Report to Friends of Venus Bay Peninsula Inc.

Monitoring of pipi (*Donax deltoides*) abundance and size frequency at Cape Liptrap Coastal Park, Venus Bay, Victoria, December 2013.

No.10

February 2014

MES

Cover Image: The author with the spade corer used to sample pipis at Cape Liptrap Coastal Park, Venus Bay beach.

Monitoring of the pipi (*Donax deltoides*) at Cape Liptrap Coastal Park, Venus Bay, Victoria, December 2013.

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Preferred way to cite: Parry G.D. (2014) Monitoring of the pipi (*Donax deltoides*) abundance and size frequency at Cape Liptrap Coastal Park, Venus Bay, Victoria, December 2013. MES Report No 10, 20 pp, Marine Ecological Solutions, PO Box 265, Queenscliff, 3225, Victoria, Australia.

Executive Summary

Pipi monitoring techniques refined during this study enabled 5-6 60 m transects across Venus Bay beach to be sampled during a 5-5.5 hr period during spring low tides. Transects were located in two regions ('North' and 'Centre') subject to high harvesting levels near access points and a region ('South') subject to minimal harvesting which was distant from access points.

A very high density of pipis (1300/m^2) was found at the 10 m site on one transect, but this dense patch of pipis was not found there two days later.

There were far more small (<20 mm) pipis in the north (NW) than in the south (SE) of Venus Bay, and more large (>37 mm) pipis in the south than the north. The low density of large pipis in the north is largely due to the high harvesting pressure there, but the low number of large pipis in the far south of Venus Bay requires further investigation. The large number of small pipis in north of Venus Bay beach may be the result of harvesting pressure reducing the abundance of large pipis which consume incoming larval pipis. Such increased recruitment in over-harvested areas should facilitate their recovery. That this recovery has not yet occurred may be due to sustained over-harvesting of pipis of harvestable size in the north of Venus Bay.

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Introduction

This study was initiated by the Friends of Venus Bay Inc., who were concerned that over harvesting of pipis may be occurring on Venus Bay Beach.

Pipis were sampled on Venus Bay beach using methods similar to those used by Lewis (2010) and Early *et al*. (2011), but including several improvements in sampling efficiency, and were intended to:

- trial more efficient methods of sampling pipis
- trial a sampling strategy that would be suitable for an ongoing assessment of the adequacy of management of pipi harvesting in the two main harvesting areas: NW of Beach 1 and SE of Beach 1; and an area >3 km SE from Beach 1, where harvesting is believed to be minimised by poor access.
- enable a comparison with previous studies, to determine whether changes have occurred in the abundance of pipis since studies in 2009/10 and 2011.

The study also provides the first quantitative estimate of harvesting pressure in different regions of Venus Bay.

Material and Methods

Pipi sampling

Pipi distribution and abundance was determined during spring tides from 2-5 December 2013.

A total of 19 transects were sampled. Transects (=a line of sampling sites) were perpendicular to the beach and 60 m long. Except for Transect 0, transects were in groups of three separated by 0.5 km (Figure 1). Three regions were sampled (South, Centre and North). Seven transects were sampled in the North region, and six in both the other regions (Figure 1). These regions were sampled to enable comparison between the abundances of pipis at the heavily harvested regions NW and immediately SE of Beach 1, and the less harvested region further (>3 km) SE of Beach 1.

Transects were located using a Garmin GPSmap 60 Cx GPS, pre-programmed with all transect coordinates.

Transects 1-3, 4-6, 7 and 8, and 13-15 were in the same positions as transects sampled by Lewis (2013), and represented his Sites 1, 2, 3 and 4 respectively. The NW transect of his Site 3 was not sampled, as it nearly coincided with the SE transect of his Site 2. The exact positions of Lewis's sites were obtained from Lewis (2010).

Early *et al.* (2011) did not publish the coordinates of their sampled transects. They were estimated (±100 m) from the map in their report, and Google Earth. The equivalence between her transects and those sampled in the current study are shown in Table 1.

On each transect, sites were sampled 10 m, 20 m, 30 m, 40 m, 50 m and 60 m from the high tide drift line. At each site three cores were sampled approximately 1 m apart.

Cores were taken using a 0.156 m diameter spade corer (Figure 2, front cover of report). Samples were sieved using a large (450 mm diameter) 2 mm sieve, using seawater pumped from a 50 L tank (Figure 3). The tank, which was attached to a plastic toboggan, was towed up the beach to provide a source of water at a sample washing station on each transect (Figure 3).

Table 1. Equivalence between transects sampled in current study and those sampled by Early *et al*. (2011).

This study	Early *et al.* (2011)
Transect 0	Transect 19
Transect 2	Transect 16
Transect 5	Transect 13 (approx)
Transect 7	Transect 12 (approx)
Transect 9	Transect 11
Transect 10	Transect 10
Transect 12	Transect 9
Transect 14	Transect 7

The length of each pipi was measured to the nearest mm using vernier callipers. The length and total weight (wet weight, including shell) of 61 pipis was measured using a balance accurate to 0.001g. A length weight regression of $\log_{10}$ (weight) vs $\log_{10}$ (shell length) was calculated and used to estimate total biomass at sampling sites, based on the length frequency of pipis at each site. Estimates of total biomass of pipis were compared to previous estimates by Lewis (2010) and Early *et al*. (2011), where individual pipis were weighed.

This sampling strategy was similar to that used in previous studies at Venus Bay, except that:

- Lewis (2010) and Early *et al.* (2011) both sampled at 5 m intervals from high tide mark, including a site 0 m from HTM. They found no pipis at this site, so it was not included in our sampling.
- At each site Lewis (2010) and Early *et al*. (2011) sampled a quadrat 0.3 x 0.3 m, without replication. In this study the total area sampled by three cores was 0.057 m^2, compared to an area of 0.09 m^2 by Lewis (2010) and Early *et al*. (2011).
- Lewis (2010) and Early *et al*. (2011) sampled to a greater depth (30 cm and 20 cm respectively) than in this study. A shallower depth was sampled in this study as Lewis (2010) found 96% of pipis in the top 10 cm of sand.

- Early *et al*. (2011) sampled a shorter transect that extended only 40 m from high tide mark.

On 3 December, a very large density of pipis was found in all cores at the 10 m site on Transect 12. Consequently, to estimate the area of this dense patch of pipis a shovel was used to either scrape the surface (where densities were high) or to remove a shovel full of sand which was spread on the substrate to reveal any pipis (where densities were lower). On 3 December an area 200 m x 10 m was surveyed. On 5 December, that part of this area with the previously highest pipi density (30 m x 50 m) was re-surveyed, as was an area near the water's edge, approximately 60 m from the high tide mark.

Harvester distribution

On 26 December 2013 a team of six volunteers counted the number of harvesters, number of holes dug, and their mean diameter in 500 m lengths on Venus Bay beach. The survey extended along 10.5 km of beach, from 800 m SE of Pt Smythe to 2.5 km SE of the access point to Beach 1.

Three groups of volunteers sampled different lengths of beach and all measurements /observations were obtained between 12:30-2:30 within approximately one hour of low tide.

A more limited survey was undertaken on 8 January 14, approximately 2.5 hrs after low tide. The distribution of holes between the access point to Beach 1 and 2.3 km SE was observed.

