Prehistoric Bird Remains from the Southern Channel Islands

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Abstract

A synthesis of archaeologically recovered bird bone from three of the southernmost channel islands of California (San Clemente, Santa Catalina, and San Nicolas) reveals that a wide variety of birds was exploited by the early maritime hunter-gatherers of this area. Most of the bird species found in the middens are winter visitors to the islands, suggesting that the islanders relied most heavily on avian resources during those months of the year when other island resources might have been less abundant. This may represent a small-scale, seasonally proscribed example of the diet breadth model of optimal foraging theory.

Introduction

Birds were a customary component in the diet of prehistoric peoples, especially on islands where diversity of other prey classes is constrained (Brothwell et al.1981; Steadman 1995). Yet archaeological bird remains frequently get less attention than other, more noted constituents of the archaeofauna (e.g, mammals, fish, and shellfish). A few California coastal site reports deal extensively with avian bone (e.g., Howard 1929; Guthrie 1980, 1990, 1993a, 1993b; Bleitz-Sanburg 1987; Brown 1989), but many others include little mention of birds.

To advance our understanding of the role of birds in Southern California archaeological collections, this paper identifies bird bone recovered from excavations on two prolific sites with controlled chronological context on the southern Channel Islands: Eel Point on San Clemente Island (CA-SCLI-43) and Little Harbor on Santa Catalina Island (CA-SCAI-17). Because of the proximity and affinity of neighboring San Nicolas Island, portions of Bleitz-Sanburg's (1987) data from the Thousand Springs Site (CA-SNI-11) are incorporated to present a broader picture of the prehistoric birds of the Southern California archipelago.

The Sites and Excavations

Eel Point

San Clemente Island is the southernmost and fourth largest (148 sq km) of the California Channel Islands (Fig. 1). It is 61 km west and north of San Diego on the mainland. The other two southern islands, Santa Catalina and San Nicolas, are approximately 39 and 97 km distant from San Clemente, respectively. Stratigraphy is extraordinarily well preserved on San Clemente because there are no burrowing animals and most of the island is a restricted military preserve.

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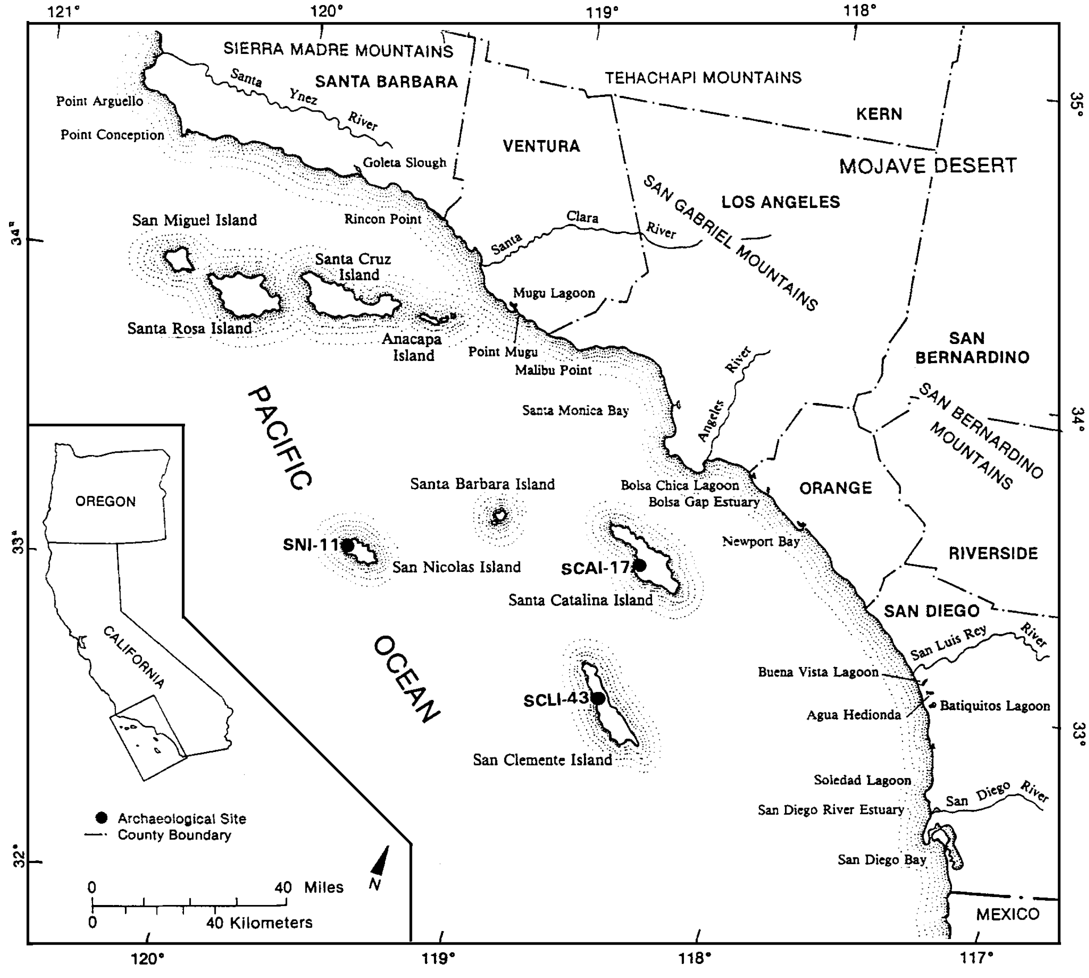

Fig. 1. Regional location of San Clemente, San Nicolas, and Santa Catalina Islands (adapted from original work by Rusty van Rossman).

The Eel Point site is located on a rocky headland jutting seaward from the western coast of the island. The resilience of this shoreline has played an important role in protecting the site from erosion from the sea. The site itself (Fig. 2) is an expansive knoll capping intact cultural deposits, often 300 to 500 cm thick. Previous research demonstrates that this site was occupied by maritime-adapted people beginning about 9000 years ago (McKusick and Warren 1959; Axford 1978, 1984; Armstrong 1985; Meighan 1984, 1986; Raab and Yatsko 1992; Salls 1988, 1990, 1991).

