

Section 5: Fishing technology and material culture

INTRODUCTION

If a modern European was cast ashore on a small uninhabited island somewhere in a remote corner of the Pacific, the few items of material culture which he or she might have on their person would be soon worn out and discarded, placing the person in peril for existence unless they learned very quickly indeed some basic skills relating to the technology of survival¹. The Polynesian immigrants who found their way to New Zealand during the pre-European era were in precisely the same position as this hypothetical European, but with one important difference – these people brought with them mental templates more closely aligned to the task of surviving with nothing except what was around them in the land and sea. That is, they possessed a knowledge or technology suited to living close to the land. Most Europeans would be hard pressed to make cordage for a fishing line, let alone a suitable fish hook to attach to it. Indeed, even a knowledge of basic knots is required for successful foraging for food. When we think about the first immigrants to New Zealand we should envisage them poorly equipped in terms of material culture, but very well equipped with basic skills and knowledge relating to fishing and other technology, which would ensure relatively easy adaptation to the challenges of this new land.

As we have seen in earlier Sections in this volume, the Polynesian immigrants experienced considerable differences in the environment of New Zealand compared to the tropical Pacific, and as far as fishing is concerned, it was not just the types of fish that were new (not to mention the cold waters of temperate New Zealand), but all the natural materials used in fishing were new too. No pearl shell is found in New Zealand, so fish hooks

could not be made from this. No coconuts grow in New Zealand, so coconut fibre could not be used to make fishing lines and nets. To the uninitiated, this restriction may be seem trivial – after all, there are many other fibres in New Zealand that could be used, especially swamp flax, *Phormium tenax*. On the contrary, the absence of coconut fibre would probably have been greeted with dismay. Coconut fibre possesses properties especially suited to long life in salt-water, and sennit made from it shrinks in the sea, making canoe fastenings even tighter than on dry land.

In considering the technology and material culture relating to fishing in pre-European New Zealand one must bear in mind adaptation to materials unfamiliar to tropical Pacific Islanders. There are several ways a Section on this subject might be organised. The simplest approach would be to take each artefact category in turn and discuss form and function. Archaeological literature is replete with examples of this approach, which I think is a rather lifeless way of observing artefacts. Artefacts represent a marriage between technology and raw material, using the hand and knowledge of an artisan. In other words artefacts come into being as the result of a process, and they are inextricably linked with function. To discuss any archaeological artefact without consideration of process and function is to treat it as an isolated *objet d'art* with little cultural meaning. I therefore propose to adopt a somewhat novel approach in exploring the subject matter in this Section – artefacts. From beginning by making artefacts for fishing, through going out to sea and catching fish, preparing them for eating, cooking them, preserving them, to finally dumping their bones, considerable knowledge was required to be effective. I shall try, wherever possible, to consider the technology associated with these various steps, rather than simply focus on artefact forms.

Since this Section is concerned with 'technology and material culture', I should clarify the way these terms should be understood here. In modern parlance the term 'technology' frequently equivo-

¹ This is dramatically and realistically illustrated by Tom Hanks in the film 'Cast Away' when he demonstrates how impossible it is for the inexperienced to get food from a coconut without some elementary knowledge which even the youngest Polynesian would take for granted.

cates between two different senses, one referring to knowledge, and the other referring to physical objects. These two meanings are best kept separate. While the term 'material culture' might be unambiguous – it refers always to objects; that is, artefacts – it is sensible to use the term 'technology' to refer to the process by which such artefacts come into being. In the previous paragraph I stated: artefacts represent a marriage between technology and raw material, using the hand and knowledge of an artisan. The word 'technology' here is very close in meaning to the common use of the word 'knowledge'. It is that ingredient which people carry around inside the brain (knowledge), and which with suitable practical skill applied to wood, stone and shell turns into material culture (artefacts).

RAW MATERIALS AND ARTEFACTS THAT MAKE ARTEFACTS

A typical fishing expedition requires a considerable range of raw materials and artefacts made from them. Setting aside everyday items such as clothing, people required various tools for making fishing gear. These included a variety of stone tools, such as adzes for cutting and trimming wooden items, flakes for cutting and scraping wood, bone and shell items, drill tips, and the ubiquitous hammer stone for making these stone tools by chipping and pecking. Bone and shell items required finishing with small files. Finally, some stone tools required grinding and polishing. A wide range of stones such as argillite, basalt, greywacke, chert, obsidian, schist and sandstone were needed for these tools. There is strong evidence that pre-European Māori intensively explored New Zealand soon after first arrival and found all significant stone resources very quickly (Prickett 1975, 1979).

The raw materials that were used for fishing equipment were also quite diverse. For example, fish hooks were made from wood, many types of shell, stone, and several types of bone. Identifying the species of shell and bone on a finished artefact is not simple, and although many museum labels declare the species involved, most of these labels are really little better than guesswork. Unfortunately, little effort has been made in New Zealand to apply well-known scientific techniques for identifying raw materials to finished artefacts in museums. For example, New Zealand museums

have abundant fish hooks partly made from wood. Yet to my knowledge no-one has carried out research identifying which species of trees were used for these hooks. Only a minute fragment is required for identification using thin-section microscopy or SEM (scanning electron microscopy). Debitage from bone hook manufacture shows that human bone was a favoured material, as well as bones of moa, sea mammals, dog, and also some types of ivory (dog and sea mammal teeth). Once again, well-known techniques of material analysis of bone and shell have yet to be applied to museum specimens of bone and shell hooks to identify what was being used for individual items. In this respect, an excellent example of what can be achieved is Wallace's pioneering research on wooden artefacts in New Zealand museums (Wallace 1985, 1989).

CORDAGE AND KNOTS AND MASS CAPTURING FISH - THE NET

A fish hook is of little use unless there is also a long line for attachment. People not experienced at fishing may not fully appreciate that cordage made from most natural fibres like flax stretches considerably, so that when a fish tugs at a hook on the end of a long line, it may be imperceptible to the person at the surface holding the line. Many fish, given a little time, will remove bait from a hook without being caught, especially if there is no resistance to the hook and line when the fish tries to swim away with the bait in its mouth. A fisherman feeling this small tug can sometimes seat the hook into the fish by jerking the line. A set-line, anchored in some way on the bottom, also provides resistance against the fish tugging so that it can be caught. However, a long line made from thick natural fibres such as flax is so heavy in the water that the fisherman cannot feel a fish chewing on the bait at the bottom, and it is therefore difficult to know when to jerk the line. There are two implications of this – one is that for most fishing activities line length is limited to fairly shallow waters in the case of Māori and tropical Pacific island fishermen. The second is that for deep water fishing, the form of the hook must be especially suited so that the fish catches itself rather than relying upon the fisherman tugging on the line to seat the hook. This is probably the reason why the jabbing hook, so familiar to European fishermen, is relatively rare amongst pre-European Māori and Polyn-

sians, and the so-called 'rotating hook' is so prevalent. This latter hook form is more effective when completely swallowed by a fish. This subject will be further explored below.

As with the wood used in making hooks, there has been little research into Māori ropes and cordage, although there are many specimens in museums collected in the eighteenth and nineteenth centuries. Notable archaeological finds of cordage are from Lee Island in central Otago (Anderson *et al.* 1991), and Kohika in the Bay of Plenty (McAra 2004). As might be expected, these rare finds are only of fragments, but a great deal has been learned from them. At Kohika there are a number of short lengths of cordage. McAra describes a novel method of making cordage which she names 'two-ply spiral-wrapped twisted anti-clockwise (Z-twist)' (McAra 2004: 149-152). One-ply spiral-wrapped cordage and three-ply braided cordage are also represented at Kohika (McAra 2004: 149, 153). All specimens are made from untreated strips of flax, not prepared fibre. The Kohika site was occupied late in pre-European times, between AD 1650 and 1700 (Irwin 2004: 240).

It is useful to make a few comments about the technical terms used here. Setting aside for a moment the use of untreated strips of flax or other species, the common method of making cordage is to twist bunches of fibres on the upper leg or thigh with the palm of the hand. Bunches of fibre used for this purpose, when rolled and twisted in this way, are termed 'yarn' or 'strand', and sometimes referred to as the 'ready' (see Figure 55). If two bunches are rolled at the same time, it will form two-ply cord, and if three bunches are used, then three-ply cord is produced. Typically, the person making two-ply cordage will hold the completed cord in the left hand, and while making sure to keep the two bunches of fibre separate on the thigh, use the palm of the right hand to twist the fibres in each strand. If the palm of the right hand is pushed forward on the thigh the fibres will twist in a clockwise direction when looking towards the end of the cord. When the left hand is released, the loose cord, already made, on the left will twist to take up the tension, twisting the two strands together into two-ply cord. It is then customary to bring the right palm backwards on the cord, to untwist it. If you look towards the end of this cord so made, the strands are twisted together anticlockwise, the opposite direction to the twisted fibre in the strands. Cord twisted in this manner is termed Z-twisted (see Figure 55). If the right palm is pulled backwards from the knee on the thigh, the

fibres will twist anti-clockwise, and the strands will be twisted clockwise, termed an S-twist. Contrary to this, a left-handed person might hold the cord in the right hand and use the left palm for twisting. In this case, pushing forward will make an S-twist, and backwards will make the Z-twist. Buck provides an excellent description of cord-making, including plaiting and braiding, in Samoa (Buck 1930: 232 ff.). In my experience, it is more common in Pacific islands for people to push the palm forward. It is therefore possible that most S-twisted cordage has been made by left-handed people, although it would be interesting to confirm this by direct observation on remote islands in the Pacific, as people still make cordage in this way in many places. It is one of the activities in which old men engage while sitting chatting about fishing in the men's house. Of some interest is the fact that twisted cordage generally loses about 30% of its tensile strength after being

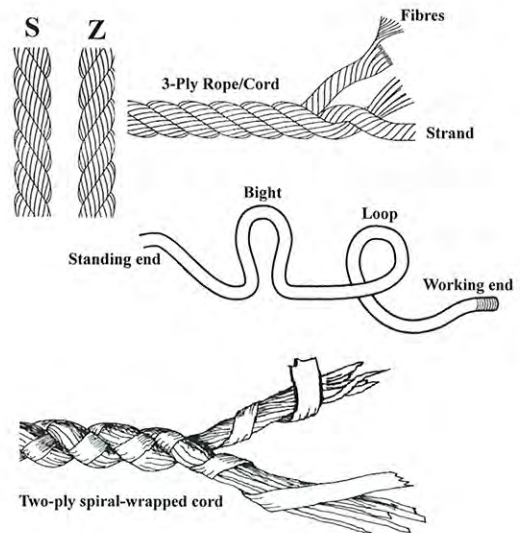


FIGURE 55

Some basic terminology relating to cordage (adapted from Budworth 1997). The two-ply spiral-wrapped cord is from McAra (2004: 152), courtesy of Geoffrey Irwin.

twisted in this manner. That is, compared with the sum of the tensile strengths of all the individual fibres, the final cord is weaker. There are two reasons for this — one is that each fibre when twisted becomes slightly weaker, and the second is that the forces along the length of the cordage are no longer axial along the length of the fibre, and this results in

weakening. The addition of any knot into the cordage also reduces the strength of the line (Turner & van de Griend 1996: 185)². Some natural fibre cordage also loses strength by as much as 70% when it is wet. I do not know of any experimental research on either of these issues for the types of cordage commonly made by pre-European Māori, or by Pacific Islanders for that matter.

Returning to archaeological finds, those from three Lee Island excavations provide a wonderful opportunity to examine something rarely found by archaeologists, and that is knots. A knot represents a single piece of pure technological knowledge. Very little is known about the discovery of individual useful knots and their spread from one human society to another³. At Lee Island, an impressive number of knots was recovered (Anderson *et al.* 1991). Forty examples of cords were found which had various knots in them, and an additional 16 pieces of twisted and plaited fibres without knots were recovered. Both S and Z-twist are represented at Lee Island. Twenty-eight examples of knotted cordage are made from *Phormium* sp. (flax), ten from *Cordyline* sp. (cabbage tree or tī), and at least one and possibly two from *Astelia* sp. (tree

flax or bush lily). Twisted fibres of *Freycinetia* sp. (kiekie) were also present. Most of the flax specimens consisted of strips of unprocessed blades, only one case of scraped, beaten and softened fibre being found (Anderson *et al.* 1991: 45).

The collection of knotted fibres from Lee Island is a veritable gold mine of pre-European cord technology. They were carefully studied and illustrated by Anderson *et al.* (1991: 52-54), so that it is possible to understand the character of each knot in the collection. By my count there are 45 knots on the 40 pieces of cord, and many of these can be identified (Table 8).

Radiocarbon dates from the Lee Island sites range from 281 to 399 years BP (CRA), which calibrate as from the sixteenth to early seventeenth century AD (Anderson 1991: 16-17). There is no reason to think that these knots have been influenced by European knowledge. The sites are away from the sea, on an island in Lake Te Anau, and although the cordage and the knots are not specifically related to fishing implements, they do form part of the knowledge system of pre-European Māori, and can be expected to have been employed in fishing and other activities. Most of these

Identified Knot	Examples	Unidentified Knot	Examples
Overhand	17	'Lee Island Knot' [†]	5
Clove hitch	8	Other special knots	6
Reef knot	4		
Half hitch	3		
Cow hitch	2		
	Totals 34		11
†see text			

TABLE 8

Knots which can be identified at the Lee Island Sites.

² This is well known amongst fly fishermen, who attach the fly using very fine line, which might have a breaking strain of only 1 kg before knotting.

³ The following incident illustrates the importance of knots. Some years ago I was asked to try and get the people of Taumako (a remote Solomon island), to make one final example of the great sailing canoe, tepuke, to celebrate the independence of the Solomon Islands. During a public meeting about this on the island the people expressed grave doubts whether this would still be possible. The main reason offered was that no-one any longer knew the correct knots to use for lashing the parts together. Twenty years later, in 1999, a tepuke was finally made by William Keizy on Taumako, and shipped to the Museum of New Zealand, where it formed a spectacular display. After much searching, William had learned the crucial lashing knot from an elderly relative on another island.

knots are quite familiar, but one in particular, which for convenience I will call the 'Lee Island knot', is represented five times and deserves some comment. There are six more knots not easily identified from literature. Unfortunately, with fragments of cordage containing knots it is not usually possible to identify which ends of the cords are 'standing ends' and which are 'working ends' (Budworth 1997: 16, see also Figure 55). This means that it is not certain how the knot was intended to function when pulled tight, or indeed exactly how the knot would form when fully tightened. It is customary when tightening knots to choose two loose ends and pull them tight. There

are two pieces of cord making up the Lee Island knot, with two ends each (ends 1&2, and 3&4). In pulling the knot tight, one of four possible pairs could be chosen (1&3, 1&4, 2&4, 2&3). When each of these pairs is pulled apart, the knot will resolve itself into one of four possible forms⁴. Referring to Figure 56, Budworth comments that #1 and #2 are most practical and either of these two versions in small cordage could be a fishing or weaving knot; but that #3 and #4 are awkward and ugly and less likely to have been functional (Budworth 2005: pers. comm.).

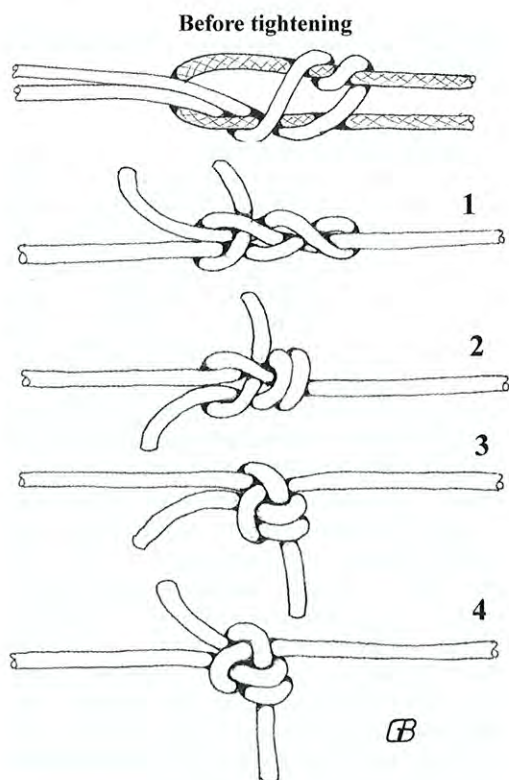


FIGURE 56

The so-called 'Lee Island Knot' – four possible forms (see text). Drawing by Geoffrey Budworth.

