BANKS

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Roger Grace Ph.D.,
Biological Consultant,
P.O. Box 12-012,
Penrose,
Auckland 5.
phone 0-9-579-8498.

BIOLOGICAL INVESTIGATION OF POUTO SAND EXTRACTION SITE, KAIPARA HARBOUR.

For: Mt Rex Shipping Company Limited

By: Roger Grace, Biological Consultant

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CONTENTS

SUMMARY.

1. Mt Rex Shipping Company Limited has for several years extracted sand from a current-swept shallow subtidal site in the entrance to the Kaipara Harbour, near Pouto on the Kaipara North Head.

2. Re-licencing is required annually from Department of Conservation, together with concurrence from MAF Fisheries. This report presents results of investigation of shellfish resources in the area, and an interpretation of the impact of sand extraction on biological and shellfish resources.

3. An association of three main animals lives in the extremely mobile medium sands of the extraction zone. These are tuatua, sand dollars, and the paddle crab. Other animals are rare. A total of 17 species occurred in the samples.

4. Tuatua are the only shellfish of major fisheries significance in the area. The modal length of tuatuas is 50 to 60mm. Tuatua densities are variable, from zero to 48.3 per square metre in the samples.

5. Tuatua density varies with depth. Mean density shallower than 8 metres is 1.09/sq.m., and deeper than 8 metres is 18.95/sq.m., thus 95% of the population in the sample area occurs below 8 metres.

6. 72.5% of tuatuas passing through the dredge were killed by the harsh mechanical action of the pump, whereas 42.7% of sand dollars were damaged beyond survival.

7. The Mt Rex Shipping Co. Ltd. sand extraction dredge can operate to extract sand on a commercial basis within a depth range of about 5 to 8 metres below mean sea level. In the 100 hectare sand extraction licence application area, about 72% is deeper than the normal working range of the dredge.

8. Working within its normal depth range, the sand extraction dredge would impact only on the shallow tuatua population of low density, avoiding disturbance of the dense population in deeper water.

9. To minimise harmful impacts of the sand extraction operation on tuatua shellfish, it is recommended that either;
(a) the licence application area be re-defined to exclude sediments deeper than 8 metres below mean sea level,
or; (b) the 100 hectare licence area application proceed on the condition that the normal operational depth of the dredge does not significantly exceed 8 metres below mean sea level.

1. INTRODUCTION.

Mt Rex Shipping Company Limited has for several years been extracting sand from a subtidal site in the entrance to the Kaipara Harbour, near Pouto on the Kaipara North Head.

Annual licencing is required for sand extraction, and the Department of Conservation is the licencing authority.

Mt Rex Shipping Company Limited is seeking relicencing for their Pouto sand extraction operation, and have applied for a somewhat larger area of seabed than previously. The previous extraction zone was approximately 45 hectares in area, whereas the new area is 100 hectares, encompassing the old site.

As part of new criteria for licencing, concurrence by Ministry of Agriculture and Fisheries (MAF Fisheries North) is required.

In relation to giving approval concurrence, MAF Fisheries has requested information on shellfish for the vicinity of the proposed extraction zone.

A letter from MAF Fisheries to Mr Steve Collie of Mt Rex Shipping Co. Ltd. outlined biological sampling required, although it was indicated that a degree of flexibility in the programme be maintained. A copy of the letter, including a map of suggested sampling locations, is attached as Appendix 5.

The programme outlined requested 28 quantitative samples from 14 locations, spread throughout the 2000 by 500 metre application area, and sampled by a technique used during investigation of an alternative sand extraction area further south in the Kaipara Harbour entrance (Grace 1990a).

All molluscs and echinoderms were to be identified and counted, and expressed as a density measurement. Size frequency of edible molluscs, and an estimate of the proportion of damaged shellfish normally returning to the substrate after passage through the dredge was also requested.

Physical sampling required was a record of water depth and brief qualitative description of sediment grainsize at each sample site.

Field work for this investigation was carried out from the Mt Rex Shipping Co. Ltd.'s sand extraction dredge on 11th January 1991.

An aerial photograph (Figure 1), with locations of sample sites and other information, is presented as a fold-out for convenience at the back of this report. It can remain open for easy reference during reading of the report.

2. METHODS.

2.1 Shellfish sampling.

Quantitative sampling for benthic animals was carried out by the same technique used at the alternative sand extraction site (Grace 1990a). The sand extraction dredge was used as a quantitative sampling tool in the following way:

1. The dredge was anchored at the sampling site, its position plotted using radar, and the snorkel lowered to the seabed.

2. The dredge was operated to lift sand from the seabed at one spot for exactly one minute.

3. Shellfish and shell material passing through the tailings discharge pipe was collected in a stainless steel wire mesh basket with 9mm mesh openings.

4. At the end of the one-minute sampling time, the snorkel was lifted clear of the bottom to flush the last of the sample through the tailings pipe with clean water.

5. Material collected was transferred to numbered bags for later processing.

6. A replicate sample was taken at the same site by letting out a small amount of anchor chain (about 5 to 10 metres), and repeating the sampling procedure.

7. Shellfish and other marine life collected were later sorted from other debris and analysed.

This sampling procedure was calibrated in my 1990 study of the alternative dredge site. Since the technique was exactly the same this time, there was no need to re-calibrate the system. Each sample thus collected covered an area of 6 square metres of seabed.

Water depth at each site was measured using a weighted line (in this instance the barge's depth sounder was not working), and the time was recorded to allow corrections to the measured depth for the state of the tide.

2.2 Station locations.

Predetermined station locations, in a pattern similar to that indicated in the suggested sampling programme from MAF Fisheries (Appendix 5), were defined in terms of distance off the cliff base straight inshore and distance from a prominent point near Pouto. Using the radar on the barge, the skipper was to move the barge to the station site by satisfying the predetermined distances.

