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Archaeological site types, and assemblage size and diversity in Aotearoa New Zealand

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ABSTRACT

Archaeological settlement models involve the identification of functional site types like base camps and extraction sites based, in part, on differences in the range and frequency of artefact types and fauna. Using reports describing such assemblages from Aotearoa (New Zealand) archaeological sites dating to the first 300 years after initial colonisation, differences in assemblage composition are assessed against total assemblage size. Aotearoa provides a particularly useful test case for the archaeological identification of site types since human colonisation was relatively late in world human history meaning that assemblage accumulation should show functional site types like those identified in the ethnographic record. To test this, SHE (Richness, Heterogeneity, Evenness) diversity analysis is used to examine 18 artefact and ten faunal assemblages dated pre-1500 CE from a variety of Aotearoa locations. Results suggest artefact and faunal diversity measures perform poorly when employed to differentiate functional site types, suggesting that the null hypothesis of assemblage size dependency cannot be rejected. This result allows for comment on the appropriateness of ethnographically derived functional site types for the study of the archaeological record even when this record accumulated over short time periods.

Keywords: assemblage composition, artefacts, fauna, diversity, Aotearoa New Zealand

RÉSUMÉ

Les modèles de peuplement archéologique impliquent l'identification de types de sites fonctionnels tels que les camps de base et les sites d'extraction en se basant, en partie, sur les différences dans la gamme et la fréquence des types d'artefacts et la faune. À l'aide de rapports décrivant de tels assemblages provenant de sites archéologiques d'Aotearoa (Nouvelle-Zélande) datant des 300 premières années après la colonisation initiale, les différences de composition des assemblages sont évaluées par rapport à la taille totale de l'assemblage. Aotearoa fournit un cas test particulièrement utile pour l'identification archéologique des types de sites puisque la colonisation humaine était relativement tardive dans l'histoire humaine mondiale, ce qui signifie que l'accumulation d'assemblages devrait montrer des types de sites fonctionnels comme ceux identifiés dans les archives ethnographiques. Pour tester cela, l'analyse de la diversité SHE (Richness, Heterogeneity, Evenness) est utilisée pour examiner 18 artefacts et 10 assemblages fauniques datés d'avant 1500 CE provenant de divers emplacements d'Aotearoa. Les résultats suggèrent que les mesures de la diversité des artefacts et de la faune fonctionnent mal lorsqu'elles sont utilisées pour différencier les types de sites fonctionnels, suggérant que l'hypothèse nulle de la dépendance de la taille de l'assemblage ne peut pas être rejetée. Ce résultat permet de commenter la pertinence des types de sites fonctionnels dérivés de l'ethnographie pour l'étude du dossier archéologique, même lorsque ce dossier s'est accumulé sur de courtes périodes de temps.

Mots-clés: Composition de l'assemblage, artefacts, faune, la diversité, Aotearoa Nouvelle-Zélande

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INTRODUCTION

The history of human occupation of Aotearoa (New Zealand) stands out in the world, not because of its long chronological sequence, but the opposite. Aotearoa was colonised relatively late in world human history by peoples voyaging from tropical east Polynesia who brought with them an economy complete with domesticated plants and animals, a ground stone and bone technology, and an extensive wood carving technology that included wind-driven voyaging canoes (Anderson, 2017; Irwin, 1992; Johns et al., 2014; Walter et al., 2017). Upon arrival,

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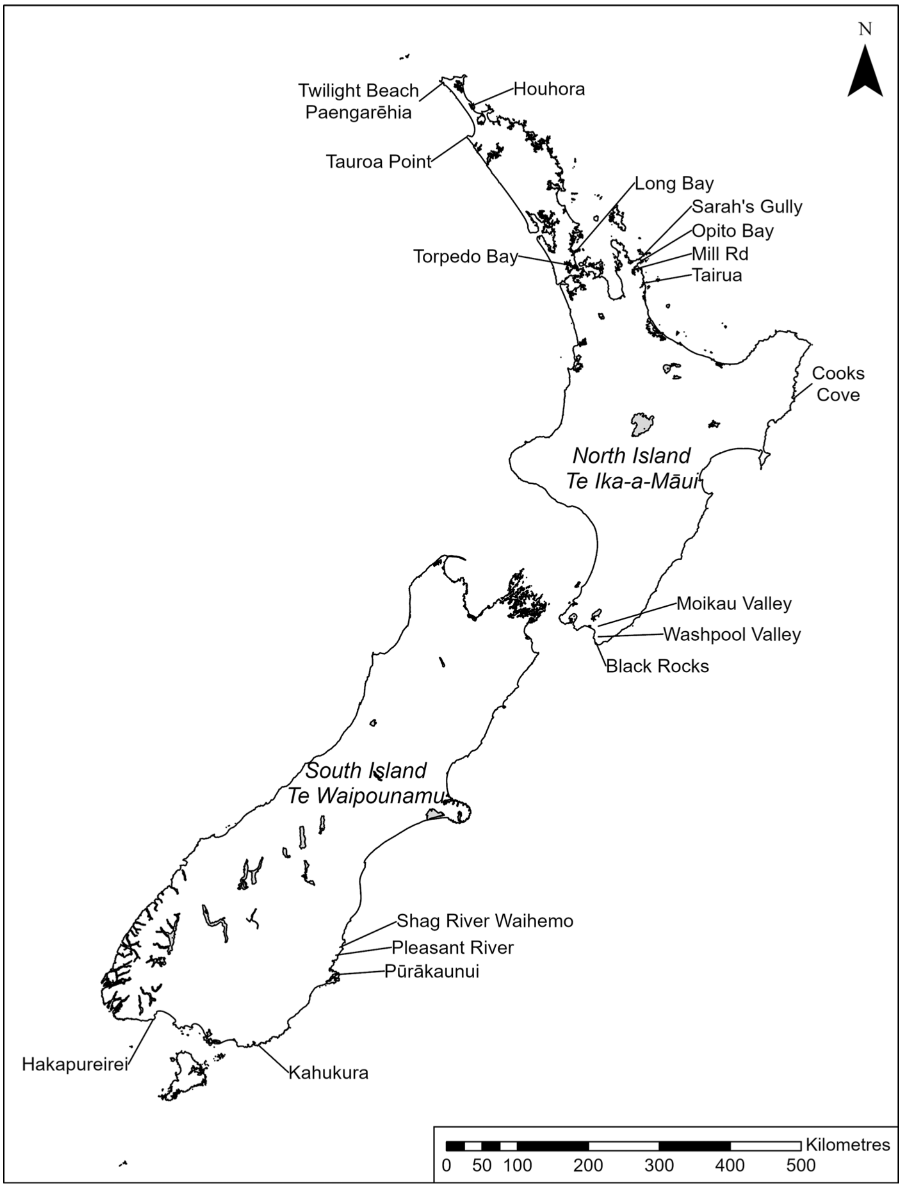
Figure 1. Aotearoa/New Zealand with the locations of case studies.



the ancestors of present-day Māori occupied a land that had, up until that point, never seen human occupation, modifying the environment in ways that suited their socio-economy (Anderson, 2013; Anderson et al., 2014; Holdaway et al., 2019; McWethy et al., 2009; Perry et al., 2014; Prebble et al., 2019; Wilmshurst et al. 2011). The length of occupation between initial colonisation and the arrival of European colonists spans centuries rather than millennia, providing one of the shortest archaeological records anywhere in the world. Initial settlement by Polynesians occurred around the mid to late thirteenth century (Jacomb et al., 2014; McGlone & Wilmshurst 1999; Wilmshurst et al. 2011), with Tasman's visit in 1642, then Cook's arrival in 1769 marking the beginning of European contact, followed by substantial European colonisation occurring from the mid-nineteenth century onward. Aotearoa is comprised of an archipelago of islands, with two large islands Te Ika-a-Māui (North Island) and Te Waipounamu (South Island), and more than 600 smaller islands of variable size within 50 km of the mainland (Figure 1). Like in many places, occupation is concentrated on the coasts, with the majority of the population living in the north of Te Ika-a-Māui (conditions that typified settlement before European arrival as well), however, current overall population density is low (approximately 15 people/km^2). This means that the archaeological record was in the near past, and to a degree continues today, to be relatively well preserved.

