

## Section 1: The archaeology of fishing

This Section describes the various procedures followed by archaeologists studying pre-European fishing in New Zealand. It is important to understand something of these processes, before going on to consider the wealth of information they can yield. Fish remains are found in various kinds of archaeological sites, but excavation is only the tip of the iceberg. The material is recovered systematically from a site and brought back to the laboratory where it is sorted and as much as possible identified. Once this has been done, it becomes possible to work out the relative abundance of different kinds of fish in a site or occupation layer, and to reconstruct the sizes of the major fish species caught. This in turn enables us to look for variations from one region to another and, even more importantly, to search for changes through time in individual regions. The contribution of fish to the diet is also an important field of enquiry.

### ARCHAEOLOGICAL SITES AND FISH BONES

The typical archaeological site containing fish bones in sufficient abundance for later study is most often found in New Zealand within a short distance of the coast<sup>1</sup>. Fish remains were transported to inland locations by pre-European Māori, but one seldom finds areas of concentrated midden<sup>2</sup> far from the coast. Native freshwater fish other than eels (which are discussed in Section 7) are small and very few remains have been reported from archaeological sites. This is probably mainly due to their being overlooked during recovery and sorting and deficiencies in comparative material. For example, no archaeological laboratory has a specimen of *Prototroctes oxyrhynchus* (grayling), which could reach a size up to 2 kg. In addition, in inland locations where freshwater species might have been more commonly caught, the soils are usually more acidic, and tiny bones may not survive so readily. In coastal sites, exposed to sea spray, the pH is usually close to neutral, which is more favourable for bone preservation. If fish bones are dumped in middens rich with shellfish remains this is also a very favourable soil chemical environment, because the calcium carbonate neutrali-

ses acid soils. The remains of crayfish very rapidly decay away, but their mandibles may survive in some environments. It has been noticed that archaeological soils rich in burnt shell or ash can contain crayfish mandibles.

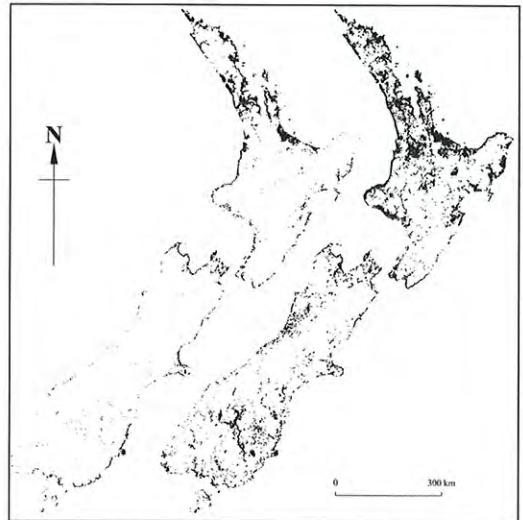


FIGURE 1

Of more than 56,000 recorded archaeological sites in New Zealand, those categorised as including midden deposits comprise 32% of the total. These are plotted on the left map. Other site types are plotted on the right hand side. The coastline is not drawn on either of these maps (Information from the New Zealand Archaeological Association Site Recording Scheme).

<sup>1</sup> Most of these sites are within 50 metres of the shore, and they are seldom more than 500 metres.

<sup>2</sup> The word midden derives from the Danish word *kjøkkenmødding*, meaning 'kitchen midden' or 'kitchen rubbish dump'.

More than 56,000 archaeological sites have been recorded in the New Zealand Archaeological Association Site Recording Scheme (Walter 2004: 82). In the computer database relating to this scheme, each site is given a single two-character code which most cogently describes what kind of site it is. The codes cover a very wide range of site types, such as fortified *pā*, stone quarry, terrace site, *kūmara* (sweet potato) storage pit, etc. Of the total sites, 32% are categorised as containing sufficient economic debris to warrant being classified as some kind of midden (Figure 1). Of these, 22% are classed as middens, and the remainder as other kinds of site with associated midden deposits.

The New Zealand coastline is not plotted in this illustration, but the high density of archaeological sites in coastal areas makes the coastline visible even so. An unknown proportion of these midden sites, but certainly a great number of them, contain fish remains. As we will see in Section 4, fish remains have been studied at an acceptable level of scholarship at only 126 of nearly 18,000 sites with midden recorded so far (Appendix 1<sup>3</sup>). It should also be noted that a large proportion of the sites not specifically classified as middens also contain economic debris including fish remains. The wealth of archaeological sites evident in this illustration shows that there are wonderful opportunities in New Zealand for studying the marine food quest. Two typical midden excavations are shown in Figures 2 and 3.