The operating range of the dredge for efficient commercial sand extraction purposes is a water depth of approximately 5 to 7 metres. For short periods, such as for the purpose of taking shellfish samples, the dredge could be operated over a depth range of approximately 3 to 10 metres.

In practice it was found that in many instances the water depth at the predetermined sample locations was greater than could be worked by the snorkel pipe and dredge unit. The dredge then had to be moved to a satisfactory working depth. In most cases the samples had to be taken closer inshore than the predetermined sites.

Precise final station locations were recorded by noting the relevant distances from shore marks as measured by radar fixes.

Figure 1 (fold-out aerial photograph at back of report) shows the licence application area, the original "target" station locations, and the final station locations. The actual sampling pattern in fact ended up bearing little relation to the predetermined sample pattern, but more correctly represents the possible working range of the dredge system.

Replicate samples were taken at each site except at station 10, where sea conditions suddenly became dangerous and the skipper had to move the dredge. At this site a single sample was taken.

2.3 Sample processing.

Material collected in the 9mm sieve basket under the discharge pipe was later sorted in the laboratory. Animals living at the time of extraction were identified as far as practical and counted, enabling quantitative estimates of their density to be calculated.

Live molluscs and echinoids damaged by the dredge to the extent that they were not likely to survive if released were recorded during sorting and counting. Some other soft-bodied animals were also damaged but their condition was not recorded, the animals being counted only.

An assessment of size was made for edible shellfish species. In some cases sizes had to be estimated rather than measured, as many of the bivalves were badly broken during passage through the pump.

2.4 Sediments.

A sample of sediment was collected from the bottom at each site using a small pipe-dredge hand-hauled from the side of the barge. Sediment type was briefly described from these samples. About

150 grams of wet sand was taken from each sample, placed in numbered glass jars and archived for future reference if required.

No formal sediment analyses have been carried out, but an indication of the shell content at each site, and for each replicate, can be gained from the shell residue volumes recorded for the biological samples (data presented in Appendix 1).

Exact percentages of shell cannot be extracted from this information as the true volume of sediment extracted for each sample is not known. Although the sample area is 6 square metres, exact depth of penetration of the intake pipe during the 1-minute sampling period is not known. A reasonable assumption, however, based on previous calibration dives and similar work on the Pakiri coast (Grace 1991a), would be that the sample was taken to a depth of about 0.9m. Allowing for tapering sides of the hole, sample volume then could be assumed to be approximately 3 cubic metres, or 3000 litres.

Based on these rather crude figures, an approximate percentage of shell larger than 9mm in each sample is given in Appendix 1.

2.5 Dead shells.

For each sample a list of the first 20 (approximately) species encountered during an examination of dead shells and fragments in the residues was made, together with an indication of the most commonly represented two or three species.

3. RESULTS.

Figure 1 (fold-out aerial photo at back of report) contains the following information:

Application area and predetermined station locations.

Actual station locations.

5-metre and 8-metre depth contours - depths below approximate mean sea level (MSL).

Locations of relevant detailed profiles of the shore and seabed carried out by Northland Regional Council.

Appendix 1 gives station data, including water depth reduced to Onehunga datum, water depth reduced to local mean sea level (approximate), number of taxa ("species") alive in each replicate sample, shell residue volume, and approximate percentage by volume of shell larger than 9mm in the sediment.

Appendix 2 presents detailed counts of live animals in the samples.

Appendix 3 indicates lengths of shellfish (tuatuas) in samples, and the proportion of tuatuas smashed during passage through the dredge.

Dead shells noted in sample residues are listed in Appendix 4.

A copy of the letter detailing the recommended sampling programme is presented in Appendix 5.

3.1 Benthic association.

The sand extraction area is an extremely harsh habitat for marine animals. There are only a few species which can live in the very mobile sands of the current-swept Kaipara entrance.

In the 23 samples taken from 12 stations, representing a total sample area of some 138 square metres, only 17 species of marine animals were retained on the 9mm mesh sieve. More than half of these were quite rare, being represented at only a single station out of the 12 sites sampled. The mean number of species per station was only 5.9.

The following table lists the more regularly occurring species, with an indication of the number and percentage of stations at which they occurred in this study.

SPECIES	COMMON NAME	NO. OF STATIONS	% OCC.
Ovalipes catharus	paddle crab	12	100%
Paphies subtriangulata	tuatua	11	92%
Fellaster zelandiae	sand dollar	11	92%
Sigalion sp.	scale worm	7	58%
Sand diver	sand diver	6	50%
Aglaophamus macroura	wriggling worm	5	42%
Glycera sp.	polychaete	5	42%

The most consistently present member of the fauna was the paddle crab Ovalipes catharus, which occurred at all stations. The number of individuals in each sample was quite low, however, reaching a maximum of only 5 in a 6 sq.m. sample. The paddle crab is a very mobile and highly active crab very well adapted to the mobile sandy habitat in this area. It is a predator and scavenger.

The tuatua Paphies subtriangulata occurred at 11 stations, but was common at only stations 4, 6, 8 and 9, where it reached a maximum density of 290 in 6 sq.m. at station 9b. This represents a density of 48.3 per square metre. The tuatua is a popular edible shellfish, which filters plankton from the water for food.

Also present at 11 stations was the sand dollar Fellaster zelandiae. This flattened biscuit-shaped sea urchin lives within the top 10 millimetres of sand, and swallows quantities of sand from which it extracts microscopic plants and animals for food. The sand dollar generally occurred in ones and twos per sample, but tended to increase in density towards the west. The highest density occurred in the western-most samples at station 12, where 21 specimens occurred in the 6 sq.m. sample from replicate 12a. There was also a correlation with depth. Shallower than 8 metres depth (measured from mean sea level MSL) sand dollar density was 0.63/square metre, whereas deeper than 8 metres they were present at a density of 1.13/sq.m. Although moderate densities of sand dollars occur in this area, their density is often much higher in other areas. For example at Mangawhai they were locally abundant in shallow water, with densities of about 20 per square metre (Grace 1990b).

