NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION MONOGRAPH 11:
Atholl Anderson (ed.), *Birds of a Feather: Osteological and Archaeological Papers from the South Pacific in Honour of R.J. Scarlett*

BIRDS OF A FEATHER

edited by

Atholl Anderson

PREHISTORIC EXPLOITATION OF CRAYFISH
IN NEW ZEALAND

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Introduction

If present day exploitation is anything to go by, it would be surprising if crayfishing had not been an important aspect of prehistoric fishing in New Zealand. Yet it is an aspect which has been all but ignored by archaeologists. Basic issues such as the recognition and identification of crayfish species from midden refuse, and the reconstruction of body weight from common anatomical survivals of these animals have not previously been investigated, and it is one purpose of this paper to make a start in rectifying this situation. The second general interest lies in interpreting the role of crayfish in prehistoric economies. Specifically, what effects does preferential selection for large size have on local crayfish stocks over long periods of time? An obvious place to begin the consideration of these questions is with the European observations of Maori crayfishing during the 18th and 19th centuries.

Early Historic Records of Crayfish in New Zealand

The relevant ethnographic literature is not particularly revealing of the role of crayfish in the economy at European contact. One reason is because the most detailed studies were of inland communities, and therefore references to crayfish were most commonly to the freshwater species. These were regarded as a delicacy, and were comparatively easily caught. Hamilton comments under 'crustaceans' in his work Fishing and sea foods of the Ancient Maori (1908:13) as follows:

> "The principle item in the bill of fare taken in this group was the koura—the large red crayfish (Palinurus or Jasus)—and the freshwater koura of the lakes and streams (Paranephrops). A number of traps and pots of various kinds were baited and set for these dainties, and they were also, in time of plenty, slightly smoked and dried, and strung on a string of flax".

Some quite revealing observations concerning marine crayfishing are to be found in the journals of the visitors who came to New Zealand in the 18th century with Captain Cook. Crayfish were apparently often brought to the boats as gifts and items of trade, and were clearly very welcome. Anderson remarked during February, 1777 that:

> "The indians likewise sometimes brought us crawfish equal to our largest lobsters, which are very fine" (Anderson, 1967:808).

Furneaux noted in his journal for November 4, 1772:

> "We again got in shore near Cape Pallisser and was visited by a
> number of the Natives in their Canoes with a great quantity of Cray
> fish, which we bought of them for nails and Otaheite Cloath...."
> (Furneaux, 1969:741).

Banks had earlier remarked on similar transactions (1963 Vol. 1:422) in
November 1 1769 when they were somewhere near White Island in the Bay of
Plenty. He noted that people were trading both mussels and crayfish with
them. The method for catching them was vividly described as follows:

> "Dr. Solander who was today in a cove different from that I was in
> .[in Mercury May] saw the natives catch many lobsters in a most
> simple manner: they walked among the rocks at low water about
> middle deep in water and still felt about with their feet till they felt
> one, on which they dived down and constantly brought them up. I do
> not know whether I have before mentioned these lobsters but we had
> them in tolerable plenty in almost every place we have been in and
> they are certainly the largest and best I have ever eat" (Banks, 1963
> Vol. 1:434).

This was the entry for November 14, 1769 and shows well just how unneeessary
elaborate fishing equipment was for catching the animals at this period.
Banks was very impressed with this item of food, and made some general com-
ments on them in March 1770:

> "But above all luxuries we met with the lobsters or sea crawfish must
> not be forgot, which are possibly the same that in Lord Ansons Voyage
> are mentioned to be found at the Island of Juan Fernandes; they are
> large tho not quite so large as those at Juan Fernandes and differ from
> ours in England in having many more prickles on their backes, and
> being red when taken out of the water. Of them we bought great
> quantities of the natives every where to the Northward, who catch them
> by diving near the shore, feeling first with their feet till they find
> out where they lie" (Banks, 1962 Vol. 2:7).

The reference to Anson was expanded by Beaglehole in a footnote to this pas-
sage as follows:

> "Walter in his account of Anson's voyage, pp. 125-6, writes, 'we
> found here one delicacy in greater perfection, both as to size, flavour,
> and quantity, than is, perhaps, to be met with in any part of the world:
> this was a sea-cra-fish; they generally weighed eight or nine pounds
> a-piece, were of a most excellent taste, and lay in such abundance
> near the water's edge, that the boat-hooks often struck into them, in
> putting the boats to and from the shore'" (ibid.).

The species found about Juan Fernandes Island is Jasus frontalis (Waugh 1973:
256) and specimens are indeed sometimes larger than those of Jasus edwardsii,

although they are surpassed by examples of the New Zealand 'packhorse crayfish' Jasus verreauxi. These latter crayfish can reach enormous size, and may have been the species referred to by Parkinson who spoke of obtaining crayfish up to 5 kg. His remarks related to Tolaga Bay after his visit there 23 to 30 October 1773!

> "This bay abounds in a variety of fifh, particularly fhell and cray- fifh; fome of the latter, which we caught, weighed eleven pounds; thefe are found in great plenty, and feemed to be the principle food of the inhabitants, at thif feafon of the year, though they have a kind of fern, the roots of which, roafted, make a good fubftitute for bread, efpecially when their koomarra is young and unfit for ufe" (Parkinson, 1773:99. Beaglehole notes that "a pencil sketch of a small specimen of the crayfish is on the back of Plate 12 in Parkinson II" in Banks, 1963 Vol. 1:422).

Best recorded several methods of catching crayfish (1929:52-59). On the subject of diving for them he noted that the Maori, unlike the pakeha, always dived feet first, sometimes to a depth of 3 fathoms (5.5 m). Apparently some Maoris claimed that women were actually more expert in the art of crayfish diving (this is also mentioned by Banks, 1963 Vol. 2:33; and the same comment has been made of Tasmanian Aboriginal women, q.v. Jones, 1977). Hoop-shaped drop nets were recorded in which either paua (Haliotis iris) or kina (Evechinus chloroticus) were used as bait in a small suspended netted bag. This is still a common non-commercial method today. One gains the impression from Best's records though, that the baited wickerwork trap was the commonest early Maori method of catching them. Again the bait was most often paua, but he also recorded the use of starfish which is unusual. Colenso noted that crayfish itself was an esteemed bait for catching groper (Taylor, 1959:6). Freshwater crayfish were taken both by hand and with a dredge net, and also by an ingenious method which involved sinking bundles of bracken fern and allowing them to remain on the bed of still water for a time. The crayfish would hide in the bundles and if these were gently raised the crustaceans could be shaken out in large numbers.

Many apocryphal stories are told of crayfishing, and these have become prodigal since the great crayfish boom in the late 1960s in the Chatham Islands. However, twentieth century fishermen have no monopoly on extravagant fishy folk stories. The great size of crayfish in the Chatham Islands is an established fact, and Baucke remarked that the now defunct Moriori of the Chatham Islands excelled in the art of crayfish diving and that:

> "a diver who appeared with three—one in each hand and one held by the antennae between the teeth, was acclaimed a tchim' tchakat' me' kye [possibly tenei tangata mahi kai (a food provider of renown)]" (Baucke, 1928:360).

What Survives Archaeologically?