The study of settlement pattern is important for understanding socio-economic variability and change through time in Aotearoa, with settlement system changes related to ideas about cultural evolution as in Polynesia more generally (e.g. Kirch, 1984, 1986; Morrison & O'Connor 2015). Studies in Aotearoa suggest that a decline

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of endemic fauna, climate change and population increase was linked to shifts in societal circumscription, social hierarchy and conflict as well as changes in the levels of mobility and sedentism (e.g. Anderson, 2017; Anderson et al., 2014; Irwin, 2020; Ladefoged et al., 2019; McCoy & Carpenter, 2014; Walter et al., 2006, 2010). What many settlement pattern models have in common both in Aotearoa and worldwide is a dependence on the ability to differentiate sets of activities represented by the artefact and faunal assemblages these sites contain (Holdaway & Davies 2020). These activities are subsumed within a typology of functional site types with settlement systems reconstructed from the distribution of these across the landscape.

The short chronology and the extant record should make Aotearoa an important location for understanding past settlement systems, including social organisation, settlement mobility and economic practices, if we expect behavioural resolution to follow chronological resolution in a direct way. Are functional site types more apparent when the archaeological record spans a short time period measured in centuries, compared for example, to cases elsewhere in the world with chronologies spanning multiple millennia or more? Here we consider this question by looking at one aspect of settlement system site type identification, differences in the diversity of artefact and faunal assemblages associated with sites thought to reflect different functional types employing a method first introduced to archaeology by Shott (2010).

In his study, Shott (2010) discusses a common issue in archaeology, but one that is rarely acknowledged. When examining settlement patterns, functional site types are often assumed to exist, but such assumptions are rarely tested. Functional site types exist in some ethnographic examples, but in archaeological contexts, what appears as functional diversity may also be accounted for by sample size. Put simply, larger assemblages are liable to have more artefact types represented than smaller assemblages. Shott (2010) provides examples of assemblage diversity as it relates to assemblages accumulated over different temporal resolutions. These include an example from !Kung San camps and Middle Palaeolithic assemblages from the site of Combe-Capelle Bas, France. The data from the !Kung San camps represent a short-term ethnographic record accumulated over days, whereas the Palaeolithic example accumulated over tens of thousands of years. These examples provide a useful comparison for assemblages in Aotearoa that accumulated over considerably shorter time spans than those of the Palaeolithic example. We therefore expect results to be more similar to the !Kung San example. Rather than attempt to test the suitability of a particular settlement model in Aotearoa, here we seek to test the richness component of functional settlement systems against abundance, specifically the claim that there are different site types identifiable based on the range of artefact forms and diversity of faunal assemblages developing the work originally presented by Shott (2010). We focus on artefacts and faunal assemblages because these data are most consistently reported. Other archaeological features such as structural elements could not be included due to inconsistencies in classification and reporting.

METHODS AND MATERIALS

We employ the same form of diversity analysis, SHE, the archaeological applications of which Shott (2010) discusses. In his study, Shott (following others e.g. Grayson, 1984) notes the expectation that diversity measures will vary with assemblage size. Therefore, to demonstrate that different types of assemblages exist, sufficient to allow inferences concerning the existence of different functional site types, variance in artefact proportions must go beyond that accountable by assemblage size alone. We therefore ask whether among sites in Aotearoa, with its short period of archaeological record accumulation, such variance exists including both material culture and faunal remains since the later feature in accounts of Aotearoa site types. We compare analysis results for Aotearoa with those Shott provides for cases with much longer and shorter chronologies. Our null hypothesis states that variability in diversity measures simply reflects sample size; in other words, the addition of new artefact types and fauna occurs in proportion to the size of assemblages. Failure to reject this hypothesis would argue against the ability to differentiate functional site types based on assemblage diversity. We present data from published and unpublished Aotearoa site reports and results of SHE analyses using these data, and comment on the utility of site type-based settlement pattern studies more generally on the basis of our short time period archaeological example.

To investigate the relationship between site type, and artefact and faunal diversity we use 18 sites from across Aotearoa with sufficient artefacts for analysis. Our sample is largely restricted to coastal sites, 10 of which also have well reported faunal assemblages. Thus, for example, we are unable to assess the assemblage diversity for the interior extraction sites Anderson (1982) identified. We explore the application of Shott's SHE method of analysis on assemblages from locations described as fishing or other resource extraction occupations and logistical nodes (i.e. villages). Settlement type identification is based on author's descriptions reporting archaeological materials in reports or academic publications. It is on these classifications we base our diversity expectation. Inevitably, there are potential sampling biases in the data used related to processes of excavation and collection strategy, and while we do not detail these here, below we do discuss similar issues such as artefact classification. All the sites included in the analysis (Table 1 and Supplementary Data A) are associated with pre-1500 CE contexts. We hypothesise that owing to the short chronology of Māori occupation (700–800 years, with settlement to 1500 CE representing no more than three centuries), the diversity pattern should appear similar to other examples with shorter time scales, such as the ethnographic cases reported by Shott (2010) and differ from the archaeological samples he provides where large time

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Table 1. Archaeological sites included in analysis. Settlement type based on classification in published literature. Diversity expectation based on settlement type. Details in Supplementary Data A.

Site name	Settlement type	Diversity expectation
Black Rocks	Short-term resource extraction	Low
Cooks Cove	Small settlement	Medium-high
Hakapureirei	Short-term resource extraction	Low
Houhora	Long term occupation (village)	High
Kahukura	Long term occupation (village)	High
Long Bay	Likely short-term resource extraction	Low
Mill Rd	Short-term resource extraction	Low
Moikau Valley	Dwelling and seasonal resource extraction	Low-medium
Opito Bay	Short-term resource extraction	Low
Pleasant River	Short-term resource extraction	Low
Purakanui	Short-term resource extraction	Low
Sarahs Gully	Short-term resource extraction	Low
Shag River	Long-term occupation (village)	High
Tairua	Short-term resource extraction	Low
Tauroa Point	Extended seasonal resource extraction	Low-medium
Torpedo Bay	Likely short-term resource extraction	Low
Twilight Beach	Short-term resource extraction	Low
Washpool Valley	Year-round occupation	Medium-high

scales (>1000 years) are represented. Aotearoa represents an ideal context to test this hypothesis with both a short chronology of human occupation and good archaeological preservation. Simply put, in Aotearoa at the very least, we should see differences in assemblage composition if the archaeological record does indeed pattern according to functional site types. We expect to see variability in material culture assemblages (artefact type) and faunal assemblages (broad taxonomic class) discussed in relation to the SHE analysis below.

The analysis uses artefact and fauna frequencies reported in publications and where available, unpublished reports (Table 1 and Supplementary Data A). Artefact categories assigned are based on descriptions provided in these sources, although standardised descriptions for artefacts in Aotearoa are lacking (Supplementary Data B). We acknowledge this is potentially problematic since observer bias might be responsible for differences in artefact frequency among sites. However, the diversity analyses we present highlight the significance of these issues. Current interpretations are based on the artefact frequencies we analyse as provided in the literature. We test whether these interpretations are supported by differences in assemblage composition as reported or whether these differences are indistinguishable from the effect of assemblage size. As shown below, if archaeologists are to identify assemblage composition differences unrelated to sample size, they need to be far more rigorous in fully reporting material culture assemblage content and considering processes like fragmentation and artefact uselife histories more generally.

