
Prehistoric Human Impacts on California Birds: Evidence from the Emeryville Shellmound Avifauna
Author(s): Jack M. Broughton
Source: *Ornithological Monographs*, No. 56, Prehistoric Human Impacts on California Birds: Evidence from the Emeryville Shellmound Avifauna (2004), pp. iii-xi, 1-90
Published by: University of California Press for the American Ornithologists' Union
Stable URL: http://www.jstor.org/stable/40166805
Accessed: 25/08/2011 15:58

PREHISTORIC HUMAN IMPACTS ON CALIFORNIA BIRDS: EVIDENCE FROM THE EMERYVILLE SHELLMOUND AVIFAUNA

By

Jack M. Broughton

Department of Anthropology, University of Utah, 270 South 1400 East, Room 102, Salt Lake City, Utah 84112, USA

ORNITHOLOGICAL MONOGRAPHS NO. 56

PUBLISHED BY
THE AMERICAN ORNITHOLOGISTS' UNION
WASHINGTON, D.C.
2004

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

From the Editor

Everyone is aware that human activities affect birds, usually negatively. In recent years, we responded to apparent declines in bird populations by developing a massive international migratory-bird conservation plan that hopes to "keep common birds common." Yet we continue to face an extinction crisis as habitat dwindles and less and less of the world remains wild.

Many of us think of these negative effects on bird populations as a modern phenomenon, one that came along with burgeoning populations virtually throughout the globe. Those of us who study island avifaunas were aware of cases such as Hawaii, where humans caused many extinctions through harvest and habitat change over 1,000 years ago, but these we thought of as special cases that revolved around the constraints of naïve island faunas. Others were aware of the arguments that many of our native North American megafauna, things like mammoths and ground sloths, may have been driven to extinction by the earliest humans on the continent. But many scientists familiar with the relevant archaeology and paleontology have argued that climate change is a far more parsimonious explanation for those losses. The general consensus was that pre-European humans living in North America had little or no effect on continental wildlife populations.

After you read *Ornithological Monograph No. 56,* I think you will agree that we need to reconsider our impressions about human impacts on bird populations in the distant past. Jack Broughton makes an excellent case that native peoples living in the San Francisco Bay area harvested enough birds to deplete populations and even cause some local extinction, perhaps as long as 2,000 years ago. He also notes that proper knowledge of prehistoric bird populations is critical to understanding present-day patterns of population change and related factors such as genetic bottlenecks. In this monograph, avian paleontology and archaeology meet modern conservation biology and teach us to be careful about what we assume.

As always, reviewing monograph-length manuscripts requires dedicated volunteers. For *Ornithological Monograph No. 56,* we thank Douglas Causey of the Museum of Comparative Zoology, Harvard University; and R. Lee Lyman, Chair of the Department of Anthropology at the University of Missouri-Columbia. While some of you may want to read around the osteological details necessary for our author to make his case, I think that all of you will be impressed by the major impacts indigenous peoples have had on continental bird populations.

John Faaborg

Ornithological Monographs
Volume (2004), No. 56, 1–90

PREHISTORIC HUMAN IMPACTS ON CALIFORNIA BIRDS: EVIDENCE FROM THE EMERYVILLE SHELLMOUND AVIFAUNA

JACK M. BROUGHTON[1]

Department of Anthropology, University of Utah, 270 South 1400 East, Room 102, Salt Lake City, Utah 84112, USA

ABSTRACT.—The abundance of artiodactyls, marine mammals, waterfowl, seabirds, and other animals in 18th- and 19th-century California astonished early explorers, and the incredible wildlife densities reported in their accounts are routinely taken as analogues for the original or pristine zoological condition. However, recent analyses of archaeological fish and mammal materials from California and elsewhere in western North America document that those early historic-period faunal landcsapes represent poor analogues for prehistoric environments, because they postdate a dramatic 16th- or 17th-century population-crash of native hunters. The superabundance of tame wildlife witnessed during the early historic period may only reflect population irruptions that followed the demise of their main predators. While analyses of archaeological faunas from California have documented that prehistoric peoples had substantial impacts on populations of fish and mammals, harvest pressure on bird populations has yet to be documented. The hypothesis that prehistoric hunters caused depressions of avian taxa is tested here through a description and analysis of the Emeryville Shellmound avifauna: the first substantial, well-documented archaeological bird sequence for the late Holocene of California. A total of 64 species is represented by the 5,736 identified bird specimens derived from the stratified Emeryville deposits that date from between 2,600 and 700 years ago; waterfowl, cormorants, and shorebirds dominate the collection. Chrono-stratigraphic trends in relative taxonomic abundances and age structure within those groups are consistent with long-term anthropogenic depressions resulting from expansion of regional human populations over the occupational history of the mound. In general, large-sized bird species, those that occupied habitats closer to bayshore human residences, and those that were otherwise sensitive to human hunting pressure decreased in numbers over time. In the waterfowl assemblage, geese (*Branta canadensis, B. hutchinsii, Anser albifrons, Chen caerulescens, C. rossii*) declined significantly over time as compared with ducks, and the remains of the largest-sized geese (*B. canadensis moffitti, A. albifrons, C. caerulescens*) declined as compared with the smaller ones (e.g. *B. hutchinsii, C. rossii*). As hunting returns from local patches decreased over time, ever-increasing use was made of more distant, marine-oriented duck taxa—namely scoters (*Melanitta fusca* and *M. perspicillata*). Double-crested Cormorants (*Phalacrocorax auritis*) were especially hard-hit by human harvesting activities, which caused the extirpation of local island-based colonies; changes in the relative age and species composition of the regional *Phalacrocorax* fauna; and, ultimately, a nearly complete abandonment of cormorant hunting. Finally, the largest species of shorebirds—Marbled Godwits (*Limosa fedoa*), Long-billed Curlews (*Numenius americanus*), and Whimbrels (*N. phaeopus*)—declined significantly over time, in comparison with smaller shorebird species. None of those patterns are correlated with changes in pertinent paleoenvironmental records that might indicate that they were caused by climate-based environmental change. They suggest, however, that activities of human foragers had a fundamental influence on the late Holocene avian fauna of the region, and that records of bird abundances, distributions, and behavior from the early historic period are anomalous in the context of the past several thousand years of intensive human harvesting. The conclusions presented here challenge the conventional wisdom regarding prehistoric landscape ecology in North America and have important implications for analyses that require information on long-term population histories, including those involving modern patterns in genetic diversity directed toward conservation-related problems. *Received 10 April 2004, accepted 6 August 2004.*

RESUMEN.—La abundancia de artiodáctilos, mamíferos marinos, aves acuáticas (Anseriformes), aves marinas y otros animales en California durante los siglos 18 y 19 deslumbró a los primeros exploradores, y las densidades increíbles de fauna silvestre

---

[1] E-mail: jack.broughton@csbs.utah.edu

mencionadas en sus informes son tomadas de modo rutinario como análogas a la condición zoológica original o prístina. Sin embargo, análisis recientes de materiales arqueológicos de peces y mamíferos provenientes de California y de otros sitios del oeste de América del Norte señalan que estos escenarios históricos tempranos de la fauna representan analogías equivocadas de los ambientes prehistóricos, ya que ellos son posteriores a una reducción dramática de las poblaciones de cazadores nativos ocurrida durante el siglo 16 o 17. La superabundancia de fauna silvestre dócil observada durante el período histórico temprano puede sólo reflejar irrupciones en las poblaciones que siguieron a la caída de sus principales depredadores. Mientras que los análisis de la fauna arqueológica de California han documentado que las poblaciones humanas prehistóricas tuvieron un impacto substancial en las poblaciones de peces y mamíferos, no se ha documentado aún la presión de cosecha en las poblaciones de aves. La hipótesis de que los cazadores prehistóricos causaron reducciones de taxa de aves es evaluada aquí a través de la descripción y el análisis de la avifauna de Emeryville Shellmound: la primera secuencia arqueológica de aves substancial y bien documentada del Holoceno tardío de California. Un total de 64 especies de aves está representado por 5736 ejemplares identificados, derivados de los depósitos estratificados de Emeryville, que datan de entre 2,600 y 700 años atrás; dominan la colección los Anseriformes, los cormoranes y las aves playeras. Las tendencias crono-estratigráficas en las abundancias taxonómicas relativas y en la estructura de edades dentro de esos grupos son consistentes con las disminuciones a largo plazo de las poblaciones humanas, resultantes de la expansión regional de estas poblaciones durante el período de ocupación del sitio arqueológico. En general, las especies de aves de gran tamaño, las que ocuparon ambientes cercanos a las playas habitadas por humanos y aquellas que de otro modo eran sensibles a la presión antrópica de caza decrecieron en abundancia con el tiempo. Entre los Anseriformes, los gansos (*Branta canadensis, Anser albifrons, Chen caerulescens, C. rossii*) declinaron significativamente con el tiempo en comparación con los patos, y los restos de gansos de gran tamaño (*B. canadensis moffitti, A. albifrons, C. caerulescens*) declinaron en comparación con los más pequeños (e.g. *B. canadensis minima, C. rossii*). A medida que la abundancia de presas cazadas en parches locales declinó con el tiempo, se incrementó el uso de taxa más afines a ambientes marinos ubicados a mayor distancia, como *Melanitta fusca* y *M. perspicillata*. El cormorán *Phalacrocorax auritas* fue especialmente afectado por las actividades de cosecha de los humanos, que causaron la extirpación de colonias locales ubicadas en islas, cambios en la edad relativa y la composición de especies de la fauna regional de *Phalacrocorax* y, finalmente, el abandono casi total de la caza de cormoranes. Finalmente, las especies de aves playeras de mayor tamaño, *Limosa fedoa, Numenius americanus* y *N. phaeopus*, declinaron significativamente con el tiempo, en comparación con especies playeras de menor tamaño. Ninguno de estos patrones están correlacionados con variaciones en los registros paleo-ambientales que puedan indicar que fueron causados por cambios en el clima. Sin embargo, estos patrones sugieren que las actividades de los humanos recolectores tuvieron una influencia fundamental en la avifauna regional del Holoceno tardío, y que los registros de las abundancias, distribuciones y comportamiento de las aves del período histórico temprano son anómalas en el contexto de los últimos varios miles de años de cosecha intensa por parte de humanos. Las conclusiones presentadas aquí desafían la creencia convencional sobre la ecología de paisajes prehistóricos en América del Norte y tienen implicancias importantes para los análisis que requieren información de historias poblacionales de largo plazo, incluyendo aquellas que consideran patrones modernos en diversidad genética dirigidos a problemas de conservación.

INTRODUCTION

> In the fall of that year [1850], my father, while going from San Francisco to San Jose, met with acres of white and gray geese...They were feeding near the roadside, indifferent to the presence of all persons, and in order to see how close he could approach he walked directly towards them. When within five or six yards of the nearest ones they stretched up their necks and walked away like domestic geese...They seemed to have no idea that they would be harmed, and feared man no more than they did the cattle in the fields...but it must be understood that in those days they were but little hunted...This seems the most plausible accounting for the stupid tameness of the geese.—Bryant (1890), quoted in Grinnell et al. (1918)

ACCOUNTS OF ENORMOUS flocks of tame geese are typical of early historical descriptions of California's avifauna. Both the sheer abundance and docility of the birds astonished many who wrote about the region in the years before the Gold Rush and the era of market hunting that came soon after. In 1833, George Yount noted of the San Francisco Bay area that "the wild geese, and every species of waterfowl darkened the surface of every bay...in flocks of millions. When disturbed, they arose to fly, the sound of their wings was like that of distant thunder" (Camp 1923). A decade earlier, in the same area, the Russian explorer Otto von Kotzebue (1830) had observed "flocks of wild geese, ducks, and snipes, so tame that we might have killed great numbers with our sticks." Indeed, some early explorers did kill great numbers with their sticks. William Thomes (1892), for instance, also encountered "thousands of geese and ducks" around San Francisco Bay in the 1840s and claimed to have never seen "so many wild fowl at one time before or since." Because the birds were so abundant and acted "more stupid [than] if they had been hatched in a barnyard, in Rhode Island, and waiting for their daily supply of corn," Thomes and his company found "no pleasure" in shooting them. So, to supply their ship, they simply "threw clubs at them, and knocked them over," thus saving their powder and shot (Thomes 1892).

Other vertebrate taxa, too, were extremely abundant in the early historic period of California. Perhaps most noteworthy were the artiodactyls—elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*)—reported to have "darkened the plains for miles" (Bosqui 1904). The abundance of marine mammals likewise deeply impressed early chroniclers; sea otters (*Enhydra lutris*), for example, hauled out in such numbers around San Francisco Bay that the shores "appeared covered with black sheets" (Ogden 1941). Predictably, large predators abounded in such an environment: Yount's report of seeing "fifty or sixty" grizzly bears (*Ursus arctos*) a day is not atypical (Preston 2002).

Many such observations were made by veteran travelers, who, like Bryant, reasoned that the unwariness of the game must have resulted from a virtual lack of human hunting pressure. Some went so far as to fault the Hispanic settlers for their lack of interest in hunting, and others even "contemplated how the relative ease of hunting contributed to the perceived 'indolence' of both settler and native alike" (Preston 2002).

Although the various 19th-century chroniclers, explorers, and settlers may have had various motivations for exaggerating in their diaries, ships' logs, and scientific survey reports, the overall consistency of the accounts suggests that their portrayal of California's early-historic faunal abundance is generally accurate. Importantly, the abundance reported in those accounts is routinely taken as an analogue for the state's original or natural zoological condition and, as a result, is used as the baseline by which modern population trends and distributions are measured and compared (e.g. Johnson and Jehl 1994).

Recent archaeological analyses suggest, however, that the superabundance of wildlife observed in California in the early historic period is, in fact, an extremely poor analogue for the zoological setting in pre-Columbian times. Guided by models from foraging theory (e.g. Stephens and Krebs 1986), systematic analyses of fish and mammal remains derived from California archaeological sites have indicated that late Holocene (i.e. the last 4,000 years) human populations in the region had substantial impacts on a variety of fish and mammal populations.

One of the most detailed of such records has come from a huge stratified archaeological site once located on the eastern shore of San Francisco Bay: the Emeryville Shellmound (Broughton 1995, 1997, 1999, 2002a). Analysis of the exceptionally rich faunal collection has shown that such large-bodied taxa as elk and sturgeon (*Acipenser* sp.) provided an ever-decreasing part of human diets across the occupational history of the site, which spanned from about 2,600 to 700 years before present (BP). That conclusion is based primarily on trends in relative frequencies of elk and sturgeon bones: both species are very abundant early on, but are virtually absent by the end of the occupation. Demographic signals of harvest pressure, such as trends in age and size profiles, have also been documented for those and other taxa in the deposit (Broughton 1995, 1997, 1999, 2002a). Similar patterns have been reported in a number of archaeological records across the state, and—whereas none appear to correlate with other potential causes for population declines, such as environmental change (e.g. Hildebrandt and Jones 1992, 2002; Broughton 1994a, b, 1999, 2002a, b; Porcasi et al. 2000; Grayson 2001)—they follow predictably from foraging theory, given conditions of ever-increasing human population densities and hunting pressure. The patterns appear to represent cases of long-term resource depression (*sensu* Charnov et al. 1976), or declines in capture rates of prey that result directly from the activities of predators.

Archaeological evidence for severe late Holocene depressions in a wide array of vertebrate taxa stands in stark contrast to the fabulous abundances reported in early historical times. It now seems clear that such accounts only reflect the irruption of animal populations after native Californians had experienced dramatic disease-based population declines, apparently initiated by limited coastal contacts between European explorers and California Indians in the early 16th century (Erlandson and Bartoy 1995, Preston 1996, Erlandson et al. 2001). From those isolated encounters, disease apparently spread rapidly through the aboriginal population of California, well before the arrival of the settlers and travelers who furnished the accounts of wildlife superabundances (Broughton 1994b, 2002b, 2004; Preston 1996, 2002). Thus, the latest prehistoric and early-historic baselines or benchmarks for California ecosystems, though separated by mere decades, appear to be worlds apart. Most importantly, those differences and the processes that produced them have implications for the management and conservation of wildlife resources today (Broughton 2004).

Analyses of archaeological faunas from California have documented that late Holocene human populations had substantial impacts on fish and mammal populations, but harvest pressure on bird populations has yet to be documented. Indeed, outside of oceanic island contexts where human-caused avifaunal extinctions and extirpations are well described (see Steadman 1995, Martin and Steadman 1999, and references therein), there have been no systematic attempts to evaluate evidence for avian resource depression by prehistoric foragers anywhere in the world.

Here, I document the entire provenienced sample of bird remains recovered from the Emeryville Shellmound. Part of the assemblage was examined by Hildegarde Howard (1929) in her classic study, but most of it has remained unexamined until now. The materials provide a unique, fine-grained anthropogenic sequence of bird harvesting, dating from about 2,600 to 700 years BP. I analyzed the collection to evaluate the role that ancient hunters played in structuring the prehistoric avifauna of the largest estuary and contiguous tidal marsh system on the Pacific coast. The results have implications for the study and management of modern California bird populations for which information on long-term population trends is required.

San Francisco Bay Shellmounds and the Emeryville Site and Fauna

Around the beginning of the 20th century, surveys of the San Francisco Bay shoreline documented the presence of 425 shellmounds—archaeological sites whose primary visual constituent is shell (Fig. 1). That figure undoubtedly underestimates the true number of sites, given that many had already been obliterated through development and other causes (Nelson 1909). The mounds were made up not only of shells, but of soil, rocks, animal bones, ash, charcoal, and artifacts—all debris and tools from the day-to-day activities of ancient people. The mounds varied substantially in size; some had basal diameters of only a few meters and stood but a few centimeters above the shore, whereas others were much larger, covering >3 ha and rising >10 m in height. Radiocarbon dating has indicated that the earliest shellmounds began to form ~4,000 years BP and that the San Francisco shoreline was occupied continuously from that time to the historic period (Broughton 1994b, 1995, 1999; Lightfoot and Luby 2002). The record clearly reflects a substantial prehistoric human presence in the region, populations supported entirely by the hunting and gathering of wild animals and plants. Those populations appear to have increased significantly across much of the late Holocene, judging from the increasing number

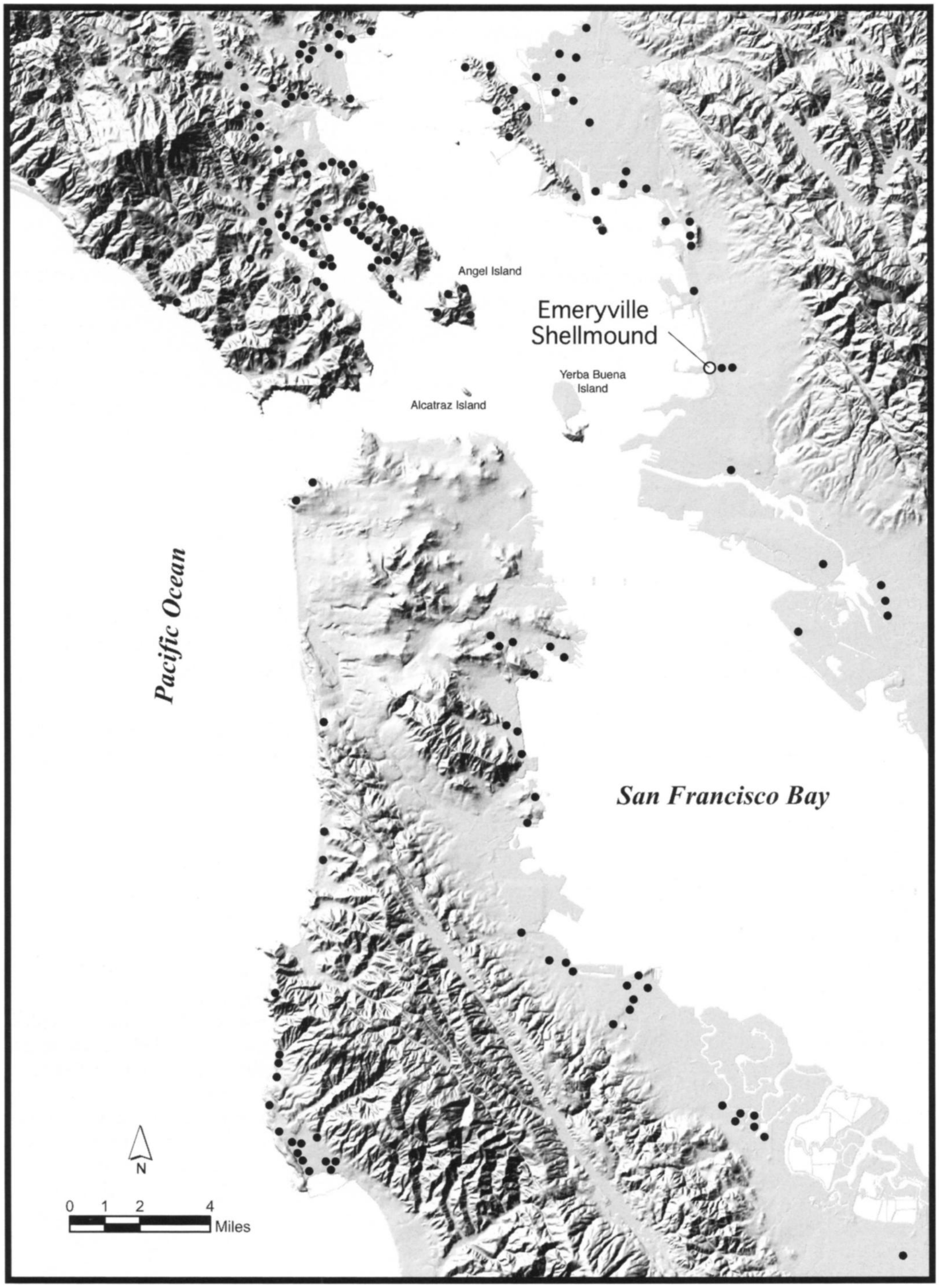

FIG. 1. Map of the San Francisco Bay area, showing location of the Emeryville Shellmound and other shellmound sites (site locations from Nelson 1909).

of dated sites and human burials over that period (Broughton 1999). Absolute human population sizes are, however, exceedingly difficult to derive archaeologically; I suspect that Kay's (2002) estimate of 2–3 million or more for the state of California is within reason. Given the richness of the San Francicso Bay environment, the human population of the region prior to European contact was likely somewhere in the range of 50,000 to 150,000 people.

The Emeryville Shellmound, located on the eastern shore of San Francisco Bay between the cities of Oakland and Berkeley, measured 100 × 300 m in area and extended to a depth of >10 m (Figs. 1 and 2). It was the largest of what was originally a complex of about six mounds located on the alluvial flat of Emeryville (Broughton 1996). Max Uhle and John Merriam conducted the first excavation of the site in 1902. At the time, the enormous site was the central feature of "Shellmound Park." As part of a recreation ground, the Emeryville mound was crowned with a dance pavilion and cypress hedge. With the pavilion atop the center of the mound, Uhle and Merriam excavated a lateral section of the mound's western slope and a tunnel that extended from there to its center. They dug >200 m^3 of midden and removed the sediments "stratum by stratum." They encountered 10 distinct strata and collected and provenienced all artifacts, including a large sample of vertebrate remains, by those strata (Uhle 1907). They collected the vertebrate materials and other artifacts with sieves of an unspecified, but apparently coarse-grain, mesh size (Uhle 1907, Schenck 1926).

Four years later, in spring 1906, Nels C. Nelson led the second excavation at Emeryville, in which a 6 × 6 ft unit was stratigraphically dug in the eastern side of the mound. He identified 11 natural strata and collected and provenienced all artifacts, including vertebrate remains, by those strata. Given the smaller volume of sediment excavated, a much smaller sample of vertebrate remains was recovered (Broughton 1996).

The Emeryville Shellmound was leveled by a steam shovel in 1924 (Fig. 2). W. E. Schenck salvaged a large series of human burials and associated artifacts, along with a large collection of vertebrate materials, as the mound was being demolished. Unfortunately, Schenck was unable to collect within-site provenience data for the vertebrate bones and teeth collected at that time, because "scientific ends were secondary" (Schenck 1926). However, after the mound had been reduced to the level of the surrounding plain, Schenck excavated three 50 × 6 ft trenches in the base of the deposit, near the center of the mound. Those trenches, excavated in 1-ft arbitrary levels to a depth of >10 ft, produced a sizable faunal collection (Schenck 1926).

CHRONOLOGY

Thirteen radiocarbon assays have now been derived from bone and charcoal specimens recovered from various strata throughout the Emeryville deposit;

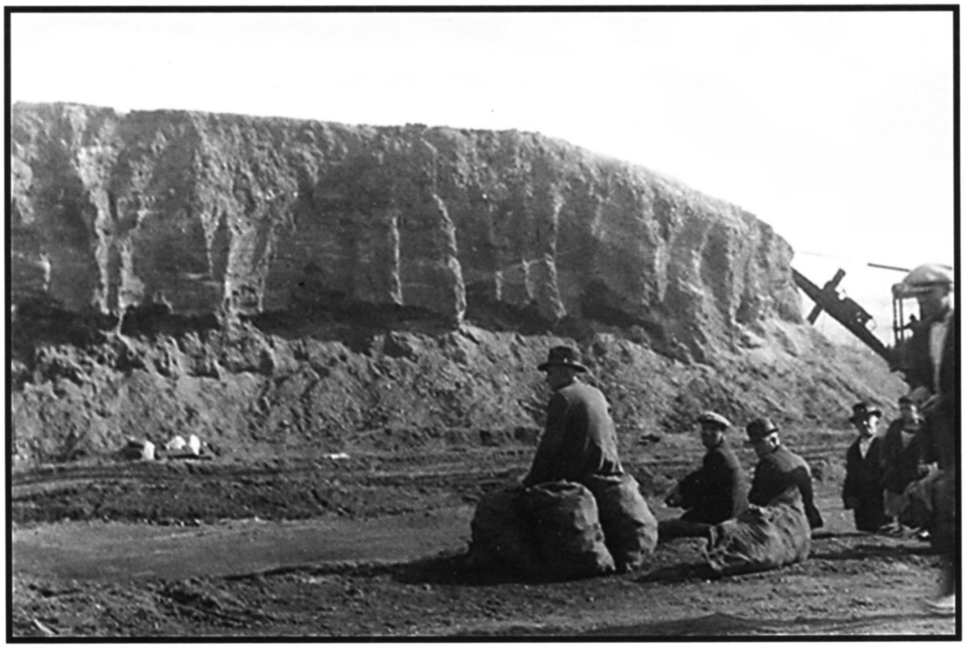

FIG. 2. Demolition of the Emeryville Shellmound by steam shovel, 1924. (Photo courtesy of the Phoebe A. Hearst Museum of Anthropology.)

exact proveniences of the dated materials are known for 11 of them (Broughton 1999). On the western side of the mound, dates range from 2,620 ± 70 years BP at the basal contact between the cultural midden and the alluvial clay on which the mound sits to 950 ± 50 years BP for stratum 2. For the Nelson strata on the mound's eastern side, three dates are available: 2,370 ± 70 years BP for basal stratum 11; 1,100 ± 50 years BP for stratum 5; and 720 ± 60 years BP for stratum 3 (Table 1). There are no chrono-stratigraphic inconsistencies in the dates from either the Uhle–Merriam or Nelson excavations; in other words, within each excavation, the oldest dates are from the lowest strata, whereas the youngest dates are from the highest ones.

A single radiocarbon date was obtained near the top (1–2 ft below the surface) of one of Schenck's trenches, and six dates were obtained for the base of the mound. Together, those dates serve to bracket the deposition of the Schenck trench sediments between 2,600 and 1,970 years BP. That interval incorporates the period of deposition for the four basal strata (i.e. strata 10 through 7) from the Uhle–Merriam excavation. Accordingly, I aggregated the 1-ft samples from Schenck's three trenches into a total of four provenience units.

The three early-20th-century excavations provided >20 independent sample units that could be assigned to the 10 primary strata of the mound (Table 1). Reporting the identified bird remains from those units will allow for a fine-grained ordinal-scale analysis of changing bird-use patterns over the period from about 2,600 to 700 years BP (see Broughton [1999] for more details on stratigraphic relationships and dating).

AVIFAUNAL MATERIALS

Reported here are 5,736 identified bird specimens that were collected from the Emeryville provenience units described above. The bird and other vertebrate remains from Emeryville are housed at the Phoebe Apperson Hearst Museum of Anthropology (PAHMA) at the University of California, Berkeley. Given the large size of the collection, I provide catalogue numbers only for specimens identified here to the species level. Numbers preceded by "EMF" refer to the field catalog of Edna M. Fisher, a curatorial assistant at the Museum of Vertebrate Zoology (MVZ, Berkeley, California) during the early 20th century (see Broughton [1999] for further details on the curation of the Emeryville fauna).

As noted above, Howard (1929) described part of the Emeryville avifauna. Although her analysis was exemplary in many ways, she did not provide associated stratigraphic information for any of the specimens she described and, for reasons unknown,

TABLE 1. Emeryville provenience units with associated radiocarbon determinations.

Provenience unit	Abbreviation	Stratum	Radiocarbon determinations (years BP)
Uhle, stratum 1	U1	1	
Uhle, stratum 2	U2	2	950 ± 50
Uhle, stratum 3	U3	3	
Uhle, stratum 4	U4	4	
Uhle, stratum 5	U5	5	1,400 ± 50
Uhle, stratum 6	U6	6	
Uhle, stratum 7	U7	7	1,980 ± 50
Uhle, stratum 8	U8	8	2,070 ± 60
Uhle, stratum 9	U9	9	
Uhle, stratum 10	U10	10	2,620 ± 70; 2,400 ± 70; 1,030 ± 60
Nelson, stratum 2	N2	1	
Nelson, stratum 3	N3	1	720 ± 60
Nelson, stratum 4	N4	1–3	
Nelson, stratum 5	N5	3	1,110 ± 50
Nelson, stratum 6	N6	4–9	
Nelson, stratum 7	N7	4–9	
Nelson, stratum 8	N8	4–9	
Nelson, stratum 9	N9	4–9	
Nelson, stratum 10	N10	4–9	
Nelson, stratum 11	N11	10	2,370 ± 70
Schenck trench level 1: 0–2′	S1	7	1,970 ± 50
Schenck trench level 2: 2–4′	S2	8	
Schenck trench level 3: 4–6′	S3	9	
Schenck trench level 4: 6–9′	S4	10	
Base of southeast corner of mound	–	~10	2,530 ± 30
Base of mound	–	~10	2,310 ± 220

reported only a sample of the Emeryville avifaunal collection. As a result, the specimens reported here and those that Howard (1929) described represent different subsets of the Emeryville avifauna, though there is substantial overlap. Specifically, almost half of the sample (1,853 of 4,155 bones) identified and reported by Howard was collected by Schenck during the steam-shovel demolition of the mound; hence, within-site provenience information was never obtained for them (see Broughton 1999). Given my interest in examining change through time across the depositional sequence, I do not report on those materials here. In addition, Howard apparently did not have access to and thus did not examine 3,710 specimens that had associated stratigraphic information. Identifications of those specimens are reported here for the first time.

I took the following approach in treating the sample (*n* = 2,026) of provenienced specimens previously identified to some level by Howard. I refined identifications for specimens that she left at the genus level or higher taxonomic categories (*n* = 1,515), but report again the relatively small sample of provenienced specimens that Howard identified to the species level (*n* = 511). I did not systematically verify the latter identifications, given the widely renowned accuracy of Howard's work (see Campbell 1980); they are simply presented again here with updated taxonomic nomenclature (Banks et al. 2004) and, most importantly, by their associated provenience units.

My identifications, listed as "additional elements" below, were based on comparisons with recent bird specimens from the following collections: MVZ; Burke Museum of Natural History and Culture, University of Washington (UWBM); and Utah Museum of Natural History (UMNH). Diagnostic osteological characters were derived from the examination of multiple individuals per species (typically six or more). Anatomical terminology follows Howard (1929) and Baumel (1993). Given the large size of the collection, identifications were not attempted for isolated cervical or thoracic vertebrae, ribs, cuneiforms, and phalanges of the foot. To minimize multiple identifications of the same fragmented element portion, only the more complete specimens were examined. Specifically, I attempted identifications for substantial cranium fragments that included either most of the frontal region, premaxillae, or posterior braincase. For mandibles, fairly complete anterior or posterior portions were identified. Identifications of furculae were based on fragments possessing the furcular process at the symphysis. For the pelvis and the synsacrum, specimens that represented >50% of the synsacral vertebral column were identified. Only sternum specimens that contained the manubrial process were studied. Finally, identifications of the long bones were attempted only for specimens possessing ≥60% of a proximal or distal articular surface.