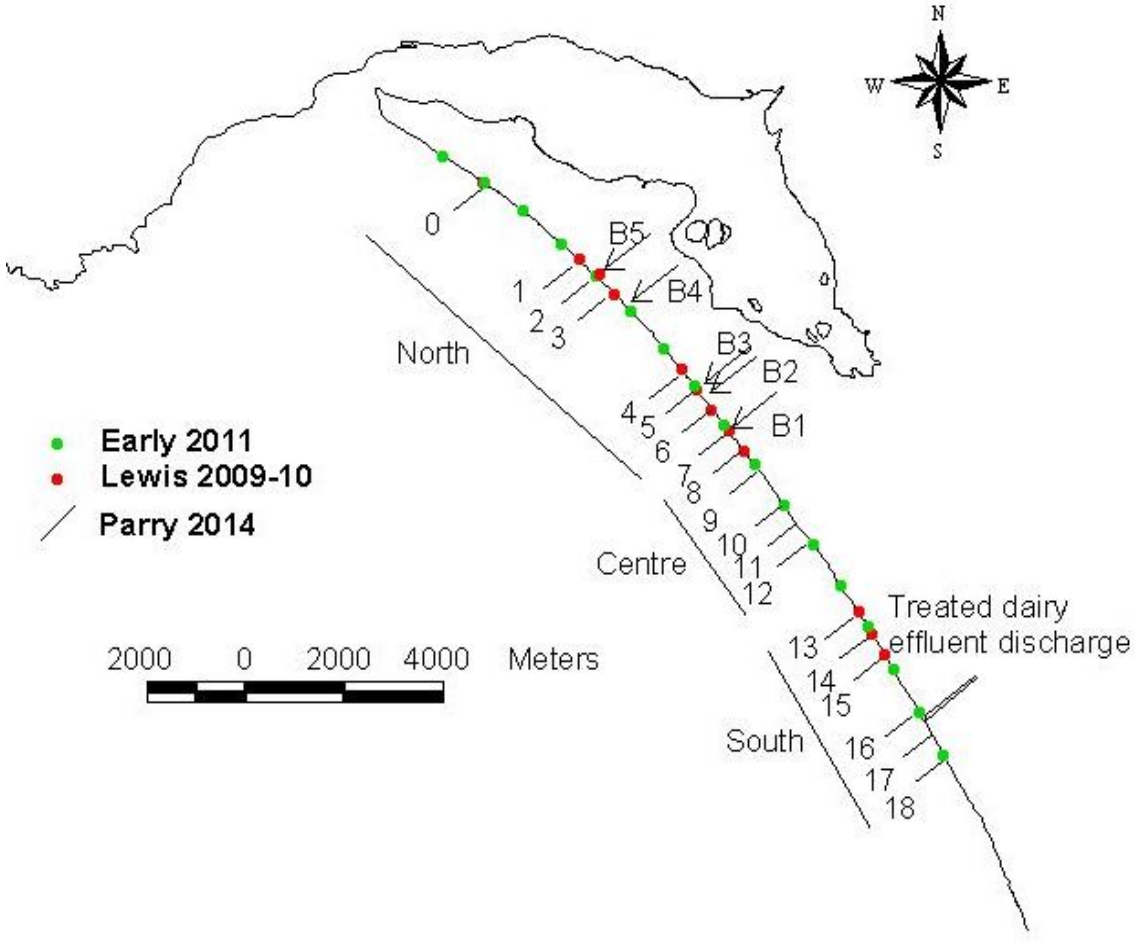


Figure 1. Map showing the location of transects sampled (numbered), and the three regions of the beach (North, Centre and South) analysed in this study. The locations of transects sampled by Lewis (2010) and Early (2011) are also shown. Arrows show the location of the access points between Beach 1 (B1) and Beach 5 (B5), and the location of the discharge point of treated dairy effluent is shown. A seldom used access track (Five mile track) occurs 3 km SE of transect 18.

Figure 2. The spade corer used to take samples in this study.

Figure 3. A sample washing station, showing large sieve, pump hose, and water tanks attached to toboggans.

Results

Distribution of pipis

The techniques we refined to survey pipis on Venus Bay beach enabled 5-6 transects to be surveyed during a working time of 5-5.5hrs during each spring low tide. This is the maximum number of transects, with triplicate cores at 10 m intervals, that can be surveyed by two staff in the time available during one low tide exposure.

The density of large pipis found at Transect 12 was exceptionally high, due to a density of 1300/m^2 at the 10 m site (Figure 4). A qualitative survey near this site found an area of high pipi density approximately 200 m × 5-10 m that was restricted to a band in the upper shore. But two days later no pipis were found in this area.

The size frequency distribution of pipis across all transects is shown in Figure 5. This suggests a recent recruitment of a cohort with a mean length of 7 mm, and other smaller cohorts with mean lengths of ~13-15 mm, 29 mm and 43 mm. Cohorts with larger shell lengths were difficult to distinguish in the size-frequency distribution.

The size frequency of pipis varied between regions, with most newly-recruited pipis in the north and very few newly-recruited pipis in the south, where there were more large pipis (Figure 6). The only cores in which there were large numbers of small (<20 mm) recently recruited pipis, were those with few or no adult (>37 mm) pipis (Figure 7).

Size frequency distributions of pipis indicated that small pipis were least abundant near the high tide mark, while large pipis increased in abundance towards the high water mark (Figure 8).

The mean abundance of pipis that were <30 mm or >30 mm (a size judged to be the minimum size most harvesters are likely to collect) in each of the three regions (South, Centre and North) is shown in Table 2. Transect 12 (2.9 km south of the access to Beach 1) was approximately the distance (3 km) Lewis (2010) estimated most harvesters are willing to walk. Consequently, this transect could be included in either the Centre (highly harvested) or South (lightly harvested) regions. Estimates of densities of large pipis in the Centre and South regions differed markedly, depending on the region to which Transect 12 was assigned (Table 2).

The abundance of large pipis was 3.1- 4.6× higher in the South than the North region, and, conversely, there were 17-20× more small pipis in the North than the South region (Table 2). The abundance of large pipis in the Centre region was similar to their abundance in the North region, if Transect 12 was included in the South region, or to their abundance in the South region, if Transect 12 was included in the Centre region.

Table 2. Abundance of pipis (mean and se) <30 mm and >30 mm shell length per transect in each of three regions monitored in December 2013 (Figure 1). Transect 12 had an exceptionally high density of large pipis and was 2.9 km from the nearest access point (Beach 1). Abundances in the Centre and South regions were estimated including and excluding Transect 12. Note that (limited) measurements of harvester activity suggests that minimal harvesting occurs more than 2.3 km SE of access to Beach 1.

Region	Length < 30 mm		Length > 30 mm	
	Mean	se	Mean	se
North	33.1	8.0	5.1	2.7
Centre*	24.2	12.7	4.0	2.1
South*	2.0	0.8	23.3	9.3

* includes Transect 12 in 'South' region.

Region	Length < 30 mm		Length > 30 mm	
	Mean	se	Mean	se
North	33.1	8.0	5.1	2.7
Centre[#]	20.8	10.9	14.8	11.0
South[#]	1.7	0.9	15.7	6.4

[#] includes Transect 12 in 'Centre' region.

Figure 4. Photo taken near 10 m site on Transect 12 showing high density of pipis (~1300/m^2) approximately 25 mm below the sand surface. The corer on the right hand side of the photo is ~16 cm in diameter.

