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Paua (*Haliotis* iris) length at maturity in PAU 3 and PAU 5A

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EXECUTIVE SUMMARY

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Length at maturity data are used in paua stock assessments to estimate spawning stock biomass. Collecting these data from a range of sites within a Quota Management Area (QMA) will improve these estimates. Length at maturity was estimated at five sites in PAU 3 and from four sites in PAU 5A. Examination of gonads indicated that visual assessment of maturity was adequate. In subsamples examined, all males and females assessed as mature had mature sperm or eggs, respectively.

Length at maturity varied slightly between sites within both QMAs, but the lengths at which 50% and 95% of samples were mature were generally about 90 mm and 100 mm, respectively. The shell length, width, height, and ratio of length to height were examined to see if they are useful predictors of length at maturity. Shell width explained slightly more of the variance in maturity, but not much more than length. Length to height ratios varied between about 3.2 and 3.7. Variation in length at maturity and length-height ratios appear to follow a similar pattern by area, except for the Paparoa and Scenery Nook sites in PAU 3.

1. INTRODUCTION

Length at maturity data are used as an input into the length-based Bayesian stock assessment model to help in the estimation of spawning stock biomass. To date, the proportion mature estimates within the model have been based on data collected from only a few sites around New Zealand and concerns have been raised about whether or not this limited pool of data accurately represents the variation in length at maturity throughout the paua fishery. The purpose of this project was to estimate the length at maturity at a number of sites within specific QMAs and estimate the level of variation in length at maturity both within and between QMAs. It is envisaged that the more extensive pool of data will help reduce uncertainty with the model and will help inform decisions on finer spatial scale assessments and management.

The relationship between shell length, width, and height was also examined to determine whether the shell length to height ratio may be a useful predictor of length at maturity or the likely maximum size within a population.

2. METHODS

Specific Objective One:
To determine length at maturity in PAU 3, and PAU 5A and the spatial variation of length at maturity throughout each QMA.

The QMAs chosen for this research were PAU 3 and PAU 5A. These were chosen after discussion with the Paua Industry Council Ltd. (PICL) and the relevant Paua Management Action Committees (PauaMacs). After discussion with the relevant PauaMac, six sites were chosen in PAU 3 and five sites were chosen in PAU 5A. One site in PAU 5A was unable to be sampled. The locations of sites are shown in Figures 1 to 3, and site coordinates are listed in Table 1. The seasonal timing of sampling was usually between December and April, but one site (Green Islets) was sampled in early August (Table 1).

Size-at-maturity was determined for the ten sites over both QMAs. At each site sampled, a minimum of 100 paua between 50 mm and 110 mm shell length were collected and assigned to 2 mm size classes. As far as possible, these paua were evenly selected over this size range. All shells were tagged through their outer respiratory pores with numbered Hallprint cable tie tags (T2175A tags) so that maturity data could be easily cross referenced with the morphometric variables assessed in the second objective. Sexual maturation was determined by visual inspection of the testis or ovary. Paua in each size class were scored as: 0, immature (no visible signs of gametes); just mature (some gametes visible but gut tissue visible through the gonad, recorded as just male, JM, or just female, JF); and 1, mature (no gut tissue visible through the gonad, recorded as either male, M, or female, F). For estimating size-at-maturity, gonads scored as ‘just mature’ were considered immature because they are unlikely to make a significant contribution to gamete production (Poore 1973; Sainsbury 1982; Wilson & Schiel 1995, Naylor et al. 2006). Rates of maturity–at–length were determined by fitting these data to the logistic equation:

$$p = \frac{e^{a+bl}}{l + e^{a+bl}}$$

where p is the proportion mature, l is shell length, and a and b are parameters of the logistic function. The 95% confidence intervals of the ogive fit were estimated as 1.96 times the calculated standard error of the mean for each value.

A subsample of five male and five female paua gonads was also examined microscopically to determine whether visual examination of the gonad effectively enabled the determination of length at maturity. Maturity was defined as the length at which mature gametes are discernable (Wilson & Schiel 1995, Poore 1973).

In the female subsample, a 2 mm^3 sample of gonad was dissected from just behind the point where the ventral horn comes off the conical appendage (Webber & Giese 1969). The sample was teased out in water and examined under a binocular microscope. Mature eggs were determined by their round shape and their size (about 250 microns, Poore 1973, McCardle 1984). The number of mature eggs in the sample was counted if few eggs were present, or estimated (as 100s or 1000s) if a large number of eggs were present.

With the male gonads, a small section of gonad was taken from the same region and smeared onto a microscope slide before examination of the slide at high magnification (× 1200, see Figure 9). There are four broad categories of gametes associated with spermatogenesis in abalone, spermatogonia, spermatocytes, spermatids, and spermatozoa (Singhakaew et al. 2003). These have been categorised into 13 or 14 stages, and in some species, spermatozoa have been classified as immature and mature (Singhakaew et al. 2003). The early developmental stages other than spermatozoa are all apparently round or oval in shape, and immature stages of spermatozoa appear to have a short and developing tail (Singhakaew et al. 2003). Numbers of sperm were recorded as "none", "few", or "lots", as maturity was ascribed on the basis of whether or not mature gametes were present, rather than the numbers present. The determination of whether or not the sperm observed were mature was based on the length of the head and flagellum (given in McCardle 1984).

Specific Objective Two:

Determine the correlation between various shell morphometric markers (e.g. height, length, width) and length at maturity.

At each of the sites sampled for objective 1, the shells of the 100 paua over the available size range were measured to determine their height, length, width, and weight. The length and width of each shell was measured to the nearest millimetre with vernier calipers. Shell height was measured to the nearest millimetre with modified vernier calipers, similar to the device described by Newman (1968), which measures the distance between the ventral plane and the highest point of the shell. Shell overhang, where it occurs, was also measured to the nearest mm with vernier callipers. Shells were also weighed to the nearest 0.1 gm and ratios of length to height were calculated.

For each site, a length at maturity relationship was fitted, and the length at 50% maturity (L_{50}) and 95% maturity (L_{95}) was calculated, along with the associated uncertainty. Regressions of these 10 maturity estimates with the shell height, width, length, and their ratios were used to determine if any overall relationship existed.

Measures of shell length, width, weight, and height and their ratios are all correlated with each other, so individual multiple logistic regressions of each variable as a covariate in the length at maturity model were used to determine which measures of size had the strongest relationship with maturity. Data regressed also included those from sites sampled in PAU 2, PAU 5B, PAU 5D, and PAU 7 as part of MPI project PAU 2012-01.

