NIWA
Taihoro Nukurangi

Intertidal shellfish survey in Te Awarua-o-Porirua Harbour (Onepoto Arm), November 2017

Prepared for GWRC

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Contents

Executive summary

Te Awarua-o-Porirua Harbour is the only significant estuary in the southern North Island but very few studies have been undertaken on the shellfish of the Onepoto Arm. After the first systematic, exploratory survey of the intertidal shellfish of Onepoto in 2015, Ngati Toa chose to undertake a stratified random survey of Te Awarua-o-Porirua Harbour Onepoto arm in 2017 with new specified target sites Takapūwāhia, Porirua stream, opposite Mana Cruising Club (MCC) and behind Paremata Railway station (the Mana sandbank), and targeting species of customary importance: cockles, mudflat topshells, mud whelk and pipi, with a target coefficient of variation (c.v.) of 15%. The distribution and density were mapped and population estimates for all species were undertaken and compared with 2015.

On November 25 and 26, 2017, teams of community volunteers undertook shellfish sampling on 16 randomly allocated intertidal transects. The four-shellfish species of customary importance were identified, counted, and measured to estimate their length frequency, numbers (abundance), density and distribution.

Cockle (*Austrovenus stutchburyi*) were found at all 16 transect sites around Onepoto. More than 8500 cockles were sampled and 4793 measured. The highest densities of cockles were found at Mana sandbank and Takapūwāhia. A total population size of 110 million cockles (c.v. 11.6%) was calculated.

Mudflat topshell (*Diloma subrostrata*) were found at 12 of 16 sampled transects from the survey of Onepoto intertidal. There were low numbers in Porirua stream and high numbers in Takapūwāhia. A population estimate of 2.2 million shellfish (c.v. 17.7%) was calculated.

Mud whelk (*Cominella glandiformis*) were found at 14 of 16 sampled transects. The highest densities were at Mana sandbank and Takapūwāhia. A population estimate of 3.2 million shellfish (c.v. 9.6%) was calculated.

Pipi (*Paphies australis*) were found at 6 of 16 sampled transects, with only 12 shellfish sampled. A population estimate of 186,296 (c.v. 38.5%) was calculated.

There was a significant increase in abundance of cockles, and probably also mud whelk, and mudflat topshells between 2015 and 2017. The reason for this is uncertain.

1 Introduction

Te Awarua-o-Porirua Harbour once boasted a healthy and diverse ecosystem that supported shellfish and fish that were prized by Ngāti Toa as kaimoana since the iwi's arrival. The physical nature of the harbour changed following the introduction of intensive industry and development within the harbour catchment. Despite Te Awarua-o-Porirua Harbour being the only significant estuary in the southern North Island very few studies have been undertaken on the shellfish of the Onepoto Arm. In 2015 this changed, with teams from NIWA and Ngāti Toa undertaking the first systematic survey of the intertidal shellfish within the Onepoto arm (Lyon and Michael 2015). From the results of the 2015 survey, several stratified random surveys were designed (Lyon 2017), each optimised for different collections of species and levels of precision required to estimate shellfish abundance. Ngati Toa chose to target four areas (strata): Takapūwāhia, Porirua Stream, Mana sandbank and opposite Mana Cruising Club (MCC) for the species cockle (*Austrovenus stutchburyi*), mudflat topshell (*Diloma subrostrata*), and mud whelk (*Cominella glandiformis*), with a target coefficient of variation (c.v.) of 15%.

On November 25 and 26, 2017, teams of community volunteers undertook shellfish sampling on 16 randomly allocated intertidal transects. The four shellfish species of customary importance were identified, counted, and measured to estimate their length frequency, numbers (abundance), density and distribution.

1.1 Objectives

Objective 1: To provide assistance as required to Mountains to the Sea Wellington staff in identifying strata and transects to be sampled for the survey in November 2017. The agreed survey design includes 16 transects, focused on the strata: Takapūwāhia, Mana sandbank, Porirua stream, and opposite Mana Cruising Club (MCC) to achieve a sampling coefficient of variation (c.v.) of 15%

Objective 2: To prepare a short report similar to that produced for the Pauatahanui survey.

2 Methods

2.1 2017 survey

Several survey designs were initially proposed (Lyon 2017) using the NIWA program *Allocate* R (RCore Team 2012) function allocate (Francis 2006). Ngati Toa chose a stratified random survey of four strata Takapūwāhia, Porirua Stream, Mana sandbank, and opposite Mana Cruising Club (MCC) using 16 transects with a target c.v. of 15%, focusing on cockles, mud whelk, and mudflat topshell. The stratified random sampling design was similar to that used in 2015 in the intertidal shellfish survey of Te Awarua-o-Porirua Harbour – Onepoto Arm (Lyon and Michael 2015). This survey was undertaken on Saturday and Sunday 26th and 27th of November 2017. The dates were selected to coincide with low tides in the early morning. The 16 random transect positions were identified using a GIS program (QGIS), two at Takapūwāhia, two opposite MCC, six at Mana sandbank and six at Porirua stream (Figure 1).

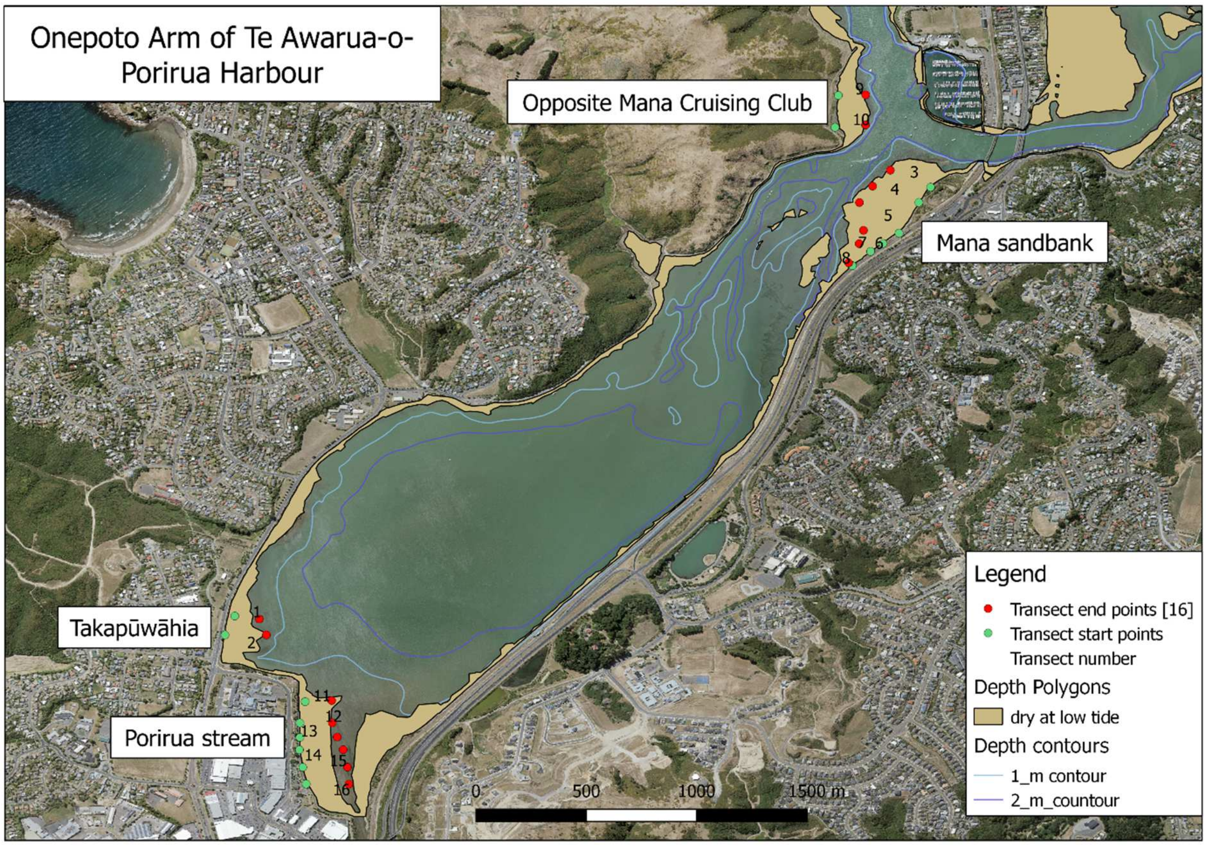

Figure 1: Onepoto arm of Te Awarua-o-Porirua Harbour showing four survey areas (strata), and the start and end points of 16 randomly generated transects.

The details of the four strata, the number of transects sampled in each stratum during the 2015 and 2017 surveys, and the number of stations in each survey, are shown in Table 1. The stratum areas (km^2) were calculated by Lyon (2017) using a GIS program. A transect was a line drawn from the high tide mark to the water line. Each transect was evenly divided into three zones: high (close to the high tide mark), low (close to the water) and mid (in between the two). Three randomly selected, replicate quadrats were placed into each zone. Each station is the sum of all the shellfish sampled in all three quadrats within each transect zone.

Table 1: Stratum details from 2015 and 2017 intertidal shellfish surveys of Onepoto, including total numbers of transects and total numbers of stations per stratum and survey.

			No. transects		No. stations	
Strata name	Stratum no.	Area km^2	2015	2017	2015	2017
Mana sandbank	0001	0.126796	4	6	12	18
Takapūwāhia	0002	0.026412	3	2	9	6
Porirua stream	0003	0.164274	2	6	6	18
Opposite MCC	0004	0.035208	2	2	6	6

The transect start and end positions (Appendix A) and stations (Appendix B) were identified with GPS, and the distances to each random sampling station were calculated as metres from the transect start position for volunteers to use. At each station, three replicate samples were taken using 25 cm x 25 cm quadrats, with one placed on the transect line, and the other two randomly dropped over a shoulder on each side of the transect. All sediment within each quadrat was dug out to a depth of 10 cm if the sediment was soft. If the sediment was hard, no digging was done and the shellfish on the surface were counted. All sediment was placed into a colander with 2 mm mesh (different from the 5 mm sieves used in 2015), then the sand or mud was washed through the colander, leaving everything larger than 2 mm. The objects retained were shellfish, stones, and other debris. All non-biological objects were removed from the sample and the shellfish were identified, counted, and measured.

An example of a completed log sheet is in Appendix C. Shellfish were measured along the anterior–posterior axis to the nearest millimetre with small plastic rulers. We defined large cockles as those individuals with shell lengths 30 mm or larger. A sub-sample of cockles could be taken if there were more than 40 in a quadrat. A NIWA staff member circulated among the transect teams to ensure species were identified correctly.

Based on the variability of species distributions and densities identified in the 2015 survey, the 2017 stratified survey design incorporated an allocation method that put more sampling effort (transects) into areas with the highest variability. Lyon (2017) estimated that sixteen transects would be needed to produce a c.v. of 15%. Sampling those transects required three people per transect, for a total of 24 volunteers per day, over two days.

Density was estimated as the mean number of shellfish per 25 x 25 cm quadrat. Mean population size (numbers), c.v., and 95% confidence intervals were estimated using *SurvCalc* (Francis & Fu 2012). Areal expansion of mean density per m^2 to the size of the stratum was used to give the survey total population size. The c.v. was calculated as the standard deviation of the unweighted means divided by the square root of the number of transects. Overall abundances were calculated as

$$B_s = AD_s a'_s / 1000$$

$$B = \sum_s B_s$$

and their standard errors (s.e.) are calculated as

$$\text{s.e.}(B_s) = \text{s.e.}(AD_s)\, a'_s / 1000$$

$$\text{s.e.}(B) = \left[\sum_s \text{s.e.}(B_s)^2 \right]^{0.5}$$

And the variable definitions are (for more detail see Francis & Fu 2012):

a'_s	Stratum area (km^2)
$\sum_s$	The sum of all strata
AD_s	Mean areal density (No./km^2)
$B\ (b)$	Total abundance (numbers)
B_s	Abundance (numbers) per stratum

2.2 Comparison of 2017 results with 2015 survey

In 2015, the whole intertidal area of the Onepoto Arm was surveyed as a single stratum. Transects were randomly placed around the entire perimeter of the Onepoto intertidal area (Lyon and Michael 2015). To enable comparison of the current 2017 survey with 2015, data from the 2015 survey for the three target species (cockle, mudflat topshell, mud whelk) plus pipi were re-run through *SurvCalc* using the four new strata, to estimate their abundance and the variability surrounding it (95% confidence limits, and c.v.'s). The 2017 stratum areas were used for all calculations in this report, including the new 2015 estimates.

