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The Native American Fishery of Cedros Island, Baja California, and a Comparison with the Fisheries of the Islands of the Southern California Bight

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We report the identification of nearly 4,000 fish bones from archaeological sites on Cedros Island, Baja California, Mexico, that range in age from approximately 10,010 cal B.C. to 1630 cal A.D. Wrasses were the most represented group of fishes, followed closely by sea basses, tilefishes, and croakers. Of the individual species identified, ocean whitefish, California sheephead, and white croaker were the most abundant. Comparisons to fishes from modern surveys and to fishes specific to particular marine habitats suggest that the diversity of fishes was very similar to that found today, and are most closely associated with kelp bed/rocky reefs and nearshore soft-bottom areas. We also compare the Cedros Island archaeological fishes to those from archaeological excavations on islands of the Southern California Bight. We infer that the fishery of the native peoples of Cedros Island and other California islands was primarily inshore in predictable locations.

The native American fisheries of the islands of the Southern California Bight have received considerable attention (Braje 2010; Colten 2001; Erlandson et al. 1999; Glassow et al. 2008; Gusick 2008[1]; Porcasi 2012; Rick 2007; Rick et al. 2001; Salls 2000). Farther south lie the islands off the Pacific coast of the Baja Peninsula, the largest of which is Cedros Island. Three decades ago, the smaller, more northerly Coronado Islands, located approximately 12 km. off the coast just south of the U.S.-Mexico border, received archaeological attention with proposed excavation (May and Ike 1981). Within the last decade, it is on Cedros Island that extensive archaeological work has been undertaken, including a limited consideration of the local fishery (Des Lauriers 2010).

In this paper we describe the results of an analysis of additional archaeological fish materials from Cedros Island. To provide some context, we also compare the fishery of Cedros Island with those of the islands of the Southern California Bight, as well as provide a literature basis for establishing the aquatic habitats exploited by the native fishers of Cedros Island. Key to the differences

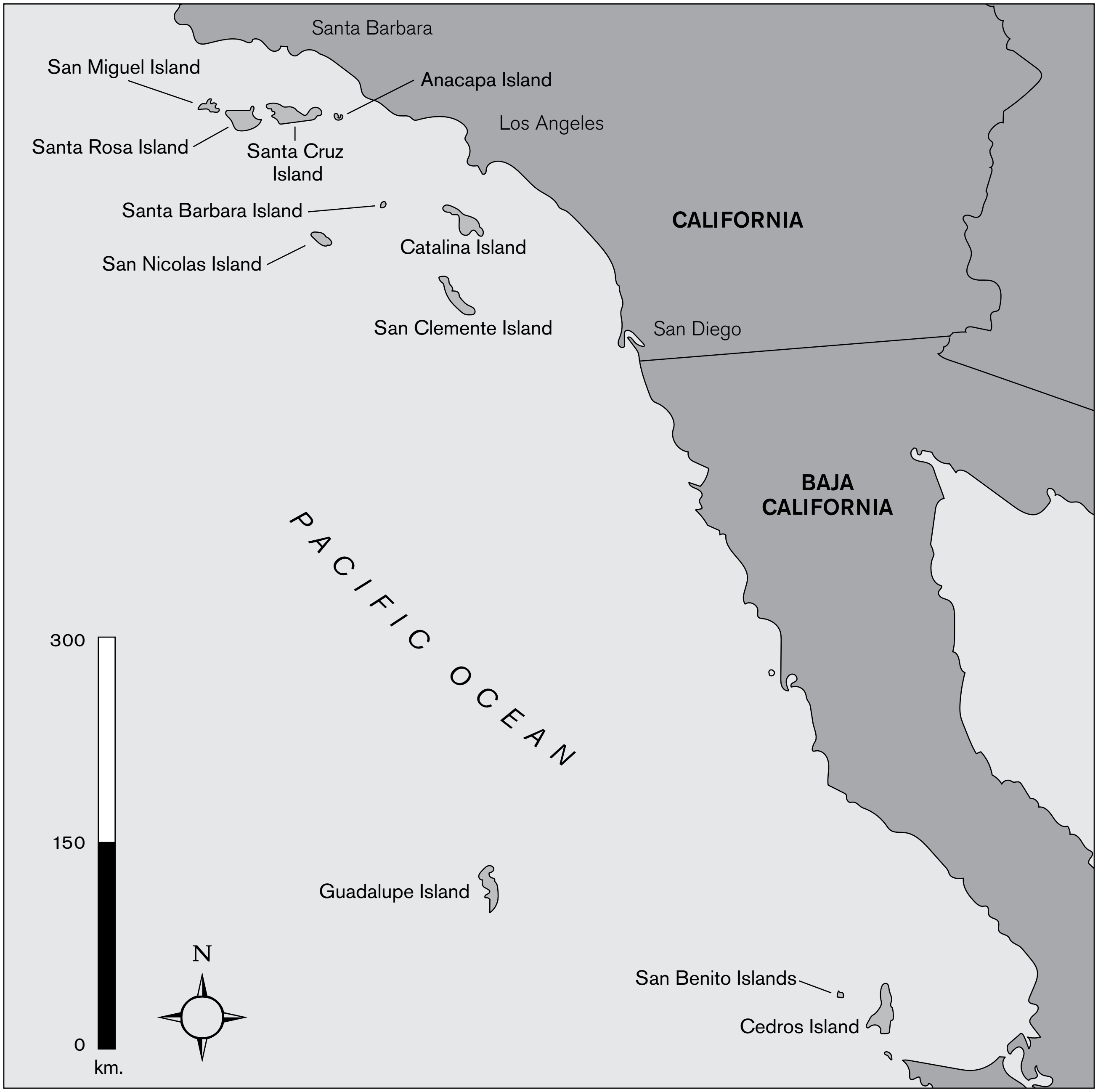

Figure 1. Location of Cedros Island relative to the islands of the Southern California Bight.

in the fisheries among the islands are biogeographic considerations that we subject to statistical analysis.

MATERIALS AND METHODS

Archaeological excavations on Cedros Island between 2003 and 2009 (Des Lauriers 2010), under the auspices of the *Proyecto Arqueológico Isla de Cedros* (Cedros Island Archaeological Project, or PAIC), provided the material analyzed here. Des Lauriers (2010) has reported on site and dwelling characteristics, artifacts, and faunal remains that indicate humans settled the area (later an island) about 12,000 cal B.P. The discovery of a number of artifacts, including single-piece shell fishhooks that date to the early Holocene (~10,300 to ~9,000 cal B.P.), suggests that these early settlers possessed a fishing technology by that time indicative of well-developed marine resource utilization (Des Lauriers 2010).

