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Sustaining toheroa (*Paphies ventricosa*) in Murihiku: Mātauranga Māori, monitoring and management

A Report to Ōraka-Aparima Rūnaka and the Ministry of Fisheries for Research Contract CU 2007-06

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He Kohinga Rangahau is the research report series of Te Tiaki Mahinga Kai, a national coalition of tangata kaitiaki, researchers and managers dedicated to sustained enhancement of the cultural, economic, social and environmental well being of Māori and New Zealand as a whole through the application of mātauranga and science associated with mahinga kai to modern customary fisheries practices. *See* www.mahingakai.org.nz for a detailed description of the kaupapa. *He Kohinga Rangahau* means "the gathering together of research findings". The report may be used and cited by anyone with due acknowledgement to *Te Tiaki Mahinga Kai* and its funders.

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Executive Summary

Toheroa (*Paphies ventricosa*) is an endemic shellfish that lives in exposed sandy surf beaches of Taitokerau (Northland), the Kapiti coast and Murihiku (Southland). Harvests of this highly-prized customary food are managed by Māori kaitiaki (environmental guardians) who appoint Tangata Tiaki under the Customary Fisheries Regulations to authorize harvesting and guide management. The Ministry of Fisheries funded the Ōraka-Aparima Rūnaka to record the mātauranga (Traditional Ecological Knowledge) associated with toheroa populations and harvesting in Murihiku and to develop monitoring and restoration protocols. Interviews of 25 kaitiaki, managers, scientists and knowledgeable locals by researchers from the *Te Tiaki Mahinga Kai* programme revealed a rich local knowledge of historical changes, current threats and some important differences between traditional harvest tikanga (protocols) and western-styled fisheries management. This study focused on three main toheroa colonies: Bluecliffs Beach and Orepuki Beach within Te Waewae Bay; and Oreti Beach near Waihopai (Invercargill).

Toheroa remain a taonga (treasured species) for the Murihiku kaitiaki. Their majestic size, taste, year-round availability, regional specialty and former inaccessibility (when the Ministry of Agriculture and Fisheries closed the harvest for long periods) have all contributed to toheroa's high status among the kai species. There was consensus amongst our research participants that, "provided you know what you are doing", you can still get a feed of toheroa in a reasonable time. This is possible even at Bluecliffs Beach where the population has declined the most over the past half century. Nevertheless, it now takes about twice as long to gather that feed than when our informants were children and more people with authorisations are failing to gather their full allocation.

Many interviewees are concerned that transmission of knowledge about toheroa was severed by the closed seasons and "Open Day" approach promulgated by the former Ministry of Agriculture & Fisheries and by other changes in modern lifestyles. Some novice gatherers do not know where to go to gather, the importance of choosing suitable tides, or even how to properly prepare the kai once it is harvested. More generally, some of our older informants were concerned that harvesters are less aware of traditional methods for gathering, tikanga ("resource use rules") and mātauranga that are all needed to protect and restore the resource.

Some customary users resent applying for authorisations to harvest toheroa because they consider that having to ask cuts across their birthright and rangatiratanga. Most interviewees know of unauthorised harvesting and some estimated that as many toheroa are poached as are harvested

following authorisation by the Tangata Tiaki. Poaching undermines the effectiveness of the customary management because the number taken remains unquantified, the added extraction cannot be managed by the Tangata Tiaki to reduce pressure on the declining population at Bluecliffs, and the legitimacy of local Māori management is more generally undermined.

Traditional resource use "rules" and management approaches included:

- Take only what you need for a feed for yourself or to share with neighbours, whānau and elders (usually 1-2 toheroa per person per meal).
- Do not waste any of the food.
- Do not shuck the shells on the beach.
- Never use an implement to dig the toheroa because this will inevitably damage and spoil many of them.
- Gather the toheroa by walking backwards in the lapping tide to spot the siphon holes of feeding toheroa as they withdraw into the sand; place ones' foot over the hole; and gently paddle the foot up and down to allow the washing tide to wash the sand away from the animal. It can then be picked up by hand without further excavation. This traditional method absolutely prevents all damage to the shells, prevents disturbance to the habitat and ensures some local escapement because not all toheroa are feeding at the same time.
- Monitor the abundance of toheroa from their siphon holes.
- Leave the largest and darker-coloured toheroa because they are the breeding stock. This is part of a wider recurring theme from the mātauranga: western fisheries management is missing an important opportunity by setting only minimum size limits for the harvest of many species. Many kaitiaki urge that a maximum size limit would improve the ecological resilience of populations and therefore increase long-term sustainable harvest levels.
- Avoid taking all the toheroa from one particular spot so as to spread the harvest impact.
- Avoid all damage to the kōhanga (nursery) beds.
- Promote local abundance by burying bull kelp in the sand – toheroa congregate around the decomposing kelp and reach prime condition, presumably because feeding is improved.
- Translocate toheroa to new sites to increase overall population resilience.

The tikanga revealed in the kōrero (discussions) were based strongly on conservation ethic to protect important mahinga kai species such as toheroa. Kaitiaki stressed the importance of the people being reconnected with the mahinga kai in order to learn and understand the tikanga to protect their kai moana resources for their mokopuna (grandchildren) and know who they are.

Many interviewees expressed concern at declining populations at Bluecliffs Beach and all associated that decline with erosion of the beach over the past 40 years. The beach used to be a wide, gently sloping, sandy beach where whānau gathered to swim and commune and occasionally harvest toheroa; it is now narrow, predominantly cobbled, steep and the tide makes it a dangerous place to swim. There was a near unanimous consensus that damming of the Waiau River for electricity generation in 1972 has caused the habitat degradation, and so caused major decline in toheroa abundance in Te Waewae Bay, but scientific debate remains. We conclude that declines have undoubtedly been accelerated at Bluecliffs Beach because of the reduced Waiau flow, but that some other ecological factor has also operated regionally to depress the population at both Te Waewae Bay and Oreti Beach.

The toheroa population remains stronger at Oreti Beach where the habitat appears stable. Vehicle traffic on the beach is believed to threaten recruitment of young toheroa and that threat is increasing. A nationally important motorcycle racing event, the Burt Munro Challenge, threatens recruitment in a 1-2 km area. The interviewees want a smarter choice on where the race track was situated to reduce the threat and prohibition of the use of a grader to flatten the beach for the race, but none expressed a wish to prevent the race entirely.

Threats affecting all populations include: illegal harvesting, pollution, predation and climate change mass mortality ("die-back") events that may be triggered by disease, biotoxins, starvation or weather, or some combination of all of these.

Some kaitiaki oppose digging of the toheroa for scientific surveys and have asked the researchers to calibrate counts of feeding holes against actual abundance to see whether the siphon counts could substitute for digging surveys to monitor the population changes in future. One of the kaitiaki emphasised the need to monitor toheroa condition, which he has observed to fluctuate widely, rather than just numbers. Condition is likely to index breeding success and recruitment. Some interviewees believe that the toheroa are smaller and have on average poorer condition than in the past.

Jack Te Au was a dedicated guardian and researcher of toheroa at Bluecliffs Beach in the 1950s and 1960s. He and several other kaitiaki transferred toheroa from Bluecliffs Beach to at least three other sites in Murihiku in the 1950s. Our recent surveys suggest that two of these populations no longer exist, but that at Orepuki Beach, at the eastern end of Te Waewae Bay is now strong. A full quadrat digging survey in December 2008 estimated there to be around 60,000 adults in the population, about a third of the number at Bluecliffs Beach in 2005. This population size equates to a 10.5-12.5% per annum increase in the population since it was founded by the kaitiaki around 50 years ago. The kaitiaki have now decided to reduce population pressure on the Bluecliffs colony by authorizing harvesting from Orepuki Beach in future.

The Orepuki population has a high proportion of young and sub-adult toheroa compared to Oreti and especially Bluecliffs. However Orepuki toheroa are not growing as large as elsewhere and it is unclear whether the habitat to the northwest of the existing colony is suitable to allow further expansion of the population.

The following table summarises the current status and threats from the three Murihiku toheroa colonies as judged from this research project and ongoing NIWA scientific monitoring. The main management priority is now to establish new breeding colonies in the Te Waewae Bay area by translocating toheroa sourced from Oreti Beach. The first step needed is to draw up a plan for a well-structured and monitored "active adaptive management" approach that minimises risk to the donor populations, maximizes the chance of success of the founder populations, and accelerates the new populations' growth rate. The first priority is to extend the stretch of the Orepuki colony by translocations northwest onto Gemstone Beach; the second priority is to establish a population at Sandhill Point. Artificial "feeding" or "supplementary feeding" of the founder toheroa populations using traditional techniques of burying bull kelp, and maybe also experimental particulate foods should be trialed as part of this restoration plan. The kaitiaki see no reason why declines at Bluecliffs Beach will not be ongoing, so the need for management intervention is now urgent. Once new populations are established in Te Waewae Bay, translocation trials should probably extend to Mason's Bay on Rakiura. Adults and sub-adults should be harvested from the southeastern end of Oreti Beach to establish these new populations.

At Oreti Beach the pressing threat requiring investigation is whether vehicle traffic is significantly disrupting recruitment. The population is sustained almost entirely by adults in one 2 km portion of the 17 km extent of the bed. Triggering recruitment to the adult stage along the rest of the beach is the key to building the strength and resilience of the Oreti population. Numbers will need to be increased by three times to restore abundance to that seen in the early 1970s.

	Orepuki	Bluecliffs	Oreti
Overall Population Size (thousands of adults)	Small (59)	Medium (165)	Large (583)
Colony extent	Short (1.6 km)	Medium (5.1 km)	Long (17 km)
Width of intertidal (maximum)	Narrow (145 m)	Narrow (140 m)	Wide (320m)
Habitat	Stable	Degrading	Stable
Density (adults per m^2)	High (0.27)	High (0.30)	Low (0.12)
Maximum size	Short	Very long	Long
Individual's growth rate	Slowest?	Fast	Medium
Population recruitment	High	Low	Medium
Harvest pressure	?	Low	Low
Traffic threats	Low	Low	High
Trend in overall population	?	Ongoing decline	Stable in last decade, lower than in 1970

Our research participants generally affirmed the customary fisheries management regime that has replaced Ministry of Fisheries' management of toheroa. They report that it is working well, is inclusive and fair and has acted in ecologically sensible ways by reducing harvesting pressure on the declining Bluecliffs Beach population. There was strong consensus that the customary authorisation system has reduced waste, increased respect for the toheroa and their habitat, and allows a rekindling of tikanga and mātauranga and connection between people and the wider environment. There was fulsome participation in all stages of this study, requests for research of vehicle and die-back threats, and whether natural recruitment failure is linked to oceangraphic and climate perturbations. The kaitiaki expressed enthusiasm to participate in translocating toheroa to establish new breeding colonies. In these, and many other ways, the kaitiaki have already demonstrated a wish and capacity to take an active and effective role in population restoration and monitoring that extends well beyond managing authorisations to harvest. The toheroa themselves, the kaitiaki, government management agencies, Southland society and the Murihiku environment as a whole have and will continue to benefit from application of mātauranga in partnership with science to protect and restore a threatened taonga for the future generations.

Contents

Introduction: the need for this research

Toheroa (*Paphies ventricosa*) is a rare endemic shellfish, found predominantly in three regions of New Zealand; Taitokerau (Northland), Levin/Kapiti, and Murihiku (Southland)[1]. This bivalve mollusc species grows to a size of 12-15 cm as an adult and is thought to live for approximately 20 years[2]. Toheroa are active burrowers and live 10-20 cm below the surface of sandy beaches in the zone between low and high tide. They feed when submerged by extending their siphons to the surface of the sand and filtering plankton out of the water. Closely related to pipi (*P. australis*) and tuatua (*P. subtriangulata*), toheroa form distinct beds, with the juveniles spread from high to low water, while the adult shellfish are concentrated between mid to low water[3].

Toheroa have long been, and remain a highly appreciated taonga (treasured) species for Māori. From the 1800s up to the 1960s toheroa were intensively harvested, not just by customary fishers but also commercially. Population numbers declined and harvest of toheroa has been prohibited since 1980, with exception of Māori customary take and occasional "Open Days" for recreational fishers. The last toheroa Open Day in Murihiku was at Oreti Beach in 1993[4]. At present, the only way to legally harvest toheroa is through the Māori Customary Fishing Regulations, under which Tangata Tiaki (Māori customary fisheries appointees) issue authorisations only for harvests providing kai (food) at important cultural events.

The Southland populations of toheroa are of national conservation importance because of their outlying and limited distribution, long term declines of both northern and southern populations, general degradation of marine ecosystem health and the importance of toheroa for cultural wellbeing of Māori. Ongoing conservation concern for toheroa in Southland stems mainly from severe decline in the population at Bluecliffs Beach since the 1960s.

Mātauranga Māori is a collective term for Māori knowledge, tikanga (traditional rules), traditions and teachings passed on over time and includes the Traditional Ecological Knowledge (TEK) for managing mahinga kai (traditional food gathering places) and the food resources themselves. TEK is defined by overseas commentators as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission,

[1] NABIS (2007).
[2] Cassie (1955).
[3] Beentjes et al. (2006).
[4] Rewi (2008).

about the relationship of living beings (including humans) with one another and the environment"[5]. This type of knowledge is invaluable for conservation management because it is built up over a long period (often several generations), detailed, locally tuned and often focussed on the culturally most important features of the environment or customary use of the resource that is most in need of protection[6].

The Ministry of Fisheries has funded Ōraka-Aparima Rūnaka to record mātauranga and community knowledge about toheroa populations and harvest management in Murihiku (Southland). The intention is to support local kaitiaki (environmental guardians) to more actively manage toheroa. Two of the Tangata Tiaki that have been successfully managing toheroa in Te Waewae Bay are now elderly and have recently been ill, so the community was particularly interested in having their knowledge recorded to guide future management. Additionally, the collected information from all local observers may eventually be incorporated into the proposals for mātaitai reserves - areas with temporary kaitiaki-led restrictions on taking nominated species, to help restore stocks in Murihiku. The design of robust "before versus after" monitoring can therefore test the success of the mātaitai or taiāpure reserves. Traditional methods for reseeding shellfish beds were combined with ecological science to determine optimum methods and sites for restoration of toheroa populations.

Another part of the requested research was to survey the abundance, size distribution and condition of toheroa at traditional harvest sites in Murihiku. This was part of a wider assessment of potential sites for reseeding and more active habitat management. The research eventually became focussed mainly on Orepuki Beach where a toheroa population has become established as a result of several transplanting events carried out by local community members. Beentjes & Gilbert (2006a) acknowledged the existence of a toheroa population at Orepuki Beach, however it has not yet been included in the regular population surveys conducted by NIWA (National Institute of Water and Atmospheric Research) for the Ministry of Fisheries. With no formal assessment of the Orepuki Beach toheroa beds, little was known about the state of the population. From the interview discussions there was mixed opinions about its status. Some interviewees were dubious of its existence entirely, or having not gathered toheroa there themselves did not wish to rely on rumours of past transplanting events or the current state of the population. Some interviewees were doubtful of the population's success, whereas others were certain it is a well established stock but that it was not growing well. A hui (meeting) held after most of the interviews with kaitiaki had been

[5] Berkes (2008).
[6] Moller (1996b); Taiepa et al. (1997); Newman & Moller (2005).

completed requested that the Orepuki population became a main focus of our subsequent field studies.

The Orepuki Beach toheroa beds provide a unique opportunity to investigate the success of transplanting efforts of toheroa to a novel beach (i.e. a beach outside their historic range). Translocation could potentially be used for enhancing the density of existing toheroa stocks[7]. If proven successful, transplanting toheroa has the potential to provide a restoration tool for enhancing existing stocks to more closely resemble historic levels and help to ensure more populations are established within Murihiku.

This toheroa research contribution forms part of *Te Tiaki Mahinga Kai*, a research coalition which works closely together with tangata whenua (local people), Tangata Tiaki, governmental agencies and institutions involved in customary fisheries management. The vision of *Te Tiaki Mahinga Kai* is for “sustained enhancement of the cultural, economic, social and environmental well-being of Māori and New Zealand as a whole through the application of mātauranga and science associated with mahinga kai to modern customary fisheries practices”[8]. The Kaitiaki are grateful for funding by the Ministry of Fisheries to make the study possible.

Aims of this research

The specific aims of the preliminary research were to:

1. Interview Murihiku kaitiaki with recent and past knowledge of toheroa populations, traditional management and harvest management.
2. Compare traditional reseeding methods with ecological science expectations of optimum methods and places for restoration. Report on mātauranga and science re toheroa monitoring and reseeding.
3. Identify threats to traditional harvest areas and what, if anything, can be done about them.
4. Survey traditional harvest sites for the ongoing presence of toheroa and their abundance; and survey potential sites for reseeding and more active habitat management.
5. Assess viability of reseeding toheroa; if likely to succeed, develop a costed plan for reseeding threatened populations and associated potential establishment of mātaitai around restored areas.

[7] This has been suggested by (Akroyd 2002).
[8] See www.mahingakai.org.nz; Moller et al. 2007; Schweikert & Moller (In press); Hepburn et al. (In press).

Study Area

Bluecliffs and Oreti beaches are the traditional toheroa harvesting sites within Murihiku. Managed as separate stocks, periodic population surveys have been conducted at both the beaches since the 1950s. The presence of a third local toheroa stock at Orepuki Beach and details of its establishment was revealed during the interviewing process for this study. It is *s*ituated between Te Puka o Takitimu (Monkey Island) and the Orepuki township, at the southeastern end of Te Waewae Bay, Southland, New Zealand (Fig. 1). Testimony of the interviewees in this study is focussed on Bluecliffs, Orepuki and Oreti Beaches, and most of the field work on Orepuki Beach. There were also additional searches for outlying breeding colonies between the western end of Te Waewae Bay and the western extremity of the Oreti Beach colony (this turned out to be about the Waimakatū Stream). The main three beaches are all classified as “dissipative” i.e. they have fine sand, heavy wave action and often also larger tide ranges so that they form flat slopes and wide surf zones in which most wave energy is dissipated[9].

Oreti Beach is 29 km long, running southeast to northwest. It has a main vehicle entrance situated 10 km from central Invercargill city (Fig. 1). The beach is a gently sloping fine-sand beach with no gravels, cobbles or rocks visible. The width of the beach (from high to low in spring tides) averages 210 m and the tidal fall is 1.2 – 1.3 m below mean sea level[10].

Beentjes et al. (2006) describe Bluecliffs Beach as follows: “Bluecliffs Beach faces south to southwest in an embayment in the coastal cliffs at the western end of Te Waewae Bay, Southland (Fig. 1 and 2). The Waiau River flows into the middle of Te Waewae Bay. The intertidal zone of Bluecliffs Beach is flat and wide but progressively narrows and steepens toward the west. A narrow vegetated (mostly marram grass, *Ammophila arenaria*) sand dune extends ca. 4 km west from the Rowallan Burn, before it ends in a steep, cobble bank. The cobble bank begins ca. 2 km west of the Rowallan Burn between the sand dunes and intertidal zone and becomes wider and steeper toward the west. The beach substrate at low tide is mainly fine or coarse sand but further up the beach, gravel and cobbles are common”.

[9] Following McLachlan’s (1990) definition.
[10] Beentjes & Gilbert (2006b).