In 1994 and 1996 this site was excavated by California State University, Northridge (CSUN), in conjunction with the U.S. Navy's Office of Natural Resources. These projects were designed to develop a detailed chronological structure of the site and a carefully controlled sample of both artifacts and faunal materials. Thirteen test units were excavated to sterile soil

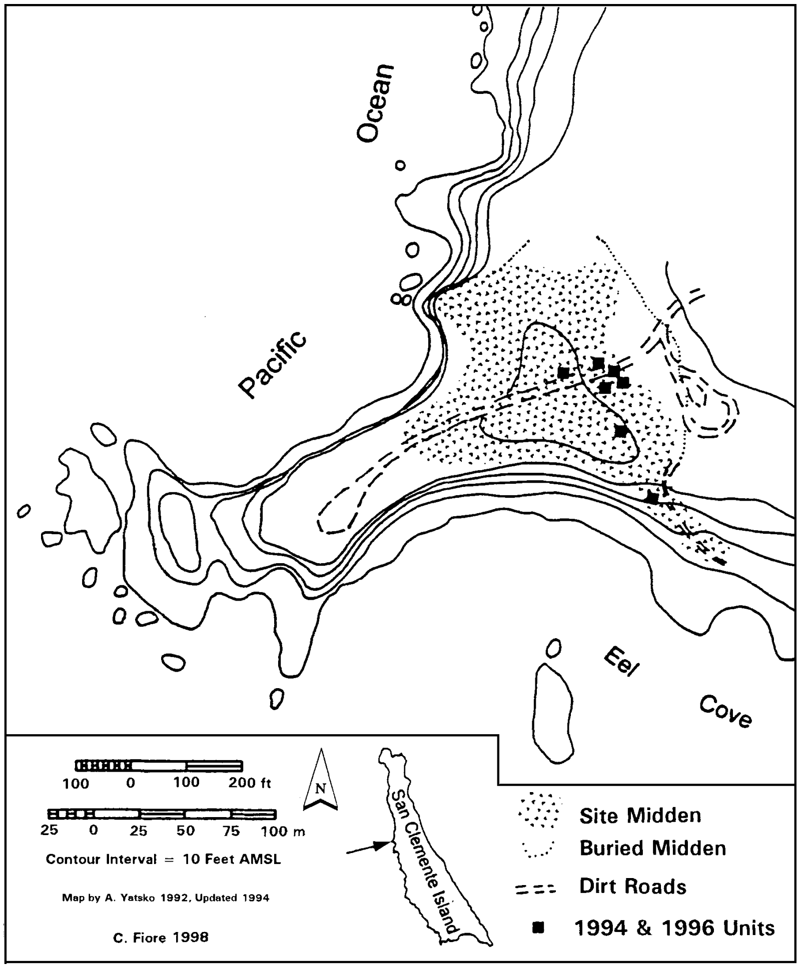

Fig. 2. Eel Point archaeological site (CA-SCLI-43) on San Clemente Island (courtesy of Christine Fiore).

for a total volume of 33.08 cubic meters, with the majority in natural strata. All material was screened through $^1/_8$ inch screen. Forty-two radiocarbon dates provided a temporal framework ranging between 8440 years B.P. and 600 years B.P. (Porcasi et al. 2000). All radiocarbon dates reported in this paper have been adjusted from a 1950 base to a year 2000 base. These combined projects yielded a total of 13,368 non-piscine bones (404 fragments per cubic meter).

Little Harbor

Santa Catalina Island is located 42 km southwest of Los Angeles Harbor and is the second largest of the California Channel Islands, 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 less than 1 km

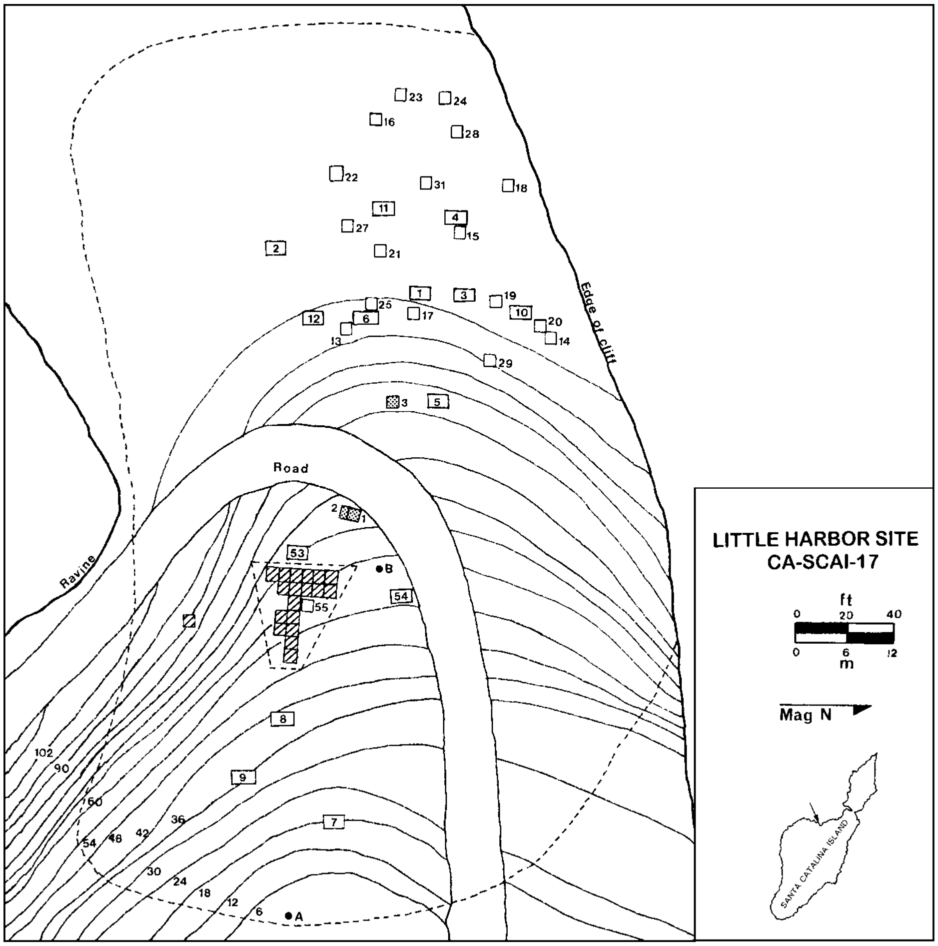

Fig. 3. Little Harbor archaeological site (CA-SCAI-17) on Santa Catalina Island. (Lined units are 1953-55 project; open units are 1973 project; dotted units are 1991 project.)

