

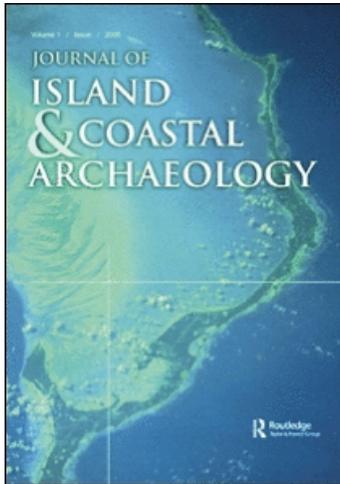
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### Antipodean Perspectives on Zooarchaeology: Behavioral Ecology, Taphonomy, and Applied Research

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# Antipodean Perspectives on Zooarchaeology: Behavioral Ecology, Taphonomy, and Applied Research

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## ABSTRACT

*Zooarchaeological research in New Zealand has a particularly long history, dating from the 1870s. Over the last century, it has both followed larger trends in the discipline and developed innovative approaches. Three types of research that reflect these broader movements and novel approaches are identified in this historical review of New Zealand archeofaunal studies. First, zooarchaeological studies have been used to not only illustrate human impacts on the environment, but also to examine the consequences of anthropogenic environmental change for resident human populations. Second, taphonomic research, beginning with Julius von Haast's qualitative examinations of moa-hunter butchering patterns, is considered, particularly studies relating to butchery and carnivore damage. Finally, examples of New Zealand research that are poised to make significant contributions to the burgeoning field of applied zooarchaeology are highlighted.*

**Keywords** archaeofauna, subsistence strategies, applied zooarchaeology, conservation biology, New Zealand, Polynesia

## INTRODUCTION

The idea that islands serve as “laboratories” for studies aimed at resolving complex relationships and evolutionary dynamics is a long-standing one (e.g., Fosberg 1965; Kirch and Hunt 1997). As often small and relatively iso-

lated land masses, islands make ideal research settings where animal immigrations and extinctions, ongoing inter-specific interactions, and the effects of local geomorphic and climatic processes can be effectively studied. In Pacific Island contexts, further advantages are provided by the fact that most plants and

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animals (including people) derive from one main source area, island southeast Asia, with a strong west-to-east decline in biodiversity. There is thus considerable overlap in the natural floras and faunas of these islands, and exotic introductions are readily apparent and their impacts tractable (e.g., Steadman 2006).

With 265,846 km<sup>2</sup> of land, New Zealand combines the research advantages of islands and continents. Although dominated by the large North and South Islands, over 700 smaller islands also are found here. The group as a whole is quite isolated, with the nearest significant land mass being New Caledonia over 1,800 km to the northwest. New Zealand's isolation has resulted in a vertebrate fauna that is dominated by birds which evolved in the absence of mammalian predators. Additionally, flightlessness, gigantism, and k-selected reproductive strategies are common, but these are traits which made native species highly susceptible to the arrival of humans and their commensals (Holdaway 1999). More in keeping with continental situations, a broad range of environments is present, ranging from subtropical to subantarctic climates, and with considerable biodiversity, the latter a function of the country's Gondwanaland heritage and isolation. This biogeographic variability contrasts with relative homogeneity in New Zealand's founding human populations, agriculturalists whose successors are known today as Maori. Although probably derived from more than one central East Polynesian island (Sutton 1994), their arrival around 800 years ago (Anderson 2008) was at a time when communities within the central East Polynesia homeland were not markedly different. These human settlers brought with them domesticated dogs, the commensal Polynesian Rat, and a limited suite of six root and tree crops. Other Polynesian domestics, such as pig and chicken, either were not introduced or failed to persist (Davidson 1984). Given this constellation of features, New Zealand offers a unique opportunity to explore the eodynamics of human populations adapting to diverse land and seascapes.

New Zealand's zooarchaeological history also has a special contribution to make to disciplinary synergy and synthesis. The

country has a long and rich tradition of faunal research that extends back to the mid-nineteenth century. As Allen and Nagaoka (2004) suggest in their more detailed review, research here is in many ways a microcosm of trends within not only zooarchaeology but also archaeology at large. In the present paper we highlight three areas of New Zealand research where there is a significant history and we have particular research interests: human impacts and related subsistence change, taphonomic studies, and applied zooarchaeology.

