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PROCESSING AND ANALYSING MIDDEN SAMPLES

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Introduction.

New Zealand archaeological sites include many different kinds of refuse deposits, which may vary according to the range of constituents, the concentration of material, and the nature of the matrix within which these remains of man's activities on the site are contained.

Techniques of analysis vary according to the kind of site. In many situations, however, during the course of an excavation, or in a field recording and sampling project, it is desirable to collect small quantitative samples for analysis at home or in the laboratory. Small samples are small sections of the deposit, including everything present, even sand or dirt, which, because they include all constituents in the proportions they occur at the point where the sample is taken, lend themselves to quantitative analysis.

Small samples should always be taken from a vertical face in an undisturbed section of deposit, whether they are taken from a hastily cleaned-up section of an eroding beach midden, or from the walls of an excavation. A lump of the deposit is merely shovelled *in toto* into a bag, preferably plastic, carefully labelled, and removed for analysis at a later date.

The following discussion is concerned with the procedure of analysing small samples once they have been collected.

Processing a Sample.

Several ways exist of handling quantitative samples in the laboratory. A series of recommendations on the processing of samples from American Indian mounds has been made (Meighan et al. 1958: 4). The method and variations on it were tested on a number of New Zealand samples, constantly balancing the time taken against the degree of accuracy achieved. I found that all the steps recommended were not always necessary. In the following discussion, processing of samples is considered step by step.

Drying the sample: This initial step may seem at first glance unnecessary. In processing midden samples, however, one soon learns that a sample taken straight from the ground holds a considerable amount of moisture, particularly if it is placed in a plastic bag. This moisture will affect its weight. Even samples collected at one time from a small area may vary considerably in moisture. A series of samples from Tairua (Davidson 1964) were weighed immediately after they had been removed from the bags, and again several times during drying, until weights were constant.

Figures for wet weight, and final dry weight (Table I) show clearly that weight of undried samples can be misleading. Moreover, a wet sample is much more difficult to process satisfactorily.

Table I

Loss of moisture from Tairua samples

Sample no.	wet weight	dry weight	moisture lost
1 N44/2	2995 gms.	2758 gms.	237 gms.
2 "	2638	2463	175
3 "	2372	2177	195
4 "	2512	2346	166
6 "	1971	1828	143
8 "	2186	2023	163
9 "	1803	1604	199
10 "	2370	2178	192
N44/41	2503	2365	138
N44/42	1920	1864	56

Size of sample: Opinions concerning this vary greatly. Two thousand gms. is a figure recommended by some (e.g. Cook & Treganza 1950, Meighan 1959, Ascher 1959), although other (e.g. Greenwood 1961) found five hundred gms. to be sufficient. The size of the sample is likely to be a function of the constituents it contains, the degree of accuracy desired, and the time available. Anything up to two thousand gms. is not likely to take an exorbitant time to sort unless the material is very fragmented or a small screen size is being used. Five hundred gms. is a minimum, below which a sample is seldom big enough to be reliable. The only occasion at which samples over two thousand gms. are likely to be of much value and not too time-consuming is when the sample contains large and heavy stone or shell, or large amounts of residue, and in either of these cases the point is approaching where small samples should be abandoned and a new method adopted.

Tests were performed on samples from Kauri Point, a large sample from Mt. Roskill, and two large samples (of unknown provenance) long resident in the Anthropology Department, to see whether sample size affected results significantly.

The Mount Roskill sample consisted of numerous shells of Chione stutchburyi of small size, a smaller amount of Cyclomactra ovata, and some very minor amounts of other shell, with a fairly small amount of fine scoria residue, and some larger pieces of scoria and charcoal. The Kauri Point middens are already familiar (Green 1963, Davidson 1964). The other two were both unusual, one being almost entirely Pecten novaezealandiae, and the other almost entirely Amphidesma subtriangulatum. In all these cases, an increase in sample size did not alter the results obtained from a five hundred gm. sample. From this, one may conclude that with concentrated shell middens at least, a five hundred gm. sample from a particular spot is sufficiently accurate, and therefore four, five hundred gm. samples a certain distance apart will provide more valuable information than one localized two thousand gm. sample for approximately the same

amount of work. Unfortunately, the tested instances cannot be taken as representative of all kinds of middens. Those from Kauri Point have already been shown to be typical of concentrated shell middens in earth (Davidson 1964: 73), and the Mount Roskill sample is very similar to samples from other volcanic cones on the Auckland Isthmus, such as Mt. Wellington and Taylor's Hill. The other two samples are unusual and it is not likely that many middens resembling them will be found. Yet the fact that they substantiate the findings from Mt. Roskill and Kauri Point samples, and also the results obtained by Greenwood from similar shell middens on the American west coast, is important.