All elements were also assigned to one of three broad ontogenetic age categories: chicks, juveniles, and adults. Those assignments were based on the size of the element and its state of development. Specimens were identified as chicks if they were very small in size, porous, and lacking adult cortical bone and muscle attachments. Juveniles were identified as those specimens that approached, or had attained adult size but lacked complete development of cortical bone. Remains of chicks clearly represent birds derived from local nesting sites, but juveniles could represent first-year migrants from distant breeding localities.

I use the numbers of identified specimens (NISP) as a measure of taxonomic abundances in the analyses that follow. Although clearly imperfect, this is the least contrived and arguably least problematic available measure of relative abundance for archaeological and paleontological faunas (see Grayson 1984). Numbers of identified specimens per taxon by stratum is provided in Table 2; numbers per taxon, element portion, and provenience unit are provided in the Appendix. Chick and juvenile specimens are presented by taxon and stratum in Table 3. Provided below is a systematic list of the taxa and elements represented in the provenienced sample from Emeryville, and the osteological criteria that I used to identify them.

SYSTEMATICS AND OSTEOLOGY

ORDER GAVIIFORMES

Family Gaviidae

Gavia stellata (Pontoppidan 1763) or *G. pacifica* (Lawrence 1858)

Referred material.—Reported in Howard (1929): tarsometatarsi (EMF A1135, 7861, 8595, A3062, 6385, 8592, 7076, 10299). Additional elements: carpometacarpus (EMF A4012), synsacrum (EMF 8745), and tarsometatarsus (EMF A3482).

Gavia stellata (Pontoppidan 1763)

Referred material.—Reported in Howard (1929): cranium (EMF 7996; listed as "no. 2996" in Howard 1929), coracoids (EMF 7043, 8577), scapula (EMF 8706), humerus (EMF 8706), ulna (EMF 10522), carpometacarpi (EMF 8324, 8019, 8054), tibiotarsi (EMF 10394, A4847, 8014, 8348). Additional elements: coracoids (EMF 17293, A5219, A5311, A11526 [Fig. 3A]), humeri (EMF

TABLE 2. Numbers of identified bird specimens per taxon by stratum at the Emeryville Shellmound (abbreviations follow text).

	Stratum																								
Taxon	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	S1	S2	S3	S4	Σ
Gavia stellata	2	8	2	2				1		1												5	3	4	28
G. stellata/pacifica		1						1	1	1												2	2	3	11
G. immer	1	5		1	1			2		4													2	3	19
Podiceps auritus		1						1		1															3
P. nigricollis		2	1					1		1											1	1	1		8
P. auritus/nigricollis	1		4	3				1		1													1		11
Aechmophorus occidentalis/clarkii		5	10	4	1			2		2								1				3	2	1	31
Phoebastria albatrus				1																					1
Fulmarus glacialis										3															3
Pelcanus sp.	1	1				1		3	3	2										1					12
P. erythrorhynchos																								1	1
P. occidentalis							1	3												1	4	4		2	15
Phalacrocorax sp.	3	7	1	4	15	22	42	98	26	71										14	106	100	38	62	609
P. penicillatus	4	3	4	2	2	3	4	2	1	1			1								9	13	10	3	62
P. auritus	2	3	8	11	8	10	17	29	2	23		1								6	44	46	24	30	264
P. penicillatus/auritus										2											1	1	1	1	6
P. pelagicus					1	1	1	1		2					1							1	1		9
Ardeidae (Bittern sized)										1															1
Botaurus lentiginosus							1																		1
Ardea herodias	1				2	1		3	1												3	2	2	1	16
Cathartes aura				1	1																		1	1	4
Anserinae (small)	14	55	39	41	28	15	34	58	18	49	1	4	5							2	32	59	49	34	537
Anserinae (medium)	11	112	86	64	36	15	42	160	18	115		5	11	1	3	1		6	2	7	94	195	146	83	1213
Chen caerulescens			1			2	1	5		5											3	6	5	1	29
C. rossii			3	1	1			1	1	1															8
Branta hutchinsii cf. *minima*			1	1			1																		3
B. canadensis cf. *parvipes*		2	1		1			2	1	1										1		3	1	2	15
B. c. cf. *moffitti*		2					1	3		5									1	4		3	1		20
Anatinae (small)	3	37	10	6	2	5	4	14	2	18			9									1	1	1	113
Anatinae (large)	86	532	108	38	23	15	17	83	22	116	4	8	50	4	3		1	5	3	3	23	24	66	30	1264
Anas sp. (teal)	2	5	4	3				1		2		1	2										1		21
Anas sp.	1	10	3	7	1	1	1	9		4			1					1			1	4	2	5	51
A. platyrhynchos	1	4	2	1	1	1		2	1													2	2	2	19
A. clypeata		2											1								1	1			5

TABLE 2. Continued.

	Stratum																							
Taxon	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	S1	S2	S3	S4	Σ
Aythya sp.	2	6		2		1	1	1	1			2	4									1	1	1	23
Aythya sp. (large)		1						1		1											1				4
A. cf. *valisneria*			1																					1	2
A. valisneria										1													1		2
A. cf. *marila*			1					1	1	1															4
A. marila			1		1																				2
A. affinis			1						1																2
Melanitta sp.	38	209	106	9	3	2		10	12	14	1	5	20	1	2			4	1		4	5	9	11	466
M. perspicillata		3	1							1															5
M. fusca		2	6																						8
M. perspicillata/fusca			5															1							6
M. perspicillata/nigra			1																						1
Bucephala sp.																							1		1
B. albeola		1	1					1		2												1			6
B. clangula/islandica	1	3	4							2													1	1	12
Mergus sp.								1					1												2
M. cf. *serrator*		2																							2
M. serrator		1		1		1		1																	4
Oxyura jamaicensis			1	2																					3
Accipitridae					1																				1
Accipitridae (small)		1			1																				2
Elanus leucurus	1																					1	1		3
Haliaeetus leucocephalus		1						4		1											1			1	8
Circus cyaneus							1			1															2
Accipiter cooperii				1																					1
Buteo sp.		1	3	2		1	2	5		1											3	1	3	1	23
B. lineatus			1							1											2				4
B. jamaicensis					1					1											1	7	1		11
B. regalis					1					1														1	3
B. jamaicensis/regalis	1	1						2														1		1	6
B. jamaicensis/lagopus										1											1				2
Falco sparverius									1																1
F. columbarius								1														1			2
F. peregrinus	1									1												1	2		5
F. mexicanus										1															1

TABLE 2. Continued.

	Stratum																								
Taxon	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	S1	S2	S3	S4	Σ
F. peregrinus/mexicanus		1		5	2																		1		9
Dendragapus obscurus	2																								2
Callipepla californica/ Oreortyx pictus				1						1															2
C. californica		1		2	1		1						1									1		1	8
Rallus longirostris								2														1	2		5
Fulica americana			2					2														5			9
Grus canadensis		2	1	4	1			6		3											5	2	1	4	29
G. canadensis tabida	1																								1
Pluvialis squatarola		2	1					1		1											1				6
Charadrius vociferus			2																						2
Recurvirostra americana			1										1												2
Catoptrophorus semipalmatus	1	9	5					3	2	3												3	1		27
Numenius americanus	6	19	7	12	7	3	2	11	7	6		1	2								5	8	11	5	112
N. phaeopus																						1			1
Limosa fedoa	1	3	1	4				3	1	2	1		1	1							1	4			23
L. fedoa/N. phaeopus		3	1		1	2		2															1		10
Calidris alba		1																							1
C. alba/alpina				1																					1
Limnodromus sp.	2	25	5						1	6												1			40
Larus glaucescens/hyperboreus										1			1												2
Larus sp. (large)		3	5	1	1	2	1	5		4											3	3	6	1	35
Larus sp. (small)		1	2			1		2		1													1		8
Uria aalge		2	1			1													1		1				6
Uria sp.	8	23	26	16	5	6	7	15	2	10									2	1	14	17	9	6	167
Cepphus columba	1																								1
Strigiformes																							1		1
Strigidae (medium)					1																				1
Otus kennicottii					1																				1
Asio flammeus										2															2
Asio sp.					1	1																1			3
Bubo virginianus																				1		4	4		9
Tyto alba	1					1	1	10	2	6											3	2	10		36
Corvus brachyrhynchos	2	2	1	5	3	6	5	29	1	13		1									5	15	14	7	109
C. corax		1				1	3	2	1	1											1	6	5	1	22
Σ	202	1127	482	259	156	121	191	607	130	523	7	28	111	7	9	1	1	18	10	41	374	569	449	313	5736

TABLE 3. Numbers of identified subadult bird specimens by stratum at the Emeryville Shellmound.

	Stratum																	
Taxon and age class	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	N3	N4	N6	N11	S1	S2	S3	S4	∑
Phalacrocorax auritus																			
Juvenile			1	3	4	5	7	17	1	8				3	34	17	5	4	109
P. pelagicus																			
Juvenile										1									1
P. penicillatus																			
Juvenile															5	8	2	1	16
P. penicillatus/auritus																			
Chick										1					1				2
Juvenile										1						1	1	1	4
Phalacrocorax sp.																			
Chick		1		2	6	5	18	39	16	39				5	34	25	23	46	259
Juvenile	1			1	6	11	23	50	7	26				9	67	62	9	13	285
Ardea herodias																			
Chick								1											1
Juvenile						1			1						3	2	1	1	9
Anserine (small)																			
Juvenile												1				1			2
Anserine (medium)																			
Chick																	1		1
Juvenile			3				1			1							1		6
Chen caerulescens																			
Juvenile																	1		1
Anatinae (large)																			
Chick	1	1	1	1	1	1	1	2											9
Juvenile	1	20	3					1		2	1	1			1				30
Melanitta sp.																			
Juvenile	1	13	7	1								4			1			2	29
Buteo sp.																			
Chick		1	2					1											4
Juvenile			1	2			1			1					1				6
B. jamaicensis																			
Juvenile															1				1
B. regalis																			
Juvenile					1														1
Corvus brachyrhynchos																			
Chick			1					2		3									6
Juvenile	1			3	3	4		13	1	7					2	3	5	1	43
C. corax										1									1
Juvenile						1	1	1								1			4
Falco peregrinus/mexicanus																			
Juvenile				5	2														7
Larus sp. (large)																			
Chick																	1		1
Juvenile				1															1
Tyto alba																			
Juvenile									1										1
Uria sp.																			
Chick		1	3																4
Juvenile	1	2		1											4				8
∑	6	39	22	20	23	28	52	127	27	91	1	6	0	17	154	120	50	69	852

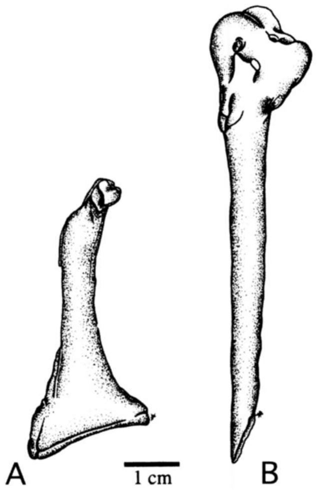

FIG. 3. (A) Right coracoid of *Gavia stellata* (EMF A11526) and (B) left proximal carpometacarpus of *Phoebastria albatrus* (EMF 8635).

A9151, PAHMA 12-1437), radius (EMF A8008), carpometacarpi (EMF A2688, A5216, A5561), synsacra (EMF A5899, PAHMA 12-1430), tibiotarsi (EMF A8688, A5354, A12266).

Remarks.—Identifications were based on criteria presented in Howard (1929). Proximal tibiotarsus of *G. stellata* is further distinguished from *G. pacifica* by a much deeper lateral undercut of the external articular surface.

Gavia immer (Brünnich 1764)

Referred material.—Reported in Howard (1929): coracoids (EMF 8168, A3117, 16882, A3231), humeri (EMF 16870, A4052, 6896), tarsometatarsi (EMF 7151, 8619, A4350). Additional elements: mandible (EMF A1204), scapula (EMF A9541), humerus (EMF 8722), radius (EMF A8678), carpometacarpus (EMF A11513), femur (EMF A5378), tarsometatarsi (EMF A6092, PAHMA 12-1427).

Remarks.—*Gavia immer* is easily distinguished from *G. pacifica* and *G. stellata* by its large size. Although the average sizes of *G. immer* elements are smaller than those of *G. adamsii*, their ranges overlap (see Fitzgerald 1980). However, postcranial materials more closely match *G. immer* than *G. adamsii* in size, and the mandible is referable to *G. immer* on the basis of the distinctive hook-shaped external articular process.

ORDER PODICIPEDIFORMES

Family Podicipedidae

Podiceps auritus (Linnaeus 1758) or *P. nigricollis* Brehm 1831

Referred material.—Reported in Howard (1929): synsacrum (EMF 8219; listed as "no. 2219" in Howard 1929). Additional elements: sternum (PAHMA 12-1434), coracoids (EMF A3055, A9220), humeri (EMF16883, A8696, A9213; PAHMA 12-1476), ulna (PAHMA 12-1437), tibiotarsi (PAHMA 12-1437, 12-1437).

Podiceps auritus (Linnaeus 1758)

Referred material.—Cranium (EMF A206), humerus (EMF A5490), ulna (EMF A2825).

Podiceps nigricollis Brehm 1831

Referred material.—Coracoid (EMF A6097), ulna (EMF A1879), carpometacarpus (PAHMA 12-1437), tibiotarsi (EMF 5359, A4253, 8022, 8357, A12624).

Remarks.—Howard (1929) lacked sufficient reference specimens to confidently distinguish the small grebes represented in the Emeryville collection, though she thought that *P. nigricollis* and possibly *P. auritus* were represented. Both species are clearly present in the Emeryville fauna.

The anterior cranium of *P. auritus* is distinguished from that of *P. nigricollis* by having a deeper tip of the premaxilla and longer external nares. Compared with that of *P. auritus*, the carpometacarpus of *P. nigricollis* has a more attenuated metacarpal I and a less extensive external projection of the pollical facet. The morphology of the cnemial crest of the tibiotarsus differs: in *P. auritus*, it tapers into a well-defined ridge along the proximal shaft; in *P. nigricollis*, it terminates abruptly, just proximal to condyles. The tibiotarsus of *P. auritus* is also distinguished by a pronounced anterior depression just distal to the external articular surface and a much deeper tendinal groove of the distal end. The remaining elements were assignable to *P. nigricollis* or *P. auritus* on the basis of their very small or very large size, respectively.

Aechmophorus occidentalis (Lawrence 1858) or *A. clarkii* (Lawrence 1858)

Referred material.—Reported in Howard (1929) as *A. occidentalis*: ulna (EMF 10007), synsacra (EMF 8184, 8605), femora (EMF A4325, 6340), tarsometatarsus (EMF 10314), tibiotarsus (EMF A3275). Additional elements: cranium (EMF A6771), sterna (EMF A12672, A6515; PAHMA 12-1157), coracoid (EMF A10335), humerus (PAHMA 12-1437), radius (EMF A4701), ulna (PAHMA 12-1437), carpometacarpus (EMF A8538), synsacra (EMF A8583 A6258, A4110; PAHMA 12-1430, 12-1434, 12-1434, 12-1434), femora (EMF A185, PAHMA 12-1313), tibiotarsi (EMF A9209, A9221, A9238), fibulae (EMF A4017, 6279), tarsometatarsus (PAHMA 1-9777).

Remarks.—In addition to size differences and the criteria presented in Howard (1929), the following features characterize *A. occidentalis–clarkii* and distinguish them from *P. grisegena.* (1) Cranium, posterior: The sagittal nuchal crest is well defined and extends posteriorly to form a sharp process. (2) Sternum: The coracoidal facets are farther apart at midline. (3) Coracoid: The coracoid is longer and thinner, with more pronounced ventral projections of the distal (furcular) end. (4) Scapula: The coracoidal articulations are less developed and less anteriorly projecting, and the ventrolateral portion of the neck bears a more prominent depression. (5) Radius, proximal: The region of the ulnar facet is more steeply sloping. (6) Femur: The femur is much stouter for its length, with more bulbous proximal and distal ends. Distally, the pronounced tubercle on the posterodistal surface in the popliteal area is not connected to the external condyle by a well-developed ridge. (7) Tibiotarsus: The proximal tibiotarsus differs by having a less laterally (fibular) extended external articular surface, an outer cnemial crest that extends distally past the external articular surface, and a profile that is rounded rather than oblong. (8) Fibula: The heads are larger, and the proximal shafts are thinner and flatter.

ORDER PROCELLARIIFORMES

Family Diomedeidae

Phoebastria albatrus (Pallas 1769)

Referred material.—Carpometacarpus (EMF A8635 [Fig. 3B]).

Remarks.—The specimen is far too large to represent *P. immutabilis* or *P. nigripes*. Howard (1929) made one probable identification of this species, a radius, from the unprovenienced Emeryville sample.

Family Procellariidae

Fulmarus glacialis (Linnaeus 1761)

Referred material.—Humerus (EMF 17286), radius (EMF 17277), ulna (EMF 17305).

Remarks.—These elements are distinguished from *Puffinus* as follows. The distal humerus exhibits (1) a much deeper depression for the *brachialis anticus*, (2) a more rounded entepicondyle, and (3) a less laterally projecting ectepicondylar prominence. In addition to being straighter and more robust for its length, the radius differs by having distal ends that are more expanded and show an obvious "neck." The scapholunar facets of this element are also oriented at more of an angle (45°) to the long axis of the bone. The proximal ulna is much broader, the dorsal (palmar) projections of the internal and external cotylae are less pronounced, and the olecranon is less pointed and prominent.

ORDER PELECANIFORMES

Family Pelecanidae

Pelecanus sp.

Referred material.—Humeri (EMF A3598, A3622, A4003, A195, A3626, A206), ulna (PAHMA 12-1476), carpometacarpus (EMF A3099), femur (EMF A3113), synsacra (PAHMA 1-9831, 12-1363).

Pelecanus erythrorhynchos Gmelin 1789

Referred material.—Reported in Howard (1929): femur (EMF 8723).

Pelecanus occidentalis Linnaeus 1766

Referred material.—Reported in Howard (1929): mandibles (EMF 5769, 7424), humeri (EMF 6760, 7397, 7398, 10420), ulnae (EMF 6303, 7775), femur (EMF 10582), tarsometatarsus (EMF 7848). Additional elements: humerus

(EMF A11185), radius (EMF A2457), ulnae (PAHMA 1-9795, 12-1329), carpal digit 2 phalanx 1 (EMF A3105).

Remarks.—The additional elements of *P. occidentalis* are distinguished from those of *P. erythrorhynchos* in the following ways. The radius differs by having (1) a convexity or bossing just medial to the prominent fossa on the palmar aspect of the distal end, (2) a sharp line or ridge extending along the distal shaft, and (3) a prominent rounded eminence just proximal to the scapholunar facet on the palmar surface. The ulna has a flatter palmar aspect of the proximal shaft, just distal to the external cotyla, and lacks a marked depression in that region. The small size, alone, of carpal digit 2 phalanx 1 distinguishes *P. occidentalis* from *P. erythrorhynchos.* The humerus was identified by criteria in Howard (1929).

Family Phalacrocoracidae

Phalacrocorax sp.

Referred material.—A total of 608 specimens, including all major elements of the skeleton, most representing chicks and juveniles (Table 3).

Phalacrocorax penicillatus (Brandt 1837) or *P. auritus* (Lesson 1831)

Referred material.—Cranium (EMF 17487), ulna (EMF 7971), synsacra (EMF A157, 7370, 8364), tarsometatarsus (EMF 9262).

Phalacrocorax penicillatus (Brandt 1837)

Referred material.—Reported in Howard (1929): mandibles (EMF 8313, 8329, 8337, 8639), coracoid (EMF 8265), scapula (EMF 8302), humeri (EMF 7379, 7432, 7969, 8157, 8267), radii (EMF 8025, 8028, 5326, 7391, 7980, 8004), synsacra (EMF 5365, 7774, 7819), femora (EMF 6888, 7065, 6749, 7443, 8196), tibiotarsus (EMF 5322), tarsometatarsi (EMF 6363, 10122, A3458, 6360, 8583, 9157). Additional elements: crania (EMF A10822, A10824, A10797; PAHMA 12-1356), sternum (EMF A10125), coracoid (EMF A1143), scapula (EMF 8594), humeri (EMF 8293, 9891; PAHMA 1-9736), radii (EMF A9229, A9210, A10484; PAHMA 12-1437), ulnae (EMF 6350, PAHMA 12-1437), carpometacarpus (EMF A5274), femora (EMF 8910, A2695, A5479, A11610), tibiotarsi (EMF A5244 [Fig. 4A], A11311, A11502, A8194, A11504; PAHMA 12-1453), tarsometatarsus (EMF A11534).

Phalacrocorax auritus (Lesson 1831)

Referred material.—Reported in Howard (1929): crania (EMF 7255, 8335, 8553, 9918, 10141, 10545), coracoids (EMF 8735, 9227, 7030, 6344, 7766, 7790, 8282, 8327, 8727, 8733, 9232, 10110, 10287, 10527), humerus (EMF 8718), radii (EMF 6316, 8018, 8041, 8244, 6290, 7832, 8356, 9208, 10587, 8211), carpometacarpi (EMF 8007, 8040, 8347, 7983, 8000, 8001, 8836, 9827), synsacra (EMF 7256, 5793, 5364, 5366, 6254, 6319, 6781, 8856, 9917), femora (EMF 5332, 5206, 8740, 6335, 8608, 8710), tarsometatarsi (EMF 6747, 7157, 5344, 6325, 6343, 8012, 8580, 9174, 10520, A3264), tibiotarsi (EMF 6305, 7083, 5325). Additional elements: crania (EMF A2486, A2852, 5369; PAHMA 12-1345, 12-1363), mandibles (EMF A9104, A88, 17103, A11242, 9980, A2102; PAHMA 12-1441), carpometacarpi (EMF A11368, A10482, A10585, A9523, A10573; PAHMA 12-1437), coracoids (EMF 17303, A100, A8725, A10897, A11284, A11321, A8726, A12639, A10889, A10835, A11296, A11312, A11306, 7811; PAHMA 12-1437, 12-1309, 1-9840), scapulae (EMF 17298, A91, 8271, 8734, 9247, 10171, 10436, 10422, A8628, A12753, A12767, A7686, A53, A12602; PAHMA 12-1449, 12-1157), humeri (EMF A824, A867, A4034, 7059, 5762, 6262, 6265, 6775, 7437, 7781, 7807, 7831, 7988, 8204, 8285, 8291, 8582, 8709, 8725, 8736, 9874, 9905, A3230, A3261, A534, A854,

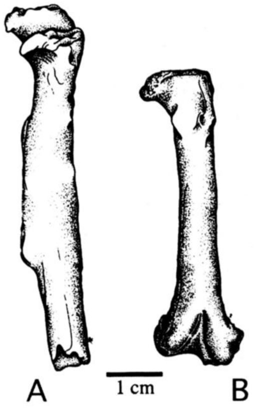

FIG. 4. (A) Left proximal tibiotarsus of *Phalacrocorax penicillatus* (EMF A5244) and (B) left femur of *P. auritus* (PAHMA 12-1462).

5776, 8254, 8600, 8720, 9223, 9233, A1730, A2389, 8721, A12622, A10315, A11289, A7153; PAHMA 1-9823), radii (EMF A83, A4073, A2409, A2402), ulnae (EMF 5783, 7409, 8610, 7760, 7963, 8595, A237, A8640; PAHMA 1-9721), synsacra (EMF A11238, A11439, A11443; PAHMA 12-1430), femora (EMF 6302, 8637, 10166, A62, A70, 17429, 16968, 16971, A74, A85, A97, 6910, 5777, 5784, 5800, 5337, 5350, 5336, 5338, 5339, 6271, 6286, 6365, 6754, 7380, 7765, 7808, 7809, 8823, 8832, 8843, 8831, 9445, 9164, 9204, 9158, 9187, 9197, 9886, 10536, A1929, A2095, A2459, A1546, A1715, A2097, A2106, A2541, A2951, A3315, A543, A8750, A10380, A9546, A10675; PAHMA 12-1437, 12-1309, 12-1462, 12-1462 [Fig. 4B], 1-9831, 1-9832, 1-9838), tibiotarsi (EMF 5343, A8622, 16957, A694, A3101, A2820, A9217, A10579, A10600, A10609; PAHMA 12-1437, 12-1456, 12-1157), tarsometatarsi (EMF A9581, A9617, A8634, A8650, A9554, A11308, A11317, A10451, A10464, A11508, 5360, 7460, 9199; PAHMA 1-9840).

Phalacrocorax pelagicus Pallas 1811

Referred material.—Reported in Howard (1929): femur (EMF 8262), tibiotarsus (EMF 7976). Additional elements: coracoids (EMF A1719, A10591), humeri (EMF A82, PAHMA 1-9760), carpometacarpus (EMF A10850), femora (EMF A838, A10368).

Remarks.—(1) Cranium: *P. auritus* has a sharply defined external midsagittal occipital crest not present in *P. pelagicus* or *P. penicillatus*. *Phalacrocorax penicillatus* is distinguished from *P. auritus* by smaller, less anteriorly projecting postorbital processes. The rostrum of *P. penicillatus* is longer, less deep dorsoventrally at the base, and narrower than that of *P. auritus*. Paired grooves extending distally from external nares are deeper in *P. penicillatus* than in *P. auritus*. The cranium of *P. pelagicus* is easily distinguished by its small size. (2) Mandible: Criteria used to distinguish mandibles of *P. penicillatus* from those of *P. auritus* are in Howard (1929); *P. pelagicus* is easily distinguished from the former species by its small size. (3) Sternum: The ventral manubrial spine is larger and thicker (mediolaterally enlarged) in *P. penicillatus* as compared with both *P. auritus* and *P. pelagicus*. Pneumatic foramina on the dorsal surface of the anterior sternum are present in *P. auritus* and *P. penicillatus* but lacking in *P. pelagicus*. (4) Furculum: An intramuscular line on the internal shaft approaches the posterior border more abruptly in *P. auritus* than in *P. penicillatus* (Howard 1929). *Phalacrocorax pelagicus* is like *P. penicillatus* in this feature, but the line is located more anteriorly on the shaft. (5) Coracoid: The head is thicker mediolaterally in *P. auritus* than in *P. penicillatus* (cf. Howard 1929) and *P. pelagicus*. Also, the neck between the glenoid facet and the bicepital attachment is markedly depressed in *P. auritus* and *P. penicillatus* but relatively flat in *P. pelagicus*. (6) Scapula: The internal margin of the acromion is smoothly rounded from blade to dorsal tip in *P. auritus*, but angular in *P. penicillatus* (Howard 1929) and *P. pelagicus*. In addition, the medial portion of the neck just distal to the acromion bears an elongated furrow in *P. pelagicus* that is absent in *P. penicillatus* and *P. auritus*. (7) Humerus: Proximal end: The capital groove is deeper in *P. auritus* than in *P. penicillatus* (Howard 1929); the bicepital crest (anconal view) forms a more well-defined ridge in *P. penicillatus* than in *P. auritus* and *P. pelagicus*; the internal tuberosity is larger, with a steeper internal face in *P. auritus* and *P. pelagicus* than in *P. penicillatus*; and the distal face projects farther distally in *P. pelagicus* and *P. penicillatus* than in *P. auritus*. Distal end: In addition to the features described in Howard (1929), *P. penicillatus* and *P. auritus* differ from *P. pelagicus* by having an entepicondyle with two prominent tubercles separated by a well-defined depression. (8) Radius: Criteria in Howard (1929) were used to distinguish *P. penicillatus* from *P. auritus*; *P. pelagicus* was distinguished by its smaller size. (9) Ulna: The external cotylae of the proximal end are longer, more sharply hooked, and undercut in *P. auritus* as compared with *P. penicillatus*. The palmar margin of the internal condyle is smoothly rounded in *P. pelagicus* but flatter with a sharp bend medially in *P. auritus* and *P. penicillatus*. I failed to observe consistent criteria to distinguish the distal ulna among these species. (10) Carpometacarpus: *P. auritus* differs from *P. penicillatus* and *P. pelagicus* by having a more sharply defined posterodistal limit of the internal articular ridge of the carpal trochlea, and a tubercle at the same limit of the parallel articular ridge. In addition, the intermetacarpal space is narrower distally in *P. auritus* and *P. pelagicus* than in *P. penicillatus*. (11) Synsacrum: Criteria in Howard (1929) were used to distinguish *P. penicillatus* from *P. auritus*; the iliac process in *P. pelagicus* is like that of *P. penicillatus*. (12) Femur: The posterior aspect of the trochanter is more rugose in *P. penicillatus* than in *P. auritus*. Moreover, the anterior aspect of the proximal end is less depressed in *P. auritus* than in *P. penicillatus* (Howard 1929); *P. pelagicus* shows an intermediate expression of this feature. The anteromedial section of the proximal shaft, just distal to the head, is marked by a distinctive groove or depression in *P. penicillatus* but is smooth to slightly roughened in *P. auritus*; this region exhibits a small tubercle in *P. pelagicus*. Relative depths of the external and fibular condyles of the distal end are distinctive in *P. auritus* and *P. penicillatus*, as described by Howard (1929); *P. pelagicus* is like *P. penicillatus* in this feature. (13) Tibiotarsus: Criteria in Howard (1929) were used to distinguish *P. penicillatus* from *P. auritus*; the tibiotarsus of *P. pelagicus* is substantially smaller than that of those two species. (14) Tarsometatarsus: Criteria in Howard (1929) were used to distinguish *P. penicillatus* from *P. auritus*. Also, trochlea for digit III projects less anteriorally in *P. auritus* than in *P. penicillatus* or *P. pelagicus*. The tarsometatarsus of *P. pelagicus* is distinctively short and stout, compared with those of *P. auritus* and *P. penicillatus*.

ORDER CICONIIFORMES

Family Ardeidae

Botaurus lentiginosus (Rackett 1813)

Referred material.—Scapula (EMF A10870).

Remarks.—The specimen compares in size with *Nycticorax nycticorax* and *B. lentiginosus*. However, the outline of the proximal margin between the furcular articulation and the coracoidal articulation is gently curved, as in *B. lentiginosus*, not sharply bent, as in *N. nycticorax*. This species was not identified in the sample of Emeryville material that Howard (1929) examined.

Ardea herodias Linnaeus 1758

Referred material.—Reported in Howard (1929): scapulae (EMF 7252, 8849), femur (EMF 6778), tarsometatarsi (EMF 7475, 7975, 8299). Additional elements: cranium (EMF A1852), mandibles (EMF A10436, 8199; PAHMA 12-1449), humeri (EMF A1732, A9520 [Fig. 5]; PAHMA 12-1476), radii (EMF 5371, A3274), femur (EMF A3648).

Remarks.—The large size of the elements rules out all other ardeids, including *A. alba*.

Family Cathartidae

Cathartes aura (Linnaeus 1758)

Referred material.—Reported in Howard (1929): radius (EMF 10544), synsacrum (EMF 8287). Additional elements: humerus (EMF A9165), synsacrum (EMF A10116).

Remarks.—The synsacrum and humerus are too large for *Coragyps atratus* and too small for *Gymnogyps californicus*. The *G. californicus* material that Howard (1929) identified lacks within-site provenience information.

ORDER ANSERIFORMES

Family Anatidae

Subfamily Anserinae (small)

Referred material.—A total of 536 miscellaneous elements are represented.

Subfamily Anserinae (medium)

Referred material.—A total of 1,212 specimens representing all major elements of the skeleton were identified.

FIG. 5. Left proximal humerus of *Ardea herodias* (EMF A9520).

Remarks.—Given the extensive intraspecific variation in the osteological characters of geese, species-level identifications were made only for anserine cranial elements and postcranial elements so large as to rule out all taxa but the largest subspecies of *Branta canadensis* (e.g. *B. c. moffitti*). Specimens identified as small anserines are similar in size to *B. bernicla, B. hutchinsii minima*, and *Chen rossii*. Medium anserines match the size of *C. caerulescens caerulescens, Anser albifrons*, and small subspecies of *B. canadensis* (i.e. *B. c. parvipes*).

Chen caerulescens (Linnaeus 1758)

Referred material.—Crania (EMF 7852, 7876 [Fig. 6A], 10415, A3224), mandibles (EMF A109, 17101, 17388, 6940, 5367, 7460, 9971, 10010, 10337, 10340, A1495, A2464, 17499, 8036, A516, A923, 6824, 7407, 8223, 10291, A11866, A8173; PAHMA 12-1348, 12-1454, 12-1454).

