Preliminary Toheroa Survey on Ninety Mile Beach

NIWA Client Report: AK98042

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Preliminary survey of toheroa (*Paphies ventricosa*) populations on Ninety Mile Beach and possible impacts of vehicle traffic

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Executive Summary

Local iwi and community representatives have been expressing their concern about the poor state of toheroa populations on Ninety Mile Beach for a number of years. Although no one is sure why the toheroa populations are in low numbers there has been a growing concern that the vehicular traffic on the beach may play an important part in hindering the recovery of the toheroa populations. Consequently the Northland Regional Council contracted NIWA to carry out a preliminary study of the effects of vehicular traffic on the toheroa population on Ninety Mile Beach. The survey was planned to coincide with the last three days of a five day fishing competition held on the beach during daylight hours from Tuesday the 17 February 1998 until Saturday the 21 February 1998.

The aims of the study were to: 1) Conduct a quantitative survey of one or two previously identified beds of toheroa to assess the population structure and density of shellfish and to establish if the toheroa population has recovered since the last survey by the Ministry of Fisheries. 2) Quantify the traffic on the beach during a major fishing contest to assess the number and type of vehicles that were on the beach and establish if the vehicles were driving over the toheroa beds. 3) Make visual assessments of any impacts of vehicular traffic on toheroa in order to see if obvious and immediate signs of effects on the toheroa and quantify this effect if possible. 4) Make a preliminary assessment of whether vehicle impacts on Ninety Mile Beach has the potential to effect toheroa populations.

A qualitative survey of the beach revealed that there were only a few small isolated beds of toheroa. The beds were all situated at the mid to upper tide region of the beach. The toheroa population was composed of mainly juvenile animals in relatively low density, with few or possibly no legal sized toheroa. High traffic volumes were recorded during the fishing contest of which most of the vehicles were four wheel drives. The distribution of the traffic was often over the main part of the toheroa beds. The high volume of traffic during the fishing contest produced reasonably high levels of immediate mortality of juvenile toheroa from one site due to the repeated impact of high volumes of vehicles. There was little immediate mortality observed of adult toheroa observed. This preliminary study was confined to the immediate impacts of vehicle traffic on the beach and it is not known what longer term impacts the vehicles may have had on the toheroa. It is not known what happens outside the fishing contest when traffic volumes on the beach are lower. There has been a reasonable spatfall of toheroa on the beach in the past year. If this is a regular occurrence then the previous spatfalls have not resulted in a healthy adult population.

INTRODUCTION

For some time it has been recognised that the toheroa (*Paphies ventricosa*) population on Ninety Mile Beach has been in decline. Recent (unpublished) Ministry of Fisheries surveys have shown that there are few toheroa on the beach and no legal sized individuals were found. Therefore, the ban on collecting toheroa established in 1971 has been continued. There has been some recent suggestions that the toheroa populations have had a partial recovery in the last year. Although no one is sure why the toheroa populations are in a poor state, there has been a growing concern from local iwi and community representatives that the vehicular traffic on the beach may play a major part in hindering the recovery of the toheroa populations.

In its role of Regional Land Transport Planning and resource management authority the Northland Regional Council (NRC) initiated a series of meetings involving, local iwi, local community members, commercial tour operators and scientific advisors to discuss the effects of vehicles on Ninety Mile Beach. One of the outcomes of the meetings was that the NRC contracted NIWA (The National Institute of Water and Atmospheric Research Ltd) to carry out a preliminary study of the effects of vehicular traffic on the toheroa population of Ninety Mile Beach (Fig. 1).

The aims of this preliminary study were to:

- Conduct a quantitative survey of one or two previously identified beds of toheroa to assess the population structure and density of shellfish and to establish if the toheroa population has recovered since the last survey by the Ministry of Fisheries.

- Quantify traffic on the beach during a major fishing contest to assess the number and type of vehicles that were on the beach and establish if the vehicles were driving over the toheroa beds.

- Make visual assessments of any impacts of vehicular traffic on toheroa and, if possible, quantify this effect.

- Make a preliminary assessment of whether vehicle impacts on Ninety Mile Beach have the potential to effect toheroa populations.

The survey was scheduled to coincide with the last three days of a five day fishing competition held on the beach during daylight hours from Tuesday 17 February 1998 until Saturday 21 February 1998. For the fishing contest the beach was subdivided into three fishing areas; from Ahipara to the Hukatere Ramp, the Hukatere Ramp to The Bluff and The Bluff to the Te Paki Stream (see Fig. 1). Field work was completed from Thursday 19 February 1998 until Saturday 21 February 1998. During these three days the specified fishing area was from the Hukatere Ramp to The Bluff. (see appendix 1).

