Community survey of cockles (*Austrovenus stutchburyi*) in Pāuatahanui Inlet, Wellington, November 2025

Update of intertidal survey time series

Prepared for the Guardians of Pāuatahanui Inlet

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Contents

Tables

Figures

Executive summary

The Guardians of Pāuatahanui Inlet (GOPI) and community volunteers have carried out twelve triennial surveys of cockles (*Austrovenus stutchburyi*) in Pāuatahanui Inlet (Porirua Harbour, Wellington) since 1992. These surveys provide an important time-series of data to monitor trends in intertidal cockle densities and their size structures over space and time. Localised changes in the demographics of cockles may provide indications of changes to environmental factors and the ecosystem health of Pāuatahanui Inlet.

All the GOPI surveys have used the same design and methods, allowing site, transect, and tide level comparisons between surveys. This report summarises the results of a survey undertaken in November 2025. Thirty of the 31 original transects were fully sampled and comprised 360 of the 372 quadrats available.

Overall, the population size of cockles in the intertidal zone of Pāuatahanui Inlet has recovered from the decline between 2013 and 2016 and is now the highest it has been since 1992. Recruitment to the intertidal population remains high, which suggests successful settlement of larvae and good survival of spat in the Inlet. There is no information on the likely levels of the movement of juvenile cockles between intertidal and subtidal areas. The increase in terrestrial sediments in 2016, considered deleterious to cockles, do not appear to have had a long-term effect on the intertidal population. This trend is not consistent with the expectation of relatively high mortality of small cockles, from high levels of mud and suspended sediments caused by floods in 2016.

This report updates the 2023 report of the 2022 survey and provides an in-depth context and discussion of the surveys. Key findings of the 2025 Pāuatahanui Inlet cockle survey are:

- The total survey count of cockles in 2025 was the highest since 1992 and increased 102% from the estimate in 1992. Most transects in 2025 had higher total counts of cockles than in previous surveys. The highest number of cockles recorded per 0.1 m^2 quadrat in 2025 was 229, which was fewer than in 2019 and 2022 but more than in 2016. Mean cockle density over the intertidal survey area in 2025 was 51.9 per 0.1 m^2, (99% Confidence Interval (CI) 47.7–56.2), higher than all previous GOPI surveys since 1992. Mean cockle density per quadrat was highest at Transects 4, 8, and 20. These three transects had an average of 88 cockles per quadrat.

- The two methods used to estimate cockle population size show upward trends and significant differences from 2007 to 2013, a decrease between 2013 and 2016, and a marked increase between 2016 and 2025. The low coefficients of variation (CVs) of 3-6% suggest statistically significant increases. The 2025 mean population size using Method 1 (519 million cockles, 99% CI 477 – 562 million) is 99.2% of the first and highest population estimate from the 1976 survey, and over twice that in 1992 (222 million cockles).

- The percentage of juvenile cockles sampled in the population has increased markedly from 1.0% of cockles sampled in 1992 to 21.4% in 2025. From 2004, the juvenile cockle population has increased, between 16.0% and 21.6% of the cockles sampled. The high percentage of juveniles and the increase in the population over this time, suggests regular recruitment and good survival of newly settled spat.

The signing of Te Wai Ora o Parirua, the Porirua Harbour Accord, is a response to the significant pressures the Porirua Harbour, including the Pāuatahanui Inlet, face today. Urban growth, sedimentation, pollutants, and the loss of natural habitat are contributing to the deterioration of the health of the Harbour. However, the intertidal cockle population of Pāuatahanui Inlet does not seem to have been affected by these pressures as a whole. Maintaining this significant time series presented in this report is vital to understanding future changes in the Pāuatahanui cockle population.

1 Introduction

Te Awarua o Porirua (Porirua Harbour) is an iconic feature of Porirua, a national treasure, and the largest and most significant estuary in the Wellington region (Te Rūnanga o Toa Rangatira 2025). The harbour, encompassing the Pāuatahanui Inlet and Onepoto Arm, is essential to the identity, heritage, and values of Ngāti Toa Rangatira (Ngāti Toa), and is at the heart of the community (Te Rūnanga o Toa Rangatira 2025). Pāuatahanui Inlet is ranked second for conservation importance in the Wellington region, after the Manawatu River (Todd et al. 2016). Estuaries such as Te Awarua o Porirua provide substantial ecosystem services, however, are highly vulnerable to anthropogenic (man-made) effects.

The ecological significance of Pāuatahanui Inlet has long been recognised by tangata whenua and the community. In 1991, a local community group founded the Guardians of Pāuatahanui Inlet (GOPI). In the same year, a Pāuatahanui Inlet Advisory Group was established by Porirua City Council (PCC) and the Greater Wellington Regional Council (GWRC) to seek community input into an action plan to protect the inlet. This advisory group included Ngāti Toa and community groups such as GOPI and Forest and Bird. The Pāuatahanui Inlet Action Plan, Towards Integrated Management was established by PCC and GWRC. The advisory group became The Pāuatahanui Inlet Community Trust in 2002. PCC and GWRC commissioned a Pāuatahanui Restoration Plan between 2002 and 2004. In recognition of the ecological significance of the entire harbour, including the Onepoto Arm, the Porirua Harbour and Catchment Community Trust (PHT) was established in 2011 and a Porirua Harbour and Catchment Strategy and Action Plan finalised in 2012. The Pāuatahanui Inlet Community Trust was disbanded in 2015, with its role integrated into PHT and Guardians of Pāuatahanui Inlet (for more information see the GOPI website, Our Policies – Guardians of Pāuatahanui Inlet).

In 2014, in response to the National Policy Statement for Freshwater Management, the Te Awarua-o-Porirua Whaitua committee, comprised of Ngāti Toa, community members, and local and regional council officers, and elected officials, was established. The committee were tasked with recommending ways to improve the management of land and water within Te Awarua-o-Porirua catchment to achieve an improvement in water quality and ecology. The Ngāti Toa Statement (http://www.gw.govt.nz/assets/Whaitua/ngatitoataopwhaituastatement.pdf) and the Te Awarua-o-Porirua Whaitua Implementation Programme (WIP) (Greater Wellington — Whaitua Implementation Programme recommendations) containing these recommendations were finalised in April 2019. Implementation of the Statement and WIP is ongoing.

On Waitangi Day, 6th February 2025, Te Wai Ora o Parirua – Porirua Harbour Accord was signed by Te Rūnanga o Toa Rangatira, Greater Wellington Regional Council, Porirua City Council, Wellington City Council, and Wellington Water. This Accord acknowledges the immense pressure the harbour and its catchment have been under due to sedimentation, pollutants, urban growth, and the loss of natural habitats. It provides a shared vision and commitment to restore the harbour, with the vision of the Porirua Harbour Accord as follows:

> *The health and mauri of Te Awarua o Porirua is restored, its waters are healthy and sustainable for future generations and for those who live, work, play or connect with the harbour (Te Rūnanga o Toa Rangatira 2025).*

Following the signing of the Accord, the Accord Coordination Group, led by Te Rūnanga o Toa Rangatira was established, and the development of a long-term Accord Action Plan is underway, and expected to be completed mid-2026. A series of workshops in 2025 focused on sedimentation, pollutants and contaminants, and restoring natural habitats, to prioritise a pathway for restoration. The workshops combined all of the mahi that has previously been mentioned, such as the Porirua Harbour Strategy, Whaitua Implementation Programme, Ngāti Toa Rangatira Statement, and the Porirua Harbour Summit. Further information, including the Porirua Harbour Accord, can be found at [Greater Wellington — Porirua Harbour Accord]. For Ngāti Toa there is no compromise, they wish for their people to be able to harvest food from, swim in, and enjoy the waters of Te Awarua o Porirua, and for the fish, insects, birds, and plants of the ecosystem to thrive once again (Te Rūnanga o Toa Rangatira 2025).

Concerns about ecosystem health, environmental threats, and sustainable development, have led to increased efforts to monitor and assess the status of estuarine ecosystem health. Determining estuarine health is difficult, as it requires knowledge of the complex ecosystem interactions, and good time-series data. Increasingly, ecological indicators or indicator species provide simple measures of change in the components of ecosystems that can infer changes in ecological processes. The GOPI surveys of intertidal cockles undertaken by community volunteers provide an important time-series of information for monitoring the health of Pāuatahanui Inlet. Significant, long-term decreases in the abundance and size structure of cockles, a keystone species in this intertidal habitat, is likely to represent changes to the ecological structure and probable loss of ecosystem function.

Cockles (tūangi) are considered a significant taonga to Māori across Aotearoa (Reihana et al. 2025) (see further information at [Tuangi | Earth Sciences New Zealand | NIWA]). The biology of cockles (*Austrovenus stutchburyi*) was summarised in the 2010 cockle survey report (Michael 2011), and further information is available from Fisheries New Zealand (Ministry for Primary Industries) (Fisheries New Zealand 2019). The first survey of Pāuatahanui Inlet cockles was undertaken by the New Zealand Oceanographic Institute in 1976. An overview of some of the early surveys of Pāuatahanui Inlet (1971 and 1976–1980) is contained within this report. Since 2008, cockle survey reports (Michael 2008, 2011; Michael and Wells 2014, 2017; Michael and Lyon 2020; Michael 2023) have provided a living document that is a depository for information on cockles in Pāuatahanui Inlet. The present report updates the 2022 cockle survey report (Michael 2023) with the results of the 12th GOPI cockle survey, carried out in November 2025.

1.1 The Guardians of Pāuatahanui Inlet cockle surveys

The Guardians of Pāuatahanui Inlet and community volunteers have undertaken surveys of the cockle population in the Inlet since 1992. Earth Sciences New Zealand (ESNZ) (formally NIWA) has assisted by analysing the survey data and updating reports containing the summaries of results. Greater Wellington Regional Council provides logistical and practical support for the surveys and funds the report preparation. All survey reports are available on the GOPI website ([Cockle Surveys – Guardians of Pāuatahanui Inlet]).

1.1.1 Survey history

The first GOPI intertidal cockle survey was undertaken in 1992 (Figure 1–1), sampling most of the survey sites sampled in 1976 (Figure 1–2) by Richardson et al. (1979), this time with the assistance of community volunteers and overseen by NIWA (Grange 1993). The 1992 survey found a decrease in the numbers of cockles in the Inlet since 1976 (see Section 3.1.1) and indicated that there were fewer adults (larger than 10 mm shell length) in the population. The most pronounced decreases were around the south-western shores of the Inlet at Brown’s Bay adjacent to the early residential development of Whitby (Estcourt and Grange 1976). Differences in population size and cockle density may also have been due to other factors such as heightened natural mortality and differences in the two survey designs.

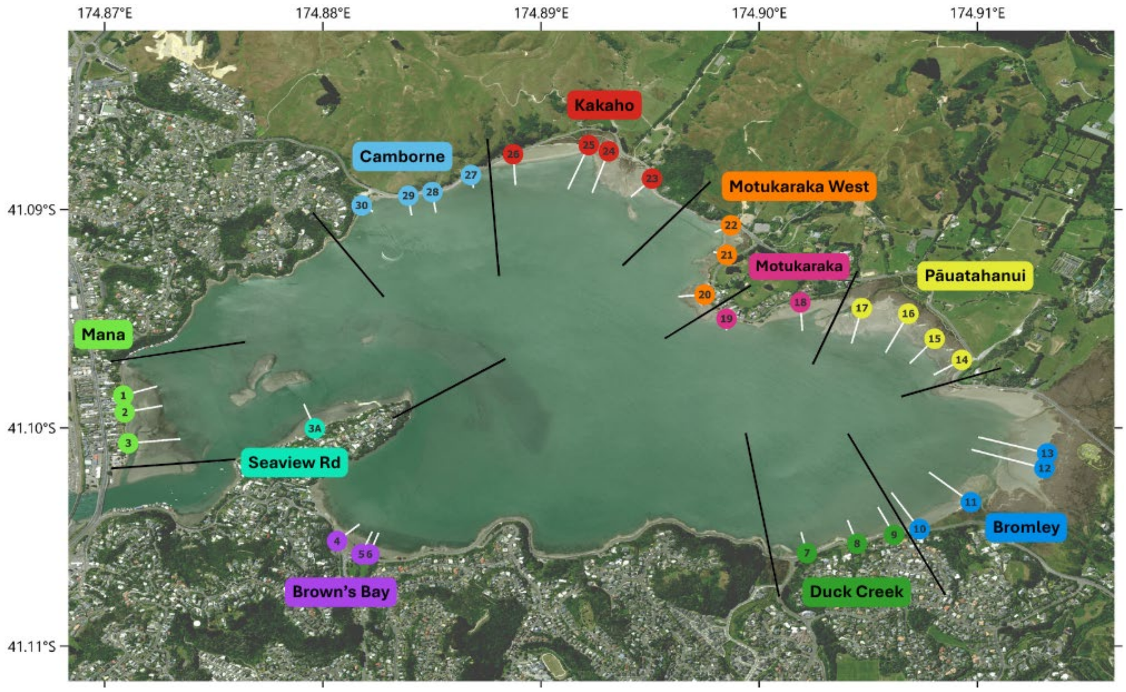

Figure 1-1: Location of all 31 transects sampled in the Pāuatahanui Inlet sampled for intertidal cockle densities and population size structure by Guardians of Pāuatahanui Inlet (GOPI) between 1992 and 2025. Since 1998, Transect 3A has been sampled instead of Transect 30.

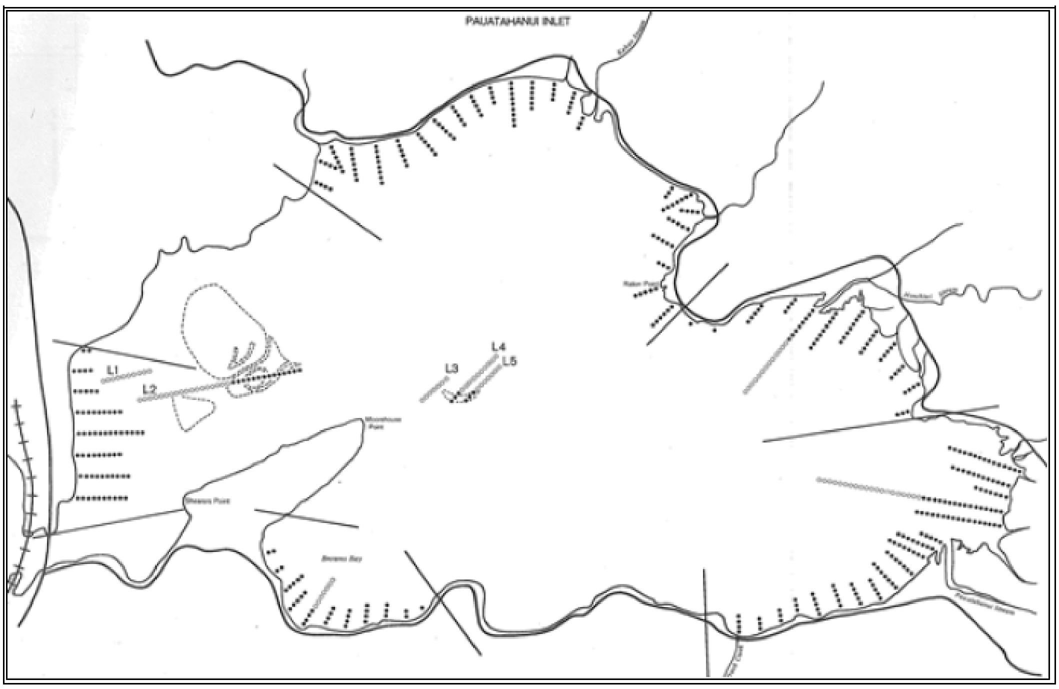

Figure 1-2: 1976 survey stratification of Pāuatahanui Environmental Programme (Healy 1980). Pāuatahanui Inlet was divided into seven sectors, and intertidal and subtidal zones were sampled in five sectors. Straight lines delineate sectors, filled circles show the location of intertidal transects, and open circle the location of subtidal transects. Figure reproduced from Richardson et al. (1979).

The second GOPI survey, undertaken in November 1995, sampled the same sites using the same methodology as the 1992 survey, and aimed to document any changes in the population. Those results indicated that the population decline had continued (Grange et al. 1996). Subsequent triennial surveys, since November 1998 (Grange and Crocker 1999; Grange and Tovey 2002; Horn et al. 2005; Michael 2008, 2011; Michael and Wells 2014, 2017; Michael and Lyon 2020; Michael 2023) used the same sites and methods as the 1992 and 1995 surveys (see section 2).

1.1.2 Population size and density

The population size of the intertidal cockles in Pāuatahanui Inlet declined between 1976 and 1995, increased in 1998, and declined again in 2001. The trend in population size between 2001 and 2013 showed a continuous increase, and between 1995 and 2013, the population increased by 87%. Following a decrease in population between 2013 and 2016 (14% decrease), the population size has shown a continuous increase from 2016 to 2022 (93% increase).

In 2022, cockle counts per 0.1 m^2 quadrat were mostly higher than in 2019 and ranged from zero to a maximum of 289 per quadrat, which is higher than in any of the previous surveys. Consequently, the total population size of cockles in the intertidal zone of Pāuatahanui Inlet was the highest since 1992, but only 84% of that estimated in 1976 (Michael 2023).

1.1.3 Juvenile Abundance

The population size of juvenile cockles (10 mm in length and smaller, Richardson et al. 1979) was low in 1992 and 1995, 2.3 million and 3.3 million respectively. Between 1995 and 1998, the population size of juvenile cockles increased to 16.3 million, and the percentages of juveniles in the total population from 1.8% to 6.4%. Since 1998, the population size of juvenile cockles has shown an upward trend, increasing to 87.1 million in 2022, 19.8% of the total population.

The higher recruitment of juvenile cockles observed from 1998 to 2022 has likely been the driver of the increase in the cockle population. This explanation, however, assumes that recruitment to the intertidal cockle population, juvenile mortality and growth rates have remained near long-term mean (average) levels, and that there has been negligible net migration of juveniles to or from subtidal areas (or from the subtidal).

2 Methods

Community volunteers have undertaken triennial intertidal surveys of the cockle population in Pāuatahanui Inlet since 1992, and most recently in 2025. These surveys sampled mostly the same transects (Figure 1-1) and used similar methods.

When using volunteers for surveys it is important to include adequate training for volunteers before they are sent to the estuary to sample cockles, for health and safety, and to allow for comparisons with other sampling sites and other survey years. The Pāuatahanui cockle count uses a method of training-the-trainers, where training occurs for all transect team leaders. Team leaders then share that knowledge with the 3–4 other people on their sampling teams. All transect leaders have the phone number of the scientific advisor, who was John McKoy in 2025, so any additional queries can be phoned in. Team leaders guided volunteers, monitored sampling and the recording of data. Volunteers were each provided with sheets that explained the sampling methods and were shown the location of sites (Appendices A and B for instruction and sampling sheets), the team leader's check list (Appendix C), and tally sheets to record cockle lengths (Appendix D).

The 2025 survey comprised 30 fixed transects (see Figure 1-1). Transect 30 has not been sampled from 2013 – 2025, because this area is now a launching place for jet skis and the beach shows relatively high degradation caused by the vehicle traffic. Although transect counts would not be comparable to years before 2013, data between 1992 and 2013 were included in analyses to give a complete description of cockles in Pāuatahanui Inlet.

As in previous years, transects were located using numbered stakes deployed before the survey and transects were orientated towards landmarks on the opposite shore of the Inlet (see Appendix B for an example). The details used to locate each of these transect markers are given in Appendix E. Transects were grouped by site (Table 2–1). Each transect was sampled at four tidal heights (high (HT), upper-mid (UMT), lower-mid (LMT), and low (LT) tides), and those tidal heights were determined by a set-number of adult paces from the location marker (see Appendix E) and marked with a stake to provide a reference for sampling. Samples were taken from three haphazardly placed quadrats (0.1 m^2), on or about 5 m either side of transects (these replicates were recorded as A, B, and C), at each tide height.

Table 2-1: The grouping of transects sampled within each site in Pāuatahanui Inlet and lengths of transects.

Site	Transect	Length (m)	Site	Transect	Length (m)
Mana	1	213	Pāuatahanui	16	241
Mana	2	277	Pāuatahanui	17	166
Mana	3	320	Motukaraka	18	177
Seaview Road	3A	86	Motukaraka	19	34
Brown's Bay	4	105	Motukaraka West	20	147
Brown's Bay	5	105	Motukaraka West	21	72
Brown's Bay	6	96	Motukaraka West	22	102
Duck Creek	7	71	Kakaho	23	174
Duck Creek	8	85	Kakaho	24	230
Duck Creek	9	151	Kakaho	25	230

Site	Transect	Length (m)	Site	Transect	Length (m)
Bromley	**10**	**215**	**Kakaho**	**26**	**173**
Bromley	**11**	**259**	**Camborne**	**27**	**57**
Bromley	**12**	**580**	**Camborne**	**28**	**41**
Bromley	**13**	**546**	**Camborne**	**29**	**44**
Pāuatahanui	**14**	**223**	**Camborne**	**30**	**80**
Pāuatahanui	**15**	**222**			

These replicate quadrats were sampled to a depth of about 7 cm, and the entire sample was sieved. In 2025, the sieving process was streamlined, with new wooden framed sieves with a 3.7 mm stainless steel mesh. Volunteers flushed sediments and stones through the sieves using seawater.

Volunteers sorted all live cockles into containers, measured them for length (along the anterior and posterior axis, Figure 2-2) to the nearest millimetre using rulers, and returned them to the intertidal seabed. They used an ID sheet to identify juvenile cockles and sampling sheets (Appendix D) to record tallies of lengths from each sample. A sampling instruction video was created and made available to all volunteers prior to the survey, through the GOPI website. Images of these activities are shown in the 2010 cockle survey report (Michael 2011).

2.1 Density and population estimates

2.1.1 Cockle counts and densities

Cockle counts from quadrats and tallies from multiple quadrats were used to estimate cockle densities at each site, transect, and tidal height. Cockle densities from the 2025 survey were compared with those from the previous eleven GOPI surveys (1992–2022). The fixed sampling locations were consistent over time, and changes in cockle density were compared at the spatial scales of transect, site and tidal height, as well as by survey for Pāuatahanui Inlet.

2.1.2 Population estimates

Two methods were used to estimate the population size of cockles in Pāuatahanui Inlet.

Method 1

Method 1 used the mean density calculated from the counts of all quadrats (up to 372 samples) scaled to the size of the intertidal area (as if a single stratum), which is assumed to be about 1 km^2 (Healy 1980) to remain consistent with previous surveys. This method used a NIWA built program SurvCalc (Francis and Fu 2012) to estimate population size. The coefficients of variation (CVs) were estimated as the standard deviation of the unweighted means of all transects (in any one year) divided by the square root of the number of transects. Estimates of population size are calculated for all sized cockles, and for juveniles (10 mm in length and smaller), and for adults (larger than 10 mm in length).

Method 2

Method 2 is similar to Method 1 in that it considers the intertidal area of Pāuatahanui Inlet as a single stratum; however, it used each quadrat count as an independent sample. Method 2 estimated mean cockle density from the three quadrats at each tidal height and from the means of each of the four tidal heights to give the mean cockle density for each transect. The transect mean cockle density was adjusted (weighted) for transect length (Figure 2–1) using the proportion of the total transect length (length of all transects combined) as a proxy for proportion of survey area. The estimate of mean population size is the sum of the weighted means from all transects (up to 30 transects in total). The CVs were estimated as the standard deviation of the unweighted means of all transects (in any one year) divided by the square root of the number of transects. Method 2 is likely to overestimate the variance in the estimate of population size, as the variance is sensitive to transect length and to changes in the distribution of cockle density over time. It should be noted here that the length of the transects have not been revisited since they were first estimated in the 2013 survey (Michael and Wells 2014). They are assumed to be the same every year, therefore if complete sampling of a transect cannot be done, this method may underestimate the size of the cockle population. Similarly, if the intertidal zone has increased overtime, this method may overestimate the size of the cockle population.