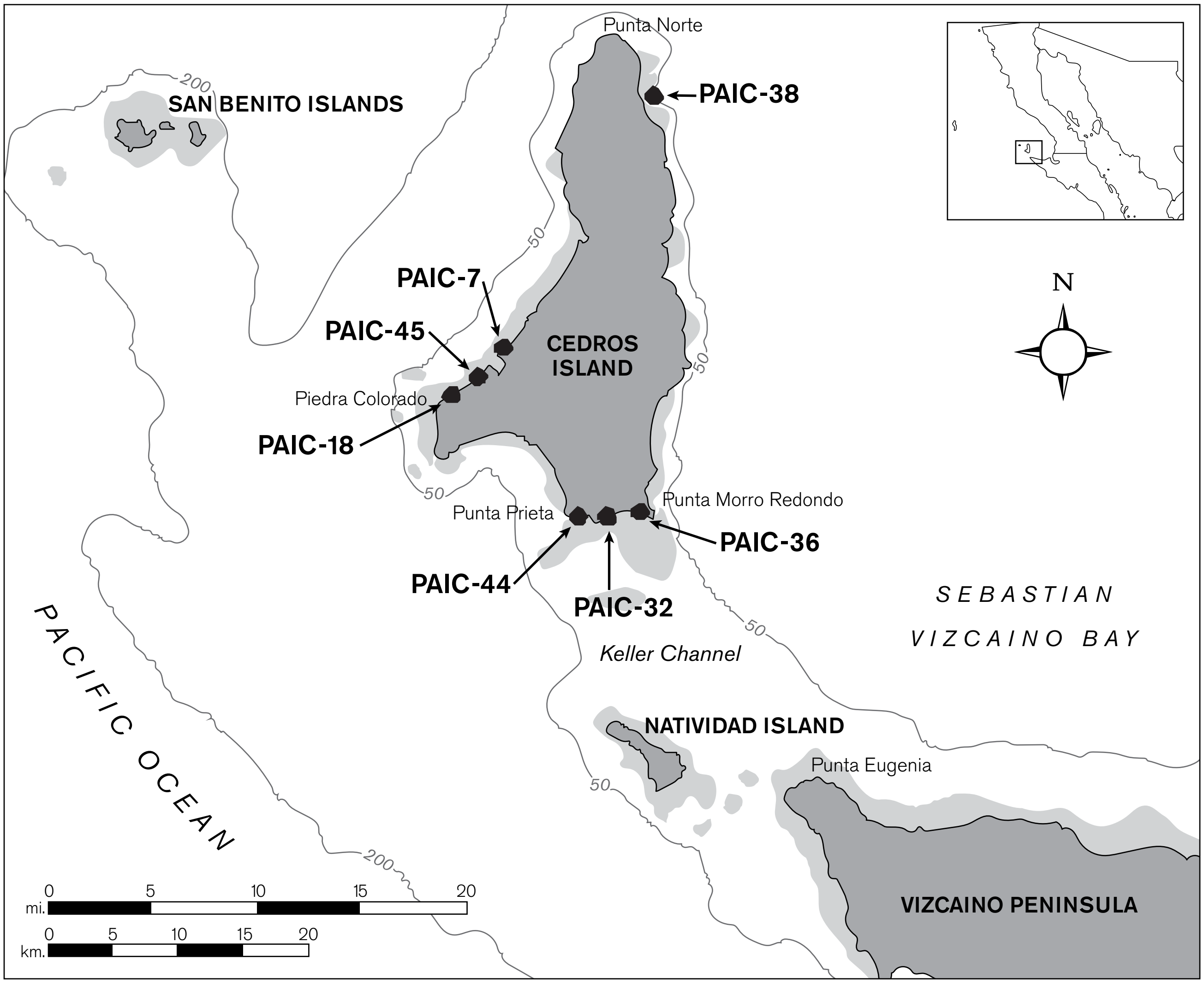

Figure 2. Archaeological site locations on Cedros Island that contributed fish remains examined. Shaded areas off the coastlines indicate water depths less than 20 meters.

Study Site

Cedros Island is a large, arid island off the west coast of Baja California, Mexico, approximately half-way between San Diego, California and the southernmost end of the Baja Peninsula (Fig. 1). The island lies on the western boundary of the 100-kilometer-wide Sebastian Vizcaino Bay, which harbors a rich diversity of marine animal and plant species (Jimenez-Rosenberg et al. 2007:204). Seventeen kilometers to the south of Cedros Island is Punta Eugenia, the northern tip of the Vizcaino Peninsula extending out from the Baja mainland. Thirty kilometers to the northwest sit the San Benito Islands, the exposed pinnacles of drowned peaks, which like Cedros Island have their bases on the continental shelf (Fig. 2).

Excavation Methods

All soil was dry screened through nested 1/8-inch and 1/4-inch mesh using standard stratigraphic excavation procedures. All bone was recovered from the screens regardless of size or degree of completeness. Units varied in size from 1 x 1 m. to 1 x 2 m. No smaller units were excavated. Preservation of faunal material was excellent, which together with macrobotanical remains (sea grass, seed hulls, agave stalk charcoal, etc.) recovered even from contexts dating over 12,000 cal B.P., clearly demonstrates relatively intact organic materials for such antiquity. The integrity of the stratigraphy at the sites was also excellent, due in part to the lack of both burrowing rodents and large-rooted vegetation such as trees in the vicinity of the archaeological sites in question.

Approach to Identifications

Bones were assigned to the lowest taxonomic level possible. Identification was by comparison with skeletal specimens of known fishes from the Gobalet osteological collection formerly housed at California State University, Bakersfield (and now housed at the California Academy of Sciences, Golden Gate Park, San Francisco) and with a specimen of the giant sea bass (*Stereolepis gigas*) from the California Academy of Sciences. Materials from excavations at Cedros Island were first reported in Des Lauriers (2010), and a complete listing of the material discussed here is included in Turnbull (2013).

Taxonomic designations followed a conservative approach, with most of the identifications being made to a family and with about a third of the elements being assigned to a more exclusive taxon. We did this primarily because the reference collection lacked all species within genera, or all genera within families, that were likely to be found in Cedros Island waters. Identifications to genera or species were possible when either a specific diagnostic feature was found or known distributions indicated a very high probability of the presence of the fish. In some instances, the taxon was chosen because families or genera were monospecific. Scientific names and common names follow Page et al. (2013). Non-diagnostic fish bones, such as fin rays, spines, and ribs, along with undecipherable degraded elements and fragments, were relegated to Actinopterygii.

The 29 examined samples were collected from nine archaeological sites that range in age from approximately 10,010 cal B.C. to 1630 cal A.D. (Table 1, Fig. 2). Notably, site PAIC-32c is dated to the middle Holocene (ca. 4,600–4,390 cal B.C.), making it much older than the layers excavated at its companion site, PAIC-32a, which date to the late Holocene (ca. 390 cal B.C.–1500 cal A.D.).

Statistical Analysis by RDA

Ordination is a statistical method that describes the relationship among variables by reducing the dimensions of a multivariate data set into fewer dimensions (referred to as "axes"), presumably grouping variables based on underlying environmental conditions that are driving the observed composition (Peck 2010). These reduced dimensions reflect the strongest relationships among variables (referred to as "species" and "sites") and capture the major trends within the original multivariate dataset (i.e., how are species and sites related or similar?). Here, our multivariate data set consisted of ten families from eight islands (referred to as "species" and "sites," respectively, in the context of the ordination analysis). For each site, we documented the percentage of bone elements, or relative familial abundance, observed for each "species" (Table 3).

A long-recognized major influence on fish species distributions and abundances is water temperature. Coastal water temperatures can be affected by multiple factors, including current and countercurrent flows, weather patterns, insularity of bays and estuaries, upwelling zones and topography, all of which are subject to seasonal variation (Hubbs 1960). To some extent, these factors are themselves related to latitude, so that latitude becomes a fundamental component affecting species composition among fishes (Stephens et al. 2006).

Therefore, *a priori*, we hypothesized that the relative family abundance (i.e., for a given family, where they were most often found) would be related to the latitudinal gradient among the islands. Accordingly, we constrained our ordination analysis in the context of latitude using a type of ordination known as a redundancy analysis (RDA; Peck 2010). Essentially, the RDA is a combination of a linear regression and an ordination. Since we are only interested in one explanatory variable, the RDA constrains the variation in the data set to the single explanatory variable along the primary dimension (axis) and then constrains the remaining variation along standard ordination axes using a method known as principal component analysis (PCA). Consequently, the species and sites are ordered along the primary RDA axes according to their relationship to the explanatory variable, latitude. The secondary axes (PCA) then organize species and sites to explain as much of the remaining variance as possible.

Ordinations are represented visually using a biplot. When assessing an ordination biplot, ordination scores of zero indicate that the unit (species or site) is neutral relative to the axis (i.e., is located relatively evenly across that axis). The strength of the relationship increases as the ordination scores move away from zero (positively or negatively). Islands (as sites) that have

Table 1

SUMMARY OF CEDROS ISLAND SITE LOCATIONS, AGES AND SAMPLES

Site	Location	Age Range*	No of Samples	NISP	Percent of Total
PAIC-44	Cedro Pedrogoso	10,010 cal B.C. – 7,490 cal B.C.	12	1,344	34.0
PAIC-45	North of La Colorada	1020 cal A.D. –1270 cal A.D.	4	939	23.7
PAIC-32a	Punta Prieta	390 cal B.C. –1500 cal A.D.	2	681	17.2
PAIC-36	Campo Quintero	1310 cal A.D. –1630 cal A.D.	3	305	7.7
PAIC-18	La Colorada area	800 cal B.C. – 330 cal B.C.	2	251	6.3
PAIC-7	Arroyo Madrid	180 cal B.C. –1630 cal A.D.	3	230	5.8
PAIC-38	Punta Norte	1270 cal A.D. –1390 cal A.D.	1	204	5.2
PAIC-32c	Punta Prieta area	4,600 cal B.C. – 4,390 cal B.C.	1	3	<1.0
PAIC-42	East of Punta Prieta	Not available	1	1	<1.0
Total			**29**	**3,958**	**100.0**

*Age ranges are based on ages determined for unit layers that yielded the examined samples (Des Lauriers 2010). Dates were calibrated using the Calib 7.0 program (Stuvier and Reimer 1993) and are reported to 2 sigma.

similar scores along an axis, therefore, have a similar species composition. Likewise, species with similar scores have similar relative abundances on the same island. Overall, species with similar scores respond similarly to the underlying drivers that are presumed to be responsible for the way in which the data were grouped into ordination space. We performed the RDA analysis in R Cran (R Development Core Team 2014) using the *rda* function in the 'vegan' package (version 2.0–10). Permutation-based model significance was estimated using the *anova* function in the 'vegan' package. However, since this method is only an estimate, we estimated the model p-value by using the mean estimate from 1,000 ANOVA runs.

