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Evaluating Native American Bird Use and Bird Assemblage Variability along the Oregon Coast

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ABSTRACT

Native American use of birds on the Oregon coast is not well known and has never been synthesized to present a regional understanding. We rectify this by analyzing data from 26 zooarchaeological assemblages, including three previously unpublished bird assemblages: Umpqua/Eden (35DO83), Whale Cove (35LNC60), and the Dunes Site (35CLT27). We employ a series of non-parametric randomization tests to directly evaluate patterns of taxonomic diversity, correlations with nearby breeding colonies, and broader procurement strategies discussed in ethnohistorical accounts. We compare the assemblages to contemporary surveys of naturally beached birds as observed by COASST (Coastal Observation Seabird Survey Team) and evaluate whether archaeological specimens were scavenged from the beach. While 71% of the identified bird remains belong to just three families (Anatidae, Alcidae, and Procellariidae), closer analysis reveals the incredible diversity of birds used by Oregon coast Native Americans. The assemblages vary considerably in terms of taxonomic diversity and composition, leading us to conclude that people used birds opportunistically, likely incorporating multiple strategies, including hunting, collecting beached carcasses and targeting cormorant colonies. We hope that the methods and approaches employed here will inspire other archaeologists to devote more attention to bird assemblages, and how their study can inform conservation efforts.

INTRODUCTION

Even though bird bones are common in Oregon (USA) coast archaeological sites, ethnographic information regarding the use of birds by local Native Americans is extremely limited (Hall 2001:20-22; Minor and Toepel 1986:63). Beyond brief mentions in early reports (e.g., Drucker 1939; Kroeber 1939), bird use in this region has not been widely discussed. From the Lewis and Clark expedition, we know that birds were so numerous—and loud—that at least some of the

explorers could not sleep for the noise (Moulton 1990:21). Suttles (1990:27) suggests birds were more important in the Pacific Northwest Coast than often assumed, with waterfowl “vastly more important” than terrestrial birds. The degree to which different birds were hunted for food, their eggs gathered, their feathers and skins used to make clothing or regalia, or their bones made into tools is not well documented. Birds have received less attention by zooarchaeologists in the Pacific Northwest Coast than fish or mammals, perhaps because they are often less abundant in these sites (Butler and Campbell 2004; Lindsay 1995).

Yet we now have an adequate number of systematically analyzed bird assemblages to begin outlining general patterns of bird use and raising questions to direct future research. Analyses of bird bones can provide information on pre-contact dietary practices, site seasonality, foraging locations, hunting and processing strategies, and dynamic coastal environments. We examine which birds were used, how they were likely obtained, and how taxonomic abundance and diversity vary by location, using original data from Umpqua/Eden (35DO83), Whale Cove (35LNC60), and the Dunes Site (35CLT27) and published data from 23 other Oregon coast sites. The methods and observations from these assemblages will be relevant to researchers studying birds in coastal settings worldwide.

BACKGROUND AND CONTEXT

Oregon Coast Environments and Cultures

The Oregon coast is located within the southern part of the Pacific Northwest Coast culture area, which extends from Icy Bay, Alaska, to northern California (Moss 2011). The 480 km-long coastline consists of rocky shorelines, headlands, and sandy beaches. Oregon is part of the Northern California Current Ecoregion, a transitional zone between colder subarctic waters of the Gulf of Alaska and subtropical waters off Baja California (OCMP 2016). The continental

shelf off Oregon is narrower, steeper, and deeper than average, contributing to a pelagic zone that is only 14 to 64 km offshore (Byrne 1962:67). Seasonal upwelling is typical (Bograd et al. 2009), with a switch from winter downwelling (on-shore flow of surface waters associated with wind direction and storm events) to summer upwelling (off-shore flow of surface waters bringing cold, nutrient-rich bottom waters to the surface). Timing of this spring transition and intensity of the upwelling season affect coastal productivity (Barth et al. 2007), including the reproductive success and mortality rates of coastal seabirds (Parrish et al. 2007).

In the early 1800s, the Oregon coast was occupied by diverse Native American tribes, including (from north to south) various bands of Chinook, Clatsop, Tillamook, Alsea, Siuslaw, Umpqua, Coos, Coquille, Tututni, and Tolowa (Figure 1). Linguistic data suggest that representatives of three language phyla (Na-Dene, Salishan, and Penutian) and at least five language families (Athapaskan, Chinookan, Alsean, Siuslaw, and Coos) were spoken (Thompson and Kinkade 1990). Cultural differences among Oregon coast groups are due to different adaptations to various Oregon coast environments and diverse origins. People were in central Oregon by at least 14,000 years ago (Jenkins et al. 2014), though the earliest date for a coastal archaeological site is ca. 9000 cal BP (35CU67; Moss and Erlandson 1998). The relative scarcity of early sites along the Oregon coast is due to post-glacial sea level rise, episodic tectonic subsidence, tsunamis, landslides, severe coastal erosion, accumulation of extensive dunes during the middle and late Holocene, and the evolution of former estuaries into lakes (Lyman 1991; Moss and Erlandson 2008). The most substantial bird assemblages studied thus far date to the late Holocene (3000 to 400 cal BP); this is the time period on which we focus.

Birds of the Oregon Coast

A diversity of birds is found on the Oregon coast, including seabirds, shorebirds, and waterfowl. Table 1 summarizes the pertinent life history information for some of the most common taxa found in archaeological sites in the region. We organize these taxa into three categories based on geographic distribution and natural history: waterfowl (ducks/geese), coastal seabirds that nest along the Oregon coastline, and pelagic (open water) seabirds nesting outside the Pacific Northwest and migrating into Oregon waters (predominantly during the non-breeding season).

Waterfowl (Anatids)

Anatidae is a large family, with 7 species of geese and swans (Anserinae), 10 dabbling ducks (Anatini), 5 pochards/bay ducks (Aythini), 11 sea ducks (Mergini) and the Ruddy Duck (*Oxyura jamaicensis*) present in coastal Oregon. Dabbling ducks/geese feed on plants or small mollusks in a variety of shallow water and terrestrial habitats. Diving ducks (pochards and sea ducks) generally winter in the Pacific Northwest, and migrate to and from their breeding grounds in northern regions or interior lakes in the spring and fall. Diving ducks, such as scoters, feed on fish and shellfish in deeper waters including estuaries and exposed coastal habitats, and can be found in large congregations.

Nesting Seabirds

The Common Murre (*Uria aalge*) is the largest (800-1300 g) and most abundant alcid breeding along the Pacific Northwest Coast, comprising over half of all seabirds nesting in Oregon (Naughton et al. 2007a:5). Breeding commences in April, with eggs appearing in May (Gladics et al. 2015). Breeders remain on-colony until July, and then disperse throughout the nearshore ecosystem of the Pacific Northwest (Gladics et al. 2015). Following breeding, Pacific Northwest murre have a flightless molt period in September-November (Jones et al. 2017). Four other alcid species breed within the nearshore ecosystem of Oregon: Tufted Puffin (*Fratercula cirrhata*),

Rhinoceros Auklet (*Cerorhinca monocerata*), Cassin's Auklet (*Ptychoramphus aleuticus*), and Pigeon Guillemot (*Cepphus columba*), albeit all in much lower numbers than murre (Naughton et al. 2007a). During the fall post-breeding season, larger numbers of both auklet species can be found in Oregon coastal shelf waters, as tens to hundreds of thousands of individuals from Washington and British Columbia colonies migrate south (Gaston and Dechesne 1996; Manuwal and Thoresen 2011).

Cormorants include the Double-crested (*Phalacrocorax auritus*), Brandt's (*P. penicillatus*) and Pelagic Cormorant (*P. pelagicus*), all of which nest on rocky spires, outcroppings and predator-free offshore islands. Double-crested cormorants also nest within estuarine systems, on islands throughout the Columbia River system, and in a variety of inland freshwater lakes (Wiese et al. 2008). Western (*Larus occidentalis*) and Glaucous-winged gulls (*L. glaucescens*) nest along the Oregon coastline in a wide range of habitats. During the fall post-breeding season, at least 8 other gull species migrate into Oregon estuarine and coastal waters to over-winter (Naughton et al. 2007a:14).

Migratory Seabirds (Pelagics)

Millions of marine birds breed entirely outside of the Pacific Northwest and migrate to or through Oregon waters during the non-breeding season. Of these, the most numerous are the highly pelagic procellariids: albatrosses, shearwaters, and Northern Fulmar (*Fulmarus glacialis*). Three species of albatrosses breed in the western Pacific and migrate to the Oregon coast in spring: the regularly sighted Black-footed (*Phoebastria nigripes*), rare Laysan (*P. immutabilis*) and truly rare Short-tailed (*P. albatrus*). Short-tails are still recovering from near extinction in the 1920s due to commercial over-exploitation (USFWS 2017), but were historically as abundant as the other two albatross species (Guy et al. 2013). While the suggestion has been made that the

distribution of the Short-tailed Albatross was once closer to shore based on their relative abundance in archaeological sites (e.g., Bovy 2005; Greenspan and Wigen 1991; Miller 1940:231), this may be more a reflection of their former absolute abundance in the coastal shelf marine bird community, as current evidence indicates Short-tails concentrate primarily at the shelf break (Kuletz et al. 2014).