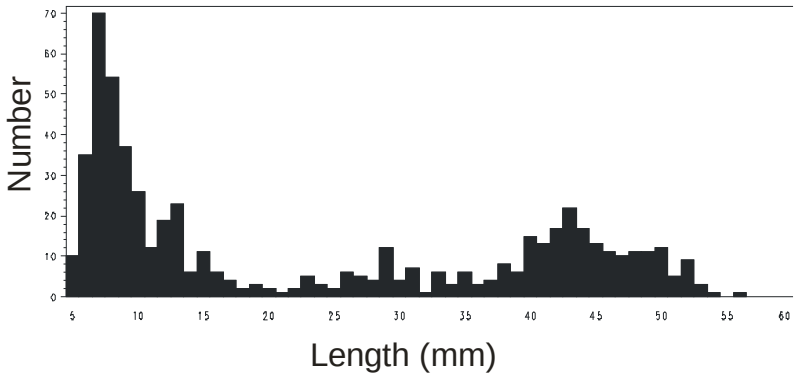


Figure 5. Size frequency distribution of all pipis measured during December 2013.

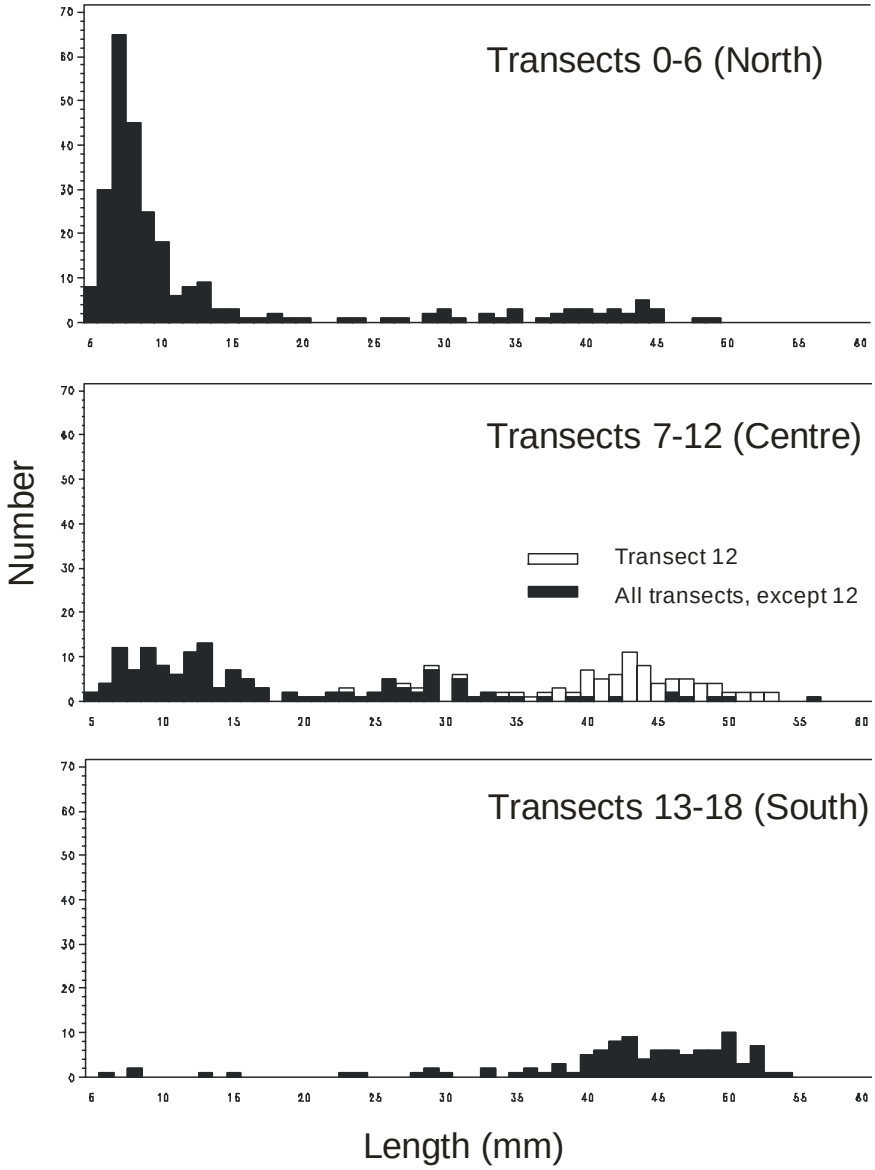


Figure 6. Size frequency distributions of pipis in the three regions of the Venus Bay study area (Figure 1). The large number of pipis at Transect 12 are shown separately.

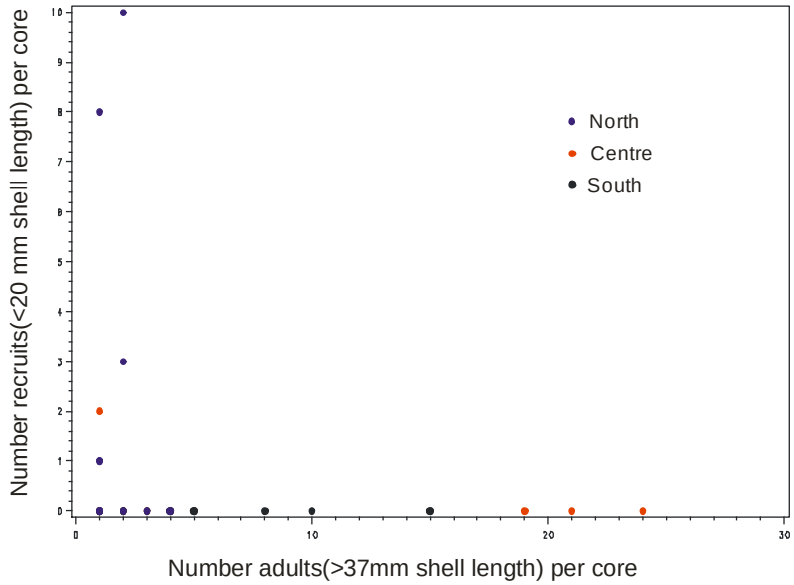


Figure 7. Comparison of the number of recruits in a core with the number of adults in a core, in each region (North, Centre and South).

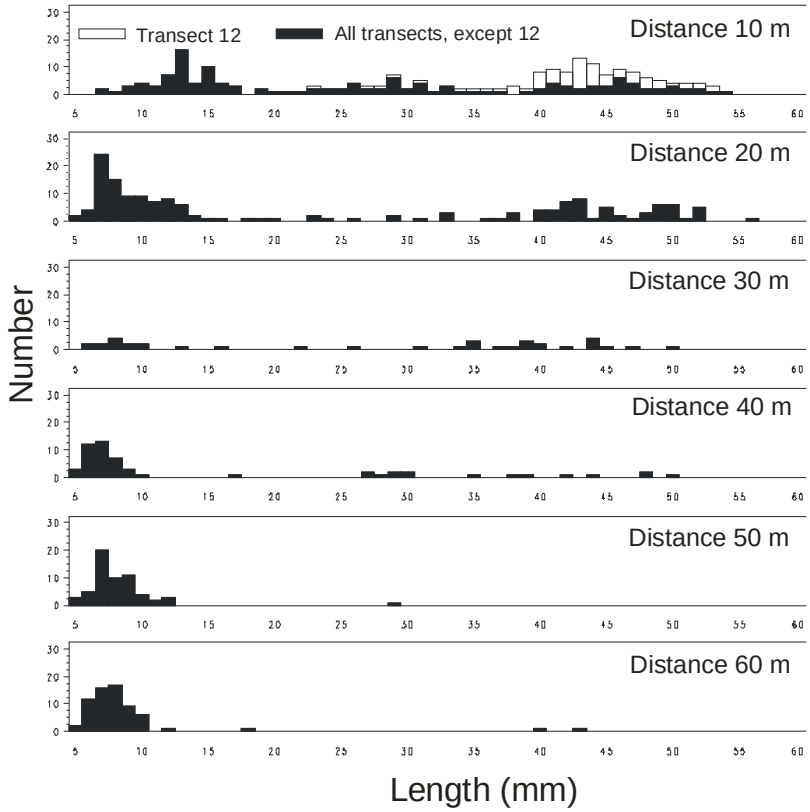


Figure 8. Size frequency distributions of pipis at 10 m, 20 m, 30 m, 40 m, 50 m and 60 m from high tide mark, averaged across all 19 transects. The large number of pipis 10 m from high tide at transect 12 are shown separately.