RESULTS

Taxonomic Identification of Cedros Island Fish Remains

We identified 3,958 fish bones from the Cedros Island samples. Contributions by site ranged from PAIC-42 with only one bone, to that of the oldest site examined, PAIC-44, with 1,344 bones accounting for 34% of the total (Table 1). Wrasses (Labridae) were the most represented group of fishes, accounting for 38.6% of the total number of identifications, followed by sea basses (Serranidae), tilefishes (Malacanthidae), and croakers (Sciaenidae) (Tables 2, 3). These four families accounted for nearly 73% of the total. Adding the New World silversides (Atherinopsidae), morays (Muraenidae), surfperches (Embiotocidae), and grunts (Haemulidae) assigns 94.3% of the identified bones to these eight families.

The sample from PAIC-32 at the southeast corner of the island (near Punta Prieta) contained three vertebrae; they are the only specimens from the middle Holocene. These three vertebrae from PAIC-32c were from the California sheephead (*Semicossyphus pulcher*). In samples from the remaining seven sites, all of the predominant eight families noted above were represented, with two exceptions. The New World silversides were found only at the late Pleistocene-early Holocene site, PAIC-44 at Cerro Pedrogoso, with a count that was second only to the croakers and drums, representing 24.9% of the total from that site, and no grunts were found at the late Holocene sites PAIC-7 and PAIC-36. Although croakers ranked first in bone count at Cerro Pedrogoso, they were poorly represented in the late Holocene samples (Table 4).

Most of the bones from the poorly represented fish groups were found at PAIC-44 and in the late Holocene sites PAIC-7, PAIC-18, PAIC-32a, PAIC-36, PAIC-38, and PAIC-45. These groups were the scorpionfishes (Scorpaenidae), sea chubs (Kyphosidae), mackerels (Scombridae), kelp blennies (Clinidae), giant sea bass, damselfishes (Pomacentridae), and barracudas (Sphyraenidae). However, the flatfishes (Pleuronectiformes) and cartilaginous fishes (Elasmobranchii) were mostly found at PAIC-44.

Table 2

NUMBER OF SPECIMENS IDENTIFIED ON CEDROS ISLAND AND THE ISLANDS OF THE CALIFORNIA BIGHT[a]

Taxon	Common Name	Cedros Island[b]	San Clemente[c]	Santa Catalina[d]	San Nicolas[e]	San Miguel[f]	Santa Rosa[g]	Santa Cruz	Anacapa Island[i]
Elasmobranchiomorphi	sharks, skates, rays	24	3	12.33		7	10	6	
Heterodontidae	bullhead sharks							47	
Heterodontus francisci	horn shark		7	0.86					
Isurus sp.	mako sharks	1							
I. oxyrinchus	shortfin mako		1	0.80					
Lamna ditropis	salmon shark					2		X	
Cephaloscyllium ventriosum	swell shark							X	
Carcharhinidae/Triakidae)	requiem/hound sharks	29	2	3.31		13	8	141	
Galeorhinus galeus	tope					1		X	
Mustelus sp.	smoothhound							X	
Triakis semifasciata	leopard shark		12	25.17				X	
Prionace glauca	blue shark		1			1		X	
Squalus acanthias	spiny dogfish							X	
Squatina californica	Pacific angel shark			4.73		1		3 X	
Torpedo californica	Pacific electric ray			0.87				X	
Rajiformes	rays and skates	16	2						
Rhinobatidae	guitarfishes	15						X	
Rhinobatos sp.		2							
R. productus	shovelnose guitarfish		2	0.14				2	
Platyrhinoidis triseriata	thornback						2	1 X	
Urobatis halleri	round stingray	3						1	
Myliobatis californica	bat ray	1	2	9.50		2		5 X	
Anguilliformes	eels	2	53						
Muraenidae	morays	124							
Gymnothorax sp.	morays	126							2
G. mordax	California moray		81	41.37				X	
Clupeiformes	herrings						6		
Engraulidae	anchovies		2			1		X	
Clupeidae	herrings	1	2		2	545	9	47 X	
Sardinops sagax	Pacific sardine		3					X	
Merluccius productus	Pacific hake							1	
Chilara taylori	spotted cusp-eel							2	
Batrachoididae	toadfishes	2							
Porichthys sp.							31		
P. notatus	plainfin midshipman							2	
P. myriaster	specklefin midshipman								
Mugil sp.	mullet	1							
Atherinopsidae	New World silversides	318	1			12	55	X	9
Atherinops affinis	topsmelt							1 X	1
Atherinopsis californiensis	jacksmelt			0.15				17 X	
Cheilopogon pinnatibarbatus	smallhead flyingfish			0.08					
Scorpaenidae	scorpionfishes	14	20		24	13	52		
Scorpaena sp.	scorpionfish	1							
Scorpaena guttata	California scorpionfish	1	18	3.82					3
Sebastes sp.	rockfishes	1	2445	60.58	3	1903	2615	1596 X	205
Sebastobulus alascanus	shortspine thornyhead							1	
Anoplopoma fimbria	sablefish							1	

Table 2 (*Continued*)

NUMBER OF SPECIMENS IDENTIFIED ON CEDROS ISLAND AND THE ISLANDS OF THE CALIFORNIA BIGHT[a]

Taxon	Common Name	Cedros Island[b]	San Clemente[c]	Santa Catalina[d]	San Nicolas[e]	San Miguel[f]	Santa Rosa[g]	Santa Cruz	Anacapa Island[i]
Hexagrammidae	greenlings					31	14	X	1
Hexagrammos sp.	greenlings							1	
Ophiodon elongatus	lingcod		8	0.54		106	52	51 X	
Zaniolepis frenata	shortspine combfish							1	
Cottidae	sculpins	1	23			37	7	X	
Artedius sp			2						
Clinocottus sp.			3						
C. analis	woolly sculpin						5		
Scorpaenichthys marmoratus	cabezon		35	3.59	2	459	66	16 X	19
Leptocottus armatus	Pacific staghorn sculpin		1					X	
Stereolepis gigas	giant sea bass	13	5					X	
Serranidae	sea basses	482	7					X	
Paralabrax sp.	bass	66	14	0.31				X	1
P. clathratus	kelp bass		406	133.22				3	
P. maculatofacsiatus	spotted sand bass		5					X	
P. nebulifer	barred sand bass		11	0.68				X	
Malacanthidae	tilefishes	2							
Caulolatis princeps	ocean whitefish	421	157	14.82		3		4	
Seriola lalandi	yellowtail jack		38	37.06			2	X	
Trachurus symmetricus	jack mackerel		90	6.78				246 X	
Haemulidae	grunts	84	3						
Anisotremus sp		22							
A. davidsonii	sargo	6	1	0.43					
Haemulon californiensis	salema	12	3						
Calamus brachysomus	Pacific porgy	3							
Sciaenidae	drums and croakers	118		2.47		24		1 X	
Atractoscion nobilis	white seabass	14	9	3.10	1			4	
Cheilotrema saturnum	black croaker	14							
Genyonemus lineatus	white croaker	93						1	
Roncador stearnsii	spotfin croaker	3	1						
Seriphus politus	queenfish	1						1	
Umbrina sp		125							
U. roncador	yellowfin croaker	6	1						
Kyphosidae	sea chubs	17	4						
Hermosilla azurea	zebrafish							1	
Girella nigricans	opaleye	1	14	1.98				1	
Medialuna californiensis	halfmoon		2	1.15				1 X	
Embiotocidae	surfperches	158	28	1.17	84	1779	719	228 X	120
Amphistichus argenteus	barred surfperch		17	0.08					
Damalichthys vacca	pile perch		4	0.46	12	149	23	16 X	2
Embiotoca sp.		6					3		
E. jacksoni	black perch		9	1.45	5			127	
E. lateralis	striped seaperch		5	0.84	2			4	
Hyperprosopon sp.					1				
H. anale	spotfin surfperch							5	
H. argenteum	walleye surfperch							45	
H. ellipticum	silver surfperch							7	

Table 2 (*Continued*)

NUMBER OF SPECIMENS IDENTIFIED ON CEDROS ISLAND AND THE ISLANDS OF THE CALIFORNIA BIGHT[a]

