Healthy Estuary and Rivers of the City:

Water quality and ecosystem health monitoring programme of Ihutai

The sediments and biota of the Avon-Heathcote Estuary/Ihutai and tidal reaches of the Avon and Heathcote rivers

Summary report on data collected in 2007

Environment Canterbury
Your regional council

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Summary report on data collected in 2007

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Introduction

The Healthy Estuary and Rivers of the City: Water quality and ecosystem health monitoring programme of Ihutai was written in 2006. It includes monitoring programmes for four environmental values. This report summarises data collected in 2007 from the Estuary and the tidal reaches of the Avon and Heathcote rivers as part of Value B – Healthy Ecosystems – soft sediments of the estuary and tidal reaches. Other parts of this value include water quality of the Avon and Heathcote rivers, water quality of the estuary and river habitat and its biota. These aspects are covered by separate summary reports.

Healthy mudflats of an estuary and tidal reaches of a river support a diverse range of animals such as anemones, snails, shellfish worms, crabs and hoppers. The presence and survival of these animals (biota) not only depends on the quality and salinity of the water[1] but also on the quality of the sediments, i.e. the mudflats, that they live on or in. The diversity and abundance of animals living on and in the mudflats provides food for fish and birds while an abundance of healthy shellfish, such as cockles, are a valued food item for many people. In addition these mudflat-living animals, by their normal actions such as feeding and burrowing, keep the sediments well oxygenated and healthy.

The quality of the sediment in the estuary and the tidal reaches of the rivers have the potential to be impacted by:

- soil that runs off the land and into the rivers and estuary
- excessive amounts of organic matter, e.g. from dead and decaying plants including seaweeds and from bird and mammal excrement
- the quality of the overlying water
- contaminants such as metals, pesticides and herbicides that enter the rivers and the estuary in stormwater and other legal and illegal discharges

The features of the sediment that influence the types and abundance of the animals that live on or in it are:

- the size of the sediment grains that make up the sediment
- the amount of organic matter in the sediment
- the concentrations of potentially toxic contaminants

In order to assess the state of the sediments and biota of the Avon-Heathcote Estuary/Ihutai and tidal reaches of the Avon and Heathcote rivers a monitoring[2] programme started in 2007. Not only does this monitoring provide information on the present state of the sediments and biota, but by sampling every year it will be possible to see if and how the sediments and biota change over time.

This report is the summary of the sediment and biota data collected in 2007. This is the first annual summary report. A report including more detailed analysis, such as analysis of trends over time, will be produced following five years of data collection.

Sampling

Sampling sites

The sites sampled are shown in Figure 1.

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[1] The water within the Avon-Heathcote Estuary/Ihutai is primarily a mix of the freshwater flowing out of the Avon and Heathcote rivers, the sea water from Pegasus Bay that flows into the estuary as the tide rises and the tertiary treated wastewater that is discharged from the oxidation ponds. The wastewater consists of nutrient and plant plankton enriched freshwater that is discharged into the estuary twice a day around high tide. Refer to the summary report on the water quality of the Avon-Heathcote Estuary/Ihutai for more information on the impact of the wastewater discharge on the water quality of the estuary.

[2] Monitoring is the routine collection of data over time in order to assess the state of the environment and identify changes over time.

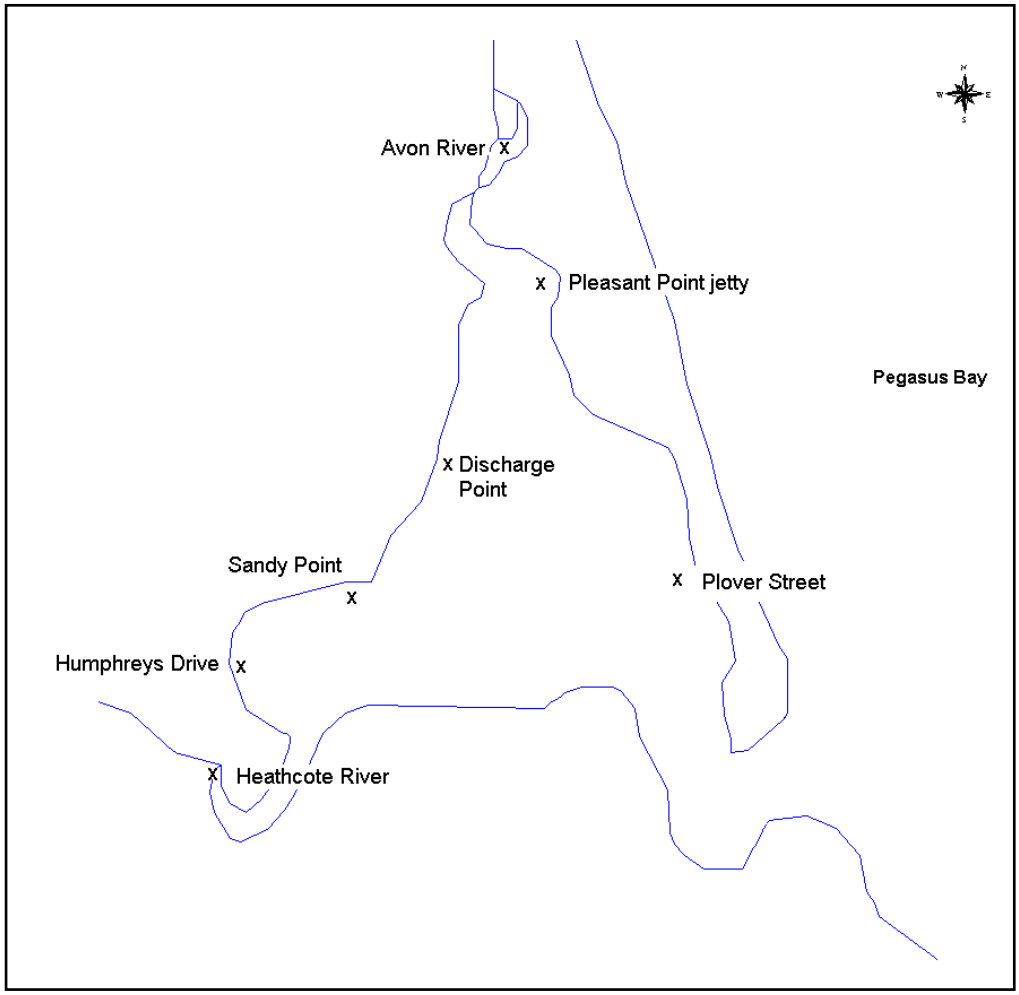

Figure 1 The sampling sites within the Avon-Heathcote estuary/Ihutai and in the tidal reaches of the Avon and Heathcote rivers

Collection of samples
The methods used followed the national protocol for monitoring estuarine environments (Robertson *et al.*, 2002). The GPS co-ordinates of each site were recorded.

Samples from the river sites were collected on 3 - 4 April and those from the estuary sites were collected on 19 - 23 April, 2007.

These sites were sampled by EOS Ecology on contract to the Christchurch City Council.

The following samples were collected at the sampling sites.

Sediments
Ten samples from the estuary sites and five composite samples from the river sites were collected and analysed. The top 20 mm of sediment was collected for analysis.

Sediment samples were analysed for:

- Sediment grain size
- Organic matter content
- Arsenic, cadmium, chromium, copper, lead, nickel and zinc concentrations

Biota

Plants and animals on the surface of the sediment

Fifteen, 50 cm x 50 cm (0.25 m^2) quadrats were sampled. The number of each different type of animal on the surface of the mud and the number of crab burrows in each quadrat was counted and recorded. The percentage cover of the surface by seaweeds was determined using a grid overlying the quadrat.

Animals living in the sediment

Fifteen 130 mm diameter x 150 mm deep cores were sampled. Each sample was sieved through a 0.5 mm screen and the material retained on the screen stored in alcohol for analysis. The number of each different type of animal in each core was counted and recorded.

Size distribution of some common animals

The height of all mudflat snails present in the quadrats was measured.
The length of all cockles in each quadrat (dug to a depth of 120 mm) was measured.

Results

The results are presented on the following pages. The data are typically presented as bar graphs. The bars have been positioned on a map and below each bar are the minimum and maximum values recorded at a site. This form of presentation makes it is easy to see the similarities and differences between sites.

Bar graphs

The bars for the sediment grain size and the biological data represent the average[3] value. The bars for organic matter content, and arsenic, cadmium, chromium, copper, lead, nickel and zinc concentrations in sediment represent the median[4] value. The height of a bar represents the value.

Pie graphs

Pie graphs have been used to show the average number of individuals of each type of animal living in the mud at each site. The size of a piece of the pie represents the average as a proportion of the total number of individuals present.

Guideline trigger values

These are values that have been established to protect living things. There are ANZECC (2000) guideline trigger values for arsenic, cadmium, chromium, copper, nickel, lead and zinc concentrations in sediment. For each metal there are two trigger values, ISQG[5] – low and ISQG – high. Where concentrations are below the ISQG-low trigger values there is a low risk of impacts on aquatic life occurring. When this trigger value is exceeded it does not

[3] The average is obtained by adding up all the vales and then dividing the total by the number of values used
[4] The median is the middle number when all numbers are ordered from lowest to highest. When there is an even number of numbers it is the average of the middle two numbers.
[5] ISQG – Interim sediment quality guideline

necessarily mean that there is an environmental problem but indicates that there is a potential risk to aquatic life, i.e. values higher than ISQG – low but lower than ISQG – high could affect some living things. Values higher than ISQG – high are likely to adversely affect living things.