A subset of the 2015 transects (n=11) and stations (n=61) that fell within the four strata surveyed in 2017 was selected for estimation of 2015 shellfish abundance.

Different mesh sieve sizes were used during the 2015 survey (5 mm sieve) and the 2017 survey (2 mm colander). To determine how that would influence the abundance estimates, the two smallest size classes of cockle (< 10 mm), that would have been affected by the differing sieve sizes, were removed from both 2015 and 2017 datasets and adjusted abundance estimates were recalculated by *SurvCalc* (Francis & Fu 2012). This was done for cockles as this was the only species measured in both 2015 and 2017.

3 Results

3.1 Overall results

A total of 8996 shellfish were sampled from 16 transects and 48 stations (Table 2) during the two-day survey: 8500 of those were cockles, 267 mud whelks, 229 mudflat topshells and 12 pipi.

Table 2: Onepoto strata with the number of transects and stations per strata, and the number that each shellfish was found at during the 2017 survey.

	No.	No.	Cockle		Mud whelk		Mudflat topshell		Pipi	
Strata name	transects	stations	Transects	Stations	Transects	Stations	Transects	Stations	Transects	Stations
Mana sandbank 2017	6	18	6	18	6	18	6	13	0	0
Takapūwāhia 2017	2	6	2	6	2	6	2	6	1	1
Porirua stream 2017	6	18	6	18	6	16	2	2	5	7
Opposite MCC 2017	2	6	2	6	2	5	2	4	0	0

Table 3: Shellfish abundance estimates for all four sites combined (Takapūwāhia, Mana sandbank, opposite MCC, and Porirua Stream), with the lower and upper bounds of the 95% confidence limits, the c.v., and the number of transects and stations where the shellfish were found (totals were 16 transects and 48 stations).

Species	lower bound	abundance	upper bound	cv (%)	No. transects	No. stations
Cockle 2017	84,270,200	109,721,000	135,171,000	11.6	16	48
Mudflat topshell 2017	1,432,840	2,215,950	2,999,060	17.7	12	25
Mud whelk 2017	2,618,500	3,244,190	3,869,880	9.6	14	45
Pipi 2017	42,690	186,296	329,902	38.5	6	8

The estimated abundance of **cockles** at all four sites was 110 million with a low c.v. of 11.6% (Table 3), indicating the abundance estimate had a high level of precision. This was less than the target c.v. of 15%. The estimated abundance of **mudflat topshells** was 2.2 million with a c.v. of 17.7% indicating a moderate level of precision, slightly above the target c.v. of 15%. The abundance estimate of **mud whelks** was 3.2 million with a low c.v. of 9.6% indicating a high level of precision, well below the target. The abundance of **pipi** was estimated, even though only 12 pipi were sampled, and the estimate was 186,296 with a high c.v. of 38.5%, indicating a low precision for the estimate.

Mana sandbank had the highest abundance estimates for the three main species cockle, mudflat topshells, and mud whelks (Table 4).

Table 4: Shellfish species abundance estimates by stratum, c.v.'s (%).

	Cockle		Mudflat topshell		Mud whelk		Pipi	
Stratum	Abundance	c.v.	Abundance	c.v.	Abundance	c.v.	Abundance	c.v.
Mana sandbank 2017	4.49E+07	14.3	1.13E+06	24.8	1.55E+06	12.5	0	0
Takapūwāhia 2017	1.16E+07	31.5	837357	29.2	367811	19.1	7826	100
Porirua stream 2017	4.88E+07	21	32449	68.6	989699	21.8	178470	40
Opposite MCC 2017	4.43E+06	30.2	219072	55.1	333824	28.1	0	0

3.2 Individual species summaries

3.2.1 Cockle (*Austrovenus stutchburyi*)

Distribution

Cockles were found at all 16 sampled transects in all four areas. The densities (numbers per transect) are shown in Figure 2. The highest number of cockles per transect was 1055 at Mana sandbank. At three of four strata (Takapūwāhia, Porirua stream and Mana sandbank), the maximum number of cockles sampled was about 1000. The highest cockle catch from opposite MCC was 307. In Porirua stream cockle increased in abundance to the north of the stratum, and at Mana sandbank numbers peaked in the middle of the stratum (Figure 3). By transect zone 43% of cockles were sampled in the high zone, 35% in the mid zone, and 22% in the low zone, closest to the water.

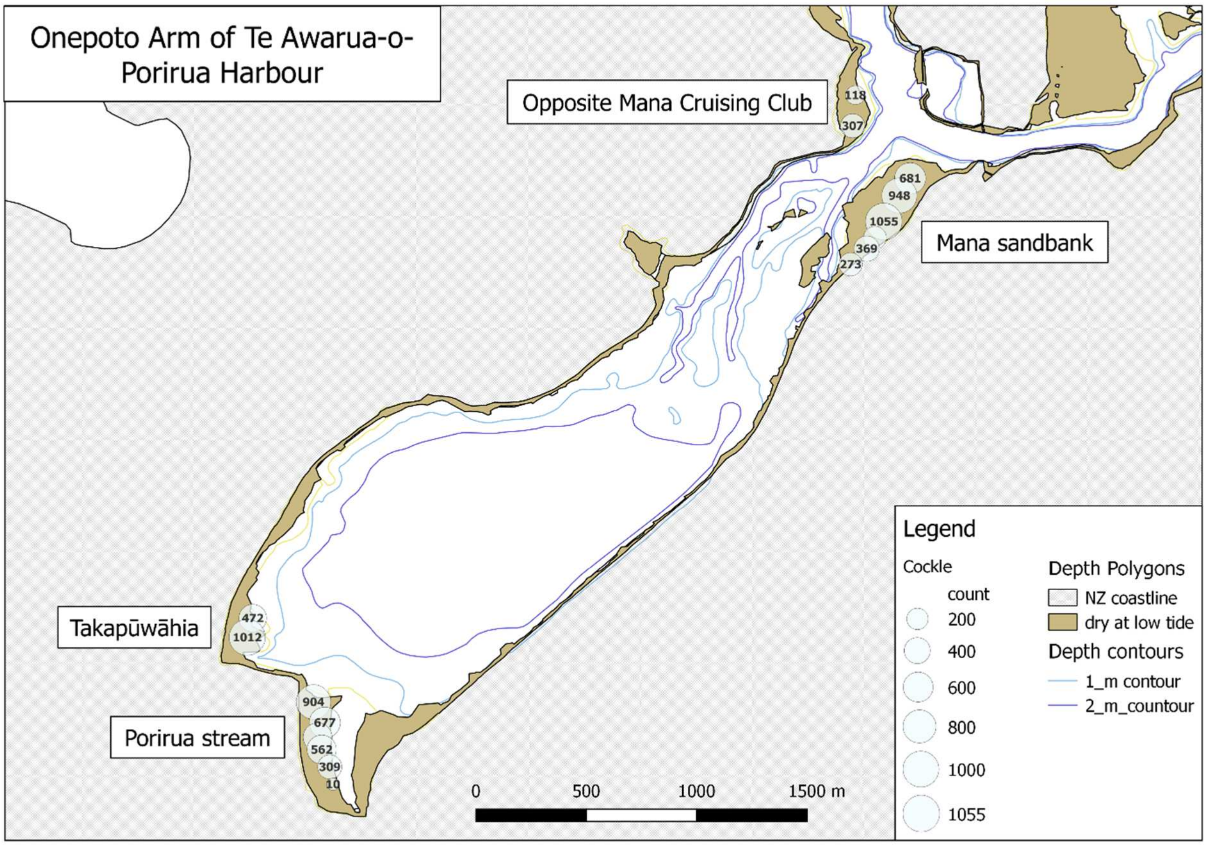

Figure 2: Density and distribution of cockle, numbers are transect totals.

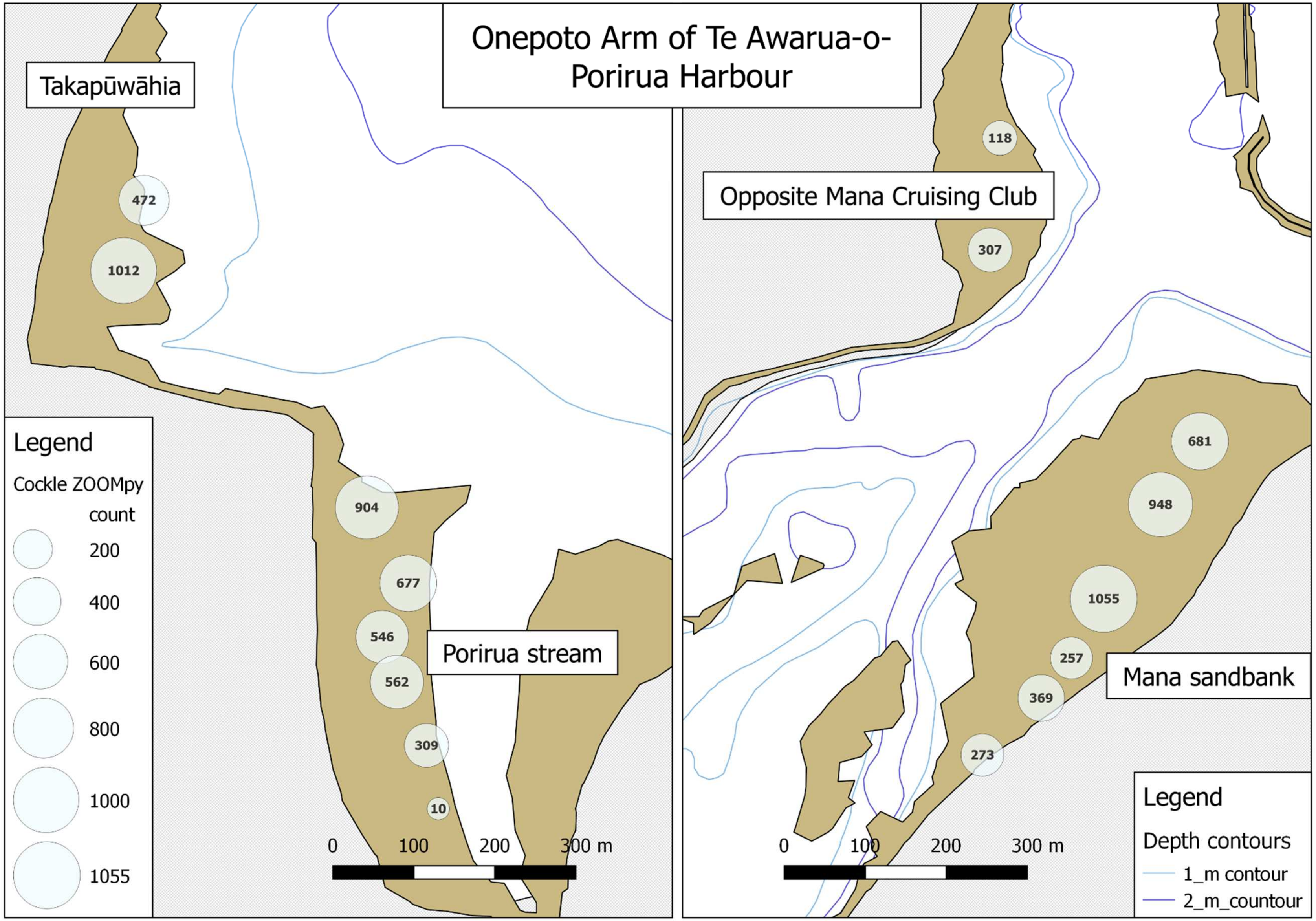

Figure 3: Close-up view of cockle catches per transect (circle size represents number caught) in four strata

Size

The cockle length-frequency distribution, based on scaling up a subsample of 4793 cockles to the total of 8500 cockles, is shown in Figure 4. The most common size sampled was 15–19 mm, and 81% of cockles were 10–29 mm; the largest cockle was 50 mm. Over half of the large cockles ($\geq$ 30 mm) were found in the low-zone areas of the transect closest to the water. The large cockles made up 10% of the cockles sampled. Cockles $\geq$ 40 mm made up only 1% of those sampled and were found at only two strata: Takapūwāhia and opposite MCC (both sites with 44 cockles).

