NEW ZEALAND JOURNAL OF ARCHAEOLOGY

Pre-European Catches of Blue Cod (*Parapercis colias*) in the Chatham Islands and Cook Strait, New Zealand

Foss Leach[1], Janet Davidson[1] and Karen Fraser[1]

ABSTRACT

Blue cod has a relatively low biomass compared with other fish which were targeted by pre-European Māori, and the small home range of individual fish makes this a particularly useful species with which to examine the effect of human predation.

Fork lengths are estimated for blue cod from three sites on the Chatham Islands with a combined Minimum Number of Individuals (MNI) of 7,224 and from two areas of a large site on Mana Island on the northern shore of Cook Strait with a combined MNI of 146 fish. Size-frequency diagrams for the various catches point to a non-selective predation strategy at Mana Island, with large numbers of small fish being taken as food. By modern standards, 59–83% were undersized fish, which are unlikely to have been taken with baited hook. Small-mesh nets or non-selective traps are indicated. By contrast, people occupying the sites in the Chatham Islands took fewer small fish, with 29–59% being undersized. Either small fish were discarded before being brought to the settlements, or a selective fishing strategy was employed.

At Mana Island, mean fish size increased significantly over time, possibly because of the predation strategy employed. The three Chatham Island sites are close together in archaeological time, but appear to form a series where mean fish size either increased or decreased significantly. High quality dating will be needed in order to decide which model is correct.

Keywords: ARCHAEOLOGY, ARCHAEOZOOLOGY, NEW ZEALAND, FISH, BLUE COD, *Parapercis colias*, SELECTIVE PREDATION.

INTRODUCTION

The New Zealand blue cod, *Parapercis colias*, is an important commercial and recreational species today and was a significant component of the fish catch of some pre-European communities in New Zealand. Blue cod have a relatively low biomass compared with other species targeted by pre-European Māori. They are found from close inshore to about 80 m depth, and are often strongly territorial with small home ranges. For these reasons they are potentially a good species with which to examine the effects (if any) of human predation.

Blue cod is present in many archaeological sites in New Zealand and the Chatham Islands, although its frequency varies considerably. It is found in 78 of the 126 sites for which we have information, and in 35 of them it contributed more than 10% of the total catch. Figure 1 graphically illustrates the importance of the species in the Chatham Islands and in the Fiordland and Foveaux Strait area, with a second cluster of significant values around Cook

[1]Museum of New Zealand Te Papa Tongarewa, PO Box 467, Wellington, New Zealand

New Zealand Journal of Archaeology, 2000, Vol. 21 (1999), pp. 119–138.

Strait. Blue cod were only rarely caught north of this, although they appear in a few sites in the far north.

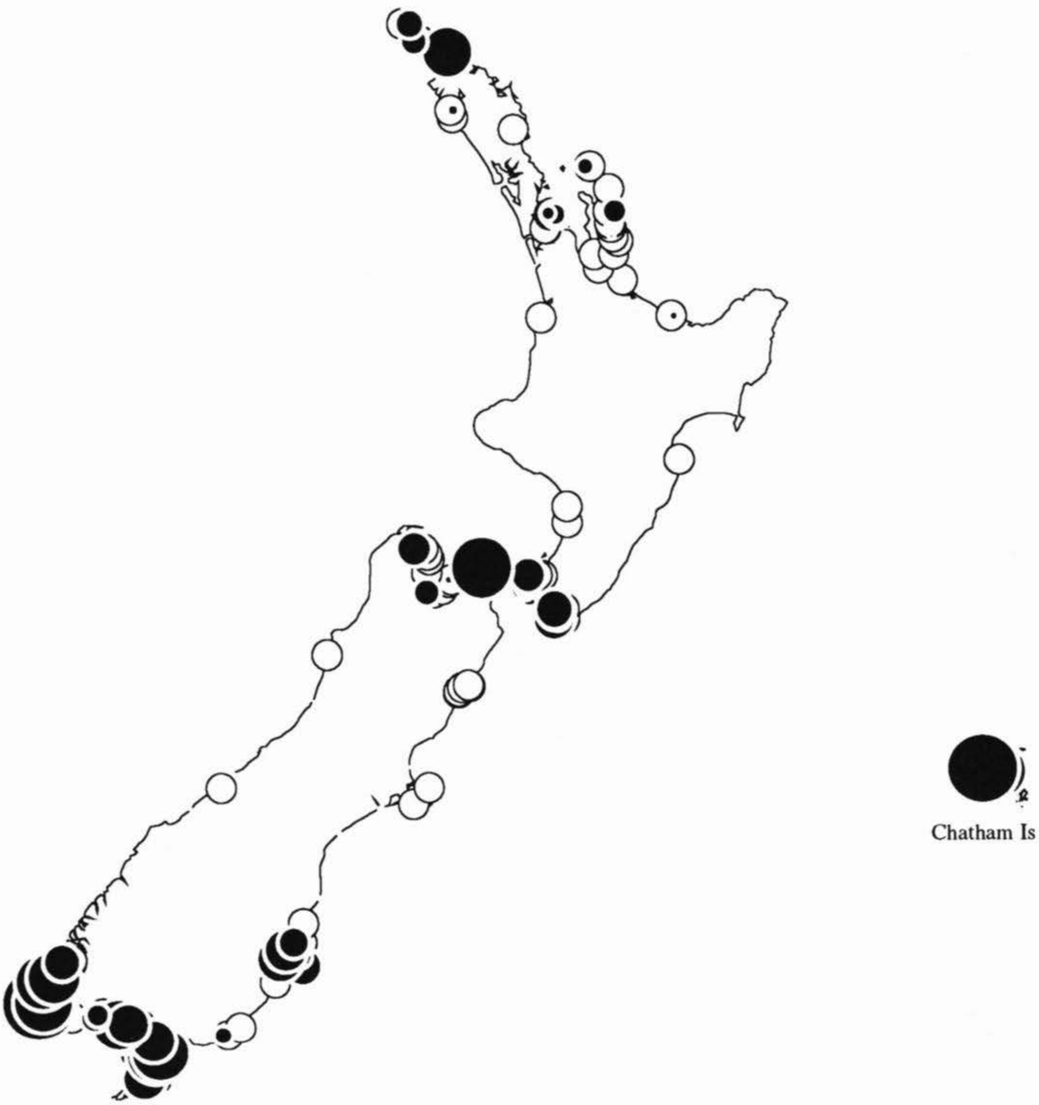

Figure 1: Map of New Zealand showing 126 archaeological sites from which fish bones have been studied. Some sites overlap. White circles indicate blue cod are absent. The size of the black circles indicates the relative abundance of blue cod in each site. A logarithmic scale is used.

Although we have reconstructed live catch information for this species from a number of sites, large archaeological samples have been difficult to obtain. In this paper we discuss three especially important large samples from Chatham Island sites and two smaller samples, with significant chronology, from Mana Island in Cook Strait. We present size-frequency diagrams for the five catches, estimate the meat weight represented by the archaeological bones, and compare the archaeological catches with modern catches from various locations. The discussion focuses on differences in mean fish size between the assemblages and the possible reasons for this.