Relationship between sediment grain size and the other sediment characteristics
The relationship between the percentage of clay, percentage of silt and percentage of sand to organic matter content, arsenic, cadmium, chromium, copper, lead, nickel and zinc concentrations was investigated. For organic matter content, copper, lead and zinc there was a strong positive correlation to the percentage of silt and a strong negative correlation to the percentage of sand. For chromium and nickel there was a positive correlation to the percentage of silt and a negative correlation to the percentage of sand. That is, as the percentage of silt increased the concentrations of organic matter, copper, chromium, lead, nickel and zinc also increased, while as the percentage of sand increased the concentrations of organic matter, copper, chromium, lead, nickel and zinc decreased. It is important to consider this relationship between sediment grain size and other measured parameters when interpreting the results. This is because higher concentrations at one site than another may be due to differences in sediment composition rather than due to the input of contaminants.

Names of plants and animals
The scientific names of the plants and animals are used but if there are common names they are also used.

Interpretation of biota data
The biota data presented summarises the types and abundance of animals, the size range of mudflat snails and cockles and the abundance of seaweeds at the sites in 2007. No analyses have been undertaken to investigate why there are differences in the plants and animals between sites. That is, the information provided only gives the state of the biota in 2007.

For the biota a whole range of different environmental factors including:

- the grain size of the sediment
- the organic matter of the sediment
- concentrations of contaminants in the sediment
- water quality
- oxygen levels in the sediment
- the level on the shore and time the site is exposed to air when the tide is out
- the salinity that occurs at the site

as well the interactions between individuals of the same species and between different types of animals influence the types and abundances of animals. The five yearly report will present the results of analyses investigating why there are differences in the plants and animals between sites.

Sediments

Grain size

This is a measure of the size of particles that make up the sediment. The sediment grain size distribution affects the types of animals that live at a site. Some types of animals live in or on sandy sediment without too much silt or clay while other types live in or on muddy (silt and clay) sediment.

From the results obtained the percentage of sand, silt and clay in each sample was calculated. The average percentages of sand, silt and clay at each site are shown in Figure 2.

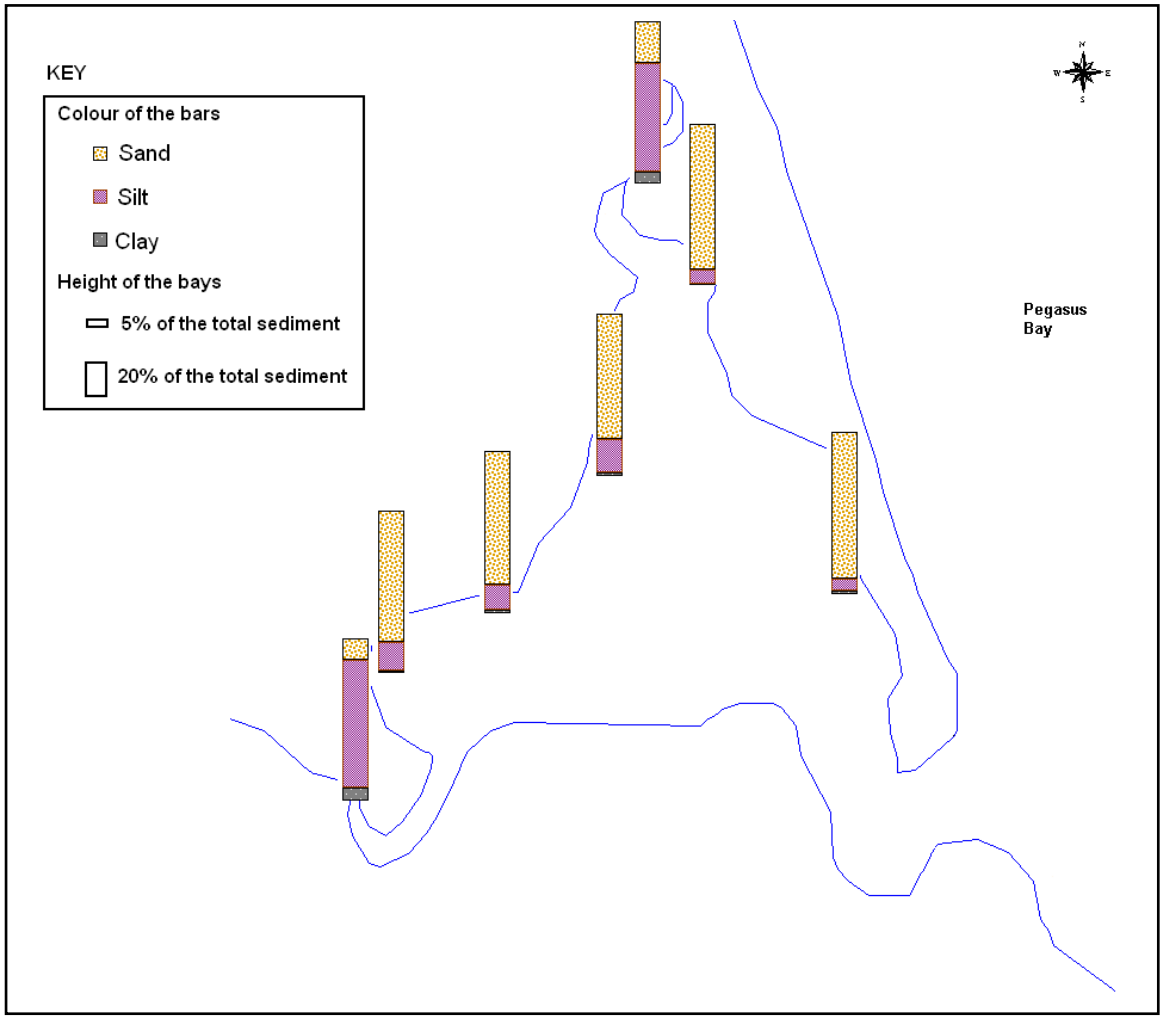

Figure 2 Percentage of sand, silt and clay at each site

The sediment at all sites in the estuary was predominantly sand (more than 75 %) with less than 20 % silt and 2 % clay. There was less sand and more silt at Discharge Point than at the other sites within the estuary. There was less silt at the sites on the eastern side than those on the western side of the estuary.

The sediment at the Avon and Heathcote river sites was predominantly silt (more than 65 %) with over 5 % clay and less than 25 % sand.

Organic matter content

Organic matter originates from living things and typically consists of dead plant and animal matter. Organic matter occurs naturally in sediments with sandy sediments typically containing less organic matter than muddy sediments. However, inputs of organic matter, such as from effluent and other wastewater discharges, can result in the amounts in the sediment being higher than normal. Elevated levels of organic matter can cause the oxygen in the sediment to be used up and affects the types and abundance of animals that can live in the sediment.

The median organic matter content at each site is shown in Figure 3.

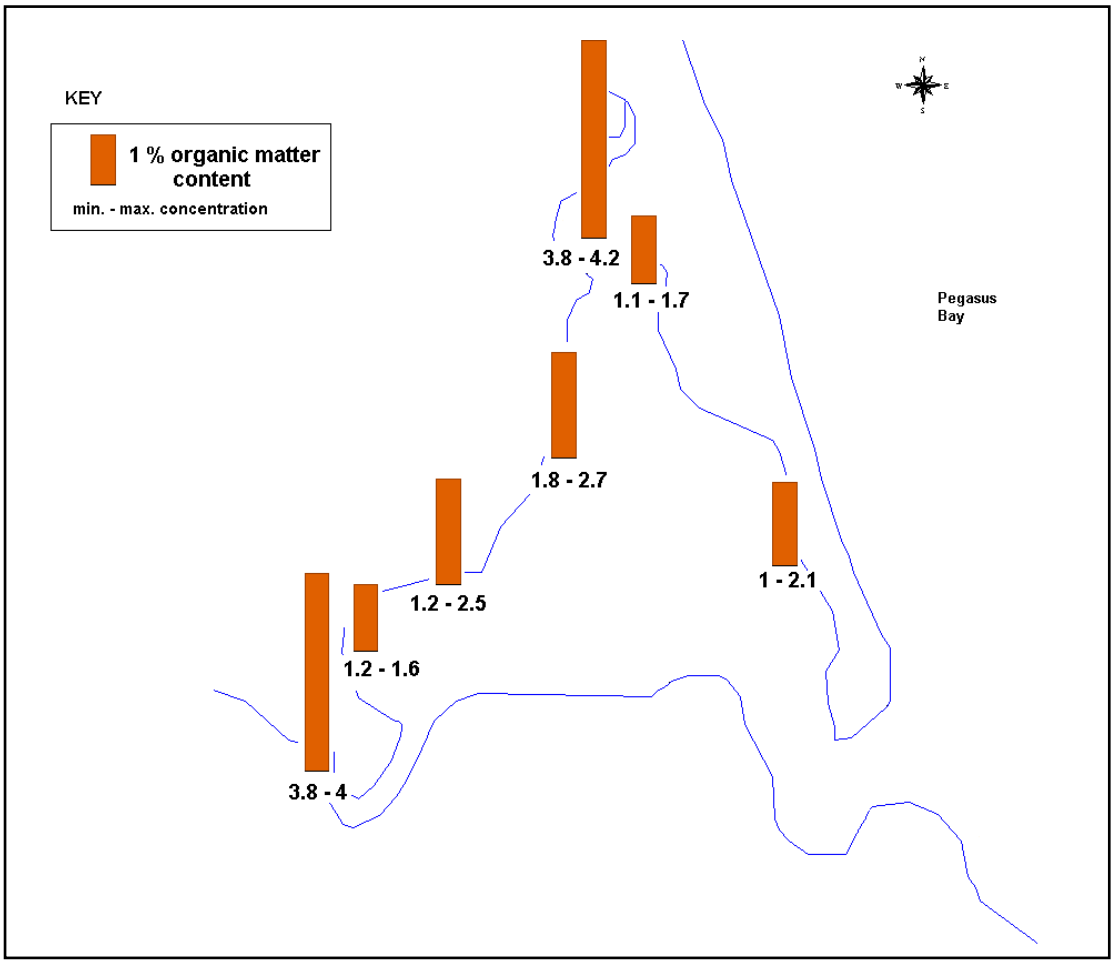

Figure 3 Organic matter content (%) each site

The sediment of the Avon and Heathcote tidal reaches contained more organic matter than that within the estuary. This is because the sediment in the tidal reaches was predominantly silt while that in the estuary was predominantly sand. That is, there is no evidence that unnatural inputs are influencing the organic matter content in the tidal reaches.

