

## Section 4: The dominant fish in pre-European catches

### INTRODUCTION

In a detailed published list of New Zealand fishes, approximately 750 species were recognised (Paulin & Stewart 1985). Many of these are either very rare or so small that they would not be considered food unless they were mass harvested in the manner by which New Zealanders gather whitebait or anchovies. Although this large number of species is important when considering issues of biological diversity, the health of ecosystems, and animal taxonomy and evolution, it is not at all important when considering matters relating to human economy and diet. Published literature describing Māori knowledge of fish life lists numerous named taxa, possibly exceeding the figure of 750 mentioned above. These taxa are not the same categories as those used by European marine biologists. For example, Māori recognised 167 different types of eel with separate names (Best 1977: 95-100). These include freshwater eels, conger, lamprey and blind eel. This would cover fewer than 20 species recognised by European taxonomists. Far from indicating that either Māori or European are ignorant when it comes to eels, this discrepancy shows a gulf between the sociological importance of eels in the two societies. In a classic anthropological study of the Nuer people of Africa, Evans-Pritchard paid particular attention to a phenomenon whereby the number of words in a society for a category signals its relative cultural importance (Evans-Pritchard 1940: 41 ff.). The Nuer recognise several hundred types of cattle, clearly signalling the importance of cattle in their society. Likewise, the marked disparity between European and Māori names for eels indicates a profoundly greater importance in one society compared with the other. However, one should not leap to the conclusion that this necessarily implies economic importance. In point of fact, eels did not figure prominently in early Māori diet. This apparent contradiction will be explored further in Section 7, but it can be noted here that

this interesting phenomenon concerning eels occurs in a number of parts of the Pacific, as well as other parts of the world.

In this Section I am concerned with the economic importance of different types of fish in pre-European New Zealand. I stress that this is not necessarily the same thing as their social or cultural importance, as perceived by Māori who lived at the time, or indeed as perceived by their modern-day descendants. Once again, a simple analogy might serve to underline this important different perspective. In modern New Zealand, the elephantfish has a considerable economic role, particularly in the South Island where it is one of the dominant species used for fish and chips. However, the average urban South Islander, if confronted with a fresh whole specimen in a fish shop would very probably view it with disgust and buy something else. This is not merely a matter of unfamiliarity with the original source of a packaged item of food (a piece of fish enclosed in batter in this instance), it is also a question of changing social attitudes towards food. For example, one of the most prestigious and expensive fish foods in New Zealand supermarkets and fish shops today is the greenbone or butterfish, *Odax pullus*, yet this species was unpopular in the fish market in the 1930s (Graham 1956: 262); and people were prejudiced against the green colour of the bones. The fish may have been believed to be rotten, whereas the green colour is actually a sign of iodine precipitation. These fish are vegetarian, have a high iodine content in their flesh, and are very nutritious. Anthropologists refer to such attitudes as *food avoidance behaviour*. There is no dietary reason why people disdain to eat such a food, but there is a strong culturally transmitted distaste even so. As we will see in Section 7, eels were subjects of food avoidance behaviour in pre-European New Zealand, in common with many of the Pacific Islands. Eel avoidance is not confined to Polynesians; the Scots disdain eels, whereas the English are fond of them.

One more example might be mentioned to highlight the difference between economic and social importance. Fishing for tuna in the Pacific is a very important activity and occupies much of the attention of fishermen on small islands. Men sit in the men's house for hours at a time discussing the habits of tuna, where to catch them, how to catch them, particularly important catches, feats of individual tuna fishermen, myths about tuna, songs, dances and chants about tuna, and so on. Anthropologists and ethnographers have collected numerous stories about tuna fishing in the Pacific. Based on this, one would be forgiven for thinking that tuna were amongst the most important foods of all Pacific Islanders; but nothing could be further from the truth. Tuna features very rarely at meal-time in the Pacific, but this is not an example of food avoidance behaviour. Tuna are very hard to catch using small canoes and there is adventure and danger in hunting them in the open sea. It is a prestigious activity, but not often successful. It is like pig hunting in the highlands of Papua New Guinea, and elephant hunting by the Pygmy people in Africa. Hardly any tuna, or pigs, or elephants are ever caught and killed, even though a lot of attention is given to the search for them. In point of fact, the common fish foods in the Pacific are much more mundane species, easy to catch and to fill bellies with.

At the risk of over-stating the obvious I therefore note that bones in archaeological sites tell us about what people ate; they tell us about human diet and economy. The presence of bones of a particular type of fish does not by itself tell us anything about the social importance of the fish, or anything about food avoidance behaviour. To reach conclusions about these matters, to some perhaps far more interesting, we must explore the remains from archaeological sites with greater cunning and insight, addressing questions, for example, as to why some taxa appear to be under-represented compared with their relative abundance in nature.

Although fish remains are very common in New Zealand archaeological sites, few have been studied intensively to yield basic lists of abundance of fish types. Almost all of the studies have been carried out either at the Museum of New Zealand or at Otago University.

These studies show that only a small number of species had a particularly strong role in pre-European Māori diet. The relative abundance of

different fish types is summarised in Table 4 and Figure 32. Only six feature in archaeological sites listed in Appendix 1 with a numeric abundance of greater than 7%<sup>1</sup>. These are barracouta, blue cod, snapper, spotty, red cod and greenbone. These six types of fish account for nearly 85% of all fish caught. Because of their great importance in the economy of the pre-European Māori, they are discussed in some detail in this Section.

The focus here is on the fish themselves and their habits. I discuss their distribution in archaeological sites and give an indication of the kind of information we may be able to find out about them using archaeological information. I show how we construct size frequency distributions for archaeological catches, and how we estimate the live weight and edible meat weight of the fish. Archaeological findings are presented in more detail in Sections 6 and 7, which deal with regional and chronological changes.

At the outset it must be admitted that our knowledge of fish behaviour, general abundance and ecology suffers from a basic problem of unknown degree of distortion and bias because it is derived from observations collected during the historic era. By using modern historical sources of information we are tacitly assuming that there has been no change in these characteristics *either* during the pre-European period, *or* during the historic period. For example, we are assuming that fish zonation and habitat preferences are basically the same now as they were 1,000 years ago. Although this is a very poor assumption, in many cases it is unavoidable. However, it should not be taken as a starting point but used as a last resort.

In Section 7, when I discuss change over archaeological time, it will be clear that pre-European Māori certainly did affect fish zonation by denuding the inshore area of larger specimens (blue cod on Mana Island). Moreover, fish are highly sensitive to the presence of humans and they do change their behaviour over quite short periods, learning from older individuals. Nowhere is this more clear

<sup>1</sup> The percentages given are weighted mean values, calculated from Appendix 1. That is, they are weighted in proportion to the size of an assemblage. This prevents very small assemblages from unduly influencing the averages. The figures have been pooled according to family, and given a common name appropriate for the dominant fish species. For example "barracouta etc." refers to barracouta and gemfish (NB: the total MNI of gemfish in the Fishbone Database = 5).

Percent	Fish Family
25.1	Barracouta etc.
16.6	Blue cod
15.8	Snapper
10.6	Spotty etc.
9.2	Red cod etc.
7.4	Greenbone
2.5	Tarakihi etc.
1.8	Ling
1.8	Leatherjacket
1.5	Trevally etc.
1.3	Scarpee etc.
1.2	Kahawai
1.2	Blue moki etc.
0.79	Maori chief
0.59	Groper
0.48	Yelloweyed mullet etc.
0.48	Conger eel
0.42	Red gurnard
0.35	Other bony fishes
0.33	Freshwater eels
0.12	Marblefish
0.097	Spiny dogfish
0.087	Ghost shark
0.085	Eagle ray
0.072	John dory
0.067	Flounder etc.
0.065	Blue mackerel etc.
0.055	Blue warehou
0.052	Elephantfish
0.027	Parore etc.
0.022	Hoki
0.022	Estuarine stargazer
0.0099	Giant stargazer
0.0075	Porcupinefish
0.0050	Sting ray
<b>100.2</b>	<b>Total</b>

TABLE 4

Relative abundance of fish caught by pre-European Māori.

than in their biting behaviour towards sharp, baited hooks, as they become increasingly hook-shy. This is further described in Section 5. I can recount one instance of a similar change from first hand experience in the tropical Pacific. On the island of Kapingamarangi, one of the commonest methods of catching fish today is with a spear gun. Visitors to this island are astonished at the length of the spear guns which these Polynesians use. Old men are adamant that fish have learned to keep further and further away from humans underwater, necessitating the guns to increase in length over time. If

New Zealand Archaeological Fish Abundance

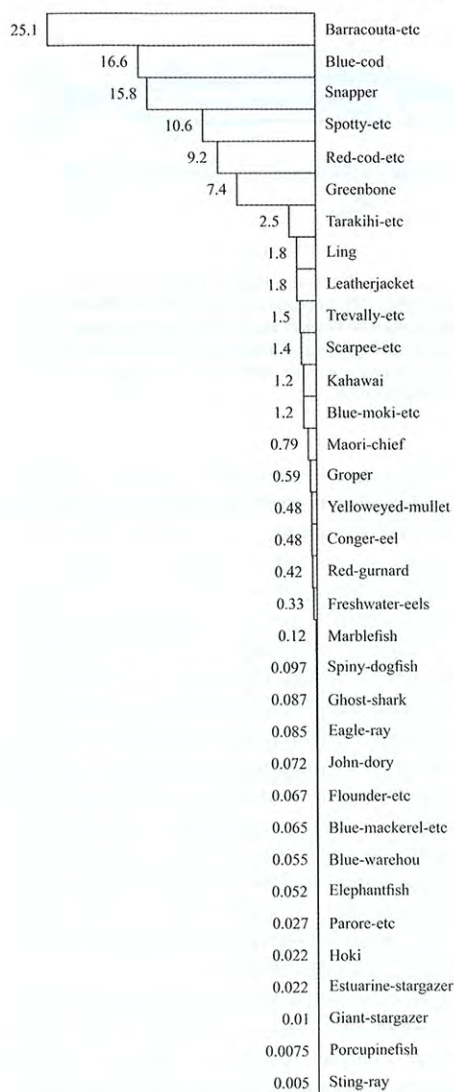


FIGURE 32

The relative abundance of different types of fish in the sites in the Fishbone Database. The figures given are mean percent of MNI, weighted according to size of assemblage. The fish types have been grouped into families for simplicity.

fish behaviour and ecology cannot be regarded as pristine at the end of the prehistoric period, it is far worse to make this assumption after 150 years of European commercial fishing. In spite of these misgivings, this Section represents a useful starting point, with the strong caveat that there could be a movable baseline here.

## BARRACOUTA

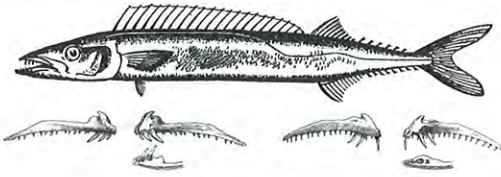


FIGURE 33

Barracouta, *Thyrsites atun*, *Mangā* (Māori) (after Doogue & Moreland 1966: 279, courtesy of Eric W. Heath). Below (left) is the right premaxilla bone of barracouta, with the right premaxilla of frostfish (right) for comparison (from Leach 1997: 67). Barracouta bones are very difficult to distinguish from both frostfish and gemfish.

This fish has the scientific binomial *Thyrsites atun*, and is classified by zoologists as a member of the family Gempylidae (sometimes Gemphyliidae), known as the snake mackerels (Figure 33). The common Māori name is *mangā*<sup>2</sup>. It is of interest that this name is not as widespread in the Pacific as the name *ono*, which is a term applied to various fishes which Europeans call barracuda, and which are classified as belonging to the family Sphyrnidae. This may sound slightly confusing, and indeed it is. Anatomically, the bones of fishes in the two families are not easy to distinguish, and although the external appearances are distinctive, one would be perfectly justified in thinking they were close relatives. The term *ono* refers not only to barracuda, but in some places to the wahoo (*Acanthocybium solandri*), and in others to swordfish (Biggs & Clark 1996).