BLUE COD CHARACTERISTICS

The New Zealand blue cod is not a true cod (family Gadidae), but belongs to the family Mugiloididae. It is a plump fish producing good fillets; a sizeable specimen is 50 cm in length. Blue cod occur on all coasts of New Zealand, but are most abundant in the Marlborough Sounds, Foveaux Strait, Stewart Island, and the Chatham Islands, especially over rough rocky ground with weed. Graham states that "Large numbers have also been caught around the Barrier Island, north of Auckland" (Graham 1956: 288). The fish are smaller in northern waters. Warren *et al.* (1997) reviewed data on the growth rates of blue cod in different parts of New Zealand which showed that the further south they are found, the faster they grow. Thus blue cod reach 33 cm at five to six years in Southland, six to eight years in the Marlborough Sounds, and eight years or more in Northland.

Graham also notes that blue cod are sensitive to turbidity, and that when sediments are stirred up 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 winter, the fish migrate into deeper water where the temperature is warmer. Graham confirmed the sensitivity of blue cod to temperature, observing that aquarium specimens became languid and uninterested in food in cold weather (Graham 1956: 289). He also recorded the unusual phenomenon that they became very nervous and agitated at the onset of stormy weather, and many would leap out of an aquarium tank to their death during thunderstorms. The influence of water temperature on abundance over fishing grounds is not apparent in northern areas (Doak 1972: 102).

Blue cod were important to the pre-European Māori in many parts of New Zealand and were known variously as *rāwaru*, *pākirikiri*, or *pātukutuku* (Williams 1971: 332). These names do not occur in the tropical Pacific, nor does the species. Williams records that among the Ngā Puhi, the name *pākirikiri* also referred to both the spotty (*Notolabrus celidotus*) and a fish known further south amongst the Raukawa people as *tāngahangaha*. His entry for the latter name refers to spotty for the Raukawa people and banded wrasse (*Notolabrus fucicola*) for the Ngāti Porou. This is somewhat confusing.

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.

Captain Cook referred to the fish as Cole-fish (Beaglehole 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.

The relationship between length and weight is an important characteristic of any fish. For economically important species, fisheries scientists have usually established the 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. In the case of blue cod, however, authoritative information is not yet available. Analysis of all data for blue cod in the NIWA (National Institute of Water and Atmospheric Research) database produces a working equation linking fork length in mm to ungutted weight in g as follows (Bradford, NIWA, 1996: pers. comm.):

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

THE ARCHAEOLOGICAL SITES

The three Chatham Islands sites considered in this paper are located in the vicinity of Point Durham on the southwest coast of the main island. They were investigated as part of a programme of research directed by Sutton (1979, 1980, 1989) between 1973 and 1976. Waihora (sometimes called the Waihora mound) is much the largest site in the area. It revealed "evidence of various aspects of village life from food preparation to burial" and is presumed to have been occupied all year round (Sutton 1979: 220). It is believed to have functioned as a central place and the centre of a seasonal round of exploitation of a variety of resources. CHA and CHB are midden sites located on opposite sides of a ridge about 1 km inland from Waihora. Both consisted essentially of a single midden layer, although at CHB a horizon at the surface of the underlying natural was defined and excavated separately. A scoop hearth in the surface of the natural, from which a radiocarbon date was obtained, was regarded as the earliest sign of occupation at the site. Both sites are interpreted as specialised food gathering sites, focusing on ground nesting sea birds. In Sutton's view they are part of the settlement pattern that centred on Waihora.

Radiocarbon dates for these sites are given in Table 1. These results led Sutton (1979: 83) to conclude that Waihora was occupied "...during a single short period, probably no longer than a century, in or about the sixteenth century A.D." The dating of CHA and CHB is less satisfactory. The two dates for CHB were interpreted to mean "that occupation there had begun by at least 1510 A.D. and that it continued for some time, perhaps after 1700 A.D." (Sutton 1979: 95). The single date for CHA is identical to the later of the two dates from CHB. It could be argued, on the basis of this evidence, that the inland midden sites are actually more recent than Waihora. In view of the potentially important differences in fish sizes from these three sites, a better understanding of their duration and relative ages is highly desirable.

TABLE 1
Chatham Island radiocarbon dates
(From Sutton 1979 and I.W.G. Smith, pers. comm. 1997)

Provenance	Lab. No	CRA Years BP
CHA Area I/2 layer 2	NZ4658	170 ± 60
CHB Area II/19 Crust of layer 2	NZ4654	370 ± 60
CHB Area II/23-24 Base of ash lens in Layer 1	NZ4655	170 ± 60
Waihora Area VII/1+2 Layer 2 (stone structure 2)	NZ3971	380 ± 40
Waihora Area VIII/6+7 layer 3	NZ3152	370 ± 30
Waihora Area IV/23 Lens D	NZ3971	370 ± 50
Waihora Area V/15 Lens B	NZ3972	420 ± 60
Waihora Area Vb/2+7 Layer 1	NZ3973	390 ± 50
Waihora Area V/6 Surface beneath layer 3	NZ3974	410 ± 50
Waihora Area VI/18+19 Layer 1	NZ3975	330 ± 60

The Chatham Island sites were excavated with hand trowels and brushes according to natural layers, and material recovered was bagged according to metre square and a layer, lens or structure. All material was sieved through 1/12 inch (2.1 mm) mesh and the fine residue discarded, except for a standard set of whole samples collected systematically from each site. In the laboratory, the material previously sieved on site was sieved again through 4 mm mesh, the fine residue stored, and the remainder sorted and identified wherever possible (Sutton 1979: 338). Fish remains were initially studied by Sutton (1979) and have been reanalysed in the Archaeozoology Laboratory of the Museum of New Zealand. Table 2 presents the Minimum Number of Individuals (MNI) from the reanalysis of fish remains from the three sites. Blue cod contributed 54% of the total catch from all three sites combined.

Mana Island is a small cliff-bound island off the southwest tip of the North Island. Cultural deposits extend for about 300 m along the beach ridge on a coastal flat in the southeast part of the island, where the main stream system reaches the coast. Excavations were carried out under Horwood's direction in 1990 in two parts of the beach ridge (Horwood 1991; Horwood *et al.* 1998). The larger northern excavation contained a relatively deep stratified deposit. The layers can be grouped into upper (predominantly or entirely an historically documented occupation by a group of Ngāti Toa in the first half of the nineteenth century) and lower (considerably earlier prehistoric occupation). A single shallow layer of concentrated midden was found in the southern excavation, 260 m to the south. This occupation was fully prehistoric. A series of radiocarbon dates suggest that the southern midden and the lower part of the northern excavation were deposited at broadly the same period, probably in the fifteenth century (Horwood *et al.* 1998: 19). In the present analysis, the assemblage is divided into two: Mana Early (southern excavation and lower part of northern excavation) and Mana Late (upper part of northern excavation).