METHODS

Toheroa qualitative surveys

Initial toheroa survey (Hukatere Ramp to Bluff)

Initial dialogue with Northland Regional Council staff indicated the presence of a semi-continuous toheroa bed starting a few kilometres north of the Hukatere ramp and extending all the way to The Bluff. An initial survey of the toheroa beds was undertaken of this area to identify a suitable higher density bed of toheroa for more detailed work. This was done by periodically stopping and checking for signs of toheroa. Toheroa and to a lesser extent tuatua (*Paphies subtriangulata*) beds are often distinguishable by a series of twin depressions in the beach left when the siphons are retracted, especially on the ebbing tide. Shellfish may also be detected after the beds have been impacted by vehicles by either direct evidence of crushed animals or as small hummocks of sand caused by the floatation of a shellfish to the surface of the beach (Plate 1). At each inspection site the latitude and longitude were recorded using a hand held GPS (Global Positioning System). This system is known to be accurate to less than 100 metres which was considered to be a useful resolution compared to the overall scale of the beach. On inspection the area initially indicated as a toheroa bed was in fact the start of a very large bed of tuatua (Plate 2).

Hukatere Ramp to Ahipara Stream

The absence of any major toheroa beds in the area necessitated a change of the aims of the study. After close consultation with the Northern Regional Council, the aims were changed to include a qualitative survey of the entire beach for beds of toheroa.

To extend the spatial extent of the initial survey, the beach south from Hukatere Ramp to the Ahipara Stream was also visually inspected for signs of adult and juvenile toheroa beds at approximately 1 km intervals. Every 1 km (measured vehicle odometer) the surface of the beach was carefully inspected for signs of shellfish in a radius of 50 metres either side of the 1 km mark and from high tide mark to low tide. Any indication of toheroa siphon depressions were dug up and inspected.

Bluff to Te Paki Stream

Discussion with some local people indicated the presence of some small toheroa beds just south of Te Paki Stream. The qualitative survey for toheroa beds was therefore continued along the beach to cover the area from The Bluff to Te Paki Stream.

Tuatua quantitative survey

The extensive tuatua bed extending from several kilometres north of the Hukatere Ramp to The Bluff was examined in more detail to determine if toheroa were present amongst the tuatua. During the ebbing tide a transect survey of the beach from the extreme high water mark to below the tuatua bed was undertaken. The population was sampled at the southern end of the bed (north of the Hukatere Ramp; position 34°52.440 : 173°03.639). A tape was laid out from mean high water to mean low water and 1 m^2 quadrats were sampled every 10 metres down the beach (Plate 3). When the dense tuatua bed was encountered the quadrat size was reduced to 0.5 m^2 and the inter-quadrat distance reduced to five metre intervals. All shellfish from each quadrat were counted and the shell length measured to the nearest millimetre using vernier calipers along the longest axis of the shell.

Toheroa quantitative survey

A small toheroa bed was located just south of Te Paki Stream (34°33.154 : 172°45.386). A quantitative survey of the toheroa bed was done by excavating the shellfish from three haphazardly selected 1 m^2 quadrats. All shellfish from each quadrat were counted and measured to the nearest millimetre. The size of the bed was assessed by visual examination of siphon holes and the width and length measured by a electronic distance measurer (EDM).

Juvenile toheroa quantitative survey

A moderately dense bed of juvenile toheroa was located between the levels of extreme high water and mid tide at the Hukatere Ramp (34°54.040 : 173°05.031). The bed was distinguishable by the presence of juvenile toheroa lying crushed on the surface, presumably a result of the morning fishing competition traffic (Plate 4). Population density, mortality and size structure was estimated using three haphazardly placed 1 m^2 quadrats in the main part of the bed. The surface of each quadrat was carefully searched for dead (crushed) juvenile toheroa and then the entire quadrat was excavated and sieved through a 2 mm mesh. All shellfish were counted and measured using Vernier calipers to the nearest millimetre.

Vehicle counts

The number of vehicles passing a fixed point were counted at two locations on 20 February 1998 just north of the Hukatere Ramp. Other counts were taken during quantitative surveys at Te Paki Stream. Vehicles were described as 4 wheel drive, cars, vans, motor bikes and tourist coaches. Motor bikes included 2, 3 and 4 wheel vehicles. Speed was estimated as slow (0-30 km/hr), medium (30-60 km/hr) and fast (60 + km/hr). Height on the beach was categorised as low, mid or high.

RESULTS

Toheroa qualitative surveys

Hukatere Ramp north to Bluff

A very dense tuatua bed was observed but no toheroa beds were identified in the initial survey of 19 February 1998 (Table 1).

Hukatere Ramp south to Ahipara Stream

Small beds of adult toheroa were found just south of the Hukatere Ramp, at 34°55.665 : 173°06.237, and a single 80 mm toheroa shell was found at position 35°01.228 : 173°09.547 (Table 2). Other than these few observations no adult toheroa were observed. Juvenile toheroa beds were found for approximately 10 km south of the Hukatere Ramp to 34°57.404 : 173°07.361. Juvenile toheroa were distributed from the high tide to just below the mid tide region. A further area of juveniles was noted on a 3 kilometre stretch of beach from 34°59.678 : 173°08.828 to 35°01.228 : 173°09.547. The presence of the juveniles indicates a relatively good toheroa spat fall during the last spawning season.