Remarks.—(1) Cranium: *C. caerulescens* is distinguished from *A. albifrons* and *B. canadensis* by a greater dorsoventral depth of the premaxilla, a more anterodorsally depressed frontal, smaller anterior supraorbital processes, and a steeper slope of the anterior margin of the interorbital septum. (2) Mandible: The dentary is distinguished from that of other geese by a greater depth and thickness of the body and a deeper ventrolateral groove. The posterior mandible is larger and more robust than that of *A. albifrons*, and distinguished from that of larger subspecies of *B. canadensis* by a shorter length between the articular facet and the coronal process. The anterior extension of the external articular process is more prominent than in *Branta* or *Anser*. The large size of the elements rules out *C. rossii*.

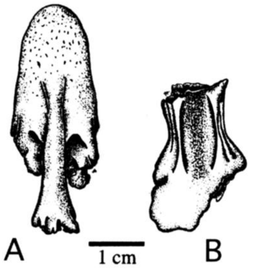

FIG. 6. (A) Premaxilla of *Chen caerulescens* (EMF 7876) and (B) frontal of *Branta canadensis* (EMF A5806).

Chen rossii (Cassin 1861)

Referred material.—Mandibles (EMF A9798, A4700, A178, A3621, A1861, A6984, A7127; PAHMA 12-1437).

Remarks.—The mandibles of *C. rossii* are easily distinguished from those of all other geese by having great depth and thickness for a very short length.

Branta hutchinsii (Richardson 1832) cf. *minima*

Referred material.—Mandibles (EMF A8177; PAHMA 12-1455, 12-1441).

Remarks.—The mandibles of *B. hutchinsii minima* are smaller and more gracile than those of all other geese.

Branta canadensis (Linnaeus 1758) cf. *parvipes*

Referred material.—Crania (EMF A5806 [Fig. 6B], 7849, 8015, 8016, A2485, A2853, 10412; PAHMA 12-1342, 1-9802), mandibles (EMF A6792, A638, 10138, 10413, 17232; PAHMA 12-1449).

Remarks.—(1) Cranium: The crania of *B. canadensis* are distinguished from those of *A. albifrons* and *C. caerulescens* by a narrow and markedly roughened or sculptured frontal between the orbits, typically with a slight ridge or line of bone encircling the dorsal margin of the orbits (Fig. 6B). These specimens are too large for *B. bernicla* and *B. hutchinsii* and too small for *B. c. moffitti*. (2) Mandible: The mandible specimens are too small and gracile to represent *A. albifrons, C. caerulescens*, or *B. c. moffitti*, and too large for *B. hutchinsii*. They are distinguished from those of *C. rossii* by a thinner dentary, a more attenuate coronal process, and a more elongate and anteriorly tapered external articular process. They are distinguished from *B. bernicla* by a more vertically oriented internal articular process, a higher coronoid process, and a more robust coronal process.

Branta canadensis (Linnaeus 1758) cf. *moffitti*

Referred material.—Mandibles (EMF 8047, A514, A6328, A11813), coracoids (EMF A1031, A855, A4028, 6311; PAHMA 1-9833, 1-9848), furculum (PAHMA 1-9848), scapulae (EMF A71, 6263), humeri (EMF A2536, A484, 7031; PAHMA 1-9783, 1-9833), ulnae (EMF A96, PAHMA 12-1462).

Remarks.—The mandibles of *B. canadensis* cf.

moffitti are distinguished from those of *C. caerulescens* as noted above, and from *A. albifrons* by a greater distance between the articular facet and the coronal process. Identifications of postcranial elements listed above were based on their large size.

Subfamily Anatinae (small)

Referred material.—A total of 113 specimens representing all the main elements of the skeleton.

Subfamily Anatinae (large)

Referred material.—A total of 1,263 elements were identified.

Remarks.—Genus- or species-level identifications of ducks were attempted for all cranial specimens but for only a subset of postcranial elements. That subset includes the humerus, sternum, tarsometatarsus, and synsacrum. These are among the most diagnostic anatinine postcranial elements (Woolfenden 1961). Osteological criteria are presented that distinguish these elements among the different duck genera represented at Emeryville: *Anas, Aythya, Mergus, Melanitta, Bucephala,* and *Oxyura*. Distinctive features of these elements were also observed for genera not recovered from the site (*Aix, Somateria, Polysticta, Clangula, Lophodytes, Histrionicus*), mostly following Woolfenden (1961), but are not described here.

All other postcranial duck elements were assigned to one of two broad size categories: Anatinae (small) or Anatinae (large). Small anatinines are similar in size to *Anas* sp. (teals), *Bucephala albeola,* and *Oxyura jamaicensis;* the Anatinae (large) category may include any number of the larger duck species.

Anas sp.

Referred material.—Humeri, sterna, synsacra, and tarsometatarsi: 51 elements.

Remarks.—Specimens identified as *Anas* sp. could represent any number of the *Anas* species larger than the teals (*Anas cyanoptera, Anas discors, Anas crecca*). Features used to distinguish *Anas* from the other duck genera are as follows. (1) Mandible: The postarticular process is long and thin, with a long, tapering proximodorsal spine; the lateral cotylae are poorly developed. (2) Sternum: The ventral manubrial spine is long and peg-like, and projects anterodorsally; pneumatic foramena are round or elliptical (Woolfenden 1961); the dorsal manubrial spine is small and typically chevron-shaped. (3) Humerus: The bone is thick for its length; the internal tuberosity is robust; the pneumatic foramen is typically deeply open, with bony struts visible inside; the facet for the anterior articular ligament is elevated (Woolfenden 1959, 1961). (4) Synsacrum: The ventral surface of the anterior ilium grades smoothly into the ischium; the median dorsal ridge is broad and flat; a well-defined ridge is absent along the ventromedial surfaces of the anterior synsacral vertebrae. (5) Tarsometatarsus: Distinguished from that of *Aythya* by a much thinner bone for a given length and a less acute angle formed between the proximal margin of the trochlea for digit II and the adjacent distal shaft. The proximal ligamental attachment is small as compared with *Mergus*. The element is not as stout for a given length as that of *Bucephala*. As distinguished from *Melanitta*, the external cotyla does not extend into the anteroproximal portion of the shaft, and the ridge on the corresponding lateral portion of the shaft is not as sharp. I could not observe criteria to distinguish the distal tarsometatarsi of *Anas* and *Melanitta*.

Anas sp. cf. *Anas discors* Linnaeus 1766
or *Anas cyanoptera* Vieillot 1816
or *Anas crecca* Linnaeus 1758

Referred material.—Cranium, mandibles, sterna, synsacra, and tarsometatarsi: 21 elements.

Remarks.—Their small size makes the teals (*Anas cyanoptera, A. discors, A. crecca*) distinctive as a group from the other species of the genus; species-level identifications were not, however, attempted among them. The cranial specimen was distinguished from *B. albeola* by (1) a less ventrally angled foramen magnum and (2) a more vertically oriented transverse nuchal crest. The posterior cranium of *Oxyura* is substantially larger.

Anas platyrhynchos Linnaeus 1758

Referred material.—Sternum (EMF A6278), humeri (EMF 8575, 7032, 9948, A10318, A10582, A7034, A8624, A3464, A5353, 6767, 8729, 10099, A8529; PAHMA 12-1314), synsacra (EMF A5886, A2904; PAHMA 12-1430), tarsometatarsus (EMF A11556).

Remarks.—These elements are substantially larger than those from all other *Anas* species.

Anas clypeata Linnaeus 1758

Referred material.—Mandibles (EMF A4444, A5607), sternum (EMF 7444), humerus (PAHMA 1-9722), synsacrum (EMF 9900).

Remarks.—The lateromedially enlarged distal end of the dentary distinguishes *A. clypeata* from all other species of the genus. The other elements were identified on the basis of size: too small to represent *A. americana* or *A. strepera* but too large to represent *Anas* sp. (teal).

Aythya sp.

Referred material.—Mandibles, humeri, sterna, synsacra and tarsometatarsi: 23 specimens.

Remarks.—Features used to distinguish *Aythya* from *Anas, Melanitta, Bucephala,* and *Mergus* are as follows. (1) Mandible: Compared with those of *Anas,* the postarticular process has greater depth and the lateral cotylae are larger. The flattened ventral surface of the dentary extends farther proximally than in *Melanitta* and *Anas,* and the element is larger and more distally flaring than those of *Bucephala* and *Oxyura.* The dentaries of *Mergus* are distinctively long and narrow. (2) Sternum: The ventral manubrial spines, if present, are paired, short, thin, and pointed. (3) Humerus: The humerus is thinner and narrower for a given length than in *Anas.* On the proximal end, the internal tuberosity is near the height of the head when the bone is laid flat, palmar side down; the head is minimally undercut; the anconal aspect of the deltoid crest is relatively smooth and straight laterally; the bicepital crest is straight, not flaring; the pneumatic foramen is deep, but lacks bony spicules, as in *Anas* (Woolfenden 1961). On the distal end, the olecranon fossa is not as deep and the margins are not clearly defined as in *Melanitta;* the depression for the *brachialis anticus* is well developed, with a sharply defined distomedial rim; the internal condyle is more deeply undercut proximally than in *Anas;* the intercondylar furrow is confluent with the olecranal fossa, not separated by a transverse ridge as in *Melanitta* (Woolfenden 1961); the attachment of the anterior articular ligament is less elevated than in *Anas* (Woolfenden 1961). (4) Synsacrum: The pre-acetabular ala of the ilium is steep and narrow, and a flat plateau of the ventral surface of the synsacral vertebrae begins near the first lumbar vertebrae and narrows anteriorly to form a sharp ridge along the synsacral thoracic vertebrae. (5) Tarsometatarsus: Distinguished from that of *Anas* by the criteria above, and from that of *Mergus* by a substantially shorter length, thicker bone, and smaller most-proximal ligamental attachments. Distinguished from *Melanitta* by a greater width for a given length (Woolfenden 1961). The smaller species of *Aythya* (*A. marila, A. affinis*) are most similar to *Bucephala;* the latter is distinguished from *Aythya* by a more deeply incised anteroproximal shaft near the proximal foramina, smaller and less laterally rotated trochlea for digit III, and a much smaller protuberance on the anconal surface just distal to the internal cotyla.

Aythya sp. (large)

Referred material.—Mandible, sternum, and humeri: 4 specimens.

Aythya cf. *A. valisneria* (Wilson 1814)

Referred material.—Humerus (EMF 8738), and synsacrum (EMF A6496).

Aythya valisneria (Wilson 1814)

Referred material.—Cranium (EMF 16927) and humerus (EMF 8200).

Aythya cf. *A. marila* (Linnaeus 1761)

Referred material.—Mandibles (EMF A3540, A511), humerus (EMF 17241), and synsacrum (EMF 12-1434).

Aythya marila (Linnaeus 1761)

Referred material.—Mandibles (EMF A7406, PAHMA 12-1449).

Aythya affinis (Eyton 1838)

Referred material.—Humerus (A12768), synsacrum (A6533).

Remarks.—Mandibles of *A. marila* are distinguished from those of *A. americana* and *A. collaris* by a broader, deeper, and more flared distal end; and from those of *A. valisneria* by a greater depth and shorter length. In comparison with those of *A. affinis*, they are deeper and thicker for specimens of comparable length. Other *Aythya* species-level identifications are based on size.

Melanitta sp.

Referred material.—Crania, humeri, synsacra, sterna, and tarsometatarsi: 466 elements.

Remarks.—(1) Mandible: *Melanitta* is distinguished from all other duck genera by a dorsoventrally flattened distal end of the dentary, with an elongated cavity on the ventral surface proximal to the symphysis. *Melanitta* is also distinguished by a short, proximally squared-off postarticular process with a short proximodorsal spine and a maximum depth at the surangular (angle of mandible) that is greater than in the largest *Anas* and *Aythya*. *Melanitta* also exhibits well-developed lateral cotylae. (2) Sternum: Distinguished by a lack of ventral manubrial spines and by small, paired, and widely spaced dorsal manubrial spines. (3) Humerus: On the proximal end, the head is undercut anconally, but not as deeply as in *Bucephala*; the internal tuberosity does not extend above the head, as in *Bucephala*; the deltoid crest extends farther distally, with the distal end prominently flared (Woolfenden 1961). On the distal end, the attachment of the anterior articular ligament is much less elevated than in *Anas*; the olecranal fossa is large, deep, and rectangular in shape, with steep sides and well-defined margins; the intercondylar furrow is separated from the olecranal fossa by a transverse ridge; the olecranal fossa is shallower and less well defined in *Anas* and *Aythya* of similar size; *Mergus* is most similar to *Melanitta*, but the walls of the olecranal fossa are not as steep. (4) Synsacrum: Distinguished from all other genera by large size; by a well-defined midsagittal ridge running along the ventral surface of the thoracic and lumbar synsacral vertebrae; by a greater length of the synsacral sacral column; and by a greater width of the ilium at the parapophysis of the last sacral synsacral vertebrae. (5) Tarsometatarsus: This element is distinctively long and thin as compared with those of other duck genera, with the exception of *Mergus*. On the distal end, it is distinguished from that of *Mergus* by a greater proximal extension of the posterior surface of the trochlea for digit II; by a greater relative depth of the lateral–posterior ridge of the trochlea for digit IV, as compared with the medial–posterior ridge of that trochlea; and by a broad, not tapering, posteroproximal extension of the trochlea for digit III. On the proximal end, the internal cotylae are deeper, with more pronounced margins than in *Mergus*.

Melanitta perspicillata (Linnaeus 1758)
or *M. fusca* (Linnaeus 1758)

Referred material.—Crania (EMF A6779, A6782, A6785, A6786, A6794, A6776; PAHMA 1-9780).

Melanitta perspicillata (Linnaeus 1758)

Referred material.—Crania (EMF A1102, A5992; PAHMA 12-1157, 12-1354, 12-1430).

Melanitta fusca (Linnaeus 1758)

Referred material.—Crania (EMF A5206, A6773, A6775, A6778, A6780, A6787; PAHMA 12-1354, 12-1157).

Remarks.—Species-level identifications were made for *Melanitta* cranial material using the following criteria. The minimum interorbital breadth of the frontal bone is greater in *M. fusca* than in *M. nigra* and *M. perspicillata* (Table 4). Two specimens with frontal breadths of 10.52 mm (PAHMA 12-1354) and 10.92 mm (EMF A5206) are beyond the range of *M. nigra* and *M. perspicillata* and were assigned to *M. fusca* accordingly. The length of the premaxilla, measured from bill tip at the midline to anterior margin of external nares, is also greater in *M. fusca* than in *M. nigra* and *M. perspicillata* (Table 5). With a premaxilla width of 27.08 mm, specimen PAHMA 12-1157

TABLE 4. Minimum interorbital frontal breadths (mm) for recent *Melanitta nigra*, *M. perspicillata*, and *M. fusca* specimens[a].

Species	*n*	Mean	Range	SD	SE
M. nigra	5	7.21	6.73–7.50	0.300	0.134
M. perspicillata	15	7.62	5.95–9.60	0.948	0.245
M. fusca	13	9.60	7.86–10.72	0.899	0.249

[a] Specimens from MVZ, UWBM, and UMNH (see text).

TABLE 5. Premaxilla lengths (mm) for recent *Melanitta nigra, M. perspicillata,* and *M. fusca* specimens[a].

Species	*n*	Mean	Range	SD	SE
M. nigra	6	21.423	20.500–22.230	0.635	0.259
M. perspicillata	17	21.721	19.110–23.780	1.769	0.429
M. fusca	22	26.223	23.140–30.350	1.723	0.367

[a] Specimens from MVZ, UWBM, and UMNH (see text).

is beyond the range of *M. nigra* and *M. perspicillata* and was identified as *M. fusca*. In addition, lachrymal bones in *M. fusca* are large and contain prominent sinuses; these bones are much smaller and lack sinuses in *M. perspicillata* and *M. nigra*. Posteriorly oriented supraorbital processes are well developed in all three species, but are longest and thinnest in *M. nigra*. The frontal is flat along its entire length in *M. perspicillata* and *M. nigra;* in *M. fusca,* the anterior portion slopes ventrally at the supraorbital processes. The anterior frontal exhibits a deep, well-defined midsagittal groove in *M. perspicillata* and *M. fusca,* but is smoothly concave in *M. nigra*. *Melanitta fusca* exhibits a deep depression just medial to the postorbital process in the posterior wall of the orbit, a feature lacking in *M. perspicillata* and *M. nigra*. Muscle attachments of the posterior cranium (e.g. *crista temporalis* and nuchal crests) are more pronounced in *M. fusca* than in *M. nigra* and *M. perspicillata*. The temporal fossae are more triangular-shaped and converge to a point, dorsally, in *M. fusca;* they are more constricted in *M. perspicillata,* forming an elongate and rounded dorsal end.

Bucephala sp.

Referred material.—Humerus (EMF 10131).

Remarks.—The specimen may be a very large *B. albeola* or a very small *B. clangula–islandica,* or may represent a hybrid.

Bucephala albeola (Linnaeus 1758)

Referred material.—Sternum (A5918) and humeri (EMF A1040, A90, A3130, 7800; PAHMA 12-1437).

Bucephala clangula (Linnaeus 1758) or *B. islandica* (Gmelin 1789)

Referred material.—Sterna (EMF 17263, A5919, A5808, A12276; PAHMA 12-1157, 12-1157), humeri (EMF 17309, A4206, 10519; PAHMA 12-1437), synsacrum (EMF 8300), tarsometatarsus (PAHMA 12-1437).

Remarks.—*Bucephala albeola* is distinguished from *B. clangula–islandica* on the basis of small size. Features that distinguish these *Bucephala* elements from those of *Anas, Aythya,* and *Melanitta* are described above; features that distinguish them from those of *Mergus* and *Oxyura* are as follows. (1) Sternum: The ventral manubrial spine is absent, and the paired dorsal manubrial spines are very small and widely spaced. The coracoidal sulcus has a strong ventral projection of the ventral lip and a sharp posterior curve of the lateroventral lip. The carina is strongly projected anteriorly, not to the extreme seen in *Mergus* (see below), but more pronounced than in any other duck genus. In *O. jamaicensis,* the dorsally projected ventral manubrial spine is short, squared off, and bifurcated distally. (2) Humerus: The head is deeply undercut anconally, and the internal tuberosity does not rise above it when the bone is placed flat, palmar side down. The lateral margin of the deltoid crest is concave; the bicepital crest is widely flaring, with a proximal depression; the pneumatic foramen is closed and internally smooth. The distal end is very similar to that of the smaller *Melanitta,* but the internal condyle is more deeply undercut proximally, and the entepicondylar prominence is less strongly margined laterally. (3) Synsacrum: Like *Melanitta, Bucephala* and *Oxyura* both have sharp ventral ridges along the lumbar and thoracic synsacral vertebrae. *Bucephala* lacks the strong ventral projection of the ilium at the pectineal process as found in *Oxyura*. (4) Tarsometatarsus: Bone length is consistently shorter than in *Mergus,* but longer than in *Oxyura;* it also lacks the heavily sculptured anterior surface of the trochlea for digit 3 found in the latter.

Mergus sp.

Referred material.—Two humeri.

Mergus cf. *M. serrator* Linnaeus 1758

Referred material.—Humerus (EMF A5267), tarsometatarsus (EMF A4260).

Mergus serrator Linnaeus 1758

Referred material.—Sterna (EMF A6276, A10787), synsacra (PAHMA 12-1441, 12-1336).

Remarks.—(1) Sternum: In *Mergus*, this element displays the greatest anterior projection of the carina of any anatinine genus and has no ventral manubrial spine. The anterior carinal margin of *M. serrator* differs from that of *M. merganser* in having a triangular depression just ventral to the coracoidal sulcus. (2) Humerus: The deltoid crest is "sharply angular" in *Mergus* (Woolfenden (1961). The pneumatic foramen is open, with bony struts, more deeply excavated than in *Anas*. In *M. merganser*, the proximal head is undercut anconally by a distinctive crescent-shaped depression (for external head of triceps), and a clear bony ridge separates the depression from the capital groove; *M. serrator* lacks this feature. (3) Synsacrum: In *Mergus*, this element is distinguished by a strongly waisted ilium just anterior to the acetabulum, a strong anterior projection of the pectineal processes, and a prominent ventral projection of the ilium just anterior to the acetabulum. *Mergus serrator* is distinguished from *M. merganser* by its smaller size. (4) Tarsometatarsus: This element is most similar to that of *Melanitta*, and differences are described above. Identification of *M.* cf. *serrator* is based on the small size of the element.

Oxyura jamaicensis (Gmelin 1789)

Referred material.—Sterna (EMF A9115, PAHMA 12-1157), synsacrum (EMF A9098).

Remarks.—Sterna are distinguished by the criteria described under *Bucephala* above. The synsacrum in *O. jamaicensis* is easily distinguished from that of all other smaller ducks (*B. albeola, A. affinis, Anas* sp. [teals]) by a strong ventral projection of the ilium just anterior to the acetabulum.

ORDER FALCONIFORMES

Family Accipitridae

Elanus leucurus (Vieillot 1818)

Referred material.—Reported in Howard (1929): coracoid (EMF 6387), ulna (EMF 8366). Additional element: tibiotarsus (PAHMA 12-1476).

Remarks.—The tibiotarsus in *Elanus* differs from that of all other genera of accipitrids and falconids by having (1) a prominent depression on the posterior shaft just proximal to the posterior intercondylar sulcus and (2) a more limited proximal extension of the intercondylar sulcus.

Haliaeetus leucocephalus (Linnaeus 1766)

Referred material.—Reported in Howard (1929): coracoid (EMF A2999), humerus (EMF A3100), carpometacarpi (EMF A3059, 8708). Additional elements: sternum (PAHMA 12-1427), furculum (EMF A317), coracoid (EMF A194), femur (EMF 7757).

Remarks.—Distinguished from *Aquila chrysaetos* as follows: (1) the coracoid is longer and lacks a deeply undercut furcular facet; (2) the furculum has a longer groove ventral to the furcular process; (3) the right coracoidal sulcus of the sternum extends medially onto the dorsal aspect of the ventral manubrial spine; and (4) the external condyle of the femur has a greater anteroposterior depth and posteroproximal extension.

Circus cyaneus (Linnaeus 1766)

Referred material.—Coracoids (EMF 16964, A11322).

Remarks.—The coracoid is shorter and stouter than in *Accipiter cooperi* and *A. striatus*.

Accipiter cooperi (Bonaparte 1828)

Referred material.—Mandible (EMF A9237).

Remarks.—The dentary is shorter, stouter, and less decurved than in *Elanus* and *Circus* and is too large to represent *A. striatus*.

Buteo lineatus (Gmelin 1788)

Referred material.—Radius (EMF 5358), ulnae (EMF A471, 5311), femur (PAHMA 12-1437).

Remarks.—Six *Buteo* species occur in California, and they range in size from smallest to largest as follows: *B. lineatus, B. swainsoni, B. lagopus, B. jamaicensis*, and *B. regalis*. The radius of *B. lineatus* is distinguished by its very small size and by having a smooth and rounded ligamental protuberance of the distal end. The ulnae identified as *B. lineatus* are substantially smaller than those of *B. swainsoni*. The femur was distinguished by its very small size and a squared-off distolateral process of the fibular condyle.

Buteo jamaicensis (Gmelin 1788)

Referred material.—Reported in Howard (1929): sternum (EMF 9884), humeri (EMF 7838, 7788, 8851, 9940, 10270), synsacrum (EMF 9998), tarsometatarsi (EMF 9986, 9999). Additional elements: tarsometatarsi (EMF A10328, A1021).

Remarks.—The tarsometatarsi were distinguished from those of *B. regalis* by greater length, thinner width, and characters described in Howard (1929); the specimens are too large to represent *B. lagopus*.

Buteo jamaicensis (Gmelin 1788)
or *B. lagopus* (Pontoppidan 1763)

Referred material.—Carpometacarpus (EMF 5789), femur (EMF 17098).

Remarks.—The elements are too large to represent *B. swainsoni*, too small to represent *B. regalis*, and within range of both *B. jamaicensis* and *B. lagopus*.

Buteo jamaicensis (Gmelin 1788)
or *B. regalis* (Gray 1844)

Referred material.—Coracoids (EMF A2125, A5251), humerus (PAHMA 12-1476), femur (EMF A3119), tibiotarsi (EMF 7338, 6248).

Remarks.—The specimens are too large to represent *B. swainsoni*, *B. lagopus*, or *B. lineatus*.

Buteo regalis (Gray 1844)

Referred material.—Radius (EMF 8635), tibiotarsus (EMF A86), tarsometatarsus (PAHMA 12-1449).

Remarks.—The width of the radius head (7.60 mm) exceeds that of 32 measured *B. jamaicensis* reference specimens and falls within range of *B. regalis*. The tibiotarsus and tarsometatarsus were identified by characters described in Howard (1929) and by their large size.

Family Falconidae

Falco sparverius Linnaeus 1758

Referred material.—Femur (EMF A3684).

Remarks.—The distal femur specimen is too small to represent *F. columbarius*.

Falco columbarius Linnaeus 1758

Referred material.—Reported in Howard (1929): humerus (EMF 9913). Additional element: coracoid (EMF A2137).

Remarks.—Identification of the *F. columbarius* coracoid was based on size: too large to represent *F. sparverius* and too small to represent *F. mexicanus*.

Falco peregrinus Tunstall 1771
or *F. mexicanus* Schlegal 1850

Referred material.—Reported in Howard (1929): coracoid (EMF 7081). Additional elements: humerus (EMF A4067), carpometacarpi (EMF A9357, A9208), ulna (EMF A9362), femora (EMF A10363, A9365), tibiotarsi (EMF A10347, A9363).

Falco peregrinus Tunstall 1771

Referred material.—Reported in Howard (1929): ulna (EMF 9989), tarsometatarsus (EMF 10292). Additional elements: mandible (EMF 10160), ulna (EMF 17099), tibiotarsus (PAHMA 12-1476).

Remarks.—These elements differ from those of *F. mexicanus* as follows. (1) Ulna: The cotyla and condyles are large, with external cotyla more sharply hooked and distopalmarly projecting. (2) Mandible: Greater depth of the dentary. (3) Tibiotarsus: The fossa between the inner and outer cnemial crests on the proximal shaft is shallower, and the distal extremity of the outer cnemial crest lacks a sharp spine.

Falco mexicanus Schlegal 1850

Referred material.—Femur (EMF 17220).

Remarks.—Distinguished from *F. peregrinus* by having a posterior rather than a lateral orientation of the impression for the *ansae iliofibularis* muscle.

ORDER GALLIFORMES

Family Phasianidae

Gallus gallus (Linnaeus 1758)

Referred material.—Coracoid (EMF A11518 [Fig. 7A]) and ulna (EMF A11490 [Fig. 7B]).

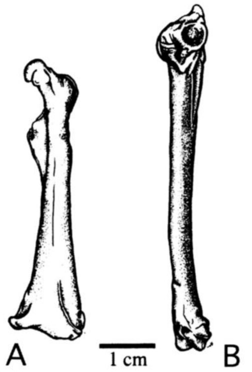

FIG. 7. (A) Left coracoid (EMF A11518) and (B) right ulna (EMF A11490) of *Gallus gallus*.

Remarks.—These elements are very similar in size and morphology to those of *Dendragapus obscurus*, but differ from that species in the following ways. (1) Coracoid: Thinner in general, with a concave internal surface at the sternal end and a more lateroproximal position of the pneumatic foramen. (2) Ulna: Less curvature of the shaft, with a more prominent extension of the external condyle of the distal end, and a smoother distal attachment of the internal cotyla to the palmar shaft.

Chickens were not identified from the Emeryville sample that Howard (1929) examined, nor were any domestic species present in the large collection of mammal materials recovered from the site (Broughton 1999). Both these elements originated from the top layer of the mound (Stratum 1) and were clearly derived from historic-period activities that took place on its surface.

Family Odontophoridae

Oreortyx pictus (Douglas 1829) or *Callipepla californica* (Shaw 1798)

Referred material.—Sterna (PAHMA 12-1441, EMF A886).

Remarks.—Substantial overlap in size of the sternum between *C. californica* and *O. pictus* and the fragmentary nature of the anterior sternum specimens precluded species-level identifications.

Callipepla californica (Shaw 1798)

Referred material.—Humeri (EMF A10868, PAHMA 1-9733), tibiotarsus (EMF A5305), tarsometatarsus (EMF A9562).

Remarks.—These elements are too small to represent *Oreortyx*.

Order Gruiformes

Family Rallidae

Rallus longirostris Boddaert 1783

Referred material.—Reported in Howard (1929): humeri (EMF 10130, 10309), femur (EMF 8049). Additional elements: femora (EMF A2160, A2698).

Remarks.—The prominent, crest-like obturator ridge of the femur distinguishes *R. longirostris* from *Fulica* and *Gallinula*.

Fulica americana Gmelin 1789

Referred material.—Reported in Howard (1929): scapula (EMF 6268), humerus (EMF 6368), ulna (EMF 6275), tarsometatarsus (EMF 6374). Additional elements: sternum (EMF A2626), radius (EMF A1736), ulna (EMF 8003), carpometacarpus (PAHMA 12-1437), synsacrum (EMF A8564).

Remarks.—These elements are too large to represent *R. longirostris* or *Gallinula*.

Family Gruidae

Grus canadensis (Linnaeus 1758)

Referred material.—Reported in Howard (1929): mandible (EMF 8639), coracoids (EMF 16967, 7417, 8572), scapulae (EMF 5362, 7421, 8180, 9929), humeri (EMF 6309, 10421), carpometacarpi (EMF 9240, 10521), carpal digit 2 phalanx 1 (EMF 9465), femur (EMF A2410), tibiotarsus (EMF A4892), tarsometatarsi (EMF A2384, A2606). Additional elements: sternum (PAHMA 12-1360), coracoid (PAHMA12-1462), humeri (EMF A8616; PAHMA 12-1447, 12-1437), radius (EMF A4336), ulna (EMF A8664), carpal digit 2 phalanx 1 (EMF 17086, A2709), synsacrum (EMF A9095), tarsometatarsi (EMF A3273, A134, A11645).

Remarks.—Both small and large subspecies of *G. canadensis* are represented in the collection.

ORDER CHARADRIIFORMES

Family Charadriidae

Pluvialis squatarola (Linnaeus 1758)

Referred material.—Radius (EMF A3101), ulnae (EMF A6164, 9166), carpometacarpus (PAHMA 12-1472), synsacrum (PAHMA 12-1157), tarsometatarsus (EMF A5595).

Remarks.—The ulna of *P. squatarola* is most similar to that of *Tringa melanoleuca* but differs from it by having a longer, more pronounced crest running distally from the internal cotyla along the palmar surface of the shaft; a deeper proximal radial depression; and greater breadth of the distal end. The other elements are smaller than those of *Catoptrophorus,* and larger than those of *T. melanoleuca, Limnodromus, Charadrius,* and *P. dominica.*

Charadrius vociferus Linnaeus 1758

Referred material.—Ulnae (EMF A7478, A7035).

Remarks.—The ulnae are too small to represent *Pluvialis* and too large to represent any other *Charadrius* species.

Family Recurvirostridae

Recurvirostra americana Gmelin 1789

Referred material.—Humerus (PAHMA 12-1437), tarsometatarsus (PAHMA 1-9724).

Remarks.—The proximal humerus is distinguished from those of *Numenius* and *Limosa fedoa* by a more pronounced excavation of the anconal surface, including undercutting of the head; it is too large to represent *Himantopus mexicanus*. The trochlea of the distal tarsometatarsi are too large to represent *H. mexicanus, N. phaeopus,* and *L. fedoa* and too small to represent *N. americanus.*

Family Scolopacidae

Catoptrophorus semipalmatus (Gmelin 1789)

Referred material.—Reported in Howard (1929): humerus (EMF 9942). Additional elements: sterna (PAHMA 12-1157; EMF 10134, A4396), scapula (PAHMA 12-1437), humerus (EMF A3122), radii (PAHMA 12-1427; EMF 6382, A699, A5248, A2824, A5231, A3164, A4427), ulnae (EMF 6287, A118, A3452), carpometacarpus (PAHMA 12-1427), synsacra (PAHMA 12-1275, 12-1157; EMF A5910), femur (EMF A6896), tibiotarsi (EMF 16885, A3465, A4177; PAHMA 12-1437), tarsometatarsus (EMF A5508).

Remarks.—The sternum of *C. semipalmatus* differs from that of *L. fedoa* by having a shorter, more anteriorly flattened manubrial process and a narrower anterodorsal base of the carina; it differs from that of *N. phaeopus* by having a smaller coracoidal sulcus. The distal humerus is distinguished from that of *R. americana* by smaller size and a sharper ectepicondylar prominence. The proximal ulna is distinguished from that of *Recurvirostra* by having a shorter proximodistal length of the external cotyla and by lacking a prominent V-shaped plateau formed by ridges extending distomedially from internal and external cotylae. The distal ulna differs from that of *Recurvirostra* by having a less prominent carpal tuberosity. Identifications of other elements were based on size.