These illustrate excavations carried out by Atholl Anderson in 1971 (Anderson 1973), which provided an important benchmark in New Zealand archaeology. The excavation strategy is therefore worth describing in some detail. Anderson carried out four excavations, two of 8 square metres and two of 2 square metres. In each case the aim was to excavate at least 10% of the volume of the midden, as far as it could be judged from surface features. The sites were quite shallow, and a total volume of 5.03 m<sup>3</sup> was excavated

<sup>3</sup> The 126 sites and abundance figures cited in Appendix 1 derive from the database maintained at the Archaeozoology Laboratory, Museum of New Zealand Te Papa Tongarewa. They relate to fish remains from 97 sites processed strictly according to methods employed in the Laboratory, and a further 29 sites which were processed outside the Laboratory, but which I consider to be trustworthy. In this volume I refer to 'The Fishbone Database' as a shorthand term for the data presented in Appendix 1.



FIGURE 2

The 'Black Midden' at Black Rocks, Palliser Bay, after excavation (Photo by Atholl Anderson).



FIGURE 3

The 'Crescent Midden' at Black Rocks, Palliser Bay, during excavation (Photo by Atholl Anderson).

(Anderson 1973: 59). The retention strategy employed is illustrated in Figure 4, and resulted in a reduction of the quantity down to about 1.5 m<sup>3</sup>. That is, of roughly 6 tonne excavated, a little less than 2 tonne was removed to a laboratory for processing (Figure 5).

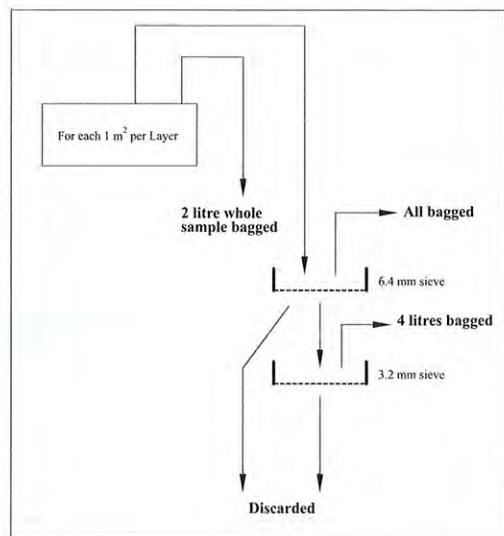


FIGURE 4

The retention strategy used by Atholl Anderson at Black Rocks, Palliser Bay (after Anderson 1973: fig. 3).



FIGURE 5

Atholl Anderson doing the preliminary sorting of a sample of 2 tonne of midden removed from the Black Rocks excavations in Palliser Bay. This sample is one-third of the midden excavated in the field (Photo by Foss Leach).

These were small excavations by most standards, and the fieldwork operations were designed to maximise recovery, so that careful attention could be given to the midden in a laboratory environment where research conditions are more favourable. Anderson's study combined careful excavation, emphasising fullest field recovery, with a detailed marine survey of the local area at Black Rocks<sup>4</sup>. This made it possible to define the nature of prehis-

toric food collection strategies in the area. Fish remains were quantified, shellfish specimens were measured and size-frequency diagrams prepared and examined for changes through time. Admittedly, this research was labour intensive, but the rewards were manifold, producing a great deal of knowledge about how pre-European Māori gathered food from the sea. With a few notable exceptions, mainly in the South Island, Anderson's trailblazing example of what can be achieved with midden research in New Zealand has unfortunately not been followed. Midden sites are being destroyed in large numbers during various forms of public and private works, and only perfunctory attention is being given to them by archaeologists.

It is noticeable in the retention scheme described above that no attempt was made in the field to discard some remains as of no later analytical value. Some excavators in the past sorted material in the field into bones which were vaguely thought to be useful or not useful. This is a specialised task, and should not be attempted in the field. It is far better to retain *everything* above a certain sieve size, and discard the rest. Anderson's excavations used rather large sieve sizes, and some may prefer to use finer mesh screens. This would, of course, have the effect of increasing the amount of material returned to the laboratory. Another criticism which might be levelled against the Anderson scheme is that the bulk samples are not very large. These types of samples are especially important for systematic collection<sup>5</sup> of otoliths (small dense bones from the ear), land snails, carbonised seeds, etc. An alternative to bulk sampling is to put all the soil passing through the sieve stack through special flotation equipment which will remove landsnails and carbonised remains. My preference is to keep much larger bulk samples (that is the soil passing through the smallest sieve), at least 100 litres, from each significant stratigraphic horizon in a site.