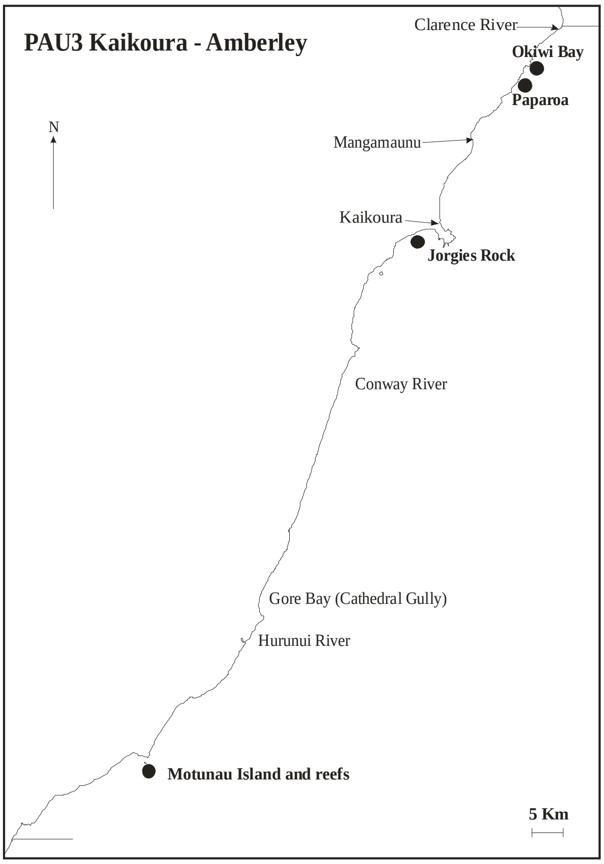

Figure 1: Location of sample collection sites in northern PAU 3 (black dots).

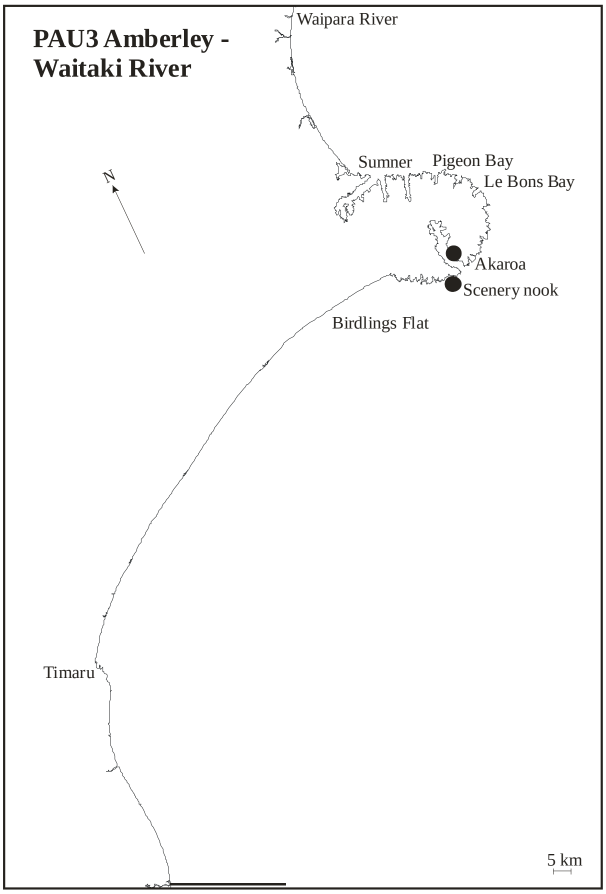

Figure 2: Location of sample collection sites in southern PAU 3 (black dots).

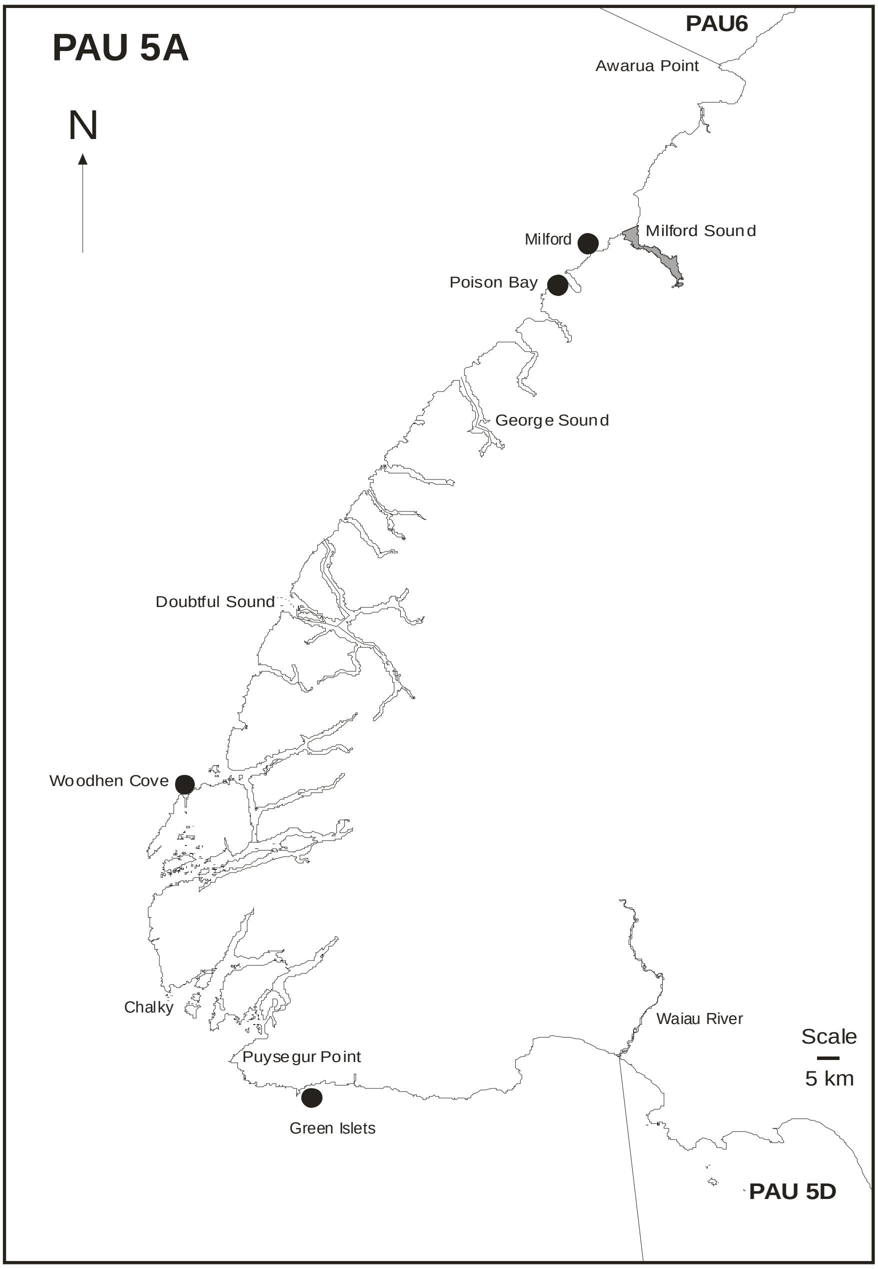

Figure 3: Location of sample collection sites in PAU 5A (black dots).

3. RESULTS

Specific Objective One:

Length at maturity in PAU 3 and PAU 5A

Site coordinates, dates of sampling, lengths at maturity, and sample size are shown in Table 1. Shell lengths at 50% and 95% maturity for sites are shown in Figures 4 and 5 for PAU 3 and PAU 5A respectively, and also in Table 1. For clarity, the numbers of samples at length are shown in Appendix 1. One site between George Sound and Dagg sound (zones F11 to F22) remains to be sampled and maturity data from this site will be added to MPI's *dive* database once the site has been sampled. A total of 1779 paua were assessed for maturity over all sites.

