Shellfish Surveys
Waikawau Bay, Coromandel 2008 and 2009[1]

1. Introduction:

Shellfish and estuarine fish abundance and status, are important indicators of estuary health. Cockles (*Austrovenus stutchburyii*) are one of the most numerous invertebrates found in our estuaries. Monitoring abundance of cockles is one relatively easy method of checking estuarine health. As cockles are an important food source for birds, fish and estuarine snails (*Amphibola crenata*), their abundance has a flow on effect on the health of other estuarine fauna.

1.1 Site description:

Waikawau Bay is situated on the Northern Coromandel on the eastern seaboard. The area surveyed comprises the outer estuary, an area of approximately 5ha, which is a remnant part of a much larger river/estuary/harbour/lagoon system, characterized by in-filled, coarse to fine grained silts, sands, and dune and marsh systems.

The Northern Coromandel has a warm moist maritime climate, influenced by two bodies of water (Hauraki Gulf – western side, Pacific Ocean – eastern side). The prevailing winds are gusty southwesterlies (bringing little rain); or easterlies bringing intense and often severe rainstorms (200mm+/hr have been recorded). Heavy rainfall is common with frequent flooding and sea wash.

Tidal influences in association with heavy rainfall events cause severe flooding because valleys are long, narrow, and low lying with abrupt steep ranges behind them. Erosion is often severe with silt laden flood water, inundating the estuary and covering shellfish beds – on occasion smothering them and killing them off. For example, the pipi bed on the northwest side of the outer estuary, was smothered and destroyed about fifteen years ago after a large flood.

Salt laden winds during severe easterly storms damage vegetation and cause coastal erosion. These easterlies and the strong southwesters have caused noticeable changes to the dune systems at the northern end of the Bay over the past ten years.

The systematic stripping of riparian forest remnants in the farming valley behind the estuary, to the northwest has contributed to this damage, and there is now little vegetation

[1] K.. Parr and W. Todd 2010.

to break the south-westerlies as they gust down the valleys. As a result of this lack of vegetation, a sand island of some 1200 cu. m (approx.) in the mouth of the estuary eroded away in two years 2006 - 2008. This has led to the mouth of the estuary being more exposed to the sea.

Geology is characterized by andesites with occasional basaltic extrusion plugs. Rhyolite clays are present behind the wetlands. Yellow clays are present throughout the rest of the estuarine area. Soils are of medium to poor fertility. There is some evidence of small peat deposits.

Thirteen streams feed into Waikawau Bay with two fourth order streams feeding the northern end wetland and estuary. Two third order streams also feed directly into the north end wetland system. The two largest stream watersheds are estimated to be in excess of 3,500ha (approx).

The Bay itself is dominated by the DOC Farm Park Reserve with a large dry stock beef and sheep farm lease. A long narrow fore dune reserve (100m wide) with regenerating native flora separates the agricultural lands from the beach. Farmlands are hard up on the southern edge of the estuary but with good fences to keep stock out. On the northern edge there are a couple of small lifestyle blocks and a large drystock farm (the Denize Farm). The Denize Farm and the Farm behind it "Three Stone Farm", form a large part of the northwestern catchment with a large number of tributary streams feeding into the Waikawau 'river'.

1.2 Human Occupation:

The Waikawau Bay area has a long history of human occupation and land modifications.

There is considerable evidence of Maori occupation throughout the Bay and includes all the common indicators (eg. kianga and pa sites, middens, fish traps, earthworks, gardens and mounds). There is evidence to suggest early occupation 850 – 950 AD

Midden evidence suggests major occupation between 1300 –1600 AD. While there is no visible evidence of land clearance, there is evidence of several large garden sites and food storage pits, suggesting that some land was cleared for gardens. There is no way of knowing exactly how the ecosystem was modified due to Maori occupation.

Coromandel was renowned for the quality of its kauri timber and extraction took place from the early 1800's right up into the early 1900's. Other high quality timbers were also being removed at this time. Gum digging and gold mining followed and there is evidence throughout the Bay of adits, mine shafts, tramway beds, dams, tailings mounds and stamper batteries.