Sooty Shearwaters (*Ardenna grisea*)¹ are the most abundant shearwater in the California Current System (Veit et al 1997). These birds breed in large colonies in the Southern Hemisphere, then migrate north during the austral winter to locations throughout the North Pacific, Bering and Chukchi seas (Shaffer et al. 2006). Sooty Shearwaters are the most abundant bird in recent summer surveys off the Pacific coast and second most abundant in fall over inner-shelf waters (between 0 and 100 m offshore; Adams et al. 2014:23-24). In contrast to albatrosses and shearwaters, Northern Fulmar breed in Alaska, migrating south down both sides of the North Pacific following breeding (Hatch et al. 2010).

Bird Hunting and Collecting Strategies

Ethnographic accounts in the Pacific Northwest Coast (and worldwide) include a range of bird hunting and collecting strategies (Serjeantson 2009; Suttles 1990). Yet distinguishing between various strategies (e.g., hunting vs. scavenging) in the archaeological record is challenging (Bovy et al. 2016; deFrance 2005). We organize ethnohistorical and archaeological information on bird procurement in the Pacific Northwest Coast into four strategies.

Nearshore Hunting

Oregon coast peoples had access to a variety of nearshore habitats, including estuaries, marshes, bays, tideflats, eelgrass beds, and open waters within a few kilometers of shore. All but the most

¹ The American Ornithological Union (AOU) recently changed the name for Sooty Shearwaters from *Puffinus griseus* to *Ardenna grisea* (Chesser et al. 2016) based on recent genetic work; most other shearwaters are also now in the genus *Ardenna*, rather than *Puffinus* (AOU 2017).

offshore birds may have been hunted in the nearshore during certain times of the year (Table 1), using bow and arrow, spears, hook and line, traps or snares. Beckham (1977:70-71) described a Tillamook method for taking waterfowl in estuaries, where men waded among the flocks wearing basketry decoys over their heads. Further north, submerged and hanging nets were used to catch large numbers of waterfowl (Suttles 1990:459).

Hunting on Breeding Colonies

Breeding colonies of seabirds may provide a relatively predictable and plentiful source of fledgling birds and eggs, and sustainable egg collection is still a staple of indigenous diets in coastal Alaska (Moss 2007; Moss and Bowers 2007; Zador et al. 2006). Adult birds may also be more vulnerable to hunting when tending their young. Ethnographic and ethnohistoric accounts discuss Native American hunting of fledgling cormorants in northern California (Gould 1966:85) and Netarts Bay (Losey 2002:81), and Barnett (1937:165) noted use of cormorant and gull eggs by several Oregon coast groups. Medullary bone and juvenile bones (indicated by porous texture and unfused epiphyses) could indicate colony exploitation for most species, although juvenile bird bones may remain unidentified or under-reported due to lack of comparative specimens or difficulties in distinguishing older juveniles (3-4 months) from adults (e.g., Bovy 2011). While many seabirds mature quickly and fledge close to adult weight (e.g., 90% for Cassin's Auklet; Ainley et al. 1990), the Common Murre is an exception at 17-24% (Ainley et al. 2002).

Offshore Hunting

Although some have questioned whether Oregon coast peoples ventured onto the open ocean in canoes for hunting, fishing, or birding (e.g., Lyman 1995), ethnographic research indicates ocean-going canoes were used at least occasionally (Andrews 1962:138; Minor 2001; Ray 1938:102), and archaeological analysis supports opportunistic whale hunting (Losey and Yang

2007; Wellman et al. 2017). The presence of pelagic seabirds in archaeological assemblages has been interpreted as evidence for offshore hunting (e.g., Greenspan and Wigen 1991; Ulrich 2009). North Pacific procellariids are attracted to modern fishing vessels (Edwards et al. 2015) and may have tracked offshore fishers and marine mammal hunters in the past, perhaps through chumming (DePuydt 1994). Breeding birds were available on offshore islands, such as Goat Island on the southern Oregon coast (Gard 1990).

Collecting Beached Carcasses

Researchers in coastal regions worldwide have recognized that beached birds could be a source of bones or feathers for tool/ornament production (see references in Bovy et al. 2016). The relative abundance of remains and/or skeletal part frequency (e.g., an abundance of wing bones) has been used to argue either for or against beach scavenging (e.g., Bovy 2002; deFrance 2005; Eda et al. 2016; Jerardino et al. 2009; Losey 2002), however, Bovy et al. (2016) found these approaches of limited utility. While any aquatic bird may end up on the beach, some occur more frequently than others (Table 1); therefore relative taxonomic abundance may indicate a scavenged assemblage. Larger numbers of beached carcasses may be available during mass mortality events or “wrecks,” when birds are deposited on the beach after large storms or following reproductive failure or food shortages (Bovy et al. 2016; deFrance 2005). Many of these “wreck” carcasses are relatively fresh and intact and could be used for meat (e.g., Work and Rameyer 1999). On the Oregon coast, pelagic birds are often assumed to have been collected off the beach (Hall 2001; Losey 2002:289).

MATERIALS AND METHODS

New Primary Data

Original, unpublished identifications by the authors are drawn from collection-based projects from three sites excavated prior to 1986: Umpqua/Eden (Bovy 2005), Whale Cove (Watson 2011), and the Dunes Site (Ulrich 2009). At Umpqua/Eden and Whale Cove, ¼” screens were used to recover the faunal remains, undoubtedly resulting in the loss of small bird bones. From the Dunes Site, we have no information as to whether screens were used. Bird remains were identified to the lowest possible taxonomic level using comparative collections from the Burke Museum of Natural History and Culture at the University of Washington (Umpqua/Eden, Whale Cove), Museum of Comparative Zoology at Harvard (Whale Cove), and the North Pacific collection at the University of Oregon’s Department of Anthropology (Dunes), along with published criteria (e.g., Broughton 2004; Woolfendon 1961). Vertebrae and ribs were not identified beyond the class level (for all analysts), and Ulrich did not identify phalanges (except phalanx I of digit II). Bovy used both morphological and metric criteria to identify taxa, and did not identify small passerines. All assemblages were quantified using NISP (Number of Identified Specimens), which is primary data (not secondary, derived data like Minimum Number of Individuals; Grayson 1984; Reitz and Wing 2008), and allows comparison with other assemblages (see below).

Site 1: Umpqua/Eden

Umpqua/Eden (35DO83) is situated on the south/central Oregon coast within the territory of the Penutian-speaking Lower Umpqua or Kalawatset (Lyman 1991). The site is located on a high terrace along the Umpqua River, about 3.2 km from the river mouth. Excavations began with Peter Stenhouse (unpublished), were continued by Richard Ross with an Oregon State University (OSU) field school from 1978 to 1980 (Ross and Snyder 1979, 1986), and later by Rick Minor (1994; Minor et al. 2012). Lyman (1991) summarized and analyzed mammal remains from the

Ross excavations, while Bovy analyzed the bird remains in her dissertation (2005), which focused on the effects of environmental change and human hunting on past waterbird populations. Ross and Snyder (1986) believed the site was continuously occupied for 3000 years, but with additional dating, Bovy (2005) found that the bulk of the deposits accumulated during two periods: 2280-1775 cal. BP and 900-250 cal BP. A 900-year long hiatus in site occupation, or at least faunal accumulation, occurred between 1800 and 900 cal BP.

Table 2 provides data on the 1553 bird bones from Umpqua/Eden. Ducks dominate the assemblage (n=1120; 72%), followed by cormorants (n=94; 6%), loons (n=86; 6%), geese (n=74; 5%), eagles/hawks (n=44; 3%) and gulls (n=44; 3%)². Waterfowl are the most abundant taxon in both the early and later components. Eelgrass occurs in coves both north and south of Umpqua/Eden (Gaumer et al. 1973:26), and dense flocks of Surf (*Melanitta perspicillata*) and White-winged Scoters (*M. fusca*) have been observed near the Umpqua River during November (Briggs et al. 1992:A-49). Given that the most abundant ducks recovered were scoters, pochards, and Buffleheads (*Bucephala albeola*), and that herring and harbor seal (*Phoca vitulina*) were also abundant (Minor 1994; Lyman 1991), site occupants may have been targeting these productive eelgrass patches, in addition to the estuarine tideflats. Bovy (2005) identified a wide range of bird species at Umpqua/Eden, but found little change in the taxonomic composition over the site's occupation, perhaps indicating environmental stability.

Site 2: Whale Cove

Whale Cove (35LNC60) occurs within areas encompassed by the territories of the Siletz (Salish speakers) in the north and the Yaquina (Penutian speakers) in the south (Ruby and Brown 1986). Ann Bennett Rogers (Bennett 1988) excavated the site in 1985 as part of an OSU field school. Located on a bluff near Depoe Bay in northern Oregon, the site contained three strata dated to

² This does not include 1 kittiwake bone.

3010-330 BP, including dense shell midden layers (Bennett and Lyman 1991). Bovy and Watson examined the avifauna in 2011 as part of Watson's undergraduate honors project at the University of Rhode Island (Watson 2011), in order to help evaluate the seasonality of the site. Most identified bird bones derive from Whale Cove I (WCI), a component dating ca. 3010-2830 BP (Bennett and Lyman 1991:244).

