Birds identified in pre-historic surface remains collected at the Unangas village site at Imuqudaagis (Witchcraft Point), Kiska Island, Aleutian Islands, Alaska

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ABSTRACT

Remote island ecosystems around the world were affected by arrival and subsequent colonization by humans, most often resulting in large changes to flora and fauna. Consequently, present day biodiversity (e.g., of birds) on many oceanic islands bears little resemblance to what was present prior to the arrival of humans. However, faunal remains preserved at midden sites are indicative of pre-historic avifaunas. I identified bird skeletal surface remains collected at Imuqudaagis (Witchcraft Point), Kiska Island, Western Aleutian Islands, Alaska, U.S.A., during the summer of 2010. At this site, abundant ancient bird remains are exposed on an eroding cliff face that cuts through nearly the entire length of the village site and its middens. Bird bones were cleaned and organized into bone type and identified to species or highest possible taxonomic resolution at the Royal Ontario Museum in Toronto, Ontario, Canada. Twenty-six taxa were identified from the remains, most of which were marine birds, including, petrels, cormorants, geese and ducks, gulls, and alcids. Bird species found in this deposit closely match the composition other midden sites investigated at Kiska and nearby Buldir, Rat, and Amchitka Islands. Imuqudaagis bird remains include four taxa thought to be extirpated on Kiska Island by introduced foxes and rats: storm-petrel, Aleutian Cackling Goose, Ancient Murrelet, and Cassin's Auklet, and remains of the currently endangered Short-tailed Albatross are present. Among the species identified were one individual Blue-winged Teal and one individual Brant Goose, known to be vagrants to the Aleutian Islands. Because all of the material collected was from deposits exposed and scattered by coastal erosion, I was not able to date any specimens, so I evaluated whether the bird remains collected were representative of the site by

comparison to an adjacent excavation. My study provides another perspective into the avifauna of a remote Aleutian island potentially useful for comparison to zooarcheological and quantitative studies of Kiska and other Aleutian Islands. My work also contributes to the development of a reference collection to aid and continue investigations in this field.

STATEMENT OF COLLABORATION

This thesis is the result of a collaborative effort of several people. Ian L. Jones, my advisor, visited Imuqudaagis in 2001 and made observations at the eroding middens. Ian, Alexander L. Bond, Corey Hutchings, Erin Penney, and I returned in 2010 to collect bird remains from the eroding face and Alex and Ian assisted with the formal archaeological excavation directed by Veronica Lech and Corey. Therefore this thesis is based on shared material and data collected by my colleagues at Memorial University, their work and ideas, as well as my own. It is my expectation that any publications arising from my research will be coauthored with my colleagues named above.

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INTRODUCTION

The present-day avifaunas of remote islands and ecosystems are in most cases extremely different from their pre-historic condition prior to human colonization. History is littered with examples of bird species extinctions directly attributable to human colonization events. The Hawaiian archipelagos offer a prime example of massive bird extinctions caused by human colonization and subsequent introduction of invasive animals and diseases (Athens 2002). Although the abundance and distribution of these avifaunas is not nearly what it once was preceding human colonization, it is nonetheless important and significant to science via its contributions to biogeography, ecology, and natural history of remote island ecosystems and similar habitats.

Isolation of islands has been found to be positively correlated with the proportion of both modern and fossil species that have gone extinct (Biber 2002). Over 90% of bird extinctions during historical time periods occurred on islands (Johnson and Stattersfield 1990). It is apparent that isolated islands are not only an important modern conservation concern but extremely significant in terms of archaeological work. Much can be learned from the ancient faunas, particularly avifaunas, of remote islands that have been colonized by humans, such as the extinction of birds in the Southeastern Polynesian islands and the Marianas (Pimm et al. 1994). The Polynesian heartland in particular has witnessed the extinction of the majority of its species in the last 3000 years (Steadman 1995). The extinction of flightless birds by human colonization is a long, depressing list, from the mascot of flightless bird; New Zealand’s moas (Dinornithidae) that went extinct (along with many other bird species) swiftly after the Maori colonized the island, to the extinction of Madagascar's Elephant Birds in 500 C.E. (Diamond 1989). It is clear that the extent of avian extinction on islands is vast and global, and that any study delving into the original pristine and natural abundances and distribution of those faunas provides valuable information with direct application to modern conservation and understanding of the island environment.

In many of these extinction analyses, excessive archaeological work and studies allowed the accurate reconstruction of the prehistoric natural avifaunas in their respective island habitats. The ancient avifaunas of these islands have been pieced together through midden sites and zooarcheological studies to understand their previous natural abundance and distribution.

The Aleutian Islands, Alaska, U.S.A., are a prototypical example of remote island ecosystems, as the archipelago consists of more than 200 islands in eastern, central, and western island groups spanning 1,800 km (West et al. 2010) and were subject to anthropogenic affects to local flora and fauna much like the colonization of Hawaii by Polynesian peoples (Boyer 2008). The natural biota of the Aleutians west of Umnak Island, prior to human contact and colonization, had been entirely free of terrestrial mammals, most notably foxes, rats, and other mammalian predators. Humans first settled in the easternmost Aleutians approximately 9,000 years ago with an east to west Unangan/Unangas (Aleut) colonization that reached the westernmost island (Attu) about 4,000 years B.P. (West et al. 2007). Subsequently the Russians colonized the Aleutians in the mid 18th century, coincident with an abrupt end to the pattern of Aleut long-term use of natural resources (West et al. 2007). Island biotas began to encounter challenges and undergo great change in 1750 with the introduction of Arctic Fox (*Alopex lagopus*) by the Russians on the westernmost Aleutian Islands (Bailey 1993). During the 19th century Russians had introduced Arctic Fox and Red Fox (*Vulpes vulpes*). At its height, fox farming had resulted in the carnivores inhabiting 450 islands (West et al. 2007). Other mammals had also been introduced to the Aleutians including Norway Rats (*Rattus norvegicus*), Ground Squirrels (*Spermophilus undulates*), and other rodents (Bailey 1993). The various introductions have resulted in the strong reduction in seabird and other bird populations (West et al. 2007), including the near extinction of the Aleutian Cackling Goose (*Branta hutchinsii leucopareia*). The potential for devastation to local seabird populations is particularly evident, from documented examples such as two foxes decimating a colony of 156,000 seabirds nesting on Shaiak Island (Bailey 1993).

The Aleutians are moderate latitude (52º - 54º N) oceanic islands with a cool, wet, windy climate and mild winters. The islands are particularly biologically relevant due to the presence of high seabird diversity including near endemic taxa, and plant and invertebrate communities that are not found in any other areas of the world.