Traditional farming of sheep, beef and dairying was carried out from the late 1800's to the early 1970's. Dune stabilization was carried out in the early 1900's and there is evidence still of ditches and berms, floodgates and tidal flood gates, which were installed to modify and drain the upper estuary and river systems. There are examples throughout the estuary of reclamations; however, most of these are now abandoned.

All farmed lands received significant government subsidies for fertilizers, clearance, fuels and stock transportation. Farm subsidies pre 1970 contributed to some major environmental impacts in the area. Farmers cleared land, dug ditches, diverted streams and drained wetlands in an effort to make the land more agriculturally productive. With the removal of subsidies much marginal agricultural land was retired, converted to forestry, or

sub-divided into smaller lifestyle blocks. The more gently rolling hill country and valley floors remained in farms.

Almost all of this retired land is now in regenerating scrub and forest (and weeds); and is contributing positively to reduction of steep hill country erosion, the water purity of streams, and the subsequent health of wetland, estuary and ocean beach ecosystems. Forest remnants are all heavily modified.

There are now only three major farms in the Bay, one of which is the DOC Farm Park lease. Farms are dry stock. Neither, the Three Stone property, the Denize Farm, nor most of the DOC lease[2], has riparian plantings or fencings. The stream banks, on one of these farms, have been regularly harvested by a firewood enterprise, denuding the stream sides, causing bank loss and considerable erosion.

There are also three large lifestyle blocks (175ha + each) which are mainly made up of regenerating forest and several small lifestyle blocks (20ha or less), two of which are small dry stock farms – the rest are regenerating forest lands.

1.3 Animal Pest Control[3] and Fauna Monitors:

Monitoring of rodent numbers, pateke and fernbird census have been carried out since 2006. Reptile monitoring, freshwater fish surveys, 5 minute bird counts, and shellfish surveys along with measurements of the growth of saltwater paspalum in the estuary (*Paspalum vaginatum*) have been carried out since 2008/2009.

In 1999, 35 traps were installed for trapping mustelids and hedgehogs[4] along the foreshore of the Bay and the northern margins of the estuary system[5]. Traps are serviced on a monthly basis, except over the summer period when they are checked weekly or fortnightly. Further trap lines for mustelids were installed on the eastern, western and southern margins of the wetlands in 2005.

In 2006, 150 rat traps were installed around the margins of the wetlands. At this time 75 bait stations were also installed around the perimeter and on two lines in the heart of the wetlands, along with another 75 on the margins of the estuary system and the road.[6] Rat traps are checked approximately every two weeks. Bait stations are serviced every three to nine months (depending on monitor results). Data is kept of all rats and mice trapped. Monitoring of the effectiveness of trapping is done every three months by independent auditors. To date, monitors show that rat numbers have declined significantly and skink, weta and other invertebrate numbers are increasing over time. More traps are presently being installed on the north western margin of the saltmarsh.

1.4 The Estuary:

The physical environment of each side of the estuary is quite different. The south side is characterized by an established (modified) dune system. This area is exposed to coastal elements and is comprised of sand convolvulus, muehlenbeckia, knobby clubrush, pingao and spinafex. Tidal mudflats and adjacent low lying sandy pastureland characterize the

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[2] The DOC lease has good fencing around the estuary, but not along most waterways, ponds or streams.

[3] All animal pest control is carried out after full consultation with landowners. Only methods approved by each landowner (be they public or private) are utilized. Approval by all landowners to carry out pest control has been given.

[4] Hedgehogs are trapped along the foreshore and dune systems, as they are one of the main predators of New Zealand dotterels and Variable Oyster Catcher eggs and chicks.

[5] This trapping system was modified and expanded in 2009 – 2010.

[6] Rat traps were not placed in the heart of the wetlands, so that human impacts are minimized in this fragile environment.

middle section of the surveyed area. The mouth of the Waikanae Valley stream feeds into this side of the estuary.

The survey area closest to the sea on the north side of the estuary is comprised of coastal forest, rocky banks and limited low lying land, covered in muddy tidal flats. Areas further inland are characterized by tidal mudflats, with low lying farmland and saltmarsh edges.

The main river channel of the Waikawau Stream and the Waikanae Valley Stream has for many years been closer to the north side of the estuary. This has meant that the north side is subject to greater environmental changes that result from flooding.

