SUPPLEMENTARY SECTIONS

Fishing strategies at an open-coast fishing site in east-Northland, New Zealand

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In the first of six supplementary sections (SS), the physical and archaeological setting of Archaeological Site Q04/44, and the changes in its extent from the 1950s to the present, are outlined. In SS 2-5, some of the archaeological material comprising the Booth Whānau Collection at Te Kōngahu Museum of Waitangi is described, with particular focus on the fishing equipment. SS6 describes the morphology and distribution of New Zealand's two coastal spiny dogfish species and discusses deep-water fishing by pre-Contact Māori.

Dedication

We Booth bros speak with love and respect to our parents, Alfred Stanton (Stan) Booth (1905-2000) and Joyce Isobel (né Miller) (1915-2005), who inspired in each of us almost insatiable curiosity concerning the natural world, keenness for artistic expression, and passion for the shores of Aotearoa.

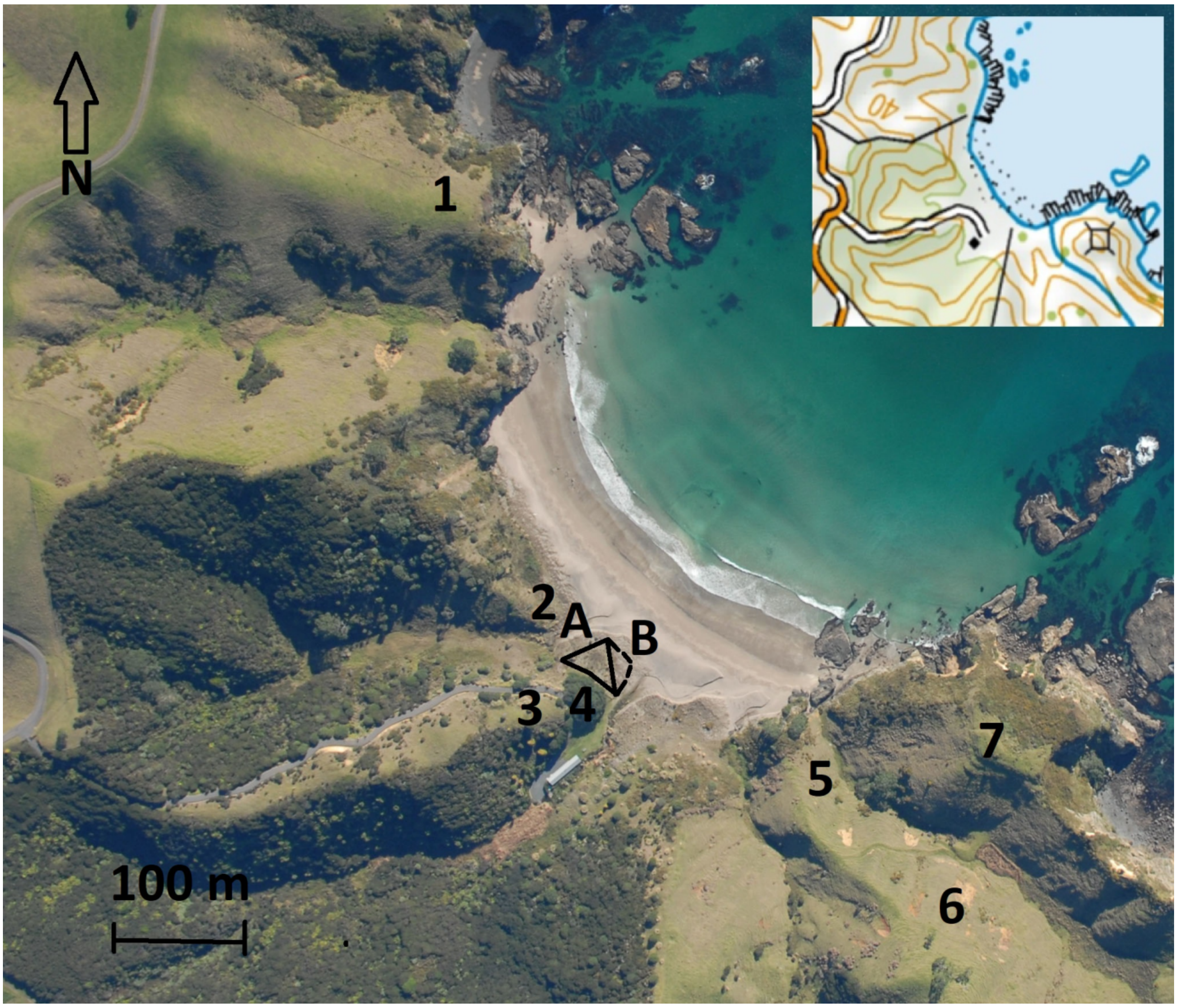
Supplementary Section 1. Physical and archaeological setting, and changes in extent over time, of Paraenui site Q04/44

Paraenui (35.151°S; 174.097°E; variously in the past 'Mataka' and 'Wiwiki') is a 350-m long, NNE-facing sand bay on the open coast 4 km west of Tikitiki (Nine Pin, the western entrance to the Bay of Islands), surrounded with - but not in any significant way protected from the sea by - reefs and high cliffs (SS1 Figure 1). The Tunapohepohe block of Mataroa (now Purerua) Peninsula (Māori Land Plan 3233) has been under the guardianship of Ngati Torehina since the eviction of Ngati Awa in about the late-1600s.

The highest ridges backing Paraenui are 60-100 m tall, the narrow valleys opening out to the shore leading to little near-beach terrain suitable for cultivation or permanent habitation being present (SS1 Figure 1); accordingly, we found no conclusive evidence for gardening (parallel lines, mounds, and so on), or food-storage pits, in our earliest aerial photograph (1951, and the one with least vegetation) or in the aerial image with highest resolution (2009). (The short parallel lines emerging up the base of the steep slope from the south side of the southern stream that flows past Q04/44 and visible in the 1951 NZ Aerial Mapping Ltd. image SN1366-84 are considered to be erosion features, rather than evidence of gardening – Bill Edwards, Heritage New Zealand, Kerikeri, pers. comm. 2017.)

The beach itself faces directly into the most frequent and largest of swells to impact east Northland, with wave heights ≥1 m around a third of the time (MacDiarmid *et al.* 2009: 32). The seafloor directly out from the beach is sand and shingle without significant reef, but extensive reefs to 20-m depth exist within 1 km of Paraenui (Bay of Islands Coastal Survey 2017). The broader shelf to the north and east of Paraenui is largely reef-bound, out to depths of 100 m and more. To be safe from sea-surge, waka would have been stored well up into the valley mouths, and the wave climate would have made it difficult to routinely launch/retrieve them.

The Purerua Peninsula has evidence of lengthy occupation, with Māori archaeological sites very early (e.g. possibly as far back as the 14th century at Wairoa Bay; Best 2003) through to Historical (e.g., Rangihoua Bay; Middleton 2003). Most of the archaeological site reports for Paraenui Bay and its immediate hinterland were furnished by Anne Leahy and Wendy Walsh in 1977-78 and Tony Fiske in 2003. Together, their accounts suggest that, although there were several pā and terraces set well back from, and high above, the shore, there was only limited habitation on and immediately behind the beach. Archaeological features on ArchSite (2017, with some shown on SS1 Figure 1) within 0.5 km of the shore of Paraenui (a setback roughly corresponding with the bay's backing ridgelines) include terraces/pā (Q04/31, 32, 37-39, 42, 46-50, 63, 65 and 67), middens (Q04/44, 45 and 66); and taro plantings (Q04/2 and 43) – but no gardens. Pits (possibly for food-storage) confidently defined were reported only at Q04/31, well back and high above the beach. The nearest evidence for gardening is 1.3 km east of Paraenui Bay (Q04/54, high and with easy contours). The single radiocarbon date for the area, from Q04/69 and 1 km inland of Paraenui, pointed to a 17th to 18th century midden, dominated by cockles *Austrovenus stutchburyi* (a shellfish found only on sheltered muddy shores), and probably representing 'transitory or limited seasonal use of the area' (Harlow 2009: 11).