The first Europeans who visited New Zealand came in sailing ships, which had ropes in great abundance, bristling with knots of many types.

⁴ I am grateful to Geoffrey Budworth, co-founder of the International Guild of Knot Tyers, for much helpful advice on matters relating to knots.

Māori coming on board would have taken notice of these and quickly adopted anything new to them into their own knot repertoire. Records of Māori knots from the historic era are therefore potentially filled with knots of European origin. This is what makes the finds at Lee Island so important. There are many examples of cords with knots in New Zealand museums collected from Māori people from the eighteenth century onwards. Many of these relate to fishing and they are a rich resource for future research.

The final archaeological example relating to cordage which merits discussion concerns fishing nets. Several specimens have been found in archaeological sites, notably Kohika (McAra 2004: 155-157) and Ruahihi (McFadgen & Sheppard 1984: 26-27, 30-31) in the Bay of Plenty, and Whakamoenga Cave on the shore of Lake Taupo in the central North Island (Leahy 1976: 58, fig. 11). Several large pieces have also been found in a cave or caves on Banks Peninsula (McAra 2001).

The Kohika specimens consist of two small remnants, the larger of which has about 14 meshes made using the boustrophedon method⁵. This is suggested because the knots are alternately front and back on different rows (this is not necessarily correct, and is further discussed below). Judging from the published illustration (McAra 2004: 156), the meshes are about 44 mm⁶. This is clearly not suited for catching larger fishes by the gills, nor for eels, which would easily escape. It is a coarsely made net which could act as a barrier to encourage fish to swim away from it into another trap. It is made from unscraped strips of flax.

The Banks Peninsula specimens consist of three pieces of what is probably one net, found at Sandy Bay/Lavericks Bay, and donated to the museum over a period of years, and a fourth piece, 'the Bowman net'⁷. The latter, which is the largest piece, is 40 m in length; the other three pieces

⁵ Boustrophedon is a term sometimes used when describing how nets are made when the rows of meshes alternate from left to right and then right to left, as with ploughing a field (see Best 1977: 15).

⁶ The standard method for measuring net mesh size is to pull the diamond as far apart as possible and measure the inside distance between knots. The left to right measurement is identical to the vertical measurement, regardless of whether the upper and lower rows of the mesh elements are the same or different lengths.

⁷ The catalogue information relating to these nets is now very confused and it was extremely difficult to relate the actual net pieces to their register numbers and accession history. Details are given by McAra (2001: 86, 99).

together total 70 m. No ends or section joints are present on any of the pieces. The untreated flax strips are very narrow, only 2-3 mm wide. The age is probably late pre-European or early historic. The mesh size is about 140 mm. The net was not made using the boustrophedon method. This may suggest that more than one person was involved in making longer nets, each working from left to right, so that several rows are made at the same time. When the boustrophedon method is followed only one row can be made at any one time and must be completed before a new row is commenced. Clearly if a very large net was being made it would speed things up a great deal if several people were knotting at the same time. It is likely that the large seine nets described by Banks and other early visitors to New Zealand were made in the non-boustrophedon manner. McAra has studied these net pieces and has clearly identified that the knot being used is identical to that described by Buck (1926: 605 ff.) (McAra 2001: 88). This knot has several names: 'the weaver knot', 'the trawlers knot', 'the sheet bend' (a nautical term), and 'the netting knot'. For the sake of consistency, I shall retain the term 'weaver knot' here.

At Ruahihi, the fragment of carbonised netting with about 2,700 knots covered an area of 1.3 m² (see Figure 57). This was a salvage excavation and it is not possible to be certain as to the precise position of the specimen stratigraphically, but it is either late pre-European or early historic (McFadgen & Sheppard 1984: 26-27, 30-31). The net itself is described as being made of unscraped split flax, with a mesh size of 40 mm (McFadgen-Richardson 1984: 53), which is similar to the piece from Kohika. Once again the 'weaver knot' was used. It is a beautifully made piece of netting with very uniformly spaced knots and joins of flax strip. The alternate facing knots suggest, but do not prove (see below), that the boustrophedon method was used.

Although a great deal of theoretical modelling has been attempted to describe species and size selectivity and capture rates of different mesh sizes (for example Helser *et al.* 1998; Kirkwood & Walker 1986), the reality is a great deal more complex, and practical catching experiments in netting New Zealand species are especially useful (Hickford & Schiel 1995, 1996). The mesh sizes of these three archaeological examples of fishing nets can be compared with observations by fishermen on typical modern nets in use in New Zealand (Clark 2005: pers. comm.). The first point which needs to

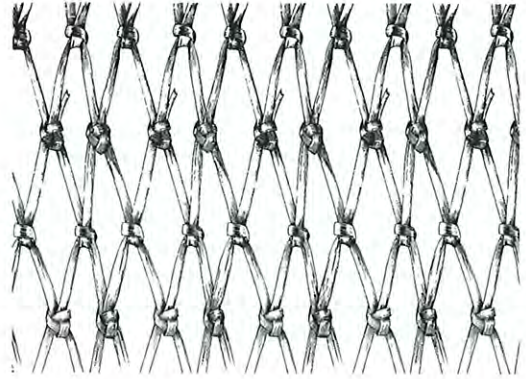


FIGURE 57

A drawing of the Ruahihi carbonised net, after McFadgen and Sheppard (1984). Courtesy of Te Papa.

be made is that nets can function in more than one way. A seine net is dragged through the water and is designed to surround fish and then beach them. It is not necessary for any fish to be entangled by the gills or spines, although some fish are caught in this way, and smaller fish will be able to swim through the mesh. A set net (or gill net) on the other hand certainly is designed to entangle the fish, and the mesh size is carefully chosen for the size of fish and the species. Snapper, for example, have strong dorsal spines which become entangled in almost any mesh size, and are seldom caught by the gills. If there are plenty of snapper to be caught it would not be necessary to spend a lot of time making anything other than a net with very large mesh size. By contrast, greenbone and flounders have no sharp dorsal spines and must be caught by the gills. In this case the mesh size is critical to what sized fish are caught, if they are caught at all. A net with a mesh size of 140 mm is ideal for catching large flounder, but not small ones. Conversely, a net with a mesh size of 107 mm will catch smaller flounders but not the bigger individuals. Moki are a little like snapper and tend to be caught along their sides in a net rather than by the gill, so once again a quickly made large-meshed net is suitable. Similarly, barracouta can be caught in just about any mesh size, and thrash about entangling their numerous spines and sharp teeth. Blue cod are usually caught by the gills and mesh of 107-114 mm is very suitable.

The Canterbury net(s) would be effective in use either as a seine or gill net.

The Kohika and Ruahihi nets have a very small mesh (44 and 40 mm respectively) compa-

red to these modern nets. They may have been used for freshwater fish. Both these sites are situated near rivers and are not directly on the coast. The three net pieces from Whakamoenga have even smaller mesh sizes. Two had a mesh size of 30 mm; a third fragile piece had a mesh size of only 15 mm (Leahy 1976: 58). All were made with untreated flax strips using the knot described by Buck. Leahy commented of the third piece that the mesh was about as small as it would be possible to make using untreated flax strips.

In the cases described here, the weaver knot used is clearly the same as that described in detail by Buck (1926: 605 ff.):

The Maori netting-knot is the same as the usual European one except that in the latter the netting-cord is passed through the loop from below and the bight is made to the left. This is the opposite to the Maori method, but the results are the same (Buck 1926: 606).

Actually, the result is not quite the same at all. These two knots, immediately prior to their being tightened, are illustrated in Figure 58. This illustration does not adequately show the method of actually tying the knot as described below. For example, the two different bights are not shown. A step by step fully illustrated explanation is provided by Ashley (1944: 64) and Buck (1926: 605). However, the difference in tying the knots may be summarised as follows. The European method requires the working end to pass *under* the loop and the bight to be thrown to the *left*; the right hand is used to pass the cord around the *back* of the loop and then over the bight, and then tightened by pulling the cord *to the left* with the right hand. Finally, when the knot is tight, the right hand is drawn to the right towards the next loop in line, twisting the knot just made. I was taught to make nets in this manner when a boy by an old fisherman and he used to laugh and call me cack-handed. I now realise that it is the knot that is cack-handed, when compared to the much simpler and more elegant method of tying the knot adopted by Māori and Polynesians.

The Māori method involves passing the working end *over* the loop, not under. The bight is thrown to the *right*, not to the left, the working end is then passed around the *back* of the loop and then over the bight (as with the European method), and then tightened by pulling the cord *to the right*, not to the left, with the right hand. Thus, the final

movement tightens the knot correctly in the same direction as the next loop to be tied, rather than across the body with the right hand towards the left. This is a much easier and more natural way to tie this knot.

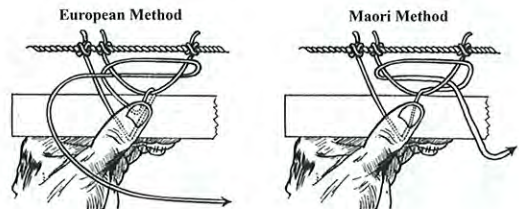


FIGURE 58

The netting knot just prior to tightening. Left: the European knot. Right: the Māori and Polynesian knot. Adapted from Collard (1948: 6).

As many authors have remarked, this is a difficult knot to master, and can easily become a slip knot unless tied exactly right. Learning this knot requires paying careful attention to the method of tying and tightening, and one must get into a consistent rhythm. It is a complex piece of technological knowledge to pass from master to pupil (described by Firth 1939: 97 ff. and also Buck 1930: 470 ff.). This being so, it is a matter of some importance to discover where and when the Polynesian weaver knot came into being. The European weaver knot is known to have been used in both Finland and Schleswig, just south of the present German border with Denmark, at least 4,000-5,000 years ago (Sirelius 1934; Brandt 1970, 1984: 208-209). According to Brandt (1984: 208), the reef knot method of tying nets was more common amongst Asiatic fishermen until recently, and a kind of 'failed reef knot', or cow hitch named the 'Peruvian knot' has frequently turned up in netting recovered in excavations in Peru. Several of these alternative netting knots are shown in Figure 59. It does not seem likely that the European weaver knot and the Polynesian weaver knot share the same ancestry, so this could be a case of independent invention.

In a very useful review of different kinds of netting knots, MacLaren studied specimens of nets from many countries in the ethnological museums at Oxford and Cambridge and researched literature on net making (MacLaren 1955). These nets were collected during and after the great period of

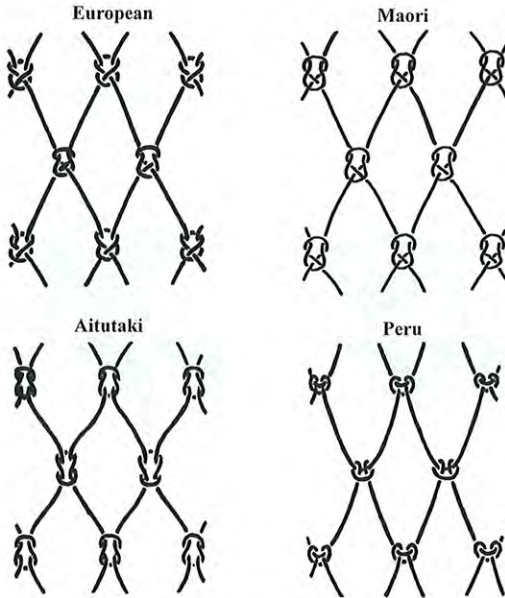


FIGURE 59

Several alternative netting knots. Adapted from Brandt (1970: 110).

European exploration of the world, and therefore novel techniques will have spread along with these contacts. As a result, an individual net displaying a certain feature cannot be claimed with certainty to be indigenous to that location. However, it is a useful starting point. MacLaren records the knot here characterised as the 'Polynesian weaver knot' in at least 17 island groups in the Pacific. He found one instance of the 'European weaver knot' in this region, from New Guinea. Although rare in other parts of the world, he records examples of the 'Polynesian weaver knot' from Texas, Bering Strait (Kotzebue), Rhodesia, Northeast Asia (Koryak), Northeast Burma, Andaman Islands, India (Central), and finally Egypt (Fayum, 12 Dynasty, and Fayum modern). The 'Polynesian weaver knot' is absent from both South and North America (apart from the Texas example), Japan, and Europe. MacLaren also makes the interesting observation "Aitutaki, Cook Islands, alone in the Pacific has the reef knot, and is without the shuttle, in contrast to the general use of the shuttle and the mesh knot in that area" MacLaren (1955: 87), citing Buck (1944: 225) as his source for this information. However, as described above (Table 8), the reef knot was present at Lee Island in New Zealand. Buck describes nets being made by this

method (illustrated in Figure 59) and notes that people on Aitutaki are very proud of the fact that their method is different from that of other Cook Islanders (Buck 1944: 226), but does not claim that the reef knot is unknown elsewhere in the Pacific. The significance of this method of making nets is that it is not necessary to use a relatively short length of cord on a mesh needle, but a very large ball of cord can be used. Moreover, very fine meshed nets can also be made with a large ball of cord (Buck 1927: 280 ff.). The use of a ball of cord for net-making was recorded by Best (1977: 15-16), something which Buck commented on, suggesting that the Aitutaki method may possibly have been present at some stage in New Zealand and the Society Islands as well (Buck 1950: 214).

One further point on a practical aspect of making nets, which suggests we need to be very cautious about interpreting fragments found archaeologically, concerns cases when the knots are shown to have alternate faces. This occurs when the boustrophedon method is employed, when one net-maker works from left to right across the face of the net with the header rope strung between two trees. When the right hand end is reached, the net-maker goes to the other side of the net, and continues working towards his right. The effect of this is that, when viewing the completed net from one face, the knots will show alternate rows with a different appearance. Although this is true of a net made by the boustrophedon method, this appearance can be produced by another method. With small nets, and also when working in a confined space, when it is not convenient to string up the header rope between two trees, the net-maker may choose to work alternately from left to right and then right to left. This method is described by Steven (1950: 20), and the effect is shown in Figure 60 for both the Māori and European knot, working to the right and to the left. It should be evident that the Māori and European knots are not mirror images of each other (see also Turner & van de Griend 1996: 48).

Early ethnographic descriptions of nets in New Zealand amongst Māori communities describe a wide variety of devices: seine nets, small hand nets, set nets, hoop nets, basket-like traps with netting sides, etc. This makes it that much more difficult to identify accurately the rare small fragments found in archaeological sites, such as a net fragment with pumice float from the upper layers of Moa-bone Point Cave, Canterbury (Skinner 1923: 101 and fig. 9). Before leaving this discussion, mention should

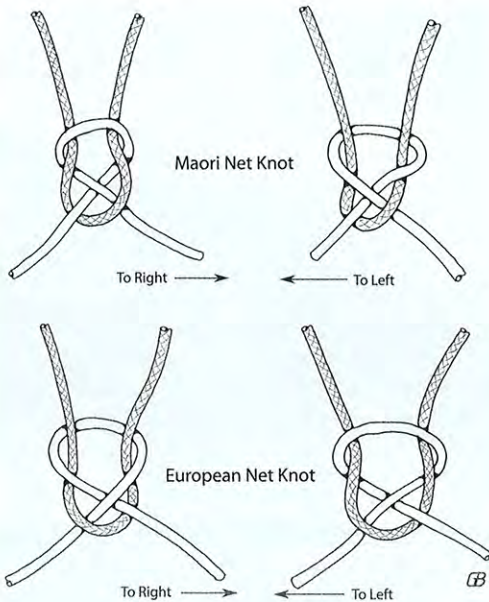


FIGURE 60

When making a net in a confined space, the net-maker may choose to work alternately from left to right and then from right to left. This results in a net that appears to have been made by the boustrophedon method, but it is not so (see Steven 1950: 20). Drawing by Geoffrey Budworth.

be made of the spectacular seine nets which the earliest European visitors to New Zealand observed. Banks described seines in his journal 4 December 1769 in the Bay of Islands thus:

and after having a little laught at our seine, which was a common kings seine, shewed us one of theirs which was 5 fathom deep and its length we could only guess, as it was not stretchd out, but it could not from its bulk be less than 4 or 500 fathom. Fishing seems to be the cheif business of this part of the country; about all their towns are abundance of nets laid upon small heaps like hay cocks and thatchd over and almost every house you go into has nets in it making (Banks 1963 (I): 444).