Numenius phaeopus (Linnaeus 1758)

Referred material.—Reported in Howard (1929): tibiotarsus (EMF 9973).

Numenius americanus Bechstein 1812

Referred material.—Reported in Howard (1929): cranium (EMF 10339), mandible (EMF 17029), sterna (EMF 7991, 8612), coracoids (EMF 7047, 6386, 10169, 6349), carpometacarpi (EMF 6792, 9152, 10524). Additional elements: crania (EMF A4700, 5795, 8365, 10171, A2663), sterna (EMF A9113, A9236, A3505, A3506, A3511, A3513, A5518, 9961, 10102, A8059; PAHMA 12-1441, 12-1157, 12-1434, 12-1434), furculae (EMF A5980, PAHMA 12-1430), coracoids (EMF A10330, A4347, A8541, A9552, A9558, A3449, A4156, A4259, A5501), scapulae (EMF A10342, A8663, A8701, A843, A4412, A10848, A11559, 6932, 69335, 8197, 9228, A2830, A1629, A2129, A3249; PAHMA 12-1437), humeri (EMF A8677, A81, A3469, A4285, A6118, A6125, 8038, 9956, A2090, A2461, A3143, A9514, A9728, A9194, 17239, A5281, A5607, 7038, 8639, 8719, 9219, 9927, 10127; PAHMA 1-9708, 12-1476, 12-1476), radii (EMF 16887, A10628, A12473, A3361, A5094, A8720), carpometacarpi (EMF A10478, A10624, A9206

[Fig. 8], A1641, A9531), carpal digit 2 phalanx 1 (PAHMA 1-9736; EMF A11094, A8407), synsacra (EMF 9266, 16919, A5890, A6301, A12601, A1469, A2365), femur (EMF 7161), tibiotarsi (EMF A9207, A4303, A5475, A5411; PAHMA 1-9739), tarsometatarsi (EMF A9214, A11600).

Remarks.—The elements of *N. americanus* are easily distinguished from those of all other scolopacids by their large size.

Numenius phaeopus (Linnaeus 1758)
or *Limosa fedoa* (Linnaeus 1758)

Referred material.—Sternum (EMF A10127), ulna (EMF A10473), carpometacarpus (EMF A10574), synsacrum (EMF 10147), tibiotarsi (EMF A5394, A5471, A5485, A2713).

Limosa fedoa (Linnaeus 1758)

Referred material.—Reported in Howard (1929): humeri (EMF 5813, 6277, 6772). Additional elements: cranium (EMF 7797), sterna (EMF A6360, A2199), scapulae (EMF 6397, A3047; PAHMA 1-9747), humeri (EMF A9190, 16955, A2711; PAHMA 12-1437, 1-9690), carpometacarpi (EMF A9218, A8685, A791, A3475, A11599; PAHMA 1-9756), synsacra (PAHMA 12-1157, 12-1311), tarsometatarsi (EMF A8723, A4258, A5270).

Remarks.—The elements of *L. fedoa* are considerably smaller than those of *N. americanus*. The cranium was readily identified by the large recurved rostrum. Other elements are very similar to those of *N. phaeopus* and were distinguished from that species as follows. The humerus exhibits a less pronounced depression distal to the head on the anconal surface; a less undercut head; a steeper slope of the medial rise to the internal tuberosity; and a shallower impression for the *brachialis anticus* of the distal end. The carpometacarpus has a more pronounced proximal slope of the process of metacarpal I and a less distinctly rounded distal end. The scapula has a more pronounced, medially oriented tubercle at the furcular articulation. The distal tarsometatarsus has a deeper groove between the medial and lateral portion of the trochlea for digit 4 and a less tapered (more squared-off) postero-proximal extension of the trochlea for digit III. The sternum has a more posteriorly oriented anterior carinal margin, with a thicker dorsal base.

FIG. 8. Right proximal carpometacarpus of *Numenius americanus* (EMF A9206).

Calidris alba (Pallas 1764)

Referred material.—Ulna (EMF A4214).

Remarks.—The ulnae of *C. alba* are most similar to those of *C. alpina*; they are distinguished from the latter by a shorter total length and a less robust olecranal process.

Calidris alba (Pallas 1764)
or *C. alpina* (Linnaeus 1758)

Referred material.—Ulna (EMF A8727).

Remarks.—This specimen falls within the range of size overlap between *C. alba* and *C. alpina*.

Limnodromus sp.

Referred material.—One ulna (EMF 7866) reported in Howard (1929) as *Limnodromus griseus*. Additional material includes 39 specimens, including all major elements of the skeleton.

Remarks.—No criteria were found to distinguish *L. griseus* from *L. scolopaceus*; the two were considered a single species until 1950 (Pitelka 1950).

Family Laridae

Larus sp. (large)

Referred material.—A total of 34 specimens, including all major elements of the skeleton.

Larus sp. (small)

Referred material.—Nine elements.

Larus glaucescens Naumann 1840
or *L. hyperboreas* Gunnerus 1767

Referred material.—Carpal digit 2 phalanx 1 (EMF A856), tibiotarsus (PAHMA 1-9739).

Remarks.—The two *L. glaucescens–hyperboreas* specimens were identified on the basis of their very large size. No other species-level identifications were attempted for the gulls, owing to the extensive interspecific overlap of osteological features. Specimens identified to the *Larus* sp. (small) category were similar in size to *L. canus, L. heermani, L. pipixcan, L. philadelphia, L. delawarensis*; the *Larus* sp. (large) category may include any of the other larger species.

Family Alcidae

Uria sp.

Referred material.—A total of 167 specimens, including all major elements of the skeleton, including 62 reported in Howard (1929) as *U. troille* (= *aalge*).

Uria aalge (Pontoppidan 1763)

Referred material.—Six crania (EMF 7400, A7041, A5208, A10695; PAHMA 12-1354, 1-9787).

Remarks.—Howard (1929) distinguished the elements of *U. aalge* from the other alcids "on the basis of larger size." She did not, however, consider whether *U. lomvia* may have been represented in the Emeryville collection, and there is considerable overlap in size of *U. aalge* and *U. lomvia* elements. Although *U. aalge* is far more abundant than *U. lomvia* along the central California coast, the latter occurs casually in the area—most records are from the Monterey area (Small 1994). Clear differences do exist in the crania of these species. *Uria aalge* is distinguished from *U. lomvia* by having a longer, thinner, and straighter premaxilla; smaller foramina in the anterior portion of the nasal fossa; deeper depressions anterior to the transverse nuchal crests; and more ventrally projecting and squared-off opistotic processes.

Cepphus columba Pallas 1811

Referred material.—Ulna (EMF A11501).

Remarks.—The ulnae of *C. columba* differ from those of *Cerorhinca monocerata* and *Fratercula corniculata* in the orientation of the carpal tuberosity; it is oriented near a right angle (90°) to the main axis of the bone in *C. columba*, but at a more obtuse angle in *C. monocerata* and *F. corniculata*.

ORDER STRIGIFORMES

Referred material.—One synsacrum fragment.

Family Tytonidae

Tyto alba (Scopoli 1769)

Referred material.—Reported in Howard (1929): coracoids (EMF 16964, A95, 9924, A2544, A2828), humeri (EMF 6901, 6903, 6922, 6919, 7039), ulna (EMF 8205), femur (EMF A3647), tibiotarsi (EMF 5788, 5363), tarsometatarsi (EMF 6918, 8258, 10113). Additional elements: coracoid (PAHMA 12-1323), humerus (EMF A3124), radii (EMF A253, 6928, 5807), ulnae (EMF A2406, A2607, A3682), carpometacarpi (EMF A3053, A3116, A10616), femur (EMF A256), tarsometatarsi (EMF A10895, A2135, A3123, A265; PAHMA 12-1476), tibiotarsi (EMF 7925, A341), ulnae (EMF A2406, A2607, A3682).

Remarks.—For most of the represented elements, I used the criteria presented in Howard (1929) to separate *T. alba* from *Strix*. *Tyto alba* is further distinguished from *Strix* by having shallower depressions on the anterior and posterior surfaces of the distal tibiotarsus, and a distinct concavity on the distal radius just proximal to the ligamental prominence.

Family Strigidae

Referred material.—One humerus.

Otus kennicottii (Elliot 1867)

Referred material.—Distal humerus (EMF A9573 [Fig. 9]).

FIG. 9. Right humerus, missing proximal end, of *Otus kennicottii* (EMF A9573).

Remarks.—The distal humerus of *O. kennicottii* differs from that of *Athene cunicularia* by having an ectepicondylar prominence that bears a small papilla and a deeper tricipital groove. *Otus kennicottii* was not identified in the Emeryville sample that Howard (1929) examined.

Bubo virginianus (Gmelin 1788)

Referred material.—Reported in Howard (1929): coracoid (EMF 9898), scapula (EMF 9949), tibiotarsus (EMF 8290), tarsometatarsi (EMF 8039, 8191, 8193). Additional elements: tarsometatarsi (EMF 10098, 7992; PAHMA 1-9823).

Remarks.—The tarsometatarsi of *Bubo virginianus* were distinguished from those of *Strix nebulosa* and *Nyctea scandiaca* by criteria in Howard (1929).

Asio sp.

Referred material.—Reported in Howard (1929): humerus (EMF 7867). Additional elements: carpometacarpus (EMF A10362), femur (EMF A10476).

Asio flammeus (Pontoppidan 1763)

Referred material.—Carpometacarpi (EMF A836, A924).

Remarks.—The total lengths of both carpometacarpi exceed the upper limit for *A. otus* as reported in Emslie (1982).

ORDER PASSERIFORMES

Family Corvidae

Corvus brachyrhynchos Brehm 1822

Referred material.—Reported in Howard (1929): coracoid (EMF 10333), scapula (EMF 7842), humeri (EMF 8320, A2977, 7813, 9221, 10118, 10293, 10417, 17097), ulnae (EMF 7442, 7840, 10162, 10319, 8020, 8362, 8623, 10010, 10588, 7254, 7441, 7972), carpometacarpi (EMF 5370, 6258, 6292, 6771, 8310, 8368, 9912, 9916), tibiotarsi (EMF 8056, 8213, 8221), tarsometatarsi (EMF A1050, A1138, A263, 7461, A2134, A2960, 6904). Additional elements: mandibles (EMF A1555, A3146), sterna (EMF 7861, A12674), coracoids (EMF A1642, A2726, A4702, A1636, A2538, A1379, A120, A1034, A10834, A10340, A9361, A8557; PAHMA 12-1454, 1-9703, 12-1462), scapula (EMF A1628), femora (EMF 7164, A246, A3455, 10429, 17279; PAHMA 12-1476), humeri (EMF A240, A1598, A9175, A8680, A10595, A10602, 6929, 7789, 10435), radii (EMF 6926, A5082, A11359, A3144, A3287), ulnae (EMF A9584, A11346, A11352, A11573, A3129, A4213; PAHMA 12-1449, 12-1314, 12-1314, 12-1314, 12-1314), carpometacarpi (EMF 17288, A2832, A10838, A10599, A10468; PAHMA 12-1462, 12-1314, 12-1314), carpal digit 2 phalanx 1 (EMF 6390, PAHMA 12-1462), tarsometatarsi (EMF 17302, A2612), tibiotarsi (EMF A2613, A2963, A2968, A9358, A10630; PAHMA 12-1462).

Corvus corax Linnaeus 1758

Referred material.—Reported in Howard (1929): humeri (EMF 8249, 7377), radii (EMF 7091, 8315), ulnae (EMF 10009, 9914, 10116), tibiotarsus (EMF 7845), tarsometatarsi (EMF 7843, 8713). Additional elements: radii (EMF A3629, PAHMA 12-1314), ulnae (EMF A10852, 10135), carpometacarpus (EMF 17434), carpal digit 2 phalanx 1 (EMF A10471, 9991), femora (EMF 7844, A3238), tibiotarsus (EMF A11361), tarsometatarsus (EMF A10862).

Remarks.—*Corvus brachyrhynchos* and *C. corax* are easily distinguished from each other and from other passerines on the basis of size.

TAXONOMIC SUMMARY AND DEPOSITIONAL ORIGIN

Sixty-four species are represented by the 5,736 identified bird specimens derived from the provenienced Emeryville sample. All the species are either present in the San Francisco Bay today or, if not, occurred there in historic times (Grinnell and Wythe 1927, Small 1994). Forty-five of the 64 species (69.8%) are waterbirds, 15 (23.8%) are raptors, and two each (3.2%) are Galliformes or large corvids. Twenty-five of those species were not reported by Howard (1929) in the Emeryville sample that she examined. Although many of the newly identified species are anatids ($n = 15$), a group that Howard did not study in any detail, the new species also include *Podiceps auritus, Fulmarus glacialis, Botaurus lentiginosus, Falco sparverius, Accipiter cooperi, Charadrius vociferus, Calidris alba, Gallus gallus, Otus kennicottii,* and *Asio flammeus.* With respect to numbers of identified specimens, ducks are the best-represented group of birds in the collection (2,028 specimens; 35.4%), followed by geese (1,825 specimens; 32.0%), cormorants (950 specimens; 16.6%), shorebirds (225 specimens; 3.9%), and murres (173 specimens; 3%).

There can be little doubt that these bird materials owe their presence in the mound to the activities of human foragers. Not only is the mound clearly of anthropic origin (Uhle 1907, Schenck 1926, Broughton 1999), but stone-tool cut-marks and evidence of burning are present on many of the Emeryville bird specimens. Indeed, it is hard to imagine any nonhuman mechanism that could accumulate bird remains at this scale in this kind of context. Thus, many of the natural processes that plague human paleoecological analyses in other contexts, such as caves and rock shelters, are simply not involved here.

The site also appears to provide evidence of human foraging activities throughout the annual cycle. Spring and summer occupation is clearly indicated by the abundance of fetal and newborn mule deer and elk (Broughton 1999), as well as cormorant chicks, nestlings, and juveniles (Table 3). Fall and winter occupation is indicated by the abundance of strictly winter-visitant avian taxa, such as all of the represented loons, grebes, and scolopacid shorebirds and the great majority of anatids (Grinnell and Wythe 1927, Small 1994). Importantly, those seasonally diagnostic specimens are well represented in all of the Emeryville strata (Table 2), which suggests that any trends present in bird use over time are not related to changes in seasonal occupation of the mound.

In sum, the provenienced Emeryville avifauna represents a large, taxonomically diverse, well-stratified and well-dated sequence of human bird-exploitation over a period of nearly 2,000 years in the late Holocene. It thus provides a unique opportunity to investigate long-term human–avian paleoecological relationships, including the possible occurrence of resource depression.

ARCHAEOLOGICAL MEASURES OF AVIAN RESOURCE DEPRESSION

Previous analyses of late Holocene archaeological faunas from California have documented the occurrence of long-term resource depression for a wide variety of large-sized fish and mammal taxa. Quantitative trends in the relative abundances of large-sized or otherwise "profitable" prey resources and demographic indicators of harvest pressure have been the primary measures of prehistoric resource depression. Similar measures are used here to investigate the potential effects of human hunting on avian populations of the San Francisco Bay area.

RELATIVE-ABUNDANCE INDICES

The use of relative-abundance indices to measure resource depression archaeologically is founded on logic from mathematical models of optimal foraging, especially the "prey model" (see Stephens and Krebs 1986 and references therein). That model focuses on how a forager should choose among a range of resources that vary in rate of energy earned for time spent in pursuing and processing (i.e. "handling") them. The model predicts that the most profitable or highest-ranked prey will be taken whenever they are encountered, whereas prey of lower rank may or may not be selected, depending on the abundance of the highest-ranked prey. As encounter rates of higher-ranked prey decrease, prey are added to the diet sequentially in order of decreasing rank (see Stephens and Krebs 1986 and references therein). It follows that the relative frequency of selection of high- and low-ranked prey within a resource patch by prehistoric foragers can provide an index of the encounter rate of high-ranked prey. Hence, decreasing frequencies of high-ranked prey species, as represented in dated archaeological deposits, should be a measure of declines in the encounter rate or density of the species in the surrounding environment over the time the fauna accumulated (Bayham 1979, 1982; Broughton and Grayson 1993; Broughton 1994a, b, 1995, 1999).

Empirical data from experimental and ethnographic settings demonstrate that for animal prey species that are singly handled by human consumers, post-encounter return rates (i.e. prey ranks) are closely scaled to prey body size. In general, the larger the size of the animal, the higher the post-encounter return rate provided to human foragers (Broughton [1999], but see Lindstrom [1996] and Madsen and Schmitt [1998] for interesting exceptions). Smith's

(1991) ethnographic analysis of the Inujjuamiut foragers of the Arctic, which includes the most detailed data set available on the energetics of bird hunting, suggests that such a relationship holds, in general, for bird resources as well. Although hunting methods and environmental context cause return rates for different birds to vary considerably, maximum post-encounter return rates reported for the five species hunted by the Inujjuamiut are correlated with the species' average body mass ($r_s = 0.90$, $P = 0.07$).

Recent research on modern hunter-gatherers further underscores the overriding significance that hunters attach to prey size. In fact, many hunters ignore small game, even when pursuing them would increase their overall caloric returns. Clearly, smaller-sized prey move into and out of the set of targeted prey for human hunters, but large prey are invariably included in it (Broughton and Bayham 2003).

Given that the prey model predicts that the highest-ranked prey types should be attacked whenever they are encountered, large-sized species should be the most susceptible to resource depression. That feature is exacerbated by the fact that large species also tend to exhibit delayed sexual maturity, slower growth rates, longer lifespans, and lower intrinsic rates of increase (e.g. Winterhalder and Lu 1997). As long as assumptions of the prey model are met, and other variables that can affect prey densities (such as climate change) can be ruled out, declining relative abundances of those taxa should signal resource depression.

One of the prey model's critical assumptions involves the spatial distribution of prey types and may be unrealistic in certain archaeological contexts. This fine-grained search assumption stipulates that different prey types are searched for simultaneously and that the chance of encountering any prey type is independent of previous encounters with it or with any other type. In other words, the model assumes that prey types are encountered in a fine-grained manner. That assumption allows search time to be detached from individual prey types and assigned to the set of resources as a whole; it is also required for relative abundances of high-ranked prey to be a valid measure of their abundances in the region surrounding a site locality. If, however, different prey types are spatially clumped across the environment surrounding a site, variation in overall net caloric returns from those clumps or patches should dictate the extent to which they are used; patch-use decisions, not just prey ranks, can thus determine prey choice (Smith 1991).

An obvious strategy for dealing with that constraint is to examine changes in differently ranked prey types within single "patches" or "hunt types." Those are defined as groups of prey taxa that were likely encountered in a fine-grained manner; that is, they are found in the same habitat types and were pursued and captured with similar technologies. Resource depression should still be signaled by declines in the relative abundances of high-ranked prey within each patch. In that approach, the fine-grained search assumption is analytically maintained.

Depression of prey within resource patches directly adjacent to a residential base can also have implications for changes in patch-use strategies in the wider environment surrounding a locality. Researchers investigating effects of prehistoric resource depression on differential time allocation to resource patches have drawn on two separate models: Charnov's (1976) marginal value theorem and Orians and Pearson's (1979) central-place-forager patch-choice model (Broughton 1999, 2002a; Cannon 2000; Nagaoka 2000, 2001). Both predict that, as once high-return patches located closer to home become depleted, more use should be made of distant, less-depleted patches located farther away, if such patches are available.

Considered together, the prey and patch models suggest that depression of high-ranked prey within local resource patches should lead to selection of more-abundant but lower-ranked prey species in those patches, or increased foraging effort devoted to less depleted patches located farther from the central place, or both.

Prey Age Composition

Patterns in the age composition of archaeological prey species are one of the most frequently used means of corroborating evidence of resource depression derived from relative-abundance indices (see review in Broughton 2002a). For many species, resource depression is commonly argued to cause declines in the mean age of individuals in exploited populations. However, the opposite trends should follow for species that are either behaviorally sensitive to predation risk or form high-density breeding colonies that can be accessed by human foragers.

High-density, seasonally based breeding colonies are typical components of the reproductive strategies of colonial waterbirds. Such colonies are often quite sensitive to predation and even to the mere presence of predators. Sustained persecution and disturbance causes survivors to abandon colonies and to form new ones in areas offering higher security—out of reach of human foragers (Boekelheide et al. 1990b, Carney and Sydeman 1999, Gonzalez 1999). Regions that lose breeding colonies forfeit not only the highest-return patches for the species but also the major local source of subadult birds. In such cases, resource depression would cause relative increases in encounter rates with adults and an increase in mean age of exploited individuals (Broughton 2002a).

Paleoclimatic Variables

The models outlined above focus on human-induced declines in prey densities and the archaeological measures of those declines. Other factors can, of course, cause changes in the natural abundances of bird species. In particular, abiotic or climatic factors can, through their effects on habitat structure, ultimately reduce the natural abundance and, hence, encounter rates of avian taxa. As a result, paleoenvironmental records are required for monitoring potential climate-based effects on encounter rates of specific birds and foraging dynamics.

Summary

Avian resource depression should be indicated by (1) decreasing abundances of large-sized species among sets of prey types that inhabit the same local resource patches or (2) steadily increasing abundances of taxa that occur in lower-return patches or those that are located at distances far from the site locality or (3) both. Additionally, increasing harvest rates that cause abandonment of local breeding colonies should be reflected by decreases in the proportional representation of chicks and juvenile birds in archaeological samples. A background record of environmental change is critical for assessing the potential effects of climatically driven environmental change on prey encounter rates and resource selection.

Anthropogenic Depressions and the Emeryville Avifaunal Sequence

As noted above, the Emeryville avifauna is overwhelmingly dominated by waterbirds: anatids, cormorants, and shorebirds. Collectively, they represent 88% of the total number of identified specimens, so I focus on them in the following analysis. I also restrict this analysis to the bird materials derived from the Uhle and Schenck excavations, because of the substantially larger samples of specimens recovered from them. Bird samples from the Nelson excavation are quite small (total $n = 233$), with most individual strata represented by <10 identified specimens. Finally, I note that both Uhle and Schenck collected separate faunal samples from the lower four strata of the mound. Although they were taken from different horizontal locations in the mound, previous analyses have shown that the faunal composition of the duplicated strata samples are amazingly similar (Broughton 1999, 2002a). Accordingly, I conjoin the separate samples collected from the same strata into single analytic units in the analyses that follow.

Waterfowl

The anatid resource base.—Fifteen waterfowl species were identified in the Emeryville avifauna—11 ducks and 4 geese. The Emeryville waterfowl hunters would have found ducks and geese in or around the bay itself or, in the case of geese, on local grassland or upland settings. Of the anatid species identified in the Emeryville sample, virtually all are primarily winter visitors to the San Francisco Bay region; they migrate to northern latitudes or the interior of the continent during spring to breed and return to the San Francisco Bay area in fall to overwinter. However, smaller numbers of nonbreeders of several species remain in the region throughout the summer. Only two species identified in the Emeryville collection, Mallard (*Anas platyrhynchos*) and Ruddy Duck (*Oxyura jamaicensis*), are consistent local breeders (Grinnell and Wythe 1927, Grinnell and Miller 1944, Small 1994).

The historically recorded seasonal occurrence pattern for the anatids is consistent with the age composition reflected in the Emeryville goose and duck remains (Table 3). With extremely rare exceptions, anatid materials at Emeryville represent either adults or younger birds that match the size and development of individuals entering their first fall. Only 10 of the 3,853 anatid specimens (0.02%) represent chicks; 9 of those could be identified only as large anatinines, and could thus represent the resident Mallards. The only other chick specimen is from an unidentified anserine.

Duck and goose resources around the Emeryville locality may have presented two broadly distinct resource patches or "hunt types" to the site's occupants. That is because ducks and geese tend to concentrate in distinct habitat types that exist in the San Francisco Bay area and occupy those patches in different densities.

On their wintering sites, the represented geese are primarily terrestrial vegetarians. Although they will roost on open water or within wetlands, foraging activities are clearly concentrated in terrestrial contexts, such as marshlands or grasslands. Diets are variable across the different species but include a variety of above- and below-ground plant parts, such as roots, bulbs, and stems of marsh plants; as well as grasses, seeds, and many other nonwoody plant materials (Bellrose 1980, Ely and Dzubin 1994, Ryder and Alisauskas 1995). The Brant (*B. bernicla*)—not identified in the Emeryville fauna but possibly represented in the "small anserine" category—is unique among the California geese with respect to preferred foraging sites. It feeds mainly on aquatic vegetation, especially eelgrass (*Zostera marina*), in the intertidal zones of bays and estuaries (Reed et al. 1998).

Wintering geese in California are also highly gregarious and can occur in extremely high densities in favored foraging pastures; impressive flocks containing >50,000 individuals have been reported (Grinnell et al. 1918). Historically, the eastern margin of San Francisco Bay was surrounded first by an extensive marshland and then by a large belt of grassland. Spectacular densities of geese were reported in the area by early explorers, into the mid-19th century (Thomes 1892, Grinnell et al. 1918, Beechey 1941). It might seem that migratory species would be less susceptible to depression than resident taxa, given that they experience a seasonal reprieve from harvest pressure, but geese exhibit a high degree of faithfulness (site fidelity) to their wintering sites (Robertson and Cooke 1999, Lindberg et al. [unpubl. data]). Moreover, birds occupying particular wintering areas may be derived from a limited number of demographically independent subpopulations (see Elser 2000). That reduces the degree to which birds killed at a wintering site would be replaced by conspecifics. With low rates of winter-site recolonization, heavy predation on wintering birds could result in depression of subpopulations that use those particular sites. Indeed, the intensive fall- and winter-focused market hunting of geese in the late 19th and early 20th centuries appears to have caused substantial declines in all the geese subpopulations that winter in California (Grinnell et al. 1918, but see Banks and Springer 1994).

Although some ducks will graze in terrestrial settings some distance from water (e.g. *Anas americana*), most focus their foraging effort on aquatic settings (Bellrose 1980). In fact, the Emeryville duck fauna is dominated by scoters (*Melanitta* sp.), taxa that are rarely found away from salt water, except when approaching nest sites (Grinnell et al. 1918, Brown and Fredrickson 1997). Although there is clearly some overlap in the local distributions of ducks and geese—most notably along the marshland margins of the bay—duck hunting would have been more restricted to the open water of the estuary itself, whereas grasslands would have provided the best opportunities for harvesting geese.

There is considerable variation in body size among the anatid species represented at Emeryville (Table 6). The geese are, in general,

TABLE 6. Average weights of anatid species identified from the Emeryville Shellmound.[a]

Taxon	Weight (g)
Chen caerulescens	2,400
C. rossii	1,250
Branta hutchinsii cf. *minima*	1,600
B. canadensis cf. *parvipes*	2,750
B. c. cf. *moffitti*	4,500
Anas crecca	350
A. platyrhynchos	1,100
A. clypeata	610
Aythya valisneria	1,220
A. marila	1,050
A. affinis	830
Melanitta perspicillata	950
M. fusca	1,670
Bucephala albeola	380
B. clangula–islandica	850
Mergus serrator	1,060
Oxyura jamaicensis	560

[a] Data from Sibley (2002).

much larger than the ducks, with the largest forms (*B. canadensis* cf. *moffitti*) reaching weights of up to ~4,500 g. The average size of the largest duck species represented, *M. fusca*, is 1,670 g. The smallest duck species, the teals (e.g. *Anas crecca*), attain weights of only ~350 g.

The correlation between prey body size and post-encounter return rates is, however, imperfect, and may not hold among species that vary substantially in handling costs. Ethnographic and ethnohistorical accounts indicate that aboriginal foragers of the San Francisco Bay area used similar methods to hunt both ducks and geese, including spears, bow and arrow, snares, nooses, and nets. The latter were set across tidal sloughs or marshes in association with stuffed-skin decoys and facilitated by the use of small boats or rafts fashioned from bulrush stems (Beechey 1941, Johnson 1978, Levy 1978). There is thus no *a priori* reason to expect that anatid resources would not follow the general positive relationship between body mass and post-encounter return rates; the limited empirical data available, as mentioned, support that conclusion (Smith 1991).

Temporal trends in the goose fauna.—All the considerations just discussed suggest that high-density goose patches directly adjacent to the site in terrestrial settings would have provided higher returns for human consumers than duck patches located out on the bay. If local wintering populations of geese were depressed through intensive harvesting, however, increasing use should then have been made of previously underused and initially lower-return duck patches. It could also be argued that even though there is spatial clustering of geese and ducks within San Francisco Bay-area habitats, continual monitoring of those settings by multiple human foragers may have produced more-or-less random encounters with the different local species, thus approximating a fine-grained encounter pattern. If that were the case, it would be appropriate to consider the collective set of anatid resources in the general vicinity of Emeryville as a single hunt type or superpatch. In either case, the predicted effect of waterfowl resource depression is the same: abundances of geese should steadily decline over time, compared with those of ducks. Further tests could involve patterns in the relative abundance of large species of geese as compared with those of smaller ones and, within the duck fauna, variation in the abundances of species derived from habitats more distant from the site locality.

The relative abundances of geese and ducks vary substantially across the Emeryville strata (Fig. 10 and Table 7). Whereas the goose index appears to increase slightly across the lower four strata (i.e. 10 through 7), it declines dramatically after that. Thus, geese appear to dominate the older, deeper strata of the mound, in general; whereas duck bones dominate the more recent layers near the surface. Those differences are fairly substantial, with geese representing ≤80% of the anatid fauna in earlier strata but only 16% of the waterfowl materials in the uppermost stratum. That pattern is derived from large samples of identified specimens, but there is, nonetheless, variation in the numbers of anatid bones represented per stratum. In particular, the range is from a total of 989 for stratum 2 to

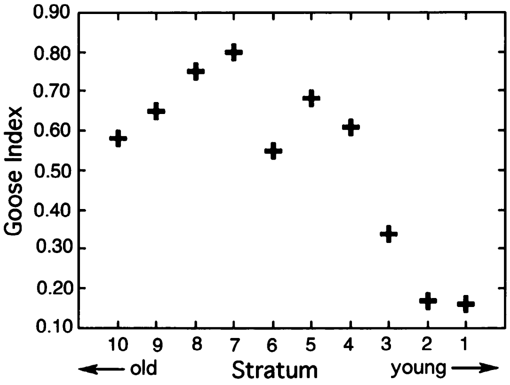

FIG. 10. Distribution of the goose index (∑NISP anserines/∑NISP anatids) by stratum at the Emeryville Shellmound.

TABLE 7. Numbers of identified specimens (NISP) of anserines and anatinines by major stratum from the Emeryville Shellmound.

Stratum	NISP anserine	NISP anatinine
1	25	134
2	171	818
3	131	256
4	107	69
5	66	31
6	32	26
7	208	53
8	495	164
9	240	125
10	296	214

58 for stratum 6. Clearly, variation in stratum sample sizes needs to be taken into account in assessing whether or not apparent trends in the data are statistically significant (Cannon 2001); Cochran's test of linear trends is a statistical method that does just that (see Zar 1996).

Cochran's test is a chi-square-based method that evaluates trends in relative abundances of samples while directly controlling for variation in sample sizes. The test is analogous to a form of regression analysis in which relative abundance values are weighted according to their associated sample sizes (Zar 1996). A Cochran's test comparing the numbers of identified geese and ducks across the Emeryville strata reveals a highly significant linear decline in the abundance of geese ($\chi^2_{\text{trend}} = 620.61$, df = 1, $P < 0.0001$). That pattern is consistent with an anthropogenically induced depression of wintering goose populations near the Emeryville locality.

A second, independent test of anatid resource depression involves patterns in the relative abundances within the anserine fauna itself. In particular, if goose densities and overall return rates from goose patches were declining, hunters should have become increasingly less selective about the types of geese to pursue upon encounter within those patches. Again, using body mass as a rough index of the post-encounter return rates for different anserine taxa, the prediction is that the abundances of large goose species should decline over time, as compared with those of small ones.

The smallest geese represented in the Emeryville fauna are *C. rossii* and *B. hutchinsii* cf. *minima* (Table 6). There is also a considerable number of specimens that could be identified only as "small anserines"; those bones match *C. rossii, B. hutchinsii minima,* and *B. bernicla* in size, but could not be securely assigned to any one of those species. For this analysis, I consider the aforementioned specimens as "small geese" and all other anserine materials as "large geese." The latter category includes *C. caerulescens, B. canadensis* cf. *parvipes, B. c. moffitti,* and the indeterminate medium-sized anserine material.