Pacific Islanders would never have seen the New Zealand barracouta before coming to this region. The New Zealand species is found in southern hemisphere temperate waters in South Africa, southern Australia, New Zealand and southern South America (Paul 1986: 120). It is found northwards to latitude 20° off the west coast of South America, corresponding to the northwards sweep of colder waters along this coast. However, there are several other species in the same family (Gempylidae) which are found in the tropical waters of the Pacific. For example, the species *Promethichthys prometheus* is widespread and known by the same name as the New Zealand barracouta, *mangā*, in both Raro-

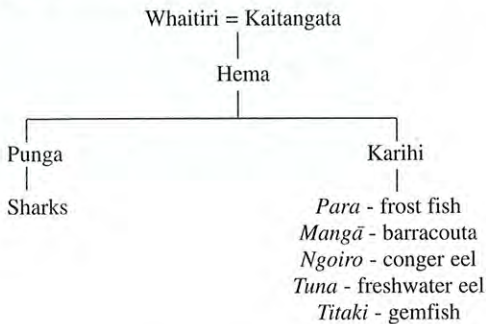
tongan and Tuamotuan (Biggs & Clark 1996). The same fish name is recorded in the Tongan language (*ibid.*), although the species is uncertain. It is worth noting that *Promethichthys prometheus* is generally smaller than the New Zealand barracouta, averaging about 380 mm length, and is found in deep water between 150 and 800 m (Munro 1967: 207; Tinker 1978: 337). The first immigrants to New Zealand must have recognised the New Zealand species of barracouta as a cousin of the rarely seen deep water tropical species, *Promethichthys prometheus*, and gave it the same name, *mangā*. Imagine their surprise when it turned up in abundance in inshore waters, unlike its oceanic counterpart.

Best notes that the Ngati Kahungunu people of the Eastern North Island told him that both *mangā* and *haku* (yellowtail kingfish) were sometimes taken on shell-lined lures (Best 1977: 51). This probably refers to the lure called *pā kahawai*, widely thought to have been specifically made for capturing the kahawai fish, and well known in museums in both New Zealand and abroad. This is not surprising because barracouta will bite almost any moving object in the water. When fishing over rocky bottom for blue cod, one occasionally feels a bang on the line while hauling up a fish. When it is taken on board it usually has just the head left, with the body neatly cut off on the way up by a barracouta. One can often see a barracouta swimming along with a fish being brought up from the depths. If one stops pulling the fish in momentarily, the barracouta will immediately lose interest and veer away. The slightest attempt to pull the fish in again captures the attention of the barracouta once more. What this shows is that movement is a major attractor principle for the barracouta, and almost any kind of lure in the water will do. However, a shiny material is even more effective, and red coloration also appears to be especially attractive. The most common lure used by pre-European Māori was known as *pohau mangā* and consisted of a piece of wood with a single bone point, often made from the jaw-bone of a dog, set into the end. These lures may seem primitive, but were perfectly effective. When metal came to New Zealand along with European people in the 18th and 19th centuries, the bone point was replaced with a bent nail. Museums have many of these artefacts. According to Best (1977: 51), Māori recognised three kinds of barracouta:

<i>mangā ripo</i>	a deep sea fish
<i>mangā tutara</i>	not eaten
<i>mangā ahuone</i>	the one commonly taken

<sup>2</sup> This should not be confused with *mangō*, which is a generic name for sharks of various kinds (the term *mako* is derived from this).

Unfortunately, it is no longer possible to identify precisely what these terms refer to, but it can be noted that other species in the same family, which occur in New Zealand waters, have different names again. Given the importance of these fish in prehistoric catches, one might have thought that there could be several names for different age grades, or shoals turning up at different seasons. Perhaps there was, and the information about this has now been lost. Some hints of the Māori taxonomy relating to barracouta is provided in a depiction of the mythical origin of several fishes by Best (Best 1977: 56):



Gemfish was added to this mythical genealogy by Best (Best 1977: 56).

Best also provides an interesting translation of an account from a South Island Māori about fishing (Best 1977: 53–55, 239–241) in which the following observations were made about barracouta:

Barracouta-fishing commenced in the seventh month—about November—and continued until April, when it ceased. The principal thing in connection with this fish is that it is not fished for with hooks in the ordinary manner, but is taken by means of a *pa*. This *pa* consisted of a piece of beech wood, in the end of which a bird-bone, or some other strong and suitable bone, was inserted; the length was 6in., the width 1<sup>1</sup>/<sub>2</sub>in. One end of a cord was fastened to this, and this cord was also secured to a carefully fashioned rod, one end of which was curved so as to be suitable for forcing to and fro in the water. Such was the form of lure used in taking that fish. When fishermen went out in their canoes to take barracouta with this implement, on seeing a school of the fish this implement was thrust into the water and dashed violently to and fro. This method is known as *kaihau* or *kaihau mangā*. A canoe would stay with the school until many fish had been taken by this *kaihau* method.

The canoes would return to land, and women would clean the fish and cut off the heads, which were thrown away. The fish were cut up, the flesh

dried, the outer part hung up on racks; the dried portions were cooked in a steam-oven (a *puna*) when required. These fish were cooked in the same manner that *kauru* was [the fibrous, fecula-containing interior part of the trunk of *Cordyline australis*]. The oven-fires were kindled when the morning stars rose. When day was well advanced the carefully arranged stones were well heated; the time allowed for cooking was the same as with *kauru*. When cooked they were taken from the oven and suspended on racks, and so dried. The inside fat of the fish was separated from the flesh when hung up for drying. Such was the process followed in dealing with barracouta until the end of the season (Best 1977: 54–55).

There are several interesting things about this passage. It must be remembered that it relates to South Island conditions, though where in the South Island is unknown. Firstly, it suggests that there is a strong seasonal pattern to barracouta fishing, from November until April. This accords with their known seasonal movements inshore at this time of year. Secondly, fishing from canoes is described. These fish may be taken from rocks casually, but by using canoes, people could chase shoals and harvest barracouta in large numbers. Thirdly, the method described is focused on surface waters, no more than the length of the wooden rod. Barracouta are now known from deep-water commercial trawling to be in deep water during winter months. Whether Māori knew this or ever caught them in deeper water is not known, but for a number of reasons it is unlikely. Fourthly, the removal and discarding of guts and head does not conform with many other accounts of the fishing practices of Māori and Polynesians in general. There are many indications that guts and head were considered delicacies. Fifthly, the idea that fish would be cooked in an earth oven for as long as *kauru* surely cannot be correct. Enormous amounts of thermal energy were required for processing *kauru*, which involved more than a tonne of heated boulders, and a cooking time of 24 hours or more. The heat generated in these ovens is known to have melted greywacke, indicating that temperatures as high as 1190°C must have been reached (Fankhauser 1986: 41, 44, 48, 50). Finally, there appear to be contradictory statements about the drying and cooking. At one point it appears that pre-dried flesh was cooked when required, and at another that fish were dried after cooking. Certainly the preserving of fish by drying in the sun was noted by many early European explorers.

At the present time we do not know how to determine, from the bones alone, the season of the year when a fish was eaten; that is, distinguishing

between fish eaten freshly caught and fish sun-dried and eaten months later. No doubt developments in archaeological science will solve this problem in the future. It is an important matter to resolve when reconstructing the annual economic cycle for a particular pre-European community, rather than simply inferring it from general ethnographic observations of 19<sup>th</sup> century Māori.

The behaviour of barracouta in the vicinity of Otago has been vividly recorded and described by David Graham in his *Treasury of New Zealand Fishes* (Graham 1956: 310 ff.). His comments derive from first hand observations over many years and describe fish stocks and fishing activities in this area which are the envy of recreational fishermen today. It is of interest that he records catching the occasional groper on a barracouta lure (Graham 1956: 311). Groper bones are so infrequently seen in archaeological sites that one wonders if this may have been the method of capture of the occasional one which is present, rather than deep water baited-line fishing. Graham also notes that seine nets in which barracouta were caught were severely damaged. This suggests that during their season of abundance inshore, it would have been sensible for pre-European Māori to have refrained from setting nets. He spoke to Māori at Opotiki in the eastern Bay of Plenty, and found that the barracouta were a great favourite among them there. Women cleaned the fish which were brought ashore, and hung them on racks to dry in the sun. He was told that a piece of *tawhai* wood (*Nothofagus fusca*) was used for the lure, because of its dark red colour.

There is a strong seasonal basis to the presence of barracouta in inshore areas, and Graham's description is summarised in the following chart:

January to March:	Large shoals of fish near Cape Saunders
April to June:	Fish in best condition. Roes well developed
July:	Fish disappear from the surface with nearly ripe roe about to spawn. Later in the month 100 mm long barracouta found in stomach of other fish
August to December:	Fish re-appear at the surface and have spawned. Very thin and hungry.

We can add to this chart Graham's observation that large migrations of immature fish (100-130

mm long) come into the Otago harbour in early summer and autumn. Barracouta of this small size are not known from any of the archaeological sites studied so far.

The barracouta is distributed throughout New Zealand waters, but is more abundant from Cook Strait southwards. It is a lean fish with medium to low fat content (Armitage *et al.* 1981: 31). The darkish flesh is sometimes heavily infected with worm parasites. Despite this, the flesh is considered good eating and is often smoked. The average size of adults varies from 60-90 cm, with some individuals reaching 120 cm. The fish are believed to have a maximum age rarely exceeding 10 years (Annala 1994: 31), although Ayling and Cox consider that otoliths from very large specimens may have been 30 years old (Ayling & Cox 1982: 287). Fish of 0 to 1 year in age have a fork length of 10-40 cm (Paul 1986: 12). Sexual maturity is reached at 2 to 3 years (50-60 cm fork length).

Barracouta bones occur in 96 sites in the Fish-bone Database. There is wide variation in the proportion of barracouta in the total catches represented at these sites. This is illustrated in Figure 34. This variation is to be expected, given the strongly seasonal nature of their occurrence in coastal waters. Sites largely occupied during winter, for example, would not have abundant remains of freshly caught barracouta. Despite this seasonal variation, Figure 34 shows a marked difference between the South and North Islands. At no site in the North Island was barracouta represented by above 20% of the catch. Surprisingly few barracouta occur along the west coast of the South Island, and almost none in sites along either the east or west shores of the North Island south of Tauranga. North of Tauranga, quite a few sites show barracouta occurring in reasonable numbers. In the upper part of Figure 34 the size of a black circle represents the relative abundance in any one site. I chose a logarithmic scale for diameter size to give emphasis even to small numbers of barracouta; consequently, the apparent focus of barracouta fishing in the far north of New Zealand is not as strong as might appear from the map. However, it does show a significant batch of sites where barracouta are found, unlike the central areas of the North Island and West Coast of the South Island. Barracouta also feature in the fish catches in the Chatham Islands. In the lower part of Figure 34 the proportions of barracouta MNI in the sites are organised by decreasing latitude from left to right. In this and subsequent similar plots, all

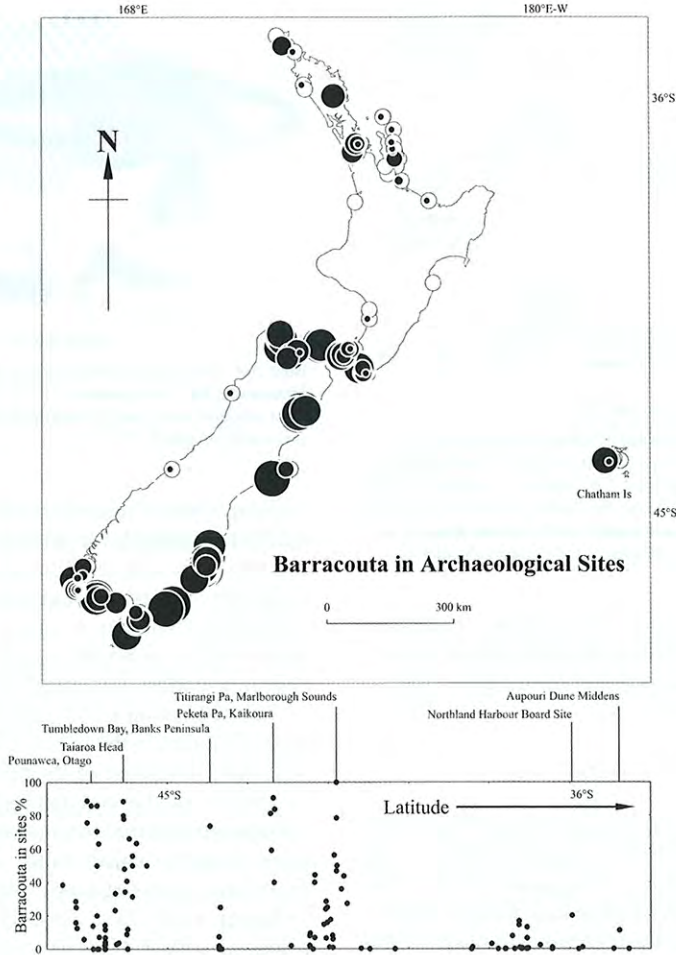


FIGURE 34

Upper: The size of the black circles indicates the relative abundance MNI of barracouta (log scale). White circles have no barracouta. Lower: Percent barracouta in sites by latitude. A few key sites are noted along the top.