Most lithic categories in the 18 site assemblages considered are stone artefacts (flakes, cores and tools) produced by hard hammer percussion, related to the manufacture of adzes (initial stages) and fishing gear, including drill points. Files for grinding are also reported and a ground adze technology is well represented. Worked bone technology, most apparent as different forms of fishhooks and ornaments, is also abundant. Owing to the inconsistencies in describing the artefact completeness, fragments of specific artefact types were combined with the parent category (e.g. adze fragments were combined into the adze/chisel category, see below for discussion). Classification of formal lithic types in Aotearoa is largely restricted to adzes, so the "taxonomic integrity" of the types included here warrants future critical discussion embedded in the contemporary discussion of assemblage formation (e.g. Dibble et al., 2017; Holdaway & Phillipps, 2020) although such a discussion is only touched upon here. Faunal analysis is well developed in Aotearoa however there are still inconsistencies in recovery methods and different methods of recording (e.g. Campbell, 2016; Harris et al., 2017). As a consequence, we use Minimum Number of Individuals (MNI) summed for general taxonomic groups as the measure that permits comparison of multiple assemblages (Supplementary Data C). Following Shott (2010), we use the classification as a heuristic tool for the purposes of understanding diversity among assemblages.

Artefact classification and faunal assemblage composition should include a consideration of the wider context of assemblage formation, including taphonomic processes (e.g. Nims & Butler, 2019). Most lithic studies, for example, are based on idealised manufacture, use, and discard sequences, finishing with a complete product (e.g. a tool). Shott (2000) highlights issues with such approaches when the complexities of assemblage formation are considered. For example, the use of Minimum Number of Flakes (MNF) in quantitative analyses of assemblages stems from the idealised material-core reduction-tool end product sequence with the numbers of flakes removed from a core reflecting reduction intensity (Hiscock, 2002).

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However, as Shott points out, most assemblages are not the outcome of such linear sequences (see also Holdaway et al., 2014) but rather result from the manufacture, use and reuse of materials multiple times. Fragmented items may be discarded at one time but functional tools at another (Holdaway & Phillipps 2020). It is likely that different types of objects had varying uselives, for example, some adzes may have been repeatedly resharpened and reused. While these issues are certainly worthy of further consideration, we do not pursue them here. As stated above, interest here focuses on whether current archaeological understanding is supported by the archaeological record as reported.

Sample richness is correlated with sample size and archaeological assemblages are usually samples themselves, therefore a small sample size may affect the result (Cochrane, 2003; Grayson & Cole, 1998; Shott, 2010: p. 890). This is important to consider as it is not always clear how representative of the wider archaeological site the assemblages are given particular recovery methods. To evaluate this possibility, a bootstrap technique is employed in the current study to assess the validity of the empirical richness values. Analysis used R version 4.0.3 (R Core Team 2020) and the Tidyverse suite of packages (Wickham et al. 2019). The analysis evaluated the degree to which a given sample statistic is reflective of the wider population. Assemblages were resampled with sample sizes at regular, increasing intervals of five per cent until the empirical assemblage size was reached. Each resample occurred 1000 times, producing a distribution of richness values for a given resample size. For example, the Torpedo Bay assemblage with a size of 62 first had three artefacts (five per cent of total assemblage size, rounded) randomly drawn with replacement, and richness calculated. This procedure was repeated 1000 times. Then six artefacts (10% of total assemblage size) were resampled 1000 times and so on, until resampling reached the empirical assemblage size of 62.

SHE analysis originated in ecology as a tool for measuring biodiversity (Hayek & Buzas, 1997) with applications in archaeology to lithics, fauna and ceramics (Shott, 2010 and references therein). In the acronym, S represents richness, the number of types present in an assemblage. H is heterogeneity, a diversity index taking into account the number of individuals as well as the number of taxa, defined by the equation,

$$H = -\sum_i \frac{n_i}{n} \ln \frac{n_i}{n}$$

where n is the number of individuals, and i is the number of individuals of type i.

E is evenness, the degree of variation among type proportions, defined by the equation,

$$E = \frac{e^H}{S}$$

consequently, H, a joint measure of richness and evenness can be defined as,

$$H = \ln S + \ln E$$

following Buzas and Hayek (1998). S may remain the same or increase as sample size increases whereas E, and therefore H, may increase, decrease or remain constant. The combination of S, H and E reflects assemblage variation and allows comparison among multiple assemblages (Shott, 2010).

The SHE method plots H and the natural log (*ln*) of S and E against the natural log of artefact number (n) for accumulated assemblages. Analysis proceeds by first calculating S, H and E for the smallest assemblage with data from the next largest assemblage added and S, H and E recalculated. This process is repeated until all assemblage data are accumulated. Accumulation by assemblage size in this manner allows investigation of sample size effects of each added assemblage on the diversity measures. Below we first present the results obtained by analysing artefact frequencies followed by the analysis of fauna frequencies.

RESULTS

Artefact types

If assemblage diversity correlates with site type, the accumulated SHE plots will show a series of slope changes. For instance, the addition of a village assemblage to a short-term resource extraction assemblage will change artefact type and faunal proportions sufficiently to contrast with proportions in assemblages accumulated up to that point. Following standard distribution fitting in ecology, the distribution should fit a log normal model, reflecting heterogeneous assemblages (Buzas & Hayek 2005; Shott, 2008). Conversely, curves that show relatively constant patterning may better fit a log series model in which assemblages are dominated by a few types, and overall composition is closely related to sample size (Hayek & Buzas 1997; Shott, 2008).

Shott (2003), following Lipo et al. (1997), distinguishes assemblages based on whether or not mean resampled richness reaches an asymptote before attaining the empirical assemblage richness value. Those that do are considered adequate samples of true assemblage richness, since resampled richness can only approach but never exceed the empirical assemblage richness. The plots in Figure 2 show the change in mean richness for each assemblage as resample size increases. Mean richness increases and tends toward an asymptote before reaching the observed empirical assemblage richness, suggesting assemblages are of sufficient size to adequately estimate true assemblage richness. While empirical richness is exceeded for Long Bay, Moikau Valley and Tauroa Point, it falls within the error range of the resampled sets suggesting no major concern. The main exception to the pattern is Mill Road which has a relatively small sample size compared to the majority of assemblages and is dominated by flakes,

