Population and biomass survey of pipi (*Paphies australis*) on Mair Bank, Whangarei Harbour, 2014.

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EXECUTIVE SUMMARY

Population and biomass survey of pipi (Paphies australis) on Mair Bank, Whangarei Harbour, 2014.

DMP Statistical Solutions Ltd was commissioned by NRC, Northport, Refining NZ, and MPI to survey the population and biomass of pipis (*Paphies australis*) on Mair Bank within Whangarei Harbour.

Mair bank is an important commercial and recreational shellfish collection area and provides a natural protection to the harbour entrance and Marsden Point. The survey was done in February 2014 – it is only the third pipi biomass estimate for Mair Bank that accounts for the subtidal population.

Following the 2005 survey (Williams et al. 2006), and the 2010 survey (Pawley et al. 2013), the 2014 Mair Bank survey had a sample extent that extended subtidally to a depth of 1.8 m . Within this area, we estimated the following (with 95% confidence):

- The absolute biomass of pipis is 73.5 ± 44.6 tonnes.
- The 2014 population of pipis at Mair Bank is 4.95 million ± 3.52 million.
- The number of 'harvestable pipis' (i.e. pipis larger than 50 mm) was 2.5 million ± 1.45 million.
- The number of pipis recruited within the last 12 months (i.e. pipis smaller than 18 mm) was 0.48 million ± 0.82 million.

Both the total abundance and biomass have plummeted since the 2010 survey – a total of only 63 pipis were found from 140 samples throughout the sample extent.

The total population has declined from around 460 million (2010) to around 4.95 million, and the 2014 estimate of absolute biomass, 73.5 t is less than 1.7% of the 2010 estimate (4,450 t) and less than 1% of the 2005 estimate (10,542 t).

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1. INTRODUCTION

1.1 Overview

This report summarises fishery and research information for pipi (*Paphies australis*) on Mair Bank, Whangarei Harbour. The report provides a description and results of the full biomass survey of pipi done on Mair Bank between 21 February and 1st March 2014.

This project was funded by the Northern Regional Council (NRC), Ministry of Primary Industries. (MPI) and Refining NZ.

1.1.1 Overall objective

1. To assess the total population of pipis (*Paphies australis*) on Mair Bank, Whangarei Harbour.

2. To estimate the size structure and absolute biomass of pipis on Mair Bank during March – April 2014.

3. To compare the results of (1) and (2) with previous studies.

Physical character of Mair Bank

Mair Bank is an intertidal sand and shell ebb-tidal delta located at the southern side of the entrance to the Whangarei Harbour, north-eastern New Zealand. The bank extends offshore from Marsden Point, and is separated from the Bream Bay coast by a narrow channel that expands westward into the harbour. Mair Bank is fully submerged at high tide, but at low tide has a subaerial component of tightly-packed shell that extends approximately 1.1 km along its southern edge (Haddon, 1989).

The planform position of Mair Bank has been seen to remain relatively stable at decadal time scales, however, extensive changes in surface morphology is common in response to local energy conditions (Morgan et al., 2011). Currents at the harbour entrance reach 1.1–1.3 m s^{-1} during spring tides (Black et al., 1989) and deliver clean oceanic water from Bream Bay, as well as enriched waters from the Whangarei Harbour, allowing for prolific growth of shellfish populations (up to 10 000 pipis per m^2) within the harbour sand bodies (Pawley, 2013; Whangarei Harbour Water Quality Management Programme, 1989). Shell material supplied by the dense aggregations of pipi on Mair Bank has created a distinct shell cap that is linked to the overall stability of the bank by armouring underlying sandy sediments (Black 1983).

Pipi

The pipi (*Paphies australis*) is a common burrowing infaunal bivalve belonging to the Mesodesmatidae family. The three main species of this family in New Zealand are the tuatua (*Paphies subtriangulata*), toheroa (*Paphies ventricosa*), and pipi (Powell, 1979). Pipis are widespread throughout New Zealand (occurring on both the North and South Islands of New Zealand, as well as on Stewart Island, the Chatham Islands, and Auckland Islands). Their broad distribution and accessibility to harvesters affords them recreational and customary popularity. Pipis inhabit sandy deposits in areas of moderate wave energy (e.g. sandbanks and harbour entrances), and generally occur stacked in aggregations (up to 1000 m^{-1}) from intertidal to subtidal areas to a depth of at least 7 m (Dickie, 1986; Hooker, 1995). They position themselves within the top few centimetres of the substrate with their posterior end protruding slightly and feed by extending a short siphon from the substrate into the water column to extract food (Dickie, 1986).