The stratum with the largest proportion of large cockles was opposite MCC, with 45% of sampled cockles > 30 mm. Takapūwāhia had 18% > 30 mm, and Porirua stream had only 1% greater than 30 mm.

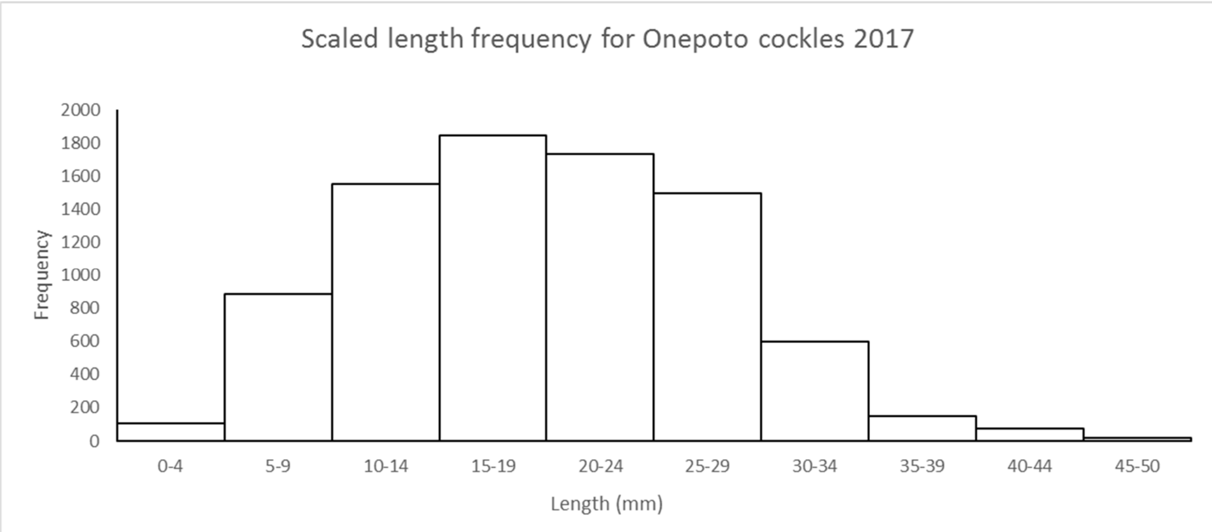

Figure 4: Scaled length frequency distribution for cockles from the intertidal survey of Onepoto in 2017.

The length at reproductive maturity for cockles is 18 mm in the Auckland region (Larcombe 1971), and if we use that size as a guide, about half of the cockle population in Onepoto were juveniles that had not yet reproduced. Porirua stream had the highest percentage of juvenile cockles (60%), Takapūwāhia was next with 55%, Mana sandbank 38%, and opposite MCC had 15% juveniles.

Density

The density and abundance of cockles at each of the four strata are shown in Table 5. The highest estimated density of cockles was at Takapūwāhia, and the next highest was Mana Sandbank. The highest abundance estimates were from Porirua Stream closely followed by Mana Sandbank. The Mana sandbank estimate had the lowest c.v. (14.3%), and Porirua stream was next lowest (21%).

Table 5: Stratum details, number of transects and stations sampled, area (km^2), cockle estimated mean density (no./km^2), abundance (no. shellfish), c.v.(%), and numbers of transects and stations where cockle were caught.

Stratum	No. transects	No. stations	Area	Density	Abundance	cv.Abundance	Transects	Stations
Mana sandbank	6	18	0.13	3.54E+11	44,870,100	14.3	6	18
Takapūwāhia	2	6	0.03	4.40E+11	11,613,400	31.5	2	6
Porirua stream	6	18	0.16	2.97E+11	48,803,500	21	6	18
Opposite MCC	2	6	0.04	1.26E+11	4,433,600	30.2	2	6

Shellfish abundance estimates from 2015 and 2017

Cockle abundance estimates increased significantly from 61.7 million in 2015 to 110 million cockles in 2017 (Figure 5, Table 6).

Table 6: Cockle abundance estimates (millions), the lower and upper bounds are the 95% confidence limits of those estimates, c.v. for 2015 and 2017 in the same four strata.

Survey	lower bound	Abundance	upper bound	cv (%)	No. stations
Cockle 2015	48.2	61.7	75.2	10.9	61
Cockle 2017	84.3	109.7	135.2	11.6	48

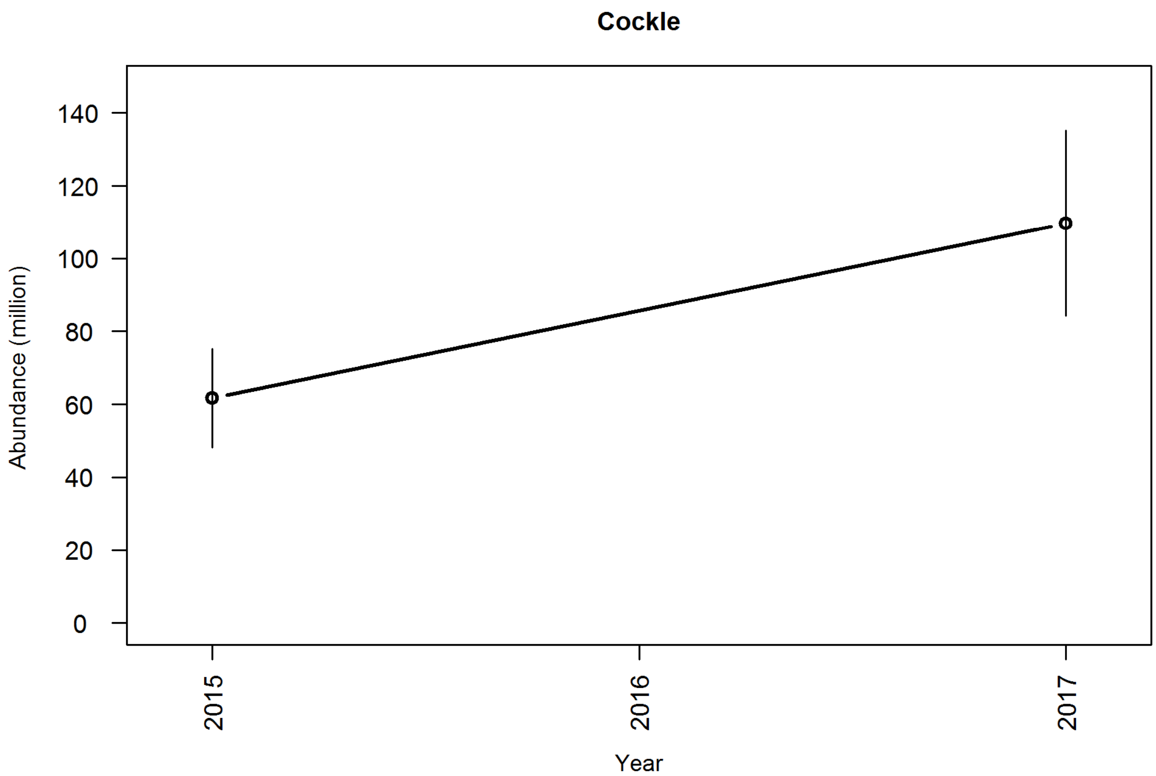

Figure 5: Cockle abundance estimates from selected strata (Takapūwāhia, Porirua stream, Mana sandbank and opposite MCC) in Onepoto in 2015 and 2017. The error bars are the 95% confidence limits of the abundance estimates.

3.2.2 Mud whelk (*Cominella glandiformis*)

Distribution

Mud whelk were found at all 16 sampled transects in all four areas. The highest number of mud whelks sampled from one transect was 32 at Mana sandbank (Figure 6, 7). Mud whelk were found in consistent numbers in all strata (from 3 – 32 per transect), and that consistency was the reason for the low c.v. for the abundance estimate. The numbers of mud whelk decreased southwards in Porirua stream, with the two southernmost transects (15 and 16) producing only 4 and 3 mud whelks respectively. Mud whelks were evenly distributed across all the sampled intertidal heights with 30–33% in each zone.

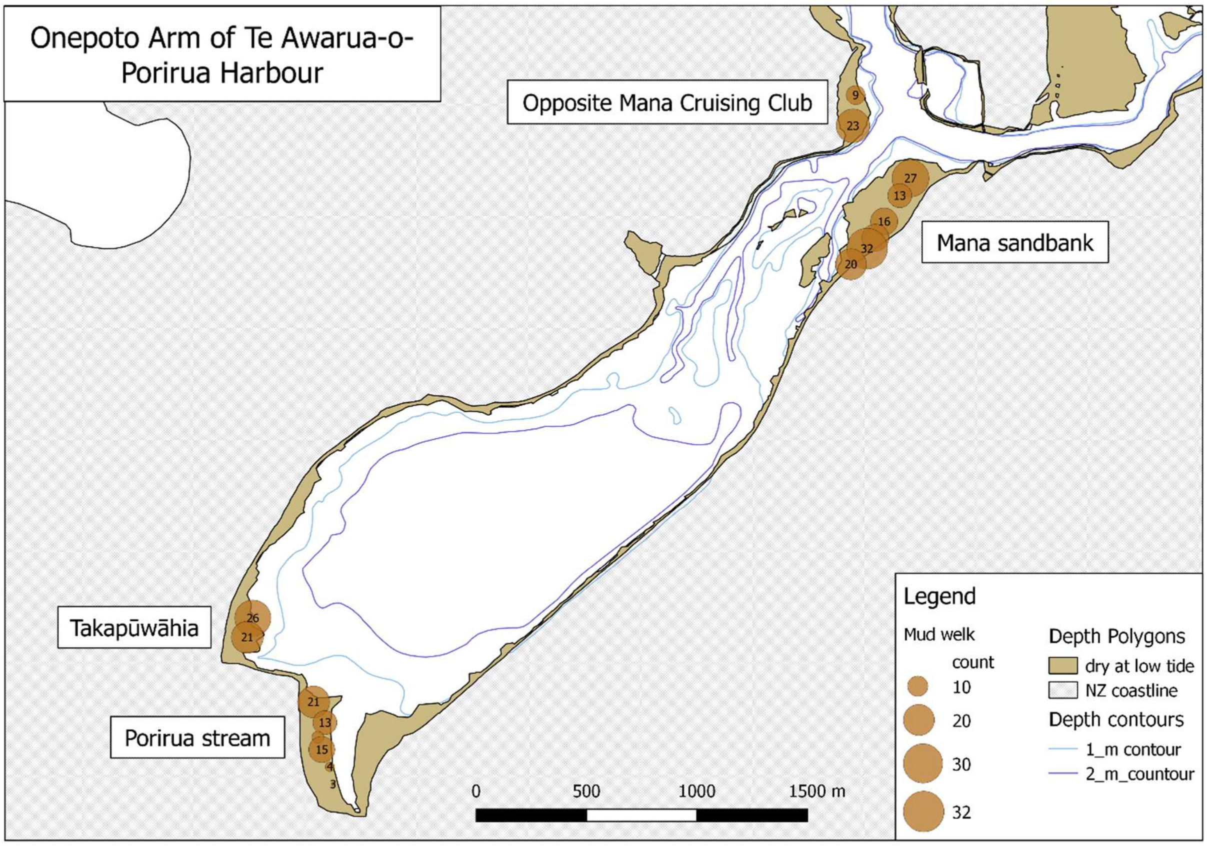

Figure 6: Density and distribution of mud whelk, numbers are transect totals.

