the dolphins again increased relative to pinnipeds. In general, marine mammal exploitation climaxed during the Middle Holocene and declined precipitously thereafter.

Optimal Foraging Considerations

Applying optimal foraging principles, pelagic dolphins should be low-ranked. Resources are ranked, in terms of the diet-breadth model, by their post-encounter return rate, the amount of energy gathered per unit time after encountering a resource (Kelly 1995:78). Convention holds that seasonally migratory pinnipeds are the highest ranked mammalian food source on the Channel Islands, where herds of breeding females and their young are considered the primary targets (Hildebrandt and Jones 1992; Lyman 1995). Most archaeofaunal assemblages reported to date have reflected this principle. Oceangoing watercraft and advanced technology (e.g., harpoons) needed to capture pelagic animals such as dolphins, not to mention the energetic costs involved, would be expected to limit dolphin capture to opportunistic entrapments in fishing nets or natural strandings. But as Jones (1991:420) states, we can assume that "resources will enter the hunter-gatherer colonist diet in the order of energetic efficiency, and that the archaeological record preserves the

Table 2. Summary of the 1973/1991 Little Harbor osteological collections.

Category	NISP	% of Total NISP	% of Ident. NISP (6075)	% of Ident. Marine Mammal (4570)
Delphinidae	3,072	14.5	50.1	67.2
Pinnipeds	1,009	4.75	16.6	22
Sea Otters	95	<1	1.6	2
Unid. Cetacea	394	1.86	6.5	8.6
Terrestrial Mammals	118	<1	1.9	--
Unid. Mammals	14,871	70.0	--	--
Birds	1,268	6.0	20.9	--
Humans	118[a]	<1	1.9	--
Snake	1	<1	<1	--
Unid. Vertebrates	281	1.3	--	--
Total	21,227			

[a] Remains of a cremation recovered during the 1991 project.

Table 3. Mammals identified at Little Harbor 1973/1991.

Marine Mammals	
Pinnipeds	
Arctocephalus townsendii	Southern (Guadalupe) fur seal
Callorhinus ursinus	Northern fur seal
Mirounga angustirostris	Elephant seal
Phoca vitulina	Harbor seal
Zalophus californianus	California sea lion
Cetacea	
Delphinus delphis	Common dolphin
Globicephala macrorhynchus	Pilot whale
Lagenorhynchus obliquidens	White-sided dolphin
Lissodelphis borealis	Northern right whale dolphin
Stenella coeruleoalba	Blue and white dolphin
Tursiops truncatus	Bottlenosed dolphin
Mustelidae	
Enhydra lutris	Sea otter
Terrestrial Mammals	
Canis familiaris	Domestic dog
Homo sapiens	Human
Odocoileus hemionus	Black-tailed (mule) deer
Peromyscus maniculatus	Deer mouse
Spermophilus beecheyi	California ground squirrel
Urocyon littoralis	Island fox