Within the estuary the organic matter content generally varied between sites. The content was highest, and comparable, at Discharge Point and Sandy Point and lowest at Humphreys Drive. It is possible that the plant plankton in the wastewater that is discharged into the estuary is the source of the organic matter to Discharge Point and Sandy Point. However, the wetland vegetation in proximity to Sandy Point could also contribute organic matter to this site.

Arsenic, cadmium, chromium, copper, lead, nickel and zinc

Arsenic

Arsenic occurs naturally in soil but some industries, preserved timber, old sheep dips and various organic herbicides and insecticides are sources of arsenic.

The median arsenic concentration at each site is shown in Figure 4.

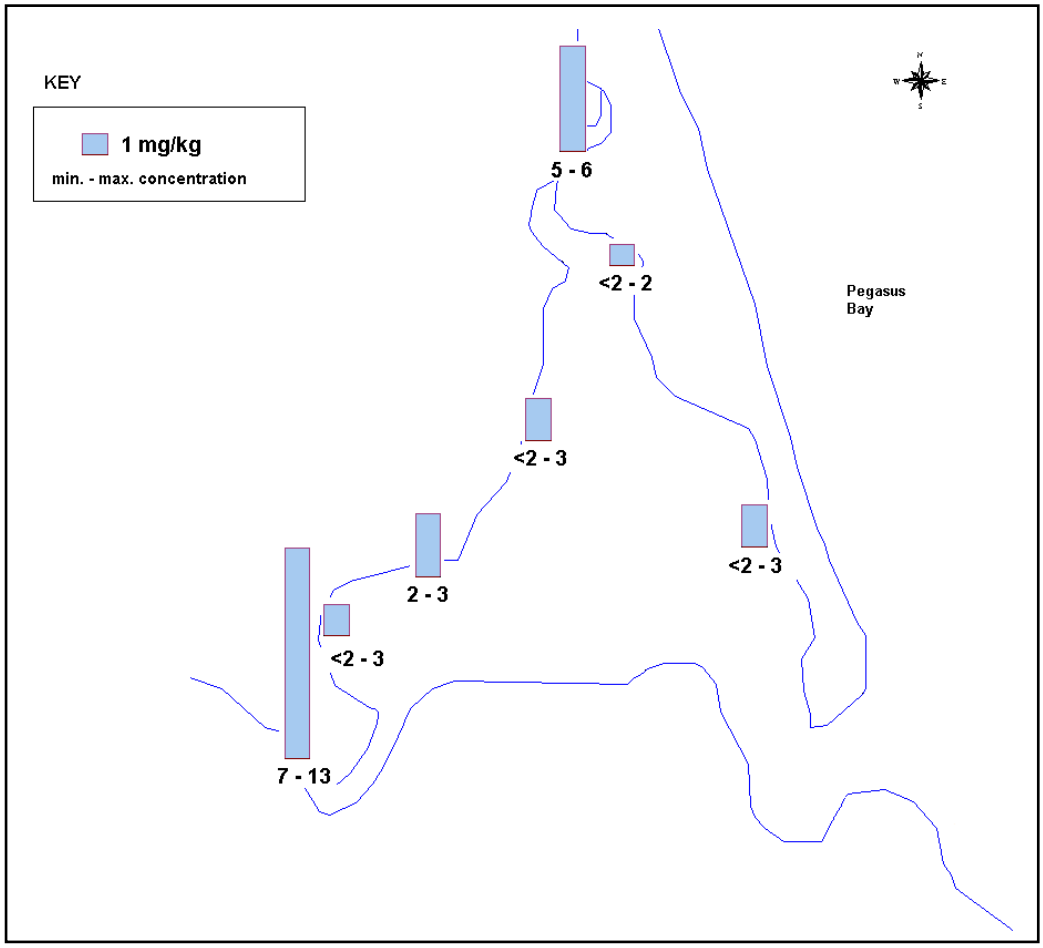

Figure 4 Arsenic concentrations (mg/kg) at each site

The highest arsenic concentrations occurred at the Heathcote River site. This arsenic may be as a consequence of historic industrial discharges into this river. However, more recent inputs from unknown sources cannot be discounted as the concentrations were in the top 20 mm of the sediment. Arsenic concentrations at the Avon River site were higher than those within the estuary. This difference between the Avon River site and these estuary sites is more than likely due to the difference in grain size composition.

The results for the estuary indicate that the treated wastewater that is discharged into the estuary is not a significant contributor of arsenic to the estuary environment.

For arsenic ANZECC (2000) ISQG-low is 20 mg/kg and the ISQG-high is 70 mg/kg. All concentrations recorded were lower than 20 mg/kg. That is, the arsenic concentrations in the estuary and rivers are unlikely to be having a detrimental impact on the plants and animals present.

Cadmium

The median cadmium concentration at each site is shown in Figure 5.

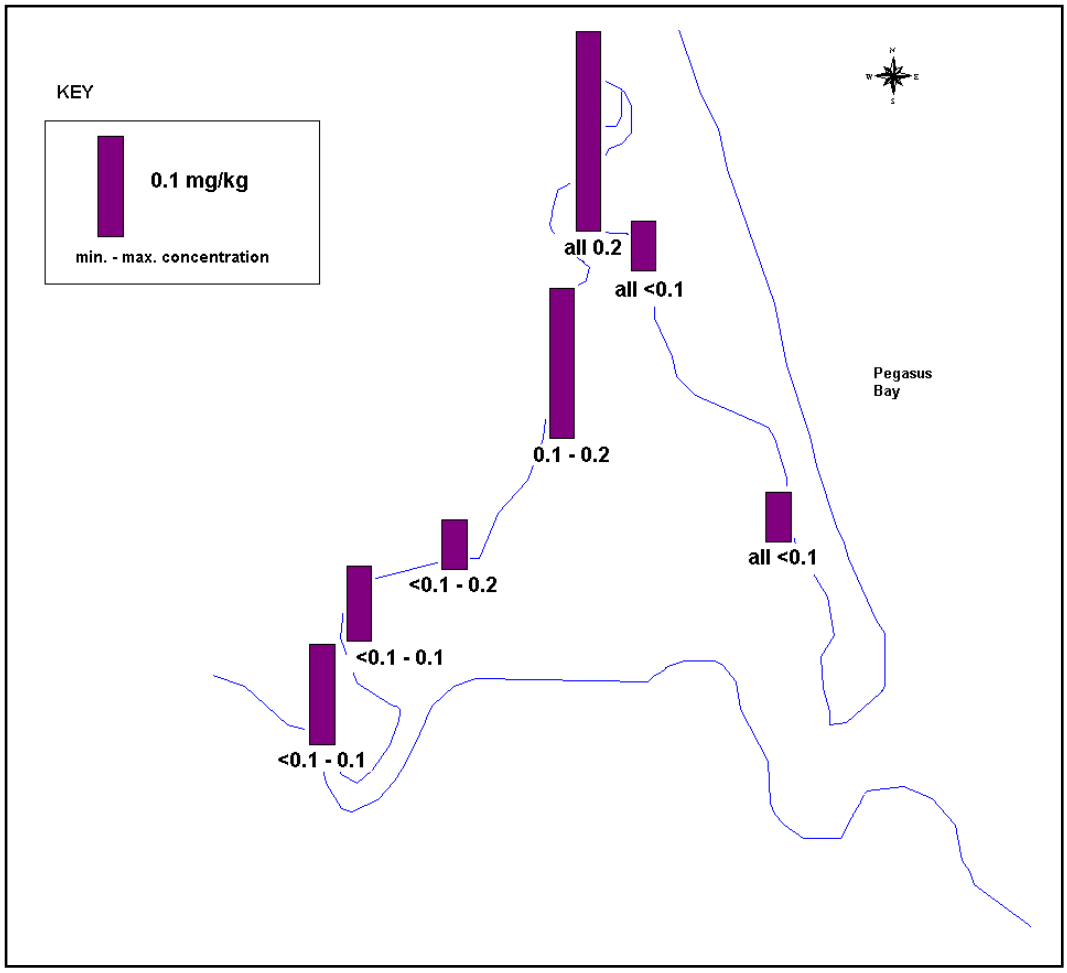

Figure 5 Cadmium concentrations (mg/kg) at each site

The difference in cadmium concentrations between sites is not due to differences in the sediment grain size composition. That is, cadmium inputs account for differences in concentrations between sites. The results indicate that the wastewater discharge from the oxidation ponds is a source of cadmium and there are inputs to the Avon River.

For cadmium ANZECC (2000) ISQG-low is 1.5 mg/kg and the ISQG-high is 10 mg/kg. All concentrations recorded were lower than 0.3 mg/kg. That is, the cadmium concentrations in the estuary and rivers are unlikely to be having a detrimental impact on the plants and animals present.