Pipis are moderately large bivalves that range in size up to 90 mm in shell length. They have a thick, solid, white shell covered with a periostracum (skin-like organic coating), and in some larger individuals, the middle of the ventral margin often becomes compressed so that it is concave.

The majority of existing information on pipi has been derived from anecdotal sources and bio-environmental monitoring exercises conducted by local governmental authorities (Boyd, 1983; Venus, 1984; Dickie, 1986). These early investigations focused on the intertidal aspect of population dynamics as subtidal populations were seen as temporary, isolated phenomena. Extensive subtidal populations have since been documented and it has been realised that only a small subset of pipi populations have been studied in any detail (Hooker, 1995). Hooker (1995) has provided the most comprehensive information on the ecology and life history of pipis (within the Whangateau Harbour); but it did not address specific biological parameters needed for fisheries stock assessment.

Pipi reproduce sexually by free-spawning, releasing sperm and eggs into the surrounding seawater for external fertilisation (Hooker and Creese, 1995). After fertilisation, eggs develop into planktotrophic larvae that settle and metamorphose after about three weeks (Hooker, 1995). Once settled, juvenile and adult pipi are thought to be sedentary. However, pipi have been observed using tidal currents to move within an inlet (Hooker, 1995). Sexual maturity occurs when individuals reach approximately 40 mm in shell length (Hooker and Creese, 1995). Spawning activity generally occurs synchronously, even amongst different sites within the same inlet, during spring and summer months (Hooker and Creese, 1995). Spawning synchronicity and gametogenesis is strongly linked to local environmental conditions in bivalves (e.g. water temperature) and observed local spatial patterns may not occur at larger scales (Hooker, 1995).

The lack of growth rings makes it difficult to estimate the age of a pipi, and the natural mortality and longevity of pipi is poorly understood. Experimental procedures have aimed to determine growth and longevity of the tuatua (*Paphies subtrigangulata*) and pipi by analysing the distribution of strontium and fluorine markings in shell cross-sections, but such methods are still being refined (see Coote and Trompetter, 1993; 1995). In absence of any data, Haddon assumed maximum ages of 10, 15 and 20 years to estimate maximum constant yield in his assessment of Mair Bank pipi in 1989. He suggested pipi are unlikely to live past a maximum age of 10 years.

The Mair Bank commercial fishery

Over 99% of the total commercial landings of pipi in New Zealand have been harvested from Mair Bank. Prior to introduction of pipi in Whangarei Harbour (PPI 1A) and Fisheries Management Area 1 (FMA1) to the Quota Management System (QMS) in 2004, the commercial fishery area formed a geographically discrete area that was defined in regulation as that areas within 1.5 nautical miles of the coastline from Home Point, at the northern extent of the Whangarei Harbour entrance, to Mangawhai Heads, south of the harbour. Snake Bank was also included in this area. Commercial harvesting has typically been focused on the southern margins of the bank where shell cover is less dense, with the central area being avoided by commercial fishers. All commercial harvesting were conducted by hand, and fishers typically used a mask and snorkel. There is no minimum legal size (MLS) for pipi, but larger organisms were generally targeted over smaller individuals. Commercial pipi harvesting occurred year-around, so there was little seasonality in harvesting pressure.

Licensed Fish Receiver Returns (LFRRs) have reported steady total commercial landings of pipi harvested in Whangarei Harbour from 1986-87 to 2007-08 (Table 1). Total commercial landings have ranged between 55 t and 326 t, generally operating well below total allowable commercial catch (TACC). Since 2007-08, the reported harvest has significantly declined from around 130 t to 55 t (2011-12).

There have been no seasonal trends established in the level of effort or catch per unit effort (CPUE) in the fishery. Since being introduced to the QMS (October 2004), the 200 kg daily limit no longer applies for pipi in the Whangarei Harbour (PPI 1A), and existing permits have been replaced with individual transferable quotas. At this same time, a total allowable catch (TAC) of 250 t was set, which was comprised of a TACC of 200 t, a customary allowance of 25 t, and a recreational allowance of 25 t. However, there is currently no reliable recreational take data available for the Whangarei Harbour fishery.