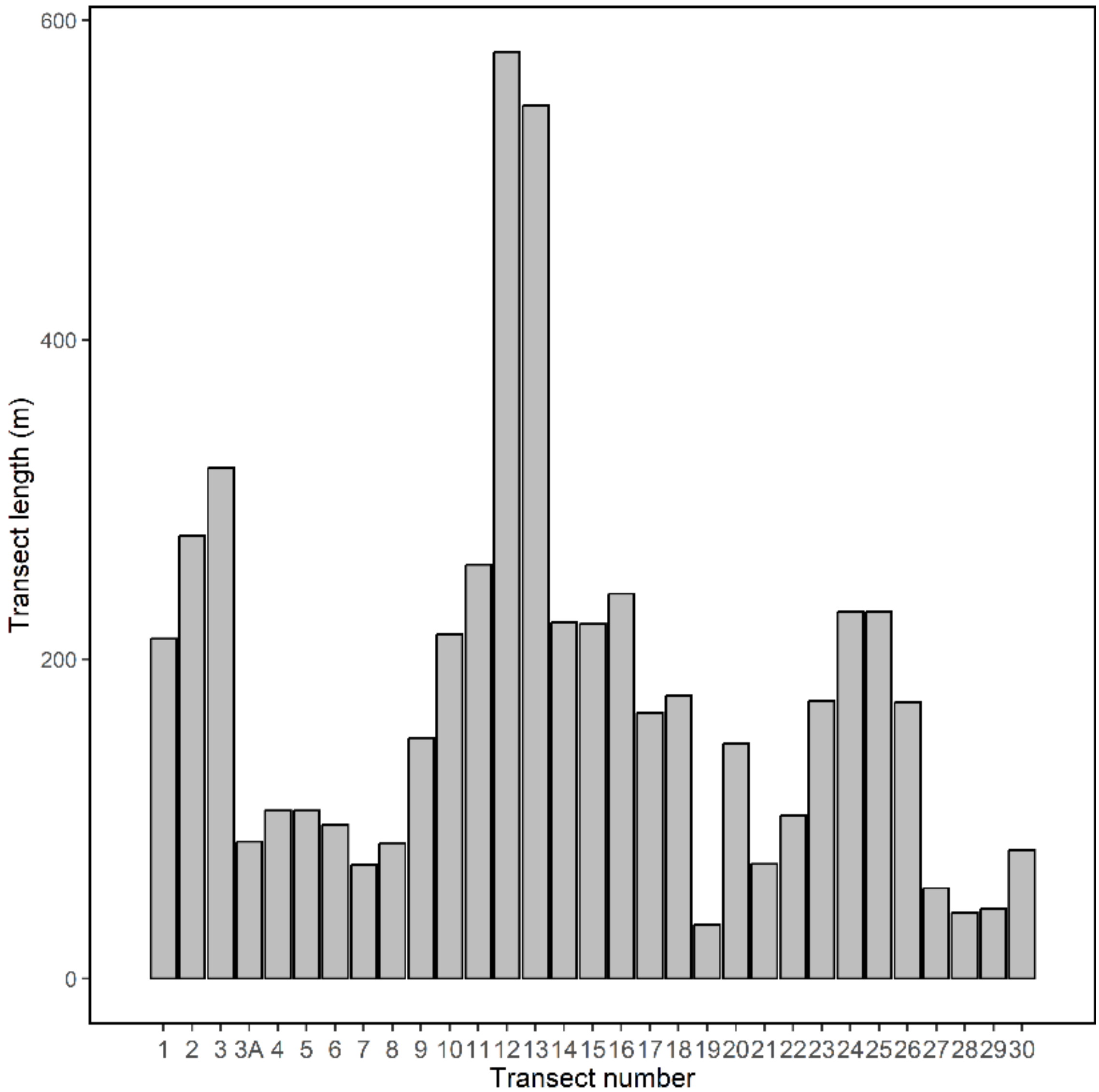

Figure 2-1: Approximate transect lengths estimated from distances between high and low water from a map of the intertidal zone.

2.1.3 Significance tests

Significant differences in cockle counts between surveys were tested using cockle counts in each quadrat in each survey. Quadrats were assumed independent samples, and the large numbers of quadrats sampled (336–372) give greater power to detect differences. The multiple comparisons amongst surveys used the Holm-Sidak test, considered to have high power to detect differences amongst paired comparisons. We discuss the methods used to estimate population size and to compare survey estimates in section 4.1.2.

2.2 Size structure of cockle populations

Shell length of cockles is defined as the longest distance along the anterior–posterior axis (Figure 2–2) and recorded as the lower whole millimetre. Cockle lengths from each quadrat were aggregated to provide estimates of population size structure by tidal heights, transects and sites, as well as by survey for Pāuatahanui Inlet. These data were summarised as histograms and cumulative percentage frequency curves so that they could be compared visually for spatial and temporal differences (e.g., differences between sites for each tidal height). In addition, cockle size structures are compared amongst surveys.

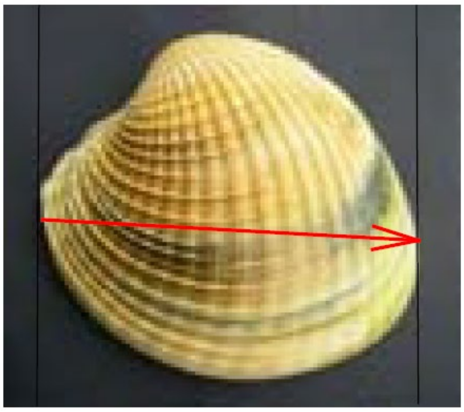

Figure 2-2: Cockle showing the length measurement along the anterior-posterior axis.

The size structure of populations was further divided into juveniles (defined as individuals 10 mm or smaller in length (Larcombe (1971) and Richardson et al. (1979)) and adults (individuals 11 mm or larger).

3 Results

The GOPI community cockle survey in Pāuatahanui Inlet was undertaken on Sunday 2nd of November 2025. Further sampling to complete the survey was carried out at 18 transects, in the week following the initial survey. For most transects with missing quadrats it was that the sampling for a particular tide level was missed, however a number of transects were just missing one or two of the quadrats. Thirty transects were sampled in total, with transect 30 not sampled in 2025.

Transects 25–29 could not be sampled on the survey day because the tide did not recede from the rock wall. Additional sampling was carried out at transects 7, 12, and 13. Transect 7 was unable to be sampled on the 2nd of November as the tide did not go out in time. When this transect was revisited, there were 40 extra paces from the low tide mark to the actual water's edge. To provide consistency with previous surveys quadrats were conducted to the low tide mark planned. Similarly, transects 12, 13, and 19 were unable to be sampled to the paced low tide sampling point on the 2nd of November. For transects 12 and 13, a sample was taken at the water edge on another day. For transect 12 this location was only 130 of the 150 minimum paces from lower mid tide, but for transect 13 the location was the full 150 paces from lower mid tide level. For transect 19, only 6 paces from lower mid tide could be achieved, rather than the 20 – 30 paces suggested.

Data from 360 quadrats were used in the analysis in 2025, compared to 336 in 2022 (29 transects), 354 in 2019 (29.5 transects), and 336 in 2016 (28 transects). To minimise the misidentification of cockles in the 0 – 10 mm size range from nutshells (*Linucula hartvigiana*), and vice versa, transects that could be expected to have a considerable population of nutshells were sampled by experienced volunteers with good identification skills. Significant misidentification of cockles could bias the numbers of juvenile cockles, and the population estimates.

Appendix F gives the numbers of cockles sampled in each quadrat in 2025 to provide a record of these data. Total survey counts of cockles increased 54.7% between 2001 and 2013, decreased 20.8% between 2013 and 2016, increased 40.9% between 2016 and 2019, and further increased 9.6% between 2019 and 2022 (see Table 3-1). There was a 26.4% increase in total number of cockles sampled in 2025 from 2022 (18676 and 14774 respectively). The total number of cockles in 2025 was made up of 3994 juveniles, and 14682 adult cockles.

The total number of cockles sampled at each transect between 2016 and 2025 generally increased at most transects during this time period (Figure 3-1). In 2025, 20 transects had an increase in total cockles counted, whereas 10 transects had a decrease in total cockles since 2022 (63% of transects increased). While numbers had increased from 2022 in transects 1, 18, 21, and 23, they still had not reached the values recorded in 2019. There was a large increase of cockles observed from 2019 to 2025 in Transects 8 – 12 (Duck Creek and Bromley sites).

Plots of the total numbers of cockles sampled at each transect and the means of total counts, each year between 1998 and 2025 are shown in Figure 3-1 and Figure 3-2. Surveys between 1998 and 2016 showed that total counts increased over successive surveys until 2013. In 2016, total survey counts were much more variable with some transects recording high total counts while others recording near historical lows. In 2022, total counts per transect were less variable, and were mostly higher than the long-term average, apart from 3 transects (15, 18, 23). In 2025, total counts per transect were again, mostly higher than the long-term average (see blue stars representing the 2025 counts), with the exception of transects 3, 15, and 19 (Figure 3-2).

Figure 3-2 is also useful to interpret spatial variation of cockle abundance around Pāuatahanui Inlet. This figure compares the transect counts of 2025 with the long-term trend around the Inlet. Consistently high counts were recorded from Mana and Bromley to Motukaraka West. Consistently low counts were recorded from Brown's Bay, Duck Creek, and Camborne sites (however, transects 28 and 29 included in the Camborne site were not sampled in 2022). In 2025, 23 transects recorded higher total counts than the long-term average, 5 were average and 2 transects (3 and 15) lower than the long-term average (Figure 3-2).

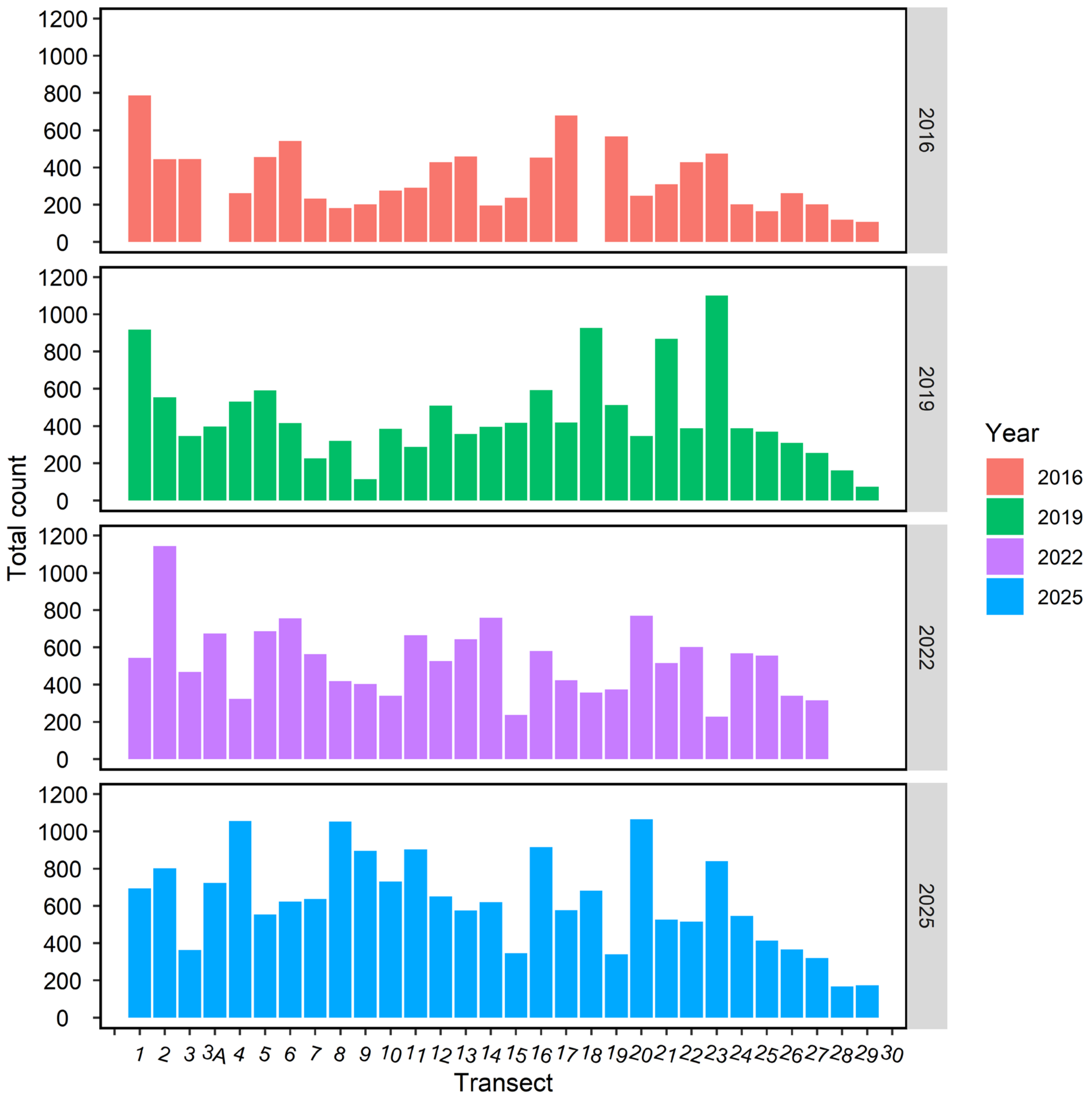

Figure 3-1: The total counts of cockles (adults and juveniles combined) sampled from each transect in the 2016, 2019, 2022, and 2025 surveys. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, transects 28 and 29 (Camborne) were not sampled in 2022, and only half of Transect 13 (Bromley) was sampled in 2019.

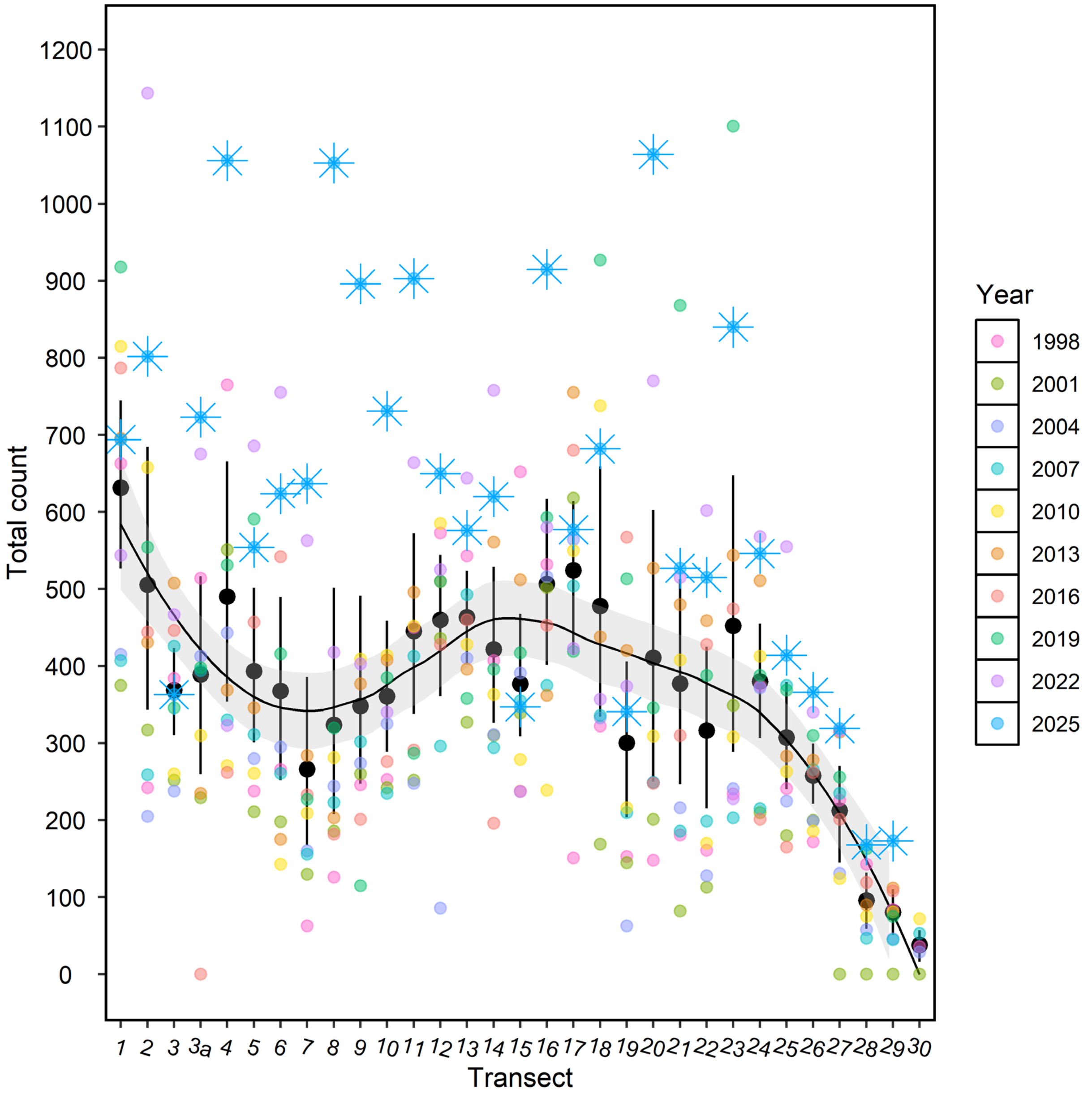

Figure 3-2: The total counts of cockles (adults and juveniles combined) sampled from each transect in surveys between 1998 and 2025. Counts shown as coloured filled circles, 2025 counts shown as blue stars, means for all years (black filled circles) and 95% confidence intervals as black lines. The spatio-temporal trend in the total numbers of cockles across Pāuatahanui Inlet are shown using a Loess smoother with the mean shown as a black line and ±1 standard error (SE) shown in grey shading. Refer to Table 2.1 for site names for each transect. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, transects 28 and 29 (Camborne) were not sampled in 2022, and only half of Transect 13 sampled in 2019.

3.1 Cockle densities and population size

3.1.1 Cockle densities

In 2025, cockle counts (of all sizes, juveniles and adults) per quadrat ranged from zero to 229 per 0.1 m^2 (at transect 20, low mid-tide, Motukaraka West). Comparing the maximum count to previous years, this was lower than for both 2022 (289 per 0.1 m^2, at transect 2, lower-mid tide, Mana) and 2019 (279 per 0.1 m^2 at transect 1, upper-mid tide, Mana). The maximum count was however higher than in 2016, (176 per 0.1 m^2) and 2013 (153 per 0.2 m^2), both recorded at transect 17, low tide, Pāuatahanui. The maximum count was also higher than for previous maximum counts recorded in 2010 (150 per 0.1 m^2 at transect 1, upper-mid tide, Mana), in 2007 (112 per 0.1 m^2 at transect 1, low-mid tide Mana), and in 2004 (95 per 0.1 m^2 at transect 1, upper-mid tide, Mana).

In 2025 no cockles were recorded from only 1 quadrat (at transect 23, low mid-tide, Kakaho), or at 0.02% of quadrats. This is compared to 7% in the 2022 survey. Mean cockle density in 2025 (51.9 per 0.1 m^2, 99% CI 47.7–56.2) was higher than in 2022 (40.4 per 0.1 m^2, 99% CI 39.6–48.4), 2019 (38.1 per 0.1 m^2, 99% CI 34.6–41.7), 2016 (28.8 per 0.1 m^2, 99% CI 25.9–31.6), and 2013 (33.6 per 0.1 m^2, 99% CI 30.9-36.2). Mean cockle density in 2025 was the highest compared to all previous GOPI surveys since 1992, and the closest mean estimate to the 1976 estimate of 52.3 per 0.1 m^2 (99% CI 43.8 – 60.8), see Table 3-1.

Mean cockle count per quadrat at each Transect is shown in Figure 3-3. Transects 4 (Brown's Bay), 8 (Duck Creek), and 20 (Pāuatahanui) had the highest mean cockle count per quadrat in the 2025 survey. Twelve Transects around Pāuatahanui Inlet had mean cockle counts per quadrat between 40 – 60, and only 2 Transects (28 and 29, Camborne), had mean cockle counts between 0-20 (Figure 3-3).

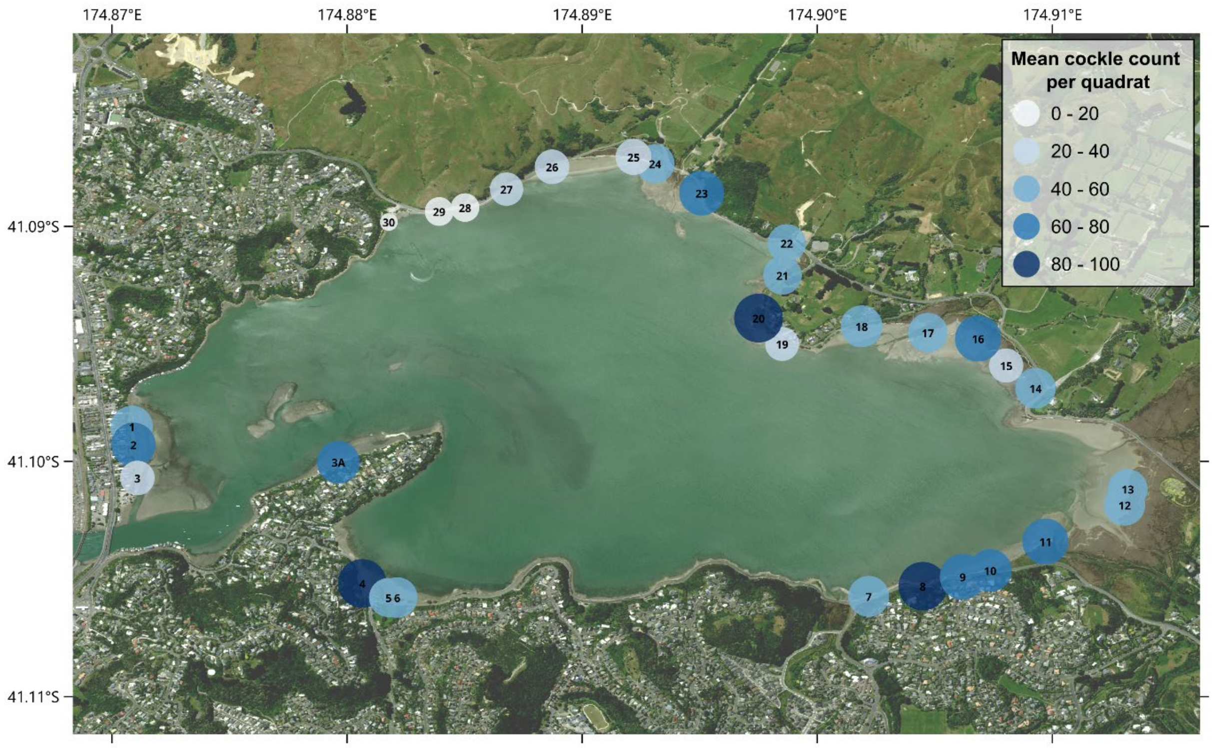

Figure 3-3: Map of Pāuatahanui Inlet showing the mean count of cockles of all quadrats per transect at each of the 30 Transects. Numbers in circles represent Transect numbers.