Together the above three species define an association of benthic animals living in a very distinctive habitat - shallow, extremely mobile clean sand with strong currents and moderate wave action.

Frequently occurring but less consistent animals include the scale worm Sigalion sp., with a double row of transparent scales attached along its back. This worm was never abundant. It occurred at just over half the stations, at a rate of one or two per sample.

Present at half the stations was a little fish called a sand diver, because of its distinctive behaviour. It lies in the sand with only the eyes showing. When disturbed the sand diver darts out of the sand, swims ahead quickly for about 200mm, then dives back into the sand again where it remains well camouflaged. Only 1 to 3 specimens occurred in 6 out of 12 stations.

Two distinctive polychaete worms, Aglaophamus macroura and Glycera sp., occurred in very low numbers at 5 out of the 12 stations.

3.2 Shellfish.

Two species of edible shellfish live in the proposed sand extraction area. These are the bivalve Paphies subtriangulata, or tuatua, and the paddle crab Ovalipes catharus.

Paddle crabs.

Small numbers of paddle crabs are found throughout the area. Paddle crabs occurred at all stations sampled, but there was usually only a single specimen in a 6 square metre sample. Maximum density was 5 specimens in 6 sq.m. in sample 4a.

Most collected were small individuals. It is likely that larger crabs can swim actively away from the immediate vicinity of the snorkel intake as they are good swimmers.

Tuatuas.

Tuatuas were present in fairly high densities in some samples, and occurred at a maximum density of 48.3 per square metre in sample 9b. The abundance of tuatuas in each sample, together with an analysis of their sizes, is indicated in Appendix 3.

Maximum density here is more than twice that recorded at the alternative dredge site (23.2/sq.m.) near the middle of the Kaipara entrance (Grace, 1990a), but still only a fraction of the density reached by similar sized tuatua on some east coast beaches (eg. 480/sq.m. at Mimiwhangata Marine Park - personal data).

Most tuatuas collected in the samples were a good edible size, the modal length being 50 to 60mm. The following table indicates the length-frequency of tuatuas in the area, based on all tuatuas collected in this study (n = 1169).

Length range (mm)	% occurrence
60 - 70	7.7
50 - 60	69.7
40 - 50	10.6
30 - 40	4.6
20 - 30	4.9
10 - 20	2.5
	100.0

A total of 77.4% of tuatuas collected were over 50mm long.

Small numbers of juveniles under 10mm long were found at station 9, but would not have been accurately sampled because of the large mesh size (9mm) of the collection sieve.

The density of tuatuas varied widely over the sampling area, but there was a general correlation with depth. Very few tuatuas occurred in samples from less than 8 metres of water (measured from mean sea level MSL), but larger numbers occurred deeper than this. Density with depth can be summarised thus:

Shallower than 8 metres (MSL)	7 stations	1.09/sq.m.
Deeper than 8 metres (MSL)	5 stations	18.95/sq.m.

3.3 Survival of dredged marine life.

Many of the animals in the samples were damaged during passage through the pump, often to the extent that they were not likely to survive if released to the sea in the tailings. Shellfish and sand dollars often had their shells broken, and soft-bodied animals were frequently broken or badly cut.

In Appendix 2, the number is recorded of animals in the samples damaged to the point that they probably would not have survived passage through the pump and return to the sea. This was recorded for molluscs and echinoids only. Most other soft-bodied animals were damaged, and would probably be eaten by predators before re-burying themselves into the sediment, even if they survived the mechanical damage caused by the dredge pump system.

The following table summarises the numbers and percentages of the major molluscs and echinoids (in this case only tuatuas and sand dollars) damaged beyond survival during passage through the dredging system. For each species the totals for all samples have been pooled.

SPECIES	TOTAL N.	DAMAGED	% DAMAGED
Fellaster zelandiae	117	50	42.7%
Paphies subtriangulata	1169	848	72.5%

In Appendix 3 details are given of the numbers and percentages of tuatuas damaged in each sample.

3.4 Sediments.

Field examination of hand-specimens of sand collected by pipe-dredge at each station indicated that the sediment at most sites was medium sand. The sand was slightly finer (medium to fine sand) at stations 2 and 3, and slightly coarser (medium to coarse sand) at stations 10 and 11.

There was clearly very little shell in the sediments. Analysis based on the shell residues from the biological sampling indicated very low percentages of shell larger than 9mm. The highest value was 1.00% shell in sample 1a, and the lowest 0.001% in sample 8b. Mean shell content for all samples was 0.095% (n=23). Details for each station are included in Appendix 1.

The sediments are also extremely clean, there being no visible evidence of any silt or clay.

Very small numbers of small sandstone pebbles occurred at 9 out of the 12 stations. They appeared more consistently in the samples towards the eastern half of the sampling area, and were probably derived from soft sandstone cliffs around the Pouto coastline. Details of occurrence of sandstone pebbles are given in Appendix 4. A few of the pebbles had subfossil shellfish imbedded in the soft rock matrix.

3.5 Dead shells in samples.

Residual shell material larger than 9mm was analysed from the biological samples. The results are indicated in Appendix 4.

The occurrence, abundance, and degree of wear of dead shells can give some indication of directions and distances of movement of sedimentary material, provided the areas of origin of the various shell species are known.

Recognisable fragments, worn shells and whole shells of the first 20 (approximately) species encountered while working through the sample were recorded, together with an indication of the most abundant few species.

Detailed results are presented in Appendix 4. The species most regularly occurring in the samples are indicated in the following table.