The Whale Cove bird assemblage is small (NISP=106) but diverse (Table 2). The most abundant taxa were ducks and geese (n=46; 43%), albatrosses and shearwaters (n=21; 20%), puffins and Common Murres (n=15; 14%), gulls (n=12; 11%) and cormorants (n=8; 7%). Watson (2011) suggested that the bird bones indicate year-round rather than seasonal occupation based on the presence of albatross and puffin (thought to be present in summer only), scoter and Northern Fulmar (fall and winter), and a juvenile cormorant (spring).

Site 3: The Dunes Site

The Dunes Site (35CLT27) is located in the Clatsop Plains dunes system, which extends 30 km south from the mouth of the Columbia River to Tillamook Head. It is positioned 1.2 km from the current shoreline, 500 meters east of Neacoxie Creek just north of the town of Gearhart, and at 15-20 m above sea level (Harrison and Longo 1991). The Lower Chinook occupied both banks of the Columbia River from the mouth to about 50 miles upstream (Ray 1938; Silverstein 1990). The Lower Chinook included the Chinook proper who occupied the north bank (to Willapa Bay) and the Clatsop who occupied the south bank (to Tillamook Head), including the Dunes Site location. The Dunes Site was occupied ca. 950-550 cal BP, and was excavated by Fred Hasle and field school students from Clatsop Community College from 1972 to 1974 (Harrison and Longo 1991). Faunal remains are housed at the University of Oregon's Museum of Natural and Cultural History. The large assemblage of bird bones was unexamined for 30 years, until Moss and

students began to tackle the project (Rose et al. 2006). Ulrich selected the site for her M.S. project, under the direction of Moss, to investigate bird use, site seasonality, and the dynamic nature of the coastal environment near the site, including the westward progradation of extensive dunes south of the Columbia River (Connolly 1992).

Ulrich's analysis yielded 2230 NISP (Table 2); as of this writing, this represents the largest archaeological bird assemblage (from a single site) from the Oregon coast yet identified. Birds from 14 families were identified, with Common Murre (n=594; 27%), scoters (n=464; 21%), and shearwaters (n=453; 20%) dominating the assemblage. Next in abundance were other ducks and geese (n=129, 6%), Cassin's Auklets (n=128, 6%), albatrosses (n=71, 3%) loons (n=60, 3%), and gulls (n=57, 3%). Also identified are other small alcids, cormorants, Northern Fulmar, and Black-legged Kittiwake (*Rissa tridactyla*). Through analysis of the taxonomic composition and consideration of the habitat requirements of the most common birds, Ulrich (2009) inferred that the Dunes Site was used during multiple seasons, was located on or very near the shoreline when occupied, and its residents made use of both outer coast and nearshore environments. Ulrich (2009) suggested that the high numbers of scoters, relative to other ducks, indicated outer coastal as opposed to estuarine use.

Comparative Bird Data

Bovy and Watson compiled data from 23 additional bird assemblages on the Oregon coast (Figure 1, Table 3). It was not possible to obtain excavated volumes and screen size information for each assemblage, so high NISP values may indicate sampling intensity, rather than the relative abundance of birds at a given site. Challenges with comparing published zooarchaeological data include differing recovery methods (screen size), availability of comparative collections, and analysts' experience and protocols (Atici et al. 2013; Driver 2011).

Since we focus inter-site comparisons on family-level identifications (Table 4), we are confident the trends discussed adequately represent human bird use in the past.

Statistical Analyses

Moss and White used various techniques to explore structure in the bird assemblage data.

Because taxonomic richness (number of taxa) is a function of sample size, which varied greatly among our sites, we used the reciprocal of the Simpson Index (Krebs 1989) to measure taxonomic diversity, which focuses instead on the equitability of abundance across taxa. To minimize sample size bias, similarity/dissimilarity matrices were created to explore assemblage relatedness across sites. Pearson product-moment correlations were computed for each pair of sites to assess inter-site comparisons using BIOMstat 3.3 (Rohlf and Slice 1999). We used cluster analysis to assess relationships among individual assemblages using arithmetic averages in the unweighted pair group method (UPGMA; Sneath and Sokal 1973:230-4) and visualized these results with dendrograms produced in Exeter Software NTSYSpc 2.11x. This technique removes size bias and allows multiple assemblages to be compared simultaneously.

We used Mantel tests to examine whether similarities between the assemblages could be related to: 1) distance between sites, 2) similarity in habitat, or 3) sample size. Mantel tests are non-parametric tests that use repeated randomizations ($n=5,000$) to examine whether an observed pattern of pairwise relationships in an observed similarity matrix is significantly higher or lower than expected by chance when compared to a specific hypothesis test matrix (Sokal and Rohlf 2012:852-8; for archaeological application, see O'Connor et al. 2016). We calculated two matrices to describe the observed pattern of similarity among the sites. In the first, similarity was based on the presence or absence of each family at each possible pair of sites. The second used the Pearson product-moment correlation between the abundance of each family for each possible

pair of sites. Both matrices were tested against two different hypothesis test matrices. The first tested the hypothesis that sites that are close together are more similar than those that are far apart, and was based on geographical distances between each pair of sites calculated using Google Earth. The second tested the hypothesis that sites from the same habitat type are more similar than ones belonging to different habitat types. To avoid the circular reasoning of using the bird assemblage to infer habitat type, we used three generic habitat categories: riverine/estuarine, intermediate, and outer coast. The intermediate type includes faunal assemblages from sites whose habitat may have been significantly different in the past than today (e.g., Connolly 1992; Ulrich 2009).

To investigate the relationship between modern seabird colonies and the taxonomic abundances of archaeological assemblages, we used data from the *Catalog of Oregon Seabird Colonies* (Naughton et al. 2007a). The most recent, accurate, or representative (MRA) estimate for each species was used (Naughton et al. 2007a:15). Moss compiled a matrix, by species, of all extant seabird colonies with a minimum of 100 birds located within 10 and 20 km straight line distance, respectively of the archaeological sites using georeferenced positions listed in Naughton et al. (2007a) and Google Earth (see Supplemental Table 1).

COASST Analysis

To explore the degree to which the archaeological assemblage composition could have resulted from scavenging, Parrish and Jones used the COASST dataset to calculate a modern day "baseline" composition of beached birds. Species counts were extracted for all COASST surveys (2001-2017) performed on beaches within a 20 km radius of each archaeological site (Figure 1; excluding a mass mortality event of Cassin's Auklets from November 2014 to February 2015).

Carcasses were placed in taxonomic categories according to Table 5 to match the taxonomic resolution possible from archaeological findings. Note that this analysis included individual species in some families, notably the Alcidae, whereas other groups were coalesced at higher taxonomic levels, up to family (e.g., Laridae). A higher level assemblage was also produced (waterfowl, gulls, grebes, loons, alcids, procellariiformes and cormorants). In the latter case, species found in the COASST dataset but unrecorded in the archaeological datasets were included (e.g., Horned Puffins were included in Alcidae). Finally, "other species" including all non-aquatic species were excluded from the analysis, such that an "other versus other" catch-all datapoint was not included in either analysis.

For both COASST and archaeological datasets, data were standardized as percent of total within site and square-root transformed to down-weight the importance of higher values. We also created a regional COASST dataset by summing species-specific counts across all sites included in the local analysis (N=87 sites). The percent composition of seabird taxa assessed as NISP was regressed against the percent composition of the corresponding seabird taxa from the COASST dataset, and used general linear models (GLMs) with normally distributed errors to identify whether correlations were statistically significant, reported at a threshold of $\alpha=0.05$.

RESULTS

Native Americans living on the Oregon coast during the late Holocene used a great variety of birds (Table 4). Over 80 bird species representing 27 families have been identified from these 26 sites. The five most common taxa were Anatidae (ducks, geese) with 43%; Alcidae (murre, puffins, auklets), 17%; Procellariidae (fulmars, shearwaters, albatrosses), 11%; Phalacrocoracidae (cormorants), 9%; and Laridae (gulls), 5%. Ducks are the most common group at more than half the sites. We focused on sites (n=15) with a minimum of 100 NISP

(Table 5) to reduce the effects of small sample size. The results are divided into four main groups (Figure 1), based on cluster analysis (Figure 2), taxonomic abundance (Table 5), Pearson correlation coefficients (Table 6), and taxonomic diversity (Table 7).

Taxonomic and Spatial Variability

Cluster 1: Anatids (Indian Point, Palmrose, Tahkenitch, Umpqua/Eden, Hauser, Nah-so-mah)

Six sites spanning two geographic groupings to the extreme north (Indian Point, Palmrose) and south (Tahkenitch, Umpqua/Eden, Hauser, Nah-so-mah) of our sampling region were principally defined by a predominance of anatids (57-77%). These sites also comprised the most structured cluster, displaying pairwise correlation coefficients above 0.9, and were relatively low in taxonomic diversity (<3.0). Assemblages at all sites with the exception of Boiler Bay, Lily Lake, and North Yaquina Head contained at least 20% anatids. Of anatids identified beyond family, 88% were ducks, with 10% geese and 2% swans. Approximately 70% of the duck bones were identified at least to the tribe level. Of these, diving sea ducks (Mergini) dominated most assemblages (70-100% of ducks), except for Indian Point and Nah-so-mah, where dabblers were most common (77%, 69%, respectively). Scoters (*Melanitta* spp.) were the most abundant sea duck identified at all sites (93% of n=1823 Mergini identified to species). Bufflehead was the second most abundant sea duck (5%), followed by mergansers (*Mergus* spp.; 1%).