Both sides of the estuary have banks of pampas. In addition, much of the south side and also parts of the Northern saltmarsh have inundations of spartina. The spartina on the south side has been sprayed, by helicopter with Gallant, in the past, which has had impacts on saltwater paspalum growth in these areas. However, the spartina had begun to regenerate at a rapid rate in 2008-2009. DOC resprayed the spartina manually, in February 2010 and again in March 2011.

However, the major botanical threat to the integrity of the estuary is the rapid expansion of saltwater paspalum. Saltwater paspalum invades and changes the composition and structure of native ecosystems. It can reduce or exclude feeding and roosting sites for birds, and may alter fish spawning and feeding grounds. It can also change estuarine hydrology by accumulating sediment."[7] It has been documented that *P.vaginatum* has similar impacts to *spartina,* in that, it:

- "out-competes native estuarine plant species changing the composition and structure of natural vegetation associations, and endangers threatened species populations (Nuttal, 1993);
- has high stem and root density which excludes burrowing fauna, such as cockles (*Austrovenus stutchburyi*) (Nicholls 1998);
- reduces access to the food and roosting sites of birds (poorly used by estuarine birds – Owen 1994);
- alters fish spawning and feeding grounds (e.g. flounder), (Nutall, 1993);
- alters estuarine hydrology patterns from the accumulation of sediments, and the associated ramifications of this (e.g. increased flooding which leads to further deposition of fine silts in the estuary, which may be to the detriment of filter-feeding shellfish and the growth of estuarine vegetation) (Swales et al. 2000, Nuttall, 1993)."[8]

The back of the Estuary has a small grove of old mangroves. Smaller mangroves and mangrove seedlings are also evident along river margins and mudflats on both sides of the Estuary. The area covered by mangroves has more than trebled in the last five years[9].

There was a small seagrass (*Zostera spp.*) bed in the estuary. This was smothered in a recent flood (Cyclone Wilma – January 2011). It is yet to be established whether it will recover.

There are saltmarsh communities comprising rush/sedgelands and saltmarsh ribbonwood (*Plagianthus divaricatus*) on both the north and south sides of the estuary. Coastal tree daisy (*Olearia solandri*) is common at the back of these areas. Seameadow communities

[7] www.nzpcn.org.nz/exotic_plant_life and weeds. Plant Conservation Network.
[8] Graeme, M. 2001. p9.
[9] Pers. observation. Authors.

are found fringing the sedge/rushlands and stream edges, but many of these are now being smothered by the saltwater paspalum.

2. Objective of Shellfish Surveys:

To determine relative abundance of cockles, as an indicator of estuarine health.

3. Methodology:

3.1 Four surveys were carried out; the first in August 2008, the second in February 2009 the third in March 2009, and the last in November 2009.

3.2 A cockle bed was located and GPS'd on the north side of the estuary. This bed was traversed by Profile Line One A. The north site (NWB1A) was surveyed in August 2008. A further site on Profile Line One A was surveyed on the south side (WB1A) of the estuary in March 2009. See Appendix One for Map.

3.3 During February 2009, cockle numbers were also surveyed on Profile Line One, on the north side of the estuary (NWB1) and the south side of the estuary (WB1), in order to gain some idea of the size of the cockle bed. Profile Line One is 118m on the seaward side of Profile One A (= which traverses nucleus the of the cockle bed).

3.4 Further surveys were done of profile Line One B, around November 2009. At this time only the South side (WB1B) of the estuary was surveyed, as the north side (NWB1B) of the channel ran over bedrock on this profile line.

3.5 A boundary stake was used as a low tide marker and from here measurements were taken for site locations of sample areas. Samples were marked out using wooden frames of 500mm X 500mm. These frames were set at a distance of 5m from each other, in a north/south direction and roughly parallel to the low tide line, and the shore. Four samples were taken at a distance of 10m above the low tide marker. A further four were taken another 20m above the marker, four more 30m above the maker and four more at 40m. A total of 16 quadrats were surveyed.