#### IDENTIFYING FISH BONES IN THE LABORATORY

When a collection of fish remains reaches the laboratory for study, the first task is usually to carry out re-bagging of the material before actually beginning analysis. Most excavation soils

<sup>4</sup> Archaeological sites in this volume are referred to by their local name. Further details about these are provided in Appendix 1.

<sup>5</sup> Unfortunately, such items have not always been collected and retained in a systematic manner, such as randomly, from sediments. This greatly limits their value for palaeoenvironmental or palaeoecological research.

contain quite a lot of moisture, and it is preferable in the field to bag midden in paper bags rather than plastic ones, so that slow drying is facilitated. During the re-bagging phase, provenance details are checked and written on the new plastic bags in a much more uniform manner than is normally done in the field. Special pens are used which etch the plastic so that provenance details can never be lost. When re-bagging is completed for the whole site, each bag is then tipped out into a sorting tray with white background and gone through systematically with tweezers, sorting into major midden categories, such as bone, shell, artefacts, stone, charcoal etc. As this is completed, the material is then again re-bagged, but this time into the separate categories. This process of sorting and re-bagging goes through a number of separate stages, with more specialised tasks carried out at each successive stage. In my laboratory the bags of fish bones are first sorted into separate anatomical elements, and in particular into parts of the cranial anatomy which have been found over the years to be the best diagnostic elements of as wide a range of species as possible (Leach 1997). These bones are:

Dentary  
 Premaxilla  
 Articular  
 Maxilla  
 Quadrate  
 Special bones

The last-mentioned are specialised bones which are characteristic of particular species, such as the dorsal erectile spine of trigger fishes (Balistidae). These bones are of great use in identifying particular species, and often there are only one or two of them per individual, which assists in the calculation of relative abundance of different fish types. The main parts of the cranial anatomy of bony fishes are illustrated in Figure 6.

The question of which bones to use for identification continues to be a matter of heated debate. The potential for obtaining more information must be weighed against the time spent in analysis, the nature of specific archaeological deposits, and the purpose of the analysis (for example a bio-diversity study, or economic research). In Europe, it is sometimes necessary to devote considerable effort to the identification of vertebrae, as other bones are rare. In New Zealand and the Pacific it has sometimes been found that a particular 'special

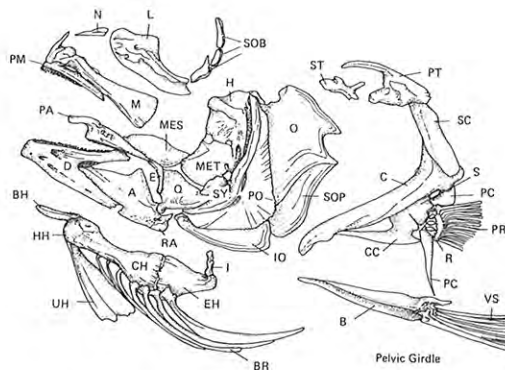


FIGURE 6

The main facial and appendicular bones of a typical fish (from Cannon 1987). A=Articular, B=Basipterigium, BH=Basihyal, BR=Branchiostegal, C=Cleithrum, CC=Coracoid, CH=Ceratohyal, D=Dentary, E=Ectopterygoid, EH=Epihyal, H=Hyomandibular, HH=Hypohyal, I=Interhyal, IO=Interopercle, L=Lachrymal, M=Maxilla, MES=Mesopterygoid, MET=Metapterygoid, N=Nasal, O=Opercle, PA=Palatine, PC=Postcleithrum, PM=Preamaxilla, PO=Preopercle, PR=Pectoral Ray, PT=Posttemporal, Q=Quadrate, R=Radial, RA=Retroarticular, S=Scapula, SC=Supracleithrum, SOB=Suborbital, SOP=Subopercle, ST=Supratemporal, SY=Symplectic, UH=Urohyal, VS=Ventral Spine.

bone', such as an otolith, provides the main evidence for a type of fish (Weisler 1993). In general, however, the bones listed here enable consistent and sufficiently detailed analysis.