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 (Fig. 3).

Little Harbor contains an extremely dense midden measuring approximately 60 by 120 m. A well-defined, dark ashy midden begins about 30 cm below the present surface and transitions into a clay basal stratum at approximately 65 cm. This midden contains abundant bone and marine shell as well as lithic artifacts and other cultural materials. Three excavation projects at this site have produced a consistent interpretation of its cultural components.

In 1953-55, a University of California, Los Angeles (UCLA) field school excavated nineteen 5-foot-square units on the upper knoll of the site (26 cubic yards of matrix) (Meighan 1959). Although the matrix was not screened, this project yielded some 6,200 bones (238 fragments per cubic yard). Five distinct depositions (Layers) were identified by Meighan. Layer 4 was the dense cultural midden which produced the most abundant collection of artifacts and faunal remains. A single Middle Holocene radiocarbon date (uncorrected) of 3930 ± 250 years B.P. was obtained from a charcoal sample collected from the base of Layer 4. This date has now been dendrocalibrated and corrected by CALIB 3.0.3 (Stuiver and Reimer 1993) to 4384 years B.P. This date remains problematic, however, 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 archaeofaunal collection from the 1953-1955 project consisted of 4,037 mammal bones, reported as 81 per cent cetacean (primarily dolphins), 16 per cent pinniped (seals), and 3 per cent terrestrial mammal. A great deal of fishbone was collected, but bird bone was neither quantified nor identified.

In 1973, a UCLA field school again excavated this site. Matrix from 31 units located throughout the site was screened through $^1/_8$ inch screen (Nelson Leonard III, personal communication 1997). The units were excavated to varying depths and were recorded in both Natural Levels (NL) and arbitrary 10-cm levels. A total of 20.5 cubic meters of matrix yielded 17,928 mammal and bird bone fragments (875 fragments per cubic meter), excluding fishbone. The 1973 excavation established four NLs related to observable changes in the cultural deposit. Of these, the most productive (NL 2) corresponds to Layer 4 described by Meighan. One Late Holocene date (cal A.D. 1022) was derived from the uppermost stratum (NL 1), and two Middle Holocene radiocarbon dates (5591 and 5336 years B.P.) were derived from the primary midden (NL 2) (Kaufman 1976; Raab et al. 1995:293). The Middle Holocene dates support correlation of NL 2 with Meighan’s Layer 4 by establishing the date of NL 2 as about 5000 years B.P. (Kaufman 1976).

Little Harbor was explored again in 1991 by CSUN. This project consisted of three units excavated in arbitrary 10-cm levels (total excavated volume 1.575 cubic meters) screened through $^1/_8$ inch mesh. This yielded 3,422 mammal and bird bone fragments (2,173 fragments per cubic meter), excluding fishbone. Six additional radiocarbon dates were obtained from various levels of the three units, including the basal level of the deepest unit. On the basis of these dates, along with the earlier published dates, Raab et al. (1995:293) established a chronology of this site and a series of five cultural components spanning the Holocene. The richest of these is Component 2, which corresponds with Layer 4 (Meighan 1959:386) and NL 2 identified during the 1973 excavation. Based on six radiocarbon dates, an average estimated date of 5316 ± 30 years B.P. was established for Component 2. The earliest date derived from the site is 7704 years B.P., or some 4000 years older than the date originally published by Meighan (1959).

Using the ten dates established for this site, I have cross-dated the 1959, 1973, and 1991 excavations into a trans-Holocene timeline for Little Harbor (Porcasi 2000). The various