TABLE 2
Fish MNI from three Chatham Islands sites

Family	**Common Name**	**Waihora**	**CHA**	**CHB**
Mugiloididae	Blue cod	2547	625	4052
Odacidae	Greenbone	1701	36	1538
Labridae	Spotty, etc.	1509	92	420
Gempylidae	Barracouta, etc.	273	-	1
Latrididae	Blue moki, etc.	183	1	62
Cheilodactylidae	Tarakihi, etc.	180	28	323
Nototheniidae	Maori chief	179	15	229
Moridae	Red cod, etc.	81	-	-
Congridae	Conger eel	72	-	4
Anguillidae	Freshwater eels	48	-	2
Balistidae	Leatherjacket	33	4	19
Percichthyidae	Groper	22	-	6
Ophidiidae	Ling	20	1	3
Chondrichthyes	Sharks, etc.	19	-	-
Carangidae	Trevally, etc.	18	-	-
Scorpaenidae	Scarpee, etc.	14	-	8
Triglidae	Gurnard	4	-	-
Pleuronectiformes	Flounder, sole, etc.	2	-	-
Aplodactylidae	Marblefish	1	-	-
Merlucciidae	Hoki	1	-	-
Uranoscopidae	Giant stargazer	-	-	1
Total	-	**6907**	**802**	**6668**

The deposits at the northern excavation were excavated by trowel according to natural layers, sieved through 2 and 5 mm mesh, and bagged according to 1 m square. The southern excavation was only 1 x 2 m and the entire deposit was removed for laboratory analysis. After initial laboratory sorting of the midden, the fish remains were analysed at the Archaeozoology Laboratory of the Museum of New Zealand Te Papa Tongarewa (Horwood *et al.* 1998). The MNI from early and late contexts at Mana Island are given in Table 3. Blue cod contributed 8.1% of the total catch from both early and late contexts combined.

TABLE 3
Fish MNI from Early and Late contexts on Mana Island

Family Name	**Common Name**	**Early**	**Late**
Labridae	Spotty, etc.	257	266
Sparidae	Snapper	186	109
Mugiloididae	Blue cod	49	97
Odacidae	Greenbone	10	124
Balistidae	Leatherjacket	77	48
Latrididae	Blue moki, etc.	18	88
Arripidae	Kahawai	45	37
Gempylidae	Barracouta, etc.	13	64
Cheilodactylidae	Tarakihi, etc.	22	35
Chondrichthyes	Sharks, skates, rays	11	45
Congridae	Conger eel	5	47
Carangidae	Trevally, etc.	16	13
Scorpaenidae	Scarpee, etc.	7	17
Aplodactylidae	Marblefish	4	18
Percichthyidae	Groper	4	16
Myliobatidae	Eagle ray	-	11
Osteichthyes	Unknown species	6	2
Squalidae	Dogfish	3	4
Ophidiidae	Ling	1	5
Moridae	Red cod, etc.	1	5
Triglidae	Gurnard	1	3
Myliobatiformes	Skates and rays	1	3
Anguillidae	Freshwater eels	-	2
Scombridae	Blue mackerel	2	-
Zeidae	John dory	1	1
Callorhinchidae	Elephant fish	-	2
Totals		**740**	**1062**

MODERN SIZE-FREQUENCY DATA ON BLUE COD

When considering a pre-European fish catch, it is necessary to have something to compare it with. The best comparative data would be a clear understanding of the population of the species in question from close to the archaeological site, preferably the natural population, unaffected by human fishing. Usually it is impossible to acquire such comparative data, because of the intense pressure on fish stocks following European colonisation and the development of technologies for mass harvesting. In the formulation of mathematical models for estimating maximum sustainable yields in fisheries management, a natural population baseline must be established or assumed for any species of interest. This is usually a hypothetical nineteenth century population structure and biomass, based more on guesswork than on any direct information of any quality. There is, therefore, some interest in acquiring knowledge of fish population characteristics from archaeological data, as an alternative to the dubious assumptions at present being made. This also recognises the possibility that pre-

European Māori may have had a significant influence on fish populations in the course of their own fishing endeavours. This is a catch 22 situation, because archaeologists also need knowledge of natural populations unaffected by humans for comparison with archaeological finds and are frequently obliged to turn to historically collected data as the only available option.

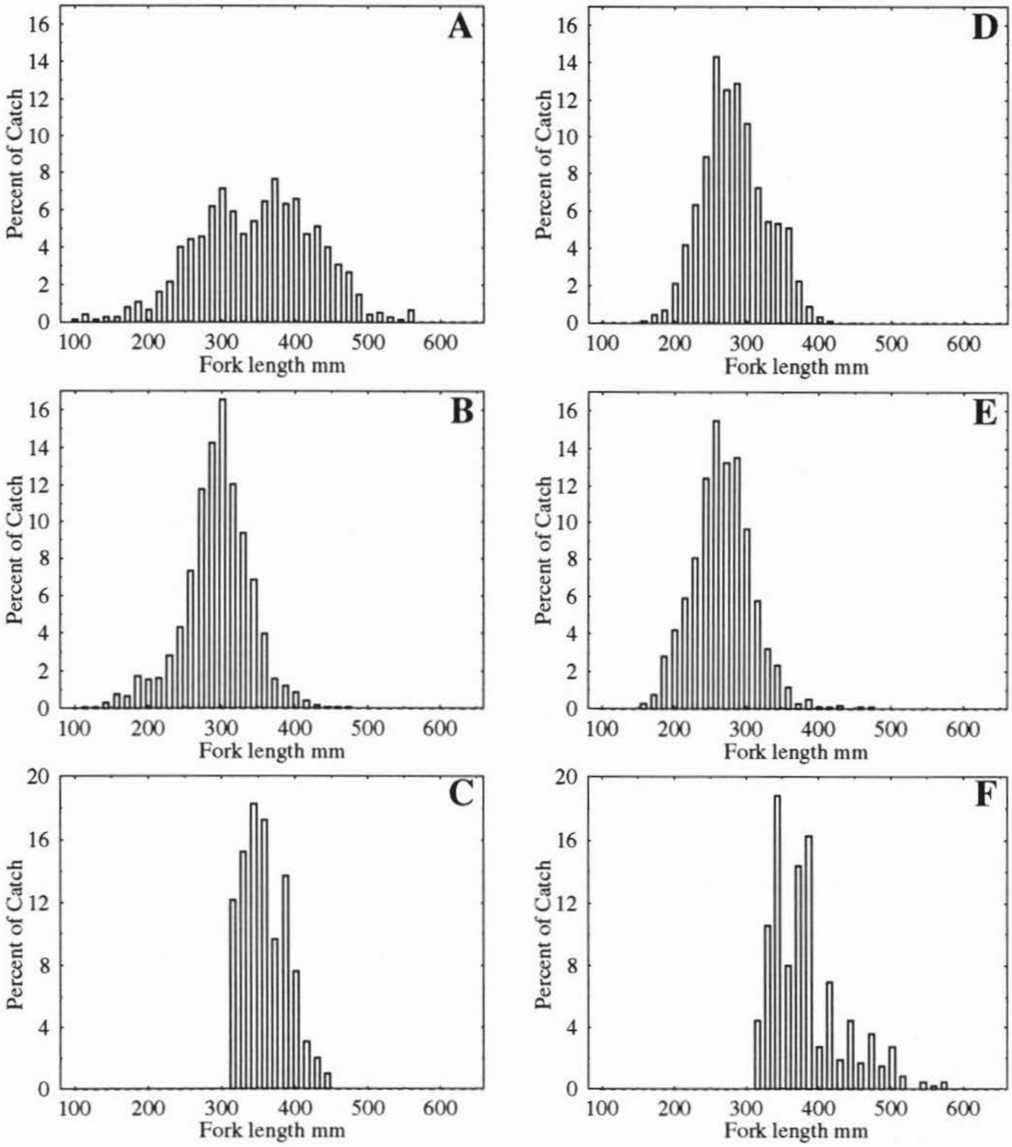

Figure 2: Size-frequency diagrams for modern catches of blue cod. A. Southern New Zealand (trawl). B. Marlborough Sounds (pots). C. Stewart Island Commercial A. D. Long Island Marine Reserve (hooks). E. Long Island Control (hooks). F. Stewart Island Commercial B.