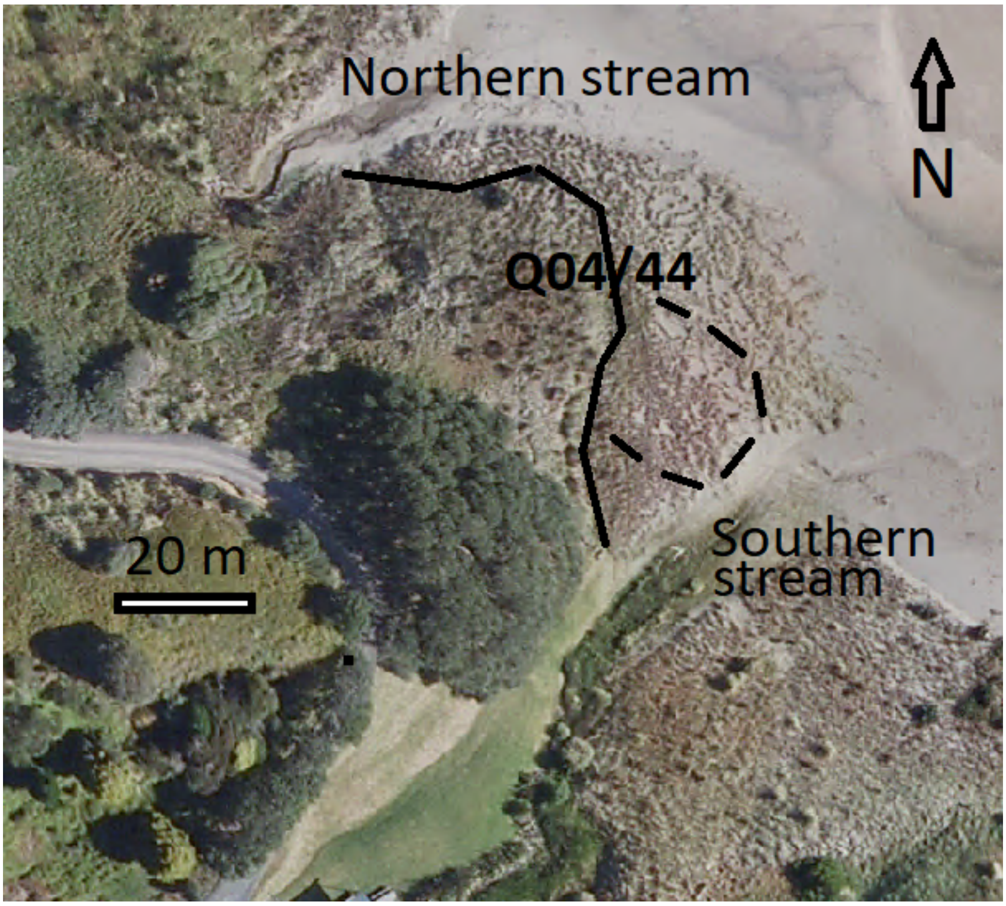


SS1 Figure 1. Paraenui Bay in June 2009. Before 1978, archaeological site Q04/44 was comprised of A and B, only A remaining today; there is virtually no other flat ground in this bay safe from flooding or sea surge. 1 is terraced ridge Q04/46; 2 is presumed location of midden Q04/45; 3 is terraced ridge Q04/42; 4 is prominent pohutukawa; 5 is ridge pā Q04/39; 6 is ridge complex Q04/38, which includes the terraces and pits of Q04/31; 7 is headland pā Q04/32. (Height contours in the inset are every 20 m.)

Our 1960s collections were focused on the dune-surface itself, but also with limited and shallow (although not systematic) excavation; the dune surface was also occasionally searched again in the 1970s. We estimate the total area of the dune, from the base of the backing hill to the seaward edge of the tongue and bounded both to the north and south by streams, to have been about 0.25 ha. It is most unlikely the occupied surface of the bay was ever much larger than this: the four streams draining into the bay would have always constrained the extent of liveable flat ground length-wise along the beach. And then the massive greywacke geology at each end of the bay would have dictated the seaward-extent of the flat ground over time in a manner that ever-changing soft-shore (e.g., gravel) beach-ends could not have done. Indeed, most of the terrain near Paraenui Bay itself seems far too steep and too exposed to have supported many people on an enduring basis.

Our zone of main interest was the only portion of the sand-dune that had surface artefacts - an area of about 400 m^2 well seaward from the base of the hill (SS1 Figure 2) and demarcated to the south by a 2-3-m high eroding bank, the shallow (<0.5 m deep) cultural layer confirmed by photographs of the time. Also, excavations up to 1 m^2 in area and to a depth of 0.5 m were made haphazardly (taking in a total of perhaps 20 m^2); excavated material was visually sorted but not sieved. Because there were variable but generally limited amounts of discarded/burnt shell or bone associated with the artefacts, the site appeared to be as much a living surface as it was a midden.

There have been significant changes to Site Q04/44 over the past half-century (SS1 Figure 2). In the 1960s, water-worn artefacts were occasionally found among debris near the beach's high-tide level confirming that erosion of the site by floods/sea surges was taking place. Insightful NZ Aerial Mapping Ltd. images of Paraenui exist from 1951 (1366-84, part of Survey No. 350) to 2009 (Bay of Islands Coastal Survey 2017). Until at least 1959 (2785-6, part of Survey No. 1223), a significant strip of ground separated the southern stream from the adjacent Q04/44 dune. But sometime before October 1978 (S.N.5006 N5), the southern stream altered its course northward, presumably after heavy rain, washing away the southeast part of the dune. It may be no coincidence that an extreme weather event took place in July 1978 (NIWA 2017): Waitangi (13 km to the south) received 850 mm of rain in 24 hours (that is what the record says!) on 18 July, and 7-8-m swells thrashed the east coast.



SS1 Figure 2. The solid black line defines a 1-1.5-m high escarpment in the Paraenui dune in 2009, the shore seaward of this line (which once included the section of Q04/44 - defined by the broken black line - from which this archaeological collection was made) presumably having been washed away in the mid-1978 storm.

Supplementary Section 2. Overview of the Paraenui archaeological collection

There are 491 archaeological items from Paraenui listed in the Booth Whānau Collection Catalogue - Part 1, with about 40 per cent directly associated with fishing, but also with a significant proportion being unworked dog bone. Flaking and degrading shell- and bone-items were stabilised using kauri-gum dust in a solvent, but Part 2 of the collection catalogue (also at Te Kōngahu Museum of Waitangi) records that in January 1977 'All bone & shell artefacts treated with polystyrene dissolved in "Kum Clean" (Toluol and Xylol). Treated by ~3-5 min immersion'.

Fishing equipment is the primary focus of this contribution. The fishhooks/points/shanks are almost entirely of Cook's turban (*Cookia sulcata*) and paua (presumably *Haliotis iris*) shell, and bone and bone-related material (teeth and spines; SS2 Table 1), and are described in Supplementary Sections (SS) 3-5.

All one-piece fishhooks (including the 17 believed to be broken examples) are of Cook's turban (SS2 Table 1). This suggests that neither the paua shell nor the bone available was robust enough for small one-piece fishhooks (even though paua has apparently been used for them in other parts of Northland; Buck 1970: 218). This may be because the black-foot paua (*Haliotis iris*) does not reach the same dimensions off east-Northland as it does off the west coast of Northland or in other, more southern places: shells >100-mm long are rare - and this is likely to have been so for centuries (Reyn Naylor, NIWA, Wellington, pers. comm. 2017). Further, the bone readily available to the Late-period people of Paraenui no longer routinely included moa or marine-mammal.

The paua fishhook points from Paraenui are similar in form to the bone ones, particularly around the presence of barbs. Nevertheless, there is a great deal of variability in size and form among the points, presumably reflecting personal preferences of the individuals who made and used these points, but almost certainly, too, to experimentation and perfecting of form.

Whereas for one-piece fishhooks a rotating function is clear, it is not necessarily obvious whether the two-piece hooks were rotating or jabbing hooks. 'Jabbing hooks are more commonly used in shallow waters where tension can be maintained on the line once a bite is felt, allowing the angler to retrieve the fish.' (Paulin 2016: 77). The sharpness and robustness of the dogfish spines, in particular, suggest a jabbing function.

SS2 Table 1. *Numbers of complete and near-complete shell and bone/bone-related items of fishing gear.*

	Cook's turban	Paua	Bone/bone-related
One-piece fishhook	19	0	0
Fishhook point	11	18	28
Fishhook shank	2	8	3
Probable fishhook shank	2	24	0
Probable fishing gorge	0	0	2
Total	**34**	**50**	**33**

Across the entire collection, and within the Cook's turban and the bone material in particular, fishhook points are better represented than are shanks (SS2 Table 1). Possible explanations for this include shanks often being made of shorter-surviving wood, but also that the overrepresented (presumed) paua shanks were widely used. With their high opalescence, paua shanks may have also had a trolling function.