It is less likely that a midden containing a variety of species of shellfish each in fair quantity would be so well represented by five hundred gm. samples. Thus, as a general rule, in middens where more than two species are important the size of the sample should be increased. Likewise, if one or two large and heavy shells are known to be present the entire sample should be increased, to avoid undue weighting by a less common but heavier species. It is always wiser to collect a larger sample than necessary and use only a portion of it, than to begin with too small a sample and have to return to the site.

Some American archaeologists have used volume rather than weight as a basis for sample size (e.g. Cook and Heizer 1951). To my knowledge nobody has yet attempted this in New Zealand. Heizer and Cook consider that it is a matter to be decided in individual cases (Heizer and Cook 1956: 232).

A concentration index (Willey & McGimsey 1954) depends on volume, but this is volume of an excavated area, rather than volume in a column or other small sample. My own experience has been that in most New Zealand refuse deposits accurate samples by volume would be difficult to obtain and seem to offer no marked advantages over samples based on weight, although obviously in attempts to compute the total composition of a site on the basis of volume the small samples should also be based on volume. Should this approach become established in New Zealand the need for samples analysed in terms of volume could become important.

Screen size: Having selected samples of the requisite size, the next step is to screen the samples. Very little has been done on this aspect of midden analysis in New Zealand. Elsewhere the criteria range from $\frac{1}{4}$ inch, found to be sufficient by Greenwood, and other recent workers at U.C.L.A. (Greenwood 1961: 418), through $\frac{1}{8}$ inch found to be the minimum by the Berkeley teams, to 1/16 inch demanded by Ascher (1959) in his more precise work with fragmentary shell.

In New Zealand, no screen was used at Kauri Point, or at Tairua, although screens have been used in as yet unpublished Auckland excavations, but without much experiment. At Waikanae, samples were screened through three meshes, $\frac{1}{2}$ inch, $\frac{1}{4}$ inch, and $\frac{1}{8}$ inch. No assessment of the relative values of these is available, although Smart remarks that he does not consider the $\frac{1}{8}$ inch mesh of much use (Smart 1962: 169).

Four sieves were used in handling many of the samples referred to here, $\frac{1}{2}$ inch, $\frac{1}{4}$ inch, $\frac{1}{8}$ inch and 1/16 inch. In almost all cases, the critical division seemed to lie between the $\frac{1}{4}$ inch and $\frac{1}{8}$ inch. Material

retained by an ⅛ inch sieve was identifiable without difficulty. Objection to it lies in the great increase in time necessary for a very small increase in exactness. The material retained by the sieve was always less than 10% of the total weight of the sample and usually considerably less than that. While affecting the proportions of total weight, the shell was usually in the same ration as in the larger sizes, and consequently the percentages of total shell would not be at all affected by the inclusion of the small amounts from the ⅛ inch screen.

Most important is the time involved. It takes about an hour to sort one hundred gms. of material passed by ¼ inch sieve but retained by ⅛ inch. It was therefore estimated that had the samples from Kauri Point been screened through ⅛ inch as well as ¼ inch, the time taken in processing the samples would have been doubled. Yet the gain in accuracy would have been minute, and considering the range of variation exhibited in the middens already, quite unnecessary.

A final objection against the ⅛ inch sieve when dealing with earth matrix middens relates to the next section. While it is often unnecessary to wash samples screened through ¼ inch sieve, it is almost always necessary to wash the finer material to eliminate lumps of dirt which make sorting very difficult. Thus a sample which otherwise might not need washing is almost certain to need it if the finer sieve is used.