SPECIES	COMMON NAME	NO. OF STATIONS
Paphies subtriangulata	tuatua	12
Perna canaliculus	green-lipped mussel	12
Chione stutchburyi	cockle	12
Umbonium zelandicum	wheel shell	12
Ostrea lutaria	mud oyster	12
Fellaster zelandiae	sand dollar	12
Spisula aequilateralis	triangle shell	11
Anchomasa similis	rock borer	11
Amalda australis	olive shell	10
Divaricella huttoniana	lace cockle	10
Myadora striata	box shell	9
Maoricolpus roseus	turret shell	8
Dosinia anus	ridged surf clam	8
Balanus decorus	large pink barnacle	8

Of the above species, the only ones found alive in the sampling area are the tuatua and sand dollar.

Dead shells of tuatuas were abundant at nearly all stations. This is not surprising because of the abundance of live tuatuas in the immediate vicinity, and the robustness of the shells.

The green-lipped mussel, Perna canaliculus, occurs on sandstone shores not far inside the harbour, and probably occurs sporadically in harbour channels. They may also occur in some of the deeper channels in the harbour entrance. Dead shells were present at all stations and abundant at four. Most probably indicate an outward movement of sediment.

Dead shells of cockles, Chione stutchburyi, were found at all stations, and abundantly at three stations. Most were well worn shells. They have come from harbour tidal flats, and indicate an outward movement of sediment. The shells are robust and would travel a long way before becoming unrecognisable.

The wheel shell Umbonium zelandicum occurs sporadically in vast numbers on sand banks just inside the harbour (eg. Millers Bank north of Pouto Point, Grace 1991b). They may also live in a few metres of water off the open west coast. The shells are robust and can probably travel a long way.

The mud oyster Ostrea lutaria lives in harbour areas, probably in fairly small numbers in harbour channels. The shells are relatively fragile, and have probably not moved very far.

Dead fragments of the sand dollar, Fellaster zelandiae, are produced on the site. The living animals also occur further into the harbour, and probably off the exposed west coast as well. No inference of sediment movement can be drawn from their occurrence in the samples.

The triangle shell Spisula aequilateralis lives off the exposed surf beaches of the west coast. The shells are very robust. Their presence infers an inward movement of sediment.

Anchomasa similis is a rock-boring bivalve common in lower intertidal and subtidal soft sandstone rocks around the shores of the outer Kaipara Harbour. The shells are relatively fragile and have probably not moved very far from their life location. They indicate an outward movement of material in this area.

The olive shell Amalda australis has a very robust shell. Its rounded shape also probably helps in its transport over long distances. The animal lives off the open coast as well as inside the harbour.

Divaricella huttoniana, the lace cockle, has a relatively fragile shell. The shells have probably not moved very far from the life position in fine sands just inside the harbour.

Myadora striata is a small bivalve living in fine sands just inside the harbour, although they may live off the west coast at moderate depth also. Little can be inferred from the presence of their dead shells in the samples.

The turret shell Maoricolpus roseus lives in harbour channels. The presence of dead shells in the samples suggests an outward movement of material.

Dosinia anus is a large robust surf clam living in the surf zone off the west coast beaches. The shells would travel a long way in recognisable condition. Their presence infers an inward movement of material from the open coast.

Balanus decorus is a large barnacle which attaches to hard objects. They are commonly found off the open coast attached to shells carried around by hermit crabs. They suggest an inward movement of material from offshore.

Analysis of the occurrence of dead shells in the extraction zone shows that shells are derived from both inside and outside the harbour. There is clearly a huge volume of sediment and shell material moved in both directions with the tidal flow. Transport distances over many tidal cycles can be several kilometres in either direction.

4. DISCUSSION.

4.1 Effect of sand extraction on shellfish and marine life.

Roughly 70% of tuatuas caught up in the dredge will be killed by the harsh mechanical action of the pump. The remainder would survive passage through the pump and return to the sea, where they would re-bury themselves in the sand.

About 40% of sand dollars caught up in the dredge would be killed in the same way. Most other soft-bodied animals caught in the dredge would be killed either by the pump or by predators before re-burying themselves in the sediments.

Apart from sand dollars and tuatuas, other marine life is extremely sparse in the area, and the loss of small numbers due to the sand dredging operation is of little consequence to the ecology of the area.

4.2 Licence application area and working depth of dredge.

In Figure 1 I have attempted to draw depth contours at 5 metres and 8 metres in relation to MSL. These are based on depths measured at the sampling stations, and on profiles measured by the Northland Regional Council in February 1990. Although there is a considerable amount of extrapolation involved between rather sparse data points, I believe the contours are a reasonable representation of reality.

The area between the 5 and 8 metre contours represents the practical working depth of the Mt Rex Shipping Co. Ltd. dredge. Although the dredge can work for short periods a little outside this range, for example for taking the deeper samples for this survey, efficient commercial sand extraction is only practical between these depth limits.

The sand extraction licence application area is approximately 100 hectares. The area between the 5 and 8-metre depth contours which is contained within the licence application area is about 28 hectares, so in practice Mt Rex Shipping Co. Ltd. would be able to work only 28% of the current licence application area with their present dredging system.

4.3 Minimising effect on shellfish and marine life.

It has been shown that there is a considerable increase in both tuatuas and sand dollars with increasing depth in the licence application area.

About 95% of tuatuas and 64% of sand dollars in the sampling area occur in water 8 metres or deeper measured from MSL.

By operating only in water shallower than 8 metres, Mt Rex Shipping Company Limited is effectively only impacting 5% of the tuatuas and 36% of sand dollars within the depth range of the samples taken.

Therefore although the licence application area extends into deeper water with a large population of tuatuas, the area occupied by considerable numbers of tuatuas is inaccessible to the dredge for commercial sand extraction purposes. Although there appears on paper to be a situation where there is a possible conflict of interest between sand extraction and protection of shellfish resources, in practice there is likely to be very little impact on shellfish populations in the area.

5. RECOMMENDATION.

The potential conflict of interest between sand extraction and shellfish resources outlined above could be solved in either of two ways.