Size

All 267 mud whelks sampled during the survey were measured (Figure 8). The most common mud whelk size was 15–19 mm in length, with 91% ranging from 10 mm to 24 mm. The largest mud whelk was 30 mm in length and came from Mana sandbank. The location with the biggest mud whelks ($\geq$ 20 mm) was Porirua stream with 35% big mud whelks, and Takapūwāhia had the lowest percentage of big mud whelks (17%). Length at maturity of mud whelks is unknown.

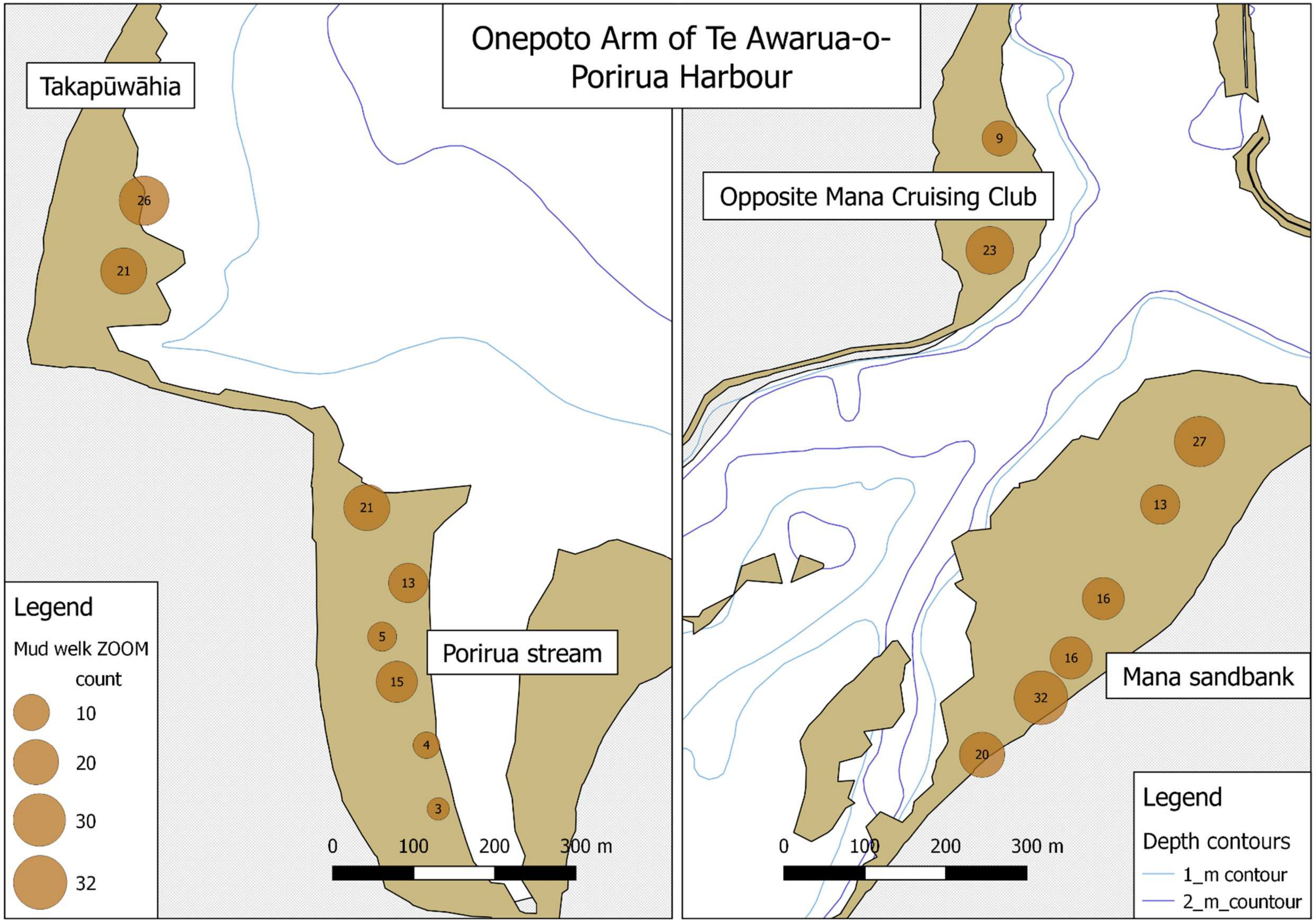

Figure 7: Close-up view of mud whelk catches per transect (circle size represents number caught) in four strata

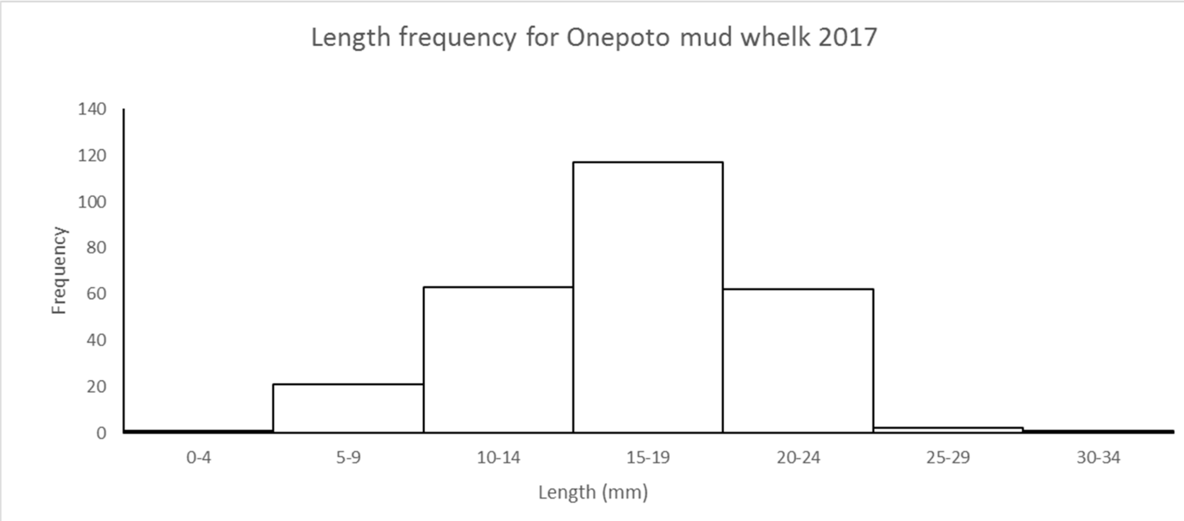

Figure 8: Length frequency distribution for mud whelk from the intertidal survey of Onepoto in 2017.

Density

The density and abundance of mud whelks at each of the four strata are shown in Table 7. The highest estimated density of mud whelks was at Takapūwāhia, closely followed by Mana sandbank. The highest abundance estimates were from Mana sandbank followed by Porirua stream. The Mana sandbank estimate had the lowest c.v. (12.5%), and Takapūwāhia was next lowest (19.1%).

Table 7: Stratum details, number of transects and stations sampled, area (km^2), mud whelk estimated mean density (no./km^2), abundance (no. shellfish), c.v.(%), and numbers of transects and stations where mud whelk were caught.

Stratum	No. transects	No. stations	Area	Density	Abundance	cv.Abundance	Transects	Stations
Mana sandbank	6	18	0.13	1.22E+10	1.55E+06	12.5	6	18
Takapūwāhia	2	6	0.03	1.39E+10	367811	19.1	2	6
Porirua stream	6	18	0.16	6.02E+09	989699	21.8	4	16
Opposite MCC	2	6	0.04	9.48E+09	333824	28.1	2	5

Shellfish abundance estimates from 2015 and 2017

Mud whelk abundance increased significantly from 1.4 million in 2015 to 3.2 million in 2017 (Figure 9, Table 8). The precision of the abundance estimates improved from 18.4% in 2015 to 9.6% in 2017.

Table 8: Mud whelk abundance estimates (millions), the lower and upper bounds are the 95% confidence limits of those estimates, c.v., for 2015 and 2017 in the same four strata.

Survey	lower bound	Abundance	upper bound	cv (%)	No. stations
Mud whelk 2015	0.9	1.4	2	18.4	61
Mud whelk 2017	2.6	3.2	3.9	9.6	48

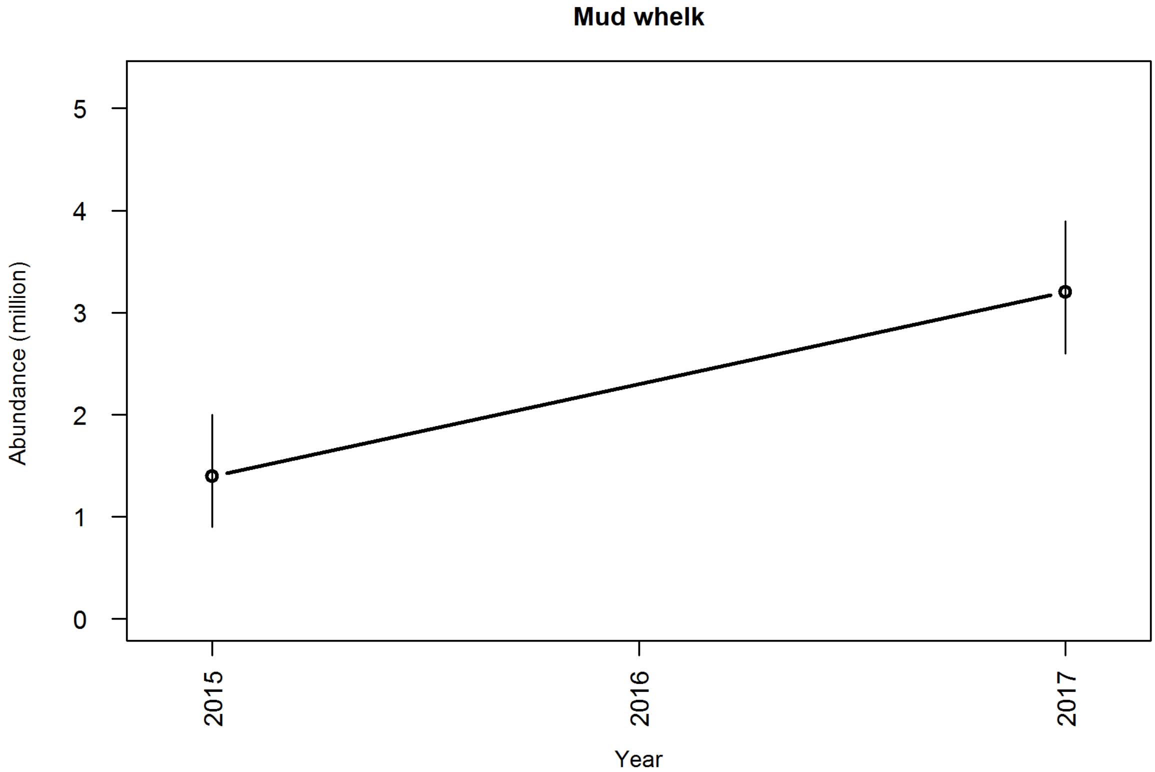

Figure 9: Mud whelk abundance estimates from selected strata (Takapūwāhia, Porirua stream, Mana sandbank and opposite MCC) in Onepoto in 2015 and 2017. The error bars are the 95% confidence limits of the abundance estimates.