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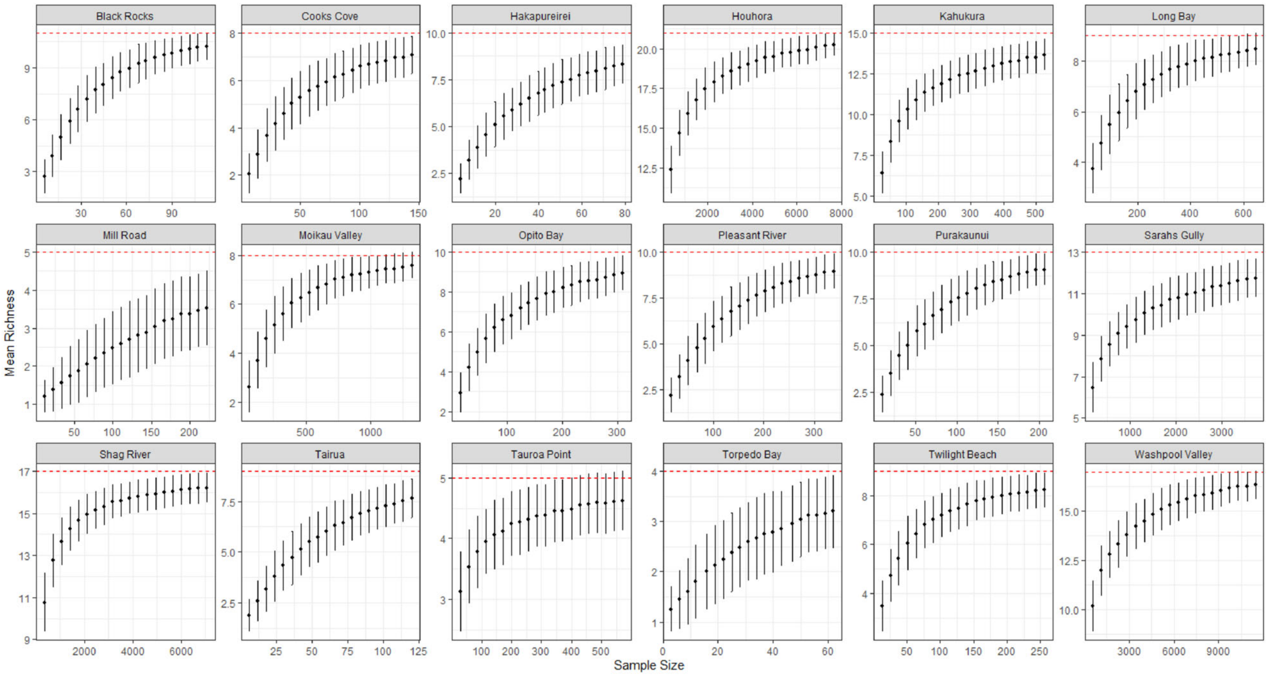
Figure 2. Bootstrapped mean estimated richness for each artefact assemblage. Error bars are one standard deviation. Dashed line indicates empirical assemblage richness value.



with four of the five artefact types present represented by only one specimen each (Table 2). This suggests sample size at Mill Road may not be sufficient to indicate true richness, though it is notable that resampled richness does not approach empirical richness.

Having established the adequacy of the empirical sample sizes in most cases, SHE analysis was conducted on the 18 assemblages (see Supplementary Data A for site descriptions) and 29 artefact types (see Supplementary Data B for type descriptions) using the freeware PAleontological STatistics (PAST) version 4.03 (Hammer et al., 2001). Table 2 lists the composition of each assemblage. The assemblages differ considerably in size with the smallest composed of 62 artefacts and the largest numbering 11451. Four sites have assemblages larger than 2000 artefacts (Washpool Valley, Houhora, Shag River and Sarahs Gully). Of the 29 artefact types represented, 15 are stone artefacts of various forms, both flaked and ground. Richness, that is the number of artefact types in each assemblage, varies from four through 21 (Table 3). Flakes are the most common artefact type in all but one of the assemblages followed by one-piece fishhooks, then drill points. The next most frequent are adzes, ornaments, files, cores, saws/cutters, two-piece fishhooks and trolling lures. A further 19 artefact types have less than 100 objects across all assemblages. Houhora accounts for the majority of one-piece fishhooks (1016 of 1256). This might suggest that Houhora represents a specialised extraction site. However, Houhora has 21 artefact types represented, the highest richness amongst the assemblages considered, the opposite to the expected pattern for a specialised extraction site, and furthermore is described as a village in publication (Furey, 2002). Ornaments (shell beads) outnumber flakes at Long Bay and this is discussed below.

Figure 3 displays the SHE plot showing accumulated diversity measures ranked by assemblage size calculated using PAST 4.03. *lnS* rises steadily until values of *lnN* above 6.5, at which point only one or two unique types are added as assemblages are accumulated. *lnE* declines steadily with *lnN*, while *H* remains relatively constant with only small deviations (discussed below). In ecology, much of the increase in richness comes from the addition of rare species (Buzas & Hayek 1998). In the current application, this equates to the addition of rare artefact types (for example, those with frequencies less than 100 across all assemblages). When ordered by sample size, *H* remains constant while *S* increases in situations where there is an increase in the proportion of abundant species and/or a decrease in proportions of rare species, both of which result in lower evenness. In the archaeological assemblages, new artefact types accumulate as *lnN* increases but not in sufficient quantities to cause much deviation in *H* and *InE*. That is, the observed patterning in the assemblages suggests size-dependence since while unique artefact types do appear with increasing sample size, proportional change in evenness is not sufficient to vary heterogeneity to any great extent as might be expected when comparing assemblages where artefact diversity varies with site function.

Four assemblages stand out as deviating from this general trend: Black Rocks, Kahukura, Long Bay and Houhora with all showing *H* values increasing in the SHE plot relative to assemblages immediately larger and smaller

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Table 2. Artefact type frequency by assemblage.

Object	Black Rocks	Cooks Cove	Hakapu-reirei	Houh-ora	Kahu-kura	Long Bay	Mill Rd	Moikau Valley	Opito Bay	Pleasant River	Purak-aunui	Sarahs Gully	Shag River	Tairua	Tauroa Pt	Torpedo Bay	Twilight Beach	Washpool Valley	TOTAL
Adze – Chisel	0	0	7	215	12	3	1	4	10	5	3	41	231	0	7	0	0	31	**570**
Awl	0	0	0	23	2	9	0	0	0	2	3	5	13	0	0	0	8	0	**65**
Bone Chisel	0	0	0	34	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**35**
Bone Point	3	0	0	7	6	0	0	0	0	0	0	0	9	0	0	0	0	0	**25**
Chopper	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	**5**
Cobble	0	2	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	**9**
Cores	0	5	3	78	15	0	0	6	22	3	0	0	61	4	34	0	5	31	**267**
Drill Point	2	0	0	803	0	0	1	9	1	2	0	13	117	1	54	0	20	99	**1122**
Files/Hoanga	3	4	2	161	11	5	0	4	0	3	5	24	70	1	0	0	6	159	**458**
Fishhook – One-Piece	8	8	1	1016	1	5	1	0	1	2	2	48	119	1	1	0	1	41	**1256**
Fishhook Tab Core	5	1	1	0	0	0	0	0	0	1	0	0	0	3	0	1	0	0	**12**
Fishhook – Two-Piece	3	0	1	4	96	20	0	0	0	0	3	1	21	0	0	3	1	5	**158**
Flake Tools	0	3	0	19	0	0	0	0	2	0	2	0	0	3	0	0	22	3	**54**
Flakes	77	120	53	5085	281	276	218	1278	257	312	174	3497	6305	102	475	57	189	10802	**29€558**
Gouge	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
Hammerstone	0	0	1	12	2	0	0	1	4	2	0	1	9	0	0	0	0	11	**43**
Harpoon	0	0	0	2	1	1	0	0	0	0	0	0	1	0	0	0	0	28	**33**
Needle	0	0	0	2	6	0	0	0	0	0	0	1	1	0	0	0	0	0	**10**
Ornaments	0	0	0	105	15	323	0	0	0	0	2	31	36	0	0	0	0	3	**515**
Pumice Float	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	**2**
Saws/Cutters	4	0	0	0	0	0	0	12	0	0	0	0	32	0	0	0	0	128	**176**
Scrapers	0	0	0	16	0	0	0	0	0	0	0	70	0	2	0	0	4	0	**92**
Sinker	0	0	0	1	0	0	0	0	3	0	1	2	7	0	0	0	0	1	**15**
Tapa Beater	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**
Tattoo Chisel	0	0	0	9	0	0	0	0	0	0	0	0	4	0	0	0	0	2	**15**
Teka Dart Head	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Trolling Lure	5	1	3	43	22	2	0	3	0	0	11	5	32	0	0	0	0	27	**154**
Worked Bone	1	0	7	0	56	0	1	0	0	6	0	0	0	3	0	0	0	0	**74**
Worked Stone Piece	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	**77**
TOTAL	**113**	**144**	**79**	**7642**	**527**	**644**	**222**	**1317**	**309**	**338**	**206**	**3739**	**7068**	**120**	**571**	**62**	**256**	**11451**	**34808**