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HUMAN IMPACT, SUBSISTENCE  
CHANGE, AND BEHAVIORAL ECOLOGY  
MODELS

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Zooarchaeological research in New Zealand began with the scientific discovery of moa in 1840 (Owen 1840). While early research was by paleontologists, by the 1860s scientific reports detailing moa remains from archaeological contexts were commonplace. As large archaeological assemblages of moa bones accumulated, it became increasingly clear that predation by ancestral Maori played a significant role in moa extinction. Today moa is a virtual poster child for proponents of megafauna overkill (Holdaway and Jacomb 2000; Martin and Steadman 1999); however, human agency is not necessarily empirically demonstrated (Anderson 1989) nor solely responsible, as both habitat destruction and predation by introduced commensals (dogs and rats) contributed (Holdaway 1999; Worthy 1999).

In 1872 Julius von Haast devised New Zealand's first cultural sequence using fauna as chronological markers, paralleling the work of Edouard Lartet in the 1860s and drawing inspiration from Lubbock (1865). As with the European Paleolithic, von Haast's early New Zealand phase, the "Moa-hunters," was defined by flaked stone tool technologies and a hunting/gathering economy focused on the exploitation of megafauna (von Haast 1872). He contrasted this with his later "Shellfish eater" period which, like the Neolithic elsewhere, featured ground stone tools,

agriculture and domesticated animals; this dichotomy, however, is no longer upheld. While von Haast's early faunal studies involved much more than chronology building, as discussed below, until the 1960s zooarchaeological data were used for little else (e.g., Duff 1950; Lockerbie 1959; Teviotdale 1932, 1938). However, with the rise of Clark's (1952, 1954) "Economic approach" and the North American "New Archaeology" archaeologists became increasingly interested in aspects of ecology, dietary reconstructions, and subsistence practices.

Among the better known studies of this time was Wilfred Shawcross' (1967, 1972) Galatea Bay and Houhora (Mt. Camel) zooarchaeological research (Figure 1). Following the "California School of Midden Analysis" (see Allen and Nagaoka 2004:200–202), Shawcross used meat weights to reconstruct the contribution of each taxon to the diet of the site's inhabitants. He recognized, for example, that despite an MNI of over 2,000 fish at Houhora, the 43 seals recovered were a more important dietary contribution because each individual carcass contained significantly more meat relative to a fish. Shawcross further attempted to estimate Houhora's population size by assuming a standard intake of calories per day per person. While the methodology has been criticized because of the large number of assumptions (e.g., Casteel 1978), the research is an excellent example of the move towards more quantitative analyses of zooarchaeological data and considerations of diet composition and proportions.

Not until the 1980s, however, did the focus of subsistence studies move from diet reconstruction to explanations of change, a shift that owes much to the work of Foss Leach, Atholl Anderson and their students. While Anderson focused on moas and broad subsistence patterns, others examined the impact of humans on small bird species (e.g., McGovern-Wilson 1986), marine mammals (e.g., Smith 1985, 1989, 2005) and fish (e.g., Anderson 1997a; Leach and Boocock 1993). Leach, for example, created an impressive database of modern and archaeological fish records unparalleled in the Pacific. Of particular interest to studies on human impact are

his efforts to tease apart the complex suite of factors that contribute to variability in fish body size (Leach and Boocock 1994, 1995; Leach and Davidson 2000, 2001; Leach et al. 1996, 1999a, 1999b). He found, for example, that historic catches consist of much smaller fish than those recovered archaeologically because of more recent use of mass harvesting techniques with fine nets. He also discovered that for some species body size increased over time. Several explanations for this unexpected pattern were considered, including changes in fishing technology, climate change, harvesting pressures, and decreased inter-specific competition as a result of increased harvest pressure.

Among the more novel efforts of this time was Anderson's (1981) early application of foraging theory to archaeological contexts (see Bayham 1979; Keene 1981; Yesner 1981 for early North American examples). Anderson drew on the prey and patch choice models of MacArthur and Pianka (1966; MacArthur 1972) to understand changes in shellfish collecting at Palliser Bay. Using shellfish size as a proxy for net returns, he predicted that larger taxa would be preferentially harvested over smaller ones (see also Botkin 1980). His study demonstrated a temporal decline in both the average size of certain large-bodied species, and an increasing reliance on smaller taxa, both the result of 'over-harvesting.' Even more interesting was his finding that after a hiatus in site occupation, shellfish size increased as species apparently rebounded.