3.2.3 Mudflat topshell (*Diloma subrostrata*)

Distribution

Mudflat topshell were found at 12 sampled transects in all four areas (Figure 10, 11). The highest number of mudflat topshells per transect was 75 at Takapūwāhia. The high numbers at Takapūwāhia may be attributed to the transect which included areas of hard surfaces (not mud) which these gastropods seem to prefer (Logan 1976; Lyon and Michael 2015). The next biggest catches of mudflat topshell were in the 30's in Takapūwāhia and Mana sandbank. There were few mudflat topshells at Porirua Stream. The mudflat topshells at Takapūwāhia were almost all small (mean size range 8–9 mm). Large mudflat topshells were distributed evenly throughout each transect.

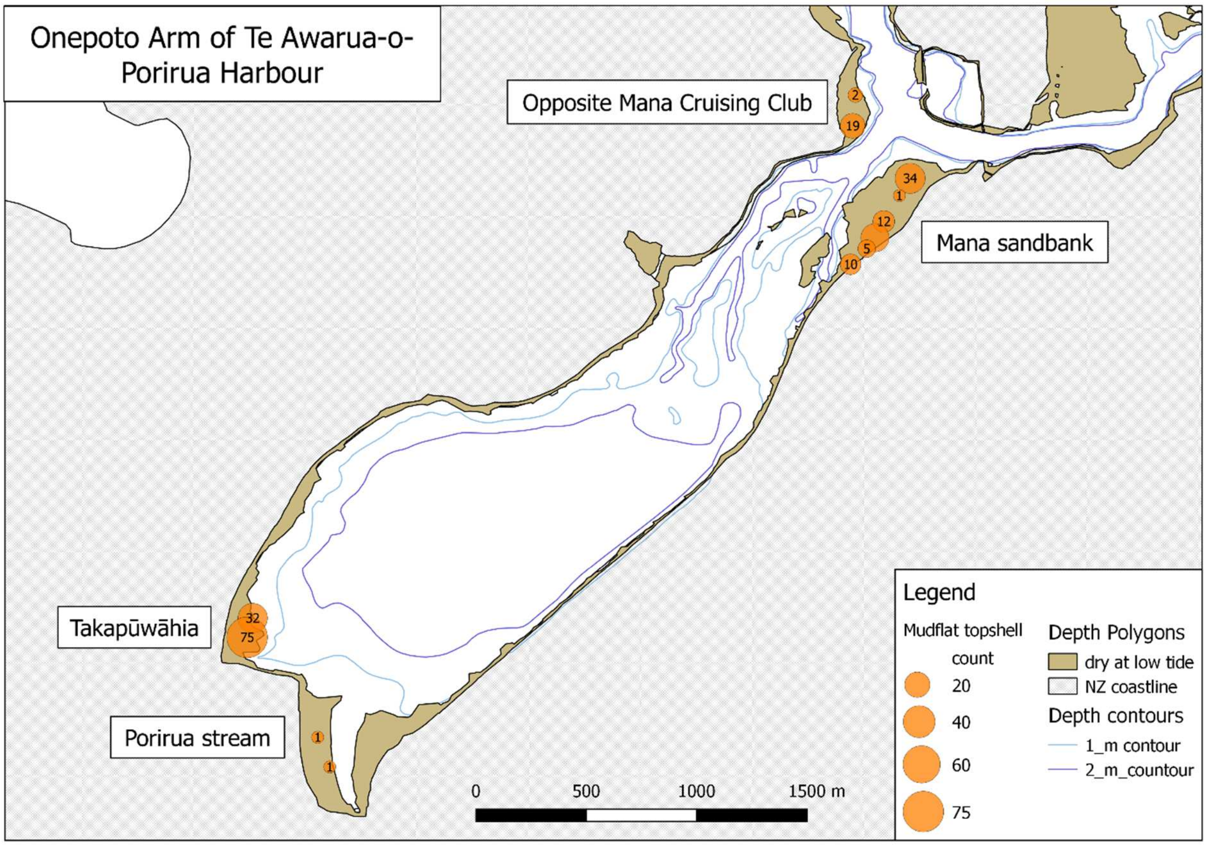

Figure 10: Density and distribution of mudflat topshell, numbers are transect totals.

Size

The mudflat topshell length-frequency distribution was based on 229 measured shells (Figure 12). The most common size sampled was 5–9 mm in length. The largest mudflat topshell was 22 mm and was sampled at Mana Sandbank where 75% of the large mudflat topshells were found. Reproductive maturity was assumed to be greater than 10 mm in width (Logan 1976), at that size 73% of the mudflat topshell population was estimated to be immature.

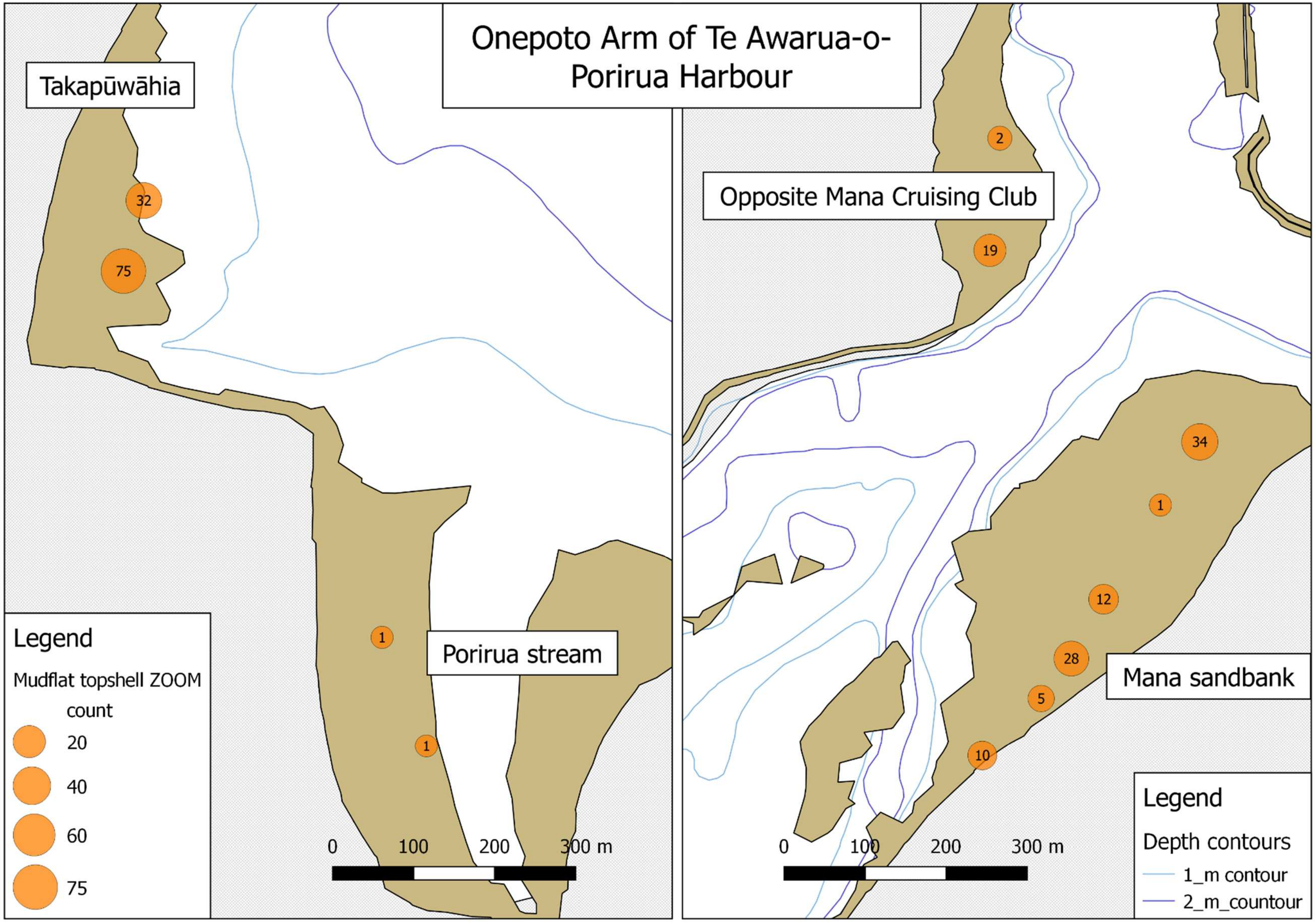

Figure 11: Close-up view of mudflat topshell catches per transect (circle size represents number caught) in four strata

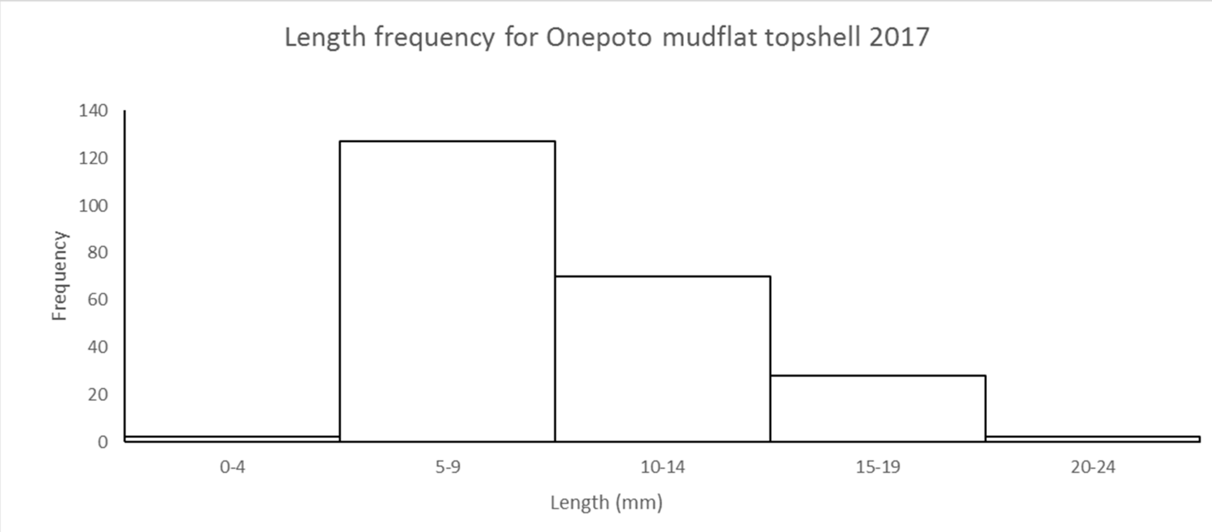

Figure 12: Length frequency for mudflat topshell from the intertidal survey of Onepoto in 2017 (selected sites were Takapūwāhia, opposite MCC, Porirua stream and Mana sandbank).

Density

The density and abundance of mudflat topshell at each of the four strata are shown in Table 9. The highest estimated density was at Takapūwāhia, followed by Mana sandbank. The highest abundance estimates were from Mana sandbank followed by Takapūwāhia. The Mana sandbank estimate had the lowest c.v. (24.8%), and Takapūwāhia was next lowest (29.2%).

Table 9: Stratum details, number of transects and stations sampled, area (km^2), mudflat topshell estimated mean density (no./km^2), abundance (no. shellfish), c.v.(%), and numbers of transects and stations where mudflat topshells were caught.