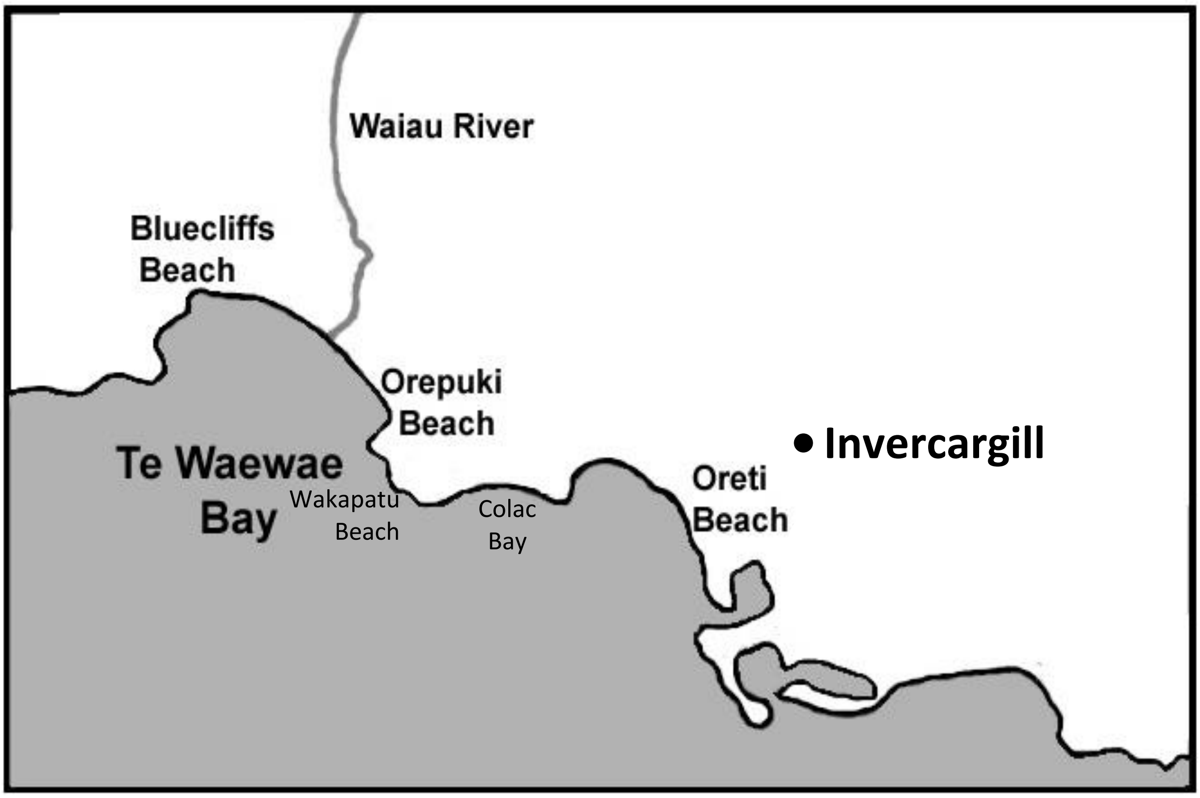

Figure 1. Locations of beaches which support toheroa populations in Murihiku (Southland), South Island, New Zealand. The main populations of toheroa occur at Oreti Beach, Orepuki Beach ('Monkey Island') and Bluecliffs Beach. Toheroa were reported to be translocated to both Wakapatu Beach and Colac Bay so these sites were checked for extant colonies.

Orepuki Beach is located at the far eastern end of Te Waewae Bay, running south from the Orepuki township (Fig 1). Although mostly homogeneous, at the northern extent of Orepuki Beach the intertidal zone is more dynamic with a steeper gradient and coarser, darker sands. Orepuki Beach is bordered by cliffs with small, marram grass covered sand dunes occurring at the cliff base for a 500 m section in the middle of the survey area north of Kaitangata Point (Fig. 2 & 3). Small freshwater streams flow down the intertidal zone at either end of the survey area.

Figure 2. Profile of Orepuki Beach facing south from the Orepuki Beach access road.

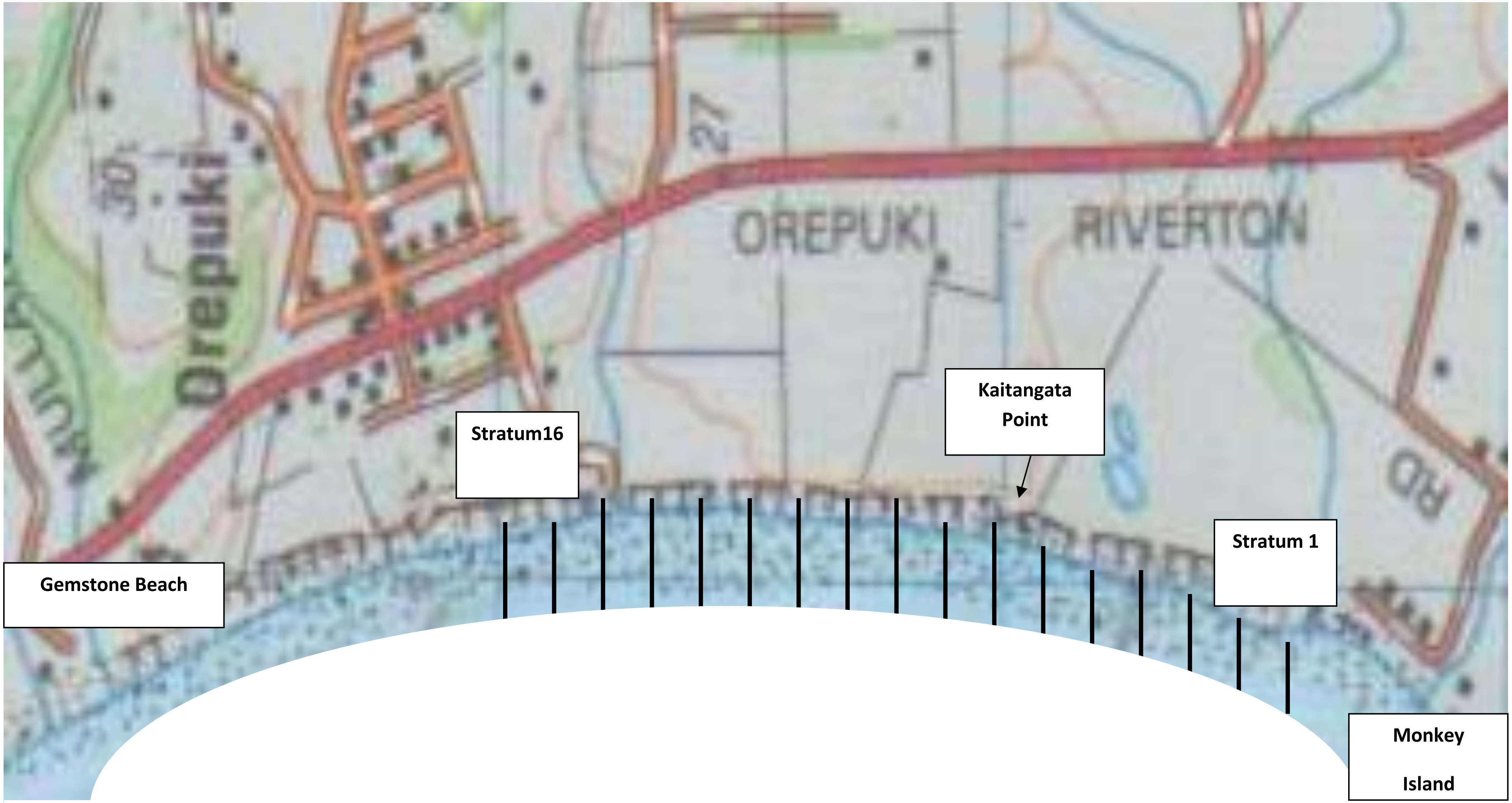

Figure 3. Map illustrating the placement of the 16 strata of the 2008 toheroa population survey at Orepuki Beach. Stratum 16 is at the northern extent of the survey area and stratum 1 at the southern end. Note: lines represent the width of the each stratum but are not related to the length of the transects.

Methods

Mātauranga Māori for managing toheroa

This present project originated from concerns of kaitiaki (environmental guardians) and locals from the Ōraka-Aparima Rūnaka who harvest toheroa from the Bluecliffs Beach population. However, the other strong hold of toheroa is at Oreti Beach, for which the Waihopai Rūnaka are kaitiaki. Several gatherers have experience of harvesting from both places. Therefore it seemed pertinent to extend the scope of the study and include the knowledge of the Oreti customary user community also.

Selected kaitiaki and local key informants were interviewed from the two communities. Subsequent interviewees were peer selected and the interviewing process continued until no new names were mentioned in discussion and the same general ideas were emerging from successive interviews[11]. Twenty kaitiaki, two local farmers from Bluecliffs and three ecologists were interviewed by *Te Tiaki Mahinga Kai* researchers. Twelve of the interviews held knowledge primarily on the Bluecliffs' population and the others were from Oreti or had knowledge of both sites. Interviews were semi directive in nature, allowing a conversational approach which can increase the likelihood of unanticipated topics coming up (Huntington, 2000). The interviews were mainly focused on the knowledge of toheroa ecology, trends in toheroa abundance and condition, the major identifiable threats, and attitudes towards past and present management.

Interviews were recorded, and had an average duration of 86 minutes. Edited transcripts of the interviews were returned to interviewees to confirm that their original meaning was captured. This also gave the informants an opportunity to remove or add any material. A bound corrected version of their interview was then returned to each participant to secure the record of the knowledge in the community. Qualitative information from the interviews was analysed using NVivo™ software. A hui (meeting) was then held on 29 May 2008[12] with key interviewees to discuss the main findings and focus on where the kaitiaki wished to concentrate field work on the toheroa populations. We also discussed research possibilities for the development of effective monitoring protocols and restoration regimes for the toheroa populations in Murihiku, including the population survey of the Orepuki Beach population. The collected information from interviews and field results were then presented back to the community in a hui at Murihiku Marae on 16th February 2009 and the

[11] Following Huntington's (2000) 'snowball sampling' approach.
[12] At Te Ao Mārama's offices in Invercargill.

participants were taken to Oreti Beach for observing population surveys[13] and trialling the proposed traditional monitoring techniques. The group discussion at both hui was recorded and transcribed so that the concepts and decisions of the kaitiaki flowing from the results could be accurately represented in this report and in two other presentations at hui involving kaitiaki from all round Aotearoa[14].

Direct quotes from the interviewees are italicised and set within double quote marks in this report. We edited out occasional umms or ahhs and false starts from the quotes to make them more understandable and inserted our own words in square brackets in places to provide the contextual meaning that is obvious from the kōrero surrounding the excerpt.

Surveying the toheroa population at Orepuki Beach

The toheroa population at Orepuki Beach was surveyed using, in broad outline, the methods used by the regular NIWA surveys so the results could be directly compared[15].

The boundaries of the survey area were first defined by assessing the presence/absence of toheroa using the traditional method of searching for the siphon holes[16]. The same method has been used to locate and demark colonies in Northland studies[17].

The survey area (1.6 km) was then divided into sixteen 100 m wide strata (strips) down the beach for positioning transects (sampling lines) of quadrats (Fig. 2)[18]. All geographical points (including stratum boundaries and transect start points) were marked out using a hand-held Global Positioning System (GPS)[19].

[13] The hui was scheduled to coincide with Dr Mike Beentjes's latest full quadrat survey on Oreti Beach. He kindly demonstrated the methods and gave an overview of the results of previous surveys.
[14] One presentation was made at a conference in Christchurch called *Ngā Kete a Rehua* on 4th September 2008. Another was at the 3rd *Te Tiaki Mahinga Kai* Forum at Puawairua Marae in Whakatāne on 20-22nd February 2009.
[15] These methods are described by Beentjes & Gilbert (2006a,b). However our survey method differed in that we did not use the complicated adaptive management methods used by NIWA to top-up the first set of transects with unsieved transects in areas where most toheroa were living.
[16] Metzger 2007.
[17] Akroyd (2002); Morrison & Parkinson (2001).
[18] This is called a 'stratified random design' by field ecologists. The strata force the samples to be spread relatively evenly throughout the colony, but the random starting points for the transects within each stratum ensures that a representative sample of the beach is sampled.
[19] GARMAN, eTrex.

Within each stratum, one sampling transect was plotted out at a randomly generated distance from the eastern stratum boundary. Transects were required to be at least 20 m apart[20]. Each transect ran perpendicular to the shore and extended from the high water (edge of cliffs/dunes) down to low water. The survey was conducted during the spring tide period between 14th and 23rd December 2008, allowing the lower extent of the intertidal zone to be sampled.

A sieving technique was used for each of the 16 transects to ensure the maximum sampling of juveniles. Along the length of each sampling transect 0.5 m^2 (1.0 x 0.5 m) quadrats were placed at 5 m intervals. All quadrats were excavated with spades to a depth of 30 cm and the sand was transported and sieved in the surf in trolleys (Fig. 4) lined with fine metal mesh (4 mm). All toheroa collected in the trolley were weighed to the nearest 0.1 g and the maximum length measurement recorded to the nearest 1 mm (rounding downwards) along the longest shell dimension on the anterior/posterior axis with vernier callipers. After processing, toheroa were returned to the substrate close to where they had been excavated. Transects extended into the spring low tide zone until no toheroa were found ensuring that the lower boundary of the beds were sampled. Altogether 428 quadrats were excavated and sieved from 16 transects. The number of quadrats per transect ranged from 20 to 30, giving an average transect length of 135 m.

A sparse and patchy distribution, as is typical of toheroa beds in Murihiku, meant that most 0.5 m^2 quadrats had no toheroa in them, while one had 18 juveniles. The skewed distribution of counts is not readily amenable to parametric statistical analysis even after severe transformation of the data[21]. Therefore we estimated the density of juvenile (0-39 mm), sub-adult (40-99 mm) and adult (≥100 mm) toheroa using 'bootstrapping' techniques[22] by computing 10,000 random draws from the observed distributions 'with replacement'[23].

Substrate type was qualitatively assessed at each quadrat following seven categories[24]: 1) fine sand; 2) coarse sand; 3) sand and some gravel/stone; 4) sand and moderate gravel/stone; 5) sand and lots

a)

b)

c)

d)

Surveying toheroa distribution elsewhere in Murihiku

The presence of established toheroa populations were investigated at Wakapatu Beach and Colac Bay, as they were reported as translocation receiver sites in the interview discussions. The western end of Bluecliffs Beach that is no longer included in the periodic population surveys by NIWA was also examined. We also searched the north-western extremity of Oreti Beach to pinpoint the extent of the colony in order to guide the kaitiaki on their potential placement of a mātaitai to protect the Oreti Beach toheroa beds.

Toheroa presence was checked at these sites using the traditional search method of looking for the toheroa siphon tips[25]. This involves slowly walking backwards in the lapping tide and checking for the depressions in the surface of the sand where the toheroa are feeding. Date, air and sand temperature, wind speed and cloud cover were recorded at each site[26]. To ensure that the four sites were searched in optimal conditions, siphon activity was checked at either Oreti or Orepuki Beach on the same low tide.

[25] This has been reported by Metzger (2007).
[26] Once a calibration study linking the counts of siphon holes to actually density in the beach is completed (JM Futter, in progress), these weather variables will be used to 'correct' the count for whether or not feeding conditions were ideal.

Results & Discussion

Mātauranga Māori for guiding management

Toheroa as a taonga species

The interviewees were unanimous in the delight and respect for the toheroa. It was described as a taonga and a delicacy. It was held in particularly high regard due to its majestic size by all 25 interviewees. Many love the taste of toheroa in particular[27], and recognised it as important amongst the other kai in providing a predictable supply of food year-round. The following passage from Interviewee U clearly illustrates that toheroa is strongly cherished amongst the local community:

> *"I think the toheroa beds are so few and so it was a real relish to have toheroa. It was such a special treat even, well for us it was because we didn't live close to one [a beach with toheroa beds] and I know some of our cousins lived in the Rowallan area they went regularly and so they perhaps didn't have the same feeling about it. Now they have because they've become so scarce. But to them it was quite a regular part of their kai moana gathering back then and for us it was the opposite. We just were very lucky to be able to have that experience of going getting them, preparing them and eating them. And I guess it's like that for people who go to the Tītī Islands and they get tītī[28] or any other relation to wait for that season and then have titi. Well toheroa was like that for us".*

Given the current state of the Murihiku stocks, having toheroa on the menu is now a luxury. Also the long periods of prohibition in taking toheroa, before the establishment of the customary fishing regulations, created a feeling amongst many of the gatherers that having toheroa was all the more a privilege and luxury, and even drove some of them to seek it out simply because of its rareness and unavailability.

There was rich kōrero about the general importance of customary gathering, the communal and cultural wellbeing and sense of identity that ensues from it. Thus gathering toheroa was not just about the value of the kai for its nutritional value. Interviewees expressed how the taonga helps form and maintain relationships within and between whānau, and links them to their tupuna (ancestors) and to their places. These more general themes will be explored

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[27] Other interviewees reckoned that not everyone could tell the difference in taste. In their view the interest in toheroa was more about its mystery, size, rareness and latterly unavailability.

[28] Muttonbirds, sooty shearwater (*Puffinus griseus)* chicks.

elsewhere when the testimony of the toheroa gatherers is added to those gathering other customary kai from right around Te Wai Pounamu[29].

State of resource

Traditional Ecological Knowledge from the users of a local resource is valuable for estimating and understanding historical and current changes in abundance, age structure and distribution of the resource. Interviewees shared local knowledge on where the denser beds and larger toheroa could be found.

Many of the interviewees believed that while the toheroa are still abundant, the toheroa beds are nevertheless deteriorating. This belief comes from stories of people getting an authorisation for toheroa and returning from the harvesting trip empty handed, and from some more regular gatherers having to walk further and take longer to gather a feed. Interviewee U described this by saying:

> *"When we were young and going there [Bluecliffs Beach] you could find them in lots of different places on the beach, whereas now it's a real hunt"*.

Interviewee F also spoke of much shorter searching times when he was a child:

> *"they were more plentiful then, you didn't have to go terribly far"*.

Some interviewees described getting their feed of toheroa (usually 5-10 large specimens) in 10-15 minutes in their youth, but having to spend at least double that time now. This difference in catch rates appears to be a result of reduced population numbers and range (fewer and smaller patches), and lower density of toheroa in the remaining patches. Indeed, the adult toheroa population was historically distributed along the entire 17 km of Bluecliffs Beach, but is now largely aggregated into a section just 2 km long at the southeastern end[30]. Nevertheless the traditionally most important section of the beach for gathering was at this same Oreti River mouth end of the beach. The toheroa there were more regularly in good condition and the population was considered to "bounce back" quicker at that end after a die-back or period of low numbers.

Some interviewees believe that many novice gatherers lack local and traditional knowledge about where to concentrate their harvesting effort, which tides to choose, or about the traditional

[29] *Te Tiaki Mahinga Kai* is collecting together the general lessons about customary food gathering and management to advise on ways to build social-ecological resilience of customary resource use in general. See www.mahingakai.org.nz for a description of this wider inquiry.
[30] Beentjes & Gilbert (2006a).

methods to find the toheroa. This declining knowledge may be contributing to falling catch rates as much as falling numbers of toheroa themselves.

For the older generation, the decreased state of the resource means that being able to harvest toheroa is a privilege:

> *"It's more like an adventure now. Like it's a privilege to be able to go and do that. But I wouldn't go and do it unless it was for something significant"* (Interviewee R).

Nevertheless, even at Bluecliffs Beach, "*provided you know what you are doing*" most people can still get a feed in a reasonable time.