Most of the above remarks apply to middens which contain non-fragmenting shell and no bone. A small amount of shell even in these cases will pass through even ⅛ inch but this is negligible. However, with middens containing rocky—shore shellfish or bone, the situation is somewhat different. A greater amount of material will pass through to the smaller screen size but it will be even more difficult to sort. In fact, the time required becomes so great that it is quite impossible to do so. Moreover, washing becomes risky as mussel and Haliotis fragments are likely to disappear through the screen along with the dirt, and in equal quantity. Fish bone is equally difficult, and a residue, less than 1/16 inch and quite unsortable, may contain a considerable amount of bone, and fragments of shell such as mussel.

Material passed by the ⅛ inch sieve and retained by the 1/16 inch was found to be quite unsortable with one exception. However, in the case of certain samples from Waiheke, Sarah's Gully and Tairua, the 1/16 inch could be used to divide unsortable residue into finer and coarser categories, which may in some instances provide useful information on the categories of material which frustrated further analysis. In one case, however, the 1/16 inch sieve proved essential. This was a rather special case. Several samples were collected from the Pig Bay site (N 38/21) on Motutapu Island, which was partially excavated some years ago by the Auckland University Archaeological Society. One of these proved to come from a working floor. A few large flakes, such as would be picked out by a troweller, were visible in the layer. The sample was hardly worth analysing for relative proportions of material. The figures in Table II show that the use of the ⅛ inch and even of the ¼ inch sieve made little difference to the proportions obtained by the use of the ½ inch sieve only, especially so when the probable inaccuracy of the sample is considered.

Table II

Effect of screen size on small sample from N 38/21

Screen size	¼"		⅛"		1/16"	
Stone flakes	338 gms.	9.7%	350 gms.	10.0%	356 gms.	11.5%
Shell	3	.08	3.5	.1	4.5	.13
Charcoal	-	-	.5	.01	1.5	.04
Residue	3135	89.96	3119	89.5	3108	89.18
Bone	9	.26	12	.34	15	.43

When the sample was dried, the sand passed very easily through the sieve, and a number of minute stone flakes were left, even in the smallest sieve. While the task of sorting all the material from the sieves was not worth while, in terms of the effect on the percentages, the flakes could be easily picked out. They were present even in the smallest sieve, and those less than ¼ inch in size, and quite possibly those less than ⅛ inch would be missed by even the most careful troweller in the damp sandy matrix in which they occurred. Yet the sample demonstrated that in excavating a site such as this, one is missing vital information about stone working and adze manufacture if one does not obtain a sample of these tiny flakes in some way. It would be quite impossible to sift an entire site through 1/16 inch sieve, or even to collect all the larger flakes. However, it seems that it would be essential to take a number of large samples, or to sift finely a selected small area or areas, in order to obtain an idea of the range of flakes and the proportions in each size group. Samples from a site like this present no problem of processing, being simple and quick, but they take up a lot of room and may be difficult to transport to the laboratory. The best method of sampling this data has yet to be devised, but the use of the fine screen in this case established the presence of these tiny flakes which would otherwise almost certainly have been passed over.

The use of some sort of screen in sorting small samples seems almost essential, if only to simplify the sorting. Green did not use a screen on the Kauri Point samples but I found his method most unsatisfactory. If one uses a screen the amount of material to be sorted is quite clear, and there is no scrabbling in the dust for small fragments and then deciding arbitrarily that one has done enough. It is also quite clear to another worker how finely the sample has been analysed, whereas one may have no idea what an archaeologist at the other end of the country considers residue, if no minimum size is mentioned. A screen is cleaner, tidier, and more precise, and it is not a particularly expensive piece of equipment. Indeed, most people concerned with the retrieval of artifacts already possess one, usually of ¼ inch mesh, to aid in their spare-time endeavours.

Having stated that a screen is obligatory, one is left with the problem of size. Further work must be done, but I would say that in all but a few cases, ¼ inch adds greatly to precision without imposing too heavy a burden of work. There are a few cases when ½ is sufficient but this is not to be recommended unless it is established by a finer analysis first.

In some cases the use of ⅛ inch is desirable, and indeed probably is so in most cases, if archaeologists are to attempt to live up to the rigorous scientific standard set by Ascher (1959). But many New Zealand archaeologists will find that the work involved in using an ⅛ inch mesh prohibits its use.

