

The Role of Seabirds in Hawaiian Subsistence: Implications for Interpreting Avian Extinction and Extirpation in Polynesia



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SCIENTISTS ESTIMATE THAT ABOUT ONE-FIFTH of the species of birds that existed in the world a few thousand years ago has disappeared as a result of human activities (Diamond 1989). Subfossil and archaeological evidence suggests that before human occupation was established, the native fauna throughout Polynesia was taxonomically more diverse than historical documents reflect (James 1983; James et al. 1987; Kirch 1982; Olson and James 1982, 1984, 1991; Steadman 1989, 1991, 1992, 1993). Archaeologists have documented extinct avian species in western Polynesia and throughout eastern Polynesia including Pitcairn Island and the islands of the Marquesas, the Societies, the Cooks, and Hawai'i (Steadman 1989, 1991, 1992, 1993).

Today, researchers commonly refer to the state of Hawai'i as "the endangered species capital of the nation" (*National Geographic*, September 1995). The Hawaiian Islands lay claim to nearly one-third of all the species listed on the endangered and threatened species list in the United States. Hawaiian taxa account for nearly three-quarters of the nation's extinct species. This count includes plants, land snails, insects, birds, and other organisms. Recent subfossil discoveries have added to the number of known endemic bird species that once inhabited these islands.

In 1926 scientists found the first avian subfossil species on the island of Hawai'i in a tunnel under 75 feet of lava (Wetmore 1943). Wetmore identified this species as *Geochen rhuax*, a member of the goose family, Anatidae. It was larger than the only known living goose in the Hawaiian Islands, the *Nene*. In 1971 scientists found a second subfossil goose on the island of Moloka'i (Stearns 1973). As was the subfossil found on the island of Hawai'i, the Moloka'i species was large and flightless (Stearns 1973).

In the two decades since the discovery of this second goose, paleontologists have identified 62 species of subfossil birds that were previously unknown (James and Olson 1991). This count is added to the 70 historically documented endemic species and subspecies that inhabit the islands or have become extinct since writ-

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Asian Perspectives, Vol. 36, No. 1, © 1997 by University of Hawai'i Press.

ten records were kept. The subfossil extinct species from all of the Hawaiian Islands fall into two general categories. The first represents large, often flightless species such as geese, ibises, rails, hawks, and owls. The second represents small, flighted forest species such as finches. These extinct forms came from several subfossil localities including sand dunes on the islands of Kaua'i and Moloka'i, lava tubes on the island of Maui, and karst sink holes on the island of O'ahu. Archaeological deposits have also contributed specimens to the increasing list of extinct fauna.

Subfossil evidence indicates that humans either directly through predation or indirectly through habitat alteration affected the abundance of birds and likely contributed to their extinction or extirpation. We know from ethnographic records that birds played an important role in Polynesian societies. Polynesians used birds in a variety of ways: their flesh was a source of food, feathers adorned cloaks and helmets, and bones were used for tools (Te Rangi Hiroa 1964).

Researchers believe that seabirds played an important role in the settlement of Polynesia. Irwin (1992) suggests that the ability of Polynesians to detect land from a considerable distance offshore was an important element in navigation. Furthermore, he suggests that this ability was important both in the initial exploration and on return voyages. Navigators likely used the detection of specific seabirds as an indication of land (Irwin 1992; Steadman in press). Researchers speculate that specific seabird species are particularly important in this capacity. For example, birds that rarely fly more than 20–100 km from island roosts would be important in determining nearness to an island and the location of schools of fish (Steadman in press). The extirpation of these and other seabird species may have altered the effectiveness of navigators and especially fishermen.

Finally, seabirds may also have been an important food source for Polynesians during colonization and settlement of new lands. Archaeologists identified seabirds as the primary food source on Henderson Island. Steadman and Olson (1986) believe the extirpation of seabirds from Henderson led to the abandonment of this island.

To date, research focusing on understanding causes of extinction has emphasized the land birds. Land birds are more interesting to study from an evolutionary standpoint (Steadman 1989:180). Hawaiian land birds, in particular, have received a great deal of attention because they are exclusively endemic. Additionally, land birds have smaller ranges and poorer dispersal abilities than seabirds. Thus they are totally dependent on the terrestrial ecosystem for food and nesting habitat. Species diversity for land birds tends to be greater, in part, because of these factors.

If we want to understand the relationship between human colonization, subsistence, and faunal extinction (or extirpation) in Hawai'i, seabirds should be an important component of our investigation. Seabirds—because of their large population sizes, wide distribution, and susceptibility to predators during reproduction—are a better indicator than land birds of the direct impact human settlement may have had on the native fauna. Seabirds are also good indicators of human impact on the native fauna because their bones are more common and better preserved in the fossil record than those of land birds.

Ornithologists and archaeologists do not have a clear understanding of either

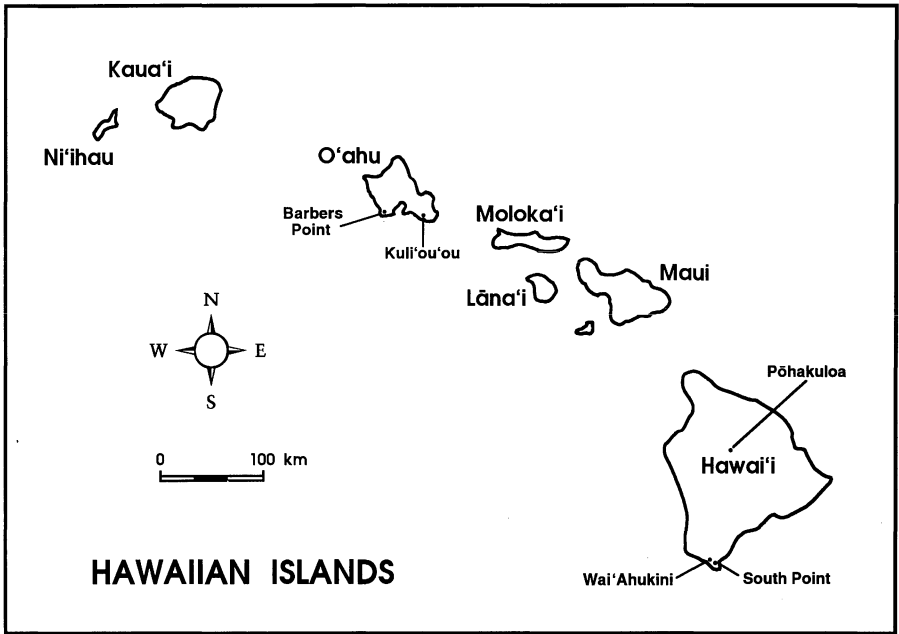


Fig. 1. Map of the main islands of the Hawaiian Archipelago showing locations of sites mentioned in the text.

the modern or prehistoric distribution of seabirds (Garnett 1984). Archaeological data can help to fill this information gap. The archaeological record provides an invaluable source of avian osteological material that is relevant for our understanding of the pre-European contact distribution and abundance of seabirds. In addition, archaeological assemblages can shed light on the impact humans and introduced animals may have had on the prehistoric avifauna. This paper presents the findings of an avifaunal analysis of two prehistoric coastal sites: at Kuli'ou'ou (Site O1) on the island of O'ahu and at South Point (Site H1) on the island of Hawai'i (see Fig. 1). The discussion focuses specifically on the relative numbers of seabirds and land birds and the role that humans may have played in the extirpation of Hawaiian seabirds.