Crayfish present a daunting exterior to would-be predators, but in fact this structure is not very strong, and rots quickly in reasonably moist aerobic

conditions. The basic material of the exoskeleton is calcium carbonate which is precipitated from the dermal layers of the animal. It is deposited in layers interspersed with a mucoprotein secretion during a process similar to the build up of nacreous shell in molluscs. In the case of crayfish, however, the final structure is not only more flimsy but the process is partly reversible. Just before the moult, some of the calcium carbonate is extracted from the exoskeleton and stored as gastroliths in the case of the freshwater crayfish; special storage bodies, which provide the material for the rapid hardening of the new shell. Crayfish also possess small gizzard raspers which are quite durable in appearance and might be expected to survive archaeologically, although this has yet to be demonstrated. The marine species, however, unlike their freshwater counterparts and marine crabs, do not possess chelae or pincers. The ends of these are very dense, and are the principal component of crab remains which are found in midden sites (for example see Anderson, 1973:Appendix E).

All these animals have one hard part in common, and this is the pair of mandibles. Strictly speaking, these are the first of the numerous paired appendages, although clearly in this case they are highly specialised in form. They occur at the ventral anterior end of the animal immediately in front of the mouth. They appear to be more durable than other parts of the body. Modern rubbish dumps of crayfish bodies show that most of the exoskeleton decomposes rather rapidly into a granular composition, and that the only easily identifiable parts are the very ends of the second antennae, and the densest cap portion of the mandibles. The tips of the antennae are sometimes seen archaeologically, but the mandibles are more common.

In appearance, crayfish mandibles closely resemble rather weathered and unidentifiable fragments of shellfish, and this fact is doubtless the reason they have been so seldom documented by archaeologists until recently. The midden excavations in Palliser Bay suggested that archaeological survival may be higher in deposits where there are substantial quantities of ash, possibly because an alkaline environment may be more favourable to their preservation than an acidic one. Most New Zealand soils are acidic, and while shell midden does raise the pH slightly (Park, 1969:26), this may not be sufficient to make much difference to the preservation of crayfish parts. Ash, on the other hand, is very rich in potash, and might be expected to raise the pH considerably in its near vicinity. In addition, the fine texture and hygroscopic nature of ash may help to create locally dry anaerobic conditions which would be most suitable to the survival of crayfish mandibles.

Despite the good chance of preservation of crayfish mandibles the first published reference to these remains in archaeological sites was in 1955, after nearly a century of New Zealand archaeology. This was from a site now known as the Washpool Stone Wall Fort (N168/27), and the discovery was by Adkin in 1952. It is worth quoting a passage from Adkin's article in full:

> "Another item was a number, 12 specimens in all, of limy bone-like objects, the largest one inch, others down to 5/8 in. in length, one side slightly convex, the other shaped somewhat like a human ear. These have not been exactly identified, but Dr. R. A. Falla, Director Dominion Museum, tentatively regards them as 'like the grinding

mouth-parts of a large kind of crayfish or some related marine crustacean.' He further remarks: '... it seems rather strange that there should be so many of them [the limy ear-shaped objects] in the absence of any other parts [of the presumed crustacean]. Perhaps they have survived owing to the quantity of lime in their composition' " (Adkin, 1955:469).

An excavation by the present authors in 1970 in the same spot as Adkin had worked revealed another dozen of these fragments, and these were later positively identified as portions of the mandibles of Jasus edwardsii (see B. F. Leach, 1976:241).

This lack of recovery of remains of crayfish or lobsters from archaeological sites is not confined to New Zealand. After an intensive search of archaeological literature only one well documented case could be found. This was from a midden-cave site at Bonteberg, 30 km south of Capetown in South Africa, and the excavations revealed 338 mandibles (both left and right) of Jasus lalandei, which is closely similar to the common New Zealand species, Jasus edwardsii (Kensler, 1967b, notes that they are synonymous). Grindley, who studied these remains (1967), performed Van Wisselingh's test on the mandibles which showed that the polysaccharide chitin was still present, but in reduced quantity compared with modern specimens. He explained the differential survival of mandibles as being due to the higher chitinous content in the rest of the exoskeleton, and higher calcification in the mandibles.

In New Zealand, large numbers of mandibles have now been recovered in excavations in Palliser Bay, the Chatham Islands, and the Fiordland area (however, the latter have not been studied ; see Coutts, 1975:28). The minimum numbers for the Palliser and Chatham finds are given in Table 10.1. It is interesting that comparatively few were found in the extensive excavations in the Chathams, bearing in mind the vast quantities of crayfish recovered commercially during the past decade (q.v. Waugh, 1973:278). It is not known whether crayfish are prone to major fluctuations in natural abundance in specific areas over centuries, but the relative lack of mandibles in prehistoric sites of the early 16th century in the Chathams, coupled with their great abundance in later periods, might argue for this. Current hypotheses regarding environmental changes during the past millennium (H. Leach, 1976: Chapter 8) suggests that these were of insufficient scale to have wrought the effects which appear to be indicated from the Chathams excavations. Besides, the Palliser Bay crayfish finds are well documented from the 12th to 17th centuries (Anderson, 1973: Appendix E; B. F. Leach, 1976:432).