Either:

1. Re-define the licence application area in such a way that areas deeper than 8 metres below MSL are excluded.

Or:

2. Proceed with the present licence application area on the condition that the practical working depth of the dredge does not extend significantly below the 8-metre depth contour as measured below MSL.

6. REFERENCES.

Grace, R.V. 1990a Kaipara Harbour Sand Extraction. Alternative Site Investigations. Report for Mt Rex Shipping Company Limited. June 1990, 13p.

Grace, R.V. 1990b Mangawhai Sand Extraction. Biological Investigations. Report for Sea-Tow Limited. December 1990, 24p.

Grace, R.V. 1991a Pakiri - Te Arai Sand Extraction. Biological Investigations. Report for McCallum Brothers Limited and Sea-Tow Limited. May 1991, 33p.

Grace, R.V. 1991b Kaipara Water Transport Limited's Sand Extraction Site. Biological Investigations. Report for Kaipara Water Transport Limited. March 1991, 19p.

APPENDIX 1. STATION DATA.

1	2	3	4	5	6
STATION	DEPTH(m) to datum	DEPTH(m) to MSL	NO. OF TAXA	RESIDUE VOL. (litres)	RESIDUE %
1	5.2	7.7	a = 4 b = 6 a+b = 6	a = 30 b = 6	1.000 0.200
2	4.1	6.6	a = 3 b = 3 a+b = 4	a = 1 b = 0.5	0.033 0.017
3	2.7	5.2	a = 3 b = 5 a+b = 6	a = 1.5 b = 1.5	0.050 0.050
4	6.0	8.5	a = 5 b = 3 a+b = 6	a = 3.5 b = 0.6	0.117 0.020
5	4.5	7.0	a = 1 b = 3 a+b = 3	a = 4.5 b = 2	0.150 0.067
6	6.9	9.4	a = 8 b = 7 a+b = 11	a = 1.5 b = 4	0.050 0.133
7	4.6	7.1	a = 2 b = 4 a+b = 5	a = 2 b = 1.5	0.067 0.050
8	7.2	9.7	a = 7 b = 3 a+b = 7	a = 0.15 b = 0.04	0.005 0.001
9	6.2	8.7	a = 7 b = 5 a+b = 10	a = 1 b = 1.5	0.033 0.050
10	5.1	7.6	a = 4 no replicate -	a = 1.5 -	0.050 -
11	6.1	8.6	a = 3 b = 4 a+b = 5	a = 0.1 b = 0.1	0.003 0.003
12	5.5	8.0	a = 3 b = 3 a+b = 4	a = 0.5 b = 0.25	0.017 0.008

Explanation of columns in Appendix 1.

1 Station number, in order of occupation.

2 Depth in metres, corrected to Onehunga chart datum.

3 Depth in metres, corrected to Pouto mean sea level (approx.)

4 Number of different types of live animals recognised, in each replicate, and combined.

5 Volume in litres of shell retained on 9mm sieve in each one-minute sample.

6 Volume of shell larger than 9mm, expressed as a percentage of the total volume of sediment taken from the seabed in one minute (approx. 3000 litres).

APPENDIX 2. COUNTS OF LIVE ORGANISMS IN SAMPLES.
[Raw data - each sample is 6 sq.m. in area]

Key: # = total number alive in sample.

* = number, included in total count, damaged to the point that they probably would not have survived passage through the pump and return to the sea. This recorded for molluscs and echinoids only. Most other soft-bodied animals were damaged, and in any case would probably be eaten by predators before re-burying themselves into the sediment.

STATION	SPECIES	COMMON NAME	NO.#	DAMAGED*
1 a	Glycera sp.		5	
	Sigalion sp.	scale worm	2	
	Ovalipes catharus	paddle crab	1	
	Paphies subtriangulata	tuatua	1	
1 b	Glycera sp.		1	
	Sigalion sp.	scale worm	1	
	Ovalipes catharus	paddle crab	1	
	Paphies subtriangulata	tuatua	2	1
	Fellaster zelandiae	sand dollar	1	
	sand diver	sand diver	1	
2 a	Ovalipes catharus	paddle crab	1	
	Amalda australis	olive shell	1	
	Fellaster zelandiae	sand dollar	2	1
2 b	Hermit crab	hermit crab	1	
	Ovalipes catharus	paddle crab	1	
	Fellaster zelandiae	sand dollar	3	2
3 a	Ovalipes catharus	paddle crab	1	
	Paphies subtriangulata	tuatua	2	1
	sand diver	sand diver	1	
3 b	Aglaophamus macroura	wriggling worm	1	
	Callianassa sp.	ghost shrimp	1	
	Ovalipes catharus	paddle crab	2	
	Paphies subtriangulata	tuatua	1	1
	Fellaster zelandiae	sand dollar	1	1
4 a	Aglaophamus macroura	wriggling worm	1	
	Ovalipes catharus	paddle crab	5	
	Paphies subtriangulata	tuatua	26	17
	Fellaster zelandiae	sand dollar	1	
	sand diver	sand diver	1	
4 b	Sigalion sp.	scale worm	1	
	Ovalipes catharus	paddle crab	1	
	Paphies subtriangulata	tuatua	251	153