Copper, chromium, lead, nickel and zinc

The median copper, lead, and zinc cadmium concentrations at each site are shown in Figure 6 and the median cadmium and nickel concentrations at each site are shown in Figure 7.

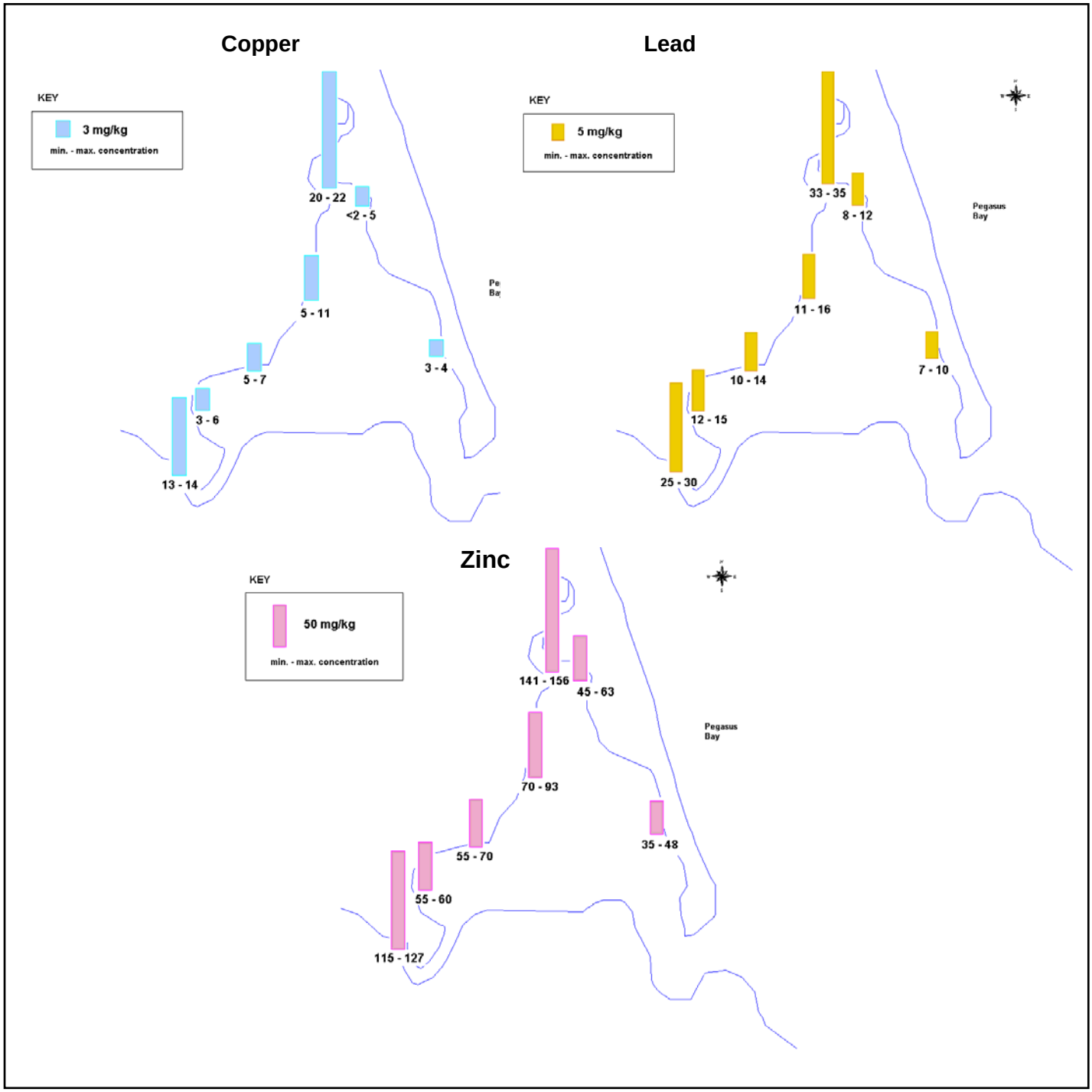

Figure 6 Copper, lead and zinc concentrations at each site

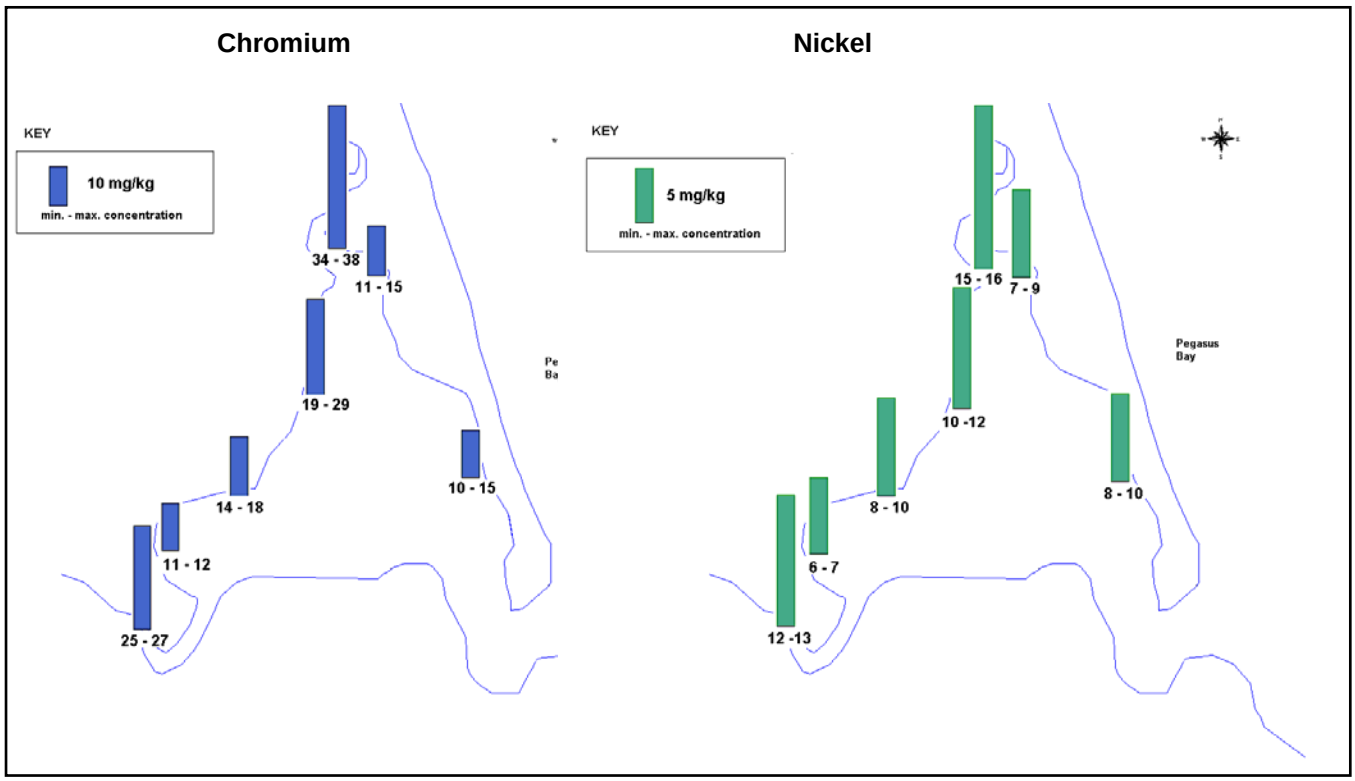

Figure 7 Chromium and nickel concentrations at each site

The difference in copper, lead and zinc concentrations between sites is due to differences in the sediment grain size composition. That is, there is no evidence that unnatural inputs of copper, lead and zinc are influencing their concentrations within the sediment.

For chromium and nickel the differences between sites are primarily due to differences in sediment grain size composition. However, the chromium concentrations at Discharge Point are higher than would be expected for the grain size composition there. That is, the oxidation pond discharge is a source of chromium to the sediments.

For copper ANZECC (2000) ISQG-low is 65 mg/kg and the ISQG-high is 270 mg/kg. All concentrations recorded were lower than 23 mg/kg.
For chromium ANZECC (2000) ISQG-low is 80 mg/kg and the ISQG-high is 370 mg/kg. All concentrations recorded were lower than 39 mg/kg.
For lead ANZECC (2000) ISQG-low is 50 mg/kg and the ISQG-high is 220 mg/kg.
All concentrations recorded were lower than 35 mg/kg.
For nickel ANZECC (2000) ISQG-low is 21 mg/kg and the ISQG-high is 52 mg/kg.
All concentrations recorded were lower than 17 mg/kg.
For zinc ANZECC (2000) ISQG-low is 200 mg/kg and the ISQG-high is 410 mg/kg.
All concentrations recorded were lower than 157 mg/kg.

That is, the copper, chromium, lead, nickel and zinc concentrations in the estuary and rivers are unlikely to be having a detrimental impact on the plants and animals present.

Biota

Plants and animals on the surface of the sediment

Number of different animals
A total of 26 types of animals were found to be present. Of these 26 types of animals 13 were of snails and shellfish, 2 were anemones, 6 were worms and 5 were crabs and hoppers.

The number of each type of animal living on the surface of the sediment at each site, is shown on Figure 8.