Cluster 2: Albatrosses (Netarts, Whale Cove, Yaquina Head)

Netarts, Whale Cove, and Yaquina Head, all located on the north-central coast, have the largest percentages of albatross (12-14%) and are characterized by the highest taxonomic diversity (>3.9). Albatrosses occur at lower percentages (<1-4%) at a number of other sites. Netarts and Whale Cove share further similarities, with a correlation coefficient of 0.94, including abundant anatids (25-43%), and similar proportions of alcids (14-17%), gulls (10-11%),

fulmars/shearwaters (6-8%), and cormorants (7-8%). While Yaquina Head has similar frequencies of some taxa, including anatids (22%) and alcids (12%), the assemblage is distinguished by having higher proportions of fulmars/shearwaters (27%), and is therefore distantly grouped with cluster 3 (Figure 2).

Cluster 3: Murres and Shearwaters (Dunes, Par-Tee, Avenue Q)

Dunes, Par-Tee, and Avenue Q, all located in the extreme northern coast, have relatively high taxonomic diversity (3.0-3.9), including substantial proportions of alcids (24-52%) and shearwaters (12-20%), in addition to anatids (20-40%). The small proportions of gulls (4-6%), loons (1-3%), cormorants (1-6%), and albatrosses (2-3%) are also similar. Boiler Bay is similar to these three sites with high proportions of alcids (65%) and shearwaters (28%), but unique in having an alcid assemblage dominated by Rhinoceros Auklet, rather than Common Murre, and an overall low taxonomic diversity (note that the assemblage is small, $n=119$; just above our threshold for consideration). Common Murre is the most numerous alcid at all other sites, comprising 98-100% of the identified alcids at Par-Tee and Avenue Q, and 76% at Dunes, which has more diverse alcids, including an unusually high proportion of Cassin's Auklet (16%). The alcid assemblages are also more diverse at Netarts and Yaquina Head (cluster 2), with greater numbers of puffins (19%, 26% respectively) and Rhinoceros Auklet (15%).

Shearwaters are more abundant than Northern Fulmar at all sites, except Yaquina Head. Shearwaters can be divided into two subgroups on the basis of their flying and aquatic habits (Kuroda 1954): good gliders (e.g., *Ardenna creatopus*) and fluttering flyers/good divers (e.g., *A. grisea*). These behavioral differences have resulted in osteological differences that make it possible (along with size) to identify archaeological specimens to species (Bovy 2005:329; Kuroda 1954). Of those shearwaters identified to species, 99% ($n=548$) were Sooty Shearwaters.

Cluster 4: Cormorants (North Yaquina Head, Lily Lake)

North Yaquina Head and Lily Lake, both located along the central coast, form a tight grouping, with a correlation coefficient of 0.94. Both sites have unusually high percentages of cormorants (65%, 97% respectively); the overall diversity at these sites is low enough to place them near the bottom of the diversity index. At Lily Lake, only eight anatid specimens were found in addition to the cormorants. Both sites are located close to modern cormorant colonies. Cormorants make up 15% of the bird assemblage at Nah-so-mah, 13% at Yaquina Head, and between 6 and 9% at many other sites (Table 5).

Habitat Comparisons

The results of the Mantel test and Pearson product-moment correlation indicate that similarities between sites were not due to distance between sites or sample size. We also checked to see if the presence/absence of bird families was related to habitat type (Table 7). The Mantel test found no relationship between the presence/absence of bird families in the 15 archaeological assemblages to habitat type. However, habitat type did correlate with assemblage composition, yielding the matrix correlation coefficient $r = 0.168$. The probability p is tested against a null hypothesis of no correlation and was found to be $p = 0.0170$. Results of the random permutations were that 4814 were $< Z$, 1 was $= Z$, and 185 $> Z$, as shown in the histogram in Figure 3. This suggests a strong correlation between assemblage composition and habitat type. In other words, the riverine/estuarine assemblages share some characteristics, as do intermediate habitat sites, and the outer coast sites. This is also apparent in the cluster analysis discussed above.

Proximity to Murre Colonies

Proximity had no bearing on the abundance of Common Murre NISP at archaeological sites (non-parametric correlation coefficient: $r=0.02$); however, extant colony size was only weakly

correlated with Common Murre NISP ($r=0.40$). While the number of murre increases with sample size (as expected), we regressed residuals to colony size (within 10 km, then within 20 km) and exact distance to colony, but no significant relationship was found. We performed a multiple regression analysis combining exact distance and colony size, but again, no significant relationship was found.

Comparisons to Modern Beached Bird Data

Correlations between COASST beaching data and NISP data across the 15 sites were more likely to be significant when regionalized COASST data (assembled across all 87 Oregon COASST sites) at the species level were used. Only one archeological site, Boiler Bay, had a significant and strong correlation (local: $r=0.940$; regional: $r=0.953$) at the higher taxonomic assemblage level but not at the species level, which may be an artifact of the relatively low number of taxa ($N=5$) at this site. That is, when coalesced at higher taxonomic levels, the prevalence of "zeroes" in the archeological data corresponding to relatively high values in the COASST dataset (e.g., for Common Murres NISP = 0 and COASST percentage = 43) was masked. This effect, together with the observation that several archeological sites had a prevalence of only one species within the Alcidae (e.g., Boiler Bay: Rhinoceros Auklet; Par-Tee: Common Murre), or one species in addition to Common Murres (e.g., Hauser: Ancient Murrelet), suggests that a species- or lowest possible taxon-level approach is most appropriate.

When examined at the regional and species-specific level, six archeological sites displayed relatively strong, positive and significant correlations (Table 8, Figure 4). In general, sites with a high proportion of ducks in the archeological data had weak, insignificant correlations principally driven by the inversion of ducks (high in NISP, low in COASST) and Common Murres (low in NISP, high in COASST). The single exception was Tahkenitch, which

also displayed a minor murre signal. Significant correlations were overwhelmingly driven by Common Murres (e.g. Dunes, Avenue Q) and secondarily by Northern Fulmars (e.g. Yaquina, Netarts).

DISCUSSION AND CONCLUSIONS

Native peoples used an impressive diversity of birds on the Oregon coast, from small species (e.g., sandpipers, auklets), to large-bodied taxa (e.g., pelicans, herons, swans); and from terrestrial birds (e.g., raptors, grouse), to taxa principally inhabiting the pelagic zone of the coastal shelf and slope (e.g., albatrosses, Northern Fulmar). While scoters, Common Murre, and Sooty Shearwater were the most frequently identified taxa overall, the 26 assemblages included in our study vary widely in the number and relative abundance of taxonomic groups.

While bird assemblages from sites within the same habitat category—estuarine, outer coast or intermediate—tended to share some characteristics, we found more site-specificity than expected, with subtle differences between and among habitat categories. These differences may reflect habitat change since the time the site was occupied, or site-specific patterns independent of habitat type (e.g., seasonality, selectivity), and underscore the need for caution when using taxonomic composition of bird assemblages alone to infer specific habitat types in the past.

Although determining where and how past peoples obtained birds requires careful examination of the context and taphonomy of a given assemblage (e.g., Bovy et al. 2016), our comparative analyses across many sites allows an evaluation of the potential for different procurement strategies within and among sites. In short, we see considerable variability, reflective of flexible and opportunistic use of birds.

Nearshore Hunting

Five of the assemblages dominated by ducks (Cluster 1: Indian Point, Palmrose, Umpqua/Eden, Hauser, Nah-so-mah) are distinctly different from the COASST dataset. Ducks, especially dabbling ducks, are not commonly found as beached carcasses on the Oregon coast today. All of these sites (except possibly Palmrose) were located in riverine/estuarine environments, where ducks would be plentiful and could be hunted with relative ease. A variety of other nearshore birds may have been hunted, though some (gulls, cormorants) are also common beached birds. Many seabirds, including scoters and murre, may be more vulnerable to a range of nearshore threats, including human hunting during their flightless molt period in fall (Jones et al. 2017).

Hunting on Breeding Colonies

Despite the abundance of breeding seabirds on the Oregon coast (Naughton et al. 2007a), there is little direct evidence that people took birds from the colonies. Contemporary seabird colonies are situated on steep islets and headland cliffs making them inaccessible to terrestrial predators, including humans. There is, however, some indication of colony-based hunting at Lily Lake and North Yaquina Head (Cluster 2). Both sites have low taxonomic diversity, are dominated by cormorants, and both are close to modern seabird colonies (Supplemental Table 1). Minor et al. (2008b) found that 75% of the cormorant specimens recovered from Lily Lake were juveniles, as were many of the unidentified bird remains, supporting the interpretation that site occupants were targeting nearby colonies. Close proximity to a productive, accessible source of young birds may have eliminated the need for site occupants to hunt or scavenge birds elsewhere. Although no information was provided about the age of specimens at North Yaquina Head (Minor 1989), the similarity in species composition suggests inhabitants of this site may also have harvested juvenile birds. Small numbers of juvenile cormorants were also recovered at Netarts (Losey 2002:288) and Whale Cove (Watson 2011:5), and evidence for hunting of

fledgling cormorants has been found in other parts of the Pacific Northwest Coast (Bovy 2007; Broughton 2004; Gould 1966). The juvenile cormorants in the Oregon coast sites are only identified to genus level.