Significant decline in toheroa abundance since the 1960s is also indicated by scientific surveys conducted over this time period at Bluecliffs Beach and Oreti Beach[31]. In the 1960s, the population of adult toheroa was estimated at over two million at each of these two beaches, while 2005 estimates were just 165 000 at Bluecliffs Beach and 714 000 at Oreti Beach[32]. The declines were steepest between the mid 1960s and mid 1970s, at Bluecliffs Beach, and in the mid 1980s at Oreti Beach, with ongoing declines at both sites since then[33]. While the abundance of many shellfish populations in exposed, open beaches are typically highly variable, the declines documented by interviewees and researchers alike are indisputable.

All those interviewees that referred to declines in toheroa at Bluecliffs Beach considered that it was likely that further declines were inevitable. None expressed a view that the past declines had stabilised in the recent decades, and generally they were pessimistic that habitat degradation would cease unless more water was put back into the Waiau River.

The toheroa at Oreti Beach are considered by interviewees to be smaller than those at Bluecliffs Beach, with those at Orepuki Beach smaller still. A decline in both the size and condition of the toheroa flesh at Oreti Beach was noted by some interviewees: e.g.

> "*but they're nothing like what they used to be in size - some of them are getting to a good size, but you actually see the shells on the beach of the size they used to be"* (Interviewee S).
>
> *"the flesh inside is pathetic, compared to what it used be like"* (Interviewee J).

[31] Beentjes et al. (2006); Beentjes & Gilbert (2006a,b).
[32] Beentjes et al. (2006); Beentjes & Gilbert (2006a,b).
[33] Beentjes & Gilbert (2006a,b).

Environmental threats to toheroa populations

Interviewees considered that the major threat to the Bluecliffs Beach population is the increasing degradation of the habitat available to the toheroa. The beach has changed dramatically, with erosion and a loss of sand exposing rocks and gravel beds. At Bluecliffs Beach, the sand cover which is critical for toheroa existence has been reduced to 54% of its former extent, with the most rapid loss occurring during the 1980s[34].

All but one interviewee attributed the decline in toheroa at Bluecliffs Beach to habitat degradation from beach erosion and loss of sand to that was caused by the altered flow of the Waiau River when the hydro-electric power scheme in Lake Manapouri was established in 1972.

> *"I don't think the beach is right there anymore, because of the river. When they made the dam, that messed up the whole river"* (Interviewee E).

The local observers who ascribe the habitat deterioration at Bluecliffs Beach to the Manapouri Power Scheme had many and varied explanations for how the impact happened. Some thought the river supplied fine sands, so that the beach is now depleted; others that the reduced force of the water means that cobbles and boulders are no longer flushed clear of the beach and so have accumulated there; others that the torrents of freshwater used to "*cut the tide*" and force a back eddy in what is a predominantly west to east flow of water – this is thought to have deposited and held sand on the western side of the Waiau mouth in the past.

In addition to the major physical changes to the beaches in Te Waewae Bay, interviewees reported that currents within the bay have been altered. Much higher tides and large undertows are now being experienced. The local people are devastated by the loss of their beautiful sandy beach and now perceive Bluecliffs as an unsafe place to swim. This is important for toheroa because harvesting used to be associated with a *"day out at the beach*" to swim, meet other whānau (families) and learn from each other how to gather shellfish and flounder. Several interviewees feared that the beaches of Te Waewae Bay will continue to degrade causing toheroa to gradually dwindle away.

Interviewee H stated that there

> *"might be the odd patches where the gravel doesn't come up, but they will never be like they used to be and I think they will actually just slowly disappear"*.

[34] Beentjes et al. (2006).

Researchers too, fear that if the erosion continues, the toheroa population may be at risk of collapsing[35].

One interviewee, a local farmer of Papatotora, believes that the increase in the presence of gravel on Bluecliffs Beach was not so much because of decreased flow of the river, more because of the decrease in stabilisation of the larger sediments up river from the extensive deforestation that has occurred in the area.

One interviewee from the local community described a small increase in gravel at Oreti Beach in recent years. The small size of the patch is consistent with a 2005 estimate of sand cover at 94%[36].

The interviewees were unanimous that the major threat to the toheroa population at Oreti Beach is vehicles driving on the beach, especially those driving along the high tide mark where the toheroa kōhanga (nursery bed) sites are: e.g.

> *"Well the other concern I've got is on Oreti Beach, it's like Ninety Mile Beach, it's a recognised road. So all the idiots from town race along the beach and they're crushing those smaller toheroa"* (Interviewee V).

> *"They drive along the beach there right on the nursery. Because it's where the tide firms the sand but it's fairly well up you know. That's right where they drive along. That's where the spawn settles and that's where they start"* (Interviewee A).

For some interviewees the frustration clearly related to their disregard for the type of person or their activity on the beach, as well as the potential threat to the toheroa themselves:

> *"Sunday afternoon hoons, flounderers, booze cruisers. You name it, they are all there. And just blokes just hooning around on two-wheel motorbikes and four-wheel motorbikes. They have nothing better to do, that is why they are there"* (Interviewee D).

> *"Oh yeah there's vehicles on Oreti Beach every day. Sometimes not a lot of vehicles but occasionally there are quite a few. There's been a bit of work done on the effect of vehicles on toheroa on Ninety Mile Beach and I've got a paper from that study there and I've been on Ninety Mile Beach. I've actually looked there for what the vehicles are doing to toheroa and I wasn't 100% sure whether it was toheroa I was seeing, but I think it's quite a different situation. The toheroa seem to be a bit higher up the beach and I definitely saw signs of*

[35] Beentjes et al. (2006).
[36] Beentjes & Gilbert (2006b).

shellfish coming up through the sand after a lot of vehicle traffic passed. But I've never seen that down here at all. There seemed to be signs of, like the sand it was sort of breaking and the shellfish seemed to be coming up through the sand. I don't know whether there had been a certain amount of liquefaction[37] *or what, but certainly the shellfish seemed to have been coming up and there was a fracture in the sand. I just felt that it was different up there to down here anyway. I'm not confident that any work done up Ninety Mile Beach would be totally transferable to the Oreti Beach situation."* (Interviewee K).

Some of the kaitiaki believe that the threat of vehicles to toheroa recruitment is increasing:

"[*Traffic has increased] since this Burt Munro film, you know, since this* Fastest Indian*. But the bike race is no worse than having cars and things all driving round the beach"* (Interviewee A).

Some interviewees voiced their frustration that repeated attempts by the kaitiaki to have the traffic problem managed have not been heard. One interviewee referred to the Ministry of Fisheries people "*having their ears on backwards*". Nevertheless provisions of the Southland Coastal plan promulgated by Environment Southland were clearly designed to reduce the vehicle threat to toheroa:

"Well back in the coastal plan days, there was always concern about the effects of vehicles on beaches and we put a rule in the coastal plan that vehicles were allowed on the beach providing they were less than 3.5 tonne. This 3.5 tonne limit was deemed pretty arbitrary really. It just kind of provided for a certain sized vehicle and also there was motorbike races. There always used to be motorbike races on the beach a lot, well not a lot, sort of annually. They got banned I think through the coastal plan process because of concerns about toheroa" (Interviewee K).

"I guess [any vehicle impacts] are concentrated around the main [Dunns Rd] entrance. Yeah, say up to the first creek north of the main entrance it's probably a couple of kilometers or so; and then down to about the floundering spot to the south. That's where most of them will be. Other people go further taking their dogs for a walk as they drive down the beach or some people that go right down to what we call "the Spit", where the Oreti River comes out. People flounder down there as well. There are quite a few people

[37] This observer was referring to the way the pressure of the vehicle tyres causes the water to separate from the sand to form a small puddle. The Northland studies suggested that this triggers the toheroa to turn on its side in the sand and become vulnerable to being squashed when another tyre runs over the spot.

that go down on the beach to gather toheroa and you see quite a few parties out there. I presume that they've got permits. The south end seems to be the favoured end for gathering toheroa. You can go, or quite a few people take motor bikes out there, or a lot of those people go up to the north entrance. A lot of the motor bikes tend to head up towards the Waimatuku and some dune areas down there and play around quite a bit". (Interviewee K).

Oreti Beach is by far the most important beach for recreation in Southland[38], and taking a vehicle onto the beach is important for both practical and enjoyment reasons. For example, Interviewee K said:

"Oh on a hot day you get a lot of people down there that park, or swim and sit beside their cars. I think the car myself is an important part of the Oreti Beach experience. It provides shelter, you know if it's a nice day there can be a bit of a breeze, or if it is a bit cool you sit beside the car on the lee side of the wind. It just makes it a wee bit more comfortable. And the other thing is if you've got the car there you've got all your facilities there, and are not worried about somebody breaking into it. There's no real decent parking areas off the beaches anyway. Yeah all sorts of activities go on, people go out there and booze up, take their girlfriends out there, that sort of stuff".

Interviewee F feels that the traffic is preventing the toheroa recruits from "*getting through*", thus hindering population sustenance or growth. The juvenile toheroa are believed to be the most susceptible to vehicle impacts such as crushing, dislodgement and suffocation as they are positioned much closer to the sands surface (Interviewee W):

"the big toheroa can look after themselves. Even with cars going over they can probably handle that - but the further up the beach you go the softer the fluffier the sand the more juveniles you get. Anything that goes over them, any tyre, any motorbike, they are just going to get crushed and dislodged. So if you are really worried about them you wouldn't allow vehicles [to drive there] and a mâtaitai could look at that. East end first, make that entirely a no-vehicle-go area".

[38] Wilson (1999).

One local environmental manager has done an experiment to see whether vehicle traffic could be important:

> *"My friend and I decided to do an impromptu experiment. My mate just drove his car up and down the same wheel track about three times at quite high speed, I was quite impressed with how accurate he was actually. Then we just grabbed a spade or a shovel, I can't quite remember and just excavated the toheroa to see how many were damaged. I remember quite a few were apparently undamaged but around about 20 or 30% were damaged. But I thought we could have been damaging them with the spade when we were excavating. It was pretty impromptu. It was not overly scientific and you know they're very papery, the shells. They're quite vulnerable to being hit on the side by a spade when you dig them up"* (Interview K).

One kaitiaki (Interviewee V) was adamant that no traffic should be allowed below the high tide mark at all, right away and without the need for more research. Others were more concerned to have research done on the impacts before management responses were formulated: e.g.

> *"Traffic wise there is a whole lot of research needs to be done on toheroa, I feel, because simple fact is there is nothing been done on the impact on Oreti Beach of the traffic, the juveniles and all that stuff really needs to be looked into. I think that those sort of things should be looked into before a mātaitai is put into place"* (Interview X).

A recurring theme of the interviews was that only science, not mātauranga, would be listened to by wider society. Reference was made by one interviewee about how concerns expressed about vehicle impacts back in the 1990s were largely disregarded when the Coastal Plan was formulated because of a lack of scientific evidence of the threat.

The beach racing element of the Burt Munro Challenge[39] (an annual motorcycle event run by Venture Southland) also came under the scrutiny of some of the interviewees who fear it must also be having some impact on the toheroa beds. The use of a grader to smooth the track prior to the race (Fig. 5) has been witnessed to dislodge juvenile toheroa – as many as one every two foot along the 800 m track (Interviewee F). Furthermore the large number of bikes racing on the track and the spectators parking their cars on the beach were also concerns expressed by some interviewees.

[39] See URLs: http://burtmunrochallenge.southlandnz.com/ and http://www.aa.co.nz/motoring/news/Pages/2008-Burt-Munro-Challenge.aspx

Figure 5. Side view (upper) and end view (lower) of the 2006 Burt Munro Challenge beach race on Oreti Beach showing preparation of the track by a grader. Photos courtesy of Dallas Bradley.

In spite of this, not one of the interviewees stated that their concerns of the bike race were enough to wish it to be stopped. However some urged that it be moved to a more appropriate location on the beach. Interviewee W stressed that

> *"having the race in the middle [of Oreti Beach] is crazy – I understand the importance of the beach race to the people of Invercargill but there are other places [on the beach] they could have it. If I was in charge of the beach I wouldn't have any traffic on it ever. If you are really worried I wouldn't have any traffic to the east at all, particularly where that race was in 2008. They should be racing to the west of the entrance. I wouldn't allow any traffic any further than 2 kilometres to the east of the entrance, to protect the main eastern bed" (Interviewee W).*

Several observers reported that traffic intensity is significantly lower at both Orepuki Beach and Bluecliffs Beach compared to at Oreti.

Internationally there is an increasing concern of the damage to macroinvertebrate fauna on sandy beaches from recreational pursuits from humans, particularly vehicular traffic[40]. The behaviour of beach traffic has been recorded to predominate in the supra-littoral zone of beaches causing damage to the fauna there[41]. This is consistent with concerns of the interviewees with the kōhanga sites being threatened. Overlap of toheroa distribution and vehicle traffic on Oreti Beach, particularly around the Dunns Road beach entrance has been noted in one brief study[42]. Overlap however only indicates there is a chance that vehicles are having adverse effects on toheroa. The type, size class, speed, intensity and driving behaviour (straight versus swerving) of vehicles need to be explored as these may all influence traffic's putative impacts on macrofauna[43], such as toheroa. The testimony from our interviews and the upcoming review for Southland's Coastal Plan, has recently led the Waihopai Rūnaka and Environment Southland to commission an investigation into the vulnerability of individual toheroa to a range of vehicle types[44].

The major predators of toheroa identified in the interviews were both black-backed gulls (*Larus dominicanus*) and red-billed gulls (*L. novaehollandiae*) and pied oystercatchers (*Haematopus ostralegus*). Interviewee W felt that if toheroa are weakened by some factor (e.g. vehicle damage)

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[40] Schlacher & Thompson (2007).
[41] eg Van Der Merwe & Van Der Merwe (1991).
[42] Gray (2004).
[43] Schlacher et al. (2008).
[44] The first report from the vehicle impact studies (Moller et al. 2009) was tabled at the same time as this report of the interviews that helped trigger the vehicle impact investigation.

then they will be more prone to being *"picked off by gulls".* Predation of toheroa by sea birds should not be under estimated as a threat[45].

> *"The other thing about the juvenile toheroa is quite often you'll see a little patch of oyster catcher poop that's got heaps of baby toheroa shell in it"* (Interview K).

Interviewee I also mentioned that flounders are predators of toheroa:

> *"My Father and my brother they were both really keen on floundering…..and that is what the flounders lived on, was the toheroa. You gutted them [the flounders] and you would find all these suckers in them because the toheroa would come up from the sand and the flounders came and nip them all off. So I supposed the toheroa died."*

Studies on predation of siphonate species by flat fish like flounder have found that siphon cropping causes a decrease in burying depth of benthic bivalves, thus increasing their risk of predation by probing predators[46].

Pollution of surrounding waterways was repeatedly identified by the interviewees as a likely threat to the health of mahinga kai. One interviewee also believed that landfills close to the coast will be having a similar effect.

Several interviewees considered that climate change influences the survival of toheroa to some degree, particularly in altering the weather and tidal patterns.

Many of the interviewees have witnessed the result of mass mortality events of toheroa and tuatua on southern beaches. This phenomenon results in large number of toheroa "*washing up*" on the beach. They appear to no longer be able to burrow back into the sand and thus perish on the high tide mark (Interviewee K). Some kaitiaki that frequent the beaches believe that die-back events are occurring more frequently. Some interviewees thought that habitat degradation and die-back events place a double jeopardy on the toheroa, i.e. that die-backs are more frequent because of habitat degradation and population recovery is slower because the habitat is poorer.

From the discussions there appears to be two different set of events causing these mass die offs. Many of the interviewees are of the opinion that toheroa are dislodged when stormy easterly weather prevails and that the shellfish are stranded by being washed up in 'windrows' at the top of the beach. However, others have witnessed the die-back events during calm weather and the

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45 As warned by Brunton (1978).
46 Zwarts (1986); de Goeij et al. (2001).

toheroa die strewn all down the beach, suggesting starvation, pollution, biotoxins, disease, high levels of freshwater and temperature-related factors were all possible causes. Interviewee P believes that an increase in the frequency of die-backs *"could be very detrimental"* to the toheroa populations.

Harvesting as a threat to toheroa abundance

In general the interviewees considered that current harvest levels were probably sustainable at Oreti Beach, but that they could be an increasing threat at Bluecliffs Beach because of the declining population there. The participants made several comments about the management issues and challenges around past and present harvest practices.

Humans' natural sense of greed was alluded to several times as being the cause of any unsustainable harvesting activities occurring. Interviewee G2 affirmed this by saying:

> *"Probably the average farmer goes down and gets a catch and is happy, but then you have got a certain number of people that go down there to see how much they can catch"*.

There is concern within the communities that there could be as much illegally harvested toheroa coming off the beaches in Murihiku as there are authorised extractions. Furthermore, there is concern that people are taking more than they are authorised to. Interviewee T described people's greed being alike to speeding while driving:

> *"It's a bit like driving your car isn't it? It doesn't matter if they feel comfortable doing a hundred km/hr, they will still want to do a hundred and ten, aye. So if people go to get twenty-five toheroa, they just go,'oh, I might just take twenty-eight' "* (Interviewee T).

Another concern is that some harvesters with authorisations are "double-dipping", using their authorisation to make a second illegal collection, by gathering on both the morning and afternoon tide on the same day. Some may apply for authorisation to gather from each of the two harvesting areas (Ōraka-Aparima and Waihopai). There are also fears within the communities that people are poaching toheroa for monetary gain (e.g. "*raffling them off at the pub*"). This is regarded as highly offensive and very abusive of the resource (Interviewee Q).

Some interviewees acknowledged that they personally did not always seek an authorisation for their own harvests. This was mainly for philosophical reasons as these people believed they had a right to harvest and considered seeking an authorisation to cut across their own agency. One Tangata Tiaki termed this type of illegal harvest as "customary harvest" and felt it was not a large threat as he knew they would be harvesting the resource in a respectful way. However, any form of poaching will go unrecorded in the Tangata Tiaki's records, leaving them within incomplete information for management purposes. Illegal harvesting is difficult to monitor, particularly in isolated areas such as Bluecliffs Beach. Furthermore, monitoring efforts within Murihiku are stretched with only two fisheries compliance officers designated to monitor the coast for all types of fisheries. With Tangata Tiaki's role only extending to the education of harvesters, some interviewees feel that perhaps it would be advisable if they also had more legal authority to prosecute those caught collecting without authorisation or exceeding the limits.

The recurring historical threat that was discussed in the interviews was the "Open Days" where the beaches were opened to everyone to harvest over a single weekend after years of banning all harvests (Fig. 6 & 7). Although these harvesting events were managed by the (former) Ministry of Agriculture & Fisheries[47], they were perceived as a great risk to the sustainability of the toheroa populations due to the sheer number of people that attended these events, the human's deep-seated greed and damage to the beds from vehicles and disturbance of the sand. The large amount of publicity prior to the open day was thought undesirable, as described by Interviewee G2:

> *"it is perhaps a pity with the open days - just so many people turned up and it was pretty hard on the toheroa beds."*

Interviewees were unanimously appalled by the "Open Day" harvests, some describing them as *"the silliest thing that could ever be done"* (Interviewee V), *"a terrible experience"* (Interviewee J) and *"a circus"* (Informant W). There was a clear denunciation of the "Open Day" events as disrespectful of the kai and the beach in a general sense, quite apart from the direct impact of the harvest and digging. Given the current state of the toheroa resource, any further Open Days would be a threat to the survival of populations. Other interviewees pointed out that the stop/start nature of "Open Days" damaged the transmittal of knowledge and respect for the resource and tika (ethical) customary practice. A recurring theme was the way the stop/start approach to harvesting also encouraged waste: Interviewee I stated that the "Open Days" *"did a lot of harm, no doubt" and* Interviewee M said *"The only feeling I've got about it [the "Open Days"] is there's too much waste, end of story"*.