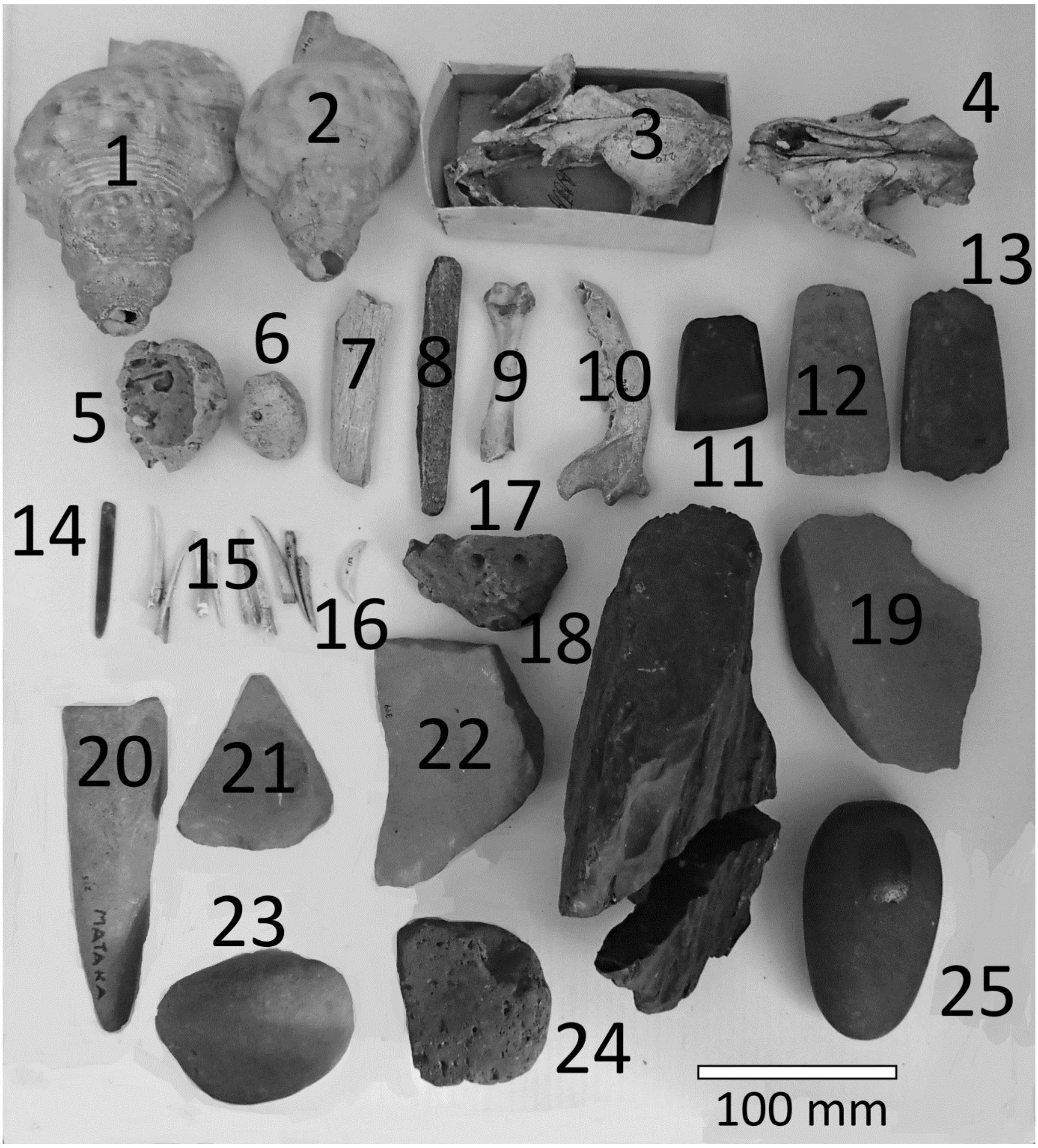
Material not directly associated with fishing takes in whole- or broken made-items (with examples illustrated in SS2, Figures 1 and 2). Among them are several stone (including slate-like) cutters/scrapers; files and pieces of grinding hoanga; hammerstones; and pieces of faced pumice and pumice plugs. There are more than 30 ochre-stained stones, two pairs having been found in apparent pestle-mortar relationships, and two having red ochre on one side and evidence of greasy black pigment on the other. The little other worked stone material includes three adzes (one broken) and one nephrite eardrop.

There is one human patella and one human tooth, each drilled for suspending; an elongate, almost-flat section of paua shell 57-mm long may also be a pendant. Further, there are 10 bone needles, three tattooing tools, and several awls; two probable sounding horns (*Charonia lampas*) in working order; and individual kauri-gum and pumice containers. The bone spear point (#186, the number referring to the Booth Whānau Collection Catalogue - Part 1) was possibly for use with such seabirds as oi, the grey-faced petrel *Pterodroma (macroptera) gouldi*, which to this day nest in numbers on Harakeke Island 4 km east of Paraenui Bay. There are four pieces of flattened whale bone, up to 12-mm thick and 130-mm long, with evidence of shaping and abrading (e.g., Cunliffe 2013): #101 and #401 each has one rounded edge suggesting they could have been derived from a mere; Items #14 and #163 are much smaller, the former clearly showing scraping marks on its corticular surface.

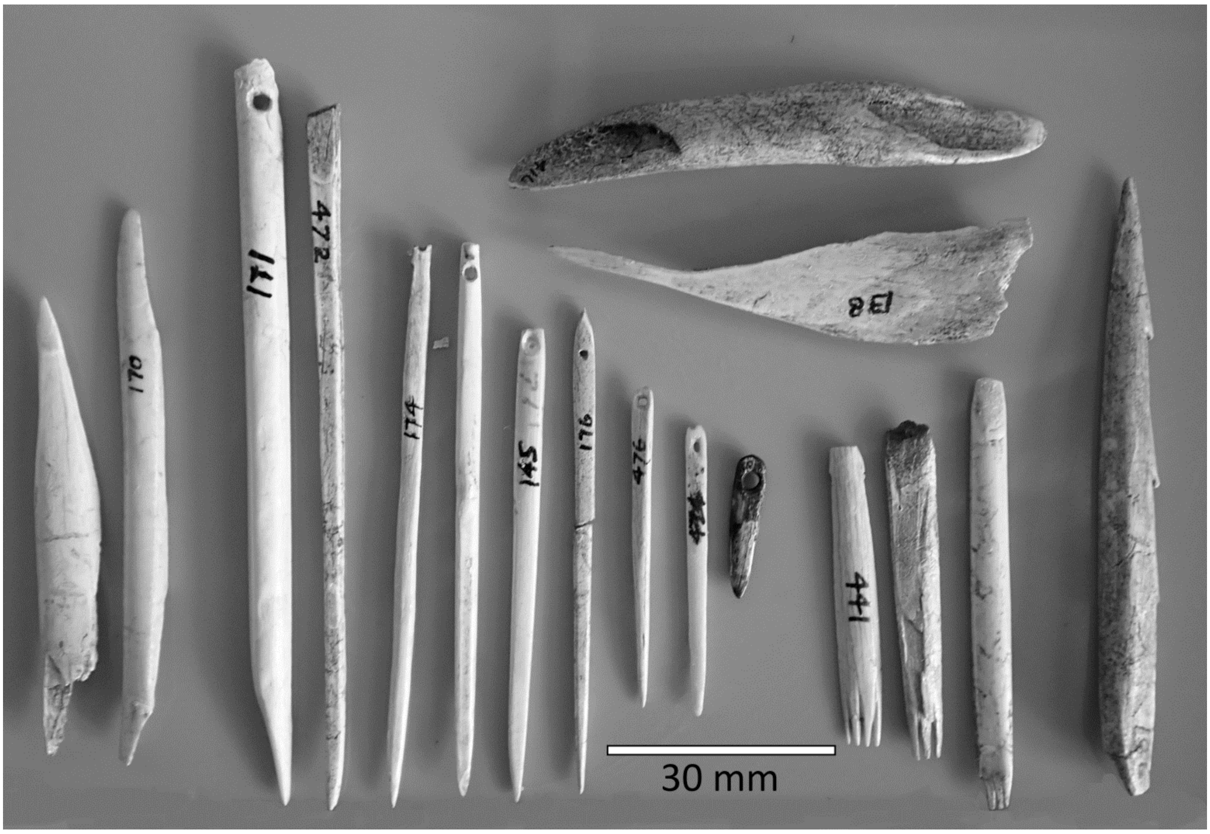
The only wooden object is a 46-cm long and up to 5-cm thick stake that has apparently been shaped by adze. One European item - a metal (probably brass) 'button' - was found but lost when posted to a European museum for assessment in the 1960s. We recall it being about 2.5-cm in diameter, and 2-mm thick, with a fleur-de-lis-type pattern around the outer surface of the disc - and there may have been gilt. It had, we think, a simple central circular fastening standing proud from its reverse side.

All obsidian is from Kaeo (McAlistair 2017), including a large, split piece (#244); and there are chippings of other stone. Kuri bone makes up most of the animal material, several leg bones bearing the deep grooves and cuts required in order to fashion such things as fishhook points, but there are also pieces of worked bone from large flying seabirds.

Unworked and unburnt kuri material includes substantial portions of two skulls, as well as three mandibles, and many individual teeth (including nine canines). The largest mandible (#316, although without its canine tooth) is 122-mm long and the others are only slightly shorter. Individual intact canines used in the fishing gear described in SS5 are of a size (29-39-mm long) to be broadly consistent with that of these mandibles; and individual intact canine teeth without signs of working are 31-38-mm long. In addition to the four spiny dogfish spines (almost certainly *Squalus griffini*) customised for use as fishhook points (*see* SS5 Figure 1B), there are a further 29 spines without evidence of working, some having been found stacked one within another.