Common Murres are the most abundant breeding bird along the Oregon coast and the most common alcid recovered from archaeological sites. There does not appear to be a relationship between murre abundance in archaeological sites and the proximity or size of current Common Murre colonies, although the breeding distribution of this species may have been different in the past. Marked population shifts at Common Murre colonies have occurred along the Washington and Oregon coasts in recent decades due to increased Bald Eagle (*Haliaeetus leucocephalus*) predation and shifts in prey due to changing oceanic conditions (Gladics et al. 2015; Thomas and Lyons 2017).

Offshore Hunting

The presence of pelagic taxa, such as albatrosses, Northern Fulmar and shearwaters at many Oregon coast sites raises the possibility of open ocean hunting, as these species actively avoid the immediate nearshore environment defined as the wave zone out to five kilometers (Parrish et al. 1998; Hyrenbach et al. 2002). The abundance of shearwater bones in the Dunes assemblage led Ulrich (2009) to infer that at least some were hunted in offshore waters. Yet offshore hunting is difficult to distinguish from beach scavenging (Bovy et al. 2016). Comparative data on pelagic fish and sea mammal remains might be used to investigate this hypothesis, but such data are not available for the Dunes site and are beyond the scope of this paper.

Collecting Beached Carcasses

The comparisons between the Oregon coast archaeological data and the COASST modern beached bird surveys demonstrate the possibility that beach collecting may also have occurred at

some sites. Netarts and Yaquina Head (Cluster 2) and Dunes, Par-Tee, and Avenue Q (Cluster 3) all have similar taxonomic composition to the COASST dataset (Figure 4, Table 8). Although these relationships are driven by Common Murres, most sites also displayed relatively high proportions of the migrant pelagic taxa (albatrosses, shearwaters and/or Northern Fulmar). Murres and fulmars are predictably common beached bird species in the fall (post-breeding mortality of murres) and winter (migration exhaustion and exposure of fulmars), respectively (Parrish et al. 2007). Both species display wrecking behavior wherein thousands of freshly dead carcasses wash ashore over a short (weeks) period of time (Parrish et al. 2007, 2017). Seabird wrecks may also explain the singular predominance of alcid species at some sites (e.g., Dunes: Cassin's Auklet; Boiler Bay: Rhinoceros Auklet; Yaquina Head: Tufted Puffin; Hauser: Ancient Murrelet; Table 5), as these birds breed largely to entirely north of Oregon, migrate south into offshore waters, and are occasionally found in mass mortality events and subsequent beaching along the Oregon coast (Parrish et al. 2017).

CONCLUDING REMARKS

This study is the first to synthesize regional data of Native American bird use along the Oregon coast, and contributes to both regional and global scholarship. We used multiple analyses, including standard taxonomic abundance, diversity and correlation measures, along with cluster and regression analysis, to better elucidate the regional patterns. We document the diverse types of birds found in archaeological sites and highlight likely procurement strategies, including nearshore hunting, hunting on colonies, and collecting beached carcasses. It is difficult to compare our findings beyond the Oregon coast, as few similar studies have been conducted, although the opportunistic and flexible use of birds has been noted for coastal foragers in other regions (e.g., deFrance 2005; Jerardino et al. 2009; Kristensen 2011).

Our interpretations incorporated life history information for major bird taxa in the Pacific Northwest, including nesting locations, habitat preference, seasonality, and scavenging potential; these discussions should provide a useful framework for others in the region. Our synthesis of all the birds recovered from Oregon coast sites will assist researchers investigating biogeographic or conservation biology questions pertaining to species of concern, such as albatrosses (Naughton et al. 2007b). Additional study of Oregon coast bird assemblages, including more detailed taphonomic studies, has enormous potential to address a variety of lingering questions, such as the role of birds within coastal subsistence strategies and the ocean-going capacities of Native American groups. Finer temporal resolution may enable us to better understand the effects of climate change on birds, such as that associated with the El Niño-Southern Oscillation. Finally, new data will help document the longer-term historical ecologies of birds, which provide essential context for understanding and addressing contemporary phenomena.

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Figure Captions:

Figure 1. A. Regional map of the Pacific Northwest Coast (USA); B. Map of Oregon coast showing location of archaeological sites with identified bird bones, COASST survey beaches included in the analysis, and major Indian tribes (in capitals). Open circles indicate sites with <100 NISP, which were excluded from the comparative analyses. See Table 3 for site numbers.

Figure 2. Dendrogram showing results of cluster analysis.

Figure 3. Mantel test histogram, showing the strong correlation between bird assemblage composition and habitat types. The solid vertical line represents the matrix correlation ($r = 0.16812$). As shown, 4814 random permutations are positioned to the left, 1 is atop the line, and 185 occur to the right. The correlation is in the significantly high range of possible correlation values.

Figure 4. The relationship between the taxonomic composition (see Table 5) of aquatic bird carcasses washing ashore on Oregon beaches (data from the COASST program) and that of archaeological sites (see Figure 1). Data are percent composition over all carcasses (or NISP) found, square-root transformed to down-weight high values. Sites with any level of association (Pearson's R above 0.4) are bolded (site name and graph outline), and have linear fits (dashed lines). Higher associations are all driven by high proportions of murre (black circles).

$\sqrt{\text{Midden composition (\%)}}$

Table 1: Life history information for Oregon coast birds (discussed in the text).

	Nesting Locations	Habitat Preference in Oregon	Seasonality (peak abundance)	Scavenging Potential ¹	References
Waterfowl (Anatids)					
Dabbling Ducks and Geese	many breed in Alaska and Canada; a few breed locally	estuaries, tidal flats, marshes, lakes, fields	winter (and spring/ fall migrations); some year-round (e.g., Canada Goose, Mallards)	rare beached bird	
Scoters	breed in Alaska and Canada	estuaries and nearshore bays	winter (and spring/ fall migrations)	uncommon beached bird (#12, 18); wreck species	Savard et al. 2015
Seabirds Nesting along the Oregon Coast					
Common Murre	cliff nester; offshore rocks/islands	nearshore and large estuaries	year-round	common beached bird (#1); post-breeding mortality species; wreck species	Ainley et al. 2002
Rhinoceros Auklet	burrow nester; offshore rocks/islands; population center in Canada	shelf waters to nearshore and large estuaries	year-round (farther offshore in winter)	common beached bird (#5); post-breeding/winterkill species; wreck potential	Gaston and Dechesne 1996
Cassin's Auklet	burrow nester; offshore rocks/islands; population center in Canada	shelf waters to nearshore	year-round (farther offshore in winter)	common beached bird (#3); post-breeding/winterkill species; wreck potential	Manuwal and Thoresen 2011
Cormorants	surface nester; offshore rocks/islands; manmade structures	nearshore, estuaries, lower Columbia river; freshwater bodies (Double-crested Cormorants)	common year-round	common beached bird (#10, 14, 27); post-breeding mortality species	Wallace and Wallace 1998; Hatch and Weseloh 2014
Gulls	surface nester; offshore rocks/islands; manmade structures	ubiquitous across marine and freshwater settings (including all species)	common year-round (but variable by species)	common beached bird (#4+); post-breeding mortality species	
Migratory Seabirds (Pelagics)					
Albatrosses	breed in western Pacific	shelf and slope waters	summer (Apr to Oct)	uncommon-to-rare beached bird	Hyrenbach et al. 2002
Sooty Shearwater	breed in New Zealand and Australia	shelf and slope waters	summer (and spring/ fall migrations)	common beached bird (#7)	Veit et al. 1997
Northern Fulmar	breed in Alaska and Canadian Arctic	shelf waters	winter (Sept to Feb)	common beached bird (#2); winterkill species; wreck species	Hatch et al. 2010

¹Based on information from the COASST website (2017). **Common**: in the top 10 species found in the COASST dataset; **uncommon**: in the top 25 species but not in the top 10; **rare**: not in the top 25 species. Numbers in parentheses indicate rank abundance in the COASST dataset; multiple ranks are shown in the case of multiple species. **Post-breeding mortality species**: carcass deposition peak in late summer/early fall following the local breeding season. **Winterkill species**: carcass deposition peak in the fall/winter following migration into the region from breeding sites in British Columbia and Alaska. **Wreck potential**: species or taxon group has had one or more unusual mortality events along the Pacific Northwest coastline, as defined by monthly deposition rates above the 95% confidence limits of the long-term monthly average

Table 2. Identified specimens from Umpqua/ Eden (35DO83), Dunes Site (35CLT27) and Whale Cove (35LNC60).