Bluff to Te Paki Stream

No toheroa beds and few tuatua were observed in this part of the beach prior to Te Paki Stream. Two small low density beds and one moderately dense bed were noted just south of Te Paki Stream (Table 3). The moderate density bed was used for the quantitative toheroa survey to gather information on density and population size structure.

Tuatua quantitative survey

During the toheroa qualitative surveys, a relatively continuous and dense (maximum density of 574 m^{-2}) bed of adult tuatua from just north of the Hukatere Ramp to just south of The Bluff was identified. The bed was approximately 30 m wide from the mid-tide level and sometimes extended into the subtidal fringe. The bed was found to have an average density of 163.2 m^{-2} (Table 4). From this information, the tuatua population was conservatively estimated to be in excess of 49 million animals. There were few toheroa within the tuatua bed. Most of the tuatua were from a single age class and had a median size of approximately 52 mm (Fig. 2). This indicates that the population may result from a very large spatfall two to three years ago.

Toheroa quantitative survey

The small bed of toheroa observed just south of the Te Paki Stream (34°33.154 : 172°45.386) was approximately 35 metres long by 22 metres wide making a total area of 770 m^2. The population of toheroa in this bed had a mean density of 76.3 mm^{-2} and tuatua had a mean density of 4.7 mm^{-2} (Table 5). Therefore the bed contained an estimated population of 58,751 toheroa and 3,619 tuatua. The population size structure of the toheroa shows a clear bimodal distribution with peaks at approximately 20 mm shell length and 60 mm shell length (Fig. 3). This indicated a recent recruitment into the population. The first peak probably corresponds to 1 year old animals and the second peak to 2-3 year old animals. No legal sized toheroa (>100 mm) were sampled.

Juvenile toheroa quantitative survey

The juvenile toheroa bed near the Hukatere Ramp was approximately 48 m long by 53 m wide giving a total area of 2544 m^2. The bed had a total mean density of 62.0 juvenile toheroa per metre squared, therefore the population was estimated to be 135,660 and the mortalities 22,048 (Table 6). Approximately 14% of the juveniles in this bed were found to be crushed on the surface of the beach. The juveniles ranged in size from 6 mm to 23 mm shell length with a mean size of approximately 10-12 mm (Fig. 4) (Plate 5).

Vehicle counts

Most vehicle types were driven at a moderate to fast speed and usually at about the mid-tide level (Table 7). The majority of vehicles on the beach were 4 wheel drives accounting for over 81% of the traffic. There were few commercial vehicles (busses, vans, other small commercial vehicles) observed accounting for 2% of the total traffic.

The Hukatere Ramp data for the 20 February 1998 was divided into two periods between 07:40 and 09:40 AM and 13:38 and 14:08 PM (Table 8). The morning data represents vehicle movement after the start of the competition on that day. These vehicles were moving from one fishing spot to the next and the occupants were looking for signs of fish in the surf. The vehicle speeds were in general slow to moderate and most were travelling at about the mid tide level.

The data for the afternoon represents the vehicle movement for 30 minutes before and 30 minutes after the end of fishing for that day. These were vehicles that were returning to the competition headquarters (south of Hukatere Ramp) to have the catch recorded. During the first half hour the vehicle speed was moderate to fast and during the last half hour the average vehicle speed was fast. Most of the vehicles during this period were travelling at the mid tide

level. Vehicles utilised a broad band of the beach as there was considerable vehicle overtaking.

DISCUSSION

Qualitative surveys

The survey indicates that the overall adult population of toheroa on Ninety Mile Beach is likely to be small, consisting of only a few scattered beds. If the size frequency distribution found at the Te Paki Stream is indicative of the entire beach population then there are unlikely to be any significant numbers of adults over three years old. The low numbers and small size of toheroa found in this survey are consistent with previous unpublished reports by the Ministry of Fisheries. Although the total population of toheroa on the beach cannot be reliably estimated by the qualitative methods used in the present study, it seems reasonable to presume that the population of has not recovered to previous levels in the early 1970's when the recreational fishery was closed. There is, however, evidence of a significant spatfall occurring in the last year. If a substantial part of this population survives then there may be some recovery of adult toheroa on the beach in the longer term.

The surveys showed the existence of a very large and dense adult tuatua bed. Similar dense beds of tuatua have been noted in the past. Adult tuatua are normally found in the subtidal fringe, in water approximately 0.5 m deep at low tide. On occasions it has been observed that adult tuatua are also found further up the shore in the lower mid tide region, slightly below the level of toheroa. It is not know why adult tuatua sometimes inhabit the lower mid tide region of the beach but it has been suggested that it occurs when the beds are extremely dense. The traffic surveyed in the present study drove over these adult tuatua bed.