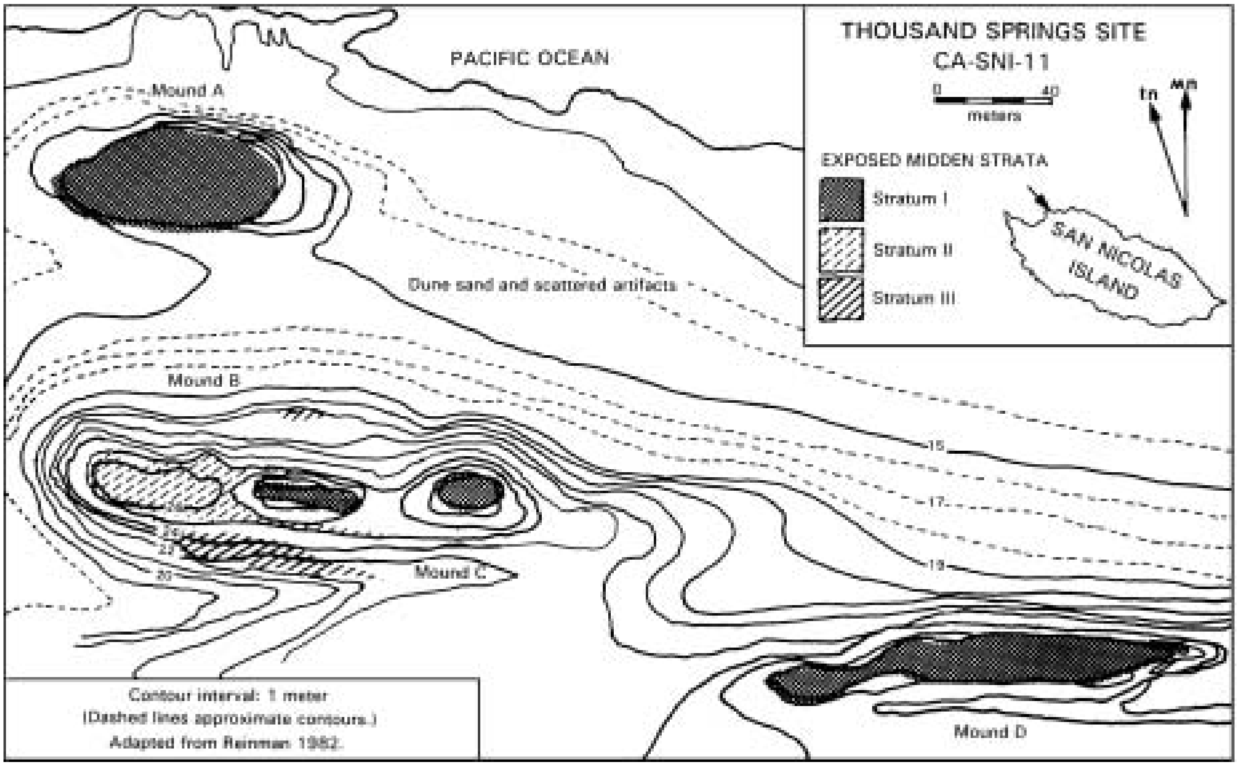

Fig. 4. Thousand Springs archaeological site (CA-SNI-11) on San Nicolas Island (adapted from Reinman 1982).

Layers, NLs, and Components identified for this site are grouped into five periods across the Holocene: Early (10,000-7000 B.P.), Middle (7000-3500 B.P.), Late (3500 B.P. to 600 B.P.), and two intervening (but not "transitional") periods, the Undated Early/Middle (UE/M) and Undated Middle/Late (UM/L). The two undated periods present the content of undated strata deposited between dated strata. Their stratigraphic position allows for their relative temporal placement. While the stratigraphic integrity of the site has been questioned (Arnold et al. 1997), both Meighan (1959) and Raab et al. (1995) observed that only the uppermost 30 to 35 cm were disturbed by pothunting or erosion. My own 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 burrows, and no other evidence of bioturbation. Therefore, stratigraphy below 30 cm is assumed to be undisturbed.

Thousand Springs

San Nicolas Island lies northwest of San Clemente and west of Santa Catalina Islands and is the outermost island of the southern archipelago, almost 105 km from the mainland. It is much smaller and lower in elevation than the other two islands, and strong northwesterly winds continually buffet the island, deflating sites and redepositing archaeological materials (Salls 1988:423-424). As a result, the stratigraphy of sites is disturbed and the chronology of many San Nicolas Island sites is enigmatic.

Bleitz-Sanburg (1987) described mammalian and avian remains recovered from 1977-1979 excavations at the Thousand Springs site on the northwestern coastal terrace of this island (Fig. 4). This is a widespread dune site with an extensive shell midden in which three cultural Strata (I, II, III) were defined on the basis of artifact typology and uncalibrated radiocarbon dates ranging between 4210 and 623 years B.P. (Reinman and Lauter 1981; Reinman 1982; Bleitz-Sanburg 1987:71). Matrix was screened through $^1/_4$ inch mesh (Bleitz-Sanburg 1987:72). Of the three cultural strata, Strata I and II produced Late Holocene dates while Stratum III produced Middle Holocene dating. Most cultural material and bone was recovered from Stratum I. Because of the disturbed stratigraphy at the site and possible contamination of the original radiocarbon samples, a new suite of radiocarbon dates was derived in 1997 bracketing Stratum I fairly late in the Holocene, between about 1650 and 650 years B.P. (dendrocalibrated) (Patricia Martz, personal communication 1997). All Thousand Springs faunal data reported here are adapted from Bleitz-Sanburg (1987).

Identification of Bird Remains

All bird bone reported here was identified by comparison with museum-curated specimens at the Natural History Museum of Los Angeles County; the Zooarchaeology Laboratory, Cotsen Institute of Archaeology; the D. R. Dickey biological collection at UCLA; and the Santa Barbara Museum of Natural History. More than 50 genera or species of birds are identified at these sites (Table 1). A list of about 200 bird species which might be found on the southern Channel Islands during all seasons is presented by Howell (1917). While some species are year-round residents or summer visitors, the majority of recovered bone represents species present on the southern Channel Islands in greatest number during the winter months (Table 2) (Peterson 1990; Garrett and Dunn 1981; Willett n.d). This winter presence suggests a seasonally proscribed subsistence pattern.

Bird Bone From Eel Point, San Clemente Island

The two-season excavation at Eel Point yielded a total of 1,549 bird bones weighing 1,194.09 grams. Of these, 469 specimens (30 per cent of the total avian collection) were identified to family, genus, and/or species level. In terms of bone frequency (Number of Identified Specimens, or NISP), the avian collection constituted 11.6 per cent of the total bone collection, excluding fishbone. This percentage, however, is inflated by a noteworthy anomaly. During the 1994 project, a concentration of more than 187 albatross (*Phoebastria* sp.) bones was found in a single natural stratum containing a small pit feature. Since the volume of that stratum was only 0.4 cubic meter, the NISP/volume (sometimes termed “density”) of albatross

Table 1. Birds identified on the Southern Channel islands.

Family/Genus/species	Common Name	Eel Point NISP	Little Harbor NISP	Thousand Springs NISP*
Accipiter cooperi	Cooper's hawk	-	1	-
Accipitridae	Hawk	-	1	-
Aechmophorus occident.	Western grebe	-	4	-
Anas acuta	Northern pintail	-	1	-
Anas cyanoptera	Cinnamon teal	-	2	-
Anas platyrhynchos	Mallard	-	3	-
Anas sp.	Duck	-	4	-
Anseridae/*Anser* sp.	Goose	1	5	-
Ardea herodias	Great blue heron	-	-	2
Aythya affina	Lesser scaup	-	1	-
Branta canadensis	Canada goose	-	1	1
Branta sp.	Goose	-	1	-
Buteo sp.	Buzzard hawk	-	2	-
Buteo jamaicensis	Red-tailed hawk	1	-	-
Cathartes aura	Turkey vulture	-	1	-
Cerorhinca monocerata	Rhinoceros auklet	2	15	5
Chen hyperboreas	Snow goose	-	1	-
Colaptes auratus	Northern flicker	-	2	-
Corvus brachyrhynchos	Crow	1	-	-
Corvus corax	Raven	9	8	-
Phoebastria sp.	Albatross	217	12	-
Phoebastria albatrus	Short-tailed albatross	1	4	150
Phoebastria nigripes	Black-footed albatross	-	1	3
Falconiformes	Falcon	-	1	-
Falco peregrinus	Peregrine falcon	-	-	4
Fratercula cirrhata	Tufted puffin	-	2	-
Fulica americana	American coot	-	2	-
Fulmarus glacialis	Northern fulmar	63	61	179
Gallinago gallinago	Common snipe	-	1	-

*From Bleitz-Sanburg 1987:224 (Table 20).