3.1.2 Population size

Population estimates using Method 1 were consistently lower than those using Method 2 (transect counts weighted by transect length) (see Tables 3-1 & 3-2, Figure 3-4). Both methods showed upward trends from 2007 to 2013, a decrease between 2013 and 2016, and marked increases between 2016 and 2025 (Table 3-1, Figure 3-4). The CVs of the survey estimates have been consistently low at 3-6% (Table 3-1).

Pairwise multiple comparisons for significant differences (Holm-Sidak method undertaken at a significance level of 0.05) among population estimates (using Method 1) between triennial surveys are given in Table 3-2 and show a similar pattern. The size of the cockle population in 2025 was statistically significantly higher than all previous surveys, except 2022. This follows a statistically significant difference in population size for all years in 2022.

In 2025, Method 1 gives a population estimate of 519 million (477 – 562 million, CV 0.04), the closest the Pāuatahanui Inlet cockle population has come to reaching the 1976 estimate of 523 million cockles (99.2%). In 2025, the mean cockle population size estimated using Method 1 was 17.95% higher than in 2022 and 14.4% higher estimated using Method 2. Since 2001 the mean cockle population size has increased between 93.7% and 160.8%. The precision of the estimates shown by the 99% confidence intervals (Figure 3-4) is expected to vary between surveys and is typical of time-series survey data from populations with patchy distributions. Using Method 2 (transect counts weighted by transect length), the results show a mean population of 532 million, with a CV of 0.03 and a population range of 525 – 538 million cockles.

Figure 3-5 shows the Method 1 juvenile and adult population estimates from 1998 – 2025. These estimates indicate an increase in both the juvenile and adult population sizes over time, contributing to the overall increase in the cockle population of Pāuatahanui Inlet.

Table 3-1: Cockle densities and population estimates for cockles in Pāuatahanui Inlet between 1976 and 2025. Estimates from Method 1 (unweighted data) and Method 2 (weighted data) given separately. The 2019 estimates given for all transects sampled; however, transect 13 was partly completed. Maximum counts per quadrat (0.1 m^2) (Max number per quadrat), the total numbers of cockles, mean numbers of cockles per quadrat (Mean number per quadrat), cockle population (millions), coefficient of variation (CV), and the estimated range of the cockle population size (millions) based on 99% Confidence Intervals (99%CI) given by survey.

Survey year	1976	1992	1995	1998	2001	2004	2007	2010	2013	2016	2019	2022	2025
Method 1													
No. transects	75	30	30	31	31	31	31	31	30	28	29	28	30
No. quadrats	NA	NA	NA	372	372	372	372	372	360	336	354	336	360
Max number per quadrat	280	168	191	273	118	95	112	150	153	176	279	289	229
Total numbers of cockles	15633	7976	6484	9543	7384	8108	8653	10290	12080	9659	13485	14774	18676
Mean number per quadrat	52.3	22.2	18	25.7	19.9	21.8	23.3	28.6	33.6	28.8	38.1	44.0	51.9
Cockle population (millions)	523	222	180	257	199	218	233	277	336	288	381	440	519
Juvenile cockle population (millions)	NA	NA	NA	16	15	35	38	44	42	50	59	87	111
Adult cockle population (millions)	NA	NA	NA	241	184	183	195	233	294	238	322	353	408
C.V.	NA	NA	NA	0.06	0.06	0.05	0.04	0.05	0.04	0.05	0.05	0.05	0.04
Population range (millions)	438-608	187-257	146-214	227-287	177-221	198-238	214-252	250-302	309-362	259–316	346-417	396–484	477 - 562
Method 2													
Mean population (millions)	NA	NA	NA	316	240	236	270	335	369	309	409	465	532
C.V.	NA	NA	NA	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Population range (millions)	NA	NA	NA	310-321	236-244	233-239	266-274	329-340	364-374	304-314	403-415	458–471	525 - 538

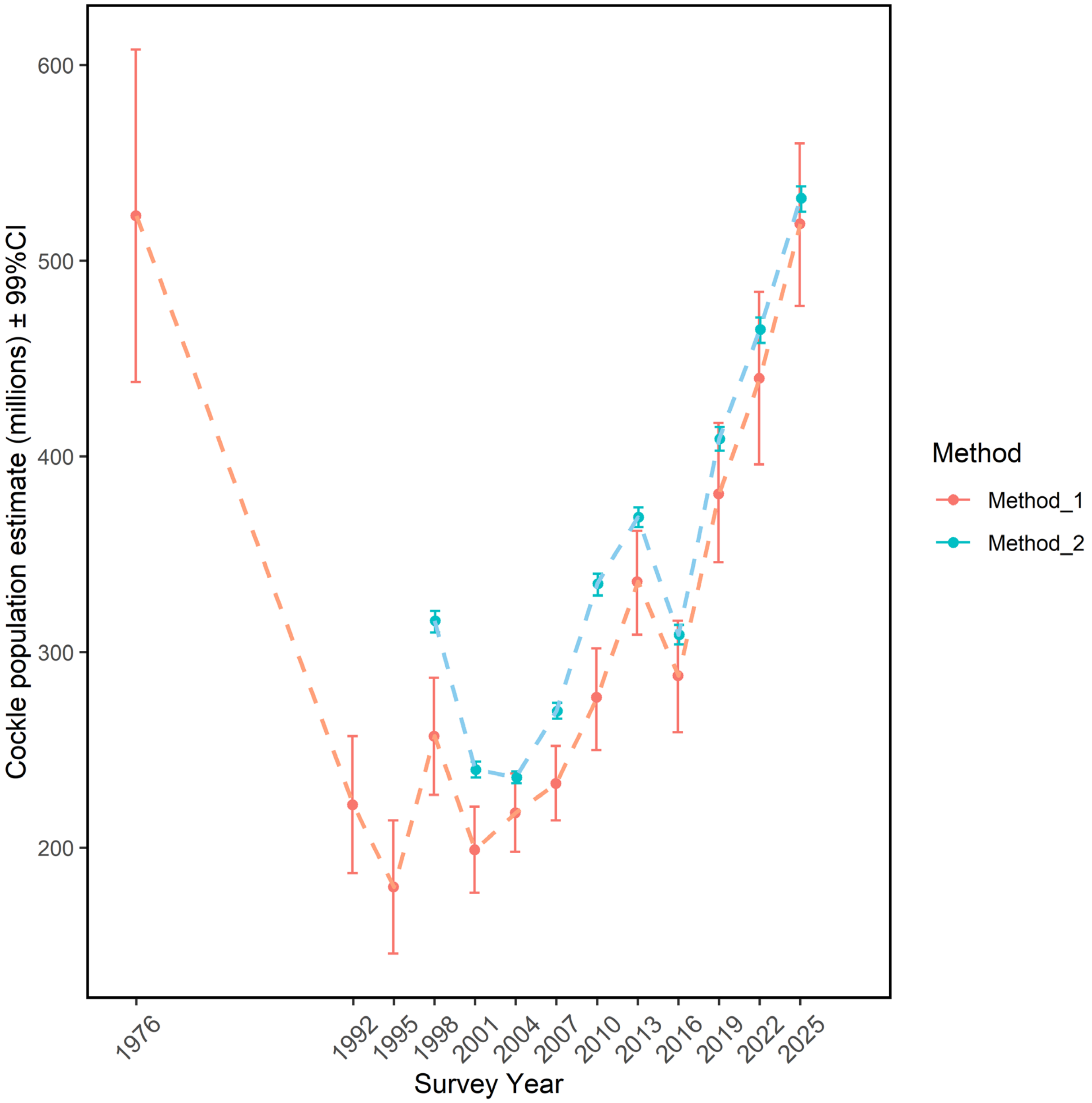

Figure 3-4: Estimates of total cockle population size and 99% confidence intervals for Pāuatahanui Inlet, 1976 – 2025. The initial survey in 1976 (Richardson et al. 1979) used a different survey design, surveys since 1992 (carried out by the Guardians of Pāuatahanui Inlet) have used the same survey design and methods. Estimates using previous method (Method 1) shown in sky blue and estimates using weighting factors for transect length (Method 2) are shown in salmon. Trends in population size shown as dashed lines. Data for surveys 1976, 1992, and 1995 not available to recalculate mean population size and 99% CIs using Method 2.

Table 3-2: Results from all pairwise comparisons (Holm-Sidak method) undertaken for survey estimates 1998 to 2025 using cockle counts by quadrat (Method 1), at a significance level of 0.05. Significant differences shown with blue shading and differences between survey years that are not significantly different given as "NS" or orange shading.

Survey years	1998	2001	2004	2007	2010	2013	2016	2019	2022
2001	0.086	-	-	-	-	-	-	-	-
2004	NS	NS	-	-	-	-	-	-	-
2007	NS	NS	NS	-	-	-	-	-	-
2010	NS	0.005	0.085	NS	-	-	-	-	-
2013	0.025	<0.001	<0.001	<0.001	NS	-	-	-	-
2016	NS	0.066	NS	NS	NS	0.038	-	-	-
2019	<0.001	<0.001	<0.001	<0.001	0.001	NS	<0.001	-	-
2022	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	-
2025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.067

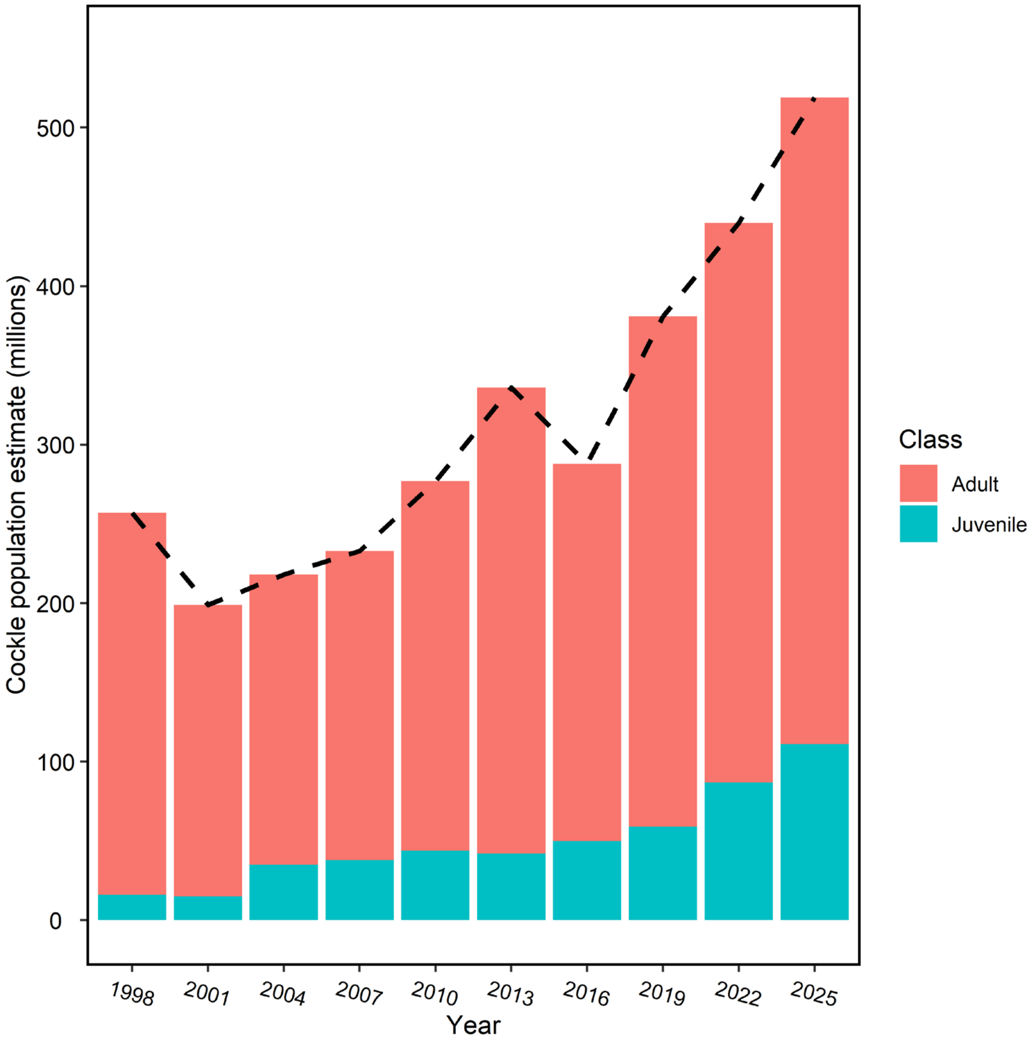

Figure 3-5: Estimates of adult and juvenile cockle population size for Pāuatahanui Inlet, 1998 – 2025, calculated from Method 1. Total population size is shown as a dashed black line.

3.1.3 Cockle densities by site

Figure 3-6 shows the numbers of cockles per quadrat and median numbers of cockles recorded at each site in 2016, 2019, 2022, and 2025. Trends in median densities varied by site. Median densities have remained broadly similar across the four surveys at Mana, Pāuatahanui, and Kakaho. In 2025, there was an increase in the median cockle density by site at Browns Bay, Duck Creek, Bromley, Motukaraka, with Duck Creek being most significant. A slight decrease was observed at Seaview Rd and Motukaraka West, the most significant decrease being at Camborne, following a big increase from 2019 to 2022 (Figure 3-6).

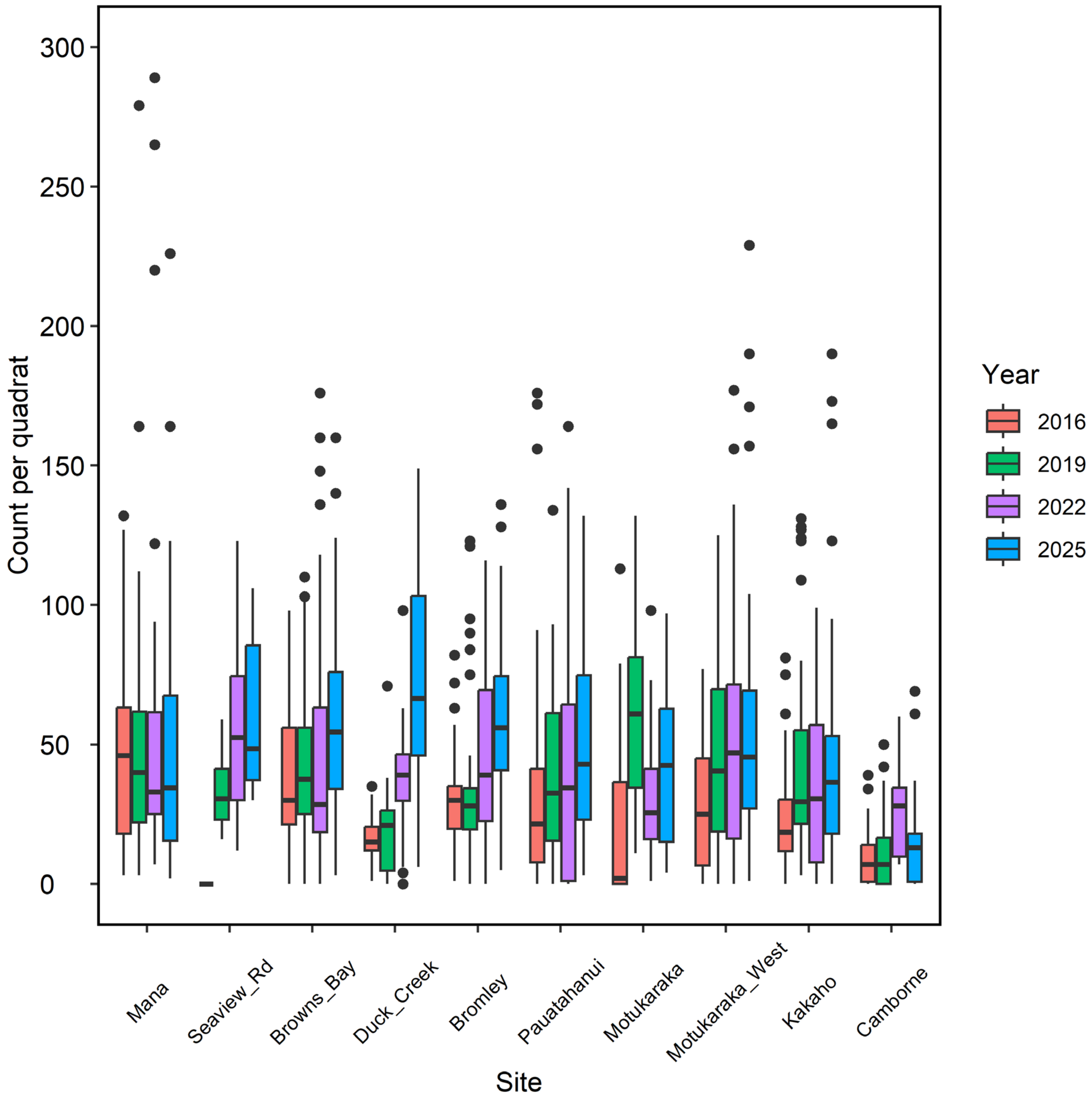

Figure 3-6: Box plots of the median count of cockles per quadrat (0.1 m^2) by site in 2016, 2019, 2022, and 2025. Boxplots show medians (solid horizontal black lines), filled boxes represent 25th to 75th percentiles, whiskers the 10th and 90th percentiles, and outliers are shown as filled black circles. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

Boxplots of cockle numbers per quadrat by site and year show similar trends to the population estimates with medians generally increasing until 2013, declining in 2016, increasing further in 2019, and generally increasing in 2022, except for Motukaraka (Figure 3-7). From 2022 – 2025, medians generally increased, with the most significant changes occurring at Duck Creek, Motukaraka, and Camborne. The former two sites had increases in median cockles per quadrat, whereas Camborne saw a decrease from 2022, along with Seaview Rd and Motukaraka West. The large numbers of outliers (represented by filled black circles, Figure 3-7) show high variation in quadrat densities at each transect and year reflecting high variation in the distribution of cockle densities at small-spatial scales.

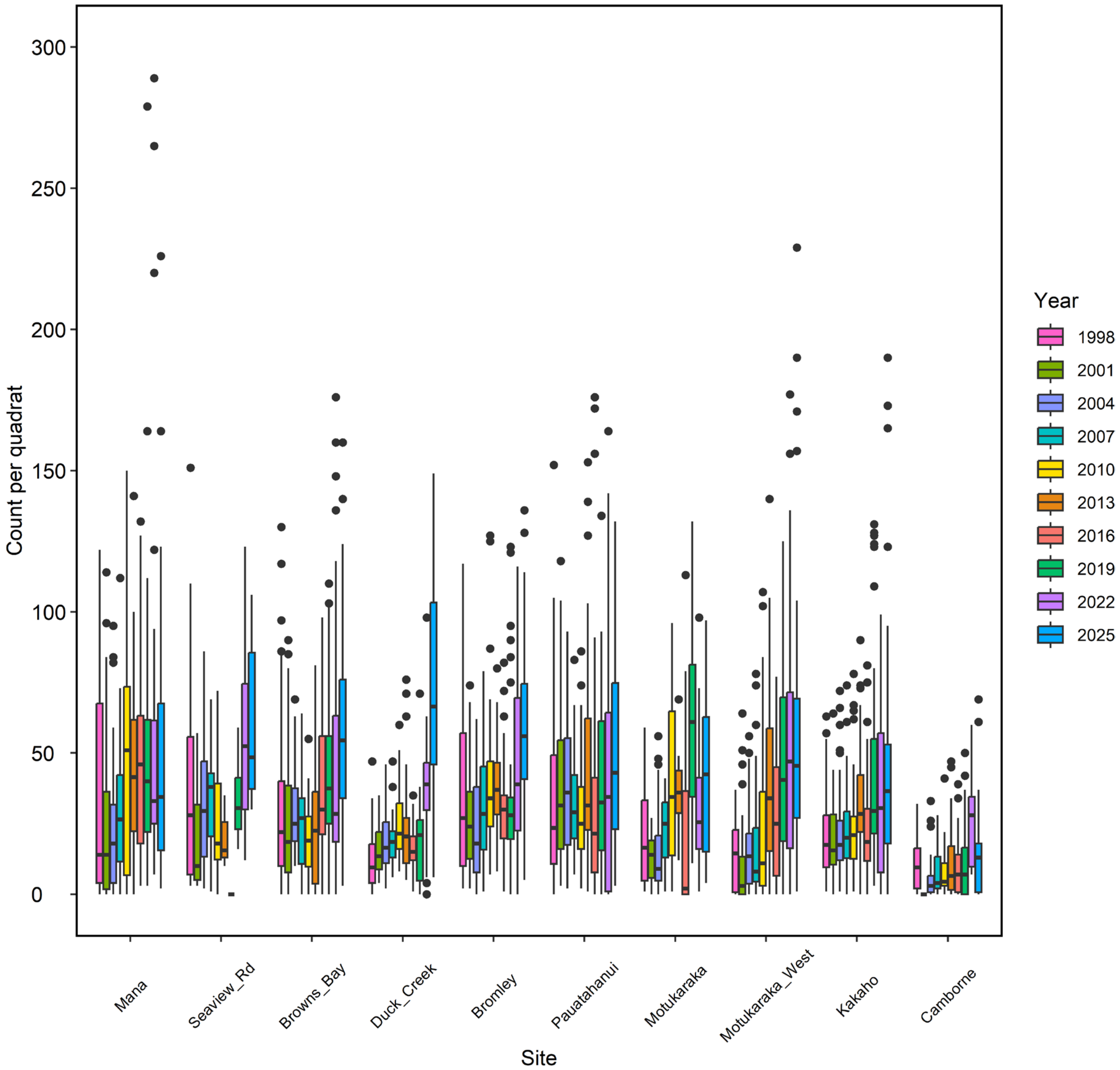

Figure 3-7: Box plots of the median count of cockles per quadrat (0.1 m^2) by site between 1998 and 2025. Boxplots show medians (solid horizontal black lines), filled boxes represent 25th to 75th percentiles, whiskers the 10th and 90th percentiles, and outliers are shown as filled black circles. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

Figure 3-8 shows bubble plots of the distributions of cockle counts by site and by size class (juvenile and adults) since 1998. Adult cockle counts have remained high at Mana, Browns Bay, Bromley, Pāuatahanui, and Kakaho since 1998. There has been a recent increase in adult cockles in Duck Creek, and an increase in numbers over time at Motukaraka West. Seaview Rd, Motukaraka, and Camborne have variable numbers of adult cockles each survey.

Juvenile cockle counts have been consistently high at Pāuatahanui, increasing over time at Brown's Bay, Duck Creek, Bromley, Motukaraka West, and Kakaho. There has been fluctuating numbers without trend at Mana and Motukaraka, whereas Seaview Road and Camborne have shown consistently lower juvenile numbers compared with other sites (Figure 3-8). In 2025, Duck Creek, Bromley, Pāuatahanui, Motukaraka West, and Kakaho had the highest numbers of juvenile cockles since 1998.