SS2 Figure 1. Some of the non-fishing items from Paraenui. 1 & 2, *Charonia* sounding horns; 3 & 4, substantial portions of kuri skulls; 5, kauri-gum bowl; 6, perforated human patella; 7 & 8, shaped whale bone, 9 & 10, kuri bones; 11-13, adzes (11 being #412); 14, nephrite pendent; 15, unworked spiny dogfish spines; 16, kuri canine; 17, perforated and carved piece of pumice; 18, Kaeo obsidian (#244); 19, 21 & 22, part hoanga; 20, shaped stone; 23, ochre-grinding stone; 24, faced pumice; 25, hammerstone.



SS2 Figure 2. Awls, needles, tattooing points and spear point (#186, at far right) from Paraenui.

The volume of bone and other remains (most unburnt, and including worked items) in the collection suggests there were significant numbers of dogs at Paraenui. Based on jaw parts, the Paraenui dog MNI was 10 - and probably many more. Further, it appears some dogs were small (and probably immature) when despatched, possibly providing bones suitable in size for fishhooks, particularly fishhook shanks.

Almost certainly the dog remains are kuri, rather than European dogs. The one largely complete cranium (Item 3 in SS2 Figure 1) has the marked sagittal crest characteristic of the Polynesian dog in New Zealand (Bay-Petersen 1979: 167); also distinctive in the skulls, as well as in the several other upper-jaw parts, is the palate shape (wide at the molars and narrowing abruptly at the third molar to a narrow snout; Bay-Petersen 1979: 178). The three almost complete mandibles (#301, 313 and 316) are (at about 120-mm length) of average size for kuri reported (Bay-Petersen 1979: 168). But some of the several clearly-worked mandibles (e.g., #94 in SS5 Figure 1D, its base having been removed for other purposes), are small (estimated to have been around 105-mm long), as are several of the incomplete, unworked mandibles, and many of the individual non-canine teeth. At fishing sites such as Paraenui, abundant fish-remains presumably meant sufficient food was available to sustain significant numbers of kuri; in turn, kuri provided food, skins and fishing componentry.

Supplementary Section 3. Cook's turban fishhooks, points and (presumed) shanks

There are complete (or near-complete) one-piece fishhooks, as well as the points and shanks of two-piece fishhooks (Supplementary Section [SS] 3 Table 1), all of which - together with the many broken parts - lack any sign of what might be taken as ornamentation (SS3 Figure 1). For most items, there is little doubt the shell used was Cook's turban, but for three (Items #8 and #31, as well as the damaged #2 [the numbers referring to the Booth Whānau Collection Catalogue - Part 1]; SS3 Figure 1A), the gastropod used is not completely clear.

SS3 Table 1. *Cook's turban fishhooks, points and shanks. Complete, referring to state of item; Rot, rotating-function; Jab, jabbing-function; presum, presumed; -, not applicable; clock and anticlock, referring to handedness (*see *Law 1984).*

					Lashing notches					
	Complete	Rot/Jab	Nearly complete	Rot/Jab	1	2	1-5	Barb	Clock	Anticlock
One-piece fishhook	2	Rot	17	Rot (presum)	15	4	-	0	-	-
Fishhook point	11	Rot (presum)	-	-	-	-	11	1	9	2
Shanks & probable shanks	4	-	-	-	4	-	-	-	3	1

The two intact one-piece Cook's turban hooks are similar in style to several illustrated by Davidson (1984: 66) (SS3 Figure 1A). The smaller (number illegible, and now labelled 'A') is 21 mm high x 16 mm across (and similar in overall dimensions to a present-day 1/0 fishhook), whereas the largest (#86, and repaired) is 28 x 22 mm (and equivalent to a 6/0 fishhook). Because their tips are clearly incurved, these hooks are of the 'rotating'-type (sometimes 'circle' or C-shaped; e.g., Sinoto 1991: 86; Leach 2006: 96).

A further 17 incomplete fishhooks appear to have been one-piece, similar to – and intermediate in size between - the first two, all lacking any notches that might point to two-piece construction (SS3 Figure 1A). It is not possible, however, to be categoric that these were of the rotating- or the jabbing- (J-) type (although we suspect all were rotating). It is also unclear if these hooks had been broken in the course of construction, during fishing, or as a result of subsequent exposure to the elements.

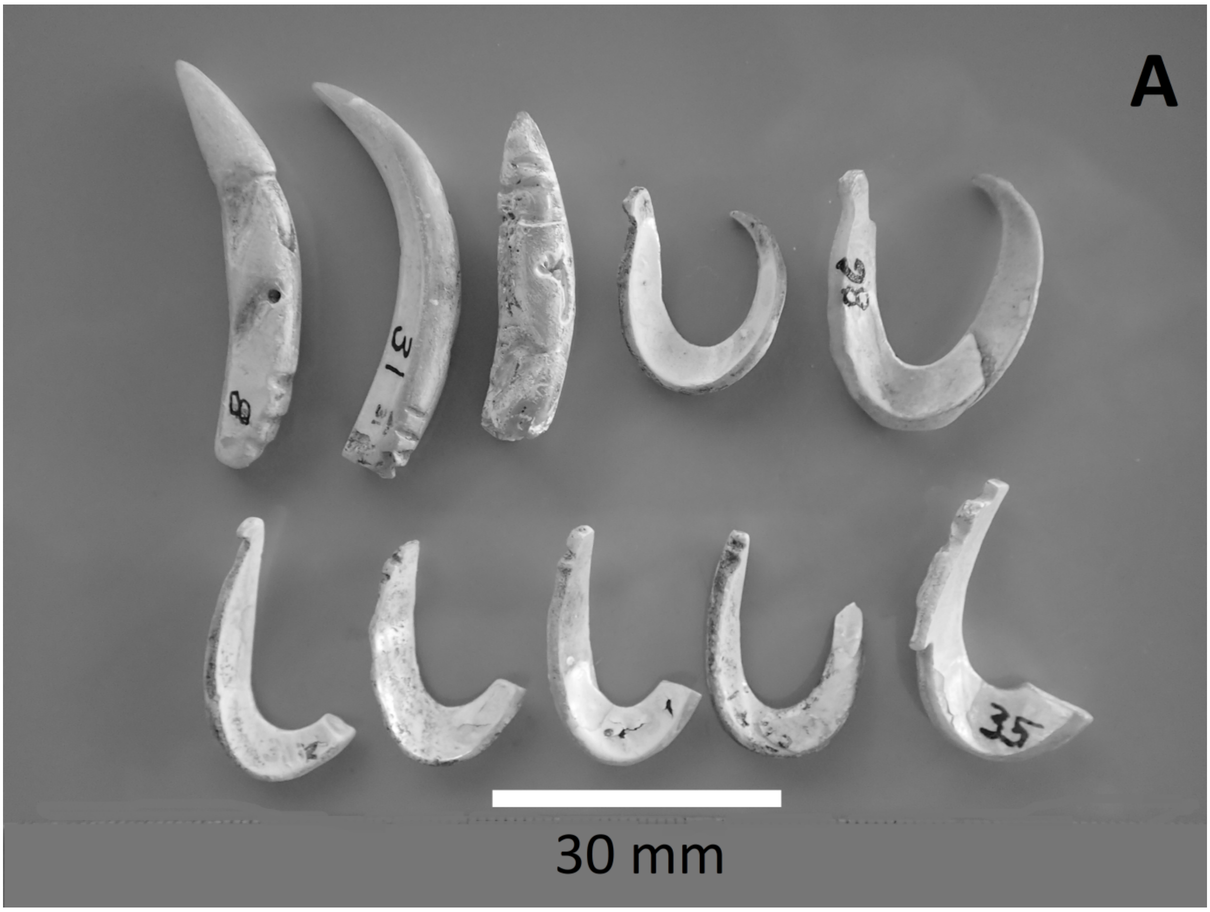
The knob of all but four of these 19 hooks is simple, with a single notch for line attachment (and similar in form to Sinoto's 1991: 98 HT1a). The exceptions (#449, and two others now labelled 'B' and 'C') have two notches, and another (#35) not only has two notches but is altogether bulkier, with a large tang on the shank, perhaps to increase strength and/or to help secure the bait (SS3 Figure 1A).