SITE DESCRIPTIONS

In recent years, as interest in extinct avian species has grown, we have seen a parallel concern for the reanalysis of previously collected archaeological materials (Broughton 1995; Collins 1995a; Livingston 1988). These collections provide archaeologists with important information and represent "new" sources of data. Archaeologists in the 1950s collected the avifaunal materials that provide the data for my analysis. The materials come from two archaeological sites in the Hawaiian Islands: Kuli'ou'ou (Site O1) and South Point (Site H1). Both sites were important to our early understanding of Hawaiian prehistory.

Kuli'ou'ou

Site O1 is a rockshelter that lies at an elevation approximately 30.5 m (100 ft) above sea level and nearly 182.9 m (200 yds) from the ocean (Emory and Sinoto 1961). At its greatest point, the floor area of the rockshelter is 15.5 m (51 ft) long. The total living floor area is 13.7 m (45 ft) in length. The maximum width of the shelter is 7.9 m (26 ft) and the maximum height is 2.4 m (8 ft) (Emory and Sinoto 1961). At the time people used the shelter for habitation, a living area of about 39.5 m² (425 ft²) was available. The shelter would have protected the inhabitants from inclement elements, but sunlight would have reached the interior during the day. Streams that once ran through the floor of Kuli'ou'ou Valley could have provided water to the inhabitants (Emory and Sinoto 1961).

The Kuli'ou'ou rockshelter has been the site of a number of investigations. John Porteus, an anthropology student from the University of Hawai'i conducted the first excavation at Kuli'ou'ou in 1938. Porteus excavated 556 m² (57 ft²) before World War II interrupted his work. During the war, the rockshelter was altered when part of the site was used as a bomb shelter. In 1950 Kenneth Emory and students from the University of Hawai'i field school continued excavation at the Kuli'ou'ou rockshelter. Emory and his students dug 36 squares 0.9 m × 0.9 m (3 ft × 3 ft) for a total of 30.11 m² (324 ft²) in 15.2 cm (6 in) arbitrary levels (Emory and Sinoto 1961)(see Fig. 2: site plan view). Archaeologists did not clearly define the stratification of the shelter, but there appear to be three major divisions (Emory and Sinoto 1961). Layer I comprises the first 15.2 cm (6 in). Archaeologists described this layer as having a "top covering of yellowish dust," which is sterile for the first 2.5–5.0 cm (1–2 in) (Emory and Sinoto 1961). Below

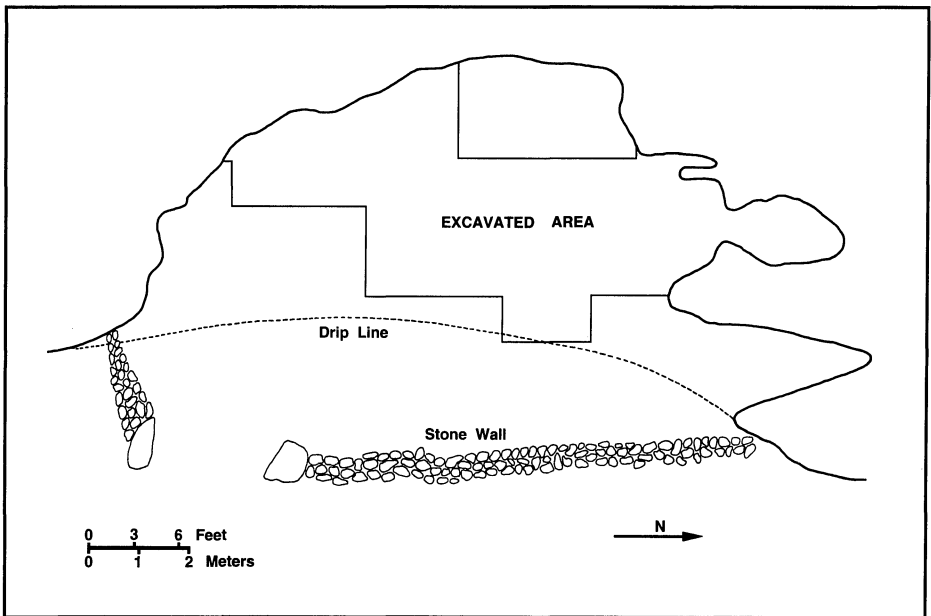


Fig. 2. Plan of excavation at the Kuli'ou'ou rockshelter (Site O1). (Courtesy of Bishop Museum Department of Anthropology)

TABLE I. STRATIGRAPHIC AND ANALYTIC ZONE INFORMATION FOR KULI'OU'OU ROCKSHELTER (SITE OI) AND SOUTH POINT SAND DUNE (SITE H1)

| SITE | STRATIGRAPHIC LAYER | ANALYTIC ZONE |
|-------------|---------------------|--|
| Kuli'ou'ou | I | Zone 1 Historic and Proto-Historic >1750 |
| | II | Zone 2 Late Prehistoric 1400/1500-1700/1750 |
| | III | Zone 3 Prehistoric 750-1400 |
| | IV | Zone 4 Sterile, No Occupation |
| South Point | I | Zone 1 |
| | II | Zone 2 Prehistoric 500-1400 |
| | III | Zone 3 Early Prehistoric <500 |

this layer, both European and Hawaiian artifacts appear in a darker band at a depth of 15.2 cm (6 in). I refer to the first 15.2 cm (6 in) as Kuli'ou'ou Analytic Zone 1. Archaeologists described the second, darker band as gray brown (Emory and Sinoto 1961). This layer is about 30.5-45.7 cm (12-18 in) wide and filled with gravel and stone fragments (Emory and Sinoto 1961). I refer to this layer as Kuli'ou'ou Analytic Zone 2. Finally, the third layer extends for approximately 30.5 cm (12 in). This layer is lighter in color but contains more gravel and larger stones than layer 2 (Emory and Sinoto 1961). I refer to this layer as Kuli'ou'ou Analytic Zone 3. Below Zone 3 is the sterile rockshelter floor (see Table 1).

Kuli'ou'ou is significant in the history of archaeology in Polynesia because it provided the first radiocarbon date from Oceania and indicated to researchers that there was a considerable time depth for the settlement of the Hawaiian Islands. In 1961 Emory and Sinoto published the results of radiocarbon analysis on two samples from Kuli'ou'ou. The first date, from square D7, 61-91.5 cm (24-36 in) was reported as A.D. 1004 \pm 180 (Chicago 550). The second sample came from 45.75-61 cm (18-24 in) in D7 and yielded a date of A.D. 1739 \pm 150 (Michigan 564). Emory and Sinoto (1961) dated the initial use of the site to the eighth century A.D. The second date (M564) indicated to the excavators a rapid rate of deposition in the last centuries (Emory and Sinoto 1961).

South Point

Site H1 is a sand dune located about one-quarter of a mile east of South Point on the island of Hawai'i. Archaeologists excavated Site H1 from 1953 to 1955 as part of the Hawaiian Archaeological Program sponsored by the Bishop Museum. The archaeological crew excavated over 200 0.9 m (3 ft) squares by 15.2 cm (6 in) arbitrary levels (Emory et al. 1968) (see Fig. 3). Archaeologists excavating at the site determined pre-Contact Hawaiians used this site for habitation. Site H1 was eventually covered by a sand dune and some time later converted to a burial ground (Emory et al. 1968). South Point yielded a large number of artifacts—over 14,000, of which 1710 were fish hooks.