The number of pipis collected in each core is shown in Table A1, and the total number of pipis at each site on each transect is shown in Table A2. The size frequency distribution of pipis at each transect is shown in Figures A1–A3 and the length-weight regression for pipis is shown in Figure A4. The total biomass of pipis (wet weight including shell) in each transect is shown in Table A3.

Comparison with previous studies

Comparison of mean biomass of pipis (kg/m^2) in the current study and Lewis *et al.* (2013) are shown in Figure 9. The abundance of pipis at Sites 1-4 in the study by Lewis *et al*. (2013) and in the current study showed no clear difference between years, although in the current study there were more pipis at Site 2 than Lewis *et al.* (2013) found.

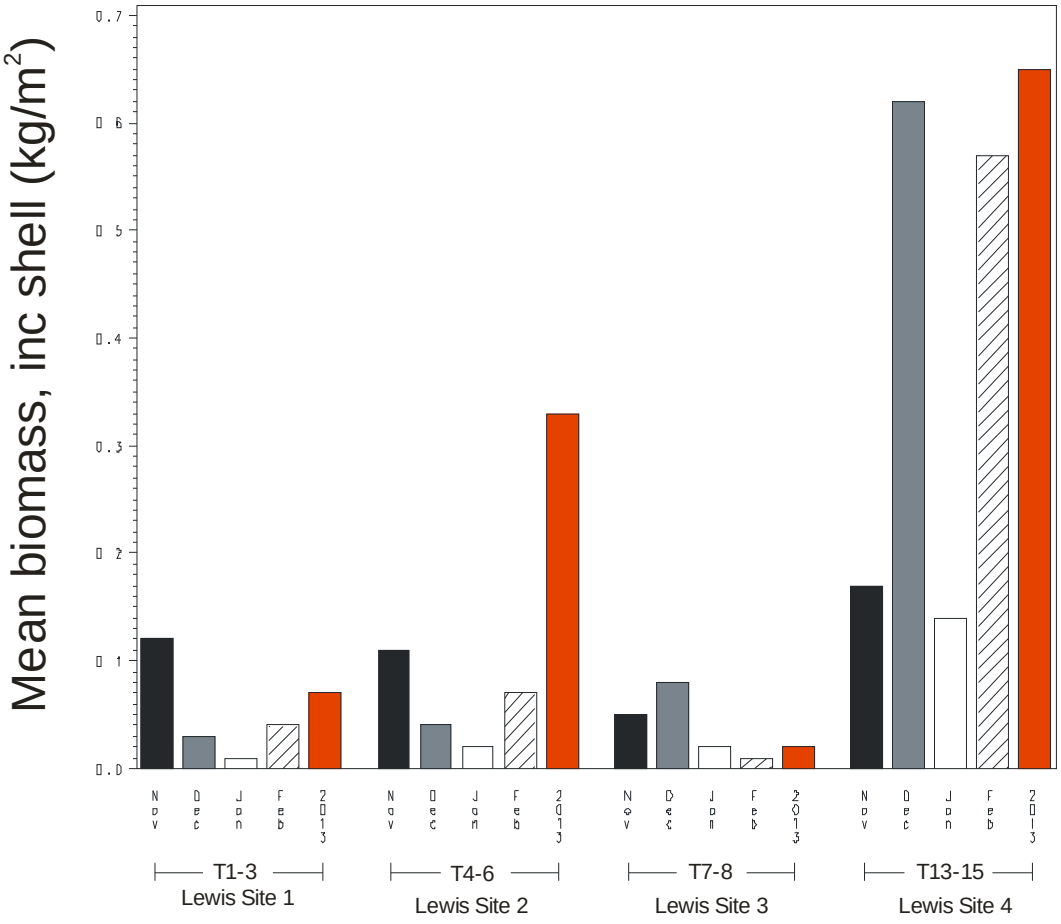


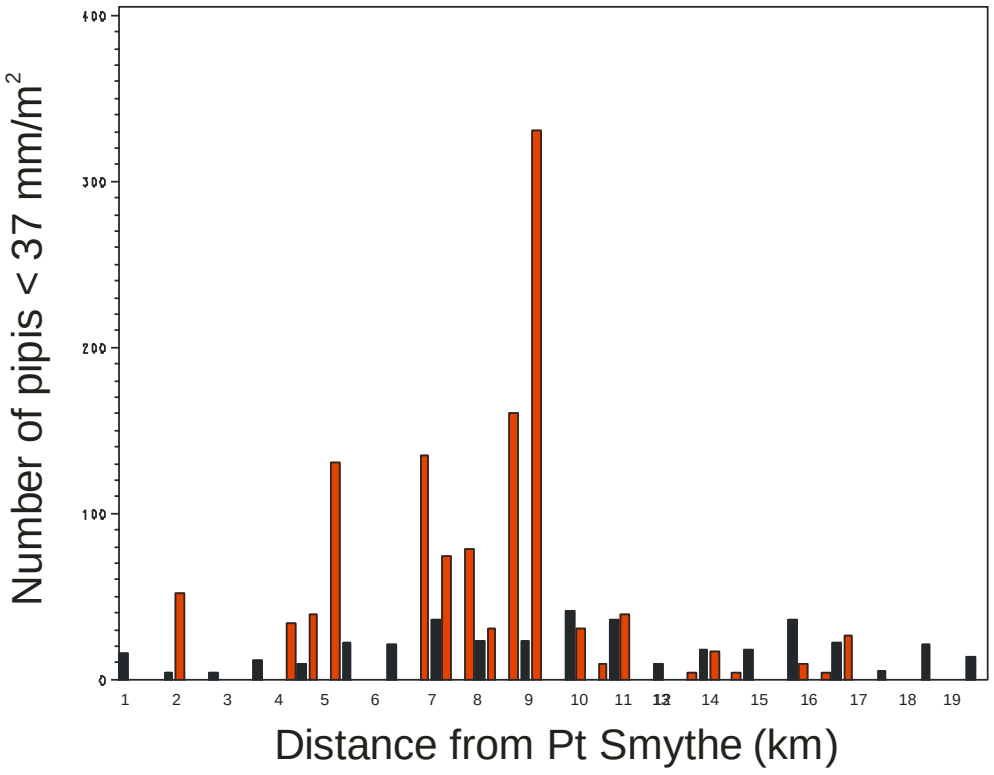
Figure 9. Biomass (total wet weight, including shell) at four locations sampled by Lewis (2013) in Nov 09, Dec 09, Jan 10, Feb 10 and in this study in 2013.

Comparison of number of small (<37 mm) and large (>37mm) pipis found by Early *et al.* (2011) and in the current study suggests that fewer small pipis were found less than 9 km from Pt Smythe by Early *et al*. (2012) than in the current study, but the number of small pipis found more than 9 km from Pt Smythe were similarly low in both studies (Figure 10). The number of large

(>37 mm) pipis appeared greater in the current study, particularly more than 10 km from Pt Smythe, than in Early *et al*.'s (2012) study. The very high pipi density 11 km from Pt Smythe in our study results from the exceptionally high density of pipis observed on Transect 12.