Although a smooth temporal trend in the relative abundance of large and small geese is not apparent, there is, nonetheless, substantial variation in the proportional representation of those taxa across the Emeryville strata (Fig. 11 and Table 8). Large geese represent a large majority (e.g. >72%) of anserine materials in the lower strata of the mound, but they represent only 44% of the identified geese in the most recent stratum. A Cochran's test of linear trends confirms that impression, showing that a significant linear decline through time occurs in the abundance of large geese as compared with that of small geese ($\chi^2_{\text{trend}} = 12.32$, df = 1, $P < 0.0001$). So, not only was steadily increasing use made of the lower-return ducks across the occupational history of the site, but goose-hunting itself appears to have increasingly concentrated on smaller, lower-return species.

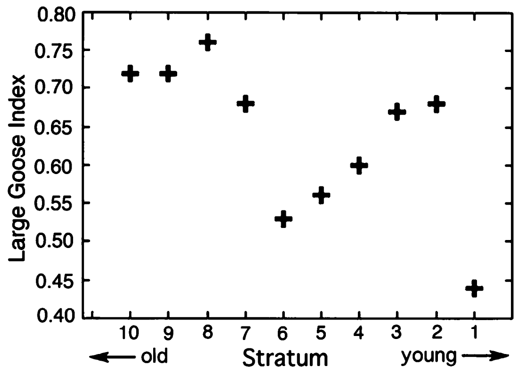

FIG. 11. Distribution of the large-goose index (∑NISP large and medium anserines/ ∑NISP anserines) by stratum at the Emeryville Shellmound. "Large and medium anserine" refers here to specimens identified as either the large or medium subspecies of *Branta canadensis* (i.e. *B. c. moffitti, B. c. parvipes*) and *Chen caerulescens,* as well as to materials identified only to the category of medium anserines. The latter may include *B. c. parvipes, C. caerulescens,* and *Anser albifrons.*

TABLE 8. Numbers of identified specimens (NISP) of large geese and small geese by major stratum from the Emeryville Shellmound.

Stratum	NISP large geese	NISP small geese
1	11	14
2	116	55
3	88	43
4	64	43
5	37	29
6	17	15
7	141	67
8	377	118
9	172	68
10	212	84

Temporal trends in the duck fauna.—Patterns within the duck fauna may provide further evidence of human impacts on local anatid resources. Insofar as the initial focus of anatid hunting was on higher-return geese in terrestrial or marshland settings, but over-harvesting of those taxa ultimately drove an increasing use of smaller ducks located within the estuary, there should be predictable patterns of change among the species of ducks exploited. In particular, duck species more strictly obligate to salt-water contexts, that rarely approach the shore or bay-side marshes, should increase in abundance over time. In other words, remains from duck species that more commonly occur adjacent to terrestrial contexts in freshwater ponds and marshes should be proportionally more abundant earlier in the Emeryville sequence than later.

The most straightforward way to capture that dichotomy taxonomically is at the level of the tribe. Both the surface-feeding ducks (tribe Anatini) and pochards (tribe Aythini) are commonly associated with freshwater contexts and marshes, settings that are found along the margins of the San Francisco Estuary—close to Emeryville. Although several pochard ducks will also use saltwater bays, sea ducks (tribe Mergini) occur almost exclusively in marine or brackish contexts outside of the breeding season. Sea ducks are well-represented in the Emeryville fauna, most notably by scoters (*M. fusca* and *M. perspicillata*), which represent 95% of identified merginines. In the San Francisco Bay area, scoters are found strictly on the open water of the bay and the outer coast (Grinnell et al. 1918, Grinnell and Wythe 1927). It follows that the relative abundance of merginines as compared with all other represented ducks should provide an index of the relative use of more-distant duck patches.

At face value, the relative abundance of merginine ducks appears to decline gradually across the lower seven Emeryville strata, but then ascend to consistently high values (>0.85) from strata 3 through 1 (Fig. 12 and Table 9). However, the middle strata of the mound (strata 7, 6, 5, and 4) are represented by very small samples of duck specimens identified to the genus level. Strata 6 through 4, for instance, are each represented by <10 such specimens. By contrast, each of the lower strata (i.e. 8–10) are represented by >30 specimens; whereas stratum 2 and 3 provided 249 and 138 genus-level duck identifications, respectively. When that variation in strata sample sizes is taken directly into account, a significant linear increase through time in sea ducks is indicated ($\chi^2_{\text{trend}} = 54.54$, df = 1, $P < 0.0001$).

Summary of waterfowl temporal trends.—Several independent tests suggest that high-return waterfowl resources, particularly geese, declined in abundance over the period that Emeryville was occupied. The overall abundance of geese declined significantly as compared with that of ducks, and indications of declining hunting returns were also evident within both the goose and duck faunas. Large geese declined significantly as compared with smaller geese; among the ducks, increasing use was made of species that occupied habitats more distant to the site locality. Although those changes are fully consistent with anthropogenic depressions, they would also follow from any factor that may have caused a general decline in wintering populations of geese in the San

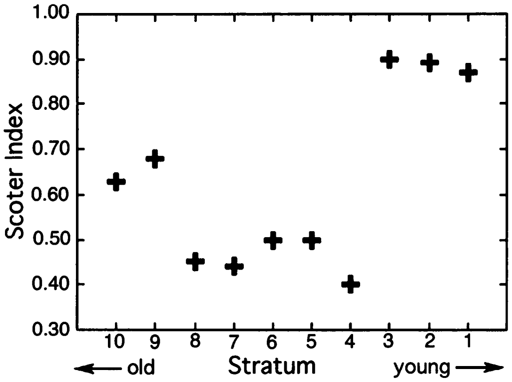

FIG. 12. Distribution of the scoter index (∑NISP merginines/∑NISP anatinines) by stratum at the Emeryville Shellmound.

TABLE 9. Numbers of identified specimens (NISP) of merginines and other ducks by major stratum from the Emeryville Shellmound.

Stratum	NISP merginine ducks	NISP other ducks
1	39	6
2	221	28
3	124	14
4	10	15
5	3	3
6	3	3
7	4	5
8	19	23
9	23	11
10	31	18

Francisco Bay area. Those include climate changes that would have affected breeding success or food availability on wintering sites, or possibly hunting pressure on either breeding grounds or migration stopover sites.

Paleoenvironmental change and the San Francisco Bay waterfowl.—The great majority of geese that winter in California originate on Arctic breeding sites, and the effects of long-term climate change on them have received recent attention, owing to growing concern over global warming (Boyd 1987, Boyd and Madsen 1997, Zockler and Lysenko 2000). That work has produced valuable summaries of how climatic and environmental variability in the recent past (since 1950) has affected populations of Arctic-breeding geese. Although there is clearly a complex matrix of factors that affect goose populations, two factors stand out as especially influential: nesting-season temperature and the extent of tundra breeding habitat.

Several studies have shown strong positive correlations between nesting season (May–June) temperatures, snow depth, and breeding success in Arctic-nesting geese, including all the species represented in the Emeryville fauna. Temperature during the nesting period apparently serves as an integrator of factors that affect the ability of geese to nest at all and the ultimate size of their clutches. Most important among those factors is initiation and growth rate of critical plant forage; plant foods emerge sooner and grow faster in warmer springs (Boyd 1987, Kostin and Mooj 1995, Skinner et al. 1998, Zockler and Lysenko 2000, Alisuaskas 2002).

The other critical variable affecting breeding success in Arctic-nesting geese is the presence of suitable breeding habitat. For most populations, coastal or upland tundra is the preferred breeding habitat (Johnsgard 1975, Bellrose 1980, Ely and Dzubin 1994, Ryder and Alisauskas 1995, Reed et al. 1998, Mowbray et al. 2002). Steady declines in tundra habitat could, thus, negatively influence breeding success and population sizes of North American geese in general (Boyd and Madsen 1997, Zockler and Lysenko 2000). Over long time-spans, the extent of tundra habitat in the North American Arctic appears to be linked negatively to variation in temperature. In fact, projected trends in global warning entail dramatic northward expansions of boreal forests at the expense of tundra in the region (Ritchie et al. 1983, MacDonald et al. 1993, Scott et al. 1997).

So, whereas spring temperature increases appear to have positive effects on breeding success and population sizes of North American geese, substantial long-term increases in temperature may reduce the extent of breeding habitat and ultimately cause population declines. Rising sea-level is also a consequence of global temperature increases; geese that breed or stage in coastal settings would thus be affected by such changes, but the ultimate effects are difficult to judge (Boyd and Madsen 1997). In sum, the data suggest that if paleoclimatic variables are responsible for the apparent late Holocene declines in densities of geese wintering around San Francisco Bay, then there should be evidence of significant linear changes in temperature or reductions in the extent of tundra habitat—or both—in the Arctic from 2,600 to 700 years BP.

Although a variety of late Holocene climatic and vegetative records exist for the Arctic and adjacent areas of northern North America, a rigorous quantitative comparison between them and the Emeryville avifaunal record is not possible. That is because there is no secure way to chronologically align the avifaunal indices derived from the 10 Emeryville strata to climatic data sets derived from distant geological contexts. However, it is possible to assess the presence or absence of significant linear changes in the latter data sets over the period that Emeryville was occupied. Such assessments do not support a paleoclimatic or environmental explanation for a general late Holocene goose population decline. Temperatures during the late Holocene—and, more specifically, between 2,600 and 700 years BP—appear to have been cool in general, with no consistent evidence for linear changes over that interval (Gajewski 1995, O'Brien et al. 1995, Hu et al. 1998, Sawada et al. 1999, Bourgeois et al. 2000, LaCourse and Gajewski 2000, Stuiver and Grootes 2000, Anderson et al. 2001, Lavoie and Arseneault 2001, Smith 2002). Many Holocene Arctic paleorecords show that modern vegetation communities—and, most notably, tundra–boreal forest interfaces—were established by mid-Holocene times (6,000–4,000 years BP; Anderson and Brubaker 1994, Edwards and Barker 1994, Richard 1994, Pellatt and Mathewes 1997). Other records suggest that mid-Holocene temperatures were higher than modern ones and that substantial increases in tree cover and northern extensions of forests occurred at that time, but subsequent cooling to near-modern conditions reversed those trends, in most places by 3,000 years BP (MacDonald et al. 1993, Scott et al. 1997). In sum, nothing in the Arctic paleoenvironmental database suggests continually deteriorating conditions for nesting geese between 2,600 and 700 years BP.

Decreasing food availability in San Francisco Bay-area wintering sites could account for declining local goose abundances as well. In that context, long-term changes in precipitation would seem to be the most important climatic variable affecting the abundance and quality of goose forage in California wintering areas. Although diets of the various California geese differ, the most important kinds of forage are underground parts of marsh plants and various seeds and grasses that occur in wetland or grassland habitats. Both the regional extent of wetland areas and the annual productivity of grasslands should correlate positively with precipitation (Murphy 1970). Moreover, along the margins of the San Francisco estuary, brackish or freshwater marshes are converted to salt marshes with increasing bay salinities, a variable driven largely by declines in regional precipitation and, hence, reduced inflow of fresh water into the bay from the Sacramento–San Joaquin river system.

Several recent analyses of late Holocene salinity changes and regional precipitation regimes have been conducted for the San Francisco Bay. The most detailed and chronologically secure record is based on analyses of diatom, pollen, and carbon-isotopic composition of a 3.5-m sediment core taken from a brackish marsh in the northern part of the San Francisco Estuary (Byrne et al. 2001). That core records substantial fluctuations in estuarine salinity, freshwater inflow, and regional precipitation over the period that Emeryville was occupied. That record is also consistent with other climatic records for the region, including other salinity records from coastal California (Davis 1992), as well as fluctuations of Sierran and Great Basin closed-basin lakes (e.g. Benson et al. 2002). Most notably, no linear shift in salinity or precipitation is indicated across the time that Emeryville was occupied.

Finally, use of fire by California Indians, well documented in ethnographic accounts, may also have affected local terrestrial habitats used by wintering geese. Although detailed records of change in anthropogenic fire regimes are not yet available for the Bay area, routine wildfires would likely have been favorable to geese, insofar as they prevent the encroachment of woody scrub into grassland communities (see Williams 2002 and references therein).

Human predation on breeding grounds.—Because the geese that winter around San Francisco Bay migrate north to breed, human predation on their breeding grounds or migration staging areas may have played a role in their declining abundances as registered in the Emeryville fauna. In spring through early fall, waterfowl hunting played an important role in the subsistence economies of native Arctic peoples, and substantial numbers of eggs, juveniles, and adult birds were taken annually in historical times—and, almost surely, in prehistoric times as well. Indeed, the exploitation of geese during their midsummer flightless molts yields exceptionally high return rates (Smith 1991), and drives of flightless geese were practiced by a variety of Arctic cultures (Hanson et al. 1956, Klein 1966, Raveling 1984, Smith 1991, Shaw 1998). Unfortunately, it is difficult to directly assess the relative effects that Arctic hunting may have had on populations of geese wintering in California, because no substantial archaeological anatid sequences from those areas are known. However, several factors suggest that temporal patterns in the Emeryville anatid fauna more likely resulted from local winter hunting activities.

First, studies of the migratory behavior in geese have shown that birds are generally faithful to their wintering sites and return year after year to the same locations (Raveling 1979, Hestbeck et al. 1991, Ely and Dzubin 1994, Reed et al. 1998, Robertson and Cooke 1999). The birds that use a given wintering site, however, include individuals derived from many different nesting locations, and birds from the same breeding population migrate to many different wintering sites (Reed et al. 1998, Lindberg et al. unpubl. data). This suggests that the anserine fauna wintering around the eastern shore of San Francisco Bay would represent only a discrete subset of the larger populations of the five species involved and cannot be viewed as a single, amorphous population that would be replenished annually by an infinitely large external pool. Indeed, given such a population structure, the depression of geese at specific wintering sites need only involve relatively small subpopulations of the represented taxa.

However, because geese that use any particular wintering site may be derived from a vast number of geographically dispersed breeding populations, far more intensive and geographically widespread breeding-ground mortality would be required to affect their densities. Snow geese wintering around San Francisco Bay, for example, may be derived from nesting sites scattered over vast stretches of the Arctic, from Wrangel Island in Siberia to the eastern shores of Hudson Bay. Intensive hunting—even complete extirpation—on selected breeding sites near larger human habitations might have little or no effect on subpopulations that winter around San Francisco Bay. Those factors notwithstanding, detailed work with Arctic archaeological anatid faunas will be required to more fully evaluate the effects of prehistoric hunting on waterfowl populations at the other end of the system.

Summary.—Trends in the rich Emeryville anatid fauna provide evidence for substantial anthropogenic depressions. The relative abundance of geese declined as compared with that of ducks; large geese declined over time, compared with smaller geese; and significant increases over time were found in use of the more distant sea-duck resources. Those patterns appear to be uncorrelated with environmental changes that may have affected anatid populations, either on their California wintering sites or in the Arctic breeding settings to the north. Although human harvesting on Arctic breeding grounds may have played some role in the declines, it seems more likely that intensive hunting at wintering sites in the San Francisco Bay area was the primary cause.

CORMORANTS

The cormorant resource base.—Next to the ducks and geese, cormorants are the best-represented group of birds in the Emeryville avifauna. A total of 950 specimens could be assigned to at least the genus level, and 335 of those were identified to one of the three local species: Pelagic Cormorant (*Phalacrocorax pelagicus*), Brandt's Cormorant (*P. penicillatus*), or Double-crested Cormorant (*P. auritus*). Taking the cormorant collection as a whole, *P. auritus* is by far the most abundant cormorant species (*n* = 264), comprising 79% of the specimens identified to species. *Phalacrocorax penicillatus* is a distant second, represented by 62 specimens, or ~18% of the cormorant fauna. Only nine specimens of *P. pelagicus* were identified. These rank-order abundances of the three species match those reported in historic times for the San Francisco Bay (Grinnell and Wythe 1927, Bartholomew 1943).

Given that a large proportion of the cormorant specimens (69.4%) represent chicks or subadults (Table 3), it is clear that the focus of cormorant harvesting by the residents of Emeryville was on the breeding colonies. The exploited colonies were most likely located on islands within the San Francisco Bay, such as Alcatraz and Yerba Buena. Several early European explorers reported an abundance of seabirds and waterfowl on those islands, some of which were "white, as if covered with snow, from the deposite [*sic*] upon them of bird-manure" (Bryant 1967). In fact, the Spanish explorer Juan Manual Ayala originally gave the name "Isla de los Alcatraces" to the present-day Yerba Buena Island after his 1775 visit there; *alcatraceo* is Spanish for cormorant. Yerba Buena Island covers 150 acres and is located ~7 km due west of Emeryville; Alcatraz Island is located a bit farther (12 km) from Emeryville and is much smaller, covering only 22 acres (Fig. 1; Boyes 1936, Martini 1990).

Unfortunately, the vast majority of chick and subadult cormorant specimens could not be identified to the species level and so could not be used to determine which of the three cormorants' colonies were harvested. However, using the small sample of young birds that were so identified (*n* = 126), it appears that Double-crested Cormorant colonies, and those of Brandt's to a lesser extent, were exploited. Specifically, 89% of the 126 subadult (juvenile and chick) cormorant specimens that were identified to the species level are Double-crested, 13% are Brandt's, and <1% are Pelagic cormorants—percentages generally similar to those derived from the entire sample of species-level cormorant identifications noted above. The dominance of Double-crested Cormorants, followed by Brandt's, also fits for the San Francisco Bay estuarine context, given the breeding habits and life-history features of the three local species. The limited availability of suitable cliff sites would seem to have precluded formation of substantial colonies of

Pelagic Cormorants within the San Francisco Bay region in prehistoric times (Grinnell and Wythe 1927, Ainley and Boekelheide 1990, Small 1994, Hobson 1997, Wallace and Wallace 1998, Hatch and Weseloh 1999).

To the human foragers that occupied Emeryville, cormorant colonies would have represented fairly discrete patches or hunt types. It is, however, difficult to estimate how profitable the exploitation of such colonies would have been, compared with that of other resource patches. Because adults do not defend their nests or young from large predators, within-patch returns for high-density colonies would likely have been high. But, if the colonies were located on the San Francisco Bay islands, which appears most likely, a 14-km round-trip excursion by boat would have been required to harvest the closest one, at Yerba Buena Island. Still higher travel costs would have been paid to reach the more distant Alcatraz and Angel islands. Insofar as other high-return resource patches were plentiful in habitats directly adjacent to the site, such high travel costs to reach the colonies would likely have made their use prohibitively expensive. At some point, however, declining returns from local patches could have made the overall returns for exploiting distant cormorant colonies a better deal. It is also likely, however, that intensive, long-term exploitation of cormorant colonies would not have been possible, given that they are well known for their sensitivity to disturbance from predators: colonies that have been harassed or vandalized are routinely abandoned (Boekelheide et al. 1990b).

Temporal trends in the cormorant fauna.—The abundance of cormorant specimens, compared with that of all other birds, is displayed in Figure 13 (see Table 10). To begin with, the comparison seems to show a subtly ever-increasing use of cormorants across the mound's lower four strata (10 through 7), or the first 800 years of site occupation—during which the returns from such local resources as waterfowl, sturgeon, and terrestrial mammals were steadily declining. A Cochran's test comparing the relative abundances of cormorants to that of all other birds across strata 10 through 7 confirms that impression ($\chi^2_{\text{trend}} = 39.84$, df = 1, $P < 0.0001$). After the deposition of stratum 7, however, cormorant exploitation appears to decline precipitously. That decline, spanning roughly 1,800 to 700 years BP is, in fact, highly significant ($\chi^2_{\text{trend}} = 585.55$, df = 1, $P < 0.0001$). Cormorants go from representing >40% of the entire avian fauna in stratum 7 to <4% from stratum 3 on up.

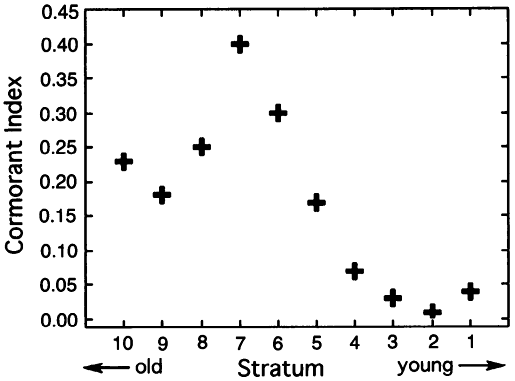

FIG. 13. Distribution of the cormorant index (∑NISP cormorants/∑NISP birds) by stratum at the Emeryville Shellmound.

TABLE 10. Numbers of identified cormorants and all other birds (NISP) by major stratum from the Emeryville Shellmound.

Stratum	NISP cormorants	NISP other birds
1	9	193
2	13	1114
3	13	469
4	17	242
5	26	130
6	36	85
7	224	341
8	291	885
9	103	476
10	195	641

Insofar as that decline reflects an anthropogenically induced loss of local breeding colonies, it should be reflected by patterns in the proportionate representation of adult and juvenile birds, as discussed above. Specifically, if local colonies were progressively abandoned, decline in overall cormorant abundances should be associated with decline in the relative abundances of chicks and juvenile birds. That is, in fact, the pattern revealed in the data. First, a highly significant declining trend occurs in relative abundance of juvenile and chick specimens, compared with adults from stratum 7 through stratum 1 (Fig. 14) ($\chi^2_{\text{trend}} = 91.48$, df = 1, $P < 0.0001$; Table 11). Second, the overall abundance of cormorant bones is

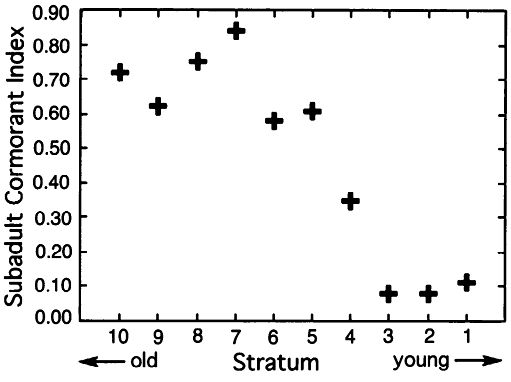

FIG. 14. Distribution of the subadult cormorant Index (∑NISP subadult cormorants/∑NISP cormorants) by stratum at the Emeryville Shellmound.

TABLE 11. Numbers of identified subadult and adult cormorants (NISP) by major stratum from the Emeryville Shellmound.

Stratum	NISP subadults [a]	NISP adults
1	1	8
2	1	12
3	1	12
4	6	11
5	16	10
6	21	15
7	189	35
8	219	72
9	64	39
10	141	54

[a] Includes both chicks and juveniles.

positively correlated with the proportion of juveniles in the collection (cormorant index vs. percentage of juvenile + chick specimens: $r_s = 0.88$, $P < 0.01$). Cormorant hunting appears to have declined with the gradual regional abandonment of their breeding colonies.

Paleoenvironmental change and the San Francisco Bay cormorants.—Although the temporal patterns in the cormorant fauna are fully consistent with anthropogenically induced depressions, they could also be related to long-term environmental changes and their effect on the regional populations of the birds. Although a complex matrix of environmental factors influences the ecology, breeding success, and population dynamics of California cormorants, effects of the El Niño–Southern Oscillation (ENSO) are by far the most well known. When warm ocean waters prevail during ENSO years, fish populations of the rich upwelling system of the California Current are disrupted, which ultimately leads to declines in breeding effort and reproductive success of all three cormorant species (Boekelheide et al. 1990a, b). Substantial, long-term late Holocene changes in the frequency and intensity of ENSOs could thus cause population declines in cormorant populations off the California coast.

Several Holocene records of ENSO variability now exist for the Pacific basin (Sandweiss et al. 2001, Moy et al. 2002, Riedinger et al. 2002). The general picture emerging from that work is that ENSO activity increased dramatically during the late Holocene, especially after ~3,000 years BP. Low ENSO event-frequency during the early and middle Holocene may have resulted from orbitally induced increases in boreal summer insolation and associated wind anomalies (Clemant et al. 2000, Moy et al. 2002).

The highest frequencies of ENSO events during the Holocene also appear to have occurred during the time when Emeryville was occupied (Fig. 15). Moreover, some fluctuations in

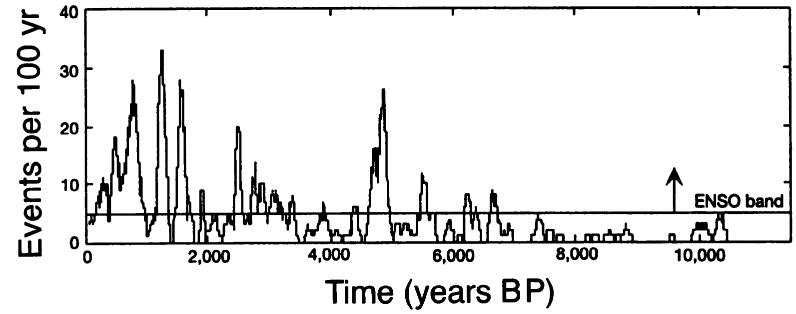

FIG. 15. Holocene variation in the frequency of ENSO events as reconstructed from the sedimentation record of Laguna Pallcacocha, southern Ecuador (from Moy et al. 2002).

the relative abundances of cormorants documented across the Emeryville strata (Fig. 14) seem to correspond with ENSO variability as reflected in fine-scale Ecuadoran sedimentation records. The prominent peak in cormorant abundances registered during the deposition of the middle strata of Emeryville (i.e. stratum 7 = ~2,000 years BP), for instance, occurs during a lull of ENSO activity. In addition, depressed abundances of cormorants at Emeryville both before and after 2,000 years BP are associated with periods of generally heightened ENSO activity. Other aspects of those records are, however, not aligned. Most notably, substantial troughs in ENSO activity—one at ~1,000 years BP and another at ~1,500 years BP—occur over a period during which cormorant numbers steadily decline. In those instances, cormorant abundances fail to respond positively to major periods of low ENSO event-frequency and, hence, favorable environmental conditions.

Further evidence bearing on the possible effect of late Holocene ENSO variability on regional cormorant populations is provided by patterns within the Emeryville cormorant fauna itself, because the different species vary in their sensitivity to ENSO-related environmental changes. Although there is substantial empirical evidence that ENSO negatively affects all three cormorant species, the effects are far more pronounced for both Brandt's and Pelagic cormorants. Those taxa are much more intimately linked to the rich upwelling system of the California Current. Double-crested Cormorants, on the other hand, focus on estuarine fish resources that are far less affected by ENSO (Boekelheide et al. 1990a, b; Hobson 1997; Wallace and Wallace 1998; Hatch and Weseloh 1999). It follows that, if ENSO is the critical factor driving variation in regional cormorant population densities and ultimately patterns in their overall abundances at Emeryville, there should be predictable changes in the stratigraphic distribution of the three species.

Specifically, the dramatic linear decline in cormorant abundances documented from strata 7 through 1, or from roughly 2,000 to 700 years BP, should be accompanied by a decline in relative abundances of the species most sensitive to ENSO: Brandt's and Pelagics. That, however, is not the case. In fact, the abundance of the collective sample of Brandt's and Pelagic cormorants actually increases significantly, compared with that of Double-crested Cormorants, across the entire occupational history of the Emeryville Shellmound ($\chi^2_{\text{trend}} = 8.47$, df = 1, $P < 0.004$; Fig. 16 and Table 12). The Emeryville cormorant fauna consists of a relatively small Brandt's–Pelagic assemblage that does not appear to vary much temporally, against the background of a very large sample of Double-crested Cormorants whose numbers decrease substantially over time. Thus, it is the proximal, estuarine species whose numbers steadily dwindle, not the more marine-oriented species most sensitive to ENSO.

Although changes in estuarine ecology unrelated to ENSO could also have potentially played a role in the decline of Double-crested Cormorants, current San Francisco Bay estuarine paleorecords do not support that suggestion. Fine-scale variations in past estuarine temperature and salinity

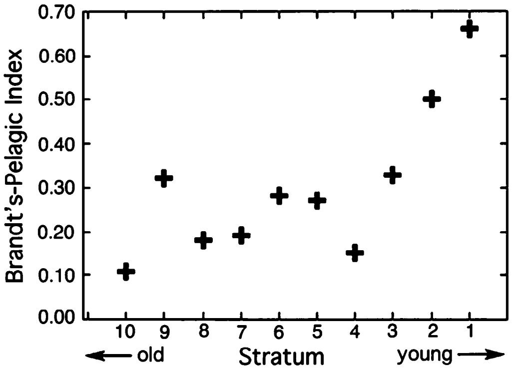

FIG. 16. Distribution of the Brandt's–Pelagic Index (∑NISP Brandt's + Pelagic Cormorants/∑NISP cormorants) by stratum at the Emeryville Shellmound.

TABLE 12. Numbers of identified Pelagic, Brandt's, and Double-crested cormorants (NISP) by major stratum from the Emeryville Shellmound.

Stratum	NISP Brandt's + Pelagic	NISP Double-crested
1	4	2
2	3	3
3	4	8
4	2	11
5	3	8
6	4	10
7	14	61
8	17	75
9	12	26
10	6	53

have now been documented from analyses of diatoms, foraminifers, pollen, and oxygen- and carbon-isotopes (e.g. McGann 1995, 2003; Ingram et al. 1996; Byrne et al. 2001). In general, those data suggest that although oscillations in San Francisco estuarine salinity and temperature occurred during the late Holocene, no major unidirectional shifts in those variables occurred as Double-crested Cormorants were declining at Emeryville.

Summary.—Dramatic changes in the nature of cormorant exploitation occurred over the occupational history of Emeryville. Those changes, driven principally by human harvesting activities, affected the relative dietary importance of cormorants as compared with other avian resources, the age composition of harvested birds, and even the proportional abundance of different cormorant species. Overall, cormorants went from being one of the best-represented groups of birds in the Emeryville fauna, ≤40% of the entire sample of birds from stratum 7, to <4% toward the end of site occupation. Intensive harvesting of Double-crested Cormorant colonies by human foragers apparently caused the abandonment of local breeding colonies: chick and juvenile specimens vanish from the fauna, and the proportional representation of Double-crested Cormorants as compared with Brandt's and Pelagic cormorants declines sharply. Those patterns are not associated with changes in local environments that may have affected cormorant populations, such as ENSO or variation in estuarine salinity and temperature.

SHOREBIRDS

Shorebirds are the third most-abundant group of birds in the collection, represented by nine species and 225 specimens; numerically, they represent 3.9% of the Emeryville avifauna. The shorebird assemblage includes two charadriids (*Pluvialis squatarola* and *Charadrius vociferus*); one recurvirostrid (*Recurvirostra americana*); and six scolopacids, of large (*Numenius phaeopus, N. americanus, Limosa fedoa*), medium (*Catoptrophorus semipalmatus, Limnodromus* sp.) and small (*Calidris alba*) size classes. Undoubtedly, the smaller species are under-represented in the collection, given the small size of their bones and the large mesh-size used to recover the fauna. Still, that bias should be systematic, affecting all the deposits in an identical fashion, so that analysis of change over time in relative abundances should still be possible.

All the represented shorebird species occur in highest densities along the margins of San Francisco Bay, in mud flats, salt marshes, and other shoreline contexts. Collectively, their presence in the San Francisco Bay area is associated with spring and fall migrations to and from their breeding ranges to the north or the interior, though substantial numbers also overwinter in the region (Grinnell and Wythe 1927, Grinnell and Miller 1944, Small 1994, Stenzel et al. 2002). The San Francisco Estuary and associated wetlands is, in fact, of "hemispheric importance" to shorebird populations (Stenzel et al. 2002).

Given similar habitat preferences and seasonal occurrence patterns, the shorebird fauna should represent another discrete local resource-patch or hunt type. Given their size, the large scolopacids, including Whimbrels (*N. phaeopus*), Long-billed Curlews (*N. americanus*), and Marbled Godwits (*L. fedoa*), should represent the highest-ranked taxa within the shorebird patch. Although information on fidelity to winter sites in those taxa is limited, what data there are for them and other Numeniini and Limosini suggest that birds return year after year to the same winter ranges (e.g. Kelly and Cogswell 1979, Colwell et al. 1995, Marks and Redmond 1996, Gratto-Trevor 2000, Elphick and Klima 2002, Marks et al. 2002). That characteristic would increase the likelihood that depression could result from intensive predation at winter sites. Anthropogenic depression within the shorebird patch should thus be signaled by declining abundances of those large-sized scolopacids as compared with all smaller shorebirds.

The relatively small sample of shorebird specimens recovered from Emeryville precludes all but the most coarse-grained analysis of change over time (Table 13). In fact, strata 7, 6, and 5 each contain <10 specimens; drawing any meaningful conclusions about shorebird use within the middle period of site occupation is thus impossible. Fortunately, larger samples exist for many of the deeper, earlier strata as well as many of the layers representing the final centuries of occupation. It is thus possible to broadly compare the relative abundances of large and small shorebirds from the aggregated samples of early (strata 10, 9, and 8) and late (strata 3, 2,

TABLE 13. Numbers of identified large and small shorebirds (NISP) by major stratum from the Emeryville Shellmound.