Taxon	Common Name	Cedros Island[b]	San Clemente[c]	Santa Catalina[d]	San Nicolas[e]	San Miguel[f]	Santa Rosa[g]	Santa Cruz	Anacapa Island[i]
Hypsurus caryi	rainbow seaperch		2					26	
Micrometris minimus	dwarf pech							1	
Phanerodon sp.		1			1				
P. atripes	sharpnose seaperch							1	
P. furcatus	white seaperch							9	
Rhacochilus toxotes	rubberlip seaperch	1	6	1.42	3			11	
Pomacentridae	damselfishes	10	29						
Chromis punctipinnis	blacksmith		8	0.88		1		131 X	68
Hypsypops rubicunda	garibaldi	1	2	4.33					
Labridae	wrasses	1,283	49			696	132	569	1
Bodianus diplotaenia	Mexican hogfish	2							
Halicoeres sp.		23							
H. semicinctus	rock wrasse			0.06				X	
Oxyjulis californica	señorita		7		1	2	62	X	31
Semicossyphus pulcher	California sheephead	220	5,674	672.49	35	172	67	372 X	342
Stichaeidae	pricklebacks					29	19	X	
Cebidichthys violaceus	monkeyface prickleback						1	X	
Xiphister sp.	rock or black prickleback						23		
Clinidae	kelp blennies	16	9			10	32	X	1
Gibbsonia sp.	kelpfish		3				4		
Heterostichus rostratus	giant kelpfish		1					17 X	4
Sphyraenidae	barracudas	4							
Sphyraena argentea	Pacific barracuda	11	42	12.04		13	15	21 X	
Scombridae	mackerels			1.45		27	80	X	
Katsuwonus pelamis	skipjack tuna		1	1.10					
Scomber japonicus	Pacific chub mackerel	17	42	0.82	2		4	112 X	1
Sarda sp.	bonitos	1							
S. chiliensis	Pacific bonito		3	0.72				X	
Thunnus sp.			3					X	
hunnus alalunga	albacore		14	3.30				1	
Xiphiidae or Istiophoridae	swordfishes/billfishes					7	13	X	
Pleuronectiformes	turbots, flounders	12				6			
Paralichthyidae	sand flounders	6							
Citharichthys sordidus	Pacific sanddab							X	
Paralichthys californicus	California halibut		25			7		4	
Pleuronectidae	righteye flounders								
Eopsetta jordani	petrale sole							X	
Hippoglossus stenolepis	Pacific halibut							1	
Parophrys vetulus	English sole							2	
Pleuronichthys ritteri	spotted turbot							2	
P. guttulatus	diamond turbot							X	
Psettichthys melanostictus	sand sole							X	
Mola mola	ocean sunfish			12.55		1		5 X	
	Total	**3958**	**9483**	**1084.46**	**178**	**6060**	**4131**	**3923 + 56X**	**811**

[a] An "X" indicates an unquantified presence at one or more sites.

[b] Cedros: Turnbull 2013.

Table 2 (*Continued*)

NUMBER OF SPECIMENS IDENTIFIED ON CEDROS ISLAND AND THE ISLANDS OF THE CALIFORNIA BIGHT[a]

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[c] San Clemente: SCLI-43B,-43C,-119,-1215,-1492 (Salls 2000, includes 17 sp. of Sebastes), SCLI-1396, -1492E, -1790, -1796, -OAF-L, OAF-N, -PB-23, PB-24, -PB-25, -PB-26, -PB-30, -PB-31, SCLI-231, -238, -1488, WRS-2, SCLI-1803 (Gobalet unpub. data).

[d] Catalina: SCAI-26, in grams, includes 12 species of Sebastes (Porcasi 2012).

[e] San Nicolas: SNI-20,-61,-173 (Gobalet unpub. data).

[f] San Miguel: Daisy Cave (Rick et al. 2001), SMI-87,-163,-468,-481, (Rick 2007), SMI-232,-608 (Braje 2010).

[g] Santa Rosa: SRI-6 (Erlandson et al. 1999), SRI-2 (Rick 2010), SRI-313 (Gobalet unpub. data).

[h] Santa Cruz: SCRI-191, -192, -330, -474 (Colten 2001; numbers are for otoliths including 44 sp. of Sebastes, other elements not quantified, X = presence), Punta Arena Site (Glassow et al. 2008), SCRI-195 (Gusik 2008).[1]

[i] Anacapa: ANI-2 (Gobalet & J. Hash unpub. data).

Table 3

PROPORTIONS OF FISHES FOUND ON CEDROS ISLAND AND ISLANDS OF THE SOUTHERN CALIFORNIA BIGHT*

Taxon	Cedros Island	San Clemente	Santa Catalina	San Nicolas	San Miguel	Santa Rosa	Santa Cruz	Anacapa Island
Elasmobranchiomorphi	0.023	X	0.053	0	X	X	0.055	0
Muraenidae (Anguilliformes)	0.064	X	0.038	0	0	0	X	X
Clupeidae	X	X	0	0.011	0.090	X	0.011	0
Atherinopsidae	0.080	X	X	0	X	X	X	0.010
Scorpaenidae (*Sebastes* sp.)	X	0.258	0.059	X	0.315	0.651	0.405	0.252
Hexagrammidae (*Ophiodon elongatus*)	0	X	X	0	0.018	0.013	0.012	0
Scorpaenichthys marmoratus	0	X	X	X	0.076	X	X	0.023
Serranidae (*Paralabrax* sp)	0.138	0.046	0.124	0	0	0	X	X
Malacanthidae	0.107	0.040	0.014	0	X	0	X	0
Trachurus symmetricus	0	X	X	0	0	0	0.062	0
Sciaenidae	0.095	X	X	X	X	0	X	0
Embiotocidae	0.042	X	X	0.607	0.320	0.177	0.122	0.148
Chromis punctipinnis	0	X	X	0	X	0	0.033	0.083
Labridae	0.386	0.604	0.620	0.200	0.144	0.064	0.239	0.460
Scomber japonicus	X	X	X	X	0	X	0.028	X
Proportion of Total	**0.814**	**0.948**	**0.908**	**0.818**	**0.963**	**0.905**	**0.967**	**0.976**
Total Number of Elements	**3,958**	**9,483**	**1,084.46**	**178**	**6,066**	**4,131**	**3,923**	**811**

*Proportions constituted more than 0.01 of the samples found at archaeological sites. An "X" indicates an unquantified presence or a presence with a proportion less than 0.01.

Of the total count, 1,220 bones were identified to 14 genera and 20 species. Among identified genera, elements from the morays (*Gymnothorax* sp.), drums and croakers (*Umbrina* sp.), and sea basses (*Paralabrax* sp.) dominated the count. Of those elements identified to species, ocean whitefish (*Caulolatilus princeps*), California sheephead, and white croaker (*Genyonemus lineatus*) were the most common (Table 2).

Comparison of Relative Abundance of Families

As described above, for Cedros and seven islands of the Southern California Bight (San Miguel, Santa Rosa, Santa Cruz, Anacapa, San Nicolas, San Clemente, and Santa Catalina), we used bone element percentages of ten well-represented families as indicators of abundance, in order to perform a redundancy analysis (constrained to latitude) and principal component analysis (unconstrained) of variance. The RDA axis constrained to the explanatory variable, latitude, explained 48.2% of the variance in the relative taxa abundance among islands, indicating that latitude is a strong predictor of relative taxa abundance. The remaining variance was assessed using unconstrained PCA analysis. The first PCA axes (the axis or dimension explaining the majority of the remaining variance) explained an additional 26.9% of the variance in the relative taxa abundance among islands.