When the fish bones have been sorted and re-bagged according to these standard items of cranial anatomy, each category is examined in turn, and the fish types present identified. It has been found that if one is only dealing with one part of the anatomy at any one time, identification of species is much easier. In any one bag of dentaries from a particular provenance, for example, one will usually have several specimens of varying size belonging to the same species. This system of identification has evolved in New Zealand over nearly 30 years, and is now at a highly organised stage whereby many thousands of bones can be identified efficiently and accurately without undue difficulty (Figure 7).

Of course in order to identify species, one must have a reference collection of modern specimens of fish. Since our identification system is based on working with one part of the anatomy at a time, the collection is organised in this manner too, with all bones of one type mounted on one board (Figure 8). Although there are hundreds of species of fish in New Zealand waters, only about 50 of these



FIGURE 7

Foss Leach sorting archaeological fish bones for identification in the Archaeozoology Laboratory at the Museum of New Zealand. In the background are bays of shelves with fish bones mounted on display boards (Figure 8) (Photo E.001124, courtesy of Museum of New Zealand Te Papa Tongarewa).

occur in any abundance in archaeological sites, and 6 of these make up more than 80% of the fish so far identified (Figure 32, Table 4). Consequently, it is not necessary to have enormous comparative collections for archaeological research. Even with excellent comparative material it is still difficult to identify some fishes to species level, and sometimes they cannot be identified to genus either. For the purposes of understanding ancient food gathering behaviour the inability to identify bones to a lower level than genus is not a serious handicap. For example, there are two species of freshwater eels in New Zealand, the short-finned and long-finned eel. The differentiation of these mainly relies on external features which are not preserved archaeologically. However, they occupy very similar habitats, and no significant information is lost when we identify only to the level of *Anguilla* sp.

One particularly troublesome group of fishes in New Zealand are those belonging to the Labridae family (Leach & Anderson 1979a; Leach *et al.* 1999a). There are 16 species of this family in New Zealand, belonging to several genera. It would probably be quite useful to be able to identify these at least to genus level, but unfortunately (at the moment) we cannot. The different species do have different habitats, and valuable information about human behaviour is lost when only identifying to family level. To complicate matters, some parts of the anatomy are identifiable to a particular species, and others are not. For example, the dentary of the scarlet wrasse, *Pseudolabrus miles*, is perfectly distinguishable from the dentary of the

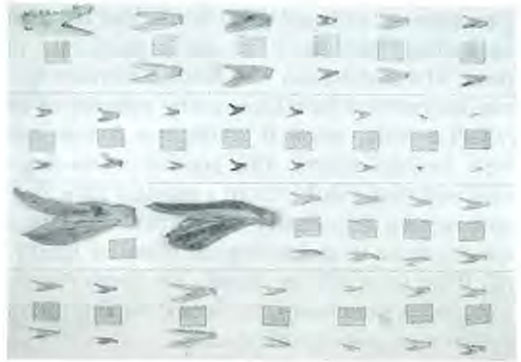


FIGURE 8

The reference collections of fish bones in the Archaeozoology Laboratory at the Museum of New Zealand and in the Anthropology Department at the University of Otago are organised by anatomy. On each display board is mounted only one part of the anatomy of the common inshore fishes of New Zealand and the tropical Pacific. This greatly simplifies and speeds up identification of bones to species. More than 300 species are mounted in this manner (Photo by Raymond Coory).

spotty, *Notolabrus celidotus*. However, the maxillas of these two species are very difficult to distinguish. This may sound like a trivial problem, but it is not. In carrying out identification work on fish remains, the first objective is to work out the relative abundance of the different fish types (discussed in the next section). For one family of fish, say labrids, if we identified the maxilla bones to the level of family, the quadrates to genus, and the dentaries to species, it would be very difficult to put all this information together and calculate how many fish are represented in the collection. The way we get around this type of problem is by identifying all parts of the anatomy to family level in the case of labrids. The resulting numeric abundance is therefore a minimum, rather than an inflated figure.

In discussing archaeological fish remains common names can be just as useful as species names, and are often used in this paper<sup>6</sup>. I have adopted a flexible approach. As already noted, bones often cannot be identified to species level. In New Zealand they can usually be identified to genus, but in the Pacific many can only be identified to family. When searching for statistical trends in time and space it is often necessary to use fish families as the unit of analysis before any trends can be observed. Moreover, to give a spe-

<sup>6</sup> Common names and their scientific equivalents are given in Appendix 2. \*\*check whether this is still the right number.

cies name to archaeological bones can be quite misleading. Jack mackerel are a good case in point. The distribution of a South American species is known to be influenced by episodes of El Niño/La Niña, when it sometimes comes into New Zealand waters. This species is osteologically indistinguishable from a resident New Zealand species. It is clearly not warranted to give a species name to archaeological bones of mackerel. If we *were* able to identify the South American species from bones, this would provide useful evidence of past climatic events.