126 sites are marked, but many on the x axis overlap. The positions of a few key sites are noted to provide landmarks along the top.

Barracouta bones from archaeological sites can be used to estimate the original live fork length and body weight in order to construct a size-frequency diagram for prehistoric catches and to estimate the relative amount of food from this source (Leach *et al.* 1996a). The archaeological site at Long Beach in Otago provides a good example. The reconstructed catch (Figure 35 upper) shows strong unimodal normal characteristics, with a mean fork length of  $795 \pm 0.4$  mm. When this is compared with modern-day trawl data for Southern New Zealand and Chatham Islands (Figure

35 lower), it is clear that the prehistoric people at Long Beach were taking individuals in the largest part of the size range.

Graham records his efforts catching surface barracouta at Otago during their seasonal abundance as being exhausting as the fish weighed between five and eight pounds [2.3 to 3.6 kg] (Graham 1956: 310 ff.). He states:

The largest seen by me measured forty-four inches [1,118 mm] and weighed eight pound [3,629 g] when cleaned. It is stated that fish of ten pound [4,536 g] are caught but, although I examined hundreds, I did not see one this weight (Graham 1956: 315).

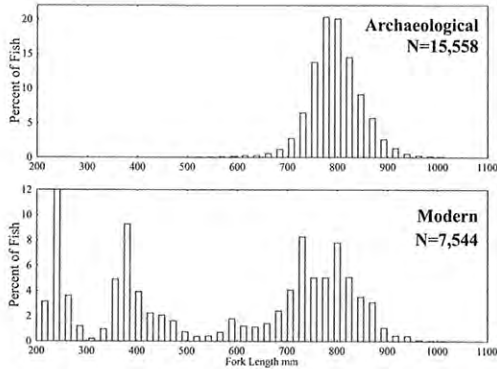


FIGURE 35

Upper: Size-frequency histogram of barracouta fork lengths from the site at Long Beach, Otago, based on 15,558 bone measurements (from Leach *et al.* 1996a: 19). Lower: A modern trawled catch of barracouta from southern New Zealand and the Chatham Islands area (after Hurst and Bagley 1987: 23 and Hurst *et al.* 1990: 29). Note the clearly different sizes of the age grades.

This is interesting information. Fisheries scientists have established the relationship between fork length and ungutted body weight of barracouta (Hurst *et al.* 1990: 35):

$$\text{weight g} = 0.009 * \text{fork length}^{2.86} \text{ cm}$$

Using this formula, we can estimate that a fish 44 inches long would have weighed 6498 g, well above Graham's figure. It suggests that he was measuring fish in their lean and hungry phase, when they reappear from October onwards into summer. We do not know when the Long Beach people were taking their barracouta, but it is likely to have been mainly during the great surface migration during the summer months when they feed inshore. This being so, the weight of meat per individual may have been on the lean side for the fishermen able to mass harvest these fish at this time. This is an example of the kind of information that can be derived from the detailed study of archaeological fishbone.

## BLUE COD

The New Zealand blue cod, *Parapercis colias*, is not a true cod (family Gadidae), but belongs to the family Mugiloididae (Figure 36). In New Zealand (as elsewhere) the name 'cod' has been given to various fish unrelated to true cod (see Leach *et al.* 2001b), although there are also two species of

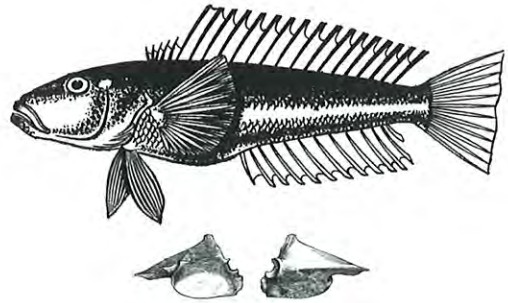


FIGURE 36

Blue cod, *Parapercis colias*, *rāwaru* (Māori) (after Doogue & Moreland 1966: 264, courtesy of Eric W. Heath). Below is the right articular bone, readily distinguishable from those of other species (from Leach 1997: 95).

Gadidae. Other examples besides blue cod are the red cod *Pseudophycis bachus* (family Moridae) and the black cod or Maori chief *Paranotothenia angustata* (family Nototheniidae). This apparently conflicting taxonomy is merely a reflection of the diverse ways in which humans classify familiar objects with different objectives in mind.

When Captain Cook visited New Zealand his sailors referred to the fish as Cole fish (Cook 1967 (II): 807 n.) because of its similarity to a European species in the cod family. The English fish, colloquially referred to as coalfish or just coley, is more properly named saithe, and is the species *Pollachius virens* [*Gadus virens* Linnaeus 1758] (Wheeler 1969: 272, 274). This species is often confused with *Pollachius pollachius*, which is a small offshore non-commercial fish. In North America, *P. virens* is called pollack. The name coalfish possibly comes from the fact that its flesh is sometimes a rather dark colour. The New Zealand blue cod has clear white flesh, but has a dark green body coloration.

Blue cod is known variously as *rāwaru*, *pākirikiri*, or *pātukutuku* by the Māori (Williams 1971: 332). These names do not occur in the tropical Pacific, nor does the species. Williams (1971) records that the name *pākirikiri* amongst the Ngāpuhi also referred to both the spotty (*Notolabrus celidotus*) and a fish known further south amongst the Raukawa people as *tāngahanga*. His entry for this name refers to spotty for the Raukawa people, and the banded wrasse (*Notolabrus fucicola*) for the Ngāti Porou. This is somewhat confusing.

The blue cod is a plump fish producing good fillets, and a sizeable specimen is 50 cm in



length. It occurs on all coasts of New Zealand, but is most abundant in the Marlborough Sounds, Foveaux Strait, Stewart Island, and the Chatham Islands, especially over rough rocky ground with weed. Graham notes that large numbers were formerly caught around Great Barrier Island north of Auckland (Graham 1956: 288), but the fish are smaller in northern waters. He also notes that these fish are sensitive to turbidity, and that when sediments are stirred they disappear to clearer water elsewhere. He believes this accounts for some dramatic changes in annual abundance in the Otago Harbour. Seasonal changes in abundance are also important, the fish coming closer inshore into the harbour as

water temperature rises in summer. As soon as water temperature starts to fall about May with the onset of autumn, they migrate into deeper water where the temperature is warmer. Graham confirmed the sensitivity of the species to temperature with aquarium observations which show them becoming languid and uninterested in food in cold weather (Graham 1956: 289). He also records the unusual phenomenon that they become very nervous and agitated at the onset of stormy weather, and many would leap out of an aquarium to their death during thunderstorms. The influence of water temperature on abundance over fishing grounds is not apparent in northern areas (Doak 1972: 102).

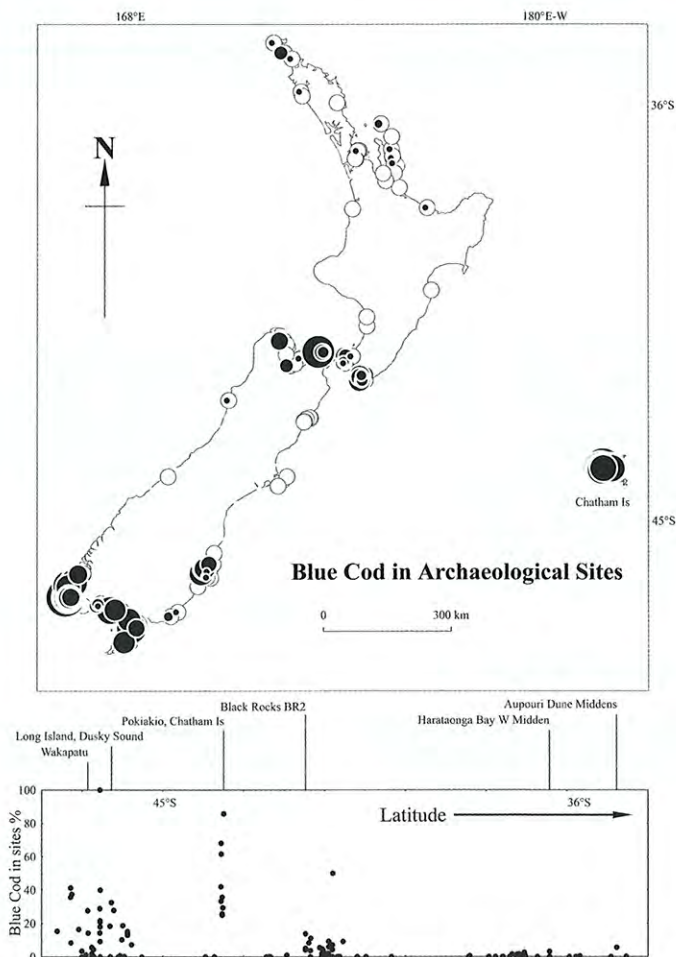


FIGURE 37

Upper: The size of the black circles indicates the relative abundance MNI of blue cod (log scale). White circles have no blue cod. Lower: Percent blue cod in sites by latitude. A few key sites are noted along the top.

Blue cod have a large gaping mouth and readily take a hook baited with almost any kind of fresh fish or shellfish. In the Marlborough Sounds, gut contents frequently contain small whole specimens of shellfish species.

Although blue cod live in waters down to about 80 m depth, they are abundant right up to the shoreline, and in many localities are strongly territorial all year round (Doak 1972: 102). This suggests that this species may be a suitable one to help document the impact, if any, of prehistoric fishermen on the inshore marine environment over archaeological time. This topic is explored in Section 7.

The frequency of blue cod in archaeological sites varies throughout New Zealand. In the Fish-bone Database, blue cod are found in 78 sites, and comprise more than 10% of the total catch in 35. The species was important to the pre-European Māori in many parts of New Zealand (See Figure 37).

This Figure illustrates the importance of the species in the Chatham Islands and in the Fiordland and Foveaux Straits area, with a second cluster of significant values around Cook Strait. They were only rarely caught further north.