Table 1 (continued). Birds identified on the Southern Channel islands.

Family/Genus/species	Common Name	Eel Point NISP	Little Harbor NISP	Thousand Springs NISP*
Gavia sp.	Loon	3	9	-
Gavia immer	Common loon	7	5	-
Gavia pacifica	Pacific loon	-	2	2
Gavia stellata	Red-throated loon	-	2	-
Laridae	Gulls	33	48	-
Larus californicus	California gull	1	-	10
Larus Heermanni	Heermann's gull	2	-	-
Larus occidentalis	Western gull	-	-	34
Larus glaucescens	Glaucous gull	-	1	11
Oceanodroma leucorhoa	Leach's petrel	-	1	-
Oceanodroma sp.	Storm petrel	-	2	-
Pandion haliaetus	Osprey	-	2	-
Pelecanus sp.	Pelican	8	1	-
Phalacrocorax sp.	Cormorant	20	22	-
Phalacrocorax auritus	Double-crested cormorant	37	3	12
Phalacrocorax penicil.	Brandt cormorant	-	-	65
Podiceps sp.	Grebe	-	1	-
Podiceps grisegena	Red-necked grebe	2	-	-
Podiceps nigricolis	Eared grebe	-	1	8
Pterodroma sp.	Petrel	-	1	-
Ptychoramphus aleuticus	Cassin's auklet	34	16	23
Puffinus sp.	Shearwater	12	11	-
Puffinus bulleri	Buller shearwater	3	-	-
Puffinus creatopus	Pink-footed shearwater	10	2	-
Puffinus griseus	Sooty shearwater	-	3	-
Puffinus tenuirostris	Short-tailed shearwater	2	2	-
Rissa tridactyla	Black-legged kittiwake	-	1	-
Uria aalge	Common murre	-	6	-
Aves	Unidentified bird	1080	1003	-

*From Bleitz-Sanburg 1987:224 (Table 20).

Table 2. Seasonality and breeding range of identified bird species.
(Code: y-yearly, w-winter, a-autumn, sp-spring, s-summer, r-rare)

Taxon	Seasonality on Islands (Peterson 1990)	Seasonality on Islands (Garrett and Dunn 1981)	Breeding Area (Peterson 1990)
Cooper's hawk	y	a/yr	Coastal mainland
Western grebe	w	w/yr	Coastal
Northern pintail	w	w/yr	Aleutian Islands
Cinnamon teal	y	y/w/a	West Coast
Mallard	y	y/sp/s	West Coast
Great blue heron	w	y	West Coast
Lesser scaup	w	w	Inland Canada/Alaska
Canada goose	w	w	Canada/Alaska
Red-tailed hawk	y	y	West Coast
Turkey vulture	y	sp/s/yr	West Coast
Rhinoceros auklet	w	w/yr	Central Coast
Snow goose	w	wr	North polar area
Northern flicker	y	y	West Coast
Crow	y	y	West Coast
Raven	y	y	West Coast
Short-tailed albatross	unstated	sr	Japanese islands[a]
Black-footed albatross	unstated	sr	Pacific islands[a]
Peregrine falcon	w/r	yr	Northern California
Tufted puffin	w/r	w/r	Coast North California
American coot	y	y	West Coast
Northern fulmar	w	w/sp/yr	Aleutian Islands
Common snipe	w	w	Canada/Alaska/NW US
Common loon	w	w	Canada/Alaska
Pacific loon	w	w	Alaska
Red-throated loon	w	w	Alaska
California gull	See note b		
Heerman's gull	See note b		
Western gull	See note b		
Glaucous gull	See note b		

Table 2 (continued). Seasonality and breeding range of identified bird species.
(Code: y-yearly, w-winter, a-autumn, sp-spring, s-summer, r-rare)

Taxon	Seasonality on Islands (Peterson 1990)	Seasonality on Islands (Garrett and Dunn 1981)	Breeding Area (Peterson 1990)
Leach's petrel	s	s	So. California islands
Osprey	w	yr	No. California to Alaska
Pelican	See note c		
Double-crest. cormorant	y	y	West Coast
Brandt's cormorant	y	y	West Coast
Red-necked grebe	w	w	Canada/Alaska
Eared grebe	w	w	Inland north to Alaska
Cassin's auklet	y	y	West Coast
Pink-footed shearwater	sp/s/a	sp/s	Chilean islands
Buller's shearwater	a	s	New Zealand
Sooty shearwater	s	sp/s	Australia/New Zealand/So. America
Short-tailed shearwater	a	w	Australia
Black-legged kittiwake	w	w/sp	Alaska
Common murre	w	w/sp	Central California coast

Notes: a. Albatrosses are entirely pelagic and generally solitary; they are found on land primarily during breeding. Range from Bering Sea to Baja California when not breeding in winter. Short-tailed albatross breeds on Japanese islands only. Black-footed albatross breeds on islands in central and west Pacific, primarily Hawaii.
b. Seasonality and breeding area varies with species. Some nonbreeders summer on California coast. Species frequently hybridize.
c. American white pelican (*P. erythrorhynchos*) is winter visitor; brown pelican (*P. occidentalis*) is resident year-round offshore with breeding colonies on coast and coastal islands. More common in summer.

in this stratum is equivalent to about 468 fragments per cubic meter (Porcasi 1995,1999a). No more than three albatross bones were recovered from any other stratum during the 9,000-year occupation of the site. The genus of albatrosses has recently been changed from *Diomedea* to *Phoebastria*; only the wandering albatross (*D. exulans*) retains the *Diomedea* genus (American Ornithologists' Union 1998:xvii).