While elements of behavioral ecology can be found in much of Anderson's work, this is the only example where he explicitly used foraging theory models. Elsewhere he focuses on describing and synthesizing regional environmental changes resulting from human actions, such as over-harvesting, and how these changes affected prehistoric human subsistence patterns (e.g., Anderson 1982, 1983a, 1997b; Anderson and McGlone 1992). His analyses of the role that moas, moa-hunting, and moa extinction played in changing subsistence and settlement patterns are particularly significant, making moa one of the world's best documented cases of megafaunal extinction (e.g., Anderson 1982,

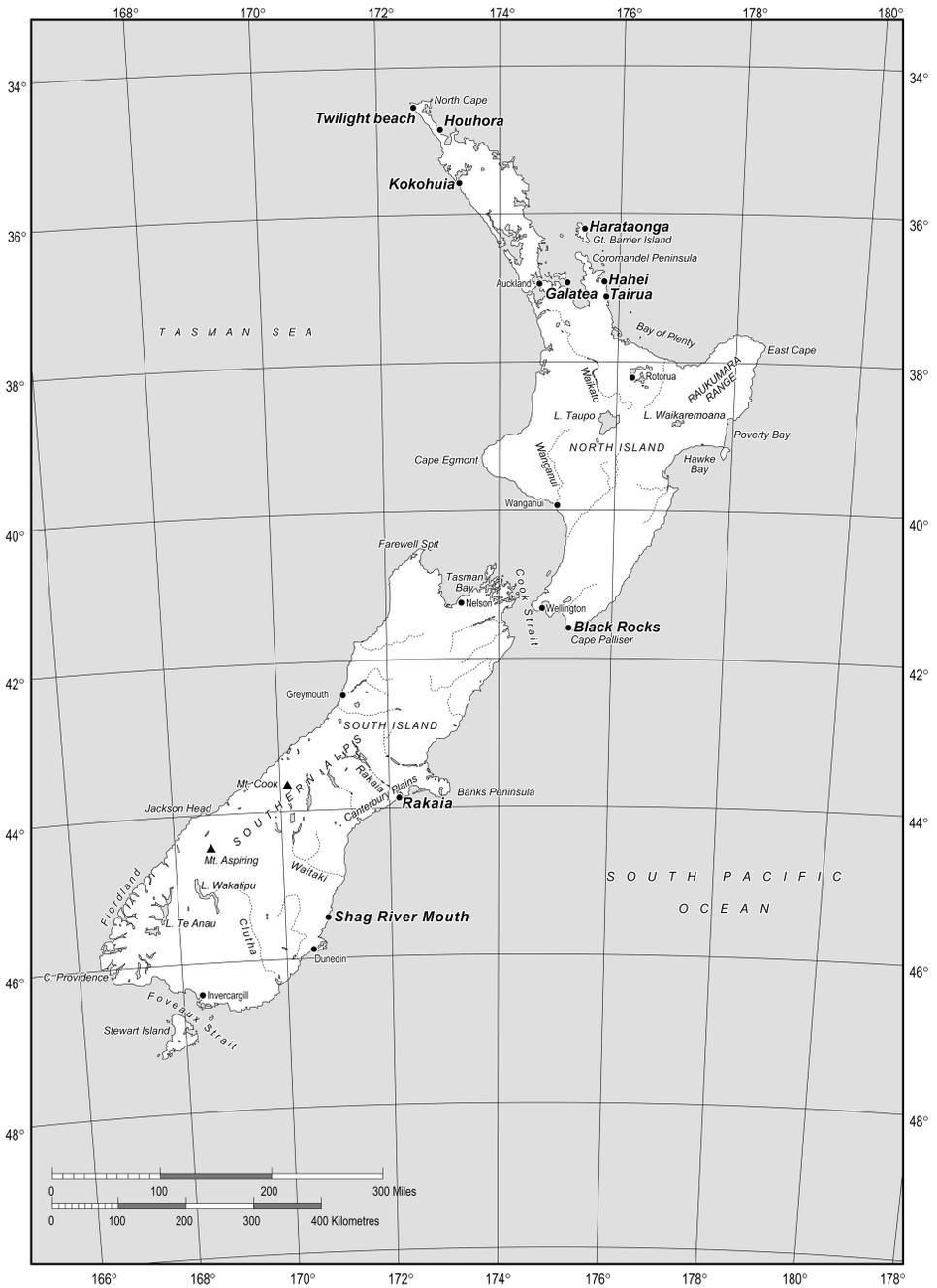


Figure 1. Location of sites and regions discussed in text.