Scientific Name ¹	Common Name	Umpqua/Eden ²	Whale Cove	Dunes
Anseriformes				
Anatidae	Duck, Goose, Swan	4		14
Anserinae	Goose, Swan			12
Anserini	Goose	49	4	
<i>Branta</i> cf. <i>canadensis</i>	Canada Goose	25		
<i>Branta canadensis</i>	Canada Goose			39
Anatinae	Duck	336	14	64
<i>Anas</i> spp.	Dabbling Duck	80		
<i>Aythya</i> spp.	Pochard	132		
Mergini	Sea Duck	75	7	
<i>Melanitta</i> spp.	Scoter	315	17	60
<i>Melanitta perspicillata</i>	Surf Scoter	54		200
<i>Melanitta fusca</i>	White-winged Scoter	32	4	204
<i>Bucephala albeola</i>	Bufflehead	81		
<i>Bucephala</i> spp.- large	Common or Barrow's Goldeneye	3		
<i>Bucephala islandica</i>	Barrow's Goldeneye	1		
<i>Mergus</i> spp.	Merganser	7		
<i>Mergus merganser</i>	Common Merganser	2		
<i>Oxyura jamaicensis</i>	Ruddy Duck	2		
Galliformes				
<i>Gallus gallus</i>	Domestic Chicken	8		
Podicipediformes				
Podicipedidae	Grebe	4		4
<i>Podiceps</i> spp.	Grebe			5
<i>Podiceps</i> spp.- small	Horned or Eared Grebe	3		
<i>Podiceps auritus</i>	Horned Grebe	6		
<i>Aechmophorus</i> spp.	Western or Clark's Grebe	5		
<i>Aechmophorus occidentalis</i>	Western Grebe			8
Columbiformes				
<i>Columba</i> spp.	Pigeons			12
Gruiformes				
<i>Grus canadensis</i>	Sandhill Crane	1		
Charadriiformes				
	Shorebird	1		
Scolopacidae	Sandpiper	5		
<i>Calidris</i> spp.	Sandpiper	5		
Alcidae	Alcid	1	2	30
<i>Uria aalge</i>	Common Murre		8	594
<i>Brachyramphus marmoratus</i>	Marbled Murrelet			8
<i>Ptychoramphus aleuticus</i>	Cassin's Auklet			128
<i>Cerorhinca monocerata</i>	Rhinoceros Auklet		2	38

Scientific Name ¹	Common Name	Umpqua/Eden ²	Whale Cove	Dunes
<i>Fratercula cirrhata</i>	Tufted Puffin		3	13
Laridae	Gull, Tern	44	12	10
<i>Rissa cf. tridactyla</i>	Black-legged Kittiwake	1		
<i>Rissa tridactyla</i>	Black-legged Kittiwake			40
<i>Larus</i> spp.	Gulls			47
Gaviiformes				
<i>Gavia</i> spp.	Loon	59	2	60
<i>Gavia stellata</i>	Red-throated Loon	8		
<i>Gavia pacifica</i>	Pacific Loon	8		
<i>Gavia immer</i>	Common Loon	11		
Procellariiformes				
<i>Phoebastria</i> spp.	Albatross		15	71
<i>Phoebastria</i> spp.- small	Laysan or Black-footed Albatross	1		
<i>Phoebastria albatrus</i>	Short-tailed Albatross	2		
Procellariidae	Shearwater, Fulmar, Petrel	1		17
<i>Fulmarus glacialis</i>	Northern Fulmar	1	3	38
<i>Ardenna</i> (=Puffinus) spp.	Shearwater		3	127
<i>Ardenna grisea</i>	Sooty Shearwater			324
<i>Ardenna creatopus</i>	Pink-footed Shearwater			2
Suliformes				
<i>Phalacrocorax</i> spp.	Cormorant	54	3	22
<i>Phalacrocorax penicillatus</i>	Brandt's Cormorant	1		
<i>Phalacrocorax auritus</i>	Double-crested Cormorant	28	1	
<i>Phalacrocorax pelagicus</i>	Pelagic Cormorant	11	4	
Pelecaniformes				
<i>Pelecanus</i> spp.	Pelican	5		
<i>Pelecanus occidentalis</i>	Brown Pelican	6		3
<i>Ardea herodias</i>	Great Blue Heron	1		
Accipitriformes				
<i>Pandion haliaetus</i>	Osprey	3		
Accipitridae- large	Bald or Golden Eagle	5		
<i>Haliaeetus leucocephalus</i>	Bald Eagle	18		1
Accipitridae- small	Hawk	2		
<i>Buteo</i> spp.	Hawk	14		
<i>Buteo jamaicensis</i>	Red-tailed Hawk	5		
Strigiformes				
<i>Megascops kennicotti</i>	Western Screech-owl	1		
<i>Bubo</i> spp.	Great Horned or Snowy Owl	1		
<i>Bubo virginianus</i>	Great Horned Owl	1		1
Piciformes				
Picidae	Woodpecker	1	1	
Falconiformes				
<i>Falco</i> spp.- large	Falcon, large-sized	1		

Scientific Name ¹	Common Name	Umpqua/Eden ²	Whale Cove	Dunes
Passeriformes				
Passeriformes (non-corvid)	Perching Bird	11	1	1
Turdidae	Robin, Thrush			4
<i>Corvus brachyrhynchos</i>	American or Common Crow	11		
<i>Corvus corax</i>	Common Raven			29
Total		1553	106	2230

¹Taxonomic names and order follows the American Ornithologists' Union *Check-list of North American Birds* (AOU 2017), including recent updates (e.g., Chesser et al. 2016).

²Simplified from Bovy (2005), which also included size class information for non-species identifications (e.g., *Anas* sp.- small). In addition, some identifications were combined (e.g., cf. *Phalacrocorax* spp. and *Phalacrocorax* spp.).

Table 3. Oregon coast archaeological sites with identified bird remains (organized from north to south).

Site No.	Site Name	Period ¹	Excavation (Excavator, Date) ²	Faunal Analyst	Report	NSP ³	NISP ³
35CLT34	Indian Point	LH, PH	Minor 1978	Wigen	Minor et al. (2008a)	804	256
35CLT27	Dunes	LH	Hasle 1972-1974	Ulrich	Ulrich (2009)	4179	2230
35CLT20	Par-Tee	LH	Phebus & Drucker 1960/70s	Colten	Colten (2002, 2015)	1396	749
35CLT47	Palmrose	LH	Phebus & Drucker 1960/70s; Connolly 1988	Crockford; Colten	Connolly et al. (1992); Colten (2002, 2015)	1483	800
35CLT13	Avenue Q	LH	Connolly 1988	Crockford	Connolly et al. (1992)	806	425
35CLT21B	Ecola Point	LH, PH	Minor 1990	Greenspan	Minor (1991a)	132	77
35TI1	Netarts	LH	Newman & Collins 1950s; Losey 1999	Losey	Losey (2002)	1241	524
35LNC45	Boiler Bay	MH	Tasa & Connolly 1993	Penton, Tasa	Tasa & Connolly (1995)	248	119
35LNC60	Whale Cove	LH	Bennett-Rogers & Lyman 1985	Watson, Bovy	Watson (2011)	151	106
35LNC50	North Yaquina Head	LH	Minor 1988	Greenspan, Wigen	Minor (1989)	162	113
35LNC62	Yaquina Head	MH, LH	Minor 1989	Wigen	Minor (1991b)	1734	716
35LNC57	Cape Creek	LH	Minor 1991, 1992	Greenspan	Minor & Greenspan (1995a)	144	75
35LNC55	Good Fortune Point	LH	Minor & Toepel 1983; Connolly & Tasa 2000	Greenspan; Tasa	Minor et al. (1985); Tasa & Connolly (2001)	32	3
35LNC56	Good Fortune Cove	LH	Minor & Toepel 1983	Greenspan	Minor et al. (1985)	68	19
35LA10	Bob Creek	LH	Tasa et al. 2000s	Singer	Tasa et al. (2009)	18	8
35LA19	Lily Lake	PH	Minor 1999	Greenspan	Minor et al. (2008b)	613	239
35DO130	Tahkenitch Landing	MH	Minor & Toepel 1985	Greenspan	Minor & Toepel (1986)	780	245
35DO83	Umpqua/Eden	LH, PH	Ross 1978-1980	Bovy	Bovy (2005)	not reported	1553
35CS114	Hauser	LH	Minor 1991- 1993	Greenspan	Minor et al. (1998a)	934	436
35CS119	Koch	LH	Minor 1993	Greenspan	Minor et al. (1998a)	324	95
35CS11	Balldiyaka/ Chief's Island	LH	Minor 1985; Fagan 2004	Greenspan; Baker	Minor & Greenspan (1995b); Ogle et al. (2005)	77	41
35CS5	Bandon Sandspit	LH, PH	Cressman & Collins 1952	Tveskov	Tveskov (2000)	49	31
35CS61	Blue Barn	MH, LH	Tveskov 2006	Tveskov	Tveskov and Cohen (2007)	209	14
35CS43	Nah-so-mah (Old Town Bandon)	LH	Ross & Hall 1978, 1986, 1988, 1990, 1991, 1993	Hall	Hall (2001)	not reported	870
35CU2	Cape Blanco	MH, LH	Minor 1997	Greenspan	Minor & Greenspan (1998b)	100	44
35CU160	Goat Island	LH	Gard 1989	Gard	Gard (1990)	152	78

¹MH= Middle Holocene: 7500- 3000 years ago; LH= Late Holocene: 3000 years ago to contact era (Aikens et al. 2011); PH= Protohistoric (just before contact)

²Many of these sites were excavated multiple times; the excavations listed here are associated with the systematically analyzed bird assemblages.