Stratum	NISP *Numenius* and *Limosa*	NISP all other shorebirds
1	7	3
2	25	37
3	9	14
4	16	1
5	8	0
6	5	0
7	8	1
8	29	8
9	20	4
10	13	10

and 1) strata sets. Such a comparison shows that large scolopacids represent 74% of the shorebird fauna in the early period of site occupation, but drop to 43% in the final years of occupation. That difference is significant ($\chi^2 = 17.14$, df = 1, $P < 0.0001$) and may suggest a decline in the local abundances and capture rates of the largest shorebird species over the occupational history of the Emeryville Shellmound.

GENERAL CONCLUSIONS

The avifauna of the Emeryville Shellmound represents the first substantial, well-documented archaeological bird sequence for the late Holocene of California. Temporal trends in the waterfowl, cormorant, and shorebird faunas are consistent with long-term anthropogenic depressions as regional hunter-gatherer populations expanded over the occupational history of the mound. In the waterfowl assemblage, the largest-sized taxa—geese—declined over time as compared with ducks. In addition, the remains of larger-sized geese declined over time as compared with those of smaller geese; over the same period, ever-increasing use was made of more distantly located anatid resources, namely scoters. As all of that was happening, Double-crested Cormorants were hit hard by human harvesting activities, which caused extirpation of local colonies, change in the relative age and species composition of the regional *Phalacrocorax* fauna, and, ultimately, the virtual abandonment of cormorant hunting all together. Finally, the largest species of shorebirds—Marbled Godwits, Long-billed Curlews, and Whimbrels—declined collectively over time as compared with smaller shorebird species. None of those patterns are correlated with changes in pertinent paleoenvironmental records that might suggest they were caused by climate-based environmental change. Indeed, the effects cross-cut a diverse set of taxa, representing widely disparate life histories, habitat preferences, and ecologies. The patterns are, however, fully consistent with detailed analyses of the fish and mammal materials from Emeryville and other sites in the San Francisco Bay area that suggest those faunas were substantially influenced by prehistoric human foragers of the region. Evidence from the Emeryville bird fauna thus provides another example of a well-documented, geographically widespread, and taxonomically comprehensive trend (Broughton 1994a, b, 1997, 1999, 2002b; Grayson 2001; Hildebrandt and Jones 2002).

It is important to emphasize that the patterns registered in the Emeryville fauna almost surely resulted not only from the residents of that particular locality, but from the many villages that lined the late Holocene shores of San Francisco Bay. The sheer number, size, and volume of the mounds themselves—again, constituted primarily of subsistence debris—is a testament to the substantial numbers of human consumers that lived there. Although no archaeological avifaunas comparable in size and scope to that of Emeryville have yet been recovered for the San Francisco Bay area—or for any other area of California—similar patterns are anticipated for spatiotemporal contexts characterized by large and expanding human populations.

Aside from presenting the first well-documented case of prehistoric resource-depression involving a continental avian fauna, the Emeryville record also shows that even migratory taxa (e.g. geese, large scolopacid shorebirds) were sensitive to intensive winter-site hunting activities. The relative importance of direct hunting mortality, disturbance effects (i.e. relocation), and increased wariness or behavioral depression (see Féret et al. 2003) on those taxa, however, remains unresolved.

For certain types of resources, such as molluscs and most fishes, evidence of depression based on declining relative abundances provides fairly secure evidence of exploitation depression (*sensu* Charnov et al. 1976) or direct harvesting-based mortality, because it is unlikely that such taxa as clams or sturgeon possess the cognitive abilities to perceive an increasing human predation threat and respond by moving to areas more protected from human activities. Many birds and mammals, on the other hand, are well known for their sensitivity to predation risk. The historically recorded variation in tameness of California geese provides a case in point. Recall that during the early historic period, they occurred in astonishingly large flocks that could scarcely be made to take wing. Yet, after many decades of intensive human hunting pressure, they have become extremely wary and now represent a challenge for seasoned hunters with shotguns. Thus, declining relative abundances of geese, and other patterns within the avifauna, may be (at least in part) attributable to behavioral depression.

In many cases, patterns in age structure or size profiles of exploited taxa can be combined with relative-abundance data to help evaluate the relative roles of exploitation versus behavioral depression. Linear declines over time in size and age profiles of harvested sturgeon at Emeryville, for instance, clearly suggest that direct harvest pressure—not increased wariness—caused the depression of that resource (Broughton 1997).

Patterns in age composition of different avian and mammalian taxa, however, do not allow such a conclusion. For instance, trends in age composition of the cormorant fauna documented here clearly show that Double-crested Cormorant colonies were locally extirpated from the region, and the initial abundance of chick remains documents intensive harvesting of nesting sites. But to the losses resulting from direct hunting mortality must be added the many individuals that abandoned local nesting sites as a result of the disturbance. Patterns in age structure, in this case, are thus silent on the relative importance of exploitation versus behavioral depression. Whatever the precise matrix of causes, it remains clear that the activities of human foragers had a fundamental influence on the late Holocene avifauna of San Francisco Bay.

Perhaps most importantly, those ancient patterns have implications for understanding and managing present and future bird populations. First, and most broadly, they challenge conventional wisdom regarding the nature of prehistoric landscape ecology in North America. While concerns over negative population trends of birds in western North America emphasize the pervasive influence of recent anthropogenic disturbances and view human population growth as one of the most critical underlying variables (e.g. Jehl and Johnson 1994, George and Dobkin 2002), most ornithologists do not consider that similar processes may have been occurring for thousands of years. Indeed, early historical records of the distributions, abundances, and other biological characteristics (e.g. genetic variation) of western birds are routinely viewed as an approximation of "pristine" conditions that can thus be used as "baselines" or "controls" with which to compare modern population trends.

Moreover, the notion that the first significant human influence on western wildlife occurred after the arrival of European colonial settlers has deeply conditioned modern views on native peoples, colonial history, and contemporary wilderness-conservation issues (Broughton 2002b, 2004; Preston 2002). Detailed paleorecords such as those at Emeryville, however, are making it increasingly clear that early European explorers had only "traversed an Edenic blip" on the California landscape (Grayson 2001). Although they witnessed an astonishing abundance of wildlife, the region had been characterized by human-induced faunal poverty only decades before and would nearly return to that condition with the wave of human consumers that came with the Gold Rush. This knowledge should be useful to any modern analysis that requires baselines or benchmarks of past bird populations or information on long-term population histories in general. But the fact that the selective milieu on California birds has had a strong anthropogenic element, not just for the past 150 years but for many thousands of years, may also have more specific implications for issues relating to phylogeography and conservation genetics—areas of increasing concern in evolutionary biology.

Studies directed toward understanding contemporary and historical processes involved in shaping geographic patterns in genetic diversity (e.g. Avise 2000, Scribner et al. 2003) are increasingly used in conservation contexts, wherein genetic factors that affect extinction risk are evaluated and management regimes are developed to minimize those risks (Frankham et al. 2002). In any particular analysis, understanding the array of factors that have affected modern patterns of genetic diversity is important for developing specific genetic management plans. Yet, nearly all the research conducted so far in that context has focused exclusively on two general classes of historical factors thought to be significant: late Pleistocene or earlier vicariant events and Euroamerican-based hunting or habitat destruction (e.g. Bouzat et al. 1998, Glenn et al. 1999, Hoelzel et al. 2002, Larson et al. 2002, Scribner et al. 2003). The potential of Holocene human effects is almost never considered but could have important implications for several aspects of such research.

First, many studies that attempt to characterize genetic effects of mid- to late-20th-century population declines use late-19th or early-20th-century museum specimens as "controls," or individuals that represent "pre-bottleneck" populations (e.g. Bouzat et al. 1998, Glenn et al. 1999, Hoelzel et al. 2002). But, insofar as the species in question experienced late Holocene population bottlenecks, the diversity represented in early-20th-century individuals may already have been substantially depressed. That "ghost of genetic diversity past" (Bouzet et al. 1998) may thus make it difficult to detect significant genetic differences between, say, late-19th and late-20th-century populations, even though substantial population declines may have occurred during the intervening years.

Second, if potential Holocene human-induced bottlenecks are not considered, factors responsible for revealed patterns in genetic diversity might be misidentified. Recent genetics-based phylogeographic work with Canada and Cackling geese provides a possible example. Mismatch distributions and Fu's F_s estimates have been used to suggest that populations of Canada and Cackling geese in western North America experienced substantial population expansions in the past and that larger-bodied forms have had smaller effective populations sizes than small-bodied ones (Scribner et al. 2003). In that case, substantial population increases are attributed to terminal Pleistocene glacial retreats (Scribner et al. 2003). Although that interpretation is plausible and may very well be correct, such a genetic signature could also have resulted from a population expansion in the early historic period, following release from intensive native harvesting and disturbance. And insofar as human harvest pressure was always stronger on populations of the larger-bodied geese, as compared with the smaller ones—a pattern suggested by the Emeryville fauna—it would also follow that larger forms should show evidence for smaller evolutionary effective population sizes and, hence, a greater degree of phylogeographic structuring.

Although the distinctive chronological implications of the terminal-Pleistocene and early-historic-period hypotheses for the population expansion of Canada and Cackling geese could perhaps be tested with spatial patterns in modern genetic data, further details could also be gained through temporal patterns of genetic diversity derived from archaeological sequences and bone-derived ancient DNA (e.g. Paxinos et al. 2002, Broughton et al. unpubl. data). In fact, because different breeding populations of geese are genetically distinct (Scribner et al. 2003), analyses of ancient mitochondrial DNA derived from temporally dispersed archaeological bone samples could possibly show when and to what degree different breeding populations suffered negative effects from human hunting activities.

Beyond the documentation of past extinctions and distributions, patterns in archaeological vertebrate data can thus contribute to the resolution of issues that are becoming more and more important to evolutionary biologists. Most significantly, many of those issues have relevance for conservation and management.

Acknowledgments

Sincere thanks to J. Knudsen, L. Freund, and P. Kirch of the Phoebe Hearst Museum of Anthropology for access to the Emeryville avifauna. For access to comparative bird skeletons, I thank S. Rohwer, R. Faucett, and C. Wood of the Burke Museum, and N. Johnson and C. Cicero at the Museum of Vertebrate Zoology. I am grateful to J. Higgins for the bone illustrations. Finally, I thank K. Beck, R. Bogiatto, K. Bovy, D. Byers, D. Causey, T. Jensen, L. Lyman, B. McEneaney, E. Nelson, and J. Faaborg for helpful comments on the manuscript. This research was funded by the National Science Foundation (Grant SBR-9707997).

Literature Cited

Ainley, D. G., and R. J. Boekelheide, Eds. 1990. Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of an Upwelling-system Community. Stanford University Press, Stanford, California.

Alisauskas, R. T. 2002. Arctic climate, spring nutrition, and recruitment in midcontinent Lesser

Snow Geese. Journal of Wildlife Management 66:181–193.

Anderson, L., M. B. Abbott, and B. P. Finney. 2001. Holocene climate inferred from oxygen isotope ratios in lake sediments, central Brooks Range, Alaska. Quaternary Research 55:313–321.

Anderson, P. M., and L. B. Brubaker. 1994. Vegetation history of northcentral Alaska: A mapped summary of late-Quaternary pollen data. Quaternary Science Reviews 13:71–92.

Avise, J. C. 2000. Phylogeography: The History and Formation of Species. Harvard University Press, Cambridge, Massachusetts.

Banks, R. C., C. Cicero, J. L. Dunn, A. W. Kratter, P. C. Rasmussen, J. V. Remsen, Jr., J. D. Rising, and D. F. Stotz. 2004. Forty-fifth supplement to the American Ornithologists' Union *Check-list of North American Birds.* Auk 121:985–995

Banks, R. C., and P. F. Springer. 1994. A century of population trends of waterfowl in western North America. Pages 134–146 *in* A Century of Avifaunal Change in Western North America (J. R. Jehl, Jr. and N. K. Johnson, Eds.). Studies in Avian Biology, no. 15.

Bartholomew, G. A., Jr. 1943. The daily movements of cormorants on San Francisco Bay. Condor 45:3–18.

Baumel, J. J., Ed. 1993. Handbook of avian anatomy: Nomina anatomica avium. Publications of the Nuttall Ornithological Club, no. 23.

Bayham, F. E. 1979. Factors influencing the Archaic pattern of animal utilization. Kiva 44:219–235.

Bayham, F. E. 1982. A diachronic analysis of prehistoric animal exploitation at Ventana Cave. Ph.D. dissertation, Arizona State University, Tempe.

Beechey, F. W. 1941. An Account of a Visit to California in 1826–27. Grabhorn Press, San Francisco, California.

Bellrose, F. C. 1980. Ducks, Geese, and Swans of North America, 3rd ed. Stackpole Books, Harrisburg, Pennsylvania.

Benson, L., M. Kashgarian, R. Rye, S. Lund, F. Paillet, J. Smoot, C. Kester, S. Mensing, D. Meko, and S. Lindstrom. 2002. Holocene multidecadal and multicentennial droughts affecting northern California and Nevada. Quaternary Science Reviews 21:659–682.

Boekelheide, R. J., D. G. Ainley, H. R. Huber, and T. J. Lewis. 1990a. Pelagic Cormorant and Double-crested Cormorant. Pages 195–217 *in* Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of an Upwelling-system Community (D. G. Ainley and R. J. Boekelheide, Eds.). Stanford University Press, Stanford, California.

Boekelheide, R. J., D. G. Ainley, S. H. Morell, and T. J. Lewis. 1990b. Brandt's Cormorant. Pages 163–194 *in* Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of an Upwelling-system Community (D. G. Ainley and R. J. Boekelheide, Eds.). Stanford University Press, Stanford, California.

Bosqui, E. 1904. Memoirs. San Francisco. Privately printed.

Bourgeois, J. C., R. M. Koerner, K. Gajewski, and D. A. Fisher. 2000. A Holocene ice-core pollen record from Ellesmere Island, Nunavut, Canada. Quaternary Research 54:275–283.

Bouzat, J. L., H. A. Lewin, and K. N. Paige. 1998. The ghost of genetic diversity past: Historical DNA analysis of the Greater Prairie Chicken. American Naturalist 152:1–6.

Boyd, H. 1987. Do June temperatures affect the breeding success of Dark-bellied Brent Geese? Bird Study 34:155–159.

Boyd, H., and J. Madsen. 1997. Impacts of global change on Arctic-breeding bird populations and migration. Pages 201–220 *in* Global Change and Arctic Terrestrial Ecosytems (W. Oechel, T. Callaghan, T. Gilmanov, J. Holten, B. Maxwell, U. Molau, and B. Sveinbjörnsson, Eds.). Springer-Verlag, New York.

Boyes, M. E. 1936. The Legend of Yerba Buena Island. Professional Press, Berkeley, California.

Broughton, J. M. 1994a. Late Holocene resource intensification in the Sacramento Valley, California: The vertebrate evidence. Journal of Archaeological Science 21:501–514.

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

Broughton, J. M. 1995. Resource depression and intensification during the late Holocene, San Francisco Bay: Evidence from the Emeryville Shellmound vertebrate fauna. Ph.D. dissertation, University of Washington, Seattle.

Broughton, J. M., Ed. 1996. Excavation of the Emeryville Shellmound, 1906: Nels C. Nelson's final report. Contributions of the University of California Archaeological Research Facility, no. 54.

Broughton, J. M. 1997. Widening diet breadth, declining foraging efficiency, and prehistoric harvest pressure: Ichthyofaunal evidence from the Emeryville Shellmound, California. Antiquity 71:845–862.

Broughton, J. M. 1999. Resource Depression and Intensification During the Late Holocene, San Francisco Bay: Evidence from the Emeryville Shellmound Vertebrate Fauna. University of California Press, Berkeley.

Broughton, J. M. 2002a. Prey spatial structure and behavior affect archaeological tests of optimal foraging models: Examples from the

Emeryville Shellmound vertebrate fauna. World Archaeology 34:60–83.

BROUGHTON, J. M. 2002b. Pre-Columbian human impact on California vertebrates: Evidence from old bones and implications for wilderness policy. Pages 44–71 *in* Wilderness and Political Ecology: Aboriginal Influences and the Original State of Nature (C. Kay and R. Simmons, Eds.). University of Utah Press, Salt Lake City.

BROUGHTON, J. M. 2004. Pristine benchmarks and indigenous conservation? Implications from California zooarchaeology. Pages 6–18 *in* The Future From the Past: Archaeozoology in Wildlife Conservation and Heritage Management (R. Lauwerier and I. Plug, Eds.). Oxbow Books, Oxford, United Kingdom.

BROUGHTON, J. M., AND F. E. BAYHAM. 2003. Showing-off, foraging models, and the ascendance of large-game hunting in the California Middle Archaic. American Antiquity 68:783–789.

BROUGHTON, J. M., AND D. K. GRAYSON. 1993. Diet breadth, adaptive change, and the White Mountains faunas. Journal of Archaeological Science 20:331–336.

BROWN, P. W., AND L. FREDRICKSON. 1997. White-winged Scoter (*Melanitta fusca*). *In* The Birds of North America, no. 274 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

BRYANT, E. 1967. What I Saw in California; Being the Journal of a Tour by the Emigrant Route and South Pass of the Rocky Mountains, across the Continent of North America, the Great Desert Basin, and through California, in the Years 1846, 1847. Ross and Haines, Minneapois, Minnesota.

BYRNE, R., B. L. INGRAM, S. STARRATT, AND F. MALAMUD-ROAM. 2001. Carbon-isotope, diatom, and pollen, evidence for late Holocene salinity change in a brackish marsh in the San Francisco estuary. Quaternary Research 55:66–76.

CAMP, C. L. 1923. The chronicles of George C. Yount, California pioneer of 1826. California Historical Society Quarterly 2:3–66.

CAMPBELL, K. E., JR. 1980. The contributions of Hildegarde Howard. Pages xi-xv *in* Papers in Avian Paleontology Honoring Hildegarde Howard (K. E. Campbell, Jr., Ed.). Contributions in Science, Natural History Museum of Los Angeles County, no. 330.

CANNON, M. D. 2000. Large mammal relative abundance in Pithouse and Pueblo period archaeofaunas from southwestern New Mexico: Resource depression among the Mimbres-Mogollon? Journal of Anthropological Archaeology 19:317–347.

CANNON, M. D. 2001. Archaeofaunal relative abundance, sample size, and statistical methods. Journal of Archaeological Science 28:185–195.

CARNEY, K. M., AND W. J. SYDEMAN. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22:68–79.

CHARNOV, E. L. 1976. Optimal foraging: The marginal value theorem. Theoretical Population Biology 9:129–136.

CHARNOV, E. L., G. H. ORIANS, AND K. HYATT. 1976. Ecological implications of resource depression. American Naturalist 110:247–259.

CLEMANT, A. C., R. SEAGER, AND M. A. CANE. 2000. Supression of El Niño during the mid-Holocene by changes in the Earth's orbit. Paleooceanography 15:731–737.

COLWELL, M., R. GERSTENBERG, O. WILLIAMS, AND M. DODD. 1995. Four Marbled Godwits exceed the North American longevity record for scolopacids. Journal of Field Ornithology 66:181–183.

DAVIS, O. K. 1992. Rapid climate change in coastal southern California inferred from pollen analysis of San Joaquin marsh. Quaternary Research 37:315–320.

EDWARDS, M. E., AND E. D. BARKER, JR. 1994. Climate and vegetation in northeastern Alaska 18,000 yr B.P.–present. Palaeogeography, Palaeoclimatology, Palaeoecology 109:127–135.

ELPHICK, C. S., AND J. KLIMA. 2002. Hudsonian Godwit (*Limosa haemastica*). *In* The Birds of North America, no. 629 (A. Poole and F. Gill, Eds.). Birds of North America, Philadelphia.

ELSER, D. 2000. Applying metapopulation theory to conservation of migratory birds. Conservation Biology 14:366–372.

ELY, C. R., AND A. X. DZUBIN. 1994. Greater White-fronted Goose (*Anser albifrons*). *In* The Birds of North America, no. 131 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

EMSLIE, S. D. 1982. Osteological identification of Long-eared and Short-eared owls. American Antiquity 47:155–157.

ERLANDSON, J. M., AND K. BARTOY. 1995. Cabrillo, the Chumash, and Old World diseases. Journal of California and Great Basin Anthropology 17:153–173.

ERLANDSON, J. M., T. C. RICK, D. J. KENNETT, AND P. L. WALKER. 2001. Dates, demography, and disease: Cultural contacts and possible evidence for Old World epidemics among the island Chumash. Pacific Coast Archaeological Society Quarterly 37:11–26.

FÉRET, M., G. GAUTHIER, A. BECHÉT, J.-F. GIROUX, AND K. HOBSON. 2003. Effect of a spring hunt on nutrient storage by Greater Snow Geese in southern Quebec. Journal of Wildlife Management 67:796–807.

Fitzgerald, G. R. 1980. Pleistocene loons of the Old Crow Basin, Yukon Territory, Canada. Canadian Journal of Earth Sciences 17: 1593–1598.

Frankham, R., J. D. Ballou, and D. A. Briscoe. 2002. Introduction to Conservation Genetics. Cambridge University Press, Cambridge, United Kingdom.

Gajewski, K. 1995. Modern and Holocene pollen assemblages from some small arctic lakes on Somerset Island, NWT, Canada. Quaternary Research 44:228–236.

George, T. L., and D. S. Dobkin. 2002. Introduction: Habitat fragmentation and western birds. Pages 4–7 *in* Effects of Habitat Fragmentation on Birds in Western Landscapes: Contrasts with Paradigms from the Eastern United States (T. L. George and D. S. Dobkin, Eds.). Studies in Avian Biology, no. 25.

Glenn, T. C., S. Wolfgang, and M. J. Braun. 1999. Effects of a population bottleneck on Whooping Crane mitochondrial DNA variation. Conservation Biology 13:1097–1107.

Gonzalez, J. A. 1999. Effects of harvesting of waterbirds and their eggs by native people in the northeastern Peruvian Amazon. Waterbirds 22:217–224.

Gratto-Trevor, C. L. 2000. Marbled Godwit (*Limosa fedoa*). *In* The Birds of North America, no. 492 (A. Poole and F. Gill, Eds.). Birds of North America, Philadelphia.

Grayson, D. K. 1984. Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas. Academic Press, Orlando, Florida.

Grayson, D. K. 2001. The archaeological record of human impacts on animal populations. Journal of World Prehistory 15:1–68.

Grinnell, J., H. C. Bryant, and T. I. Storer. 1918. The Game Birds of California. University of California Press, Berkeley.

Grinnell, J., and A. H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna, no. 27.

Grinnell, J., and M. W. Wythe. 1927. Directory to the bird-life of the San Francisco Bay region. Pacific Coast Avifauna, no. 18.

Hanson, H. C., P. Queneau, and P. Scott. 1956. The geography, birds, and mammals of the Perry River region. Arctic Institute of North America Special Publications, no. 3.

Hatch, J. J., and D. V. Weseloh. 1999. Double-crested Cormorant (*Phalacrocorax auritus*). *In* The Birds of North America, no. 441 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

Hestbeck, J. B., J. D. Nichols, and R. A. Malecki. 1991. Estimates of movement and site fidelity using mark–resight data of wintering Canada Geese. Ecology 72:523–533.

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.

Hildebrandt, W. R., and T. L. Jones. 2002. Depletion of prehistoric pinniped populations along the California and Oregon coasts: Were humans the cause? Pages 72–110 *in* Wilderness and Political Ecology: Aboriginal Influences and the Original State of Nature (C. Kay and R. Simmons, Eds.). University of Utah Press, Salt Lake City.

Hobson, K. A. 1997. Pelagic Cormorant (*Phalacrocorax pelagicus*). *In* The Birds of North America, no. 282 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

Hoelzel, A. R., R. C. Fleischer, C. Campagna, B. J. Le Boeuf, and G. Alvord. 2002. Impact of a population bottleneck on symmetry and genetic diversity in the northern elephant seal. Journal of Evolutionary Biology 15:567–575.

Howard, H. 1929. The avifauna of the Emeryville Shellmound. University of California Publications in Zoology, no. 32.

Hu, F. S., E. Ito, L. B. Brubaker, and P. M. Anderson. 1998. Ostracode geochemical record of Holocene climatic change and implications for vegetational response in the northwestern Alaska Range. Quaternary Research 49:86–95.

Ingram, B. L., J. C. Ingle, and M. E. Conrad. 1996. Stable isotope record of late Holocene salinity and river discharge in San Francisco Bay, California. Earth and Planetary Science Letters 141:237–247.

Jehl, J. R., Jr., and N. K. Johnson, Eds. 1994. A Century of Avifaunal Change in Western North America. Studies in Avian Biology, no. 15.

Johnsgard, P. A. 1975. Waterfowl of North America. Indiana University Press, Bloomington.

Johnson, N. K., and J. R. Jehl, Jr. 1994. A century of avifaunal change in western North America: Overview. Pages 1–3 *in* A Century of Avifaunal Change in Western North America (J. R. Jehl, Jr. and N. K. Johnson, Eds.). Studies in Avian Biology, no. 15.

Johnson, P. J. 1978. Patwin. Pages 350–360 *in* Handbook of North American Indians: Volume 8, California (R. F. Heizer, Ed.). Smithsonian Institution Press, Washington, D.C.

Kay, C. 2002. Afterword: False gods, ecological myths, and biological reality. Pages 238–261 *in* Wilderness and Political Ecology: Aboriginal Influences and the Original State of Nature (C. Kay and R. Simmons, Eds.). University of Utah Press, Salt Lake City.

Kelly, P. R., and H. L. Cogswell. 1979. Movements and habitat use by wintering populations of Willets and Marbled Godwits. Pages 69–82 *in* Shorebirds in Marine Environments (F. A. Pitelka, Ed.). Studies in Avian Biology, no. 2.

Klein, D. R. 1966. Waterfowl in the economy of the Eskimos on the Yukon-Kuskokwim Delta, Alaska. Arctic 19:319–336.

Kostin, I. O., and J. H. Mooj. 1995. Influences of weather conditions and other factors on the reproductive cycle of Red-breasted Geese *Branta ruficollis* on the Taimyr Peninsula. Wildfowl 46:45–54.

LaCourse, T., and K. Gajewski. 2000. Late Quaternary vegetation history of Sulphur Lake, southwest Yukon Territory, Canada. Arctic 53:27–35.

Larson, S., R. Jameson, M. Etnier, M. Fleming, and P. Bentzen. 2002. Loss of genetic diversity in sea otters (*Enhydra lutris*) associated with the fur trade of the 18th and 19th centuries. Molecular Ecology 11:1899–1903.

Lavoie, C., and D. Arseneault. 2001. Late Holocene climate of the James Bay area, Quebec, Canada, reconstructed using fossil beetles. Arctic, Antarctic, and Alpine Research 33:13–18.

Levy, R. 1978. Costanoan. Pages 485–495 *in* Handbook of North American Indians: Volume 8, California (R. F. Heizer, Ed.). Smithsonian Institution Press, Washington, D.C.

Lightfoot, K. G., and E. M. Luby. 2002. Late Holocene in the San Francisco Bay area: Temporal trends in the use and abandonment of shell mounds in the east bay. Pages 263–281 *in* Catalysts to Complexity: Late Holocene Societies of the California Coast. Perspectives in California Archaeology, vol. 6 (J. M. Erlandson and T. L. Jones, Eds.). Cotsen Institute of Archaeology, University of California, Los Angeles.

Lindstrom, S. 1996. Great Basin fisherfolk: Optimal diet breadth modeling the Truckee River aboriginal subsistence fishery. Pages 114–179 *in* Prehistoric Hunter-gatherer Fishing Strategies (M. Plew, Ed.). Boise State University, Boise, Idaho.

MacDonald, G. M., T. D. Edwards, K. A. Moser, R. Pienitz, and J. P. Smol. 1993. Rapid response of treeline vegetation and lakes to past climate warming. Nature 361:243–246.

Madsen, D. B., and D. Schmitt. 1998. Mass collecting and the diet-breadth model: A Great Basin example. Journal of Archaeological Science 25: 445–455.

Marks, J. S., and R. L. Redmond. 1996. Demography of Bristle-thighed Curlews *Numenius tahitiensis* wintering on Laysan Island. Ibis 138:438–447.

Marks, J. S., T. L. Tibbitts, R. E. Gill, and B. J. McCaffery. 2002. Bristle-thighed Curlew (*Numenius tahitiencis*). *In* The Birds of North America, no. 705 (A. Poole and F. Gill, Eds.). Birds of North America, Philadelphia.

Martin, P. S., and D. W. Steadman. 1999. Prehistoric extinctions on islands and continents. Pages 17–52 *in* Extinctions in Near Time (R. D. MacPhee, Ed.). Kluwer Academic–Plenum Publishers, New York.

Martini, J. 1990. Fortress Alcatraz: Guardian of the Golden Gate. Pacific Monograph, Kailua.

McGann, M. 1995. 3500-year B.P. record of climate change in estuarine deposits from south San Francisco Bay, California. Pages 225–236 *in* Recent Geologic Studies in the San Francisco Bay Area (E. Sangines, D. Andersen, and A. Buising, Eds.). Pacific Section of the Society of Economic Paleontologists and Mineralogists, no. 76.

McGann, M. 2003. High-resolution faunal and isotopic records from Holocene estuarine deposits of San Francisco Bay, California. *In* the Symposium "High Resolution Records from Late Quaternary Estuarine and Marine Deposits." Poster presented at the XVI INQUA Congress, July 23–30, Reno Nevada.

Mowbray, T. B., C. R. Ely, J. S. Sedinger, and R. E. Trost. 2002. Canada Goose (*Branta canadensis*). *In* The Birds of North America, no. 682 (A. Poole and F. Gill, Eds.). Birds of North America, Philadelphia.

Moy, C. M., G. O. Seltzer, D. T. Rodbell, and D. M. Anderson. 2002. Variability of El Niño/ Southern Oscillation activity at millennial timescales during the Holocene epoch. Nature 420:162–165.

Murphy, M. 1970. Predicted forage yield based on fall precipitation in California annual grasslands. Journal of Range Management 23: 363–365.

Nagaoka, L. A. 2000. Resource depression, extinction, and subsistence change in prehistoric southern New Zealand. Ph.D. dissertation, University of Washington, Seattle.

Nagaoka, L. A. 2001. Using diversity indices to measure changes in prey choice at the Shag River Mouth site, southern New Zealand. International Journal of Osteoarchaeology 11: 101–111.

Nelson, N. C. 1909. Shellmounds of the San Francisco Bay Region. University of California Publications in American Archaeology and Ethnology 7:309–356.

O'Brien, S. R., P. A. Mayewski, L. D. Meeker, D. A. Meese, M. S. Twickler, and S. I. Whitlow. 1995. Complexity of Holocene climate as reconstructed from a Greenland ice core. Science 270:1962–1964.

Ogden, A. 1941. The California sea otter trade, 1784–1848. University of California Publications in History 26:1–251.

Orians, G. H., and N. E. Pearson. 1979. On the theory of central place foraging. Pages 154–177 *in* Analysis of Ecological Systems (D. J. Horn, R. D. Mitchell, and G. R. Stairs, Eds.). Ohio State University, Columbus.

Paxinos, E., H. James, S. Olson, J. Ballou, J. Leonard, and R. Fleischer. 2002. Prehistoric decline of genetic diversity in the Nene. Science 296:1827.

Pellat, M. G., and R. W. Mathewes. 1997. Holocene tree line and climate change on the Queen Charlotte Islands, Canada. Quaternary Research 48:88–99.

Pitelka, F. A. 1950. Geographic variation and the species problem in the shore-bird genus *Limnodromus*. University of California Publications in Zoology, no. 50.

Porcasi, J. F., T. L. Jones, and M. L. Raab. 2000. Trans-Holocene marine mammal exploitation on San Clemente Island, California: A tragedy of the commons revisted. Journal of Anthropological Archaeology 19:200–220.

Preston, W. 1996. Serpent in Eden: Dispersal of foreign diseases into pre-mission California. Journal of California and Great Basin Anthropology 18:2–37.

Preston, W. 2002. Post-Columbian wildlife irruptions in California: Implications for cultural and environmental understanding. Pages 111–140 *in* Wilderness and Political Ecology: Aboriginal Influences and the Original State of Nature (C. Kay and R. Simmons, Eds.). University of Utah Press, Salt Lake City.