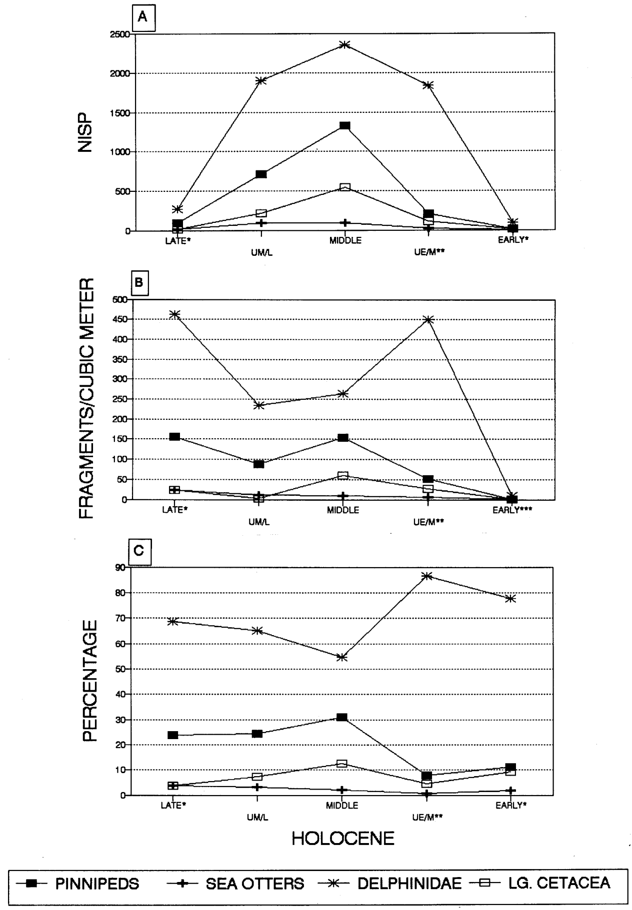

Figure 2. Little Harbor marine mammal data. (A) NISPs over time; (B) volume-controlled NISPs; (C) percentages over time. (*1991 data; **1973 data; ***1991 data based on only .10 cu/m; middle and UM/L data are averaged for both years.)

history of this resource use." How then can we explain the Little Harbor faunal evidence which clearly shows that dolphins were the highest rank prey?

DISCUSSION

The composite Little Harbor faunal collection reveals a consummate maritime adaptation in which the highest ranked prey mammals are dolphins, not pinnipeds. This finding is contrary to the extant body of faunal analyses on the southern California coast and is equally contrary to presently accepted concepts of optimal foraging as applied to the early islanders. To explore the implications of this surprising circumstance, we must deal with the crucial question of how the dolphin were obtained. That is the key to this apparent optimal foraging anachronism.

The Strandings Question

Whenever archaeological dolphin bone is recovered, the question arises of natural strandings versus active hunting. This question is especially relevant for Little Harbor where the quantity of dolphin bone introduces a wholly new perspective on maritime adaptation. While we have no direct evidence of active dolphin hunting at Little Harbor, there are several reasons for rejecting the alternative that the dolphin bone was the result of natural strandings.

Faunal reports from other coastal or island sites include only small quantities of dolphin bone, if any. If archaeologically recovered dolphin bone was the result of strandings alone, we would expect to find rather evenly distributed quantities, chronologically and spatially. This is not the case.

Nor can strandings account for the overwhelming prevalence of dolphin bone at Little Harbor. The beaches of the three southern counties of the Southern California Bight (Los Angeles, Orange, and San Diego Counties) experience about 15 stranded dolphins per year (25 in a very "bad" year), along hundreds of miles of coastline; the southern islands with their relatively small coastal lengths, experience one or two reported stranded dolphins per year per island (J. Heyning, pers. comm. 1997). The same general pattern is found in the northern three counties of the Bight: Ventura, Santa Barbara, and San Luis Obispo (C. Woodhouse, pers. comm. 1997). While these numbers are probably less than complete, they provide a general level of expected strandings.

Furthermore, if the Little Harbor dolphins were strandings, they would have to have been within a reasonable "schlepping" range of the site. It is unlikely that the foraging range of Little Harbor, a few kilometers of island coastline, yielded the prodigious quantities of dolphin found there. While the method of dolphin capture is archaeologically invisible, it appears that the economics of dolphin capture were more beneficial than those of pinniped hunting.

The Economics of Dolphin Hunting

What factors could mitigate our traditional, intuitive constraints against active hunting of pelagic dolphin by archaic people? Some characteristics of dolphin life history might be considered. Unlike seasonally migratory pinnipeds which return each year to ancestral rookeries where they can be exploited to scarcity, dolphins need no on-shore rookeries or haulouts and need not return to habitual feeding grounds. Therefore, they are less vulnerable to overexploitation, especially breeding females and their young. Dolphins are also less affected by short-term climatic events, such as El Niño, or extended periods of warm waters which can decimate pinniped populations (Trillmich and Ono 1991; Colten 1993). In short, dolphins are a more stable resource than pinnipeds. A site occupied throughout the year would tend to accumulate more dolphin than pinniped bone each year because pinnipeds are absent for part of the year. Nevertheless, these factors alone cannot explain the predominance of dolphin at Little Harbor. The daunting problem of dolphin capture is still unanswered. In order for dolphin to be a high-ranked prey, the islanders must have used a hunting technique which reduced technological and energetic costs to the point that dolphins were more economical to capture than beached pinnipeds.