The National Institute of Water and Atmospheric Research (NIWA) has a large database of fish length information for many species, some from research trawls by the former MAF (Ministry of Agriculture and Fisheries) Fisheries Division, now incorporated in NIWA, and some collected in various fish processing factories and landing sheds around New Zealand. There has also been recent catch-and-release research in a newly established marine reserve at Long Island in the Marlborough Sounds and various control sample areas. A selection of this information is provided in Table 4 and Figure 2.

TABLE 4
Modern blue cod catches at several locations
(fork length in mm)

	Marlborough Sounds	**Long Is. Reserve**	**Long Is. Control**
N	2049	885	1214
Range of Values	120 to 478	160 to 417	161 to 478
Mean	293.9 ± 1.0	283.2 ± 1.5	266.6 ± 1.2
Standard Deviation	45.3 ± 0.7	44.2 ± 1.1	41.4 ± 0.8
Coefficient of Variation	15.4 ± 0.2	15.6 ± 0.4	15.5 ± 0.3
Skewness g1/w1	-0.4 and 11.5	0.2 and 5.6	0.4 and 9.1
Kurtosis g2/w2	4.1 and 10.5	2.7 and 1.8	4.2 and 8.3
	Southern Trawls	**Stewart Is. A**	**Stewart Is. B**
N	744	197	473
Range of Values	100 to 565	310 to 451	310 to 580
Mean	347.4 ± 2.9	358.6 ± 2.2	382.7 ± 2.3
Standard Deviation	80.3 ± 2.1	30.6 ± 1.5	50.8 ± 1.7
Coefficient of Variation	23.1 ± 0.6	8.5 ± 0.4	13.3 ± 0.4
Skewness g1/w1	-0.1 and 3.6	0.5 and 3.9	1.2 and 9.8
Kurtosis g2/w2	2.8 and 1.2	2.5 and 1.3	4.2 and 5.3

The Southern trawl data (Fig. 2A) was obtained during a visit to several stations of the Shinkai Maru vessel, from Foveaux Strait south to the Snares Islands area (Hurst *et al.* 1990: 12, 17) and was supplied to us by Larry Paul of NIWA, Wellington.

The Marlborough Sounds data (Fig. 2B) is from pot catches and was supplied by Ron Blackwell of NIWA, Nelson.

The Stewart Island A data (Fig. 2C) was supplied by Graeme McGregor, Ministry of Fisheries, Auckland. The exact status of this data is not known, but in view of the complete lack of specimens shorter than 300 mm, it must be assumed to be from commercial landings.

The Long Island Reserve data (Fig. 2D) was taken from Davidson (1995: Appendix 10–12) and relates to fish caught by lure hook in 1994–1995. The reserve was established in May 1993, so these catches were one and two years after fishing had ceased.

The Long Island Control Sample (Fig. 2E) was also taken from Davidson (1995: Appendix 10–12) and relates to fish caught by lure hook in 1994–1995 in an area close to the reserve, in which recreational fishing had continued.

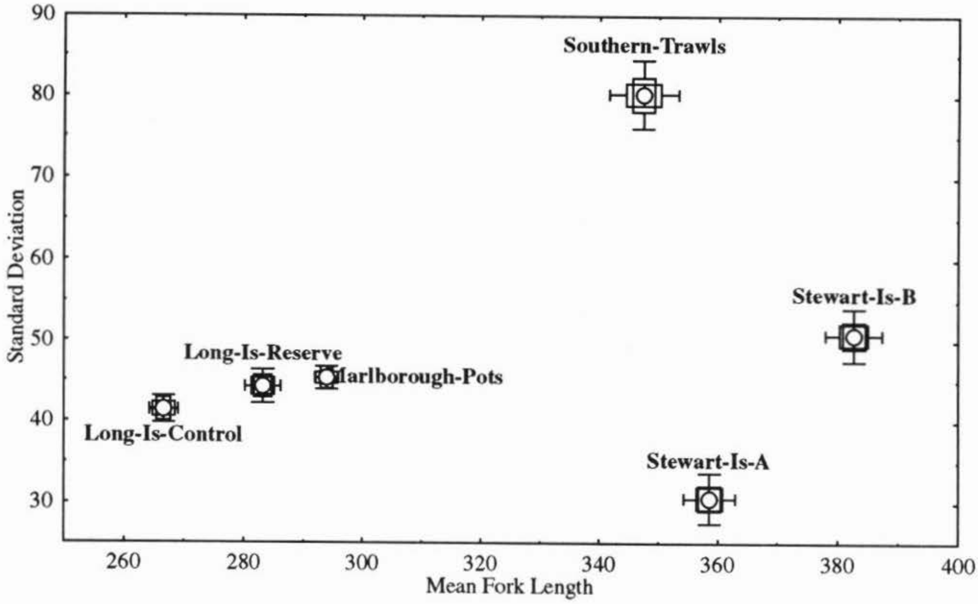

Figure 3: Dispersion characteristics of several modern catches of blue cod.

The Stewart Island B data (Fig. 2F) was supplied by Glen Carbine, NIWA Dunedin. Once again, the exact status of this data is not known, but because of the complete lack of specimens less than 300 mm, it is assumed to be from commercial landings.

The size-frequency curves of these modern catches are widely divergent. The Southern trawl data is likely to be representative of the actual fish population present in this area, because the fish were captured in a net with one inch mesh (25.4 mm). It is clear from Table 4 and Figures 2 and 3 that this sample has a far greater standard deviation than all other samples. It is also interesting that this size-frequency curve displays characteristics closer to Gaussian than all others.

It is also clear that the Stewart Island and Southern Trawl catches have a much higher proportion of large fish than any of the three catches in the Marlborough Sounds. Whether this is because of more intensive fishing in the Cook Strait region during the last century compared with the southern area is unknown.

The fish caught in pots in the Marlborough Sounds might also be a fair representation of the present-day population structure, because the pot capturing technique may not be particularly selective by fish size. There are certainly more smaller fish in this sample than in either of the Long Island samples. The latter were taken with hooks, which would certainly be selective by size.