1983b, 1984, 1989; Anderson and Smith 1996).

While behavioral ecological models of this kind have become more commonplace in zooarchaeological research, particularly in the U.S. (for recent reviews see Bird and O'Connell 2006; Lupo 2007; Winterhalder and Smith 2000), they were only recently reintroduced to New Zealand (Nagaoka, 2002, 2005, 2006). Nagaoka's re-analysis of the large Shag River Mouth assemblage not only further illustrated the value of these models but diverged from prior studies in some important ways. First, in many earlier studies change had been examined at specific sites rather than across a region or the country as a whole. Faunal data were often treated as culture historical traits, leading to overly simplistic categorizations of sites and/or assemblages as either early (moa hunting) or late (post-moa hunting). In addition, because many sites only had a few cultural layers, occupations at individual sites often were perceived to be too short to record significant change. A notable exception was the original research on the Shag River Mouth assemblage (Anderson et al. 1996). This well-stratified site, with nine cultural layers, produced one of the largest faunal assemblages in New Zealand. As a result, the site provided an ideal dataset for examining changes that occurred as moa declined in abundance at the site. Indeed, both the original analysis and the re-analysis of the Shag River Mouth fauna demonstrated that significant change occurred even within the period of moa hunting. Nagaoka's study also differed in the integrated analysis of varied faunal classes (fish, bird, mammals) that are more commonly the purview of independent specialists. Previously, the use of differing methodologies by particular faunal specialists had made it difficult to synthesize the results into one cohesive explanation. Further, by using foraging theory models Nagaoka offered a framework that integrated changes in resource availability due to human actions with the consequences to human subsistence. Finally, patterns of changing species exploitation and butchery practices were examined under one framework. As a whole, this work provided a fine-grained

picture of the process of resource substitution and broadening of diet breadth that occurs with resource depression. More generally the integrated faunal findings supported the view that moa extinction was probably aided by habitat modification, perhaps carried out in the context of hunting.

While there has been considerable research documenting the impacts of humans and their commensals (dogs and rats) on native New Zealand fauna (e.g., Anderson 1983a; Worthy 1999; Worthy and Holdaway 2002), less attention has been drawn to the human consequences of the ensuing changes. More recently Allen (2009) has considered variability in local responses to human-induced environmental change. As outlined above, declines in large-bodied shellfish and intra-specific shellfish size at Palliser Bay, along with other processes, eventually led to abandonment of the coast and the cessation of shellfish gathering at this locality. When Maori returned in the eighteenth century, the local shellfish beds had recovered. Studies elsewhere on the North Island indicate that this pattern of declines in large shellfish taxa is not unusual. At Haratonga Bay, Great Barrier Island, Maori foragers used the area intermittently for roughly 500 years (Allen 2009). Several large-bodied taxa figure prominently in the earliest occupation and include species such as *Cookia sulcata* and *Haustrum baustorium*. By late prehistory, some important large taxa had declined and the diminutive *Nerita* was a popular species. The Haratonga evidence suggests a situation where foragers tolerated losses of large meaty taxa and offset them by intensifying exploitation of smaller species over an extended period of time. At the Hahei site, on the nearby Coromandel Peninsula, local losses of large shellfish species resulted in foragers moving to more distant patches where these same favored taxa were available. Nearby offshore islands lacking permanent settlements were likely new source areas. Finally, at Tairua, also on the Coromandel, declines in large rocky shore species led to these habitats being abandoned and a shift to local soft-shore species. Although soft-shore taxa required more effort to locate and extract, because they occurred in dense beds they offered

improved return rates and ultimately a more sustainable resource. These sites usefully illustrate a range of responses on the part of Maori foragers to the common problem of resource declines and local extirpations. The varied local solutions were undoubtedly tied in complex ways to other economic and social conditions.