No evidence of canoes or harpoons has been recovered at Little Harbor. This lack of open-ocean artifacts at Early and Middle Holocene island and coastal sites has been tacitly accepted as negative evidence that marine mammals (i.e., pinnipeds) were simply clubbed on shore. However, numerous large projectile points are found at these sites, and these may have been used to hunt marine mammals offshore. Netting dolphins, perhaps along with schools of fish, is possible, especially within a narrow embayment such as Little Harbor, but there is no direct evidence of large-scale net-fishing at the site. Some indirect evidence of net-fishing may be the large quantity of scombridae bone (tuna family) found at Little Harbor (Salls 1988:408). These schooling fish, along with associated dolphin pods, have been commonly taken in large quantities with nets both prehistorically and historically. While the islanders certainly had watercraft, these are assumed to have been simple rafts or dugout canoes. The more elaborate plank canoe is not known in the islands until some 2,000 to 1,000 years ago, and the seaworthiness of dugouts and their application to pelagic hunting of large mammals is debated (Gould 1968; Jobson and Hildebrandt 1980; Hudson 1981; Hildebrandt and Jones 1992). In the following section I present global archaeological and ethnographic data which may serve as analogs of the Little Harbor dolphin hunting technique. In these scenarios, only the simplest watercraft and little or no weaponry is needed to capture large numbers of dolphin.

Examples of Prehistoric Dolphin Hunting

Archaeological data and ethnology from several island nations suggest how archaic people may have captured large quantities of dolphin with little or no "technology" or energetic cost, especially at sites with narrow embayments such as Little Harbor. The techniques used by these different groups of dolphin hunters are remarkably similar, whether archaic, late prehistoric, or even modern. They all use primitive watercraft (usually dugouts) and rarely depend on weaponry, simple or advanced. Instead, they all apply their knowledge of a fatal vulnerability of the dolphin—its otherwise splendid socio-biologic communication and echo-location system—to their advantage. This natural system of the dolphin, which serves so well in marine life, can be manipulated by humans to capture numerous dolphins during a single hunt.

The unanimous technique found thoughout the island nations is to surround and drive herds of dolphin using disruptive and aversive sound until the animals are exhausted and confused, floundering into narrow coves, shallow waters, or mangrove swamps where they are easily captured, even by hand.

First, two recent examples with prehistoric antecedents. In the Solomon Islands, hunters offshore in an armada of dugouts locate and surround pods of incoming dolphins. The hunters then knock together, underwater, 15-cm cobbles (called nagi). The dolphins become disoriented and flee the sound, often following a societal leader, into narrow passages where they can be captured among the shallow waters and mangrove roots. There, "everyone from the village," including women and children, jumps into the water to hand-catch the dolphins. Each villager holds a dolphin softly by its mouth and swims with it toward a canoe. The dolphins are hauled into canoes, killed on shore and taken back to the village (Takekawa 1996:67-72).

In the Faroe Islands a drive fishery of small cetaceans (mainly pilot whales) which began thousands of years ago continues today. Known as the "grind," this procedure, like that of the Solomon Islands, involves driving the cetaceans ashore with shouting, slapping the water, making aversive underwater sounds by knocking rocks together. In most cases it takes only two to four hours to drive an entire herd of cetaceans onshore, where they are dispatched in minutes using knives (Bloch et al. 1990; Zachariassen 1993; Bjorge et al. 1994). While the early Norsemen had spears and harpoons, these are not needed to kill the cetaceans at sea. Today the weapons are retained as ceremonial regalia, and special permission is required to use them in the hunt.