Vehicle effects

In general the level on the beach that a vehicle is driven is affected by the state of the tide, the height of the surf, the depth of the beach water table, and obstructions on the beach such as other vehicles or pedestrians. The depth of the water table in the beach is partially dependent on the state of tide, but is also affected by the freshwater runoff either by way of streams or the freshwater water table. Most drivers on the beach prefer to drive on damp firm sand where there is the least chance of losing control of the vehicle. At low tide, this is about the mid tide level. This beach level is often the level of the toheroa population. The impact of each wheel of a moving motor vehicle on a beach has the momentary effect of compressing the sand particles which causes the interstitial beach water to rise towards the sand surface. Repeated passage of several vehicles increases this 'puddling' effect.

Fishing competitions create special traffic conditions. A good example of this can be seen in Plate 6. These are the vehicle tracks of the traffic that travelled north along the beach from the competition headquarters on the morning of the 21 February 1998. The tide was high and the

vehicles were forced to travel in the relatively soft sand in the high tide levels. A convoy of vehicles will produce deep ruts in the beach under these conditions.

During the ebb tide, the toheroa and tuatua, in the wet intertidal sand will be positioned with the longitudinal axis vertical and the shell slightly gaped, with the foot partially or fully anchored into the underlying sand. The siphons will be fully or partially retracted. The toheroa adductor muscles in this position are relaxed and the shell cavity is full of seawater. The back pressure of the surrounding sand allows the animal to retain this relaxed position. When the animal is disturbed the natural action is to retract the foot and siphons and the shell valves are clamped together. Some water is usually jetted out of the shell cavity during this reaction. The pressure effect of a vehicle passing over the beach will disturb the animal. The animal at this time have reduced their purchase in the sand (foot retracted and valves clamped) and will tend to float in the released interstitial water. Repeated puddling by the passage of several vehicles will float the animal towards the sand surface. As the animal approaches the sand surface a small hummock of sand is raised on the beach and if the floatation effect continues, the hummock surface will crack and expose the dorsal end of the animal (Plate 7).

Providing the animal remains in the longitudinal vertical position, the major direct damage may only be the repeated loss of water from the shell cavity. The shell is unlikely to be damaged. The indirect effect of this situation is that the animal is exposed in summer to rapid heating from solar radiation and similarly will be rapidly chilled in winter if the air temperature is lower than the beach and seawater temperature and the animal will be more exposed to seabird predation. If the animals are shifted from the vertical position such that the passing vehicle wheels impact with shell at an angle then the animal will sustain shell damage and the animals may be killed immediately or at a later time if the damage is so severe that the shell cannot be readily repaired. Bivalve molluscs are able to effect some internal repair to a shell by secretion of nacre to cement the damaged area.

The vehicle counts and impacts demonstrated in this report were confined to a few days during a fishing contest. In order to allow a better understanding of whether the impacts of vehicles on toheroa are restricted to very high traffic volumes or are a more wide spread problem the research would need to be expanded to include other times of the year when there is a "normal" volume of traffic on the beach.

There is sufficient evidence of damage to toheroa to warrant further investigations of mortality in relation to the volume of traffic, type of vehicles and the distribution of vehicles on the beach so that effective management options can be developed. These issues will only be effectively addressed through longer term and more direct experimental studies.

Other possible factors not investigated

The vehicle impacts on toheroa found in this study are likely to be relatively modest compared with the historical fluctuations in the Ninety Mile Beach toheroa population. However, with the toheroa population in its current depleted state, even a modest impact may be important in the recovery of the beds in the longer term. Other possible reasons for the low toheroa populations need to be investigated to allow a full understanding of the relative importance of vehicle effects compared to other potentially important influences.

Other alternative explanations of why the toheroa populations are not recovering are:

- That climatic changes have caused a loss of phytoplankton food for the toheroa
- That the over fishing of snapper has caused an increase in paddle crabs that predate on juvenile toheroa
- That illegal poaching of toheroa is sufficient to maintain the toheroa populations in their present state
- That the reduction of freshwater streams on beaches due to increased forestry plantings has adversely impacted on the preferred habitat of the toheroa
- That the current depletion of toheroa on Ninety Mile Beach is part of a natural cyclical event
- That historical over fishing of toheroa (commercial and recreational) has reduced the populations to such an extent that a critical stock level has been crossed resulting in insufficient adult biomass to produce successful juvenile recruitment.

The poaching of toheroa despite the poor state of the population seemed to be a common occurrence as most people encountered while performing the surveys admitted taking a few toheroa or had regularly observed others collecting toheroa on the beach. These obvious signs of poaching toheroa on the beach make this an important issue that needs to be examined.

Conclusions

- The qualitative survey of the entire Ninety Mile Beach found only scattered small beds of toheroa. The beds were all situated at the mid to upper tide region of the beach.