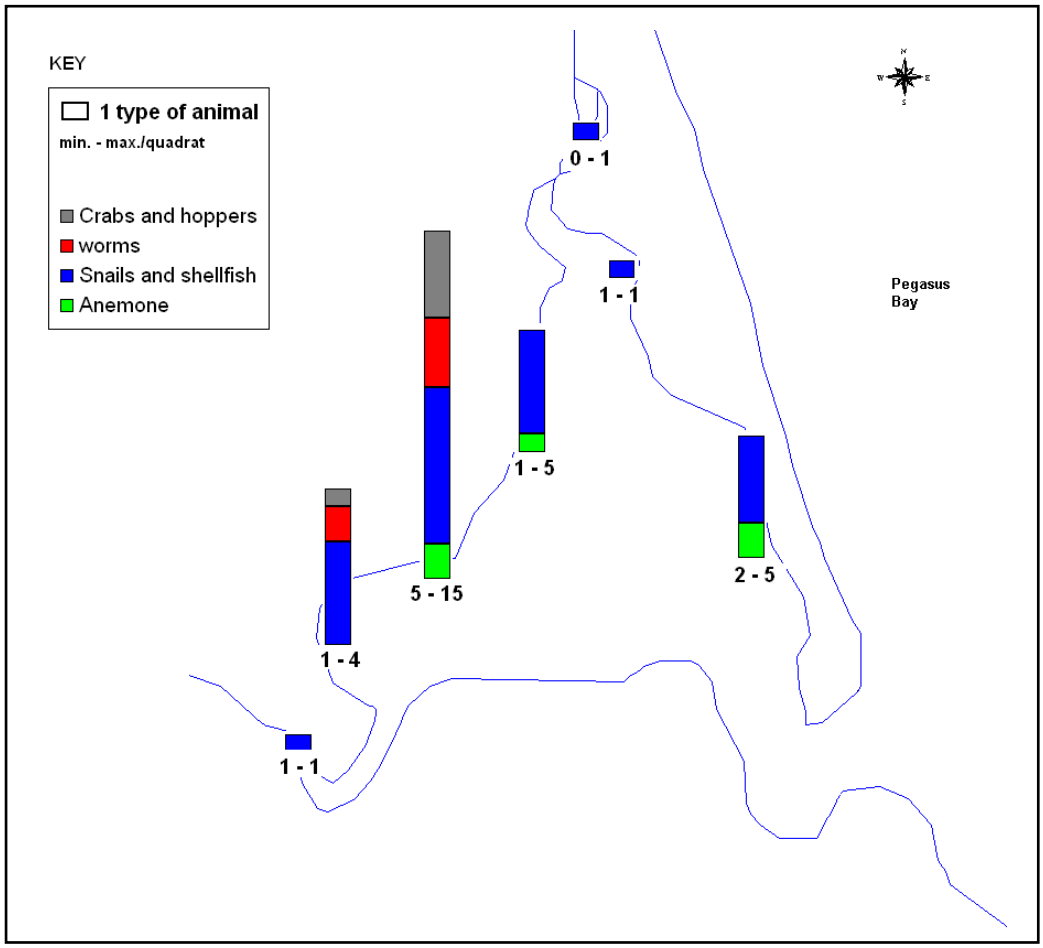

Figure 8 Number of different types of animals living on the sediment surface at each site

There were more types of animals at Sandy Point than at any of the other sites. There was only one type of animal at the Avon and Heathcote rivers and the Pleasant Point jetty sites. This animal was the mud flat snail.

Snails and shellfish were present at all sites, anemones were present at two sites and worms and crabs (not including crab burrows) and hoppers were present on the surface at two sites. The worms and crabs and hoppers were living amongst the sea weed that was on the surface of the mud.

Mudflat snail (Amphibola crenata)
Mudflat snails feed on the micro-organisms and organic matter in the sediment. As they feed they leave a string-like trail of waste on the surface of the mud. They lay there eggs into a tyre-like rim of mud. These egg cases can be seen on the mud surface from late November to March. Mudflat snails can tolerate a wide range of salinities and temperatures and exposure to air for considerable periods of time.

Number of snails
The average number of snails per m^2 at each site is shown on Figure 9.

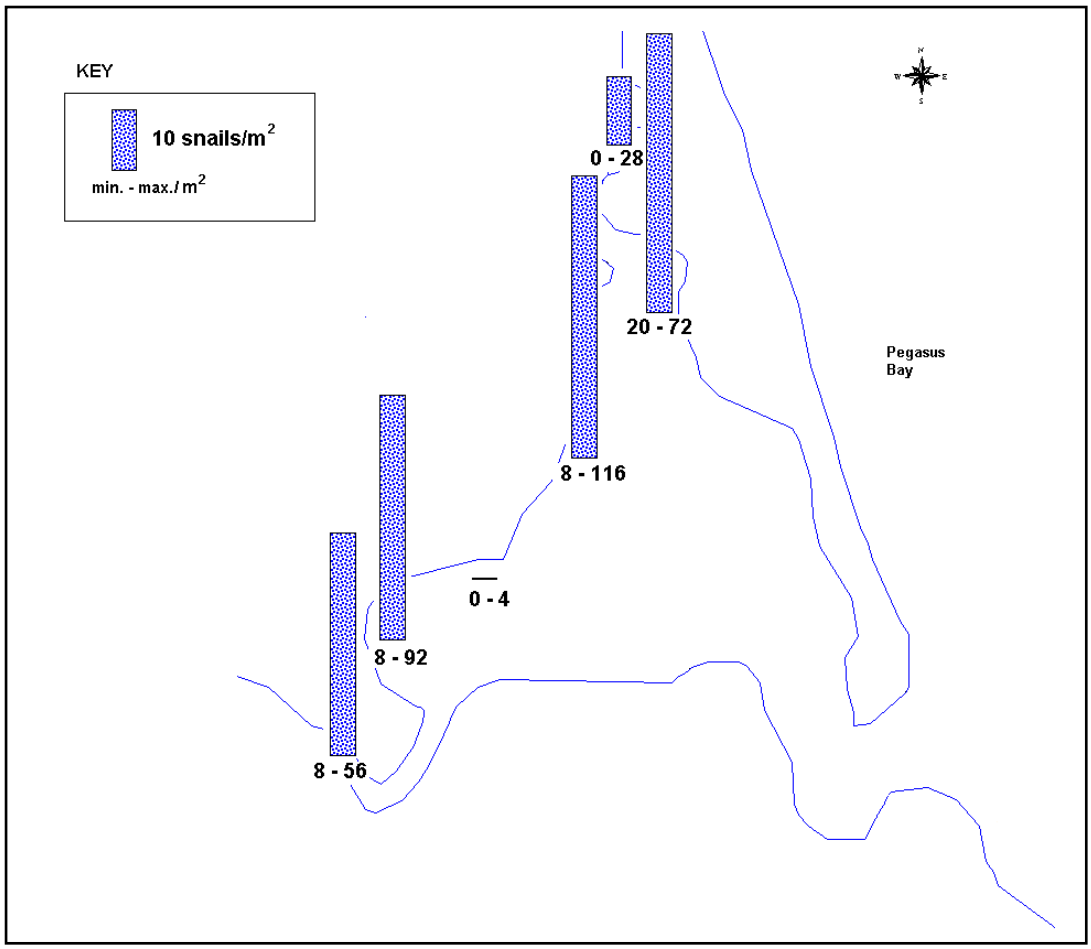

Figure 9 Average number of mudflat snails living on the surface of the sediment at each site

Mud flat snails did not occur at Plover Street and there were very few snails at Sandy Point. The average number of snails at Discharge Point and the Pleasant Point jetty was similar with slightly fewer snails at Humphreys Drive. There were more snails at the Heathcote River than the Avon River site.

Size of mud flat snails

The height distribution of all mud flat snails present in the fifteen quadrats sampled at each site are shown in Figure 10.