The stratum which produced this albatross concentration was dated to 3743 years B.P. (Beta-76135) as the mean intercept of the 1-sigma range, dendrocalibrated and corrected by CALIB 3.0.3 (Stuiver and Reimer 1993). This stratum produced a greater frequency per cubic meter of all mammal and bird bone than any other stratum at the site and was the apparent culmination of a "Mid-Holocene Peak" of bone deposition which began about 4597 years B.P., reached its apex ca. 3750 years B.P., and then abruptly "crashed" (Porcasi 1995, 1999a). It is also likely that most of the unidentified bird bone (fragments and phalanges) in this feature is albatross because of its large size and direct association with the identified albatross bone. Because of the limited availability of museum-curated comparative specimens of the nearly extinct *Phoebastria albatrus* (Short-tailed Albatross), the largest albatross to visit California, it was necessary to establish a reliable size-range guide to distinguish between that species and the somewhat smaller *P. nigripes* (Black-footed Albatross), which also visits California. See Porcasi 1999b (this issue).

At least eight individual albatrosses were represented in this feature. This unusual concentration raised the percentage of bird bone to nearly more than 20 per cent of the total bone collection for that year, and the albatross bone constituted 71 per cent of the identified bird bone for that season. Bleitz-Sanburg reported a concentrated deposit of albatross bone at the Thousand Springs site (1987:225), almost all of which was in Stratum I, dated later in the Holocene than the Eel Point albatross bone. This albatross is not contemporary with the Eel Point concentration and may reflect a subsequent presence of these birds on the California islands, although this Late Holocene presence has not been found on San Clemente Island. At both island sites the strata yielding the albatross concentrations are exceptional, differing markedly from any strata dated before or after. For the 1996 season, bird bone constituted 6.8 per cent of the total mammal/bird collection (Table 3).

Table 3. Summary of the 1994/1996 Eel Point archaeofauna.

Category	NISP	Per cent of Total NISP	Per cent of Identified NISP (4,703)[c]
Pinnipeds	791	5.9	16.8
Delphinidae	922	6.9	19.6
Cetaceans	189	1.4	4.0
Sea Otters	501	3.7	10.65
Unidentified mammals	7,715	57.7	-
Unidentified vertebrates	950	7.1	-
Other[a]	92	< 1	1.96
Terrestrial mammals	659[b]	4.9	14
Birds	1,549	11.6	32.9
Total	13,368		

Notes: [a]Rodents and lizards; [b]Includes a feature of more than 600 neonate/fetal dog bones, probably a buried litter; [c]Excludes unidentified mammals and vertebrates.

Subsequent to the 1994/1996 excavations, another site on San Clemente Island (CA-SCLI-152) yielded an albatross concentration which rivals that from Eel Point and which is similarly dated to the Mid-Holocene Peak. Evidence of at least five albatrosses was recovered from only 0.2 cubic meters of matrix. This material was radiocarbon-dated to 3570 ± 40 years B.P. (Beta-105603) (Dennis R. Gallegos, personal communication 1997).

Bird Bone From Little Harbor, Santa Catalina Island

The Little Harbor 1973 and 1991 projects yielded a combined total of 1,282 bird bones weighing 452.53 grams. Of these, 298 bones (23 per cent of the avian collection) were identified to family, genus, or species. Overall, bird bone made up 6 per cent of the total non-piscine collection (Table 4); this is similar to the 6.8 per cent reported for the 1996 collection at Eel Point, which may be a "typical" proportion of bird bone for these island sites (when not inflated by an anomalous feature such as the 1994 Eel Point albatross concentration).

Bird Bone from Thousand Springs, San Nicolas Island

This site produced a total of 5,079 mammal and bird bones, 509 of which (10 per cent) were bird. Of the marine mammal bone, 690 fragments were derived from a single whale scapula;

Table 4. Summary of the 1973/1991 Little Harbor archaeofauna.

Category	NISP	Per cent of Total NISP	Per cent of Identified NISP (6,119)[b]
Pinnipeds	1,033	4.8	16.9
Delphinidae	3,073	14.4	50.2
Cetaceans	394	1.8	6.4
Sea Otters	96	< 1	1.57
Unidentified mammals	14,917	69.9	-
Unidentified vertebrates	314	1.47	-
Human	118[a]	< 1	1.9
Snake	1	< 1	< 1
Terrestrial mammals	122	< 1	1.96
Birds	1,282	6.0	21
Total	21,350		

Notes: [a]Remains of a cremation recovered during the 1991 project;
[b]Excludes unidentified mammals and vertebrates.

thus, the marine mammal bone NISP can be revised as 3,880. Surprisingly, in terms of bone weight, both Strata I and II (Late Holocene strata) produced extremely high percentages of bird bone (calculated from Bleitz-Sanburg 1987:87). Of the total mammal and bird bone weight in these two strata, 15 per cent was bird bone. This is an exceptionally high value in light of the vast size differences and osteological dissimilarity between marine mammals (which made up the majority of the mammalian collection) and birds. In Stratum III (Middle Holocene) the percentage of bird bone weight was somewhat less (12 per cent), but still extraordinarily high. These percentages, both in terms of specimen counts and weights, are considerably higher than bird bone percentages at either Eel Point or Little Harbor. Apparently the people of San Nicolas Island exploited birds far more than did the people on the other two islands. As on Santa Catalina and San Clemente, however, the predominant birds in the Thousand Springs site were pelagic winter visitors.