The first fox removal program began in 1949 on Amchitka Island (Bailey 1993). Removal of foxes from the Aleutian Islands continued progressively until the 1970s, when foxes were removed from one island a year (Williams 2003). In several cases, foxes had completely wiped out natural avifauna to the point that the foxes themselves died out (Williams 2003). By 2002, foxes had been successfully removed from 39 islands and populations of seabirds have shown population increases of four to five times within 10 years of fox removal (Ebbert and Byrd 2002). The effects of other mammals such as ground squirrels and rats are not as well documented, but disturbance from rats have been shown to have devastating effects on burrow-nesting species and most ground nesting species (Ebbert and Byrd 2002) including having a negative effect on productivity and chick growth rate in Least Auklets (*Aethia pusilla*) (Major and Jones 2006). The removal of foxes from the Aleutian Islands appears to be successful, but in order to fully and completely restore biotas to their natural levels it is imperative we know the natural biodiversity.

Paleontological work and knowledge in the Aleutians is not extensive. The number of excavated archaeological sites decrease with distance west of the Alaska Peninsula, and there are only a few that incorporated quantified sampling methodologies, complete with identified zooarcheological material and material directly associated with radiocarbon dates (Causey et. al 2005). Savinetsky et al.'s (2004) study on Chuchotka, Amchitka and the Aleutian and Commandor Islands examined the changes in species composition of mammal and birds of several islands through identification of osteological material and concluded that the dynamics of the biotas had been mostly due to precipitation, temperature, sea ice conditions, and not a result of the traditional hunting methods of the Aleuts. Causey et al.'s (2005) archeological work on Amchitka, Buldir, and Shemya islands found a similar pattern and that very few species had remained constant in abundance over the past 3000 years. Excavations at Buldir Island, one of the few remaining pristine islands untouched by fox and rat introductions, revealed trends and information on the anthropogenic culture and condition of the island based on the presence and abundance of faunal bones (Lefevre 1997).

Kiska (52ºN 177ºE, 35 km long, 278 km^2 area), part of the Alaska Maritime National Wildlife Refuge, is the second largest island in the Rat Island group of the western Aleutian Islands, Alaska, USA. St. Stephen Island (Kiska Island) was discovered by the Russian explorer Chirikov in October 1741 (Jochelson 1968). Russian Promyshlenniki introduced Arctic foxes to the island in 1825, by which time the Unangas presence at the island was nearing the end of a steep decline (West et al. 2007). The last two Aleut fox trappers left Kiska in 1941. Norway Rats (*Rattus norvegicus*) were introduced to Kiska during WWII, further decimating the native avifauna. Arctic Foxes were removed from Kiska in 1987 by the Alaska Maritime National Wildlife Refuge using aerially dispersed poison baits (Ebbert 2000). Presently, the avifauna of Kiska is likely in recovery (at least from the depredations of introduced foxes) but its composition prior to Unangas and Russian colonization is unknown.

The Unangas village site at Witchcraft Point, Kiska, was investigated by Ales Hrdlicka in 1936 and he recorded observations of a deep midden, water management system, bone and stone tools, human bones, shell, and sea urchin remains (Funk 2009). Much more recently, Witchcraft Point was visited to test the known archaeological site to examine changes in Aleut subsistence from prehistoric to historic times, and use any subsistence shifts through time to understand shifts in avian population (Funk 2010). The island of Kiska and Witchcraft Point have experienced intense disturbance from WWII activity of Canadian, American, and Japanese military since Hrdlicka's original visit to Witchcraft Point.

The objectives of my study were: 1) To gather information about birds present historically on Kiska Island from identifications of bones retrieved from eroding middens at Imuqudaagis, 2) To make a preliminary comparison and facilitate future comparison of taxonomic composition of my collection to bird remains collected in a simultaneous adjacent traditional archaeological excavation, 3) To gather a reference collection of bird bones for identification of remains in related, ongoing and future studies, and 4) Help gather information useful to wildlife managers engaged in island restoration.

METHODS

Study Area

Kiska Island (52° N 177° E) is located in the Alaska Maritime National Wildlife Refuge (AMNWR), 800 km from the nearest continental land mass. Kiska is approximately 39.8 km long with variation in width from 2.8 km to 11km. It is the second largest island in the Rat Islands group in the western Aleutian Islands, Alaska (Figure 1) and is 117 km from the nearest island to the west, Buldir. Kiska has no native terrestrial mammals and insular avifauna is scarce throughout the island, likely due to the presence of introduced rats and former presence of Arctic Foxes. The island is characterized by an active volcano on its northern tip, lowland areas of tall grasses and ferns, alpine heaths and meadows, and barrens across variations in elevation throughout the island.

Imuqudaagis (Fig. 2) at Witchcraft Point is an ancient Unangas village site occupied prior to Russian colonization and subsequent introduction of rats and foxes. The village site contains depressions of former Aleut houses (barabaras) and middens where an archaeological excavation took place during June to August, 2010 (Lech 2010). The excavation site was located approximately 50 m from the westernmost point and 200m from the easternmost point of the eroding face collection area (Fig. 2). WWII debris and remnants of Japanese and Allied occupation during 1942-1944 lie scattered in and around the village site. The eroding beach face from which the bones were collected is approximately 200 m long and 8 to 10m vertical at its highest point (Fig. 2). Flag pins left by crews in previous years suggest the rate of erosion to approach 1 m each year (Funk 2009). This erosion freshly exposed significant amounts of bird bones and other faunal material as well as some cultural artifacts along the beach face.

Collection and Identification

Avian bones were collected at weekly intervals during the period June 9 to August 2, 2010 along the eroding beach face at Imuqudaagis (Fig. 2). The collection procedure involved thoroughly checking all accessible areas on and below the eroding face and retrieving all visible bird bones (bone fragments and badly broken specimens were later discarded). Wind and natural movement of the sandy substrate throughout the collection period continuously exposed and revealed fresh material for examination throughout the summer. From my examination of the site and the specimens, I believe all avian skeletal material collected was of ancient origin and uncontaminated by recent material (see Results and Discussion).

For identification, the bones were first organized into bone anatomical type and left and right sides where appropriate and then into apparent species- or taxonomic-specific groups. Once organized as much as possible into their distinct groups within bone types I compared every specimen in my collection to the avian skeleton reference collection at the Royal Ontario Museum in Toronto, Ontario to resolve identity to the lowest taxonomic level possible (i.e. species level). To facilitate identification, all bones were measured for length, defined by the longest possible measurement of a bone held completely vertical on a 90° angle. All bones were measured with Mastercraft electronic digital calipers and given an individual reference number for cataloguing and future reference collection storage. To make a preliminary comparison of bird taxa present in the eroding face to those from the excavation, all intact humeri from the excavation site were measured by the same methods.

I calculated the minimum number of individuals (MNI), i.e., the smallest number of individual birds for a given taxon represented in the sample (Lyman 1994). For the purposes of my study, my main objective was the description and quantification of what avian taxa were present at this site, and their relative abundance. Since the bones are on an ancient village site, the presence of any species likely reflects both natural presence as well as availability and catch ability by the Aleut people. As well the sample is affected by the likelihood of tool processing, and any collection bias by the collectors, whether specific and intentional or not. This bias and its effects will be addressed in the Discussion.