From a late prehistoric context, Steadman et al. (1994) report that Easter Islanders used dugout canoes in an economy based largely on dolphin hunting. Dolphin bones are the top ranked and most numerous prey at the site until ca. 500 years ago when the island became totally deforested. These islanders used dugouts and spears to capture dolphin, but when the trees were gone, dugouts could no longer be manufactured and dolphin hunting abruptly ceased. Dolphin were replaced in the islanders' diet by rats and native birds. Pinnipeds were the sixth ranked prey (Steadman et al. 1994:89-91).

Perhaps the most telling archaeological evidence for trans-Holocene dolphin hunting by the herding technique comes from Jomon, Japan. In Japan ca. 5,000 years ago (at about the same time the Little Harbor dolphin were being heavily harvested), the Jomon people collected, butchered, and communially shared hundreds of dolphin at several sites in the Hokkaido and Kyushu regions (Hiraguchi 1992, 1993b; Tanigawa 1997). The Jomon created aversive noise to drive the dolphin into nets at the beach by slapping the water with rods, screaming, and banging on the sides of their boats. At the Mawaki site on the Noto peninsula the bones of more than 286 individual dolphins were recovered in a large-scale driving fishery where harpoons and hooks were undeveloped (Hiraguchi 1992:35). In other areas of Japan toggle harpoon heads are found dated to the Early Jomon Period (ca. 4,000 to 3,000 BC) (Hiraguchi 1993a). Dolphin were so important to these people that some crania appear to have been ritually buried and at least one skull appears to be part of a shrine. Hiraguchi comments that the activities associated with dolphin fishing must have contributed greatly to the formation of Jomon-period social organization at Mawaki. The Mawaki inlet is ideal for herding and netting dolphins and is described as "the best fishery in the bay and the best place for catching live whales" (Ishikawa Library Association 1938). An illustration of Noto area (Mawaki) fishing drawn in 1838 notes that a thousand dolphin could be driven into a net, where it took two days to dispatch them all (Hiraguchi 1992). In several respects, Mawaki is much like Little Harbor during the Middle Holocene. It has a large embayment, many dolphin remains, and warmer waters than other nearby areas (Hiraguchi 1992:36). Kennett (1998:123) has reported that during several sustained Middle Holocene periods, the waters of the Santa Barbara channel were much warmer than in the Late Holocene.

In summary, the technique of driving small cetacean herds onshore with disruptive and aversive underwater sounds appears to have been recognized by a number of prehistoric peoples (Bjorge et al. 1994). Little or no technology other than simple dugouts was required. This same technique might have been employed at Little Harbor. The narrow Little Harbor embayment and the deep submarine canyon, and perhaps a warm-water environment, might have facilitated this harvest.

I do not imply from these global illustrations that the early southern California islanders were associated with other Pacific island cultures. However, I am willing to hypothesize that the biological vulnerability of the dolphin to this means of capture was as easily recognized by the California islanders as by the other islanders. From there it would be a simple step, almost second nature, to devise a hunting technique using only dugouts and cobbles to drive dolphins into Little Harbor's shore.

CONCLUSION

The early inhabitants of Little Harbor exploited dolphin as their primary mammalian resource throughout the Holocene. Further research is needed to determine the details of dolphin hunting methods and the geographical and chronological extent of this or similar adaptations along the southern California coast. There is already some evidence that dolphin hunting was not limited to Little Harbor. The Eel Point site (CA-SCLI-43) on neighboring San Clemente Island yields an faunal collection nearly as focused on dolphin as Little Harbor (Raab et al. 1998). Other sites on San Clemente also produce small-sample indications of dolphin exploitation (Noah 1987). Preliminary data from the Punta Arena site on Santa Cruz Island reveal notable quantities of dolphin dated to the Middle Holocene (M. Glassow, pers. comm. 1998). A recently completed faunal analysis from a Sea of Cortez site south of La Paz, Baja California Sur, has produced an archaeofauna 98% dolphin (Fujita 1998). As more coastal and island sites with long time depth are explored, this aspect of early California lifeways may be more clearly understood.

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LITERATURE CITED

Arnold, J. E. 1992. Complex hunter-gatherer-fishers of prehistoric California: Chiefs, specialists, and maritime adaptations of the Channel Islands. American Antiquity 57:60-84.