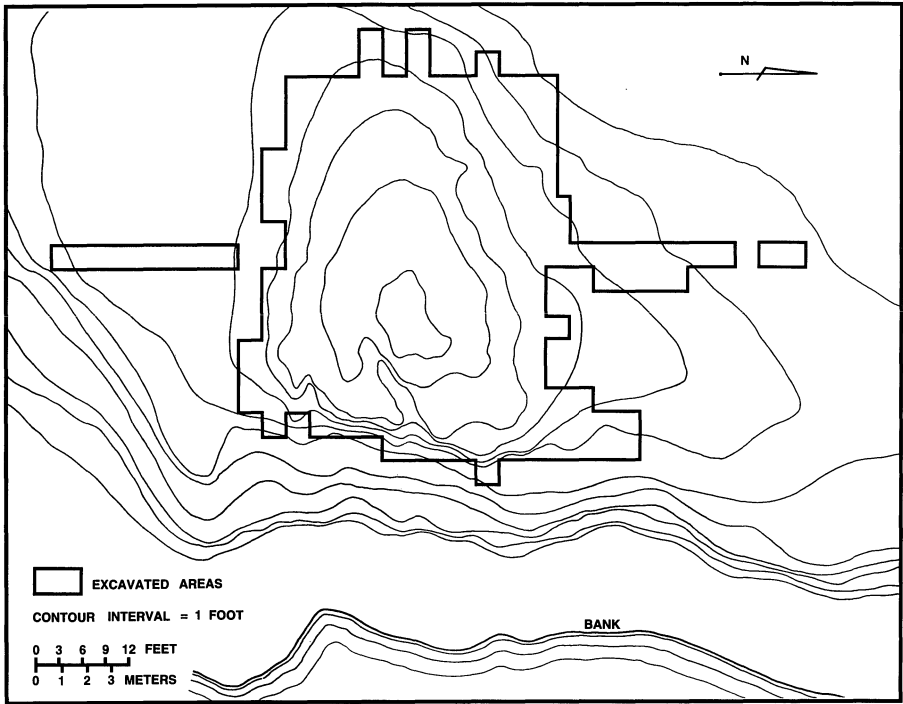


Fig. 3. Plan of excavation at the South Point sand dune (Site H1). (Courtesy of Bishop Museum Department of Anthropology)

Archaeologists have written a number of articles and reports about the remarkable fish hook collection recovered at South Point (Emory et al. 1968; Emory and Sinoto 1969; Green 1971). The excavators, however, never provided a complete site report for the South Point project. From notes made by Kirch (1985) and my own brief examination of the original records, it appears that South Point consists of at least three layers. The excavators described the sediment in Layer I as dark brown sandy soil (DBSS). This layer consists of only the top 7.6 cm (3 in) across the site, herein referred to as South Point Analytic Zone 1. Below Layer I is the first major cultural deposit. The excavators referred to this layer as the first high density cultural layer (1st HDCL). Information gleaned from excavation notes indicates that this deposit is approximately 7.6 cm (3 in) thick. Near the base of this cultural deposit, the excavators identified a coral pavement layer (CPL) that begins midway between the second layer (at approximately 22.8 cm [9 in]). Below the coral pavement layer, to approximately 30.5 cm (12 in), is the second high density cultural layer (2nd HDCL). Layer II appears to end at approximately 30.5 cm (12 in). I refer to this layer as South Point Analytic Zone 2. The third layer, which I refer to as South Point Analytic Zone 3, appears to consist of approximately 12.7–15.2 cm (5–6 in) of dark brown sandy soil (DBSS). Below Layer III the sediment is sterile.

The radiocarbon dating of the site only serves to confuse the picture of South Point. The following information regarding the chronology of South Point

comes entirely from previously published sources (see Emory and Sinoto 1969; Hunt and Holson 1991; Kirch 1985; Spriggs and Anderson 1993). I made no attempt to reanalyze these dates. New samples are presently being submitted for reanalysis and dating by others (T. Hunt and M. S. Allen, personal communication 1996).

Based on artifact typologies and radiocarbon dates established at this site and others (in particular the nearby site at Wai'Ahukini), archaeologists believed South Point to be the earliest site in the Hawaiian Islands. Emory and Sinoto (1969) submitted 27 samples of charcoal, shell, and sea urchin spine for dating. Hunt and Holson (1991) determined that ten of these samples yielded "early" dates (that is, dates that calibrate to ages prior to A.D. 1000). Dates from samples taken within the same stratum, however, are quite variable. In addition, dates between strata are also confused (the majority of samples, except GrN 2225, from Layer III postdate Layer II). These problems, recognized by Emory and Sinoto (1969), led them to speculate that they were dating ancient driftwood possibly used for fuel.

The first cultural deposit at South Point may date to as early as the beginning of the sixth century A.D. (Kirch 1985:84). Occupation may have continued through the thirteenth and fourteenth centuries (Kirch 1985:84). Kirch writes that most of the dates from Layer III, except for GrN 2225 (A.D. 290±60) were probably contaminated. The GrN 2225 date is consistent with both the Layer II dates as well as the fish hook typology (Kirch 1985). Kirch argues that until there is further analysis on the South Point assemblage, archaeologists should accept the GrN 2225 date. Spriggs and Anderson (1993), however, reject all of the dates from South Point as unreliable. Perhaps the new materials presently under analysis will help clarify these issues.

FAUNA

Much of the focus of excavations in the early 1950s in the Hawaiian Islands was on determining settlement patterns and chronology. Archaeologists recognized the importance of reconstructing prehistoric subsistence patterns through the use of fauna, but it was not a major concern at the time. Analysts rarely identified taxa to the level of genus or species, and the Kuli'ou'ou and South Point assemblages were never completely identified. In addition, archaeologists gave little consideration to the effect of recovery techniques on faunal collections. Excavators screened both collections through 0.625 mm (0.25 in) mesh. Recent research on faunal studies indicates that smaller screen sizes will catch small bones that are lost in the 0.625 mm mesh (Gordon 1993; Grayson 1984; Nagaoka 1994). Thus the faunal collections from these sites are biased against small species and small bone elements.

Despite the effects of recovery bias, both assemblages provide a wealth of faunal material from which we can learn more about the distribution of Hawaiian seabirds and their role in traditional Hawaiian subsistence. Because there is no evidence that Polynesians were able to catch birds at sea (Steadman and Olson 1986), Hawaiians probably collected all of the taxa represented in these collections locally. Although there is the possibility of inter-island trade, the presence of suitable native habitats at both South Point and Kuli'ou'ou suggests that the birds were obtained from these areas.

Kuli'ou'ou

The Kuli'ou'ou rockshelter yielded a large number of bird bones, particularly from the lowest levels of the site. Emory and Sinoto (1961) chose to do an in-depth analysis of squares D6 and D7. Olson and James (1982) looked at the avifaunal material from this site and identified bones from several extirpated seabirds (dark-rumped petrel, *Pterodroma phaeopygia*; Newell's shearwater, *Puffinus newelli*; and Bonin petrel, *Pterodroma hypoleuca*), an extinct rail, and a flightless goose (*Thambetochen* sp.). Olson and James (1982) did not provide any discussion, however, regarding the full array of taxa or the stratigraphic distribution of these specimens at the site. I have analyzed the entire avifaunal collection from the 1950 excavation, and I will account for all of the number of identified specimens (NISP), as well as discuss the chronological distribution of the fauna found at the rockshelter.