RESULTS

The collection of 1,495 bones from the eroding face at Imuqudaagis resulted in the identification of 26 avian taxa (Table 1). All the bird bones collected showed staining, wear, and evidence of decomposition characteristic of ancient material, and were picked directly from the eroding face of middens or from the slope and beach immediately below. Among the taxa identified were many bird species commonly found in the Aleutians and Kiska (alcids), and other taxa of formerly abundant species and groups, such as the Short-tailed Albatross (*Phoebastrus albatrus*). The groups represented by the highest minimum number of individuals were auklets (*Aethia* spp.) especially Least Auklets (*Aethia pusilla*), as well other alcids including Ancient Murrelets (*Synthliboramphus antiquus*), puffins (*Fratercula* spp.) and murres (*Uria* spp.) (Table 1). Common Eider (*Somateria mollissima*) and Aleutian Cackling Goose (*Branta hutchinsii leucopareia*) were the most frequently encountered Anseriformes. Although proportionally rare, other species of waterfowl were also represented in the collection through Blue-winged Teal (*Anas discors*), Northern Pintail (*Anas acuta*), Harlequin Duck (*Histrionicus histrionicus*), and Brant Goose (*Branta bernicla*). The sole passerine taxon identified was the Common Raven (*Corvus corax*) and the sole Falconiform identified was a Bald Eagle (*Haliaeetus leucocephalus*), each with low numbers of minimum number of individuals at 4 and 1, respectively.

The most abundant bone type collected, humeri, also showed the most taxonomic diversity (Table 2). Limb bones far outnumbered axial elements, and wing bones were more numerous than leg bones.

In comparison to previous archaeological excavations in the Western Aleutians that recorded birds (Table 3), my study and the other sites share the presence of some alcids (auklets, murres, puffins) as well as Short-tailed Albatross. Many of the taxa were only found in two of the sites, few in three or four sites, and the majority found in only one site, although there are some slight discrepancies in that some studies had identified bones to genus and others to species (e.g., *Larus* spp. and *Larus glaucescens* and *Phalacrocorax* spp.), accounting for some of the dissimilarity between taxa identified at each site.

The collection of avian bone elements from the eroding face was similar to avian remains from the excavation (Lech 2010) based on percent frequency of occurrence of humeri (Figs 3, 4, and 5). The eroding face collection is comparatively representative of both the excavation as a whole (Figures 3 and 4) and across the levels of the excavation (Figure 5). The modal distribution of the eroding face was similar to the excavation in the relative amount of Least Auklet bones (the most abundant taxon in both, comprising c.15% in the face and c.35% in the excavation), but the eroding face had greater taxonomic diversity than the excavation. Based on the analysis of humeri (only) frequency, many taxa present in the eroding face collection were not present in the excavation (e.g., murres, some waterfowl etc., Figs 3 and 4). It appears that the proportion of Least Auklet humeri (and likely bones) increases with increasing depth within the excavation and most other taxa remain minimally represented (Fig. 5), in relative similarity to the eroding face collection. The eroding face was characterized by more of a bimodal distribution than that of the excavation, with auklet (*Aethia* spp.) humeri showing a substantial proportion of the overall humeri. In addition, the eroding face had a more diverse overall representation of less rare taxa.

DISCUSSION

Collection Biases

Although the avian remains collected along the eroding beach face of Imuqudaagis cannot be dated, I believe them to be representative of bird remains present at Imuqudaagis, and a likely indication of past avian community composition on Kiska and nearby areas. In order to properly understand the meaning of my results, one must discuss any of the biases affecting the samples. First, there was likely an observer bias in the collection of the bones of the eroding face itself, as larger, more intact bones were much more likely to be noticed and collected (e.g., no bones of small passerine birds were collected). What bones were readily noticeable and available for collection was also likely prone to bias, as small and light bones would be more likely to be blown away by wind and storms. Bone elements showed variation in preservation and resistance to aging and erosion as thicker, denser bones are more likely to remain intact and in place over time, and are thus were more subject to collection. The chain of events leading to collections at the eroding face was thus: birds present at Kiska (of interest to this study), followed by human predation selectivity, human processing and differential deposition in middens, coastal erosion, and finally collection for my study with the above mentioned biases.

The proportion of bones collected and identified (Table 2) is likely a reflection of the preservation and resistance to taphonomy and disturbance of the bone types. Limb bones, and particularly wing bones, remained intact much better than axial elements of the sternum and synsacrum, and were much more useful in their diagnostic and identification potential (hence my use of the humerus for comparative purposes). More sterna and synsacrum elements were collected than listed, but most were too broken or fragmented to be identified.

Which bird bones were thrown away and deposited in middens, in contrast to processed for tools and usage by the Aleut people, is another form of bias affecting my sample and subsequent interpretation. Bird bones of value for tool making would not be expected to appear intact in middens nor would they be represented in my sample. For some bird species, body parts (e.g., wings, feet and heads) might have been discarded before prey was transported to Imuqudaagis. The ecology of the birds and hunting technology and culture of the Unangas interact to determine the harvest potential of any bird, creating the ultimate bias in the sample. Species that are more common or present for longer periods of the year are more likely to be hunted and caught by the Aleuts, and thus more likely to be found and collected along the beach face. An accessible species of bird that spends more time inland or inshore (waterfowl) would be much more likely to be killed and harvested as opposed to a bird that spends the majority of its time at sea (e.g., Black-footed Albatross). In addition, a larger, slower bird is easier to hunt and catch. Birds in groups or aggregations would also increase the ease of catching them, or at least, the ease of catching multiple individuals at one time (e.g., Least Auklets). However, vagrants and birds uncommon to the region could have been easy prey, as they might have been exhausted, sick, unhealthy, and disoriented and perhaps attracted to features of a village site (e.g., cover and tall vegetation). In effect, there are multiple historical anthropogenic biases interacting to affect the abundance and diversity found within the eroding face collection. These matters are beyond my expertise and the scope of this study. I hope to collaborate with zooarchaeologists to solve some of these questions, as they are crucial to understanding the history of avian diversity and relative abundance at Kiska.

Species Composition and MNI

The number of taxa identified indicates a relatively diverse avian community across time, although there is no way of knowing the relative dates of any of the collected materials from the face without carbon dating of individual bone fragments (difficult, see James et al. 1987). The minimum number of individuals (MNI), although not a concrete source of abundance, does provide some indication of the relative abundance of a taxon. The minimum number of individuals, though, is subject to essentially all of the aforementioned biases, and as such, can only infer so much as to the past relative abundance of a species or taxon within the area. There is no way in determining if the MNI is more subject to the natural abundance of the species/taxon or any given bias or combination of biases. For example, Aleutian Cackling Geese have a summer flightless period when they congregate in family groups and might be an easy target and a golden opportunity to the Aleuts. As a result, multiple individual Aleutian Cackling Geese could have been caught at one time, and the MNI would be more reflective of the hunting availability then their natural abundance, in this scenario. In fact, my collection included at least one tarsus bone of a juvenile (pre-fledging) Aleutian Cackling Goose (evidence of this species breeding on Kiska prior to its extirpation by Arctic foxes in the 19th century, Murie 1959). To exemplify this point, consider the ratio of minimum number of individuals of Least Auklets to Aleutian Cackling Geese, a ratio of 87:13. It is highly unlikely that for every 87 Least Auklets, there were 13 Aleutian Cackling Geese at any given time or across time. Although potentially informative anthropologically, in this study, interpretation of the minimum number of individuals to accurately infer past avian abundances is essentially impossible.