#### TAPHONOMIC STUDIES: BUTCHERY AND CARNIVORE DAMAGE

As in many other regions of the world, the 1980s saw the rise of taphonomy in zooarchaeological research in New Zealand (Allen and Nagaoka 2004), with recent studies focusing on cultural rather than natural transforms, particularly moa and seal butchery. Again, however, there is a long history of this kind of research, with von Haast (1875a, 1875b) providing an early example in his qualitative comparisons of patterns of moa element abundances and fragmentation from the moa-rich sites of Shag River Mouth and Rakaia. At Shag River Mouth he found fewer skeletal elements represented than at Rakaia and that only tibiotarsi (the element with the largest marrow cavity) were consistently processed for marrow extraction; at Rakaia, in contrast, most long bones were broken. While his methods were qualitative, von Haast's interpretations are consistent with those derived from modern foraging theory. He concluded that the availability of moa differed at the two sites. At Shag River Mouth the abundance of moa suggested to him that Maori "selected for their food only the most valued portions of the birds killed" and marrow was extracted only from elements that were "worthwhile" (von Haast 1875b:94). In contrast, at Rakaia the more intensive exploitation of each moa carcass, and extraction of marrow from all long bones, suggested a less productive local environment relative to Shag River Mouth.

Von Haast's work remained the most significant butchery study until the 1980s when researchers returned to questions about Maori use of both moa and seals (Kooyman 1984, 1985; McGovern-Wilson 1992;

Smith 1985, 1989, 1996). Most notably Smith has amassed an impressive database on seal remains from archaeological sites throughout the country. In addition to providing important data on the temporal distribution of marine mammals, Smith also examined butchery patterns of fur seals in particular. Based on skeletal element representation and demographic data, he found that smaller individuals such as pups and juveniles were transported to the site whole, while larger individuals were butchered at kill sites and lower return elements discarded (Smith 1985, 2005).

Behavioral ecological models have also been applied to moa and seal butchery remains with interesting results (Nagaoka 2005, 2006). At Shag River Mouth, decreases in foraging efficiency from declining resource availability led to changes in carcass exploitation, which were linked to the distances between kill and habitation sites (e.g., transport costs). Moa butchery increasingly focused on transportation of high-return parts because the distance to hunting areas increased as local moa populations were depleted. For seals, a different pattern was found, with more of each carcass being transported to the home base. The more intensive use of seal carcasses indicates that the harvest locale for seals was constant over time. Thus, while butchery practices for both moa and seals changed through time, the patterns of change differed depending on transport costs.

Another notable area of taphonomic research relates to patterns of carnivore (i.e., dog) damage, which appear to vary with environmental contexts (e.g., McGovern-Wilson 1992; Taylor 1982). Von Haast (1872) noted that very few bones at the South Island sites of Rakaia and Shag River Mouth bore dog gnaw marks, observations which have been supported by later taphonomic studies (Kooyman 1985; McGovern-Wilson 1992; Nagaoka 2005). North Island assemblages, conversely, show much more evidence of dog gnawing. At Twilight Beach, a large early coastal midden, significant carnivore damage was detected. Although only 9% of the seal remains were affected, 40–55% of certain long bones (humerii, radii, tibiae,

and metapodials) were gnawed (Nagaoka and Wolverton 2006; Taylor 1982). Similarly, a recent study on bulk samples from another North Island site, Kokohuia (Leach et al. 1997), showed that the fish remains were highly fragmented, with most elements being less than one-third complete. The pattern of vertebrae deformation and surface modification, together with the fragmentation data, suggests that the fish remains had been chewed and consumed, probably by dogs (Nagaoka 2004).

The differential carnivore damage on faunal remains from the North and South Islands may relate to differences in resource availability and foraging efficiency. Because carnivore damage was more prevalent on bones from North Island sites relative to South Island assemblages, Clark (1997) argued that in North Island sites, where high return resources such as moas and seals were often less abundant, dogs may have been fed scraps; in resource-rich areas, alternatively, they may have had greater access to meat. In addition, he found a pattern suggestive of larger dogs in 'plentiful nutritional environments' (Clark 1997:211). While a larger sample of sites is needed to fully evaluate these patterns, the idea that the degree of carnivore damage on bones could provide an independent line of evidence for human foraging efficiency is intriguing.