Of the 446 bird bones collected from the Kuli'ou'ou rockshelter, 147 are identifiable at least to the level of family (see Table 2). Many of the Kuli'ou'ou bird

TABLE 2. SYSTEMATIC LIST OF EXTINCT AND NONEXTINCT ENDEMIC AND INDIGENOUS SPECIES IDENTIFIED IN THE KULI'OU'OU ROCKSHELTER SITE (O1) AND SOUTH POINT SAND DUNE SITE (H1)

| BIRD SPECIES | COMMON NAME | KULI'OU'OU | SOUTH POINT |
|--------------------------------|--|------------|--------------------|
| | | NISP | NISP |
| LAND BIRDS | | | |
| Anatidae | Ducks, Geese, and Swans | | |
| Extinct goose? | | 1 | 0 |
| cf. <i>Branta sandvicensis</i> | <i>Nene</i> | 0 | 1 |
| Phasianidae | Gallinaceous birds | | |
| cf. <i>Gallus gallus</i> | Chicken | 0 | 4 |
| Rallidae | Rails, Moorhens, Gallinules, and Coots | | |
| cf. <i>Rallidae</i> | | 1 | 1 (2) ^a |
| MIGRATORY BIRDS | | | |
| Scolopacidae | Sandpipers and related birds | | |
| <i>Numenius tahitiensis</i> | Bristle-thighed curlew | 0 | 1 |
| Charadriidae | Plovers and Dotterels | | |
| <i>Pluvialis dominica</i> | Lesser golden-plover | 0 | 1 |
| SEABIRDS | | | |
| Laridae | Jaegers, Gulls, and Terns | | |
| <i>Anous stolidus</i> | Brown noddy | 0 | 1 |
| Phaethontidae | Tropicbirds | | |
| <i>Phaethon lepturus</i> | White-tailed tropicbird | 11 (1) | 1 |
| Procellariidae | Shearwaters and Petrels | 10 (2) | 9 (2) |
| <i>Puffinus</i> sp. | Shearwaters | 2 | 8 |
| <i>Puffinus pacificus</i> | Wedge-tailed shearwater | 11 (3) | 26 (6) |
| <i>Puffinus nativitatus</i> | Christmas shearwater | (2) | 2 (3) |
| <i>Puffinus newelli</i> | Newell's shearwater | 12 | 3 (1) |
| <i>Pterodroma</i> sp. | Petrels | 7 | 0 |
| <i>Bulweria bulwerii</i> | Bulwer's petrel | 12 | 4 (3) |
| <i>Pterodroma hypoleuca</i> | Bonin petrel | 1 (2) | 7 (11) |
| <i>Pterodroma phaeopygia</i> | Dark-rumped petrel | 64 (4) | 14 |
| <i>Pterodroma</i> sp. | | 1 | 5 |
| Total | | 133 (14) | 88 (28) |

^a Numbers in parentheses indicate elements tentatively assigned to species.

bones are fragmented. In addition, 74 bones (17 percent) indicate burning. I identified nine (possibly ten) species. I found only a single landbird (tentatively identified as a rail), represented by one element. Seabird bones make up 89 percent of the Kuli'ou'ou avifaunal assemblage. Of the seven (possibly eight) seabird species identified, only one is a tropicbird (the white-tailed tropicbird, *Phaethon lepturus*). White-tailed tropicbirds are widely distributed throughout the Pacific, and historically they are known to breed on the islands of O'ahu, Maui, Lāna'i, Hawai'i, and Kaua'i (Berger 1981:50). The number of white-tailed tropicbird elements identified in this assemblage is an indicator that this taxa bred on O'ahu during the prehistoric period.

A majority of the seabirds recovered are either shearwater (3) or petrel (4) taxa. Three of the seabirds identified from the Kuli'ou'ou assemblage (Bulwer's petrel, *Bulweria bulwerii*; Bonin petrel; and Christmas shearwater, *Puffinus nativitatus*) are not known to have bred historically on O'ahu (Berger 1981; Pratt et al. 1987). Collins (1995b) identified the Bonin petrel from sites at Barbers Point. The presence of this species at Kuli'ou'ou expands its prehistoric range on O'ahu.

This assemblage also confirms the presence of the wedge-tailed shearwater (*Puffinus pacificus*), the Newell's shearwater, and the dark-rumped petrel on O'ahu. Berger (1981:43) reports of wedge-tailed shearwaters attempting to nest at Black Point, on O'ahu, but that predators (most likely cats, dogs, or mongooses) killed both the adults and juveniles. This taxa is currently found at Black Point on O'ahu (Sheila Conant, personal communication 1996).

On O'ahu, carcasses of Newell's shearwater have been recovered on the ground, but there are no reported nesting sites. Ornithologists do not know whether these individuals came from nesting populations on O'ahu or from known populations found on Kaua'i (Berger 1981:45). The presence of Newell's shearwater in the Kuli'ou'ou assemblage suggests that the historical accounts may represent an attempt of this species to reestablish nesting sites on O'ahu.

Munro (1944) wrote that Hawaiian predation on the dark-rumped petrel led to their extirpation on O'ahu. Berger (1981), however, is not clear as to whether this extirpation occurred during the historic or prehistoric period. The presence of dark-rumped petrel bones in Layer I of the Kuli'ou'ou assemblage indicates that this species was present on O'ahu in the early historic period (see Table 3).

Finally, the single skeletal element I refer to as *Pterodroma* sp. may be an extinct petrel species found in subfossil sites on both O'ahu and the island of Hawai'i (Olson and James 1991). This species is smaller than the Bonin petrel but larger than the Bulwer's petrel. Collins (1995b) identified this species from Barbers Point as well. The presence of this species in Kuli'ou'ou expands its prehistoric range on O'ahu.

South Point

The South Point dune site yielded a vast amount of faunal material. The faunal material includes an incredible number of fish bones (personal observation, 1996). In addition to the fish bone, this dune site also yielded a large sample of bird bone: 227 identified specimens (NISP). The avifauna from Site H1 represents one of the largest and most well preserved collections recovered from the lowland region of the island of Hawai'i. Despite the problems regarding the chronol-

TABLE 3. NUMBERS OF IDENTIFIED AVIAN SPECIMENS PER TAXON BY ANALYTIC ZONE AT THE KULI'OU'OU ROCKSHELTER (SITE O1)

| TAXON | ANALYTIC ZONE | | | TOTAL ^a |
|---------------------------------|---------------|-----|----|--------------------|
| | 1 | 2 | 3 | |
| Rallidae | — | — | 1 | 1 |
| <i>Phaethon lepturus</i> | 3 | 7 | — | 10 |
| Procellariidae | — | 8 | 3 | 11 |
| <i>Puffinus</i> sp. | — | 1 | — | 1 |
| <i>Puffinus pacificus</i> | — | 11 | — | 11 |
| <i>Puffinus nativitatus</i> | — | 1 | — | 1 |
| <i>Puffinus newelli</i> | — | 9 | — | 9 |
| <i>Bulweria bulwerii</i> | 1 | 7 | — | 8 |
| <i>Pterodroma</i> sp. | — | 2 | — | 2 |
| <i>Pterodroma hypoleuca</i> | — | 1 | — | 1 |
| <i>Pterodroma phaeopygia</i> | 3 | 41 | 6 | 50 |
| cf. <i>Pterodroma jugabilis</i> | — | 1 | — | 1 |
| Unidentified | 16 | 186 | 19 | 221 |
| Total ^a | 23 | 275 | 29 | 327 |

Note: Specimens securely identified to a given specimen and those simply referred to that specimen are combined.

^aA total of 41 identified specimens and 78 unidentified elements could not be assigned to any provenience.

ogy of the site, South Point, like Kuli'ou'ou, is an excellent representation of the lowland seabird avifauna at the time of early Hawaiian occupation.

Of the 227 bird bones or fragments collected from this site, 116 are identifiable at least to the level of family (see Table 2). I identified at least 14 species of land birds and seabirds from the South Point assemblage. Of the total number of bird bones identified, 21 percent are land birds (including *Gallus gallus*), 14 percent are migratory birds, and 65 percent are seabirds. Unlike the Kuli'ou'ou assemblage, there are no burnt bones in the South Point assemblage.