Raveling, D. G. 1979. Traditional use of migration and winter roost sites by Canada Geese. Journal of Wildlife Management 43:229–235.

Raveling, D. G. 1984. Geese and hunters of Alaska's Yukon Delta: Management problems and political dilemmas. Transactions of North American Wildlife National Resource Conference 49:555–575.

Reed, A., D. H. Ward, D. V. Derksen, and J. Sedinger. 1998. Brant (*Branta bernicla*). *In* The Birds of North America, no. 337 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

Richard, P. J. H. 1994. Postglacial palaeophytogeography of the eastern St. Lawrence River Watershed and the climatic signal of the pollen record. Palaeogeography, Palaeoclimatology, Palaeoecology 109:137–161.

Riedinger, M. A., M. Steinitz-Kannan, W. M. Last, and M. Brenner. 2002. A ~6100 ^{14}C yr record of El Niño activity from the Galapagos Islands. Journal of Paleolimnology 27:1–7.

Ritchie, J. C., L. C. Cwynar, and R. A. Spear. 1983. Evidence from north-west Canada for an early Holocene Milankovitch thermal-maximum. Nature 305:126–128.

Robertson, G. J., and F. Cooke. 1999. Winter philopatry in migratory waterfowl. Auk 116: 20–34.

Ryder, J. P., and R. T. Alisauskas. 1995. Ross' Goose (*Chen rossii*). *In* The Birds of North America, no. 162 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

Sandweiss, D. H., K. A. Maasch, R. L. Burger, J. B. Richardson III, H. B. Rollins, and A. Clement. 2001. Variation in Holocene El Niño frequencies: Climate records and cultural consequences in ancient Peru. Geology 29:603–606.

Sawada, M., K. Gajewski, A. de Vernal and P. Richard. 1999. Comparison of marine and terrestrial Holocene climatic reconstructions from northeastern North America. Holocene 9:267–277.

Schenck, W. E. 1926. The Emeryville Shellmound: Final report. University of California Publications in American Archaeology and Ethnology 23:147–282.

Scribner, K. T., S. L. Talbot, J. M. Pearce, B. J. Pierson, K. S. Bollinger, and D. V. Derkson. 2003. Phylogeography of Canada Geese (*Branta canadensis*) in Western North America. Auk 120:889–907.

Scott, P. A., C. Lavoie, G. M. MacDonald, B. Sveinbjörnsson, and R. W. Wein. 1997. Climate change and the future position of Arctic tree line. Pages 245–265 *in* Global Change and Arctic Terrestrial Ecosytems (W. Oechel, T. Callaghan, T. Gilmanov, J. Holten, B. Maxwell, U. Molau, and B. Sveinbjörnsson, Eds.). Springer-Verlag, New York.

Shaw, R. D. 1998. An archaeology of the central Yupik: A regional overview for the Yukon-Kuskokwim Delta, northern Bristol Bay, and Nunivak Island. Arctic Anthropology 35: 234–246.

Sibley, D. A. 2000. The Sibley Guide to Birds. Alfred A. Knopf, New York.

Skinner, W. R., R. L. Jeffries, T. J. Carleton, R. F. Rockwell, and K. F. Abraham. 1998. Prediction of reproductive success and failure in the Lesser Snow Goose based on early-season climatic variables. Global Change Biology 4:3–16.

Small, A. 1994. California Birds: Their Status and Distribution. Ibis Publishing Company, Vista, California.

Smith, E. A. 1991. Inujjuamiut Foraging Strategies: Evolutionary Ecology of an Arctic Hunting Economy. Aldine De Gruyter, New York.

SMITH, I. R. 2002. Diatom-based Holocene paleoenvironmental records from continental sites on northeastern Ellesmere Island, high Arctic, Canada. Journal of Paleolimnology 27:9–28.

STEADMAN, D. 1995. Prehistoric extinctions of Pacific Island birds: Biodiversity meets zooarchaeology. Science 267:1123–1131.

STENZEL, L. E., C. M. HICKEY, J. E. KJELMYR, AND G. W. PAGE. 2002. Abundance and distribution of shorebirds in the San Francisco Bay area. Western Birds 33:69–98.

STEPHENS, D. W., AND J. R. KREBS. 1986. Foraging Theory. Princeton University Press, Princeton, New Jersey.

STUIVER, M., AND P. M. GROOTES. 2000. GISP2 Oxygen isotope ratios. Quaternary Research 53:277–284.

THOMES, W. H. 1892. On Land and Sea: Or, California in the Years 1843–1844–1845. Laird and Lee, Chicago.

UHLE, M. 1907. The Emeryville Shellmound. University of California Publications in American Archaeology and Ethnology, no. 7.

VON KOTZEBUE, O. 1830. A New Voyage Round the World in the Years 1823, 24, and 26, vol. II. Henry Colburn and Richard Bentley, London.

WALLACE, E. A. H., and G. E. WALLACE. 1998. Brandt's Cormorant (*Phalacrocorax penicillatus*). *In* The Birds of North America, no. 162 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

WILLIAMS, G. W. 2002. Aboriginal use of fire: Are there any "natural" plant communities? Pages 179–214 *in* Wilderness and Political Ecology: Aboriginal Influences and the Original State of Nature (C. Kay and R. Simmons, Eds.). University of Utah Press, Salt Lake City.

WINTERHALDER, B., AND F. LU. 1997. A forager-resource population ecology model and implications for indigenous conservation. Conservation Biology 11:1354–1364.

WOOLFENDEN, G. E. 1959. A Pleistocene avifauna from Rock Spring, Florida. Wilson Bulletin 71: 183–187.

WOOLFENDEN, G. E. 1961. Postcranial osteology of the waterfowl. Bulletin of the Florida State Museum, no. 6.

ZAR, J. H. 1996. Biostatistical Analysis, 3rd ed. Prentice Hall, Upper Saddle River, New Jersey.

ZOCKLER, C., AND I. LYSENKO. 2000. Water birds on the edge: First circumpolar assessment of climate change impact on arctic breeding water birds. World Conservation Monitoring Centre Biodiversity Series, no. 11.

APPENDIX

TABLE A1. Numbers of identified bird specimens by element and portion for stratum 1, Uhle excavation.

	Element (portion)																															
	Man	Ste	Fur		Cor			Sca		Hum			Rad		Uln			Car			Pha	Syn	Tib			Tar			Fem			Σ
Taxon	a	p	a	s	d	p	w	a	w	d	p	w	d	w	d	p	w	d	p	w	a		d	p	w	d	p	w	d	p	w	
Gavia stellata							1																	1								2
G. immer																				1												1
Podiceps auritus/nigricollis												1																				1
Pelecanus sp.																1																1
Phalacrocorax sp.																		1					1						1			3
P. penicillatus																								1	1			1			1	4
P. auritus			1																									1				2
Ardea herodias											1																					1
Anserinae (small)					1		2	4	1	2	1			1				1													1	14
Anserinae (medium)					1	1				2	3							2			1					1						11
Anatinae (small)							2										1															3
Anatinae (large)		1		1	6	4	15	8		2	2		3	1	2	1		2	1	10	3	2	5	4		4	1		1	4	3	86
Anas sp.											1																					1
Anas sp. (teal)																						1				1						2
A. platyrhynchos																												1				1
Aythya sp.										1	1																					2
Melanitta sp.	1		4							16	12											2						3				38
Bucephala clangula/islandica			1																													1
Elanus leucurus																							1									1
Buteo jamaicensis/regalis										1																						1
Falco peregrinus																								1								1
Dendragapus obscurus							1										1															2
Grus canadensis tabida																											1					1
Catoptrophorus semipalmatus																						1										1
Numenius americanus								1			2		1									1					1					6
Limosa fedoa																				1												1
Limnodromus sp.															1		1															2
Uria sp.								1		1	1						1			1			1						1		1	8
Cepphus columba															1																	1
Tyto alba																										1						1
Corvus brachyrhynchos															1																1	2
Σ	1	1	6	1	8	5	21	14	1	25	24	1	4	2	5	2	4	6	1	13	4	7	8	7	1	7	3	6	3	4	7	202

Abbreviations for elements: Cra = cranium, Man = mandible, Ste = sternum, Fur = furculum, Sca = scapula, Hum = humerus, Rad = radius, Uln = ulna, Car = carpometacarpus, Pha = wing phalanx, Syn = synsacrum, Tib = tibiotarsus, Tar = tarsometatarsus, Fem = femur.

Abbreviations for portion: For crania and mandibles: a = anterior, p = posterior, f = frontal. For postcranial elements: a = anterior, s = symphysis, d = distal, p = proximal, w = whole. For phalanges: a = digit 2, phalanx 1; b = digit 2, phalanx 2; c = pollex.

Table A2. Numbers of identified bird specimens by element and portion for stratum 2, Uhle excavation. Abbreviations same as Table A1.

	Element (portion)																																				
	Cra				Man		Ste	Fur	Cor			Sca	Hum		Rad			Uln			Car			Pha			Syn	Tib			Fib	Tar			Fem			Σ
Taxon	a	f	f+p	p	a	p	a	s	d	p	w	a	d	p	d	p	w	d	p	w	d	p	w	a	b	c		d	p	w	p	d	p	w	d	p	w	
Gavia stellata/pacifica																							1															1
G. stellata											2												2				2		2									8
G. immer														1																		2	1			1		5
Podiceps auritus														1																								1
P. nigricollis											1																			1								2
Aechmophorus																																						
occidentalis/clarkii																											3				1					1		5
Pelecanus sp.													1																									1
Phalacrocorax sp.										1	1		1	2													1	1										7
P. penicillatus																							1					1							1			3
P. auritus													1		1												1											3
Anserinae (small)					3	1	7	3	1	7	7	8	3	4		1						2					1	5	1			1						55
Anserinae (medium)	1	1					8	3	4	6	7	9	16	23	1	1	1	2	2	1		2	1	12			2	6	1			1		1				112
Branta canadensis																																						
cf. *parvipes*		2																																				2
B. canadensis cf. *moffitti*						1					1																											2
Anatinae (small)					3			1		2	3	3			3		1	2	1		3		11											1			3	37
Anatinae (large)					2	3	1	19	16	39	80	47	6	7	11	4	3	13	8	8	14	17	61	12	1	1	30	33	22	1	2	11	12	2	15	11	20	532
Anas sp. (teal)					1		2				1			1																								5
Anas sp.							3						1	4													1					1						10
A. platyrhynchos							1							1													2											4
A. clypeata					2																																	2
Aythya sp.													1	2													2					1						6
Aythya sp. (large)							1																															1
Melanitta sp.				1	2	2	22					2	42	63													44					5	1	25				209
M. perspicillata	1		1	1																																		3
M. fusca		1	1																																			2
Bucephala albeola							1																															1
B. clangula/islandica							2							1																								3
Mergus cf. *serrator*														1																		1						2
M. serrator							1																															1
Accipitridae (small)																												1										1
Haliaeetus leucocephalus							1																															1
Buteo sp.																																	1					1

Table A2. Continued.

	Element (portion)																																				
	Cra				Man		Ste	Fur	Cor			Sca	Hum		Rad			Uln			Car			Pha			Syn	Tib			Fib	Tar			Fem			Σ
Taxon	a	f	f+p	p	a	p	a	s	d	p	w	a	d	p	d	p	w	d	p	w	d	p	w	a	b	c		d	p	w	p	d	p	w	d	p	w	
B. jamaicensis/regalis									1																													1
Falco peregrinus/ mexicanus													1																									1
Callipepla californica																														1								1
Grus canadensis																1												1										2
Pluvialis squatarola																				1													1					2
Catoptrophorus semipalmatus							1								1	1	2				1						1	1						1				9
Numenius americanus							1	2		1	3	1	3	2		1											2	2	1									19
N. phaeopus/Limosa fedoa																												3										3
L. fedoa							1																									1		1				3
Calidris alba																				1																		1
Limnodromus sp.													1				1			12			2				1	1				1	2	2			2	25
Larus sp. (large)											1		1									1																3
Larus sp. (small)																											1											1
Uria sp.	1	1									3		1	1		1			2	2			2				1	5	1								2	23
U. aalge		1		1																																		2
Corvus brachyrhynchos															1				1																			2
C. corax																								1														1
Σ	3	6	2	3	13	7	53	28	22	56	110	70	79	114	18	10	8	17	14	25	18	22	81	25	1	1	95	60	28	3	3	25	18	33	16	13	27	1127

Table A3. Numbers of identified bird specimens by element and portion for stratum 3, Uhle excavation. Abbreviations same as Table A1.

																	Element (portion)																					
	Cra			Man			Ste	Fur	Cor			Sca		Hum			Rad			Uln			Car			Pha	Syn	Tib			Fib	Tar			Fem			Σ
Taxon	a	f	p	a	p	w	a	s	d	p	w	a	w	d	p	w	d	p	w	d	p	w	d	p	w	a		d	p	w	p	d	p	w	d	p	w	
Gavia stellata															1			1																				2
Podiceps nigricollis																									1													1
P. auritus/nigricollis							1															1						1	1									4
Aechmophorus																																						
occidentalis/clarkii			1				2									1				1					1		4											10
Phalacrocorax sp.											1																											1
P. penicillatus	1																	1				1							1									4
P. auritus							1				1	1			1								1						1	1							1	8
Anserinae (small)					1		4	7	2	1	2	3		5	4									1	2	1	5	1										39
Anserinae (medium)		2					6	2		6	5	7	1	17	14			3		1		1	1	2		1	8	3			1	1	1	2	1			86
Chen caerulescens				1																																		1
C. rossii					3																																	3
Branta hutchinsii																																						
cf. *minima*				1																																		1
B. canadensis																																						
cf. *parvipes*				1																																		1
Anatinae (small)								1			4		1					1					1		1	1												10
Anatinae (large)		1			2	2	5	8	2	2	16	13	2	3	3		2	2	1	1	4	1	2	2	10	4	9	2	1	5					1	2		108
Anas sp. (teal)							1															1					2											4
Anas sp.							2																				1											3
A. platyrhynchos														1	1																							2
Aythya cf. *valisneria*																											1											1
Aythya cf. *marila*																											1											1
A. marila				1																																		1
A. affinis																											1											1
Melanitta sp.		2	1	3	7	5	24							8	8												39					1		8				106
M. perspicillata			1																																			1
M. fusca	1		5																																			6
M. perspicillata/fusca			5																																			5
M. perspicillata/nigra			1																																			1
Bucephala albeola															1																							1
B. clangula/islandica							2								1																			1				4
Oxyura jamaicensis							1																															1
Buteo sp.														2						1																		3
B. lineatus																																					1	1
Fulica americana																									1		1											2

Table A3. Continued.

																Element (portion)																					
	Cra			Man			Ste	Fur	Cor			Sca		Hum			Rad			Uln			Car			Pha	Syn	Tib			Fib	Tar			Fem			Σ
Taxon	a	f	p	a	p	w	a	s	d	p	w	a	w	d	p	w	d	p	w	d	p	w	d	p	w	a		d	p	w	p	d	p	w	d	p	w	
Grus canadensis															1																							1
Pluvialis squatarola																											1											1
Charadrius vociferus																				1		1																2
Recurvirostra americana															1																							1
Catoptrophorus																																						
semipalmatus							1					1															1	1									1	5
Numenius americanus							4			1		1														1												7
Limosa fedoa														1																								1
L. fedoa/N. phaeopus																									1											1		
Limnodromus sp.							2															1						1						1				5
Larus sp. (small)																				1					1													2
Larus sp. (large)	2		1	1	1																																	5
Uria sp.					1	1	1	1			4	1	1	2	2				2			1			1		1	1	1					1		1	3	26
U. aalge	1																																					1
Corvus brachyrhynchos											1																											1
Σ	5	5	15	8	15	8	57	19	4	10	34	27	5	39	38	1	2	8	3	6	4	8	5	5	18	8	76	10	5	6	1	2	1	13	2	3	6	482

TABLE A4. Numbers of identified bird specimens by element and portion for stratum 4, Uhle excavation. Abbreviations same as Table A1.

	Element (portion)																																		
	Cra	Man			Ste	Fur	Cor		Sca		Hum			Rad			Uln			Car			Pha			Syn	Tib			Tar			Fem			Σ
Taxon	a	a	p	w	a	s	d	p	w	a	w	d	p	w	d	p	w	d	p	w	d	p	w	a	b		d	p	w	d	p	w	d	p	w	
Gavia stellata													1														1									2
G. immer																1																				1
Podiceps auritus/nigricollis									1			2																								3
Aechmophorus occ./clarkii																1												3								4
Phoebastria albatrus																						1														1
Phalacrocorax sp.													2															2								4
P. penicillatus															1	1																				2
P. auritus			2				1		1	1										1							1		1		2			1		11
Cathartes aura												1																								1
Anserinae (small)					2		3	1	2	7		8	6		1	2		2			1		1	2	1		1			1						41
Anserinae (medium)			1		4	3	1	2	6	5	2	7	16					1			2	3	2	2		4	2			1						64
Chen rossii		1																																		1
Branta hutchinsii cf. *minima*		1																																		1
Anatinae (small)									1	2					1	1						1														6
Anatinae (large)						5	1	4	7	2					2	2	1	1	4		1	1	2	1				1	2				1			38
Anas sp. (teal)																										3										3
Anas sp.					2							2	2													1										7
Anas platyrhynchos													1																							1
Aythya sp.					1							1																								2
Melanitta sp.					1							2	3													1				1		1				9
Mergus serrator																										1										1
Oxyura jamaicensis					1																					1										2
Accipiter cooperii				1																																1
Buteo sp.														1																1						2
Falco peregrinus/mexicanus																				1	1	1						1						1		5
Callipepla californica/O. pictus					1																															1
Callipepla californica														1													1									2
Grus canadensis												1	1					1								1										4
Numenius americanus	1				3					2		1	1				1					1					1			1						12
Limosa fedoa												1										1	1							1						4
Calidris alba/alpina																				1																1
Larus sp. (large)																																1				1
Uria sp.			1		4		2						3				1	1		2							1								1	16
Corvus brachyrhynchos									2			2															1									5
Σ	1	2	4	1	19	8	8	7	20	19	2	28	36	2	5	8	3	6	4	5	5	9	6	5	1	12	9	7	3	6	2	2	1	2	1	259

Table A5. Numbers of identified bird specimens by element and portion for stratum 5, Uhle excavation. Abbreviations same as Table A1.

	Element (portion)																														
	Man		Ste	Fur	Cor			Sca		Hum		Rad	Uln			Car			Pha		Syn	Tib		Fib	Tar			Fem			Σ
Taxon	a	p	a	s	d	p	w	a	w	d	p	d	d	p	w	d	p	w	a	b		d	p	p	d	p	w	d	p	w	
Gavia immer								1																							1
Aechmophorus occidentalis/clarkii							1																								1
Phalacrocorax sp.						1	1				3		3	3									1	1			1			1	15
P. penicillatus		1	1																												2
P. auritus								1			1							1							1	1	1			2	8
P. pelagicus																														1	1
Ardea herodias		1									1																				2
Cathartes aura																					1										1
Anserinae (small)				1	6	3		5		2	2		1			1			2		2	1	1					1			28
Anserinae (medium)			3	2	4	1	1	4		5	6					1	2	1	2	1				1		1			1		36
Chen rossii	1																														1
Branta canadensis cf. *parvipes*	1																														1
Anatinae (small)															1			1													2
Anatinae (large)				2	2	5		2			1	4	1			1		1				2	1							1	23
Anas sp.			1																												1
A. platyrhynchos										1																					1
Aythya marila	1																														1
Melanitta sp.										2																	1				3
Accipitridae																									1						1
Accipitridae (small)																							1								1
Buteo jamaicensis																											1				1
B. regalis																										1					1
Falco peregrinus/mexicanus																						1							1		2
Callipepla californica																											1				1
Grus canadensis			1																												1
Numenius americanus						1	2	1			2							1													7
N. phaeopus/Limosa fedoa			1																												1
Larus sp. (large)													1																		1
Uria sp.							2		1						2																5
Strigidae (medium)											1																				1
Otus kennicottii										1																					1
Asio sp.																		1													1
Corvus brachyrhynchos							1						2																		3
Σ	3	2	7	5	12	11	8	14	1	11	17	4	8	3	3	3	2	6	4	1	3	4	4	2	2	3	5	1	2	5	156

Table A6. Numbers of identified bird specimens by element and portion for stratum 6, Uhle excavation. Abbreviations same as Table A1.

	Element (portion)																																
	Cra				Man	Ste	Cor			Sca	Hum		Rad			Uln			Car			Pha	Syn	Tib			Fib	Tar		Fem			Σ
Taxon	a	f	f+p	p	p	a	d	p	w	a	d	p	d	p	w	d	p	w	d	p	w	a		d	p	w	p	d	w	d	p	w	
Pelecanus sp.																							1										1
Phalacrocorax sp.		1					2	2		1	3	3				1	1					1		1	1		3	1		1			22
P. penicillatus					1										1										1								3
P. auritus	1																		1	1	1					3			2			1	10
P. pelagicus									1																								1
Ardea herodias					1																												1
Anserinae (small)						1	2	1	1	1	2	1		1		2		1			1			1									15
Anserinae (medium)				1			2		1	3	3	3				1															1		15
Chen caerulescens					2																												2
Anatinae (small)										1	1							2												1			5
Anatinae (large)					1	1			2	3		1	1				1		1	1				1	1							1	15
Anas sp.											1																						1
Anas platyrhynchos											1																						1
Aythya sp.					1																												1
Melanitta sp.												2																					2
Mergus serrator						1																											1
Buteo sp.																												1					1
Numenius americanus													1						2														3
N. phaeopus/ *Limosa fedoa*																1					1												2
Laridae (small)												1																					1
Larus sp. (large)									1			1																					2
Uria sp.					1				1									2														2	6
U. aalge			1																														1
Asio sp.																															1		1
Tyto alba																			1														1
Corvus brachyrhynchos									1		2										2			1									6
C. corax																						1											1
Σ	1	1	1	1	7	3	6	3	8	9	13	12	2	1	1	5	2	5	5	2	5	2	1	4	3	3	3	2	2	2	2	4	121

TABLE A7. Numbers of identified bird specimens by element and portion for stratum 7, Uhle excavation. Abbreviations same as Table A1.

	Element (portion)																																	
	Cra		Man		Ste	Fur	Cor			Sca		Hum			Rad		Uln			Car		Pha		Syn	Tib			Fib	Tar		Fem			Σ
Taxon	a	f	a	p	a	s	d	p	w	a	w	d	p	w	d	p	d	p	w	d	w	a	b		d	p	w	p	d	w	d	p	w	
Pelecanus occidentalis													1																					1
Phalacrocorax sp.					2		2	3	3	1	1	5	3				2	2					1	1	2	1	2	1	1	1	2	2	4	42
P. penicillatus	2	1																							1									4
P. auritus				1			2	1	5				1							1				3			1			2				17
P. pelagicus																					1													1
Botaurus lentiginosus											1																							1
Anserinae (small)					3	3		2	5	4		5	6			3					1			1				1						34
Anserinae (medium)	1	1			2	1	2	3	5	12		6	5							1		1		1					1					42
Chen caerulescens			1																															1
Branta hutchinsii cf. *minima*			1																															1
B. canadensis cf. *moffitti*				1																														1
Anatinae (small)										2	1								1															4
Anatinae (large)					1	2	1	1		2			1			1	2		1	1	1				1	1				1				17
Anas sp.					1																													1
Aythya sp.												1																						1
Circus cyaneus									1																									1
Buteo sp.									1											1														2
Callipepla californica														1																				1
Numenius americanus										1												1												2
Larus sp. (large)												1																						1
Uria sp.			1													1		1	2							2								7
Tyto alba																													1					1
Corvus brachyrhynchos								1							1		2				1													5
C. corax																	1								1				1					3
Σ	3	2	3	2	9	6	7	11	20	22	3	18	17	1	1	5	7	3	4	4	4	2	1	6	5	4	3	2	4	4	2	2	4	191

TABLE A8. Numbers of identified bird specimens by element and portion for stratum 8, Uhle excavation. Abbreviations same as Table A1.

	Element (portion)																																				
	Cra		Man		Ste	Fur	Cor			Sca		Hum		Rad			Uln			Car			Pha			Syn	Tib			Fib	Tar			Fem			Σ
Taxon	a	f	a	p	a	s	d	p	w	a	w	d	p	d	p	w	d	p	w	d	p	w	a	b	c		d	p	w	p	d	p	w	d	p	w	
Gavia stellata																				1																	1
G. stellata/pacifica																															1						1
G. immer								1	1																												2
Podiceps auritus																		1																			1
P. nigricollis																		1																			1
P. auritus/nigricollis									1																												1
Aechmophorus occidentalis/clarkii																												1								1	2
Pelecanus sp.																					1			1										1			3
P. occidentalis														1				1					1														3
Phalacrocorax sp.				1	1		3	5	4	5		5	9	1	2		1	4				3					10	6	7	5	3	5	5	3		10	98
P. penicillatus				1																																1	2
P. auritus	3			1					1			3	2	1	1												1		1				1			14	29
P. pelagicus									1																												1
Ardea herodias	1									1		1																									3
Anserinae (small)			3		3	5		5	5	4		10	10	1	1							2		1		3	3			1					1		58
Anserinae (medium)			3		5	7		20	12	26	3	25	21		2		1	3		3		1	6		4	2	5				4			3	4		160
Chen caerulescens		1	3	1																																	5
C. rossii			1																																		1
Branta canadensis cf. *parvipes*		2																																			2
B. canadensis cf. *moffitti*				1								1						1																			3
Anatinae (small)			4					2		4										1						3											14
Anatinae (large)				1		4	2	10	18	13	1	1	1	1	8		2		2		1	5	2		2	4					3				1	1	83
Anas sp. (teal)													1																								1
Anas sp.					2							2	5																								9
A. platyrhynchos													1													1											2
Aythya sp.					1																																1
Aythya sp. (large)			1																																		1
Aythya cf. *marila*			1																																		1
Melanitta sp.					2							1	4													3											10
Bucephala albeola													1																								1
Mergus sp.													1																								1
M. serrator																										1											1
Haliaeetus leucocephalus						1		1					1								1																4
Buteo sp.								1	1								1														1	1					5
B. jamaicensis/regalis								1																											1		2
Falco columbarius									1																												1

TABLE A8. Continued.

	Element (portion)																																			
	Cra		Man		Ste	Fur	Cor			Sca		Hum		Rad			Uln			Car			Pha			Syn	Tib			Fib	Tar			Fem			Σ
Taxon	a	f	a	p	a	s	d	p	w	a	w	d	p	d	p	w	d	p	w	d	p	w	a	b	c		d	p	w	p	d	p	w	d	p	w	
Rallus longirostris																																			2		2
Fulica americana					1										1																						2
Grus canadensis								1															1								3				1		6
Pluvialis squatarola														1																							1
Catoptrophorus semipalmatus												1			1	1																					3
Numenius americanus	1									4		3									1					2											11
Limosa fedoa					1					1		1																									3
L. fedoa/N. phaeopus																										1	1										2
Larus sp. (large)	1							2													1							1									5
Larus sp. (small)					1						1																										2
Uria sp.			1			1		1	1	2		1	2		1	1					1						1									2	15
Tyto alba									3				1				2					2									2						10
Corvus brachyrhynchos				2			1	1	3	1		1	1	1	1		3	2			1	3	1				4				2	1					29
C. corax														1																					1		2
Σ	6	3	17	8	17	18	6	51	52	61	5	56	61	8	18	2	10	13	2	5	7	16	11	2	6	20	25	8	8	6	19	7	6	7	11	29	607

Table A9. Numbers of identified bird specimens by element and portion for stratum 9, Uhle excavation. Abbreviations same as Table A1.

	Element (portion)																														
	Cra	Man	Ste	Fur	Cor			Sca	Hum			Rad		Uln			Car		Pha	Syn	Tib			Fib	Tar			Fem			Σ
Taxon	a	a	a	s	d	p	w	a	d	p	w	d	p	d	p	w	p	w	a		d	p	w	p	d	p	w	d	p	w	
Gavia stellata/pacifica																										1					1
Pelecanus sp.									2	1																					3
Phalacrocorax sp.										5	1				4						3	6	2	1	2				2		26
P. penicillatus																											1				1
P. auritus								2																							2
Ardea herodias																													1		1
Anserinae (small)		1	1		2		3	1	1	2				1			2			1	2								1		18
Anserinae (medium)			1			2		3	1	3		2			1		1	1	3												18
Chen rossii		1																													1
Branta canadensis cf. *parvipes*	1																														1
Anatinae (small)				1		1																									2
Anatinae (large)				1	2	1	7						1		1	1	1	3		2	2										22
Anas platyrhynchos										1																					1
Aythya sp.																									1						1
Aythya cf. *marila*		1																													1
A. affinis									1																						1
Melanitta sp.		1	4						2	2										1					2						12
Falco sparverius																												1			1
Catoptrophorus semipalmatus																1					1										2
Numenius americanus			4				1		1				1																		7
Limosa fedoa																		1													1
Limnodromus sp.																1															1
Uria sp.																1														1	2
Tyto alba															1															1	2
Corvus brachyrhynchos																														1	1
C. corax												1																			1
Σ	1	4	10	2	4	4	11	6	8	14	1	3	2	1	7	4	4	5	3	4	8	6	2	1	5	1	1	1	4	3	130

TABLE A10. Numbers of identified bird specimens by element and portion for stratum 10, Uhle excavation. Abbreviations same as Table A1.

	Element (portion)																																						
	Cra			Man			Ste	Fur	Cor			Sca		Hum			Rad			Uln			Car			Pha		Syn	Tib			Fib	Tar			Fem			Σ
Taxon	a	f	p	a	p	w	a	s	d	p	w	a	w	d	p	w	d	p	w	d	p	w	d	p	w	a	b		d	p	w	p	d	p	w	d	p	w	
Gavia stellata										1																													1
G. stellata/pacifica																																	1						1
G. immer					1						1				1										1														4
Podiceps auritus	1																																						1
P. nigricollis																															1								1
P. auritus/nigricollis														1																									1
Aechmophorus																																							
occidentalis/clarkii							1																															1	2
Fulmarus glacialis														1					1			1																	3
Pelecanus sp.															2																								2
Phalacrocorax sp.										3	5	2	1	3	10		1	1		3	5								4	7	7	1	5	2	4	3	2	2	71
P. penicillatus											1																												1
P. auritus					2		1				3		2	3	1		1												2								2	6	23
P. penicillatus/auritus		1																										1											2
P. pelagicus														1																								1	2
Ardeidae (Bittern sized)												1																											1
Anserinae (small)				1			2	10	1	7	3	5	1	2	5			1	1	1			1	2	4			1									1		49
Anserinae (medium)	1			3			1	4		9	11	21		23	17	1	1	1		1			1	4		7	1	1	4			1			1	1			115
Chen caerulescens				3	1	1																																	5
C. rossii				1																																			1
Branta canadensis																																							
cf. *parvipes*					1																																		1
B. canadensis cf. *moffitti*											2	1			1						1																		5
Anatinae (small)				1				1		2	3	2		1						1		1		2	3			1											18
Anatinae (large)								6	7	2	14	13		1			2	3		2	2	1	3	4	39	5		2	1	3			4				1	1	116
Anas sp. (teal)															2																								2
Anas sp.															4																								4
Aythya sp. (large)															1																								1
A. valisneria			1																																				1
Aythya cf. *marila*															1																								1
Melanitta sp.				1			3								5													4							1				14
M. perspicillata		1																																					1
Bucephala albeola														1	1																								2
B. clangula/islandica							1								1																								2

Table A10. Continued.