The 1/16 inch mesh is quite out of the question in the kinds of analytical projects we are presently engaged on, except where, as in the Motutapu example, one is interested in recovering all fragments,no matter how minute, of a particular constituent, whether it be stone flakes, bone, obsidian or some other small objects. In such a case total sorting of a small section of an excavated area, using a 1/16 mesh to isolate the item desired, which can then be picked out from other debris, is well worth while, as is analysis of small samples, using the fine screen.

As others have said before, the final decision on screen is a matter for the individual worker to decide in each case. And as Ascher (1959) says, it should not be an arbitrary decision. In small sample analysis in the laboratory it is easy enough at the start of a project to experiment with screen size, discovering the effect of each smaller screen on the total result, and also on the time involved.

Washing: Most workers recommend washing and drying of screened samples. Neither Green at Kauri Point, nor Smart at Waikanae did this. A large number of samples which I processed were first analysed unwashed, and then washed and dried, and weighed to see whether a measurable amount of matrix was eliminated by washing. In no case was more than one gm. of dirt present in one hundred gms. or more of material ¼ inch or larger, provided lumps of dirt and obvious lumps on or in shells were first removed. If one is using ¼ inch sieve, washing will make very little difference to the accuracy of the analysis. It then becomes a matter of preference, whether or not to wash the sample. Samples with sandy matrix, provided they do not contain a large amount of charcoal or grease, are likely to be so clean when dry that washing becomes totally unnecessary. Earth matrix middens, however, will be dirty in varying degrees so that it will often be necessary to scrape or brush some of the shells, and may be unpleasant and dusty to process them, in which case washing is the obvious solution. All middens with earthy matrix will need a certain amount of cleaning. Whether one chooses to wash or brush depends on whether one has time and facilities for washing and drying shell, or objects to the dust and grime of brushing samples. Washing is the easiest solution, but it is not essential for accuracy, and equally accurate results can be achieved by brushing and scraping away the dirt.

I would say that with material ¼ inch or larger which does not contain large amounts of charcoal, it is a matter of personal preference

whether or not one washes the sample. I would seldom wash a sample from a sandy matrix, but would prefer to wash most earthy middens, given the equipment to facilitate this.

However, as already stated, once one proceeds to finer analysis and the use of ¼ inch screen, washing becomes more important and more of an aid in processing. Sandy middens of the cleaner variety will still not need to be washed in many cases. But most earth middens will contain relatively large quantities of small lumps of dirt which are difficult to sort by hand. These dissolve easily in water, and by washing the fine material before sorting it, sorting is made much easier. It is, of course, essential to weigh the material before washing, if any analysis by weight is contemplated, so that the amount of residue which has washed down the drain can be calculated and added to the amount which passed through the sieves.

An example where washing proved invaluable was in the analysis of certain samples from Oruarangi Pa (N 49/28). In these samples shell was cemented in a matrix of charcoal and mud, which defied sorting before it was washed. Washing removed all this material rapidly, leaving the shell clean and easy to sort.

Care must be taken in washing material containing fragmentable shell, that it is not unduly broken up in the process.

There is another occasion in which water is a great aid, and this is in sorting samples containing large amounts of charcoal, which can often be sorted quickly by floating off the charcoal. This will never be completely efficient, as there seems always to be a small amount which does not float, but this can be fairly quickly picked out afterwards. No doubt more efficient procedures can be devised. What I did was to make sure that the sample was completely dry, then tip it gently into a tray partly submerged in cold water and stir it gently to free the charcoal, which could then be scooped off the surface into a separate container. Both charcoal and other constituents must then be dried, remembering that the charcoal is likely to take longer to dry than the other material, and finally any remaining pieces of charcoal picked out. This process is generally far quicker than picking out all the charcoal by hand. It is of course only practical when the sample contains a fair amount of charcoal.

It is possible that a more sophisticated flotation process could be found to separate small fragments of bone or shell from the residue, in those middens in which a considerable quantity of bone or shell fragments passes through the finest mesh and cannot be sorted by hand. Indeed, some such process is essential if the troublesome bone and mussel middens are to be properly analysed. No solution has yet been found to this, but it is quite possible that it could be done if it were deemed necessary, in a more precise analysis than those under discussion here.