Table 1: The greenweight (t) commercial landings of pipi (from Licensed Fish Receiver Returns: LFRR) in Whangarei Harbour between 1986-87 to 2010-11 fishing years. [Source: Report from the Fisheries Assessment Plenary, May 2012].

Year	Reported landings (t)	Limit (t)	Year	Reported landings (t)	Limit (t)
1986 - 87	131	657	1999 - 00	143	657
1987 - 88	133	657	2000 - 01	184	657
1988 - 89	134	657	2001 - 02	191	657
1989 - 90	222	657	2002 - 03	191	657
1990 - 91	285	657	2003 - 04	266	657
1991 - 92	326	657	2004 - 05	206	200
1992 - 93	184	657	2005 - 06	136.7	200
1993 - 94	258	657	2006 - 07	134.7	200
1994 - 95	172	657	2007 - 08	141.6	200
1995 - 96	135	657	2008 - 09	131.1	200
1996 - 97	146	657	2009 - 10	136	200
1997 - 98	122	657	2010 - 11	87	200
1998 - 99	130	657	2011 - 12	55	200

Recreational and Maori harvest

The pipis at Mair Bank have been a resource of cultural and recreational significance to local residents and Iwi for many years. Recreational limits for pipi in this area are 150 per person per day. Customary fishing permits may be granted to Maori to exceed this daily limit. Customary and recreational harvesters are largely boat users entering and exiting the harbour as the channel that runs adjacent to Marsden Point restricts access to Mair Bank. Harvesting is largely confined to the eastern sandy margin of the bank because of its position close to the main harbour channel and less dense shell cover. Despite a lack of formal quantitative estimates, the impact of recreational harvest compared to the commercial fishery is minimal. A national marine recreational fishing (telephone and diary) survey in 1996 (Boyd, 1998), 1999/2000 (Boyd and Reilly, 2002) and 2000/2001 (Boyd et al., 2004) estimated the number of pipi harvested in FMA1 to be 2.2, 6.8, and 7.2 million, respectively[1]. However, there have been no recreational estimates of mean harvest weights, or harvest estimates specific to Mair Bank.

Environmental impact of the Mair Bank pipi fishery

During the 1980s, speculation began that the morphology of Mair Bank had changed (decreased in elevation and extent) due to commercial shellfish harvesting in the area. The dense stacking of live pipi in the substrate is thought to increase the shear resistance of sediments to tidal currents and reduce sediment transport. Pipi harvesting removes these live organisms as well as the shell material, which is important to local geomorphology as it armours underlying finer-grained sediments reducing actual sediment transport rates well below the potential rates of transport (Black, 1983).

Mair Bank is effective at reducing wave energy and mitigating erosion on the landward shoreline. A significant shift in morphology is likely to adversely impact Marsden Point and its infrastructure. Significant declines in pipi have been documented to increase the 'erodibility' of Mair Bank under storm conditions (Whangarei Harbour Water Quality Management Programme, 1989). Morgan et al., (2011) showed that over the medium-term, pipi harvesting had not impacted the gross delta morphology due to the small proportion of harvested individuals relative to total biomass and the relatively non-invasive harvesting methods used. Furthermore, current catch landings over the past decade have consistently been below the TACC (Table 1).

[1]As a guide, if we assumed all harvested pipis were 60 mm, these estimates would equate to a greenweight of approximately 52 t, 161 t and 170 t respectively.

2. METHODS

2.1 Sample extent

2.1.1 Mair Bank

The sample extent for Mair Bank was based on the area defined by Williams et al (2006), i.e. pipi were sampled within the area defined by the 1.8 m below chart datum (CD) contour. The sample extent was split into an intertidal area (defined by 0.5 m above CD) and subtidal area (the remaining area) (see Figure 1). Contour lines were found using a high-resolution RTK-GPS system that mapped the bathymetry of the bank (the full bathymetric map is shown in the Appendix).