Wooden quadrat frame

cockle counting March 2009

3.6 Below is a grid of how the quadrats are numbered

Table One:

Inland	Low tide line channel		sea
site**1A**	**1B**	**1C**	**1D**
site**2A**	**2B**	**2C**	**2D**
site**3A**	**3B**	**3C**	**3D**
site**4A**	**4B**	**4C**	**4D**

five metre spacing between each quadrat A – D X ten metres spacings between each Site 1-4

3.7 Independent volunteers were used to do most of the work. Volunteers were divided into four groups and each assigned a line; A,B,C and D. Each group surveyed four quadrats; one at each of Sites 1-4.

3.8 For each sample a depth of 7-8cm was dug and sorted. Cockles were gathered from each sample and recorded according to size:

- Under 10mm
- 10-20mm
- 20-30mm
- Over 30mm.

3.9 Relative density classifications were as follows:

- High = >500/m2
- Moderate = 100 – 500/m2
- Low = < 100/m2.

3.10 Abundance was calculated by multiplying the number of cockles counted in each sample by 4 (to give per square metre density).

3.11 All cockles (and other shellfish) were returned to their sample areas.

3.12 Any other shellfish encountered during the March 2009 surveys were also recorded[10].

3.13 At 25m intervals along all Profile lines, quadrat samples were taken – to a depth of 7-8mm, and all fauna, soil conditions and other variables noted. Data from these surveys are not included in this report.

3.14 Surveys were intended to measure density rather than age of shellfish populations.

[10] Wedge shells (*Macomona* liliana) and pipis (*Paphies* australis) were also counted and measured during the March survey. Univalves were also noted, but not consistently across all sites. A note about the findings is appended to this document.

3.15 **Limitations of the Study:**
Due to availability of volunteers counts were done over an extended period of time rather than all at one time. Because the estuary channel has moved over the time of the survey, and because cockle beds are also mobile, counts are indicative only.

4. Results:

4.1 PROFILE LINE ONE Cockles counted on North side of Estuary (NWB1)

E2735884
N6509040

February 2009

Cockle counts

Site one	A	B	C	D
<10mm	0	0	0	2
10-20mm	1	66	94	99
20-30mm	4	40	49	57
>30mm	0	0	2	1
totals	**5**	**106**	**145**	**159**
no./ mtr2	**20**	**424**	**580**	**636**
Site two				
<10mm	0	1	0	2
10-20mm	7	20	8	8
20-30mm	13	49	45	46
>30mm	0	2	0	0
totals	**20**	**72**	**53**	**56**
no/ mtr2	**80**	**288**	**212**	**224**
Site three				
<10mm	2	0	0	1
10-20mm	19	38	23	29
20-30mm	27	45	17	3
>30mm	0	0	0	0
Totals	**57**	**83**	**39**	**33**
no/ mtr2	**228**	**332**	**156**	**132**
Site four				
<10mm	1	7	12	2
10-20mm	20	54	32	17
20-30mm	3	3	2	0
>30mm	0	0	0	0
Totals	**24**	**64**	**46**	**19**
no/ mtr2	**96**	**256**	**186**	**76**

Table Two

North Side of Estuary (NWB1):

- Total cockle numbers in each 500mx500m quadrat closest to the low tide line ranged from 5-159 individuals. When multiplied by four, relative densities varied from 20-636 /m2.
- Total cockles counted in each quadrant at Site 2 ranged from 80-288/m2.
- Totals at Site 3 ranged from 132-332/m2
- Totals at Site 4 ranged from 76-256/m2.
- Cockle densities were consistently low across all survey samples.
- From the cockles measured few were found within the smallest range and the largest range. There were a total of 30 <10mm, and only 2 found >30mm. and at both times of the year.
- From the 16 quadrats there were a total 981 cockles counted.
- There was an average of 245 cockles per square metre in this survey area.