In his general observations about Māori written 30 March 1770 in Admiralty Bay off D'Urville Island, immediately before *Endeavour* departed for Australia, Banks commented further about seines and nets in general:

Netts for fishing they make in the same manners as ours, of an amazing size. A seine seems to be the joint work of a whole town and I suppose the joint property: of these I have seen as large as ever I saw

in Europe. Besides this they have fish pots and baskets workd with twiggs, and another kind of net which they most generally make use of that I have never seen in any country but this. They are circular about 7 or 8 feet in diameter and 2 or 3 deep; they are stretchd by two or three hoops and open at the top for near but not quite their whole extent; on the bottom is fastned the bait, a little basket containing the gutts & c. of fish and sea ears which are tied to different parts of the net. This is let down to the bottom where fish are and when enough are supposd to be gatherd together are drawn up with a very gentle motion by which means the fish are insensibly lifted from the bottom; in this manner I have seen them take vast numbers of fish and indeed it is a most general way of fishing all over the coast (Banks 1963 (II): 25-26).

What Banks is describing here is depicted in a pen and wash drawing by Sydney Parkinson (Figure 61) of men⁸ fishing from canoes in Queen Charlotte Sound (Cook 1968: fig. 41 facing p. 209). This fishing group has been included in an engraving of a very different location – the picturesque hole in the rock at Mercury Bay, far to the north of where the fishing scene was actually observed (Figure 62, Hawkesworth 1773: II: Plate 18, opp. p. 341). In my own personal experiments with replicas of these hoop nets in Queen Charlotte Sound, observing them with scuba gear, fish enter the traps but escape easily, despite careful pulling of the traps to the surface, or indeed pulling them up rapidly. My expectation of the behaviour of this fish species upon attempting to lift the pot was that it would immediately dive to the bottom rather than escape from the open entrance at the top, because this is a ground hugging species, which is seldom caught with hooks much above the bottom. However, this did not occur, and the fish rapidly exited at the top. Why these pots worked with blue cod in 1769, and do not work now is a good question, and appears to represent a change in fish behaviour. The difference can, perhaps, be attributed to the devastation of stocks of blue cod and other species in these waters since the arrival of Europeans, resulting in extreme wariness of modern fishermen and any artificial devices.

⁸ Banks (1963 (I): 454) reported that the curious head-dresses depicted in this image were worn by women and “some men”. Beaglehole, in an editorial footnote to this statement, shows that later writers believed them to be worn mainly, if not exclusively, by women. However, Parkinson has provided the wearers of the head-dresses with short beards, clearly showing that these people were men.



FIGURE 61

Māori people fishing in Queen Charlotte Sound using hoop nets. Painting by Sydney Parkinson (Cook 1968: fig. 41 facing p. 209). Courtesy of British Library. See also Figure 62.

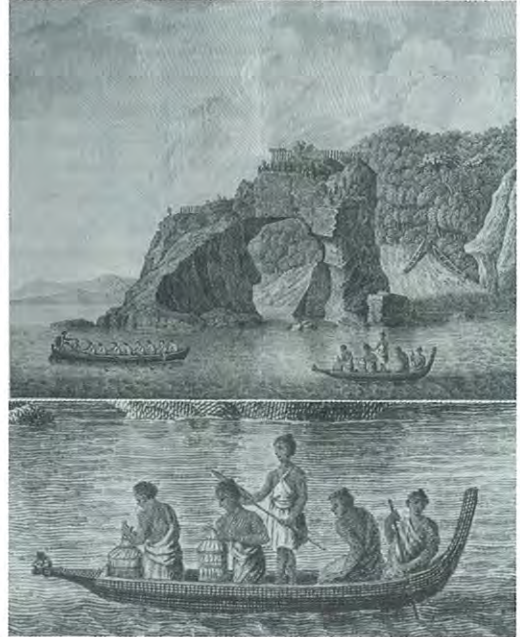


FIGURE 62

The fishing group depicted in Figure 61 now transposed into the very different location of Mercury Bay on the Coromandel Peninsula (from Hawkesworth 1773. II: Plate 18, opp. p. 341). Courtesy of Te Papa, negative #E3538.

More information about seines comes from French visitors to the far north of the North Island. In 1769, during de Surville's visit to Doubtless Bay, Pottier de l'Horme described them as follows:

The nets are very large, made like the ones we call seines. Instead of using lead, they fill with stones a kind of pocket fashioned to extend the whole length of the net. The material they use to make these nets is a very fine rush, which knots superbly. These nets are so big that it takes all the inhabitants of a village working together to pull one. So I assume that it is common property (Ollivier & Hingley 1982: 133-134).

During Marion du Fresne's visit in 1772, Lehoux observed large nets in Spirit's Bay:

a fairly large seine made of screw pine which had, instead of sinkers, little round pebbles in a casing of netting with very much smaller mesh than that of the seine... (Lehoux reported by de Montesson in Ollivier 1985: 227).

A few days later, Roux also made a useful observation about these nets:

They are meshed like ours, being 80 to 100 fathoms long and 5 to 6 feet wide. At the bottom there is a pouch which contains stones to make it sink, having the same effect as the lead we attach to ours. At the top are attached at intervals little pieces of a round and very light wood, which replace the cork which we employ for this purpose (Ollivier 1985: 131, 133).

Unfortunately, these impressive nets would leave little trace in archaeological sites and would be difficult to distinguish from other types of net. However, a keen observation by Knapp on Rabbit Island, Waimea River estuary, Nelson, revealed lines of uniformly shaped slate stones in hollows in the sand dunes which may have been the remains of nets (Knapp 1940). Hamilton provides an illustration of such a net (Figure 63) which shows several distinct sections, each with its own Māori name, the effect of which was to provide a belly in the net. This would be a very useful feature in a large seine to prevent fish escaping when it was full, as the fishes move towards the centre of the net while it is being pulled through the water (Hamilton 1908: 72, fig. 77).

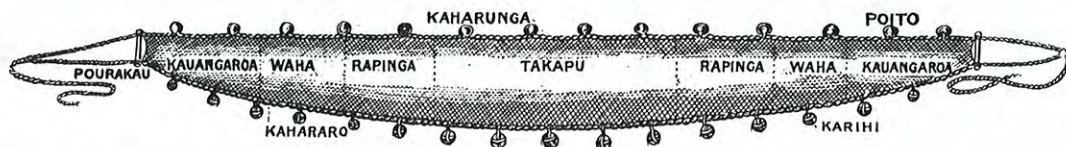


FIGURE 63

A Māori seine net, showing the named sections (from Hamilton 1908: 72, fig. 77). Courtesy of Te Papa, negative #E5505.

Before leaving the subject of nets, it is worth noting that although many species of fish have excellent eyesight, they give more attention to information about obstacles in their environment from pressure sensors in their lateral line than from their eyes. This is well known by modern commercial fishermen when using trawl nets, the wings of which have wide mesh which fish could easily swim through. Rather than believing the evidence of their eyesight fish trust their lateral line which detects this part of the net as an impenetrable barrier, and they veer away from it. They are eventually funnelled into the far end of the trawl net which has a finer mesh and prevents escape. By contrast, cephalopods are very difficult to capture in this type of net, because they do believe their eyesight and simply swim through the wide mesh of the trawl net wings (Wells 1998: 164-165). This is worth bearing in mind when examining the mesh size of nets and trying to infer the size of fish which might have been caught by it. Best records the following of Māori in the early historic period:

The mesh of a large net, such as seine, differed considerably in size, being much smaller at the middle part than at the ends of the fabric (Best 1977: 15).

Clearly, Māori were familiar with the phenomenon just described. I know of no comparable example in Polynesia, though this may well exist. It is hoped that the origin of this knowledge of fish behaviour will be found in due course by paying careful attention to any evidence of changes of mesh size in fragments of netting that are found in swamps or dry caves.

CATCHING AN INDIVIDUAL FISH - THE HOOK

Probably thousands of Māori fish hooks, collected historically or found in archaeological sites throughout New Zealand, are in museums.

Unfortunately, only a relatively small number have been recovered during controlled excavations; most have been found by fossickers and curio hunters on the surface, or in some cases by wholesale digging for artefacts. Consequently, relatively little is known about stylistic and functional changes through time, although there have been some valiant attempts to order fish hook types into regional chronological sequences, usually with little scientific basis (Hjarno 1967; Simmons 1973). Many works of this kind suffer from the tendency to categorise entire archaeological sites as 'early' or 'late', 'Moa-hunter' or 'Classic Māori', etc., quite often on the basis of their artefacts, and then use the artefact forms in tabulations to illustrate change through time. This is circular reasoning. Moreover, the suggested reasons for these hypothetical changes through time are often pure speculation:

In this analysis the major groups of fishhooks only have been taken together to illustrate the evolutionary trends (Simmons 1973: 43).

To use the term evolution in this context implies change, which in some manner involves moving to increasingly higher planes of organisation, complexity or diminishing entropy. One might apply the term 'evolution' if the observed changes resulted in greater efficiency during manufacture while maintaining the same degree of effectiveness functionally, or better still, actually improved function. In other words, evolution should involve change that in some way transcends from one level to another. In the case of pre-European Māori fish hooks, no such change has ever been identified, and we should forget about using the term evolution until this can be properly demonstrated.

Very few New Zealand archaeological sites have so far been excavated in which hooks have been found in reasonable abundance in several

clearly defined stratigraphic horizons, so that significant changes in form through time can be convincingly demonstrated. At best one might say that if one took ten archaeological sites most reliably dating to the earliest period throughout the whole of New Zealand and combined all their fish hooks into one assemblage, this would look different from a combined assemblage of all the fish hooks collected from Māori by the earliest European visitors to New Zealand in the eighteenth and nineteenth centuries. There would be overlaps between these two hypothetical collections and there would be differences. Between these two extremes are bewildering complexity and changes. There are numerous factors that have the potential to explain change both through time and regionally. For instance, one factor is broad regional differences, such as the matrix of dominant fish species; another is local regional differences, where the coastal ecology might change from rocky shore to sandy beach; another relates to seasonal occupation of some sites compared to others; another is changing access to raw materials, such as decline in availability of moa bone⁹. In order to identify causes of observed changes, it is necessary to establish very local chronologies first as the basic building blocks of higher level interpretations. In my view, when it comes to fish hooks, we have only just begun to identify the first level of building blocks in New Zealand, and need to use more caution and constraint in how we interpret changes from one site to another.

A good example of building upwards from a local chronology is the research published by Leach and Hamel about the Long Beach site in southern New Zealand:

In the Archaic layers there are characteristic silcrete blades, schist files, and the one-piece fish hook which later disappear, but there are also several composite fish hooks and good evidence that the barracouta point is being transformed already into the dominant Classic Maori dog-legged or lugged type. Within two or three centuries the assemblage displays some of the characteristic Classic Maori artefacts... The composite fish hook points, while still made in the Late Archaic shapes, now show res-

⁹ This may be the reason for the observed change through time in the raw material used for hooks at the site of Cross Creek on the Coromandel Peninsula, where Sewell shows that early in the site's history moa and other bone was common, but shell dominates later. This is not accompanied by any significant change in the mix of fish species (Sewell 1988).

trained but common use of serrations. In keeping with its date in the Classic Maori period, the "baroque" style is not yet evident in the fishing gear (Leach & Hamel 1981: 139).

Contrasting with this, in another region of New Zealand where a detailed regional chronology has been thoroughly researched (Palliser Bay) no significant changes in fish hook styles over time were observed, and unlike at the Cross Creek Site, both bone and shell hooks are equally common over a long period at both the Washpool and Black Rocks (Anderson 1979; Leach 1979b).

Another important factor relating to fish hook design is personal. This is not usually considered very important, but when we examine the few caches of fish hooks that can be considered to have belonged to an individual fisherman, there is a strong consistency of form across a small number of basic types. When we compare a pair of such assemblages the differences are striking. In other words, the difference is an insight into what one fisherman considers is right and proper for fishing, compared to another fisherman. It would be folly to put two such assemblages into their chronological sequence and suggest evolutionary or functional change. An excellent example of this are two caches which are very different, one from Pohara near Takaka in the north-west of the South Island, and the other from Serendipity cave, near Jacksons Bay, South Westland (Figures 64 and 65).

I sometimes wonder if a modern fisherman, after reading an exposition about archaeological fish hooks, would conclude that the author has little or no practical experience of fishing. That is because archaeologists tend to dwell on features which a fisherman might consider trivial, such as how many denticulations (serrations or notches) a hook has. On the contrary, archaeologists have no monopoly on the emphasis given to minute details of style – modern fishermen are equally focused on trivia. A visit to any modern fish tackle shop will reveal this. Some years ago I went to a tackle shop in Anchorage, Alaska, to buy the small amount of gear to catch a local salmon. The shop was an enormous supermarket with a plethora of goods and every conceivable form of fish hook imaginable, each declaring its superior catching qualities compared with all others. I thought at the time that there were probably far more hooks in this shop than salmon in the nearby rivers. Although this might seem an amusing statement about the gullibility of recreational fishermen, it also

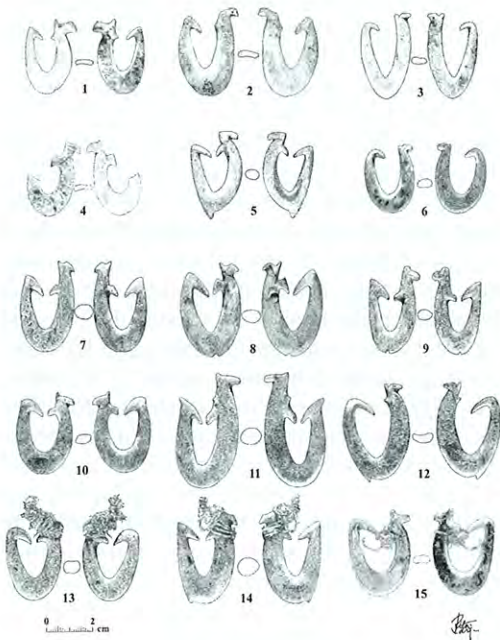


FIGURE 64

A selection of fish hooks from a cache at Pohara near Takaka (Courtesy of Manawhenua ki Mohua).

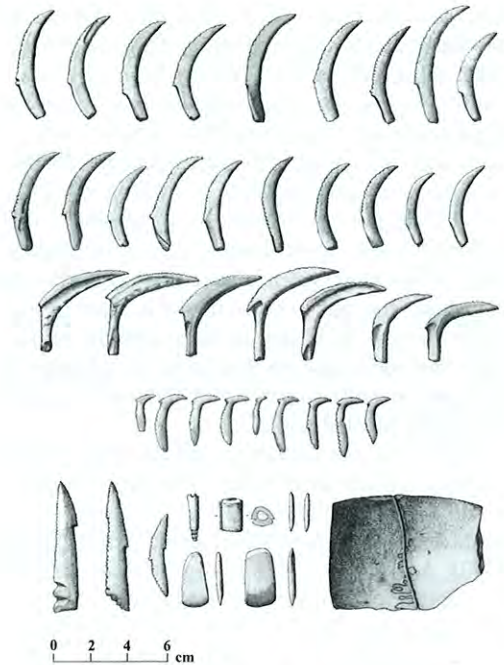


FIGURE 65

A selection of fish hook points and a few other items from a cache at Serendipity Cave, South Westland.

made me think of the no less diverse range of prehistoric hooks from New Zealand and tropical Polynesia. The reality is that fishermen of all levels of sophistication, no matter how ancient or modern, are constantly engaged in experimental research with fishing tackle. Each fisherman has his own theory as to what works best, and while this ongoing research is not always very scientific, in my opinion it was alive and well throughout pre-European New Zealand. We should therefore think twice before attributing changes in form to changes in function, let alone use words like 'evolution'.