Crossdating the Sites and the Faunal Remains

Using the suite of ^{14}C dates derived from Eel Point, the crossdated cultural midden at Little Harbor, and the radiocarbon-dated Cultural Strata from Thousand Springs, the avian collections from these neighboring islands can be assessed on an areal basis within a broad chronological framework. Figure 5a presents the three-site avian specimen count (NISP) over the five-period timeline. For this report, Thousand Springs Strata I and II data are grouped into Late Holocene, and Stratum III represents the Middle Holocene. Because this report deals with three sites in which the middens have been dated with differing levels of chronological precision (i.e., midden contents have been chronologically “lumped” differently at each site based on the availability of ^{14}C dates), sample-size bias is of utmost concern. For example, most cultural material at Eel Point and Little Harbor was dated to the Middle Holocene, and the Middle Holocene peaks at both Little Harbor and Eel Point reflect this. On the other hand, the primary (Stratum I) midden at Thousand Springs is dated to the Late Holocene, and NISP at that site is seen to increase in the Late Holocene.

Sample-size bias can be mitigated to an extent by converting NISP values to NISP/cubic meter (frequency/volume), sometimes referred to as “density” (Fig. 5b). In this case, exploitation of birds at Eel Point and Little Harbor remains greatest during the Middle Holocene, but the quantity of bird bone per cubic meter actually declines in the Late Holocene midden at Thousand Springs. The anomalous Early Holocene value for Little Harbor is based on a single 0.10 cubic meter sample, exemplifying an extreme case of small sample bias.

Finally, a measure which more effectively avoids sample-size bias is the relative proportion (percentage) of bird in the diet during each of the five trans-Holocene periods for each site (Fig. 5c). Here we see several trans-Holocene trends:

> 1. Birds were a greater constituent of the islanders’ diet during the Early Holocene than during the Late Holocene.

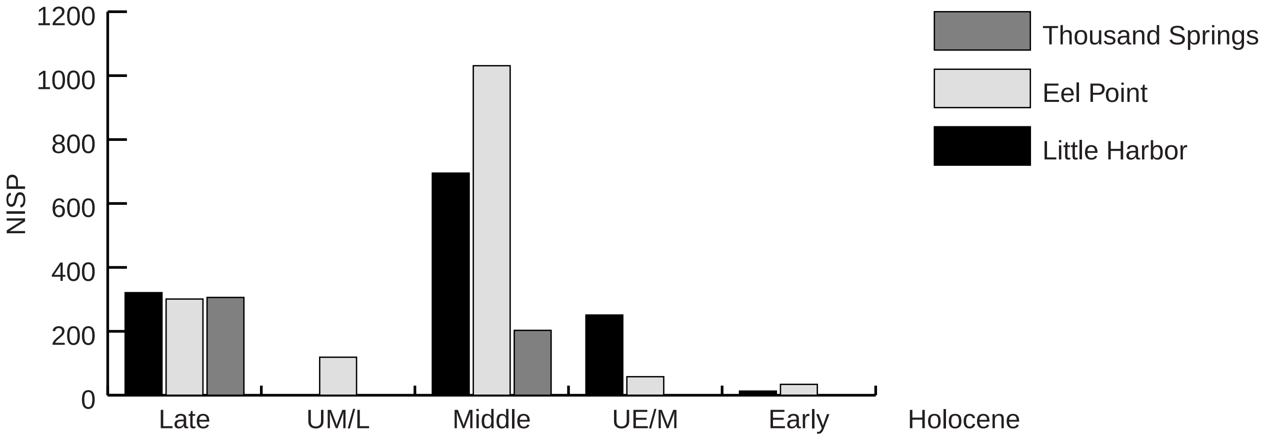

Fig. 5a. Three sites: Avian bone NISP over time.

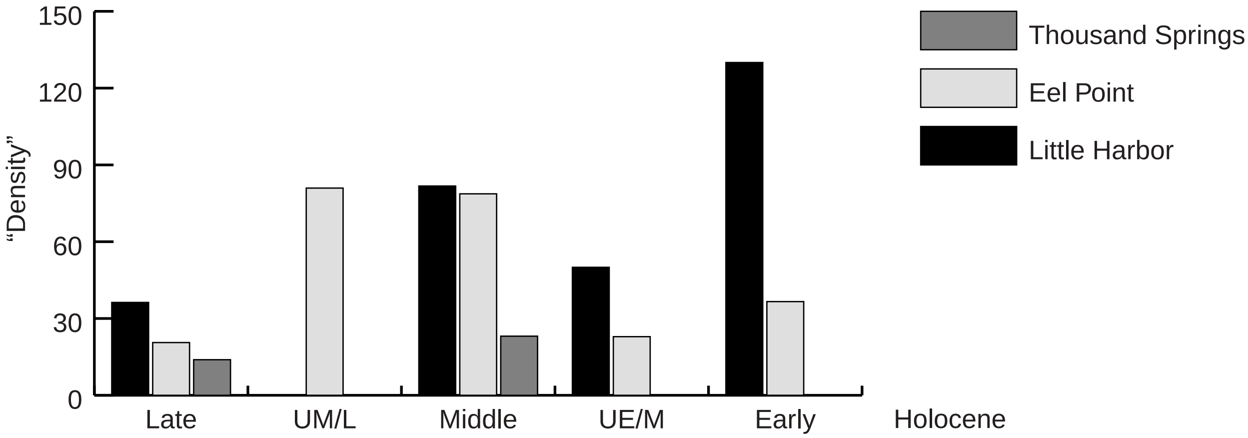

Fig. 5b. Three sites: Avian bone “density” over time.