Stratum	No. transects	No. stations	Area	Density	Abundance	cv.Abundance	Transects	Stations
Mana sandbank	6	18	0.13	8.89E+09	1127070	24.8	6	13
Takapūwāhia	2	6	0.03	3.17E+10	837357	29.2	2	6
Porirua stream	6	18	0.16	1.98E+08	32449	68.6	2	2
Opposite MCC	2	6	0.04	6.22E+09	219072	55.1	2	4

Shellfish abundance estimates from 2015 and 2017

Mudflat topshell abundance increased significantly from 0.9 million mudflat topshells in 2015 to 2.2 million mudflat topshells in 2017 (Figure 13, Table 10). The precision of the abundance estimates changed little from 19.8% in 2015 to 17.7% in 2017.

Table 10: Mudflat topshell abundance estimates (millions), the lower and upper bounds are the 95% confidence limits of those estimates, c.v., for 2015 and 2017 in the same four strata.

Survey	lower bound	Abundance	upper bound	cv (%)	No. stations
Mudflat topshell 2015	0.5	0.9	1.2	19.8	61
Mudflat topshell 2017	1.4	2.2	3	17.7	48

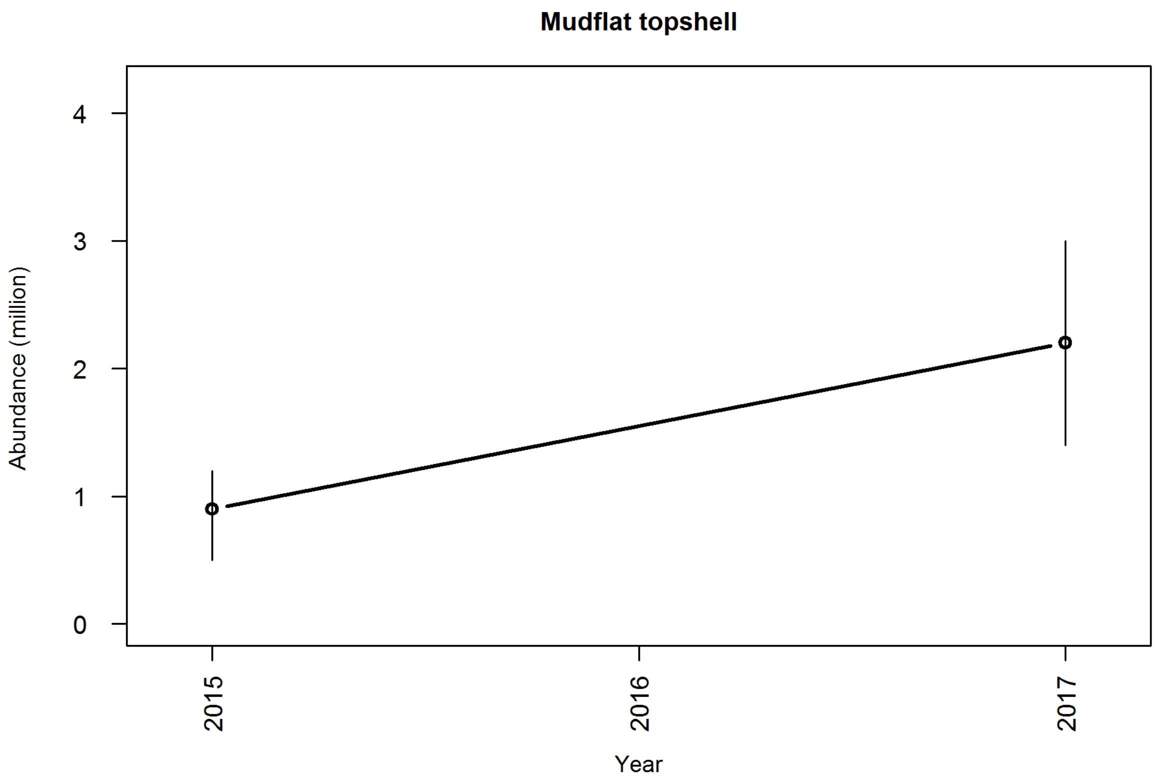

Figure 13: Mudflat topshell abundance estimates from selected strata (Takapūwāhia, Porirua stream, Mana sandbank and opposite MCC) in Onepoto in 2015 and 2017. The error bars are the 95% confidence limits of the abundance estimates.

3.2.4 Pipi (*Paphies australis*)

Distribution

Only 12 pipi were found at 6 sampled transects in two areas (Figure 14). Almost all (11) were caught at Porirua stream, with abundance increasing at transects to the north of the strata. The low numbers were expected but their distribution in 2015 also included opposite MCC which did not occur in 2017.

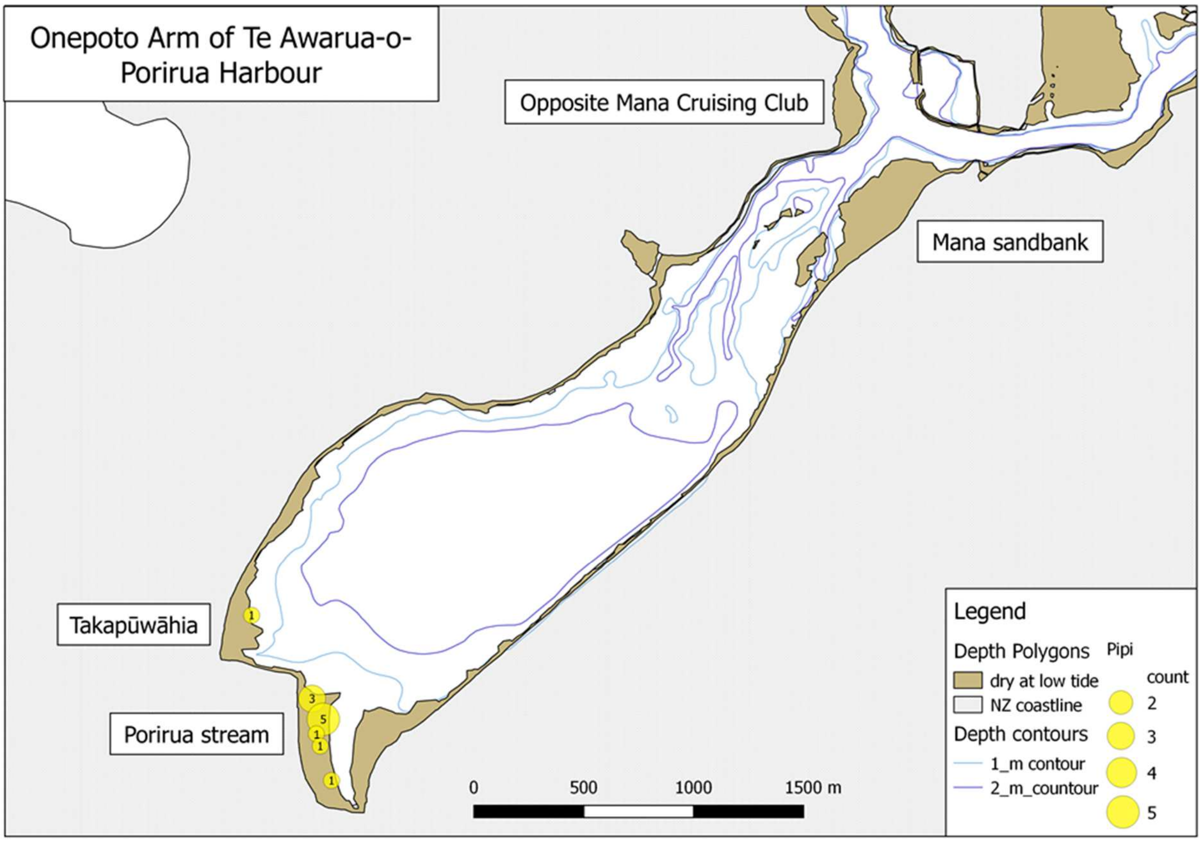

Figure 14: Density and distribution of pipi, numbers are transect totals.

Size

The pipi length-frequency distribution was from 12 sampled and measured pipi (Figure 15). The most common size sampled was 20–29 mm in length, the largest pipi was 33 mm from the low zone at Porirua stream. There were no large pipi sampled in 2017, but in 2015 pipi up to 44 mm were caught. Reproductive maturity in pipi occurs at greater than 40 mm in length (Hooker 1995). No pipi were larger than this, indicating that pipi in the four sampling areas are immature.

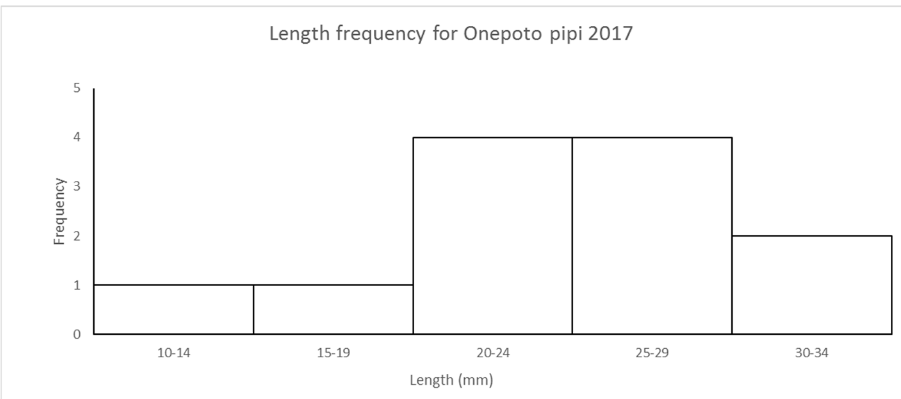

Figure 15: Length frequency for pipi from the intertidal survey of Onepoto in 2017 (selected sites were Takapūwāhia, opposite MCC, Porirua stream and Mana sandbank).

Density

The density and abundance of pipi at each of the four strata are shown in Table 11. The highest estimated density and abundance was at Porirua stream, the Porirua stream estimate also had the lowest c.v. (40%).

Table 11: Stratum details, number of transects and stations sampled, area (km^2), pipi estimated mean density (no./km^2), abundance (no. shellfish), c.v.(%), and numbers of transects and stations where pipi were caught.

Stratum	No. transects	No. stations	Area	Density	Abundance	cv.Abundance	Transects	Stations
Mana sandbank	6	18	0.13	0	0	0	0	0
Takapūwāhia	2	6	0.03	2.96E+08	7826	100	1	1
Porirua stream	6	18	0.16	1.09E+09	178470	40	5	7
Opposite MCC	2	6	0.04	0	0	0	0	0

Shellfish abundance estimates from 2015 and 2017

There was no significant change in the abundance estimates for pipi between 2015 and 2017. Estimated pipi abundance decreased slightly from 0.3 million in 2015 to 0.19 in 2017. The precision of the abundance estimates decreased from 57.3% in 2015 to 38.5% in 2017 (Figure 16, Table 12).

Table 12: Pipi abundance estimates (millions), the lower and upper bounds are the 95% confidence limits of those estimates, c.v., for 2015 and 2017 in the same four strata.