Table 4

NUMBER OF IDENTIFIED SPECIMENS BY TAXA FOR NINE CEDROS SITES
(DESCENDING ORDER BY TOTAL NISP, AGES L. TO R., OLDEST TO YOUNGEST)

	10,010–7,490 cal B.C.	4,600–4,390 cal B.C.	800–330 cal B.C.	390 cal B.C.–1500 cal A.D.	180 cal B.C.–1630 cal A.D.	1020–1270 cal A.D.	1270–1390 cal A.D.	1310–1630 cal A.D.		
	Group									
Taxon	PAIC-32c	PAIC-32c	PAIC-18	PAIC-32a	PAIC-7	PAIC-45	PAIC-38	PAIC-36	PAIC-42*	Total NISP
Labridae	159	3	184	327	96	492	134	133	–	1,528
Serranidae	198	–	5	153	14	99	30	49	–	548
Malacanthidae	15	–	14	140	47	140	20	47	–	423
Sciaenidae	334	–	5	3	4	25	2	1	–	374
Atherinopsidae	318	–	–	–	–	–	–	–	–	318
Muraenidae	55	–	18	7	39	70	15	46	–	250
Embiotocidae	78	–	4	28	13	39	–	4	–	166
Haemulidae	54	–	6	5	–	58	1	--	–	124
Triakidae	21	–	–	5	1	–	–	2	–	29
Scombridae	3	–	–	–	–	1	–	14	–	18
Kyphosidae	9	–	2	1	4	2	–	–	–	18
Scorpaenidae	7	–	2	2	–	3	–	3	–	17
Rhinobatide	17	–	–	–	–	–	–	–	–	17
Clinidae	7	–	–	2	1	2	–	4	–	16
Sphyraenidae	4	–	–	–	10	–	–	1	–	15
Polyprionidae	–	–	4	8	–	–	–	–	1	12
Pomacentridae	5	–	2	–	–	4	–	–	–	11
Paralichthyidae	6	–	–	–	–	–	–	–	–	6
Myliobatidae	3	–	–	–	–	1	–	–	–	4
Sparidae	1	–	–	–	–	–	2	–	–	3
Batrachoididae	2	–	–	–	–	–	–	–	–	2
Clupeidae	1	–	–	–	–	–	–	–	–	1
Cottidae	–	–	–	–	–	1	–	–	–	1
Mugilidae	1	–	–	–	–	--	–	–	–	1
Urolophidae	1	–	–	–	–	–	–	–	–	1
Rajiformes	15	–	–	–	–	1	–	–	–	16
Pleuronectiformes	11	–	–	–	–	–	–	1	–	12
Anguilliformes	–	–	–	–	1	1	–	–	–	2
Elasmobranchii	19	–	5	–	–	–	–	–	–	24
Count Total:	**1,344**	**3**	**251**	**681**	**230**	**939**	**204**	**305**	**1**	**3,958**

Site age ranges are based on ages determined for unit layers that yielded the examined samples (Des Lauriers 2010). Dates were calibrated using the Calib 7.0 program (Stuvier and R 1993) and are reported to 2 sigma.
*PAIC-42 undated.

Combined, these two axes explained 75.4% of the variance in the dataset. The average p-value of the ANOVA analysis was $p < 0.02$, with a range of $0.03 > p > 0.005$. The relationships among species, islands, and latitude can be assessed visually using a biplot (Fig. 3).

The RDA axis (constrained to latitude) indicates that the composition of the families found on Cedros Island differs greatly from that of the islands of the Southern California Blight. Indeed, representatives of the Atherinopsidae, Sciaenidae, Malacanthidae, Muraenidae, and Serranidae were relatively abundant at low latitudes (i.e., on Cedros Island) while Hexagrammidae, and Scorpeanidae had higher relative abundances at high latitudes (i.e., on the islands of the Southern California Bight; Fig. 3, Table 3). However, abundances of the Clupeidae, Embiotocidae, and Labridae were not strongly related to latitude. After latitude is taken into account, the first PCA axis suggests that the relative

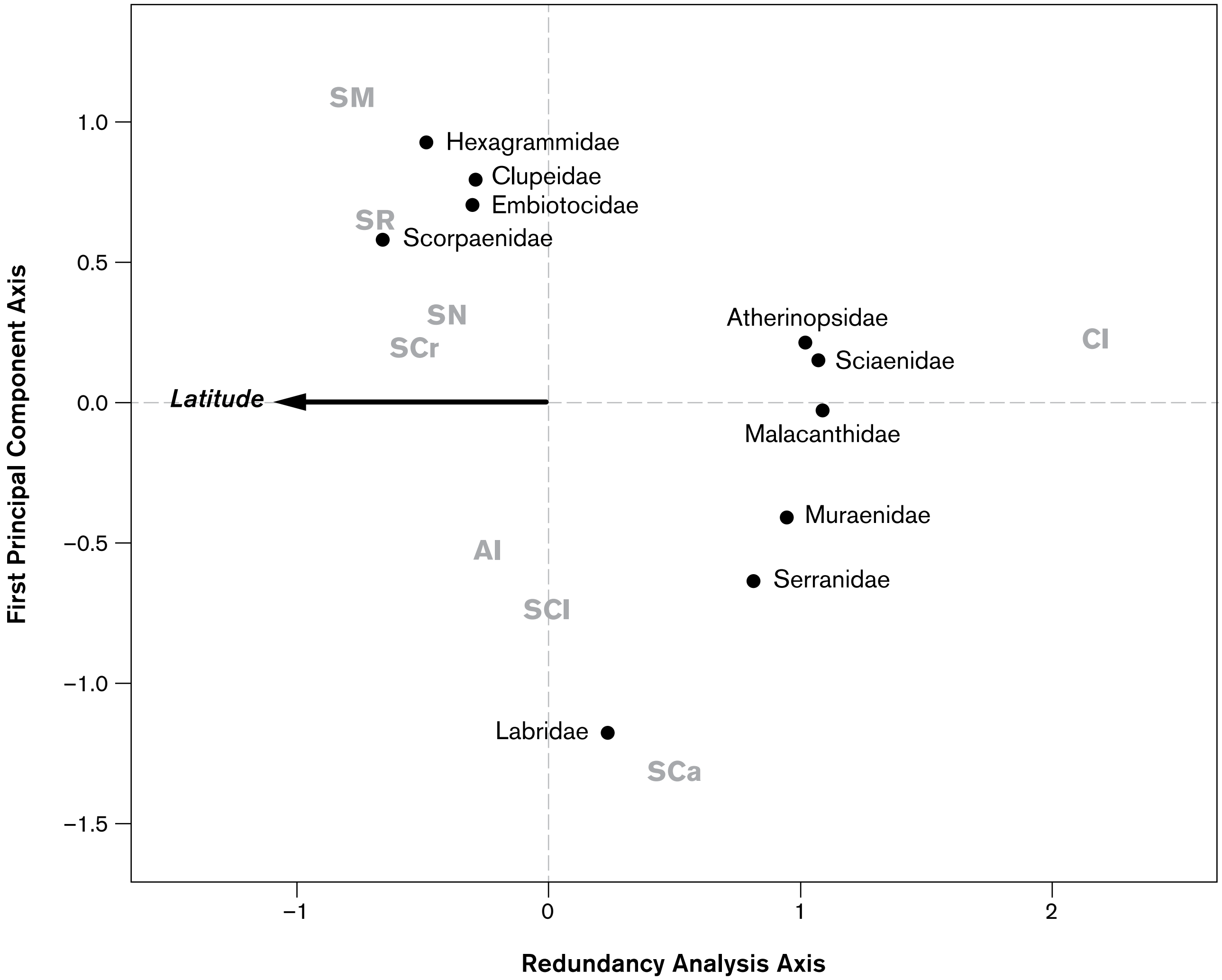

Figure 3. Redundancy analysis (RDA) of fish family abundances correlated to island location. Arrow indicates direction of increasing north latitude (SM=San Miguel, SR=Santa Rosa, SN=San Nicolas, SCr=Santa Cruz, AI=Anacapa, SCl=San Clemente, SCa=Santa Catalina, CI=Cedros).

abundance of labrid elements was greatest on Santa Catalina Island and, to a lesser extent, on San Clemente and Anacapa islands. Conversely, the relative abundances of hexagrammids, clupeids, embiotocids, and scorpaenids were greater on San Miguel and Santa Rosa.

DISCUSSION

Our results suggest that across the late Pleistocene-early Holocene boundary, at approximately 11,650 cal B.P. (Smith et al. 2011:1846), and again during the period from approximately 800 B.C. to 1630 A.D., the fishes harvested at Cedros Island were similar to those found today and the ranges of the fishes were the same. We know of no published scientific survey of the fishes or marine habitats at Cedros Island, but two surveys conducted in the Vizcaino Bay area within the last decade provide a basis for comparing groups of fishes present today with those identified from the Cedros Island remains.

Jimenez-Rosenberg et al. (2007) identified 71 families during their three-year, seasonal surveys of larvae found in mesopelagic (200–1,000 meters in the water column), coastal pelagic (offshore, beyond the surf zone to the shelf edge), and demersal (near bottom) environments in the Sebastian Vizcaino Bay area. Twelve of those families were found in the archaeological remains at Cedros Island. Aside from the absence of the cartilaginous fishes and surfperches, the low overlap is explained by the dominance in abundance of far offshore, deep water, mostly mesopelagic fish families that accounted for 50% to 90% of the larval totals within the surveys (Jimenez-Rosenberg et al. 2007:215). Such fishes were most likely beyond the reach of the Cedros islanders.