5 a	Paphies subtriangulata	tuatua	3	1
5 b	Ovalipes catharus	paddle crab	2	
	Paphies subtriangulata	tuatua	4	4
	sand diver	sand diver	2	
6 a	small yellow sponge	sponge	1	
	Aglaophamus macroura	wriggling worm	1	
	Sigalion sp.	scale worm	2	
	Hermit crab	hermit crab	1	
	Ovalipes catharus	paddle crab	3	
	Paphies subtriangulata	tuatua	40	32
	Fellaster zelandiae	sand dollar	2	
	sand diver	sand diver	3	
6 b	sponge fragment	sponge	1	
	nemertine (white)	ribbon worm	1	
	Glycera sp.		1	
	Sigalion sp.	scale worm	1	
	Hermit crab	hermit crab	2	
	Paphies subtriangulata	tuatua	84	55
	Fellaster zelandiae	sand dollar	6	4
7 a	Paphies subtriangulata	tuatua	2	2
	Fellaster zelandiae	sand dollar	2	
7 b	Glycera sp.		1	
	Sigalion sp.	scale worm	1	
	Ovalipes catharus	paddle crab	1	
	Fellaster zelandiae	sand dollar	1	
8 a	Aglaophamus macroura	wriggling worm	1	
	Glycera sp.		1	
	Sigalion sp.	scale worm	1	
	Ovalipes catharus	paddle crab	4	
	Paphies subtriangulata	tuatua	143	114
	Fellaster zelandiae	sand dollar	4	1
8 b	Ovalipes catharus	paddle crab	3	
	Paphies subtriangulata	tuatua	74	58
	Fellaster zelandiae	sand dollar	5	4
9 a	Sigalion sp.	scale worm	1	
	Hermit crab	hermit crab	1	
	Ovalipes catharus	paddle crab	2	
	Paphies subtriangulata	tuatua	205	155
	Fellaster zelandiae	sand dollar	13	1
	Corella eumyota	sea squirt	1	
	sand diver	sand diver	2	
9 b	Aglaophamus macroura	wriggling worm	1	
	Glycera sp.		1	
	Lumbriconereis sphaerocephala		2	
	Paphies subtriangulata	tuatua	290	221
	Fellaster zelandiae	sand dollar	16	5

10 a	Ovalipes catharus	paddle crab	2	
	Squilla armata	mantis shrimp	2	
	Paphies subtriangulata	tuatua	38	30
	Fellaster zelandiae	sand dollar	5	2
10 b	(NO REPLICATE)			
11 a	Hermit crab	hermit crab	1	
	Ovalipes catharus	paddle crab	1	
	Fellaster zelandiae	sand dollar	16	9
11 b	Sigalion sp.	scale worm	1	
	Ovalipes catharus	paddle crab	1	
	Paphies subtriangulata	tuatua	2	2
	Fellaster zelandiae	sand dollar	5	1
12 a	Ovalipes catharus	paddle crab	4	
	Paphies subtriangulata	tuatua	1	1
	Fellaster zelandiae	sand dollar	21	12
12 b	Siphunculus maoricus	siphon worm	1	
	Ovalipes catharus	paddle crab	1	
	Fellaster zelandiae	sand dollar	13	7

				Grace
5 a	Paphies subtriangulata	tuatua	3	1
5 b	Ovalipes catharus	paddle crab	2	
	Paphies subtriangulata	tuatua	4	4
	sand diver	sand diver	2	
6 a	small yellow sponge	sponge	1	
	Aglaophamus macroura	wriggling worm	1	
	Sigalion sp.	scale worm	2	
	Hermit crab	hermit crab	1	
	Ovalipes catharus	paddle crab	3	
	Paphies subtriangulata	tuatua	40	32
	Fellaster zelandiae	sand dollar	2	
	sand diver	sand diver	3	
6 b	sponge fragment	sponge	1	
	nemertine (white)	ribbon worm	1	
	Glycera sp.		1	
	Sigalion sp.	scale worm	1	
	Hermit crab	hermit crab	2	
	Paphies subtriangulata	tuatua	84	55
	Fellaster zelandiae	sand dollar	6	4
7 a	Paphies subtriangulata	tuatua	2	2
	Fellaster zelandiae	sand dollar	2	
7 b	Glycera sp.		1	
	Sigalion sp.	scale worm	1	
	Ovalipes catharus	paddle crab	1	
	Fellaster zelandiae	sand dollar	1	
8 a	Aglaophamus macroura	wriggling worm	1	
	Glycera sp.		1	
	Sigalion sp.	scale worm	1	
	Ovalipes catharus	paddle crab	4	
	Paphies subtriangulata	tuatua	143	114
	Fellaster zelandiae	sand dollar	4	1
8 b	Ovalipes catharus	paddle crab	3	
	Paphies subtriangulata	tuatua	74	58
	Fellaster zelandiae	sand dollar	5	4
9 a	Sigalion sp.	scale worm	1	
	Hermit crab	hermit crab	1	
	Ovalipes catharus	paddle crab	2	
	Paphies subtriangulata	tuatua	205	155
	Fellaster zelandiae	sand dollar	13	1
	Corella eumyota	sea squirt	1	
	sand diver	sand diver	2	
9 b	Aglaophamus macroura	wriggling worm	1	
	Glycera sp.		1	
	Lumbriconereis sphaerocephala		2	
	Paphies subtriangulata	tuatua	290	221
	Fellaster zelandiae	sand dollar	16	5

10 a	Ovalipes catharus	paddle crab	2	
	Squilla armata	mantis shrimp	2	
	Paphies subtriangulata	tuatua	38	30
	Fellaster zelandiae	sand dollar	5	2
10 b	(NO REPLICATE)			
11 a	Hermit crab			
	Ovalipes catharus	hermit crab	1	
	Fellaster zelandiae	paddle crab	1	
		sand dollar	16	9
11 b	Sigalion sp.			
	Ovalipes catharus	scale worm	1	
	Paphies subtriangulata	paddle crab	1	
	Fellaster zelandiae	tuatua	2	2
		sand dollar	5	1
12 a	Ovalipes catharus			
	Paphies subtriangulata	paddle crab	4	
	Fellaster zelandiae	tuatua	1	1
		sand dollar	21	12
12 b	Siphunculus maoricus			
	Ovalipes catharus	siphon worm	1	
	Fellaster zelandiae	paddle crab	1	
		sand dollar	13	7

APPENDIX 3. LENGTHS OF TUATUAS IN SAMPLES, AND % DAMAGED.