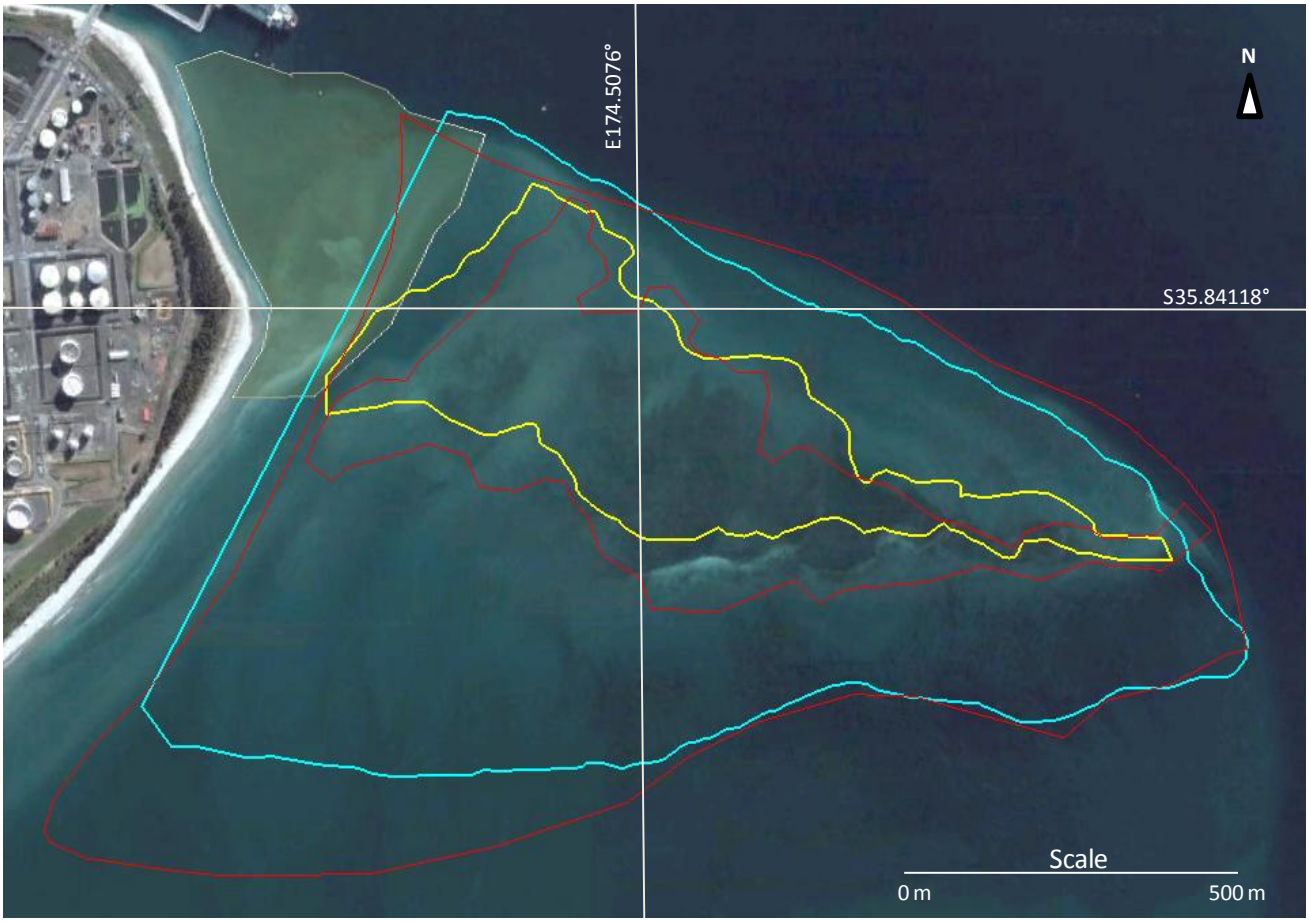

Figure 1: The 2010 Mair Bank survey split the bank into intertidal and subtidal strata. Intertidal and subtidal sample extents are shown by the yellow and blue contours respectively. Red lines show the intertidal and sample extent from the 2005 survey (Image: Google Earth).

The subtidal area was divided into four strata (A –D) based on the pipi density and variance estimates found in the 2005 and 2010 surveys (see Figure 2). In the previous surveys, subtidal strata A and B had low densities of pipis and stratum C had the highest density. In contrast, no pipis have been found in stratum D.