Comparison to Western Aleutian Archaeological Sites

The comparison of the presence of taxa to other archaeological sites in the Western Aleutians (Table 3) is extremely informative with respect to the ecology and composition of avian communities. Only four taxa, Short-tailed Albatross, Northern Fulmar (*Fulmarus glacialis*), murres (*Uria* spp.) and auklets (*Aethia* spp.) were found to be present in all of the sites. In the case of the Short-tailed Albatross, this is an excellent sign of the Short-tailed Albatross's former abundance and range in the Western Aleutians, where it is now extremely rare. Notably, all previous studies (Lefevre et al. 1997, Causey et al. 2005, Funk 2010) identified all albatross remains as Short-tailed Albatross, yet I identified a MNI of 4 Black-footed Albatrosses (*Phoebastria nigripes*) in the eroding face collection, in addition to a MNI of 5 Short-tailed Albatrosses (Table 1). Multiple Laysan Albatross (*Phoebastria immutabilis*) remains have been identified from nearby Buldir Island (I.L. Jones pers. comm.) but not identified by zooarchaeologists (Lefevre et al. 1997). These points suggest that the two smaller albatross species may have been missed by previous studies. Murres and auklets are both present and abundant on Kiska and the other islands in the modern day, and the Northern Fulmar is commonly observed in the Western Aleutians. All sites had identified cormorants and gulls (*Phalacrocorax* and *Larus*) to either species or the genus. Notable is the presence of storm-petrel, Aleutian Cackling Goose, Cassin's Auklet and Ancient Murrelet remains in the eroding face collection. These species are not currently on Kiska; thus the discovery of their remains indicates they have been extirpated; possibly due to the introduced foxes and rats. The ongoing examination of the 2010 excavation at Imuqudaagis will provide further details into this discovery, and future and continuing studies of similar nature are recommended to properly understand the avian community prior to Unanagas and Russian colonization of Kiska and other Aleutian Islands.

This comparison across archaeological sites and collections of the Western Aleutians is significant in that it emphasizes the unique composition of avian biotas of each island and area. The vast number of Least Auklet remains is consistent with a long term presence of the vast auklet colony at Sirius Point, Kiska (this species is absent as a breeder from Rat and Amchitka islands, which lack suitable breeding habitat). Imuqudaagis is the sole site of the Western Aleutians to have recorded remains of Bald Eagle, Common Raven, Black-footed Albatross (*Phoebastrus nigripes*), Harlequin Duck, Northern Pintail, and Blue-winged Teal, Brant Goose, Marbled Murrelet (*Brachyramphus marmoratus*), and Pigeon Guillemot (*Cepphus columba*). From this, it is clear that each island has a unique and distinct habitat that should be directly protected in order to conserve these natural biotas. These findings raise a series of questions, such as whether the species identified, including those only found in the eroding face compared to other sites, were in dynamic population fluctuations across time or remained relatively constant. In comparison to Funk's (2010) preliminary report of avian bones collected from several test sites on Kiska, there is a substantial difference in that Funk had not found many Least Auklet bones, at least not as high a proportion as in our findings. Although there are some differences between the findings, it is difficult to stress their importance as Funk had identified bones to family. Again, the detailed analysis and dating of bird remains from the 2010 Imuqudaagis excavation site will offer further clarification of these findings.

Comparison of eroding face to excavation

How did the remains collected on the eroding beach face compare to those collected at the archeological excavation (Lech 2010)? To begin to address this question, I measured all humeri from the excavation and compared them to all humeri from the eroding face to give an indication if the eroding face collection is representative of the excavation (Figs. 3 and 4). The humerus was selected as it is a bone that preserves well and is relatively easy to identify to species. Based on the modal distribution of the frequencies of humeri length of the two sources, it appears that the eroding face is fairly representative of the excavation. The eroding face also appears representative of the different levels (roughly corresponding to increasing depth of burial and time since deposition) of the excavation (Fig. 5). Despite some fluctuations and changes in frequencies of taxa across levels (and thus apparently time), Least Auklets were consistently by far the most abundant species at Kiska, or, at the very least, the most harvested and thrown away by the Aleut people. The eroding face was accurately representative of this as Least Auklet bones were more numerous than any other species, as can be seen in the MNI (Table 1). This is consistent with the observation that one of the largest seabird colonies in Alaska is located at Sirius Point, only 11 km north of Imuqudaagis, and that this colony supports more than 1 million auklets, nearly all of which are Least Auklets. The levels analysis of humeri (Fig. 5) may suggest that this colony has been present for millennia. The collection from the eroding face differs in its apparent greater diversity of species and higher proportion of less common species, as well as a more bimodal distribution centered around primarily Least Auklets and other *Aethia* auklets. Of notable difference between the sample frequencies is the increased proportion of murres, puffins, and Pigeon Guillemot and similarly sized birds. Albatross species were not represented in the humeri measured (Figs. 3-5), even though many albatross humeri were collected at the eroding face. The reason for this was that no fully intact albatross humeri were found on the eroding face – all had been precisely sawed off about 2 cm from their proximal end during processing by inhabitants of Imuqudaagis. We suspect that other taxa are missing from the measured humeri samples (Figs. 3-5) due to human processing (e.g., cormorant and murre humeri frequently appeared as awls).

Preliminary implications for ecology, management and conservation of Rat Island avifauna

The abundance of Least Auklet remains at the eroding face and throughout the excavation suggests a long-term presence of a super-colony of Least Auklets at Sirius Point, Kiska. Presence of ancient storm-petrel, Aleutian Cackling Geese, Ancient Murrelet and Cassin's Auklet remains would potentially confirm their presence on Kiska before their extirpation by Arctic foxes introduced in 1825 (Murie 1959). My discovery of the tarsus of a nestling goose is highly suggestive of local breeding in proximity of Imuqudaagis. Any generalizations cannot be made about Kiska avifauna until the excavated bird remains are dated and analyzed, and further collections from representative sites are completed from other parts of Kiska Island. For example, since seabird colonies represent highly localized centers of abundance, midden contents are expected to represent local resources but perhaps not be representative of the island as a whole (e.g., at Imuqudaagis, super-abundance of Least Auklet remains close to Sirius Point).