Having raised the concept of function, I must admit that this poses a considerable problem. When it comes to evaluating the effectiveness of design elements in hooks from archaeological sites in New Zealand (no less than in Polynesia and further afield in Oceania) we are on very shaky grounds. A European fisherman faced with a tray full of bone and shell fish hooks¹⁰ would immediately notice several things which distinguish them from anything in his experience. These are:

- 1: the parts of the hook are very thick
- 2: the point is blunt
- 3: the gap between the point and the shank is very narrow

The fact that the parts of the hook are very thick is unavoidable, given the materials available to non-industrialised non-metal cultures, such as shell and bone, which are far less strong than steel. This would have been the main thing which, conversely, Māori would have noticed about the first European metal fish hooks they observed.

The fact that the point is relatively blunt is interesting. It is possible to make a very sharp point with bone or shell, although it would not be very strong. Pre-European Māori fish hooks were not as sharp as it would be possible to make them, and therein might be a clue about some functional or operational difference between European hooks and those found archaeologically.

Finally – the narrow gap. This certainly is a most striking feature to any modern fisherman. A typical example is illustrated in Figure 66 (see also Figure 64). This hook is from the cache found at Pohara near Takaka. The gap is 2 mm. It can be

¹⁰ In this discussion I am only concerned with the most common type of fish hook; that is, the one-piece bait hook.

seen that the shank has a projection, closing the gap between the incurved point and the leg of the hook. This projection is usually referred to as a 'barb', but that prejudices what the function of the projection was. It may simply have been a convenient way of narrowing the gap during manufacture, which was accomplished by drilling holes in a tab of bone and then punching out the centre. This cache of hooks from Pohara is very instructive. Four of the hooks do not have this projection on the shank; the gap in these hooks is three to four times the size of the gap in those with the projection. The hook gaps for this cache are plotted out in Figure 66 and compared with those on a sample of modern Mustad hooks¹¹.

Why did pre-European Māori make hooks with such a narrow entrance? The short answer is we do not know, although there is a theory, which might be termed *the rotating hook theory* (Leach 1973). According to this theory the fish does the catching, not the fisherman. In Figure 67, at A, the fish approaches the hook (bait not shown). Many fish are accustomed to eating extraneous matter, such as fragments of shell, with their food and a hook with no sharp projection could easily be

swallowed without discomfort (shown at B). If the line is tugged at this point, the hook would come out of the fish's mouth, but if left alone the fish will swim away, carrying the line along its side (shown at C). The line will eventually become taught, and begin to pull the hook out of the fish's mouth. At first, the force on the hook is towards the front of the fish, but the instant the shank becomes clear of the mouth the direction of the force changes towards the rear of the fish, causing it to rotate rapidly. It will come to rest with the shank of the hook lying outside the jaw, and the point lying inside the jaw (shown at D). From this stage on the fish cannot escape. If the line is now tugged or the fish tries to change direction, the hook will rotate in the mouth, acting as a lever, and the point will penetrate behind the jawbone. In theory, to a certain extent, the narrower the gap between the shank and the point the better. In addition, the hook rotates more effectively if the shank is the same length as the leg on which the point occurs. The hook is therefore rounded, not elongated like typical metal hooks.

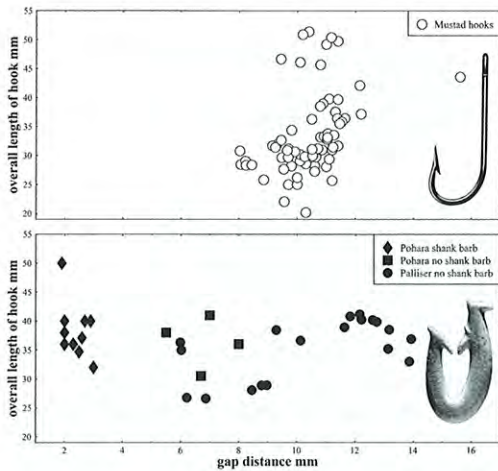


FIGURE 66

The gap between the point and leg (x-axis) compared to overall hook size (y-axis) for samples of modern and ancient fish hooks. Upper: Six different types of Mustad hooks, the one illustrated is Mustad Norway #34968. Lower: Samples of Pre-European Māori fish hooks from Pohara and Palliser Bay. The gap in the illustrated hook from Pohara is 2 mm.

¹¹ These Mustad hooks are all size 1. Six different types of hook are included in the sample plotted.

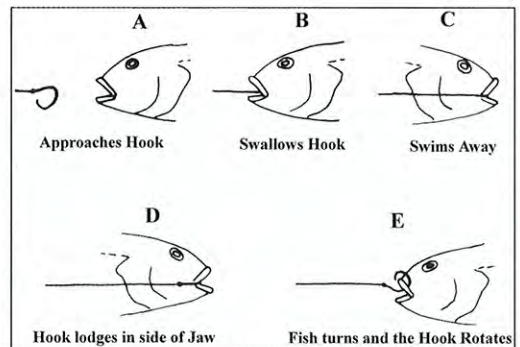


FIGURE 67

The rotating hook theory (after Leach 1973: 59).

Is this theory correct? It has never been observed under water with real fish using replicas of rotating hooks, so it remains only an untested theory¹². I have tried fishing with rotating hooks, using a series of replicas of a shell rotating hook (Figure 68), based on those found in excavations in Palliser Bay at the Washpool (Leach 1979b: 109) and Black

¹² The description which I published (Leach 1973) was pure speculation, and not based on any observation or influence from published or unpublished inferences by anyone else. It was simply an 'educated guess'.

Rocks (Anderson 1979: 57). These hooks do not have a shank barb but do have incurved points and with their short leg qualify as rotating hooks. Several types of fishing grounds have been tested, including those dense with blue cod (which has a big mouth) and banded wrasse, spotties and scarlet wrasse. Attempts were made to jab the hooks to seat them (contradicting the rotating hook theory), as well as leaving the line slack so the fish could swallow it whole uninterrupted. On all occasions bait was readily and consistently removed from the hooks within seconds. Despite numerous attempts to catch fish with these replicas, not one fish has been successfully hooked. It must be concluded that this theory about the functioning of the rotating hook remains a theory only, and requires far more research.



FIGURE 68

A sample of replica shell fish hooks based on examples from excavations at the Washpool and Black Rocks in Palliser Bay. They were made from pāua shell (*Haliotis iris*), and the two-ply cordage was made from New Zealand flax (*Phormium* sp.).

Some European metal hooks do have similar characteristics to the Māori and Polynesian rotating hook. One well known example is the *Mustad tuna circle #3997L* hook, which has an incurved point and short leg. These hooks are also known as either 'Circle hooks' or 'C' hooks, to distinguish them from the more familiar 'J' hook, which has a longer shank and a straighter upward facing point (Figure 69).

Experimental research on these hooks might shed some light on their different catching characteristics (as a proxy for the pre-European Māori forms). In one study (Orsi *et al.* 1993) in southeast Alaska, which was aimed at trying to reduce the mortality of undersized by-catch of salmon, it was found that C-hooks lodged in the periphery of the mouth more frequently than J-hooks, and wounds

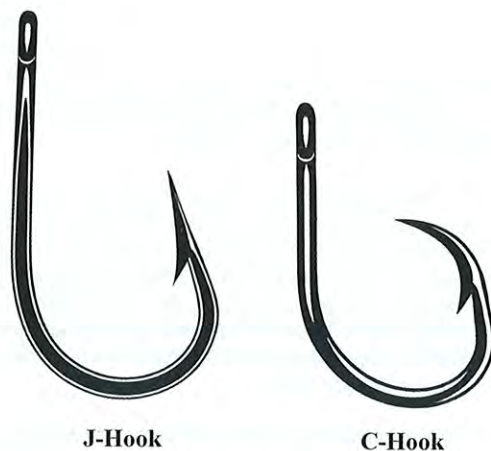


FIGURE 69

Modern European steel hooks. Left: the 'J' hook (example: Mustad - Southern and Tuna #7691); Right: The 'C' hook (example: Mustad Tuna Circle #3997L).

in this area had a lower mortality. In addition, C-hooks caught twice the number of fish as J-hooks. One especially interesting find relates to the size of the two types of hook and what fish they caught. In the case of J-hooks, small hooks caught more fish than large hooks¹³. However, in the case of C-hooks, the largest hooks caught more fish than smaller ones. Admittedly these experiments were carried out with hooks disguised in various lures, and were targeting a species not found in pre-European New Zealand, so they may not have any direct relevance, but it does serve to point the direction that research into these pre-European hooks might take.

A similar study, carried out in the Bay of Biscay off the coast of France, was inspired by South Pacific examples of traditional hooks with incurved points (Forster 1973). They chose size 6/0 hooks with the same patterns as those shown in Figure 69, and fished in 800 to 3,600 m depths with 1 m long snoods¹⁴ at 10 m intervals, alternating between one form and the other. They caught 14 species of fish,

¹³ Experimental research on hook size shows that while small hooks may often be ejected from the mouth, once a fish is hooked they are more likely to stay hooked than if a larger hook is used for a particular species (Shimizu *et al.* 1993).

¹⁴ The term 'snood' is here used to refer to the short piece of cordage between the hook and the main line being used by a fisherman. However, it is sometimes used to refer to the often complex method of attaching this line to the actual hook itself.

and the C-hook caught far more fish than the J-hook (93 and 58 fish respectively). The discrepancy was most marked in the case of gadoid species (cods). They hypothesised the following explanation of the functioning of the incurved point:

For the incurving hook to function there must be some slack in the line or snood, allowing the fish to move away with snood trailing. At the end of the slack the fishes head is pulled around and the hook (providing the point has engaged) makes a half turn usually in the corner of the mouth. Once one of these hooks is engaged it is very difficult for it to be shaken out (Forster 1973: 751).

This explanation is very similar to the *rotating hook theory*, cited above, but is obviously not based on any direct observation, in view of the depth at which these hooks were used. What is important in this research is the fact that the C-hook was so effective in long-lining, which is effectively passive fishing. The J-hook is more effective as a *jabbing hook*, which the fisherman seats into the fish's mouth when he feels it nibbling on the bait. The observations already made above about the use of cordage made of flax fibre, which is insensitive in communicating information from the fish to the fishermen, might suggest one of the reasons why the C-hook was so popular amongst Pre-European Māori. Further information about the passive nature of fishing with rotating hooks is provided by Nordhoff, who was encouraged by H.D. Skinner in 1928 to record observations about fishing in the Society Islands before old customs completely disappeared (Nordhoff 1930: 137). He had this to say:

In one respect the use of all these in-curved or angular native hooks differs from that of ours. When the fisherman using a European hook "gets a bite", he strikes to set the point and barb in the fish's mouth. With the native hook, on the other hand, one must never strike; a steady gentle tension is kept on the line and the fish allowed to hook itself. The pull of the line, leading from the *inner* head of the shank and causing the hook to revolve, sets the point deeper and deeper in the fish's jaw (Nordhoff 1930: 156).

This observation related to the very large wooden hook used for deep water fishing of *palu*, the ruvettus or oilfish. It is not quite the same as fishing in relatively shallow water with small shell or bone C-shaped hooks. When fishing in deep water, as noted above, the heavy sennit lines make use of jabbing hooks impossible. Similar comments

about fishing for ruvettus have been made by Powell (1964) for Rarotonga. He argues that the incurved-point hook was developed precisely because of the insensitivity of sennit lines in deep water. He suggests that ruvettus fishing was undertaken at depths of up to 500 fathoms (914 metres), and that even on a fine day there is a normal lone ocean swell so that the canoe rise and falls. In these conditions it is impossible to feel any fish biting. In addition, trying to seat a hook by jabbing is ineffectual because of the elasticity of the line, and the fact that it will form a curve down to the bottom. Attaching a large sinker might help, but it would have to be very heavy and therefore not easy to pull up. Polynesians developed several ways around this problem, such as using a 7 kg stone lightly attached to the bottom of the line which was released when the line reached the bottom or when a fish struck the hook:

The hook depends on rolling through part of a circle when pressure is applied to the point and operates so that when the fish seizes the bait the hook is swallowed to the back end of the mouth while the fish moves off with a trailing line. If the line is struck at this time, the hook will be pulled out of the mouth easily. If, however, the fish is allowed to move off with the leader trails behind, the fish will at a certain moment pull against the tightened line, pulling the hook down into the corner of its mouth, or the top edge of the jaw is forced between the hook's shank and its point. If the line is kept steadily taught at this position the fish will change direction so that it swims at right angles to the line. In this position all the pressure bears on the hook's point and it rolls through a part circle coming out very often through the top of the head or the side of the jaw (Powell 1964: 288).

Although these comments are about ruvettus fishing, they are certainly useful observations, and may be partly appropriate to small circular shell hooks too. Unfortunately we do not know if these were direct observations, or from questioning old informants, since sennit lines of such length are unlikely to have been still used in 1964.

Although museums have very large quantities of stone sinkers from pre-European Māori archaeological sites, virtually nothing is known of their functional characteristics. The 7 kg example, cited above, provides a clue on the need for a heavy weight to take a line down any depth of water. It is probably not widely appreciated outside the circle of fishermen that stone is an appallingly bad sinker in sea water. The specific gravity of sea water

($\rho=1.025$) offers greater buoyancy than fresh water, and modern fishermen are used to their lead sinkers ($\rho=11.34$) plummeting to the bottom with nylon lines. Attach the same lead sinker to a 30 metre long line made of three-ply flax and it will be nowhere near as fast through the water. Replace the lead sinker with a stone sinker of the same size and it might never take the line down 30 metres because not only does the line have vastly greater friction, but it also has buoyancy. Increasing the weight of the stone sinker is necessary, but that is a mixed blessing because it also increases its surface area, providing further friction. Since the specific gravity of stone is less than one-quarter that of our familiar lead sinker, you will begin to appreciate the problem. The shape of the sinker will also have an important bearing on how fast it will reach the bottom and what it is like pulling it up again. No wonder some Polynesian fishermen are known to have invented a way of detaching their stone sinker once it got to the bottom. The sad fact is that most types of stone have a low specific gravity of about $\rho=2.7$, which is the same as aluminium. If you imagine attaching a block of aluminium to your three-ply fishing line you have a fair reflection of what pre-European Māori faced. So, choosing which rock type to use is important. Granite, for example, has a specific gravity of $\rho=2.69$, whereas basalt has $\rho=3.01$. This small advantage must be offset against another problem with using stone for sinkers – it is not easy to attach a line to a stone. Most modern fishermen will be familiar with this problem, when they have thrown their last piece of lead into the sea, and are forced to try tying rocks on to a line. Pre-European Māori used another harder stone as a hammer to laboriously peck a groove around their stone sinkers to help keep cords attached to them. There is much that can be learned from the numerous stone sinkers which we have in museums – there will be excellent reasons for the choice of stone type, the shape of the stones, and their weights and specific gravities. Hamilton illustrates a fishing sinker made of stone with a horseshoe carefully tied on to the outside of it (Hamilton 1908: 54, fig. 55). This would greatly increase its ability to sink (iron $\rho=7.8-7.9$).

Another aspect of the pre-European Māori rotating hook only appreciated by modern fishermen in relatively recent times is that it has more efficient penetrating power than most traditional forms of European metal hooks. This is illustrated in Figure 70, and is easily tested personally by put-

ting the finger of one hand gently on the point of each of these hooks in turn, and holding the snood attached to the eye of the hook in the other hand. The hook will naturally resolve the two vectors of force by rotating, at which point you can observe the direction in which the point of the hook is facing. The two vectors are drawn in Figure 70 – one shows the direction of the line pulling the hook, and the other shows the direction of penetration of the hook. In the case of the pre-European Māori hooks, both the rotating and jabbing hooks show vectors which are equal and opposite, and therefore fully efficient in ensuring that all the force on the line is translated into a force penetrating the jaw of the fish. However, for the Mustad Norway hook, so typical of almost all European metal fish hooks until recently, the angle of the point is approximately 30° from the angle of the snood line and the penetration efficiency is reduced to about 87% (i.e., Cosine 30°).