Distribution of harvesters

Surveys on the 26 January 14 recorded 873 harvesters and 2546 holes dug by harvesterson Venus Bay beach. Harvesting was confined to the region 3–11.5 km SE of Pt Smythe. The southern most area where harvesting was observed was 2.3 km SE of the access point to Beach 1. During less favourable weather on 8 January 14, there were fewer harvesters and the most distant hole dug by harvesterssouth of Beach 1 was 1.8 km from the access point to this beach.



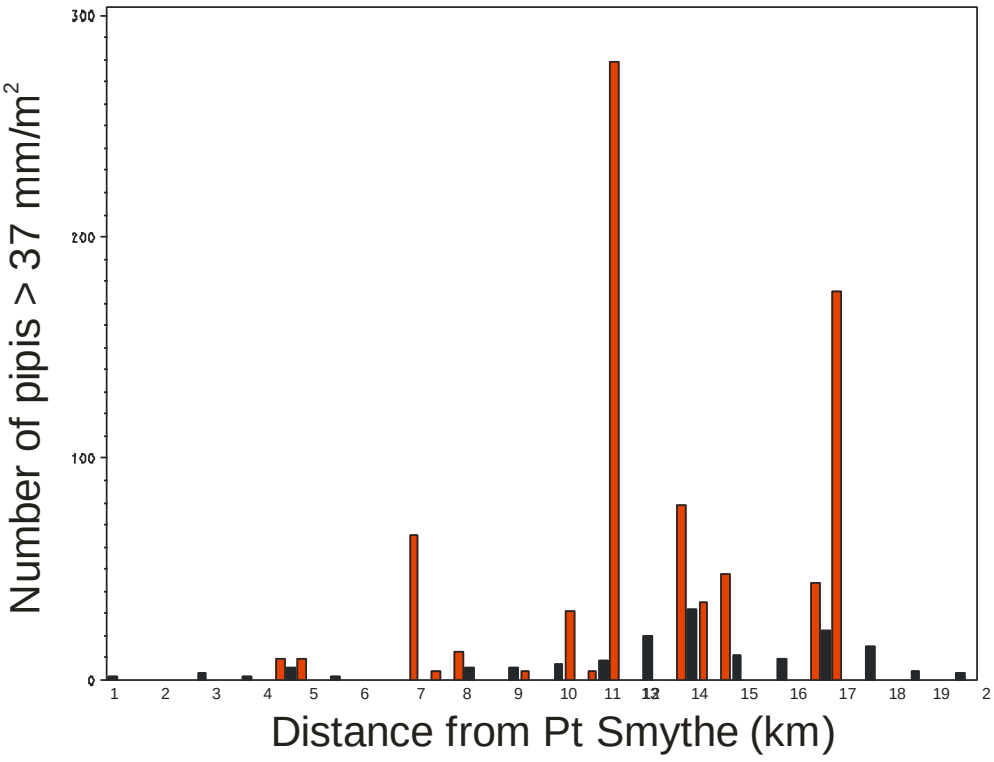


Figure 10. Comparison of density of small (<37 mm) pipis and large (>37 mm) pipis sampled by Early *et al*. (2011) (Black) and in this study (Red) at transects located different distances from Pt Smythe. Note that Early *et al*. (2011) sampled every 1 km, whereas in this study samples were taken at some of the same sites, and also at sites midway between sites sampled by Early *et al*. (2011).

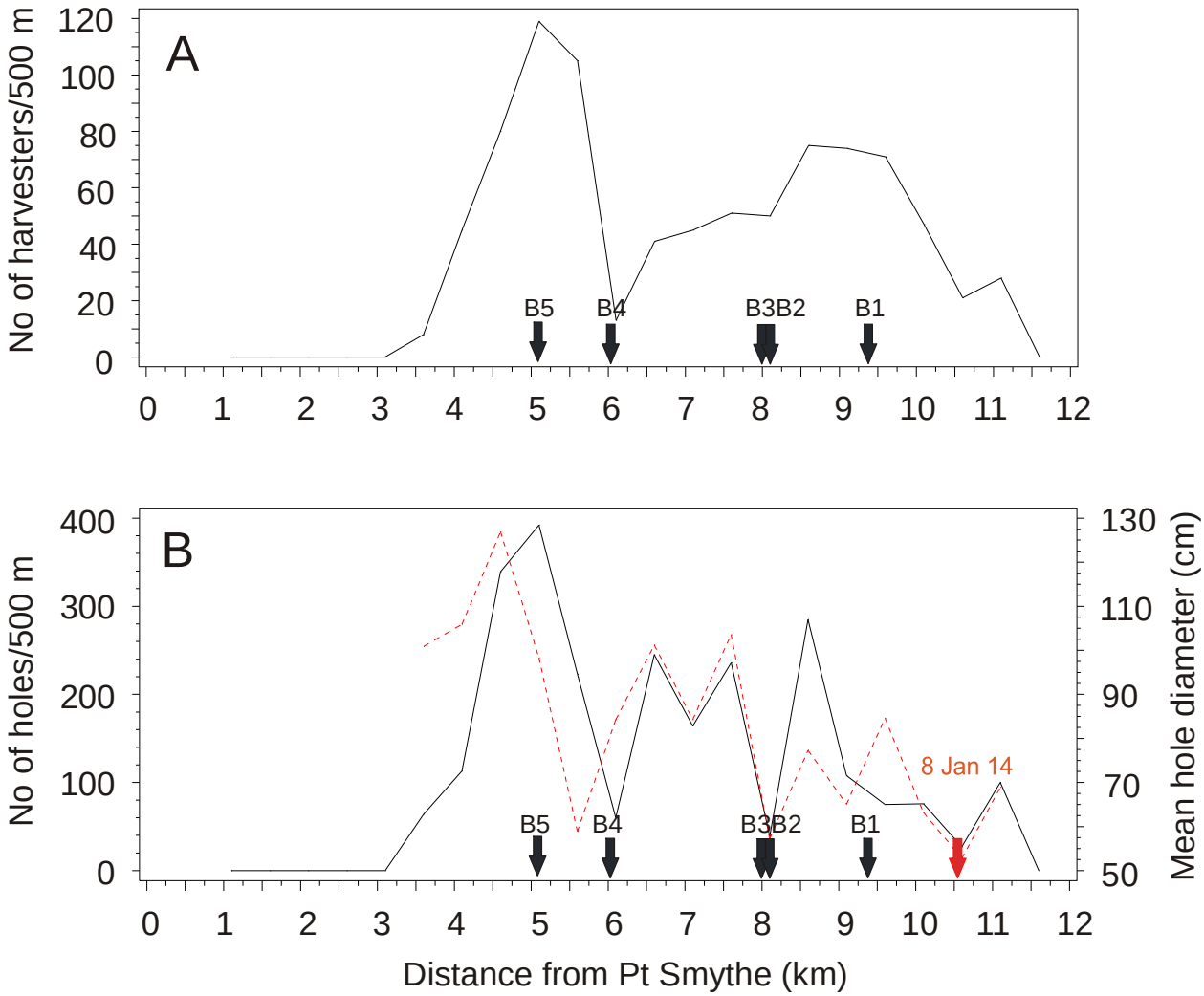


Figure 11. A. Number of harvesters plotted against distance from Pt Smythe (km), B. Number of holes dug by harvesters and their mean diameter (broken red line). The red arrow indicates the location of the most distant hole south of the access point to Beach 1 on 8 Jan 14. The location of access points to Beaches 1-5 (B1-B5) are shown.

Discussion

Adequacy of field methods

The methods refined during this study enabled two staff to sample 5-6 transects within a spring low tide. The corer used, the large sieve (45 mm diameter) and the system developed to wash samples using seawater dragged up the beach on a toboggan, all worked efficiently. This will enable accurate costing of any future monitoring studies.