The Identification of Archaeological Remains

There are four species of crayfish in New Zealand; two freshwater and two marine. The freshwater species are variously grouped, but the commonest view is that one predominates in the North Island, and the other further south (q.v. Hopkins, 1970). The North Island species, Paranephrops planifrons (Figure 10.1A) has a somewhat fuller carapace and more slender chelae than the other species. It extends into Marlborough in its distribution. The South Island species, Paranephrops zealandicus has a much narrower carapace, but is most noted for its very hairy chelae (see Figure 10.1B). Unfortunately
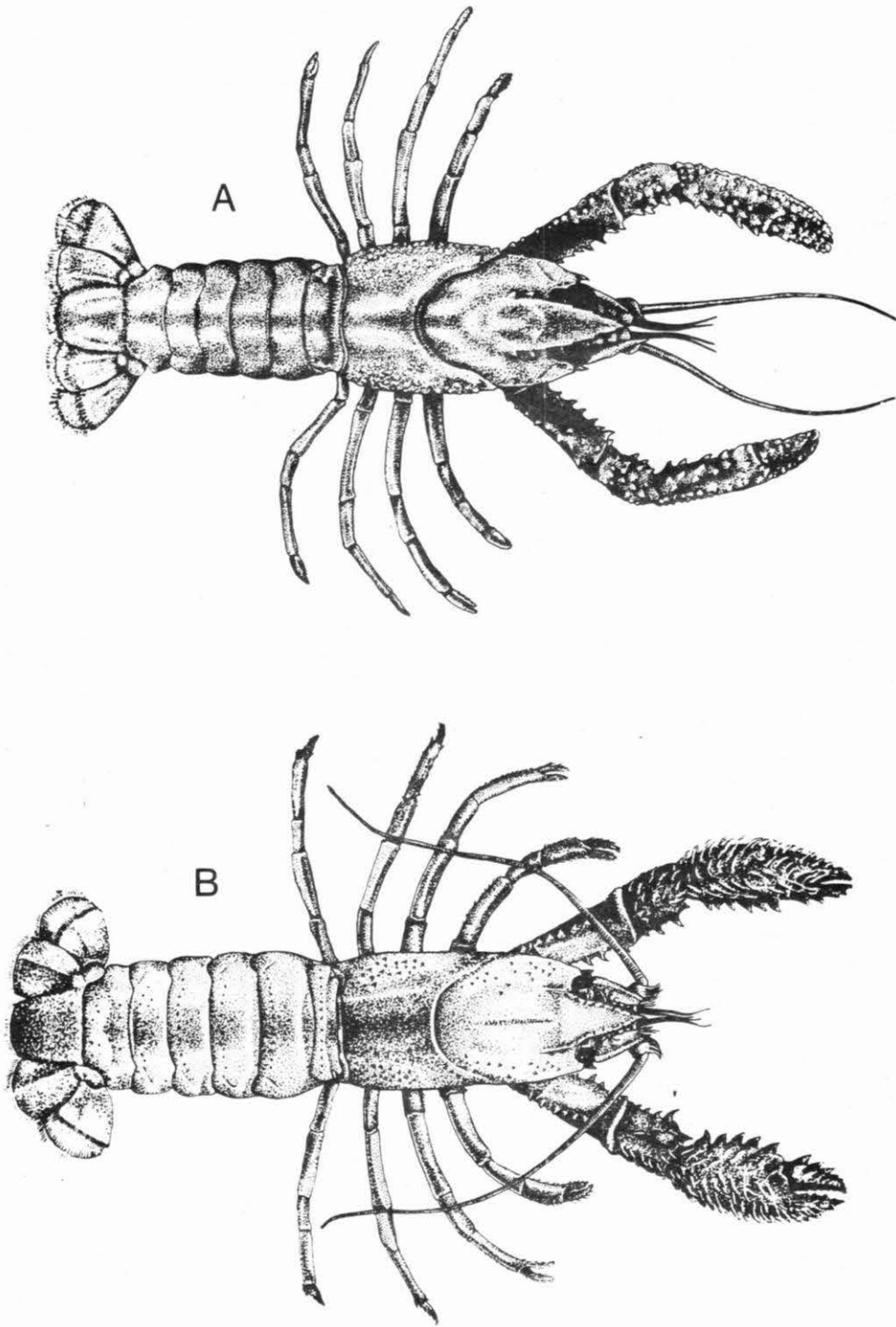
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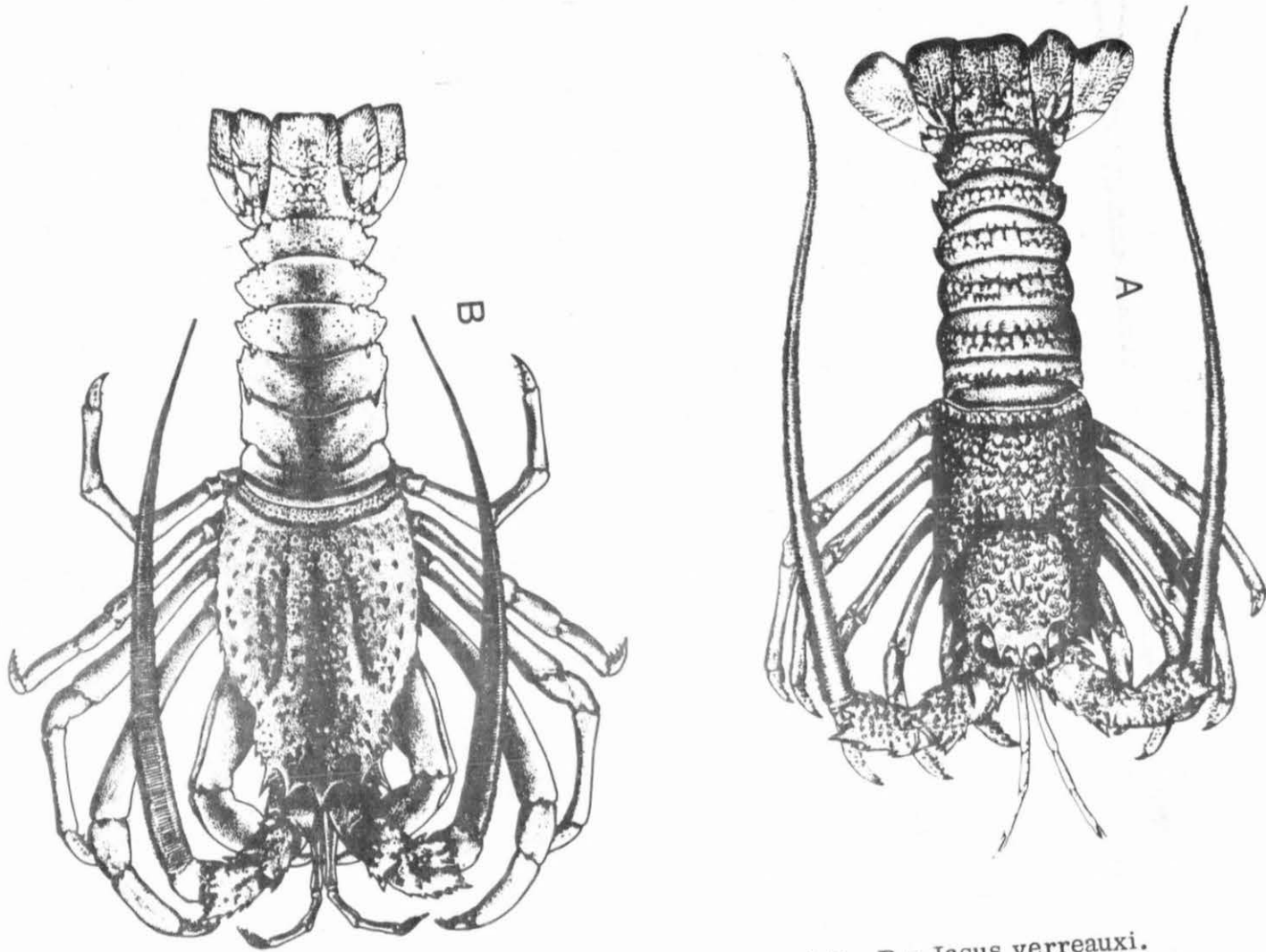Fig. 10.1 New Zealand Freshwater Crayfish. A = _Paranephrops planifrons_; B = _Paranephrops zealandicus_