I tentatively assigned six bird bones to three land bird species in the South Point assemblage: *Branta sandvicensis* (a goose or *Nene*), *Gallus gallus* (chicken), and an unknown Rallid. Both the goose and chicken occur on the island of Hawai'i. There is a single goose bone at this site, and certainly one, but possibly two rail bones. The *Nene* and chicken are not unexpected because both taxa occur on Hawai'i and the relatively large bones would not have been lost during screening.

I identified two migratory birds from this assemblage. The bristle-thighed curlew (*Numenius tahitiensis*) and the lesser golden-plover (*Pluvialis dominica*) are each represented by a single element. Neither species likely represents a significant part of the pre-European contact Polynesian diet, if consumed at all. A single bone of the brown noddy (*Anous stolidus*) and a single bone of the white-tailed tropicbird are identified in the South Point assemblage. The brown noddy is a resident species found throughout the Hawaiian Islands (Pratt et al. 1987:335). Its nesting sites range from "sandy beaches to tall forest trees far inland" (Pratt et al. 1987:184). The white-tailed tropicbird is also a resident species on the island of Hawai'i. This taxa can often be found nesting on cliffs.

Four of the nine seabird species identified in the South Point assemblage (Bulwer's petrel, Bonin petrel, Christmas shearwater, and the wedge-tailed shearwater) are not known to have bred historically on the island of Hawai'i. Pratt et al. (1987:330) list the Newell's shearwater as a possible migratory breeder on Hawai'i, but its status is still uncertain. The presence of this species in the South Point assemblage indicates that this species did come ashore, probably to breed. The dark-rumped petrel is an endangered species in the state of Hawai'i, and it is known to occur only at high elevations on the islands of Hawai'i and Maui (Banko 1990; Berger 1981:47; Hodges 1992). Finally, the species referred to as *Pterodroma* sp. may be the extinct species *Pterodroma jugabilis* identified by Olson and James (1991), and thus far found only at subfossil sites on O'ahu and in lava tubes in the North Kona district. Since no reference collection is available for direct comparison, I measured all complete skeletal elements and compared the results to metric measurements provided in Olson and James (1991). The results of this analysis indicate that the measurements of the elements found in the archaeological assemblages are within range of the subfossil species reported by Olson and James (1991). Results of this analysis are provided below.

The presence of the four extirpated and one possibly extinct seabird species in the South Point assemblage suggests that their nesting range once extended farther down the island chain. Extirpation of these species from the island of Hawai'i likely occurred after the arrival of humans on the island. The presence of the Bonin petrel in the South Point and in upland Pōhakuloa assemblages (Athens and Kaschko 1989; Reinman and Schilz 1994) confirms historic records that this species bred on Hawai'i. The identification of dark-rumped petrel bone at South Point indicates that this petrel was much more abundant than historic populations on the island of Hawai'i, and also that it nested at lower elevations than its present distribution suggests. Analysis of other assemblages across the island of Hawai'i will be necessary to determine the mechanisms involved in the extirpation of these species from, as well as their distribution throughout, the island.

Species Accounts

The following is a systematic listing and brief description of all of the taxa identified in the collections from the Kuli'ou'ou rockshelter and the South Point sand dune. The numbers in parentheses refer to those elements tentatively assigned to this species. Elements identified only to level of family or genus are not included in this count. See Tables 3 and 4 for stratigraphic distribution of taxa.

Extinct Goose?

Kuli'ou'ou Material. Number of Identified Specimens = 1

REMARKS: A large unidentified bone. Olson and James (1982) examined a humerus of the extinct flightless goose (*Thambetothen* sp.). No reference collection of this species was available at the Bernice P. Bishop Museum, so no conclusive identification is available for this analysis.

cf. *Branta sandvicensis*, Nene Goose

South Point Material. Number of Identified Specimens = 1

REMARKS: The Hawaiian goose, or *Nene*, is known historically only from the island of Hawai'i. There are early reports of this species on Maui, but there is

some question regarding whether or not it nested there (Berger 1981:68; Olson and James 1982:34). Olson and James (1982) reported subfossil remains of *Branta* from the islands of Hawai'i, Moloka'i, O'ahu, and Kaua'i. The remains from Hawai'i, Moloka'i, and Kaua'i resemble the extant form, but those from O'ahu appear to be different (Olson and James 1982).

The identification of the *Nene* in the South Point assemblage extends the distribution of this species to the lowlands on Hawai'i. This trend parallels the subfossil assemblage finds on O'ahu, Moloka'i, and Kaua'i, which were excavated from sites near the shoreline (Olson and James 1982:34). The South Point assemblage substantiates Olson and James' contention that this species is not "naturally restricted in the Hawaiian Islands to the high altitudes and harsh environments it generally inhabits at present" (1982:34). The *Nene* nearly became extinct in the early 1950s, but an aggressive program to rear these birds in captivity resulted in an increase in numbers with their release on the islands of Maui and Hawai'i (Berger 1981).

cf. *Gallus gallus*, Chicken

South Point Material. Number of Identified Specimens = 4

REMARKS: The chicken was first introduced to the Hawaiian Islands by Polynesians as a domesticated animal.

cf. Rallidae

Kuli'ou'ou Material. Number of Identified Specimens = 1

South Point Material. Number of Identified Specimens = 1 (2)

REMARKS: No conclusive identification of this species is available. Historically, ornithologists recorded only two species of rail from the Hawaiian Islands: *Porzana palmeri* of Laysan Island and *Porzana sandwichensis* from the island of Hawai'i (Berger 1981:80-84; Olson and James 1991). Olson and James (1991) have added at least ten new rails to the list of extinct species from bones recovered at various subfossil sites in the Hawaiian Islands.

Numenius tahitiensis, Bristle-thighed Curlew

South Point Material. Number of Identified Specimens = 1

REMARKS: The bristle-thighed curlew is a migratory bird that breeds in Alaska but is known to regularly reside on the Northwestern Hawaiian Islands in the winter. This species also occurs on the main Hawaiian Islands but in much smaller numbers (Berger 1981:230). Its preferred habitat includes sand bars, mudflats, and open grasslands, and it ranges from sea level to the uplands (Pratt et al. 1987). This species was probably a very occasional or accidental visitor to the South Point area.

Pluvialis dominica, Lesser Golden-Plover

South Point Material. Number of Identified Specimens = 1

REMARKS: The lesser golden-plover is a common winter resident in all the Hawaiian Islands. It ranges from sea level to 3125 m (10,000 ft) on the islands of Maui and Hawai'i (Berger 1981:231).

Anous stolidus, Brown Noddy

South Point Material. Number of Identified Specimens = 1

REMARKS: Berger (1981) reports that the brown noddy breeds on the Northwestern Hawaiian Islands and many islets offshore of the main Hawaiian Islands. Pratt et al. (1987) identified the bird as a resident that is present all year but not necessarily breeding. Munro (1944:63) believed that Hawaiians exterminated these birds from offshore islands but that later this taxa recolonized the islands.

Phaethon lepturus, White-tailed Tropicbird

Kuli'ou'ou Material. Number of Identified Specimens = 11 (1)

South Point Material. Number of Identified Specimens = 1

REMARKS: This species is widely distributed throughout the Pacific. In the Hawaiian Islands it breeds on several of the main islands: Hawai'i, Maui, Lāna'i, O'ahu, and Kaua'i (Berger 1981).

Puffinus pacificus, Wedge-tailed Shearwater

Kuli'ou'ou Material. Number of Identified Specimens = 11 (3)

South Point Material. Number of Identified Specimens = 26 (6)

REMARKS: The wedge-tailed shearwater is the most abundant shearwater found in both the Kuli'ou'ou and South Point assemblages. This taxa nests on the Northwestern Hawaiian Islands and offshore islands. Unlike the Bonin petrel, wedge-tailed shearwaters do nest in the main Hawaiian Islands (Berger 1981:43). Ornithologists recorded several colonies on Kaua'i and at Black Point on O'ahu (Berger 1981:43). The species may also nest on Ni'ihau (Berger 1981:43).