There is an inevitable trade-off between sites sampled per transect and the number of transects sampled. The increased allocation of sampling effort to sampling more transects, but fewer sites per transect, compared with Lewis (2010) and Early *et al*. (2011) (both of whom sampled at 5 m intervals rather than 10 m intervals along each transect) should increase the accuracy of the estimate of pipi abundance as most of the variation occurs between transects.

Pipi distribution and abundance

The density of pipis found at the 10 m site on Transect 12 (1300/m^2, Figure 4) on 3 December 2013, far exceeded the highest density observed for this species previously.

This very high density, which persisted for less than two days, may have been associated with spawning. Examination of these pipis showed they had ripe gonads. No similar aggregations of surf clams were found from an examination of relevant scientific literature.

Observations at Transect 12 also illustrate the patchy and temporally variable distribution of pipis, which make monitoring changes in the abundance of pipis on Venus Bay beach challenging.

When pipis are highly aggregated they are also more vulnerable to over-harvesting as they are more easily collected. Figure 12 a shows an extended linear hole dug by harvesters on 31 Dec 13, which suggests that they were exploiting a linear aggregation of pipis, similar to that observed near Transect 12.

There were two conspicuous trends in pipi distributions. There were far more small pipis in the North than in the south of Venus Bay, and more large pipis in the south than the north. There were also few small pipis high on the shore, and more large pipis high on the shore.

Neither Lewis (2010) nor Early *et al.* (2011) detected these patterns, although Early *et al*. (2011) found a high recruitment of pipis at Pt Smythe. Settlement patterns may have differed between years. In both the previous studies the authors also combined data from several time periods, and this may have obscured short-lived distributional patterns. Pipis may be found at different distances from the high tide line at different times, so that on average they may show no conspicuous pattern.

The most likely explanation for the low density of adult pipis in the North and Centre regions (excluding Transect 12) is the high rates of harvesting in these areas compared to the South region (Lewis 2010, 2013, Early *et al.* 2010, Parry 2013). There was no clear trend in the abundance of large pipis in the heavily harvested region between 2009 and 2013, but pipi recruitment was higher in this region in 2013. The abundance of large pipis may have increased in the lightly fished area between 2011 and 2013.

The distribution of large and small pipis appeared to be negatively correlated at both large km) and small (m) scales. Defeo and McLachlan (2005) also found that recruits of the surf clam *Mesoderma mactroides* were only found in areas where the density of adults was low. This pattern they attributed to the adult population filtering out settling larvae. This may also explain the pattern observed in this study, but other explanations are possible. For example, oceanographic conditions around the time of larval settlement in 2013 (and other years?) may have resulted in higher settlement of juveniles in the north and centre of Venus Bay beach.

There are several unexplained aspects of the distribution of pipis on Venus Bay beach. While harvesting probably explains much of the difference between the accessible and less accessible populations, the number of adult pipis also decreased towards the southern end of the beach, where there appears to be minimal harvesting. Larval transport by ocean currents may also have an important influence on the distribution of juvenile pipis and contribute to distributional patterns. There was also a very low adult pipi density 16 km from Pt Smythe (Figure 10), near Transect 16 (Table A1C), where there is an offshore treated effluent discharge from a dairy factory (Figure 1).

Management implications

Parry (2013) suggested that in addition to the existing controls (a fishing licence, no digging implements to be used, and a 2L bag limit/person/day) that rotational closures be considered in the heavily fished regions. There are only five access points to Venus Bay beaches and all of these are north of Beach 1, which is the only beach with a public toilet and more than a handful of car parking spaces. This means that rotational closures of beaches to pipi harvesting would appear to be practical only on alternate sides of the Beach 1 access point. Therefore, the current study surveyed in detail beaches north (North region) and immediately south of Beach 1 (Centre region), as well as an area subject to minimal harvesting (South region). If the high densities of recently recruited pipis in the North and Centre regions of Venus Bay are due to reduced predation of larvae by large pipis, then the reduction in density dependent mortality would be expected to speed up the recovery of closed areas with few adult pipis.

It would be desirable that before any further monitoring occurs that further statistical (power) analysis is undertaken to establish the number of transects that should be monitored to detect changes of significance. It would also be desirable to better understand at least those circumstances that cause very high densities of pipis to occur sporadically on the beach. These aggregations make accurate monitoring more difficult, and also may make pipis more vulnerable to harvesters should they become predictable.

It would also be valuable to have more quantitative information on the spatial distribution of harvesting at Venus Bay beach. This would avoid the ambiguity associated with categorising Transect 12 as occurring in a lightly or heavily harvested area. Long term records of harvesting intensity would also provide an efficient means of documenting any trends in harvesting in regions currently believed to be too remote to be significantly impacted by harvesting.

Figure 12. A linear trench dug by harvesters that suggests they may be exploiting a linear aggregation of pipis, similar to that found near Transect 12 in the current study. Photo looking north from Beach 5 on 31 December 12 (Photo taken by Heather Shimmen).

Acknowledgements

Thanks to Mae Adams and Janet Carey for their hospitality while in the field at Venus Bay. Thanks to Lina Caneva and Ian McGill for providing accommodation while at Venus Bay.

Jonathon Stevenson provided very useful advice on driving techniques on the beach to avoid getting bogged, and to avoid disturbing Hooded Plovers.

John Barry provided much valued assistance and companionship in the field.

Jordan Whitmore (B.Sc. graduate Latrobe University) coordinated volunteers who collected information on harvesting pressure on Venus Bay beach on 26 December 2013.

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Appendix

Table A1. Number of pipis collected in each replicate core from each transect sampled in this study.

Distance from high tide (m)	Transect, replicate																							
	0			1			2			3			4			5			6			7		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
10	1	0	0	2	1	0	2	3	1	1	1	0	0	0	0	2	1	1	1	1	0	0	0	0
20	1	2	3	1	1	1	2	3	0	1	2	1	16	9	6	5	2	1	3	2	6	0	0	0
30	1	0	0	2	2	0	0	0	0	1	0	0	3	4	4	0	0	0	1	0	0	2	0	0
40	2	1	1	0	0	0	0	0	0	13	5	5	1	2	1	5	1	0	2	4	1	1	3	1
50	0	0	0	18	14	7	1	1	0	1	0	0	2	0	0	2	4	4	0	0	0	1	1	0
60	1	0	0	17	1	7	2	2	5	1	1	0	6	8	8	3	2	1	1	0	0	0	0	0

Distance from high tide (m)	Transect, replicate																							
	8			9			10			11			12			13			14			15		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
10	0	0	0	10	21	39	1	0	0	0	0	0	23	26	24	0	0	0	1	0	0	0	0	0
20	9	14	8	1	5	0	3	3	1	1	0	0	0	0	0	5	5	8	2	5	0	3	5	3
30	3	2	0	1	0	0	2	4	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
40	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	1	0	0	0
50	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Distance from high tide (m)	Transect, replicate								
	16			17			18		
	1	2	3	1	2	3	1	2	3
10	0	1	0	0	0	1	21	71	7
20	0	0	0	4	1	6	0	0	0
30	0	0	1	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0

Table A2. Total number of pipis collected in three cores sampled at each site on each transect.