[47] The Ministry of Agriculture & Fisheries (MAF) formerly managed fisheries and agriculture. These functions were split in 1995 so that fisheries are now managed separately by the Ministry of Fisheries ('MFish'). Several interviewees still referred to the current government body as MAF where they clearly meant MFish.

Figure 6. Oreti Beach 1993 Open Day. Collage supplied by Dallas Bradley, photos taken by Deidre Francis.

Figure 7. Series of photos from past Open Day seasons at Bluecliffs Beach. Photos taken by Bill Howden of Tuatapere.

Many people who participated in the "Open Days" appeared to have no knowledge of how to process toheroa and hundreds of thousands of unshelled toheroa ended up in the local dumps. Interviewee Q's insight on management of a resource such as toheroa is that

> *"The thing about resources, it's not about the shortage of it, it's about the utilisation of it …. the only thing that you should waste is actually the shells".*

Interviewee F felt that the "Open Days" were highly offensive to Māori customs:

> *"Oh no, I'm not keen on it at all, I don't think it's a good way to manage the fishery. In Māori custom – you only take what you need, and some things you also take enough to sustain you for the year, but with those events there's so much waste. And in Māori custom you're related to those things in whakapapa. So with all harvesting there's karakia because yes it was alright to harvest to feed oneself and ones own, but not to waste. You should absolutely not waste anything. We've had reports of hundreds or thousands of toheroa ending up in the dump [after the open days]. That's the reality of what happens. You know that's a real crime in our culture for that to be happening"*.

The current customary regulations and steady minimal harvesting was seen as much preferable to the earlier management by the Ministry of Agriculture & Fisheries using seasonal and annual prohibitions to moderate overall harvest.

Traditional management and tikanga

Tikanga (customary rules and practices[48]) and mātauranga associated with toheroa and mahinga kai seek to ensure minimal disturbance to the toheroa populations. Together they have guided natural resource use for centuries in Aotearoa New Zealand[49]. Some of the teachings referred to were meta-physical in nature, some referred to general values and beliefs of humans and their relationship to toheroa and mahinga kai, some to "resource use rules" that clearly are designed to protect the resource, and others to particular customs while harvesting the toheroa. Examples of the latter are the way karakia (prayers) used to be said before a harvesting event to ensure the harvesters' safety. Some interviewees were taught to return their first catch. The purpose of this tikanga was described by Interviewee J as an "*acknowledgement of thanks*" to Tangaroa (God of the sea[50]) who supplied the gift of kai moana to them – some acknowledged that this custom was probably of negligible

[48] Cultural rules of use and other social mechanisms employed by indigenous people have been demonstrated to support sustainability in a wide variety of ways (Gadgil *et al.* 1993; Colding & Folke 1997, 2001; Berkes *et al.* 2000, 2003; Berkes 2008).
[49] Roberts et al. (1995) ; Kawharu (2002) ; Kitson & Moller 2008 ; Moller et al. (In press b, c).
[50] http://en.wikipedia.org/wiki/Tangaroa

direct effect in conserving the stocks, but had much wider and more fundamental value in reminding the people of their mutual relationship with the sea and its resources, and their responsibility to treat it wisely so that it would treat them well in return. Recurring overarching themes to emerge unprompted in the interviews were ones of respect for the environment and other people and the reciprocity between people and the taonga, in this case toheroa. These broad themes are reflected in several other customary harvests by Māori in New Zealand[51], and the views were clearly shared by many Pākehā participants in this study.

The need to respect the resource was a recurring theme when the interviewees spoke about harvesting their kai moana. Interviewee B described this attitude as:

> *"But I believe we always did it with a sense of preservation and not wishing to abuse the source, but it wasn't a consciously taught thing. I don't quite know how to quite explain it but we never went out to exploit it. And we knew we shouldn't. We just knew that and that must have been the result of the values we were raised with around mahinga kai".*

Another key teaching from their elders was to only take what you need for a feed, and perhaps some to share with other whānau in the community. Interviewee H explained this by saying:

> *"You only took what you wanted. You only cooked what you wanted. Went down and got them, you never wasted them, you just got what you wanted and used them because they were there and we were allowed to take them. The wasting didn't start until they started seasons* [closed periods with occasional "Open Days"]. *And it's like everything else, it is just greed."*

In most cases in the past a whānau would gather 5-10 large toheroa on a single gathering expedition, or more if they were going to gift food to relatives or neighbours. In general they harvested 1-2 per person they intended to feed.

There was much unprompted kōrero about the threat posed by freezers, especially when coupled with loss of the tikanga around only taking what you need. As a general rule, the kaitiaki much preferred to eat fresh kai moana, especially when harvesting shellfish, but they considered overall harvest pressure on mahinga kai had gone up in recent decades because freezers allowed occasional harvesters to take bulk quantities. A related concern was that compared to when our participants were children, most people now had cars and some had boats. In the past whānau would either walk or bicycle to the Murihiku beaches to gather toheroa, and so they generally went for a longer day

[51] Kitson & Moller (2008); Lyver & Moller (In press); Moller & Lyver (In press).

outing with lots of other whānau members or other whānau altogether. These days the gathering experience was more solitary, and more people could do it easily because most have access to cars or even four-wheeled drive vehicles. One informant believes that the number of four-wheeled drive vehicles has increased markedly over the past decade in particular and this potentially increases the threats of damage to beach ecology[52].

Interviewees were taught never to shuck or eat the kai moana on the beach below the high tide mark. Toheroa shells are never thrown on the beach, because

> *"people don't live in cemeteries, so you don't throw your shellfish back in the water where the live ones are"* (Interviewee O).

These rules are believed to revolve around respecting the resource so that it persists in the area. As young children, the interviewees were taught to never use implements to harvest toheroa. This was designed to protect the toheroa from damage and minimise disturbance to the shellfish beds. Toheroa shells are remarkably brittle, so even using a "*wooden spade*" risks damaging the shellfish, then making it harder to prepare, and more likely, to it being left on the beach to despoil the mahinga kai. Interviewee C expressed that *"you just don't go shellfish digging with a spade"*, and went on to say that this would be *"cheating"* and *"you need to minimise disturbance in the toheroa beds"*. The strict teaching to only use hands (or feet) when harvesting toheroa was explained by Interviewee C as: *"It's a matter of conserving. Don't over disturb things"*. Similar strict taboos were to avoid the kōhanga areas (nursery beds), always return undersized shellfish, take only what they could eat for one feed and to never, ever waste them.

The juvenile toheroa are thought to be the most susceptible to the potential risk of the excavation surveys as described by Informant F:

> *"It's better to do it by hand, then you're not going to damage the little ones, because the smaller ones their shells are thinner and if you damage their shell they are not going to survive."*

Should an undersized toheroa get damaged while harvesting with an implement, it cannot and should not be returned to the population.

[52] Moller et al. (2009).

Disturbance adds "harvest pressure" on the recruits before they can contribute to the population sustainability. Furthermore the use of implements can also damage the quality of the kai as broken shells full of sand are much harder to prepare for eating. Informant A stated that:

> *"Some of them would have forks stuck through them and that sort of thing and sand all in it [laugh] just an absolute… like something that you'd boil up and give to the pigs".*

This illustrates the strength of feeling of some of the kaitiaki about digging. Not only are toheroa being damaged during harvesting and scientific surveys using implements, and thereby violating tikanga, but also digging with implements is reducing their valued kai moana to being something fit only for the consumption of a animal of perceived lesser value. It is another example of the kaitiaki's abhorrence of waste, but also the recurring expression of the frustration of some kaitiaki that scientists and ignorant harvesters are disregarding traditional teachings that were designed to protect the resource.

Some interviewees were also taught to distribute their harvesting effort across several large patches of toheroa and to leave the less dense beds alone. A similar teaching for managing pāua (*Haliotis iris*) harvesting was mentioned by one of our interviewees – he was instructed to always leave two big pāua in the same pool or rock crevice.

Some kaitiaki believe that harvesting strengthens the resource. For example, Interviewee A noted that the 'thinned out' toheroa beds in the traditional harvest site at the southeastern end of Oreti Beach were the first to rebuild after a die-back event. Far from the traditional western preservation-oriented view that harvesting inevitably adds risk, some kaitiaki believe the reverse provided that traditional tikanga is applied in management.

Interviewee A was taught that toheroa with dark coloration on the shell are the older individuals, which make up the breeding population, and should not be harvested. We later found that some of these collected darkly coloured adults lost their colouration when we held them for two days in the laboratory[53]. This suggests that the colouration is a surface contamination in the shell's pores and we found dark sand at the lower depths of the quadrats that we dug for ecological surveys. As the adults dig deeper they are indeed more like to be discoloured, and the larger shells definitely are more likely to be darker on average. However we think that the temporary and external nature of the colouration probably indicates that we will find only a very loose correlation between dark

[53] The specimens were held in aerated seawater while awaiting bioassays.

colouration and breeding activity, and what relationship that exists is more likely to be driven by size of the animal rather than its colour.

Some interviewees were taught to restrict the toheroa harvest to only medium-sized individuals, therefore leaving both the new recruits and the breeding stock alone. Interviewee V made an analogy to this teaching to a how a farmer is most productive:

> *"A farmer doesn't breed from the smallest stock he's got, he breeds from the biggest and strongest"*.

There was recurring mention by the interviewees of this general principle – leave the larger breeding stock alone by setting a maximum size limit so the breeding stock can reproduce for years to come. Many interviewees, even some that did not follow the tikanga for toheroa, stressed that leaving the large breeders was a valuable teaching of their tupuna that is generally ignored in the western fishery management regimes. Some interviewees expressed interest in follow-up research to test whether it is indeed best that the larger toheroa are left unharvested. It is possible that the very largest ones are generally spent, or have reduced number or quality of offspring. The *Te Tiaki Mahinga Kai* research team is hoping to launch a long-term research and mathematical modelling programme to test these general rules of thumb as more resilient harvest management strategies.

Nevertheless, most interviewees particularly targeted large toheroa and disregarded their colour and the customary permits are usually issued with a stipulation of a minimum size (100 mm), not a maximum size.

Traditional re-seeding techniques: translocations, feeding and burying kelp

The movement of toheroa to beaches with no previous known beds is regarded as a traditional stock enhancement tool (Interviewee F). Many of the interviewees are aware of past attempts to translocate toheroa to new beaches within Murihiku including Orepuki, Wakapatu and Colac Bay and beyond (e.g. Moeraki). Translocating toheroa is recognised as a customary practice for the maintenance and enhancement of toheroa (Interviewee F). The philosophies behind past translocation efforts were ones of both conservational concern and the desire to spread the fishery across the area for more people to have access to it. In the past when travel was more difficult, a practical solution was to seed new mahinga kai close to where they live for most of the year.

Both Interviewee F and R alluded to the use of poha (bags of the lamina of 'bull kelp'[54]) to transplant toheroa spat in. The original source of this kōrero has passed away and unfortunately the finer details of his methodology were not captured in this present study. Poha may provide protection and nurture the toheroa spat in their new location in order to help them establish.

The main kaitiaki initiating translocations in living memory of the informants was Jack Te Au (Fig. 8). Jack was a local farmer who devoted much of his time to toheroa surveillance and management at Bluecliffs Beach in particular, especially in the 1950s until the mid 1960s. He guided gatherers to the best spots on the beach where the toheroa were most abundant and largest and eventually became an Honorary Fisheries Officer with the Ministry of Agriculture & Fisheries. Jack and some other local kaitiaki were particularly instrumental in seeding a new population of toheroa on Orepuki Beach, at the eastern end of Te Waewae Bay. No clear information was provided about how many toheroa or on how many separate occasions Jack moved toheroa from Bluecliffs Beach to Orepuki Beach, however he was known to "feed them" there.

Interviewee D shared the following passage about his own personal transplanting efforts of toheroa to Orepuki Beach:

> *"Many years, about 50 years ago, there was no toheroa on the Monkey Island end of Te Waewae Bay. So an old chap Te Au was the honorary ranger way back at that time. And we said to him now we are going to be taking a few more than what we are supposed to be having.[He asked] "Why?",[to which we replied] we are not going to be using any of the ones we are able to take, but we would like to take a few more. We are going to take them down to what used to be known as Kaitangata Point, which is back this way [west] a wee bit from Monkey Island, and we are going to plant them on the beach. So we did that a couple of times and never told anybody that we had put them there, and we just kept an eye on them to check they were surviving. Then they must have started multiplying. Unfortunately some of the locals found them, so yeah, they got a bit of a hammering. But to the best of my knowledge they are surviving quite well down there"*.

This interviewee estimates that he moved approximately fifty adult toheroa to the middle of the Orepuki Beach, near Kaitangata Point (Fig. 2) in each of three successive years.

[54] Bull kelp is *Durvillaea antarctica*. Southern Māori have for centuries formed it into bags for transporting and storing food, and the practice continues today amongst some mutton birding families.

JACK TE AU.

Figure 8. This picture of Jack Te Au was taken sometime around 1962 on Bluecliffs Beach by Bill Howden.

The latest recorded transplanting event was the efforts of another informant from the Bluecliffs area, who recalled:

> "*We did our ones* [transplanted toheroa] *about twenty years after Jack, and took about two or three hundred from Bluecliffs, around Whiskey Creek……all in one go. We swung them in our backpacks on our motorbikes, shot round the road to Monkey Island and threw them down where the freshwater stream comes down between Gemstone and Monkey Island. We dug a trench down at low tide and just buried them in there in a long row and just let them go. So we are not sure if our planting survived or if Jack Te Au's had survived and carried on. We just think we helped the population grow and establish"* (Interviewee X).

The origin of the Orepuki Beach toheroa population is of particular interest to the kaitiaki who are concerned that if active management is not undertaken in the near future the Bluecliffs Beach, toheroa may become extinct in Te Waewae Bay. Interviewee D expressed this by saying:

> *"Now what has been concerning me for the last while is that their habitat around here [Bluecliffs Beach] is decreasing markedly. I'd say from what it originally was it will be down to less than a quarter of the habitat for them on the coast round here. My biggest concern was if we don't try and shift them somewhere else and get them established we are going to lose them".*

Jack Te Au experimented with active "*feeding*" of the Bluecliffs Beach population and the founding populations in translocation sites. Jack's support of newly establishing and vulnerable populations is akin to the 'soft release'[55] strategies used by conservation biologists in recent decades for species recovery programmes. One interviewee knew Jack very well and spent a lot of time with him. He was told by Jack himself that he first thought of feeding the toheroa by noticing that they grew larger and had better condition in spots on the beach where an orange/brown seepage flowed off the cliffs or where small creeks flowed onto the beach. He reasoned that the water was providing nutrient or particulate food particles (presumably phytoplankton and other organic food particles[56]) for the toheroa.

It was described that Jack used a small Massey Furguson tractor and plough to make furrows parallel to the water line into which he placed "*the feed* [so that] *the tide would come in and wash it through the toheroa [beds]"* (Informant E). The ingredients of this "feed" have not yet been confirmed,

[55] Brown & Day (2002).
[56] Marine ecologists call these particles the 'seston' (Gardner 2008).

although at least one other community member is familiar with the recipe[57]. One informant considered it to have been masses of rolled oats and had been shown the grocery bill by a bemused family member who pointed out that they couldn't possible eat so much porridge! However another informant is adamant that the mixture was not oats or porridge, but a "natural product". We do not know how to resolve this conflicting testimony – either Jack devised a range of different feeds, or perhaps he abandoned using oats and substituted a more successful or cost effective material after trialling oats?

Jack was assisted in repeatedly applying the feed to areas at Wakapatu and Colac Bay where he had earlier translocated toheroa. Jack's entire quest for finding a supplementary feed for the toheroa was obviously prolonged, expensive and ultimately may have helped the establishment of the Orepuki Beach population. Several of the interviewees believe the secret mixture had a positive effect on the growth rate of the toheroa. This, when coupled with his constant vigilance through the 1950s and early 1960s, and his guidance of toheroa gatherers on Bluecliffs Beach, is an inspirational story of a local kaitiaki taking immense interest and responsibility for enhancing and protecting the toheroa in Murihiku.

One kaitiaki was taught to actively bury the kelp in the sand that had blown up on the beaches. As children they were required to "*give the kelp a start*" by burying a small bit of it to ensure it stayed and eventually became totally covered in sand. He reported that there was a connection between buried kelp and toheroa:

> *"where that kelp* [got] *buried you'd get an amalgamation of toheroa…… and they'd be good fish as well" (Interviewee A*).

However Interviewee A also fears this teaching has been lost and due to less kelp appearing on the beaches, and believes it is even more important to bury it now than ever. From Interviewee A's training in the use of kelp he believes there is a possibility that by burying kelp the health of a sandy shore could be restored. He wishes that a formal experiment is conducted to test the effectiveness of buried kelp on toheroa populations.

[57] This interviewee had promised that he/she would not tell anyone what Jack used and had burnt a notebook after Jack died in which he had recorded several systematic trials of different feeding regimens.

Continued customary practice, education and awareness

Several interviewees expressed concern that people are losing their relationship with mahinga kai and are not being taught gathering skills and appropriate tikanga to protect the kai species. Interviewee Q stressed this by saying:

> *"I think the younger generation are actually getting further away from mahinga kai, not because they want to, it's because it is not a necessity [now]"*.

Several kaitiaki expressed concern that their people do not now know how to search for, open or prepare traditional kai such as toheroa. There is a need to ensure future generations can continue to harvest their traditional kai and gain the hands-on experience needed to maintain knowledge, identity, spirituality and sense of place[58]. It is from this experience that the connection with mahinga kai will be rekindled and the traditional sustainable management will be upheld. Educating and reconnecting the younger generations with mahinga kai were identified as priorities to help successful toheroa management. In order to learn the tikanga and more importantly to understand why they exist and how they work the community needs to be engaged with hands on experience/training. Informant U expressed this by saying:

> *"I think you do have to experience to know because otherwise it's just a nice story and you know, you don't have the feeling and understanding behind it".*

The main damage to knowledge regarding toheroa management resulted from the fishery being closed for prolonged periods. Some interviewees were concerned that there is less opportunity for elders to teach the tikanga and pass down their knowledge. Some particularly knowledgeable members of the Murihiku community are becoming frail and have not had the opportunity to pass their teachings on (Interviewee A). Given that toheroa is no longer relied on as a staple food, the tikanga surrounding it is gradually being lost. The Tangata Tiaki themselves expressed their distress that some of their people are not fully aware of the tikanga and the traditional ways of processing their kai. Interviewee F is concerned that the lack of following tikanga will be detrimental to the mahinga kai resources and Interviewee N emphasised that people need to be taught how to correctly prepare their kai to ensure wastage does not occur.

There is a growing realisation that in order to conserve the traditional knowledge and teachings there needs to be an active effort to get the Tangata Whenua down on the beach seeking the hands-on experience. One Tangata Tiaki stated that it is not a matter of telling your people how to do it

[58] Kitson & Moller (2008); Lyver & Moller (In press); Moller & Lyver (In press); Moller et al. (In press b, c).

but of showing them. There is a call from the kaitiaki to get their people, especially the younger generations, down on the beach and actively aware of the toheroa and other kai moana resources. If this connection is not rekindled soon, no-one will be knowledgeable of traditional ways of managing their taonga species. A managed transition to new Tangata Tiaki should be actively sought to ensure that the current knowledge is retained and applied to future management.

Current and future harvest management

The interviewees were generally happy with the current customary harvest management system (customary authorisations) in relation to sustainable management: e.g.