Survey	lower bound	Abundance	upper bound	cv (%)	No. stations
Pipi 2015	0	0.3	0.6	57.3	61
Pipi 2017	0.04	0.19	0.33	38.5	48

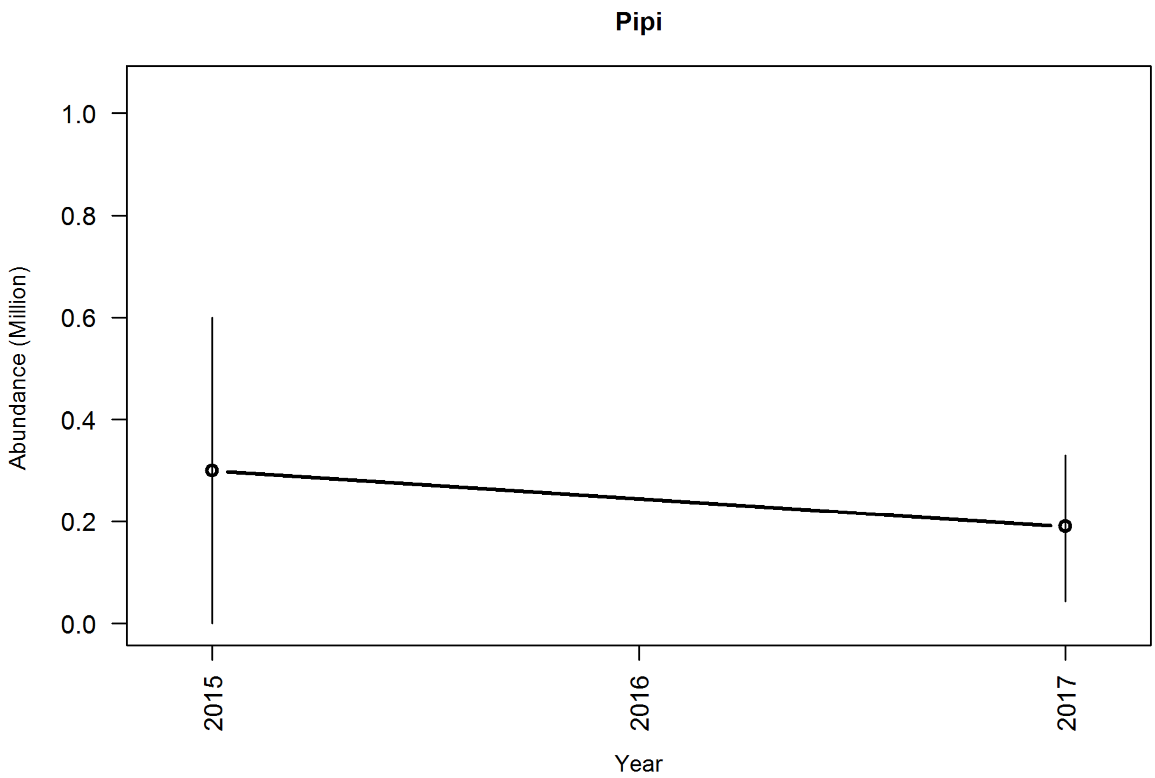

Figure 16: Pipi abundance estimates from selected strata (Takapūwāhia, Porirua stream, Mana sandbank and opposite MCC) in Onepoto in 2015 and 2017. The error bars are the 95% confidence limits of the abundance estimates.

3.3 Comparison of 2015 and 2017 survey results

Transect locations in 2015 and 2017 are shown in Figure 17 and 18, and the number of transects in the 2015 and 2017 surveys are shown in Tables 13 and 2 respectively.

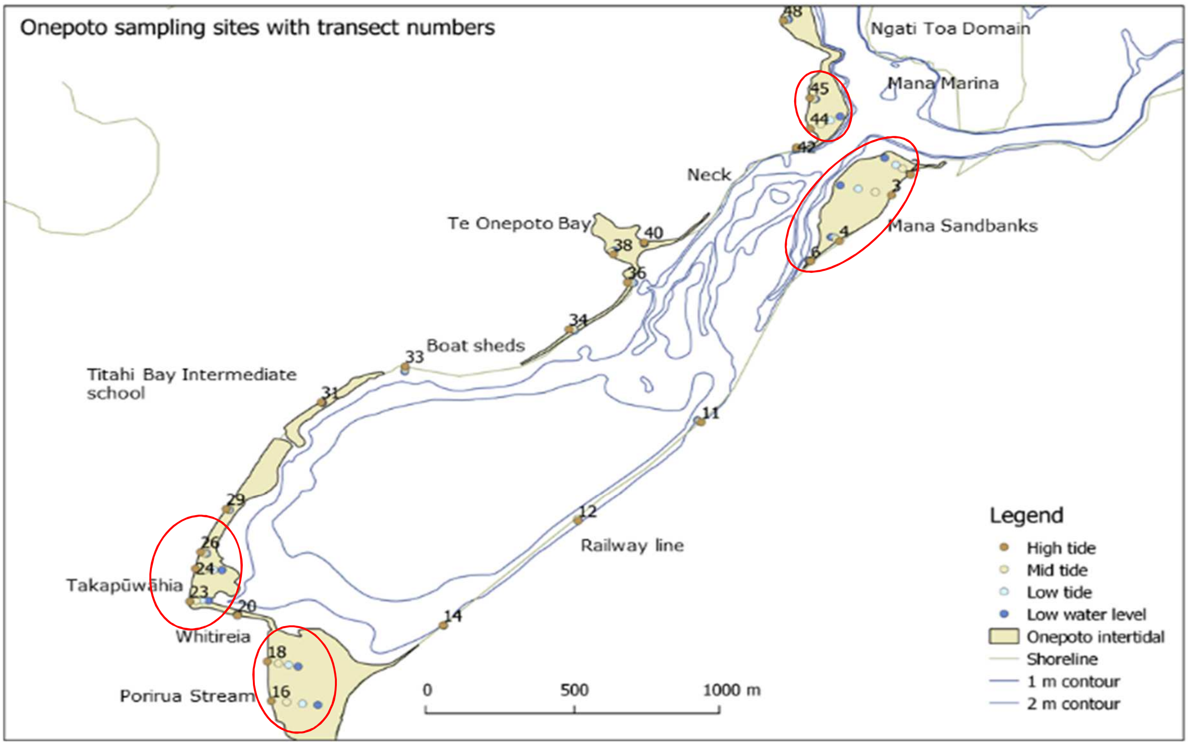

Figure 17: The 2015 random transect locations from Lyon and Michael (2015). The circles indicate the transects used for comparison with the 2017 survey.

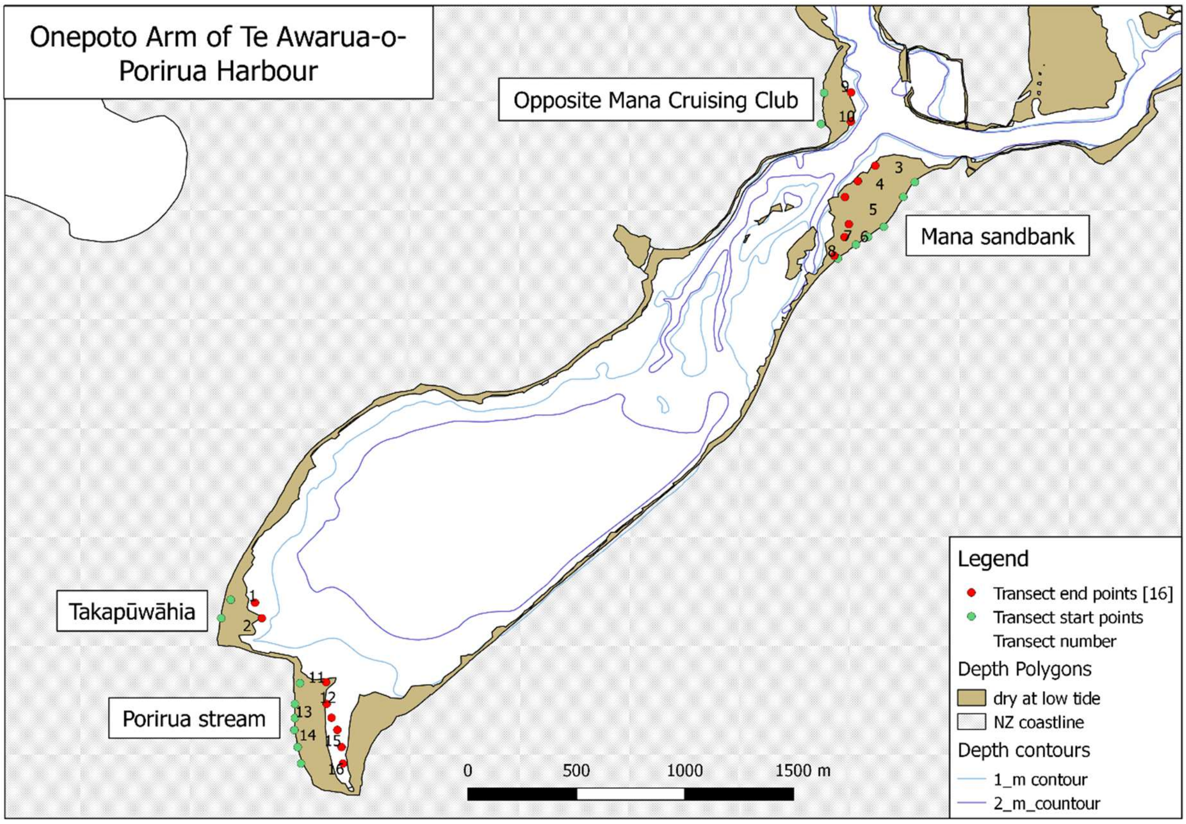

Figure 18: The 2017 transect locations. The green dots indicate the start of the transect and the red dots the finish of the transect.

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Table 13: The 2015 Onepoto strata with the number of transects and stations per strata, and the number that each shellfish was found at during the 2015 survey.

	No.	No.	Cockle		Mud whelk		Mudflat topshell		Pipi	
Strata name	transects	stations	Transects	Stations	Transects	Stations	Transects	Stations	Transects	Stations
Mana sandbank 2015	4	12	4	11	4	11	4	9	1	1
Takapūwāhia 2015	3	9	3	7	3	8	3	7	0	0
Porirua stream 2015	2	6	2	6	2	4	1	1	1	1
Opposite MCC 2015	2	6	2	6	2	5	1	3	1	3

A survey with many transects should produce more precise population estimates (lower c.v.'s) than a survey with few transects. The 16 transects sampled in 2017 should produce a more precise population estimate than the 11 transects sampled in 2015, all other things being equal. The c.v.'s for mudflat topshells and mud whelks both improved from 2015 to 2017. But the c.v. for cockles increased marginally although it was still well below the 15% c.v. limit.

From 2015 to 2017 the length frequency distribution of cockles became broader with the appearance of larger and smaller shellfish (Figure 19). The 2017 survey had 12% of cockles < 10 mm, whereas only 5% were in this range in 2015. In the mid-range 10–39 mm, the percentages were 87% and 95% in 2017 and 2015 respectively, and for cockles ≥ 40 mm they were similar at 1% and 0.2% respectively.

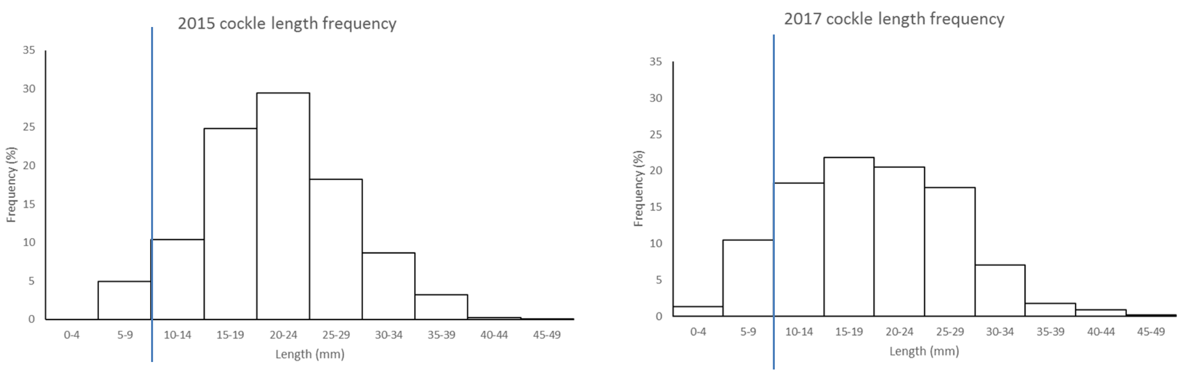

Figure 19: Scaled length frequencies from 2015 and 2017, as a percentage of total cockle catch. The blue line indicates the size of cockles effected by the different sieve sizes.