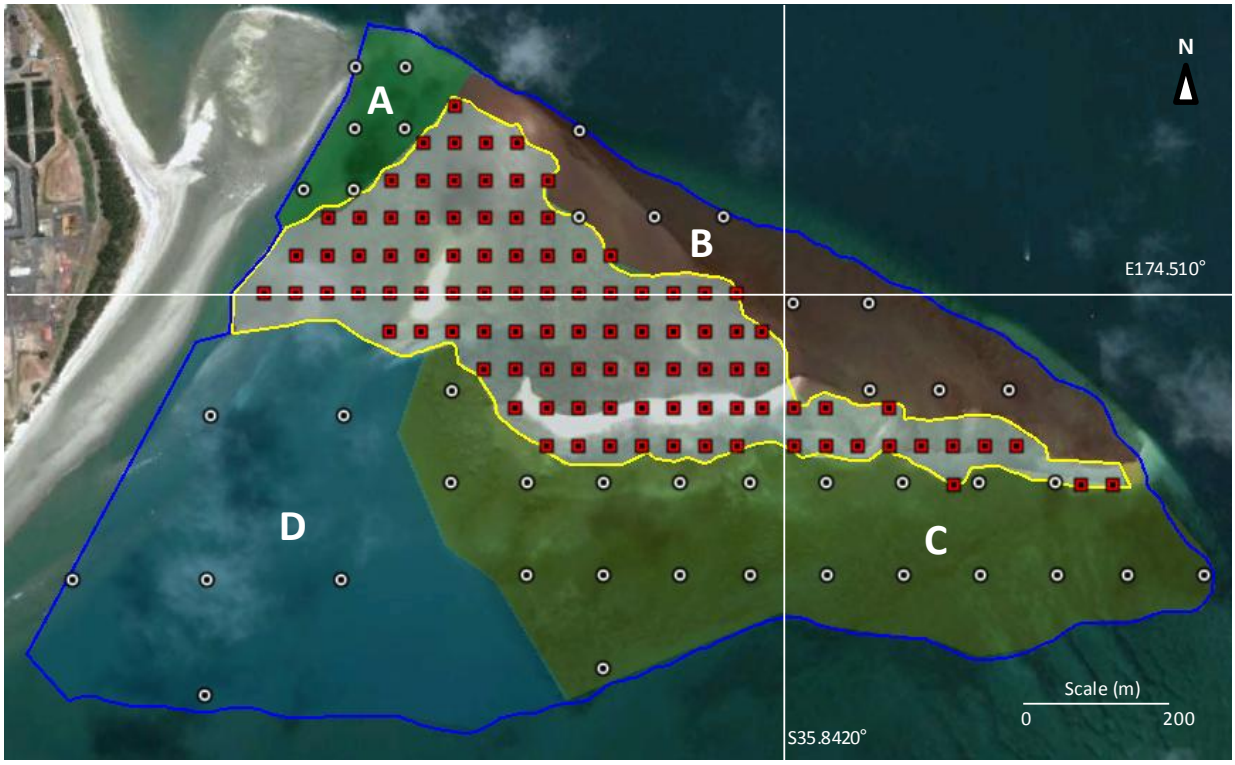

Figure 2: The 2014 Mair Bank survey split the subtidal zone into four strata (A – D). Red points indicate intertidal sample positions, white points subtidal sample positions (Image: Google Earth).

2.1 Sampling methods

The intertidal and subtidal samples were collected by taking a sample unit consisting of two adjacent, circular cores (with a 15 cm diameter) pushed into the substrate to a depth of 15 cm. The contents from the two cores were aggregated (so each sample unit covered a cross sectional area of 0.0353 m^2) and passed through a 5 mm aperture sieve. All individuals of the target species retained on the sieve were identified, counted and measured across their widest axis to the nearest millimetre. The intertidal and subtidal sample extents were sampled using a random start systematic design (see Figure 2).

The total biomass for Mair Bank was calculated by calculating the average biomass (per m^2) for each stratum, and then reweighting this value by the stratum area (see equation 1).

$$Total\ biomass(X) = \sum_{i=1} W_i \bar{x}_i \quad \textbf{[1]}$$

where W_i is the stratum area (m^2), and

$\bar{x}_i$ is the average density or biomass (per m^2) in stratum *i*.

