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(NATURAL ENVIRONMENT RESEARCH COUNCIL)

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NATIONAL ENVIRONMENT PROGRAMME: MONITORING OF THE DENVER LICENCE. THE 2006-2007 SURVEYS OF INTER-TIDAL SEDIMENTS, INVERTEBRATES AND BIRDS OF THE S E WASH.

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CONTENTS

EXECUTIVE SUMMARY

1. The work reported here forms part of a study whose purpose is to monitor and evaluate the impact on the inter-tidal sediments, invertebrates and the shorebirds that eat them, of variations in the flow of freshwater into the south-east corner of the Wash via the river Great Ouse. This report deals with the results of sediment, invertebrate and shorebird surveys of the inter-tidal areas of the Wash adjacent to the outfall of the river Great Ouse made during autumn and winter of 2006-2007 (September -January). Comparisons are made with the results of 2005-2006 surveys, with particular consideration being given to how any changes were related to the distance from the river's outfall.

2. Sediment and invertebrate samples were taken from 42 sites during late September and October 2006. Bird surveys were undertaken during the period late-November 2006 to late January 2007. These surveys followed a 12 month period (September 2005 to August 2006) during which freshwater flow into the Wash from the Gt Ouse of 449.3 Mm^3 was considerably lower than the long-term average of 1005 Mm^3 for the period 1974 to 2005.

Changes in sediment particle size and organic content between the 2005 and 2006 surveys.

3. Of the 42 sites sampled, 30 were muddy and 12 were sandy. All sites located on the shore to the west of the Gt Ouse were muddy. Most sites (13 out of 22 sites) on the shore to the east of the river were also muddy. The exceptions were mid-to low- level sites of transects 18, 19 and 20 which were sandy. On the outer banks three sites were muddy and three were sandy.

4. Overall there was very little change in the sediment type of sites within the study area between the 2005 and 2006 surveys. Of the 42 sites there were 30 muddy sites in 2006 compared to 31 in 2005. The difference was due to three sites changing from mud to sand in 2006 (sites 18.7, 18.8 and 19.3 on the east shore) and two sites changing from sand to mud (site D2 on Daseley's Sand and 17.7 on the west shore). Although one fewer sites was classed as mud in 2006 than in the previous year, most sites became muddier.

5. After the effect of changes in the proportion of fines in the sediment was taken into account, the sediment's organic content over the whole of the study area in 2006 differed significantly from that in 2005 due to sandier sites being less organically rich in 2006 than they were in the previous year. The organic content of the muddier sites was unchanged.

6. The sediment organic content did not differ significantly between 2005 and 2006 in most of the 10 individual sampling transects. The exceptions were transects 16, 18, and 19. In both transects 16 and 18, sites with the muddiest sediments were more organically rich in 2006 than they were in the previous year, whereas in transect 19, all sites were significantly less rich in 2006 compared to 2005.

7. During the course of the study sediments were muddiest in 2000 and sandiest in 1998 in both the inner bank areas and the entire area, while sediments in the current survey were similar to the average for the inner bank areas but the fourth muddiest for the entire study

area. Sediment organic content was highest in 2005 and lowest in 1999 in both areas. In the current survey the organic content was the fourth highest out of the 12 surveys of the inner banks and third highest of the 10 surveys of the entire study area.

Changes in invertebrate densities between the 2005 and 2006 surveys.

7. Of the 71 invertebrate families or species and species size categories that were sufficiently abundant to allow statistical comparisons to be made, the densities of 17 of them changed significantly over the whole study area between the 2005 and 2006 surveys.

8. Of the worms, two increased in density while that of seven other species decreased in 2006 compared with 2005.

9. Of the crustaceans, small shore crabs *Carcinus maenas* increased in density in 2006 compared with 2005.

10. The density of five molluscs decreased significantly in 2006 compared with 2005 densities while two others increased in density.

11. There was no statistical evidence of the spatial changes in invertebrate densities being associated with the distance from the Gt Ouse outfall, even after the changes in sediment particle size and organic content between the two years and the shore level had been taken into account.

12. Annual variations in the densities of the main classes of invertebrates were summarized as follows. Over the 12 successive years of this study, worm densities were at their lowest in 1996 and with the exception of 1998, increased annually until 2003 but have declined since then to a point where the 2006 density is almost as low as that in 1996. Crustacean density was lowest in 1996 and again in 2000 since when it increased annually to the highest density recorded in 2003. It dropped markedly in 2004, increased in 2005 but in the current survey, decreased to a density that was the fourth lowest for the period of the study. There had been a general upward trend in snail densities between 1996 and 2001 but they dropped in 2002 since when they have risen annually to the highest density ever recorded in the study in the 2005 survey. However, densities dropped in the current survey. Bivalve mollusc density was at its highest in 2000 when there was a large spat-fall of many species, notably cockle and *Macoma*. Since then their densities have remained relatively low with the 2006 density around the average for the period of the study.