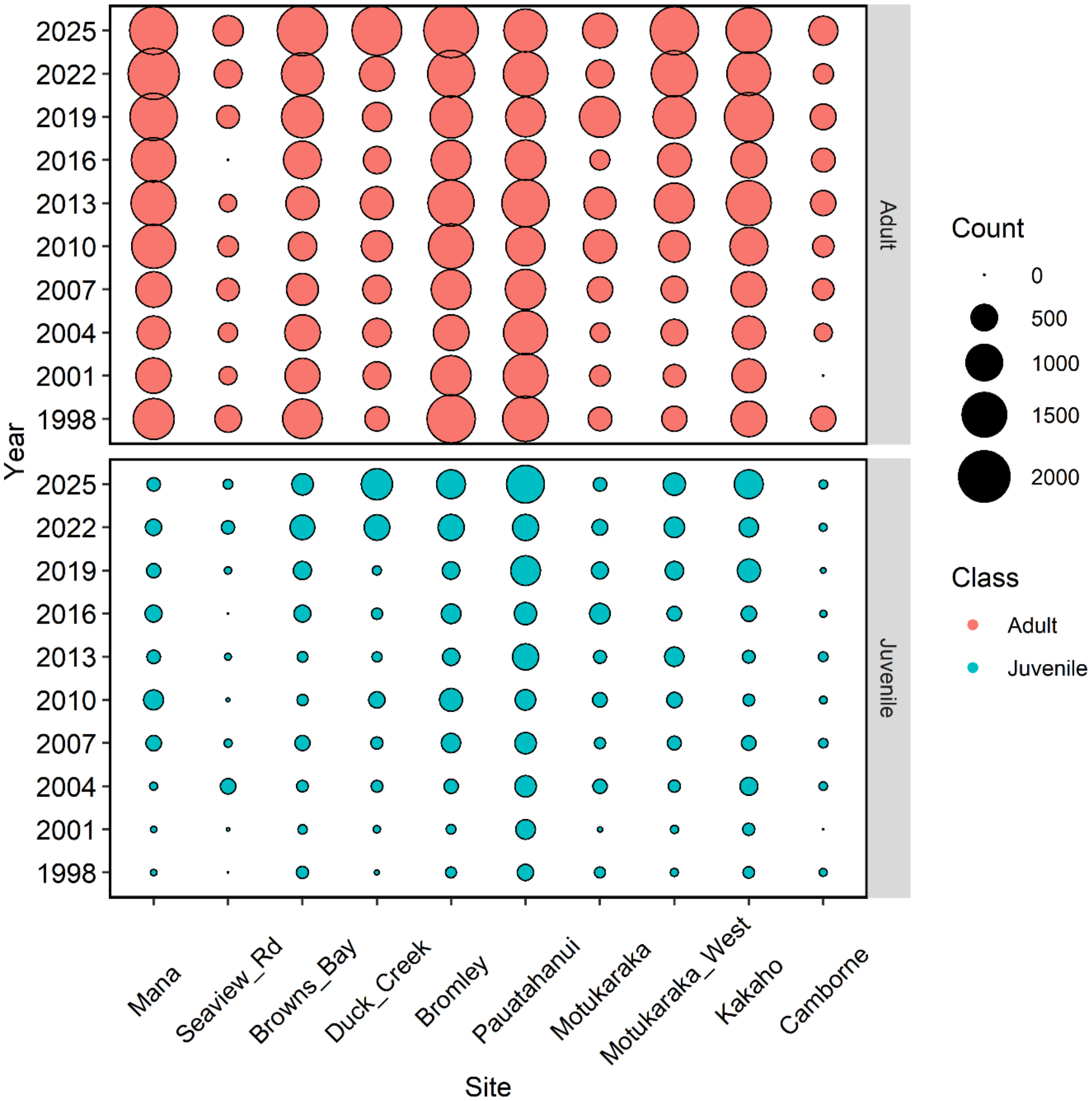

Figure 3-8: Bubble plot representing changes in counts of adult (>10 mm in length) and juvenile cockles (<=10 mm in length) at each site between 1998 and 2025. The size of the bubbles scaled to total count per site. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

3.1.4 Cockle densities by tidal height

Median cockle densities were broadly similar across all tidal height zones in all four of the most recent surveys (2016, 2019, 2022, and 2025) (Figure 3-9). In 2025, counts were higher at all tidal zones except for the lower tidal zone. Consistently higher counts were recorded for the high (HT), upper mid (UMT), and lower mid (LMT) tide zone quadrats in all years. While the 2025 median cockle number by tidal height was similar to 2022 in the low tide zone (31 in 2025, 32 in 2022), it remained higher than the median in 2016 (16) and 2019 (24).

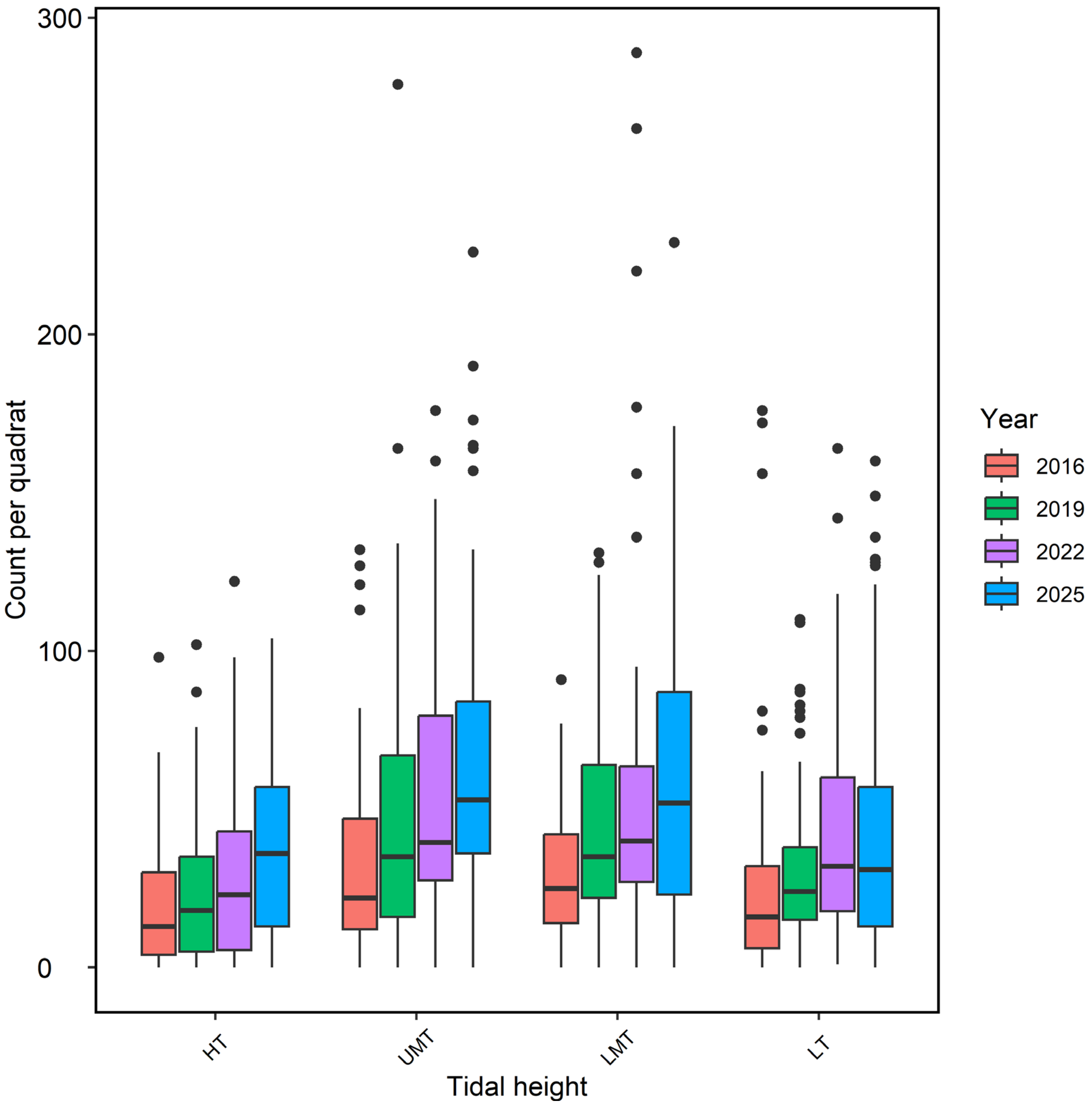

Figure 3-9: Boxplots of the median count of cockles per quadrat by tidal height for years 2016, 2019, 2022, and 2025. High tide (HT), upper-mid tide (UMT), lower-mid tide (LMT), and low tide (LT) zones. Boxplots show medians (solid horizontal black lines), filled boxes represent 25th to 75th percentiles, whiskers the 10th and 90th percentiles, and outliers are shown as filled black circles. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

Variation in cockle counts by quadrat was higher at the site than tidal height level (Figure 3-10) for all four surveys (2016, 2019, 2022, 2025). In 2025, cockle counts were higher at all tidal zones for Duck Creek, Bromley, and Kakaho. At Seaview Road, Browns Bay, and Motukaraka, all tidal zones had a higher cockle count except for the upper mid tide zone. Pāuatahanui had higher cockle counts across all tidal zones except for the low tide zone, which was the only site to have less cockle counts in that tidal zone for 2025. Motukaraka West had higher cockle counts in all tide heights except for the upper mid tide zone. Mana had an increase in cockle counts in the upper mid tide and low tide zones, but a decrease in the high and lower mid tide zones. Cockle counts were less than in 2022 across all tide zones except for the low tide zone for Camborne.

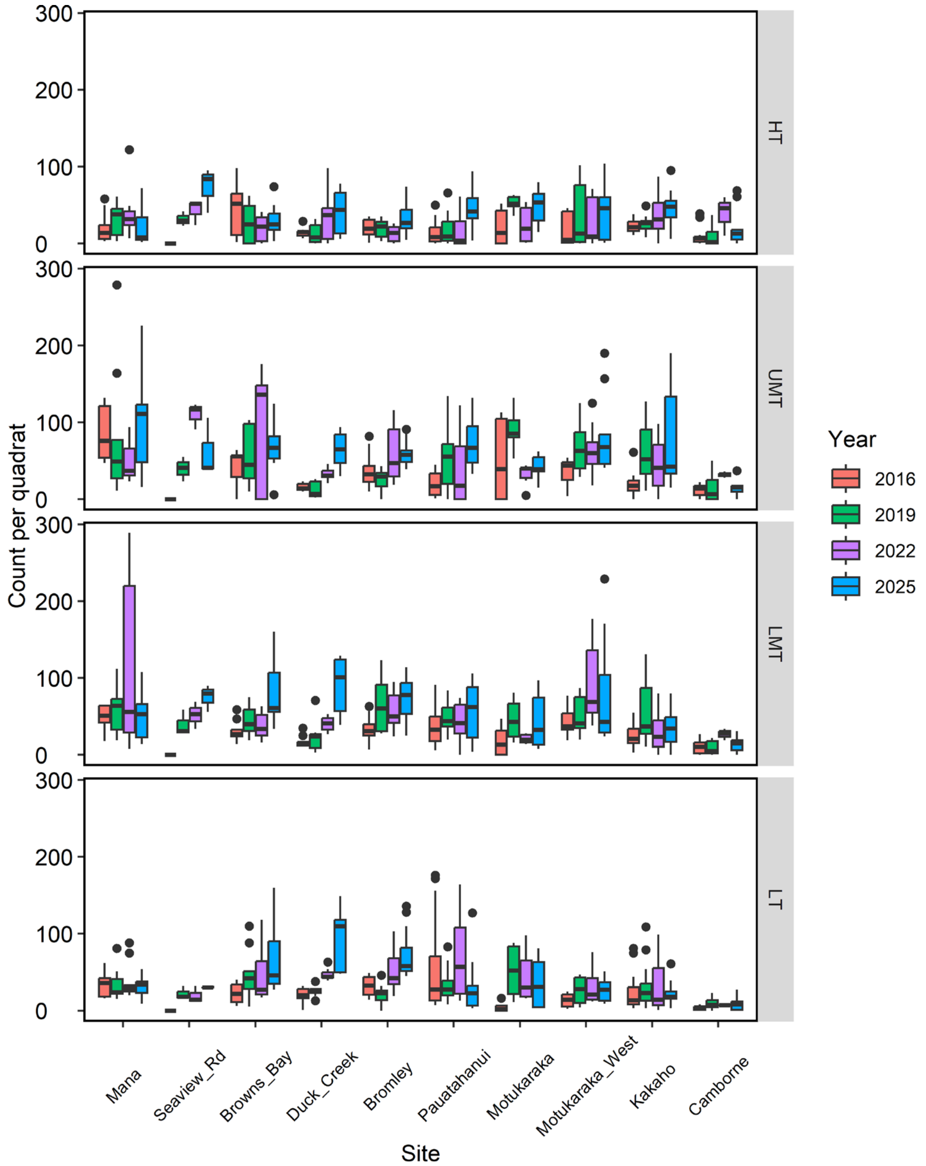

Figure 3-10: Boxplots of the median count of cockles per quadrat by tidal height and site for years 2016, 2019, 2022, and 2025. High tide (HT), upper-mid tide (UMT), lower-mid tide (LMT), and low tide (LT) zones. Boxplots show medians (solid horizontal black lines), filled boxes represent 25th to 75th percentiles, whiskers are 10th and 90th percentiles, and outliers are shown as filled black circles. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

Spatio-temporal changes in cockle densities between 1998 and 2025, by tidal height and site are given in Figure 3-11. The spatial patterns have not changed substantially through time. Cockle densities have been consistently low at all tide zones over surveys at Camborne, and high at Pāuatahanui. Cockle densities have also been lower and more consistent at the high tide zone when compared to the lower three tide levels. The highest counts from 1998 – 2025 have been recorded at the upper and lower mid tidal areas at all sites except Pāuatahanui, where counts have been consistently higher at the low and lower mid tides. Cockle densities show the greatest patchiness at low tide, particularly before 2007 (Figure 3-11).

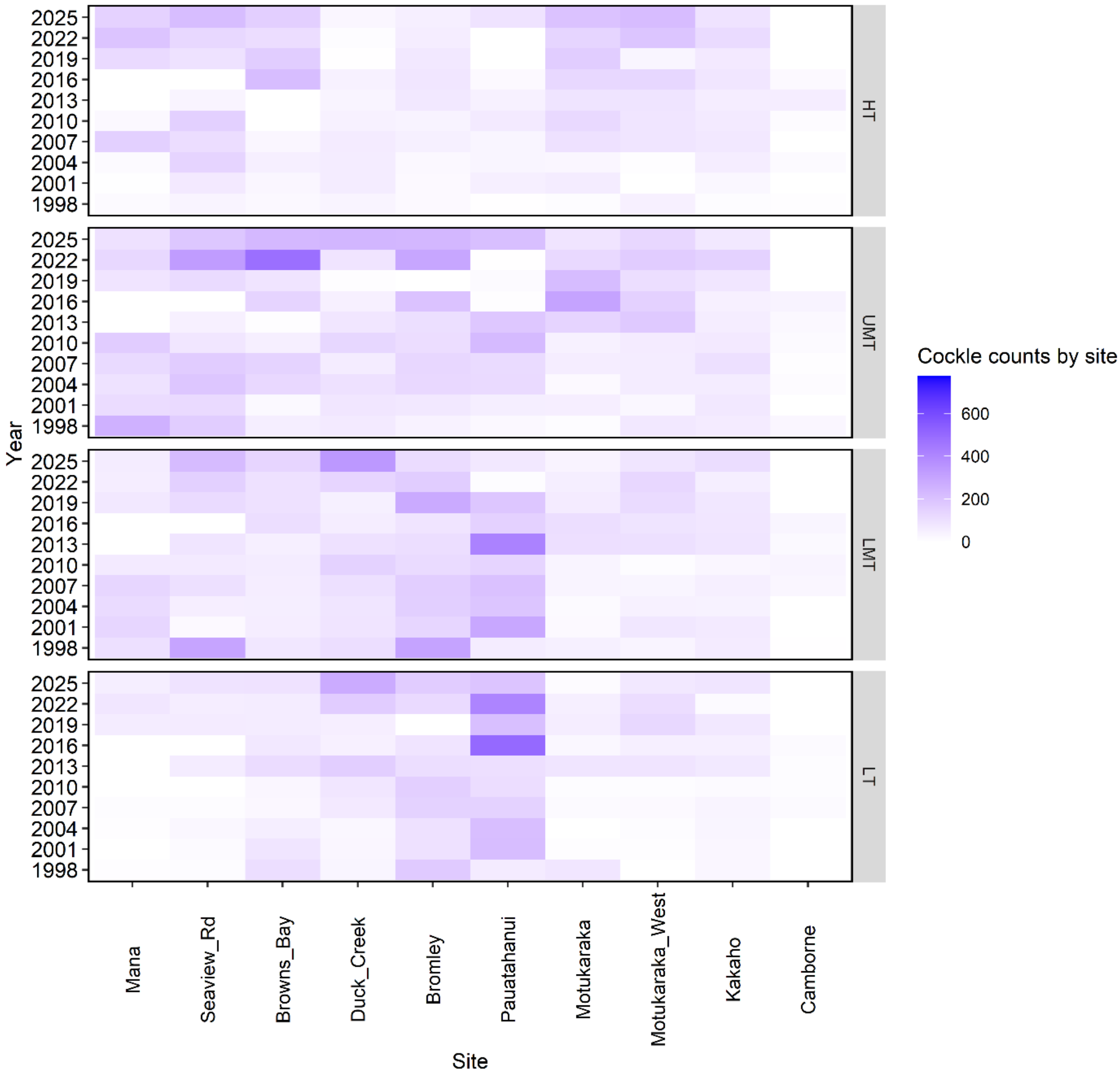

Figure 3-11: Heat map plots representing the changes in cockle counts at each site between 1998 and 2025 by tidal height. High tide (HT), upper-mid tide (UMT), lower-mid tide (LMT), and low tide (LT). Cell colour intensity is scaled to total count per site. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2022, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

3.2 Cockle size frequencies

Cockles sampled in the intertidal zone of Pāuatahanui Inlet between 2016 and 2025 ranged in length from 1 mm to 53 mm (Figure 3-12). In 2025, the largest cockle was 53 mm in length. The size percentage frequency in 2025 does show a unimodal distribution, with a high number of cockles 10 – 17 mm in length. The size distributions observed (Figure 3-12) do not show clearly separated modes of cohorts to identify the progression of different cockle settlements and age classes. Size composition (the proportions of each size group), was broadly similar in 2016 and 2019, however the last three surveys (2019, 2022, and 2025) show fewer large cockles over 20 mm in length relative to previous surveys. Histograms for all sites combined for each of the triennial surveys between 1998 and 2025 are shown in Appendix G (Figure G-1).

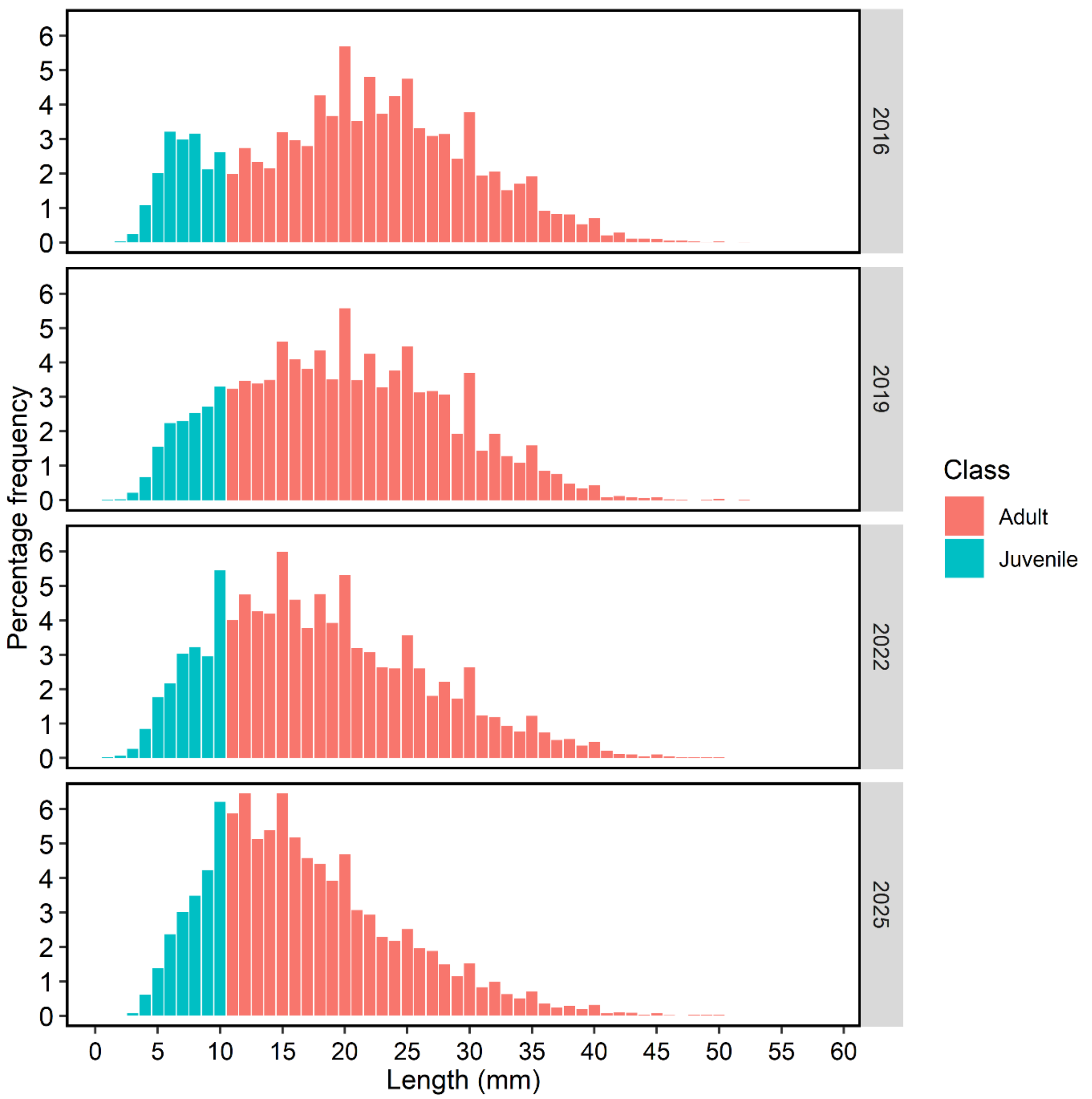

Figure 3-12: Percentage length frequencies of cockles sampled in the intertidal zone of Pāuatahanui Inlet in 2016, 2019, 2022, and 2025. Juvenile cockles classified as those 10 mm in length and smaller shown in blue and adults greater than 10 mm in length shown in red. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

The cumulative percentage length frequencies from 1998 – 2025 show changes in the proportions in the sizes of cockles that make up the cockle population for a given year (survey). The size structures of the intertidal cockle populations in Pāuatahanui Inlet show a high proportion of large cockles in 1998 and 2001, compared to later survey years. Between 2004 and 2019, cockle sizes were broadly similar, however smaller than those prior to 1998 and 2001 (Figure 3-13). In 2022, there were proportionately more smaller cockles in the population, with the cumulative percentage length frequency in 2022 showing that 80% of cockles were 25 mm or smaller in length. In 2025, there was a higher proportion of smaller cockles again seen in the population, with 81% of cockles 23 mm or smaller in length. The median cumulative size of cockles in 2022 was reported as being smaller than all previous surveys, at 18 mm. The 2025 size has returned a smaller median again, at 17 mm, the smallest median cockle size in the survey series (Figure 3-14).