Conclusions

Overall, my collection and identification of bird remains from the eroding face at Imuqudaagis has offered an insight into the historical bird community of Kiska Island. The presence of species has direct conservation management implications, as restoration efforts would be expected to attempt to restore all breeding birds native to Kiska historically. In order to comprehensively restore an area, one must know the natural habitat or community to develop an appropriate restoration goal. Should conservation efforts be made on or around Kiska in relation to birds or the entire environment, conservation managers should take steps to conserve the birds currently on the island and restore the birds identified in the eroding face on the island, with exception of extreme vagrants and some seabirds (e.g., albatross). The collections from the eroding face identified three taxa presumed to be extirpated from Kiska by foxes and rats: storm-petrel, Cassin's Auklet, and Ancient Murrelet. Should conservation managers decide to restore Kiska to as natural a setting as possible, it is recommended that they develop research and techniques to re-colonize the aforementioned taxa on Kiska.

TABLES

Table 1 Species summary of minimum number of individuals (MNI) from bones collected on the eroding beach face at Imuqudaagis, Kiska Island, Aleutian Islands, Alaska during 2010.

Common Name	**Species Name**	**MNI**
Short-tailed Albatross	*Phoebastria albatrus*	5
Black-footed Albatross	*Phoebastria nigripes*	4
Northern Fulmar	*Fulmaric glacialis*	3
Shearwater	*Puffinus* spp.	2
Storm-Petrel	*Oceanodroma* spp.	1
Cormorant	*Phalacrocorax* spp.	10
Brant Goose	*Branta bernicla*	1
Canada Goose	*Branta canadensis*	13
Northern Pintail	*Anas acuta*	1
Blue-winged Teal	*Anas discors*	1
Common Eider	*Somateria mollissima*	11
Harlequin Duck	*Histrionicus histrionicus*	4
Bald Eagle	*Haliaeetus leucocephalus*	1
Glaucous-winged Gull	*Larus glaucescens*	2
Thick-billed Murre	*Uria lomvia*	6
Common Murre	*Uria aalge*	1
Murre	*Uria* spp.	16
Pigeon Guillemot	*Cepphus columba*	4
Ancient Murrelet	*Synthliboramphus antiquus*	41
Marbled Murrelet	*Brachyramphus marmoratus*	1
Cassin's Auklet	*Ptychoramphus aleuticus*	1
Aethia	*Aethia* spp.	65
Least Auklet	*Aethia pusilla*	87
Parakeet Auklet	*Aethia psittacula*	1
Crested Auklet	*Aethia cristatella*	14
Rhinoceros Auklet	*Cerorhinca monocerata*	1
Puffin	*Fratercula* spp.	21
Common Raven	*Corvus corax*	4

Table 2 Frequency and diversity per bone type of bones collected on the eroding face at Imuqudaagis, Kiska Island, Aleutian Islands, Alaska during 2010.

Bone Type	# Of Bones	Proportion of Total	Taxa
Humerus	484	0.324	15
Ulna	309	0.207	14
Radius	92	0.062	12
Carpometacarpus	155	0.104	12
Femur	80	0.054	12
Tibiotarsus	44	0.029	11
Tarsometatarsus	85	0.057	13
Coracoid	172	0.115	10
Synsacrum	29	0.019	7
Sternum	34	0.023	10
Phalanx	11	0.007	4
TOTAL	**1495**		

Table 3 Presence of identified avian bone elements from excavations and collection from Western Aleutian Islands, Alaska

Species/level	Site: Amchitka	Buldir	Shemya	Imuqudaagis Eroding face
Phoebastria albatrus	•	•	•	•
Phoebastria nigripes	-	-	-	•
Fulmarus glacialis	•	•	•	•
Oceanodroma spp.	-	•	•	•
Puffinus tenuirostris	•	-	-	-
Puffinus spp.	•	-	•	•
Phalacrocorax auritus	•	-	-	-
Phalacrocorax pelagicus	•	-	-	-
Phalacrocorax urile	•	-	-	-
Phalacrocorax spp.	-	•	•	•
Branta bernicla	-	-	-	•
Branta hutchinsii leucopareia	•	•	-	-
Branta spp.	-	-	•	•
Anas acuta	-	-	-	•
Anas discors	-	-	-	•
Somateria mollissima	•	-	-	•
Somateria spp.	-	-	•	-
Histrionicus histrionicus	-	-	-	•
Haliaeetus leucocephalus	-	-	-	•
Larus glaucescens	•	-	-	•
Larus spp.	•	•	•	-
Rissa spp.	-	•	•	-
Uria aalge	-	-	-	•
Uria lomve	-	-	-	•
Uria spp.	•	•	•	•
Cepphus columba	-	-	-	•
Synthliboramphus antiquus	-	•	•	•
Brachyramphus marmoratus	-	-	-	•
Ptychoramphus aleuticus	-	•	•	•
Aethia psittacula	-	•	-	•
Aethia pusilla	-	-	-	•
Aethia spp.	•	•	•	•
Cerorhinca monocerata	-	•	•	•
Fratercula spp.	-	•	•	•

• = Present, - = Not Present. Data obtained from Causey et al. (2005). Taxa listed exactly as identified and listed in Causey et al. (2005).

FIGURES

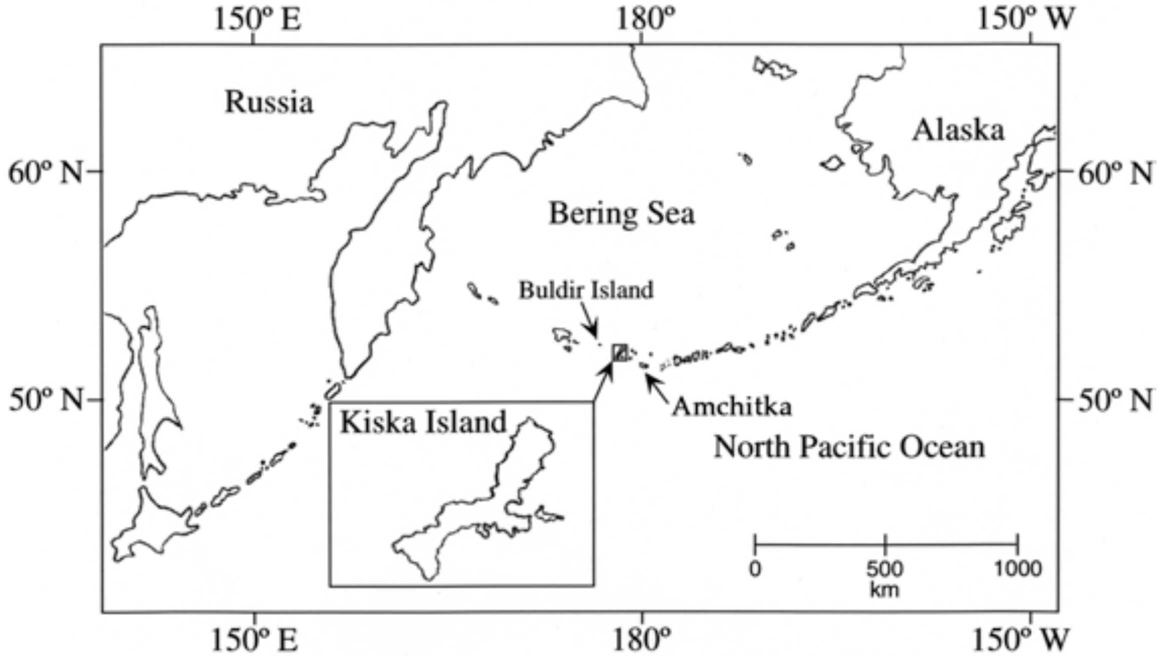

Figure 1 Map of the North Pacific showing the location of Kiska Island, Aleutian Islands, Alaska. The study site Imuqudaagis, Witchcraft Point is along the northern face of the middle of the island.