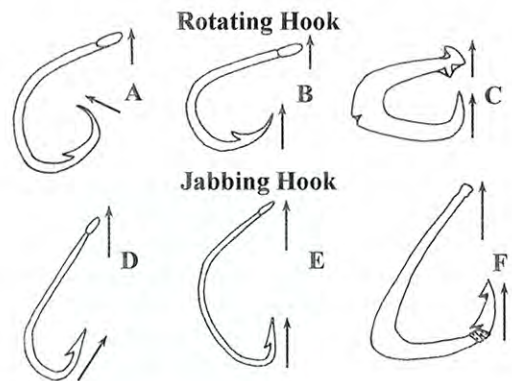


FIGURE 70

Penetration efficiency of various hook designs (after Leach 1973: 59). A: Mustad Tuna Circle #39960ST, B: Mustad Special Tuna #399L, C: Typical pre-European Māori rotating hook, D: Mustad Norway #34968, E: Mustad Wide Gap #37140, F: Typical pre-European Māori jabbing hook.

While early European explorers into the Pacific region might have been astonished at the peculiar circular form of fish hooks being used by the indigenous peoples, the realisation that pre-European Māori and other Polynesian hook forms have superior ability to hook fish has led to dramatic changes in modern hook manufacture. Pottier de l'Homme recorded during de Surville's voyage to New Zealand in 1769:

Their lines, or rather their hooks, are pieces of root shaped as in Plate Number 10¹⁵. To one end they attach a very sharp fish bone, the point of which bends inwards following the shape of the wood; I doubt whether they catch great quantities of fish with this implement (Ollivier & Hingley 1982: 134).

In 1777, Anderson expressed a similar view:

They [Māori] live chiefly by fishing, which they do either with nets of different kinds or wooden fish hooks pointed with bone but so oddly made that a stranger is at a loss to know how they can answer such a purpose (Anderson 1967: 811).

Pottier de l'Homme and Anderson, have, on the contrary, eventually been proven wrong; for although the materials from which Māori hooks were made are inferior in many respects to tempered steel, the superior form of their hooks is now being finally appreciated. Sales figures of different types of Mustad hooks clearly show this. The traditional J-hooks (Norway and Kirby) declined from 90% of the market in 1987 to less than 10% in 1990. Conversely, sales of the Mustad Wide Gap hook and the EZ hook (Easy baiter circle hook) dramatically increased over the same period from about 10% to 90% (Løkkeborg *et al.* 1993: 43).

This functional superiority has been backed up with results from experimental research on the two forms of hook in the laboratory. The traditional J-hook gave a probability of catching cod of about 15%, compared to 36% for a hook with incurved point (Mustad Wide Gap hook). When the latter was used in commercial fishing trials, the catch rate increased by 17%. Similarly, the second form of incurved pointed hook (EZ Easy Baiter Circle) also gave significantly greater catch rates in long line fishing at sea. This is attributed to the point being in the same direction as the line of pull (Løkkeborg *et al.* 1993: 43).

When considering the function of these hooks it must not be forgotten that (trivial stylistic features aside, no matter how important these may be for magico-religious observance) whether a particular hook form and size will or will not catch a fish and how frequently, does depend to some extent on the species of fish itself, its behaviour towards these hooks, the bait which is on them and its size (Fernö *et al.* 1986; Løkkeborg 1991; Fernö 1993). To my knowledge, systematic research on fish behaviour towards baited hooks has not been

carried out for New Zealand species, with either modern hooks or copies of pre-European Māori ones. This requires use of scuba gear and underwater video filming and the capacity to bait different kinds of hooks quickly and lower them to the bottom. In this way research can also be carried out on the effectiveness of different kinds of bait (see for example Johnstone & Hawkins 1981). An example of the different behaviour of two species towards baited hooks is shown in Figure 71.

In this illustration:

- B= Bite, the fish takes in the baited hook and closes its mouth
- P= Pulling, the fish swims slowly with stretched snood with the baited hook in its mouth
- C= Chewing, the fish chews on the baited hook
- J= Jerk, the fish moves its head rapidly sideways with the bait and hook in its mouth
- Js= Jerk series, the fish performs several very fast jerks in succession from side to side with the baited hook in its mouth
- R= Rush, the fish accelerates rapidly with the baited hook in its mouth
- S= Hook out of mouth, the hook with or without bait is spat or pulled out of the mouth
- H= Hooking, not a behaviour pattern. The fish was considered hooked when the hook was retained in its mouth for 20s while the fish was struggling (Huse & Fernö 1990: 290).

In the case of cod (*Gadus morhua*), 139 bites are recorded in the flow chart in Figure 71, and we can see what happened in each case, finally resulting in 15 hooked fish (10.8%). For haddock (*Melanogrammus aeglefinus*), there are 46 recorded bites and 23 fish were hooked (50%). This type of experiment has been carried out for different hook types (a total of 19,500 hooks). Of interest here is the fact that two different versions of hooks that possess the characteristics of the pre-European Māori rotating hook out-performed the standard jabbing hook (Huse & Fernö 1990: 294). These are the so-called 'Rush' hook, and the Mustad Wide Gap 5/0 hook. Both these hooks have points which are incurved towards the shank. The same result has been obtained with long-shanked hooks, one with the point curved inwards towards the shank and the other without, on dogfish catches (*Squalus acanthias*) off the Shetland Islands in 20-50 m depth. A sample of 2,400 hooks of each type were tested, catching a total of 1,067 fish. The incurved hook gave 18.6% greater catch (Hamre 1968).

¹⁵ This shows a wooden-shanked two-piece rotating hook.

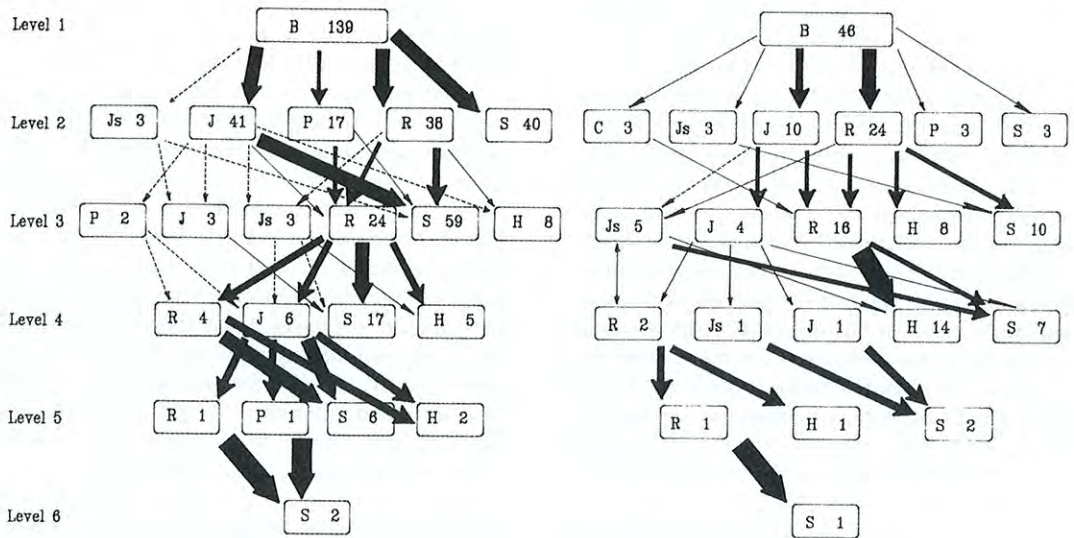


FIGURE 71

Behaviour flow chart of two different species taking a baited hook. Left: Cod (*Gadus morhua*), Right: haddock (*Melanogrammus aeglefinus*), after Huse & Fernö (1990: 292-291). See text for explanation. Courtesy of Elsevier.

There are many factors involved in assessing the effectiveness of different hook forms and baiting methods (Løkkeborg & Bjordal 1992), and there is disagreement about how best to interpret the complex data produced from experimental research (Kenchington 1993). Fish may have strongly diurnal feeding patterns and their behaviour towards baited hooks therefore varies through the daily cycle (Løkkeborg & Bjordal 1989). It also varies through the tidal range and seasonally. The presence of other species affects behaviour, and also different sized fish behave differently. Above all, prior experience with hooks has a dramatic effect on fish behaviour and this is one of the main problems in carrying out useful experimental research in New Zealand, where conditions are now so far removed from those of pre-European times. The inshore fishery has been massively depleted by commercial and recreational fishing in the last 150 years since Europeans arrived here¹⁶. Useful experiments with replicas of pre-European Māori fish hooks would only be meaningful if carried out in a fishing reserve, where fish had been left alone for several (fish) generations. Such fish suck the whole bait into the

mouth, whereas fish which are hook-shy make incomplete bites, very often as a conditioned response to bad experiences in the past.

Fernö & Huse (1983) provide some very useful documentation on changes in fish behaviour towards hooks from their experimental research on cod in an aquarium¹⁷. They carried out two experiments, one lasting 10 days with 15 cod from offshore trawls, and the second lasting 17 days with 20 coastal cod. Five trials were made each day using a barbless Mustad Norway #6 hook. They used a similar recording protocol as Huse & Fernö (1990: 290), which is described above and ranged through several stages of the sequence from initial biting to being hooked or releasing the hook and bait. The fish were not fed during the period of these experiments. They found considerable variation in the behaviour of individual fish towards hooks. Two fish exhibited no behaviour at all towards hooks. Of the 27 fish which showed responses to the baited hook, 21 made at least five sequences, 11 fish made more than 20 sequences, and one fish made 413 sequences (slow learner?!). They found that

¹⁶ The extent of pre-European Māori impact on the fishery will be discussed in sections 7 and 9.

¹⁷ It has been pointed out that there are important differences between fish behaviour relating to baited hooks in the open sea and that in aquaria (Løkkeborg *et al.* 1993: 43). Research results can therefore only be applied to the open sea with due caution.

most hookings took place in the first 3 days, and slowly decreased in frequency after that. Ten fish were never hooked, 11 fish were hooked twice, one fish was hooked three times, and two fish were hooked four times. Overall the hooking probability was 25% on the first strong response by the fish.

The most important finding of this research was that the intensity of behaviour responses to the hook and bait decreased over time, regardless of whether a fish was hooked or not. Physical stimulation from the hook was regarded as the most important factor in this decreased response. Even though the critical stimulus for this conditioned response was probably the hook itself, the fish did not seem to be able to distinguish between the hook and the bait. After this conditioning had set in, bait without hook was tested, and the fish showed the same reluctant and low intensity behaviour. In this respect, the form of the hook is of great importance, in particular how sharp it is and where any sharp projections are. Fernö and Huse make the following observation:

In many Pacific types of hooks, the point is bent heavily inwards so that the hook almost forms a circle or a triangle. This hook shape may decrease the probability that a fish comes into contact with the point of the hook and thus experiences aversive stimulation when biting which in turn could lead to a greater number of strong responses and higher percentage of hooked fish. Such an effect could combine with a higher hooking probability when fish rush on a bent hook as opposed to a straight hook (Fernö & Huse 1983: 27).

This decrease in response to baited hooks, although well known, is not well quantified for different species, but does appear to be highly variable. For example, Beukema (1970) has shown that one single hooking experience makes carp (*Cyprinus carpio*) more difficult to catch for at least a year. The main point is that experience with hooks makes fish less vulnerable to capture by this method. Another aspect of aversion behaviour of fish concerns the fishing line itself. It has been shown that by adopting monofilament line for long line fishing in place of multi-twine line, the catch rate for cod increases by 40 to 300% (Huse & Karlsen 1977, cited by Fernö & Huse 1983: 27). There are at least two possible causes for the aversion of fish to multi-twine line compared to monofilament – one is that the avoidance is because of prior association with baited hooks, and another is initial avoidance of novel prey attached to a more visible

line. Whatever is the case, pre-European Māori baited line fishing was at a distinct disadvantage, because highly visible lines were being used.

Another aspect of fish behaviour that has a bearing on catch rates is the response to the use of wooden spreaders with multiple baited hooks. These devices are well documented amongst Māori fishermen during early historic times in New Zealand (see for example Best 1977: 25, fig. 8), but would be difficult to document in the pre-European era unless intact specimens were found in swamps or dry caves. Many species of fish have been observed making rapid and intensive movements which stimulate feeding behaviour. A fish that has been hooked starts to fight vigorously, and this has been shown to stimulate other fish to attack neighbouring hooks (Johannessen *et al.* 1993: 49). Another aspect of these spreaders (and long lines too) is the length of the snood. A balance must be reached between the likelihood of the snood becoming tangled if too long, and the fact that catch rates fall if the snood length is decreased too far (Lee *et al.* 1990: 48). Many bone and shell hooks with snoods attached were collected by early European explorers to New Zealand and are now in museum collections. These offer useful research opportunities for the future.

The way in which a fish pulls against the snood has been studied in some detail (Lee *et al.* 1989). This research has indirectly shed some light on a possible reason for the incurred design of many pre-European Māori hooks. Lee *et al.* studied the behaviour of a species of fish (walleye pollock, *Theragra chalcogramma*) in an aquarium, recording the movements of the fish during capture with a baited hook with a video taking 30 frames per second. The steps in the process closely followed those documented by Huse & Fernö (1990), described above. However, at the moment the fish was actually hooked, Lee *et al.* carefully recorded the angle of the snood, and the angle of the fish's head moving away from the hook. They also recorded the velocity of the head movement in cm/s, and the force on the hook in newtons (kg.m/s²) with a strain gauge attached between the mainline and the snood. The results of this study that are significant for the present discussion about ancient forms of hooks are summarised in Figure 72.

The upper part of this Figure shows a plan view of a fish with a hook (schematic only) caught in its mouth. The several lines on the left are recordings of the various angles between the snood and the longitudinal axis of the fish, when

individual fish were being hooked. This angle is labelled α . The thick line is the mean angle of the snood, 55.4° . On the right hand side several vectors are shown, which are recordings of the angle at which the head was moving at the moment of hooking. The length of each arrow indicates the velocity of this movement. This angle is labelled β . The thick line is the mean angle of this vector, 79.7° . It should be obvious that the greatest possibility of the sharp point of the hook penetrating the flesh of the fish is when the point is facing exactly the opposite direction to the movement of the head away from the hook. This is where the shape of the hook becomes extremely important. In the example shown here, it will be observed that the point of the schematic hook is not in the opposite direction to the mean vector on the right hand side, and is therefore very inefficient. In this schematic hook, the line of the point is exactly the same as the shank, that is 0° . For the point to be facing in the opposite direction to the vector on the right hand side, the angle between the shank and the point would have to be $180-(\alpha+\beta)$, which I will call θ .

So, the fish hook most likely to penetrate the jaw of this species of fish and hook it is one which has the optimum angle between the shank and the point that conforms to the predicted behaviour of this species. In the lower part of Figure 72, the recorded hookings, $N=19^{18}$, are presented as a scatterplot, with the angle θ on the x axis and the velocity of the fish's head on the y axis. The mean value of θ is 45.0° ; the mean velocity was 75.7 cm/s. The mean force was 4.3 newtons. Above the scatterplot a bar graph is given, combining the results into groups in an effort to show the pattern more clearly. There is a central tendency in the band between 40 - 60° . Above each bar the average velocity in each band is given as a number, and this also indicates something interesting – that there is a central tendency in this too, with the highest velocity occurring at the optimum angle. This reinforces the conclusion that the highest probability of a hook penetrating the fish's jaw is in this same band of angles. Above the bar graph are schematic drawings of what a fish hook would

look like with these various angles between the shank and the point. In the band between 40 and 60° , the mean observed successful hookings was at 54.3° .