4.2 Cockles counted on Profile Line One, South side of Estuary (WB1)

E2735868

N6509006

February 2009

Cockle counts

Site one	A	B	C	D
<10mm	5	0	0	0
10-20mm	11	3	0	0
20-30mm	10	0	0	0
>30mm	0	0	0	0
totals	**26**	**3**	**0**	**0**
no./ mtr2	**104**	**12**	**0**	**0**
Site two				
<10mm	3	0	0	0
10-20mm	9	0	0	0
20-30mm	22	0	0	0
>30mm	0	0	0	0
totals	**34**	**0**	**0**	**0**
no/ mtr2	**136**	**0**	**0**	**0**
Site three				
<10mm	4	0	0	0
10-20mm	17	0	0	0
20-30mm	3	0	0	0
>30mm	0	0	0	0
totals	**24**	**0**	**0**	**0**
no/ mtr2	**96**	**0**	**0**	**0**
Site four				
<10mm	4	0	0	0
10-20mm	12	0	0	0
20-30mm	8	0	0	0
>30mm	0	0	0	0
totals	**24**	**0**	**0**	**0**
no/mtr2	**96**	**0**	**0**	**0**

Table Three

South Side of Estuary (WB1)

- Total cockle numbers in each 500mx500m quadrat closest to the low tide line ranged from 0-26 individuals. When multiplied by four, relative densities varied from 0-104 /m2.
- Total cockles counted in each quadrant at Site 2 ranged from 0 -34/m2. with relative densities of 0 -136/m2
- Totals at Site 3 ranged from 0-24 with relative densities of 0 - 96 /m2
- Totals at Site 4 ranged from 0 – 24, with relative densities of 0 – 96/ m2.
- Cockle densities were consistently low across all survey samples.
- From the cockles measured few were found within the smallest range and none were found >30mm.
- From the 16 quadrats there were a total 111 cockles counted.
- An average of 27 cockles were found /m2 in this survey area.
- The results from this 16 group quadrat suggest that the southern boundary of the cockle bed was found and that it was approximately 118 m from the nucleus (on Profile Line One “A”).

4.3 Profile Line One "A" North Side of Estuary (NWB1A)

GPS E2735814

N6509058

August 2008

Cockles counts

Site one	A	B	C	D
<10mm	95	34	5	5
10-20mm	411	253	55	67
20-30mm	486	246	45	173
>30mm	12	14	15	121
totals	**1004**	**547**	**120**	**257**
no./m2	**4016**	**2194**	**480**	**1028**
Site two				
<10mm	1	12	0	0
10-20mm	17	53	11	39
20-30mm	31	85	37	99
>30mm	1	2	5	3
totals	**50**	**152**	**53**	**141**
no/m2	**200**	**608**	**212**	**564**
Site three				
<10mm	6	10	0	4
10-20mm	69	82	61	78
20-30mm	83	41	75	86
>30mm	0	0	0	0
totals	**158**	**133**	**136**	**168**
No/m2	**632**	**532**	**544**	**672**
Site four				
<10mm	16	22	1	6
10-20mm	118	107	48	78
20-30mm	65	30	48	36
>30mm	0	0	0	0
totals	**199**	**159**	**97**	**120**
no/m2	**796**	**636**	**388**	**480**
Site three				

Table Four

North Side of Estuary: (NWB1A)

- Total cockle numbers in each 500mx500m quadrat closest to the low tide channel line ranged from 120 - 1004 individuals. When multiplied by four, relative densities varied from 480 – 4,016 /m2.
- Total cockles counted in each quadrat at Site 2 ranged from 200 – 608/m2.
- Totals at Site 3 ranged from 532 – 672/m2.
- Totals at Site 4 ranged from 388 – 796/m2.
- On average, higher densities of cockles were counted on the "A" and "D" site lines. Interestingly, the lowest density of any quadrat was also counted on the "A" site line.
- From the cockles measured few were found within the smallest range and the largest range. From the 16 quadrants there were a total of 217 cockles <10mm and 64 cockles >30mm.
- Those cockles measuring <10 were found at Sites One, Two, Three and Four, but most were located close to the low tide line (Site One) or at Site Four, the site furthermost from the low tide mark.
- Those cockles measuring >30mm were all found at Sites One and Two, with far greater numbers found close to the low tide channel.
- Cockles within the 10–20mm and 20-30 were both consistently high across most quadrats. From the 16 quadrants a total of 1547 individuals at 10-20mm were measured and 1666 in the 20-30mm size range.

- In general, Group “C” quadrats recorded consistently lower numbers than others, in most other quadrats surveyed.
- An average of 873.5 cockles/ m2 were found in this survey area.