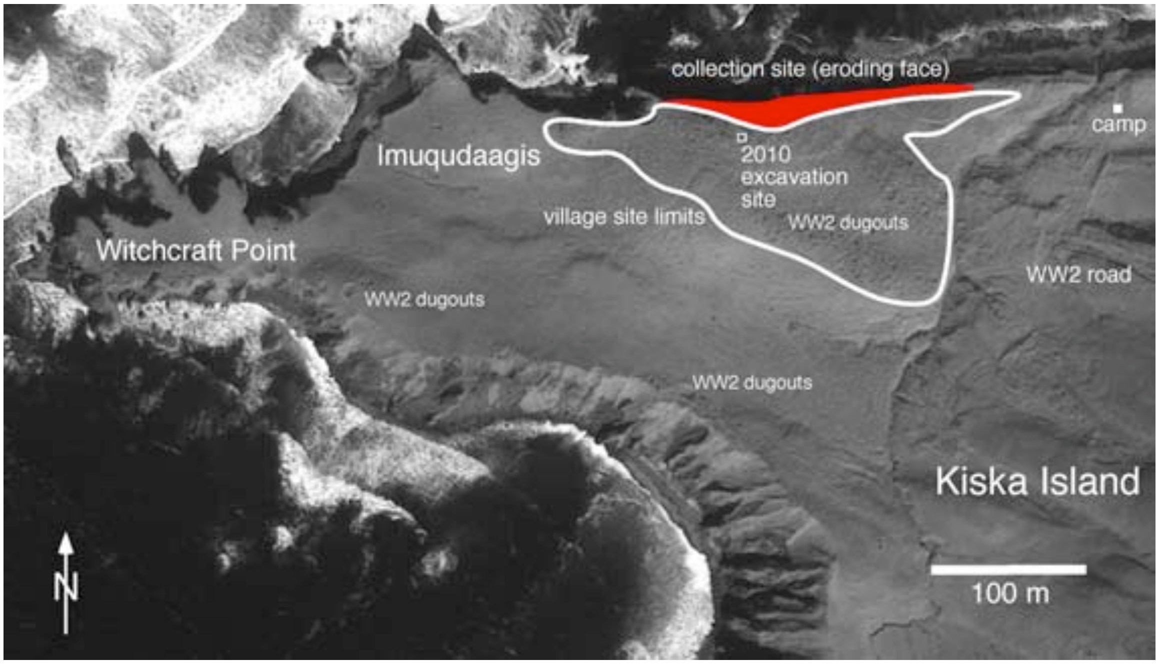

Figure 2 Map of the northern face of the middle of Kiska Island showing the location of the collection site and Imuqudaagis, Witchcraft Point where bird bones were collected from May to August 2010.

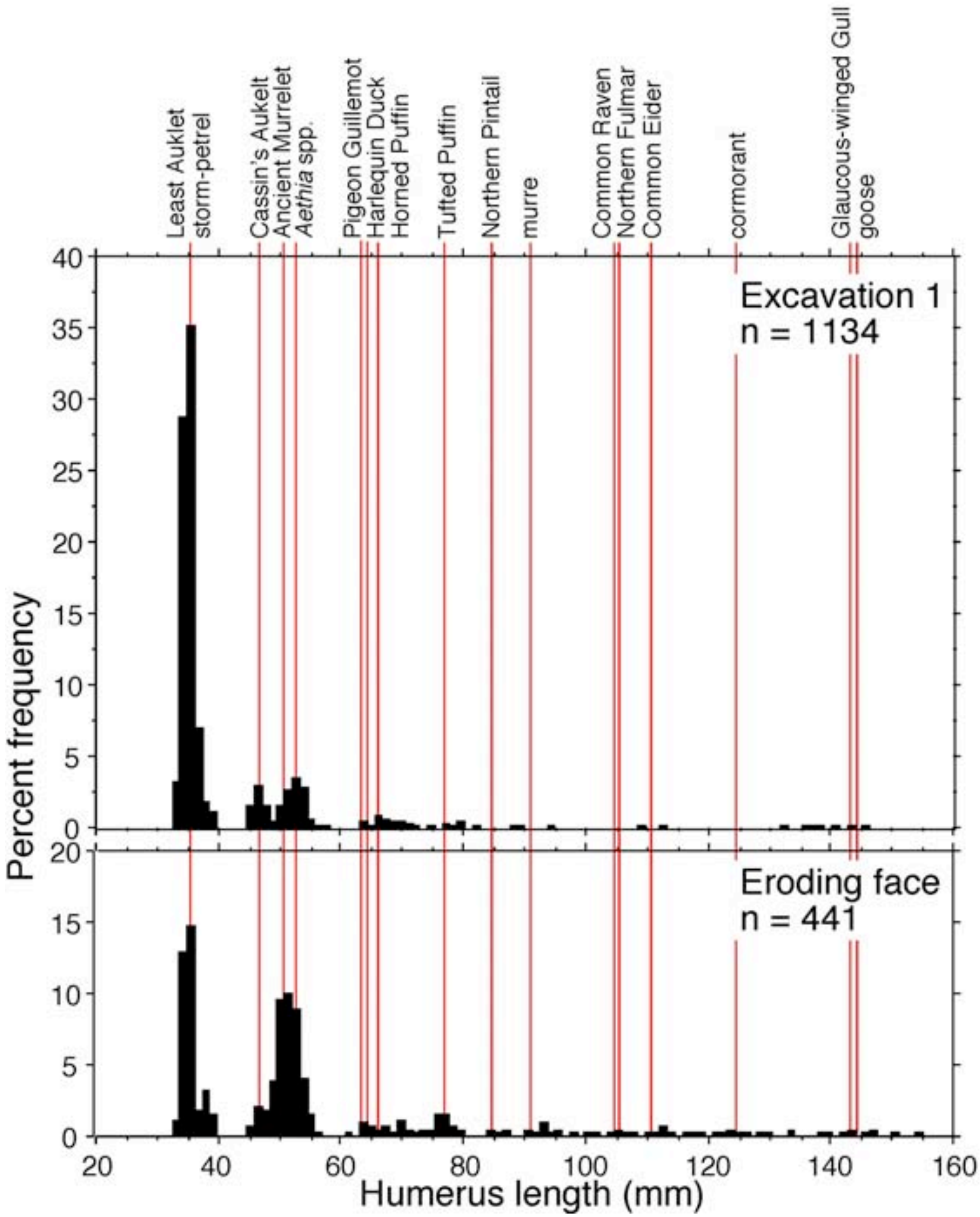

Figure 3 Frequency of humeri by length and mean values of humeri length of respective taxa of bones collected in 2010 at Imuqudaagis, Witchcraft Point, Kiska Island, Aleutian Islands, Alaska.