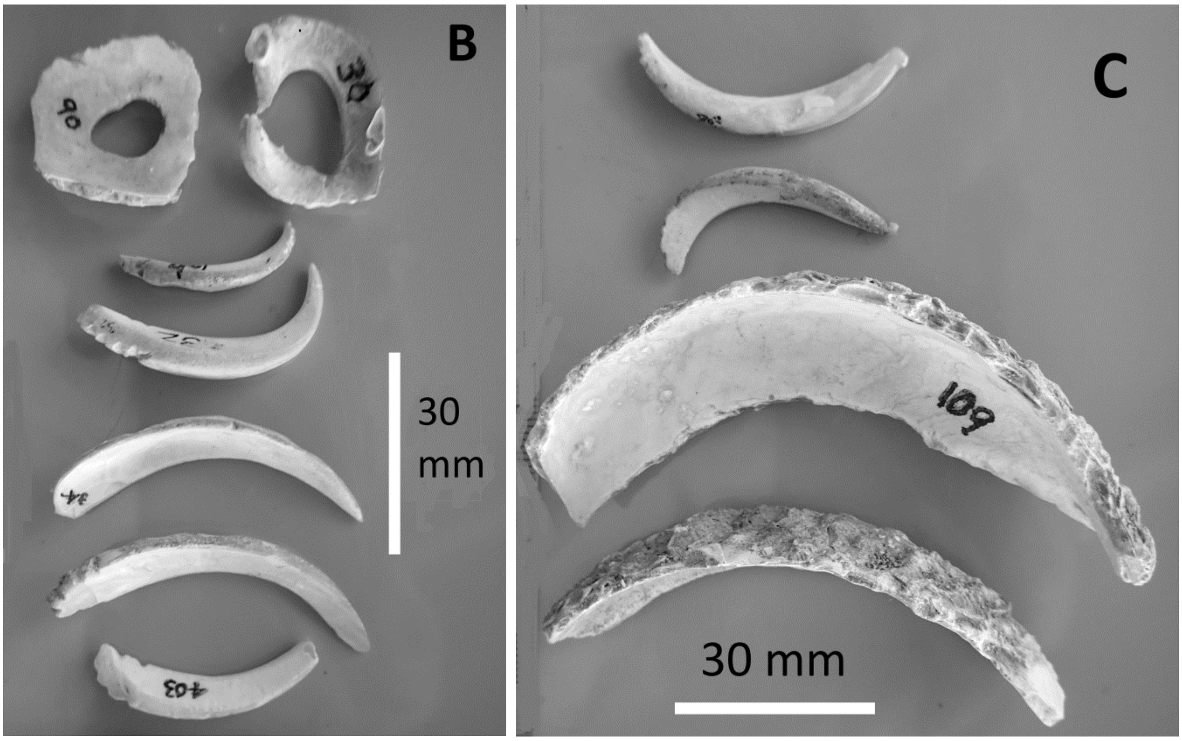
There are several presumed-blanks (or parts thereof) for one-piece fishhooks. Two of them (#30 and #90, both about 25-mm OD and 10-15-mm ID) have had their holes formed by flat-rasping of the outer curved surface of the shell, presumably followed by pecking and then finger-filing (SS3 Figure 1B).

There are 11 complete (or nearly-so) fishhook points, 27-48-mm long (SS3 Figure 1B). Apparently, all are constructed for lapped – rather than butted - attachment, but no shanks suitable for these points were found (presumably because they were of wood that did not survive, or other material such as paua was used). Only one (#8) has a barb, which is external (*sensu* Buck 1970: 227-28). Most are likely to have been large hooks, and suitable for medium and large fish up to and including small sharks and small rays. All but two (#34 and 451) are clockwise-tipped (*sensu* Law 1984: 6-7), and all have 1-5 lashing grooves. Six are consistent with Law's (1984: 9) BbA base type. Items #32 and #403 have grooves on both sides of the base, and we align them most with Law's Bad; #33 aligns with Baf; and #34, being without grooves, is similar to Bae (SS3 Figure 1B).

There are two essentially complete shanks (36 to 40-mm long, one anticlockwise [#262? and now 'D', although this is possibly of paua] and the other clockwise [#82? and now 'E']); each is designed to be lapped and has a single knob notch and 4-6 grooves for point-attachment (SS3 Figure 1C). These are too small to have been used with most of the points above.

Two items (#108 and #109) appear to be large shanks in the making, the largest 83-mm long, with chipping evident on its edges (SS3 Figure 1C). Both are clockwise in handedness, and it is possible they were to be lure shanks that made use of their iridescence to attract fish, but it is unclear just how the point would have been attached.





SS3 Figure 1. Cook's turban fishhooks, points and (presumed) shanks. A, from top left: the three points (#8, #31 and #2) for which the shell-type is not entirely clear, #8 being barbed; the two intact one-piece hooks (#A and #86); an example of the 17 broken one-piece hooks, this one having a single lashing notch at head (#354); the four broken one-piece hooks that have two lashing notches at the head (#449, #B, #C and #35). B, from top: one-piece fishhooks in the making (#90 and #30); two examples of the clockwise points (#461 and #32); the only two anticlockwise points (#34 and #451); fishhook points #403 and #33 (which we align most with Law's [1984] base types Bad and Baf respectively). C, from top: shanks #D, #E, #109 and #108).

Supplementary Section 4. Paua fishhook points and (presumed) shanks

All paua hooks are two-piece, and there appears to be some ornamentation (Supplementary Section [SS] 4 Figure 1; SS4 Table 1). The presence of a barb on many of the points suggests a different style of use (perhaps jabbing, rather than rotating) to that of most of the equivalent-sized Cook's turban fishhook points.

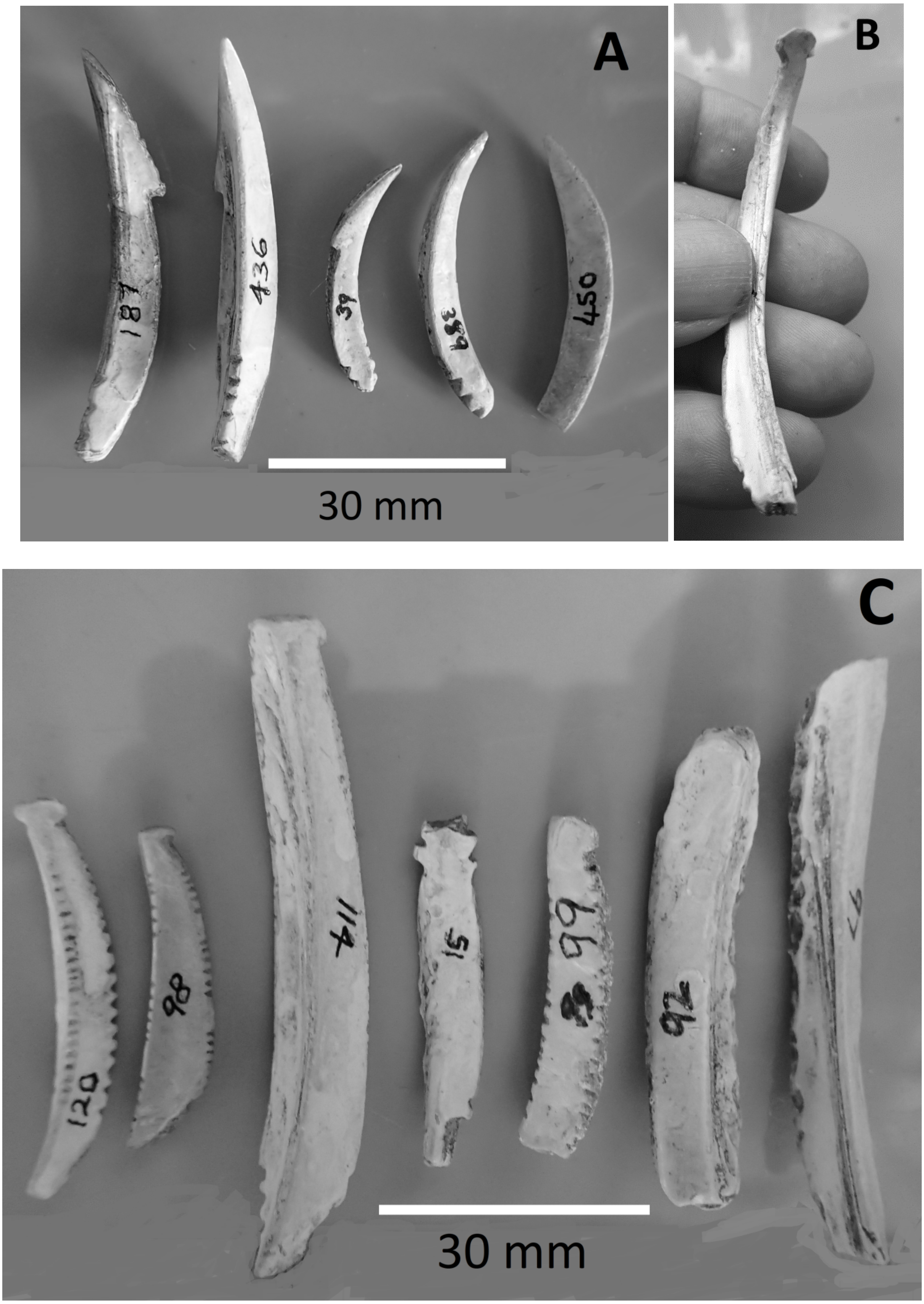
The largest complete points (#187 and #436) are 50-mm long; the smallest is 31 mm (#39; the numbers referring to the Booth Whānau Collection Catalogue - Part 1) (SS4 Figure 1A). Eleven points have barbs, most external and often with nicks, presumably to help secure the bait; seven are without barbs or nicks (e.g., #389 and #450; SS4 Figure 1A).