- The quantitative survey of one toheroa bed at Te Paki Stream revealed that the population was composed of mainly juvenile animals with few or possibly no legal sized (>100 mm) toheroa, and the animals were distributed in relatively low density.

- The fishing contest creates unique traffic conditions on the beach. Extremely high traffic volumes were recorded during the fishing contest of which most of the vehicles were four wheel drives. The distribution of the traffic was modified by the state of the tide, which often resulted in the vehicles driving over the main part of the toheroa beds.

- The high volume of traffic during the fishing contest produced reasonably high levels of immediate mortality of juvenile toheroa from one site due to the repeated impact of high volumes of vehicles. There was little immediate mortality observed of adult toheroa observed during this study.

- This preliminary study was confined to the immediate impacts of vehicle traffic on the beach and it is not known what longer term impacts vehicles may have on toheroa. Toheroa may have been stressed by the vehicle passage and died sometime later. The study was also confined to a high traffic volume fishing contest and it is not known what happens outside the fishing contest when traffic volumes on the beach are lower.

- There has been a reasonable spatfall of toheroa on the beach in the past year. It is not known if this is a regular occurrence. If it has occurred in most years previously then the spatfall has not resulted in a large adult population.

Table 1.

Initial survey for toheroa beds from Hukatere Ramp to Bluff.

Start	Position (Latitude and Longitude)	Toheroa Density	Tuatua Density
Hukatere	34°54.024; 173°05.017	None	Low
North to	34°53.018; 173°05.005	None	Very high
	34°53.195; 173°04.315	None	Very high
	34°53.259; 173°04.281	None	Very high
	34°51.828; 173°03.124	None	Very high
	34°49.888; 173°01.432	None	Very high
Bluff	34°41.601; 172°54.075	None	Very high

Table 2.

Position and density of adult and juvenile toheroa beds on from Hukatere Ramp to Ahipara.

Start	Position (Latitude and Longitude)	Juveniles Density	Adult Density	Observed Mortality
Hukatere	34°54.040;173°05.031	Moderate	Low	Yes
South	34°54.154;173°05.037	Moderate		Yes
	34°54.564; 173°05.385	Moderate		Yes
	34°55.064; 173°05.749	Scattered		
	34°55.610; 173°06.067	Low		
	34°55.665; 173°06.237	Moderate	Low	
	34°55.952; 173°06.423	Low		
	34°56.449; 173°06.813	Low		
	34°56.894; 173°07.098	Scattered		
	34°57.404; 173°07.361	Low		
	34°57.861; 173°07.727			
	34°58.507; 173°08.124			
	34°58.716; 173°08.285		Shell 90 mm	
	34°59.215; 173°08.587			
	34°59.678; 173°08.828	Medium		
	35°00.233; 173°09.084	Light		
	35°00.724; 173°09.316	Scattered		
	35°01.228; 173°09.547	Medium	Shell 80 mm	Yes
	35°01.755; 173°09.746			
	35°02.325; 173°09.924			
	35°02.632; 173°10.043			
	35°03.163; 173°10.208			
	35°03.708; 173°10.328			
	35°04.263; 173°10.423			
	35°04.768; 173°10.465			
	35°05.305; 173°10.488			
	35°05.850; 173°10.485			
	35°06.389; 173°10.469			
	35°06.974; 173°10.355			
	35°07.464; 173°10.271			
	35°08.007; 173°10.088			
	35°09.454; 173°09.399			
Ahipara	35°10.010; 173°09.014			

Table 3.

Position and density of toheroa beds at Te Paki Steam

Start	Position (Latitude and Longitude)	Juveniles Density	Adult Density	Observed Mortality
Te Paki	34°33.723; 172°46.085	None	Low	None
	34°33.763; 172°46.201	None	Moderate	None
	34°33.765; 172°46.239	None	Low	None

Table 4.

Numbers of tuatua and toheroa from the transect from mean high water to low tide at position 34°52.440 : 173°03.639 just north of the Hukatere Ramp.

Quadrat	Distance (m)	Quadrat Area (m^2)	Tuatua Number	Toheroa Number
1	1	1	-	-
2	10	1	-	-
3	20	1	-	-
4	30	1	-	-
5	40	1	-	-
6	50	1	-	-
7	60	1	-	-
8	70	1	-	-
9	80	0.5	95	2
10	85	0.5	287	-
11	90	0.5	180	-
12	100	1	9	-
13	110	1	2	-
14	120	1	-	-
Total			573	2

Table 5.

The numbers and density of toheroa and tuatua from three 1 m^2 quadrats from Te Paki Stream.

	Toheroa	Tuatua
Quadrat 1	83	2
Quadrat 2	96	6
Quadrat 3	50	5
Total	229	13
Mean/m²	76.3	4.7
SD	23.71	2.3

Table 6.

The numbers and density of toheroa from three 1 m^2 quadrats near Hukatere Ramp. The numbers in the brackets are the percentages of the total number of toheroa found in each category.