Arnold, J. E. and B. N. Tissot. 1993. Measurement of significant marine paleotemperature variation using black abalone shells from prehistoric middens. Quaternary Research 39:390-394.

Arnold, J. E., R. H. Colten, and S. Pletka. 1997. Contexts of cultural change in insular California. American Antiquity 62:300-318.

Bjorge, A., R. L. Brownell, Jr., G. P. Donavan, and W. Perrin. 1994. Significant direct and incidental catches of small cetaceans. Pages 76-128 *in* Perrin, W., G. P. Donavan, and J. Barlow (eds.), Gillnets and Cetaceans. International Whaling Commission Special Issue 15, Cambridge.

Bleitz-Sanburg, D. E. 1987. Changing exploitation of mammalian and avian food resources at SNI-11, San Nicolas Island, California. Unpublished masters thesis, Department of Anthropology, California State University, Los Angeles.

Bloch, D., G. Desportes, K. Hoydal, and P. Jean. 1990. Pilot whaling in the Faroe Islands, July 1986-July 1988. North Atlantic Studies 2(1, 2):36-44.

Bowser, B. 1993. Dead fish tales: Analysis of fish remains from two middle period sites on San Miguel Island, California. Pages 95-136 *in* Glassow, M. A. (ed.), Archaeology on the Northern Channel Islands of California. Archives of California Prehistory No. 34, Coyote Press, Salinas, CA.

Broughton, J. M. 1994. Declines in mammalian foraging efficiency during the late Holocene, San Francisco Bay, California. Journal of Anthropological Archaeology 13:371-401.

Carbone, L. A. 1991. Early Holocene environments and paleoecological contexts on the central and southern California coasts. Pages 11-18 *in* Erlandson, J. M. and R. H. Colten (eds.), Hunter-Gatherers of Early Holocene Coastal California. Perspectives in California Archaeology, Volume 1, Institute of Archaeology, University of California, Los Angeles.

Colten, R. H. 1991. Fishing during the millingstone horizon? New data from the Glen Annie Canyon site, Santa Barbara County. Pages 81-88 *in* Erlandson, J. M. and R. H. Colten (eds.), Hunter-Gatherers of Early Holocene Coastal California. Perspectives in California Archaeology, Volume 1, Institute of Archaeology, University of California, Los Angeles.

Colten, R. H. 1993. Prehistoric subsistence, specialization, and economy in a southern California chiefdom. Ph.D. dissertation, Department of Archaeology, University of California, Los Angeles.

Colten, R. H. 1995. Faunal exploitation during the Middle to Late Period transition on Santa Cruz Island, California. Journal of California and Great Basin Anthropology 17:93-120.

Erlandson, J. M. 1997. The Middle Holocene along the California coast. Pages 1-10 *in* Erlandson, J. M. and M. A. Glassow (eds.), Archaeology of the California Coast During the Middle Holocene. Perspectives in California Archaeology, Volume 4, Institute of Archaeology, University of California, Los Angeles.

Erlandson, J. M. 1988a. Of millingstones and molluscs: Cultural ecology of early Holocene hunter-gatherers on the California coast. Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

Erlandson, J. M. 1988b. The role of shellfish in prehistoric economies: A protein perspective. American Antiquity 52:102-109.

Erlandson, J. M. 1991. Shellfish and seeds as optimal resources: Early Holocene subsistence on the Santa Barbara Coast. Pages 89-100 *in* Erlandson, J. M. and R. H. Colten (eds.), Hunter-Gatherers of Early Holocene Coastal California. Perspectives in California Archaeology, Volume 1, Institute of Archaeology, University of California, Los Angeles.

Fenenga, F. 1953. The weights of chipped stone points: A clue to their functions. Southwestern Journal of Anthropology 9(3):309-323.

Fujita, H. 1998. Informe del rescate arqueológico en el sitio #31 Las Tinas #3, Municipio de La Paz, B.C.S. Instituto Nacional de Antropología e Historia, La Paz, Baja California Sur.