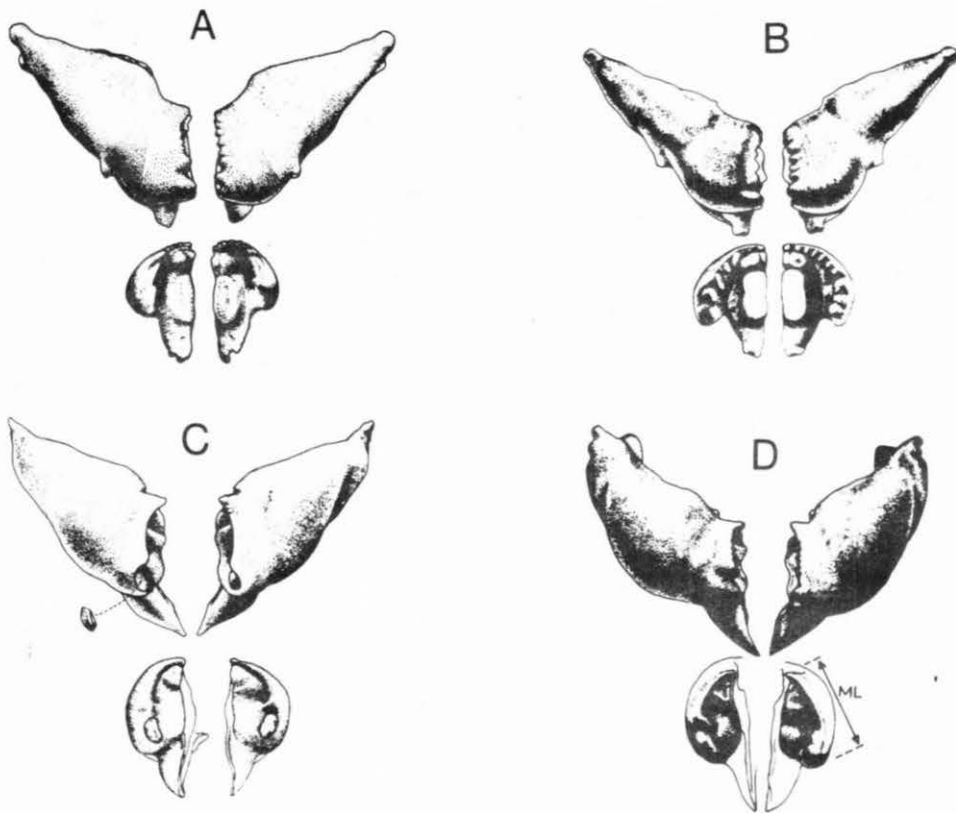Fig. 10.2 New Zealand Marine Crayfish. A = _Jasus_ _edwardsii_; B = _Jasus_ _verreauxi_.

Fig. 10.3 New Zealand Crayfish Mandibles
A = _Paranephrops_ _planifrons_
B = _Paranephrops_ _zealandicus_
C = _Jasus_ _edwardsii_
D = _Jasus_ _verreauxi_
ML = Mandible Length as measured

the mandibles of these two species are very similar, and probably impossible to distinguish reliably. For large specimens, the mandibles are only about 5 mm across the occlusal surface, and although they are quite distinctive in shape, are liable to be overlooked unless midden refuse is very carefully examined. The two mandible forms are shown in Figure 10.3, and these show the same basic shape as for other crayfish, except that the outer edge is more denticulated, and there are two sensory pads along the inner edge of each mandible. Specimens of freshwater crayfish have yet to be recovered from New Zealand archaeological sites, and when they are portions of the chelae may well be found to be present also.

Marine crayfish possess mandibles of about 6 to 35 mm in size, and are readily identified during midden analysis. Again, there are two species which may be distinguished - Jasus edwardsii (Figure 10.2A), the commonest species, and Jasus verreauxi (Figure 10.2B), the packhorse crayfish, which may reach a considerably larger size. It can be seen from the two figures that Jasus verreauxi has a less sculptured and spiky tail, and also the carapace is more rounded in appearance. In addition, the foremost rostral spine is much larger than for Jasus edwardsii. The general morphology of the mandibles is similar for the two species with the exception of one important feature. At the most anterior part of the outer edge of the mandible the surface has a raised rounded cusp. In Jasus edwardsii (Figure 10.3C) this cusp is quite smooth, and many archaeological specimens show considerable attrition in this zone. However, a small sensory pad is found in the same region in specimens of Jasus verreauxi (Figure 10.3D), and this pad becomes detached during decomposition to leave a small regular shaped pit in its place. This difference would be easily detected on archaeological specimens, although a careful search of the many fragments from both Palliser Bay and the Chatham Islands failed to reveal a single example. It is quite certain, therefore, that all the remains examined from these sites are those of Jasus edwardsii.

Prehistoric Crayfish Remains from New Zealand

Grindley's study of crayfish mandibles from the Bonteberg excavation in South Africa (1967) included an assessment of the corresponding crayfish body size and weight using information from modern examples of Jasus lalandei. These data were then compared with those from modern commercial catches in the region. The commercial size-frequency distribution is severely truncated at the smaller end due to a minimum size regulation. Despite this, the prehistoric size-frequency distributions resemble those of the modern catches more closely than those of the modern natural population. Grindley argues that this indicates a pattern of relatively heavy prehistoric exploitation (1967: 99), and that the people occupying the site consumed a total of about 2000 kg of crayfish (589 kg of which would be tails). This figure should be revised to about half the stated value, since the calculation was not based on minimum numbers, but on the total count of both left and right mandibles. Moreover, the view that the size frequency distribution indicates heavy prehistoric exploitation is one which could be challenged. The modern distributional figures include very large numbers of tiny specimens, and this is typical of natural populations. However, it is likely that prehistoric people would select larger specimens, as appears to be the case with other marine resources found in

archaeological sites (see Anderson, n.d.). In such cases initial and moderate exploitation would not show the dominance of tiny specimens, apparent in modern samples but in fact be similar to the distribution figures found in the site. Indeed, it might well be argued that under conditions of sustained heavy predation, the archaeological remains should eventually show a bias to ever smaller examples. The Bonteberg figures appear to show a pattern of moderate exploitation without the imposition of a 'minimum size'.

The Palliser Bay excavations produced remains of nearly 15 times as many crayfish as those from Bonteberg, and it was thought that the sample recovered would be useful to compare with some modern New Zealand figures. In addition, the excavations were of sites which covered much of the span of New Zealand prehistory, and any long term effects of human predation upon crayfish populations might be revealed from such a numerical study. To facilitate this, it was first necessary to undertake a survey of the modern crayfish in the region.

During several periods of archaeological fieldwork in Palliser Bay and the Chatham Islands opportunities arose to measure live or freshly killed Jasus edwardsii and to extract their mandibles for further study. For a number of reasons it was not always possible to weigh or sex all of the specimens, but sufficient records were obtained to enable reasonable regression formulae to be calculated. Most of the larger specimens were from the Chatham Islands and some very small examples were measured alive and returned to the water. The main aim of the study was to establish the numerical relationship between mandible length (ML) and tail length (tL), since regression formulae linking most other measurements (see Table 10.2), were already well documented in the literature. Some basic statistics from the present study are given in Table 10.3. Correlation between mandible length and tail length was high, but noticeably lower in the case of females. This is probably a reflection of the smaller sample size in this case. In Figure 10.4 a scatter plot is presented which shows the cluster of values about the regression lines predicting tail length from mandible size. The various equations obtained are given below:

$$tL_M = 9.9425 \times ML_{LM} + 4.75 \ (\pm 14.6, \ r = 0.93)\ldots\ldots 1$$

$$tL_M = 9.7057 \times ML_{RM} + 5.71 \ (\pm 15.0, \ r = 0.93)\ldots\ldots 2$$

$$tL_F = 4.8458 \times ML_{LF} + 78.38 \ (\pm 5.4, \ r = 0.77)\ldots\ldots 3$$

$$tL_F = 4.9589 \times ML_{RF} + 74.94 \ (\pm 5.2, \ r = 0.79)\ldots\ldots 4$$

$$tL_B = 9.2205 \times ML_{LB} + 17.86 \ (\pm 12.2, \ r = 0.95)\ldots .5$$

$$tL_B = 9.1206 \times ML_{RB} + 16.18 \ (\pm 12.3, \ r = 0.95)\ldots .6$$

Other Jasus edwardsii measurements have been subjected to regression analysis, and amongst these studies that of Sorensen (1970) is especially useful (see also Kensler, 1967a). Using a sample of nearly 500 crayfish, he established the relationships between total length (TL) and tail length, and also between total length and rostrum to carapace length (RCL). Unfortunately, he does not give the equation for total length from tail length. Although it is not strictly legitimate, a fair approximation may be made by transposing his formulae for the reverse relationship (Sorensen, 1970:13), viz:

$$TL_M = (tL_M - 4.98)/0.571 \; (r = 0.989)\ldots\ldots 7$$

$$TL_F = (tL_F + 0.81)/0.604 \; (r = 0.991)\ldots\ldots 8$$

$$TL_B = (tL_B - 2.31)/0.586 \; (r = 0.989)\ldots\ldots 9$$

The additional formulae for predicting rostrum to carapace length from total length are as follows:

$$RCL_M = 0.389 \times TL_M - 3.33 \; (r = 0.989)\ldots\ldots 10$$

$$RCL_F = 0.352 \times TL_F + 2.90 \; (r = 0.989)\ldots\ldots 11$$

$$RCL_B = 0.372 \times TL_B - 0.61 \; (r = 0.984)\ldots\ldots 12$$

It has been suggested several times (for example Sorensen, 1970:17) that a preferable carapace measurement is not from the rostrum, which is variable in length, and sometimes broken, but from the platform between the second antennae. Fielder (1964:78) has documented a simple conversion factor between the two measurements regardless of sex for Australian Jasus lalandei, and this is unlikely to be much different for New Zealand Jasus edwardsii. Sorensen (1970:18) gives a blanket conversion factor of 4.8 mm for Jasus edwardsii, which is equivalent to Fielder's conversion for a moderate sized specimen of TCL = 118 mm.

$$TCL = RCL \times 1.042 \ldots\ldots\ldots\ldots\ldots\ldots\ldots 13$$

As is well known, predicting live body weight from body dimensions is usually difficult, probably more so for animals like crayfish where dehydration can be a most significant factor. Nevertheless, the study by Fielder (1964) of nearly 600 Australian Jasus lalandei resulted in fairly reliable cubic functions for this species. In the absence of similar data from New Zealand, the formulae used here are based on Fiedler's results, and are therefore subject to some scaling factor. This is not regarded as a serious problem since it is the comparative results which are important especially in the shape of size frequency distributions. The weight estimation formulae are as follows:

$$W_M = antilog \; (2.7389 \times log_e \; (TCL_M/10) - 0.2609)\ldots\ldots 14$$

$$W_F = antilog \; (2.7449 \times log_e \; (TCL_F /10) - 0.2760)\ldots\ldots 15$$

$$W_B = antilog \; (2.7419 \times log_e \; (TCL_B /10) - 0.2682)\ldots\ldots 16$$

The foregoing equations allow for the estimation of all the main variables which are used in modern crayfish studies directly from the remains of mandibles in archaeological sites. Some of the calculations are obviously rather indirect; however, residuals were calculated for the 126 Jasus edwardsii collected during fieldwork and even for the weight determination these showed that the formulae are reasonably precise.

As an example of the application of these equations consider the right mandible from a male crayfish with ML = 17.44 mm. Tha tail length can be predicted using equation 2 giving a value of 175.0 mm. The total length may now be calculated using equation 7, and this gives a value of 297.7 mm. Application of equation 10 yields a value of 112.5 mm for the rostrum to carapace length, and this can be converted to the alternative total carapace length

TABLE 10.1

NEW ZEALAND CRAYFISH REMAINS

Sites	Minimum Numbers
A Palliser Bay	
Black Rocks BR3 (N168/77)	481
Black Rocks BR4 (N168/77)	947
Black Rocks BR2 (N168/77)	101
Washpool Midden (N168/22)	69
Stone Wall Fort (N168/27)	3
TOTAL:	2519
B Chatham Islands	
CHB (C240/680)	31
Waihora (C240/283)	11
Te Ngaio (C240/277)	3
TOTAL:	45

TABLE 10.2

MODERN CRAYFISH MEASUREMENTS

TCL = <u>Total Carapace Length</u>: From the posterior margin of the carapace to the union of the second antennae.

TL = <u>Total Length</u>: From the tip of the rostral spine to the extended tip of the telson.

RCL = <u>Rostrum to Carapace Length</u>: From the tip of the rostral spine to the posterior margin of the carapace.

tL = <u>Tail Length</u>: From the extended tip of the telson to the calcified bar on the ventral side of the tail.

Unless otherwise stated all measurements given are in mm or gm, and the different subscripts used are as follows:

L = Left	M = Male	B = Both sexes pooled
R = Right	F = Female	

TABLE 10.3

SOME BASIC STATISTICS FROM MODERN CRAYFISH STUDY

		Males	Females	Both
ML_L	Mean	17.05	13.74	15.43
	SD	3.83	1.36	3.85
ML_R	Mean	17.37	14.12	15.79
	SD	3.91	1.36	3.89
tL	Mean	174.29	144.97	160.15
	SD	40.80	8.56	37.57
Sample Sizes		72	31	126

Table 10.4   Basic Statistics of Prehistoric Crayfish (Means and Standard Deviations)

Site	Age	N	ML	tL	TL	TCL	RCL	W
BR2/1	AD1750	44	19.1(3.9)	190.5(36.0)	321.1(61.4)	123.8(23.8)	118.8(22.8)	824.4(427.4)
BR4/1	AD1350	72	16.8(3.8)	169.7(35.1)	285.7(59.8)	110.1(23.2)	105.7(22.3)	608.6(368.2)
BR4/2	AD1300	93	17.7(4.6)	177.6(42.1)	299.2(71.8)	115.3(27.8)	110.7(26.7)	713.3(495.3)
BR4/3	AD1270	89	18.1(5.2)	181.1(47.5)	305.0(81.1)	117.6(31.4)	112.9(30.2)	774.1(590.0)
BR4/4	AD1250	44	17.5(4.8)	175.8(43.5)	296.0(74.3)	114.1(28.8)	109.5(27.6)	700.7(530.4)
BR3/1	AD1170	73	20.7(4.9)	205.4(44.4)	346.5(75.7)	133.7(29.3)	128.3(28.2)	1040.0(559.8)
BR3/2	AD1150	91	22.8(4.3)	224.3(39.1)	378.9(66.7)	146.2(25.8)	140.3(24.8)	1282.6(556.6)
CHB	AD1550	52	23.2(2.7)	229.5(25.1)	387.8(42.9)	149.7(16.6)	143.6(16.0)	1312.4(404.6)
Waihora	AD1550	16	23.0(3.8)	228.7(34.7)	386.3(59.3)	149.1(23.0)	143.1(22.0)	1329.2(548.0)
Te Ngaio	AD1660	3	19.7(-)	197.4(-)	332.8(-)	128.4(-)	123.2(-)	837.6(-)
Bonteberg		358	12.8(2.9)	134.6(26.2)	225.8(44.7)	86.9(17.3)	83.4(16.6)	314.3(162.4)
Gisborne	AD1976	3287	-	-	-	-	-	563.6(517.9)
Palliser	AD1972	252	15.6(3.9)	159.9(36.4)	270.1(64.0)	105.1(26.2)	100.9(25.2)	520.1(133.6)