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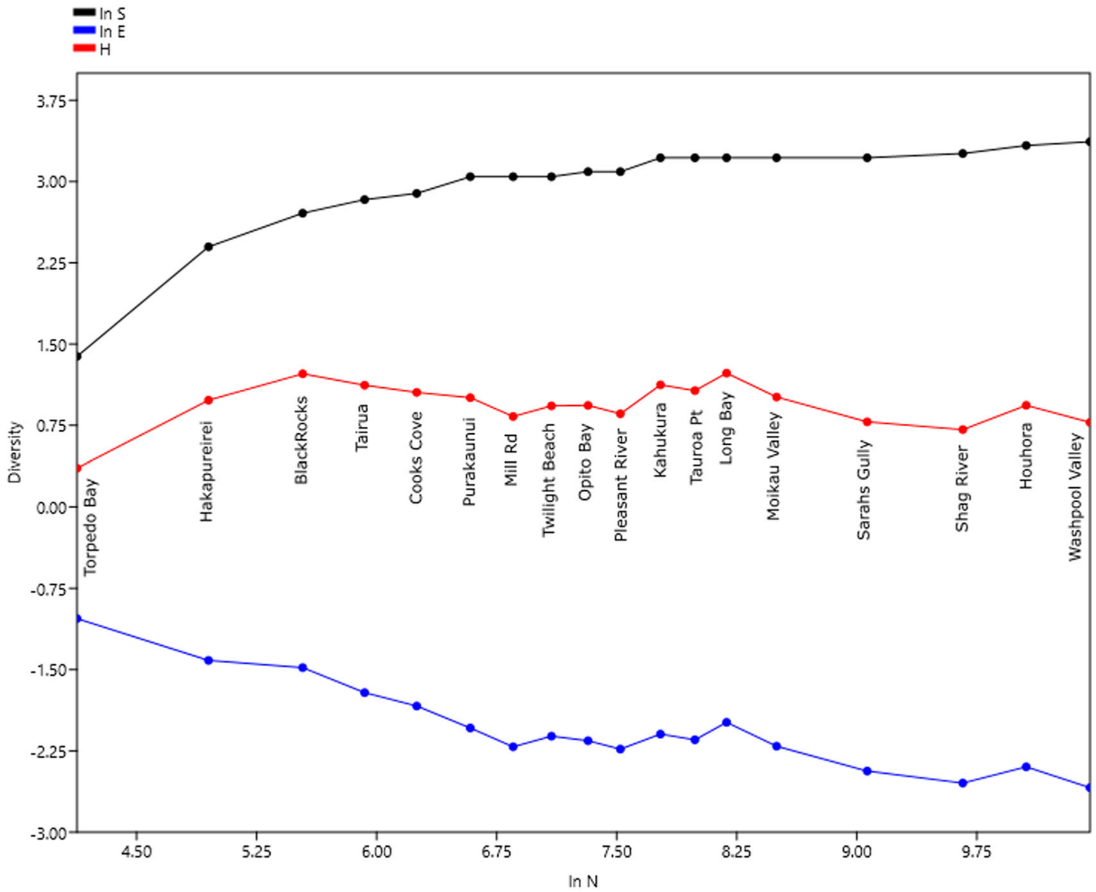
Figure 3. SHE plot for accumulated Aotearoa artefact assemblages ranked by size.



(Figure 3). Black Rocks is one of the smallest assemblages yet has 11 artefact types represented – the highest richness of assemblages less than 500 artefacts in size, which accounts for the shift in the slope of *H*. Long Bay is the only assemblage where another artefact type outnumbers flakes – these are ornaments (shell beads), causing the shift in *H* and *lnE* away from the general trend. At Long Bay, all of the shell beads were found in a single closed context associated with the burial of a young infant, suggesting the beads were part of an ornament or garment adorning the body (Campbell et al., 2019: p. 31). Kahukura contained almost 3000 pieces of whale bone interpreted as a single-event whale bone working floor (Cunliffe & Brooks, 2016; Walter et al., 2018), which accounts for the higher number of worked bone pieces (56) reported at this site. Like Long Bay, the high numbers for a particular artefact type cause a shift in *H* and *lnE*. Finally, Houhora has 21 artefact types, more than the preceding Shag River Mouth assemblage (17) and the larger Washpool Valley assemblage (17) which also causes a shift in *H* and *lnE*. These examples accepted, following Buzas and Hayek (1998: p. 234, 2005: Table 1), the SHE patterning from the assemblages more closely matches a log series than a log normal distribution. The pattern also resembles Shott's (2010) Combe-Capelle Bas, long time scale, Palaeolithic example, with the assemblages from Aotearoa dominated by a small number of artefact types (see also Magurran, 1988: pp. 18–19) more so than the plot created by analysing artefact numbers from !Kung San camps (Shott, 2010: fig. 4). At Combe-Capelle Bas, 20 Middle Palaeolithic assemblages were assigned to Typical Mousterian facies, with artefacts classified according to the Bordean typology (Dibble & Lenoir 1995). The Combe-Capelle Bas SHE plot (fig. 2 from Shott, 2010: fig. 4) shows assemblages varying in richness and evenness but not heterogeneity, reflecting a continuous relationship with sample size. Shott (2010) suggests that the Combe-Capelle Bas pattern reflects the presence of a few dominant artefact types, the product of differential artefact life-history and rates of discard rather than functionally distinct site types as previously suggested.

Fauna

The bootstrap and SHE analysis were also applied to available faunal data from the same sites. Minimum Number of Individuals (MNI) was the abundance measure most frequently reported, as noted by others interested in comparative analyses of faunal assemblages (e.g. Harris et al., 2017). Ten of the 18 sites in Table 1 reported this measure for all broad faunal taxonomic classes (bird, fish, mammal, reptile and shellfish, described in Supplementary Data C), thus only those assemblages are considered in this analysis. Individual species were placed into taxonomic

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Table 3. Richness (S), heterogeneity (H), evenness (E) and total artefact count (N) values for each artefact assemblage. Diversity measures calculated using PAST 4.03 and the data in Table 2.

	S	H	E	N
Torpedo Bay	4	0.357	0.3573	62
Hakapureirei	10	1.26	0.3525	79
Black Rocks	11	1.317	0.3392	113
Tairua	9	0.7161	0.2274	120
Cooks Cove	8	0.7378	0.2614	144
Purakaunui	10	0.7349	0.2085	206
Mill Rd	5	0.1152	0.2244	222
Twilight Beach	9	1.016	0.3068	256
Opito Bay	10	0.7418	0.21	309
Pleasant River	10	0.4303	0.1538	338
Kahukura	15	1.566	0.3191	527
Tauroa Pt	5	0.6092	0.3678	571
Long Bay	9	1.005	0.3036	644
Moikau Valley	8	0.1851	0.1504	1317
Sarahs Gully	13	0.3626	0.1105	3739
Shag River	17	0.5723	0.1043	7068
Houhora	21	1.203	0.1586	7642
Washpool Valley	17	0.3394	0.08259	11451

categories based on the broad ecological habitat in which they are found (see Supplementary Data C). Any unidentified specimens were included in the “mixed” category for each faunal type. These categories assume different technological components were required for procurement of fauna from different habitats, allowing analysis to highlight potential differences in procurement and processing activities reflecting functional site types. In addition, grouping species by habitat negates patterning in diversity that simply reflects the geographic availability of different species (see Supplementary Data C for more information).