SS4 Table 1. *Paua fishhook points and (presumed) shanks. Rot, rotating-function; Jab, jabbing-function; presum, presumed; Nicks, refers to nicks along length of shank; -, not applicable; ?, not clear.*

			Knob lashing notches			
		Rot/Jab	1-2	3	Barb	Nicks
Fishhook point	18	Jab (presum)	-	-	11	-
Shanks	8	-	7	1	-	4
Probable shanks	24	-	?	?	-	?

In all (presumed) whole- (or nearly-whole) shanks (SS4 Figure 1B, C), the knob attachment is simply of one or two notches (although there are three in #114). The largest complete shank (#96) is 76-mm high, yet so remarkably slender as to draw into question precisely how it functioned (SS4 Figure 1B); the smallest shank is 35-mm high (#98; SS4 Figure 1C). Three are clearly made from the thick and strong part of the shell's lip, which is also highly opalescent and may point to a trolling function (e.g., #114); once again, it is unclear how the point would have been attached. Of the eight intact shanks, four have nicks along almost their entire lengths that are additional to the lashing grooves (e.g., #120, #98 and #114 in SS4 Figure 1C): it is hard to fathom what function these nicks would have had, and so they are considered here to be ornamental.

There are a further 24 paua items that are almost certainly part-shanks [e.g., #15 and #99 in SS4 Figure 1C], or possibly shanks in the making [e.g., #92 and #97 in SS4 Figure 1C], many similar in form to #114.



SS4 Figure 1. Paua fishhook points and (presumed) shanks. A, fishhook points, from left #187, #436, #39, #389 and #450. B, large, slender fishhook shank #96. C, (presumed) fishhook shanks, from left #120, #98, #114, #15, #99, #92 and #97.

Supplementary Section 5. Bone and bone-related fishhooks and (presumed) shanks and gorges

The largest fishhooks in the collection are of bone (or tooth or spine), and all are two-piece in construction (Supplementary Section [SS] 5 Figure 1, Table 1). With the possible exception of Item #1 (SS5 Figure 1A, the number referring to the Booth Whānau Collection Catalogue - Part 1), there is no evidence of ornamentation. The bone used for the points was not seabird (apart from #23 in SS5 Figure 1, identified by Michael Taylor, Archaeology North Ltd. in 2017 as being the humerus of the little blue penguin *Eudyptula minor*), leaving - given the bone dimensions - kuri and human as the remaining Late-period options.

For the fishhook points, kuri hard-parts appear to have been the most frequently used raw material, but are categorically identifiable by us only when teeth are present. There are five canine-tooth points, most with 3-5 lashing grooves (e.g., #188; SS5 Figure 1A). For those with barbs, two (e.g., #190) have both inner and outer barbs, and one (#189) has only an inner barb.

SS5 Table 1. *Bone fishhook points and (presumed) shanks. Rot, rotating-function; Jab, jabbing-function; presum, presumed; Nicks, refers to nicks along length of point; -, not applicable.*

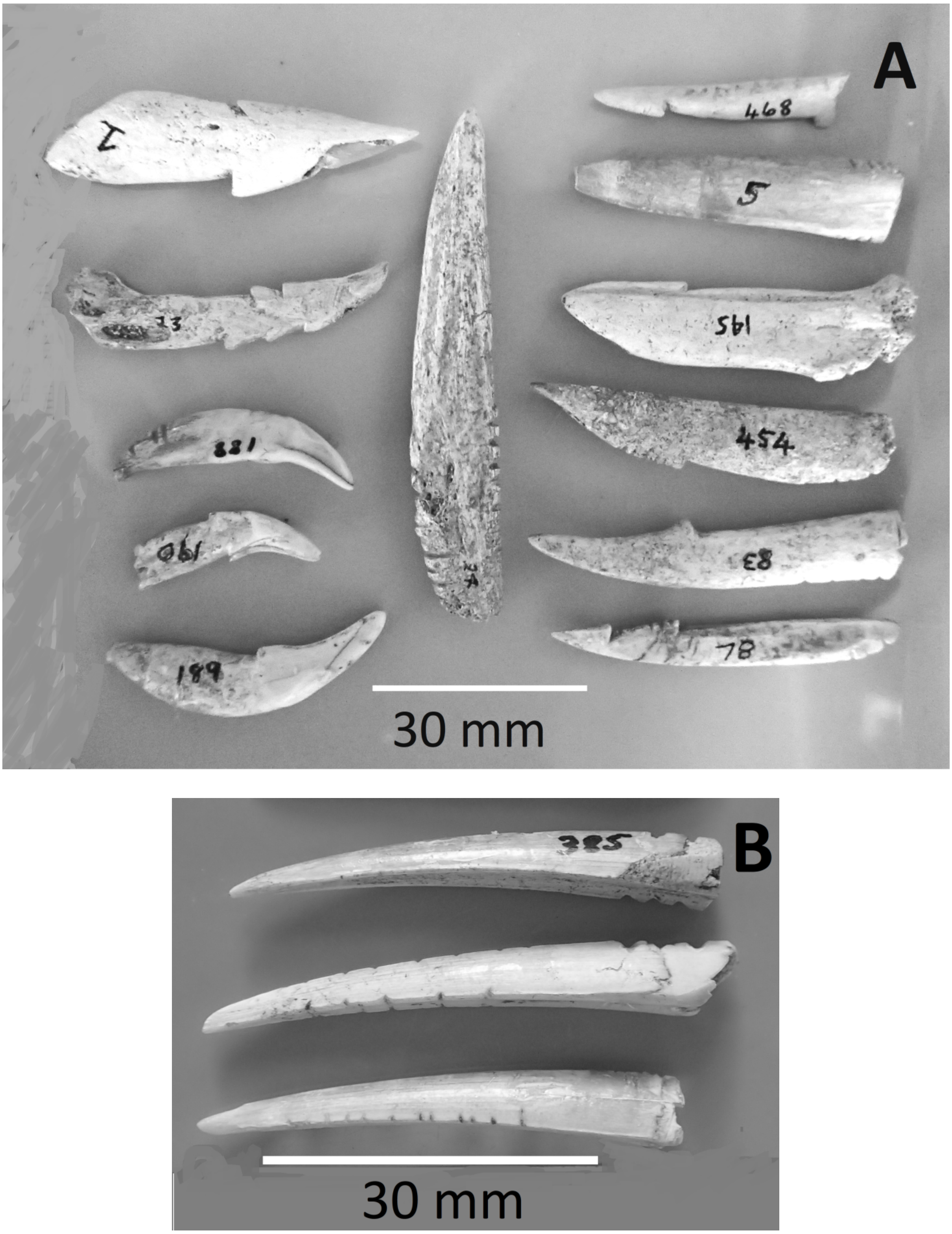
			Lashing notches				
		Rot/Jab	1-3	3-5	4-8	Barb	Nicks
Canine fishhook point	5	Jab (presum)	-	4	-	3	-
Spiny dogfish fishhook point	4	Jab (presum)	-	4	-	0	2
Other fishhook point	19	Jab (presum)	-	-	18	14	-
Shanks	3	-	3	-	-	-	-