PRE-EUROPEAN BLUE COD CATCHES

The methods by which the live fork lengths and weights of a prehistoric fish catch can be estimated from archaeological bones are described in a series of published papers in which we focus on one species at a time (Leach and Boocock 1995; Leach *et al.* 1996a, 1996b, 1997a). A study of blue cod is described by Leach *et al.* (1997c), using the blue cod bones from Waihora as the archaeological example.

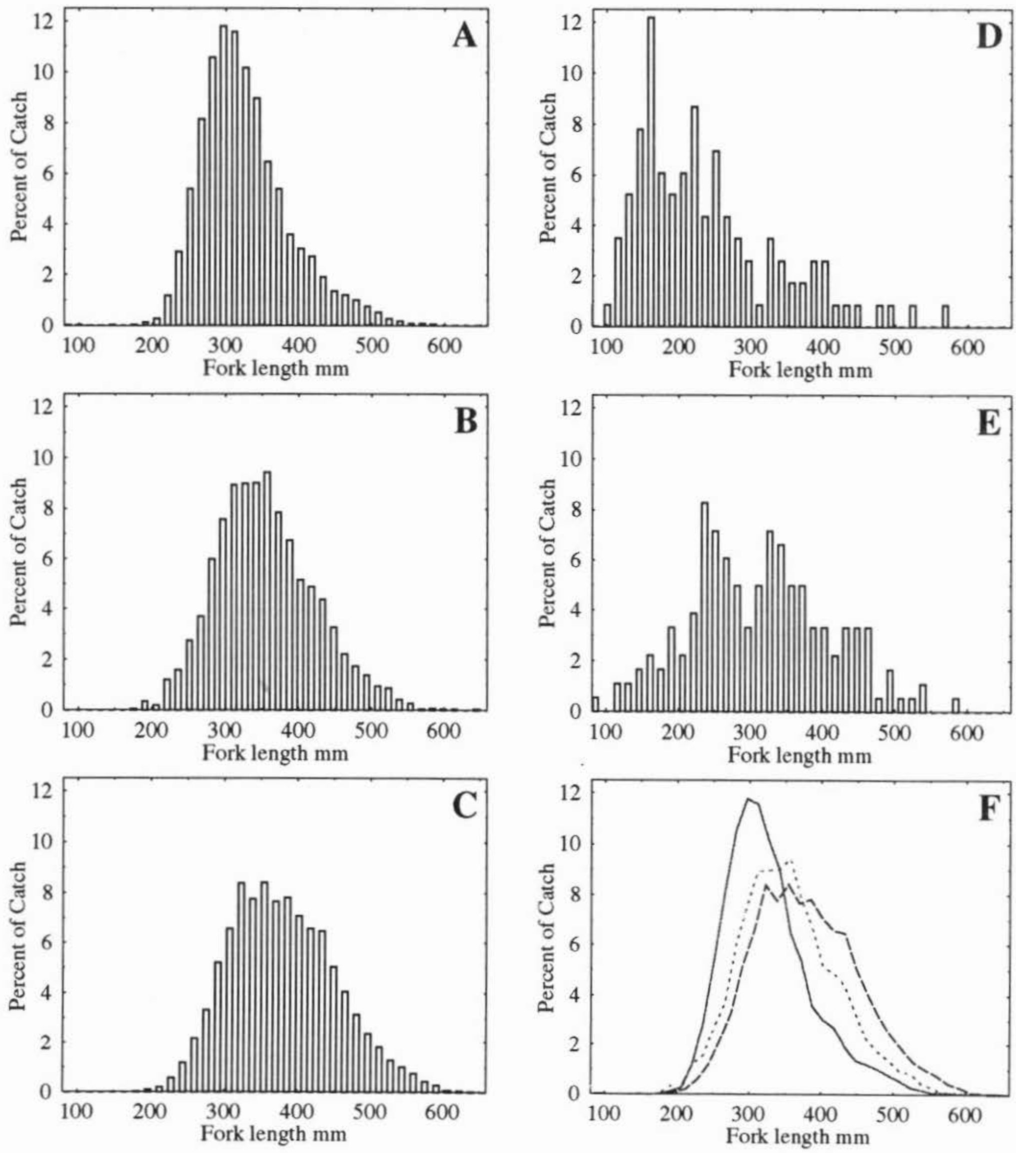

Figure 4: Pre-European blue cod catches. A. Waihora (Chatham Islands). B. CHA (Chatham Islands). C. CHB (Chatham Islands). D. Mana Island Early. E. Mana Island Late. F. Three Chatham Island sites superimposed.

CHATHAM ISLAND SITES

Of the 22,249 fish bones we were able to identify to species from Waihora, 10,301 belonged to blue cod, of which measurements were able to be made on 8,047. After the live fork length is estimated from the bone measurements, the data are pooled into a size-frequency histogram showing the character of the original catch (Fig. 4A). The reasons for measuring more bones than the actual MNI for the species are discussed in detail elsewhere (Leach and Boocock 1995: 24 ff.).

Table 5 compares the figures for the length of blue cod from Waihora with those from the other two Chatham Island sites, CHA and CHB. The size-frequency histograms for these two sites are shown in Figure 4B and 4C. The size-frequency curves of the blue cod catches at these three sites show close to Gaussian characteristics, although the small departures are significant. The most notable feature of these distribution curves is the very low number of fish less than 250 mm. Blue cod reach sexual maturity at an age of 2 years and a length of 100–190 mm (Annala 1994: 42). The general lack of small specimens in these distributions could not reflect the structure of the natural population, and must be due to a culturally selective process. This could be the result of one or both of two possibilities — either the technology being used had the effect of selecting against small specimens, or the captured fish were hand sorted and small ones thrown back. If nets were used, they must have had a relatively large mesh size, so that small specimens escaped. Baited hook and line fishing would result in the same type of distribution curve, selecting against small specimens.

TABLE 5
Prehistoric blue cod catches at several sites in the Chatham Islands
(fork length in mm)

Chatham Islands	**CHB**	**CHA**	**Waihora**
N	14,517	2,671	8,047
Range of Values	119 to 685	181 to 651	81 to 616
Mean Fork Length	380.6 ± 0.6	355.1 ± 1.3	326.7 ± 0.6
Standard Deviation	73.4 ± 0.4	67.4 ± 0.9	61.1 ± 0.4
Coefficient of Variation %	19.3 ± 0.1	18.9 ± 0.2	18.7 ± 0.1
Skewness g1/w1	0.4 and 30.0	0.4 and 13.9	0.8 and 33.9
Kurtosis g2/w2	2.9 and 3.1	3.1 and 1.5	4.0 and 19.2

It is also noticeable that some very large fish are present in these catches, with a high proportion over 400 mm. The largest fish was 685 mm long, which certainly would have pleased the fisherman and attracted interest when taken home.

One of the aims of the estimation of live fish size from archaeological bones is to estimate the meat weight represented in archaeological sites. In our previous study of blue cod we estimated the mean ungutted weight of the fish represented by the bones from Waihora as 569 ± 3.8 g (i.e., ± 0.67%.). From this, the total weight of blue cod in the excavated part of the site was 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 could be calculated as:

Mean Weight	x MNI		Total Body Weight	Usable Meat Weight
569 g	x 2547	=	1,449 ± 10 kg	1,015 kg

The stated error of ± 10 kg for the total body weight is based on the standard error of the mean weight of fish, which is ± 0.67%. Smith (1985: 487–88) recommends 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 was therefore estimated to be about 1.0 metric tonne of blue cod meat.