Faunal MNI vary by orders of magnitude among assemblages with the Shag River Mouth the most abundant and Torpedo Bay the least (Table 4). Shellfish, both muddy bottom/estuarine and rocky shore species are the most frequent, accounting for the majority of the nearly quarter million individuals identified from all sites, with benthopelagic and bottom feeding fish the next most frequent. In the context of Aotearoa, terrestrial mammals represent dogs and rats, brought by the first Polynesian colonisers with endemic terrestrial mammals, other than a species of bat, absent before human colonisation. Other species occur in much lower numbers including birds of a variety of species and a single species of reptile, the tuatara (*Sphenodon punctatus*). The extinct ratite species referred to collectively as moa, often associated with initial settlements in Aotearoa, are represented by a total of 180 individuals from all 10 sites.

Figure 4 shows the bootstrapped mean estimated richness for each of the faunal assemblages using the same technique and settings applied to artefact assemblages. In most cases, mean richness increases and tends towards an asymptote before reaching the observed empirical assemblage richness as was the case for the artefact assemblages, suggesting samples are of sufficient size to adequately estimate true assemblage richness. For the Washpool Valley assemblage, the empirical assemblage richness falls within the error range for several of the resampled sets, suggesting that sample sizes may not be adequate. Washpool Valley, while dominated by shellfish, proportionally has a large number of forest birds and terrestrial mammals relative to other species. This assemblage is among the smaller total MNI of the assemblages considered and exhibits greater evenness compared to other assemblages with similar richness values (Table 5), suggesting sample size may be too small to differentiate absences due to sample size rather than population differences. However, patterning in the bootstrap analysis for the Washpool Valley and each of the other assemblages suggests increased sampling from the archaeological record would not result in significant increases in the number of faunal categories represented since in no instance do bootstrapped mean richness values exceed the empirical assemblage values (Figure 4).

Figure 5 shows the SHE plot for fauna. *lnS* rises to a value of around three, then remains unchanging as larger

Figure 4. SHE plots from Shott 2010 Figures 4 and 6. !Kung San (left) and Combe Capelle Bas (right).

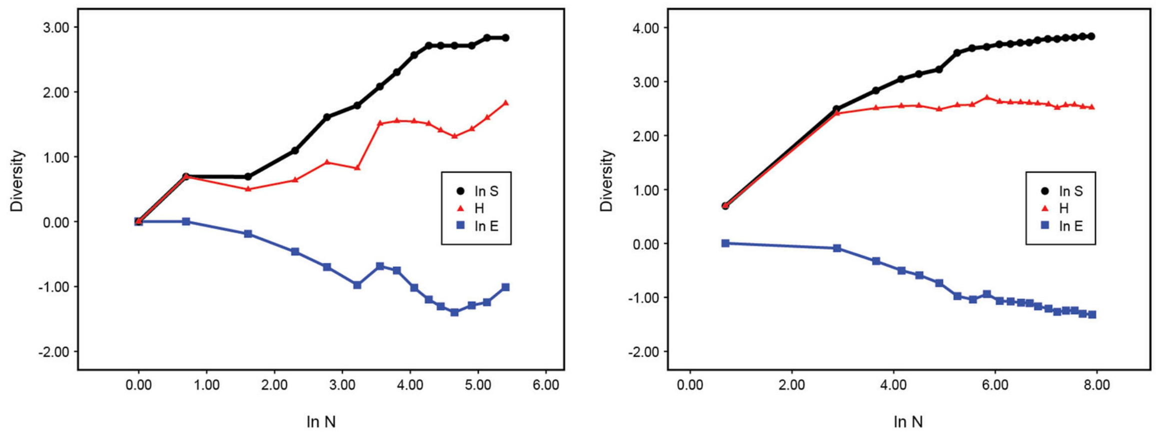

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Table 4. Faunal type frequency (MNI) by assemblage.

Category	Black Rocks	Cooks Cove	Houhora	Kahukura	Pleasant River	Purakaunui	Sarahs Gully	Shag River	Torpedo Bay	Washpool Valley	TOTAL
Bird - Wetland	3	1	19	1	17	4	6	36	0	7	**91**
Bird - Forest	47	8	19	15	13	6	16	212	6	217	**546**
Bird - Coastal	17	6	38	14	23	13	36	170	15	12	**317**
Bird - Mixed	2	6	15	3	4	6	10	31	3	18	**90**
Bird - Sea	22	3	70	4	9	14	10	80	1	10	**214**
Bird - River/coastal	1	0	0	1	1	0	0	11	0	0	**14**
Bird - Moa	5	2	50	1	29	2	5	72	8	10	**180**
Fish - Reef	469	48	2210	37	27	27	345	129	22	103	**3190**
Fish - Demersal Rocky	7	1	2	3	0	2	4	14	0	4	**33**
Fish - Pelagic	14	1	55	5	1	0	6	0	1	43	**120**
Fish - Benthopelagic	38	2	13	107	467	1318	3	1005	0	65	**3015**
Fish - Demersal Soft	19	11	4	4	0	3	6	1	0	18	**60**
Fish - Demersal	49	4	2	131	29	1386	0	275	0	53	**1929**
Fish - Mixed	50	25	2	40	4	9	23	26	0	79	**242**
Mammal - Terrestrial	36	6	72	5	29	21	24	131	4	135	**447**
Mammal - Sea	7	4	59	4	32	4	16	87	3	9	**213**
Reptile - Terrestrial	0	0	2	0	0	0	3	0	1	0	**5**
Shellfish - Rocky shore	48551	1411	136	5523	503	15800	639	14541	178	2396	**89367**
Shellfish - Soft shore	4615	424	29	23	23	465	338	0	40	173	**5832**
Shellfish - Muddy/estuarine	9	2775	339	143	14098	35878	62	60689	10	1433	**115393**
Shellfish - Mixed	9743	3406	17	203	129	3094	202	49	7	619	**17369**
TOTAL	**63704**	**8144**	**3153**	**6267**	**15438**	**58052**	**1754**	**77559**	**299**	**5404**	**238667**

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Figure 5. SHE plot for accumulated Aotearoa faunal assemblages ranked by size.