Toheroa	Alive (*in situ*)	Crushed	Total
Quadrat 1	34	5	39
Quadrat 2	53	9	62
Quadrat 3	73	12	85
Total (%)	160 (86)	26 (14)	186 (100)
Mean/m²	53.3	8.7	62.0
SD	19.5	3.5	23.0

All juveniles < 32mm

Table 7.

Total numbers of vehicles for each category counted passing fixed positions between the 19-20 February 1998.

Vehicle type	Speed	Number	Beach level	Number
4 Wheel Drive	Slow	28	Low tide	6
	Medium	104	Mid tide	279
	Fast	189	High tide	36
Totals		321		321
Cars	Slow	4	Low tide	2
	Medium	15	Mid tide	30
	Fast	16	High tide	3
Totals		35		35
Vans	Slow	4	Low tide	0
	Medium	9	Mid tide	20
	Fast	9	High tide	2
Totals		22		22
Bikes (2 to 4 wheel)	Slow	2	Low tide	0
	Medium	3	Mid tide	8
	Fast	4	High tide	1
Totals		9		9
Tourist Coach	Slow	0	Low tide	0
	Medium	8	Mid tide	8
	Fast	0	High tide	0
Totals		8		8

Table 8.

Numbers of vehicles passing a fixed point in thirty minute intervals at three estimated speeds and three estimated beach levels.

Date & Time	Position	Speed	Number	Level	Number
20/02/98 07:40	Hukatere Ramp	Slow Medium Fast	6 21 3	Low tide Mid tide High tide	 26 4
Total			30		30
20/02/98 08:10	Hukatere Ramp	Slow Medium Fast	12 9 8	Low tide Mid tide High tide	 17 12
Total			29		29
20/02/98 08:40	Hukatere Ramp	Slow Medium Fast	5 12 2	Low tide Mid tide High tide	2 5 12
Total			19		19
20/02/98 09:10	Hukatere Ramp	Slow Medium Fast	2 12 7	Low tide Mid tide High tide	1 14 6
Total			21		21
20/02/98 09:40	Hukatere Ramp	Slow Medium Fast	2 2 2	Low tide Mid tide High tide	1 5 0
Total			6		6
20/02/98 13:38	Hukatere Ramp	Slow Medium Fast	6 34 35	Low tide Mid tide High tide	0 75 0
Total			75		75
20/02/98 14:08	Hukatere Ramp	Slow Medium Fast	0 32 161	Low tide Mid tide High tide	2 191 0
Total			193		193

Figure 1.

Map of the northern tip of the North Island of New Zealand showing Ninety Mile Beach and the location of the areas referred to in this report.

Figure 2.

Tuatua length frequency distribution from transect down the shore just north of Hukatere Ramp.