The meat weights for the CHA and CHB sites can be estimated in the same way. The mean fish weight at CHA was 731 ± 8.2 g (± 1.12%, N=2,671); at CHB it was 902 ± 4.4 g (± 0.49%, N=14,517). The blue cod MNI values are 625 and 4,052 respectively. Thus, the total weight of blue cod can be calculated as:

Mean Weight	x MNI		Total Body Weight	Usable Meat Weight
CHA 731 g	x 625	=	457 ± 5 kg	312 kg
CHB 902 g	x 4,052	=	3,655 ± 18 kg	2,559 kg

These figures provide a sound basis for further studies of diet which are beyond the scope of the present paper.

MANA ISLAND

Blue cod is not a common fish in the Mana Island sites, but because there is significant time depth in the occupation deposits, these two small samples are quite valuable. The catch statistics are given in Table 6 and the size-frequency diagrams in Figure 4D and 4E.

TABLE 6
Prehistoric and nineteenth century blue cod catches on Mana Island
(fork length in mm)

Mana Island	**Early**	**Late**
N	115	181
Range of Values	78 to 563	80 to 591
Mean Fork length	237.5 ± 9.1	313.1 ± 7.2
Standard Deviation	98.4 ± 6.4	96.9 ± 5.0
Coefficient of Variation %	41.4 ± 2.7	30.9 ± 1.6
Skewness g1/w1	1.0 and 4.5	0.2 and 2.5
Kurtosis g2/w2	3.6 and 1.6	2.6 and 0.8

These two catches are quite unlike those from the Chatham Islands. In the catches from the Chathams there is a notable absence of fish less than 250 mm. These two Mana Island catches, in contrast, are dominated by fish less than 250 mm. As can be seen in Figure 4D and 4E and Table 6, however, very large fish were obtainable in the vicinity of Mana Island too. This is important evidence from several points of view. Firstly, it shows that large blue cod were present in Cook Strait not only in the pre-European period but into the nineteenth century, even though the present-day catches from the Marlborough Sounds on the southern margin of Cook Strait show no evidence of this. Thus the substantial difference, noted earlier, between the modern catches in Foveaux Strait and southwards and those in the Marlborough Sounds may be due to differences in fishing pressure or to faster growth rate further south. Secondly, the Mana Island catches could only have been accomplished using a technology which did not select by size. This must have been some form of trap, such as pots or nets. If nets were used, they must have had a small mesh size. The third important conclusion which arises from this is that small fish were considered good food by the people living at Mana Island. This subject is further discussed below.

The meat weights for the two Mana Island catches were estimated in the same way as for the Chathams. The mean fish weight at Mana Early is 315 ± 38.9 g (± 12.37%, N=115); at Mana Late it is 587 ± 37.6 g (± 6.40%, N=181). The blue cod MNI values are 49 and 97 respectively. Thus, the total weight of blue cod is estimated as:

	Mean Wt x MNI	=	Total Body Wt	Usable Meat Wt
Mana Early	315 g x 49	=	15.4 ± 1.9 kg	10.8 kg
Mana Late	587 g x 97	=	57.0 ± 3.7 kg	39.9 kg

CHANGES THROUGH TIME

For human communities to have a significant influence on a fish population, they must be harvesting the fish at a rate which is not sustainable. In the case of commercial species, sustainable fishing rates have been estimated by modelling a number of variables, including estimates of biomass, recruitment rates and catch rates. Although no estimates of blue cod biomass in different parts of New Zealand are currently available, there are estimates for Maximum Constant Yield (Table 7).

TABLE 7
Estimated Maximum Constant Yield of blue cod in various regions (from Annala 1994: 43)

Region	tonne per annum
BCO1: Auckland	15
BCO2: Central East	5
BC03: South East Coast	55
BC04: South East Chathams Rise	525
BCO5: Southland and Sub-Antarctic	565
BC07: Challenger	85
BC08: Central Egmont	40

These estimates are based on average catch rates over a period of time when stocks do not appear to be diminishing. These are very low values compared with other species of importance to pre-European Māori, such as barracouta and snapper. This supports the view that blue cod might be a good species with which to look for any evidence of over-fishing in the pre-European period. As mentioned above, blue cod are found in very shallow water and down to about 80 m depth, and are known to be strongly territorial all year round. There can also be dramatic changes in local abundance of blue cod inshore depending on turbidity and seasonal water temperatures. These factors may be more important in southern than northern waters. These biological and behavioural matters are important when examining changes within an archaeological site and from one site to another.

The fish bone assemblages from the three sites in the Chatham Islands are very large, containing not only high numbers of blue cod, but also of labrids and greenbone; moreover, the sites they derive from show all the signs of being short duration settlements. They therefore offer an exceptional opportunity for detailed study. There is, however, a major problem in that radiocarbon dates do not reliably place the three sites into chronological order (Table 1). This is fundamental when considering change through time. There is no published information on the likely extent of any inbuilt age in the samples dated and, given their close proximity in time, this is a great disadvantage. Sutton (1979: 236) presents a case that all these sites in the Point Durham area of the Chatham Islands were part of one cultural system; that is, each site is a different specialised functional entity within the activities of one community. This implies that any differences between the age of the sites is due to small statistical variation rather than representative of significant temporal difference. There is, however, an important difference between real and effective temporal contemporaneity. These sites could actually be 20, 50 or 100 years apart in time, and still effectively be part of the same functioning social system. If the total span was indeed 20–100 years overall, then this could be a significant period of time when studying human impact on the local marine environment. Moreover, if they are exactly contemporary (say 1–5 years), then any differences between the catch data for the various sites, no matter how small or large, is of considerable interest because it may indicate partitioning of the catch according to social rank or other criteria. In short, precise dating of these sites, while it may not have been possible when the excavations were carried out, is of great interest now. It would be very useful to re-visit this problem in the future.

Despite the proposed short duration of these sites, we thought it worth while to split the largest assemblage, CHB, into two samples from the two main stratigraphic units to see if any change could be detected. Unfortunately, Layer 2 (the earlier) has only 132 measurements, whereas there are 13,748 from Layer 1 (the later). The statistics for these two layers are: Layer 1, mean fork length = 379.9 ± 0.62, SD = 72.9 ± 0.4; and Layer 2, mean fork length = 397.6 ± 6.3, SD = 72.4 ± 4.5. The student's t value is 2.80, which is significant $p=0.05$ and not significant $p=0.01$. This appears to indicate a small increase in mean size over time, but is not well supported by the statistics.

The absence of fine control over chronology between the sites is frustrating, but it is useful to point out the characteristics of the assemblages. There are important differences in the dispersion characteristics of the blue cod assemblages from these three sites (Figs 4, 5, Table 5).