In their survey of the San Benito Islands, Pondella et al. (2005) reported 40 species of fishes in 20 families. Fourteen of the actinopterygian families and both elasmobranch families found are present in our Cedros Island material. This strong overlap in presence most likely results from these islands' proximity and marine topographic similarity to Cedros Island.

Our data also suggest which habitats were predominately exploited by the Cedros Island inhabitants, especially in the early millennia of settlement, the period from which most of the remains came. It has been well documented that the presence of certain fish species is indicative of particular marine habitats (Allen and Pondella 2006; Bond et al. 1999; Engle 1993; Pondella et al. 2005; Quast 1968; Stephens et al. 2006). Allen and Pondella (2006), in the most comprehensive ecological study, identified 15 major habitat types, among which were seven shallow water habitats (<30 m.). They also identified 42 groups of fish species that are associated with and are diagnostic of these 15 habitats.

We compared the fishes from our Cedros Island identifications to those within these habitat groupings, under the assumption that the current associations between fish groups and habitats have existed for at least the past 12,000 calendar years. This assumption is supported by the work of Gobalet (2000), who established that the archaeological record of the California coast was consistent with current fish distributions throughout the Holocene. Using these species associations, we infer that the fishes identified from the Cedros samples are most closely associated with kelp bed/rocky reefs and nearshore soft-bottom areas, including the surf zone.

Pondella et al. (2005) and Stephens et al. (2006) generally reinforce Allen and Pondella's (2006) fish habitat associations. Pondella et al. (2005) surveyed the kelp bed and rock substrate habitats of the San Benito Islands, and of the 16 families identified as closely associated with these habitats, 15 are found in the Cedros Island samples. Of the nine fish families found by Stephens et al. (2006) to be closely associated with the kelp beds/rock reefs along the California coast, seven are represented in the Cedros Island samples. Additionally, the New World silversides, barracudas, and the ocean whitefish—all found in the Cedros Island remains—were recognized as transient fishes that frequent the rocky reefs and kelp forests.

The reduced presence of the cartilaginous fishes, flatfishes, croakers, and New World silversides, from the late Pleistocene-early Holocene elements (PAIC-44) to the later Holocene material, is notable (Table 4). A number of factors could account for this, but with only three sheephead specimens here spanning the intervening time period, to consider causal factors such as variations in overall climate and changes in seasonal marine conditions would be purely speculative.

Likewise, our data from the PAIC-44 material are not sufficient to consider how these factors may have also influenced reduced percentages at that site across the late Pleistocene-early Holocene boundary. Only five of the 12 samples are dated, and three of these are from layers in a single unit. Specimen counts vary within a total of only 1,344 specimens, and with seven samples undated, any attempt here to describe changes in fish abundance over this time period would be premature (Table 5).

However, one possible major influence may have been changes in available habitats resulting from the well-documented event of rising sea levels. Many cartilaginous fishes (skates, rays, small sharks) and flatfishes are known to favor soft, often sandy bottoms, but most species of Pacific coast croakers are most abundant in these shallower nearshore habitats (Love 2011). A greater representation of these fishes may reflect a situation in which the shallower habitats were more extensive during the initial settlement of Cedros Island. This seems consistent with the scenario of how rising seas created Cedros Island.

The island's offshore topography today is in most places much steeper than that of the mainland coastline of Vizcaino Bay. This reduces the area available for nearshore shallow water habitats. Current bathymetric chart readings reveal that only patches of littoral environment (<20 meters) exist along the northern half of the island's coastline. Conversely, longer stretches of shallow depths of 20 meters or less exist along the southern half of the island, but they extend offshore only one kilometer or

Table 5

NUMBER OF IDENTIFIED SPECIMENS BY TAXON FOR PAIC-44 SAMPLES (CEDRO PEDROGOSO)

	Sample													
	F13*	F14	F15	F24*	F25*	F26*	F16	F17	F18	F28*	F29*	F30*		
	Unit/Layer													
Taxon	2/B	2/C2	2/D	2/CpE	2/CapaA	2/C1	1/B	1/C	1/D	3/A1	3/A2	3/A3	Total NISP	% Total
Labridae	5	4	11	1	–	6	42	67	7	–	4	12	159	11.8
Serranidae	1	14	10	1	1	14	16	104	14	–	5	18	198	14.7
Malacanthidae	–	3	1	–	–	–	6	4	–	–	–	1	15	1.1
Sciaenidae	5	8	1	5	–	2	95	209	2	3	–	4	334	24.9
Atherinopsidae	–	1	4	1	–	5	128	165	1	–	8	5	318	23.7
Muraenidae	–	–	1	–	–	1	15	26	2	–	–	10	55	4.1
Embiotocidae	–	1	2	–	–	–	11	24	4	–	11	25	78	5.8
Haemulidae	–	–	1	–	–	1	21	31	–	–	–	–	54	4.0
Scorpaenidae	–	–	–	3	–	–	–	2	1	–	1	–	7	<1.0
Kyphosidae	–	–	1	–	–	1	1	5	1	–	–	–	9	<1.0
Sparidae	–	–	–	–	–	–	1	–	–	–		–	1	<1.0
Scombridae	–	3	–	–	–	–	–	–	–	–		–	3	<1.0
Clinidae	–	4	–	–	–	–	–	–	–	–	1	2	7	<1.0
Clupeidae	–	–	–	–	–	–	–	1	–	–		–	1	<1.0
Mugilidae	–	–	–	–	–	–	–1	–	–	–		–	1	<1.0
Sphyraenidae	–	–	–	–	–	–	–	4	–	–		–	4	<1.0
Pomacentridae	–	–	1	–	–	–	–1	–	–	–	1	2	5	<1.0
Paralichthyidae	–	4	–	–	–	–	–	–	2	–		–	6	<1.0
Bactracoididae	–	–	–	–	–	–	–	2	–	–		–	2	<1.0
Pleuronectiformes	4	1	2	1	–	1	–	2	–	–		–	11	<1.0
Triakidae	3	–	1	–	–	1	7	6	2	–	1	–	21	1.6
Rhinobatidae	1	–	5	–	–	–	3	6	2	–	–	–	17	1.3
Urolophidae	–	–	–	–	–	–	1	–	–	–	–	–	1	<1.0
Myliobatidae	–	–	–	–	–	1	–	1	1	–	1	–	4	<1.0
Rajiformes	6	1	3	–	–	–	2	–	1	–	2	–	15	1.1
Elasmobranchii	2	1	–	1	–	7	2	–	2	–	3	–	18	1.2
Count Totals:	**27**	**45**	**44**	**13**	**1**	**40**	**353**	**659**	**42**	**3**	**38**	**79**	**1,344**	

Sample Age Ranges: F14=10,480 – 10,250 cal B.P.; F15=11,070 –10,550 cal B.P.; F16=9,440 – 9,140 cal B.P.; F17=11,070 –10,680 cal B.P.; F18=11,960 –11,410 cal B.P.
*Age ranges not available.

so. Only at the most southerly coast, between Punta Prieta and Punta Morro Redondo, does the sub-20 meter depth extend outward two to four kilometers, created by submerged elevated features (Fig. 2).

However, there is a 30- to 40-meter-deep submerged ridge that connects Cedros Island to the present Vizcaino Peninsula (Fig. 2, 50-meter contour). At the height of the Last Glacial Maximum, 21,000 to 18,000 cal B.P., global mean sea level stood approximately 125 meters lower than at present (Fleming et al. 1998:340). With the late Pleistocene-early Holocene global sea level rise, the western coast of Baja California experienced inundation by the transgressing Pacific Ocean, approaching present levels by about 7,000 cal B.P. (Fleming et al. 1998:328). Smith et al. (2011:1846) propose that the last 60 meters of the total rise in global sea level has occurred since the beginning of the Holocene. If so, at that time Cedros Island was the northernmost mountainous headland of a much larger Vizcaino Peninsula (formed by the now submerged ridge) and had already been settled by humans (Des Lauriers 2010).

As the early Holocene ocean encroached, it would have created transient shallow water zones on the steep slopes around most of the peninsula tip, but along the western and eastern shores of the then-exposed ridge, it would have produced fairly extensive shallow water areas on the southern coast of the new Cedros Island, most likely surrounding small islands—areas accessible for fishing. Eventually, these islands would disappear, but for a relatively short period of time a shallow channel would have persisted. This channel would eventually deepen, and by the middle Holocene the current global sea level had been reached. Cedros Island was then the island it is today, with limited nearshore shallow marine habitats.