Distance to high tide (m)	Transect																		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
10	1	3	6	2	0	4	2	0	0	70	1	0	73	0	1	0	1	0	46
20	6	3	5	4	31	8	11	0	31	6	7	1	0	18	7	11	0	11	0
30	1	4	0	1	11	0	1	2	5	1	6	2	0	0	0	1	1	0	0
40	4	0	0	23	4	6	7	5	1	0	0	0	0	1	4	0	0	0	0
50	0	39	2	1	2	10	0	2	1	0	0	0	0	0	2	0	0	0	0
60	1	25	9	2	22	6	1	0	0	0	0	0	0	0	0	0	0	0	0

Table A3. Mean biomass (wet weight including shell) on each 60 m transect (kg/m²).

Transect																		
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
West							Centre						East					
0.03	0.13	0.08	0.01	0.74	0.05	0.23	0.02	0.02	0.37	0.46	0.05	3.05	0.94	0.43	0.58	0.00	0.48	2.16

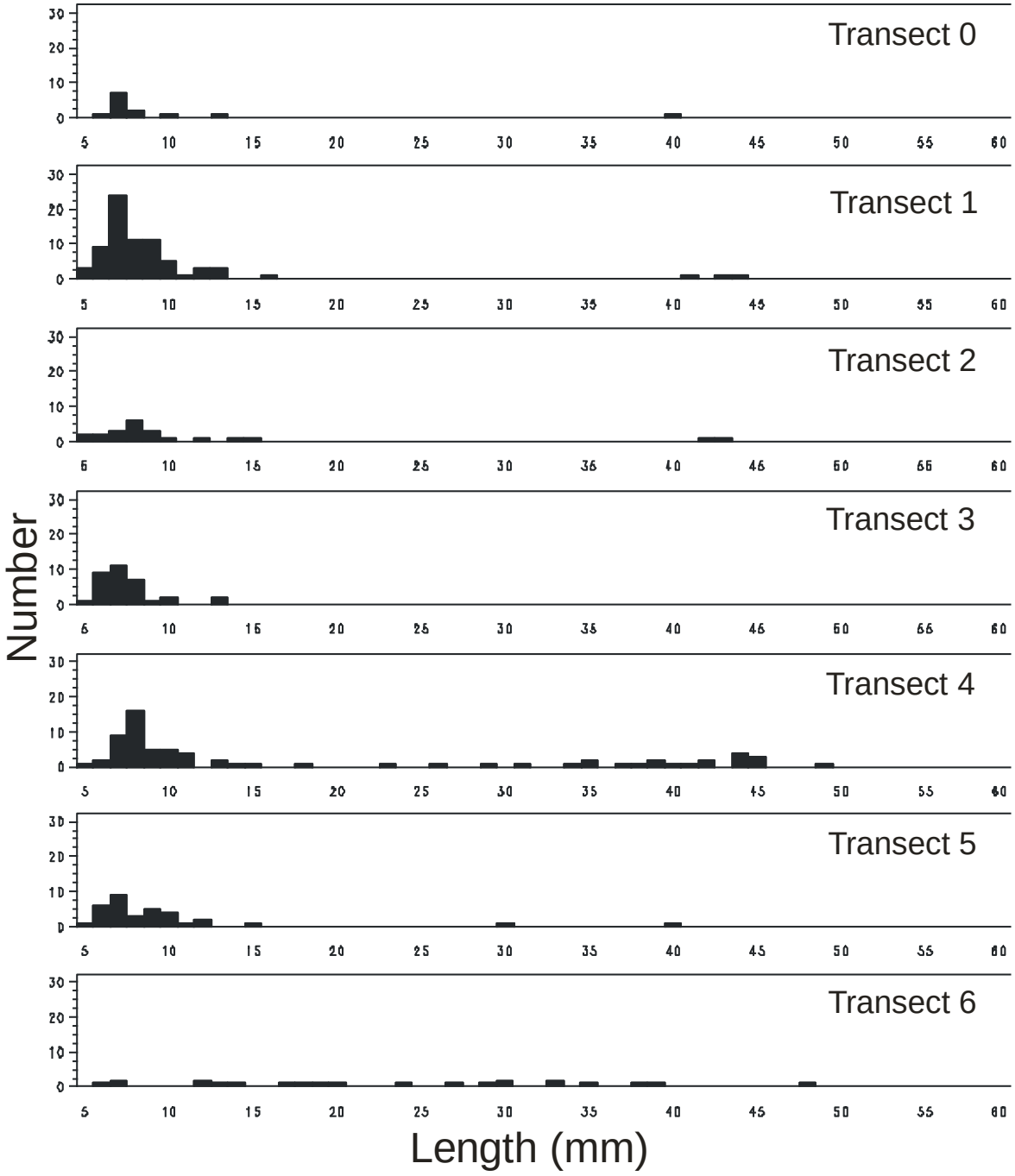

Figure A1. Size frequency distributions of pipis on transects 0 - 6 in the north region of the Venus Bay study area (Figure 1).

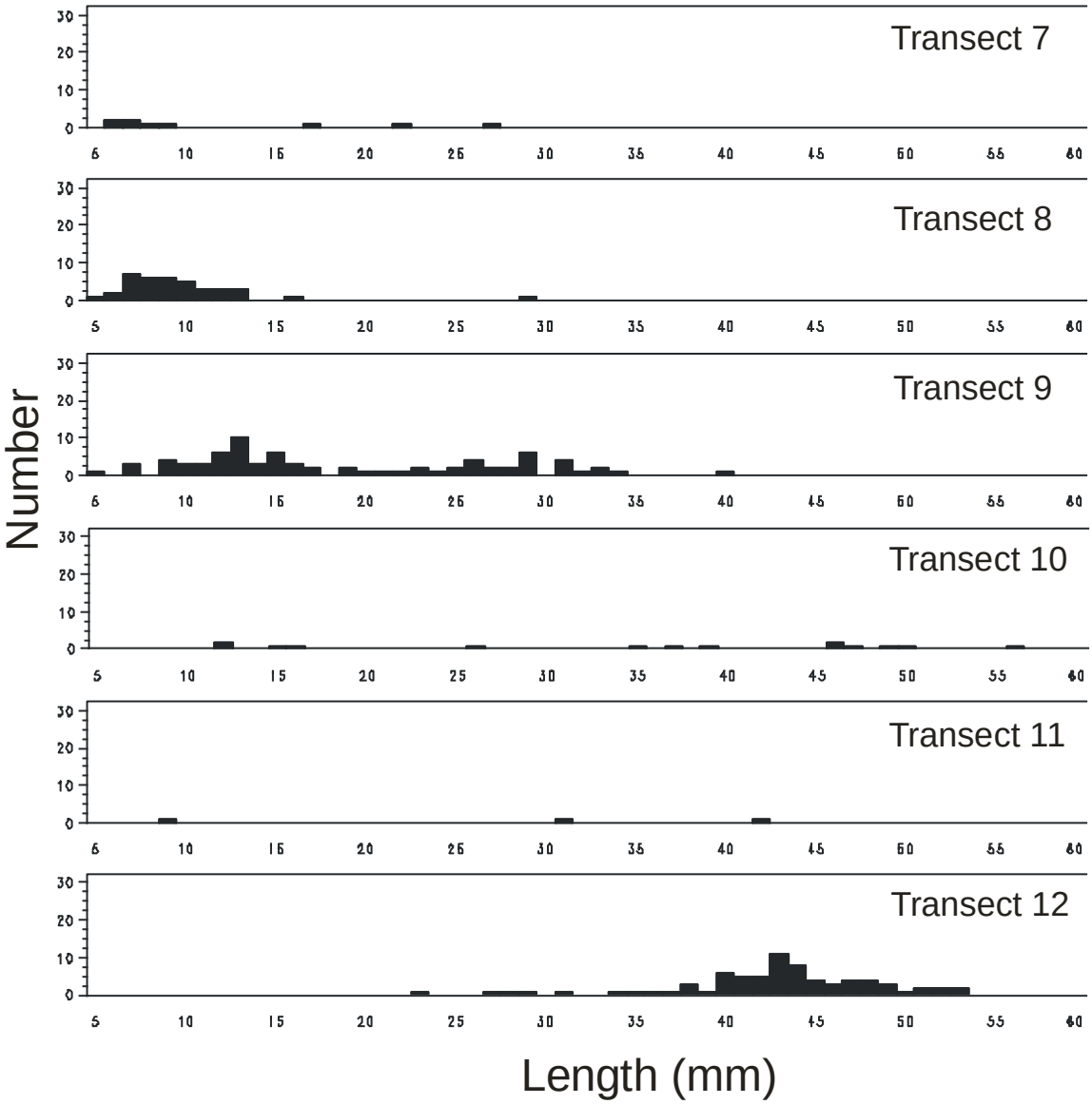

Figure A2. Size frequency distributions of pipis on transects 7- 12 in the central region of the Venus Bay study area (Figure 1).