For economically important species Government fisheries scientists usually have a well established relationship between fork length and body weight for very large samples of fish, and also for different sexes, at different seasons, and at different localities. However, in the case of blue cod, authoritative information is not yet available. Analysis of all data in the Ministry of Fisheries database for blue cod produces a working equation linking fork length in mm to ungutted weight in g as follows (Bradford 1996: pers. comm.):

$$\text{weight g} = 0.0000119428 * \text{fork length}^{3.05} \text{ mm}$$

The relationship between archaeological bone measurements and live fish characteristics has been established for blue cod (Leach *et al.* 1997b), and enables the sizes of fish in prehistoric catches to be determined. The site at Waihora in the Chatham Islands (Sutton 1979a, 1980, 1989) provides a good example of this process. Of the 22,249 fish bones we were able to identify to species from this site, measurements were made on 8,047 bones from blue cod. After the live fork length and weight are estimated from the bone measurements, the data are pooled into

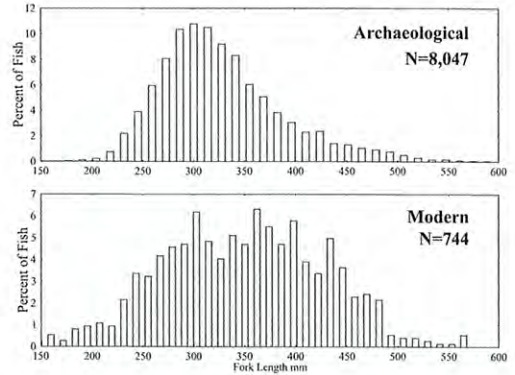


FIGURE 38

Upper: Size-frequency histogram of blue cod fork lengths from the Waihora Site in the Chatham Islands, based on 8,047 bone measurements. The largest specimen has a fork length of 616 mm. The mean is  $327 \pm 0.7$  mm. Lower: modern trawled blue cod from Foveaux Strait south to the Snares area (after Hurst *et al.* 1990: 12, 17).

a size-frequency histogram showing the character of the original catch (Figure 38 upper). This can be compared with modern blue cod trawled from various locations in southern New Zealand from Foveaux Strait to the Snares area (Figure 38 lower).

The mean weight of the fish represented by the bones from Waihora was estimated to be  $569 \pm 3.8$  g (i.e.,  $\pm 0.67\%$ ). From this, the total weight of blue cod in the excavated part of the site can be estimated, using the MNI value for the species. Of the total MNI of 6,907 fish at this site, 2,547 were blue cod (36.9%). Thus, the total weight of blue cod can be calculated as:

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

Smith (1985: 487–488, 2004: 8, 10) recommends using a figure of 70% for the amount of usable meat weight per total body weight for the common species of New Zealand fishes. At Waihora, this is estimated to be about 1.0 metric tonne of blue cod meat. The stated error of  $\pm 10$  kg for the total body weight is based on the standard error of the mean weight of fish, which is  $\pm 0.67\%$ .

## SNAPPER

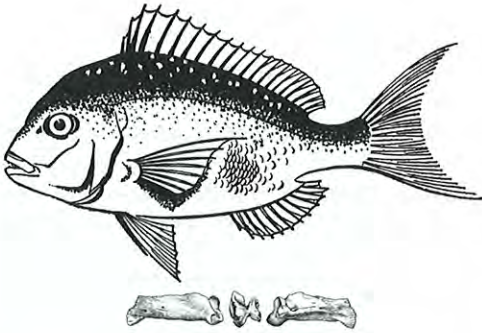


FIGURE 39

Snapper, *Pagrus auratus*, *tāmure* (Māori) (after Doogue & Moreland 1966: 239, courtesy of Eric W. Heath). Below is the right maxilla bone, highly distinctive of this New Zealand species (from Leach 1997: 101).

This fish, *Pagrus auratus* (Figure 39), belongs to the Sparidae family. It is known as *tāmure* by the Māori. In the tropical Pacific, the most commonly occurring species in this family is *Monotaxis grandoculis*, which is widely known as *mū*. This name is traceable right back to the Malayo-Polynesian proto language (Biggs & Clark 1996), and is therefore very widespread. Where a recorder was able to identify the precise fish of this name, *Monotaxis grandoculis* is invariably noted. Although the New Zealand snapper is not present in the tropical Pacific, it is surprising that the first immigrants to New Zealand did not name this fish *mū*. Despite the fact that they are clearly two different fish, they also have similarities, including strongly molariform teeth, somewhat human-like. Some years ago during a collecting expedition in the Solomon Islands I wished to obtain a specimen of *Monotaxis grandoculis*, but the people on the island where I was working did not recognise the name *mū*. When I described the fish as *te ika niho o te tangata* (the fish with teeth like a man) I was immediately understood and the fish was caught for the comparative collection. Of even greater surprise than the fact that the earliest Māori did not name the snapper after its Pacific counterpart, is that they gave the name *mū* to some other sea fish. Unfortunately, the identity of this second fish is not recorded (Williams 1971: 213; Biggs & Clark 1996). The word *tāmure* as *tāmule* is traceable as far back as the Central East Polynesian proto-language, and derived cognates are present on Puka-

puka (Northern Cook Islands) referring to *Lethrinus mahsena*, on Rapa referring to *Lethrinus fulvus*, and in the Tuamotus referring to *Lethrinus rivulatus*. It is hard to understand why the Māori gave the snapper the same name as a species in the tropical Lethrinidae family (emperors), but it highlights the importance of recognising that there is no single taxonomy of the natural world.

This fish is more common in northern waters than further south, and is easily taken in the spring spawning season, when it is referred to as school snapper. There appear to be several spawning grounds. The average size varies regionally, and it is thought that there are reasonably isolated populations, possibly genetically distinctive. Graham observed that fish in Otago waters were much thinner than those further north (Graham 1956: 243). Specimens on the north-east coast of New Zealand average 30-50 cm, whereas fish on the west coast tend to be somewhat larger (Paul 1986: 96) and have a faster growth rate. The maximum size is about 100 cm. The fish reaches maturity at 3-4 years, and adults often reach 20-30 years. Some individuals are thought to live for as much as 60 years. It is important to note that these fish are not strongly migratory in their habits, so a heavily fished locality takes time to recover. This makes it a useful species with which to assess human impact on marine environments. This matter is further discussed in Sections 7 and 9.

An interesting feature of snapper is the tendency of large fish to develop pronounced exostoses (bony growths), particularly on the supraoccipital crest (one of the head bones). These growths are known as 'tilly bones', and occur in several fish species. All individuals of the same species do not necessarily have tilly bones, but if these bones are present they will occur on the same anatomy in individuals of one species. The presence or absence and function of tilly bones are not clearly understood, but may relate to age or other factors. Tilly bones are robust and in some archaeological sites and natural deposits provide the only evidence that fish were once represented (Konnerth 1966: 8). In the case of mackerel (*Trachurus* spp.) up to three tilly bones can be present in the skull of an individual; one in the supraoccipital region, and one attached to each cleithrum (Leach *et al.* 1994a). Tilly bones are relatively common in archaeological sites containing snapper and mackerel, and can be used for calculation of MNI. These bones were evidently of interest to Maori, as a number of archaeological examples have been

carved, and sometimes perforated for use as pendants. Furey (2002: 44-45 and figure 58) describes a single example from Houhora, noting that this is the only reported example from an early site, and illustrates other examples from the later site of Oruarangi (Furey 1996: 43 and figures 51-54).

Snapper readily take a baited hook and can also be taken in either dragged or set nets. They are usually a bottom dwelling fish. Although they shoal during the spawning season, older individuals leave the shoal and become solitary in shallow coastal waters. The fish spawn in late spring or summer when the surface temperature reaches 18°C. They gather at this time in large shoals, in November and December, rising and falling in depth with changes in water temperatures. This process extends to January and February in some areas (Annala 1994: 197). Knowledge of these movements enables mass capture to be undertaken. Adults move to inshore feeding grounds in late summer after the spawn, and move into deeper waters in the winter.

It has been found that water temperature is a very important factor in the recruitment process – strong year classes are produced in warm years, and weak year classes in colder years. This is illustrated in Figure 40, which shows the abundance of one-year-old snapper in the Hauraki Gulf plotted against the mean February to June water temperature. The plot on the left shows the estimated num-

ber of one-year old fish in the trawlable area of the Hauraki Gulf during the years 1982-1994, and that on the right shows the modelled relationship between temperature and recruitment, which is exponential in character.

This strong relationship has important implications for archaeological studies of snapper fishing. In cases where short-term seasonal camps are being investigated, we might expect to see some significant changes in size-frequency catch distributions between one site and another, or from one layer to another. However, for sites occupied for many seasons, such short-term fluctuations will be smoothed over, and observed differences in catch statistics can be expected to signal the existence of longer term trends, such as human impact on the local marine stock, or changes in climate. It is now well established that there have been significant climate changes in New Zealand during the last thousand years (further discussed in Section 7), and this is bound to have had an effect on the relative abundance of different fish species regionally at different periods of time.

Fisheries scientists at NIWA (National Institute of Water and Atmospheric Research) have undertaken many studies of the New Zealand snapper over a long period and a great deal is now known of the biology and habits of this species. This provides a rich background source of knowledge against which to evaluate archaeological

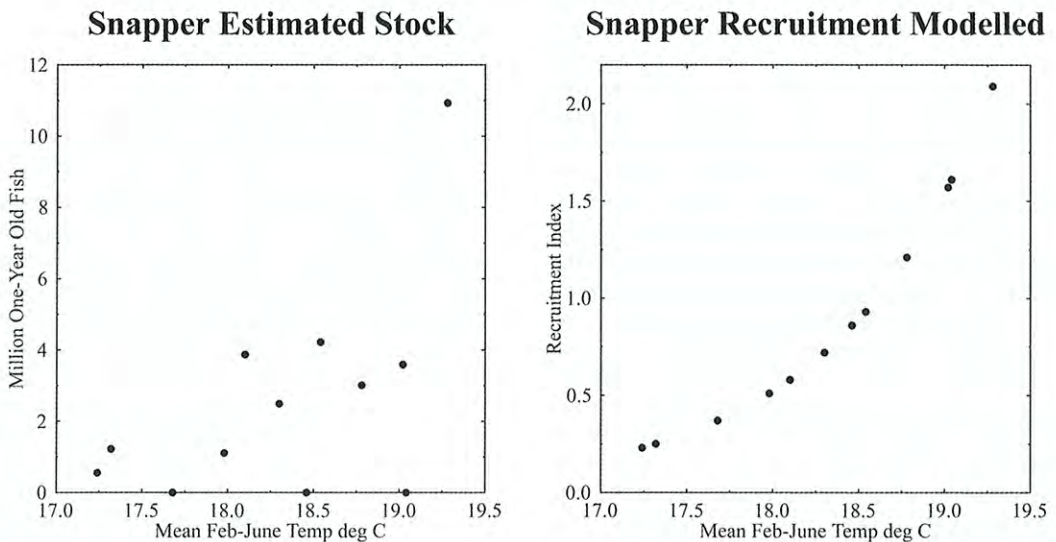


FIGURE 40

The relationship between water temperature and recruitment of one-year-old snapper in the Hauraki Gulf (after Annala 1994: 198).

Area	Virgin Biomass	Current Biomass	Biomass Lost	MCY
SNA1	450,000	40,427	91%	3,470-6,130
SNA8	73,200	12,700	83%	1,175
SNA7	20,700	1,000	95%	448

TABLE 5

Estimates of biomass and Maximum Constant Yield per annum of snapper for three areas of New Zealand. SNA1 = Auckland East (Cormandel to North Cape), SN8 = Auckland West/Central West (North Cape to Cook Strait), SNA7 = Challenger (Cook Strait to Haast). Values are in tonnes. After Annala (1994: 199 ff.).

finds. For example, the likely effect of modern human populations on fishing for snapper is now reasonably well understood. When we come to examine the possible impact of pre-European Māori on inshore snapper in Sections 7 and 9, this is very useful information. One important concept used in these studies is the Maximum Constant Yield, MCY. This is defined as:

The maximum constant catch that is estimated to be sustainable, with an acceptable level of risk, at all probable future levels of biomass (Annala 1994: 10).