It will be readily observed in Table 5 that the mean fork length for blue cod is largest at CHB, followed by CHA, and smallest at Waihora. The differences are highly significant. The change in central tendency is clearly seen in Figure 4, and it will also be observed that the right hand shoulder (the largest fish) of the curves steadily diminishes from CHB to CHA to Waihora. This is made clear in Figure 4F, where the three curves are superimposed. This shape change is partly reflected in a uniform lowering of the standard deviation from site to site. When these changes are plotted out in Figure 5, the trend in characteristics from one site to another is striking. It is tempting to think that this might follow a time series,

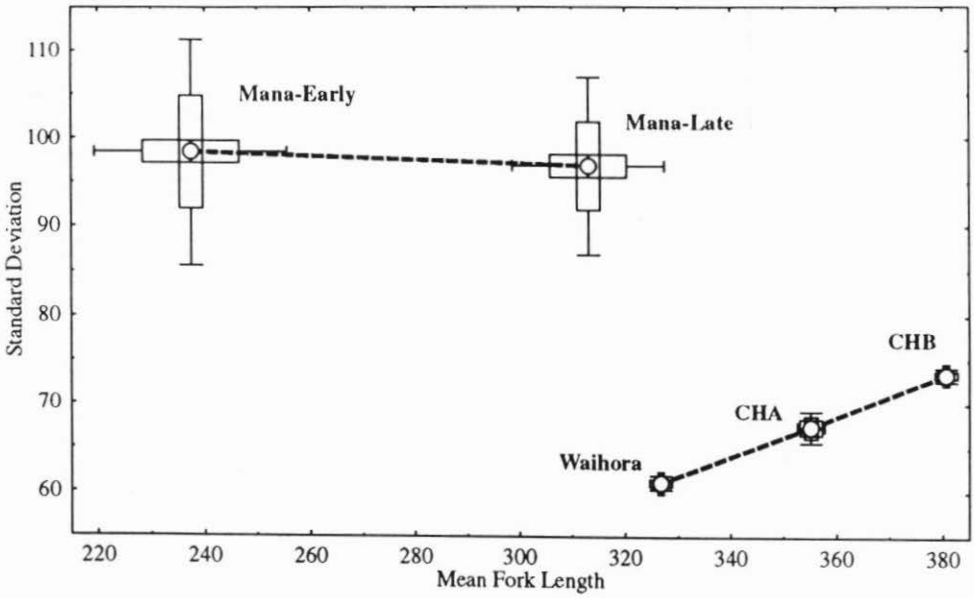

Figure 5: Trends in dispersion characteristics of blue cod catches from archaeological sites at Mana Island and the Chatham Islands.

but there is no concrete evidence for this. Could the consistent trend be an increase in mean size over time or a decrease?

When the characteristics of the blue cod assemblages from Mana Island are plotted out on the same graph, a change through time is clearly indicated. Possibly contrary to expectation, the Mana Island trend is towards an increase in mean fork length over time. Once again, the difference is highly significant. The earliest people on Mana Island were clearly taking very small fish. The current legal minimum size limits for blue cod in New Zealand are: Marlborough Sounds 280 mm, South East Fisheries Management Area (FMA) 300 mm, other areas 330 mm. Using the figure of 330 mm, we can calculate the amount of undersized blue cod which were caught at these and other sites in the prehistoric period (Table 8). Kokohuia is in Northland (Leach *et al.* 1997b) and the three Black Rocks middens are in Palliser Bay at the southeastern tip of the North Island (Anderson 1979). These sites were used in this study because the assemblages of bones were available for measurement.

TABLE 8

Proportion of 'undersized' blue cod in various archaeological sites

Site	Undersize %	Oversize %	N
Kokohuia	100.0	0.0	5
Mana Island Early	82.6	17.4	115
Black Rocks BR3	81.8	18.2	11
Black Rocks BR4	76.3	23.7	59
Black Rocks BR2	73.9	26.1	23
Waihora Chatham Islands	59.3	40.7	8,047
Mana Island Late	59.1	40.9	181
CHA Chatham Islands	38.9	61.1	2,671
CHB Chatham Islands	27.3	72.7	14,517

These results challenge a widely held view that fishing pressure results in a lowering of mean size over time, which could turn out to be more an item of faith than a statement of reality. It was certainly surprising to find evidence of an increase in mean size of blue cod through time at Mana Island, although an increase in size of snapper catches has previously been found at Rotokura (Leach and Boocock 1994). In the Mana Island example, the two catches are separated by several hundred years. The archaeological sequence in this part of the North Island is not well known. In particular, although early occupation is relatively well documented both at Mana and at Paremata on the adjacent mainland, information about later prehistoric occupation in the vicinity is negligible. It is conceivable that the Mana Early catch reflects the activities of an already established human population, whereas the Mana Late catch represents the activities of incoming Ngāti Toa after a considerable period of virtual abandonment. One conclusion that can be drawn, however, is that human activities do not appear to have had any long term adverse effect on blue cod in the vicinity of Mana Island by the mid nineteenth century.

Whether there was an increase in blue cod size at the Chatham Islands awaits better information on the chronology of the sites there. However, at this point we must sound a note of caution. These three sites are just that, three separate sites, with no guarantee of continuous local marine exploitation by the occupants of this area. A respite from fishing of say 50 years in a small coastal area is virtually undetectable with current archaeological techniques, but could result in substantial recovery of inshore fish stocks. This has certainly been the finding after as little as three years respite when areas are set aside as marine reserves, for example at the Long Island marine reserve, which is about 5 km in length (Davidson 1995).

Even so, it is tempting to hypothesise that we have here an indication in the archaeological record that sustained fishing of a species sensitive to human predation may lead to an increase in mean size over time if it is permitted to take as many small specimens as one wishes. Polynesian people are no strangers to capturing and eating small fish in the Pacific. There is no reason to think that the first immigrants to New Zealand brought with them a newfangled conservation notion that stocks are best preserved by taking the largest specimens and leaving the small ones alone. Baited line fishing using hooks made from bone and shell is not nearly as efficient as baited line fishing with modern steel hooks. It is very hard to make bone or shell hooks that are small enough to catch small fish. The small fish found in archaeological sites are most likely to have been taken with various net and trap techniques which do not select according to size. Polynesian people do not waste small fish by throwing them back. This "take everything" approach may not be as damaging to coastal ecology as is widely believed.

It is important to note that this practice of taking very small fish, which is strongly indicated in the sites on Mana Island (59–83% undersized), is much less clearly indicated in the sites in the Chatham Islands (27–59%). It is possible that taking predominantly small fish as at Mana could result in an increase in mean size over time, while the taking of fewer small fish, as in the Chatham Islands, could result in a decrease. There is a hint of this in the small decrease in mean size from Layer 2 to Layer 1 at the CHB site. It is hoped that these three sites in the Chathams can be subjected to intensive dating research in the future to help decide between these alternatives, as this could have important implications for management of the inshore fishery.

DISCUSSION AND CONCLUSIONS

This study of pre-European blue cod fishing has shown that a non-selective predation strategy was employed during two chronologically distinct occupations at Mana Island in Cook Strait, with large numbers of very small fish being taken as food. By contrast, the people occupying the three sites in the Chatham Islands rejected small fish to a much greater extent. Comparison of the size-frequency curves of the various prehistoric catches with modern distribution curves suggests that at least in Cook Strait, blue cod were much larger in the pre-European and early European period than they are today.