In PAU 3, length at 50% maturity varied only very slightly between 88.7 – 90.7 mm for Jorgies Rock, Motunau, inside Akaroa, and Scenery Nook (Figure 4). At Okiwi Bay and Paparoa, length at 50% maturity was 82.3 and 79.2 mm respectively (Figure 4). Length at maturity at Okiwi Bay was not well described by the sample (Figure 4). This was noted at a previous meeting of the Shellfish Working Group, and NIWA were asked if more data could be collected from that site. The NIWA dive team subsequently attempted to re-sample paua at Okiwi Bay, but because of the wind direction at the time they were not able to, so instead sampled a site about 300 m to the south of Okiwi Bay (Paparoa). Length at maturity for Okiwi Bay and Paparoa combined are shown in Figure 5. L_{50} and L_{95} for these sites separately and combined were similarly about 80 mm and 90 mm respectively (Figures 4 and 5). L_{95} for Jorgies Rock, Motunau, and Scenery Nook was about 100 mm, and was about 95 mm at the Akaroa site (Figure 4).

Table 1. Date of sampling, lengths at maturity, sample size, and coordinates of sites sampled in PAU 3 and PAU 5A.

QMA	Date	Site	L_{50} (mm)	L_{95} (mm)	n	Latitude	Longitude
PAU 3	26/4/2012	Okiwi Bay	82.3	88.8	114	-42.223	173.857
PAU 3	12/4/2013	Paparoa	79.2	89.6	101	-42.228	173.854
PAU 3	26/4/2012	Jorgie's Rock	88.7	98.5	106	-42.442	173.587
PAU 3	15/3/2012	Motunau Island	90.7	99.3	117	-43.064	173.080
PAU 3	8/12/2012	Akaroa	89.1	94.8	120	-43.856	172.942
PAU 3	8/12/2012	Scenery Nook	89.0	101.0	103	-43.898	172.925
PAU 5A	9/2/2012	Milford	91.4	100.4	124	-44.578	167.771
PAU 5A	9/2/2012	Poison Bay	93.8	104.5	120	-44.662	167.625
PAU 5A	18/2/2016	Woodhen Cove	92.7	108.3	111	-45.631	166.552
PAU 5A	4/8/2012	Green Islets	97.0	97.1	63	-46.223	166.785

In PAU 5A, L_{50} was 91.3 mm, 93.8 mm, 97.0 mm and 92.7 mm at Milford, Poison Bay, and Green Islets respectively. L_{95} was 100.4 mm, 104.5 mm, 97.1 mm and 108.3 mm for the same sites respectively (Table 1). At the Green Islets site the transition between immature and mature appeared to be rapid, however, the transition was poorly described (Figure 6). In general, the lengths at maturity appeared to be similar within both QMAs, apart from the Okiwi Bay and Paparoa sites in PAU 3, where L_{50} and L_{95} were both about 10 mm lower than at all other sites (Table 1).

Length at maturity by QMA for males and females is shown in Figure 7. In PAU 5A, L_{50} and L_{95} were very similar for both sexes, about 91 mm and 103 mm respectively for males, and about 93 mm and 101 mm respectively for females. In PAU 3, L_{50} and L_{95} were about 87 mm and 98 mm respectively for males, and about 80 mm and 96 mm respectively for females, however, there was less certainty surrounding the female estimates in PAU 3 (i.e. there were no data at the bottom of the curve, Figure 7). Lengths at 50% maturity for all sites are shown in Figure 8 where Paparoa appears to be significantly lower than all other sites except Okiwi Bay.

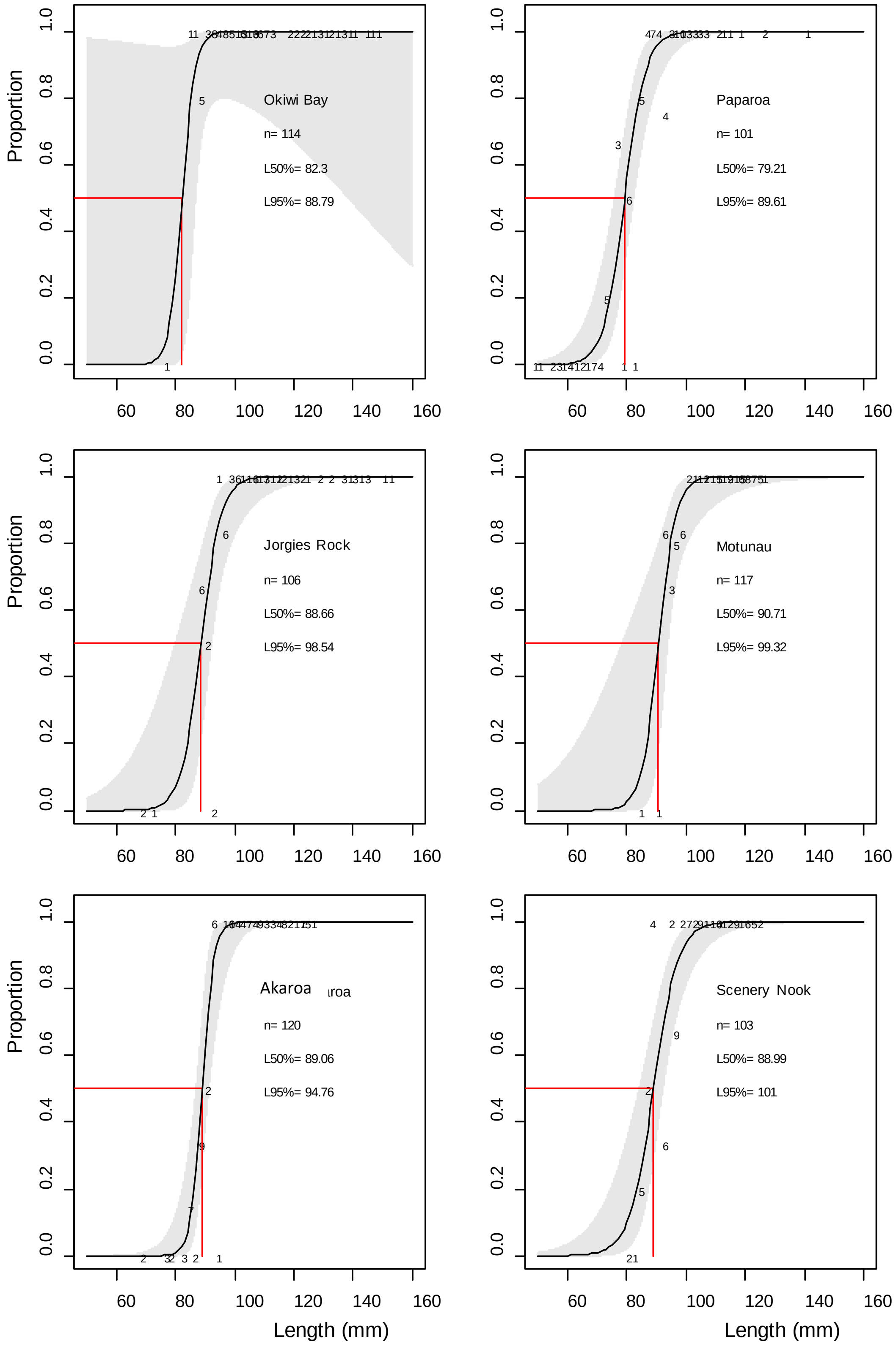

Figure 4: Proportion mature at length and fitted logistic curves for sites sampled in PAU 3. Numbers adjacent to ogives are the number of samples at that length.