#### APPLIED ZOOARCHAEOLOGY: WILDLIFE CONSERVATION

Although applied zooarchaeology is a rapidly growing subfield (see Frazier 2007; Lyman 1996, 2006; Lyman and Cannon 2004), archaeological data on prehistoric distributions of native fauna have been important in New Zealand conservation efforts for some time. Syntheses by Worthy (1999) and Holdaway (1999) have not only identified biogeographic patterns, but have also aided identification of past predators, prey vulnerabilities, and extinction rates—information now being used by wildlife managers in both conservation and restoration. Two species that have benefited from zooarchaeological

research are the Takahe (*Porphyrio mantelli*) and the New Zealand fur seal (*Arctocephalus forsteri*).

The Takahe is a large, flightless endemic rail, documented by early Europeans but thought to have become extinct historically. The Takahe was 'rediscovered' in 1948 in the subalpine tussockland of the Murchison Mountains of Fiordland, but by the early 1980s, their population had dwindled to 118. Researchers assumed that, based on its modern behavior and distribution, the bird was a tussock grassland specialist, and initial conservation efforts were based on this understanding (Lee and Jamieson 2001). These efforts included boosting the Fiordland population by eradicating predators and competitors, minimizing human disturbance, enriching the tussockland, and hand-rearing chicks (Lee and Jamieson 2001). Unfortunately, the Takahe population did not rebound. By the 1980s, translocation of endangered native species onto small predator-free offshore islands was becoming commonplace (McHale 1998), so this strategy was also considered for the Takahe. Such offshore reserves would create effectively meta-populations, spatially separated subpopulations of a species that retain some gene-flow (Akçakaya et al. 2007). In conservation efforts, the term is often applied to populations in artificially or naturally fragmented habitats. For the Takahe, creation of metapopulations was considered a more sound conservation strategy than having a single population confined to a specific location in Fiordland. However, questions arose about the Takahe's ability to successfully live on these islands given their supposed habitat specialization.

Fortunately, archaeological and paleontological data provided new insights. Paleozoological data showed that Takahe were once widespread across New Zealand (Beauchamp and Worthy 1988; McGovern-Wilson 1986; Trewick and Worthy 2001). Further, prehistoric distribution patterns suggested Takahe were originally adapted to edge habitats and would have done well in the forest-shrubland-grassland mosaics. This not only refutes the notion that they are tussockland specialists (Beauchamp and Worthy 1988) but also suggested their current range

is the result of predation pressure and habitat destruction. The Takahe of Fiordland thus are a relict population and the Murchison Mountains merely the last inhospitable refuge from the onslaught of introduced competitors and predators. While there are still many hurdles to overcome in Takahe recovery efforts, translocations have helped to increase the overall population size. Over the last 20 years, the Takahe population has doubled, from about 120 to 250 individuals, with nearly one-third now living on four offshore islands.

Another species whose biogeography is being aided by archaeofaunal research is the New Zealand fur seal. As discussed earlier, Smith's (1985, 1989, 2005) research has shown that at Polynesian arrival, fur seals were widely dispersed throughout the country and maintained breeding colonies on both islands. Maori subsequently made extensive use of the seal, in some cases heavily exploiting it alongside moa. Over time, breeding colonies in more northern areas disappeared, although the underlying causes are not well demonstrated. At historic contact, fur seals were concentrated around the southeastern end of the South Island with an estimated population of 10 million (Smith 2005). While Maori may have played a role in the loss of some breeding grounds, it was nineteenth-century sealers who nearly drove the species to extinction, intensively exploiting them for their skins and oil. Within 30 years, the species was no longer commercially viable.

Today the New Zealand fur seal is protected. Their numbers have been slowly climbing with a current population of about 50,000 individuals and importantly, their breeding range is expanding. Paralleling zooarchaeological marine mammal research in other regions, such as the Pacific Northwest Coast (e.g., Etnier 2002, 2004; Lyman 1988; 1989), Smith's zooarchaeological research has been important to fur seal conservation because it provides information on taxonomic distributions over longer time scales (i.e., hundreds of years rather than decades). This long-term perspective aids wildlife managers and conservation biologists in understanding the evolutionary rather than just the ecological causes of modern

distributions, and developing effective management plans.