> *"I think it is good that it [toheroa management] is under kaitiaki-ship, definitely"* (Interviewee J).

Similarly Interviewee T felt:

> *"it does feel successful ... we are gaining a wee bit of knowledge and understanding of how much is being accessed"*.

Interviewee D agreed that the current harvest management is helping to slow the decline of the toheroa and Interviewee N shared her thoughts on how it ensured the wastage of the resource was controlled:

> *"And I mean obviously these people that do come and get the permits must know what they're doing because they wouldn't be coming up there. But if you just say there's an Open Day, like how they used to announce it over the radio. People used to just flock out there in the thousands and didn't know what they were looking for. But as I say, the way things are now with the permits, they know what they're looking for and they wouldn't waste their petrol and time going out there."*

However, there was some resentment amongst the older locals who feel that the authorisation system has restricted their access to their kai. Interviewee H expressed this by stating:

> *"I hate going to get a bloody permit! Because as I say I am 70 years old and I have been eating toheroa off that beach and all that and I don't see why I should have to get a permit. I do get permits, because I got too, but I don't see why I should have to get a permit. Because as far as I understand we are allowed our kai. It's a violation of freedom [to have to get an authorisation]. Put it that way. I don't go down there and take toheroa and waste them. If I want a feed of toheroa, well I can't just go down and get them now [without first*

seeking an authorisation]. We just used to go down and got a feed and we ate it! And that was it. I know it is a law and all that jazz, but it just seems like our freedom has been taken off us".

Some interviewees pointed out that Tangata Tiaki need to have the expertise to ensure that the toheroa are managed properly. They are providing an important service to the community, while still protecting the species. Interviewees describe a successful Tangata Tiaki as an individual who:

- has an understanding of the fishery.
- holds traditional knowledge.
- can *"handle power and authority okay".*
- is available.
- is able to regularly visit the beach and see for themselves how the resource is going.
- is honest and has integrity to say 'no' to an application when need be .
- is well respected and has mana (standing, authority) within the local community.

One of the main concerns voiced (Interviewee Q) is the lack of monetary support for Tangata Tiaki. The person appointed to the position should not be dependent on regular work for an income, and it should be ensured that they are available to provide the service. Additional concerns were raised that ill health and age of the Tangata Tiaki prevented this active surveillance and monitoring. Clearly, there is a need for an actively managed transition of knowledge and responsibility to younger local Māori who know the history of the area and local community. Only one of the Tangata Tiaki interviewed alluded to having an "*understudy*", somebody that they are encouraging to learn the traditional ways and sharing their knowledge with. There seems to be a gap in the system with Tangata Tiaki aging and no-one coming through that has learnt the intimate knowledge of the resources from the past Tangata Tiaki.

One Tangata Tiaki stressed the importance for the harvesters reporting back about their take, and that this was vital to protecting the resource. It has also been suggested that Tangata Tiaki should be present when harvesters exercise the customary authorisation, to ensure compliance and prevent 'double dipping' from occurring. Interviewee T stated that:

"*the customary permitting system would work better if the kaitiaki were given more authorisation to go and approach people and to go and talk to people [harvesters] and be recognised as such"*.

Interviewee X also believed that Tangata Tiaki should have more legal authority over people who harvest illegally. However other kaitiaki stated firmly that compliance and enforcement is seen as fundamentally the role of Ministry of Fisheries, even though the kaitiaki are the eyes and ears that can assist with surveillance to make the fisheries jobs easier and more effective.

Tangata Tiaki stated that authorisations to harvest toheroa would only be given for a significant, worthy occasion within the rohe:

> *"They would need to have a good reason, and we don't give them a lot because it is just a taste"* (Interviewee F).

Authorisations were often granted for elderly or ill people, special family events, occasionally for civic occasions at Tuatapere and never simply for a party. The ethnicity of the applicant was not considered in the decision about whether to grant the authorisation or not. Indeed the kaitiaki expressed a strong value of manaakitanga and a duty to feed their people and visitors.

Tangata Tiaki from Bluecliffs Beach said they attempt to reduce the number of the toheroa harvest in order to reduce the harvest pressure on the declining population which they believe is very vulnerable at the moment. Interviewee D described that they may turn down up to fifty percent of requests for harvesting toheroa from Bluecliffs, whereas Interviewee F suggested that the Waihopai Rūnaka are turning down approximately ten percent. Even when the authorisation at Bluecliffs was granted, the number allowed was nearly always reduced from that originally requested by the applicant.

Current monitoring issues

The current scientific population monitoring regime for the Murihiku toheroa populations is a 3-4 yearly survey conducted over 17 km at Oreti Beach and 5 km at Bluecliffs Beach by NIWA under contract to Ministry of Fisheries. The Orepuki population has not yet been included. The surveys involve the excavation with spades and the sieving of sand from quadrats placed 5 m apart from the sand dunes to the low water mark at a series of points along the. The density of toheroa found in these quadrats are then extrapolated to give an estimate of the toheroa populations present at each of the two beaches. Most interviewees were accepting that digging toheroa for science was necessary and valuable for sustainable management. However, two felt very strongly that digging should not be allowed even for scientific studies, two others would prefer an alternative if one can be found, six wanted the digging to only be by hand, and one interviewee considered the information return justified the risk but urged the researchers to be as careful as possible.

Informant D said:

> *"they are using shovels and forks. If that doesn't scrunch up the small ones I would love to know what does! No it does not impress me at all".*

Nevertheless there was a general affirmation that the inclusion of science in customary management of toheroa is needed and valuable eg.

> *"It's only through science that sometimes we know that the things we are doing are wrong, aye. Or even justifying that we are right, that we're okay"* (Interviewee T).

One interviewee who was very critical of the scientific surveys using spades was also sceptical about the science "*just getting the numbers*". He believes that the key for understanding the population changes is reflected in the condition of the shellfish and recalls some years where the volume of flesh from shucking shells was less than half what is normally encountered:

> *"They count them to see what's there which tells them absolutely nothing because you know you can have a shell that big and it's got nothing in it, it's the state of the fish itself that tells you whether it's healthy or under stress"* (Interviewee A).

The "skinny" ones didn't taste nearly as nice as when they were "fat", but most importantly an understanding of why the condition was fluctuating was seen as a key lead to understanding why the population itself fluctuates.

Toheroa restoration management

One restoration option discussed in the interviews included the construction of groynes, in an attempt to capture the sand onto Bluecliffs Beach. The majority of the interviewees felt that groynes would be a waste of resources, voicing opinions such as *"It's against nature"* (Interviewee C), *"Oh, that would be impossible"* (Interviewee I), *"Do you think that you can beat that [the sea]"* (Interviewee H) and *"I don't know, she would be a pretty big undertaking that, wouldn't it?"* (Interviewee O).

Although enhancing the existing toheroa beds was not mentioned within the kōrero of this present study, there is certainly scope for the use of this technique in the future. Kaitiaki from Northland have been developing a restocking regime over the last 20 years, transplanting toheroa between

40-60 mm to lower density areas within their historic range[59]. One kaitiaki from Taitokerau disclosed[60] that climate, sediment, beach projection and moisture are all important for successful translocation. The kaitiaki from Murihiku would benefit greatly to learn from the Northland kaitiaki who have had many years of trial and error efforts to develop their methodology. This technique could be used to successfully enhance the number of spawning adults at both Oreti and Orepuki Beaches. We recommend that a study tour or invitation to bring the toheroa kaitiaki from Taitokerau down to guide Murihiku management be organised in future if at all possible[61]. Research of ways of "feeding" toheroa in the way Jack Te Au has pioneered and then applying the method to the existing population at Orepuki Beach could potentially accelerate its population growth.

Using a mātaitai reserve to protect the toheroa was urged by some kaitiaki. However, concerns about the local community feeling disadvantaged and issues of compliance were also raised. The main advantage identified by interviewees from having a mātaitai reserve was the possibility that its regulations could ban vehicle traffic on the beach to enhance toheroa recruitment. Clearly having a mātaitai reserve at Bluecliffs Beach can do little to counteract the issue of habitat degradation which is presumed by most of the kaitiaki to be ongoing.

Given the extensive and probably ongoing habitat degradation at Bluecliffs Beach, restocking and enhancement by supplementary feeding is probably no longer an option there. Finding new sites to introduce toheroa into is the logical alternative. Indeed, all the Tangata Tiaki considered that translocation is the only remaining practical option to protect the Bluecliffs population that has been impacted by severe (and probably ongoing) degradation. Typical quotes included:

> *"My biggest concern was if we don't try and shift them somewhere else and get them established we are going to lose them"* (Interviewee D)

> *"It's all about looking after them and it's dangerous to only have one or two populations of anything. I'd hate to lose anything"* (Interviewee F).

The majority of marine resource translocation examples within the literature are undertaken with the primary incentive for ensuring commercial fisheries (i.e. for monetary gain) and also to support community's growing populations[62]. However, given the obligations of kaitiaki to ensure kai moana

[59] Akroyd (2002).
[60] Kōrero at Te Tiaki Mahinga Kai's forum hui at Whakatāne in February 2009.
[61] Two kaitiaki from the Kapiti coast attended *Te Tiaki Mahinga Kai*'s Forum meeting in February of this year and expressed a similar wish to network to pool knowledge for restoration management.

[62] e.g. Richards et al. (1994).

stocks are there for their mokopuna (grandchildren) and the limited distribution and taonga status of toheroa, sufficient motivation is provided for the active management of this resource to ensure its persistence for both cultural health and wellbeing and biodiversity conservation reasons. To restore toheroa populations in Murihiku to resemble historical numbers is desirable.

Sealers' Bay beach on Whenua Hou and the beaches west of Sandhill Point (towards Puysegar Point) were repeatedly mentioned as potential sites to receive translocations. However, Interviewee H asserted that toheroa should only be shifted to beaches within their current range (i.e. between Oreti and Bluecliffs Beach) and that anywhere other than this would be unnatural. The philosophy behind this is that if toheroa were meant to live in a certain area, then a population would be there already. It was also voiced that source populations should come from within the area (i.e. not shifting Oreti toheroa west of Te Waewae Bay). Interviewee D feared that bringing Oreti toheroa towards the west would be *"shifting them completely out of their environment"* and had a feeling they may not *"cope"* as well as those sourced from within Te Waewae Bay itself.

Aspects of toheroa ecology need to be thoroughly considered during the process of selecting translocation sites to ensure high success from translocation efforts (Interviewee K)[63]. Interviewees recommended that habitats for receiving translocated toheroa should ideally include features such as exposed beaches, fine sands, large intertidal zone, ample food supply, freshwater seepage and minimal human disturbance. Interviewee W also contended that potential translocation sites must feature a counter-current system to ensure spat is self seeded back into the source population to ensure successful recruitment. The presence of other shellfish may also need to be considered, as toheroa beds are reported as being solely toheroa and their interactions with other intertidal clams is therefore unpredictable (i.e. competition may prevent the translocated populations from reaching the 'Minimum Viable Population Size' that secures the new population[64]). Interviewees also recommended that toheroa are translocated to isolated sites and their location kept secret until the population has a chance to establish before harvest pressures are introduced (Interviewee C & X).

Tangata Tiaki advised that a precautionary approach would be most appropriate. Interviewee C expressed this by saying:

> *"I would hate us to take 50 out [and translocate them] and find that we had 50 dead".*

[63] And also see Brumbaugh et al. (2006).

[64] Moller (1996a) referred to this Minimum Viable Population as the crucial threshold to secure a "bridgehead" population, and Moller (1996b) recommended its use to set threshold population sizes for re-instigation of customary harvests.

He then went on to say the process would be one of trial and error using small numbers to test the suitability of the new sites – *“put a pocket of them in and just monitor them”.* This was echoed by Interviewee D who stated that:

> *“I think I would put in say about 50 and sit and wait and watch. And see what they were doing. If they survive - put some more in”.*

In order to successfully establish a new self sustaining population a *“critical”* number of both sexes would need to be translocated to ensure fertilisation (Interviewee W). However Interviewee F felt that given toheroa’s mass spawning nature, only a relatively small number of founding individuals will be needed. Density of the founding population also needs to be addressed to ensure optimal fertilisation[65]. Informants advised that it would be best to take a range of size classes, including those about to spawn and toheroa spat.

One interviewee suggested that during the periodic NIWA surveys would be the ideal time to source a range of toheroa size classes for translocating purposes *“because they are actually digging them up”* thus would reduce the amount of disturbance to the beds (Interviewee C).

A survey of the toheroa population at Orepuki Beach

The interviewees identified translocation as the main practical management option for restoring toheroa in Murihiku, considered this to be a traditional strategy used for a wide range of animals and plants by Māori in earlier generations, and pointed to the apparent success of the kaitiaki in establishing the Orepuki population as proof of feasibility of translocating toheroa. The researchers were therefore asked to concentrate their field work on characterising the size and ecological performance of this newly established population at Orepuki Beach.

Extent of the colony and overall population size

The presence of toheroa at the northern reach of Orepuki Beach was repeatedly checked during the survey period, using the siphon hole counting technique to ensure the full extent of the bed was included in the survey. No siphon holes were found between the northern boundary of stratum 16 and the neighbouring Gemstone Beach (Fig. 2). Therefore the current northern boundary of the

[65] Doall et al. (2008).

colony is at 46° 17' 03.90"S 167° 43' 57.65"E; and its southern extremity is at 46° 17' 51.66"S 167° 43' 48.54"E.

Toheroa were found present in 188 out of the 428 excavated quadrats. The number of individuals for the three size classes sampled in each of the 16 transects are given in Table 1 and for each quadrat in Appendix 1 to allow future statistical comparisons from raw data.

Toheroa were present in all strata covering 1.6 km along Orepuki Beach. However, the adult size class was absent from the outer margins of the breeding colony (strata 1, 14 and 16; Table 1). The three-dimensional distribution plots show that the toheroa bed is continuous, however, there are definable zones in which each of the different size classes dominated (Fig. 9). Juveniles had the largest and most evenly spread distribution across the beach, followed by sub-adults. The adults were concentrated in the mid section of the beach. This aggregation is also represented in the cumulative distribution plot showing over 80% of the adult toheroa occur within the 600 m between strata 4 and 10 (Fig. 10). The toheroa bed appears to thin out towards the edges of the sampling area.

Interestingly, the aggregation of the adult toheroa is occurring around the area that Interviewee D released toheroa in the mid 1950s. However, the toheroa released around Falls Creek, at the Orepuki beach access road by Interviewee X "*about 30 years ago*" are not present in the same relatively high density. Although toheroa density is often elevated in the vicinity of freshwater[66], they may have been placed too close to the stream, have migrated alongshore to more favourable habitat , or alternatively the latest translocation may have failed.

The three size classes occupied different vertical zones between high and low water (Fig. 9 & 11). Juveniles appeared first at an average shore height of 43 m, whereas the overall mean shore position for them was 75 m from the cliffs. Sub-adults appeared first at an average shore height of 71 m and had an overall mean shore position of 93 m. Adults were the furtherest down the shore, appearing first at an average shore height of 105 m and at an overall mean shore position of 113 m. Juveniles had the widest vertical distribution down the beach, with the largest average down shore range of 68 m, followed by sub-adults at 35 m, and adults with only a 14 m average vertical range. This is a much narrower strip width than for adults at Oreti Beach in particular[67], but also at Bluecliffs

[66] Rapson (1952); Redfearn (1974).
[67] See Fig. 6 of Beentjes & Gilbert 2006b.

Beach[68]. It is clear that one disadvantage of the Orepuki site for building the overall toheroa population is its relatively narrow intertidal reach.

We estimated the population at Orepuki Beach to consist of approximately 240,000 juveniles[69]; 84,000 sub-adults[70]; and 59,000 adults[71] (Table 2)[72]. Comparing these population estimates for the most recent surveys elsewhere suggests that the adult population at Orepuki is approximately a third the size of the toheroa population at Bluecliffs Beach, and a tenth the size of the population at Oreti Beach (Table 2).

Density of toheroa

Density (toheroa per m^2 of the beach) provides a complementary, and in some respects better indicator of how well the toheroa bed is performing ecologically than its overall population size. The latter is governed largely by the overall dimensions of the colony, and in the case of the Orepuki population, this may partly be explained by its newness (ca. 55 years since translocation). The average adult density at Orepuki Beach was comparable to that obtained at Bluecliffs and higher than at Oreti Beach in 2005 (Table 3, Fig. 12). There was a higher density of sub-adults at Orepuki Beach compared to Bluecliffs and Oreti. Orepuki Beach has a more consistent coverage of adult toheroa than the other colonies, and Oreti Beach's larger adult abundance is simply the result of a relatively lower adult density being extrapolated across a much larger colony size (17km at Oreti, 5.1 km at Bluecliffs and 1.6km at Orepuki).

These comparisons suggest that ecological conditions at Orepuki are comparable, if not better than both other main colonies, but the overall contribution of the population to the Murihiku 'metapopulation' is constrained mainly by its small spread along the beach and comparatively narrow intertidal zone. There may be considerable scope to extend the dimensions of the Orepuki population along the beach by translocations, but this is dependent on the sand beyond the western boundary of the colony being suitable and water flows to ensure settlement of spat in the area west of the existing colony.

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[68] See Fig. 6 of Beentjes & Gilbert 2006a

[69] All statistical subsampling of a population leads to a 'margin of error'. Most often ecologists express this uncertainty as a "95% confidence interval'. This is the range of values for the mean that would have occurred 95 times out of 100 surveys like the one we did. In the case of the juveniles the 95% confidence interval was 188,000 – 297,000 toheroa.

[70] The 95% Confidence Interval was 62,000 – 107,000.

[71] The 95% Confidence Interval was 35,000 – 86,000.

[72] Total population size is calculated by multiplying average density per quadrat by the estimated area of the beach as determined by average quadrat length and the extent of the colony

The density of juvenile and sub-adult toheroa in Murihiku is very much lower than have been recorded in Taitokerau (Table 3) populations, but the density of adults is similar, even though the Dargaville study uses a smaller size class to define the adults.

Table 1. Sampling design details, total number of toheroa and density from each size class in each transect within the 16 strata at Orepuki Beach, December 2008. Juv = juveniles (0-39 mm); Sub = sub-adults (40-99 mm); Ad = adults (≥100 mm).

Stratum	Beach length (m)	Number of quadrats	Transect length (m)	Total number per transect			Density per transect (toheroa per m^2)		
				Juv	Sub	Ad	Juv	Sub	Ad
1	100	28	135	7	1	0	0.50	0.07	0.00
2	100	30	145	14	3	1	0.93	0.20	0.07
3	100	27	130	19	1	1	1.41	0.07	0.07
4	100	28	135	7	9	3	0.50	0.64	0.21
5	100	29	140	8	5	12	0.55	0.34	0.83
6	100	26	125	12	5	9	0.92	0.38	0.69
7	100	30	145	8	5	6	0.53	0.33	0.40
8	100	30	145	35	9	11	2.33	0.60	0.73
9	100	28	135	25	4	4	1.79	0.29	0.29
10	100	29	135	35	8	6	2.50	0.57	0.43
11	100	29	140	20	4	2	1.38	0.28	0.14
12	100	26	125	17	7	1	1.31	0.54	0.08
13	100	25	120	4	7	1	0.32	0.56	0.08
14	100	24	115	11	5	0	0.92	0.42	0.00
15	100	21	100	13	9	1	1.24	0.86	0.10
16	100	20	95	3	1	0	0.10	0.10	0.00

Table 2. Recent population size estimates of juvenile, sub-adult and adult toheroa in Murihiku and Dargaville Beach (Taitokerau). Data for Orepuki Beach are from 2008 (present study); Bluecliffs Beach for 2005 (Beentjes & Gilbert 2006a); Oreti Beach for 2005 (Beentjes & Gilbert 2006b) and Dargaville Beach (Akroyd et al. 2008). Brackets show the 95% confidence intervals.