Glassow, M. A. 1992. The relative dietary importance of marine foods through time in western Santa Barbara County. Pages 115-128 *in* Jones, T. L. (ed.), Essays on the Prehistory of Maritime California. Center for Archaeological Research at Davis Publication No. 10, University of California, Davis.

Glassow, M. A. 1993. Changes in subsistence on marine resources through 7,000 years of prehistory on Santa Cruz Island, California. Pages 75-94 *in* Glassow, M. A. (ed.), Archaeology on the Northern Channel Islands of California. Archives of California Prehistory No. 34, Coyote Press, Salinas, CA.

Glassow, M. A. 1996. Purisimeño Chumash Prehistory: Maritime Adaptation Along the Southern California Coast. Harcourt Brace & Co., Fort Worth.

Glassow, M. A. 1997. Middle Holocene cultural development in the central Santa Barbara Channel region. Pages 73-90 *in* Erlandson, J. M. and M. A. Glassow (eds.), Archaeology of the California Coast during the Middle Holocene. Institute of Archaeology, University of California, Los Angeles.

Glassow, M. A. and L. R. Wilcoxon. 1988. Coastal adaptations near Point Conception, with particular regard for shellfish exploitation. American Antiquity 53:36-51.

Gould, R. A. 1968. Seagoing canoes among the Indians of northwestern California. Ethnohistory 15:11-42.

Hildebrandt, W. R. and T. L. Jones. 1992. Evolution of marine mammal hunting: A view from the California and Oregon coasts. Journal of Anthropological Archaeology 11:360-401.

Hiraguchi, T. 1992. Catching dolphins at the Mawaki site, central Japan, and its contribution to Jomon society. Pages 35-45 *in* Aikens, C. M. and S. N. Rhee (eds.), Pacific Northeast Asia in Prehistory: Hunter-Fisher-Gatherers, Farmers, and Sociopolitical Elites. Washington State University Press, Pullman.

Hiraguchi, T. 1993a. The variety of ancient whaling. International Marine Biological Research Institute (IBI) Reports 4:49-56.

Hiraguchi, T. 1993b. Dolphin fishing in the inshore of the Noto Peninsula and the Tsushima Islands. Nihonkai Cetology 3:37-42.

Hudson, T. 1981. To sea or not to sea: Further notes on the "oceangoing" dugouts of north coastal California. Journal of California and Great Basin Anthropology 3(2):269-282.

Ishikawa Library Association 1938. Noto Schicho 2, Kanazawa. (Republication in 1969) in Japanese.

Jobson, R. and W. R. Hildebrandt. 1980. The distribution of oceangoing canoes on the north coast of California. Journal of California and Great Basin Anthropology 2(2):165-174.

Jones, T. L. 1991. Maritime-resource value and the priority of coastal settlement: a California perspective. American Antiquity 56:419-443.

Jones, T. L. and W. R. Hildebrandt. 1995. Reasserting a prehistoric tragedy of the commons: reply to Lyman. Journal of Anthropological Archaeology 14:78-98.

Jones, T. L. and G. Waugh. 1995. Climatic consequences or population pragmatism?: A Middle Holocene prehistory of the central California coast. Pages 111-128 *in* Erlandson, J. M. and M. A. Glassow (eds.), Archeology of the California Coast During the Middle Holocene. Perspectives in California Archaeology, Volume 4, Institute of Archaeology, University of California, Los Angeles.

Kaufman, T. S. 1976. Environmental analysis of the Little Harbor archaeological site, Santa Catalina Island, California. Unpublished masters thesis, Department of Anthropology, University of California, Los Angeles.

Kelly, R. L. 1995. The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways. Smithsonian Institution Press, Washington D. C. and London.

Kennett, D. J. 1998. Behavioral ecology and the evolution of hunter-gatherer societies on the northern Channel Islands, California. Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

Larson, D. O., J. Michaelsen, and P. L. Walker. 1989. Climatic variability: A compounding factor causing culture change among prehistoric coastal populations. Paper presented at the 54th Annual Meeting of the Society for American Archaeology, Atlanta.