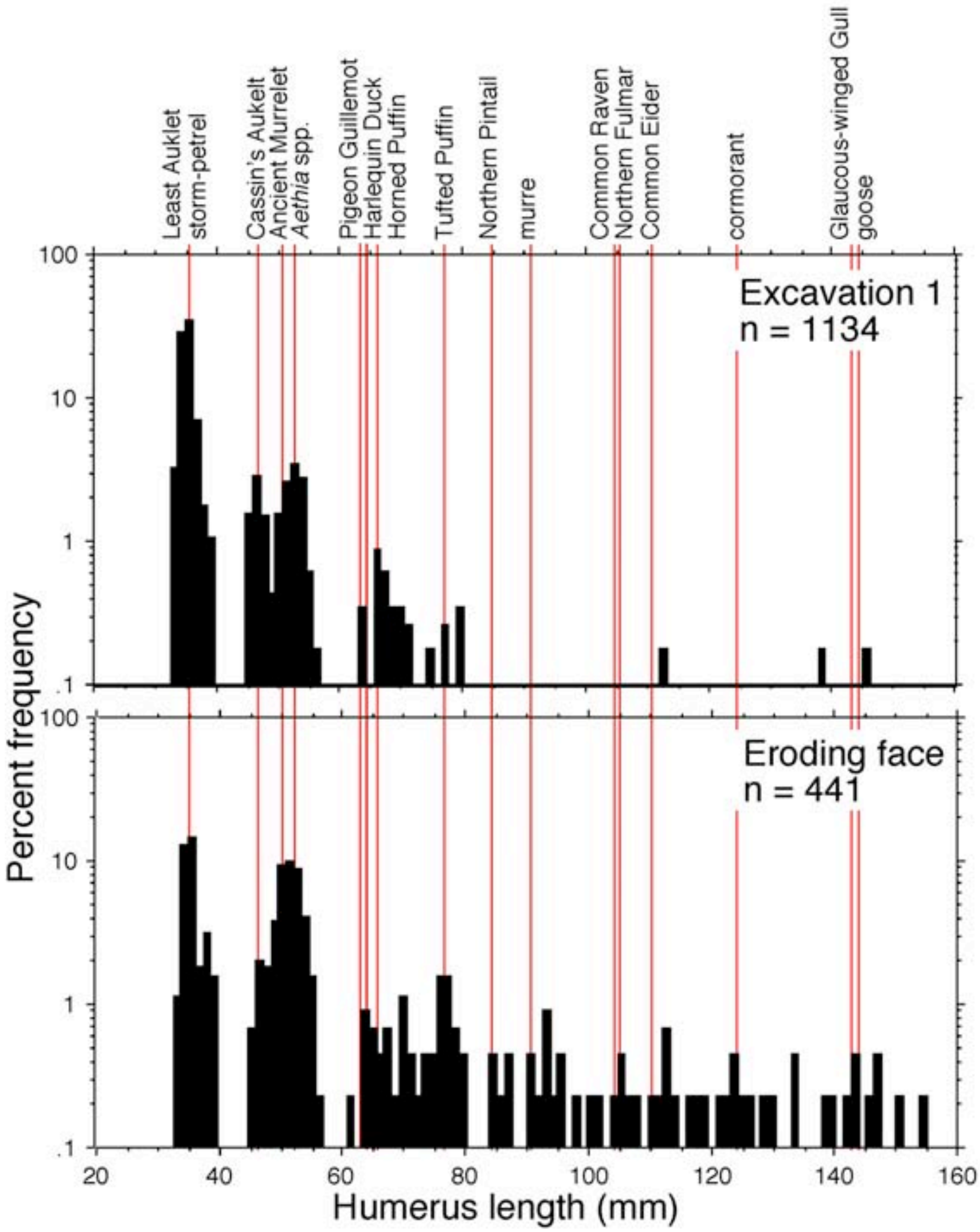

Figure 4 Log scale frequency of humeri by length and mean values of humeri length of respective taxa of bones collected in 2010 at Imuqudaagis, Witchcraft Point, Kiska Island, Aleutian Islands, Alaska.