### FIGURING FISH CATCHES - MINIMUM NUMBERS

As pointed out above, the first objective in the study of archaeological fish bones is to work out the relative abundance of the different fish types in a collection. This tabulated information provides us with the first glimpse of what all these bones meant to the prehistoric people who dumped them. It tells us which particular fishes were most important to these people, at least in terms of food value. That is, it defines the relative economic role in the society. A species of fish low down in the table of relative abundance may nevertheless have had great social significance in a society, even though its economic importance was low. This is certainly the case with tuna and bonito in Pacific Island societies. They were only rarely caught, but bestowed great social prestige when captured by an individual. In ancient New Zealand the same role may have fallen to the groper because, as we will see in Section 4, these fish were very seldom caught by pre-European Māori.

How then do we work out the relative abundance of each fish type? It is difficult to credit the amount of hot air and confusion which this issue has generated in archaeological literature. Quite a few different measures have been developed, and each has its devotees whose adherence borders on religious fervour. Advocates of weighing bones cannot see the point of counting them and vice versa. Some think that the Minimum Number of Individuals (MNI) is the best measure, and others that the Number of Identified Specimens (NISP) is better. Some like to multiply the MNI by the number of mis-matched paired bones to yield yet another yardstick. In short, there is no end to the number of choices here.

Anatomy	Number of Bones
Left Dentary	499
Right Dentary	503
Left Articular	72
Right Articular	55
Left Premaxilla	525
Right Premaxilla	<b>565 MNI</b>
Left Maxilla	461
Right Maxilla	500
<b>Number of Bones</b>	<b>3.180</b>

TABLE 1

Typical example of MNI calculation.  
Blue Cod from CHA Site, Chatham Islands.

This is not the place to engage in extended discussions on the merits and demerits of the different techniques which have been proposed. My opinion is that if we focus on the phrase *relative abundance* and ignore *absolute abundance* a lot of the problems dissolve. I also think that so long as the bone collection is of reasonable size (number of bones > 500) the difference between the relative abundances yielded by several of the techniques becomes insignificant. A notable exception to this is the NISP. In my view a tabulation of relative abundance based on NISP is frequently absurd, assuming of course that the whole point of establishing the relative abundance curve is that it is meant to reflect the proportions of fishes caught by prehistoric people. The basic problem with NISP as a measure of relative abundance is that a fish has different numbers of bones for each part of the anatomy – there may be 60 vertebrae, whereas there are only two dentaries. Similarly, some fish species have up to 500 highly diagnostic spines, and another species has only one or none.

The NISP measure has a number of extremely useful functions in archaeological research, such as enabling us to identify patterns of butchering and preferential apportioning of different body parts to different social groups, but in my view it has little or no value as a measure of relative abundance of species.

The technique which I prefer is the MNI and a typical example of the calculation is given in Table 1. Actually, it is so simple it should not really be called a calculation. These are results from a site known as CHA in the Chatham Islands. There are 3180 bones identified as belonging to blue cod, a common inshore fish in these islands. This number

is the NISP. The greatest number of bones identified for any one part of the anatomy is 565 bones of the right premaxilla. This is the MNI. To define this term in technical language:

MNI = The smallest number of individuals which is necessary to account for all of the skeletal elements of a taxon in a faunal assemblage.

It should be obvious from Table 1 that the number of fish could not possibly be less than 565, but it could be more. For example, if one of the left premaxillas was a lot bigger than the largest of the right premaxillas, then the number of fish might have been 566. This is a case of what is termed increasing the MNI by taking into account size mis-matching. The type of MNI which I employ does not involve size mis-matching.

#### FISH SIZE RECONSTRUCTIONS

A second important objective in carrying out analysis of archaeological fish bones is estimating how big the original fish were. If most of the specimens of a species are of very similar size, this can be an important clue to the use of selective fishing activity or selective technology. Modern fishermen employ selective procedures, based on minimum legal size limits. Prehistoric people may have had notions on how best to conserve limited stocks of fish, and used similar types of prohibitions. In addition, some fishing methods are selective by size. A simple example of this is the size of baited hooks. A large hook will more frequently catch large fish, and hardly ever catch small fish. Conversely, a small hook can catch both small and big fish. Nets which are set in place and left for a time catch fish by entangling their gills as they try to swim through the net. So gill nets are selective by size. Seine nets, on the other hand, which are dragged through the water by hand, will capture everything which is in front of the net down to a certain minimum sized fish, which can get through the mesh.