Length range (mm)	STATION AND REPLICATE 1 a	1 b	2 a	2 b	3 a	3 b	4 a	4 b	5 a	5 b	6 a	6 b
60 - 70	-	-	-	-	1	-	-	2	1	-	2	7
50 - 60	-	1	-	-	-	-	11	130	1	1	27	46
40 - 50	-	-	-	-	-	-	5	46	-	-	6	11
30 - 40	-	-	-	-	-	-	6	22	1	2	2	2
20 - 30	1	1	-	-	-	1	2	19	-	1	2	5
10 - 20	-	-	-	-	1	-	1	6	-	-	1	3
unmeasurable	-	-	-	-	-	-	1	26	-	-	-	10
Total	1	2	0	0	2	1	26	251	3	4	40	84
Total a+b	3		0		3		277		7		124	
No./sq.m.	0.25		0.00		0.25		23.17		0.58		10.33	
No. smashed	0	1	0	0	1	1	17	153	1	4	32	55
a+b smashed	1		0		2		170		5		87	
% smashed	33%		-		66%		61%		71%		70%	

(continued.....)

APPENDIX 3 (continued)

Length range (mm)	STATION AND REPLICATE											
	7		8		9		10		11		12	
	a	b	a	b	a	b	a	b	a	b	a	b
60 - 70	1	-	6	5	19	25	6		-	-	1	-
50 - 60	1	-	85	49	135	179	18		-	1	-	-
40 - 50	-	-	10	5	6	13	2		-	-	-	-
30 - 40	-	-	4	1	-	3	2		-	-	-	-
20 - 30	-	-	5	3	3	4	-		-	1	-	-
10 - 20	-	-	3	2	2	6	-		-	-	-	-
unmeasurable	-	-	30	9	40	60	10		-	-	-	-
Total	2	0	143	74	205	290	38		0	2	1	0
Total a+b	2		217		495		38		2		1	
No./sq.m.	0.17		18.50		41.25		6.33		0.17		0.08	
No. smashed	2	0	114	58	155	221	30		0	2	1	0
a+b smashed	2		172		376		30		2		1	
% smashed	100%		79%		76%		79%		100%		100%	

APPENDIX 4. SKELETAL REMAINS (SHELLS, WORM TUBES, BARNACLE PLATES ETC.) IN SAMPLE RESIDUES.

Key: x = whole shell, worn shell or fragments.
A = most abundantly represented.
Occ = number of occurrences

	STATION												
	1	2	3	4	5	6	7	8	9	10	11	12	Occ
POLYCHAETES													
Hydroides norvegicus									x				1
GASTROPODS													
Amalda australis	x	x	x	x	x	x	x	x	x			x	10
Austrofusus glans		x	x	x	x	x	x						6
Cominella adspersa				x	x	x				x			4
Cominella glandiformis						x		x					2
Duplicaria tristis	x							x					2
Maoricolpus roseus	x		x	x	x	x	x	x	x				8
Maoricrypta monoxyla							x						1
Maurea punctulata	x							x					2
Patelloidea corticata							x						1
Pelicaria vermis			x										1
Penion adusta				x									1
Siphonaria zelandica						x	x						2
Trochus tiaratus				x	x	x							3
Umbonium zelandicum	A	x	x	A	x	x	x	x	x	x	x	x	12
Xymene plebejus	x							x	x				3
Zeacolpus fulminatus								x					1
Zediloma subrostrata					x				x				2
Zegalerus tenuis	x			x		x	x						4
BIVALVES													
Anchomasa similis	x	x	x	x	x	x	x	x	x	x		x	11
Chione stutchburyi	x	A	A	x	A	x	x	x	x	x	x	x	12
Chlamys zelandiae	x	x				x	x		x	x			6
Divaricella huttoniana	x		x	x	x	x	x	x	x	x		x	10
Dosina zelandica					x								1
Dosinia anus		x	x		x		x	x	x	x		x	8
Dosinia subrosea					x								1
Felaniella zelandica	x												1
Leptomya retiaria	x	x		x		x							4
Maorimactra ordinaria					x		x		x	x	x		5

	STATION												
	1	2	3	4	5	6	7	8	9	10	11	12	Occ
BIVALVES (continued)													
Myadora boltoni	x					x	x						3
Myadora striata	x	x		x			x	x	x	x	x	x	9
Notirus reflexus						x	x	x	x	x			5
Nucula hartvigiana	x												1
Ostrea lutaria	x	x	x	x	x	x	x	x	x	x	x	x	12
Paphies australis	x				x		x		x				4
Paphies subtriangulatum	A	x	A	x	A	A	A	A	A	A	A	A	12
Paphies ventricosum				x	x								2
Pecten novaezelandiae		x											1
Perna canaliculus	A	A	x	A	x	x	x	A	x	x	x	x	12
Spisula aequilateralis	x		A	x	x	x	x	x	x	A	x	x	11
Tawera spissa	x			x	x			x					4
Tellina liliana	x												1
Venerupis largillierti	x	x		x	x			x	x			x	7
Xenostrobus pulex	x												1
CEPHALOPODA													
Spirula spirula							x						1
CRUSTACEA													
Balanus decorus	x	x		x	x	x	x	x	x				8
Balanus trigonus										x			1
ECHINODERMATA													
Evechinus chloroticus					x								1
Fellaster zelandiae	x	x	x	x	x	x	x	x	x	x	x	x	12
Sandstone pebbles	x	x	x	x	x	x	x		x	x			9
Subfossils in sandstone			x		x								2

APPENDIX 5. LETTER OUTLINING SAMPLING PROGRAMME.