In New Zealand, wildlife biologists fully expect that fur seal breeding grounds will eventually be re-established across New Zealand, as human-related declines have been significantly mitigated (e.g., Bradshaw et al. 2000, 2002). Given this outlook, it would be useful to know the locations of prehistoric rookeries so that conservation efforts can be focused at these specific localities. Smith (1985) used morphometric and tooth section data from modern specimens to determine age and sex profiles for archaeological samples. In particular, Smith identified metric cut-off points on long bones and mandibles that could be used to distinguish pups, juveniles, subadults, and adults. This data allowed him to map possible prehistoric rookeries based on the presence of pup remains (Smith 1985, 2005). Nagaoka and Wolverton (2006) are now expanding on this research, building a larger modern sample of morphometric analyses from aged individuals, and applying the results to archaeological collections. Measurements for element portions that preserve well (e.g., midshafts) have been especially important, increasing the sample of specimens that can be aged. Thus far, application of this new technique to the Twilight Beach fur seal collections has not only confirmed Smith's original findings of pups, but also determined that sub-adult males were absent. Both lines of evidence suggest that rookeries rather than haul-outs were being exploited because pups do not leave rookeries until they are weaned at about 10 months and sub-adult males generally cannot compete with adult males to gain access into rookeries (Crawley 1990). The conservation implication of this research is that rookeries once existed in an area where today only haul-outs are found. Thus, potential breeding habitat along this coastline should be identified and targeted for protection.

## DISCUSSION AND CONCLUSIONS

We have used a small number of studies to illustrate the long tradition of zooarchaeological research in New Zealand and some of the

ways in which historical interests continue to the present. In part it is the accumulation of so many datasets, from such varied environmental contexts, that is now allowing subsistence and settlement processes and human eco-dynamics to be considered in new and interesting ways. The New Zealand record in particular demonstrates the fluidity and flexibility of Polynesian subsistence strategies in response to resource availability. This is seen most dramatically in the early South Island record where ancestral practices of plant cultivation and animal husbandry were abandoned in favor of large game hunting and novel foraging strategies. It is, however, also witnessed in more subtle shifts in population aggregations, distributions, and mobility throughout New Zealand prehistory, as resources in one locale were reduced and Maori sought novel ways of meeting their nutritional needs. The culmination of these small-scale shifts ultimately led to a redistribution of human populations to the North Island, where plant cultivation, coupled with mass harvesting of concentrated resources, offered a more sustainable existence.

The New Zealand record also offers insights into the processes of extirpation and extinction. The large assemblage of dated sites has been the springboard for lively debates about the rapidity and character of moa decline (e.g., Anderson 2000; Holdaway and Jacomb 2000). These ideas are now seeing currency in the tropical Pacific (e.g., Allen 2007; Steadman 2006) where rapid change has been similarly suggested but incompletely demonstrated by the available data. Further, while the New Zealand case provides some of the best evidence for human-aided extinction anywhere in the world, even here Anderson (1989) argues there is insufficient evidence to support overkill per se, with implications for more general debates about Pleistocene megafaunal losses. In addition, it is questionable whether these island losses are directly applicable to understanding extinctions in continental contexts (see Grayson 2007).

New Zealand also saw some of the first efforts to apply behavioral ecology models to archaeological data, an area where New Zealand researchers continue to make contri-

butions. The applicability of this framework to a range of fauna has been demonstrated and the potential for varied responses to the common process of resource depression is being explored. However, what is perhaps most illuminating about foraging studies in New Zealand is the demonstration of how sustained use of this kind of framework has the potential to build systematic knowledge.

New Zealand taphonomic studies have an even longer historical tradition, dating to the early work of geologist Julius von Haast. Again, the cumulative studies of two key species, moa and seals, have allowed for large-scale syntheses. These syntheses are now being used to identify regional patterns of variation and as a foundation for novel research questions, as exemplified by Clark (1997) and Nagaoka's (2004) studies of carnivore damage and its potential as a proxy measure of human diet and foraging efficiency.

Finally, the New Zealand record offers some examples of how archaeological data might be used to aid contemporary problems. Widely recognized as a world leader in wildlife conservation and restoration, New Zealand's many small offshore islands provide manageable contexts for preserving and re-establishing vulnerable native species. Archaeological studies are playing a modest but important role in supporting these efforts. Complementing paleontological evidence from longer time frames, archaeological data provides numerous, well-dated, geographically extensive samples that inform on not only prior species ranges, but also the timing of reductions and losses, the role of various predators, and past behavioral practices.

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