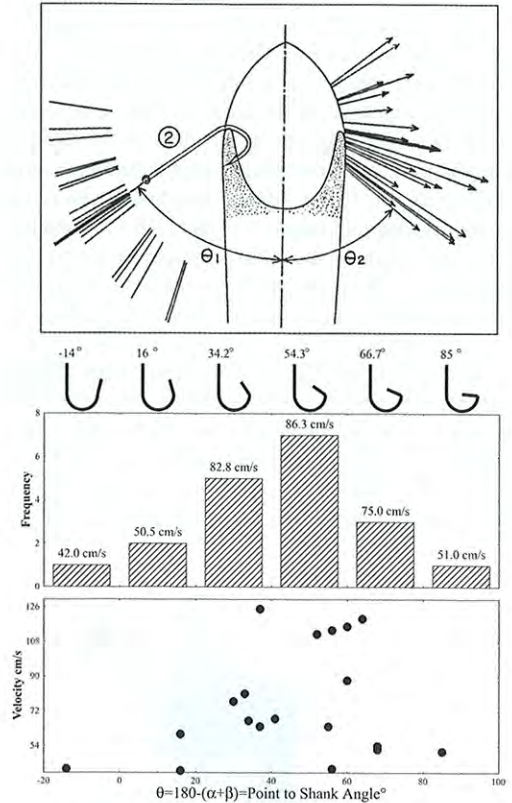


FIGURE 72

Upper: snood and head movement angles of fish during hooking (after Lee *et al.* 1989: 1556). Lower: analysis of angles and fish movement during hooking. See text for explanation. Courtesy of Chun-Woo Lee.

This research provides compelling mechanical evidence of why a hook with the point facing inwards is much more likely to catch a fish than the traditional Mustad Norway hook with its straight shank and straight upwards-facing point. Of course this research relates to a particular species and it is very likely that the behavioural details of strike angle, velocity and force will vary from one species to another. But this research gives us an insight into why pre-European Māori made their 'rotating hooks' the way they did – to improve the chance of a fish being hooked.

¹⁸ It may be thought that this is a small number of observations. However, obtaining these results was a formidable undertaking. Altogether, 974 observations were made of a fish approaching the baited hook. In 629 the fish tasted it, in 260 it took a bite, in 229 it spat it out, and in only 35 did it steal the bait or get hooked.

So much for the apparently peculiar shape of many of these hooks found in archaeological sites. It is only in the last 20 years or so that Europeans have finally discovered something which pre-European Māori knew a very long time ago. Where this technology arose and how it came to be in New Zealand is beyond the scope of this Section. From the time of Captain Cook, when iron, copper and other metals began to find their way into New Zealand, Māori took no time to recognise the superior qualities of this new, malleable yet durable material, and quickly abandoned bone and shell in its favour for making fish hooks and other items of material culture. Yet they did not abandon their own fishing technology, superior to that of Europeans. They continued to fashion their fish hooks according to the shapes which had served so well for many centuries, but used metals in place of shell and bone (Figure 73). One aspect of this, unstudied to date, is what else Māori did to iron, in addition to bending pieces into the shapes they desired. A thin piece of untempered iron does not make a very suitable hook and easily bends with a decent sized fish struggling on the end of a fishing

line. Māori in the early historic period also used pieces of copper to make fish hooks. These would be useless unless tempered in some way, such as work-hardened. Did Māori temper the newly made metal hooks after forming them into a hook shape? Pre-European Māori were thoroughly familiar with the use of fire for tempering nephrite, which greatly increases the hardness of tools made from this material (Beck 1981). It is but a small step to apply this existing technology to fish hooks made from iron after it was discovered how easily they bend when strain is applied. As well as being familiar with their own tempering technology, Māori were very quick to adopt new ideas from Europeans. Many early European visitors, not just blacksmiths, would have known of the principle of tempering iron. Museums in New Zealand and abroad have abundant examples of early historic Māori metal fish hooks, offering opportunities for future research to see if tempering was employed.

ATTRACTING FISH - THE USE OF BAIT AND LURE

So far, I have only considered the technology required for the most basic items of material culture for some hypothetical pre-European fishermen. They are now equipped with fishing lines, nets and hooks. There are many other smaller things also required, such as stone sinkers, net floats, etc., but these require less technical knowledge and merit less discussion. When it comes to using fishing equipment it is often necessary to attract fish in some way so that they may be caught. One very common item used in the tropical Pacific for attracting sharks is the *shark rattle*. It is made by stringing together a number of half coconut shells on to a rope made from vine or thick cordage. These are shaken in the water beside the canoe and are very effective in attracting sharks, which can then be captured by a number of methods. It is thought that noise in the water simulates struggling fish and it is this which attracts sharks. Sharks are cartilaginous fish but teeth and quantities of calcified vertebrae are regularly found in archaeological sites. The absence of bones makes it difficult to estimate relative abundance of sharks in archaeological assemblages, but we do know that elasmobranchs (sharks, skates and rays) were caught by pre-European Māori. Whether or not they were attracted using some equivalent of the Pacific shark rattle made

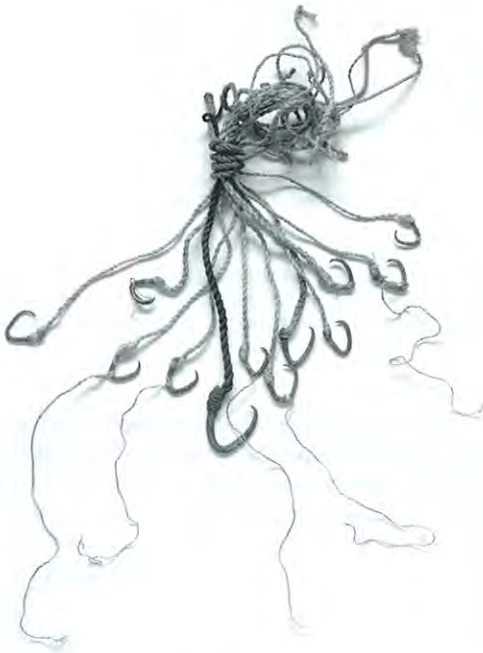


FIGURE 73

Nineteenth century Māori fish hooks made from iron following the ancient rotating hook form with incurved point (based on Hamilton 1908: 45. Courtesy of Te Papa, negative #E3598).

from New Zealand materials in the absence of coconuts is a matter for conjecture. This attracting method has not been recorded amongst Māori during the period of early European contact. This is somewhat surprising considering how widespread shark rattles are in the Pacific.

Other species that are attracted by sound and movement are various off-shore pelagic fishes, such as albacore and tuna, which straggle southwards into New Zealand waters. These require moving live bait or artificial lures. On the northern parts of the east coast of the North Island, larger pelagic fishes such as swordfish are reasonably common. Once again, trolled live bait or artificial lures are required for catching these species. Not one bone of any of these pelagic fishes has been found in archaeological sites in New Zealand. No doubt a few will be found in the future, but the message here is clear – offshore pelagic fishing was either very rare or non-existent in pre-European New Zealand. This is further discussed in Section 10. Despite this, lures do occur in archaeological sites, and it is a matter of debate exactly what they were used for. Many species of fish are attracted to the vibration of an object being towed through the water, and some are attracted to an object which is red coloured. Barracouta will strike at just about anything towed through the water, and I imagine that if one tied some red cloth to a big toe and dangled this over the side of a moving boat it might attract unwelcome interest too. This example points to the fact that there is only a low level of technology associated with lure fishing compared with baited hook and line. That does not mean that pre-European Māori did not appreciate the subtleties of lure forms, but it does call into question just how many lures were intended for fishing and how many might have served some other function, such as decoration or magico-religious observance. I find it hard to believe that anyone would spend 100 hours carving a lure from stone and then risk losing it by trying to catch a mackerel. Hamilton included these stone shanks in a discussion of fishing amulets. He described them as *manea* (sometimes *whatu*) or charm-stones, and reported that they were often used, without a point and after appropriate incantations, to attract fish or “draw the fish from the fountains of the sea” (1908: 21).

Quite a few early archaeological sites contain lures made from stone, and the form of these is very reminiscent of the pearl shell trolling lure, so widespread in eastern Polynesia and there used for

catching tuna. These lures (Davidson 1984: 53, fig. 46) are made from a variety of stones including serpentine, slate, and argillite. Some are made from shell or bone. One especially interesting lure, found at the site of Tairua on the Coromandel peninsula (Figure 74), is reputed to be made of pearl shell, a species only found in tropical waters of the Pacific to the north of New Zealand (Green 1967). If confirmed by suitable scientific analysis¹⁹, this would imply that this artefact came with some immigrant Pacific Islanders to New Zealand. The lures more commonly found in New Zealand archaeological sites had a bone or ivory point attached to them. These points are less often found in archaeological sites. Some of the stone lures, particularly, are shaped like small fish, and hence they are sometimes called minnow lures. At Wairau Bar, 80 stone lure shanks were recovered (Duff 1956: 207). There are no ethnographic or historical examples of lures from New Zealand with stone shanks, although a related form with a round-sectioned shank of bone, usually moa bone, survived into the early historic period (Hamilton 1908: 33-34).

Making lures from stone was a considerable undertaking, and it is clear from ethnographic research in Polynesia that these items of material culture acquired their own *mana* (prestige) and endowed the owner with respect (Nordhoff 1930: 192). It is possible that some of these lures in New Zealand were symbols of rank, but the sheer number of them suggests that they were actually used in fishing also. Apart from tuna, some New Zealand species which could have been caught with them are kingfish, trevallies, kahawai and carangids. At the moment there is no obvious correlation between the archaeological occurrences of these lures and any species of fishes.

One special lure, which in the historic period was said to be designed to catch a particular species (kahawai), is a wooden lure with pāua shell inlay. Numerous specimens of these characteristic lures are in museums around the world. The bone point on them is quite distinctive, and as far as I am aware, not one has been found in an reliable archaeological context. These lures are not known from the late eighteenth century Cook voyage collections. Beasley (1928: 16) claims that the ear-

¹⁹ There are several ways that the supposed tropical origin of this lure could be confirmed. An obvious method would be to analyse the ¹⁶O/¹⁸O ratio to determine the water temperature in which the organism lived.



FIGURE 74

Centre: The lure shank (catalogue number AU1785) from Tai-rua on the Coromandel Peninsula, reputed to be made from tropical Pacific pearl shell. The other six lure shanks, of similar form, are surface finds, made from local materials, from the collections of the Auckland War Memorial Museum. Photo courtesy of Roger Green.

liest reference to them is by Labillardière, off North Cape in 1793. However, although Labillardière's account mentions the use of feather lures, it does not describe the shape of the hooks to which they were attached (Labillardière 1800: 328). Crosby (1966: 148, 157) suggested that they originated in the Taranaki area on the west coast of the North Island and spread with the musket wars and tribal migrations of the early nineteenth century. Parts of a probable pāua shell plate were associated with other pieces of worked pāua shell in a context probably relating to Paremata pā, a nineteenth century Maori settlement in the southern North Island (Davidson 1978: 219, 221). It seems likely that many of these lures were manufactured in the nineteenth century as trade goods to meet the apparently inexhaustible demand by Europeans for artefacts from the South Seas.

Another lure, known archaeologically almost entirely from the bone point rather than the wooden shank, appears to have been made specifically to catch barracouta. Figure 65 illustrates a number of examples of points from Serendipity Cave, which also produced one wooden shank. These so-called barracouta points were made from a number

of types of bone and a specially distinctive form was made from the lower jaw of dogs. Large numbers of barracouta points have been recovered from southern South Island archaeological sites, where barracouta bones are also common. There is little doubt that this was the main purpose for these lures. Many wooden shanks are known from the nineteenth century with a metal nail in place of the bone point.

The most common form of lure for catching fish is some kind of edible bait attached to a hook. Clearly, we will never know what pre-European Māori used for baiting their fish hooks, but some clues can be found in the customs of early historic Māori. Buck, in his intensive study of the fishing activities of Māori along the East Coast north of Gisborne and also in the Bay of Plenty devoted an entire section of his report on the subject of bait for warehou. This deserves quoting in full:

The best bait is the flesh of the crayfish (Buck 1926: 625).

Elsewhere he notes that some types of fish traps were also baited, and in this case the cephalothorax of crayfish was used with the carapace and legs removed. Most people today would consider that baiting hooks and traps with crayfish flesh is a prodigal waste of delicious food; however, fish adore this flesh as much as humans, and in earlier days before the inshore stocks had been devastated by the taking of vast quantities for export, this would have been an obvious choice for bait.

It was mentioned above that I have carried out experiments with replicas of one-piece shell fish hooks to see how they functioned. One of the problems encountered was how best to attach the bait to these hooks. A common method used with steel hooks is to attach the bait to the barbed point, or to the leg containing the point. Some proper fishermen attach a sizeable bait, most of which hangs down from the elbow of the hook so that the fish swallows the bulk of the bait before encountering the hook itself. The fact that I have been unable to catch any fish at all with these replica shell hooks (Figure 68) could be because I did not know how best to attach the bait, having experience only with steel hooks. Unfortunately, there is very little historic or ethnographic information for advice on this point. Nordhoff made an interesting observation about baiting the hook for a type of albacore caught in deep water:

Very small fish are used whole; larger ones are *harara* (split), removing head, tail, and backbone. A whole small fish is placed on the hook by piercing, tail down, leaving the shank of the hook exposed and the point just breaking the skin of the head. Cut bait is sometimes similarly placed on the hook; sometimes tied on with thread. When tied on to the hook of native type, a fillet is placed on each side, and made fast just below the in-curved point, hiding the point, and allowing the tail ends of the two fillets to trail invitingly below. Then the baited hook, together with half-a-dozen small fish, or cut bits of larger fish, is made fast to a stone with the fisherman's hitch, and the whole dropped overboard (Nordhoff 1930: 157).

When the line hits the bottom it is jerked to release the stone and the chum on it, which also acts to attract fish. The second description with the two fillets is slightly ambiguous, stating that the two fillets are placed on each side. This could refer to one side of each of the two legs of the hook, or both sides of one leg. In any event, these are very large hooks, and the advice is not likely to be relevant to small hooks.

It can be observed in Figure 64 that 7 of the 15 hooks illustrated have a small notch immediately below the elbow. These notches are referred to as 'bait notches' by archaeologists. There are specimens collected in the late eighteenth or nineteenth century that have a thin piece of cord tied on to this notch, in addition to a thicker snood attached to the upper shank. It is assumed that the purpose of this cord is to assist with attaching bait to the hook, although there are no direct records of this. It could, for example, be a chum line, as described by Nordhoff above. If we accept that it is for attaching bait, it will be further noticed that three of the specimens in Figure 64 are notched slightly differently from the others with a small projection on the leg containing the point (items #5, 12, 14). One of these even has denticulations running above the notch on the point leg (item #5). If these notches functioned to tie bait on, then the bait would have been on the point leg because the cordage loop around the notch would slip away unless it was being wrapped around that leg. Moreover, the denticulations on the point leg could have given further assistance by holding the bait in place while fish tried to nibble it off. Modern fishermen are only too aware of how bait slips away from where it was placed on the hook after small fish have pecked at it a few times. Shell-fish bait, such as mussel, while excellent for attracting fish, comes off the hook very quickly unless

wound around the point and/or leg with thin cord such as cotton. Even then, the bait quickly slips down to the elbow of the hook, exposing the point, which is very off-putting for the fish. Denticulations along the edges are an effective way of stopping the bait from slipping. Some modern steel hooks have additional shank barbs which serve this useful purpose (e.g., Mustad Beak #92641, #92646, Best Kirby #3164E).

All of this is actually surmise. It is possible that the bait was attached at some distance underneath the hook and this notch was designed to assist that. In this way, the fish would swallow the bait first, followed by a piece of shell attached to it, without any sharp projections. Only when completely swallowed might the hook function by rotating in the margin of the jaw, enabling the point to penetrate the flesh of the fish. This, or course, is merely one surmise built on top of another surmise; and it underlines the need for some definitive research to be carried out on this unsolved problem. There are many examples of fish hooks made from metal by Māori in the early historic era, and a considerable number carry a thin line in addition to the snood. Hamilton provides several illustrations of these (Hamilton 1908: figs. 41, 43), and refers to them as bait strings, *pākaikai* or *tākerekere* in the Māori language. Some of these thin strings are attached to the elbow of these metal hooks and some are an extension to the snood. However, we should not leap to the conclusion that supposed bait strings on the much thicker shell and bone rotating hooks from the pre-European era functioned in precisely the same way as those found on metal hooks in the historic period.