This proposed reduction in these habitats does not explain the absence of New World silversides in all but PAIC-44 material. These fishes currently are found in open coastal waters, amid kelp forests, in estuaries, as well as in nearshore habitats (Love 2011). Analysis of more samples (including those from other sites) of fish remains from middle Holocene periods, and of more artifacts related to fishing technology, may provide some insight into the question.

Fisheries Comparison: Cedros Island with the Islands of the Southern California Bight

The prehistoric data presented here are consistent overall with our current understanding of the distribution of these fishes (Love 2011,) and Gobalet (2000) has illustrated a consistency in fish distributions in the archaeological record throughout the Holocene north and south of Point Conception. Given this distribution, and in light of the concerns expressed below, we compare our results with those from several studies undertaken on the islands of Southern California (Table 2; see table footnotes for sources; many of the data are published here for the first time). Some of the differences we see are easily explained by the current range of the fishes and by latitudinal differences (Fig. 3).

Sebastes spp. (rockfishes). The paucity of rockfishes (less than 1% of the Cedros samples versus over 25% for five of the six islands to the north where rockfishes ranked first or second in abundance; Table 3) is probably explained by Cedros Island having considerably warmer water due to southern tropical influences. Cedros Island is thus south of the range of most rockfishes (Love et al. 2002), and this is especially true of the relatively shallow water species that are rare around Cedros Island (Milton Love, personal communication, May 1, 2014).

Embiotocidae (surfperches). The scarcity of surfperches among the Cedros materials (4.8% versus the typical proportion of over 12.2% for all but one of the northern islands; Table 3) is explained by most of the 18 marine embiotocids from California having the southern edge of their range at or north of central Baja California. Only the black perch ranges to southern Baja (Love 2011:411–428). As with the rockfishes, the current biogeography explains the differences in abundance at the archeological sites.

Caulolatis princeps (ocean whitefish). The Cedros Island samples are distinctive due to the abundance of ocean whitefish, where their ratio of 12.2% makes them the second most abundant fish group (Table 3). This is consistent with Love (2011:370), who notes that ocean whitefish are common in Southern California but "are startlingly abundant starting in Bahia de Sebastian Vizcaino."

Gymnothorax mordax (California moray). Cedros Island has the greatest percentage of what are likely moray eels (7.3% of the sample; Table 3). Love (2011:89) indicates that moray eels are abundant as far north as Santa Catalina Island. This accounts for their larger numbers at Cedros Island in contrast to the northern Channel Islands, but raises the question of their comparative rarity in the midden materials from San Clemente Island.

Ophiodon elongates (lingcod) and *Scorpaeonichthys marmoratus*. The lack of any lingcod or cabezon in the Cedros Island remains, in contrast to their presence in the northern island remains, is explicable because the southern edge of the current range of lingcod is north of Cedros Island, and that of the cabezon is just to the south (Love 2011:293, 323).

Labridae (wrasses, mostly California sheephead, Semicossyphus pulcher). Though the percentages vary from 14.4% to over 60% in abundance for the samples from the seven islands studied, the labrids rank among the three most abundant fish groups found at all of the islands and are first in abundance at Cedros and San Clemente islands (Table 3). Though this suggests a California sheephead fishery on both islands, Cedros Island is distinctive as being the only island with Mexican hogfish (*Bodianus diplotaenia*), which range only as far north as Isla Guadalupe (Love 2011:444) to the northwest of Cedros Island (Fig. 1). The abundance of California sheephead among the archaeological remains is consistent with Love's (2011:439) description of them as "crazy abundant" along parts of central Baja California. The current distribution of the California labrids thus supports the obvious conclusion that the peoples were fishing for the abundant species in their regions.

Sciaenidae (drums and croakers). The current distribution of drums and croakers cannot explain the greater proportion of these fishes at Cedros Island sites as compared to the six islands farther north. All seven of the local sciaenids listed by Love (2011:393–403) range from the Pacific side of the Baja Peninsula to at least Point Conception. A better question is why the sciaenids are so rare on the California Islands, when some Santa Barbara County coastal sites (e.g., SBA-27 with 23% of 4,900 specimens) have a substantial proportion of sciaenids among their fish bone remains?

Enigmatic species. An evaluation such as the one we have undertaken here is not without its enigmas. As cases in point, the percentage of atherinopsids is highest from Cedros Island with 9.2%, and all the other sites are at or below 1%. The 7.6 percent of cabezon among the 6,000 remains at San Miguel Island, the 6.2 percent of jack mackerel among the nearly 4,000 remains on Santa Cruz Island, and the comparatively large percentage of blacksmith on Santa Cruz (3.3% of 3,943) and Anacapa (8.3% of 811) also demonstrate the challenges we face in understanding the complexities of the archaeological record (Tables 2, 3).

Some Concerns Regarding Archaeofaunal Analysis

It can be quite a challenge to compare fish remains recovered from one excavation with those from another, because sampling methods vary, the decisions made by individual analysts vary, and findings are biased by the availability of comparative materials, the elements considered diagnostic, and the criteria applied when there is no uniform standard (Gobalet 2001). Particularly noteworthy examples from the literature are the reporting of a category of "Pacific or jackmackerel" by Glassow et al. (2008:Tables 11, 12) and "mackerel undif." by Rick (2007). This raises concern because discriminating between the jack mackerel (Carangidae: *Trachurus symmetricus*) and the Pacific chub mackerel (Scombridae: *Scomber japonicas*) is not difficult. A glaring point like this raises questions regarding the credibility of all of the data.

Another reason for concern is the reporting of 44 species of *Sebastes* by Colten (2001) and 17 by Salls (2000). Colten did not provide information regarding their identification in his paper, but in a personal communication (to KWG, April 22, 2014) he shared the information that the otoliths were identified by Richard Huddleston and the other elements by John Johnson. Gobalet et al. (2004) and Love (2011) suspect that neither otoliths nor most other elements of *Sebastes* allow for discrimination to species. There are additional reasons for concern regarding Colten's data. Regarding the 44 species of *Sebastes* that Colten (actually Huddleston) reported, Milton Love (personal communication to KWG, May 1, 2014; see also Love et al. 2002 and Love 2011) considers several species (e.g., *S. melanostomus*, *S. phillipsi*) to be abundant only at depths of at least 200 meters, which is likely too deep for the technology available to the Chumash. If there was deep-water fishing going on, some of the species were quite rare or uncommon around Santa Cruz Island (e.g., *S. babcocki*, *S. flavidus*, *S. helvomaculatus*, *S. macdonaldi*, *S. melanops*, and *S. vexilaris*), the location of the archaeological study.

In addition, an abundant species, *S. caurinus*, which should be present, does not appear in the archaeological record. Furthermore, Love considers the 17 species identified by Salls (2000) at San Clemente Island more likely, with the qualification that *S. flavidus* and *S. melanops* are not found there today. The 14 species of surfperches indentified by Huddleston (for Colten 2001) among the remains from Santa Cruz Island is a staggering accomplishment. Though the range of all these species includes the Channel Islands (Miller and Lea 1972), one of us (KWG) has struggled with embiotocid otolith identifications enough to be skeptical of the results. These examples serve to illustrate the conclusion that readers need to be suspicious of all the data reported, and that there is a need for blind testing in accordance with the models of Gobalet (2001) and Andrews et al. (2003).

Summary of the Comparison of Island Fisheries

The overall conclusion apparent from all of these studies is that the ancient peoples of these islands were exploiting similar marine habitats, with the kelp bed/rocky reef environment of Allen and Pondella (2006) especially prominent. At all of the sites (except as qualified above for range limitations), the three primary fish groups exploited by the peoples of all these islands were rockfishes, surfperches, and wrasses. Where rockfishes and surfperches become less abundant at the southern edge of their ranges (Cedros Island), moray eel and ocean whitefish make up higher percentages of the fish materials. The California moray and ocean whitefish are less abundant or absent farther north. Conspicuous by their rarity among these island sites are remains of large pelagic fishes like swordfishes, which are considered by Davenport et al. (1993) and Bernard (2001) to have been of almost mystical importance to the Chumash. The data reported here suggest that the fishery of the native peoples of these California islands was primarily inshore in predictable locations.

Archaeological Importance

The archaeological fish bone samples from Cedros Island represent the largest and most time-transgressive, fully analyzed samples of fish remains from any archaeological sites on the Pacific coast of Baja California. Stratigraphic context is excellent, due in part to the lack of both burrowing rodents and large-rooted vegetation such as trees in the vicinity of the archaeological sites in question. Variance from stratigraphic level to level can therefore be considered a reliable indicator of actual changes through time. Cultural processes of site formation may result in greater variability, although the larger than average size of the excavation units, compared to those often used in Alta California to provide similar data sets, suggests that the data reported here accurately represent these archaeological contexts.