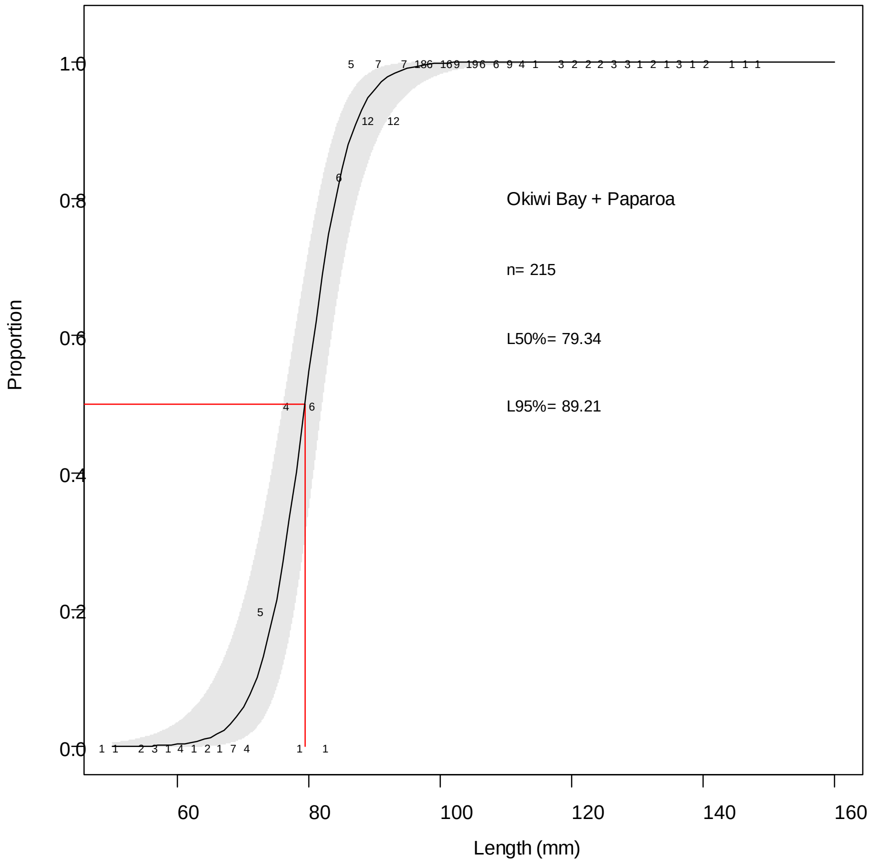

Figure 5: Length at 50% and 95% maturity at Okiwi Bay and Paparoa combined.

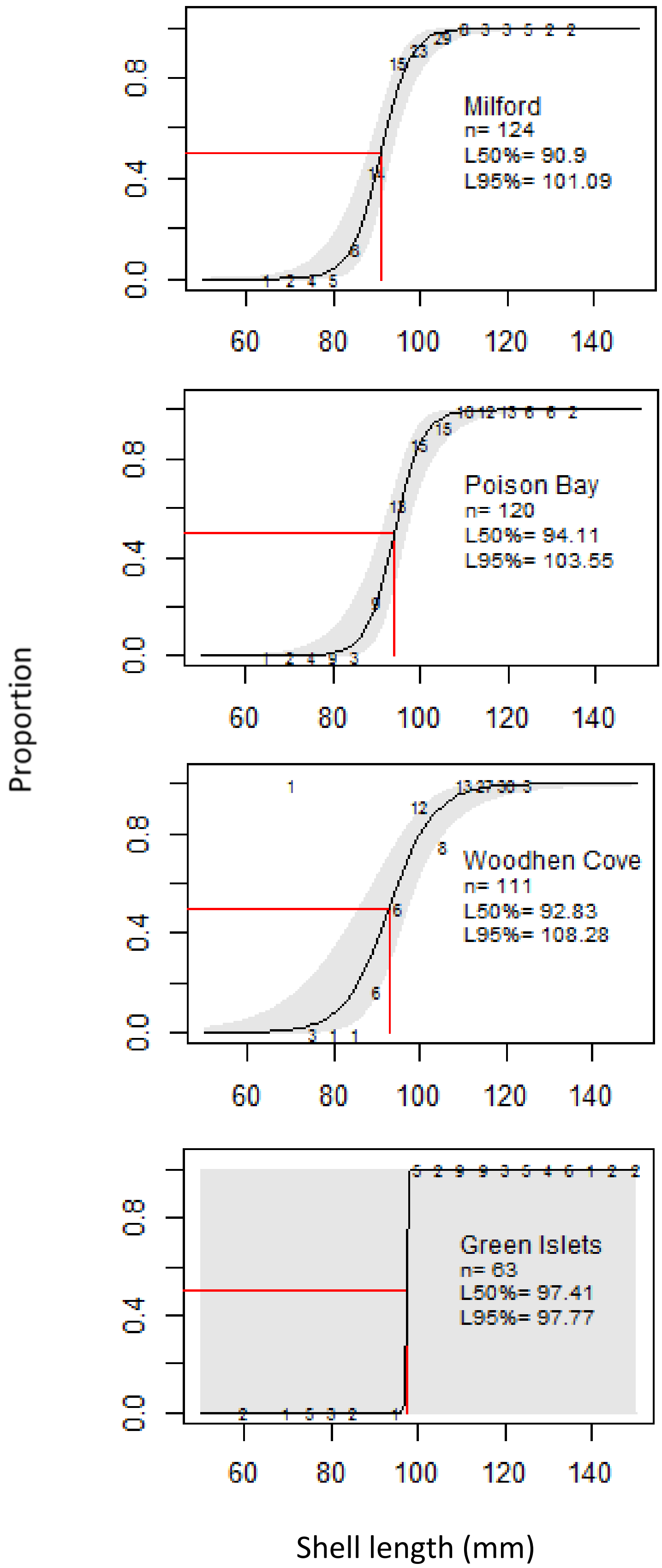

Figure 6: Proportion mature at length and fitted logistic curves for sites sampled in PAU 5A. Numbers adjacent to ogives are the number of samples at that length.