TRANSPORTATION - THE CANOE

This volume is almost entirely concerned with fishing in the sea, but when it comes to water transportation, the ubiquitous canoe can serve several functions, on fresh waterways as well as on the open sea. However, there are limitations to how seaworthy a river canoe could be out at sea, especially in New Zealand waters which are quite different from the Pacific homeland of the earliest Māori immigrants. When it comes to fishing activities around the New Zealand coast, there are several quite different habitats requiring a different approach to transportation. For the present purpose, and at the risk of over-simplification, these habitats may be split up into the following:

- Estuaries at the mouth of major rivers, and deep bays with shallow tidal water
- Sandy beaches with low energy surf
- Sandy beaches with high energy surf
- Rocky coastline
- Small rocky islets and pinnacles within 1-2 km of the beach
- Open sea

The fish species available at these different types of habitat are obviously quite different, requiring different equipment, and also different transportation. On fine days without significant swell, fishing parties might venture out in a canoe more suited to rivers, using it to transport fishing gear including nets and pots to a well known fishing spot further along the coast somewhere, which would then be used as a base for fishing. This type of fishing expedition still takes place amongst tropical Polynesians today, and is for men only. They frequently use a cave or cliff shelter to rough it for a few days at a time. It is likely that many of the cave shelters around New Zealand with midden deposits are the result of this kind of activity.

Fishing from sandy beaches with seine nets requires no special transportation, and neither does fishing from rocky headlands. As soon as a group of men start to consider setting out to sea to fish pinnacles and small rocky islands within a few km of the shore, the local weather becomes the most important consideration. This determines what kind of canoe would be safe, and whether one can put to sea at all. In New Zealand, sea conditions can rapidly deteriorate, with calm seas turning into a maelstrom as a result. This was touched upon in Section 3 (see Figure 24). Having a seaworthy craft was therefore important.

The types of fish found in all archaeological sites in New Zealand consistently show that fishing activities were almost entirely carried out within a short distance of the shore, so any canoes that were used would have been designed mainly to fulfil this purpose. There are exceptions to this which will be considered shortly. In my experience in small Pacific islands, where people still use canoes for fishing, there are several functional attributes that are necessary for fishing within a few km of the shore. One of these requirements relates to the need to empty the canoe of water, because they frequently get swamped. One might think that a bailer is all that is necessary, but a bailer is useless when a canoe is swamped. In anticipation of this happening, small canoes designed to

go out to sea have a slanting floor at both ends. When the canoe is swamped, the men jump into the water and while treading water swing the canoe fore and aft, so that the water swills back and forth up this slanting floor, debouching over the end. When sufficient water has been emptied in this way for gunwales to appear, bailing can begin, even if for a time this must be done while the men are still overboard. Eventually, the men can get back into the canoe and complete the bailing. The point that I am making here is that if one finds a canoe with these sloping floors fore and aft, there is a good chance that it has been used for fishing out at sea.

Some canoes are known to have had special wooden covers lashed on to one or both ends. While this device may be useful for stopping wave slop from getting into the canoe, it has the unfortunate effect of prohibiting water from being removed from a swamped canoe in the manner just described.

Above all, to me the most curious thing about the canoes that are known from New Zealand is that almost none have an outrigger²⁰. Outriggers provide a dugout canoe with far greater flexibility and stability than a dugout by itself. Best has this to say:

It is evident that the outrigger gradually fell into desuetude in New Zealand. Cook and his companions saw it at two places only, and the early missionaries and settlers in these isles do not mention it at all. Polack, who resided in the Bay of Islands for some years in the "thirties" of last century, and also visited the east coast as far as Tolaga Bay, writes as follows: "Outriggers, invariably made use of by the South-Sea-Islanders, are unknown in New Zealand, and the canoes are never or rarely lashed together; nor are platforms raised over the gunwales, and sheds erected on them, as is the usage of the above nations" (Best 1976: 38, citing Polack 1840: 224).

There were only a few recorded sightings of outrigger canoes during Cook's voyages to New Zealand. During the first voyage, several were seen off Mahia Peninsula. Monkhouse on 12 October 1769 recorded "Here, were seen two Canoes with outlayers" (Monkhouse 1968: 575) and Parkinson added on 13 October 1769 "Several of the canoes

²⁰ A contrary view to this is given by Anderson in 1777 who, in describing canoes, states "Some are fifty feet long and so broad as to be able to sail without an outrigger, but the smaller sort commonly have one and they often fasten two together by rafters which we then call a double canoe" (Anderson 1967: 811).

had outriggers" (Parkinson 1972: 91). During the second voyage, Forster made the unlocalised observation 9 June 1773 "The single canoes have, especially when small & narrow, an outrigger fixed to the canoe by two transverse beams. They make very seldom use of a sail" (Forster 1982: 301).

Buck believed that the general abandonment of the outrigger in New Zealand was due to the fact that much larger trees are available in New Zealand (Buck 1929: 205), and while this might be reasonable if one was only interested in very large canoes, it certainly does not apply to everyday canoes when only one, two, or perhaps up to six people were going to sea for fishing. A large canoe requires a team effort by a considerable number of people just to launch it. Fishing in waters even close inshore with any kind of swell is not always safe in a small canoe, and the outrigger offers great advantages of stability and safety.

Archaeological evidence of the use of outriggers on canoes in New Zealand is rare. What appears to be an outrigger float was found in Monck's Cave, Banks Peninsula, measuring 1816 mm long and 82.6 mm maximum width, with holes for attaching three booms (Skinner 1924: 155, Plate XXV). Unfortunately, its age is not known. A second float, found in a swamp near Te Horo, north of Wellington, is very similar in form to the Monck's Cave one, but much larger, 4,343 mm long and 29.9 mm maximum width (Adkin 1962: 271-272). These two floats share a somewhat unusual feature – the method of attachment to each boom on the canoe appears to have been the same. There are holes for two pegs to be driven into the float, and held in place by rope passed through a pair of converging holes, which meet in the middle. This V-form of perforation is situated between the two pegs. In the Te Horo example there are five sets of these holes, each of which would have had a separate boom to the canoe. Of special note was the high degree of wear in the V-perforation for the 2nd and 4th booms. It has been suggested that originally there were only three booms (2nd, 3rd and 4th positions), but that two additional ones were added later (1st and 5th) when it was found that the outrigger float was suffering excessive wear and tear (Adkin 1962: 276). Buck considered that the use of three booms with the Monck's Cave specimen was extraordinary, considering how small the canoe that it was attached to must have been. In my view, the obvious explanation is that the rougher waters around coastal New Zealand compared to Polynesia necessitated greater strength of

attachment. The unusual method of attaching the float to the boom is illustrated in Figure 75.

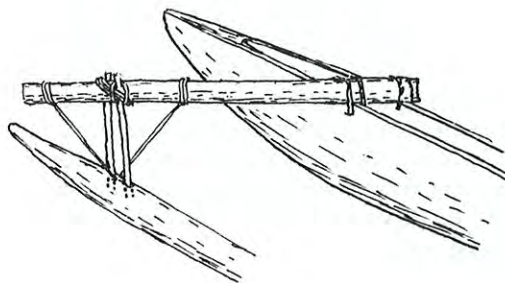


FIGURE 75

Buck's suggestion as to how the float found at Monck's Cave was attached to a boom (after Buck 1929: 212). A float from Te Horo (see text) would have been identical in this respect.

A canoe found in the Taieri river area of Otago provides additional evidence of outriggers. In this case the canoe is closed in at the top (a typical feature of many Polynesian outriggers), but in general is so narrow that it could not have functioned without an outrigger (Best 1976: 44). A second example was also found in the vicinity of the Taieri river, at Henley. It seems likely that this one was used on the nearby Waipori and Waiholo lakes in that vicinity. This canoe also has a narrow entrance. Once again the generally narrow cross-section of this canoe makes it unsuitable for use unless it possessed an outrigger. There are holes along the side which are thought to be for lashing booms (Best 1976: 41 ff.).

No doubt smaller canoes without outriggers certainly put to sea during good weather and were used for fishing. There are many examples of simple dugouts, generally thought of as river canoes, because that is where they are still found lying today after having been abandoned at least a century ago. A typical example is shown in Figure 76. This one was photographed in 1906 during the expedition organised by Major Brown (shown on the left of the photo) to examine cultural features in the lower Wairarapa area²¹. This canoe is about

²¹ Hoani (also spelled Hone) Paraone Tunuiarangi, later known as Major Brown Tunuiarangi was a chief in Southern Wairarapa who took an active interest in preservation of archaeological sites during the late nineteenth and early twentieth centuries (Leach 1991: 84). The incident with the canoe is recorded by Smith as follows: "After photographing a large canoe and a number of large hinakis on the lake shore we partook of lunch and afterwards proceeded to Whatarangi under the guidance of Major Tunuiarangi" (Smith 1906, cited by Davidson 2003: Document Bank page 969).

7 metres long and could easily have taken six or seven men and fishing gear. Most canoes of this kind do not have holes along the sides, which is the best evidence of side strakes. Adding side strakes to a dugout makes it much more suitable for being at sea, serving to raise the gunwales and avoid being swamped. Examples of this have been found exposed in beach sands at Mason Bay, Stewart Island (Gillies & Skerrett 1998). In this case many of the pieces are elaborately carved, suggesting an important canoe, rather than an ordinary fishing canoe.



FIGURE 76

A dugout canoe at Kiriwai, Western Lake area, South Wairarapa. Major Brown is on the left, unknown children on the right. Note the hīnaki for eeling in the nearby lake and river channels.

The type of New Zealand canoe that has attracted the greatest interest is the war canoe, a much larger vessel, capable of venturing considerable distances out to sea, but once again not a very suitable canoe to be in during any kind of rough weather. A typical example is shown in Figure 77. The upper part shows an illustration from the official report of Dumont D'Urville's visit to New Zealand 1826-1827 (Dumont D'Urville 1833: Tome 1, Plate 38, see also Wright 1950: facing page 65). The scene is at Astrolabe Bight, a small bay behind Adele Island in Tasman Bay. These early historic pictures were frequently copied by other artists who often took liberties with them, and one must be careful about examining details too closely in these copies. In the lower part is shown an engraving from an 1846 publication of Captain Cook's voyages to New Zealand (Anon. 1846: 149). In the latter, the man standing beyond the canoe could be mistaken for a European, but in the original he is more clearly a Māori wearing a rain cape. Simi-

larly, the man at the front of the canoe in the original is pulling the boat and has bare buttocks, whereas the later engraving shows him pushing and more decently clad. Finally, the setting has changed completely in the engraving. These early pictures can be a veritable gold-mine of information if authentic. The details of houses, elevated platforms for food storage, clothing, equipment lying about, etc., are all important clues about Māori life during the earliest stages of European contact. Despite the liberties taken by the artist in the later engraving, it is a beautiful action drawing, possibly showing greater artistic skill than the original.



FIGURE 77

Two versions of the launching a large war canoe at Astrolabe Bight, Tasman Bay. Upper: the original illustration in Dumont D'Urville 1833: Tome 1, Plate 38, entitled *Village à L'Anse de L'Astrolabe (Nouvelle Zélande)*. Courtesy of Te Papa, negative #E3473. Lower: An engraving from Anon. 1846: 149.

These canoes greatly impressed early European visitors. They were reputed to be up to 30 metres in length, and capable of carrying 40-100 men. They were highly decorated and fast in the water. Impressive though they may have been, they do not really qualify as fishing canoes, although no doubt they could be used for that purpose. Banks says:

The common fishing canoes had nothing but the face of a man with a monstrous tongue and whose eyes were generally inlayd with a kind of shell like

mother of Pearl in the fore part of them, but the larger sort which seemd to be intended for war were really magnificently adorn'd... They sometimes joint two small canoes together and now and then made use of an outrigger²² ... (Banks 1963 (II): 23).

These smaller boats, joined together, could well have been designed for fishing trips further out to sea. On February 15, 1770, Cook records four double canoes off Kaikoura with 57 men on board (Cook 1968: 252), and Banks notes that these canoes were further out to sea than they had ever seen canoes previously (Banks 1963 (I): 467). According to Salmond the distance was 15 to 19 miles (Salmond 1991: 262)²³. These four double canoes with 57 men on board would have a crew of seven men per hull on average. This strongly suggests fishing canoe size.

The first double canoe seen by Cook and his party was in the Bay of Plenty off White Island 2 November 1769, and the next day it followed them under sail (Cook 1968: 189-190). Banks comments:

Just at night fall we were under a small Island from whence came off a large double canoe, or rather 2 canoes lash'd together at a distance of about a foot which was coverd with boards so as to make a kind of deck; (Banks 1963 (I): 423).

Unfortunately there is no mention of the length of this vessel or how many people were on board. Banks described Māori as being expert paddlers of their canoes, but considered their sailing skills to be less expert; he comments:

But in sailing they are not so expert, we very seldom saw them make use of Sails and indeed never unless when they were to go right before the wind. They were made of mat and instead of a mast were hoisted upon two sticks which were fastned one to each side, so that they require two ropes which answerd the purpose of sheets and were fastnd to the tops of these sticks; in this clumsy manner they saild with a good deal of swiftness and were steerd by two men who sat in the stern with each a paddle in his hand. I shall set down the dimensions of one that we measurd that was the largest size: it was in length 68¹/₂ feet, breadth 5, depth 3¹/₂; this was the only one that we measurd or indeed had an opportunity of measuring (Banks 1963 (II): 23-24).

²² Beaglehole footnotes this word, and after some discussion suggests that this was probably a balancing platform on one side, rather than an outrigger. We will never be sure.

²³ The end of the Kaikoura peninsula is 42°25'28", 173°42'41", and at noon on 14 February 1770 they were adjacent to Kaikoura (Banks ed. Beaglehole 1963: 466), at 42°34'06", 173°56'54", which is a distance of 25.1 land km.

Beaglehole adds an editorial comment that he considered this description somewhat unclear, but it seems perfectly clear to me, and an illustration of it appears in Salmond (1991: 189). This is a large canoe with a large number of people on board. The illustration does not, however, appear to be of a double canoe.

The earliest description of a double canoe in New Zealand was made during Abel Tasman's brief visit here:

Their boats consisted of two long narrow prows side by side, over which a number of planks or other seats were placed in such a way that those above can look through the water underneath the vessel... (Salmond 1991: 79, quoting Muller and co. (eds) 1965: 19).

The drawing by Gilseman reproduced in Salmon (1991: 80) shows a flotilla of nine Māori craft in the background attacking the longboat. These are all clearly double canoes, showing two prows, and two rows of six paddlers in each. On the left there are nine more Māori craft. These are not nearly so clearly drawn as double canoes, but most may be. One canoe, however, bears a sail, and is quite plainly a single hulled canoe. Once again, they are drawn with six paddlers along one side. In the foreground, the detailed double canoe appears, showing five paddlers on the facing side, and four on the other. Two additional men could have steering oars; at least one of them certainly appears to be steering. Of interest is the fact that the man apparently steering is at the front of the canoe, facing the paddlers. This is contrary to Banks' description cited earlier.

The significant point to note here is the generally small size of these canoes. They are not typical war canoes and are much more like ordinary fishing canoes, designed to take six or seven men, and when two are lashed together twice that number. This would be a much easier vessel to launch and take to sea for fishing offshore and, more importantly, would be a more stable craft in choppy seas than a single dugout.

AFTER CATCHING THE FISH - WHAT NEXT?

At the end of a good day's fishing, there is still fish-related work to be done, a number of social niceties to be observed, and also some thought to be given to the possibility of hard times to come in the future, such as long term storage. In short, the

actual fishing part is only half of the story. It is the enjoyable part to be sure, and the reason men still go to sea, rough it by camping overnight in cave shelters, and then return to the village expecting to be met as heroes returning with a huge catch.

However, fish may require scaling and cleaning and large fish might require butchering and dividing up in a certain way to be distributed according to rank or other social considerations. The catch itself may need to be divided and shared amongst different families. Then there is cooking and eating the fish, and afterward discarding bones. Finally, some fish may be split and dried in the sun, or smoked, and set aside preserved for later times of hardship or in some cases traded for other commodities if there is an abundance. All of these activities are aspects of human culture which vary from one society to another and should not be taken for granted; with keen attention to detail some of these things have an archaeological signature. This final part of this Section then deals with these less tangible aspects of fishing technology.