Puffinus nativitatus, Christmas Shearwater

Kuli'ou'ou Material. Number of Identified Specimens = (2)

South Point Material. Number of Identified Specimens = 2 (3)

REMARKS: Scientists know little about the Christmas shearwater. Its present nesting sites include the offshore islets and most of the Northwestern Hawaiian Islands (Berger 1981:44).

Puffinus newelli, Newell's Shearwater

Kuli'ou'ou Material. Number of Identified Specimens = 12

South Point Material. Number of Identified Specimens = 3 (1)

REMARKS: This shearwater is endemic to the Hawaiian Islands and is considered a threatened species. Munro (1944) believed that this species was once a common nester on the islands of Hawai'i, Maui, Moloka'i, and Kaua'i. He believed that humans led to the extermination of this taxa by introducing predators such as mongooses, rats, and feral cats and dogs to the islands. Scientists have not seen this bird on Maui since 1894 nor on Moloka'i since 1908. Birds are often found on the ground on O'ahu, but it's not known if they nest there. King and Gould (1967) reported that Kaua'i is the only breeding locality for this species.

Historians believe that this bird, called the *a'o*, was a source of food for native Hawaiians. Munro (1944) wrote that the native Hawaiians in Waipio Valley ate the birds found nesting in the valley.

Bulweria bulwerii, Bulwer's Petrel

Kuli'ou'ou Material. Number of Identified Specimens = 12

South Point Material. Number of Identified Specimens = 4 (3)

REMARKS: There are no historical records of this species nesting on either O'ahu or Hawai'i. This species, however, nests on the offshore islands as well as on Nihoa and Necker (Berger 1981:48).

Pterodroma hypoleuca, Bonin Petrel

Kuli'ou'ou Material. Number of Identified Specimens = 1 (2)

South Point Material. Number of Identified Specimens = 7 (11)

REMARKS: Ornithologists have no record of this species nesting in the main Hawaiian Islands. Presently, it nests only on the Northwestern Hawaiian Islands, the Bonin Islands, and the Volcano Islands (Berger 1981:48).

Pterodroma phaeopygia, Dark-rumped Petrel

Kuli'ou'ou Material. Number of Identified Specimens = 64 (4)

South Point Material. Number of Identified Specimens = 14

REMARKS: This species was once very common on the island of Hawai'i. Historically, researchers report nesting sites on the slope of Mauna Loa, Mauna Kea, Kīlauea, and at the mid-high elevation of Hualālai (Berger 1981:47; Hu 1996). The abundance of this petrel in the saddle region and on the slopes of Mauna Kea is reflected in the large numbers of bones recovered from archaeological assemblages at the Pōhakuloa Training Area and at the Mauna Kea Adze Quarry (Athens and Kaschko 1989; Athens et al. 1991; McCoy 1983; Reinman and Schilz 1994). Presently, the only place on the island of Hawai'i where nests of the dark-rumped petrel are found is the upper elevations of Mauna Loa and the numbers are very low (Hu 1996). Munro (1944) indicated that this bird formerly nested on all of the main Hawaiian Islands. He believed that use of this bird for food by native Hawaiians led to its extirpation on O'ahu. Munro (1944) suggests the extermination of this taxa on other islands is due to introduced animals (especially mongooses, cats, and pigs).

Pterodroma sp. (referred to *Pterodroma jugabilis*)

Kuli'ou'ou Material. Number of Identified Specimens = 1

South Point Material. Number of Identified Specimens = 5 Measurements (mm) of complete elements: Carpometacarpus: length, 34.49, 34.52. Humerus: length, 32.92. Ulna: length, 71.88.

REMARKS: These bones are smaller than those of the Bonin petrel, and I refer them to the extinct species *Pterodroma jugabilis*. Paleontologists identified this taxa at Barbers Point and in lava tubes in the North Kona district (Olson and James 1991). Further analysis, including direct comparison with available reference collections, is required to confirm the identification of this species in both the Kuli'ou'ou and South Point assemblages.

TEMPORAL DISTRIBUTION

The avifaunal data for both the Kuli'ou'ou and South Point assemblages provides some information on the temporal distribution of these taxa at these sites. Poten-

tially, archaeologists can use this information to document resource change. The original excavators did not quantify the avifaunal material from either site; my analysis includes the number of identified specimens (NISP) and minimum number of individuals (MNI). In zooarchaeological analyses, the unit of measurement or counting is an important consideration because different units may affect the abundance of taxa in an assemblage and can therefore preclude accurate quantitative comparisons among taxa. Grayson (1984) recommends the use of number of identified specimens (NISP) as the basic unit for counting faunal material. NISP includes both whole and partial faunal items recovered from the site. Minimum number of individuals (MNI) is an alternate measure of taxonomic abundance based on NISP. The analyst may skew estimates of MNI, however, depending on how he or she chooses to aggregate the assemblage. Thus, for this analysis I chose to use NISP only.

Some of the stratigraphic data are lost from the Kuli'ou'ou assemblage because of the time difference between the excavation of these materials and this analysis. I could not assign 109 elements from Kuli'ou'ou to any particular stratigraphic provenience. The earliest layer (Kuli'ou'ou Analytic Zone 3) yielded only ten identifiable bird bones. Only one bird bone was not a seabird. Dark-rumped petrel bones have the highest NISP in the earliest zone. Taxonomic richness increases in Kuli'ou'ou Analytic Zone 2 (KAZ2) as the sample increases in size. Land birds, however, drop out completely in KAZ2. The number of seabirds being exploited increases; seven species are added to the assemblage. In this zone there are specimens from a possibly extinct petrel species (referred to *Pterodroma jugabilis*) and four other species (wedge-tailed shearwater, Christmas shearwater, Bulwer's petrel, and Bonin petrel) presently extirpated from the island of O'ahu. I identified only three species in Kuli'ou'ou Analytic Zone 1 (KAZ1), none of which is a land bird. Taxonomic richness decreases in KAZ1 either as a function of sample size or extirpation due to human predation or habitat alteration. Throughout the sequence at Kuli'ou'ou, dark-rumped petrels are more abundant than any other species identified.

In terms of sample size, both the Kuli'ou'ou and South Point assemblages are comparable. The number of identifiable specimens assignable to a stratigraphic unit are relatively equivalent for the two assemblages (106 and 113, respectively). Species richness, however, is greater in the South Point assemblage (see Table 4). At least five additional species are identified at South Point that are not present at Kuli'ou'ou. The diversity of the South Point assemblage may be due in part to the island's larger size (Hawai'i = 10,458 km²; O'ahu = 1574 km²). Nonetheless, the South Point assemblage displays the same trends as are identified for Kuli'ou'ou. I identified six species in South Point Analytic Zone 3 (SPAZ3). Again, seabirds dominate the assemblage. Only a single element is referable to a land bird (*Branta sandvicensis*). The extirpated wedge-tailed shearwater ranks most prevalent, with the dark-rumped petrel ranking second. The dark-rumped petrel drops in rank to third in South Point Analytic Zone 2 (SPAZ2), and the wedge-tailed shearwater is replaced by another extirpated species, the Bonin petrel. South Point Analytic Zone 2 has the highest species richness. I identified a total of 11 species in SPAZ2. *B. sandvicensis* drops out of the assemblage, but chicken and an unidentified rail are added. Again, however, seabirds dominate the assemblage. The number of bird bones identified in South Point Analytic Zone 1