Lyman, R. L. 1995. On the evolution of marine mammal hunting on the west coast of North America. Journal of Anthropological Archaeology 14:45-77.

Meighan, C. W. 1959. The Little Harbor site, Catalina Island: An example of ecological interpretation in archaeology. American Antiquity 24:383-405.

Noah, A. C. 1987. A meeting of paradigms: A late-century analysis of mid-century excavations on San Clemente Island. Unpublished masters thesis, Anthropology Department, San Diego State University, San Diego.

Pisias, N. G. 1978. Paleoceanography of the Santa Barbara basin during the last 8,000 years. Quaternary Research 10:366-384.

Pisias, N. G. 1979. Model for paleoceanographic reconstructions of the California current for the last 8,000 years. Quaternary Research 11:373-386.

Porcasi, J. F. 1995. Trans-Holocene marine mammal hunting on San Clemente Island, California: Additional data to assess a prehistoric "tragedy of the commons" and declining mammalian foraging efficiency. Unpublished masters thesis, Department of Anthropology, California State University, Northridge.

Raab, L. M. and A. Yatsko. 1992. Ancient maritime adaptations of the California bight: A perspective from San Clemente Island. Pages 173-193 *in* Jones, T. L. (ed.), Essays on the Prehistory of Maritime California. Center for Archaeological Research at Davis Publication No. 10, University of California, Davis.

Raab, L. M., K. Bradford, J. F. Porcasi, and W. J. Howard. 1995. Return to Little Harbor, Santa Catalina Island, California: A critique of the marine paleotemperature model. American Antiquity 60(2):287-308.

Raab, L. M., J. F. Porcasi, K. Bradford, T. S. Garlinghouse, and A. Yatsko. 1998. Rethinking maritime southern California during the Late Holocene: A southern channel islands perspective. Paper presented at the annual meeting of the Society for American Archaeology, Seattle.

Raab, L. M. and D. O. Larson. 1997. Medieval climatic anomaly and punctuated evolution in coastal Southern California. American Antiquity 62:319-336.

Salls, R.A. 1988. Prehistoric fisheries of the California Bight. Ph.D. dissertation, Department of Anthropology, University of California, Los Angeles.

Steadman, D. W., P. V. Casanova, and C. C. Ferrando. 1994. Stratigraphy, chronology, and cultural context of an early faunal assemblage from Easter Island. Asian Perspectives 33(1):79-96.

Stine, S. 1994. Extreme and persistent drought in California and Patagonia during mediaeval time. Nature 369:546-548.

Stuiver, M. and P. J. Reimer. 1993. Extended 14C data base and revised CALIB 3.0 14C age calibration program. Radiocarbon 35:215-230.

Takekawa, D. 1996. The method of dolphin hunting and the distribution of teeth and meat: Dolphin hunting in the Solomon Islands 2. Pages 67-80 *in* T. Akimichi (ed.), Coastal Foragers in Transition. Senri Ethnological Studies No. 42, National Museum of Ethnology, Osaka.

Tanigawa, K. 1997. Kujira, iruka no minzoku. Nihon minzoku bunka shiryo shusei Vol. 18, San'ichi shobo, Tokyo.

Trillmich, F. and K. A. Ono (eds.). 1991. Pinnipeds and El Niño. Ecological Studies 88. Springer-Verlag, Berlin.

Zarchariassen, P. 1993. Pilot whale catches in the Faroe Islands, 1709-1992. Pages 69-88 *in* Donavan, G. P., C. H. Lockyer, and A. R. Martin (eds.), Biology of Northern Hemisphere Pilot Whales. International Whaling Commission Special Issue 14, Cambridge.

SOURCES OF UNPUBLISHED MATERIALS

Glassow, M. A. Anthropology Department, University of California, Santa Barbara. Personal communication 1998.

Heyning, J. E. Natural History Museum of Los Angeles County. Personal Communication 1997.

Leonard III, N. A. Eagle Point, Oregon. Personal communication 1997.

Woodhouse, C. D. Santa Barbara Museum of Natural History. Personal communication 1997.