Adjusted abundance estimates for cockles

As expected, removal of the two smallest size classes of cockles (< 10 mm), because of the different mesh sized sieves used, had a larger effect on the 2017 abundance estimate, which declined by 11.1%, than on the 2015 estimate, which declined by 3.7% The abundance of cockles ≥ 10 mm was 59 million for 2015 and 97 million for 2017 (Table 14) and still significantly different.

Table 14: Adjusted abundance estimates (millions) for cockles from 2015 and 2017 that were ≥10mm in length, with the lower and upper 95% confidence limits, and c.v.'s, in the same four strata.

Reduced abundance survey	lower bound	Abundance	upper bound	cv (%)	No. stations
Cockle 2015	46.6	59.4	72.3	10.8	61
Cockle 2017	74.8	97.5	120.1	11.6	48

4 Discussion

This 2017 randomly stratified intertidal shellfish survey for Ngati Toa focused on species of interest, and sites of interest. The survey design randomly placed 16 transects and 48 quadrats over four areas of interest to estimate the abundance of cockles, mudflat topshells, mud whelk and pipi at Takapūwāhia, Porirua stream, Mana sandbank and opposite MCC. Pipi occurred infrequently and their abundance could not be precisely estimated and is not considered further.

Precision of the abundance estimates

The target precision for the abundance estimates was a c.v. of 15%. The three main target shellfish species (cockles, mud whelk, mudflat topshells) had c.v.'s below or near the target. The mudflat topshell c.v. of 17.6% might be improved in future surveys by adding another transect to the stratum with the highest c.v. (Porirua stream). Opposite MCC would be next best site to add a transect as it has some of the highest c.v.'s for the three main target species indicating lower precision at that stratum.

Comparison of the abundance estimates between 2015 and 2017

The results from the 2015 survey (Lyon and Michael 2015) were for the entire intertidal area of Onepoto. These results were re-run with a selected set of the 2015 transects to enable between-survey comparison of abundance estimates for four intertidal areas of interest to Ngati Toa and on the species of interest to Ngati Toa. There was a significant increase in estimated abundance for all species except for pipi which was in low numbers. There was no indication from the length-frequency distributions that the increases in shellfish abundance were recruitment driven.

Removal of the two smallest size classes of cockles to adjust for the selectivity of different sieve sizes did not alter the significant differences in abundance between surveys. Reasons for the cockles abundance increase between surveys are unknown. The other two main shellfish species were not measured in 2015, so similar abundance adjustments could not be made for them, but may have been more of an issue for mudflat topshells as a large proportion was in the 5–9 mm class. Consequently, the extent and statistical significance of the changes in abundance for those species are uncertain.

Issues to be considered in future surveys

The raw cockle length frequency data showed peaks every 5 mm, indicating that volunteers sometimes rounded cockle lengths to 5 mm lengths rather than measuring them precisely. This was remedied here by grouping the lengths into 5 mm bins. This problem did not occur when NIWA and Ngati toa measured the shellfish with callipers in 2015.

There was a change in the sieving methodology between the two surveys 2015 and 2017. In 2015, 5 mm sieves built by Ngati Toa were used. In 2017, these sieves were unavailable, and instead the sampling kit was borrowed from the Guardians of Pauatahanui Inlet who use colanders with hole sizes down to 2 mm for their Pauatahanui inlet intertidal cockle count. The adjusted analysis carried out on cockles ≥10mm resulted in a reduced difference in abundance between surveys, indicating a slight difference in selectivity occurred between surveys.

Mud whelks sometimes aggregate when feeding on dead material, and this may increase the variability among quadrats. However, this was probably not a problem on the 2017 survey, because c.v.'s were relatively low (12.5–28.1%).

Some data sheets were not fully completed, with the recorder failing to record whether a sub sample was taken. The importance of such recording should be emphasised during training for future surveys, and the data sheets may need to be modified to clarify this.

Ngati Toa selected a survey design optimised for three species: cockle, mudflat topshell and mud whelks. Ngati Toa wanted to focus on the four strata and achieve a c.v. of 15%, requiring a total of 16 transects. The c.v.s achieved were 11.6%, 9.6% and 17.7%, respectively. Future surveys with a similar amount of sampling effort should provide abundance estimates that can be compared, and the results able to identify whether the shellfish populations are increasing or decreasing over time. A c.v. of 15% enables detection of about a 2-fold (halving or doubling) change in abundance.

5 Conclusions

- The abundance estimates for cockles, mudflat topshells and mud whelk had high enough precision to give confidence in the population abundance estimates, and will enable the monitoring of abundance trends over time.
- There has been a significant increase in abundance of cockles, and probably also mudflat topshells and mud whelks, since 2015. The reason for these increases is uncertain.
- The stratum with the largest proportion of large cockles (> 30 mm) was opposite MCC where almost half were large, although numbers were not high. Porirua stream had the lowest proportion of large cockles with only 1% larger than 30 mm.

6 Acknowledgements

Thanks to Te Rūnanga o Toa Rangatira for their partnership, support, and sharing their knowledge during the survey. Special thanks to Jorge Jimenez Senen from Mountains to Sea Wellington for running a successful Onepoto shellfish survey. Thanks to Greater Wellington Regional Council (GWRC) and Mountains to Sea Wellington for planning and running the survey and the BBQ, Thanks to Mountains to Sea Wellington for returning to finish the incomplete transects the following week. Thanks to the Guardians of Pauatahanui (GOPI) for lending the sampling equipment, and sharing such knowledgeable volunteers. Thanks to all the volunteers that gave up their weekend to help. Thanks to Megan Oliver (GWRC) for funding this research and ensuring the data was punched and checked. Thanks to Malcolm Francis (NIWA) for reviewing this report.

7 Glossary of abbreviations and terms

c.v.	Coefficient of Variation
Opposite MCC	Opposite Mana Cruising Club
GWRC	Greater Wellington Regional Council
NIWA	National Institute of Water and Atmospheric Research

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Appendix A Transect start and end coordinates.

	Transect start positions		Transect finish positions	
Transect No.	Longitude	Latitude	Longitude	Latitude
1	-41.122666	174.83784	-41.122787	174.838843
2	-41.123434	174.837443	-41.123436	174.839127
3	-41.10519	174.866167	-41.104501	174.864529
4	-41.10581	174.86569	-41.105148	174.863807
5	-41.107057	174.864882	-41.105815	174.86327
6	-41.10748	174.864231	-41.106946	174.863436
7	-41.107802	174.863725	-41.107489	174.863257
8	-41.108386	174.862984	-41.108268	174.86283
9	-41.101458	174.862409	-41.101439	174.863525
10	-41.102758	174.862277	-41.102661	174.863518
11	-41.126147	174.840705	-41.126104	174.841785
12	-41.127012	174.840494	-41.12701	174.841811
13	-41.127601	174.840492	-41.127587	174.842011
14	-41.128104	174.840473	-41.128098	174.842253
15	-41.128814	174.840609	-41.128813	174.842427
16	-41.129498	174.840747	-41.129501	174.842484

Appendix B Onepoto intertidal sampling locations (stations).

Transect No.	Date	Time	Zone	Quadrat	Latitude	Longitude
1	25/11/2017	0740	low	all	-41.122768	174.838751
1	25/11/2017	0825	mid	all	-41.122753	174.838573
1	25/11/2017	0905	high	all	-41.122718	174.838264
2	25/11/2017	0730	low	all	-41.123571	174.838689
2	25/11/2017	0855	mid	all	-41.123534	174.838347
2	25/11/2017	0955	high	all	-41.123480	174.837829
3	26/11/2017	0845	low	all	-41.104699	174.864942
3	26/11/2017	0948	mid	all	-41.104834	174.865334
3	26/11/2017	1050	high	all	-41.105133	174.866012
4	26/11/2017	0900	low	all	-41.105296	174.864192
4	26/11/2017	1000	mid	all	-41.105537	174.864895
4	26/11/2017	1056	high	all	-41.105721	174.865423
5	26/11/2017	0855	low	all	-41.106141	174.863689
5	26/11/2017	0950	mid	all	-41.106589	174.864261
5	26/11/2017	1045	high	all	-41.106915	174.864694
6	26/11/2017	0915	low	all	-41.107064	174.863623
6	26/11/2017	0953	mid	all	-41.107249	174.863902
6	26/11/2017	1022	high	all	-41.107398	174.864129
7	25/11/2017	1000	low	all	-41.107567	174.863372
7	25/11/2017	1045	mid	all	-41.107693	174.863565
7	25/11/2017	1120	high	all	-41.107775	174.86369
8	30/11/2017	1428	high	all	-41.108351	174.86294
8	30/11/2017	1459	mid	all	-41.108329	174.862909
8	30/11/2017	1525	low	all	-41.108286	174.862845
9	26/11/2017	0838	low	all	-41.101444	174.863282
9	26/11/2017	0908	mid	all	-41.101448	174.863104
9	26/11/2017	0955	high	all	-41.101471	174.862463
10	26/11/2017	0835	low	all	-41.102684	174.863266
10	26/11/2017	0923	mid	all	-41.102699	174.862994
10	26/11/2017	0955	high	all	-41.102725	174.862471
11	25/11/2017	0745	high	all	-41.126147	174.840705
11	25/11/2017	0835	low	all	-41.126171	174.841402
11	25/11/2017	0904	mid	all	-41.126162	174.841046
12	25/11/2017	0730	high	all	-41.127015	174.840762
12	25/11/2017	0845	low	all	-41.127003	174.841796
12	25/11/2017	0915	mid	all	-41.127003	174.841505
13	30/11/2017	1328	low	all	-41.127582	174.841648
13	30/11/2017	1232	mid	all	-41.127598	174.841216
13	30/11/2017	1120	high	all	-41.127591	174.84068
14	25/11/2017	0900	low	all	-41.128094	174.842044
14	25/11/2017	0920	mid	all	-41.128098	174.841379
14	25/11/2017	1030	high	all	-41.128104	174.841039
15	27/11/2017	1039	low	all	-41.128794	174.842224
15	27/11/2017	1059	mid	all	-41.128802	174.841708
15	27/11/2017	1210	high	all	-41.128804	174.841052
16	25/11/2017	0800	low	all	-41.129498	174.842449
16	25/11/2017	0830	mid	all	-41.129506	174.841839
16	25/11/2017	0900	high	all	-41.129504	174.84121

Appendix C Example quadrat sampling sheet.

Transect No.	**1**			**Tidal zone**	**Low**	**Mid**	**High**
Date	**26-Nov-17**	**Time**	**9:04 a.m.**	**Name**	Warrick Lyon ph.021 029 20221		
Quadrat	**1**	**2**	**3**	**Ph./email**	Warrick.lyon@niwa.co.nz		
Cockles (mm)		**Is this a subsample?**		**YES**	**NO**	**50**	**%**
15, 21, 33, 14, 6, 9, 11, 15, 16, 17, 14, 17, 22, 23, 21, 18, 19, 24, 22, 12, 11, 14, 15,14, 16, 17, 22							
							Total measured
							27
Mud whelk (mm)		9, 10, 10, 13, 8,					5
Mudflat topshell (mm)		12, 11, 9, 9, 11,					5
Pipi (mm)	22,						1
Comments							

Transect No.	**1**			**Tidal zone**	**Low**	**Mid**	**High**
Date	**21-Nov-17**	**Time**	**0900**	**Name**	For Example		
Quadrat	**1**	**2**	**3**	**Ph./email**	Ph 04 2338 8721		
Cockles (mm)		**Is this a subsample?**		**YES**	**NO**	**100**	**%**
15, 11, 9, 14, 11, 10, 9							
							Total measured
							7
Mud whelk (mm)		none					0
Mudflat topshell (mm)		15, 16, 18, 11, 11, 14, 12					7
Pipi (mm)	none						0
Comments							