The variance for the total biomass was then estimated using equation 2:

$$\mathrm{var}(X) = \sum_{i=1} \frac{W_i^2 s_i^2}{n_i} \quad \textbf{[2]}$$

where s_i^2 is the sampling variance of the site density biomass estimates in stratum *i*, and

n_i is the number of samples within stratum *i*.

2.2 Biomass estimation

2.2.1 Length-Weight relationship

We used the relationship between length and weight of pipis derived by Pawley et al. (2013) to assess biomass estimates (see Table 2). To assess the robustness of the length-weight model in our biomass estimate, we also used the relationship found by Williams et al (2006). If the Williams et al relationship is used, it results in a slightly smaller estimate of the total biomass (2.6% smaller).

Table 2: Pipi length-weight relationship estimates. The relationship was determined from data with sample size (*n*) used to estimate the model coefficients, *a* and *b*, from the equation: Weight = *a* x Length^b. The proportion of total variability explained by the model (R^2) is also shown in the table.

Year	*a*	*b*	*n*	R^2	*Reference*
1989	4.5×10^{-5}	3.2794	526	0.995	Haddon (1989)
2005	3.114×10^{-6}	3.8701	200	0.943	William et al. (2006)
2010	5.861×10^{-5}	3.1523	300	0.987	Pawley et al. (2013)

The modelled relationship between length and weight is shown in Figure 3. Although the model fits individuals above 25 mm well, it appears to consistently underestimate smaller individuals.