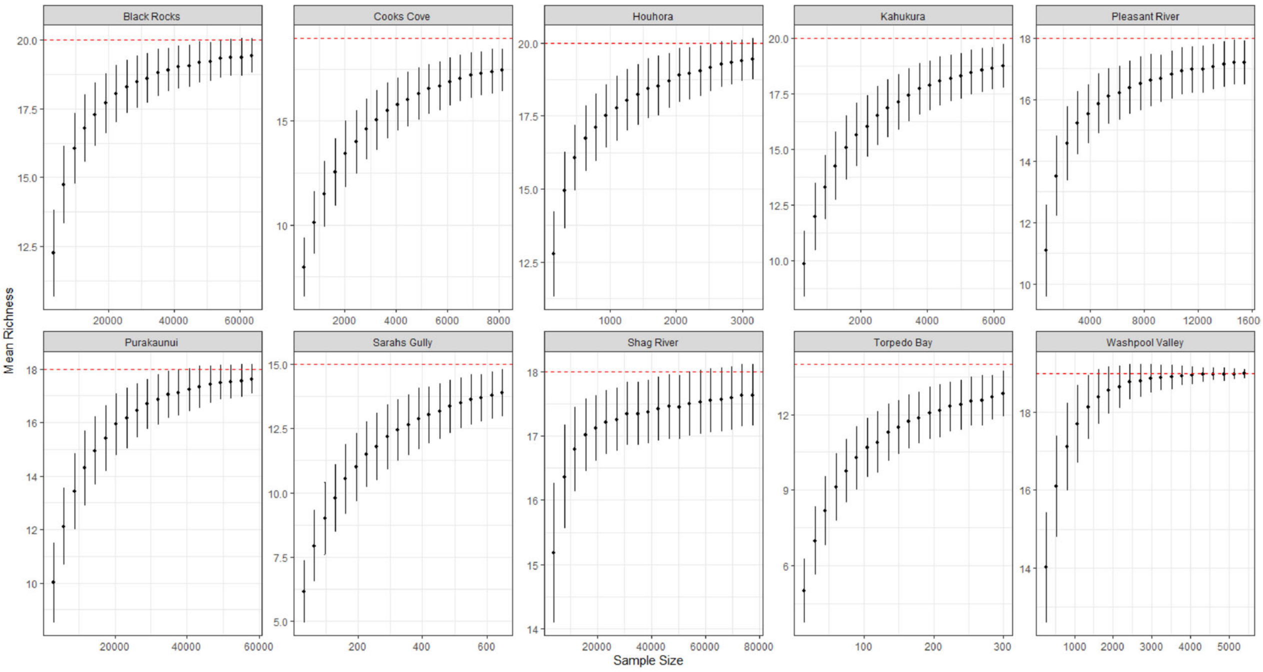

Table 5. Richness (*S*), heterogeneity (*H*), evenness (*E*) and total MNI values for each faunal assemblage. Diversity measures calculated using PAST 4.03 with the data in Table 4.

	S	H	E	MNI
Torpedo Bay	14	1.504	0.321	299
Sarahs Gully	15	1.521	0.305	1754
Houhora	20	1.267	0.178	3153
Washpool Valley	19	1.666	0.279	5404
Kahukura	20	0.607	0.092	6267
Cooks Cove	19	1.286	0.191	8144
Pleasant River	18	0.442	0.086	15438
Purakaunui	18	1.038	0.157	58052
Black Rocks	20	0.76	0.107	63704
Shag River	18	0.671	0.109	77559

assemblages are added following the addition of the Kahukura assemblage. *InE* initially falls until Washpool Valley is added, then declines again after the addition of Cooks Cove with *H* showing the same pattern. Very few faunal categories are added with increasing assemblage size with the exception of Torpedo Bay, the assemblage with the lowest overall size. The slight increase in *InE* and *H* is attributable to Washpool Valley, the assemblage where the bootstrap analysis indicates concern over sample size. Results show that even more so than the artefact assemblages, faunal assemblages reflect the dominance of a few taxonomic categories, the divisions for shellfish and fish, with assemblage size largely reflecting the discard rates of these species. Apart from the increase in assemblage size, there is very little indication of differences among assemblages using the fauna grouped into the categories described in Supplementary Data C.

DISCUSSION

The SHE analysis results allow comparison with the case studies Shott (2010) reported including both ethnographic and Palaeolithic archaeological examples (Figure 6). Given the short chronology for Māori occupation (700–800 years), reduced even further in duration to 300 years since the sites considered here are dated pre-1500 CE, it might be expected that diversity measures ranked against assemblage size would show the type of differentiation envisioned by settlement models based on the identification of functional site types. However, neither artefact nor faunal diversity show the pattern expected. Indeed, rather than a pattern close to the !Kung San example Shott uses to illustrate short term, ethnographic scale artefact accumulation, the Aotearoa assemblages seem closer to the Combe-Capelle Bas Middle Palaeolithic example that accumulated over many thousands of years (Valladas et al., 2003), fitting a log series model in which assemblages are dominated by a few types and overall composition is closely related to sample size. Thus, the short chronology Aotearoa example is comparable to a deep time Palaeolithic example. As noted above, Shott (2010) suggests this pattern reflects the presence of a few dominant types, which relates to artefact use life and rates of discard. The same pattern likely explains faunal diversity related to the life-history of faunal elements. Therefore, based on these results the null hypothesis of changes in diversity as a function of sample size cannot be rejected.

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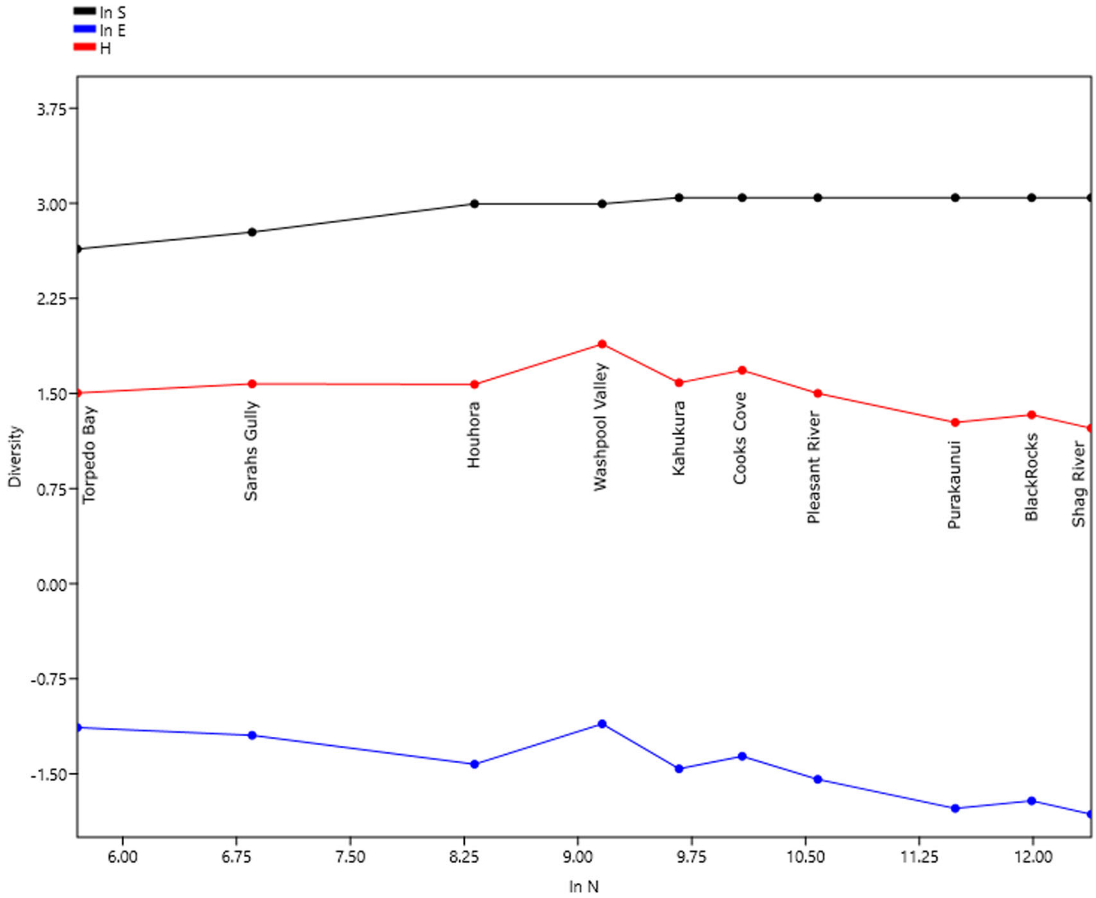
Figure 6. SHE plot for accumulated Aotearoa faunal assemblages ranked by size.



Most large lithic and faunal assemblages in Aotearoa are simply bigger versions of small assemblages. Rather than simply assuming different assemblages reflect different functional site types as has been the case in the past, we suggest assemblage size cannot be ruled out, at least based on the examples and materials considered here. However, rather than disproving the existence of villages or base camps and short-term resource extraction sites, this result instead indicates that there are issues involved in identifying such entities using the types of archaeological proxies typically included in discussions of settlement systems such as functional classifications of material culture and faunal diversity, at least as they are currently reported.