Clearly the size of fishes caught by prehistoric people can tell us a lot about selective behaviour. However, this is not the only reason we are interested in fish size. Another, possibly more important objective, is that the study of fish sizes through time enables us to learn something about the impact which humans have on their local fis-

hery over long sustained periods of harvesting. It is common knowledge that there has been massive over-fishing in the European era of New Zealand history, and that this has led to a lowering of the average size of fish. It is perfectly reasonable to assume therefore that if pre-European people had any impact on the fishery in earlier times, this would also have lowered the average size. It is easy to see how this line of thinking leads to a convincing scenario that when Polynesians first arrived in Aotearoa the fish were huge, and in the ensuing centuries of fishing by Māori, fish got smaller – perhaps not a lot smaller, but smaller all the same. Then, when Europeans arrived with more advanced technology such as steel fish hooks and motivated by unbridled greed, the fishery was stripped away so that now only tiny fish remain.

Scenarios like this, based on assumptions, no matter how plausible, are still just that: scenarios. We will see later in this paper that if pre-European Māori had an effect on the inshore fishery by their fishing activities, it may have been the exact opposite – an increase in the average size of fishes.

Needless to say, it is important for us to develop and use reliable methods which enable us to estimate fish sizes from the bones which we find in archaeological sites. This is easy to say and hard to do; not hard in the sense of being intellectually difficult, but in the sense of being labour intensive and extremely boring. It is achieved in the following manner. First we must collect 100 to 200 modern specimens of the species of interest, which, most importantly, cover the whole range of sizes we can expect to encounter archaeologically. This is not so easy, given the effect of the last 150 years of European fishing around New Zealand. Finding a good sample of large specimens of the main species of interest has been very difficult. We always keep an eye open in the summer fishing season for reports of large fish being caught by recreational fishermen. On one occasion we read of a possible claim of a world record snapper being caught in the Bay of Plenty. After contacting the person we found that the specimen had been given to a taxidermist for stuffing. After contacting the taxidermist we were able to borrow the head bones (which were needed in the stuffed specimen) for a period, long enough to make plaster casts of each, so we have a permanent copy of the specimen.

When we have procured a large sample of modern fish, they are weighed (ungutted because the entrails of many species were considered good food in most traditional Polynesian societies), and

the length measured. Then the head is cut off and boiled down to extract the five paired cranial bones mentioned earlier, and any special bones which are important to keep. These are then dried, each one numbered so as not to lose its original identity, and boxed. When all specimens are thus processed, the laborious process of measuring them begins.

A typical example of the anatomical landmarks used on bone specimens is illustrated in Figure 9. These relate to the blue cod fish, *Parapercis colias*, which is often found in New Zealand archaeological sites. Wherever possible, the largest dimension (such as the maximum length) is measured on an archaeological bone, but in many cases archaeological bones are broken, so it is desirable to have alternative measurements which are appropriate to fragments. This is why several measurements are defined for any one bone, as indicated in Figure 9.

The methods by which the live fork lengths and weights of a prehistoric fish catch are estimated from archaeological bones are described in a series of papers in which one species at a time is considered (Leach & Boocock 1995; Leach *et al.* 1996a, 1996b, 1997b, 1997d). When we plot a

bone measurement against the original fish length (Figure 10) it is evident that there is a clear relationship between the two measurements. In our work we use the least squares regression method to derive a power curve equation, and use this to estimate the original fish size from bone measurements.

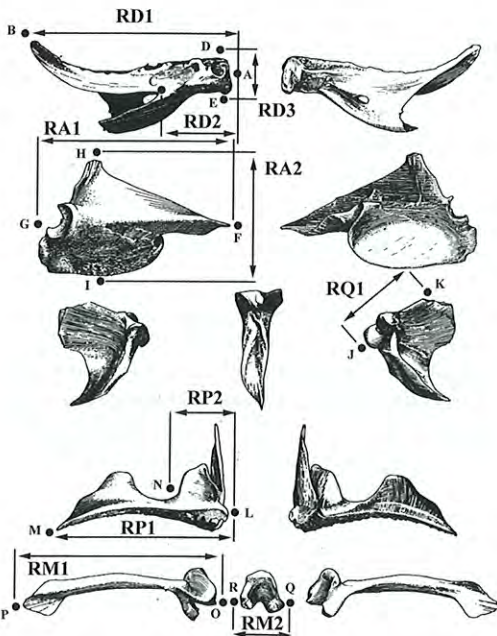


FIGURE 9

Measurements made on cranial bones of blue cod (from Leach *et al.* 1997b: 483).