This covers the various steps which are necessary or desirable in processing samples. One now has the material which contains the information separated from the remainder which is likely to be of further

use only in chemical analysis. The next step is to sort the material into constituents, stone, bone, shell, charcoal, pumice, and depending on the kind of data sought, these constituents may be further subdivided into species of shell, kinds of stone, fish and other bone.

Manipulating the information.

Several methods of collecting raw data have been discussed, some of which have yet to be tested. About others there is already a certain amount of information. The data which are furnished by these various methods are of two main kinds, quantifiable and non-quantifiable. Of the latter, little need be said. The number of species present, and their relative frequencies in terms such as very common, rare, present, absent, and the observed size range, together with frequency and nature of stone, and similar information, is all that can be derived from such data.

If the information is potentially quantifiable, however, there will be a choice between a number of ways of expressing it, governed in part at least by the archaeological questions which it is to answer. Firstly, the relative proportions of different constituents may be expressed as percentages of the total. This may be done in several different ways. The total may include residue, or all constituents except residue, as in cases where material is sieved in the field and only material of a certain size included in the sample. The most widely used method of expressing constituents as part of the total is by percentage by weight. The less popular alternative to this is percentage of total volume. This has not been tried in New Zealand, as it is somewhat more difficult, and does not seem to hold any particular advantage. The difficulties of obtaining a sample of the exact volume required have been mentioned. Unless samples analysed in terms of volume are specifically called for, as in estimating total volume, percentages by weight seem to be adequate and simpler, but unless analysis by volume is tested its exact usefulness cannot be known.

A third method of expressing relative proportions is by percentage of total number. This also has not been tried, and again would seem unsatisfactory unless called for by a specific project, because numbers of shells and numbers of other items are likely to be not meaningfully comparable.

A combination of procedures leading to yet another way of expressing total content is the concentration index, which is a more sophisticated way of handling variation in representation of individual constituents. The difficulties attendant on percentage by number can operate here, and care would be necessary to ensure that each category included only comparable items. It might be necessary to subdivide a component such as bone, to avoid reaching the same index for bone, from three minute fish bones in one unit, and three large moa bones in another. Until the concentration index is tried out in New Zealand, its usefulness cannot be fully assessed.

Expressing the relative proportions of the various constituents is only a first step in manipulating the data. Each separate constituent, or a combination of constituents, can be treated as a whole unit for

further analysis. In New Zealand so far only shell has been quantified, apart from tentative work with stone, such as that of Trotter at Wenthorn (Trotter 1961:31) or Shawcross (1964). The possibilities have by no means been fully explored as yet. Sometimes components such as charcoal and pumice do not lend themselves to further analysis, although there may be sites in which the quantity and size range is such that further division and analysis is possible or necessary. Recent work in the United States has shown that charcoal of similar appearance in an archaeological site may be of very different origin, and can be separated by chemical analysis (Cook 1964).

Small total samples from shell middens are likely to yield only shell in sufficient quantity for further analysis. Sites from which all screened material is kept such as Whitipirorua, or where all material is kept, as at Whakamoenga and Skipper's Ridge, are likely to provide stone and bone also in manipulatable quantities. The kinds of analysis to be applied to stone depend on the kind of stone present and the petrological knowledge of the analyst. Analyses must be devised for each problem. Even the least skilled can usually identify obsidian, for example, and distinguish struck flakes and worked stone from cooking stone and other unworked stone. Very often they will only be able to express the relative proportions of these two. By skilled petrological analysis very much more data can be obtained, subdividing each category, and eventually working out trade routes and sources of supply as Mason has suggested (Mason 1963). Most people will be able to proceed further in analysis of flake material, as has been done for example for flakes from Wheritoa (Crosby pers. com.). Whangamata and Kauri Point swamp (Shawcross 1964), some Opito sites (Green 1963a and unpublished data in site record files), and Tairua (Smart and Green 1962). With the intelligent use of the 1/16 inch sieve on certain sites, our knowledge of stone working can be greatly increased, as we begin to learn the relative proportions of different sized flakes and of used and unused flakes, and cores.

While bone can provide the foundations for a large number of inferences, it is difficult for unskilled amateurs to furnish quantitative data beyond crude percentages by weight of fish and other bone. Few people have the knowledge to make accurate identifications or even to recognise the individual bones, as bird tibia, bird femur and so on, let alone to count individuals, and to assess immaturity or size. This is the kind of data which leads to some of the most interesting inferences about past ecology and activity, but unfortunately, even in New Zealand where bone is limited compared with some countries, this must remain largely a specialist's field.