Table 10.5   Estimates of Crayfish Meat Weight

Site	Mean Weight	Minimum Number	Minimum Weight (kg)	Percentage Site Excavated	Total Meat Weight (kg)
BR2/1	824.4	101	83.26	25	333.0
BR4/1	608.6	162	98.59		
BR4/2	713.3	543	387.32	15	4423.4
BR4/3	774.1	185	137.66		
BR4/4	700.7	57	39.94		
BR3/1	1040.0	259	269.36	14	3957.8
BR3/2	1282.6	222	284.74		
CHB	1312.4	31	40.68	80	50.8
Waihora	1329.2	11	14.62	66	22.2
Bonteberg	314.3	192	60.35	8	754.4

NB: The figures given are total body weight. Of this, tail weight is gauged to be about 30% (q.v. Grindley, 1967:99).

Table 10.6 Prehistoric Crayfish: Skewness and Kurtosis of Weight-Frequency Distributions

Site	Skewness			Kurtosis		
	W1	g1	Sig	W2	g2	Sig
BR2/1	2.7	0.9	S	0.6	3.2	NS
BR4/1	4.6	1.3	HS	6.8	6.4	HS
BR4/2	4.6	1.1	HS	2.2	4.0	PS
BR4/3	4.6	1.2	HS	2.6	4.2	S
BR4/4	3.7	1.3	HS	3.8	5.2	HS
BR3/1	2.2	0.6	PS	-1.1	2.4	NS
BR3/2	2.1	0.5	PS	-0.1	2.9	NS
CHB	2.9	0.9	S	1.9	4.0	NS
Waihora	1.8	0.9	NS	2.1	4.3	PS
Bonteberg	6.3	0.8	NS	-0.6	2.8	S
Modern	60.4	2.6	HS	60.4	17.2	HS

NB: Significance levels are as follows:

Not significant $> .05$
Possibly significant $.05-.01$
Significant $.01-.001$
Highly significant $< .001$

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of 117.2 mm using formula 13. Finally, the weight of the live animal may be estimated using equation 14 giving a body weight of 652.4 gm. This is remarkably close to the actual weight of this specimen which was 650 gm. The sex of mandibles from archaeological sites cannot be determined at present, and therefore equations 6, 9, 12, 13 and 16 would have been used in this case. A weight of 601.1 gm would have been thus obtained, which is still quite close to the correct figures.

Computer programmes were written for the analysis of the archaeological finds from Palliser Bay and the Chatham Islands. In addition, the above formulae were applied to the mandible data from the Bonteberg site for comparative purposes. The results were similar but not identical to those obtained by Grindley (1967).

The basic results are set out in Table 10.4. In the case of the Bonteberg material all the data is placed in one assemblage. Grindley grouped the mandibles into two levels, but since the basis of the division was not properly explained, this procedure could not be followed here. However, of the 358 mandibles, only 12 belonged to the earlier level, and their inclusion in the present analysis should make little difference. In Table 10.5 the total meat weight figures are given for each site. The values of the proportion of each site excavated follow estimates given by Anderson (1973:118) and Grindley (1967:99).

The weight frequency histograms of the crayfish are given in Figure 10.5. The data were first standardized to give zero mean and unit variance, and then scaled so that the largest value does not exceed unity. In this way, standard histograms of 20 cells are formed, and this facilitates direct comparison of one distributional shape with another. In addition, statistics for skewness and kurtosis (q.v. Snedecor and Cochran, 1967:86 ff) were calculated (for reasons discussed below) and these appear in Table 10.6. The values for g1 are all positive, indicating positive skewness throughout. Values for g2 greater than 3.0 indicate a leptokurtic shape, and less than this figure platy-kurtic. The W statistics given in Table 10.6 are the normalised deviates and are used to assess the significance of the g values using the distribution of t. Overall significance of departure from normality in each case is also given in Table 10.6.

Discussion

The interpretation of differences in mean size and weight-frequency distributions between prehistoric and modern populations is not without difficulties, particularly in the case of marine invertebrates where so little background research has been carried out. Live populations of these animals frequently exhibit changeable, and sometimes multi-modal size-frequency distributions. Archaeological samples of species in which the surviving parts of young individuals are fragile can blur or bias these characteristics. Another source of error is introduced by the impossibility at present of sexing crayfish from surviving mandible fragments. Perhaps the single most important problem, however, is one which at least partly may be solvable by archaeological means. Crayfish, more than most marine invertebrates, are strongly seasonal in their movements (see Kensler, 1969). At various times of the year, usually

in late summer, some large adult crayfish enter shallow water to moult and mate. Reliable seasonal evidence is clearly a matter of crucial importance in interpreting differences in mean size encountered in different archaeological sites. In the case of those at Black Rocks, all are firmly believed to have been occupied over the summer months (see Anderson, 1973:117 ff). In this case therefore, the seasonal effect can be regarded as a constant.

Even with these problems firmly in mind, there are gross differences between the archaeological samples and the modern one, and this calls for comment. Clearly, the crayfish in the modern samples considered are significantly smaller than those obtained during the prehistoric period, and the variation about the mean size is, today, much narrower. There are several possible explanations. One is that the archaeological samples are biased by differential survival of the larger mandibles. Given the excellent condition of most of the prehistoric mandibles recovered, and the fact that much smaller and less resistant objects were abundant in the sites in question (such as numerous examples of Haliotis iris of about 1 cm in length), this does not appear to be a reasonable hypothesis. Much more likely is that prolonged pressure of exploitation has driven down the mean size of the accessible population. In support of this interpretation for the Black Rocks samples the following must be noted. Firstly, the general pattern is in the right direction - a progressively lower mean size through time (see Figure 10.6). Secondly, there is a minor recovery in mean size following the well attested settlement hiatus along the eastern Palliser Bay coast for several hundred years prior to the occupation of BR 2 - the Pond Midden Site (see B.F. Leach, 1976:296, 306, 326; H. M. Leach, 1976:188; Anderson, 1973: 163). Thirdly, other species in the sites are also prone to similar fluctuations in mean size, and those for Haliotis iris are shown in Figure 10.7. With this species it can be seen that the occupation hiatus resulted in dramatic recovery in the mean size of the shellfish, and that more recent exploitation seems to have had only a small impression on local stocks. On the face of it, comparison of Figures 10.6 and 10.7 seems to show that given the same lack of predation for a period of about 300 years prior to A.D. 1700, the crayfish population has been unable to rejuvenate itself to anywhere near the same extent as Haliotis iris. In addition, modern crayfish size in Palliser Bay is well below anything seen in this region during the previous 800 years.