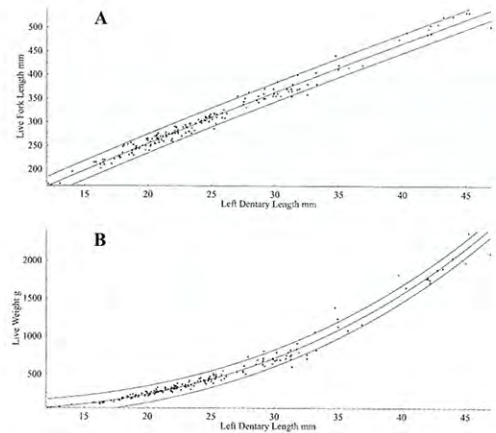


FIGURE 10

Bone measurement plotted against fork length (upper) and live weight (lower) for blue cod. The lines show the 95% confidence limits for power curve fits (from Leach *et al.* 1997b: 487).

It is instructive to follow a worked example of how we get from a bone measurement to an estimate of the original size of the live fish. In this example, we will take the measurements which relate to a modern specimen of blue cod of medium size from our comparative collection. This fish had a live fork length of 350 mm, and an ungutted weight of 610 g. The left dentary length was 27.63 mm.

The best fit equation for estimating fork length from the left dentary length bone measurement is a power curve fit as follows:

$$\text{Fork Length mm} = 18.63431 * \text{LD1}^{0.8729386} \pm 10 \text{ mm}$$

The best fit equation for estimating live weight from the left dentary length bone measurement is the power curve fit as follows:

$$\text{Weight g} = 0.0669148 * \text{LD1}^{2.727114} \pm 56 \text{ g}$$

By substituting the bone measurement of 27.63 into these two equations, we derive estimates for



the fork length of 338 mm, and for weight of 571 g. The actual error in estimating the fork length is therefore 12 mm (350–338), and in estimating the weight 39 g (610–571).

With the aid of a simple computer program, large numbers of archaeological bone measurements can thus be converted into estimates of fork length and weight, and these in turn can be used to calculate statistical data such as mean and standard deviation. These data also provide the basis for reconstructing the size-frequency histogram which represents the prehistoric fish catch.

For example, at the archaeological site of Waihora in the Chatham Islands we calculate that the mean weight of blue cod caught by the prehistoric people there was  $569 \pm 3.8$  g (Leach *et al.* 1997b). From this, we can calculate the total weight of blue cod, using the MNI value for the species. Smith (1985: 487–488, 2004: 8, 10) recommends using a figure of 70% for the amount of usable meat weight per total body weight for the common species of New Zealand fishes.

Mean Body Weight	×	MNI	=	Total Body Weight	×	Usable Meat Weight
569 g	×	2,547	=	1,449 ± 10 kg	×	1,015 kg

At Waihora, therefore, we can estimate that blue cod amounted to about 1.0 metric tonne of fish meat. This information is an important first step towards understanding the contribution of various components of diet in the overall economic system of a prehistoric people.

We have found that archaeological bones are often from much larger fish than are easily caught today in New Zealand waters, and this poses special problems in obtaining a good comparative collection which covers the full size range available to prehistoric people. Snapper, *Pagrus auratus*, is a good case in point. Our comparative collection of measured snapper numbers 110 fish. Of these only 7 have a fork length greater than 400 mm. The average fork length of snapper from prehistoric catches is frequently above this value (for example: Twilight Beach 532, Kokohuia