	Element (portion)																																						
	Cra			Man			Ste	Fur	Cor			Sca		Hum			Rad			Uln			Car			Pha		Syn	Tib			Fib	Tar			Fem			Σ
Taxon	a	f	p	a	p	w	a	s	d	p	w	a	w	d	p	w	d	p	w	d	p	w	d	p	w	a	b		d	p	w	p	d	p	w	d	p	w	
Haliaeetus leucocephalus											1																												1
Circus cyaneus											1																												1
Buteo sp.																	1																						1
B. lineatus																					1																		1
B. jamaicensis																																			1				1
B. regalis																													1										1
B. jamaicensis/lagopus																																						1	1
Falco peregrinus																						1																	1
F. mexicanus																																				1			1
Callipepla californica/ Oreortx pictus							1																																1
Grus canadensis										1																1								1					3
Pluvialis squatarola																									1														1
Catoptrophorus semipalmatus																			1	1									1										3
Numenius americanus				1								1		1	1		1											1											6
Limosa fedoa														1											1														2
Limnodromus sp.																									6														6
Larus sp. (large)											1	1		1										1															4
Larus sp. (small)															1																								1
L. glaucescens/hyperboreus																										1													1
Uria sp.							1	1				1		1	4							1								1									10
Asio flammeus																									2														2
Tyto alba											2						1													1				1		1			6
Corvus brachyrhynchos							1		1	2					1	1									1								3	1			1	1	13
C. corax																									1														1
Σ	2	2	1	11	5	1	11	22	8	25	48	48	4	41	58	1	8	6	3	9	9	5	5	13	57	14	1	11	13	12	8	2	10	4	7	6	6	12	523

TABLE A11. Numbers of identified bird specimens by element and portion for stratum 2, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)						
	Fur	Cor		Hum	Car	Fem	Σ
Taxon	s	d	w	p	w	p	
Anserinae (small)	1						1
Anatinae (large)		1	1		1	1	4
Melanitta sp.				1			1
Limosa fedoa				1			1
Σ	1	1	1	2	1	1	7

TABLE A12. Numbers of identified bird specimens by element and portion for stratum 3, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)										
	Ste	Cor		Hum		Rad	Uln	Syn	Tib	Tar	Σ
Taxon	a	p	w	d	p	d	w		d	p	
Phalacrocorax auritus							1				1
Anserinae (small)		2		1	1						4
Anserinae (medium)	1	1			1		2				5
Anatinae (large)			4			1		1	2		8
Anas sp. (teal)					1						1
Aythya sp.					1					1	2
Melanitta sp.				2	3						5
Numenius americanus					1						1
Corvus brachyrhynchos			1								1
Σ	1	3	5	3	8	1	2	1	2	1	28

Table A13. Numbers of identified bird specimens by element and portion for stratum 4, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)																											
	Cra	Ste	Fur	Cor			Sca		Hum		Rad			Uln		Car			Pha		Syn	Tib		Tar		Fem		Σ
Taxon	p	a	s	d	p	w	a	w	d	p	d	p	w	d	w	d	p	w	a	b		d	p	d	w	d	w	
Phalacrocorax penicillatus									1																			1
Anserinae (small)						2												1				1			1			5
Anserinae (medium)		1							2	4		1								1	1			1				11
Anatinae (small)			1	1										1				3			1	2						9
Anatinae (large)					1	15	4				2	1	4		1	2	2	7			1	3	1	1		1	4	50
Anas sp. (teal)	1								1																			2
Anas sp.									1																			1
A. clypeata									1																			1
Aythya sp.									1	1											1				1			4
Melanitta sp.									5	6											4			1	4			20
Mergus sp.									1																			1
Callipepla californica										1																		1
Recurvirostra americana																								1				1
Numenius americanus																			1				1					2
Limosa fedoa								1																				1
Larus glaucescens/ hyperboreus																							1					1
Σ	1	1	1	1	1	17	4	1	13	12	2	2	4	1	1	2	2	11	1	1	8	6	3	4	6	1	4	111

Table A14. Numbers of identified bird specimens by element and portion for stratum 5, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)					
	Cor	Sca	Rad	Car	Syn	Σ
Taxon	d	a	w	w		
Anserinae (medium)	1					1
Anatinae (large)	1	1	1	1		4
Melanitta sp.					1	1
Limosa fedoa				1		1
Σ	2	1	1	2	1	7

Table A15. Numbers of identified bird specimens by element and portion for stratum 6, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)					
	Ste	Cor	Sca	Hum		Σ
Taxon	a	w	a	d	p	
Phalacrocorax pelagicus					1	1
Anserinae (medium)	1		1	1		3
Anatinae (large)		2	1			3
Melanitta sp.	1			1		2
Σ	2	2	2	2	1	9

Table A16. Numbers of identified bird specimens by element and portion for stratum 7, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)	
	Hum	Σ
Taxon	d	
Anserinae (medium)	1	1
Σ	1	1

Table A17. Numbers of identified bird specimens by element and portion for stratum 8, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)	
	Sca	Σ
Taxon	a	
Anatinae (large)	1	1
Σ	1	1

Table A18. Numbers of identified bird specimens by element and portion for stratum 9, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)												
	Cra	Ste	Fur	Cor	Sca	Hum		Rad	Car	Syn	Tib	Tar	Σ
Taxon	p	a	s	w	a	d	p	d	w		p	w	
Aechmophorus occidentalis/clarkii												1	1
Anserinae (medium)					1	2	2			1			6
Anatinae (large)				2				1	1		1		5
Anas sp.			1										1
Melanitta sp.		1				1				2			4
M. perspicillata/fusca	1												1
Σ	1	1	1	2	1	3	2	1	1	3	1	1	18

Table A19. Numbers of identified bird specimens by element and portion for stratum 10, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)							
	Cra	Man	Ste	Fur	Cor	Hum	Car	Σ
Taxon	w	a	a	s	w	p	w	
Anserinae (medium)					1		1	2
Branta canadensis cf. *moffitti*						1		1
Anatinae (large)				1	1		1	3
Melanitta sp.			1					1
Uria sp.		2						2
U. aalge	1							1
Σ	1	2	1	1	2	1	2	10

Table A20. Numbers of identified bird specimens by element and portion for stratum 11, Nelson excavation. Abbreviations same as Table A1.

	Element (portion)																
	Cra	Fur	Cor		Hum			Uln			Car	Syn	Tib	Tar			Fem	Σ
Taxon	f	s	d	p	w	d	p	d	p	w	w		d	d	p	w	w	
Pelecanus sp.												1						1
P. occidentalis									1									1
Phalacrocorax sp.					2	2	3	1	2			2	1		1			14
P. auritus					1	1										1	3	6
Anserinae (small)								1			1							2
Anserinae (medium)			1		1	1	1	1			1	1						7
Branta canadensis cf. *parvipes*	1																	1
B. canadensis cf. *moffitti*		1		2			1											4
Anatinae (large)					2						1							3
Uria sp.										1								1
Bubo virginianus														1				1
Σ	1	1	1	2	6	4	5	3	3	1	3	4	1	1	1	1	3	41

Table A21. Numbers of identified bird specimens by element and portion for trench 1 (0–1 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																							
	Cra	Man	Cor		Sca	Hum			Rad			Uln		Car			Pha		Syn	Tib			Fib	Fem	Σ
Taxon	a	p	p	w	a	d	p	w	d	p	w	d	p	d	p	w	a	b		d	p	w	p	w	
Pelecanus occidentalis		1																							1
Phalacrocorax sp.						1		1				1	3	1	2					1	3	1	1		15
P. auritus						1	1						1						1					3	7
Anserinae (small)			1		1	1	1		1	2	1														8
Anserinae (medium)			1	1		3	1									1	1	1	1						10
Anatinae (large)																1									1
Buteo jamaicensis/lagopus																1									1
Numenius americanus	1																								1
Limosa fedoa						1																			1
Uria sp.						1	1																		2
Tyto alba									1											1					2
Σ	1	1	2	1	1	8	4	1	2	2	1	1	4	1	2	3	1	1	2	2	3	1	1	3	49

Table A22. Numbers of identified bird specimens by element and portion for trench 1 (1–2 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																				
	Cra	Man	Fur	Cor		Sca	Hum		Rad		Uln	Car			Syn	Tib			Tar	Fem		Σ
Taxon	f	a	s	p	w	a	d	p	d	p	w	d	p	w		d	p	w	w	d	w	
Podiceps nigricollis																1						1
Phalacrocorax sp.					2	1	3	6									2					14
P. penicillatus										1					1	1						3
P. auritus	1														2	1		1	2	1	5	13
Ardea herodias										1												1
Anserinae (small)					2		2	2					1									7
Anserinae (medium)				2	3	2	6	3						2								18
Chen caerulescens		1																				1
Anatinae (large)			1		1											1						3
Buteo lineatus									1		1											2
Grus canadensis						1																1
Tyto alba																1						1
Corvus brachyrhynchos												1										1
Σ	1	1	1	2	8	4	11	11	1	2	1	1	1	2	3	5	2	1	2	1	5	66

TABLE A23. Numbers of identified bird specimens by element and portion for trench 1 (2–3 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																																
	Cra	Ste	Fur	Cor			Sca		Hum			Rad			Uln			Car			Pha	Syn	Tib			Fib	Tar			Fem			Σ
Taxon	f	a	s	d	p	w	a	w	d	p	w	d	p	w	d	p	w	d	p	w	a		d	p	w	p	d	p	w	d	p	w	
Gavia stellata/pacifica																												1					1
Aechmophorus occidentalis/clarkii																										1					1		2
Pelecanus occidentalis																1																	1
Phalacrocorax sp.		4		3	5	4	4	1	2	3				1	4	5		1	1				4	4	1							1	48
P. penicillatus																1											1		1				3
P. auritus						1			2			1	1									2		1					2	1		4	15
Anserinae (small)		1	2				3			2										2													10
Anserinae (medium)	1	3	1		1	4	6		7	9			1						2	4	1												40
Branta canadensis cf. *moffitti*						1	1																										2
Anatinae (large)						1										1							1										3
Elanus leucurus						1																											1
Buteo sp.						1																											1
B. jamaicensis/regalis																								1									1
Fulica americana							1			1							1										1						4
Grus canadensis									1																								1
Catoptrophorus semipalmatus													1				1																2
Numenius americanus						2																											2
Limosa fedoa							1		1																								2
Uria sp.		1							1		1		1							1	1											1	7
Corvus brachyrhynchos																				2	1												3
Σ	1	9	3	3	6	15	16	1	14	15	1	1	4	1	4	8	2	1	3	9	3	2	5	6	1	1	2	1	3	1	1	6	149

TABLE A24. Numbers of identified bird specimens by element and portion for trench 1 (3–4 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																					
	Man	Cor		Cor	Sca	Hum		Rad		Uln		Car	Syn	Tib		Tar			Fem			Σ
Taxon	w	p	w		a	d	p	d	w	p	w	w		d	p	d	p	w	d	p	w	
Pelecanus occidentalis						1																1
Phalacrocorax sp.			3	3			2			5		1		2	2	1	1	1	1		1	20
P. penicillatus																					1	1
P. auritus						1							1				1				1	4
Ardea herodias																				1		1
Anserinae (small)		1	2	3	1	2	1	1					1			1						10
Anserinae (medium)			2	2	2	5	1					2										12
Chen caerulescens	1																					1
Anatinae (small)																					1	1
Anatinae (large)			2	2	1				1		1	1										6
Anas platyrhynchos							1															1
Callipepla californica																					1	1
Numenius americanus												1										1
Limosa fedoa						1																1
Corvus brachyrhynchos												1										1
Σ	1	1	9	10	4	10	5	1	1	5	1	6	2	2	2	2	2	1	1	1	5	62

TABLE A25. Numbers of identified bird specimens by element and portion for trench 1 (4–5 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																			
	Man	Ste	Fur	Cor		Sca	Hum			Rad		Car		Syn	Tib		Tar		Fem	Σ
Taxon	a	a	s	d	w	a	d	p	w	d	w	d	w		d	p	d	w	w	
Gavia immer								1												1
Phalacrocorax sp.								2							1				1	4
P. penicillatus																			1	1
P. auritus																			1	1
Anserinae (small)		1				2		1					1						1	6
Anserinae (medium)			2	1	1	1	2	6				1		1		1				16
Chen caerulescens	1																			1
Anatinae (large)					1	2	1													4
Numenius americanus						2														2
Uria sp.					1				1											2
Tyto alba							3	1		1							1			6
Corvus brachyrhynchos								1			1							1		3
Σ	1	1	2	1	3	7	6	12	1	1	1	1	1	1	1	1	1	1	4	47

Table A26. Numbers of identified bird specimens by element and portion for trench 1 (5–6 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																
	Fur	Cor		Sca	Hum		Rad	Car	Syn	Tib		Fib	Tar		Fem		Σ
Taxon	s	p	w	a	d	p	p	w		p	w	p	p	w	p	w	
Gavia stellata			1														1
G. stellata/pacifica														1			1
Phalacrocorax sp.						1				1		1			2	3	8
P. penicillatus																1	1
P. auritus			1		1						1						3
Anserinae (small)	1		1	1													3
Anserinae (medium)	2	1	6	7	4	8		3									31
Branta canadensis cf. *moffitti*						1											1
Anatinae (large)			2	1													3
Anas sp.						1											1
A. platyrhynchos						1											1
Melanitta sp.													1				1
Falco peregrinus/mexicanus			1														1
Numenius americanus			1			1											2
Larus sp. (large)						1					1						2
Strigiformes									1								1
Tyto alba						1											1
Corvus corax							1										1
Σ	3	1	13	9	5	15	1	3	1	1	2	1	1	1	2	4	63

Table A27. Numbers of identified bird specimens by element and portion for trench 1 (6–7 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																
	Ste	Fur	Cor	Sca	Hum			Uln	Car	Pha	Syn	Tar		Fem			Σ
Taxon	a	s	w	a	d	p	w	d	w	a		d	w	d	p	w	
Gavia immer												1					1
Phalacrocorax sp.			1						1								2
P. auritus													1				1
Anserinae (small)	1		1		1			1									4
Anserinae (medium)	1	2	1	3	7	6				1	1	1					23
Anatinae (large)				1													1
Anas sp.						1											1
Aythya sp.							1										1
Numenius americanus														1			1
Uria sp.																1	1
Corvus brachyrhynchos															1		1
Σ	2	2	3	4	8	7	1	1	1	1	1	2	1	1	1	1	37

TABLE A28. Numbers of identified bird specimens by element and portion for trench 1 (7–8 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)													
	Cra	Ste	Fur	Cor		Sca	Hum		Uln	Car	Pha	Syn	Tib	Σ
Taxon	a	a	s	p	w	a	d	p	w	d	a		p	
Phalacrocorax sp.					1			1						2
P. auritus	1											1		2
Ardea herodias						1								1
Anserinae (small)		1			1	1		1		1				5
Anserinae (medium)			1		2	1	3	1			1			9
Anatinae (large)				1	1	1								3
Anas sp.							1	2						3
Buteo jamaicensis/regalis													1	1
Corvus brachyrhynchos									1					1
Σ	1	1	1	1	5	4	4	5	1	1	1	1	1	27

TABLE A29. Numbers of identified bird specimens by element and portion for trench 2 (1–2 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																												
	Cra	Man				Ste	Fur	Cor		Sca	Hum			Rad	Uln			Car		Tib			Tar			Fem			Σ
Taxon	f	p	a	p	w	a	s	p	w	a	d	p	w	p	d	p	w	d	w	d	p	w	d	p	w	d	p	w	
Pelecanus occidentalis					1							2																	3
Phalacrocorax sp.								1	1			1	1			2				2	5	1		1			1		16
P. penicillatus											1	1		1														1	4
P. auritus											1					1									1			1	4
Ardea herodias																							1						1
Anserinae (small)						2			2	1	3	2			1								1						12
Anserinae (med.)	1		1				2		3	3	7	12						2											31
Chen caerulescens			1		1																								2
Anatinae (large)							1	1	3	1									2										8
Anas sp.						1																							1
A. clypeata						1																							1
Aythya sp. (large)												1																	1
Melanitta sp.					1																								1
Haliaeetus leucocephalus																										1			1
Buteo sp.												1																	1
Grus canadensis								1		1																			2
Larus sp. (large)											3																		3
Uria sp.											1	1																	2
U. aalge		1																											1
Corvus brachyrhynchos															1		1						1						3
C. corax													1																1
Σ	1	1	2	1	2	4	3	3	9	6	16	21	2	1	2	3	1	2	2	2	5	1	3	1	1	1	1	2	99

TABLE A30. Numbers of identified bird specimens by element and portion for trench 2 (2–3 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																													
	Cra		Man		Ste	Fur	Cor			Sca	Hum		Rad			Uln			Car			Pha	Syn	Tib			Tar	Fem			Σ
Taxon	a	f	a	p	a	s	d	p	w	a	d	p	w	d	p	d	p	w	d	p	w	a		d	p	w	d	d	p	w	
Gavia stellata										1																					1
G. stellata/pacifica																											1				1
Pelecanus occidentalis																	1										1				2
Phalacrocorax sp.																1	1							3	1	1			1		8
P. penicillatus																							2								2
P. auritus									3		3				1			1												3	11
Anserinae (small)					1	3		1	4	1	1	2			1								1				2				17
Anserinae (medium)			1	1	1	2	1	2	4	10	6	9		1		1	1		1	3	2	4					1				51
Chen caerulescens	2																														2
Branta canadensis cf. *parvipes*		1																													1
Anatinae (large)						1			1	1																					3
Anas sp.					1																										1
Melanitta sp.												1																			1
Bucephala albeola													1																		1
Buteo jamaicensis											1	1																			2
Limosa fedoa	1																														1
Limnodromus sp.																		1													1
Larus sp. (large)							1				1																				2
Uria sp.											1		1											1						1	4
Asio sp.												1																			1
Tyto alba																								1							1
Corvus brachyrhynchos					1					1		2				1															5
C. corax																									1		1	1			3
Σ	3	1	1	1	4	6	2	3	12	14	13	16	2	1	2	3	3	2	1	3	2	4	3	5	2	1	6	1	1	4	122

TABLE A31. Numbers of identified bird specimens by element and portion for trench 2 (3–4 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																												
	Cra		Man			Ste	Fur	Cor			Sca	Hum			Rad		Uln			Car			Pha	Syn	Tib			Tar		Fem	Σ
Taxon	a	f	a	p	w	a	s	d	p	w	a	d	p	w	d	p	d	p	w	d	p	w	a		d	p	w	d	w	p	
Gavia stellata	1																					2				1					4
Podiceps nigricollis																											1				1
Phalacrocorax sp.												2		1			3	1								1					8
P. penicillatus													1		2	2															5
P. auritus												1			2				1	1	1	3							1		10
P. penicillatus/auritus																			1												1
P. pelagicus																									1						1
Ardea herodias																												1			1
Anserinae (small)			1				2			2	1	1	4																		11
Anserinae (medium)			2		1	1	2	1	4	3	3	4	11								1	2	4	2	1	1		1			44
Chen caerulescens				1																											1
Branta canadensis cf. *parvipes*		2																													2
B. canadensis cf. *moffitti*				1																											1
Anatinae (large)										1	1																				2
Melanitta sp.												1																			1
Rallus longirostris																														1	1
Fulica americana																	1														1
Numenius americanus						1						1																			2
Bubo virginianus																													2		2
Corvus brachyrhynchos																		1	1						1						3
Σ	1	2	3	2	1	2	4	1	4	6	5	10	16	1	4	2	4	2	3	1	2	7	4	2	3	3	1	2	3	1	102

TABLE A32. Numbers of identified bird specimens by element and portion for trench 2 (4–5 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																												
	Man			Ste	Fur	Cor			Sca	Hum		Rad			Uln	Car		Pha	Syn	Tib			Fib	Tar			Fem		Σ
Taxon	a	p	w	a	s	d	p	w	a	d	p	d	p	w	d	d	w	a		d	p	w	p	d	p	w	d	w	
Gavia immer																	1												1
Podiceps auritus/nigricollis																			1										1
Aechmophorus occidentalis/clarkii																			1										1
Phalacrocorax sp.				1																	2	1	1					1	6
P. penicillatus											1																	1	2
P. auritus										1		1		1													1		4
Ardea herodias		1																											1
Anserinae (small)				1					1	3	2								1					1					9
Anserinae (medium)					2	1	2	4	1	4	5					1		2		1					1				24
Chen caerulescens			1																										1
Anatinae (small)													1																1
Anatinae (large)	1							3	1			1			1		2			1								1	11
Aythya valisneria											1																		1
Melanitta sp.										1	1																		2
Buteo sp.																									1				1
Grus canadensis									1																				1
Numenius americanus									1																				1
Uria sp.				1							1																		2
Bubo virginianus																										2			2
Tyto alba															1														1
Corvus brachyrhynchos																				2									2
Σ	1	1	1	3	2	1	2	7	5	9	11	2	1	1	2	1	3	2	3	4	2	1	1	1	2	2	1	3	75

TABLE A33. Numbers of identified bird specimens by element and portion for trench 2 (5–6 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																											
	Cra	Man	Ste	Fur	Cor		Sca		Hum			Rad		Uln		Car		Pha	Syn	Tib			Fib	Tar		Fem			Σ
Taxon	a	p	a	s	p	w	a	w	d	p	w	d	p	d	p	p	w	a		d	p	w	p	d	w	d	p	w	
Gavia stellata																1					1								2
Podiceps nigricollis																						1							1
Phalacrocorax sp.					2				2		1			2						2	1		1						11
P. penicillatus		3				1		1		2																			7
P. auritus	1					2		1	2	1			1			1													9
P. penicillatus/auritus																			1										1
P. pelagicus																												1	1
Ardea herodias																								1					1
Cathartes aura																			1										1
Anserinae (small)			1	1			1		2	4														1		1	1		12
Anserinae (medium)				1	2	3	4		6	9							1	1					1	1			1		30
Anatinae (large)					4	8	4					1		1						2	2							2	24
Melanitta sp.										3									2										5
Bucephala clangula/islandica																			1										1
Elanus leucurus														1															1
Numenius americanus	1																												1
Larus sp. (large)									1																				1
Uria sp.																						1						1	2
Bubo virginianus																				1									1
Tyto alba																									1				1
Corvus brachyrhynchos									1						1		2												4
C. corax										1			1																2
Σ	2	3	1	2	8	14	9	2	14	20	1	1	2	4	1	2	3	1	5	5	4	2	2	3	1	1	2	4	119

TABLE A34. Numbers of identified bird specimens by element and portion for trench 2 (6–7 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																														
	Cra	Man	Ste	Fur	Cor			Sca	Hum			Rad			Uln			Car			Pha	Syn	Tib			Tar			Fem			Σ
Taxon	a	p	a	s	d	p	w	a	w	d	p	w	d	p	w	d	p	w	d	w	a		d	p	w	d	p	w	d	p	w	
Gavia stellata							1				1																					2
G. stellata/pacifica																						1				1	1					3
G. immer											1															1						2
Aechmophorus occidentalis/clarkii																						1										1
Pelecanus erythrorhynchos																														1		1
Phalacrocorax sp.			1				1			1	6					1	3						2	16	4				1	1	7	44
P. penicillatus		1							1																			1				3
P. auritus	1				1		2		1	4	2	2					1	1										1	1	1	2	20
Anserinae (small)				1				1		2	2				1				1													8
Anserinae (medium)			2			3	2	3		1	7		1								1	1										21
Anatinae (small)					1																											1
Anatinae (large)							4	4						1		1						1		2								13
Anas sp.										1																						1
A. platyrhynchos										1	1																					2
Aythya cf. *valisneria*											1																					1
Melanitta sp.			1								3																	3				7
Haliaeetus leucocephalus																				1												1
Buteo sp.																	1															1
B. regalis														1																		1
Callipepla californica																														1		1
Grus canadensis		1					1																									2
Numenius americanus			1								2																					3
Uria sp.							1															1	1		1							4
Corvus brachyrhynchos																	1															1
C. corax																										1						1
Σ	1	2	5	1	2	3	12	8	2	10	26	2	1	2	1	2	6	1	1	1	1	5	3	18	5	3	1	5	2	4	9	145

TABLE A35. Numbers of identified bird specimens by element and portion for trench 3 (0–1 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																
	Fur	Cor	Sca	Hum			Rad		Uln	Car		Syn	Tib			Tar	Fem	Σ
Taxon	s	w	a	d	p	w	d	p	p	p	w		d	p	w	w	w	
Phalacrocorax sp.		1		2	2				1				2	1	2	1	1	13
P. penicillatus																	1	1
P. auritus											1	1					4	6
Ardea herodias			1															1
Anserinae (small)		1						1										2
Anserinae (medium)	2	2	1	2	2					2								11
Anatinae (large)		2	2								1			1				6
Melanitta sp.				1												1		2
Buteo sp.							1											1
B. jamaicensis					1													1
Uria sp.		1				1												2
Σ	2	7	4	5	5	1	1	1	1	2	2	1	2	2	2	2	6	46

TABLE A36. Numbers of identified bird specimens by element and portion for trench 3 (1–2 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																									
	Ste	Cor			Sca		Hum		Rad	Uln			Car			Pha	Syn	Tib			Fib	Tar		Fem		Σ
Taxon	a	d	p	w	a	w	d	p	p	d	p	w	d	p	w	a		d	p	w	p	p	w	p	w	
Phalacrocorax sp.	3			6	8		3	6	2	1	4				1	1	1	2	3	4			2	1		48
P. penicillatus																							1			1
P. auritus		1		1		1		2	1														2		6	14
P. penicillatus/auritus																							1			1
Anserinae (small)				1				1					1													3
Anserinae (medium)	3		2		2		8	6						1				1				1				24
Anatinae (large)				2	1						1				1											5
Melanitta sp.								1																		1
Buteo sp.				1																						1
Grus canadensis														1		1										2
Pluvialis squatarola												1														1
Numenius americanus					1			1							1		1									4
Uria sp.					1		1	4											1		1					8
Corvus brachyrhynchos								1																		1
Σ	6	1	2	11	13	1	12	22	3	1	5	1	1	2	3	2	2	3	4	4	1	1	6	1	6	114

TABLE A37. Numbers of identified bird specimens by element and portion for trench 3 (2–3 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																		
	Cra	Ste	Fur	Cor			Sca	Hum			Rad		Uln	Car	Syn	Tib	Fem		Σ
Taxon	a	a	s	d	p	w	a	d	p	w	p	w	w	w		d	p	w	
Phalacrocorax sp.						3		1								1			5
P. penicillatus									1										1
P. auritus	1							2						1	1			1	6
Anserinae (small)						1		1	2								1		5
Anserinae (medium)		3		1	2	3	1	4	4					1					19
Anatinae (large)			1		1	1													3
Anas clypeata															1				1
Aythya sp.		1																	1
Buteo jamaicensis		1																	1
Falco columbarius										1									1
Grus canadensis							1												1
Numenius americanus									1										1
Larus sp. (large)								1											1
Uria sp.									1	1	1	2							5
Bubo virginianus						1													1
Tyto alba						1													1
Corvus brachyrhynchos														2					2
C. corax													1						1
Σ	1	5	1	1	3	10	2	9	9	2	1	2	1	4	2	1	1	1	56

TABLE A38. Numbers of identified bird specimens by element and portion for trench 3 (3–4 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																								
	Cra	Man		Ste	Fur	Cor			Sca		Hum			Uln		Car	Pha	Syn	Tib			Tar		Fem	Σ
Taxon	a	a	p	a	s	d	p	w	a	w	d	p	w	d	p	w	a		d	p	w	d	p	w	
Aechmophorus occidentalis/clarkii														1											1
Phalacrocorax sp.							1					2			1				3	3				1	11
P. auritus			1																						1
Anserinae (small)					1		2	2	1																6
Anserinae (medium)	1				1	1		6	4		2	12				1	1								29
Chen caerulescens		2																							2
Anatinae (large)	1						1	4	1																7
Anas sp.				2								1													3
A. platyrhynchos												1													1
Melanitta sp.											1	1						1							3
Buteo jamaicensis												1						1				1	1		4
Falco peregrinus														1											1
Catoptrophorus semipalmatus												1													1
Numenius americanus				1							1														2
N. phaeopus																					1				1
Uria sp.													1												1
Bubo virginianus										1															1
Corvus brachyrhynchos															1										1
C. corax														1			1								2
Σ	2	2	1	3	2	1	4	12	6	1	4	19	1	3	2	1	2	2	3	3	1	1	1	1	78

Table A39. Numbers of identified bird specimens by element and portion for trench 3 (4–5 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																						
	Cra	Man		Ste	Fur	Cor			Sca		Hum		Rad		Uln			Syn	Tib	Fib	Tar		Fem	Σ
Taxon	a	a	p	a	s	d	p	w	a	w	d	p	d	p	d	p	w		w	p	d	w	d	
Phalacrocorax sp.						1		1					1											3
P. penicillatus																					1			1
P. auritus	1							1		1													1	4
Anserinae (small)					2		1	2	1		2	1						1						10
Anserinae (medium)		1		3				1	3		5	4						1		1		1		20
Branta canadensis cf. *parvipes*			1																					1
Anatinae (large)							1	6	1					1	1	1		1						12
Anas sp. (teal)				1																				1
Anas sp.																		1						1
A. platyrhynchos												1												1
Bucephala sp.												1												1
Buteo sp.																					1			1
Falco peregrinus			1																					1
Rallus longirostris												1												1
Catoptrophorus semipalmatus				1																				1
Numenius americanus	1			1				1				1												4
N. phaeopus/*Limosa fedoa*																		1						1
Larus sp. (large)											1													1
Uria sp.												1							1					2
Bubo virginianus																					1			1
Tyto alba																						1		1
Corvus brachyrhynchos												1			1									2
C. corax															1		1							2
Σ	2	1	2	6	2	1	2	12	5	1	8	11	1	1	3	1	1	5	1	1	3	2	1	73

TABLE A40. Numbers of identified bird specimens by element and portion for trench 3 (5–6 ft), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)																							
	Cra	Man		Ste	Fur	Cor			Sca	Hum		Rad	Uln	Car		Pha	Syn	Tib			Tar			Fem	Σ
Taxon	a	a	w	a	s	d	p	w	a	d	p	w	d	d	w	a		d	p	w	d	p	w	p	
Gavia stellata/pacifica																							1		1
Aechmophorus occidentalis/clarkii																						1			1
Phalacrocorax sp.																		1	2	2					5
P. auritus	1							1																	2
Anserinae (small)					1			1		1	1			1	2		2								9
Anserinae (medium)				1			2	3	5	3	6				1	2		1			1				25
Chen caerulescens		2	1																						3
Anatinae (large)						2		6											2					2	12
Aythya sp.																	1								1
Melanitta sp.																	1								1
Buteo sp.									1																1
B. jamaicensis											1														1
Falco peregrinus																							1		1
Rallus longirostris											1														1
Numenius americanus	1																								1
Larus sp. (large)							1								1										2
Larus sp. (small)												1													1
Uria sp.									1																1
Corvus brachyrhynchos								1			1		1												3
Σ	2	2	1	1	1	2	3	12	7	4	10	1	1	1	4	2	4	2	4	2	1	1	2	2	72

TABLE A41. Numbers of identified bird specimens by element and portion for trench 3 (6–7 ft), Schenck excavation. Abbreviations same as Table A1.

Taxon	Element (portion)																	Σ
	Cra		Man		Cor			Sca		Hum		Uln	Syn	Tib	Tar	Fem		
	f	p	a	p	d	p	w	a	w	d	p	d		d	d	p	w	
Gavia stellata														1				1
Pelecanus occidentalis											1							1
Phalacrocorax sp.											1							1
P. auritus									2									2
Anserinae (small)			1				2	1					3					7
Anserinae (medium					1	1	3	2		2	1		1		1	1		13
Chen caerulescens	1																	1
Branta canadensis cf. *parvipes*		1		1														2
Anatinae (large)					1		2						2					5
Melanitta sp.													1					1
Grus canadensis										1								1
Larus sp. (large)												1						1
Corvus brachyrhynchos											2						1	3
Σ	1	1	1	1	2	1	7	3	2	3	5	1	7	1	1	1	1	39

TABLE A42. Numbers of identified bird specimens by element and portion for trench 3 (7–8 ft), Schenck excavation. Abbreviations same as Table A1.

Taxon	Element (portion)																			Σ
	Cra	Fur	Cor		Sca	Hum		Rad		Uln		Car		Pha	Tib		Tar	Fem		
	a	s	p	w	a	d	p	d	p	d	p	p	w	a	p	w	w	p	w	
Gavia stellata											1									1
Phalacrocorax sp.						1	2			1					2	2		1	1	10
P. auritus	1			1													1		1	4
Cathartes aura								1												1
Anserinae (small)			1	1	3	1	1													7
Anserinae (medium)		1		2	1	1	2		1					1						9
Anatinae (large)				4	1						1									6
Melanitta sp.							1													1
Bucephala clangula/islandica							1													1
Grus canadensis												1								1
Numenius americanus													1							1
Σ	1	1	1	8	5	3	7	1	1	1	2	1	1	1	2	2	1	1	2	42

TABLE A43. Numbers of identified bird specimens by element and portion for trench 3 (8 ft to 8 ft 6 in), Schenck excavation. Abbreviations same as Table A1.

	Element (portion)											
	Cor	Sca	Hum		Rad	Uln		Syn	Tib	Tar	Fem	Σ
Taxon	p	a	d	p	p	d	p		d	p	p	
Pelecanus occidentalis											1	1
Phalacrocorax sp.		1							1	1		3
P. auritus					1							1
Anserinae (small)						1						1
Anserinae (medium)	1	1		1								3
Anatinae (large)								1				1
Melanitta sp.			1									1
Corvus brachyrhynchos							1					1
Σ	1	2	1	1	1	1	1	1	1	1	1	12