It will be noticed in Figure 10.7 that paua appear to recover to about twice their mean size in the earliest archaeological sample. However the sample from BR3/2 may well have come from an already exploited population, since there is no reason to suggest that this site represents the first exploitation of the Black Rocks area. Similarly crayfish may well have been larger before the exploitation phase represented by BR3/2.

Finally, it is clear from Table 6 that there have been dramatic changes in the shape of the weight-frequency distributions over the period concerned. This is illustrated in Figure 10.8 where it will be seen that the crayfish from the earliest sites (BR3/1 and BR3/2), and presumably representing the most natural populations, exhibit a platykurtic shape, and a minimum of positive skewness. As time goes by, sustained exploitation by the people responsible for the BR4 site resulted in a rise in positive skewness, and pronounced leptokurtosis. The modern catches are at the extreme end of this trend, suggesting

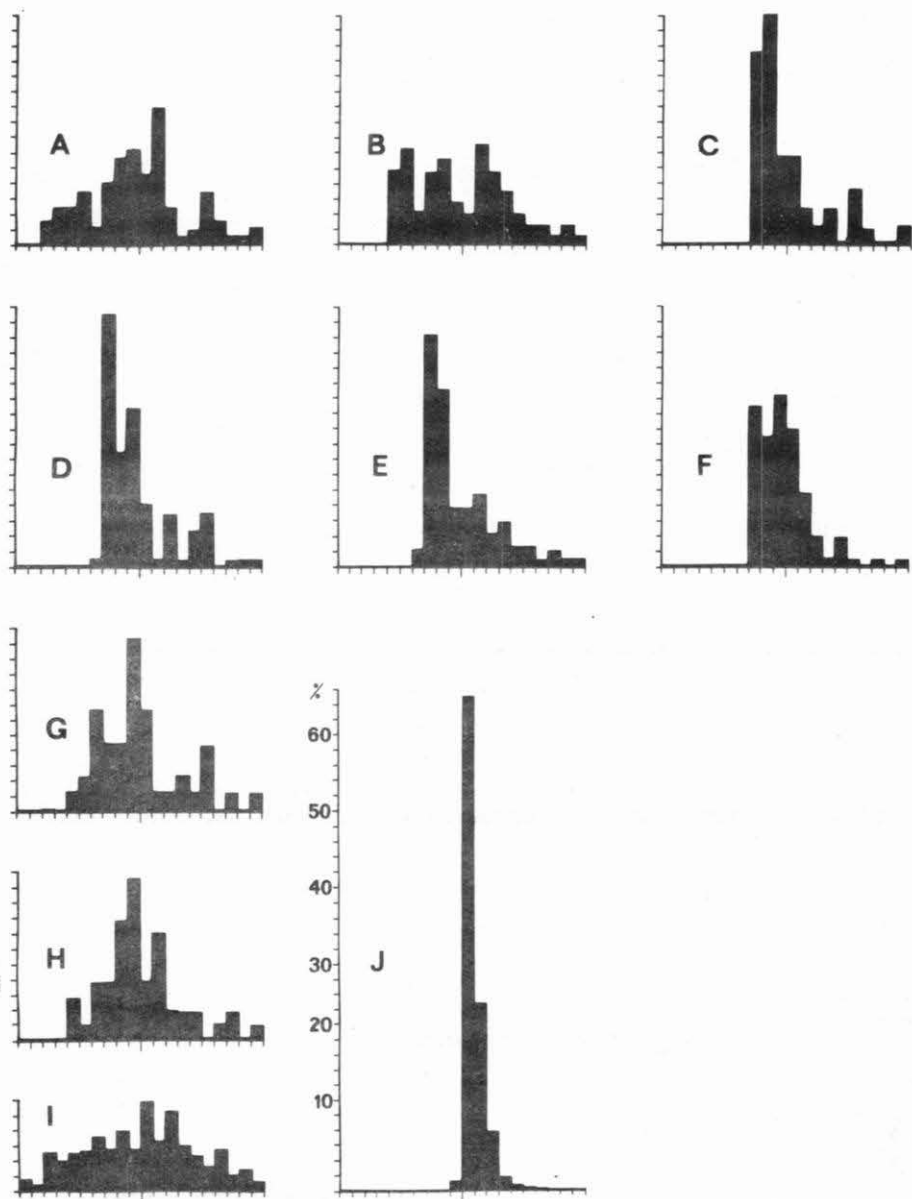Fig. 10.5   Crayfish Weight-Frequency Distributions
          A = BR3/2
          B = BR3/1
          C = BR4/4
          D = BR4/3
          E = BR4/2
          F = BR4/1
          G = BR2/1
          H = CHB
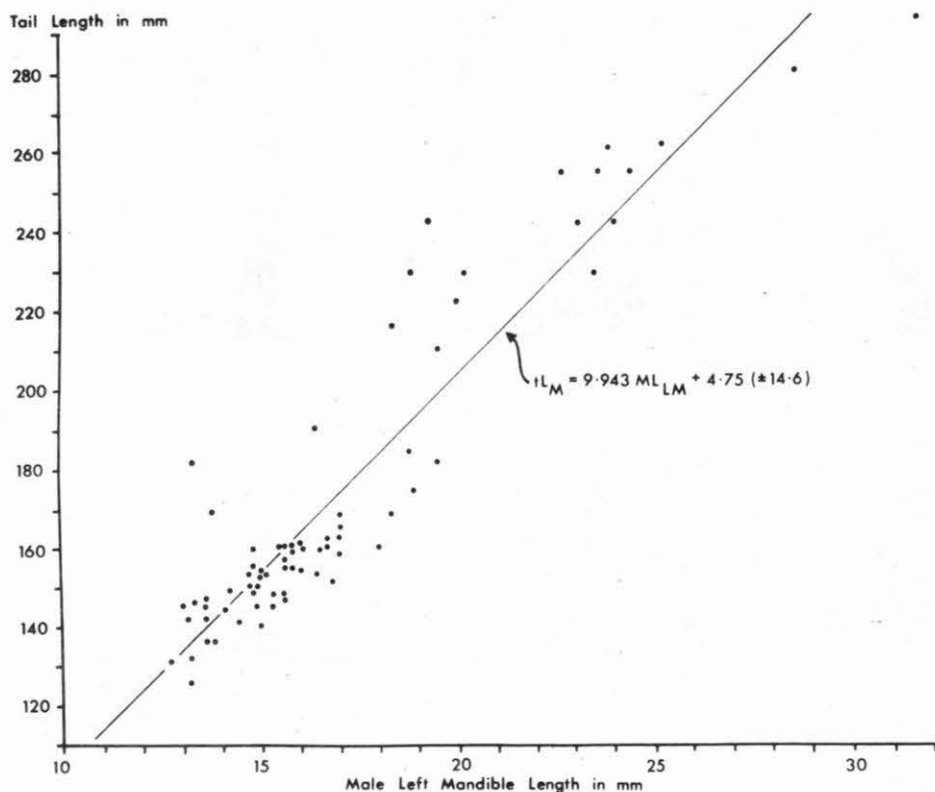   I = Bonteberg
          J = Modern Gisborne Sample, N = 3287