In the case of a species like snapper, prone to major fluctuations in annual recruitment, there is a greater risk associated with a higher than average annual catch than for another species not prone to such fluctuations. It is a complex problem to work out what the MCY is for a particular species, but one important variable is the *Virgin Biomass*. In New Zealand, this is assumed to be the biomass at some time between the end of the prehistoric period and the beginning of significant European impact on the fishery. In other words, when trying to set limits to fish catches, it is currently assumed that the pre-European Māori had no significant impact on any commercial species. This has yet to be demonstrated in an acceptable manner, and is one of the focuses of archaeological research. Table 5 gives the currently accepted values for the Virgin Biomass, Current Biomass, and MCY, for the three main fisheries regions for snapper.

These figures relate to the entire area of waters covered by the New Zealand 200 nautical mile EEZ (exclusive economic zone), and the fish are largely taken by trawling. This species is most common in waters of 10–60 m depth range, although they are found to 200 m depth. The area where snapper are located is therefore within a few miles of the shoreline in many places; and although pre-European Māori fishermen would have traversed most of the area covered by modern

trawling for snapper, their catch rate beyond the immediate shoreline is bound to have been orders of magnitude lower than that of modern fishing activities for this species. In other words, the effective biomass available to pre-European fishermen would have been considerably less than the suggested virgin figures cited below. This is something which needs to be taken into account when assessing the likely impact of early fishermen on the fishery. Annala calculates the maximum catch which could be sustained by the stock (the Maximum Sustainable Yield, MSY) as being reached when the catch to biomass ratio is 9.2% (Annala 1994: 202). This is a useful rule of thumb to bear in mind.

Of further interest are the relative catch rates of commercial and non-commercial (recreational) fishing activities. Some estimates for different areas and different years between 1984 and 1991 are given in Table 6.

This provides another useful yardstick against which to evaluate the relative size of the pre-European snapper catch. This will be considered further in Section 9.

Snapper remains have been found in 54 of the archaeological sites studied. As might be expected from the foregoing, they are especially abundant in North Island sites, falling off dramatically to the south. The influence of latitude, as well as local

Area	Catch tonne	Percent of Commercial Catch
Bay of Plenty	400	30
Hauraki Gulf	830	20
East Northland	370	17
West Coast North Island	250	13
Tasman/Golden Bay	15	8

TABLE 6

Estimates of annual non-commercial snapper catches (from Annala 1994: 197).

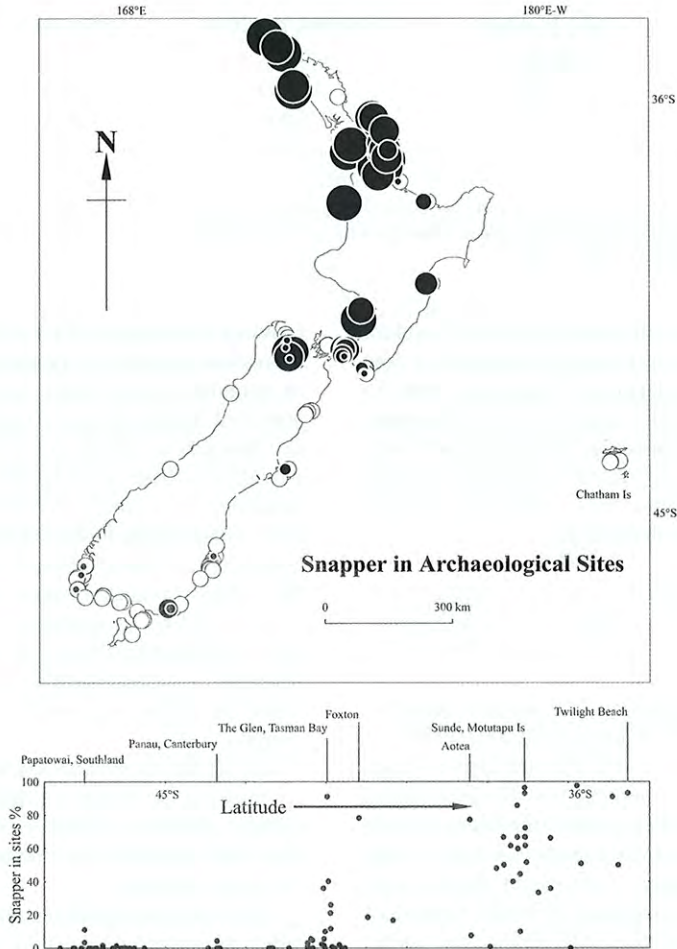


FIGURE 41

Upper: The size of the black circles indicates the relative abundance MNI of snapper (log scale). White circles have no snapper. Lower: Percent snapper in sites by latitude. A few key sites are noted along the top.

fluctuations in frequency, are evident in the lower part of Figure 41. Sites with significant fish remains but low proportions of snapper probably indicate habitation during the months of the year when snapper moved offshore into deeper waters and were much harder to catch.

The map (Figure 41 upper) shows that some snapper occur as far south as Pounaweia and Papatowai in the Catlins area of Southland. These sites are relatively early in the archaeological sequence, and the somewhat warmer climatic conditions which prevailed in New Zealand at that time may be the explanation for these very southerly catches in the prehistoric period. This remains to be verified. It is a little surprising that very few snapper

appear on the map along the west coast of the South Island. Although not abundant there today, snapper do straggle down this coast. We could again be observing the influence of changing climatic conditions, since the sites excavated in the Fiordland area are very late in the prehistoric sequence, possibly all dating to the period of the Little Ice Age<sup>3</sup>. Archaeological sites studied in the Chatham Islands contain no snapper. However, these sites are relatively late in the prehistoric sequence. It will be interesting to see if any snapper remains occur in early sites in these outlying islands.

<sup>3</sup> This is discussed fully in Section 7.

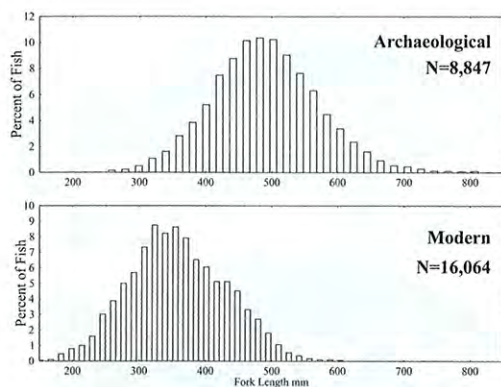


FIGURE 42

Upper: Size-frequency histogram of snapper fork lengths from the site of Houhora in Northland, based on 8,847 bone measurements. The largest specimen has a fork length of 1,010 mm. The mean is  $491 \pm 0.8$  mm. Lower: Modern-day commercial trawls along Ninety Mile Beach (mean =  $385 \pm 0.6$  mm).

Research has been carried out to estimate live catch characteristics from archaeological bones of snapper (Leach & Boocock 1995), and this enables the sizes of fish in prehistoric catches to be determined. The site at Houhora in Northland, excavated by Roe (1969) and Shawcross (1972), provides a suitable sample with which to evaluate a prehistoric catch. We were able to measure 8,847 snapper bones. After the live fork length and weight are estimated from the bone measurements, the data are pooled into a size-frequency histogram showing the character of the original catch. This catch is compared with modern commercial trawl data for snapper along Ninety Mile beach in Northland in Figure 42; the archaeological specimens are much larger than the modern catch, on average 133 mm longer.

The mean weight of the fish represented by these archaeological bones was estimated to be  $2473 \pm 13$  g (i.e.,  $\pm 0.53\%$ ). From this, the total weight and usable meat weight of snapper in the excavated part of the site can be estimated. The snapper MNI at the site was 2,207 fish. Thus, the total weight of snapper can be calculated as:

Mean Body Weight	×	MNI	=	Total Body Weight		Usable Meat Weight
2,473 kg	×	2,207	=	5,458 ± 29 kg		3,821 kg

The stated error of  $\pm 29$  kg for the total body weight is based on the standard error of the mean weight of fish, which is  $\pm 0.53\%$ . The usable meat

weight is estimated using the figure of 70% of total body weight, as described above for blue cod.

The largest snapper at Houhora has an estimated fork length of 1,010 mm. This is an exceptionally large individual. Several other very large fish were around the 800 mm mark. If we use the formula suggested by Annala (1994: 198) of:

$$\text{weight g} = 0.04467 * \text{fork length}^{2.79} \text{ cm}$$

this would provide an estimate of the body weight of this individual of 17,705 g. Our own metrical study, estimating live weight directly from bone measurement in our modern comparative collection of snapper, provides an estimate just on 1 kg higher than this at 18,762 g. The largest specimen in the comparative collection has a fork length of 940 mm, and weighed 17,200 g. Two points can be noted – Annala's equation does seem to underestimate for very large fishes, because the archaeological fish is 70 mm longer than our largest specimen, yet the estimated increase in body weight would only be 505 g. The second point is that whatever formulae are used, they represent extrapolation beyond the limits of our modern samples, and this is fraught with difficulties. We can, however, say that this fish was extremely large, and would have been a cause of great celebration when some early Māori fisherman brought it home in his canoe at Houhora.

#### SPOTTY, SCARLET WRASSE, AND BANDED WRASSE

A very popular book entitled *New Zealand Sea Anglers' Guide*, by Doogue and Moreland, first appeared in 1960. This useful reference work provides a short summary of the biology, habits, food qualities, and where and how to catch the most common fishes in New Zealand. The advice given on how to catch spotties is: "ask any small boy at the wharf" (Doogue & Moreland 1966: 257). This tongue-in-cheek comment conveys the simple message that the humble spotty is both ubiquitous and very easy to catch with even the most rudimentary fishing gear. This fish belongs to the Labridae family (also known as wrasses). Labrids are solitary foraging carnivorous animals with sharp conical teeth. They possess a highly developed pharyngeal mill for crushing up shell and other food-bearing matter. These specialised bones are characteristic of this family, and common in archaeological sites.

There are seven genera and 16 species of labrid in New Zealand waters (Paul 1986: 107), but most of these are found in northern offshore waters. There are only three common inshore species (Figure 43): the spotty (*Notolabrus celidotus*), the scarlet wrasse (*Pseudolabrus miles*), and the banded wrasse (*Notolabrus fucicola*). Although these eat a wide variety of food, the spotty prefers bivalves, the scarlet wrasse hermit crabs, and the banded wrasse crabs, hermit crabs, and molluscs such as limpets, small pāua<sup>4</sup> and mussels (Doak 1972: 76, 82).

The Māori names for members of the Labridae family are somewhat confusing. Doogue and Moreland give *paketi* and *pakirikiri* for spotty, and *pau* and *puwaiwhakarua* for scarlet wrasse (Doogue & Moreland 1966: 257–258). Graham provides *paekirikiri* for spotty, and *puwai-whakarua* for scarlet wrasse (Graham 1956: 270, 272); these are possibly southern dialect names. Ngata gives *pākirikiri*, *kopukopu* and *tāngāngā* for spotty; and *tāngahangaha* for banded wrasse (Ngata 1993: 27, 446). Williams is a more authoritative source, particularly as names are often attributed to dialect. He records *pākirikiri* as being the name for spotty amongst Ngapuhi and that the same fish is known as *tāngahangaha* and *kopukopu* further south. He lists both *tāngahangaha* and *tāngāngā* as the name for spotty amongst Ngāti Raukawa, and the name for banded wrasse for Ngāti Porou (Williams 1971: 254, 378). Biggs and Clark show that the Māori word *taangaha* (also *taangahangaha*) is the same word as *tagafa*, widespread throughout Western Polynesia, occurring in a number of cognate forms in different islands (Biggs & Clark 1996). The name in the tropics refers to *Cheilinus undulatus* (a very large labrid, usually over 1 m in length with a bulbous head), or *Cheilinus fasciatus* (the scarlet-breasted Maori wrasse).