³NSP= Number of Specimens in the assemblage; NISP= Number of Identified Specimens (specimens identified more specifically than "bird")

Table 4. Number of Identified Specimens (NISP) by major taxonomic groups of birds.¹

Taxonomic Name	Common Name	Ind Pt	Dunes	Par- Tee	Palm rose	Ave Q	Ecola Pt	Net- arts	Boil Bay	Whl Cve
Anatidae	Ducks, Geese, Swans	165	593	302	456	83	6	132	3	46
Phasianinae	Domestic Chicken	44								
Tetraoninae	Grouse	2			4					
Podicipedidae	Grebes	1	17	3	8	9	2	7		
Columbidae	Pigeons	1	12			1				
Rallidae	Coots	2								
Gruidae	Cranes				1					
Haematopodidae	Oystercatcher									
Charadriidae	Plovers					1				
Scolopacidae	Sandpipers				2	1		2		
Alcidae	Auks (Murre, Puffins)		811	181	80	220	10	89	77	15
Laridae	Gulls		97	40	82	26	2	51	4	12
Gaviidae	Loons	16	60	19	15	6	1	33		2
Diomedidae	Albatrosses		71	22	28	7	4	64		15
Procellariidae	Fulmars, Shearwaters	2	508	131	52	55	16	40	33	6
Hydrobatidae	Storm-petrels						18			
Phalacrocoracidae	Cormorants	2	22	46	59	5	7	36	2	8
Pelecanidae	Pelicans		3	1	4			15		
Ardeidae	Hérons	3						3		
Pandionidae	Osprey									
Accipitridae	Eagles, Hawks	6	1	2	2	3	9	12		
Strigidae	Owls	2	1		1			3		
Alecedinidae	Kingfishers	3								
Picidae	Woodpeckers					2				1
Falconidae	Falcons				1					
Passeriformes	Perching Birds	7	34	2	4	6	2	37		1
Total NISP		256	2230	749	799	425	77	524	119	106

Table 4. (Continued)

Taxonomic Name	N Yaq Hd	Yaq Hd	Cape Crk	Gd Frt Pt	Gd Frt Cve	Bob Crk	Lily Lke	Tahk Land	Ump/ Edn	Hau- ser
Anatidae	20	157	17		13	2	8	151	1198	264
Phasianinae			9						8	
Tetraoninae		1								
Podicipedidae		11						11	18	10
Columbidae										
Rallidae								3		
Gruidae									1	
Haematopodidae										
Charadriidae										1
Scolopacidae									11	2
Alcidae	3	87	5	1				10	1	76
Laridae	9	34	7		6	4		9	45	13
Gaviidae	4	23		1				14	86	26
Diomedeidae		92	4						3	
Procellariidae	1	194						12	2	18
Hydrobatidae		13								
Phalacrocoracidae	73	93	28			1	231	21	94	26
Pelecanidae									11	
Ardeidae								8	1	
Pandionidae									3	
Accipitridae	3								44	
Strigidae			3						3	
Alecedinidae										
Picidae									1	
Falconidae									1	
Passeriformes		4	1			1		5	22	
Total NISP	113	709	74	2	19	8	239	244	1553	436

Table 4. (Continued)

Taxonomic Name	Koch	Bald- iyaka	Ban- don	Blue Barn	Nah- so- mah	Cape Blnc	Goat Isl ²	Grand Total	% of Ident- ified
Anatidae	74	29	14	12	502			4247	43
Phasianinae								61	1
Tetraoninae								7	<1
Podicipedidae	2				12			111	1
Columbidae								14	<1
Rallidae					22			27	<1
Gruidae								2	<1
Haematopodidae		3						3	<1
Charadriidae					24			26	<1
Scolopacidae								18	<1
Alcidae	3				41	5	2	1717	17
Laridae	10		3		47	1		502	5
Gaviidae	2	3	3		25			339	3
Diomedidae		2			11			323	3
Procellariidae				1				1071	11
Hydrobatidae							76	107	1
Phalacrocoracidae	4	4		1	130	38		931	9
Pelecanidae					1			35	<1
Ardeidae			1		8			24	<1
Pandionidae								3	<1
Accipitridae			10		19			111	1
Strigidae					10			23	<1
Alecedinidae								3	<1
Picidae					3			7	<1
Falconidae								2	<1
Passeriformes					15			141	1
Total NISP	95	41	31	14	870	44	78	9855	

¹Subfamily identifications are shown for Phasianidae to distinguish grouse (which are native) from introduced chickens. All passerines are grouped to Order (Passeriformes) as these are less frequently identified to family level. At least three families of Passeriformes (Corvidae, Turbidae, and Cardinalidae) have been identified in Oregon coast sites. A small number of specimens identified only as "Charadriiformes" were excluded from this table for CLT47 (n=1), DO130 (n=1), LNC62 (n=7), LNC 57 (n=1), and LNC55 (n=1).

²Gard (1990) concluded that the identified bird remains, storm-petrels (*Oceanodroma* spp.) and Tufted Puffin (*Fratercula cirrhata*), were naturally incorporated into the site, given that both taxa are burrow nesters currently breeding on Goat Island. Three unidentified fragments were deemed to be archaeological, rather than intrusive (given their context).

Table 5: Number of Identified Specimens (NISP) for sites with >100 identified bird specimens. Percentages are shown in parentheses for major taxonomic groups (bold). More specific identifications are shown for the four most abundant families.

Taxonomic Name	Common Name	Indian Pt	Dunes	Par-Tee
Cygni	Swans	35		
Anserini	Geese	32	51	6
Anatini	Dabbling Ducks	17		12
Aythiini	Bay Ducks/ Pochards	1		
Mergini ¹	Diving Sea Ducks	4	464	231
Oxyurini	Stiff-tailed Ducks			
Anatidae (unid.)	Unid. Anatids	76	78	53
Anatidae Total	Ducks, Geese, Swans	165 (65)	593 (27)	302 (40)
Podicipedidae	Grebes	1 (<1)	17 (1)	3 (<1)
<i>Uria aalge</i>	Common Murre		594	181
<i>Cepphus columba</i>	Pigeon Guillemot			
<i>Brachyramphus marmoratus</i>	Marbled Murrelet		8	
<i>Synthliboramphus antiquus</i>	Ancient Murrelet			
<i>Ptychoramphus aleuticus</i>	Cassin's Auklet		128	
<i>Cerorhinca monocerata</i>	Rhinoceros Auklet		38	
<i>Fratercula cirrhata</i>	Tufted Puffin		13	
Alcidae (unid.)	Unid. Alcids		30	
Alcidae Total	Auks (Murres, Puffins)		811 (36)	181 (24)
Laridae	Gulls		97 (4)	40 (5)
Gaviidae	Loons	16 (6)	60 (3)	19 (3)
Diomedidae	Albatross		71 (3)	22 (3)
<i>Fulmarus glacialis</i>	Northern Fulmar		38	
<i>Ardenna</i> (=Puffinus) spp. ²	Shearwaters	2	453	130
Procellariidae (unid.)	Unid. Procellariids		17	1
Procellariidae Total	Fulmars, Shearwaters	2 (1)	508 (23)	131 (18)
<i>Phalacrocorax penicillatus</i>	Brandt's Cormorant			7
<i>Phalacrocorax auritus</i>	Double-crested Corm.			4
<i>Phalacrocorax pelagicus</i>	Pelagic Cormorant			27
<i>Phalacrocorax</i> spp. (unid.)	Unid. Cormorant	2	22	8
Phalacrocoracidae Total	Cormorants	2 (1)	22 (1)	46 (6)
Other Birds		70 (27)	51 (2)	5 (1)
Total NISP		256	2230	749

Table 5. (Continued)

Taxonomic Name	Palmrose	Ave Q	Netarts	Boil Bay	Whl Cve	N Yaq Hd	Yaq Hd
Cygni			2				
Anserini	20	9	16		4		1
Anatini	17	3	18				1
Aythini	6	1				1	
Mergini ¹	319	13	86	3	28		63
Oxyurini							
Anatidae (unid.)	94	57	10		14	19	92
Anatidae Total	456 (57)	83 (20)	132 (25)	3 (3)	46 (43)	20 (18)	157 (22)
Podicipedidae	8 (1)	9 (2)	7 (1)				11 (2)
<i>Uria aalge</i>	64	214	50		8	3	33
<i>Cephus columba</i>			1				
<i>Brachyramphus marmoratus</i>	3	2	4				9
<i>Synthliboramphus antiquus</i>							
<i>Ptychoramphus aleuticus</i>	1		4				1
<i>Cerorhinca monocerata</i>		2	13	77	2		11
<i>Fratercula cirrhata</i>			17		3		19
Alcidae (unid.)	12	2			2		14
Alcidae Total	80 (10)	220 (52)	89 (17)	77 (65)	15 (14)	3 (3)	87 (12)
Laridae	82 (10)	26 (6)	51 (10)	4 (3)	12 (11)	9 (8)	34 (5)
Gaviidae	15 (2)	6 (1)	33 (6)		2 (2)	4 (4)	23 (3)
Diomedidae	28 (4)	7 (2)	64 (12)		15 (14)		92 (13)
<i>Fulmarus glacialis</i>	2	5	15		3	1	155
<i>Ardenna</i> (=Puffinus) spp. ²	49	50	6	33	3		37
Procellariidae (unid.)	1		19				2
Procellariidae Total	52 (7)	55 (13)	40 (8)	33 (28)	6 (6)	1 (1)	194 (27)
<i>Phalacrocorax penicillatus</i>	14		1				
<i>Phalacrocorax auritus</i>	7	3			1		
<i>Phalacrocorax pelagicus</i>	8		4		4		
<i>Phalacrocorax</i> spp. (unid.)	30	2	31	2	3	73	93
Phalacrocoracidae Total	59 (7)	5 (1)	36 (7)	2 (2)	8 (8)	73 (65)	93 (13)
Other Birds	19 (2)	14 (3)	72 (14)		2 (2)	3 (3)	18 (3)
Total NISP	799	425	524	119	106	113	709