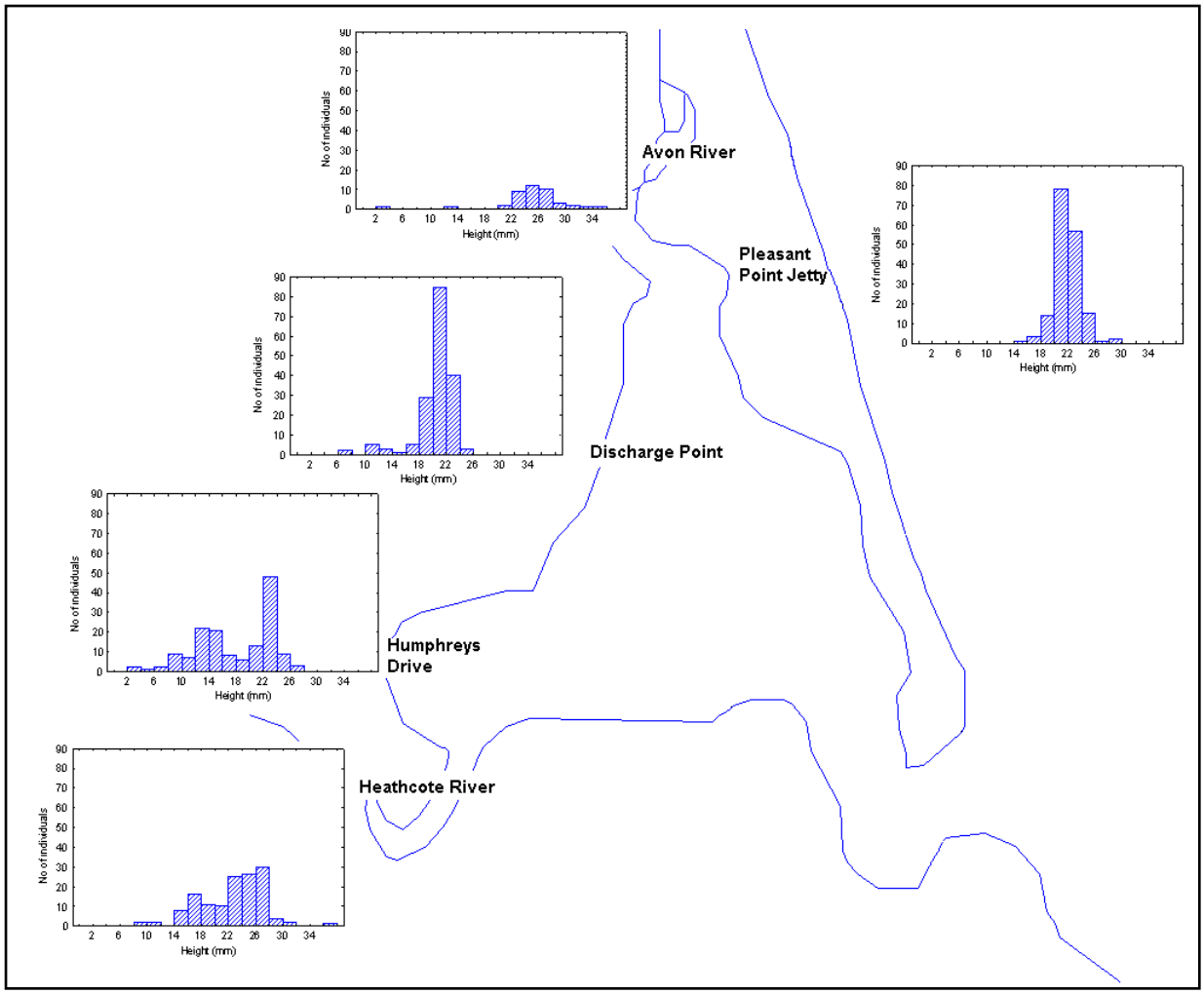

Figure 10 Height (mm) distribution of the mud flat snails at each site

There were no snails smaller than 14 mm at Pleasant Point jetty with four individuals (3 %) at the Heathcote River and seven individuals (4%) at Discharge Point smaller than 14mm. At the Avon River there were two individuals (5 %) smaller than 20 mm. That is, at these sites there were very few juvenile snails with almost all snails being adults. The snail population at Humphreys Drive consisted of juveniles and adults.

Crab burrows

Crab burrows are a common sight in the estuary. Burrows are easily counted but whether a crab lives in the burrow is not known nor is the type of crab in the burrow known. The two common crabs that burrow in the estuary are the stalk-eyed mud crab (*Macrophthalmus hirtipes*) and the short-eyed mud crab (*Helice crassa*).

The average number of crab burrows at each site is shown in Figure 11.

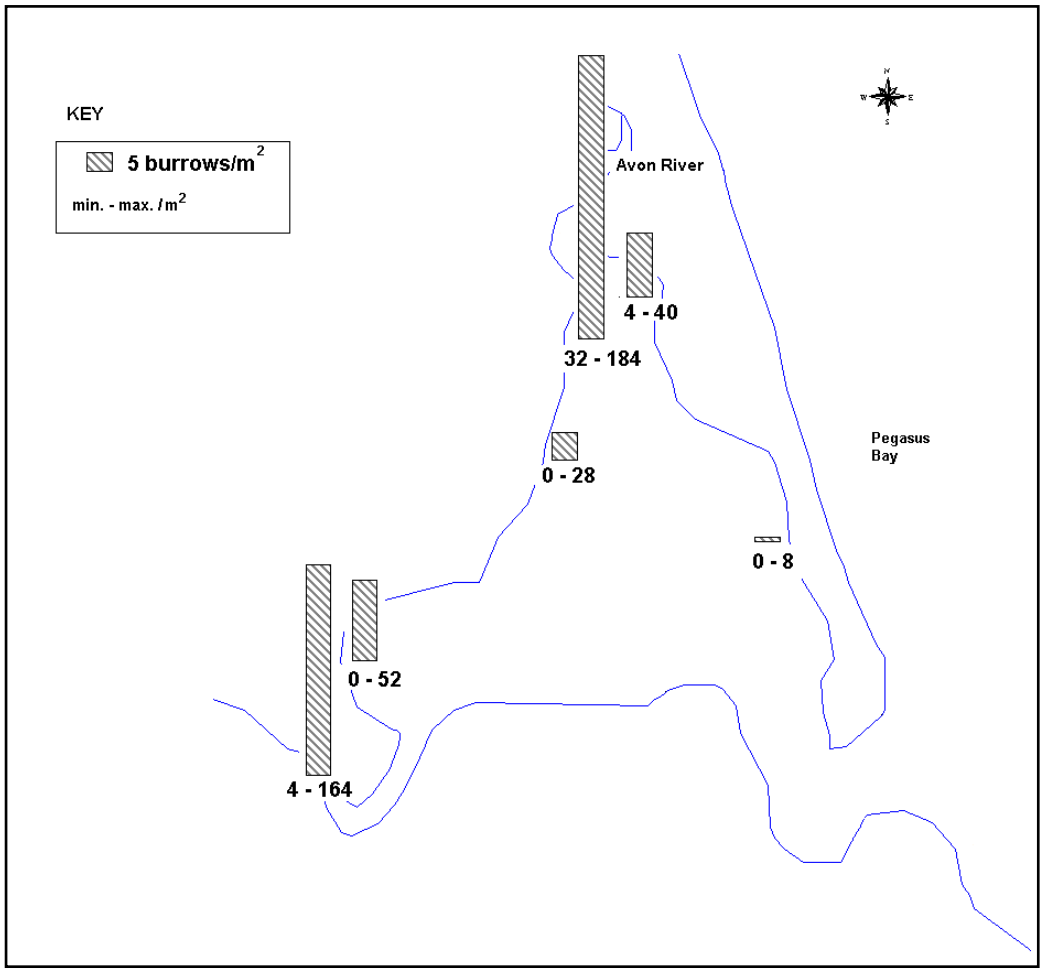

Figure 11 Average number of crab burrows at each site

Crab burrows were not present at Sandy Point and there were very few burrows at Plover Street. There were more crab burrows in the lower Avon and Heathcote rivers than in the estuary and there were more burrows in the Avon River than the Heathcote River.

Seaweed cover

The most abundant seaweed within the estuary is the green sea lettuce (*Ulva* sp.) with the red seaweed *Gracilaria chilensis* also common. Where these seaweeds occur they cover the mudflats, so in a quadrat it is the percentage of the mudflat covered by seaweed that is used as a measure of seaweed abundance.

The average percentage seaweed cover at each of the sites is shown in Figure 12.

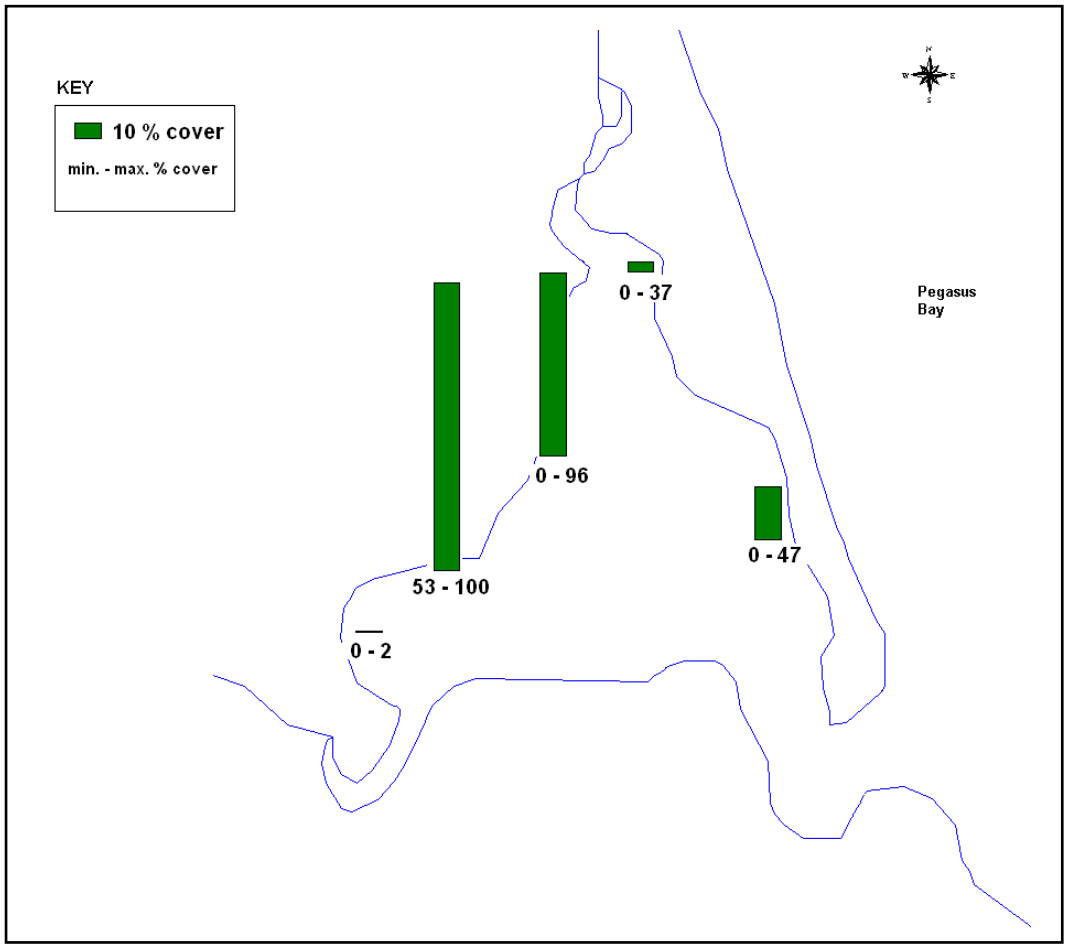

Figure 12 Average abundance of seaweeds (sea lettuce and *Gracilaria chilensis*) at each site

Seaweed was not present at the lower Avon and Heathcote river sites and there was very little at Humphreys Drive. At Pleasant Point jetty there was no seaweed in most of the quadrats but 37 % cover in one quadrat. At Discharge Point and Plover Street seaweed cover was patchy with no seaweed in some, and up to 96 and 47 % cover (respectively) in one or more, quadrats. At Sandy Point the mudflat was generally extensively covered with seaweed.