TABLE 4. NUMBERS OF IDENTIFIED AVIAN SPECIMENS PER TAXON BY ANALYTIC ZONE AT THE SOUTH POINT SAND DUNE (SITE H1)

| TAXON | ANALYTIC ZONE | | | TOTAL |
|---------------------------------|---------------|-----|----|-------|
| | 1 | 2 | 3 | |
| Anatidae | | | | |
| cf. <i>Branta sandvicensis</i> | — | — | 1 | 1 |
| Phasianidae | | | | |
| cf. <i>Gallus gallus</i> | — | 4 | — | 4 |
| Rallidae | 1 | 2 | — | 3 |
| Scolopacidae | | | | |
| <i>Numenius tahitiensis</i> | — | 1 | — | 1 |
| Charadriidae | | | | |
| <i>Pluvialis dominica</i> | — | 1 | — | 1 |
| Laridae | | | | |
| <i>Anous stolidus</i> | — | 1 | — | 1 |
| Phaethontidae | | | | |
| <i>Phaethon lepturus</i> | — | 1 | — | 1 |
| Procellariidae | | | | |
| <i>Puffinus</i> sp. | — | 7 | 3 | 9 |
| <i>Puffinus pacificus</i> | 1 | 3 | 4 | 8 |
| <i>Puffinus pacificus</i> | 1 | 11 | 20 | 32 |
| <i>Puffinus nativitatus</i> | — | 4 | 1 | 5 |
| <i>Puffinus newelli</i> | — | — | 4 | 4 |
| <i>Bulweria bulwerii</i> | 1 | 6 | — | 7 |
| <i>Pterodroma hypoleuca</i> | — | 14 | 4 | 18 |
| <i>Pterodroma phaeopygia</i> | 1 | 7 | 6 | 14 |
| cf. <i>Pterodroma jugabilis</i> | — | 2 | 3 | 5 |
| Unidentified ^a | 3 | 59 | 31 | 93 |
| Total | 8 | 123 | 77 | 208 |

Note: Specimens securely identified to a given specimen and those simply referred to that specimen are combined.

^aAn additional 21 unidentified elements could not be assigned to any provenience.

(SPAZ1) drops significantly, and we see a parallel decrease in richness. This zone contained a single rail and three taxa of seabird. All four species are represented by only one element. Only a single species, the dark-rumped petrel, presently nests on the island of Hawai'i, and only in small numbers at high elevations.

The temporal patterns suggested by the relative abundance of bird taxa at Kuli'ou'ou and South Point are consistent with the patterns identified in many archaeological assemblages across the Pacific. Throughout the sequence, seabird bones dominate the archaeological assemblages and constitute a large proportion of the avifaunal assemblage even during the early phases of Polynesian settlement of the Hawaiian Islands. Land birds, never particularly common in these deposits, decrease in number and richness through time.

DISCUSSION

The marked difference in the abundance of seabird and land bird bone is not limited to Kuli'ou'ou or South Point. Seabird bones, primarily shearwaters and

petrels, dominate most central East Polynesian avian assemblages. For example, over 90 percent of the bird bone from the Hane Dune site (MUH 1) is of seabirds (Steadman 1989); from the Hanamiai site on Tahuata in the southern Marquesas, 80 percent of the bird bone is seabird; and from the Fa'ahia site on Huahine in the Society Islands, over 60 percent of the bird bone is seabirds (Steadman and Pahlavan 1992). Faunal assemblages from Barbers Point and Kawailoa on O'ahu also indicate large numbers of seabird bones (Collins 1995*b*). Thus we should not be surprised that a majority of the bird bone from both Kuli'ou'ou and South Point is also seabird.

Despite the abundance of seabird bones in these assemblages, archaeologists and ornithologists have done little more than describe the seabird species identified. Traditionally, paleontologists and archaeologists favor land birds in their attempts to understand extinction mechanisms. Seabirds, however, are valuable to study if we want to understand the relationship between predation by humans and extinction (or extirpation), if only because seabirds dominate many archaeological assemblages.

Unlike land birds, seabirds have wide ranges and their ability to disperse is enormous. Although seabirds obtain their food from the ocean, like land birds they are also dependent on the terrestrial environment for nesting sites and to maintain their colonies. Thus a shift in the island ecosystem that accompanies the introduction of predators affects not only land birds but also seabirds. Two factors make many seabirds vulnerable in the presence of humans: their behavior on land and their breeding ecology.

Mobility on Land

Adapted to life at sea, shearwaters and petrels are awkward on land. These birds cannot walk well on land because their legs are placed relatively far to the rear. Unless disturbed, while ashore wedge-tailed and Christmas shearwaters prefer to either sit or undertake only short waddling runs (Harrison 1990). Thus once on land they are easy prey for humans, perhaps even more so than most land birds. Their vulnerability is at least equivalent to that of flightless land birds.

Population Size and Density

Because of the characteristics of their breeding ecology, seabirds are also a large and predictable resource for humans. Hawaiian seabirds regularly breed during the spring and summer seasons (Harrison 1990:68). Except for the Bonin petrel, petrels and shearwaters return to their nesting colony between February and April and depart in October and November. Bonin petrels return in August and September and leave in June. Once on land, 95 percent of all marine birds breed in colonies (Harrison 1990). Such colonies are rare among terrestrial birds. Seabirds will seek nest sites near other birds (Harrison 1990). The result is a large population of birds in a relatively small fixed area (Plate I).

The population size and density of land birds make them less vulnerable to predation. Unlike seabirds, colonial nesting is not a general characteristic of land birds. Thus land bird density in a limited area is generally relatively low to mod-



Pl. I. A colony of Laysan albatross (*Diomedea immutabilis*) on Laysan Island showing large number of birds in a fixed area.

erate. Predators do not find a large resource in a relatively small circumscribed area as they do with seabird colonies on land.

Nesting Fidelity

Another characteristic of seabirds that makes them vulnerable in the presence of humans is high site fidelity, the tendency to nest in familiar physical surroundings (Harrison 1990). Offspring often return to their hatch site and breed near it, and nesting fidelity for seabirds is high if left undisturbed by predators. Such taxa make consistent prey for predators, especially humans, who need only locate a nesting site and return each year to gather both the adults and young chicks.

Reproductive Strategy

The reproductive strategy of seabirds also makes them highly vulnerable to predation. The interval between breeding seasons and the investment made in each egg is extremely high. Once a seabird pair has established its nest, clutch size is usually a single egg (Plate II), only once a season (Harrison 1990). Adult birds exert considerable effort in raising the young chick; seabirds have long incubation and fledging periods. Most land birds, on the other hand, lay several eggs and the young fledge much sooner than seabirds. Thus the investment in raising chicks



Pl. II. Sooty terns (*Sterna fuscata*) showing the reproductive strategy of laying a single egg.