The Cedros Island results provide a significant control for arguments about human-environment interactions along the coast of Alta California. The records of human fishing provided by the archaeological deposits on Cedros Island are remarkable for their degree of preservation and for their location at the most southerly extension of the California Current. When compared to archaeological sites further north along the Alta California coast, the sites on Cedros Island provide a more direct indicator of cultural ecological relationships, especially for the last 2,000 years, since the island economies of the Southern California Bight were inextricably linked to one another and to the adjacent mainland. The reciprocal human-environmental interactions on Cedros Island were more self-contained and localized than those elsewhere along the California Coast, thus giving us a clearer image, unobstructed by more complex and variable social and economic systems.

NOTES

[1] Data from unpublished 2008 manuscript by Amy Gusick. "Prehistoric Fishing Practices on Santa Cruz Island: Evidence from CA-SCRI-195."

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REFERENCES

Allen, L. G., and D. J. Pondella II
2006 Ecological Classification. In *The Ecology of Marine Fishes: California and Adjacent Waters*, L. G. Allen, D. J. Pondella II, and M. H. Horn, eds., pp. 81–113. Berkeley: University of California Press.

Andrews, A. H., K. W. Gobalet, and T. L. Jones
2003 Reliability Assessment of Season of Capture Determination from Archaeological Otoliths. *Bulletin of the Southern California Academy of Science* 102(2):66–78.

Bernard, J. L.
2001 *The Origins of Open-ocean and Large Species Fishing in the Chumash Region of Southern California.* Master's thesis, University of California, Los Angeles.

Bond, A. B., J. S. Stephens, Jr., D. J. Pondella II, M. J. Allen, and M. Helvey
1999 A Method for Estimating Marine Habitat Values Based on Fish Guilds, with Comparisons between Sites in the Southern California Bight. *Bulletin of Marine Science* 64(2):219–242.

Braje, T. J.
2010 *Modern Oceans, Ancient Sites, Archaeology and Marine Conservation on San Miguel Island, California.* Salt Lake City: The University of Utah Press.

Colten, R. H.
2001 Ecological and Economic Analysis of Faunal Remains from Santa Cruz, Island. In *The Origins of a Pacific Coast Chiefdom, the Chumash of the Channel Islands*, J. E. Arnold, ed., pp. 199–244. Salt Lake City: The University of Utah Press.

Davenport, D., J. R. Johnson, and J. Timbrook
1993 The Chumash and the Swordfish. *Antiquity* 67:257–72.

Des Lauriers, M. R.
2010 *Island of Fogs*. Salt Lake City: The University of Utah Press.

Engle, J. M.
1993 Distribution Patterns of Rocky Subtidal Fishes Around the California Islands. In *Third California Islands Symposium: Recent Advances in Research on the California Islands*. F. G. Hochberg, ed., pp. 475–484. Santa Barbara: Santa Barbara Museum of Natural History.

Erlandson, J. M., T. C. Rick, R. L. Vellanoweth, and D. J. Kennett.
1999 Maritime Subsistence at a 9300-year-old Shell Midden on Santa Rosa Island, California. *Journal of Field Archaeology* 26(3):255–265.

Fleming, K., P. Johnston, D. Zwartz, Y. Yokoyama, K. Lambeck, and J. Chappell
1998 Refining the Eustatic Sea-level Curve Since the Last Glacial Maximum Using Far- and Intermediate-field Sites. *Earth and Planetary Science Letters* 163:327–342.

Glassow, M. A., J. E. Perry, and P. F. Paige
2008 The Punta Arena Site: Early and Middle Holocene Cultural Development on Santa Cruz Island. *Santa Barbara Museum of Natural History Contributions in Anthropology* 3. Santa Barbara.

Gobalet, K. W.
2000 Has Point Conception Been a Marine Zoogeographic Boundary Throughout the Holocene? Evidence from the Archaeological Record. *Bulletins of the Southern California Academy of Sciences* 99(1):32–44.
2001 A Critique of Faunal Analysis; Inconsistency Among Experts in Blind Tests. *Journal of Archaeological Science* 28:377–386.

Gobalet, K. W., P. D. Schultz, T. A. Wake, and N. Siefkin
2004 Archaeological Perspectives on Native American Fisheries of California, With Emphasis on Steelhead and Salmon. *Transactions of the American Fisheries Society* 133:801–833.

Hubbs, C. L.
1960 The Marine Vertebrates of the Outer Coast. *Systematic Zoology* 9(3/4):134–147.

Jimenez-Rosenberg, S. P. A., R. J. Saldierna-Martinez, G. Aceves-Medina, and V. M. Cota-Gomez
2007 Fish Larvae in Bahia San Sebastian Vizcaino and the Adjacent Oceanic Region, Baja California, Mexico. *Check List* 3(3):204–223.

Love, M. S.
2011 *Certainly More Than You Want to Know About the Fishes of the Pacific Coast: A Postmodern Experience*. Santa Barbara: Really Big Press.

Love, M. S., M. Yoklavich, and L. Thorsteinson
2002 *The Rockfishes of the Northeast Pacific*. Berkeley: University of California Press.

May, R. V,. and D. L. Ike
1981 Coronado Islands, Baja California, Mexico: Research Design. *Pacific Coast Archaeological Society Quarterly* 17(1):43–62.

Miller, D. J., and R. N. Lea
1972 *Guide to the Coastal Marine Fishes of California*. Sacramento: State of California Department of Fish and Game. *Fish Bulletins* 157.

Page, L. M., H. Espinosa-Perez, L. T. Findley, C. R. Gilbert, R. N. Lea, N. E. Mandrake, R. L. Mayden, and J. S. Nelson
2013 *Common and Scientific Names of Fishes from the United States, Canada, and Mexico, Seventh Edition. American Fisheries Society Special Publication* 34. Bethesda: American Fisheries Society.

Peck, J. E.
2010 Multivariate Analysis for Community Ecologist: Step-by-step using PC-ORD. MjM Software Design, Gleneden Beach, Oregon.

Pondella II, D. J., B. E. Gintert, J. R. Cobb and L. G. Allen
2005 Biogeography of the Nearshore, Rocky-reef Fishes at the Southern and Baja California Islands. *Journal of Biogeography* 32:187–201.

Porcasi, J. F.
2012 Return to Ripper's Cove: Vertebrate Fauna from CA-SCAI-26, Catalina Island. *Pacific Coast Archaeological Society Quarterly* 46(3):1–17.

Quast, J. C.
1968 Fish Fauna of the Rocky Inshore Zone. In *Utilization of Kelp Bed Resources in Southern California. Fish Bulletin* 139. W. J. North and C. L. Hubbs, eds., pp. 35–55. Sacramento: California Department of Fish and Game.

R Development Core Team
2014 *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing.

Rick, T. C.
2007 The Archaeology and Historical Ecology of Late Holocene San Miguel Island. In *Perspectives in California Archaeology*, *Volume 8*, J. E. Arnold, ed. Los Angeles: Cotsen Institute of Archaeology, University of California.
2010 Weathering the Storm: Coastal Subsistence and Ecological Resilience on Late Holocene Santa Rosa Island, California. *Quaternary International* 239 (2011):135–146.

Rick, T. C., J. M. Erlandson, and R. L. Vellanoweth
2001 Paleocoastal Marine Fishing on the Pacific Coast of the Americas: Perspectives from Daisy Cave, California. *American Antiquity* 66(4):595–613.

Salls, R. A.

2000 The Prehistoric Fishery of San Clemente Island. *Pacific Coast Archaeological Society Quarterly* 36(1&2):52–71.

Smith, D. E., S. Harrison, C. R. Firth, and J. T. Jordan

2011 The Early Holocene Sea Level Rise. *Quaternary Science Reviews* 30:1846–1860.

Stephens, Jr., J. S., R. J. Larson, and D. J. Pondella II

2006 Rocky Reefs and Kelp Beds. In *The Ecology of Marine Fishes*. L. G. Allen, D. J. Pondella II, and M. H. Horn, eds., pp. 227–252. Berkeley and Los Angeles: University of California Press.

Stuvier, M., and P. J. Reimer

1993 Extended (Super 14) C Data Base and Revised CALIB 3.0 (Super 14) C Age Calibration Program. *Radiocarbon* 35(1):215–230.

Turnbull, J.

2013 *Identification of Fish Skeletal Remains from Archaeological Sites on Cedros Island, Baja California, Mexico*. Master's thesis, California State University, Bakersfield.