Observations by divers have shown that labrids are solitary, aggressive, home-ranging fishes that will defend a particular territory. They frequent rocky areas and are active during daylight hours. At night they hide in crevices and do not feed. Spotties, the smallest of the three main species (mean fork length 183 mm), are found in greatest concentration in shallow water, tapering off at about 12 m. The scarlet wrasse, which is a medium-sized fish (mean

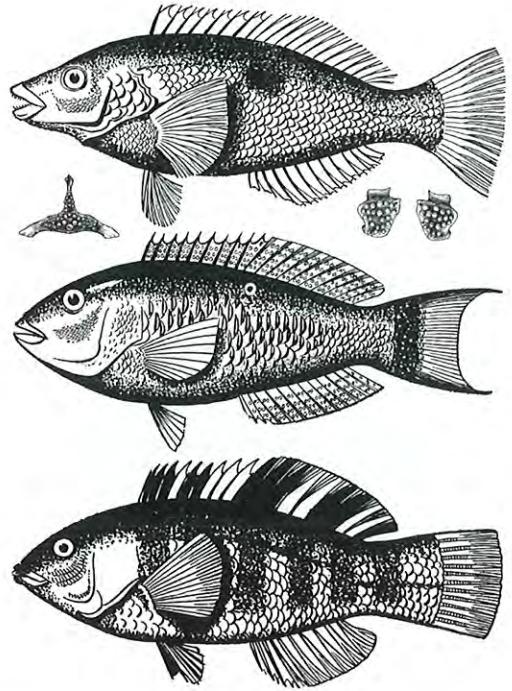


FIGURE 43

Three common species of New Zealand labrids. From top to bottom: spotty (*Notolabrus celidotus*), scarlet wrasse (*Pseudolabrus miles*), and banded wrasse (*Notolabrus fucicola*) (after Doogue and Moreland 1966: 257–259, courtesy of Eric W. Heath). Below the spotty on the left is its inferior pharyngeal bone, and to the right its paired superior pharyngeal bones (Leach 1997: 43).

fork length 290 mm), starts to appear at about the depth at which spotties tail off, occurring from about 9 m to 120 m. The banded wrasse (mean fork length 330 mm) lives amongst seaweed and at night rests in the upper 5 m depth range, covered in a protective mucous envelope. It is found down to a depth of about 36 m. It is interesting that these types of fish are almost never eaten by modern European New Zealanders, who consider them fit only for use as bait. However, they were a very popular food item in pre-European times.

Graham provides wonderful descriptions of each of these three fish with observations about their behaviour in an aquarium, their eating qualities, and general biology. The scarlet wrasse he describes as a rather docile fish, quite unlike the other two. Spotty are constantly on the move, darting this way and that, and will eat just about anything. Banded wrasse are extremely territorial and aggressive, and are capable of killing and eating pāua and even

<sup>4</sup> Pāua, *Haliotis* spp. (family Haliotidae), are univalve molluscs closely related to European ormer and North American abalone. Pāua are prized by Maori as food and the shells are valued for their iridescent quality. In former times they were used in fish lures, as well as for ornaments and inlaid decoration on wood carvings.



large crayfish. He was particularly fascinated by the fact that labrids went to sleep at night, lying flat on the bottom, but woke instantly if disturbed. He cites Aristotle<sup>5</sup> as being the first to make this observation of labrids (scarus is another name for labrids):

Scarus alone their folded eyelids close  
In grateful intervals of soft repose,  
In some sequestered cell, removed from sight,  
They doze away the dangers of the night (Graham 1956: 273).

The biology and behaviour of the labrids can provide important clues about prehistoric human fishing behaviour. The fact that they are only really active during daytime suggests that pre-European Māori fishermen would only be able to catch them during daylight hours. The relative abundance of different species can also be a useful guide to the depth where fishermen were focusing their effort. The solitary and home-ranging behaviour of these fish makes this family a useful one with which to explore issues of overfishing and environmental impact of prehistoric human communities over archaeological time.

Although it is easy to identify live labrids to species from their colour and external shape, they are far more difficult to identify from their bones. The three common species, referred to above, have a distinctive spine formula (D. IX, 11; A. III, 10)<sup>6</sup>,

<sup>5</sup> This English verse is obviously not attributable directly to Aristotle. When I traced the source of this it appeared that Graham had copied Holder (1903: 275) without acknowledgement, who in turn had copied without acknowledgement Diaper's translation into verse of Oppian's didactic poem about fish c. A.D. 190 entitled the *Halieutica* (Diaper and Jones 1722 [Book 2]: 105). The original Greek of Oppian was translated by Thompson as "It is never caught at night, for it sleeps all night long" (Thompson 1947: 239, citing *Halieutica* ii: 662). Athenaeus, in his *Deipnosophistae*, probably written soon after Oppian's work, cites Seleucus of Tarsus in *The Art of Angling* (also called *Halieutica*) as saying: "is the only one of all the fishes that does not go to sleep: hence it cannot be caught at night" (Gulick 1929: 437). Gulick notes that Casaubon, in his 1595 edition of Athenaeus, added the negative to the Greek; it is obvious that without the negative the sentence did not make sense. No amount of searching uncovered any comment on the sleeping habits of Scarus by Aristotle himself.

<sup>6</sup> The spine formula refers to the number of spines on the back (dorsal) and lower body (anal) fins, counting from front to back in each case. The two sets of two kinds of spine can be seen in Figure 43. There is slight variation around the formula, sometimes as a result of injury to the fish. Even so, this formula clearly distinguishes these fish from other species and reflects their close relationship. The formula cited here D. IX, 11 means the dorsal fin has 9 sharp spines and 11 soft spines, and A. III, 10 means the anal fin has 3 sharp spines and 10 soft spines.

fairly reflecting the difficulty confronting archaeologists. I believe that with a greatly improved modern comparative collection (multiple specimens from all 16 species) it may be possible to identify some species from some of the anatomy. However, it is unlikely that we will ever be able to identify species reliably from *all* five paired cranial bones which we routinely analyse from archaeological sites. The first step towards understanding ancient fishing behaviour is to establish the relative abundance of different types of fish. This is done, not on the basis of one part of the anatomy, but on the combined results from several parts of the bony skeleton (Leach 1997). Unfortunately, we have to accept that it is very difficult to separate bones into the different labrid species. Some recent attempts to do this rely on the different size-frequency distributions of the different species, and also on different allometric relationships between bone dimensions. The size-frequency distributions of samples of the three common species are shown in Figure 44, and some dispersion statistics in Table 7.

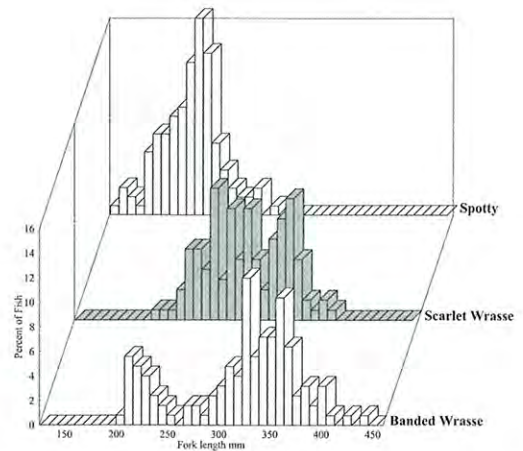


FIGURE 44

Size-frequency diagrams of modern specimens of three common species of labrids in New Zealand: spotty (N=138), scarlet wrasse (N=122) and banded wrasse (N=126) (after Leach & Davidson 2001b: 139).

Although there is overlap between the species, this is sufficiently small to raise the possibility of separating archaeological bones on the basis of size. Some bone dimensions of the same specimens are plotted out in Figure 45. This shows encouraging signs of separation of at least the banded wrasse from the other two species in the relative dimensions of the dentary. Dentary measure-

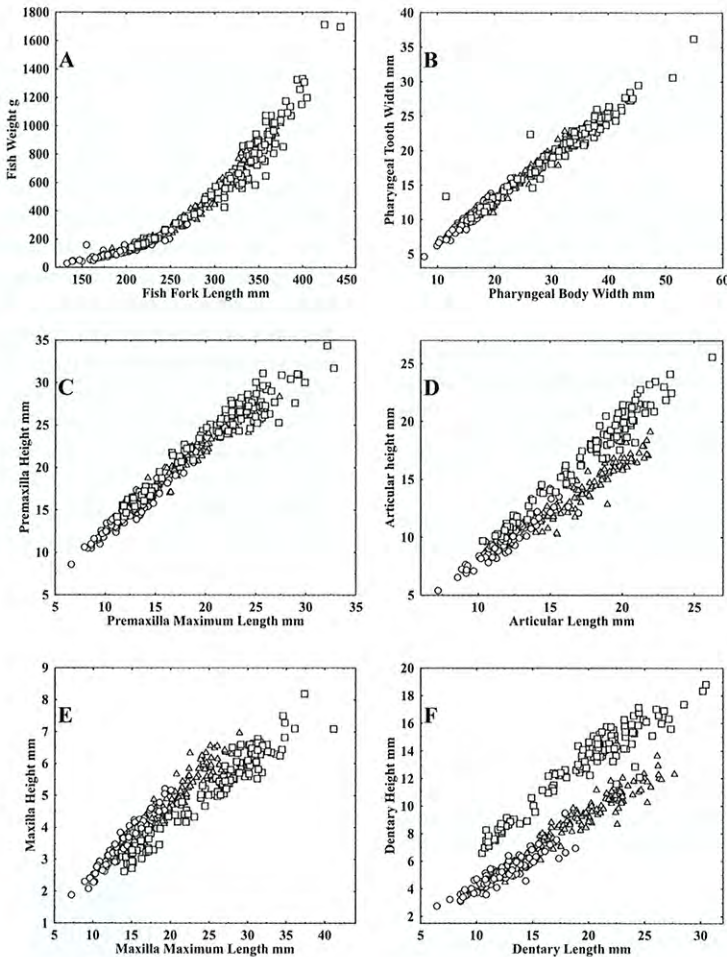


FIGURE 45

Scatter plots of various dimensions showing the extent of overlap between the three species of labrid. The open circles are the spotty at the small end of the size range, the triangles are the scarlet wrasse in the middle size range, and the squares represent the banded wrasse at the large end of the size range (after Leach & Davidson 2001b: 140).

Species	N	Range	Mean	SD
Spotty	138	133-283	202.9	28.1
Scarlet Wrasse	122	184-375	290.3	39.9
Banded Wrasse	126	206-443	319.1	57.0

TABLE 7

Modern fork lengths for three common Labrid species.

ments have been subjected to multivariate analysis to see if reliable identification could be made using canonical equations (Leach & Davidson 2001a, 2001b), and this has proven to be very successful for separating the banded wrasse, and

moderately successful for separating spotty from scarlet wrasse (Figure 46). Unfortunately, other bones of the three species do not vary sufficiently in size to enable them to be distinguished at all using this kind of approach.

The frequency of labrids in archaeological sites in New Zealand is rather variable. In the Fish-bone Database, 62 sites contain labrids at more than 5% of the total catch. The highest figures are from sites in Cook Strait, Foveaux Strait, and the Chatham Islands (Figure 47). This partly reflects variations in natural abundance, but as discussed in Section 3 and illustrated in Figure 25, it also reflects preferential fishing close inshore at times

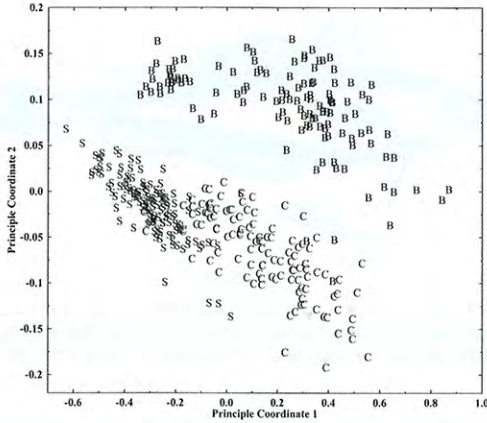


FIGURE 46

Principal coordinates analysis of dentary measurements of labrids permits separation of the three main species in New Zealand (S=Spotty, C=Scarlet wrasse, B=Banded wrasse) (after Leach & Davidson 2001b: 146).

when sea conditions made it very difficult to use canoes for access to favoured deeper water fishing spots (Leach & Anderson 1979a).