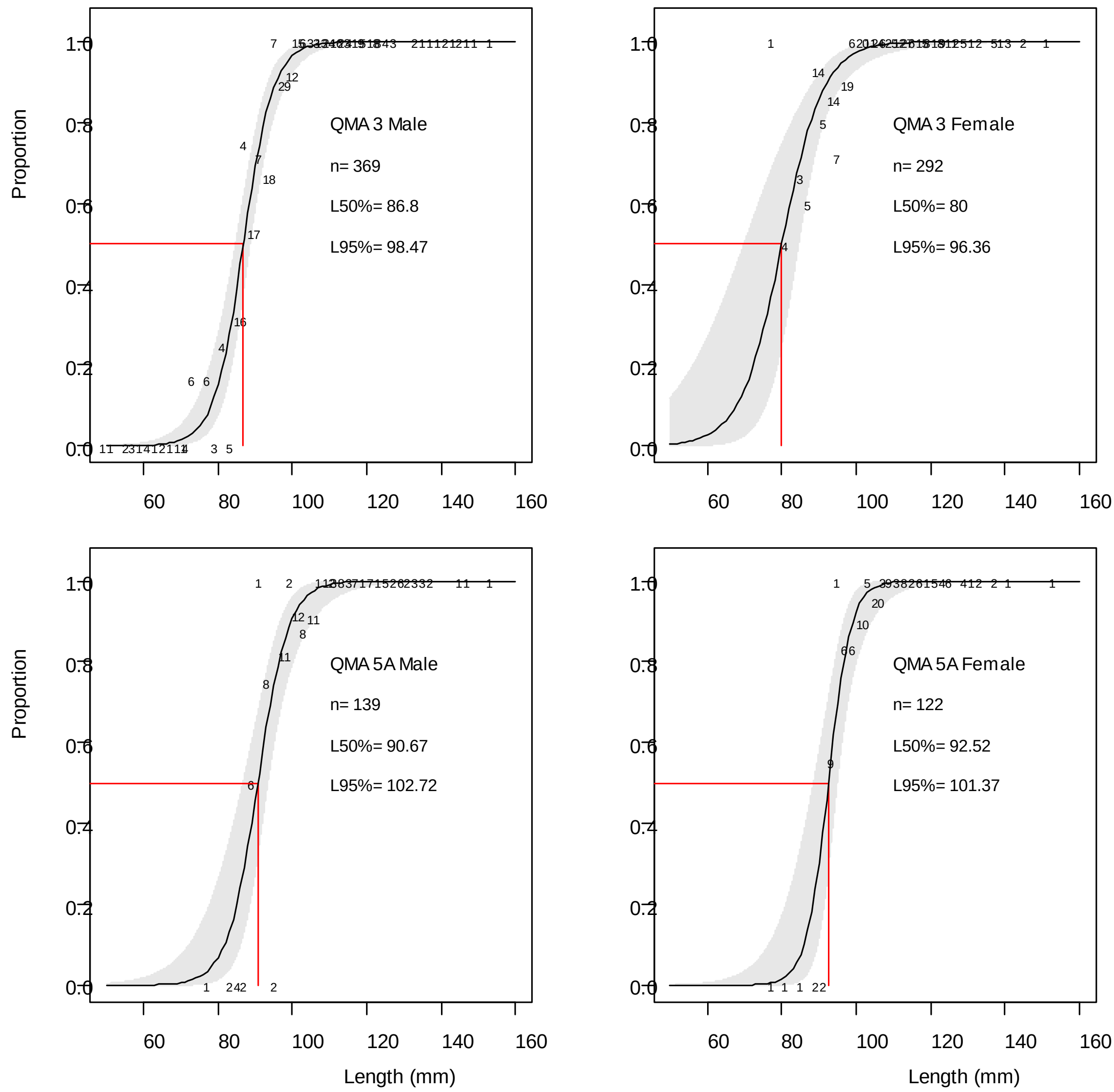

Figure 7: Proportion mature at length and fitted logistic curves for sites combined in PAU 3 and PAU 5A. Numbers adjacent to ogives are the number of samples at that length.

The numbers of paua categorised as immature (just female, JF or just male, JM) and mature (male, M or female, F) and the number of eggs or sperm present in a subsample of the gonad are shown in Tables 2 and 3 respectively. All females visually assessed as mature contained mature eggs. In PAU 3, 26% of female paua categorised as mature had 30 or fewer mature eggs in the subsample. Most female gonads in the subsample contained 100s or 1000s of mature eggs (Table 2). Of the fifteen female paua visually classified as just female (JF) five had small numbers of mature eggs in the subsample. One had about 200 eggs, the other four had 30 or less mature eggs and the remaining five had none (Table 2).

The heads of sperm observed were in the order of 4 microns long and the flagella were in the order of 40 microns long Figure 9). These dimensions correspond with those reported by McCardle (1984) who examined gametes from *H. iris* which had been collected from spawning animals. Of the 20 males categorised as just male (JM), 8 had a small number of apparently mature sperm. None of the JM subsamples contained a lot of mature sperm. All males visually categorised as mature contained mature sperm (Figure 9). Of the 25 subsamples of mature male gonad taken, most contained a lot of sperm, and 28% (7 samples) contained only a few.

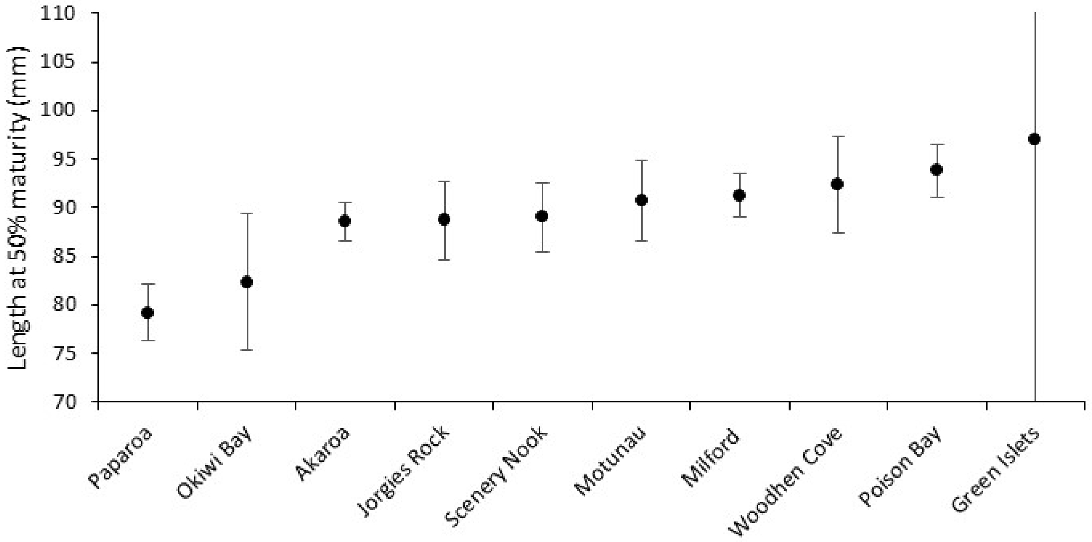

Figure 8: Length at maturity and 95% confidence intervals for sites sampled in PAU 3 and PAU 5A.