	OREPUKI	BLUECLIFFS	ORETI	DARGAVILLE BEACH
JUVENILES	238,333 (188,308 – 297,063)	805,670 (636,728-974,612)	6,981,762 (5,677,097-8,286,427)	55,436,432 (20,687,680 -90,185,184)
SUB-ADULTS	83,873 (62,434 – 106,741)	51,263 (27,262-75,264)	400,894 (250,034-551,754)	2,825,733† (2,338,612-3,312854)
ADULTS	58,585 (35,245 – 85,594)	165,121 (117,734-212,508)	582,829 (480,735-684,923)	849,831† (675,933-1,023,729)
TOTAL	381,553 (320,224-451,133)	1,022,054	7,965,485	58,262,165 (23,492,804-93,031,526)

† Dargaville estimates sub-adults are classed as 41-75 mm and adults >75 mm following Akroyd et al. (2008)

Table 3. Recent toheroa density (number per m^2) estimates of juvenile, sub-adult and adult toheroa in Murihiku and Dargaville Beach (Taitokerau). Data for Orepuki Beach are from 2008 (present study); Bluecliffs Beach for 2005 (Beentjes & Gilbert 2006a); Oreti Beach for 2005 (Beentjes & Gilbert 2006b) and Dargaville Beach (Akroyd et al. 2008). Brackets show the 95% confidence intervals.

	OREPUKI	BLUECLIFFS	ORETI	DARGAVILLE BEACH
JUVENILES	1.10 (0.87-1.38)	1.44 (1.14-1.74)	2.00 (1.63-2.37)	10.94 (4.08-17.80)
SUB-ADULTS	0.39 (0.29-0.49)	0.09 (0.05-0.13)	0.17 (0.13-0.21)	0.56† (0.46-0.65)
ADULTS	0.27 (0.16-0.40)	0.30 (0.22-0.38)	0.12 (0.09-0.15)	0.17† (0.13-0.20)
TOTAL	1.77 (1.48-2.09)	1.83	2.29	11.23 (4.36-18.08)

† Dargaville estimates sub-adults are classed as 41-75 mm and adults >75 mm following Akroyd et al. (2008)

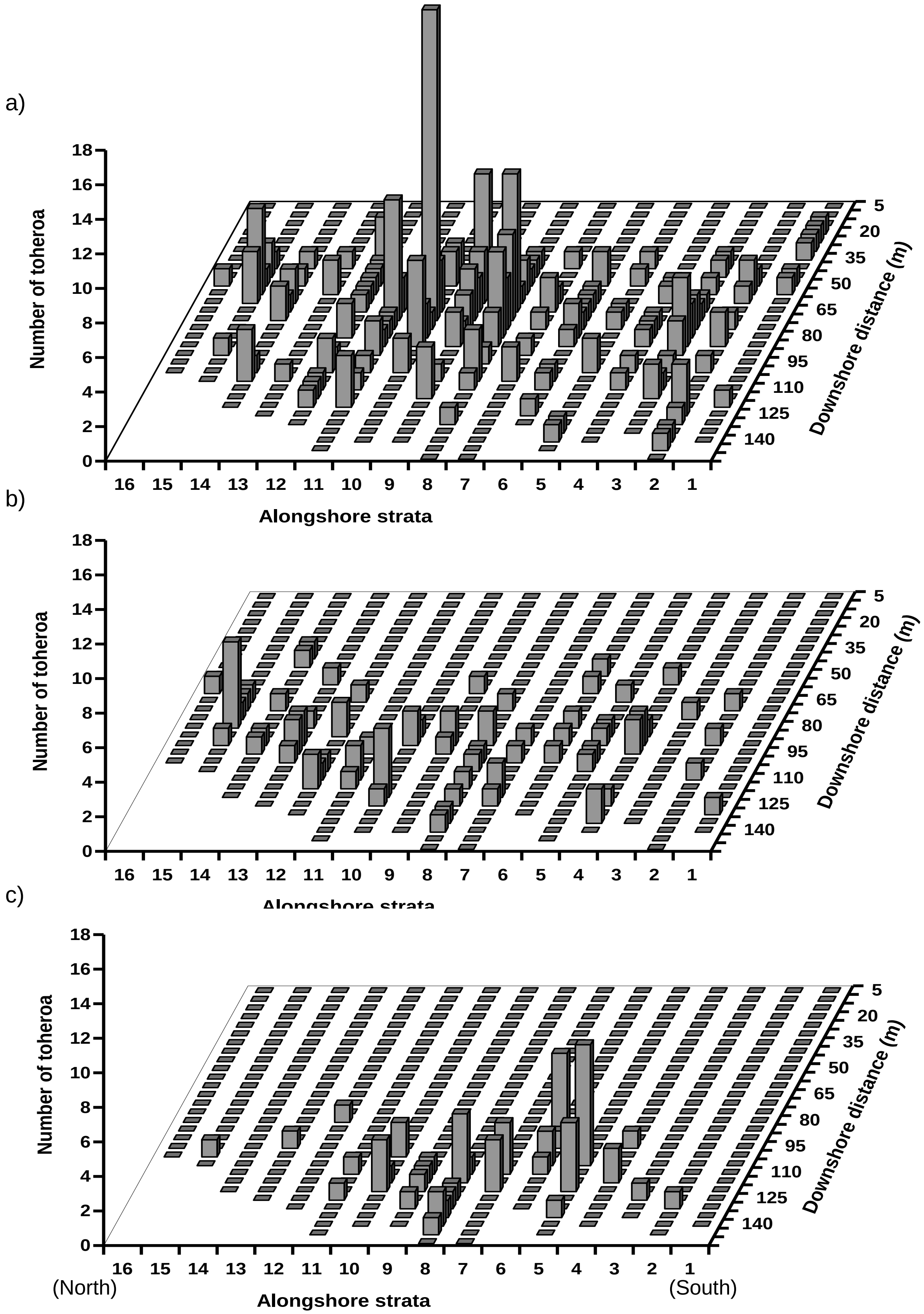

Figure 9. Three dimensional distribution plots of the Orepuki Beach toheroa beds from December 2008 survey for a) juveniles, b) sub-adults and c) adults.

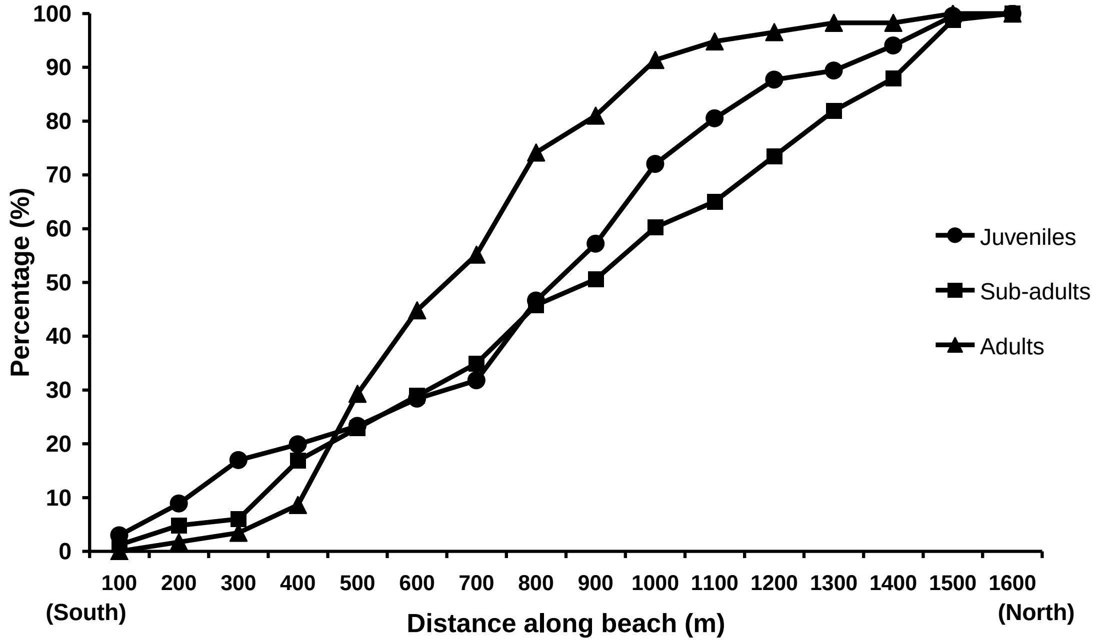
Percentage (%)
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
(South)
Distance along beach (m)
(North)
Juveniles
Sub-adults
Adults

Figure 10. Cumulative distribution of toheroa along Orepuki Beach from south (stratum 1) to north (stratum 16) for each of the three size class.

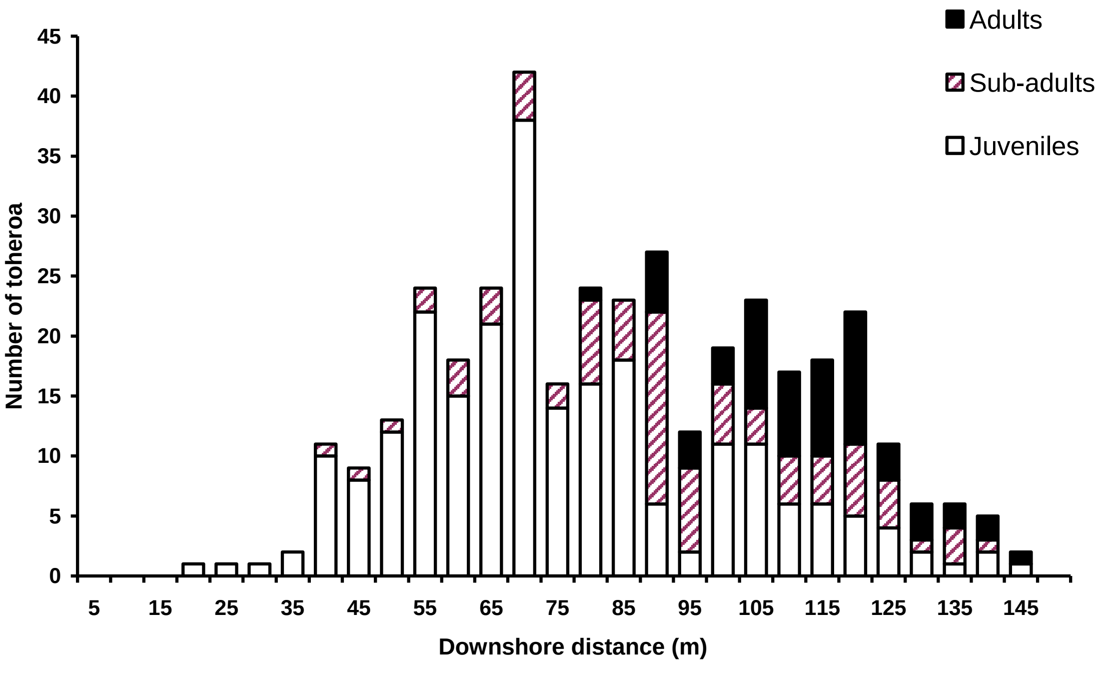

Figure 11. Total number of toheroa sampled in each size class down the length of Orepuki Beach (highwater to low water).

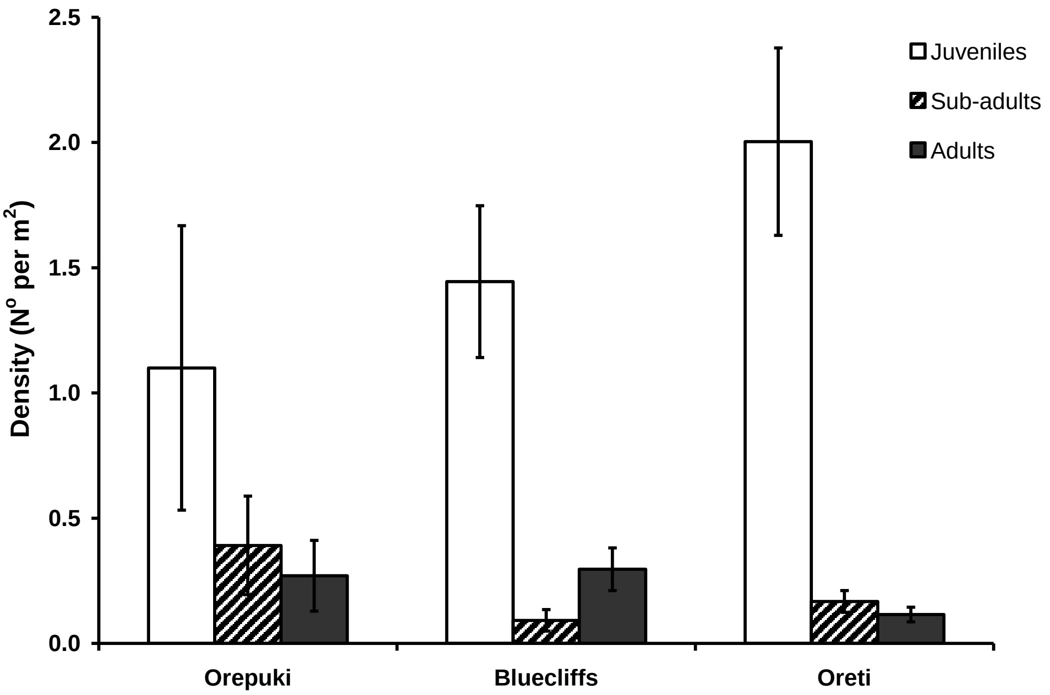

Figure 12. Density of juveniles, sub-adult and adult toheroa at the three Murihiku toheroa colonies.

Size, age structure and sexual maturation at Orepuki

The length frequency curve indicates a bimodal distribution with a strong juvenile group between 10-20 mm extending down to the low sub-adults numbers (40-50 mm) and a second less dominant mode also exists in the adult size class between 100-120 mm (Fig 13). The largest size observed was 124 mm, much smaller than commonly encountered at Bluecliffs (ca. 155 mm)[73], and slightly shorter than the maximum size found at Oreti (ca. 135 mm)[74]. A reduced growth rate and/or a lack of reaching maximum sizes could be the result of a single or combination of biotic and abiotic factors. The most likely cause is a limiting factor such as nutrient availability. Poor nutrient supplies would explain the slower growth rate of recruits and the restricted size of the adults.

Orepuki Beach has two small streams contributing freshwater input from the surrounding area, but they are not as substantial as those present at Bluecliffs or Oreti beaches. Perhaps this lack of freshwater in-flow is not providing sufficient nutrient supply? There may be increased competition for available food particles between the toheroa at Orepuki because of their more crowded

[73] Fig. 3 of Beentjes & Gilbert 2006a.
[74] Fig. 3 of Beentjes & Gilbert 2006b.

conditions (Table 3, Fig. 12). Other possible factors may include pollution and temperature variations[75]. Alternatively, the reduction in the maximum size of the Orepuki Beach toheroa maybe in direct relation to a genetic bottle-neck phenomena, common in founding populations. There is the possibility that the adults transplanted to Orepuki Beach did not provide a complete representation of the genetic diversity available in the Bluecliffs Beach population. This conclusion is unlikely if the all of the reported transplanting efforts to Orepuki Beach were successful. This discussion highlights the importance of having a large enough founding population to ensure maximum genetic diversity is present, helping ensure the founding population's success in establishment and future population growth.

The stock structure of the Orepuki Beach toheroa population consisted of 64% juveniles, 22% sub-adults and 14% adults when we used the standard size range definitions for each population stage class[76]. The proportion of sub-adults is much higher at Orepuki than recently observed at both Bluecliffs and Oreti and overall the Orepuki population has the "youngest" age structure (Table 4). Beentjes & Gilbert (2006a) described the lack of the sub-adult mode as being a "distinguishable feature" of the 2005 Bluecliffs toheroa population. Our collective results may reflect relative recruitment failure at Bluecliffs in particular and also at Oreti (albeit to a lesser degree). However these comparisons may be partly confounded by different growth rates between the populations. If the overall shorter maximum length of the Orepuki population reflects poorer growth, then the middle sized ('sub-adult') toheroa there may be considerably older and contain a higher proportion of breeders than at the other two beaches. If so, a more robust comparison of age structure between the populations might be to aggregate sub-adult and adult size classes. That comparison suggests around the same age structure at Orepuki and Oreti, but still signs of relative recruitment failure at Bluecliffs.

Our results indicate that the habitat degradation at Bluecliffs Beach is depressing the population abundance by compromising recruitment to the population. This may mean the adult survival is not compromised there, though of course both adult survival and recruitment failure could be contributing.

[75] Griffin (1995).

[76] Following Beentjes et al. (2006); Beentjes & Gilbert (2006a,b)

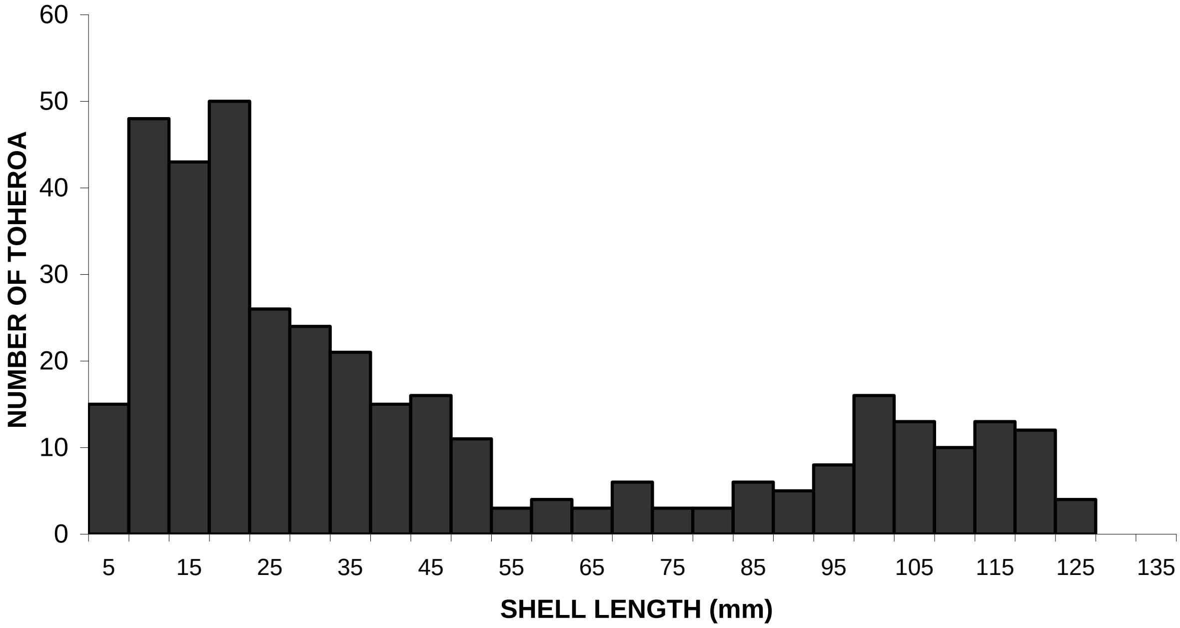

Figure 13. Size frequency distribution of all sampled toheroa at Orepuki Beach, December 2008.