The osteometric problems associated with these closely related species become obvious when trying to estimate the size-frequency of pre-European catches from archaeological bones. This is illustrated in Figure 48 in which the bones of all species are pooled together. The upper part of Figure 48 shows the estimated fork lengths of a collection of archaeological labrid bones from the CHB site in the Chatham Islands. The lower part of the Figure shows the pooled values of the modern comparative collection in the Archaeozoology Laboratory at the Museum of New Zealand. This appears to be bimodal, but in fact is trimodal, with the middle peak less obvious.

This trimodal character of the length frequency distribution is a blessing in disguise. It makes it

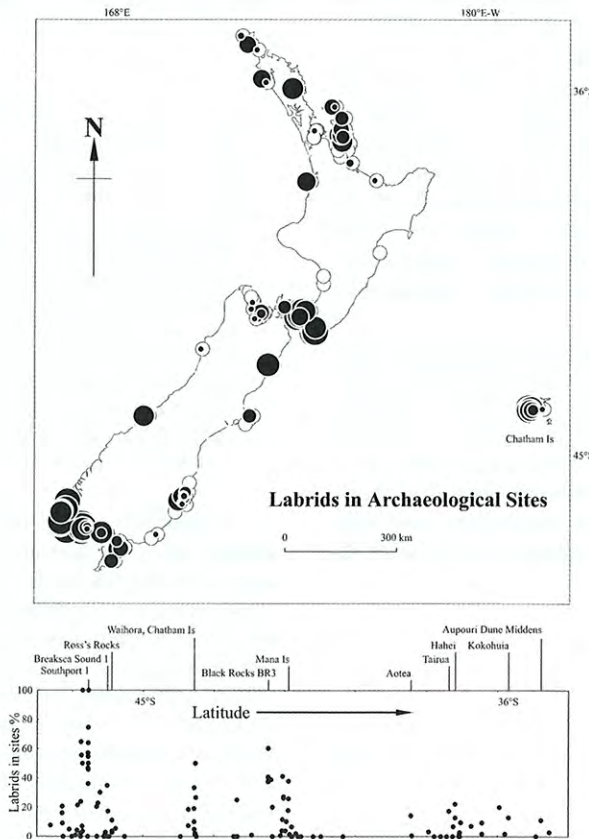


FIGURE 47

Upper: The size of the black circles indicates the relative abundance MNI of labrids (log scale). White circles have no labrids. Lower: Percent labrids in sites by latitude. A few key sites are noted along the top.

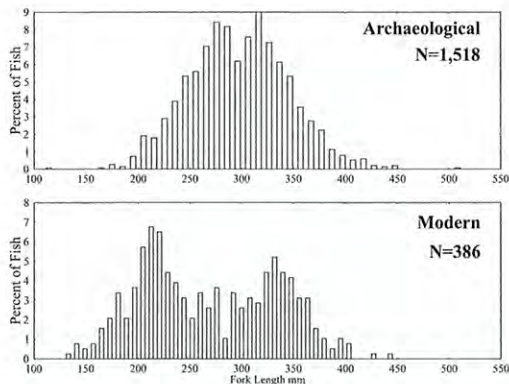


FIGURE 48

Upper: Size-frequency histogram of labrid fork lengths from the site of CHB in the Chatham Islands, based on 1,518 bone measurements. The mean fork length is  $297 \pm 1.2$  mm. Lower: Modern comparative collection of labrids (pooled species).

possible to examine the reconstructed size-frequency diagram of the undifferentiated pre-European labrid fish catch, and to separate it into its constituent species on the basis of their individual size-frequency distributions. This is a technique used for decomposing age-grades of fish from age mixtures. It has been shown to be moderately successful for archaeological assemblages from the Chatham Islands (Leach *et al.* 1999a: 126). This will be considered again in Section 7 when changes in fish catches through time are considered in detail.

Estimating live weight from archaeological bones for use in economic reconstruction is not easy in the case of labrids. The failure to identify cranial bones accurately to species, with the exception of the dentary, creates this problem. A number of alternative methodologies have been investigated; none is very satisfactory, and they have at best an error of about  $\pm 7\%$  (Leach & Davidson 2001b: 143).

## RED COD

The New Zealand fish commonly known as red cod (*Pseudophycis bachus*) is a member of the family Moridae (Figure 49). It is not a true cod of the family Gadidae.

The Māori name for the red cod is *hoka*, a word which, in various forms (such as *hoka* Paumotuān [Tuamotuān], *so'aso'a* Samoan, *hoahoa* Hawaiian), is widespread in Polynesia, referring to

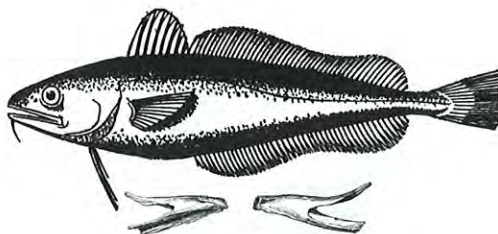


FIGURE 49

Red cod, *Pseudophycis bachus*, *hoka* (Māori) (after Doogue & Moreland 1966: 208, courtesy of Eric W. Heath). Below is the distinctive right dentary bone of this species (Leach 1997: 61).

a variety of sharp-pointed objects or activities associated with them. For example, the word *okaoka* in Mangarevan means to poke about with sticks amongst coral looking for fish (Tregear 1891: 78). The New Zealand red cod has a single barbel below the lower jaw, which functions in a very similar manner to *okaoka* amongst the Mangarevans, as the following passage makes clear:

The barbel or feeler below the chin of Red Cod has special uses, which I have often observed in the Red Cod kept in captivity in the large outside ponds which have muddy bottoms. Lying flat on the ground, face downwards as near as possible to the pond, I have seen a Red Cod sink to the bottom and begin moving along the floor, using his barbel to feel and poke the mud. Again and again I saw him swim backwards and open-mouthed, and then swallow some creature he had evidently touched with his feeler. This barbel is an extra sense and very sensitive, for it no sooner feels some crab or worm than the Red Cod slips into reverse gear in a flash and the animal is not only in his shovel-shaped mouth but well down his gullet (Graham 1956: 170).

Perhaps this is why this New Zealand fish was named *hoka*, on account of the barbel, poking about looking for food. Certainly, when the first Polynesians came to New Zealand, this fish would have been entirely new to them, as it is not found outside temperate waters. It is interesting that the Māori also named the ling *hoka* and *hokarari* (Williams 1971: 56). In one important respect a ling has a superficial resemblance to a red cod – it has slender pelvic fins set well forward beneath the lower jaw, where they are easily mistaken for barbels (Ayling & Cox 1982: 152).

Red cod are voracious carnivores, feeding on a wide variety of marine organisms. They average 30 to 50 cm in length, but very large specimens are

known to reach 1 m in length and weigh over 6 kg (Ayling & Cox 1982: 142). They reach 25 cm in the first year, and 40, 50 and 55 cm in subsequent years. They are sexually mature at the age of two to three years (Annala *et al.* 2000: 338). They are found throughout New Zealand, but more commonly around the South Island. Ayling and Cox (1982: 143) suggest that there may be two distinct populations, one in rocky areas down to about 50 m depth, and the other in deeper water on the continental shelf over sandy and muddy bottoms from 50 to 550 m depth. They also note that the same species is found in southern Australia.

Red cod are schooling fish, migrating seasonally but irregularly from deeper to shallower

waters, possibly in connection with their breeding activities and changes in food supply. There is conflicting information about the pattern of these seasonal movements and their abundance in various waters around New Zealand. Paul (1986: 57) states that spawning occurs about August, probably in offshore waters. Schools appear in the Canterbury Bight and Banks Peninsula around November, and are not found in any number in these waters after about June. Commercial catch data indicate that they move into deeper water at this time. However, even though in former times red cod were known to be especially abundant in the Otago harbour in summer months, local fishermen relied upon their catch of

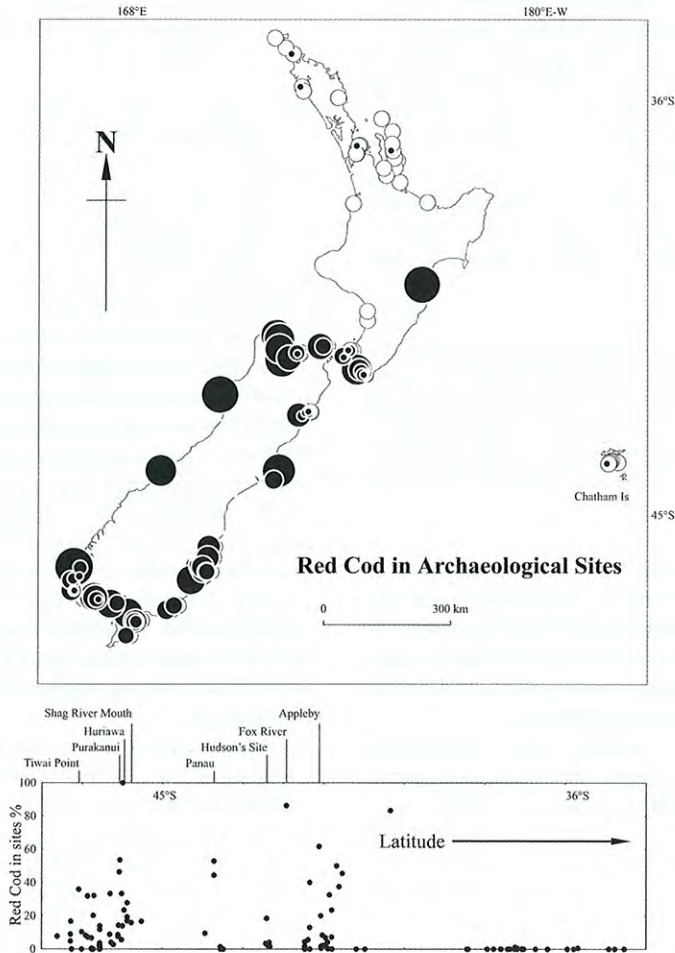


FIGURE 50

Upper: The size of the black circles indicates the relative abundance MNI of red cod (log scale). White circles have no red cod. Lower: Percent red cod in sites by latitude. A few key sites are noted along the top.

the species outside the harbour in winter (Graham 1956: 168). Moreover, commercial landing figures for red cod at Akaroa and Timaru show greatest abundance in winter (Leach 1979a: 114), and for Wellington between May and July. These observations hint that low water temperature may be one of the triggers determining changes in local abundance. Recruitment is highly variable, resulting in large variations in catches from one year to another (Annala *et al.* 2000: 338). In an interesting study of the types of fat present in red cod, Carter & Malcolm (1926: 649) argued that in Otago waters at least, these fish gorge themselves on whale feed<sup>7</sup> during summer and autumn, retiring to deep cold water in winter and basically living on their fat reserves until the whale-feed season occurs again. Generally speaking, at least on the east coast, these fish are more easily caught in inshore waters during spring and summer, before moving into deeper water during winter. In years when surface sea water temperatures are lower than normal, we might expect a somewhat different pattern.

These fish have a poor reputation amongst many modern fishermen. Doogue and Moreland, with their usual flair for getting straight to the point, comment:

It is doubtful if anyone would go out with the firm intention of seeking out these fish. As they do not have speed, stamina or particularly good eating qualities, they are easily caught — if you want them. ... Food qualities: little fat, a flaky rather flavourless flesh. Unsuitable for frying (Doogue & Moreland 1966: 208).