Animals that live in the sediment

Number of different animals
A total of 30 types of animals were found to be present. Of these 30 types of animals 8 were of snails and shellfish, 3 were anemones, 14 were worms and 5 were crabs and hoppers.

The number of each type of animal living in the sediment at each site is shown in Figure 13.

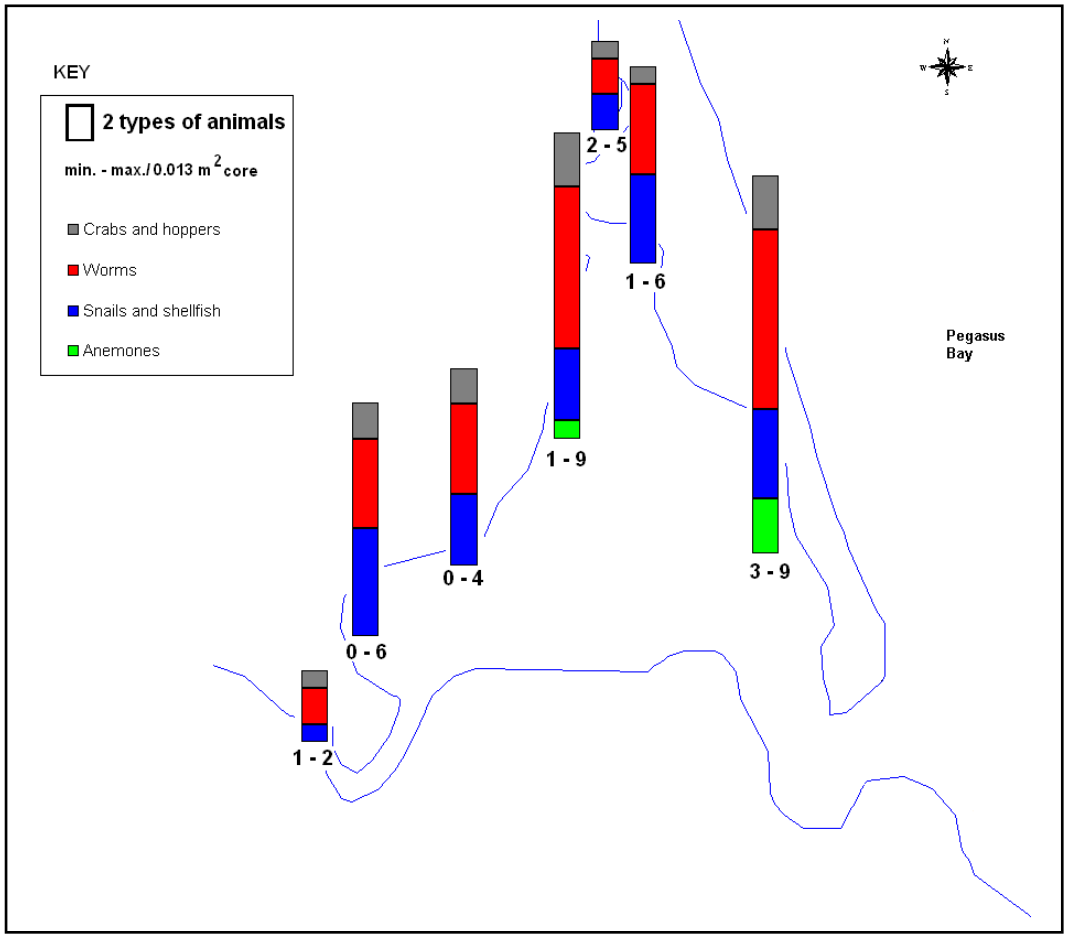

Figure 13 Number of different types of animals living in the sediment at each site

Worms, snails and shellfish and crabs and hoppers were present at every site while anemones were only present at Discharge Point and Plover Street.

At Discharge Point, Plover Street, Sandy Point and Heathcote River there were more types of worms than types of crabs and hopper or snails and shellfish or anemones. At Humphreys Drive, Pleasant Point jetty and the Avon River the number of worm and snails and shellfish species was similar. There were more types of crabs and hoppers at Discharge Point and Plover Street than at the other sites.

There were more types of animals at the sites in the estuary than in the rivers. Within the estuary there were more types of animals at Plover Street than at the other sites. There was a similar number of different types of animals at Pleasant Point jetty, Sandy Point and Humphreys Drive. There were no animals in some samples from Humphreys Drive and Sandy Point.

Number of animal individuals
The average number of animals per square metre is shown in Figure 14.

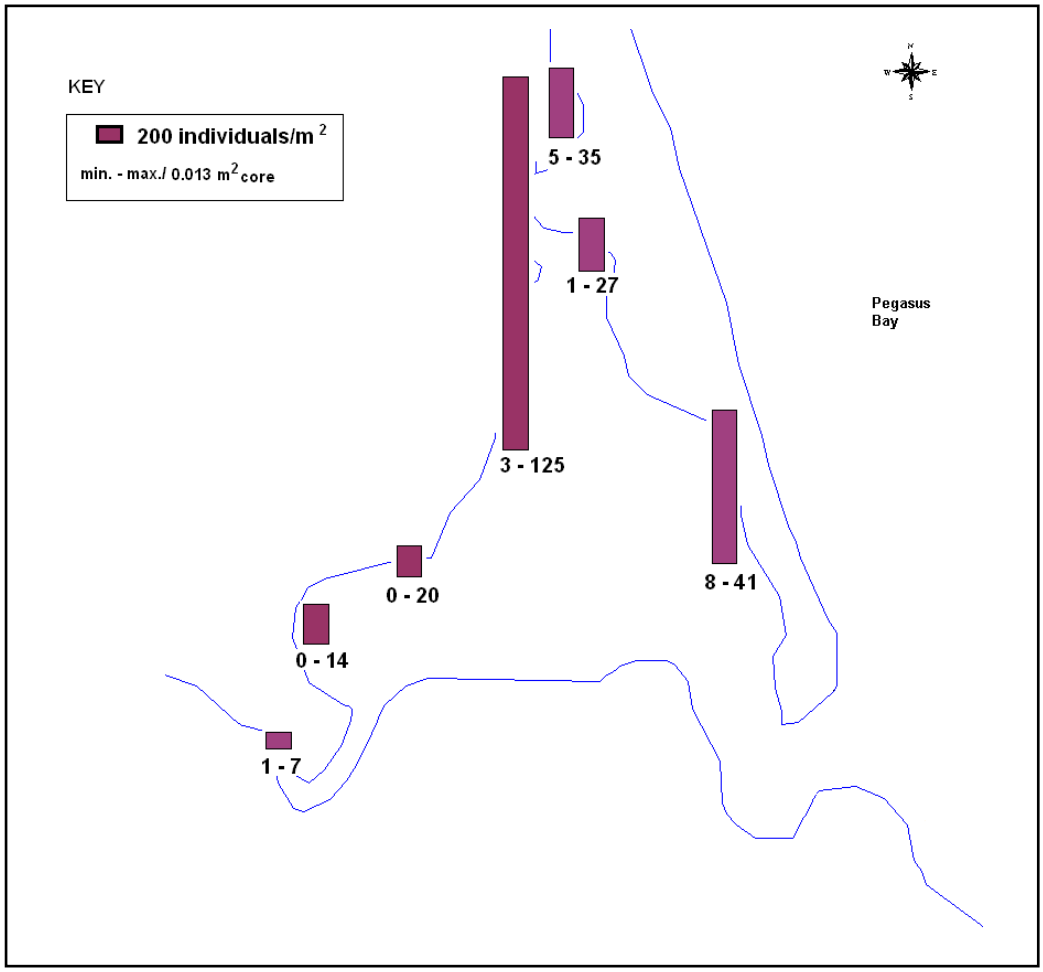

Figure 14 Average number of animal individuals living in the sediment at each site

More individuals were present at Discharge Point than at any other site. The average number of individuals at Plover Street was about half that at Discharge Point but about three times that at Pleasant Point jetty and Humphreys Drive. The estuary site with the lowest average number of individuals was Sandy Point. There were more animal individuals at the lower Avon River than the lower Heathcote River site.

The proportion of individuals of each type of animal present at each site is shown in Figure 15.