MINISTRY OF AGRICULTURE AND FISHERIES
TE MANATU AHUWHENUA AHUMOANA

3 October 1990

Steve Collie
Mt. Rex Shipping Ltd.
P.O.Box 33-282
Takapuna

Dear Mr Collie

Environmental information required by MAF Fisheries for sand xtraction at Pouto

Details of the biological sampling required to provide the environmental assessment requested by MAF Fisheries are given below. These requirements assume an extraction area of about 2000 m by 500 m as detailed in your licence application, and are written following discussions with the consultant you have contacted, Dr Roger Grace. I have listed specific requirements, but also intend that a degree of flexibility be maintained. A copy of this letter has been sent to Dr Grace.

Biological sampling

A total of 28 biological samples is required. These will be taken from 14 stations (as indicated on the attached map) with two replicate samples at each station, about 10 m apart. The sampling method should be the same as that which was used at the alternative site, i.e., 6 m^2 of seafloor sampled by running the suction dredge for 1 minute. All molluscs and echinoderms retained on a mesh not coarser than 10 mm, should be identified to species level, counted, and a density given (i.e. number of that species per unit area of seafloor). Some qualitative assessment of size-frequency should be made for edible mollusc species (e.g. tuatua, other "surfclams", scallops). An estimate of the proportion of damaged shellfish normally returning to the substrate after going through the snorkel unit would be useful.

Any additional biological features relevant to fisheries which are noted during field sampling should be recorded.

Physical sampling

At the location of each biological sample the water depth should be recorded and sediment grainsize should be assessed. A qualitative description of sediment grainsize is all that is

MAF Fisheries
1st Floor Challenge Realty House, 10 - 14 Hobson Street, PO Box 3437, Auckland, New Zealand.
Telephone (09) 794 700 Facsimile (09) 774 245

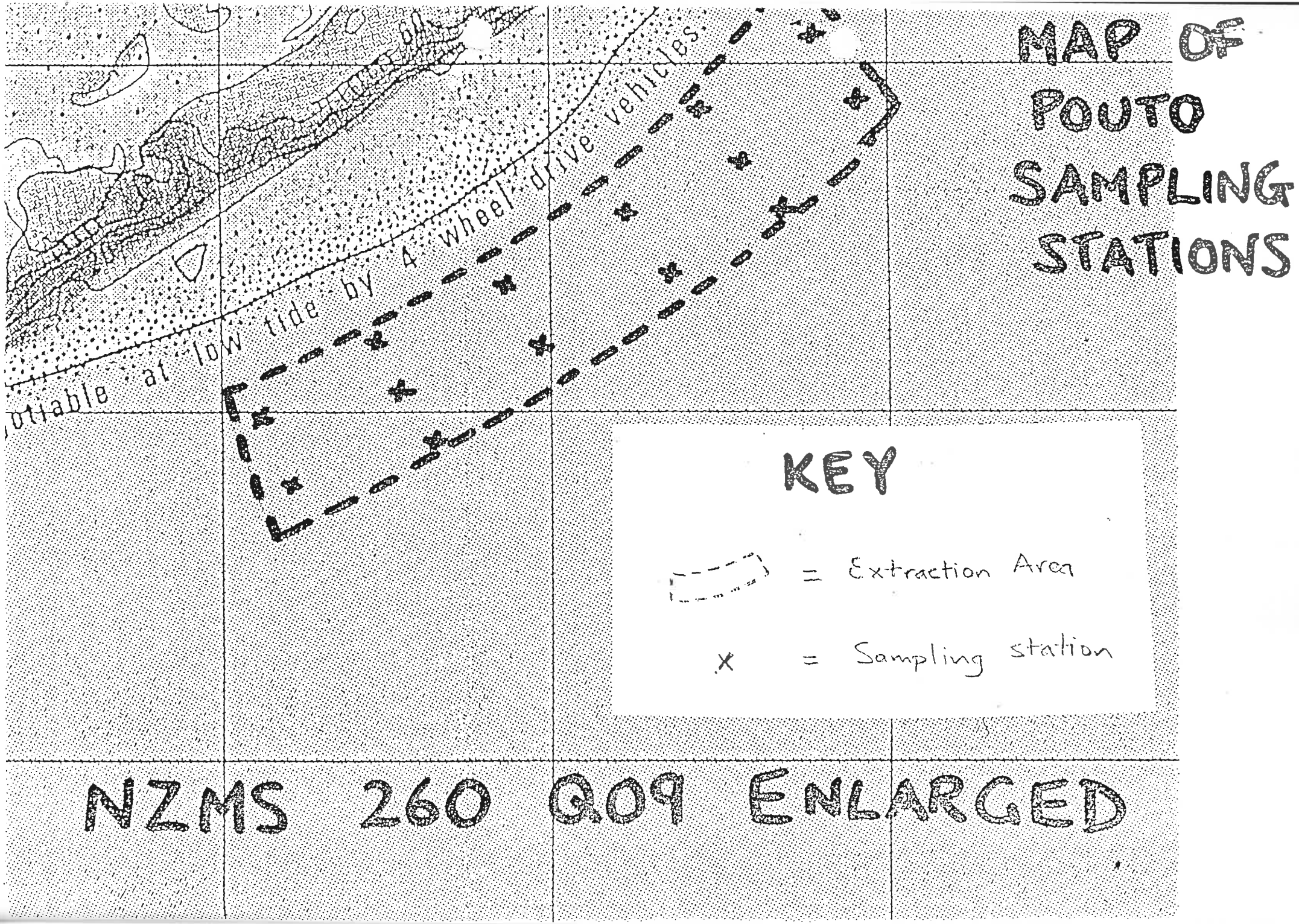
required at this stage; e.g. fine sand with about 10% shell gravel and no mud.

Should you have any queries please do not hesitate to contact either Rodney Roberts or myself.

Yours sincerely

(David Allen)
Fisheries Management Scientist
MAF Fisheries North

cc. Roger Grace


MAP OF POUTO SAMPLING STATIONS
ottable at low tide by 4 wheel drive vehicles
KEY
= Extraction Area
x = Sampling station
NZMS 260 Q09 ENLARGED