Actually it is not always necessary or desirable to remove scales from fish. Fish can be baked whole, and the scales and skin lifted off whole and the flesh eaten. So it cannot be taken for granted that all catches were scaled. However, there is quite a lot of sound archaeological evidence of scaling fish amongst pre-European Māori communities. Probably the best evidence of this is when stacks of shells are found filled with scales, as was the case at the Station Bay Pā site, recorded by Davidson (Davidson excavation diary 23-12-1970). Similarly, I found abundant scales belonging to several species in the Washpool midden site in discrete lenses, suggesting scaling activities on the midden dump. Best records of early historic Māori that "a shell served as a fish-scaler" (Best 1924: 102), and this is verified by shells which show wear marks characteristic of scrapers from excavations of fish-rich middens. A good case is a salvage excavation at Raumati north of Wellington, where 130 tuatua shells were found with a distinctive concave wear pattern along the edge from some scraping activity. The site was a highly specialised midden with large quantities of shellfish from the open sandy beach and fish remains. The obvious interpretation is scaling. Since only right valves of this bivalve were retained for study, the number of scrapers at the site would have been considerably greater than those identified. The wear pattern is illustrated in the upper part of Figure 78. Some of the specimens show two concavi-

ties, one less shallow than the other. These could have been employed along the superior and inferior ridges of the fish, while the shallow concavities are more likely to have been used along the flatter sides²⁴.

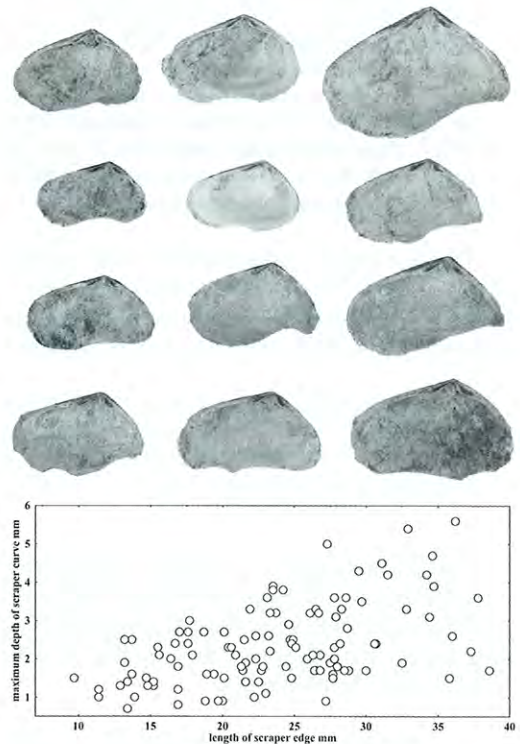


FIGURE 78

Upper: Some examples of tuatua shells from the Raumati site showing concave wear after heavy use as scrapers, presumed to be for fish scaling. Lower: A scatterplot showing progressive wear on tuatua scrapers from the Raumati site (Leach *et al.* 2000a: 27-28).

As these scrapers are used more and more, the width of the scraping edge increases along with the deepest part. This is illustrated in the lower part of Figure 78, which effectively shows the life history of these scrapers from their first use to ones that have had considerable use. It would be useful to carry out some experimental research scaling

²⁴ Terrell reported finds of pipi shells that had been used as scrapers (Terrell 1967: 63), but the illustrations of these show somewhat different wear patterns from those at Raumati. Although some may have been fish scalers, it is doubtful that all were so used.

fish with these shells to see how long it takes to accumulate the amount of wear observed on these specimens. It certainly looks like considerable wear and tear.

The assemblage of fish from the salvage excavation at Raumati was quite small (MNI=86). However, 14 families of fish are represented, although only 2 species were common, kahawai and red cod in about equal numbers (Leach *et al.* 2000a: 21). Kahawai are not often found in high abundance in archaeological sites. They are most likely to have been caught during the late summer, when huge shoals come into coastal waters to spawn (Ayling & Cox 1982: 222). Kahawai have large scales which are removed easily when the fish is freshly caught. However, soon after they dry out they are very difficult to scale. Only 13 sites in New Zealand show catches of greater than 2% abundance (Table 9).

A common method of treating fish in European society is filleting, that is, removing the flesh of the fish so that no bones remain. It is very unlikely that pre-European Māori filleted their fish. As far

are simply crunched up and swallowed. Most Europeans have an irrational fear of being choked by fish bones, and are very wary of having them in the mouth. Moreover, the head is considered a delicacy amongst many Polynesians, and given to high status people.

Regarding treatment of fish bodies by Māori, "Colenso explains that mackerel were gutted, and heads and tails were cut off; after which they were split into halves, steamed in a *hāngi*²⁵, dried on racks in sun and wind, then packed in large baskets for winter use" (Best 1977: 114). Although the earth oven was probably the most common method for cooking fish, they were also grilled over an open fire (Buck 1926: 634). Nicholas also refers to this method:

Their mode of cooking it [fish] was extremely simple. After cleaning the fish very carefully, they thrust a stick through it, which being stuck in the ground near the fire, sustained it till one side was roasted, when, the the stick being drawn up, and the other side applied in the same manner till it was sufficiently done, the whole process was finished (Nicholas 1817 (I): 236-237).

Name of Site	MNI all species	% Kahawai
Raumati	88	27.9
Foxton, Manawatu	270	18.9
Kohika, Bay of Plenty	184	12.5
Paremata, Wellington	147	11.6
Washpool Site, Palliser Bay	771	8.2
Kokohuia, Hokianga	844	7.2
Black Rocks BR3 Black Midden, Palliser	191	6.8
Mana Island South Midden	596	6.7
Te Ika a Maru, Base of Pa, Wellington	199	4.5
Mana Island North Settlement	1,206	3.5
Harataonga Bay	231	3.5
Black Rocks BR4 Crescent Midden Palliser	705	2.8
Hot Water Beach, Coromandel Peninsula	278	2.5
Houhora, Far North	2,425	2.3

TABLE 9
Kahawai in New Zealand Archaeological Sites.

as I know, the universal practice among Polynesians is to cook fish whole, and eat the flesh with the fingers. In my experience in small islands in the Pacific, people are extremely adept at avoiding small fish bones while eating and have no fear of putting flesh with bones in the mouth. Some bones

²⁵ This is an earth oven in which fire-heated stones are placed, then vegetation to protect food from being scorched, then baskets of food, followed by mats, then earth heaped over and left for a few hours. This is the common method of cooking throughout the Pacific region.

Nicholas was intrigued by another method of cooking fish which he had read in Savage's account of New Zealand, but never observed himself:

The fish being cleaned, is enveloped in a quantity of leaves of the cabbage, and bound about with tendrils; it is then laid upon a stone that has been previously heated, upon which it is occasionally turned, so that the steam extricated from the leaves serves the purpose of boiling water. The leaves being taken off, the fish is found to be well cooked and unbroken. I have tasted them cooked in this manner by the natives, and thought them excellent (Savage 1807: 60).

Furieux recorded in 1773 that the normal method of cooking fish was the earth oven, but they might be roasted²⁶ when people were in a hurry, as the following passage makes clear:

they never take the guts out, as they prefer them to the Fish, they like-wise spit them and place them round the Fire to roast, but this is done only when they are in a hurry (Furieux 1969: 739).

It will also be noted from this passage that Māori were particularly fond of the guts of fish. This is confirmed by Peter Bucks's observations about marblefish²⁷ whose guts were especially highly prized by Māori, particularly when the fish was fat, and specialised methods were used to catch them. He records:

The entrails of the *kehe*²⁸ become very fat in the right season, and are better esteemed by the local people than the flesh of the fish.

Hence, in the saying below, used as an invitation to a visitor, they make a display of hospitality and at the same time reserve the tit-bits for themselves:-

Hoatu ki te kainga,
Kotaku ika ki a koe,
Ko te ngakau ki au.

Go on to my home;
My fish will be for you
And the entrails for me
(Buck 1926: 620).

Few Europeans will eat even the flesh of the marblefish, considering it to be most unpalatable. Cook records of Māori in Hawkes Bay "some fishing boats came off to us and sold us some stinking fish" (Cook 1968: 177). Beaglehole footnotes this passage and states "Not necessarily bad fish: probably the standard Maori food, fish cleaned and dried in the sun, which had a strong smell and taste" (ibid. fn. 3). Strong smelling or strong tasting food is considered a delicacy amongst many societies. Buck records a practice of partially decaying crayfish called *koura mara*, literally crayfish steeped in water.

This is prepared by soaking the crayfish in fresh water for about three days if the water is warm, and four or five if it is colder. The test is the loosening of the shell. When it comes away easily it is termed *mahiti*. People used to crayfish will then eat them raw and enjoy them: the smell is worse than the taste. When thoroughly *mara* the fish separates into three parts – the *tuke*, *papa*, and *hiku*. The flesh of the legs easily separates and comes away with the *tuke*. The flesh is placed on a wooden platform and support and left to dry for a day. Two *tuke* are placed together (*karapiti*), beaten or pounded to stick together, and exposed for another day. They are again beaten, cooked in an earth oven and dried. When dry they are packed in baskets, and will keep for a year. The other parts are dealt with in a similar manner. The *papa* part is usually consumed by the family, but the *tuke* and *hiku* parts are kept in the storehouse for occasions. Crayfish preserved in this way, whilst very palatable, create a great thirst (Buck 1926: 630)²⁹.

Unfortunately, most of these behavioural details are not able to be inferred from archaeological sites, although preferential abundance of different body parts can provide clues on the treatment of fish after they were caught. Shawcross attempted to study this at the site of Galatea Bay in the Hauraki Gulf, and considered that up to three-quarters of the body of the fishes had been taken away elsewhere (Shawcross 1967a: 113-114, 128, fig. 5).

This was also suggested for the Purakanui site in Otago (Anderson 1981a: 219). However, this suggestion was not based on archaeological obser-

²⁶ Anderson had a slightly different view in 1777: "The only method of dressing their fish is roasting for they are entirely ignorant of the art of boiling" (Anderson 1967: 811).

²⁷ A vegetarian fish, abundant close inshore in weedy areas, *Aplodactylus arctidens*.

²⁸ Marblefish.

²⁹ This method of steeping food in water was applied to sweet corn when it was introduced into New Zealand by Europeans, and gained the name *pirau* or *piro* corn, meaning rotten corn, a practice more or less abandoned because of criticism by Europeans (Buck 1950: 111), but recently revised for the niche-food market.

ventions, but on more general considerations. From the squares excavated at the site, the total fish MNI was 2,745 (Anderson 1981a: 206); this is scaled up to 230,000 fish after estimating the total size of the site from test pits. It is further argued that the site was only used over a short period of a few years (Anderson 1981a: 217), and that 100,000 specimens of each of the two main fish species could have been caught in 278 and 87 days respectively by a single fisherman (Anderson 1981a: 219). Clearly, a few people living at this site for a short period could not consume such large numbers of fish. It is concluded that the site was therefore likely to have been a specialised site for drying and preserving fish for later consumption (Anderson 1981a: 219). This type of argument could be applied to many sites in New Zealand, and it should not really be put forward as a conclusion to be left alone at that point, but rather as a hypothesis requiring testing using archaeological techniques.

There are abundant ethnographic records of Māori preserving fish for later use or trade with other groups³⁰, but only hard won direct archaeological evidence. Banks observes the following of Māori in the South island:

To the Southward where little or nothing is planted Fern roots and fish must serve them all the Year. Here therefore we saw that they had made vast piles of Both, especially the latter which were dryd in the sun very well, I suppose meant for winter stock when possibly Fish is not so plentifull or the trouble of catching it greater than in Winter³¹ (Banks 1963 (II): 21).

Best also describes in great detail the capturing of large quantities of eels by Māori and their preservation by smoking or drying in the sun (1924: 114-115). Buck records marblefish being split in half and preserved (Buck 1926: 619, and also kahawai (Buck 1926: 622). Figure 79 shows a drying rack for fish sketched by Heaphy in the Hauraki Gulf in the nineteenth century.

³⁰ There is no evidence of salt ever being used by Māori for assisting with drying fish or as a preservative. Beattie asserts that 'old-time Māori' never used salt (Beattie 1994: 115, 182). Preservation of fish by drying or curing was not customary in most of tropical Polynesia. Apparently only the Hawaiians, who made salt by evaporation, were using it to cure both fish and pork at first European contact (Cook 1967: 279). Following European contact, they were quick to develop a trade provisioning visiting ships with salt and salted products (Kurlansky 2003: 125; 405).

³¹ This appears to be an error, as the fishing would be more difficult in winter.



FIGURE 79

Fish being sun-dried at Pakihi or Sandspit Island, near Thames. Charles Heaphy sketch, courtesy Auckland War Memorial Museum, negative #B4827.

Archaeological occurrences of drying racks are not common, partly because the stakes that were used for their construction were probably not designed for permanency. Some single lines of post-holes found in sites may have been drying racks, but have been incorrectly interpreted as one side of a dwelling. A double row of small paired post-holes, ten in number and 4.2 m long, at the Washpool midden site was interpreted as a drying rack (Leach 1979b: 82-83). Two further examples have been found during an excavation at Papāhīnu, an early nineteenth century Māori settlement in Manukau City, South Auckland. Like the Washpool example, both had a double row of postholes; one was 4 m long and the other 3.5 m (Foster & Sewell 1995: 28).

DISCUSSION

The main purpose of this Section has been to explore the knowledge base of pre-European Māori relating to fishing technology. This is not an easy task because the subject matter is essentially intellectual. However, it finds its concrete expression in the artefacts which people fashioned, and through them we can gain glimpses of the human mind. Much as I would like to have confined this discussion to things found archaeologically, this has not been possible. As so often happens with studies of pre-European communities in New Zealand and the wider Pacific generally, recourse is made to early historic literature to fill in gaps of understanding. In one respect this is perfectly

understandable; after all, as it is often remarked, the early explorers 'caught prehistory alive' when they first visited here. In addition, in some areas life continued much the same as it was before. However, great caution must be used in 'filling in the gaps' with historic ethnographic data, lest the whole attempt to understand the past merely becomes a matter of assumption rather than discovery. As much as possible, archaeology should always be concerned with discovery. Ethnographic information does have its uses though. For example, in this Section I believe it has been shown that canoe outrigger technology was vestigial at best by the time the first Europeans arrived in New Zealand. Given the widespread use of this technology throughout the Pacific region, and the likelihood that the first Polynesian immigrants were thoroughly familiar with it, there must be a good reason for its virtual disappearance over time. The obvious conclusion is 'no longer relevant'. This matter is intimately connected with fishing activities. The outrigger is something which brings stability to a dugout and enables far greater flexibility in where and when one can put to sea. The fact that outrigger canoes were not abundant implies that not a lot of fishing was done far out to sea.

In this Section I have dwelt on the functional attributes of the incurved fish hook to a considerable extent, paying special attention to information gained from studies of modern steel fish hooks. In my view we do not yet have a clear understanding of something that pre-European Māori took for granted every time they made and used these hooks. We do not yet know how they functioned, and attempts to observe replicas of them catching fish underwater have failed. This is an area crying out for intelligently designed research. The studies in Korea by Professor Lee and his collaborators, and those in Norway by Bjordal, Huse, Fernö, and

Løkkeborg, have put up very good signposts directing us to the right approaches. This will require collaboration with commercial fishermen and government fisheries scientists to trap and catch live specimens from relatively unaffected fish communities and bring them back to a laboratory with aquaria for experiments. This is because the fish communities in the inshore environment of New Zealand have become totally savvy to humans and their fishing activities, and no longer behave in a way which is remotely like the pre-European period.

Even if archaeologists do not understand how these hooks worked, there can be no doubt that they were extremely effective when used properly. Modern commercial fishermen, always on the lookout for any way of improving catch rates, have seized upon the circular hook form and done their own experiments with steel versions, greatly increasing catches as a result. Although these hooks are not the same thing as their ancient counterparts, there should be no doubt that the most sophisticated modern fishermen and fisheries scientists have here learned something of enormous commercial importance from pre-European people.

I have also given some attention to the question of cordage and knots. This is not often considered in written accounts of archaeological fishing, yet it is such a basic matter, arising every time a hook is attached to a fishing line today when we are fishing. Knots are really important. Buck stands out as a highly practical person who recorded the most detailed information in the fishing communities he studied, both in New Zealand and the Pacific Islands. The rare finds of cordage and knots that are made in swamps and dry caves benefit from Buck's records when it comes to rediscovering the knowledge which is locked up in these fragments.