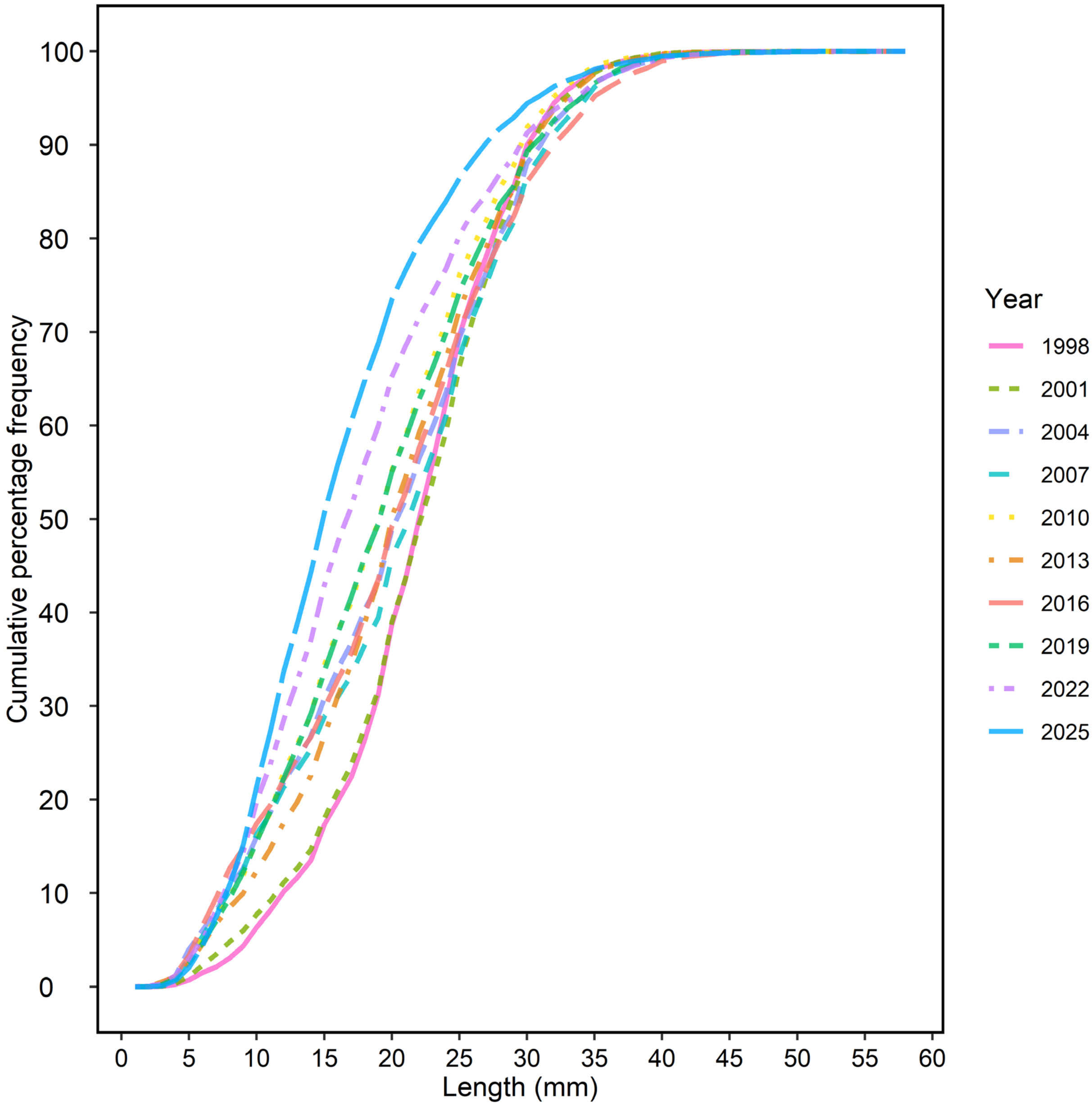

Figure 3-13: The cumulative percentage length frequencies of cockles sampled in the intertidal zone of Pāuatahanui Inlet between 1998 and 2025. 2025 is shown as a dashed blue line.

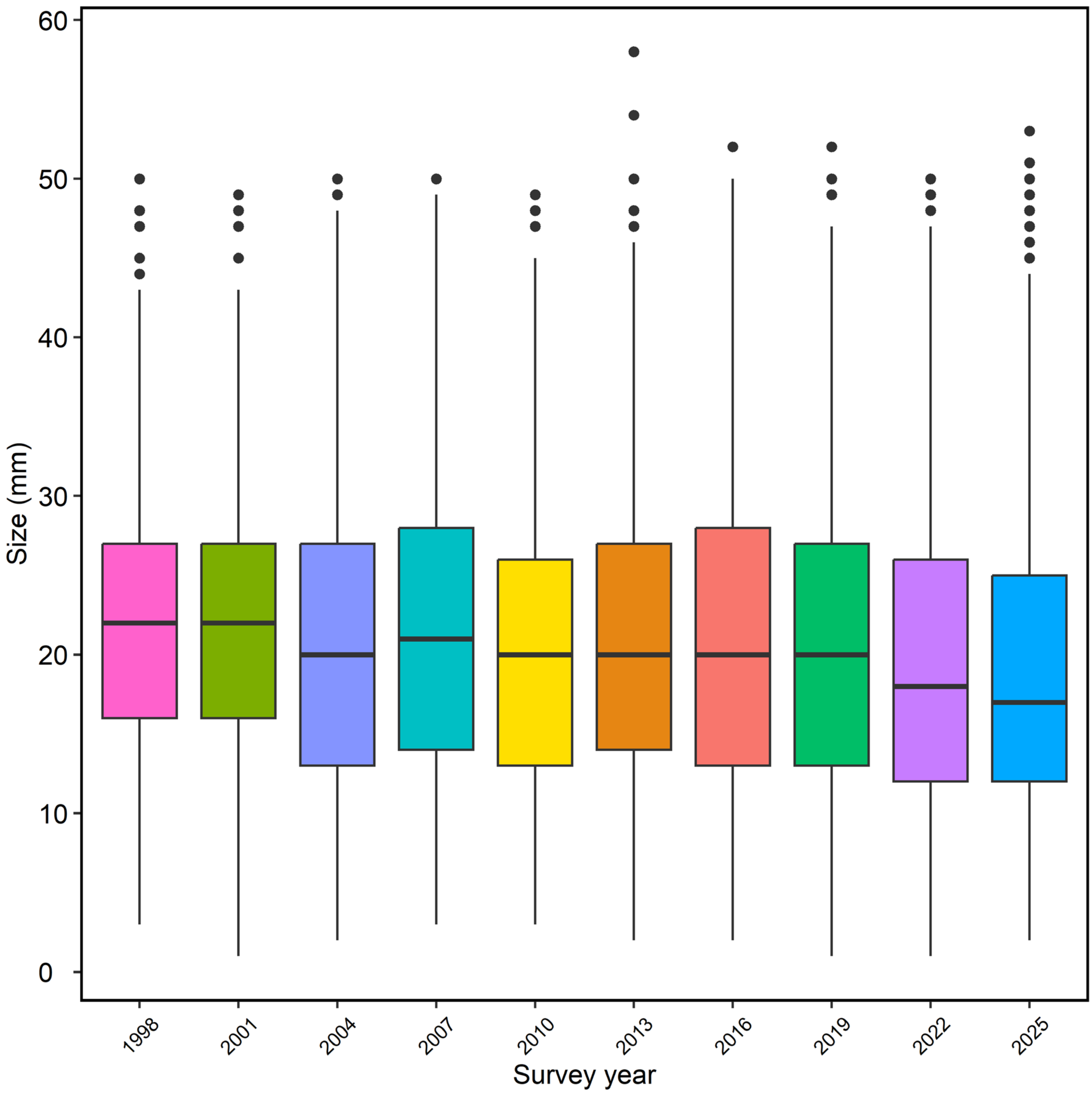

Figure 3-14: Boxplots of the sizes of cockles in Pāuatahanui by survey year 1998 – 2025. Boxplots show medians (solid horizontal black lines), filled boxes represent 25th to 75th percentiles, whiskers the 10th and 90th percentiles, and outliers are shown as filled black circles.

3.2.1 Percentage of juvenile cockles

There has been a substantial increase in the percentages of juvenile cockles in the Pāuatahanui Inlet since the 1990s, when the juvenile population percentage was <10%. There was little apparent change between the 1998 and 2001 surveys (1-7.7%). However, between 2001 and 2010, the percentage of juvenile cockles in the total population has more than doubled to 16%, then declined to 12% in 2013. There was a slight decline from 2016 – 2019 (17.4% - 15.5%), however, there has been an increase of 5.6% since 2019. The percentage of juvenile cockles in the population increased from 15.6% in 2019 to 19.8% in 2022. Since 2022, the percentage of juvenile cockles has increased again, and is now 21.4% of the cockle population of Pāuatahanui Inlet (Figure 3-15). The 2025 percentage of juvenile cockles is the highest it has been in the time series.

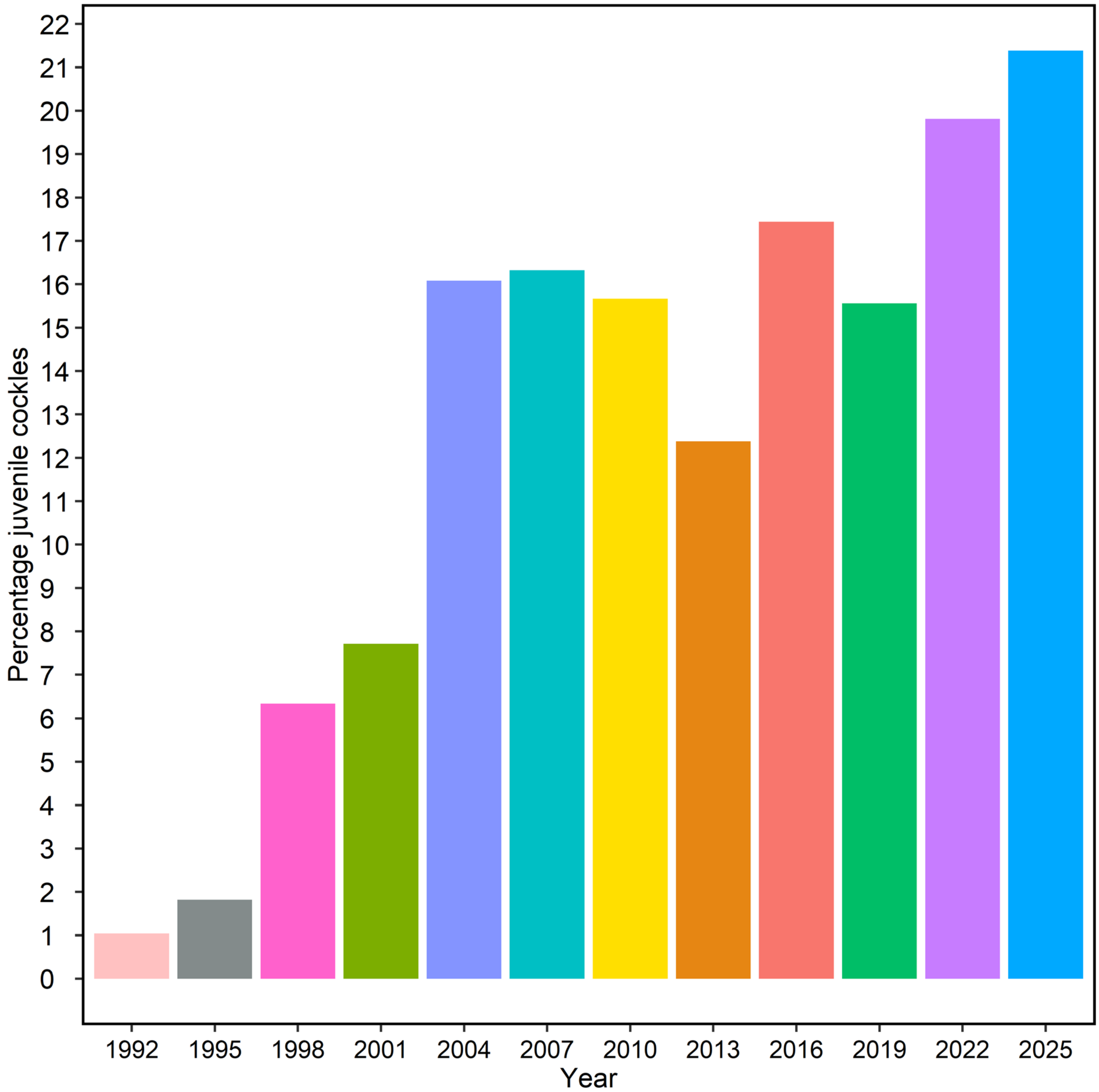

Figure 3-15: Juvenile cockles (10 mm and smaller in length) as a percentage of total cockle population, 1998 – 2025.

Figure 3-16 shows the proportion of juveniles and adults in the total number of cockles sampled at each of the 10 sites across Pāuatahanui Inlet, in 2025. Pāuatahanui had the highest percentage of juveniles, with 42% of cockles surveyed being under 10 mm. Both Duck Creek and Kakaho had about 27% juveniles, followed by Bromley which had 21%. Camborne and Mana had the lowest percentage of juvenile cockles sampled, with 6% of cockles being under 10 mm (Figure 3-16).

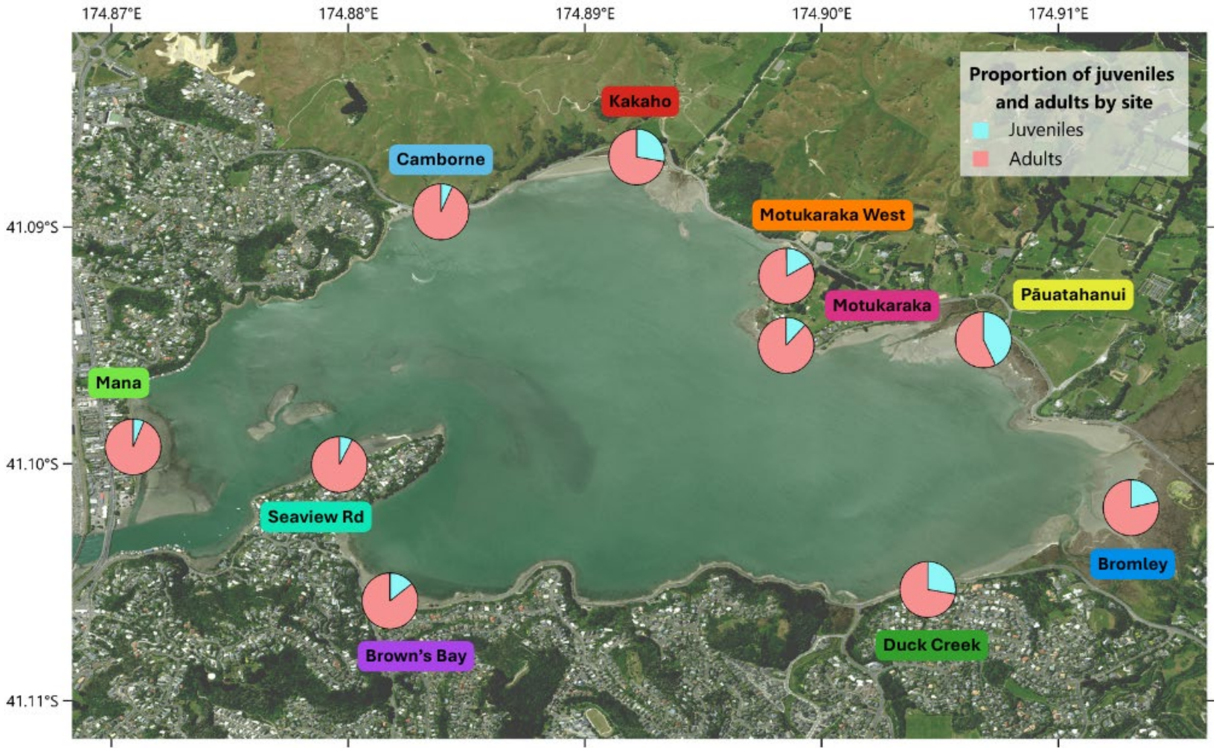

Figure 3-16: Map of Pāuatahanui Inlet showing the proportion of juveniles and adults at sites in the survey.

3.2.2 Cockle size frequencies by site

The size structure of cockles varied among sites around Pāuatahanui Inlet in 2025 (Figures 3-17 & 18). Size distributions ranged from flat (a single, broad size group with no definitive modal structure) as at Camborne and Motukaraka, to distributions with a unimodal normal distribution structure such as Bromley, Browns Bay, Duck Creek, and Seaview Road (Figure 3-17).

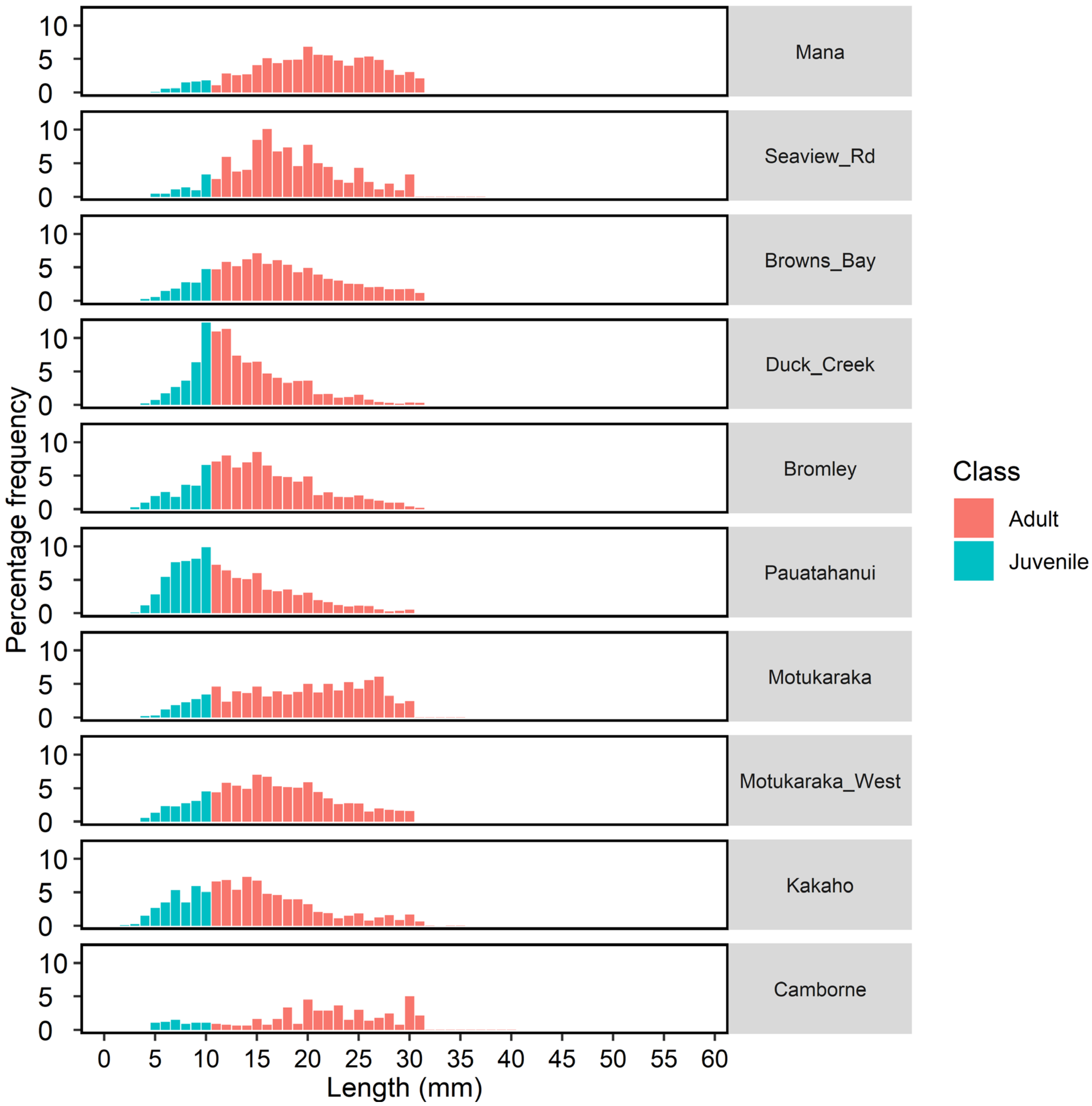

Figure 3-17: Histograms of the size (length) frequency of cockle by sites from the 2025 survey. Juvenile cockles classified as those 10 mm in length and smaller shown in blue and adults greater than 10 mm in length shown in red. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

Bromley, Browns Bay, Duck Creek, Mana, Motukaraka West, Pāuatahanui, and Seaview Road have all shown some levels of modal structure between 2019 and 2025 (Figure 3-18). In 2019, Pāuatahanui shows a high percentage of juveniles, and Camborne and Mana show higher percentages of large cockles. In 2022, Duck Creek, Kakaho, Motukaraka and Pāuatahanui show high percentages of juveniles, and Camborne, Kakaho, Mana, Motukaraka, and Seaview Road show higher percentages of large cockles. In 2025, the majority of cockles are below 30 mm, and Pāuatahanui show the highest percentage of juveniles (Figure 3–18).

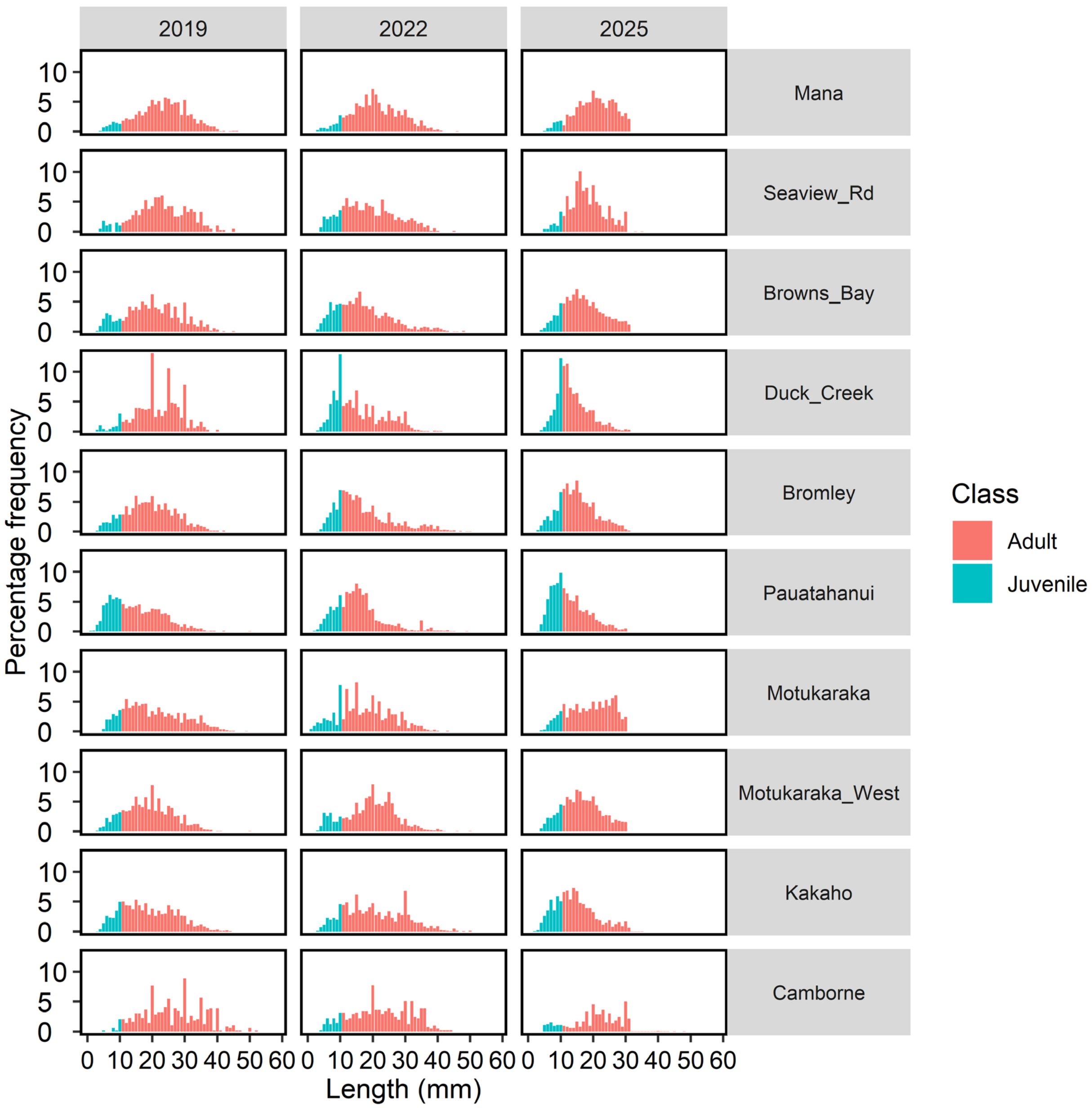

Figure 3-18: Histograms of the size (length) frequency of cockle by sites from the 2019, 2022, and 2025 surveys. Juvenile cockles classified as those 10 mm in length and smaller shown in blue and adults greater than 10 mm in length shown in red. Transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

The cumulative percentage frequency identified differences in cockle size distributions between sites in 2025 (Figure 3-19). The percentages of cockles 30 mm in length and less ranged from 47.9% at Camborne to 98.7% at Bromley. This is compared to a smaller range in 2022, with 77.7% of cockles 30 mm in length at Camborne, and 97.2% at Duck Creek. The juvenile cockles ranged from 6.3% of the population at Mana, and 42.9% of cockles at Pāuatahanui. Compared with 2022, Mana had 8.3% juvenile cockles and Duck Creek had 34%. Similarly to 2022, Camborne has a higher cumulative percentage frequency of cockle size than all other sites.