Table 4: Size/age structure of three Murihiku toheroa populations

	Orepuki (2008)	Bluecliffs (2005)	Oreti (2005)
Juveniles	64%	50%	63%
Sub-adults	22 %	7 %	9%
Adults	14%	41%	27%

The higher proportion of sub-adult size class coupled with the reduced maximum size of the Orepuki Beach toheroa raises a question whether the toheroa are reaching sexual maturity at relatively smaller sizes (i.e. less than 75 mm) there. It is not known whether toheroa maturation is triggered by overall size, age, or a mixture of both. If the size of onset of sexual maturity of the Orepuki Beach population is lower, optimum sizes for harvest would be different between the Murihiku toheroa populations. We recommend that the size at sexual maturity and fecundity levels of the Orepuki Beach toheroa population be investigated as soon as practicable to assess whether harvest management strategies should be different there.

Substrate analysis

Of the 428 quadrats sampled, 94% contained fine sand. The remaining 6% were classified as coarse sand. The coarse sand was situated in stratum 15 and 16, which both fell on the north-western side of the freshwater stream (Falls Creek) at the Orepuki Beach access road. The sand there was also darker in colour, particularly in the higher reaches of the beach. Furthermore, the beach profile was steeper, explaining the relatively shorter transects seen in strata 15 and 16. It should also be noted that a few small stones were found dispersed amongst the lower quadrats.

Interviewee W described Oreti Beach as being the model of an ideal habitat for toheroa:

> *"Well, if you look at Oreti Beach it is a perfect habitat. It has fine sand, it has a very gentle slope, it has a wide inter-tidal zone. Now if you contrast that with Bluecliffs, which is quite steep, steeper now than it used to be, it doesn't have as much sand and it has coarse material over the beach".*

Orepuki Beach more closely resembles these characteristics of Oreti Beach, as did Bluecliffs Beach before 1970. All sampling quadrats consisted of either fine sand (substrate type one) or coarse sand (substrate type two). However given the presence of so few and randomly dispersed stones at Orepuki, it can be assumed that the sand cover is much greater there than Bluecliffs Beach. Strata 15 and 16 consisted of less suitable habitat with the presence of much coarser sand, however stratum 15 still had relatively high juvenile and sub-adult densities. It could also be argued that stratum 16 is less dense because it occurs on the edge of the bed (as in stratum 1), so the lower toheroa abundance there may result from a slowly expanding translocated population rather than because it has coarser sands. If the western extremity of the colony is not limited by habitat quality, there is considerable scope to extend the dimensions of the Orepuki colony and thereby build resilience into the overall Murihiku population by further translocations of toheroa to fill in the gap between the existing boundary and the Waiau River mouth.

Toheroa distribution elsewhere in Murihiku

Objective 4 of the project was to: *survey traditional harvest sites for the ongoing presence of toheroa and their abundance; and survey potential sites for reseeding and more active habitat management*. We focussed most of our effort on the Orepuki Beach population to meet this objective, but also performed four checks for the ongoing presence of toheroa where earlier translocations were tried by the kaitiaki, and to measure the western-most extent of both the Bluecliffs Beach and Oreti Beach colony to guide future monitoring and potential mātaitai establishment and boundary setting.

On all four days surveyed, the toheroa in the known beds at Orepuki Beach and Oreti Beach were actively feeding. Given the close proximity in distance and time between our new survey spots and these benchmark colonies, we are sure that, had toheroa been present, they would also have been active and we would have seen their siphon holes.

No evidence of toheroa was found at either Wakapatu Beach or Colac Bay (Table 5). These two beaches are relatively sheltered, have a similar substrate of coarser sand with shell fragments, large cobble beds in the high intertidal zone and the transforming to a rocky shoreline in the western extent - all aspects which are uncharacteristic of Oreti and Orepuki beaches. Furthermore no ghost shrimp[77] burrows were seen at any of the three sites which are commonly inter-dispersed within the adult beds at the Oreti and Orepuki sites.

Some of our interviewees referred to degradation of the beach at Wakapatu Beach since the late 1950s and early 1960s when translocations and supplementary feeding was tried there. Accordingly, current absence of toheroa at Wakapatu does not necessarily indicate the translocation failed – the population may have taken hold but then been extinguished by habitat changes similar to those occurring at Bluecliffs Beach.

No adult or sub-adult toheroa were witnessed at the western extent of Bluecliffs Beach, however three juveniles were found drifting on the surface of sand on a receding wave[78]. This area has not degraded to the same degree as the central and eastern beach. However the sand was also coarser than that at Oreti Beach and Orepuki Beach.

[77] *Callianassa filholi.*

[78] A large number of juvenile toheroa drift in the upper reaches of the tide to redistribute the juveniles along the beaches.

There was no sign of siphon holes, ghost shrimps or drifting juvenile toheroa west of the Waimatuku Stream (Table 5).

Table 5. Summary table of the weather conditions and presence of toheroa at Murihiku beaches.

Beach	Date	Air temp ^{0}C	Sand temp ^{0}C	Wind speed m/s	Cloud cover (%)	Presence
Wakapatu Beach	1/05/09	14.6	13.5	1.9	80%	**No**
Colac Bay	2/05/09	15.3	13.9	0.8	50%	**No**
West Bluecliffs	3/05/09	14.1	13.2	1.6	80%	**Yes**[†]
Oreti Beach, west of Waimatuku Stream	25/05/09	12.0	11.0	1.2	80%	**No**

[†] No established adult population is present, but the site is being tested by the arrival of juveniles drifting from the Bluecliffs Beach colony.

Conclusions & recommendations

Recording and using mātauranga for toheroa restoration

Interviewing the local people and kaitiaki of the two main customary gathering areas in Murihiku provided wonderfully detailed information on past changes to the population, the current situation and the most pressing threats to toheroa populations. The knowledge of the locals in most instances corroborates the scientific studies that have been done over the past four decades at Oreti Beach and Bluecliffs Beach and demonstrates the accuracy and validity of the mātauranga to guide management. Most of the customary users were well aware of the long term decline in toheroa abundance in Murihiku, that decline was most severe at Bluecliffs, that a new population at Orepuki exists but is perhaps not growing well, that growth is strongest at Bluecliffs, and that the main breeding area at Oreti Beach is at the southeastern end. The kaitiaki and local experts also identified much the same threats as noted by ecologists, especially the potential importance of vehicle impacts on recruitment and mass die-back events.

The traditional tikanga described above aim to protect habitats and minimise disturbance to the kōhanga (breeding beds), protect the breeding adults and minimise harvesting impacts. The traditional method of locating and extracting feeding toheroa with ones foot also guarantees a level of local escapement from harvest because not all of the adults would be showing at any one time. Strategies for spreading the spatial impact of harvesting were coupled with active reseeding by translocation. Jack Te Au, a particularly active kaitiaki at Bluecliffs during the 1950s and early 1960s, systematically experimented with supplementary feeding interventions and applied them to support translocated toheroa in ways that conservation biologists have only followed in the last 20 years. In common with TEK from several other indigenous communities, the knowledge stretches a long way back and is locally detailed. More than just local history, it is embedded in customs, beliefs and ethical codes of how best to manage the resource in ways that reinforce the relationship of the people to their environment, their sense of self and place, and a passionate commitment to protecting and enhancing the resource.

A primary goal of the Ōraka-Aparima Rūnaka was to gather together the mātauranga about toheroa and disseminate it to where it can help most. A summary of some of the testimony of 25 interviewees and two community hui to consider the collective results are now reported here and in two further written reports that are soon to be published[79]. A more detailed analysis of the concepts emerging from the interviews will be formed in the coming year as part of *Te Tiaki Mahinga Kai*'s search for ways to improve the social-ecological resilience of local Māori-community led fisheries management. This report has been written in lay terms and scientific concepts explained to maximise learning by all participants and to allow maximum dialogue between mātauranga and scientific knowledge. Copies will now be sent to all the interviewees and a copy can be downloaded from the *Te Tiaki Mahinga Kai* website. Accordingly, we believe the process of gathering the mātauranga (for Objective 1), checking it with our informants and reporting it has been inclusive and extensive. Much of the future value of the information is contained in the detail of the testimony now recorded in 25 bound reports back in the hands of the kaitiaki. The benefits of interviewing goes well beyond the valuable specific information received. Participation in the research builds ownership and control by the kaitiaki[80]. Participation at all levels builds and locks-in '*environmentality'*[81] amongst the kaitiaki and other stakeholders that impact upon or wish to support toheroa.

Several interviewees lamented the loss of knowledge and application of traditional tikanga around toheroa and mahinga kai management in general. Some called for instigation of more structured ways for them to educate their people to better look after the taonga in the future.

One kaumātua referred with considerable sadness and frustration to how repeated requests by his parents' generation to manage toheroa in traditional Māori ways was refused by the (then) Ministry of Agriculture & Fisheries. They had asked to be given a stretch of the traditional harvesting area at the southeastern end of Oreti Beach to apply their tikanga. For this elder and many of the other kaitiaki that we interviewed, the Customary Fisheries Regulations are therefore fundamentally important for reinstating mana and maintaining ahi kā (continued use, knowledge and authority). Apart from the displeasure of some kaitiaki that did not wish to apply for authorisations to gather toheroa, there was widespread support for the customary regulations in general. Careful and restricted allocation of gathering at Bluecliffs Beach was considered entirely appropriate for supporting a declining population. The honesty and responsibility of the Tangata Tiaki was recognised and active successional planning to ensure transition of knowledge and responsibility to younger 'understudies" was urged. There was unanimous agreement that the customary regulations have delivered large cultural and environmental gains by instigating continuous wise

[79] Moller & Lyver (In press); Moller et al. (In press d).
[80] Egs. Moller et al. (In press b); Schweikert & Moller (In press).
[81] Agrawal (2005).

customary management in the place of past toheroa fishery closures (with occasional shambolic open days). The kaitiaki in general, key facilitators of designing and instigating the regulations and the Ministry of Fisheries customary relationship facilitators deserve congratulation and thanks from all the stakeholders for their national work, just as the local Tangata Tiaki that have guided toheroa management and instigated this inquiry are discharging their roles with cultural, environmental and legal integrity.

Partnership between mātauranga and science

The was some unease about past and current toheroa research using science but general enthusiasm that it be applied alongside mātauranga for toheroa enhancement. The main areas identified for follow-up research were: calibration of the traditional abundance index, the number of toheroa feeding holes, against actual toheroa abundance; investigation of the damage caused by vehicles; and assessment of the degree of illegal take occurring. Other areas identified in the kōrero for investigation included a maximum size limit for harvesting[82] and the development of a restoration plan using translocations to start new populations. Potential areas for the translocation of new populations and reseeding strategies were also identified. Partnership of mātauranga and science is one aspect of adaptive co-management to meet new ecological threats and maintain safe customary use in the new cultural and social context of modern lifestyles[83]. A key safeguard is to have the kaitiaki in the driving seat for any such scientific research[84]. Funding by the Ministry of Fisheries Customary Research Fund enabled this investigation to assess research priorities, and the research process was guided by the kaitiaki themselves.

Status of the Orepuki Beach Population

The success of the historic translocation of toheroa to Orepuki Beach has two major implications for the management of the Te Waewae Bay toheroa stocks. Firstly it demonstrates the feasibility of translocation to build resilience into the Murihiku 'meta-population'; and secondly it offers the kaitiaki an opportunity to spread the current low harvest pressure at Bluecliffs even more thinly by

[82] This study and parallel ones underway by *Te Tiaki Mahinga Kai* identified this recurring theme across several customary harvests – set maximum rather than minimum size limits to protect the breeding resource. This led to formation of a coalition of Lincoln University, University of Otago, Victoria University of Wellington and Manaaki Whenua scientists (ecologists, mathematical modellers, economists) to explore the general principle behind the tikanga. That separate study will focus on pāua harvesting in the first instance, but follow-up work on toheroa would add a valuable additional test. Funding applications for the pāua case study are under consideration at the time of writing this report.

[83] Another Murihiku example is provided by the *Kia Mau te Tītī Mo Ake Tōnu Atu* research project Moller et al. (In press a,b & c).

[84] Moller et al. (In press c & Subm.)

issuing authorisations to gather from Orepuki and Bluecliffs Beach. 'Meta-population' is the term used by ecologists to refer to the overall population of a species in a region that is made up of smaller sub-populations that can support each other with immigrants or propagules[85]. Immigration from nearby populations can rekindle local populations that have been snuffed out by local habitat disturbance, or an intense local "ecological catastrophe". It is unknown if the Orepuki Beach population is ecologically "connected" to the Bluecliffs Beach population.

It seems most likely that the population now flourishing at Orepuki Beach was indeed the result of the translocations done over the past half century, but we cannot automatically rule out the possibility that the reduction in the flow of the Waiau River has now allowed alongshore drift of toheroa juveniles within Te Waewae Bay that could then settle at the south eastern end of the bay. Many marine invertebrate propagules are killed by fresh-water[86] and some of our interviewees referred to the "*wall of water*" caused by the Waiau outflow as "*cutting the tide*". Perhaps natural seeding of Orepuki from Bluecliffs has assisted the translocated population.

The central and most abundant area of the Orepuki colony is precisely where one of our interviewees released toheroa in 1950. The simplest and entirely plausible explanation is that the population has slowly expanded from this early beginning. A low rate of population growth is expected in view of the recurring recruitment failure noted by several earlier researchers. A long-lived adult stage with repeated spawning, as seen in toheroa, is normally a characteristic of a slow population cycle and low overall capacity for population increase, and it is this that makes harvesting of adults or the appearance of any new threats to the adults so potentially disastrous. If we assume around 50 adult toheroa were released and all survived the translocation, the current population estimate of 59,000 adults 60 years later at Orepuki Beach represents an annual compounding growth rate of around 12.5% p.a. If all 150 adults translocated over the 3 years survived, the observed growth rate has been 10.5% per year. This seems biologically feasible even if there were no immigrants from the Bluecliffs Beach colony to assist the population expansion.

Another possibility is that the Orepuki population has already run out of suitable habitat. It was noticeable that more course sand appears at the northern extremity of the colony i.e. the population may have grown at a much faster rate than 10.5 – 12.5% p.a. and then slowed as it reached ecological carrying capacity at Orepuki. Nevertheless, the area further towards the Waiau Mouth (Gemstone Beach) beyond the current northern extent of the colony does look generally suitable to support toheroa, and much more suitable than what remains at Bluecliffs Beach. We urge

[85] Hanski & Gilpin (1997); Hanski (1999).
[86] Keough & Swearer (2007).

structured and well monitored translocations of toheroa (sourced from the Oreti Beach population) in steps between the current boundary to the beginning of cobbled beach nearer the Waiau Mouth to test our hypothesis that suitable habitat remains uncolonised in this region of Te Waewae Bay.

Monitoring the trends in abundance and extent of the Orepuki Beach colony is now very important in view of the degraded habitat and declining toheroa numbers at Bluecliffs Beach. We recommend that survey of this colony be added to the 3-4 yearly surveys being done by NIWA in future.

A population approximately a third the size of the 2005 Bluecliffs population now exists at Orepuki Beach, providing a significant start towards preserving the Te Waewae Bay toheroa stocks. The community hui called at Murihiku Marae in February 2009 to consider the results of our study discussed whether it was better to spread harvest pressure between both Te Waewae populations, to retain the harvesting only at Bluecliffs, or to divert all the harvest pressure to Orepuki. The kaitiaki collectively decided to take the former option and will now issue authorisations for both beaches.

Studies of growth, size and age at maturity and recruitment success at Orepuki are now of high priority. It may be that smaller sizes should be harvested at Orepuki, especially if the traditional tikanga of only taking the intermediate-sized specimens is followed in future. Assessing the available food supply at Orepuki Beach would be valuable in terms of managing the current stock to decide whether artificial feeding would assist. Understanding what is limiting the growth of the Orepuki Beach toheroa is important as it is a vital factor to ensure future translocation successes. Lastly threats of poaching, traffic impacts and predation need to be assessed and managed. Signage to discourage people from driving on to the beach would potentially reduce risks, and start a public education campaign to minimise driving on intertidal areas of beaches.

Threats to Murihiku toheroa populations

An overall picture of concern for cultural and environmental wellbeing emerges when the results of our study and the baselines provided by NIWA (and before them Ministry of Agriculture & Fisheries) are combined. The population at Oreti Beach is the strongest, but this stems mainly from the broad extent of the breeding beds (Table 6). However there are large gaps on Oreti Beach which have no sub-adults or adults despite broad scale settlement of juveniles along its full length[87]. The population density remains lower there than in Te Waewae Bay and the population is reduced by at least 75% from that present at Oreti in the early 1970s. Historical declines have been all the more dramatic at

[87] Beentjes & Gilbert (2006b); Moller et al. (2009).

Bluecliffs Beach but the habitat there is badly degraded and the alongshore extent of the colony is now less than half what it was when surveys began.

Age/size structure comparisons suggest that broad scale and prolonged recruitment failure at Bluecliffs Beach is the immediate cause of the decline, presumably driven by habitat degradation. The ultimate cause of the habitat degradation is debated, but the kaitiaki are near unanimously of the opinion that it was caused by diversion of water out of the Waiau River since 1972. This explanation seems plausible, because the scheme has significantly reduced the flow of the river, which empties into the middle of Te Waewae Bay, and reduced the sediment carried in the water by 75%[88]. However some scientists have challenged this interpretation[89]. There was a decline in toheroa abundance at Bluecliffs Beach in the last half of the 1960s before the water was diverted[90]. However we caution that this is too short a period to be sure that declines were, or were not, underway before the Manapouri Power Scheme came in to operation. Sporadic recruitment will cause major fluctuations in abundance through natural causes, so at least20 years is needed to confidently assert population trends. Also, the Oreti Beach population has declined greatly over the same period. The Waiau River mouth is 56 km from the middle of the Oreti Beach toheroa beds, so diversion of its water is unlikely to have caused the decline of toheroa at Oreti. Nor is there any sign of habitat degradation at Oreti. We conclude that some other ecological factor has contributed to declining toheroa numbers in Murihiku, even though declines at Bluecliffs have been greatly accelerated and more pronounced because of the changes in the Waiau River flow. Multiple stressors are common in ecology, so this conclusion is unsurprising.

Whatever the cause, the kaitiaki, Ministry of Fisheries, and conservation agencies in Southland would be prudent to apply the 'environmental precautionary principle'[91] by assuming that habitat degradation and further decline of the Bluecliffs Beach population will continue. There has been a reasonably stable population of toheroa at both Bluecliffs and Oreti Beach in the last decade of monitoring (surveys in 1996, 1998, 2002 and 2005), but when viewed in historical context of prolonged decline, and when recruitment is obviously sporadic, there is obvious ongoing risk to the Murihiku meta-population.