The comment about lack of fat contrasts with the observation of Carter and Malcolm, noted above. Recent research suggests that some recreational fishermen do indeed target this species, particularly in the southern North Island and South Island (Fisher & Bradford 1999: 24).

Graham (1956) makes some fascinating observations about red cod, although his suggestion that the name *hoka* is appropriate because in Māori it means “to eat anything” (Graham 1956: 167), one of the characteristics of this fish, is not correct. This meaning is not recorded in any known source on the Māori language (Harlow

<sup>7</sup> Whale feed, also known as krill, consists of huge quantities of tiny planktonic crustaceans. It is referred to as the ‘red tide’ when it comes inshore and washes on to the Otago beaches.

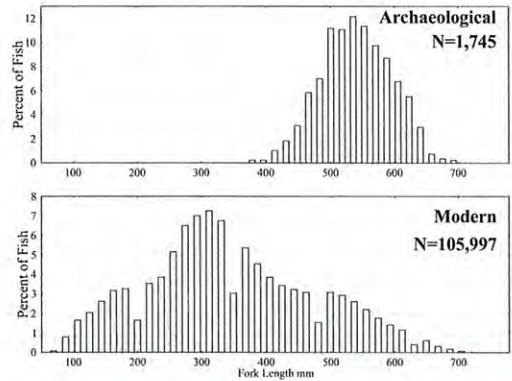


FIGURE 51

Upper: Size-frequency histogram of red cod fork lengths from the Tumbledown Bay site on Banks Peninsula, based on 1,745 bone measurements. The mean fork length is  $540 \pm 1.3$  mm. Lower: Modern research trawl data.

2000: pers. comm.). Graham considered that the bad reputation that red cod has for poor eating qualities was not well founded, but then it is hard to find a species in his volume which he does not consider good eating. He has much to say about the eating qualities of red cod and suggests adding salt to the flesh some hours before cooking to firm it up. He also notes that although they can be caught in great abundance in some years, they can disappear completely from inshore waters for up to seven years at a time. His story that fishermen’s wives refused to go into the harbour in rowing boats on account of the unnatural numbers of fish they had to pull through (Graham 1956: 168) stretches credulity, although very large quantities of red cod probably did come into the Otago harbour during this incident.

Red cod bones have been identified in 77 sites in the Fishbone Database. The sites where red cod are most abundant (measured as a percentage of MNI) have a strong southern bias. This is evident in Figure 50.

An indication of the size of red cod in archaeological sites can be obtained from bone measurements from Tumbledown Bay on Banks Peninsula presented in Figure 51 (upper). This is compared with the fork lengths of all red cod from research trawl surveys from east and west South Island and Tasman and Golden Bays (lower). Pre-European Māori were catching large older fish.

A study has been carried out linking live fish size and weight from bone dimensions of red cod (Leach *et al.* 2001b). The relationship between total length and ungutted body weight was found to be:

$$\text{weight g} = 0.0000265 * \text{total length}^{2.84} \text{ mm}$$

## GREENBONE

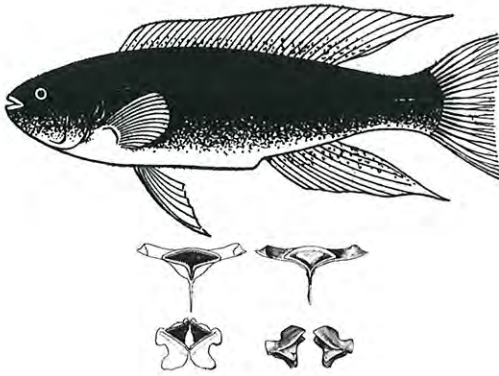


FIGURE 52

Greenbone, *Odax pullus, mararī* (Māori) (after Doogue & Moreland 1966: 256, courtesy Eric W. Heath). Below are its upper and lower pharyngeal bones (left: after Waite 1911: 228; right: after Leach 1997: 43). These bones are characteristic of this species.

The final fish type to be considered in this Section is the greenbone (Figure 52), also known as butterfish (*Odax pullus*). Of the two common names, greenbone is preferable because the name butterfish is also associated with the warehou family (Centrolophidae), and the name greenbone is not likely to be confused with any other fish. The reason for this name is the tendency for the bones to turn to a green colour fairly quickly after the fish dies. This is due to precipitation of an iodine salt. The flesh of this fish is very rich in iodine, something which makes it very useful for prevention of goitre. New Zealand soils are naturally low in iodine, and endemic goitre was noted in the 19<sup>th</sup> century. From 1924 onwards salt was iodised to alleviate this. Goitre would have been endemic amongst pre-European Māori unless they had some means to augment iodine in their diet. Consumption of greenbone would have helped.

The Māori name for this fish is *mararī*, or *rarī*. This name is common in many parts of the

Pacific, often, but not always, applied to some form of labrid or wrasse. The word has many cognates and has been reconstructed to Proto-Polynesian *\*m(a,o)lali* by Hooper (Hooper 1994: 217)<sup>8</sup>. The word *maa-lali* and its cognates (Māori *mārarī*) refers to things that are smooth, wet or slippery. This is an appropriate description for the greenbone fish, which has very tiny scales and no sharp spines and is very slippery when wet.

The greenbone is a vegetarian fish, feeding on seaweeds. They prefer a single species of kelp, *Ecklonia radiata*, but also eat *Macrocystis pyrifera* (giant kelp) and other species, including the reproductive branches of *Carpophyllum* plants. Their teeth are fused into a sharp beak-like jaw, similar to the tropical parrotfishes, and they bite pieces from the kelp leaving a neat oval hole in the frond. They have three sharp-edged pharyngeal bones in the throat (Figure 52 lower), and these cut the piece of kelp into smaller pieces before swallowing. Stomach contents also contain small crustaceans and shellfish. Greenbone are a beautiful deep blackish green or blue colour and thick in cross-section, providing good-sized fillets. They average 30-50 cm length, but can reach 70 cm or more. Thompson (1981: 213-215) provides some useful information about the species in the Leigh Marine Reserve north of Auckland. She notes that they are diurnal, something Graham also commented on (Graham 1956: 264), and that they are most abundant in waters less than 13 m deep. In the Reserve they reach densities of 14 fish per hectare, and are also present in deeper waters where *Ecklonia* forests are found, but at densities of about 2.5 fish per hectare.

In theory, the vegetarian habits of greenbone preclude the use of hooks, but I have heard that a tiny hook baited with a shrimp or even a fragment of kelp will occasionally capture them. However, this is a species which in pre-European times would have been taken almost exclusively by netting or spearing. Greenbone are found throughout New Zealand, around kelp-rich rocky shore habitats, but are not so common in the warmer waters of the far North. Graham describes them as having a range of colours, depending on environment and amount of light present. He also notes their habit of apparently sleeping in a vertical position in an aquarium, instantly returning to a swimming posi-

<sup>8</sup> Tregear lists the Māori word as *marare*, which is probably an error (Tregear 1891: 215).

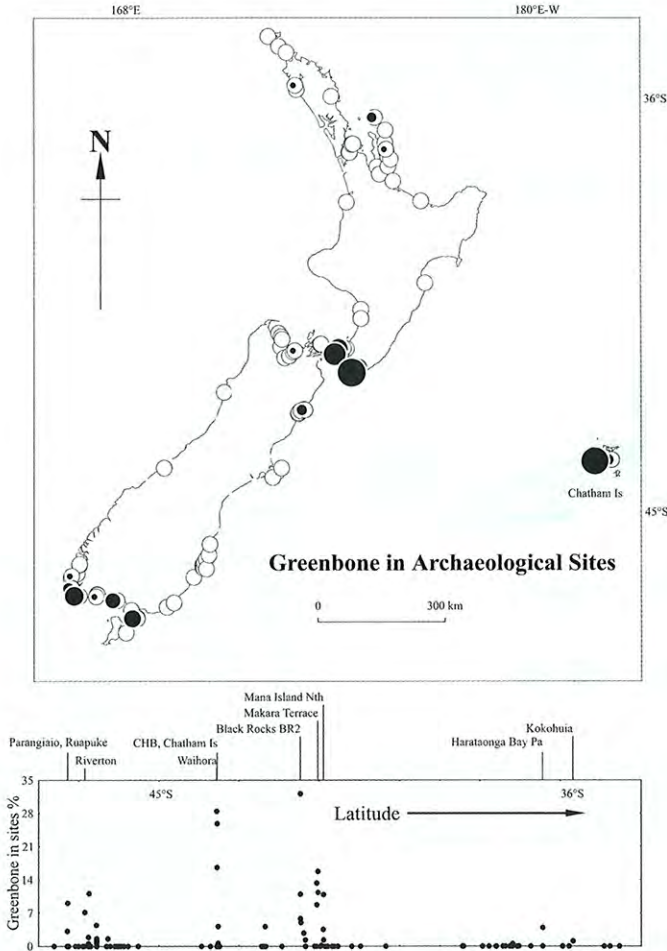


FIGURE 53

Upper: The size of the black circles indicates the relative abundance MNI of greenbone (log scale). White circles have no greenbone. Lower: Percent greenbone in sites by latitude. A few key sites are noted along the top.

tion when lights are turned on (Graham 1956: 264). These comments and those of Thompson are somewhat at variance with the use of gill nets by modern fishermen, whose nets are often set in the evening and collected in the morning after a tidal change. My own experience is that night netting is very productive, and when seen with a torch during night diving, these fish seem quite active.

Bones of greenbone have been identified in 35 sites in the Fishbone Database. There is a strong bias towards southern sites (Figure 53); the species has been identified from only three sites north of Hawkes Bay (Kokohuia, Harataonga Bay, Hahei). Greenbone are abundant in sites in Cook Strait, Southland and Fiordland and Chatham Islands.

Biometrical studies of greenbone osteology are yet to be published, but a comparative collection of 306 individuals netted in the Cook Strait region has been assembled, rendered down and bones measured. A preliminary relationship between total length and gutted body weight is:

$$\text{weight g} = 0.00011334 * \text{total length}^{2.646} \text{ mm}$$

Bones from the site of Waihora in the Chatham Islands have been studied in detail. The size-frequency diagram of the greenbone catch is given in Figure 54 (upper). It is compared with greenbone caught in a netting experiment in Cook Strait by NIWA staff (Figure 54 lower).



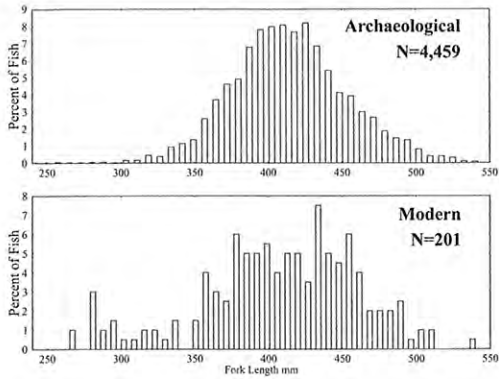


FIGURE 54

Upper: Size-frequency histogram of greenbone fork lengths from the Waihora site in the Chatham Islands, based on 4,459 bone measurements. The mean fork length is  $414 \pm 0.6$  mm. Lower: Modern greenbone from netting experiment in Cook Strait (Paul 2000 : pers.comm.).

## DISCUSSION

In this Section, only the six most abundant fish types in archaeological sites have been considered. Although these account for nearly 85% of the fish caught by pre-European people in New Zealand and nearby Chatham Islands in terms of numerical abundance, this is only one way of assessing importance. The food available from one large shark, for example, is worth a lot more than a netful of smaller fishes. Nevertheless, it should be clear from Table 4 that pre-European Māori did tend to focus attention on a small number of species, even though the composition of catches varied from one part of New Zealand to another.