Table 5. (Continued)

Taxonomic Name	Lily Lke	Tahk Land	Ump/Edn	Hauser	Nah-so-mah	Total (%)
Cygni					7	44
Anserini		4	74	71	18	306
Anatini		1	80	5	314	468
Aythiini			132		79	220
Mergini ¹	3	16	570	41	64	1905
Oxyurini			2			2
Anatidae (unid.)	5	130	340	147	20	1135
Anatidae Total	8 (3)	151 (62)	1198 (77)	264 (61)	502 (58)	4080 (44)
Podicipedidae		11 (5)	18 (1)	10 (2)	12 (1)	107 (1)
<i>Uria aalge</i>		10		34	34	1225
<i>Cephus columba</i>					1	2
<i>Brachyramphus marmoratus</i>				1		27
<i>Synthliboramphus antiquus</i>				24		24
<i>Ptychoramphus aleuticus</i>					6	140
<i>Cerorhinca monocerata</i>						143
<i>Fratercula cirrhata</i>						52
Alcidae (unid.)			1	17		78
Alcidae Total		10 (4)	1 (<1)	76 (17)	41 (5)	1691 (18)
Laridae		9 (4)	45 (3)	13 (3)	47 (5)	469 (5)
Gaviidae		14 (6)	86 (6)	26 (6)	25 (3)	329 (4)
Diomedidae			3 (<1)		11 (1)	313 (3)
<i>Fulmarus glacialis</i>			1			220
<i>Ardenna</i> (=Puffinus) spp. ²		12		18		793
Procellariidae (unid.)			1			41
Procellariidae Total		12 (5)	2 (<1)	18 (4)		1054 (11)
<i>Phalacrocorax penicillatus</i>			1	3		26
<i>Phalacrocorax auritus</i>			28	3		46
<i>Phalacrocorax pelagicus</i>			11			54
<i>Phalacrocorax</i> spp. (unid.)	231	21	54	20	130	722
Phalacrocoracidae Total	231 (97)	21 (9)	94 (6)	26 (6)	130 (15)	848 (9)
Other Birds		16 (7)	106 (7)	3 (1)	102 (12)	481 (5)
Total NISP	239	244	1553	436	870	9372

¹Of those Mergini identified to species (n=1823), 93% (n=1701) were Scoters (*Melanitta* spp.).²Of those shearwaters identified to species (n=555), 99% (n=548) were Sooty Shearwaters (*Ardenna grisea*).

Table 6. Pearson correlation coefficients for each pair of archaeological bird assemblages.

[illegible]

Table 7. Oregon coast bird assemblages in order of taxonomic diversity (measured by reciprocal of Simpson's Index).

Site # 35-	Site Name	Reciprocal of Simpson's Index	Habitat
TI-1	Netarts	7.305	riverine/estuarine
LNC-62	Yaquina	5.662	outer coast
LNC-60	Whale Cove	3.991	outer coast
CLT-27	Dunes	3.863	intermediate
CLT-20	Par-Tee	3.850	intermediate
CLT-13	Avenue Q	3.050	intermediate
CLT-47	Palmrose	2.796	intermediate
CS-43	Nah-so-mah	2.760	riverine/estuarine
DO-130	Tahkenitch	2.490	riverine/estuarine
CS-114	Hauser	2.455	riverine/estuarine
CLT-34	Indian Point	2.377	riverine/estuarine
LNC-50	North Yaquina	2.185	outer coast
LNC-45	Boiler Bay	2.010	outer coast
DO-83	Umpqua/Eden	1.656	riverine/estuarine
LA-19	Lily Lake	1.069	intermediate

Table 8. Correlation between taxon-specific NISP at each of 15 archeological sites and corresponding beached bird taxonomic assemblages from the COASST dataset. COASST sites: number of data collection sites within 20 km of the archeological site. Significant regressions are indicated in bold.

Archeological Site	COASST Sites	Pearson's R	Regression Coefficient	95% CI	
Indian Point	5	-0.33	-0.38	-0.89	0.12
Dunes	13	0.58	0.59	0.21	0.97
Par-Tee	14	0.45	0.50	0.04	0.96
Palmrose	14	0.30	0.31	-0.15	0.77
Avenue Q	15	0.76	0.83	0.50	1.16
Netarts	9	0.43	0.35	0.01	0.69
Boiler Bay	16	0.15	0.19	-0.39	0.77
Whale Cove	17	0.37	0.38	-0.06	0.82
North Yaquina	15	0.39	0.49	-0.05	1.04
Yaquina	17	0.52	0.50	0.12	0.87
Lily Lake	11	0.16	0.21	-0.41	0.83
Tahkenitch	4	0.42	0.45	0.00	0.90
Umpqua/Eden	4	-0.13	-0.15	-0.66	0.37
Hauser	8	0.25	0.25	-0.21	0.71
Nah-so-mah	14	0.06	0.06	-0.42	0.55

Supplemental Table 1. Proximity and abundance of colony breeding birds (modern data from Naughton et al. 2007) to Oregon archaeological sites. Note that the numbers within a 20 km distance are cumulative (i.e., added to the numbers within a 10 km distance).

		Breeding Birds				Notes on archaeological assemblage
Site #	Site Name	colonies w/in 10 km		colonies w/in 20 km		
		#	Taxon	#	Taxon	
CLT-34	Indian Point	3942	La	3942	La	gulls not represented at all, very few (0.8%) cormorants
		766	Ph au	1026	Ph au	
				284	Ph pel	
CLT-27	Dunes			69987	Ur aa	all colonies to south of the site; largest are Bird Rocks and Sea Lion Rocks (16 km away). 27% murres.
				2444	Ph pe	
				315	La	
CLT-13	Avenue Q	69987	Ur aa	70286	Ur aa	all colonies to south of the site; largest are Bird Rocks and Sea Lion Rocks (8-9 km away). Highest proportion of murres (50%) of CLT sites
		2444	Ph pe	3664	Ph pe	
		315	La	1574	La	
				612	Fr ci	
				366	Ph pel	
CLT-47	Palmrose	69987	Ur aa	73197	Ur aa	all colonies to south of the site; largest are Bird Rocks and Sea Lion Rocks (7-8 km away). 8% murres.
		2444	Ph pe	4406	Ph pe	
		315	La	1574	La	
				612	Fr ci	
				366	Ph pel	
CLT-20	Par-Tee	69987	Ur aa	73197	Ur aa	all colonies to south of the site; largest are Bird Rocks and Sea Lion Rocks (7-8 km away). 24% murres.
		2444	Ph pe	4406	Ph pe	
		315	La	1574	La	
				612	Fr ci	
				366	Ph pel	
TI-1	Netarts	241763	Ur aa	241763	Ur aa	large colonies at Three Arch Rocks are <6

		25104	Oc le	25104	Oc le	km away. colonies to north & south. 25% anatids, 10% murrees.
		3030	Fr ci	3030	Fr ci	
		2518	Ph pe	2786	Ph pe	
		1490	La	1490	La	
		924	Ph au	1362	Ph au	
		178	Ph pel	178	Ph pel	
LNC-45	Boiler Bay	69737	Ur aa	70680	Ur aa	largest colonies at Yaquina Head, 17 km away. 65% rhinoceros auklets.
		2304	Ph pe	2442	Ph pe	
		612	Ph pel	982	Ph pel	
		290	La	578	La	
LNC-60	Whale Cove	69737	Ur aa	70680	Ur aa	largest colonies at Yaquina Head, 12.5 km away.
		2826	Ph pe	2964	Ph pe	
		1830	Ph pel	2200	Ph pel	
				288	La	
LNC-50	North Yaquina Head	69737	Ur aa	69737	Ur aa	adjacent to large Yaquina Head colony, from which 98% of the birds within 10 km derive; no addition within 20 km. 65% cormorants.
		2826	Ph pe	2826	Ph pe	
		1830	Ph pel	1830	Ph pel	
		124	La	124	La	
LNC-62	Yaquina Head	69737	Ur aa	69737	Ur aa	adjacent to large Yaquina Head colony, from which 98% of the birds within 10 km derive; no addition within 20 km. 27% procellariids.
		2826	Ph pe	2826	Ph pe	
		1830	Ph pel	1830	Ph pel	
		124	La	124	La	
LA-19	Lily Lake	3238	Ph pe	3488	Ph pe	The largest colonies are Heceta Head South (4.5 km away) and Sea Lion Caves Headlands (<3 km away). 97% cormorants
		2178	Ur aa	2178	Ur aa	
		260	La	410	La	
		250	Ph pel	384	Ph pel	
		159	Ce co	159	Ce co	
		100	Ph au	250	Ph au	
		100	Oc le	100	Oc le	
DO-130	Tahkenitch			1128	Ph au	Not close to large colonies; 62% anatids.