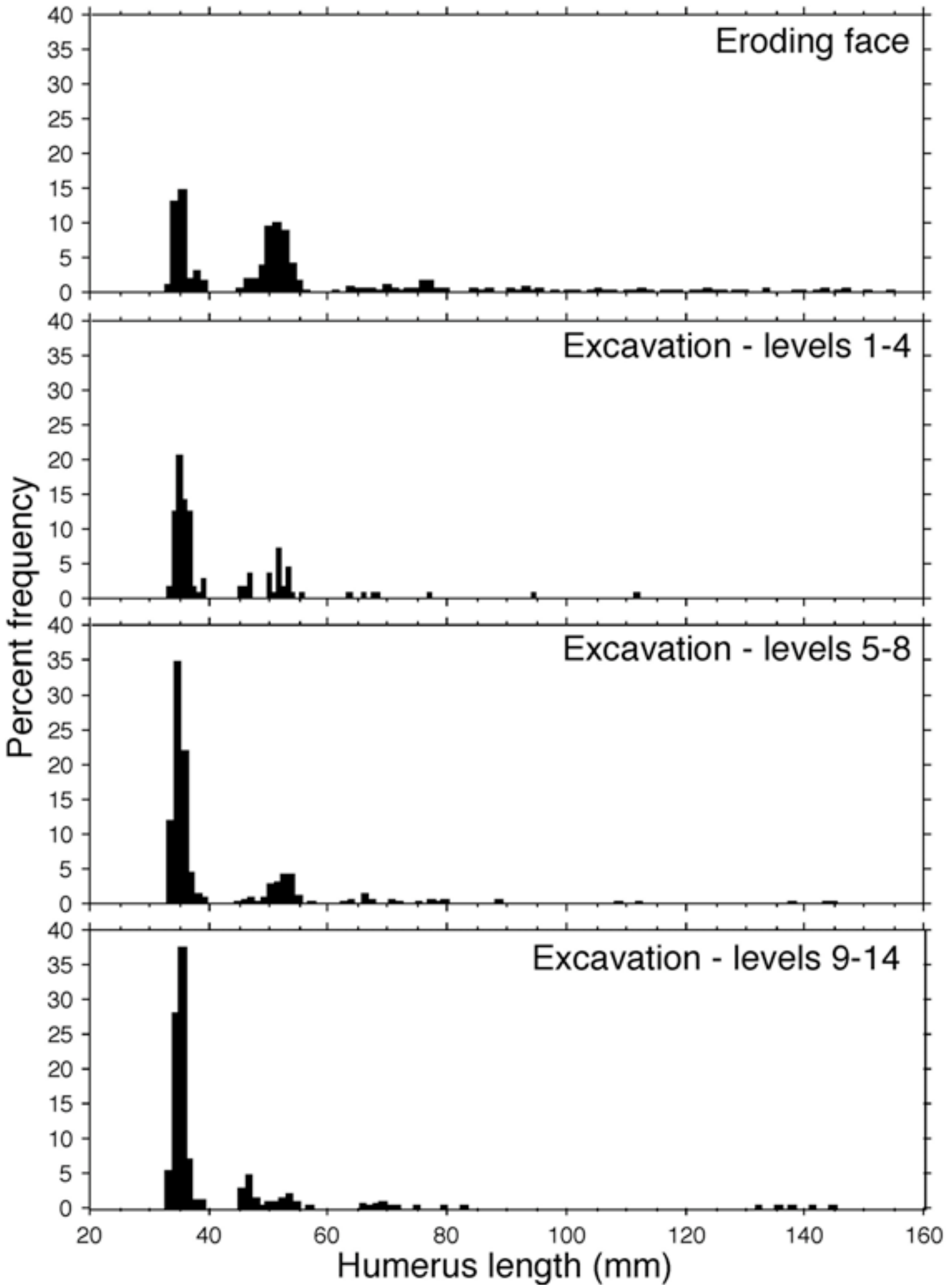

Figure 5 Frequency of humeri length by collection site and level, for specimens collected in 2010 at Imuqudaagis, Witchcraft Point, Kiska Island, Aleutian Islands, Alaska.

LITERATURE CITED

Athens, S. J., Tuggle, D. H., Ward, J. V., and Welch, D. J. (2002). Avifaunal extinctions, vegetation change, and Polynesian impacts in prehistoric Hawaii. *Archaeological Oceania, 37*, 57-78.

Biber, E. (2002). Patterns of endemic extinctions among island bird species. *Ecography, 25*, 661-676.

Boyer, A. G. (2008). Extinction patterns in the avifauna of the Hawaiian islands. *Diversity and Distributions, 14*(3), 509-517.

Corbett, D., LeFevre, C., Siegel−Causey, D. (1997). The Western Aleutians: cultural isolation and environmental change. *Human Ecology 25*(3), 459-479.

Causey, D., Corbett, D. G., Lefevre, C., West, D. L., Savinetsky, A. B., Kiseleva, N. K., Khassanov, B. F. (2005). The palaeoenvironment of humans and marine birds of the Aleutian Islands: three millennia of change. *Fisheries Oceanography, 14*, 259-276.

Diamond, J. M., Ashmole, N. P., and Purves, P. E. (1989). The present, past, and future of human-caused extinctions [and Discussion]. *Philosophical Transactions of the Royal Society of London, Biological Sciences, 325*(1228), 469-477.

Ebbert, S. E. and Byrd, G. V. (2002). Eradications of invasive species to restore natural biological diversity on Alaska Maritime National Wildlife Refuge. *Turning the tide: the eradication of invasive species, IUCN SSC Invasive Species Specialist Group, Internation Union for the Conservation of Nature*, 102-109.

Funk, C. (2010). Report: Rats and Birds: Tracking ecological change with evidence from prehistoric to historic Aleut village midden test excavations. Rat Island, Alaska. Unpublished Report.

James, H. F., Stafford, T. W., Steadman, D. W., Olson, S. T., Martin, P. S., Tull, A. J., McCoy, P. C. (1987). Radiocarbon dates on bones of extinct birds from Hawaii. Proceedings of the National Academy of Sciences, USA Vol. 84: 2350-2354.

Jochelson, W. (1968). History, ethnology and anthropology of the Aleut. Anthropological publ. Netherlands.

Johnson, T. H., and Stattersfield, A. J. (1990). A global review of island endemic birds. *Ibis, 132*, 167-180.

Lech, V., Hutchings, C. (2010). Preliminary Report: Archaeological Investigation of the Witchcraft Point midden site, Kiska Island, AK.

Lefevre, C., Corbett, D. G., West, D., Siegel-Causey, D. (1997). A zooarchaeological study at Buldir Island, Western Aleutians, Alaska. *Arctic Anthropology, 34*(2), 118-131.

Lyman, R. L. (1994). Quantitative Units and Terminology in Zooarchaeology. *American Antiquity, 59*(1), 36-71.

Major, H. L. (2004). Impacts of introduced Norway Rats (*Rattus norvegicus*) on Least Auklets (*Aethia pusilla*) breeding at Kiska Island, Aleutian Islands, Alaska during 2001-2003. Master of Science Thesis, Department of Biology, *Memorial University of Newfoundland*.

Major, H. L., Jones, I. L., Byrd, G. V., Williams, J. C. (2006). Assessing the effects of introduced Norway rats (*Rattus norvegicus*) on survival and productivity of Least Auklets (*Aethia pusilla*). *The Auk, 123*(3), 681-694.

Milberg, P., and Tyrberg, T. (1993). Naïve birds and noble savages – a review of man-caused prehistoric extinctions of island birds. *Ecography, 16*, 229-250.

Murie, O.J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. North American Fauna, Volume 61, U.S. Fish and Wildlife Service.

Pimm, S. L., Moulton, M. P., Justice, L. J., Collar, N. J., Bowman, D. M., and Bond, W. J. (1994). *Philosophical Transactions: Biological Sciences, 344*(1307), 27-33.

Pimm, S. L., Raven, P., Peterson, A., Sekercoglu, C. H., and Erhlich, P. R. (2006). Human impacts on the rates of recent, present, and future bird extinctions. *Proceedings of the National Academy of Sciences of the United States of America, 103*(29), 10941-10946.

Savinetsky, A. B., Kiseleva, N. K., Khassanov, B. F. (2004). Dynamics of sea mammal and bird populations of the Bering Sea region over the last several millennia. *Palageogeography Palaeoclimatology Palaeoecology, 209*, 335-352.

Siegel-Causey, D., Lefevre, C., Savinetskii, A. B. (1991). Historical diversity of cormorants and shags from Amchitka Island, Alaska. *The Condor, 93*(4), 840-852.

Steadman, D. W. (1995). Prehistoric extinctions of Pacific island birds: biodiversity meets zooarchaeology. *Science, New Series, 267*(5201), 1123-1131.

West, D., O'Rourke, D., Crawford, M. H. (2010). Introduction: origins and settlement of the indigenous populations of the Aleutian Archipelago. *Human Biology, 82*(5-6), 481-486.

West, D., Crawford, M. H., and Savinetsky, A. (2007). Genetics, prehistory and the colonization of the Aleutian Islands. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh, 98*, 47-57.

Williams, J. C., Byrd, G. V., Konyukhov, N. (2003). Whiskered Auklets *Aethia pygmaea*, foxes, humans and how to right a wrong. *Marine Ornithology 31*, 175-180.