It is no doubt because shell is the easiest constituent for the layman to identify and analyse, and also the most common, that the few studies so far have concentrated on it. Most amateurs, armed with a manual of New Zealand shells (e.g. Powell 1962) can identify most shells, and can usually have doubtful ones identified by an expert. Smart's recommendation that a collection of type specimens properly identified be built up for reference is a very sensible one. Assuming, then, that most shell can be identified by the analyst, who can obtain expert

assistance where necessary, and that the shell has been sorted as far as possible into species, there are still a number of ways in which the data can be expressed. Smart and Green counted shells, Green at Kauri Point both weighed and counted. All the samples which I analysed were counted and weighed, where possible. There are some cases when counting is not possible, particularly where rocky-shore shellfish are concerned. If one is counting, the most sensible procedure is to count individuals, and obtain a figure for the minimum number of individuals present. Counting fragments is of little value. With bivalves one can only count entire individuals or those in which a complete hinge portion is preserved, as Green did at Kauri Point.

Counting univalves requires more individual discretion, depending on the state of the shells. If there are more complete protoconches than spiral apertures one counts the former. If the situation is reversed one counts the latter. Complete shells are, of course, the most satisfactory but are not always available. Percentage by number is not always feasible, but percentage by weight is, given an adequate sample. I found in analysing a number of samples that percentage by weight was usually slightly less variable than percentage by number. Green found little difference at Kauri Point. I feel that percentage by weight is likely to be a far more accurate measure of the relative proportion in the diet than percentage by number. Ten shells of Nerita melanotragus will far outweigh one large Cookia sulcata by number, but their relative percentages by weight will give a more accurate picture of the amount of food derived from each. As one of our aims is that of learning about diet, this should be borne in mind, together with the fact that estimates of amount of edible meat to shell are usually phrased in ratios according to weight. For this kind of information, weight is to be preferred to number, and it has yet to be demonstrated that number provides a more satisfactory measure of change through time. This does not mean that shells should not be counted as well as weighed. Counting of whole shells will give at least an average weight which may be of interest, and counting of fragments of individuals, will permit one to compare the weight of whole shells with the weight of fragmented individuals and uncounted fragments. Other sorts of information which may be obtained include the proportions of whole and broken shell, which may say something about the nature of the site or may reflect subsequent disturbance. In time, it is likely that such data will be more informative than in our present state of knowledge.

The weight of each species as a percentage of total shell weight may be recommended as the most useful minimum way of handling the data, but there is no doubt that counting and experimenting with ratios and percentages of many different kinds will be rewarding. I would say that where time and condition of shell permit, counting should be done as well as weighing, even if only to obtain average weights of different species. Undoubtedly, it takes longer than weighing but not exorbitantly so. The only occasion where counting would seem to measure up to weighing as an expression of relative importance of different species, would be in that rare deposit such as Green encountered in Mangareva, where all the shells were complete and where they were of approximately equal size. That such middens occur but rarely is unfortunate, for counting is a much easier technique to use in the field. In most situations, however, it is not as satisfactory a solution as weighing.

Ambrose has suggested that weighing shells is not sufficient for an understanding of the processes involved in change of midden composition, but that we should aim to reconstruct shell populations by measurement (Ambrose 1963:157). I have demonstrated that there may be a considerable range in size and percentage of Chione stutchburyi, and Amphidesma australe in one small midden. Moreover, the range of shellfish at any one time in the beds of a large harbour such as the Tauranga harbour must be very great. The apparent changes in shellfish might reflect nothing more significant than a varying state of tide and weather, and a tendency to gather shells from a number of beds within a small area. Until results of Ambrose's work appear, it is not possible to evaluate the usefulness of this approach, which I did not attempt to test because of lack of time and equipment. It is an approach which is beyond the means of any but full-time researchers in well equipped laboratories. Even if it is demonstrated that this is ultimately the only approach that will permit an accurate assessment of the variation between A. australe and Chione stutchburyi, there will still be projects for which the simpler approach of percentages by weight and number will be valid.

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