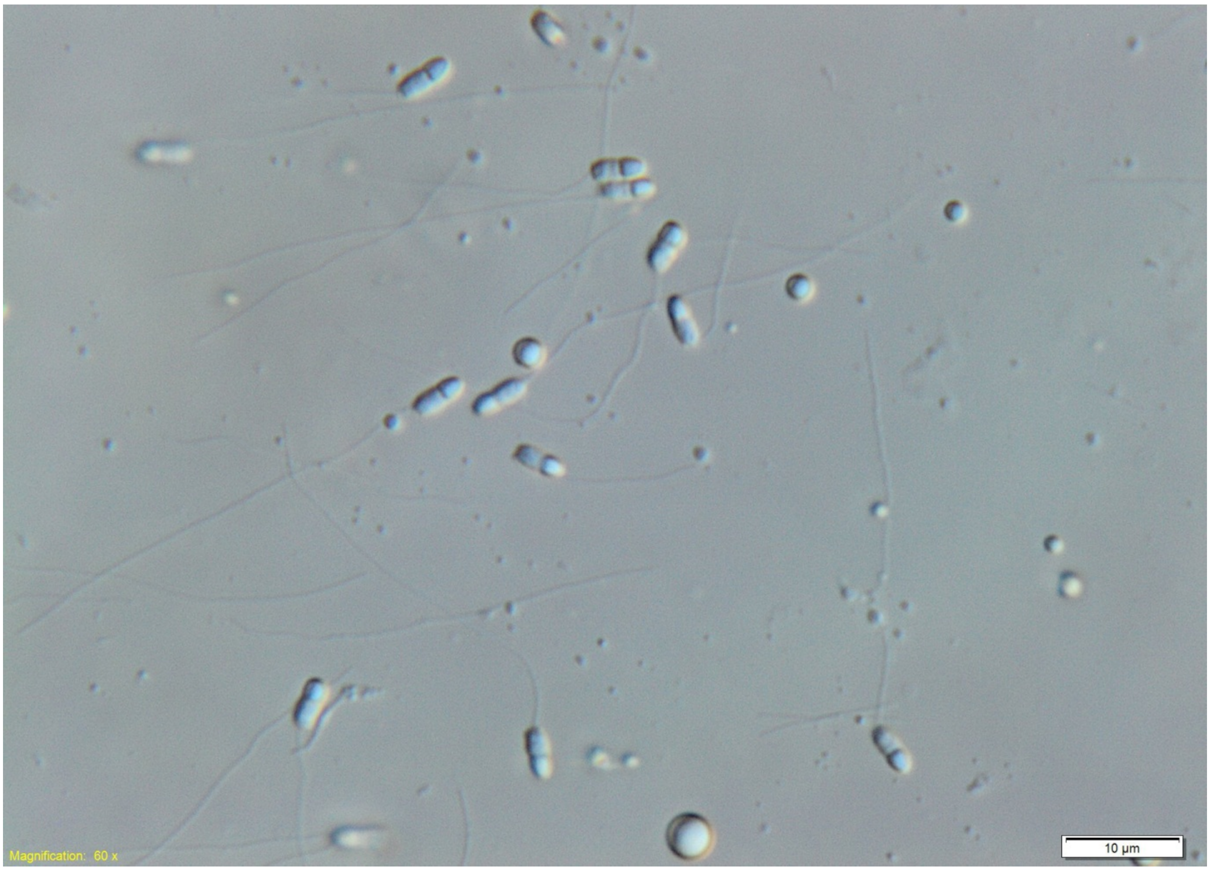

Figure 9: Sperm (× 1200) from a paua in PAU 5A.

Table 2. Approximate number of eggs in subsamples of female gonad from sites in PAU 3 and PAU 5A.

QMA	Site	Date of capture	Shell length (mm)	Maturity	Approx. no of mature eggs
PAU 3	Akaroa	8/12/2012	85	JF	0
PAU 3	Akaroa	8/12/2012	88	F	12
PAU 3	Akaroa	8/12/2012	89	JF	0
PAU 3	Jorgies Rock	26/04/2012	89	F	20
PAU 3	Jorgies Rock	26/04/2012	91	JF	0
PAU 3	Jorgies Rock	26/04/2012	96	F	1,000s
PAU 3	Jorgies Rock	26/04/2012	100	F	1,000s
PAU 3	Jorgies Rock	26/04/2012	103	F	1000s
PAU 3	Motunau	15/03/2012	92	F	12
PAU 3	Motunau	15/03/2012	94	JF	0
PAU 3	Motunau	15/03/2012	98	F	20
PAU 3	Motunau	15/03/2012	98	F	30
PAU 3	Motunau	15/03/2012	98	F	200
PAU 3	Motunau	15/03/2012	100	F	100
PAU 3	Motunau	15/03/2012	104	F	1,000s
PAU 3	Motunau	15/03/2012	117	F	1,000s
PAU 3	Motunau	15/03/2012	119	F	1,000s
PAU 3	Motunau	15/03/2012	122	F	1,000s
PAU 3	Motunau	15/03/2012	124	F	1,000s
PAU 3	Okiwi Bay	26/04/2012	88	F	1,000s
PAU 3	Okiwi Bay	26/04/2012	88	F	1000s
PAU 3	Okiwi Bay	26/04/2012	88	F	100s
PAU 3	Okiwi Bay	26/04/2012	90	F	20
PAU 3	Okiwi Bay	26/04/2012	92	F	1,000s
PAU 3	Squally Bay	8/12/2012	80	JF	0
PAU 3	Squally Bay	8/12/2012	88	F	100s
PAU 3	Squally Bay	8/12/2012	93	JF	30
PAU 5A	Green Islets	4/08/2012	95	JF	0
PAU 5A	Green Islets	4/08/2012	98	F	1,000s
PAU 5A	Green Islets	4/08/2012	98	F	1,000s
PAU 5A	Green Islets	4/08/2012	120	F	1,000s
PAU 5A	Green Islets	4/08/2012	123	F	1,000s
PAU 5A	Green Islets	4/08/2012	124	F	1,000s
PAU 5A	Green Islets	4/08/2012	152	F	1,000s
PAU 5A	Milford	9/02/2012	91	JF	0
PAU 5A	Milford	9/02/2012	92	JF	0
PAU 5A	Milford	9/02/2012	93	F	100s
PAU 5A	Milford	9/02/2012	98	F	100s
PAU 5A	Milford	9/02/2012	98	JF	200
PAU 5A	Milford	9/02/2012	103	JF	3
PAU 5A	Milford	9/02/2012	107	F	100s
PAU 5A	Milford	9/02/2012	108	F	100s
PAU 5A	Milford	9/02/2012	115	F	100s
PAU 5A	Milford	9/02/2012	127	F	1,000s
PAU 5A	Poison Bay	9/02/2012	76	JF	0
PAU 5A	Poison Bay	9/02/2012	89	JF	10
PAU 5A	Poison Bay	9/02/2012	101	JF	30
PAU 5A	Poison Bay	9/02/2012	103	JF	0
PAU 5A	Poison Bay	9/02/2012	104	F	100s

Table 3. Relative number of sperm in subsamples of male gonad from sites in PAU 3 and PAU 5A.