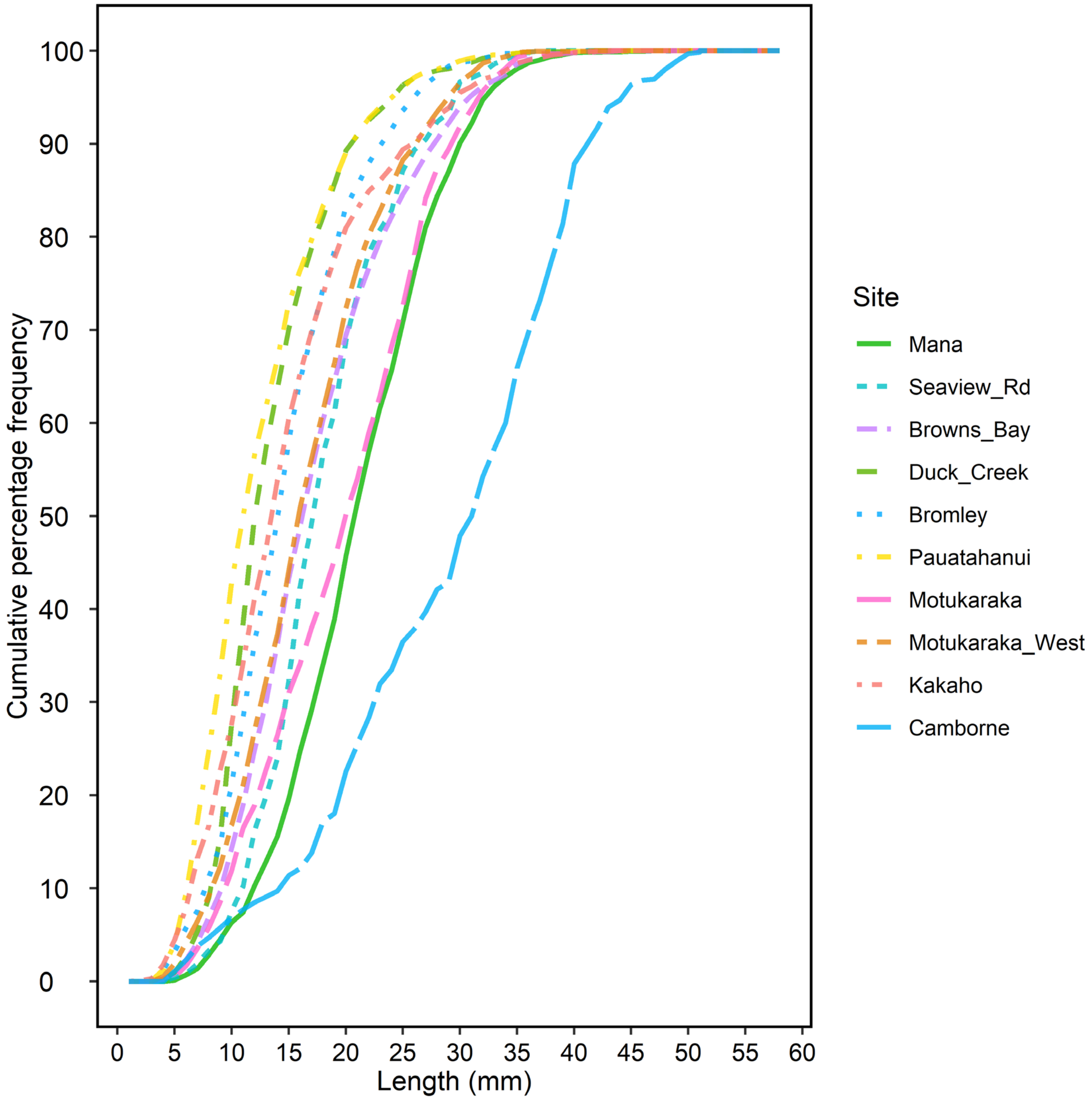

Figure 3-19: Cumulative percentage frequencies of cockle lengths by site sampled in 2025. Transects 3A (Seaview Road), 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

Cumulative percentage frequencies 1998 – 2025, by tidal height (Figure 3-20) showed increases in the proportions of larger cockles at lower tidal levels. High tide (HT) and upper mid-tide (UMT) levels contained fewer small-sized cockles in 1998 and 2001 than in later surveys and more small-sized cockles from 2016 to 2022. The size structures of cockles at lower mid-tide (LMT) were broadly similar across years, except for more small sized cockles at low tide (LT) in 2022 (Figure 3-20). In 2025, high, upper mid, and lower mid tidal heights all had a higher number of small-sized cockles than previously reported in any other survey. In the low tide zone, both 2022 and 2025 show more small-sized cockles in comparison to previous years. Across all years, the low tide zone has higher percentages of larger cockles compared with other tide zones.

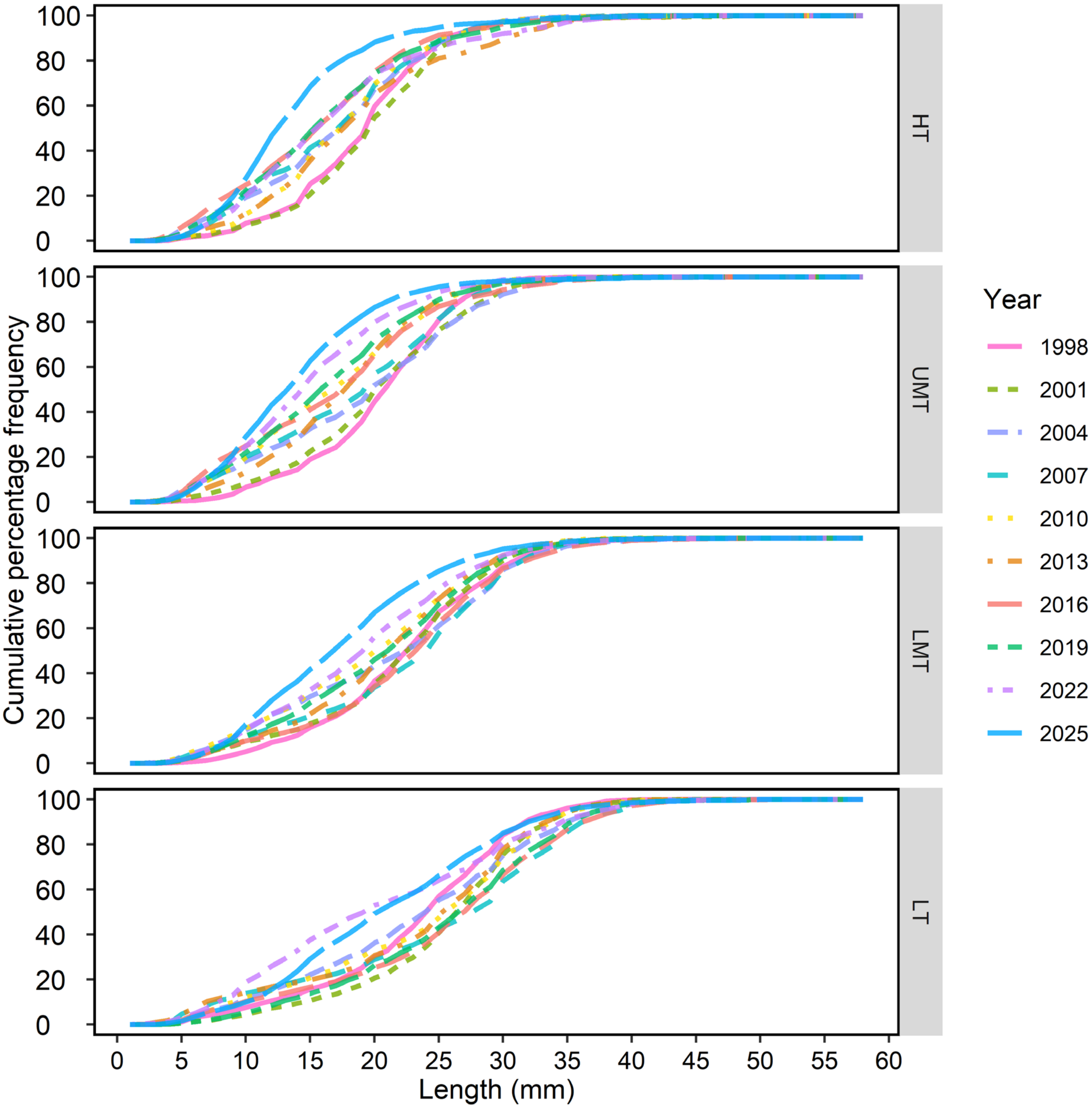

Figure 3-20: Cumulative percentage frequencies of cockle lengths by tidal height for surveys between 1998 and 2025. Transects 3A (Seaview Road) 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019, and transects 28 and 29 (Camborne) were not sampled in 2022.

4 Discussion

4.1 Survey comparability

4.1.1 Consistency of sampling and effects on data quality

Maintaining sampling methods and sampling intensities is important to determine reliable trends from time-series data. Changes in the data will therefore reflect changes in the cockle population and not differences in sampling methods and numbers of samples. The 2025 survey used the same sample locations and methods including quadrats. Sieve size in 2025 was smaller (3.7 mm mesh) than used in surveys since 1992 (3 – 5 mm). While the sieves significantly streamlined the sampling process, it is unknown what effect the 3.7 mm mesh has had on the numbers of juvenile cockles retained; however, it is unlikely to be substantial. A calibration trial is suggested before the next survey.

All transects had some follow up sampling after the survey to sample quadrats. At some transects, a particular tide level was missed and therefore sampled later, however at others one or two quadrats were all that was missing from the initial sampling attempt. As mentioned in Section 2, some Transects were unable to be paced to the estimated low tide point.

Thirty transects were sampled, with transect 30 the only transect to not be sampled in 2025. This is compared to twenty-nine transects in 2022, which did not sample transects 28 and 30, and omitted uncertain data from transect 29. In 2022, 336 of the 372 quadrats available for data analysis were included in population estimates, compared to 360 of 360 in 2025. The area sampled and number of quadrats are similar and should not introduce significant inter survey variation in the cockle population estimates. The effect of missing data from the few quadrats not sampled on estimates of population size is unknown, but unlikely to change the increasing trend in the population size.

Transect 30 has not been sampled since 2010 because of the degradation of its intertidal area due to its location next to the Camborne Jet Ski Club and, because of that, a lack of comparability to previous surveys. Only half of Transect 13 was sampled in 2019, Transects 3A (Seaview Road) and 18 (Motukaraka) were not sampled in 2016, and transects 28 and 29 (Camborne) were not sampled in 2022. These missing data are unlikely to have had a substantial effect on density estimates and comparisons; however, the relatively high spatio-temporal variation in cockle densities does not allow any effects on estimates to be determined.

The effect of misidentification of small bivalve shellfish, especially two visibly similar species (cockles and nutshells) is not quantifiable. However, this effect is thought to be small and reasonably constant from survey to survey, which is unlikely to hinder temporal comparisons. Where nutshells have been counted as cockles, these data will show higher than actual juvenile cockle densities. The analysis assumes that the recording of juvenile cockles has been consistent.

4.1.2 Survey analysis

In previous surveys, the cockle population size was estimated using the mean density estimated from each individual quadrat (0.1 m^2) as an independent (random) sample (as if from a single stratum) and scaled to the size of the intertidal area, assumed to be about 1 km^2 (Richardson et al. 1979) - Method 1.

Method 2 takes into account that cockle densities in the intertidal zone of Pāuatahanui Inlet can vary over tidal height, with the highest cockle densities at mid- and lower- tide levels, and the intertidal area should be stratified by tidal height. Because of this, the samples taken from each transect cannot be assumed to be a truly random sample from a single area of similar cockle density. It is more appropriate to average the density for each tidal height and then average all the tidal heights to get a transect mean. Moreover, as the width of the intertidal areas varies around the Inlet, transect length reflects the size of the intertidal area. Transect means therefore need to be adjusted (weighted) for these differences. Transect means are then averaged to get a mean cockle density for the whole inlet that is then scaled up to the estimated area of the intertidal zone. There are no direct measurements of transect length available and best estimates from maps are used. Both Method 1 and Method 2 show similar trends (see Figure 3–3). The population estimate in 2025 using Method 2 was 2.5% higher than that from Method 1.

Multiple, paired comparisons for differences amongst population sizes for surveys between 1998 and 2025 (see Table 3-2) used the Holm-Sidak test, as has been done in previous surveys. This test is considered to have high power to detect significant differences. The precision of survey estimates since 1998 has been high, indicated by the CVs of the population estimates being low (ranging from 0.03 – 0.06, see Table 3-1). Low CVs allow more reliable detection of differences in population size between surveys to be identified.

Whether the size of the intertidal area in Pāuatahanui Inlet has changed over the sequence of surveys, is not known. Some transect lengths have reportedly changed due to road works, and possibly the movement of intertidal sediments. Because mean cockle density is multiplied by the size of the intertidal area, any error in the estimate of the survey area will be proportionally represented in the estimate of cockle population size. All previous estimates of population size use the same estimate of the size of the intertidal area (1 km^2). This estimate differs from the size of the intertidal area of Pāuatahanui Inlet estimated from the interpolation of depth soundings from a report to the Porirua City Council (DML 2009) and from a map of the Pāuatahanui Inlet bathymetry (Irwin 1978), which suggests that the intertidal area is about 2.13 km^2. Using a larger survey area in the calculation of population size will increase the population size of cockles for each survey, but it will not change the relative trend between surveys, as the same survey area has been used in all survey analyses.

The physical low water mark will vary from survey to survey as it depends on many variables: the wind direction and strength that may hold water in the Inlet, the weather (barometric pressure), and the continual changing magnitude of the tidal flows. The higher numbers of cockles are usually sampled in the mid-tide zones (UMT and LMT). The relatively low cockle counts at low tide quadrats may reflect the difficulty in sampling this tidal zone and underestimate cockle densities there. If sampling effectiveness is the same at all tidal zones, the physical low tidal height would have more of an influence on the estimate of population size. Cockles can occur at high densities below low water. There may be a slight underestimate in the numbers of large cockles in Pāuatahanui Inlet due to the changing physical low tide mark as larger sized cockles are sampled at low water levels, and a differing low water level (between surveys) might include more or less of those large cockles, depending on where that physical low water level is for a given survey.

4.2 Trends in population estimates

4.2.1 Cockle recruitment

Larval settlement may be conspecific (Fisheries New Zealand 2024) i.e., there is greater settlement of cockle larvae in areas with higher densities of adults that are not directly related to the densities of spawning individuals (as larvae can disperse some distance in their three-week planktonic larval phase). Sites with high adult densities in 2025, as in previous surveys had high densities of juvenile cockles (see Figure 3-7). It has been observed that the presence of adult cockles increases the retention and survival of juveniles in high-density beds, with adults providing a refuge for juvenile cockles from predation by crabs (Fenton et al. 2024). These findings from Fenton et al. (2024) emphasise the importance of the presence of high densities of adult cockles, for the successful post-settlement survival and recruitment of juvenile cockles.

Recruitment in 2025 is estimated to be the number of juveniles, ≤ 10 mm long, typically by the end of the first summer after settlement. Juveniles and thereby recruitment was 21.4% of the cockles sampled (3994 juveniles of all 18676 cockles sampled). This was the highest percentage of juveniles since 1992. The population of cockles was the highest since 1992, and juvenile and adult population estimates support the idea that the increase in the percentage of juvenile cockles is likely attributed to recruitment, rather the higher mortality of adult cockles. The increasing trend in cockle densities and population size since 2001 suggest considerably significant cockle recruitment and survival of small cockles. The small decline in the percentage of juvenile cockles in 2019 is likely to be caused by the increase in fine sediments from the 2016 floods, whereas the increase in juvenile cockles between 2016 and 2025 may be in part due to overall recovery of habitat, as muds are winnowed away and redistributed within the inlet.

The proportion of juvenile cockles has ranged from 12.0% to 21.4% from 2004 to 2025. The relatively high percentage of juveniles since 2004, combined with an overall increase in the population, suggests regular recruitment and good survival of newly settled spat over their first winter. This increasing trend is unlikely to be due to high levels of misidentification in recent surveys or any change in the detection of juvenile cockles. There are many factors that may drive the recruitment strength of cockles in Pāuatahanui Inlet; some that may be associated with the health of the Inlet such as levels of fine suspended silt, some that are likely to be driven by climate, and others associated with the ecology of Pāuatahanui Inlet such as predation pressure. There are also several other unknowns:

- The proportion of the total inlet-wide population that occurs subtidally and the contribution that these subtidal cockles make to recruitment of juvenile cockles in the intertidal zone.
- While extensive movement of juvenile cockles has been documented, individuals over 25 mm in shell length tend to remain largely sessile, unless they are responding to a disturbance (Fisheries New Zealand 2024). Whether juvenile cockles are moving from the subtidal to the intertidal and vice versa, is unknown.
- The intertidal areas of the large offshore sand banks in the Western half of the Inlet have not been sampled since 1976. Whether cockles still occur in these areas is unknown, however the area of these sand banks has increased significantly in the last decade or so. Sampling these areas is not suitable for GOPI surveys, due to safety concerns for the volunteers involved in the survey.

- Cockles do not reach sexual maturity until they are about 18 mm in length (Larcombe 1971). In 2025, over half of the intertidal population (65%) was sexually mature, compared with 56% in 2022, and 39 – 46% between 2014 and 2019. These percentages indicate the potential for high larval production, a prerequisite for good recruitment.

4.2.2 Trend in cockle population size

Cockles can be a dominant species in estuaries around Aotearoa, where cockle densities are observed as being as high as 4500 per m^2 (Fisheries New Zealand 2024). The mean cockle density in Pāuatahanui Inlet in 2025 was 519 per m^2 (99% CI 477–562), higher than in 2022 (440 per m^2 99% CI 396–484), and the highest since 1992.

Population estimates from 1992 – 2025 using Method 1 and Method 2 have shown similar trends, albeit estimates from Method 1 are consistently lower than from those using Method 2 (transect counts weighted by transect length) (see Figure 3–4). With the effects of the floods and earthquake in 2016 considered, both methods show upward trends from 2004 (Table 3–1, Figure 3–4). The decline in population size between 2013 and 2016 can be attributed to the 2016 floods.

The 2025 mean population size using Method 1 is 99.2% of the 1976 estimate of 523 million cockles, which is the closest the Pāuatahanui Inlet cockle population has come to reaching this estimate. Since 2022 there has been a 26.4% increase in total number of cockles sampled. Surveys since 2016 have shown an increase in cockle numbers, however the previous 3 surveys show that there are fewer larger cockles making up the population. Also, while not significantly different, the median cockle size in 2025 was 17 mm, which is the smallest in the survey series.

Infaunal bivalves such as cockles can have reduced growth rates when populations have high densities, often due to competition for food, space, or presence of predators (Tricklebank et al. 2021). Cockle growth rates were investigated using estuarine middens, and declines in growth rates were greatest at estuaries with highly modified catchments (Tricklebank et al. 2021). It would be suspected that the highly modified Pāuatahanui Inlet and wider Te Awarua o Porirua may cause a decrease in the number of large cockles. However, analyses of juvenile and adult population estimates indicates an increase in both population sizes. While this suggests a level of resilience within the Pāuatahanui population of cockles, it also highlights the importance of continuing cockle and environmental monitoring, to identify potential future causes of decline.

Changes in the distribution of cockle densities amongst transects between 2022 and 2025 may affect estimates of population size. These changes may be driven by changes in the deposition or erosion of sediment in the Inlet. The latest sediment plate monitoring results available from Te Awarua o Porirua are for the 2023 year (Stevens and Rabel 2024). There has been an increase in the annual sedimentation rate (averaged over the 5-year period 2020 – 2024) to 1.9 mm/yr (Stevens and Rabel 2024). Between January 2023 and December 2023, sediment accretion was high near the GOPI survey sites Mana and Duck Creek (Stevens and Rabel 2024). In 2025, Duck Creek had a significant increase in cockle counts per quadrat, while Mana saw a slight increase (see Figure 3-5). Also reported was significant sediment erosion at Kakaho and Horokiri (near GOPI site Motukaraka), which is indicative of improvements at these sites, following several years of intensive rain events increasing fine sediment deposition (Stevens and Rabel 2024). The 2025 survey results show a significant increase in cockle population at Motukaraka, and a slight increase in Kakaho (see Figure 3-5). While there has been observed recovery from deposition events, the estuary quality is still considered to be declining (Stevens and Rabel 2024).

The precision of the estimates shown by the 99% confidence intervals (Figure 3-4) is expected to vary between surveys and is typical of time-series of survey data from populations with patchy distributions. The CVs are low for these surveys: 0.04 to 0.06 for Method 1, and 0.03 to 0.04 for Method 2. These low CVs are likely to reflect the large numbers of quadrats sampled (up to 372). Further, these CVs are well below the target of 0.20 set for other shellfish surveys conducted by Fisheries New Zealand. The low CVs suggest that the estimated increasing trend in population size is likely to be reliable.

4.3 Impacts on the cockle population in Pāuatahanui Inlet

As mentioned in previous reports (Michael and Wells 2017; Michael and Lyon 2020; Michael 2023), significant floods on 13th August, 16th September, and 15th November 2016 increased the fine sediment over the intertidal survey area. This was compounded by the Kaikoura earthquake on the 14th of November 2016, and several slips exacerbated runoff and sediment loads to the inlet. Extensive deposition of terrestrial mud was evident in Pāuatahanui Inlet, with widespread mud deposition quickly remobilised from the intertidal areas to the subtidal, and sediment deposition impacting the entire intertidal area (Michael 2023). The increase in the Pāuatahanui cockle population since 2016 does indicate recovery, however sediment deposition is known to negatively affect cockle densities and population sizes (Lohrer et al. 2004). The GOPI survey time series has shown this impact, emphasising the importance of continuing the surveys, to provide correlations between the health of the cockle population, and the environmental changes and events being observed around Te Awarua o Porirua.