4.4 Shellfish counted on Profile Line One “A” South side of Estuary

GPS E2735772
N6509006

March 2009

COCKLES					**WEDGE SHELLS**				**PIPIS/nut shells**			
Site one	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
<10mm	18	33	27	30	2	7	12	8	6	0	12	12
10-20mm	137	35	131	207	6	9	9	21	6	0	0	10
20-30mm	99	210	318	203	24	16	21	22	0	0	0	3
>30mm	13	9	0	9	10	6	6	15	0	0	0	0
totals	**267**	**467**	**476**	**409**	**42**	**38**	**48**	**68**	**12**	0	**12**	25
no./sq mtr	**1068**	**1148**	**1904**	**1796**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Site two												
<10mm	27	31	3	11	0	3	0	0	22	12	5	7
10-20mm	201	198	175	151	21	27	21	16	1	19	7	11
20-30mm	83	208	119	116	38	25	19	17	0	2	0	1
>30mm	2	6	0	2	8	25	13	16	0	0	0	0
totals	**313**	**443**	**297**	**280**	**78**	**14**	**53**	**49**	**23**	**33**	**12**	**19**
no./sq mtr	**1252**	**1772**	**1188**	**1120**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Site three												
<10mm	7	22	17	5	4	3	5	5	6	2	11	6
10-20mm	186	135	127	146	7	17	21	21	7	19	7	7
20-30mm	79	91	116	88	36	17	31	25	2	1	0	0
>30mm	0	4	1	0	14	37	23	12	0	0	0	0
totals	**272**	**252**	**261**	**239**	**61**	**74**	**79**	**63**	**15**	**22**	**18**	**13**
no./sq mtr	**1088**	**1008**	**1044**	**956**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Site four												
<10mm	8	12	14	5	6	0	0	3	13	9	0	0
10-20mm	119	26	42	92	46	4	4	13	10	0	2	0
20-30mm	85	65	52	45	43	25	14	19	1	0	0	0
>30mm	3	5	10	2	17	3	10	21	0	0	0	0
totals	**215**	**108**	**118**	**144**	**112**	**29**	**28**	**56**	**24**	**9**	**2**	**0**
no./sq mtr	**860**	**432**	**472**	**576**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table Five

South Side of Estuary:

- Total cockle numbers in each 500mx500m quadrat closest to the low tide line ranged from 267 - 476 individuals. When multiplied by four, relative densities varied from 1068 – 1904 /m2.
- Total cockles counted in each quadrant at Site 2 ranged from 280 - 443/m2.
- Totals at Site 3 ranged from 956 -1088/m2
- Totals at Site 4 ranged from 432 -860/m2.
- In general cockle densities were consistently high across all survey samples.
- From the cockles measured few were found within the smallest range and the largest range. Although, more small cockles were found than during the August 2008 survey of the north estuary. Cockles over 30mm were of consistent numbers on both sides of the estuary and at both times of the year.
- From the 16 quadrats there were a total 4673 cockles counted.
- An average of 1221 cockles per m2 were found in the 16 quadrats.

4.5 Profile Line One B North Side of the Estuary: (NWB1B)

No survey as channel runs across gravel and bedrock

4.6 Profile Line One B: South Side of Estuary:

GPS: E2735550
N6508841

November 2009

COCKLES

Site one	**A**	**B**	**C**	**D**
<10mm	11	14	18	32
10-20mm	41	58	44	58
20-30mm	46	133	92	55
>30mm	0	0	0	0
totals	**98**	**205**	**168**	**145**
no./m2	**392**	**820**	**672**	**58**
Site two				
<10mm	130	22	25	32
10-20mm	117	82	156	184
20-30mm	140	98	84	144
>30mm	0	0	0	0
totals	**387**	**202**	**265**	**360**
no./m2	**1548**	**808**	**1060**	**1440**
Site three				
<10mm	26	31	78	20
10-20mm	66	157	148	129
20-30mm	263	107	133	131
>30mm	27	1	0	0
totals	**382**	**296**	**281**	**280**
no./m2				
Site four				
<10mm	26	103	132	58
10-20mm	133	100	166	152
20-30mm	93	85	126	164
>30mm	0	0	0	0
totals	**252**	**288**	**424**	**374**
no./m2	**1008**	**1152**	**1696**	**1496**