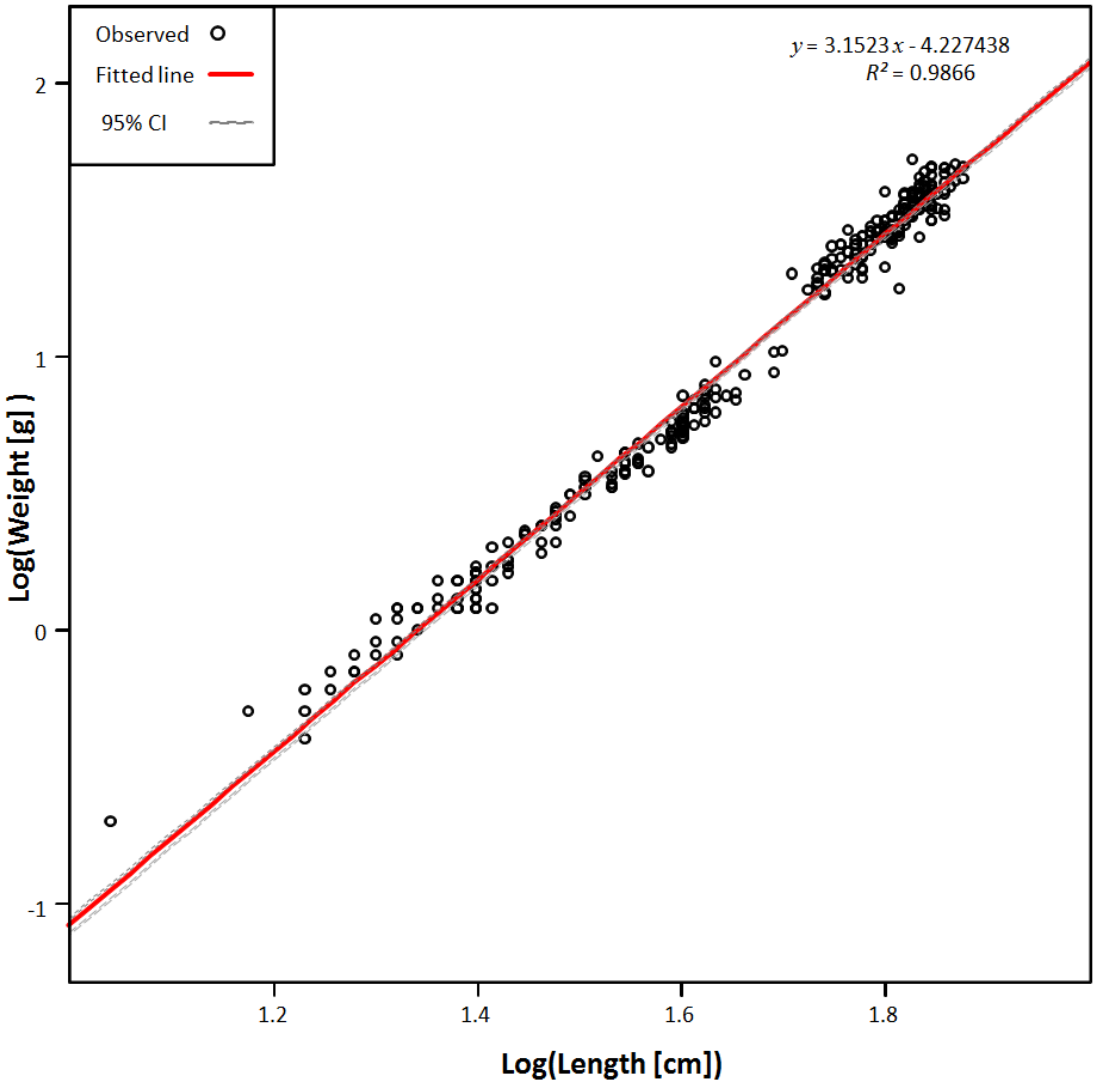

Figure 3: The relationship between the length and weight of pipis (from Pawley et al., 2013).

3. RESULTS

3.1 Total Population

In the 2014 survey, a total of only 63 pipis (including two subtidal pipis) were found from 140 samples. In contrast, the 2010 survey found 2,028 pipis (from 93 samples [the same sample unit type was used in both surveys]).

Table 3: Pipi densities found within each stratum.

Stratum	Sample size (*n*)	Pipi density (per m^2) (SE)	Stratum Area (m^2)	Total (millions)
Intertidal	101	17.09 (7.0)	242,560	4.14
Subtidal - A	6	0	34,290	0
Subtidal – B	9	6.28 (4.2)	127,860	0.81
Subtidal – C	19	0	279,090	0
Subtidal – D	5	0	272,150	0

- We estimate that the 2014 population of pipis at Mair Bank is 4.95 million ± 3.52 million (95% confidence interval).
- We estimate that the number of 'harvestable pipis' (i.e. pipis larger than 50 mm) was 2.5 million ± 1.45 million.
- We estimate that the number of pipis recruited within the last year (i.e. pipis smaller than 18 mm) was 0.48 million ± 0.82 million.

3.2 Biomass

We estimate the absolute biomass of pipis in the entire Mair Bank sample extent is 73.5 ± 44.6 tonnes (95% confidence interval) (see Table 4).

Table 4: Absolute biomass estimates (1 mm recruited shell length) of pipis on Mair Bank.

	Intertidal stratum		Subtidal stratum		**Mair Bank Total**	
Year	*Biomass (t)*	*c.v. (%)*	*Biomass (t)*	*c.v. (%)*	***Biomass (t)***	***c.v. (%)***
2005	3 602	11.4	6 940	19.5	**10 542**	**13.4**
2010	2 233	17.4	2 218	33.0	**4 452**	**15.2**
2014	46.1	50.8	27.5	25.9	**73.5**	**30.8**

There has been a significant decrease in the total (absolute) biomass of pipis at Mair Bank since the previous (2010) survey.

3.2 Length Frequency Distribution

The length frequency distributions (weighted by stratum are) are shown for the Mair Bank intertidal, and subtidal population for the 2010 and 2014 studies (Figure 4). Note – the graphics are standardized by the sample size.