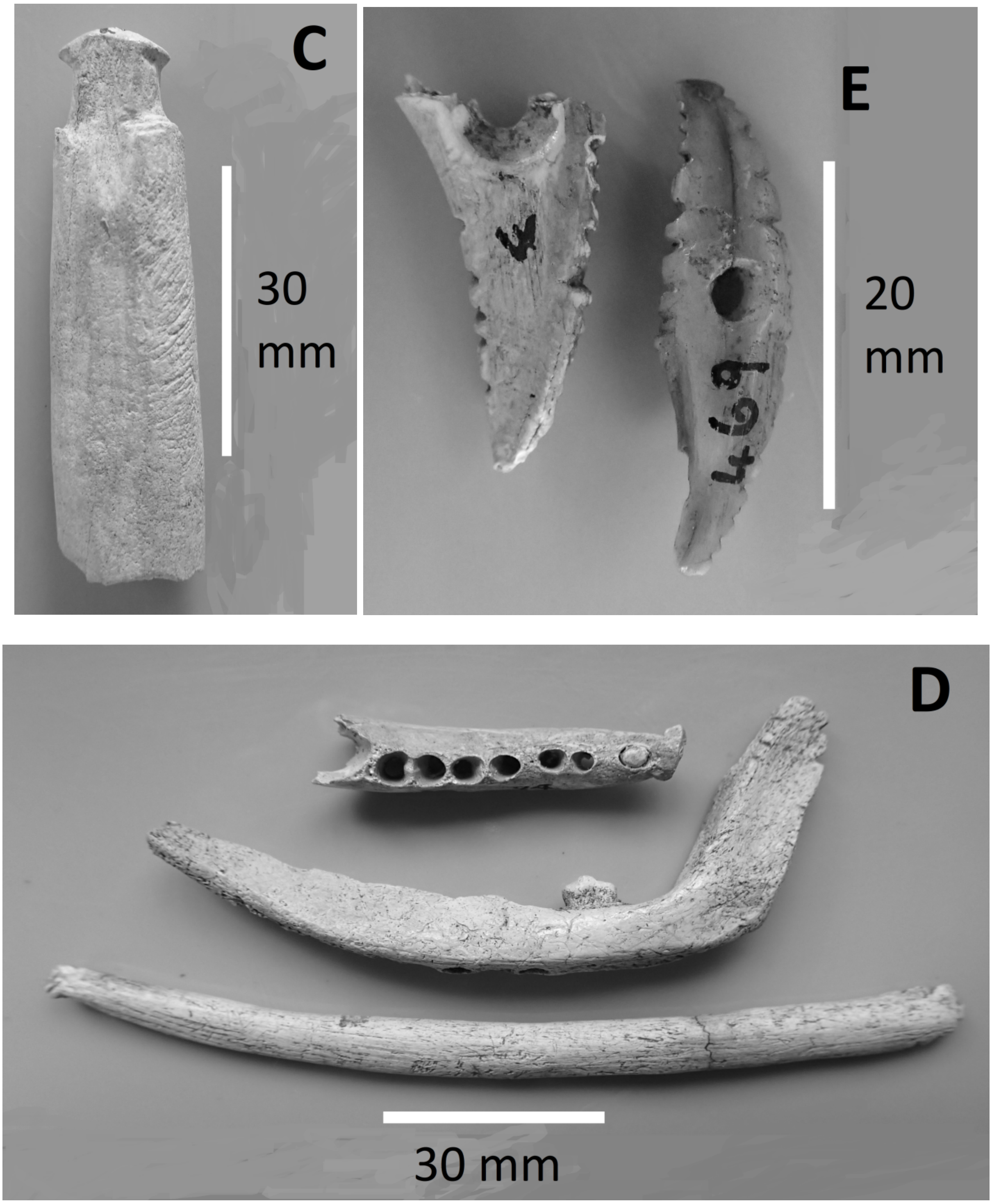
There are many similarities in form between our bone points and various of those illustrated by Davidson (1984: 69). Our largest is 71-mm long (#24); the smallest 33 mm (#468) (SS5 Figure 1). Of the 19 complete or near-complete bone points, five are without barbs (e.g., #24 and #5); three have what we take to be inner barbs (e.g., #145); three have outer barbs (e.g., #454); and eight have both inner and outer barbs (e.g., #1, #23 and #83; #1 having a piece of shell inserted into its medullary cavity at the distal end, perhaps ornamentally because the bait would have made it otherwise invisible - or merely as a stopper). The proximal ends typically bear 4-8 grooves for attachment to the shank, although Item #23 uses the natural form of the bone articulation for binding purposes. We consider Item #78 to be a fishhook point, rather than a spear tip, because of the nicks along one barb that presumably helped hold the bait; the grooving on Item #145 is, at the one time, intriguingly purposeful yet inexplicable (SS5 Figure 1A).

Four dogfish spines (almost certainly from the northern spiny dogfish *Squalus griffini*) have been used as fishhook points, denoted by lashing grooves at the base; two of them (#197 and #198) also have nicks along their lengths (SS5 Figure 1B).

The presence of only one complete shank (#184 in SS5 Figure 1D, and an enormous 124-mm long; similar to Fig 4A of Sinoto 1991: 89 [but possibly for the capture of petrels; Paulin 2016: 84, 86]) again suggests widespread use of wooden shanks or possibly paua. Two kuri mandibles (#94 and #427) are presumably shanks (each having had their sturdy basal part removed for other use) (SS5 Figure 1D). Additionally, there is an anomalous broken shank of formidable proportions, possibly of moa bone (Michael Taylor, pers. comm. 2017) (#46? and now ‘F’; SS5 Figure 1C); we have not found any identical head and knob among published accounts.

There are two (possible) gorges (#4 and #469); both have lashing grooves, and #469, at least, is made of a centrally-drilled kuri canine (SS5 Figure 1F).





SS5 Figure 1. Bone and bone-related fishhooks, points, shanks and (possible) gorges. A, fishhook points from top left #1, #23, #188, #190, #189, #24, #468, #5, #145, #454, #83 and #78. B, three of the four spiny dogfish fishhook points, from top #385, #198 and #197. C, upper part of (presumed) shank of moa bone (#F). D, bone (presumed) shanks, the upper two (#94 and #427) of kuri mandible, with #184 at bottom; E, (presumed) gorges #4 and #469.

Supplementary Section 6. Morphology and distribution of spiny dogfish and certain other deep-water fishes

There are two spiny dogfish in New Zealand coastal waters: the (spotted) spiny dogfish *Squalus acanthias* (globally widespread) and the northern spiny dogfish *S. griffini* (previously *S. mitsukurii*) (Southwest Pacific Ocean; Duffy & Last 2007). In both (but particularly in spotted spiny dogfish), the posterior spine is much the larger; and the posterior spines of spotted spiny dogfish are significantly shorter than those of northern spiny dogfish of similar fish-length. For both dogfish species in New Zealand waters, males reach about 900-mm length, and females 1100-1200 mm (Duffy & Last 2007: 97; MPI Plenary 2017: 1400).

Spiny dogfish have one spine in front of each of their two dorsal fins. The spines are made of dentine, with an enamel surface covering the fully exposed part (as well as the portion of the spine hidden within the cutaneous fold but which is not embedded; e.g., *see* Soldat 1982: 48).

For individual northern spiny dogfish 972-mm and 1070-mm long examined by Duffy & Last (2007: 95), the posterior spines had exposed lengths of about 46 mm and 53-mm respectively (Last *et al.* 2007: 4); the respective enamel-layer lengths were about 58 and 66 (the exposed length being about 80 per cent of the enamel-layer length, based on the drawing of Holden & Meadows 1962: 180). For a dogfish 473-mm long, the lengths are 31 and 39 mm respectively. (The equivalent enamel-lengths of the anterior spines for each of these three fish-lengths are, respectively, 44, 50 and 24 mm.)

Posterior spines of 1000- and 1100-mm long individual spotted spiny dogfish from the North Atlantic were about 42- and 46-mm long respectively (based on Holden & Meadows 1962: 184, using the uncorrected [i.e., no provision made for spine-tip wear, as also applies to the northern spiny dogfish lengths given above], 'external' [but, in fact, the same thing as 'enamel-covered' in the present context] spine length); similar values are suggested for large individuals from Australasia (White *et al.* 2007: 111). For a dogfish 500-mm long, the posterior spine length is 22 mm. (The equivalent enamel-lengths of the anterior spines for each of these three fish-lengths are, respectively, 28, 30 and 14 mm.)

Most of the Paraenui spines are large (mean 42.26-mm enamel-layer length, range 36-47 mm, SD 3.21 mm, for the 27 measurable individuals), and are therefore far more likely to be posterior spines from northern spiny dogfish than from spotted spiny dogfish. Indeed, more than 60 per cent (almost 20 per cent) of our spines equal or exceed the spine-lengths for large [1000-mm long], and necessarily female (extremely large - 1100-mm long female) spotted spiny dogfish.

Whereas the Paraenui spine lengths are compelling with regard to the species of spiny dogfish, the distribution patterns of the two species emphatically point to them being northern spiny dogfish. Based on >19 000 mainly random research trawls over recent decades, the spotted spiny dogfish was rare in northeast New Zealand, whereas the northern spiny dogfish was common (SS6 Figure 1). (The same conclusion can be derived from combined research and commercial trawls, for both immature and adult sharks; O'Driscoll *et al*. 2003).

Not only are their geographic distributions very different, but there are also key differences in the depths in which the two dogfish species live, and in their migratory behaviour. The northern spiny dogfish is essentially a bottom-dweller, seldom being taken up in the water column (Clinton Duffy, Department of Conservation, pers. comm. 2017; Larry Paul, 236

Main Road North, Otaihanga, Kapiti 5254, pers. comm. 2018). In 50 years of recreational fishing to depths of 70 m and more in and near the Bay of Islands, we (the Booth brothers) have never caught a single spiny dogfish. With 90 per cent of the northern spiny dogfish population found within the 100-500-m depth range (SS6 Figure 1), and a mean depth of 290 m (range 15-954 m; Anderson *et al.* 1998), this shark is part of the outer shelf and upper slope, rather than inshore, fish assemblage (Francis *et al.* 2002: 218; Roberts *et al.* 2015). Although the spotted spiny dogfish has a similar mean depth, it is not uncommon high in the water column, and as adults it undertakes (albeit limited, it seems) migrations towards shallower waters associated with reproduction (MPI Plenary 2017: 1399).

If the northern spiny dogfish ever undertook extensive forays into shallow waters - in a manner similar to the spotted spiny dogfish, and particularly to rig (the spotted dogfish *Mustelus lenticulatus*) or school shark (*Galeorhinus galeus*), in the past (e.g., Matthews 1910) or now (MPI Plenary 2017: 1134, 1120) - we should know about them. In fact, there appears to be no evidence for northern spiny dogfish undertaking any significant inshore/offshore migrations in recent geological times.