Blue cod were a far more important species for people in the Chatham Islands than at Mana Island, accounting for an average of 50% of all fish taken at the three Chatham Island sites, compared with only 8.1% on Mana Island. The consumable meat weight represented by these fish in the Chatham Islands is close to 4 metric tonne, compared with just over 50 kg in the Mana Island samples. The large number of fish in the Chatham Islands samples offer exceptional opportunities for further detailed study.

Blue cod have a relatively low biomass compared with other fish which were targeted by pre-European Māori, and small home ranges. These characteristics make them a particularly useful species with which to examine human predation effects.

It was found that there are clear signs of an increase in mean fish size over time on Mana Island; this could possibly be partly attributed to the large number of undersized fish being taken, 59–83% by modern standards. By contrast, in the Chatham Islands, the three sites examined showed less emphasis on small fish (27–59% undersized), but there are equally strong indications of a change through time in mean size. However, the direction of this change is not known at present because the three sites are not clearly differentiated by radiocarbon dating. Although the time range of these three sites may be small (less than 100 years), blue cod are known to recover dramatically in a small area when fishing ceases for as little as three years. Intensive fishing in the same area may well have an equally dramatic effect over a short period, effectively within the error range of radiocarbon dating. It would be very useful to return to these three sites in the Chatham Islands and carry out an intensive project of high quality dating to try and separate them in time.

ACKNOWLEDGEMENTS

Sincere thanks are due to Larry Paul at the National Institute of Water and Atmospheric Research (NIWA) for many useful discussions about fishing and fisheries issues over a long period, and for providing us with research trawl data which are used in this paper. We would like to thank Ron Blackwell of NIWA (Nelson), Glen Carbine of NIWA (Dunedin), and Graeme McGregor of Ministry of Fisheries (Auckland) for supplying us with blue cod catch data. Jim Samson and Penny Leach, research assistants in the Archaeozoology Laboratory at the Museum of New Zealand, did many of the bone measurements which are incorporated in this study, and this tedious work is gratefully acknowledged. Finally, we would like to thank the Foundation for Research, Science and Technology for financial support for research projects in the Archaeozoology Laboratory at the Museum of New Zealand.

REFERENCES

Anderson, A.J. 1979. Prehistoric exploitation of marine resources at Black Rocks Point, Palliser Bay. *In* B.F. Leach and H.M. Leach (eds), *Prehistoric Man in Palliser Bay*, pp. 49–65. National Museum of New Zealand Bulletin 21.

Annala, J.H. 1994. *Draft Reports from the Fishery Assessment Working Groups. February–March 1994*. Unpublished report, MAF Fisheries.

Beaglehole, J.C. (ed.) 1967. *The Journals of Captain James Cook. The Voyage of the* Resolution *and* Discovery, *1776–1780*. Cambridge University Press for the Hakluyt Society.

Davidson, R.J. 1995. *Long Island-Kokomohua Marine Reserve Subtidal Biological Baseline Report*. Occasional Publication 17, Nelson/Marlborough Conservancy, Department of Conservation.

Doak, W. 1972. *Fishes of the New Zealand Region*. Hodder and Stoughton, Auckland.

Graham, D.H. 1956. *A Treasury of New Zealand Fishes*. A.H. and A.W. Reed, Wellington.

Horwood, L.M. 1991. Prehistoric and nineteenth century Maori settlement on Mana Island, Cook Strait: excavations at site R26/141. *New Zealand Journal of Archaeology* 13: 5–40.

Horwood, L.M., Leach, B.F. and Davidson, J.M. 1998. Prehistoric and historic Māori fishermen of Mana Island, Cook Strait, New Zealand. *New Zealand Journal of Archaeology* 18 (1996): 5–24.

Hurst, R.J., Bagley, N.W. and Uozumi, Y. 1990. *New Zealand-Japan Trawl Survey of Upper Slope Species off Southern New Zealand, June 1986*. New Zealand Fisheries Technical Report 18.

Leach, B.F. and Boocock, A. 1994. The impact of pre-European Māori fishermen on the New Zealand snapper, *Pagrus auratus*, in the vicinity of Rotokura, Tasman Bay. *New Zealand Journal of Archaeology* 16: 69–84.

Leach, B.F. and Boocock, A. 1995. The estimation of live fish catches from archaeological bone fragments of the New Zealand snapper *Pagrus auratus*. *Tuhinga: Records of the Museum of New Zealand* 3: 1–28.

Leach, B.F., Davidson, J.M., Horwood, L.M. and Anderson, A.J. 1996a. The estimation of live fish size from archaeological cranial bones of the New Zealand barracouta *Thyrsites atun*. *Tuhinga, Records of the Museum of New Zealand* 6: 1–25.

Leach, B.F., Davidson, J.M., Horwood, L.M. and Mallon, S. 1996b. The estimation of live fish size from archaeological cranial bones of the New Zealand kahawai *Arripis trutta*. *Tuhinga, Records of the Museum of New Zealand* 7: 1–20.

Leach, B.F., Davidson, J.M., Samson, J. and Burnside, G. 1997a. The estimation of live fish size from archaeological cranial bones of New Zealand Labridae. *Archaeofauna* 6: 41–58.

Leach, B.F., Davidson, J.M. and Horwood, L.M. 1997b. Prehistoric Māori fishermen at Kokohuia, Hokianga Harbour, Northland, New Zealand. *Man and Culture in Oceania* 13: 99–116.

Leach, B.F., Davidson, J.M. and Horwood, L.M. 1997c. The estimation of live fish size from archaeological cranial bones of the New Zealand blue cod *Parapercis colias*. *International Journal of Osteoarchaeology* 7: 484–96.

Smith, I.W.G. 1985. Sea mammal hunting and prehistoric subsistence in New Zealand. Unpublished PhD Thesis, Anthropology, University of Otago.

Sutton, D.G. 1979. Polynesian Coastal Hunters in the Subantarctic Zone: a case for the recognition of convergent cultural adaptation. Unpublished PhD Thesis, Anthropology Department, University of Otago.

Sutton, D.G. 1980. A culture history of the Chatham Islands. *Journal of the Polynesian Society* 89 (1): 67–93.

Sutton, D.G. 1989. Moriori fishing: intensive exploitation of the inshore zone. *In* D.G. Sutton (ed.), *Saying So Doesn't Make it So: Papers in Honour of B. Foss Leach*, pp. 116–31. New Zealand Archaeological Association Monograph 17.

Warren, E, Grindley, R., Carbine, G. and Teirney, L. 1997. Characterisation of the Southland blue cod fishery. Report held by Ministry of Fisheries, Dunedin. 38 p.

Wheeler, A. 1969. *The Fishes of the British Isles and North-West Europe*. Macmillan, London.

Williams, H.W. 1971. *A Dictionary of the Maori Language*. Government Printer, Wellington.

Received 1 August 1998
Accepted 3 November 2000