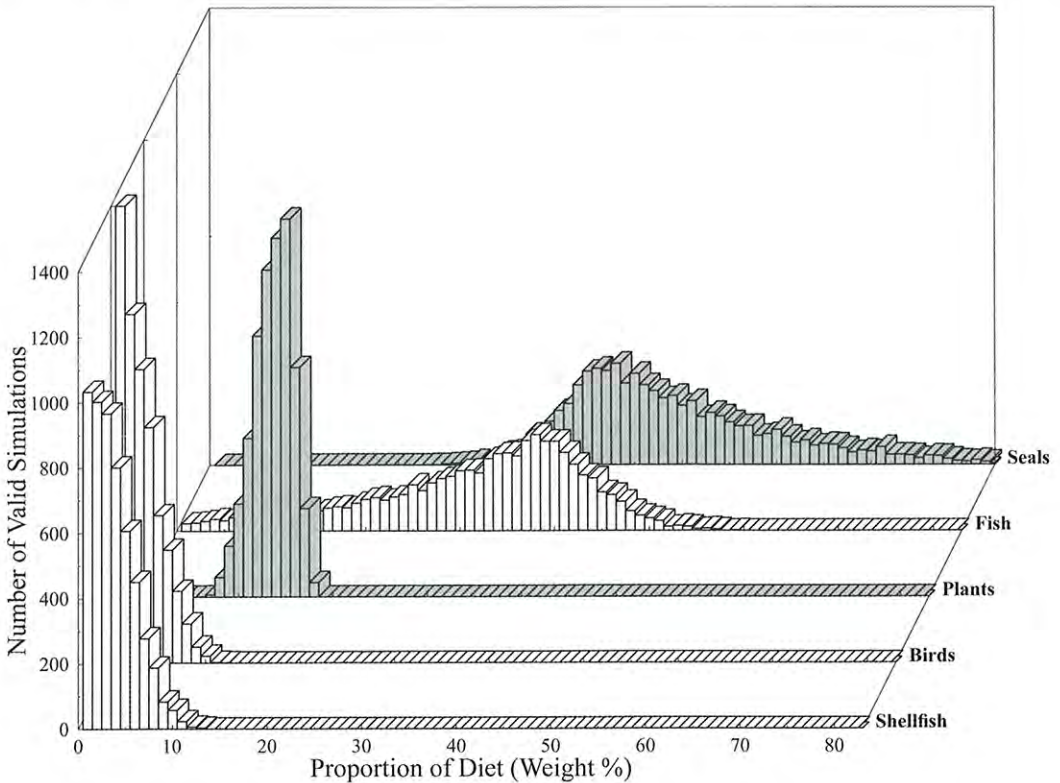


FIGURE 11

Contribution of the main food components to the diet of Moriori from isotope research (from Leach *et al.* 2003: 70).

467, Houhora 491, Galatea Bay 464, Cross Creek 400). Fortunately, we have one very large snapper in the collection (940 mm fork length), and until recently we have not had to extrapolate beyond this size with any archaeological bones; however, at the site of Houhora a snapper was estimated to have had a fork length of 1010 mm. The measurements on this bone were checked several times and it is certainly larger than the largest specimen in our comparative collection.

#### FISH AND ANCIENT DIET

Human dietary requirements involve three basic ingredients in various proportions depending upon the type of economy involved. These are protein, carbohydrates and fat. Unfortunately, one of these poses special problems for archaeologists when trying to quantify the relative contributions of each for a particular group of prehistoric people; that is, the dietary contribution of carbohydrates, which largely derives from plant foods. Archaeological evidence of food mainly consists of bones, which as can be seen from the foregoing are relatively easy to quantify. Quantifying the contribution of plant foods, and therefore carbohydrates, is much more difficult. So while we are able from bone evidence to make quantitative statements about the relative importance of various kinds of fish, birds, and mam-

mals, the contribution of any one or all of these to diet as a whole requires additional knowledge of the role of plants.

This subject is explored in greater detail in Section 8, but it is useful to comment briefly on the matter here. It has been found that three isotopes,  $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$  fractionate in nature so that animals and plants from the sea contain different values than those deriving from the land. By analysing these isotopes in a tiny fragment of human bone belonging to a prehistoric person it is therefore possible to determine how much of their total diet came from the sea and how much from the land (Davidson & Leach 2001; Leach *et al.* 2003). The regular archaeological study of midden remains permits us to work out the proportion of food from protein sources which came from the land and the sea. From this information, it is possible to estimate the contribution of the various components of the diet, including plant foods from the land and fish, shellfish, and sea mammals from the sea.

An example of the process in action is illustrated in Figure 11, where the contribution of fish to the overall diet is shown to be about 32% by weight of all food consumed by the people inhabiting the southwestern corner of the Chatham Islands.

These results also permit us to estimate that 73% of the protein in the diet of these people came from fish, and that fish contributed 17% of the caloric energy in the diet.