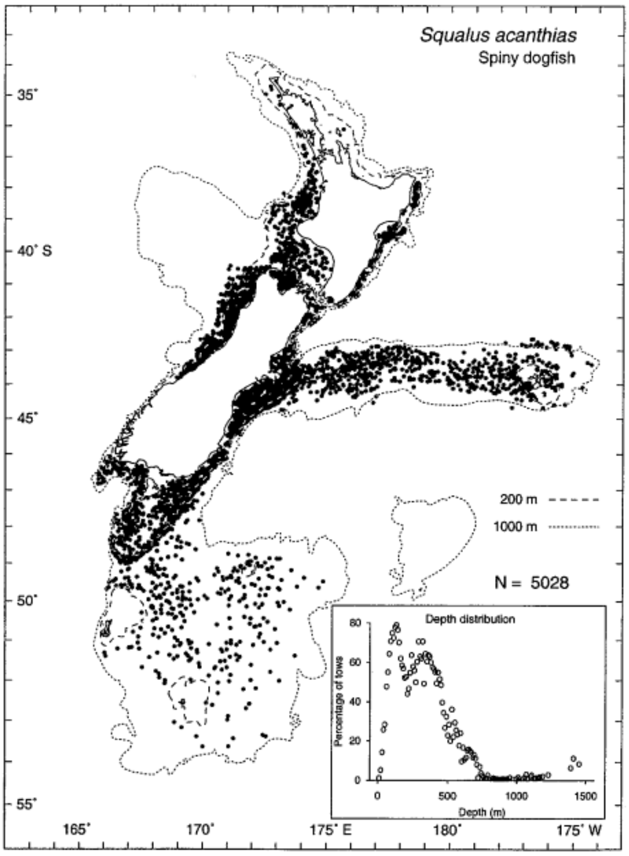
Certain fish distributions in New Zealand (e.g., hapuku *Polyprion oxygeneios*) appear to have altered as a result of exploitation, and climate change may have affected the range of other species, but we argue the northern spiny dogfish is unlikely to be among them. Mostly a bycatch, the northern spiny dogfish has never been sought commercially or recreationally to any extent; total (presumably) annual commercial weights for 2008-13 were on the order of only 40 t (Francis 2015: 10). Furthermore, we believe it highly unlikely that the higher landings of the similarly shunned spotted spiny dogfish (around 6300 t landed during 2008-13 in New Zealand, mostly in the south; Francis 2015: 10) has brought about today's low abundance of that species off east Northland. Finally, although air temperatures (and, in turn, sea-surface temperatures) during the Little Ice Age (1500-1900 AD, which takes in the Late Period) were about 1°C cooler than today (Anderson *et al.* 2014: 121), it is hard to see how this could have led to vastly different geographic or depth distributions between the Late Period and the present time for such a deep-water fish.

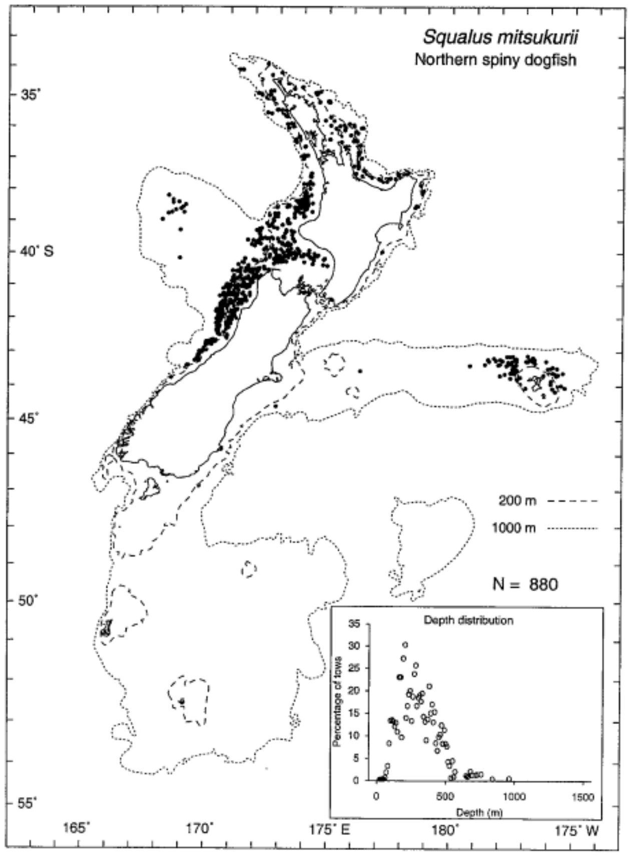
We cannot categorically rule out the occasional inshore catch near Paraenui of northern spiny dogfish during the Late Period, but it seems unlikely that chance catches would have led to the capture of so many of them. Even though our collection technique was not as quantitative as would it have been if a formal excavation, our 33 spines (representing at least 16 large individual fish – but probably many more) can be considered much more than incidental inshore catches. Accordingly, we argue that focussed fishing in waters of at least 100-m depth (and therefore at least 8 km from shore) had taken place from Paraenui. Although other explanations for the spines are possible, ours may be among the few lines of strong evidence for waka bottom-fishing in pre-Contact Northland having taken place at points well beyond the goldilocks zone defined by Leach (2006: 265), and bounded by the 50-m depth, and 100-m offshore horizontal, contours. (Paulin 2016: 18 has recently extended the depth attribute from 50 m to between 50 m and 100 m. We now extend this to ≥ 100 m.)

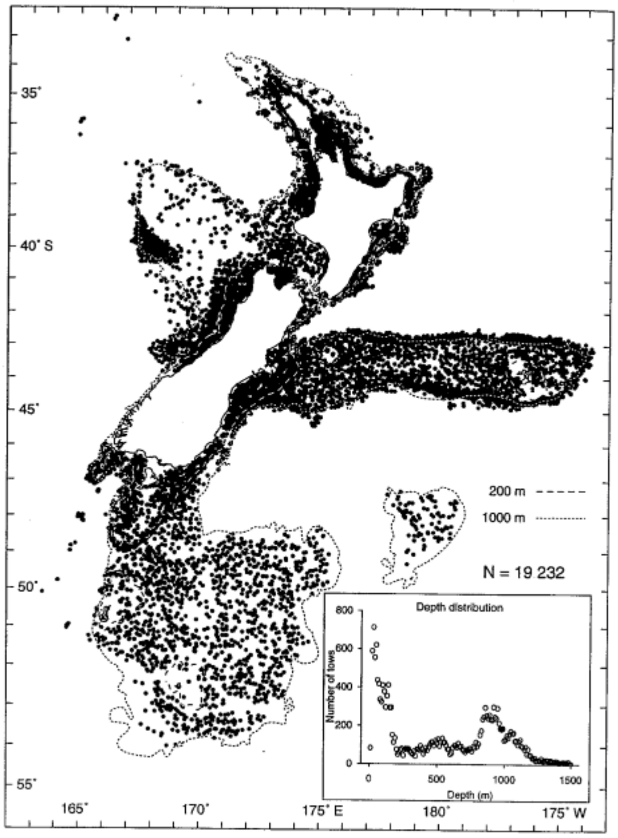
Māori fishing many kilometres offshore was often reported by early Europeans (see examples in Paulin 2016: 36, 53), so what is novel here is the depth of fishing. Few deep-water fishes have been reported from northern middens: Smith (2013: 15, 20) reported the occasional ghost shark (as *Callorhincus milii*, now *Hydrolagus novaezealandiae* and found today mainly at depths >150 m; MPI Plenary 2017: 442), bluenose (*Hyperoglyphe antarctica* - mainly >250 m today; MPI Plenary 2017: 125), hapuku (mainly >100 m today; MPI Plenary 2017:

482), and sea perch (*Helicolenus barathri*, now *H. percoides* – mainly >150 m today; MPI Plenary 2017: 1254), in addition to northern spiny dogfish (as *Squalus blainvillei*), in Hauraki Gulf and/or Otago/Catlins middens. (To these species can be added, from more southern middens, ling *Genypterus blacodes*, and the occasional hoki *Macruronus novaezelandiae* [Leach 2006: 252, 265-266; Smith 2013: 20], both of which today are most common at depths >100 m.) Whereas these apparently small and infrequent catches of what are today essentially deep-water fishes are difficult to put into any meaningful context, our finding of 33 large northern spiny dogfish spines at Paraenui is compelling evidence for deep-water fishing.

The technological issues associated with fishing waters ≥100-m deep – anchoring in persistent currents; only relatively low-density, stone sinkers being available; and constructing lines long-enough to reach the bottom and robust-enough to withstand the teeth, abrasive skin and sheer strength of such sharks (e.g., see Leach 2006: 84, 99) - are daunting. Presumably it was worthwhile to fish to these depths for northern spiny dogfish (and presumably other deep-water fish such as bluenose), the dogfish yielding meat for drying, spines for use as fishhook points, skin that could be used for burnishing, and liver oil for the application of red-ochre pigment.







SS6 Figure 1. Geographic and depth distribution of spotted spiny dogfish *Squalus acanthias* (upper left) and northern spiny dogfish *S. griffini* (previously *mitsukurii*) (upper right) from recent random research trawls (lower) (Anderson *et al*. 1998).

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