Table Six

South Side of Estuary:

- Overall, densities were all in the high range, from; 580 – 1696 /m2. These densities are comparable to the densities of the south side of Profile Line One A. Profile Line One B is 118m from Profile Line One A.
- The lowest densities recorded were those closest to the low tide channel.
- Comparatively fewer large cockles (>30mm) were found in this survey area than in other survey areas.
- Quadrats on site four line (30m from the low tide channel) all had high cockle densities, indicating that the back boundary of the cockle bed was not reached (other surveys indicated a thinning of cockle numbers at 30m from the low tide channel).
- There were many more cockles <10mm found than in other survey areas.
- There was an average of 1102 cockles /m2 in this survey area.

5.0 Discussion:

Cockles flourish between mid and low tide water. They feed on micro algae filtered from water for several hours on each tide. Fine stable sediments are essential for them to thrive and they can only live in sediments with between 10-85% fine silt. Therefore, they are sparse in excessively muddy sediments. Muflats such as those at Waikawau Bay where cockles flourish, are the “most biologically productive of our soft shores. The

detritus is rich enough to provide food, but never so heavy as to smother gills or feeding organs.[11]"

Cockles cannot feed if salinity is lower than 1.8% and must be covered by water for at least one and a half hours of every tidal cycle (Robertson, G and Peters, M. 2006. p.47).

Cockles are shallow burrowers. They leave their back end protruding through the surface and siphon water in monitoring it with tentacles and filtering plankton from the "thin soup" of water above. Cockles are fairly mobile, for a bivalve, and move with the aid of a "foot" which pulls the shellfish into a deposit and along the surface for small distances.[12] Cockle mobility also accounts for cockle beds shift over time. It is almost certainly the case that the beds at Waikawau Bay have shifted during the survey time/s.

Cockles can be found up to a depth of 20cm, but are more usually found at a depth of 2-3cm. Most of those found in this survey were at a depth of 2-4cm. However, this may have been due to the fact that there was a marked difference in silt quality at about 4-5cm mark. Here the silt quality changed from more sandy to muddy and also from mid grey to dark grey-black in colour.

Densities for cockles at the higher limit recorded in New Zealand, are around 4,500/m2. The nucleus of the Waikawau cockle bed recorded 4000+/m2.

The sample counts may have included some observer error, as there appeared to be consistently lower counts carried out by one group of people counting in the August 2008 survey (Profile Line One A, sites "C"), and again in the February 2009 survey (Profile Line One "A" sites on north side of estuary). However, as these were probably cases of undercounting, their impact would be to make any remarks in this report about densities, conservative rather than extravagant.

Cockles can live up to 20 years. However, the size of a cockle is not a true indicator of age. Factors such as food supply and density influence size. It has been contended[13] that the largest cockles live at the outer edges of the mudflats in shallow water, where their large size appears to be the result of a longer feeding time. This contention appears to be the case at Waikawau Bay, (see Table Four, site One, August 2008) however, there is not enough data to say this is a certainty.

Age can be determined by counting the darker growth rings on the shell. Size, does however, appear to be the prime factor in determining maturity to breed. Sexual maturity of both sexes occurs at about 18mm. Growth in the first two years appears to be fairly rapid and growth is fastest during spring and summer. Almost all cockles found in the bed were between 10-30mm. However, sieving for smaller cockles was not carried out. Smaller cockles may not have been encountered by observer handling. Therefore some random sieving needs to be done in future to establish whether small numbers of cockles (< 10mm) found was due to method error or due to other factors. For example, if there is too much silt present in the estuary, cockles will put their energy into feeding rather than growing. Similarly, there may be so many cockles that it is causing pressure on food and therefore not many cockles are growing over 30mm (cockles can grow to 75+mm, but there were only a few of cockles of 40mm or over during the Waikawau Bay surveys) . Or there may be some other factor, such as natural growth patterns or seasonal growth rates which account for the lack of mollusks under 10mm and over 30mm.

[11] Morton, J and Cometti, R. 1985. pp.70.
[12] Miller,M and Batt, G. 1973. pp.95.
[13] ibid.