QMA	Site	Date of capture	shell length (mm)	maturity	no. of sperm
PAU 3	Akaroa	8/12/2012	75	JM	none
PAU 3	Akaroa	8/12/2012	76	JM	none
PAU 3	Akaroa	8/12/2012	88	JM	none
PAU 3	Akaroa	8/12/2012	107	M	few
PAU 3	Jorgies Rock	26/04/2012	91	JM	none
PAU 3	Jorgies Rock	26/04/2012	91	M	lots
PAU 3	Jorgies Rock	26/04/2012	98	M	lots
PAU 3	Jorgies Rock	26/04/2012	106	M	Lots
PAU 3	Jorgies Rock	26/04/2012	106	M	lots
PAU 3	Jorgies Rock	26/04/2012	110	M	lots
PAU 3	Motunau	15/03/2012	93	JM	few
PAU 3	Motunau	15/03/2012	93	M	lots
PAU 3	Motunau	15/03/2012	93	M	lots
PAU 3	Motunau	15/03/2012	98	M	few
PAU 3	Motunau	15/03/2012	122	M	lots
PAU 3	Okiwi Bay	26/04/2012	76	JM	none
PAU 3	Okiwi Bay	26/04/2012	86	M	few
PAU 3	Okiwi Bay	26/04/2012	88	JM	few
PAU 3	Okiwi Bay	26/04/2012	93	M	few
PAU 3	Okiwi Bay	26/04/2012	98	M	few
PAU 3	Squally Bay	8/12/2012	83	JM	none
PAU 3	Squally Bay	8/12/2012	92	JM	none
PAU 3	Squally Bay	8/12/2012	97	M	lots
PAU 5A	Milford	9/02/2012	84	JM	few
PAU 5A	Milford	9/02/2012	85	JM	few
PAU 5A	Milford	9/02/2012	85	JM	few
PAU 5A	Milford	9/02/2012	91	M	lots
PAU 5A	Milford	9/02/2012	92	JM	few
PAU 5A	Milford	9/02/2012	92	M	lots
PAU 5A	Milford	9/02/2012	127	M	lots
PAU 5A	Milford	9/02/2012	130	M	lots
PAU 5A	Milford	9/02/2012	130	M	lots
PAU 5A	Poison Bay	9/02/2012	86	JM	none
PAU 5A	Poison Bay	9/02/2012	89	JM	none
PAU 5A	Poison Bay	9/02/2012	91	JM	none
PAU 5A	Poison Bay	9/02/2012	94	JM	few
PAU 5A	Poison Bay	9/02/2012	96	JM	none
PAU 5A	Poison Bay	9/02/2012	106	M	few
PAU 5A	Poison Bay	9/02/2012	107	M	few
PAU 5A	South coast	4/08/2012	77	JM	few
PAU 5A	South coast	4/08/2012	86	JM	none
PAU 5A	South coast	4/08/2012	108	M	lots
PAU 5A	South coast	4/08/2012	113	M	lots
PAU 5A	South coast	4/08/2012	127	M	Lots
PAU 5A	South coast	4/08/2012	131	M	Lots

Specific Objective Two:

Determine the correlation between various shell morphometric markers (e.g. height, length, width) and length/age at maturity.

Width had the most explanatory power but was not much better than length (Table 4). Given the relative ease of measuring length and the large database of length measurements, shell length is probably the most useful variable to associate with estimates of maturity.

Length/height ratios (Table 5) and lengths at 50% maturity are shown in Figure 10. The length to height ratios at Jorgies' Rock and at Paparoa were significantly larger than those at all other sites except Green Islets where the difference was not significant (Student's t-test). The sites on Banks Peninsula had the lowest ratios (Figure 10). Length/height ratios ranged between about 3.2 and about 3.7 (Table 5). Variation in length at maturity and length-height ratios by area appear to follow a similar pattern, except for the Paparoa and Scenery Nook sites in PAU 3 (Figure 10, Table 5).

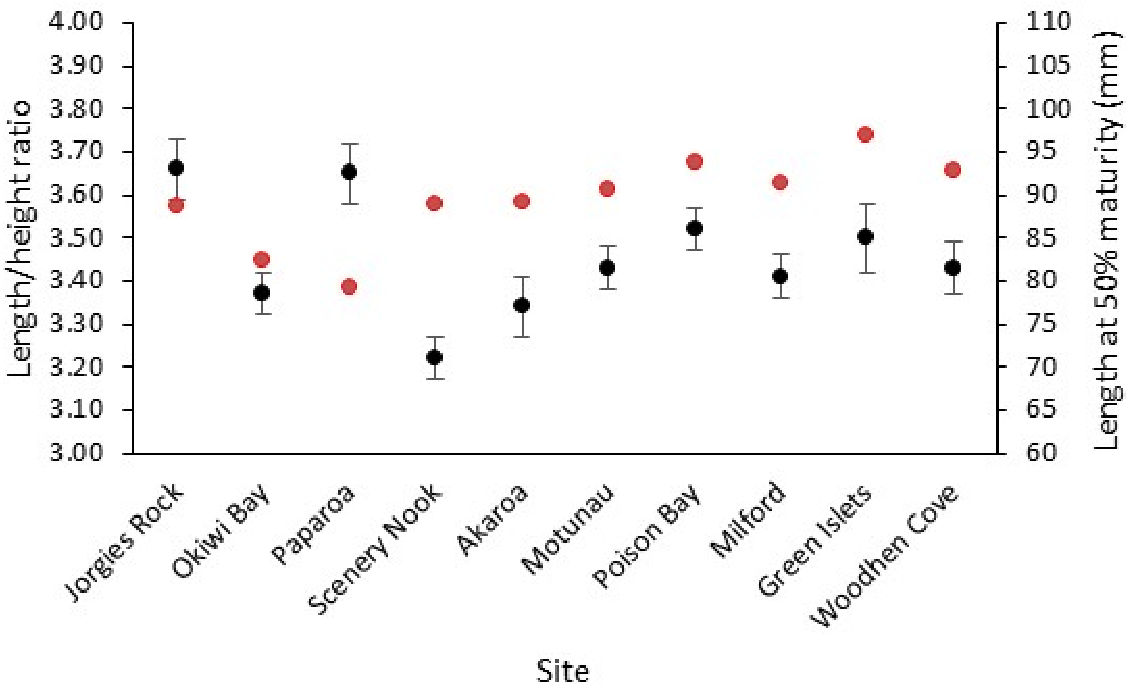

Figure 10: Length/height ratios (black dots) their 95% confidence intervals (vertical lines) and length at 50% maturity (brown circles) for sites sampled in PAU 3 and PAU 5A.

Table 4. Regression fits to morphometric data.

Regression fits	dF	AIC
Length+Site	2537	1184.8
Height+Site	2537	1252.8
Weight+Site	2537	1693.4
Width+Site	2537	1154
HLR+Site	2537	2289.1
WidthLR+Site	2537	2699
HWeightR+Site	2537	1923.7

Table 5. Length to height ratios of paua sampled at sites in PAU 3 and PAU 5A.

QMA	Site	Length/height ratio
PAU 3	Jorgies Rock	3.66
PAU 3	Okiwi Bay	3.37
PAU 3	Paparoa	3.65
PAU 3	Akaroa	3.22
PAU 3	Scenery Nook	3.34
PAU 3	Motunau	3.43
PAU 5A	Poison Bay	3.52
PAU 5A	Milford	3.41
PAU 5A	Green Islets	3.50
PAU 5A	Woodhen Cove	3.43

4. DISCUSSION

Maturity was determined visually and the adequacy of visual determination was assessed by the microscopic examination of a subsample of gonads. Visual determination of maturity is the most common method used in the literature (e.g. Officer 1999, Tarbath & Officer 2003, Button & Rogers-Bennett 2011, Naylor et al. 2006) and the determination of maturity is commonly according to whether the sex of the abalone can be determined (eg. Officer 1999, Button & Rogers-Bennett 2011). Many studies involving histological examination of the gonad attribute maturity to the presence of mature gametes (e.g. Wilson & Schiel 1995, Rogers-Bennett et al. 2004, Webber & Giese 1969, Poore 1973).