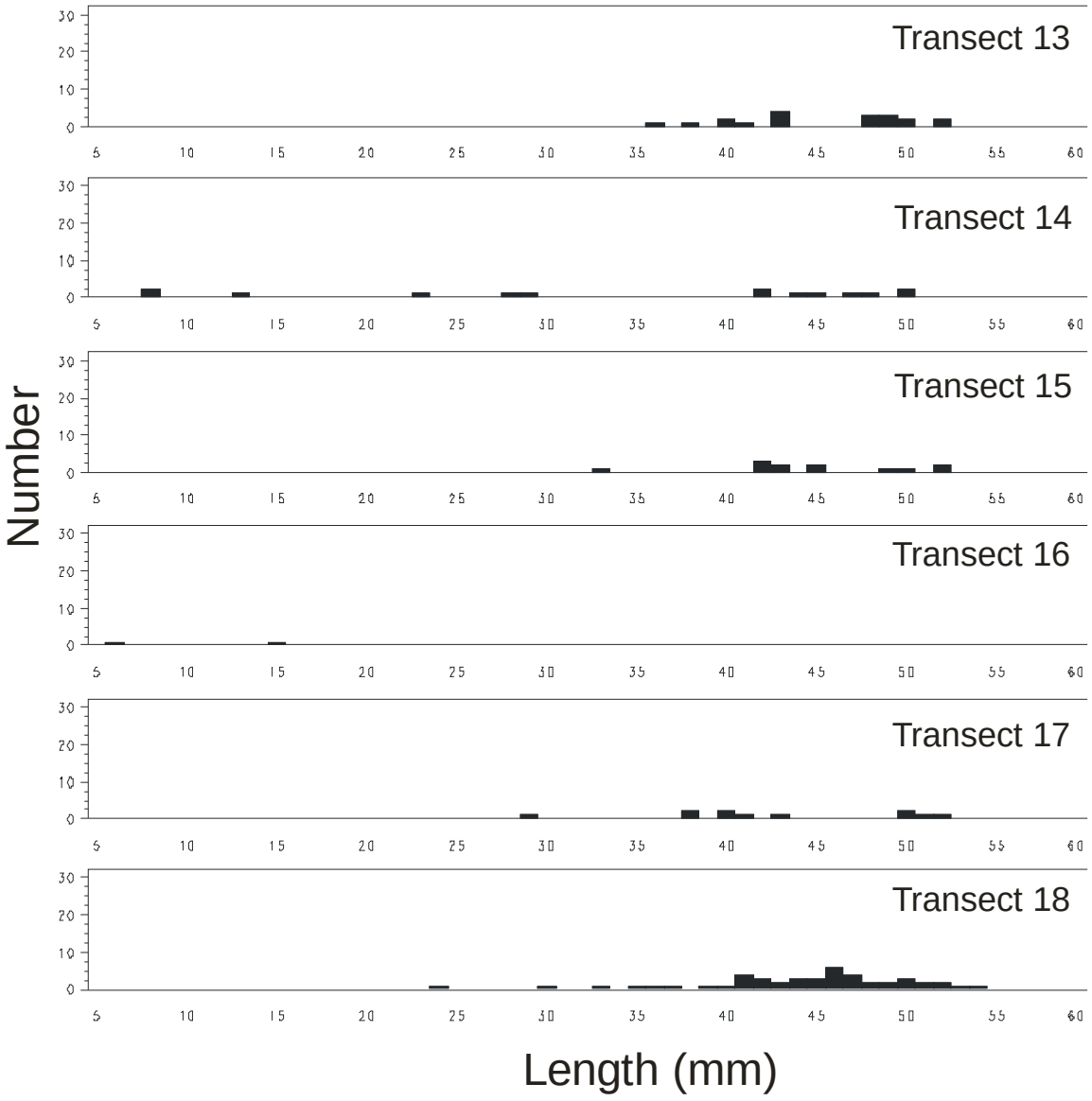

Figure 13. Size frequency distributions of pipis on transects 13- 18 in the south region of the Venus Bay study area (Figure 1).

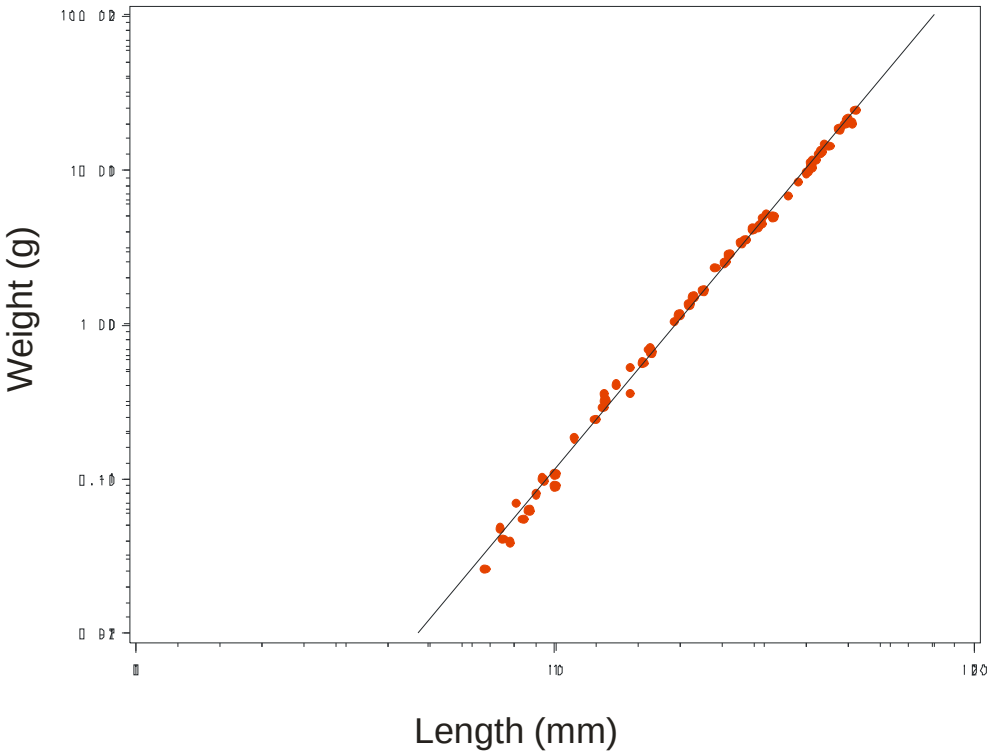

Figure A4. Plot of total wet weight (including shell) against shell length for individual measurments. The best fit regression line, Log_{10} (Weight) = -4.183 + 3.248*log_{10} (Length) is shown.