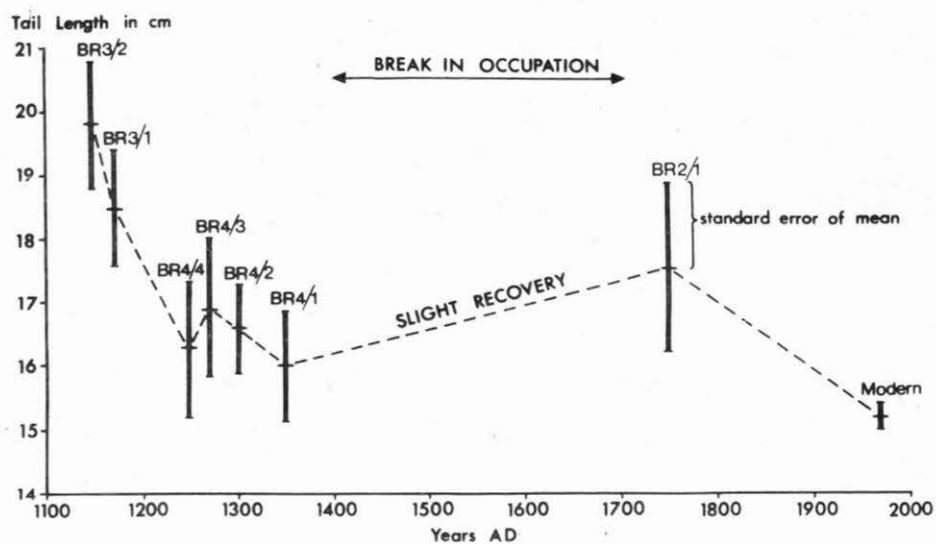Fig. 10.4   Correlation between Mandible Length and Tail Length.

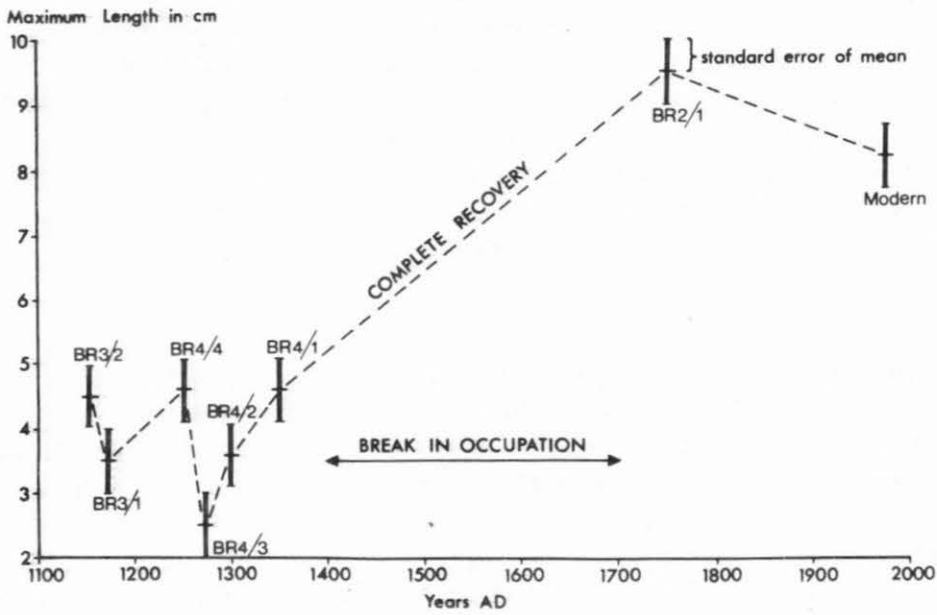Fig. 10.6   Time Trends in Crayfish Size.

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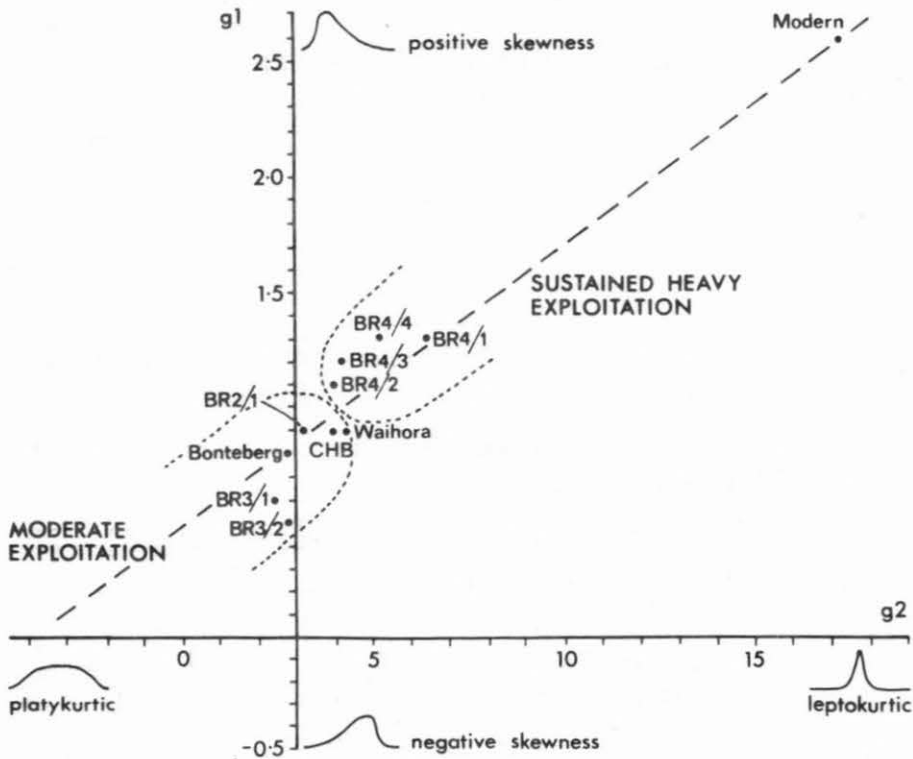Fig. 10.7   Time Trends in the Size of _Haliotis iris_.

Fig. 10.8   Departure from normality for Crayfish.

considerable departure from a pristine condition. It is interesting that the hypothesised break in occupation resulted in a return to the earlier population shapes (represented by BR2/1 in Figure 10.8), even though the mean size hardly recovered in the same interval (evident in Figure 10.6). It will also be noted that both samples from the Chatham Islands archaeological sites fit within the shapes apparently more characteristic of relatively unexploited populations. Although the Chatham sites are fairly late by New Zealand standards, there is little direct evidence of habitation much earlier than this in the region examined in the Chathams so far.

Conclusions

This study has been instructive from a number of viewpoints. It is clear that crayfish as a source of food were just as important in antiquity in New Zealand as they were when the first Europeans came to these shores. Equally, it has been demonstrated that reasonable estimates may be made of the characteristics of prehistoric catches of these animals - their overall size, and size-frequency shapes. Comparing the figures obtained for several archaeological sites and from modern catches suggests that the effects of previous exploitation may be identified from these characteristics. It would appear that while a long period of relaxed pressure does result in a return to the shape structure of earlier catches, mean size is much slower to respond to lack of predation. On the whole, it seems unlikely that the modern New Zealand fisherman will ever gain access to the kind of crayfish stocks which were available to prehistoric man a millennium ago.

Acknowledgements

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