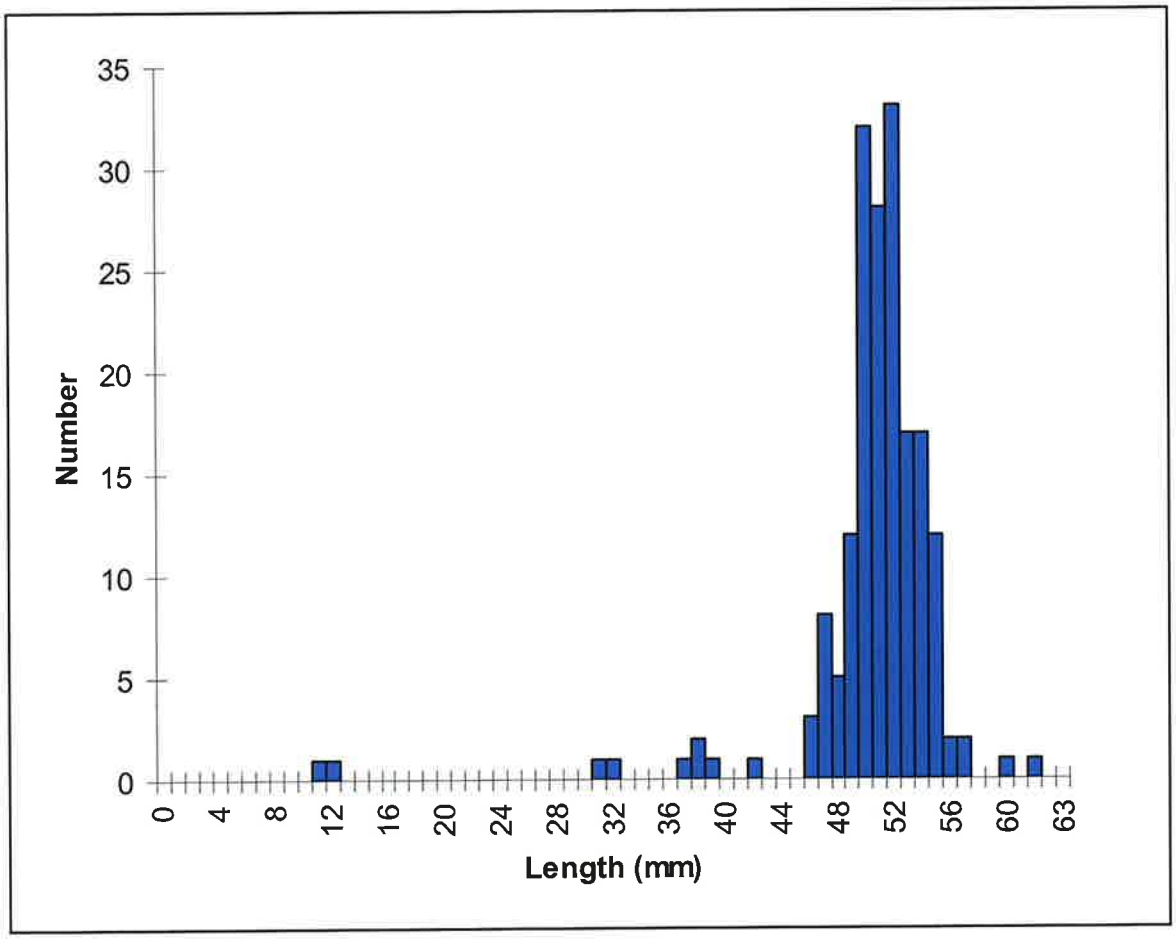

Figure 3.

Toheroa length frequency distribution from the three 1 m^2 quadrats in the bed near Te Paki Stream.

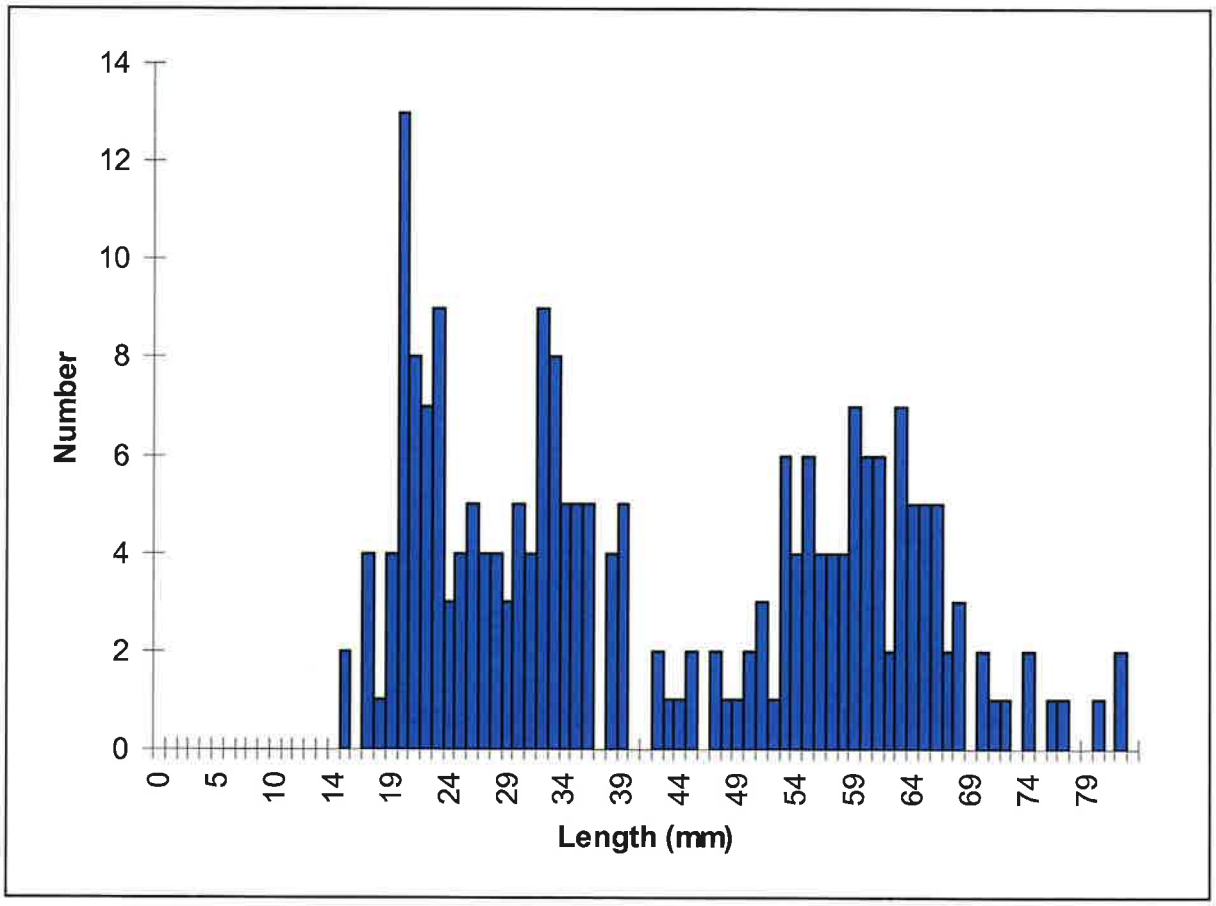

Figure 4.