Cockles are eaten by a large variety of fauna living in the estuary. These include: pateke[14], variable oyster catchers, flounder, snapper, mud welks. During the course of other survey work 82 VOCs were observed feeding on the edge of the cockle bed (20 March 2009), and 34 pateke were also observed feeding around the cockle bed (18 March 2009). Small numbers of horn shells and mud welks (both cockle predators) were found in the samples taken during the March 2009 surveys. Numerous flounder holes were observed in the midst of the cockle beds at low tide during the course of survey work. Snapper[15] are thought to be present in the estuary. Trevalli are often seen and caught in the Estuary.

7. Conclusions:

- More work needs to be done to more accurately determine the size of the cockle bed.
- Cockle numbers are consistently high in the nucleus of the bed, indicating good estuary health.
- Few large cockles were found. Further research may determine reasons for this.
- Few small cockles (smaller than 10mm) were found.
- Fauna in the estuary is well supported by the size and abundance of the cockle bed.

8. Recommendations:

8.1. Do further surveys to more accurately determine the size of the bed. For example; random sampling to more accurately determine size and abundance of the bed

8.2. Some random sieving needs to be carried out to establish whether small numbers of cockles (< 10mm) is due to method error or due to other factors such as natural growth patterns or seasonal growth rates.

8.3 Further research may be able to determine reasons for the small number of large cockles in the estuary.

8.4. Random sampling could be carried out to determine the age of cockles, by counting growth rings on shells.

9. Notes on other Shellfish.

Other bivalves: wedge shells (*Macomona liliana*), pipis (*Paphies australis*) and nut shells (*Nucula hartvigiana*) were encountered frequently during the March surveys (see table 2)

Wedge Shells were found at a deeper depth than cockles, putting up long siphons to the surface “Unlike the cockle it concentrates on the “thick soup” of surface sediment.[16] .They

[14] Pers com. Richard Goombes, who observed feeding when a DOC Ranger on Gt Barrier Island. Considerable research is presently being carried out in this area – see browntеal.com for details of research.

[15] There is a seagrass bed (essential to snapper life cycle) further up the estuary from the cockle beds.

[16] Morton,J and Cometti, R. cit op.

feed when the tide is out and the detritus is steady and is concentrated in the shallow water film. Since they live up to 150mm deep an estimate of abundance cannot be made on the data gathered (as samples for cockles were only take to a depth of 70-80mm) However, of those found there were numerous over 30mm and many over 40mm. Larger numbers were encountered around some outer edges (sites 3 and 4) of the 16 quadrats surveyed, suggesting that they may be more abundant further from the low tide channel.

Some pipis were found in the top few milimetres of many samples taken which were closest to the low tide channel. Overall numbers were low. The samples found coincided with the location of the old pipi bed that was destroyed about 15 -20 years ago. However, nut shells were also found and they were indistinguishable from the small pipis. All found pipis were small. None were recorded over 30mm and only 10 at 29-30mm.

Some gastropods were also found in many samples taken. However because of observer error, (not all observers counted univalves and not all identified various species), no substantive comments can be made. Of those samples taken that were able to be used, the following comments can be made. Between 2-7 gastropods were found in most samples. All were either mud welks (*Cominella glandiformis*) or horn Shells (*Zeacumantus lutulentus*). Abundant evidence of mud snails (*Amphibola crenata*) and various mud crabs were found on the surface of many samples.

References:

Graeme, M. 2001. Saltwater Paspalum (*Papalum vaginatum*) – A Weed Review. Report prepared for Environment Waikato. Natural Solutions. January 2001.

Miller,M and Batt,G. 1973. Reef and Beach Life in New Zealand. Collins.

Morton,J and Cometti,R. 1985. Margins of the Sea. Exploring New Zealand's Coastline. Hodder and Stoughton.

Robertson, G and Peters, M. 2006. Turning the Tide. An estuaries toolkit for New Zealand Communities. TAIERI Trust.

Hauraki Gulf Forum. Tikapa Moana. Shellfish Identification Guide.

www.nzpcn.org.nz/exotic plant life and weeds. Plant Conservation Network.

Appendices:

Appendix One
Shellfish Surveys
Profile Lines 1, 1A, 1B. (on both the North and South sides of the Estuary 10m - 40m from the main channel)