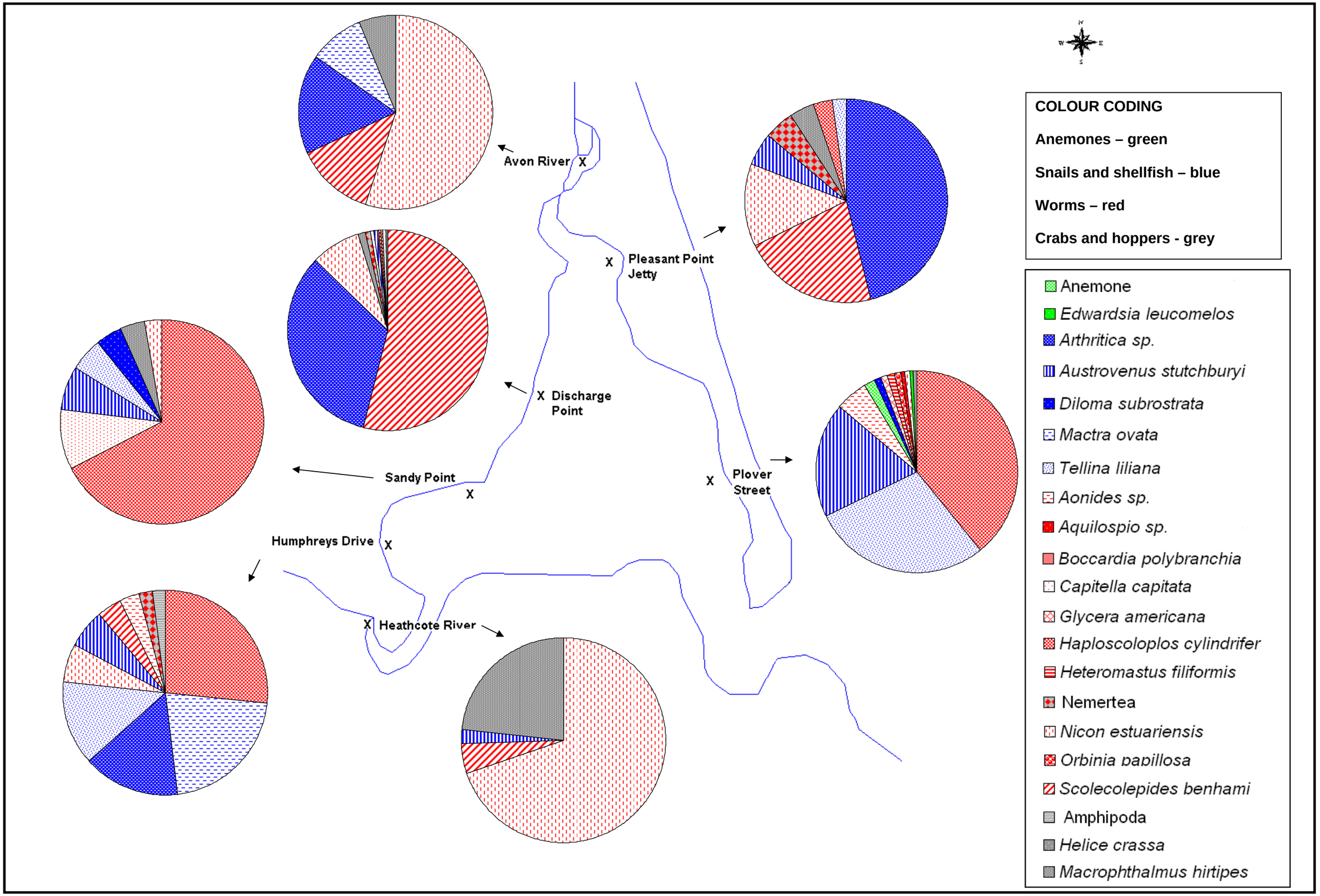

Figure 15 Proportion of individuals of each type of animal living in the mud

Size of cockles (Austrovenus stutchburyi)
The length distribution of the cockles present in the fifteen quadrats at each site are shown in Figure 16.

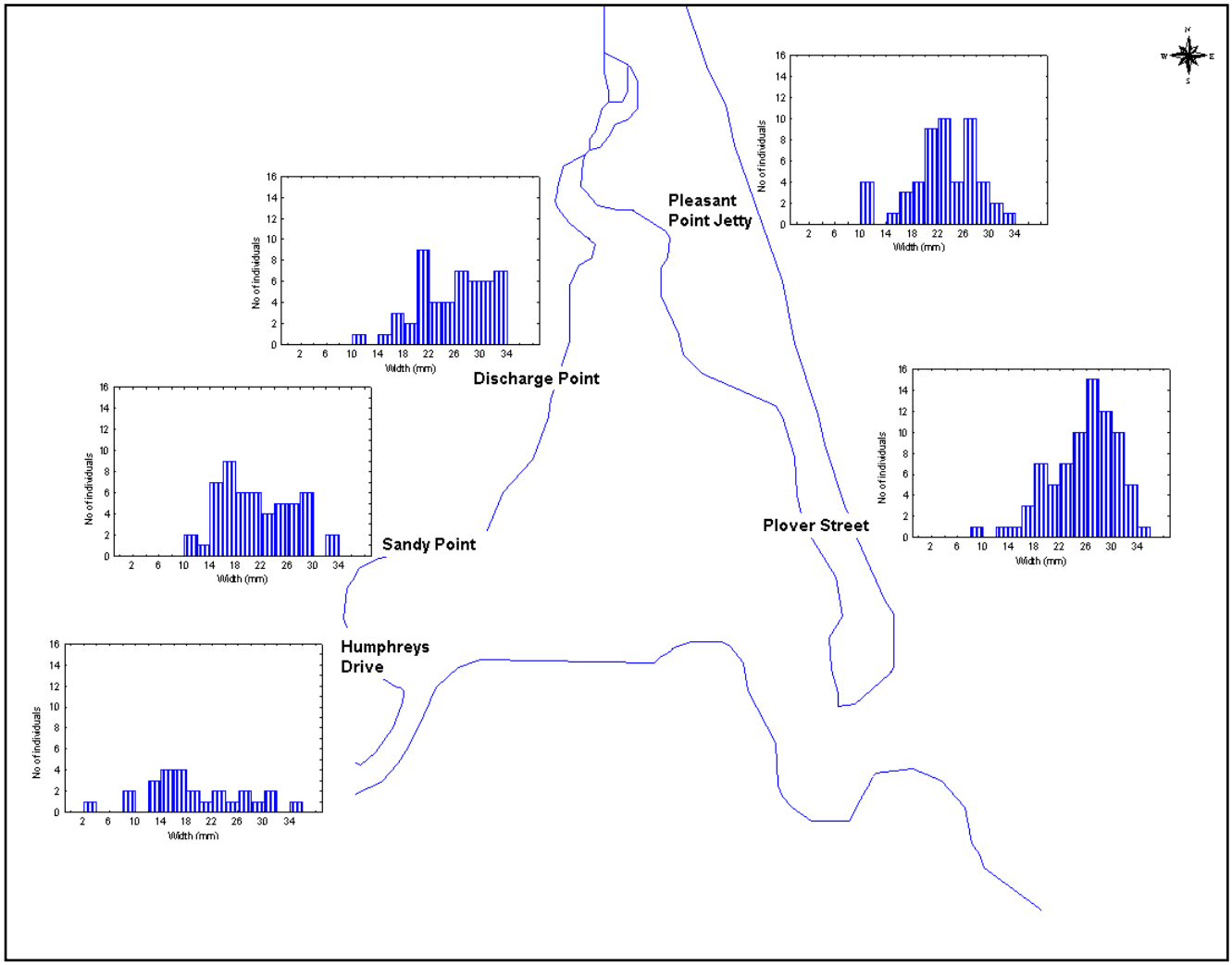

Figure 16 Length (mm) distribution of cockles at each site

No cockles were found at the lower Avon River site while there were some cockles present in the cores from the lower Heathcote River site. Cockles were present at all sites within the estuary.

There were no cockles smaller than 10 mm at Pleasant Point jetty, Discharge Point and Sandy Point, with two individuals (8 %) at Humphreys Drive and one individual (1%) at Plover Street smaller than 10mm. At all sites the largest individuals were 33 – 36 mm long. There were more large cockles at Plover Street than at the other sites.

Conclusion

Sediments

There were differences in the sediment grain size between sites. In general the sediment in the tidal reaches was mostly mud (mud = silt+clay) while in the estuary it was mostly sand. There were small differences in the grain size between sites in the estuary. The differences in grain size between sites accounts for the differences in organic matter content, copper, lead and zinc and to some extent the chromium and nickel concentrations between sites. However, the results indicate that:

- the wastewater discharged from the oxidation ponds is a source of organic matter, cadmium and chromium to the sediment at Discharge Point (the site in close proximity to where the wastewater is discharged into the estuary)
- there is arsenic contamination of the sediment of the Heathcote River tidal reach

The arsenic, cadmium, copper, chromium, lead, nickel and zinc concentrations in the estuary and rivers are below ANZECC (2000) trigger values and are unlikely to be having a detrimental impact on the plants and animals present.

Biota

There were differences in the types and abundance of animals living on and in the sediments between sites.

The low number of different types of animals in the tidal reaches of the Avon and Heathcote rivers is because of the typically low salinity at these sites.

It is likely that there more types of animals living on the surface of the sediment at Sandy Point than at any other site in the estuary because of the extensive coverage of the site by seaweeds. The people collecting and analysing the samples did note that there were lots of animals living on and under the seaweed.

At all sites there were a range of types of animals living in the sediment. The types of animals and their abundances differed between sites. That is, in term of the type and abundance of animals present, each site was biologically different.

Overall

Routine monitoring of the sediments and biota will provide information on their state each year and allow for comparisons over time. In particular it will allow us to determine if there are changes to the sediments and biota as a result of the removal of the wastewater discharge to the estuary.

References

ANZECC (Australia and New Zealand Environment and Conservation Council) 2000: *Australian and New Zealand Guidelines for fresh and marine waters.* Australia and New Zealand Environment and Conservation Council. Melbourne

Robertson, B., Gillespie, P., Asher, R., Frisk, S., Keeley, N., Hopkins,G., Thompson, S and Tuckey,B. 2002. Estuarine environmental assessment and monitoring: A national protocol. Part A. Development, Part B. Appendices, and Part C. Application. Prepared for supporting Councils and the Ministry for the Environment, Sustainable Management Fund Contract No 5096. Part A. 93p. Part B 159p. Part C. 40p plus field sheets.

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