Juvenile toheroa length frequency distribution from the three 1 m^2 quadrats in the bed near the Hukatere Ramp.

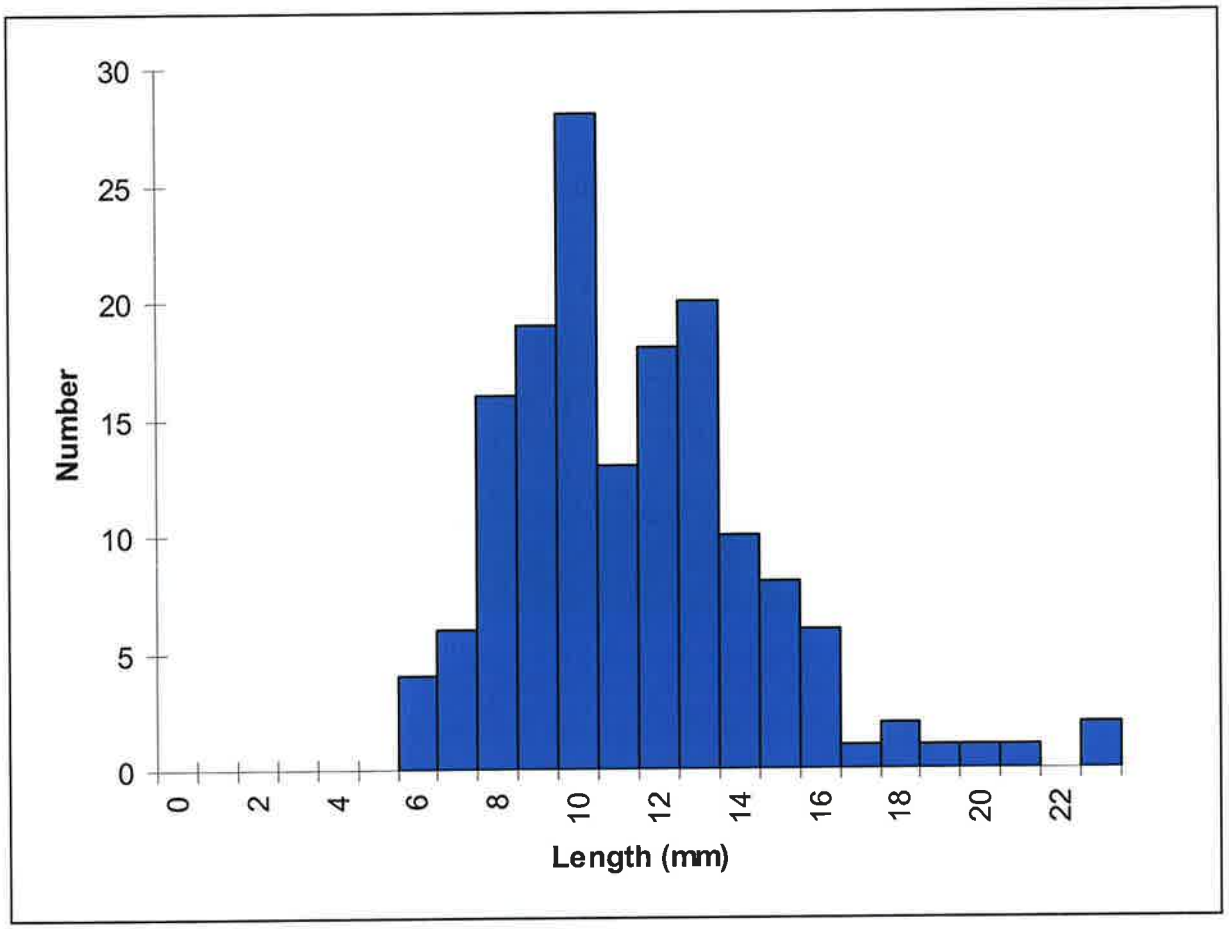

Plate 1.

Detail of tuatua hummocks of sand in the mid tide region caused by the floatation of a shellfish to the surface of the beach.

Plate 2.

Photograph of a part of the dense bed of tuatua looking south. The photo was taken just north of the Hukatere Ramp.

Plate 3.

Photo of the tuatua sampling transect north of the Hukatere Ramp.

Plate 4.

Juvenile toheroa crushed by vehicular traffic on the 21 February 1998. Note the vehicle tire tread marks in the sand.

Plate 5.

Photo of juvenile toheroa from a 1 m^2 quadrat near Hukatere Ramp.

Plate 6.

Tracks in the beach left by morning fishing competition traffic on the 21 February 1998.

Plate 7.

Tuatua hummocks produced by repeated passage of several vehicles (puddling effect).

APPENDICIES