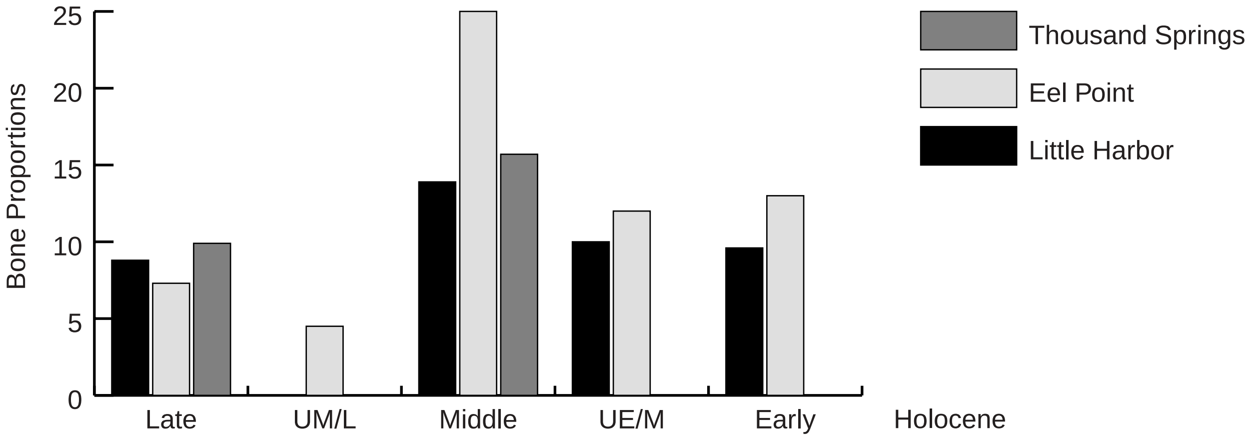

Fig. 5c. Three sites: Avian bone proportion over time.

2. Usage of birds peaked during the Middle Holocene, with evidence of extremely intense exploitation of birds at Eel Point.
3. The Middle-to-Late Holocene porporations at Little Harbor and Thousand Springs are very similar, albeit with higher values at Thousand Springs.
4. In the Late Holocene all three island sites had similar proportions of birds in the diet (ranging between 7 per cent and 10 per cent), which may represent a typical pattern for the southern Channel Islands.
5. Taphonomic destruction of slender bird bone is not a major concern in these island sites. Early Holocene deposits produced more bird bone than did Late Holocene deposits.

The Little Harbor bird collection showed greater variation in species while Thousand Springs yielded the least variation in bird species. This may be partly due to screening with $^1/_4$ inch mesh rather than $^1/_8$ inch as was used at Little Harbor and Eel Point. In terms of species, the three sites presented remarkably similar patterns (Table 1). The most commonly collected birds at all three sites included albatross, northern fulmar, cormorant, gulls, and two auklets (Cassin's and rhinoceros). Both Eel Point and Thousand Springs yielded what may be unique concentrations of albatross bone (Porcasi 1999a), but the most common bird at Thousand Springs was the northern fulmar. Eighty per cent of the Thousand Springs albatross was found in (Late Holocene) Stratum I, while 70 per cent of the northern fulmar bones were recovered from earlier (Middle Holocene) Stratum III. Albatrosses are more common in the islands during winter months, and the northern fulmar is almost exclusively a winter visitor. While cormorants and gulls can be found on the islands during any month, they are present in greatest number during the winter (the gull population varies by species [Garrett and Dunn 1981:51]). Cassin's auklet is a year-round resident in the islands, but the rhinoceros auklet is a winter visitor. Thus, the most consistently found bird species in large number, as well as many of the other species found in smaller quantities, are those which visit the islands during their winter migrations along the Pacific flyway.

Discussion

Since about 200 species of birds are potentially available on the islands in different seasons of the year, the dominance of wintering species in the archaeological record calls for explanation. Optimal foraging theory may present a direction for this deliberation.

Optimal foraging theory (as expounded by MacArthur and Pianka 1966; Bettinger 1991; and Kelly 1995, among others) consists of several models which collectively posit that subsistence resources are ranked and utilized by hunter-gatherers according to the post-encounter return rate of each resource (the amount of energy gathered per unit time after encountering a resource) and that the diet of a population will be widened to include lower-ranked prey species when the more preferred species become more costly to obtain. Return rate of a prey species is determined by search costs (encounter rates) and handling costs (time, energy, and risk involved in pursuing, capturing, and processing the resource). Specifically, the diet-breadth model of optimal foraging theory implies that large-bodied, highly productive food resources will be exploited as long as their availability and the energy expenditures of obtaining these resources permits. When these resources are no longer available in sufficient quantity that they are easily obtained, lower-ranked, less-productive resources will be substituted into the diet.

Terrestrially breeding pinnipeds were a major food resource for prehistoric islanders. These were most abundant and vulnerable to hunters during spring and summer while females and pups basked in their beach rookeries and males were briefly present for breeding (although males were infrequently taken [Porcasi et al. 2000]). Most common species were the California sea lion (*Zalophus californianus*) and the southern or Guadalupe fur seal (*Arctocephalus townsendi*). During winter, adult males leave the area and some (but not all) females and pups, especially the sea lions, move south into warmer areas (Nowak and Paradiso 1983:1101-1110; Ingles 1989:401-404; Reidman 1990; Hildebrandt and Jones 1992; Jones and Hildebrandt 1995). In short, the winter focus on exploitation of birds may signal a heightened seasonal reliance on birds—as predicted by the prey choice model—when higher-ranked prey (the large-bodied pinnipeds) were somewhat less abundant, increasing the required energy and risk input. Obviously, when a resource is less available (as are pinnipeds in winter), their return rate drops; i.e., search and handling costs increase. This increase prompts a widening of dietary choices to include lower-ranked, less productive resources such as birds. Overall, this amounts to loss of foraging efficiency since the lower-ranked prey cannot provide the same nutritional levels as the original high-ranked prey (Broughton 1994, 1995).

Conclusions

This paper provides evidence that the early inhabitants of the southern Channel Islands exploited birds primarily during winter months. While numerous bird species are resident on the coast and islands year-round or are visitors during other seasons, the species most commonly found in the middens are wintering waterfowl and open-ocean pelagic birds. While certainly not conclusive, this pattern of bird exploitation suggests three conclusions: (1) the island sites were occupied during winter months when these birds could be exploited; (2) the dietary pattern of the island inhabitants may have been seasonally proscribed by the life-histories of the pinnipeds; and (3) the widening of dietary breadth may reflect a pattern of short-term (seasonal) decline in optimal foraging efficiency. Furthermore, in terms of a trans-Holocene pattern, birds were a more important constituent in the islanders' diet during the Early and Middle Holocene than during the Late Holocene, and the typical Late Holocene island diet probably consisted of 7 per cent to 10 per cent bird protein.

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