Disruption of toheroa recruitment by vehicles being driven along Oreti Beach was identified by several interviewees as a potentially significant reason for low toheroa population abundance. A

[88] Kirk & Schulmeister (1994); as cited in Beentjes et al. (2006); Beentjes & Gilbert (2006a).
[89] See divergent views expressed by Gibb (1978), Kirk & Shulmeister (1994) and Cranfield (1996).
[90] See Fig. 12 of Beentjes & Gilbert (2006a).
[91] Raffensperger & Tickner (1999).

recent preliminary study has demonstrated that normal traffic on the beach does kill juvenile toheroa, and a main motorbike beach racing event kills a high proportion of the juveniles and even some sub-adults that live on the racetrack[92]. Although that research demonstrates unequivocally that vehicles damage juvenile toheroa, this is not tantamount to having demonstrated that vehicles significantly disrupt recruitment to the Oreti Beach population. Making recommendations about managing the year-round vehicle threat will be entirely premature until the overall risk is better quantified. The most important next steps are to quantify how many cars, utilities and motorbikes go onto Oreti Beach in the different months of the year, how far they drive on the intertidal area and the distribution of that traffic accross the intertidal zone. Oreti Beach is the most important beach for recreation in Southland – the average number of visitors per day between 16th December 1998 and 10th February 1999 was 961, carried to the beach in approximately 374 vehicle visits per day (Wilson 1999[93]). All vehicles drive at least part way onto the beach by the main (Dunns Rd.) entrance, but a minority travel more than a kilometer either side of the entrance. In another (2004) study, two extremely brief (2.5 hour) surveys[94] of vehicle traffic on Oreti Beach were used (very inappropriately) to assert evidence of vehicle impacts on toheroa[95]. Certainly, large numbers of people from Invercargill and Riverton and surrounding areas drive vehicles onto the beach to picnic and party, surf, kite surf, swim, paddle, fish, exercise themselves and their dogs. A minority also race their motorbikes and cars along the beach. It is likely that overall traffic volumes have increased since the 1998/99 study at Oreti, especially four-wheeled drive utility wagons. The threat will now be investigated further by Te Ao Mārama and Environment Southland. Mitigation measures are potentially expensive and public concern about restricting vehicle access to the beach is likely to be intense considering how important recreation on the beach is to so many people. Robust scientific evidence of consequences of various management interventions is needed to guide the debate and search for sustainable solutions. In the meantime it should not be presumed that crushing by vehicles is the main, the only or even an occasionally significant blocker of recruitment.

Die-back events were identified by the kaitiaki as potentially particularly significant. These events kill a large number of adults, some of which might otherwise live and breed for 20 years[96]. They can

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[92] Moller et al. (2009).
[93] This was calculated by adjusting the estimated number of visitors by 94% (the estimated proportion that arrived by car – others walked, cycled or rode a horse) and dividing by the estimated average number of people in each car visit (calculated as 2.41 after weighting by weekend and week days from the data presented in Table 4.1 of Wilson 1999).
[94] The only counts made were on Saturday 20th March 2004 and Sunday 13th June 2004 (the latter during a public mid-winter swim event).
[95] Gray (2004).
[96] Beentjes & Gilbert (2006b).

therefore be classed as "ecological catastrophes" (rare, high-impact events)[97] that are particularly important threats to small or fragmented populations like toheroa. The concerns expressed by our interviewees has led to our preparation of a sampling protocol to learn more about the causes and impact of die-back events next time one happens in Murihiku[98]. Until the size of the knockdown in the adult population is scaled against the number of breeders, we cannot assess the long term population impact. The only estimate reported so far was for death of about 5,000 adult toheroa at Bluecliffs Beach in September 1970[99]. It was estimated that there were about 1.1 million adults in the population at that time[100], so this knockdown represents less that 0.5% of the breeding population. The die-backs are conspicuous and alarming, but thorough and immediate scientific surveys are needed before they can be conclusively identified as a major threat.

There is widespread interest amongst the interviewees and scientists to learn about fluctuations in condition and food supply, and whether these cause the die-back events and are linked to the inter-annual rhythms seen in tio[101] and tītī. It is interesting that the 1993 mass dieback of toheroa on Oreti Beach[102] coincided with an El Niño weather pattern and kiaka year[103] amongst the tītī; and that a kiaka year and a small die-back of toheroa appeared in April of this year[104]. This suggests oceanic conditions and presumably food availability or naturally occurring biotoxins could trigger the die-backs. We recommend testing of the food/biotoxin hypothesis by formal analysis of links between (i) the recruitment ratios revealed in historical surveys of toheroa[105], (ii) interannual variation in tītī chick size[106], (iii) abundance and condition of Bluff oysters, and incidence of *Bonamia* parasites in Bluff Oysters[107] to (a) El Niño/La Niña conditions, (b) wind and ocean conditions, and remote sensing indices of (c) marine productivity, (d) sea-surface temperature, and (e) strength of the Southland Current[108].

Significant predation of toheroa by birds has been identified in Taitokerau[109]. Predation by birds on Murihiku beaches has also been observed[110], but no formal assessment of its potential impact have

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[97] Hamilton & Moller (1995).
[98] Moller & Futter (2009).
[99] Eggleston & Hickman (1972).
[100] See Fig. 12 of Beentjes & Gilbert (2006a).
[101] 'Fouveux dredge oyster' or 'Bluff Oyster', *Ostrea chilensis.*
[102] See Moller & Futter (2009) for photographs.
[103] Chick starvation year (Lyver et al. 1999) .
[104] Dallas Bradley and Lloyd Esler, pers. comm.).
[105] See Fig. 13 in each of Beentjes & Gilbert (2006a,b).
[106] See Clucas (2009) and Bragg et al. (In press).
[107] See Dunn et al. (2000) and Michael et al. (2006).
[108] Sutton (2003).
[109] Brunton (1978).

been undertaken. Interviewees also mentioned flounder predation occurs. We cannot exclude the possibility that predation is a significant threat to recruitment, but research to measure its impact would be time consuming and expensive. When scaled against existing evidence for potentially significant vehicle impacts, die-backs and habitat degradation, we recommend that research on predation be at the bottom of the priority list in the meantime.

Monitoring to guide future management

Some kaitiaki were concerned that current scientific surveys by NIWA are damaging the toheroa. Their shells are thin and fragile, but perhaps more importantly, digging quadrats with spades violates the long-standing teaching to not use an implement of any nature for toheroa extraction. Furthermore, excavation styled abundance surveys are intrusive, expensive and labour intensive[111] and cannot therefore be performed by the kaitiaki themselves. The kaitiaki are not alone in wanting to reduce the risk from scientific monitoring - an increasing body of scientific studies are concerned with the development of non-destructive indices to determine the size of benthic populations. In the marine environment this has largely been applied to cryptic and burrowing invertebrates to increase the feasibility and decrease environmental disturbance of population surveys[112]. Devising a monitoring method that can be applied by local experts using mātauranga would be especially valuable. There is a huge and growing scientific literature on the way involvement of local communities in natural resource management is very important for conservation, surveillance, enforcement and locally-tuned decision-making. The traditional index for toheroa abundance is by counting the number of feeding holes present in an area[113]. Therefore, at the request of the kaitiaki consulted for this study, we have already commenced a calibration study to link the traditional monitoring method of counting the feeding holes for actual toheroa abundance[114]. An important part of that study is to determine whether the temperature of the water or air, and cloud or sunshine conditions, affect the proportion of the toheroa that are actively feeding when the count is made. If so, a standardised protocol for doing the siphon-hole counts will be devised to make it a more precise index of toheroa density.

Even if weather condition effects can be “filtered” or “corrected” from the counts, the state of the tide and amount of food could also influence the proportion of the toheroa that are actively feeding.

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[110] Street (1971); Dallas Bradley pers. comm.
[111] Jordao & Oliveira (2003).
[112] McPhee & Skilleter (2002).
[113] Metzger (2007).
[114] The first phase of this calibration will be reported in Julie Futter’s MSc thesis at the University of Otago which will be submitted in September 2009.

At best we expect a very course population abundance measuring tool to result, but we will do our best to perfect it as much as possible. A potentially crucial added bonus of using the quadrat digging approach is that the size/age structure of the population is monitored along with the number of animals. Recruitment to the sub-adult and then adult toheroa population is sporadic, and finding out why is probably the key to more active restoration management in Murihiku. Therefore, cultural and environmental risk minimisation and scientific considerations suggest that the kaitiaki should continue to support the excellent and rigorous scientific surveys being conducted by NIWA for the Ministry of Fisheries in the meantime. Most of the interviewees agreed with this strategy, albeit reluctantly in some instances.

If a monitoring programme using siphon-hole counting can be run in parallel with the scientific surveys using dug quadrats for several overlapping years, it will then be possible to more reliably evaluate whether it is safe to reduce the scientific monitoring. There are many instances around the world where traditional and scientific monitoring methods are nicely complementary and add strength to each other[115] and research to 'calibrate' one against the other is an obvious first priority.

Another potentially practical method of monitoring the toheroa resource is to formalise catch per unit effort (CPUE) data. A stipulation of each customary authorisation is that the applicant must inform the Tangata Tiaki about how many shellfish or fish they actually caught. A simple form could be designed and used by experienced harvesters to gather more details on where they went, method used, number of helpers and how long it took to gather their catch. Our interviewees have noted a broad increase in the time taken to catch a feed off toheroa in their life time, and this corroborates the general decline seen in toheroa population size from scientific surveys[116], so we are confident that CPUE indices can provide an inexpensive and locally managed indicator of toheroa population health.

Translocations to build metapopulation resilience

Three different types of stock enhancement efforts are described within the scientific literature regarding restoration of marine resources: 1) enhancement of natural recruitment using wild spat; 2) transplantations from nearby natural populations; and 3) reseeding using hatchery-reared stock[117]. It appears toheroa have traditionally been transplanted using option two. Option 3 involves developing a hatchery in which spat from wild or captive toheroa is developed and released when

[115] Moller et al. (2004).
[116] See Fig. 12 in both Beentjes & Gilbert 2006a,b).
[117] Arnold (2002); Tettelbach et al. (2002).

believed to be resilient enough survive in the environment. This option is the most expensive and requires the most resources and can be discounted for toheroa in the meantime.

Translocation from natural stocks before they become too depleted is inexpensive. Approximate cost of hui and planning the adaptive management strategy and performing the first translocations in year 1 will be around $7,000; there will then need to be investments of around $2,000 pa. for years 2-4 to support repeated translocation and monitoring in the TeWaewae Bay area; followed by $6,000 pa. for years 5 & 6 to trial releases at Rakiura. Analysis and reporting of results and revision of the restoration plan in year 7 would require around $10,000. Altogether this programme is likely to cost in the region of $35,000 spread over 7 years.

If translocation is done in a structured way that is also formally monitored, it can simultaneously build the resource while the kaitiaki learn useful aspects of toheroa ecology and behaviour for more general application for sustainable harvest management. Ecologists call this type of management experiment 'adaptive management' or 'learning by doing'[118]. There is a natural synergy between adaptive management and mātauranga (or 'Traditional Ecological Knowledge' as it is known overseas[119]), and in the cross-cultural context it is often referred to as 'Adaptive Co-management'[120]. We strongly recommend adaptive co-management of toheroa translocations over the coming decade to build the number, spread and strength of toheroa breeding colonies within Murihiku. More particularly we urge the use of an 'active adaptive management' approach[121] in which different experimental treatments are set up to accelerate learning – this is quite distinct from the more 'trial and error' approach characterised as 'passive adaptive management'. It will require an ongoing partnership between the kaitiaki and science teams to maximise the synergies between each others' knowledge systems. A formal plan for an adaptive translocation strategy should be devised next.

Some of our interviewees emphasised a need for having a full range of cohorts present in the establishing population will secure the population's reproductive potential and fast track its spawning capacity[122]. Nevertheless we recommend that mainly well-grown sub-adults and adults are transferred. It would be important to identify which size/ages of toheroa have the highest reproductive potential to get the maximum immediate output possible from the transplanted

[118] Walters & Holling (1990).
[119] Berkes et al. (1997); Berkes (2008).
[120] Berkes & Turner (2006); Turner & Berkes (20060.
[121] Walters & Holling (1990).
[122] Peterson et al. (1996).

Table 6. Status and threats to Murihiku toheroa populations. Data are combined from the present study and the most recent NIWA surveys reported by Beentjes & Gilbert (2006a,b).

	Orepuki	Bluecliffs	Oreti
Overall Population Size (thousands of adults)	Small (59)	Medium (165)	Large (583)
Colony extent	Short (1.6 km)	Medium (5.1 km)	Long (17 km)
Width of intertidal (maximum)	Narrow (145 m)	Narrow (140 m)	Wide (320m)
Habitat	Stable	Degrading	Stable
Density (adults per m^2)	High (0.27)	High (0.30)	Low (0.12)
Maximum size	Short	Very long	Long
Individual's growth rate†	Slowest?	Fast	Medium
Population recruitment	High	Low	Medium
Harvest pressure	?	Low	Low
Traffic threats	Low	Low	High
Trend in overall population	?	Ongoing decline	Stable in last decade, lower than in 1970

† Comparison of growth rates at Bluecliffs and Oreti provided by Beentjes & Gilbert (2006a,b). We have inferred 'Lowest growth rate' at Orepuki from the shorter maximum length measured in our study.

population. It is also important to make sure that selection of the number and optimum size of toheroa for success of the translocation does not create risk for the donor community.

Ecologists measure the 'reproductive value' of the different life stages – this is a measure of the effect of removing each life stage on the number in the future population and is calculated from the current and expected reproductive performance of an animal of a given size or age combined with its expected life span from then on. Although formal estimates are not available, we expect the reproductive value of a juvenile toheroa to be 100 times less than that of a sub-adult or adult which breeds continuously and may live for 20 years[123], primarily because most of the juveniles will die before they get to breed even once, whereas most sub-adults and adults will survive for several years. Accordingly the removal of more than 100 juveniles (probably several hundred) would have less of an impact on the future donor population than removing a single adult. However, few of the juveniles will be expected to survive at the receiving site[124]. The sizes/ages with highest reproductive value are most likely to start-up a new population in the receiving site. Following this rationale, we recommend that as many sub-adults and adults are transferred as is considered safe for the donor population.

Collection of toheroa for translocation should be from Oreti Beach, especially from the southeastern end where the strong-hold of the breeding stock has remained for years. During the 2005 NIWA survey there was also a small cluster of adults around 5 km to the northwest of the Dunns Road entrance[125]. We recommend that this population be left to build without depletion by harvest to maximise the changes of spreading the adults more widely along Oreti Beach in future.

Recruitment of young is sporadic in toheroa populations, and die-back events suggest that there are years where adult mortality can be unusually high. The kaitiaki should therefore plan and expect to release batches of toheroa several times at one place before a self-sustaining population reaches 'Minimum Viable Population Size'. Repeated transfers would be particularly important if a large number of the translocated animals are juveniles or small sub-adults.

In view of the concerns expressed about digging, only the siphon hole counting method should be used to gauge the success of each transfer. We recommend that releases are pulsed at two yearly

[123] Rapson (1952); Redfearn (1974).

[124] Mortality of the small toheroa is high, partly because they are washed out of the sediment by the fetch of waves and then drift before they can dig into the substrate again (Moller et al. 2009). It is probably very important for toheroa to grow quickly to reach the sub-adult size where they can remain secure and feed efficiently in the same place.

[125] Beentjes & Gilbert (2006b).

intervals and the siphon hole counting technique is used to check for ongoing survival of the founder population. Repeated seeding should follow if no siphon feeding holes can be located in the vicinity of the release sites which should be accurately recorded by GPS. If no sign of escalating population size is registered by 5 years after initial release, the suitability of that receiving site should be reviewed.

For some shellfish, aggregations of the adults is important to trigger spawning and ensure that it is successful[126]. Therefore we recommend that the transferred animals are released in a grid pattern (square or oblong with the long dimension running down the beach) to be 0.5 m from their nearest neighbour and that they are spread from around mid-tide level to low-tide level.

There seems little point in reseeding to the western extremity of the Bluecliffs colony because that area has naturally lost its population over the past decades. A check should be made of the beach at Sandhill Point and, if no toheroa are there already, transfers to there would be high priority. After that, the strategy for translocation should be aimed at securing distant and even more inaccessible populations, like at Mason's Bay on Rakiura (Stewart Island). Some kaitiaki advocated releases at Sealers' Bay on Whenua Hou, but the beach there is relatively short and narrow, and the prospect of release into a National Nature Reserve will raise several environmental impact questions.

Top priority for translocation should be in a series of well-spaced locations to the north of the existing Orepuki colony. This seems a relatively safe bet because translocation has probably been the key to success nearby, suggesting habitat and food is adequate. There is a need to accelerate population growth in the Orepuki population as the Bluecliffs population is most likely to decline further and there is a cultural wellbeing imperative to maintain a viable population that is accessible for locals in Te Waewae Bay to harvest. Nevertheless the beach at Orepuki and Gemstone is narrow and in the longer run is therefore constrained in terms of the total population size that it could carry. Translocation to other sites should therefore also be tried immediately.

If our estimate of approximate annual growth rate at Orepuki (10.5% - 12.5% p.a.) is accurate and repeated elsewhere, it will be several decades before several additional sites above 'Minimum Viable Population Size' for harvest can be established. It is possible that the Bluecliffs population may go extinct before these new populations are available to harvest, so rapid and extensive translocations are recommended.

[126] For example, Pāua (Bird et al. 2009).

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Appendix 1. Raw data for number of juvenile (J), sub-adult (S) and adult (A) toheroa sampled in the 2008 Orepuki Beach survey. The alongshore strata is the 16 100m wide strata from the northern Orepuki end to the southern Monkey Island end. The quadrat distances indicate how many meters they were placed downshore from the cliff/sand due toe.

DOWNSHORE QUADRAT DISTANCES	ALONGSHORE STRATA																																															
	16			15			14			13			12			11			10			9			8			7			6			5			4			3			2			1		
	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A	J	S	A
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
40	0	0	0	1	0	0	1	1	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
45	0	0	0	2	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
50	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	2	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0
55	1	0	0	5	0	0	0	0	0	2	1	0	1	0	0	0	0	0	0	0	0	7	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	2	0	0	1	0	0
60	1	0	0	3	0	0	2	0	0	0	0	0	1	0	0	1	0	0	0	0	0	3	1	0	1	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
65	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	2	0	0	3	0	0	2	0	0	8	0	0	2	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
70	0	0	0	0	1	0	2	1	0	0	0	0	0	0	0	7	0	0	18	0	0	3	0	0	5	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0
75	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0	0	3	0	0	1	0	0	1	0	0	1	0	0	1	0	0	2	1	0	1	0	0	0	0	0
80	0	0	0	0	5	0	0	0	0	0	1	0	2	0	1	1	0	0	2	0	0	1	0	0	5	0	0	0	0	0	2	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0

85	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	5	1	0	2	0	0	2	0	0	0	0	0	1	0	0	0	1	0	1	1	0	4	0	0	2	0	0	0	0	0
90	0	0	0	1	1	0	0	1	0	0	2	0	0	0	0	2	0	0	0	2	0	0	2	0	0	2	0	1	1	0	0	1	5	0	1	0	0	2	0	2	0	0	0	1	0	0	0	0
95	0	0	0	0	0	0	0	1	0	0	2	1	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0
100	0	1	0	0	0	0	1	0	0	0	1	0	2	0	0	1	0	0	2	0	2	0	0	0	0	1	0	0	1	0	0	1	0	2	1	0	1	0	0	1	0	0	1	0	0	0	0	0
105				0	0	1	3	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	3	1	0	2	0	0	1	0	2	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0
110							0	0	0	0	0	0	1	1	0	1	2	1	0	0	0	0	0	1	1	0	1	0	0	3	1	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
115							0	0	0	0	0	0	1	2	0	0	1	0	0	0	1	3	0	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0
120							0	0	0	0	0	0	1	0	0	3	0	0	0	4	3	0	0	1	0	0	0	0	2	3	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	1	0	0
125										0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0	0	0
130													0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
135																0	0	0	0	0	0	0	0	0	0	1	1	0	0	0				1	0	1	0	2	0	0	0	0	0	0	0	0	0	0
140																0	0	0	0	0	0	0	0	0	0	1	2	0	0	0				1	0	0	0	0	0				1	0	0	0	0	0
145																0	0	0							0	0	1	0	0	0				0	0	0							1	0	0			
150																									0	0	0	0	0	0													0	0	0			