In part these issues relate to mobility definitions and ethnographic analogues that apply to settlement models. For example, when Binford coined the terms “residential” and “logistical” to describe mobility based on his ethnographic observations, he did not intend the models these terms referenced to explain long-term artefact patterning as found in the archaeological record (Binford, 1980: p. 19). Instead, he used the terms to conceptualise the organisation of technology as it related in the short-term to the discard of artefacts at different landscape locations, reflecting responses to the seasonal availability of resources in environments differentiated by effective temperature. Unfortunately, the appeal of his mobility models led some scholars to sidestep his ethnographic focus and use of his models has proliferated in archaeological considerations of hunter gatherers and low level-food producers (Holdaway & Wandsnider, 2006).

Archaeologists have discussed issues with definitions of mobility and sedentism (e.g. Close, 2000; Kelly, 1992), particularly problems with definitions of different types of mobility or ordered sets of states. Kelly (1992: p. 49) suggests the archaeological record forms a palimpsest combining societal and individual events, single “tracks” and lifetime “tracks”, that can “vary independently of the others”. The artefacts analysed here are the outcome of varying combinations of these tracks, so specific functional definitions like base camp or extraction camp do not fit easily with this understanding of the archaeological record. For example, it does not follow that all artefact types align with mobility in the same way at the same scale, or indeed that artefacts belonging to the same type always indicate the same level of mobility. Specifying how mobility and sedentism relate to the accumulation of artefacts require some understanding of who was mobile or sedentary and for how long when making and using certain artefacts. In this sense, artefact diversity based on functional typology provides a very imprecise measure with which to assess material remains. And as the SHE analyses show, diversity

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based on currently available data cannot be distinguished from the effect of sample size.

Ethnographic analogues provide one way to conceptualise how artefacts or features functioned, but it has long been recognised that there are limitations to making direct inferences from such sources (e.g. Allen et al., 2008; Gould, 1978; Wylie, 1985, 1988, 1989, 2002). There may be no ethnographic examples of past behaviour, raising the issue of incorrect analogies (Gould & Watson 1982). In addition, archaeological applications may rely on singular (geographic and temporal) ethnographic examples to develop an explanatory analogy, which is then applied to a range of different spatial and temporal contexts. Such approaches value conformity rather than variability, at times masking discontinuous relationships. The concern is that attempts to differentiate site types ensues, with limited opportunity to identify sites that depart from this typology (O'Brien & Lyman 2000). The results from the analysis presented here demonstrate how richness at times varies contextually, for example the Kahukura and Long Bay artefact assemblages. With the addition of numerous examples of an otherwise rare artefact type, these assemblages stand out in the SHE plots, but other examples may be more difficult to detect or to explain, such as Black Rocks and Houhora, subsumed by what appears as an overwhelming relationship with assemblage size when in fact they evidence varied responses to mobility and sedentism.

As Shott (2010: p. 894) comments in relation to general mobility and place use;

> It is naïve to suppose that ancient people always occupied different places for different purposes, for fixed periods that witnessed little or no fluctuation in resident population, and that they rarely if ever reoccupied the same places for similar or different purposes, for long or short intervals, in larger or smaller groups, in different years….simplistic ethnographic scenarios of brief, single uses of places assume away the complexity that would enrich our understanding of the past and ignore the formation processes needed to interpret the past. Instead, complex land use and formation produce complex assemblage variation, including size dependence in derived measures. Discrete site types may exist sometimes, but seeking "hunting camps" or "hamlets" in most assemblages is like seeking one person's portrait in a long film exposure of crowds passing on a busy street.

The attraction of identifying short-term functional events played out over landscapes is that they allow for the creation of narratives of past human behaviour. A focus on the significance of rare objects like ornaments, or rarer fauna, like moa in the Aotearoa case study, can lead to tangible reconstructions. However, these often occur to the exclusion of other objects and fauna that might allow us to consider process, including formation processes over longer timeframes. Shott (2010) highlights the temporal disjuncture between the ethnographic scale on which settlement typologies are based and the time frames of archaeological record formation. As he and others (e.g. Bailey, 2007; Perreault, 2019) suggest, where archaeologists continue to use microscale processes (sometimes referred to as the ethnographic scale) this temporal disjuncture remains, and so interpretations cannot be tested. Shott's concerns echo those raised earlier by Allen (1996) in the context of Aotearoa when he questioned the existence of direct archaeological material correlates for villages. As both authors note, at issue is not whether particular settlement types existed in some form at times in the past but rather whether a simple relationship exists between ethnographically founded settlement types, and the patterns observable in archaeological material culture and faunal assemblages. Use of functional designations like villages or fishing camps reflects a desire to write ethnographies of the past despite the limitations noted above. As Shott (2010) shows, even examining ethnographic data suggests the notion of deriving individual activity or temporal instances of behaviour from material culture accumulations is problematic.

Studies conducted elsewhere indicate that use of locations for a variety of purposes over time will see artefact depositional patterns coalesce around the outcome of certain repeated actions (Davies & Holdaway 2019; Davies et al., 2021; Haas & Kuhn 2019; Haas et al., 2019; Holdaway & Davies 2020). In such cases, repeated activities leading to artefact deposition, more so at some locations than at others, produce differences in assemblage size. Places with different artefact densities reflect persistent places (Schlanger 1992), those locations that saw greater (or lesser) levels of activity and therefore variability in the nature of persistence. For example, places where people left lots of lithic material become those to which people returned multiple times, in part attracted by the potential for materials to be reused (Holdaway & Phillipps 2020). Place use histories derived from the accumulation of such visits are often the product of many variables, both environmental and cultural, that combine to form the archaeological record as visible in the present. This discussion also encourages us to think about the fundamental nature of the archaeological record. We therefore hypothesize that differences in assemblages across the landscape, and the archaeological record as a whole, relate to formation and place use history rather than particular sets of activities.

Careful consideration of the historical contexts in which assemblages accumulated may provide the opportunity to understand how artefact numbers accumulated with variables like the degree of fragmentation representing occupation intensity as well as artefact reuse, but these histories are likely to vary from location to location. This calls into question the utility of the functional site type concept. Faunal assemblages are also prone to fragmentation, and taphonomic factors will reflect local site environments. The challenge that diversity measures introduce is therefore not that they provide a definitive measure of the presence or absence of particular site types in the past, but rather that they lead to questions about the utility of the conceptual basis for such functional settlement model analyses. To unlock the complexity of the

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archaeological record and temporally appropriate human behavioural measures we need to move beyond functional proxies, and analyses need to be more nuanced with greater consideration given to materials and places in future assessments.

CONCLUSION

With a very short history of human occupation, compared to archaeological records found elsewhere, and an archaeological record characterised by a range of artefact types and faunal taxonomic categories, sites dating from the early period of Aotearoa settlement in the first 200–300 years should show variation in diversity consistent with functionally differentiated site types. However, when artefact and faunal assemblages in Aotearoa are analysed using a diversity measure (SHE), the expected differences reflecting site types are not found. Instead, like sites elsewhere that accumulated over prolonged time periods, artefact and faunal diversity vary with assemblage size rather than just functional use of place that fit a settlement typology. Rather than seek site types, a variety of contextual variables need to be considered when assessing assemblage diversity meaning that abundant and functionally varied material culture on its own is not a sufficient criterion with which to differentiate site types. In interpreting archaeological assemblages, emphasis on the spatial distribution of sites with artefact accumulation interpreted using concepts such as persistent places, more so than with functional site type settlement models, aligns better with the content of the archaeological record.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Supplementary Data A: Site descriptions
Supplementary Data B: Artefact type definitions
Supplementary Data C: Faunal assemblages
Supplementary Data D: Data tables and R scripts

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