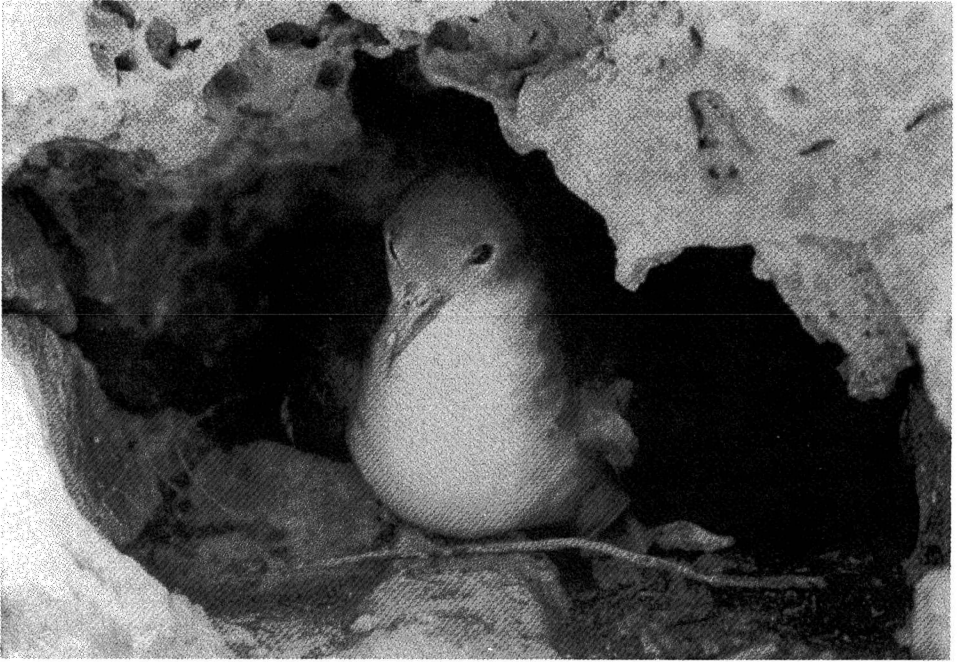
for land birds is more variable. When predators are introduced, the reproductive strategy of seabirds can have serious negative consequences.

Nesting Location

Most seabirds are ground or burrow nesting species (Plate III). Thus newly introduced predators, against which they have no defense, can easily attack these species. For example, rats take eggs as well as young birds. Harrison (1990) writes that rats attack adult incubating albatrosses on Laysan. Larger predators such as dogs, pigs, mongooses, cats, and humans can also diminish breeding success. Introduced predators adversely affect land bird populations as well (Berger 1981:16–18). It's believed, however, that until humans introduced tree-climbing predators to the islands, human colonization did not severely effect the populations of land birds.

Dispersal Pattern

The persistence of specific seabird taxa on the main islands of the Hawaiian Archipelago may be directly correlated to dispersal ability in the face of increased predation pressure. Historically, seabirds respond to predation pressure by nesting where predators are few or absent (Harrison 1991:74). I propose the following hypothesis for the petrels and shearwaters found in the Kuli'ou'ou and South Point assemblages: after the introduction of predators, petrel and shearwater col-



Pl. III. A wedge-tailed shearwater in its nesting burrow.

onies declined in the lowlands. Subsequently, these taxa were restricted to the uplands. Over time, as the human population expanded into the upland region, petrels and shearwaters were eventually limited to the offshore islands, where predators are still few.

I identified two migratory birds (lesser golden-plover and bristle-thighed curlew) and two additional seabirds (white-tailed tropicbird and brown noddy) in these assemblages. These four species still occur on their respective islands. There may be several reasons for this. In the case of the migratory birds, the lesser golden-plover is a winter resident on the islands during the non-breeding season and the bristle-thighed curlew is merely a visitor to O'ahu and Hawai'i. Neither species breeds in the Hawaiian Islands. Thus their survival and continued presence in the islands is enhanced by their ability to escape predation on young chicks and eggs.

Both the white-tailed tropicbird and the brown noddy are also better able to escape human and animal predation. The white-tailed tropicbird, like the petrels and shearwaters, is awkward on the ground. These birds are very slow and clumsy on land (Harrison 1990:169). An important difference between the petrels, shearwaters, and tropicbirds, however, is their ability to escape. Tropicbirds have strong wings that allow them to take off quickly and easily from the ground. Thus adults are better able to escape predation. In addition, the white-tailed tropicbird nests on cliffs, and the brown noddy nests in various areas from bare ground to rock ledges and flat and steep slopes (Berger 1981:62). The nesting locations of the white-tailed tropicbirds in the Hawaiian Islands are unusual, because in other parts of the world these birds nest in trees (Harrison 1990:170).

Perhaps predation pressure "pushed" this species to cliff nesting sites. Whether these birds nest in trees or cliffs, they are difficult for humans and other predators to reach. In addition, habitat alteration probably affects these species less. Humans have to expend considerable energy to exploit these species in their nesting sites.

CONCLUSION

A closer investigation of seabirds from archaeological assemblages is necessary if we want to investigate the effects of predators on the extinction of Hawaiian birds. Seabirds are significant for two reasons. First, seabirds were a more accessible resource than most land birds and one that yielded a higher amount of food per individual. Their accessibility to predators also made them a more predictable resource, so they likely represented a significant food source for humans. Second, seabirds are buffered from extinction due to their population size and ability to seasonally or periodically escape from predators. Thus seabirds likely have had a longer history of interactions with humans. As predator populations grow and move inland, and as environmental change occurs, we should see a parallel decrease in the abundance of seabirds as well as suitable nesting sites.

In the future researchers must consider the following issues: If archaeologists and paleontologists continue to rely on deposits that are spatially and temporally discontinuous, it may not be possible to track changing land bird resources over time. The subfossil and archaeological records are quite different in terms of modes of deposition and the species likely to be recovered from these records. The conditions under which land birds come to be represented in large numbers in archaeological deposits are different from conditions under which the subfossil deposits are commonly produced. Archaeological assemblages are dominated by seabirds, the most abundant and predictable avian resource; subfossil assemblages represent natural death traps or collections, not biased by human selection. The relative lack of land birds in one and the abundance of seabirds in the other does not inform directly on the rates of change in taxa over time but rather reflects the conditions by which the respective records were formed. Additionally, the scarcity of land birds in the archaeological record and our inference that they underwent early extinction with the arrival of humans may have been conditioned by the early and heavy exploitation of more abundant seabirds, whose extirpation exposed land birds to predation pressures in defense from which they had few adaptive alternatives.

ACKNOWLEDGMENTS

This paper was originally presented at the Ninth Annual Society for Hawaiian Archaeology Conference, Maui, Hawai'i. A number of individuals and institutions have made this paper possible. I would like to thank the Bernice P. Bishop Museum for providing me access to the two avifaunal collections as well as to their Hawaiian bird reference collection. I would like to extend a special thanks to Carla Kishinami, Zoologist at the Bishop Museum, who graciously lent her time and expertise in helping me identify these specimens. I would also like to thank those who provided useful and insightful comments: Melinda Allen, Sheila Conant, Lena Schnell, Kathleen Sherry, and Greig Nakamura. I would especially like to thank

Michael Graves, without whose help this paper would not have been written and whose continued support is greatly appreciated. Thanks also to JoLynn Gunness for providing Figures 1-3 and to Sheila Conant for providing the photos. Support was also provided by the Postgraduate Environmental Management Participation Program at the U.S. Army Environmental Center (USAEC), onsite at the Pōhakuloa Training Area, U.S. Army Garrison, Hawai'i, and administered by the Oak Ridge Institute for Science and Education.

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ABSTRACT

The extinction of Hawaiian birds has been of interest to many archaeologists and paleontologists. The present subfossil evidence indicates that humans affected the abundance of these birds either through predation or habitat alteration. Land birds have heretofore been the primary focus in discussing the extinction process. The bones of seabirds, however, generally dominate archaeological assemblages. Analyses of avifaunal assemblages from two sites (Kuli'ou'ou on the island of O'ahu and South Point on the island of Hawai'i) support the argument that if we want to understand the relationship between human colonization, subsistence, and extinction (or extirpation), then seabirds are an important resource. Because of their large population sizes, wide distribution, and reproductive susceptibility to predators, seabirds are important indicators of the impact human settlement has on the native fauna. I have identified at least four seabird species previously unknown to have bred historically on the islands, in addition to a possible extinct petrel. This suggests that the distribution of these species was much wider than previously thought and the introduction of predators may have had an effect on the occurrence of these bird colonies. Keywords: Avian Extinction and Extirpation, Zooarchaeology, Hawai'i, Polynesia.