The determination of maturity on the basis of being able to determine sex is likely to underestimate functional length at maturity as gametogenic cells may be present, when mature gametes are not. In *H. iris* sex determination can commonly be made because there is a speckling of either green or white gametogenic material on the digestive gland. These paua will most likely not spawn (Graeme Moss, NIWA, pers. comm.) but if they did, they would make a negligible contribution to gamete production within the population. For this reason, these paua are not considered mature for the purpose of estimating maturity ogives. Only paua in which the digestive gland is completely covered by gametogenic cells (i.e. all white or all green) are treated as mature. A sizable proportion of paua examined at lengths below about 92 mm had relatively few mature eggs in the section of gonad sampled, although they all contained mature eggs. It is likely that these animals would not have made a large contribution to gamete production within the population. It was suggested at a meeting of the Shellfish Working Group that the ogives could be adjusted to take this into account. With the information available, this presents several problems. The first is how the adjustment should be applied. As all females in the category of being called mature but having relatively few mature eggs are from PAU 3, the correction, if carried out, should presumably only be applied to this QMA. The ratios of occurrence of the category also vary by site within PAU 3. If applied at the scale of site, at three sites, the adjustment would be based on only one data point of a given length. The data also don’t provide any good guidance as to the length range of shells over which the adjustment should be carried out.

Most samples were collected over summer (December to April) so bias in maturity estimates is likely to be minimal. Samples from the Green Islets site were collected at the beginning of August, however, the transition to maturity is poorly described by the data from this site. Paua usually spawn in late summer or early autumn (Poore 1973, Sainsbury 1982) but may spawn as late as August (McShane & Naylor 1996). It is possible that paua at this site had already spawned at the time of collection. If enough paua had spawned to the extent that gonad tissue was not discernible even though they were mature, estimates could be biased upwards. It is very unusual; however, for paua to completely spawn so that no coloured gonad tissue is visible on the digestive gland (authors unpublished information).

Length at maturity did not vary much between sites within either QMA. Large variation in length at maturity for paua has sometimes been reported in the literature (e.g. Naylor et al. 2006), and much reduced lengths at maturity have usually been associated with ‘stunted’ populations, such as those around Taranaki or Banks Peninsula. Because the sites chosen for sampling in both QMAs in this work were chosen on the basis of their representing areas of the commercial fishery, it is not surprising that estimates of maturity were similar.

Length at maturity and length-height ratios appear to follow a similar pattern, except for the Paparoa and Scenery Nook sites in PAU 3. It is generally accepted that for paua, the shells of stunted or slow growing populations are relatively higher for their length, and this relationship was proposed by Saunders et al. (2008) as a possible method to identify ‘stunted’ populations. The range of values in their study was similar to those found here and they proposed that a shell height to length ratio of 3.25 or lower indicated that the local population was ‘stunted’. A major difference in their work was that they deliberately sampled populations they knew to be ‘stunted’. If ‘stunted’ paua were sampled their shell length to height ratios may indicate that they were from areas of either slow growth or low maximum size. Because ‘stunted’ paua are easily distinguished from normal paua on the basis of the general shape of their shells determination of shell morphometric ratios is unlikely to be very useful.

The length at maturity information collected as part of this project should better inform the determination of spawning stock biomass in PAU 3 and PAU 5A.

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6. APPENDIX 1

Number of samples in 2 mm bins by site

Bin	Okiwi Bay	Paparoa	Jorgies Rock	Motunau	Akaroa	Scenery Nook
60	0	1	0	0	0	0
62	0	1	0	0	0	0
64	0	2	0	0	0	0
66	0	4	0	0	1	0
68	0	4	2	0	1	0
70	0	4	0	0	0	0
72	0	5	1	0	0	0
74	0	3	0	0	1	0
76	1	0	0	0	2	0
78	0	3	0	0	2	1
80	0	4	0	0	0	1
82	0	2	0	0	5	3
84	1	4	0	1	5	3
86	1	8	0	0	5	3
88	5	3	6	0	6	3
90	3	4	4	1	6	1
92	8	4	0	6	2	5
94	6	6	3	3	5	3
96	6	7	4	5	6	8
98	6	2	4	7	2	4
100	12	2	5	1	3	5
102	13	3	8	5	7	3
104	9	3	5	7	4	8
106	6	3	10	5	10	5
108	3	0	9	8	3	6
110	9	2	13	9	4	7
112	1	1	6	15	2	9
114	0	1	4	8	7	4
116	0	0	1	9	5	7
118	3	1	3	10	8	4
120	1	0	1	4	11	3
122	2	0	2	10	3	5
124	2	0	1	5	3	2
126	3	2	2	3	1	0
128	1	0	1	0	0	0
130	2	0	0	0	0	0
132	1	0	2	0	0	0
134	1	0	1	0	0	0
136	3	0	2	0	0	0
138	1	0	2	0	0	0
140	1	1	2	0	0	0

Bin	Milford	Poison Bay	Woodhen Cove	Green Islets
60	0	0	0	1
62	0	0	0	0
64	1	1	0	0
66	0	0	0	0
68	1	0	1	1
70	0	1	0	0
72	2	2	2	0
74	1	2	0	2
76	2	1	1	3
78	2	6	0	1
80	1	2	1	1
82	2	1	0	1
84	6	1	0	1
86	2	2	1	1
88	2	6	3	0
90	7	3	0	0
92	10	3	5	0
94	4	6	2	1
96	6	4	2	0
98	7	4	5	4
100	9	6	5	0
102	15	8	4	2
104	14	5	2	0
106	7	7	4	1
108	3	5	5	2
110	4	3	4	4
112	3	3	9	6
114	0	5	13	4
116	1	6	9	2
118	2	4	15	0
120	1	4	8	3
122	1	7	9	2
124	1	3	1	2
126	3	1	0	1
128	0	5	0	2
130	2	1	0	2
132	0	1	0	2
134	2	1	0	3
136	0	0	0	1
138	0	0	0	0
140	0	0	0	1

Bin	QMA 3 Male	QMA 3 Female	QMA 5A Male	QMA 5A Female
60	0	0	0	0
62	0	0	0	0
64	0	0	0	0
66	0	0	0	0
68	0	0	0	0
70	0	0	0	0
72	0	0	0	0
74	1	0	0	0
76	2	0	1	1
78	0	0	0	0
80	0	1	0	1
82	4	0	2	0
84	3	2	4	1
86	3	3	4	0
88	7	11	4	2
90	8	6	3	4
92	11	9	6	7
94	11	9	6	5
96	14	14	7	2
98	12	10	6	9
100	13	13	8	7
102	14	21	14	11
104	22	11	5	14
106	21	15	7	8
108	15	14	6	4
110	24	18	6	5
112	14	19	5	6
114	10	11	6	3
116	12	10	4	5
118	11	17	3	3
120	11	9	5	3
122	8	13	2	8
124	4	7	4	2
126	2	5	4	1
128	0	1	4	3
130	1	1	3	2
132	1	2	2	1
134	1	1	4	2
136	1	4	1	0
138	2	1	0	0
140	1	2	0	1