Significant infrastructure projects in the region, such as the construction of Transmission Gully highway, and the development of Plimmerton Heights are expected to have impacted the health of the Pāuatahanui Inlet. The scale and quantities of sediment entering the harbour due to these projects are however unknown at this stage. Elevated turbidity was observed in several tributaries to the Harbour during the Transmission Gully project, following failures in sediment controls after high rainfall (sediment plate). The Pāuatahanui Inlet population of cockles indicate resilience to sedimentation, as observed after the 2016 floods. While cockles may be resilient to native sediment deposition, thicker sediment deposits is predicted to result in a higher mortality of larger sized cockles (Anderson et al. 2019). Estimates of adult population size indicate an increase in adult population cockles over time, therefore the Pāuatahanui Inlet cockles show resilience to sedimentation. However, the continuation of the monitoring of these cockles will be important to show future changes and responses to sedimentation.

4.4 Status of the cockle population in Pāuatahanui Inlet

The increase in overall population size, the percentage of juvenile cockles, and recovery from the decline between 2013 and 2016, show the population of cockles in the intertidal zone of Pāuatahanui Inlet is in an improving state. The consistent increase in the percentage of juvenile cockles suggests successful settlement of larvae and good post-settlement survival of spat. The high percentage of cockles above spawning size, combined with a steady increase of the adult population numbers, should maintain larval production in the Inlet.

Pāuatahanui Inlet, as with all other estuaries around Aotearoa, is subject to changes in environmental conditions such as increases in terrestrial sediments. These environmental changes have not caused a reduction in the intertidal cockle population of Pāuatahanui Inlet; however, this may have altered the size distribution of the Inlet. Furthermore, any interaction between intertidal and subtidal cockle populations is unknown. The increase of sedimentation in the subtidal zone and any impacts on the cockles there, or in the intertidal zone, cannot be evaluated.

5 Recommendations for future research

The Pāuatahanui Inlet Community Cockle surveys have been successfully completed triennially since 1992. There is high value in continuing the current time-series of surveys to enable changes to the cockle population and therefore likely habitat changes to be detected. Depending on the questions that are being asked, there may be value in considering additional sampling if required.

The current survey design allows spatial and temporal changes in cockle densities and cockle sizes to be determined, and how they might differ at different intertidal locations around the inlet. The time-series of survey data already suggests the deleterious effects of terrestrial sediment inputs at some locations within Pāuatahanui Inlet, and thereby the time-series of data are of high value for determining future changes.

The time series of GOPI cockle data plays an important part in the implementation of Te Awarua o Parirua. The signing of the Accord solidified a commitment to restoring the Harbour, and the GOPI surveys aid in telling the story of the health of the Pāuatahanui Inlet, and a significant taonga species. As further steps in the restoration strategy are explored, the impact of sedimentation that has been detailed over GOPI surveys can be used as evidence for accountability.

5.1 Options

The easiest way to improve the intertidal cockle survey, and to provide the greatest value to the data time-series is to ensure that all sampling of survey sites is standardised as much as possible:

1. Use the same quadrats with depth gauges, sieves, and measuring boards or rulers for every survey
2. Accurate location of sample sites, Global Positioning System positions (GPS) of each tide level on each transect would be helpful for sampling, especially for mapping, and to keep transect lengths consistent
3. Excavate the substrate accurately without "infilling" or "out filling" and to a standard depth
4. Accurate sorting of taxa and identification of small cockles from nut shells. Shell samples of cockles and nutshells should be provided to each survey team for reference
5. Accurate measurement of cockle size

This will ensure changes in the numbers and sizes of cockles reflect what is happening in the inlet. Additional recommendations include:

- Undertake a comparison of the size selectivity of the new sieves with the sieves used in previous surveys to quantify difference, and to enable an adjustment factor to be estimated.

- To estimate recent mortality of cockles by counting the numbers of cockle shells and measuring their sizes. This however would require clear shell descriptors to enable accurate identification of the shells of cockle that had died within the last year.
- To undertake cockle tagging studies for growth, mortality, and movement
- Similarly, investigating subtidal cockle populations to gain further insight into population dynamics of the entire Pāuatahanui Inlet
- Investigate the impact of changing sediment composition and rates of sedimentation in the intertidal zone have on changes in cockle density.
- It was previously suggested (Michael and Lyon 2020) that estimates of the diversity of taxa in samples should be undertaken. This has in part been covered by the fine scale monitoring programme (Forrest et al. 2020), however could be extended to give better coverage across the survey area.

6 Acknowledgements

We acknowledge the contribution Professor John Wells made to these surveys before he passed away in late 2018. John organised the triennial Cockle Population Surveys (known to the Inlet community as cockle counts) from 2004 until 2016. With help and support from his wife Marjery, John managed the planning, organisation, training and logistics, the post count follow-up analysis with NIWA, and dissemination of the findings. John's scientific skills and the careful, rigorous methodology he applied to the cockle counts meant that the surveys were accepted by the scientific and local authority communities as a reliable and valuable indicator of the health of the Inlet. Thanks to John's work in successfully managing the process over 12 years, the Inlet cockle counts have become the longest running community science project in New Zealand.

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7 References

Anderson, T., Barrett, H., Morrisey, D. (2019) Effects of sediment deposition on the New Zealand cockle, *Austrovenus stutchburyi*. *New Zealand Journal of Marine and Freshwater Research*, 53(3): 363–376.

DML (2009) *Porirua Harbour Bathymetric Survey Report – April 2009*.

Estcourt, I., Grange, K. (1976) *Biology of subtidal and intertidal zones of Pauatahanui Inle*t.

Fenton, K., Salmond, N., Foreman, S., Curtis, J., Jowett, T., Savage, C., Wing, S. (2024) High densities of large tuaki, the New Zealand cockle *Austrovenus stutchburyi*, provide a post-settlement predation refuge for conspecific juveniles. *Marine Ecology Progress Series*, 726: 85–98.

Fisheries New Zealand (2019) *Fisheries Assessment Plenary, May 2019: stock assessments and stock status*. Compiled by the Fisheries Science and Information Group. Wellington, New Zealand: Fisheries New Zealand.

Fisheries New Zealand (2024) *Fisheries Assessment Plenary, May 2024: Stock assessments and stock status*. Wellington, New Zealand: Fisheries New Zealand.

Forrest, B., Stevens, L., Rabel, H. (2020) *Fine Scale Intertidal Monitoring of Te Awarua-o-Porirua Harbour*.

Francis, R., Fu, D. (2012) *SurvCalc User Manual v1.2-2011-09-28*. Wellington, New Zealand: NIWA.

Grange, K. (1993) Distribution, abundance and population size structure of cockles (*Austrovenus stutchburyi*) in Pauatahanui Inlet. *NIWA Contract Report* 1993/1, prepared for Guardians of the Inlet, Pāutahanui.

Grange, K., Cole, R., Parker, N. (1996) Distribution, abundance and population size structure of cockles (*Austrovenus stutchburyi*) in Pauatahanui Inlet. Guardians of Pauatahanui Inlet.

Grange, K., Crocker, T. (1999) *Cockles in Pauatahanui Inlet: results of the 1998 sampling programme*. Guardians of Pāuatahanui Inlet.

Grange, K., Tovey, A. (2002) *Cockles in Pauatahanui Inlet: results of the 2001 sampling programme*. Nelson: NIWA.

Healy, W. (1980) *Pauatahanui Inlet - an environmental study*.

Horn, P., Grange, K., Cairney, D. (2005) *Cockles in Pauatahanui Inlet: results of the 2004 sampling programme*. Nelson: NIWA.

Irwin, J. (1978) *Pāuatahanui Inlet Bathymetry (1:5000)*. NZOI, New Zealand Oceanographic Institute, DSIR.

Larcombe, M. (1971) *The Ecology, Population Dynamics, and Energetics of Some Soft-Shore Molluscs*, Doctoral thesis, University of Auckland.

Lohrer, A., Thrush, S., Hewitt, J., Berkenbusch, K., Ahrens, M., Cummings, V. (2004) Terrestrially derived sediment: response of marine macrobenthic communities to thin terrigenous deposits. *Marine Ecology Progress Series*, 273: 121–138.

Lohrer, A., Thrush, S., Hewitt, J., Berkenbusch, K., Ahrens, M., Cummings, V. (2004) Terrestrially derived sediment: response of marine macrobenthic communities to thin terrigenous deposits. *Marine Ecology Progress Series*, 273:121–138.

Michael, K. (2008) *Community survey of cockles (Austrovenus stutchburyi) in Pauatahanui Inlet, Wellington, November 2007*. Guardians of Pauatahanui Inlet.

Michael, K. (2008) *Community survey of cockles (Austrovenus stutchburyi) in Pauatahanui Inlet, Wellington, November 2007*. Guardians of Pauatahanui Inlet.

Michael, K. (2011) *Community survey of cockles (Austrovenus stutchburyi) in Pauatahanui Inlet, Wellington, November 2010*. Guardians of Pauatahanui Inlet.

Michael, K. (2011) *Community survey of cockles (Austrovenus stutchburyi) in Pauatahanui Inlet, Wellington, November 2010*. Guardians of Pauatahanui Inlet.

Michael, K. (2023) *Community survey of cockles (Austrovenus stutchburyi) in Pāuatahanui Inlet, Wellington, November 2022: update of intertidal survey time series*. Guardians of Pāuatahanui Inlet.

Michael, K. (2023) *Community survey of cockles (Austrovenus stutchburyi) in Pāuatahanui Inlet, Wellington, November 2022: update of intertidal survey time series*. Guardians of Pāuatahanui Inlet.

Michael, K., Lyon, W. (2020) *Community survey of cockles (Austrovenus stutchburyi) in the intertidal zone of Pāuatahanui Inlet, Wellington, November 2019*. Guardians of Pāuatahanui Inlet.

Michael, K., Lyon, W. (2020) *Community survey of cockles (Austrovenus stutchburyi) in the intertidal zone of Pāuatahanui Inlet, Wellington, November 2019*. Guardians of Pāuatahanui Inlet.

Michael, K., Wells, J. (2014) *Community survey of cockles (Austrovenus stutchburyi) in Pauatahanui Inlet, Wellington, December 2013*. Guardians of Pauatahanui Inlet.

Michael, K., Wells, J. (2014) *Community survey of cockles (Austrovenus stutchburyi) in Pauatahanui Inlet, Wellington, December 2013*. Guardians of Pauatahanui Inlet.

Michael, K., Wells, J. (2017) *Community survey of cockles (Austrovenus stutchburyi) in Pauatahanui Inlet, Wellington, December 2016*. Guardians of Pauatahanui Inlet.

Michael, K., Wells, J. (2017) *Community survey of cockles (Austrovenus stutchburyi) in Pauatahanui Inlet, Wellington, December 2016*. Guardians of Pauatahanui Inlet.

Reihana, K., Paul-Burke, K., Ellis, J., Bulmer, R., Burke, J., O'Brien, T., Bluett, C. (2025) Ko Ōhiwa e (our Ōhiwa), how weaving knowleges is shaping marine research in Ōhiwa Harbour. *Journal of Ocean Technology*, 20(4).

Reihana, K., Paul-Burke, K., Ellis, J., Bulmer, R., Burke, J., O'Brien, T., Bluett, C. (2025) Ko Ōhiwa e (our Ōhiwa), how weaving knowleges is shaping marine research in Ōhiwa Harbour. *Journal of Ocean Technology*, 20(4).

Richardson, J., Aldridge, A., Main, W. (1979) Distribution of the New Zealand cockle, Chione stutchburyi, at Pāuatahanui Inlet. *NZOI Oceanographic Field Report*, 14: 10.

Richardson, J., Aldridge, A., Main, W. (1979) Distribution of the New Zealand cockle, Chione stutchburyi, at Pāuatahanui Inlet. *NZOI Oceanographic Field Report,* 14: 10.

Stevens, L., Rabel, H. (2024) *Te Awarua-o-Porirua Harbour Sediment Plate Monitoring 2023/2024*. prepared for Greater Wellington Regional Council, July 2024.

Stevens, L., Rabel, H. (2024) *Te Awarua-o-Porirua Harbour Sediment Plate Monitoring 2023/2024*. prepared for Greater Wellington Regional Council, July 2024.

Te Rūnanga o Toa Rangatira (2025) *Te Wai Ora o Parirua Porirua Harbour Accord*.

Te Rūnanga o Toa Rangatira (2025) *Te Wai Ora o Parirua Porirua Harbour Accord*.

Todd, M., Kettles, H., Graeme, C., Sawyer, J., McEwan, A., Adams, L. (2016) *Estuarine Systems in the Lower North Island, Te Ika-a-Māui: Ranking of Significance, Current Status and Future Management Options*. Department of Conservation.

Todd, M., Kettles, H., Graeme, C., Sawyer, J., McEwan, A., Adams, L. (2016) *Estuarine Systems in the Lower North Island, Te Ika-a-Māui: Ranking of Significance, Current Status and Future Management Options*. Department of Conservation.

Tricklebank, K., Grace, R., Pilditch, C. (2021) Decadal population dynamics of an intertidal bivalve (Austrovenus stutchburyi) bed: pre-and post-a mass mortality event. *New Zealand journal of marine and freshwater research*, 55(2): 352–374.

Tricklebank, K., Grace, R., Pilditch, C. (2021) Decadal population dynamics of an intertidal bivalve (Austrovenus stutchburyi) bed: pre-and post-a mass mortality event. *New Zealand journal of marine and freshwater research*, 55(2): 352–374.

Appendix A 2025 Sampling instructions hand-out

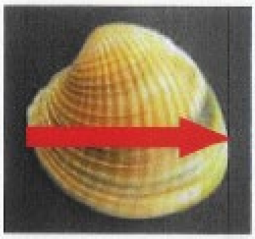
Cockle **First recognise your cockle!** **Nut Shell**

<u>Cockle shells (large and small) have a distinctive pattern of ridges and a prominent recurved 'beak'</u>

<u>Nut Shells are much smaller than adult cockles and have a smooth shell.</u>

<u>They can be mistaken for small juvenile cockles</u>

INSTRUCTIONS FOR DIGGING, MEASURING, TALLYING



Length (anterior-posterior axis)

- Assign one person as <u>recorder</u>. Recorder must try to keep hands dry and clean.
- The transect is sampled by 3 quadrats at 4 tidal levels (see your transect sheet)
- Your first task is to mark the High Tide sample site with a stake.
- Then mark each of the other sites by pacing them out according to the site information at the top.
- Begin sampling at the Low Tide site, if it is exposed, and work up the beach to High tide site. **If LT site is not exposed begin sampling at the Lower Mid Tide site, and sample the LT site if and when you can. T**
- At each site quadrat B should be on the transect line and A and C be about 5 paces to the right and left of the line.
- For each quadrat:
  - Drop the quadrat frame randomly (don't <u>choose</u> good places).
  - Dig out the mud and animals inside the frame to a depth of about 7 cm and place in your sieve. Take care not to excavate an area larger or smaller than the quadrat.
  - The best way to sieve is to lower it into water and jig it up and down.
  - Pick out stones and empty shells to make it easier to find live cockles.
  - Take out each live cockle and put it into an ice cream carton.
  - **Be careful not to count nut shells as small cockles — see photos above.**
  - Measure length (see illustration above) of each cockle to the nearest mm. and call the measurement to the recorder.
  - Recorder puts a single tally dash (/) for each cockle beside the correct mm size. Tallies are marked in groups of 5 like this: "//// //" = 7

Appendix B 2025 transect data sheet

Pāuatahanui Inlet Cockle Survey

Transect number 1

Mana beach; access by lane beside 34 Mana Esplanade.	Turn left and walk to a large taupata bush, a clump of Agapanthus and the second blue rubbish bin about 65 paces north of access lane.
Aim transect towards → **(see photo on back of this sheet)**	Kakaho Stream mouth.
Number of **ADULT** paces from —	
location marker to **high tide** site	**20**
high tide site to **upper mid tide** site	**70**
upper mid tide site to **lower mid tide** site	**70**
lower mid tide site to **low tide** site	**80-90**
Estimated time of low tide	**2:45pm**

Lat & Long Decimal **-41.098517,174.87085**

INSTRUCTIONS

- Use pink topped stakes to mark position of each sampling site.
- **Begin sampling at the Low Tide site, if it is exposed, and work up beach to High Tide site. If LT site is not exposed begin sampling at the Lower Mid Tide site, and sample the LT site if and when you can.**
- Do not attempt to sample if standing water at the site is deeper than about 3 cm.
- If sampling area is covered by stones or large green seaweed, lift off gently before digging.
- Follow instructions for sieving out, measuring and recording cockles.
- **Take care not to confuse nutshells and cockles (see photos).**
- Write any comments about this transect at the bottom or on back of this sheet.
- When finished check you have all your gear – especially the quadrat.
- Return all equipment and this sheet to Stout Cottage.

Thank you for your help. We hope you enjoy your day.


Kakaho Stream
Graye's Road
Camborne Walkway
Motukaraka Point
Horokiri Stream
Mana beach
3A
Seaview Road
Brown's Bay
Duck Creek
Pauatahanui Stream
1
2
3
4
5
6
7
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9
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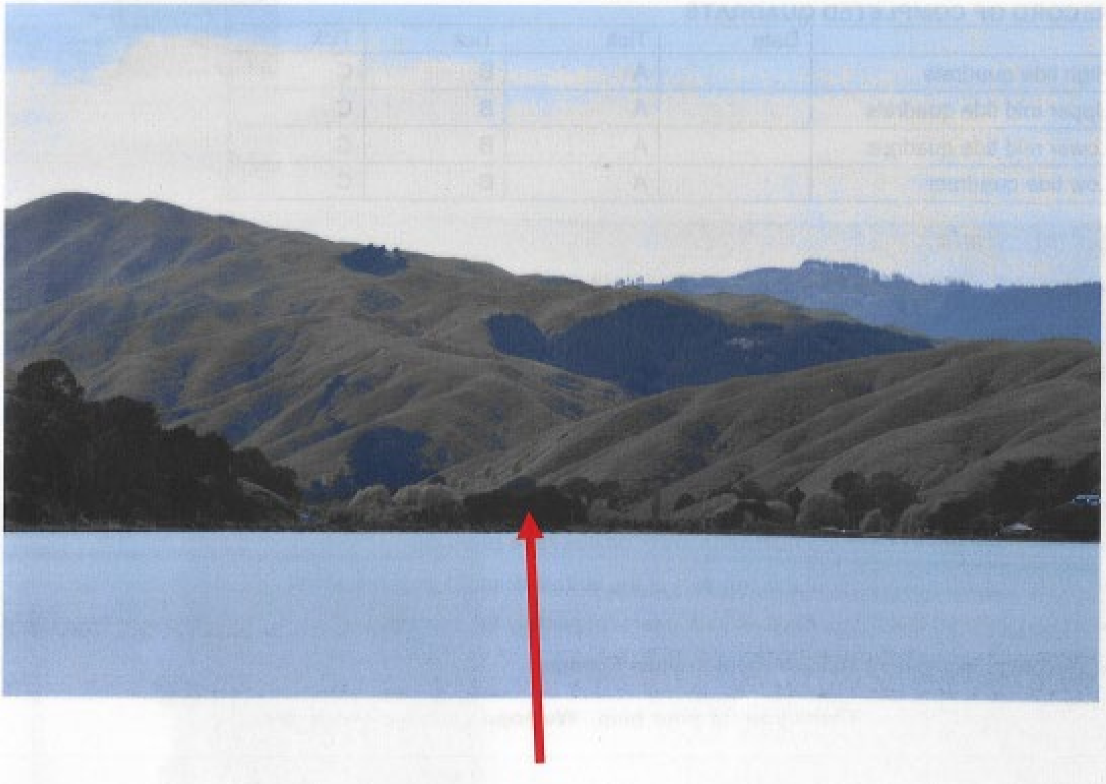

Appendix C 2025 team leader check list

GOPI cockle survey

Checklist for Team Leaders

Before you meet and brief your team --

1. **Read and understand the Sampling Instructions sheet – especially the order in which to do the sampling stations.**
2. **Read and understand the Health & Safety guidelines on safety issues.**
3. **Check that you have the correct gear for your allotted transect.**
4. **Check that you have a spade**
5. **Check that you have your transect book.**
6. **Check that you are fully familiar with the transect location and direction.**
7. **Check that you are fully familiar with any instructions on car parking and access to the shore – this is a health and safety issue.**

Before you head off with your team --

- **Check that your team know where to park and how to get there safely (instructions are on transect sheet). If possible, use one vehicle only as parking space may be limited.**
- **Make sure that your team understands the Health & Safety guidelines.**

Appendix D 2025 survey tally sheet

Transect No.		**Name**	

2025	Pauatahanui inlet cockle tally sheet

Tide location (circle one)	**Low-tide**	**Lower mid-tide**	**Upper mid-tide**	**High-tide**

Use Tally marks (~~////~~ //)

Contact

Size (mm)	Quadrat A	Size (mm)	Quadrat B	Size (mm)	Quadrat C
1		1		1	
2		2		2	
3		3		3	
4		4		4	
5		5		5	
6		6		6	
7		7		7	
8		8		8	
9		9		9	
10		10		10	
11		11		11	
12		12		12	
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14		14		14	
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41		41		41	
42		42		42	
43		43		43	
44		44		44	
45		45		45	
46		46		46	
47		47		47	
48		48		48	
49		49		49	
50		50		50	

Notes

Appendix E 2025 Pāuatahanui Inlet cockle count transect location details

No.	Locality	Start marker description	Start Lat/long	Start NZ-map grid	Aim towards	Paces to high tide site	Paces from high tide to upper mid tide site	Paces from upper to lower mid tide site	Paces from lower mid tide to low tide site
1	Mana	**Mana beach; access by lane beside 34 Mana Esplanade.** Turn left and walk to a large taupata bush, a clump of Agapanthus and the second blue rubbish bin about 65 paces north of access lane.	S:41 05 911 E:174 52 252	E2667 131 N6010 344	Kakaho Stream mouth	20	70	70	80-90
2	Mana	**Mana beach; access by lane beside 34 Mana Esplanade.** Just south of the access road – on the beach in front of two large Pohutukawa's with a swing.	S:41 05 955 E:174 52 258	E2667 135 N6010 250	Southern edge of Motukaraka Point	30	65	65	65-75
3	Mana	**Mana beach car park just over Paremata Bridge.** Walk north along the wall from the toilet block to the end of the sloping wooden retaining wall.	S:41 06 258 E:174 52 295	E2667 151 N6010 090	2 storey house with 2 green roofs at beach level on Golden Gate.	30	100	100	100-120
3A	Mana (Golden Gate) (Seaview Road)	**Park at Ivey Bay car park. CROSS ROAD VIA UNDERPASS TO KINDERGARTEN.** Walk east to front west corner of boatshed with ramp by house number 37A.	S:41 06 082 E:174 52 423	E2667 777 N6010 093	Most easterly boatshed on Camborne walkway	0	13	13	13-20
4	Browns Bay	**Browns Bay.** Access from Browns Bay parking lot. Follow the path west & enter beach at end of seawall (by roundabout). Walk ~25 paces north of large storm drain, just before 50 sign to half buried pole, large brown house opposite.	S:41 06 320 E:174 28 41	E2667 847 N6009 562	Houses at Motukaraka Point	10	40	40	40-50
5	Browns Bay	**Browns Bay.** Access from Browns Bay parking area. Foot of western set of steps down to beach.	S:41 06 344 E:174 52 910	E2668 038 N6009 515	Kakaho Stream mouth	22	38	38	38-45
6	Browns Bay	**Browns Bay.** Access from Browns Bay parking area. Foot of western set of steps down to beach.	S:41 06 347 E:174 52 947	E2668 099 N6009 502	Moorhouse Point (end of Golden Gate peninsula)	30	27	27	27-35
7	Duck Creek	**Park in space by water side traffic lane of SH 58, about 100 metres east of James Cook Drive. Approach via Joseph Banks Drive route and not from the Pāuatahanui roundabout side. Take extreme care when parking and when exiting your vehicle.** Walk westward along beach to concrete sea wall about 50 metres *east* of junction of James Cook Drive and SH 58, opposite the third lamp post on SH58.	S:41 06340 E:174 54 123	E2669 738 N6009 474	Large white gabled house at Motukaraka Point.	15	25	25	30-35