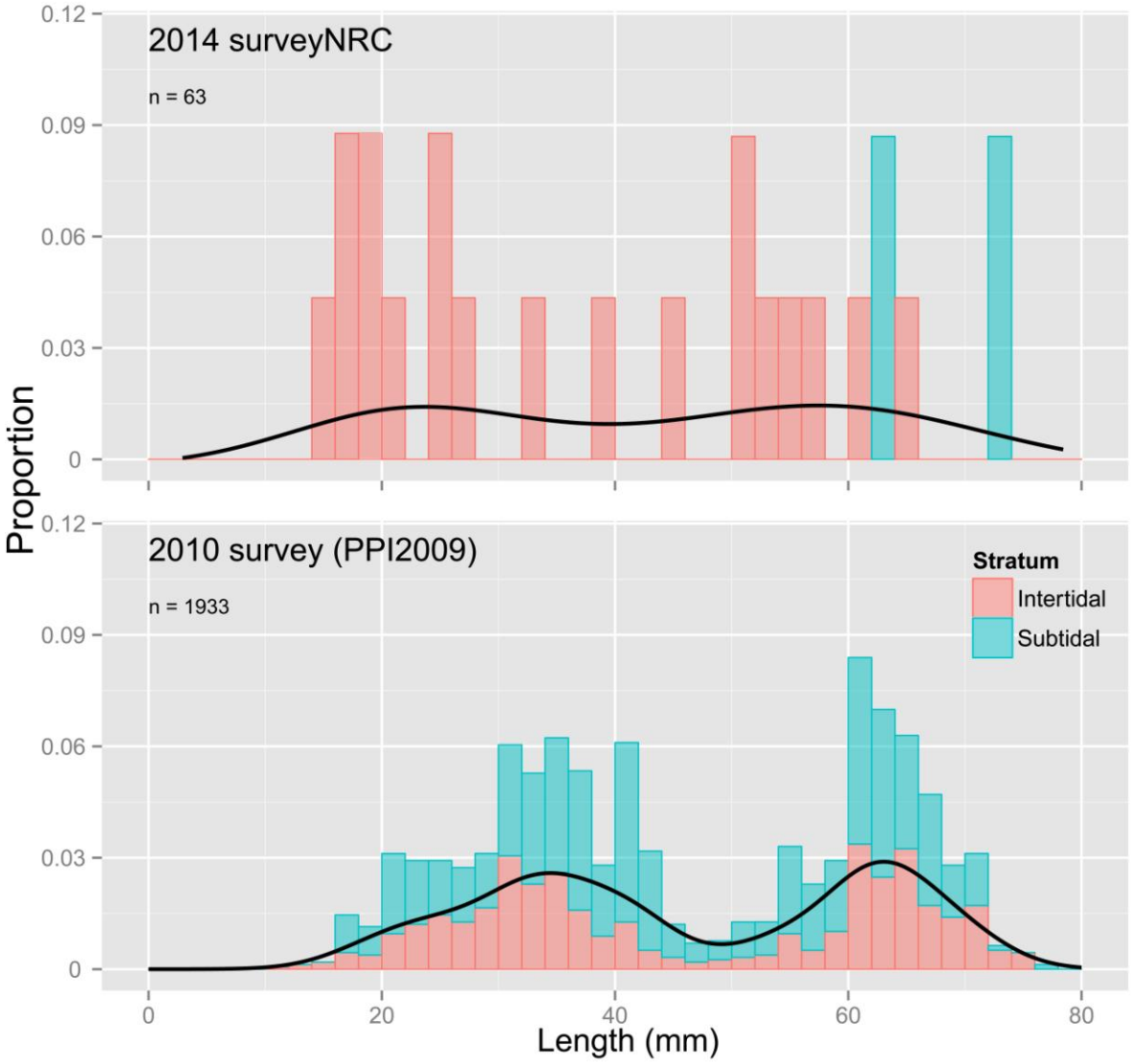

Figure 4: The length frequency distribution of Mair Bank pipis in 2010 and 2014. The black line is a smoothed estimate of the length frequency histogram.

The Mair Bank distribution of pipi length in 2010 was bimodal in both intertidal and subtidal areas - with modes around 30 mm and 62 mm. Unfortunately, there were not enough pipis to accurately estimate the length frequency distribution of the 2014 population, but the pipis that were found were relatively uniformly distributed between around 14 and 70 mm.

4. Discussion

The 2014 survey of Mair Bank is only the third pipi biomass estimate that accounts for the subtidal population. The pipi population there appears to have declined drastically – a total of only 63 pipis were found from 140 samples throughout the sample extent.

Both the total abundance and biomass have plummeted since the 2010 survey. The total population has declined from around 460 million (2010) to around 4.95 million, and the 2014 estimate of absolute biomass, 73.5 t is less than 1.7% of the 2010 estimate (4,450 t) and less than 1% of the 2005 estimate (10,542 t).

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APPENDIX

Bathymetric Map of Mair Bank – 2013