No.	Locality	Start marker description	Start Lat/long	Start NZ-map grid	Aim towards	Paces to high tide site	Paces from high tide to upper mid tide site	Paces from upper to lower mid tide site	Paces from lower mid tide to low tide site
8	Duck Creek	**Park in space by water side traffic lane of SH 58, about 100 metres east of James Cook Drive. Approach via Joseph Banks Drive route (see map).** Walk eastward along beach **(do not walk alongside road)** to rip rap rock sea wall below twin palm trees.	S:41 06 304 E:174 54 240	E2669 908 N6009 535	Large white gabled house at Motukaraka Point.	25	33	33	30-40
9	Duck Creek	**Park in space by water side traffic lane of SH 58, about 100 metres east of James Cook Drive. Approach via Joseph Banks Drive route (see map).** Walk eastward along beach **(do not walk alongside road)** to 2 water culverts in rip rap rock sea wall below entrance of house number 374 (with 2 red brick pillars).	S: 41 06 294 E: 174 54 341	E2670 045 N6009 571	Prominent white house in trees.	20	55	55	55-65
10	Bromley	**Park in space by water side traffic lane of SH 58, about 100 metres east of James Cook Drive. Approach via Joseph Banks Drive route (see map).** Walk eastward along beach **(do not walk alongside road)** to Wildlife Reserve sign on SH58 and sign for non-powered vessels (B&W post).	S:41 06 274 E:174 54 442	E2670 193 N6009 602	Aim for the gap in the trees to the left of the white gabled house at Motukaraka Point.	48	60	60	70-85
11	Bromley	**Park in space by waterside traffic lane of SH 58, about 100 metres east of James Cook Drive. Approach via Joseph Banks Drive route (see map).** Walk eastward along beach **(do not walk alongside road)** to Wildlife Reserve sign and on to just before stream mouth (~300 paces). Marker lines up with RHS of white house in background. (Large tree stump?)	S:41 06 227 E:174 54 543	E2670 322 N6009 702	Camborne water tower and radio masts.	25	60	60	60-70
12	Pāuatahanui Wildlife Reserve	Pāuatahanui Wildlife Reserve (Closer from Grays Road Park than from Stout Cottage). Walk through Reserve to Thorpe Hide. From seat on corner, at pink stake, head west out to the shore following the stream. From stake at #13 walk about 90 paces south to tree stump.	S: 41 06 129 E: 174 54 463	E2670 654 N6009884	Moorhouse Point.	20	150	150	150-160
13	Pāuatahanui Wildlife Reserve	Pāuatahanui Wildlife Reserve (Closer from Grays Road Park than from Stout Cottage). Walk through Reserve to Thorpe Hide. From seat on corner, at pink stake, head west out to the shore following the stream. Stake immediately to left of entry point to beach.	S: 41 06 104 E: 174 54 468	E2670 674 N6009 976	Camborne water tower and radio masts.	20	150	150	150-170

No.	Locality	Start marker description	Start Lat/long	Start NZ-map grid	Aim towards	Paces to high tide site	Paces from high tide to upper mid tide site	Paces from upper to lower mid tide site	Paces from lower mid tide to low tide site
14	Pāuatahanui (Ration Point)	**Park either side of Horokiri bridge (sign "Horokiri Estuary Restoration Project") and walk eastward along pathway to Ration Point.** Enter shore at this point. Turn right and go to pink stake numbered 14 (about 70 paces).	S:41 05 814 E:174 54 539	E2670 339 N6010 440	Yellow cliffs at mouth of Duck Creek. Right of large white house on the cliff.	10	30	30	30-40
15	Pāuatahanui (Ration Point)	**Park either side of Horokiri bridge (sign "Horokiri Estuary Restoration Project") and walk eastward along pathway to Ration Point.** Enter shore at this point. Turn right and go to pink stake numbered 15 (about 220 paces from beach entry point). **Keep to edge of shell banks where you can to avoid mud patches. Take care crossing the drainage channel just past pink stake 14. It may be necessary to go down the stream to a shallow part.**	S:41 05 755 E:174 54 475	E2670 251 N6010 555	Yellow cliffs at mouth of Duck Creek. Right of large white house on the cliff.	10	35	40	50-60
16	Pāuatahanui (Horokiri Stream)	**Park either side of Horokiri bridge (sign "Horokiri Estuary Restoration Project") and walk back to Ration Point.** Enter shore at this point. Turn right and go past location markers for stations 14 and 15 to pink stake numbered 16 (about 400 paces from beach entry point). **Keep to edge of shell banks where you can to avoid mud patches. Take care crossing the drainage channel just past pink stake 14. It may be necessary to go down the stream to a shallow part.**	S:41 05 690 E:174 54 400	E2670 166 N6010 673	Yellow cliffs at mouth of Duck Creek. Right of large white house on the cliff.	20	50	50	50-60
17	Motukaraka (Horokiri Stream)	**Park either side of Horokiri bridge and walk eastward along pathway to Ration.** Enter shore at this point. Turn right and walk along the shell banks on the upper shore (Past #14, 15, 16), **DO NOT WALK LANDWARD OF SHELL BANK AS THE MUD IS DEEP** until you almost reach the Horokiri Stream. Between Black & white house (LHS of black house).	S:41 05 673 E:174 54 287	E2669 993 N6010 712	Yellow cliffs at mouth of Duck Creek. Right of large white house on the cliff.	15	40	40	40-50
18	Motukaraka Point	Motukaraka Pt: Park near vehicle turnaround area at the east end of Motukaraka Point. On beach below and about 10 paces east of blue seat under a very large tree at vehicle turn around area.	S:41 05 655 E:174 54 113	E2669 745 N6010 742	Yellow cliff amongst bush west of Duck Creek (note: do not mistake this for a much larger yellow cliff east of Duck Creek).	20	80	80	80-90

No.	Locality	Start marker description	Start Lat/long	Start NZ-map grid	Aim towards	Paces to high tide site	Paces from high tide to upper mid tide site	Paces from upper to lower mid tide site	Paces from lower mid tide to low tide site
19	Motukaraka Point	Motukaraka Point. Park by information board at the point. Enter beach at this point & walk east along the beach about 50m to the remnants of a brick & stone fireplace beneath a small cliff.	S:41 05 705 E:174 53 941	E2669 505 N6010 669	Bradey Bay (bush filled gully below east end of Mercury Hill).	10	20	20	20-30
20	Motukaraka Point	Motukaraka Point. Park by information board at the point. Find house #7; pink stake at edge of planting when looking toward Camborne boat sheds marks an indistinct track to shell bank and stake #20.	S:41 05 631 E:174 53 850	E2669 389 N6010 805	Moorhouse Point (tip of Golden Gate peninsula).	20	25	25	25-30
21	Motukaraka Point	**Motukaraka Point. Park at car park by public toilets.** Find culvert outlet from grass bank in front of toilet block.	S:41 05 519 E:174 53 911	E2669 479 N6011 003	Camborne.	15	35	35	30-40
22	Motukaraka Point	**Motukaraka Point. Park at car park by public toilets.** Follow walkway west to find easy access to shell bank about 50m beyond entrance to “Barrowside” & yellow/ black 55 chevron sign. Stake in front of small Ngaio on shell bank.	S:41 05 442 E:174 53 922	E2669 493 N6011 145	Moorhouse Point (tip of Golden Gate peninsula).	15	15	15	15-25
23	Kakaho	**Park at Kakaho Bridge.** Follow walkway east and enter beach at start of rock wall. Follow wall about 50m to drain opposite #283 Grays Rd.	S:41 05 315 E:174 53 705	E266 9207 N6011 392	Paremata Bridge. **Note**: this transect crosses the two Kakaho stream outfalls. Find a shallow place to cross them. **Adjust sample sites to miss it.**	10	80	80	70
24	Kakaho	**Park at Kakaho bridge alongside construction site. NOTE: when leaving do not attempt to turn car right to go back to Pāuatahanui. It is safer to go on to the Wellington Jet Sport Club at the end of Camborne walkway and turn in the car park there.** Follow walkway west and jump down (carefully) where there’s easy access to shell bank. Cross small stream and follow shell bank till directly in line with road up hill.	S: 41 05 240 E: 174 53 586	E2669 027 N6009 540	Browns Bay.	20	80	80	80-90

No.	Locality	Start marker description	Start Lat/long	Start NZ-map grid	Aim towards	Paces to high tide site	Paces from high tide to upper mid tide site	Paces from upper to lower mid tide site	Paces from lower mid tide to low tide site
25	Kakaho	**Park at Kakaho bridge. Note: it may be safer to go on to Camborne walkway car park to turn around when returning to reserve.** Follow walkway west and jump down (carefully) where there's easy access to shell bank. Cross small stream and follow shell bank. Take a transit of seat on walkway with garage of blue house, a small ditch running out from the walkway ~130 paces beyond stake #24.	S: 41 05 233 E: 174 53 493	E2668 896 N6011 565	Prominent hill (Mercury Hill) in foreground just east of Browns Bay.	25	70	80	80-90
26	Kakaho (Camborne)	**Park at Wellington Jet Sport Club at north end of Camborne walkway.** Follow walkway east to memorial cross. From there ~220 paces to end of fence and blue drain marker opposite. (There is a gate at end of fence, now overgrown). Marker at drain.	S: 41 05 254 E: 174 53 327	E2668 664 N6011 535	Bradey Bay.	15	50	50	50-60
27	Camborne	**Park at Wellington Jet Sport Club at north end of Camborne walkway.** Walk east along Grays Road walkway to a memorial cross by a large drain.	S: 41 05 324 E: 174 53 172	E 2668 450 N 6011 397	Bradey Bay.	30	25	25	25-30
28	Camborne	**Park at Wellington Jet Sport Club at north end of Camborne walkway.** Walk east along Grays Road walkway to black/ white striped poles. About 100 paces beyond poles there is the remaining top step of a former set of steps to beach set into the wall from road, about 15 paces beyond a blue drain marker opposite.	S: 41 05 349 E: 174 53 097	E 2668 342 N 6011 345	Prominent hill (Mercury Hill) in foreground just east of Browns Bay.	10	8	8	8-15
29	Camborne	**Park at Wellington Jet Sport Club at north end of Camborne walkway.** Walk east along Grays Road walkway to black/white striped pole. Descend to the beach very carefully across the boulders.	S: 41 05 361 E: 174 53 037	E2668 255 N6011 331	Prominent hill (Mercury Hill) in foreground just east of Browns Bay.	10	10	10	10-20

Appendix F The number of cockles sampled from each of the three quadrants (A-C)

The numbers of cockles sampled from each of the three quadrats (A-C), tidal heights (HT, high tide; UMT, upper mid-tide; LMT, lower mid-tide; and LT, low tide) by class (juveniles 10 mm or smaller and adults larger than 10 mm in length) during the 2025 GOPI intertidal survey of Pāuatahanui Inlet. “-“ denotes not sampled in 2025.

Transect	Site	Class	HT	HT	HT	HT	LMT	LMT	LMT	LM	LT	LT	LT	LT	UMT	UMT	UMT	UM	Tota
1	Mana	Juvenile	0	0	0	0	2	1	0	3	0	5	0	5	7	2	4	13	21
1	Mana	Adult	2	2	8	12	106	95	66	267	43	18	31	92	76	119	107	302	673
2	Mana	Juvenile	0	0	0	0	2	4	1	7	1	0	2	3	8	46	14	68	78
2	Mana	Adult	10	5	7	22	51	60	22	133	34	38	52	12	115	180	150	445	724
3	Mana	Juvenile	2	3	1	6	1	2	0	3	0	0	2	2	1	3	4	8	19
3	Mana	Adult	70	38	33	14	26	12	21	59	34	9	11	54	15	31	44	90	344
3A	Seaview Rd	Juvenile	6	8	2	16	5	1	6	12	1	0	3	4	8	3	12	23	55
3A	Seaview Rd	Adult	78	87	38	20	75	55	84	214	29	30	29	88	33	36	94	163	668
4	Browns Bay	Juvenile	7	3	8	18	10	7	19	36	22	7	11	40	2	2	8	12	106
4	Browns Bay	Adult	18	16	31	65	97	153	121	371	138	114	79	33	4	122	57	183	950
5	Browns Bay	Juvenile	0	8	0	8	12	21	5	38	2	3	8	13	34	24	20	78	137
5	Browns Bay	Adult	6	10	3	19	49	52	51	152	72	32	38	14	48	29	27	104	417
6	Browns Bay	Juvenile	13	8	15	36	2	4	2	8	4	4	4	12	4	4	13	21	77
6	Browns Bay	Adult	61	26	35	12	55	43	32	130	34	23	25	82	63	63	87	213	547
7	Duck Creek	Juvenile	5	8	8	21	3	5	3	11	10	12	17	39	7	2	2	11	82
7	Duck Creek	Adult	73	58	68	19	36	41	54	131	38	55	32	12	40	32	28	100	555
8	Duck Creek	Juvenile	7	10	10	27	67	42	29	138	19	16	9	44	34	49	37	120	329
8	Duck Creek	Adult	37	36	17	90	57	83	45	185	110	100	140	35	25	25	49	99	724
9	Duck Creek	Juvenile	1	0	0	1	37	33	51	121	11	4	7	22	68	37	56	161	305
9	Duck Creek	Adult	10	6	13	29	64	82	78	224	107	46	103	25	26	28	28	82	591
10	Bromley	Juvenile	47	37	27	11	20	7	15	42	1	2	0	3	22	22	20	64	220
10	Bromley	Adult	27	21	26	74	52	69	33	154	49	55	72	17	33	33	41	107	511
11	Bromley	Juvenile	1	6	2	9	27	19	19	65	2	9	11	22	8	13	13	34	130
11	Bromley	Adult	4	35	18	57	75	70	95	240	126	127	99	35	43	55	26	124	773

Transect	Site	Class	HT	HT	HT	HT	LMT	LMT	LMT	LM	LT	LT	LT	LT	UMT	UMT	UMT	UM	Tota
12	Bromley	Juvenile	2	3	8	13	22	19	7	48	5	7	8	20	18	29	25	72	153
12	Bromley	Adult	25	24	20	69	84	61	84	229	40	51	38	12	23	32	15	70	497
13	Bromley	Juvenile	3	0	4	7	0	1	4	5	18	8	15	41	15	17	21	53	106
13	Bromley	Adult	17	7	21	45	25	54	32	111	34	50	45	12	47	68	70	185	470
14	Pāuatahanui	Juvenile	47	12	6	65	8	15	13	36	0	0	0	0	43	8	4	55	156
14	Pāuatahanui	Adult	20	24	36	80	79	77	60	216	4	7	3	14	74	35	45	154	464
15	Pāuatahanui	Juvenile	11	14	2	27	10	2	5	17	0	1	2	3	41	22	17	80	127
15	Pāuatahanui	Adult	12	29	2	43	17	19	18	54	23	20	26	69	22	11	21	54	220
16	Pāuatahanui	Juvenile	68	33	33	13	42	54	52	148	6	10	4	20	84	73	105	262	564
16	Pāuatahanui	Adult	26	26	26	78	38	52	50	140	16	13	41	70	9	27	27	63	351
17	Pāuatahanui	Juvenile	28	13	4	45	0	6	2	8	0	2	3	5	57	30	63	150	208
17	Pāuatahanui	Adult	14	25	9	48	4	46	19	69	5	61	124	19	14	21	27	62	369
18	Motukaraka	Juvenile	9	6	38	53	0	1	0	1	0	0	0	0	7	25	3	35	89
18	Motukaraka	Adult	13	9	16	38	84	45	97	226	65	81	57	20	53	37	36	126	593
19	Motukaraka	Juvenile	7	8	5	20	3	0	1	4	0	0	0	0	2	5	2	9	33
19	Motukaraka	Adult	46	60	75	18	16	8	10	34	4	4	5	13	13	34	33	80	308
20	Motukaraka West	Juvenile	0	0	0	0	27	45	49	121	9	5	0	14	2	15	50	67	202
20	Motukaraka West	Adult	1	3	5	9	77	126	180	383	22	44	51	11	71	175	107	353	862
21	Motukaraka West	Juvenile	14	10	15	39	0	0	0	0	0	0	0	0	6	3	11	20	59
21	Motukaraka West	Adult	32	35	60	12	27	54	43	124	11	16	9	36	78	46	57	181	468
22	Motukaraka West	Juvenile	19	17	13	49	6	7	6	19	0	2	0	2	11	8	4	23	93
22	Motukaraka West	Adult	85	40	47	17	23	17	27	67	27	35	13	75	33	33	42	108	422
23	Kakaho	Juvenile	9	25	40	74	0	0	0	0	11	1	18	30	31	55	69	155	259
23	Kakaho	Adult	60	35	55	15	1	0	5	6	7	2	43	52	142	135	96	373	581
24	Kakaho	Juvenile	0	17	23	40	8	1	4	13	0	0	0	0	31	64	9	104	157
24	Kakaho	Adult	6	23	16	45	45	79	44	168	11	11	18	40	50	59	27	136	389
25	Kakaho	Juvenile	25	29	35	89	2	0	1	3	11	13	8	32	7	4	9	20	144
25	Kakaho	Adult	25	21	11	57	37	32	20	89	12	6	10	28	24	43	29	96	270
26	Kakaho	Juvenile	4	4	7	15	3	1	0	4	2	1	1	4	10	4	3	17	40

Transect	Site	Class	HT	HT	HT	HT	LMT	LMT	LMT	LM	LT	LT	LT	LT	UMT	UMT	UMT	UM	Tota
26	Kakaho	Adult	14	50	13	77	50	22	37	109	37	30	16	83	24	21	12	57	326
27	Camborne	Juvenile	1	2	10	13	2	2	4	8	2	0	1	3	2	1	0	3	27
27	Camborne	Adult	12	67	51	13	17	28	27	72	7	7	9	23	15	36	16	67	292
28	Camborne	Juvenile	2	3	0	5	2	1	2	5	0	0	0	0	0	2	0	2	12
28	Camborne	Adult	9	15	18	42	17	17	15	49	5	1	12	18	19	15	13	47	156
29	Camborne	Juvenile	1	0	0	1	1	0	1	2	2	1	0	3	0	0	0	0	6
29	Camborne	Adult	15	7	13	35	7	13	10	30	25	18	12	55	15	13	19	47	167
30	Camborne	Juvenile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	Camborne	Adult	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix G Histograms of the size (length) frequency of cockles for all sites for triennial surveys 1998 – 2025

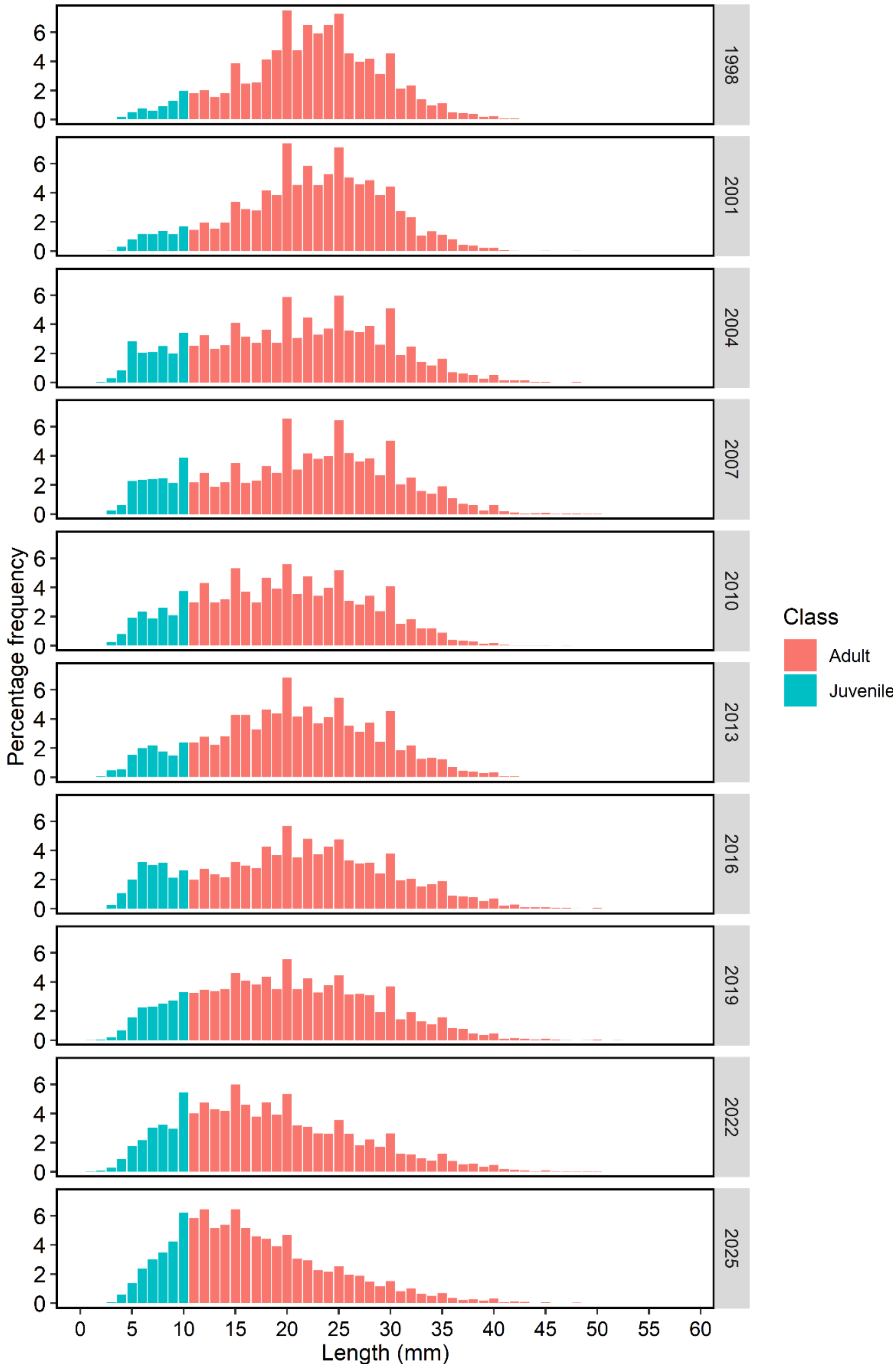

Figure G-1: Histograms of the size (length) frequency of cockles for all sites for triennial surveys 1998 - 2025. Juvenile cockles classified as those 10 mm in length and smaller shown in blue and adults greater than 10 mm in length shown in red. Transects 3A (Seaview Road) and 18 (Motukaraka) were not sampled in 2016, transect 30 (Camborne) was not sampled between 2013 and 2025, only half of Transect 13 sampled in 2019**,** and transects 28 and 29 (Camborne) were not sampled in 2022.