Changes in bird numbers between the 2005-2006 and 2006-2007 surveys.

13. As in previous winters, the number and distribution of seven species of wading birds and the shelduck feeding at low tide in the study area was surveyed on two occasions between late November 2006 and late January 2007.

14. All species with the exception of knot, were less abundant in 2006-07 than they were in the previous winters' survey.

15. Dunlin, redshank and curlew were the most widespread species occurring in most of the survey transects including those adjacent to the Gt Ouse. In contrast to the former three species, the distributions of knot, grey plover, bar-tailed godwit, oystercatcher and shelduck were aggregated in a few parts of the study area.

16. There was no evidence of any relationship between the change in bird distribution between the current and previous survey and distance from the Gt Ouse outfall for any of the species except shelduck. Its numbers decreased most in areas near the outfall.

17. Change in shorebird numbers within the study area between the current winters' survey and the previous winter was compared with that recorded the whole Wash to determine whether changes were local or Wash-wide. Relative to the winter of 2005-06, the numbers of all species except knot decreased in the study area in winter 2006-07. In the case of grey plover, shelduck and, to a lesser extent, redshank, this decrease was of a similar proportion to that in the whole Wash implying that changes were Wash-wide. This was also the case for the increases recorded in knot numbers. In contrast, the decrease in dunlin, bar-tailed godwit, oystercatcher and curlew numbers in the study area was not matched in the whole Wash where numbers increased. This implies that the study area was much less preferred for feeding by these species in winter 2006-07.

18. The numbers of shorebirds feeding on the inner banks of the Gt Ouse study area at low tide have been surveyed for a total of 15 winters to date and were summarised to put into perspective the changes that have occurred during the course of this study.

1. INTRODUCTION

The work reported here forms part of a study whose purpose is to monitor and evaluate the impact on the inter-tidal sediments, invertebrates and the shorebirds that eat them, of variations in the flow of freshwater into the south-east corner of the Wash via the river Great Ouse.

1.1 Objectives

Our study has the following objectives.

i) To monitor the particle size and organic content of sediments, the densities of invertebrates and the numbers of shorebirds feeding on the inter-tidal area adjacent to the Great Ouse outfall by annual surveys.

ii) To relate changes detected by the monitoring surveys to the distance from the outfall and to variations in river flow.

1.2 Reporting strategy

This report, like those produced annually since 1996-97, deals with objective i) and addresses year on year changes in distribution of sediments, invertebrates and birds and how these changes relate to the distance of the areas concerned from the Gt Ouse outfall. The underlying assumption being that any impact of variations in freshwater flow is most likely to be evident in those areas closest to the river outfall.

1.3 River flow conditions prior to the 2006-2007 surveys

River flows in the Gt Ouse during the 12 months (September 2005 to August 2006) preceding the 2006-2007 surveys resulted in a discharge volume into the Wash of 449.3 million cubic metres (Mm^3) which was approximately 205 Mm^3 less than was discharged prior to the previous years' survey. The average for the same 12-month period from 1974 to 2005 was 1005 Mm^3, therefore, the current survey followed a period of much lower than average river flow. Indeed it was the 2nd lowest recorded over the period of this study (behind flows in 1997).

2. SURVEY AND SAMPLING METHODS

A full description of the survey and sampling methods used in this study were given in Volume 2 of our report of the 1996-97 surveys (Yates *et al* 1998) so only a summary is given here. Readers requiring details are referred to that report, copies of which are held by Black and Veatch, or to the author. Details of specific statistical analyses used are presented in the relevant parts of the Results and Discussion section.

2.1 Survey areas and sample sites

Sediment and invertebrate samples are taken from sites, 1 ha in area, arranged in 10 transect lines orientated from upper to lower levels of the shore within the Gt Ouse study area (Figure 2.1)

Forty-two of the 45 sites that had been sampled since 1997 were again sampled in 2006. The exceptions were site 2 of transect 19 which was abandoned in 2002 because of encroaching salt-marsh vegetation and site 2 in transects 17 and B which were abandoned in 2003 for the same reason.

At each site, samples of sediment were taken to a depth of 2.5cm from five, randomly selected locations and placed in sealed plastic bags. These samples were frozen as soon as possible after collection. In addition five samples of substrate were taken using two, 10cm diameter by 30cm deep cores and the invertebrates were sieved from them on site using a 0.5mm mesh sieve. These invertebrate samples were placed in plastic pots and fixed in 4% buffered formaldehyde solution made up with sea-water.

Shorebird surveys were made over the inter-tidal areas shown in Figure 3.3.1. The distribution and number of feeding shorebirds was determined by walking an area, following a route that minimised disturbance, and observing the birds through a telescope.

Sediment and invertebrate sampling was undertaken during spring tides during late September and October 2006. Two shorebird surveys were undertaken during the period late-November 2006 to late January 2007. Each survey was conducted at the same time of year as previous surveys to allow them to be directly compared.

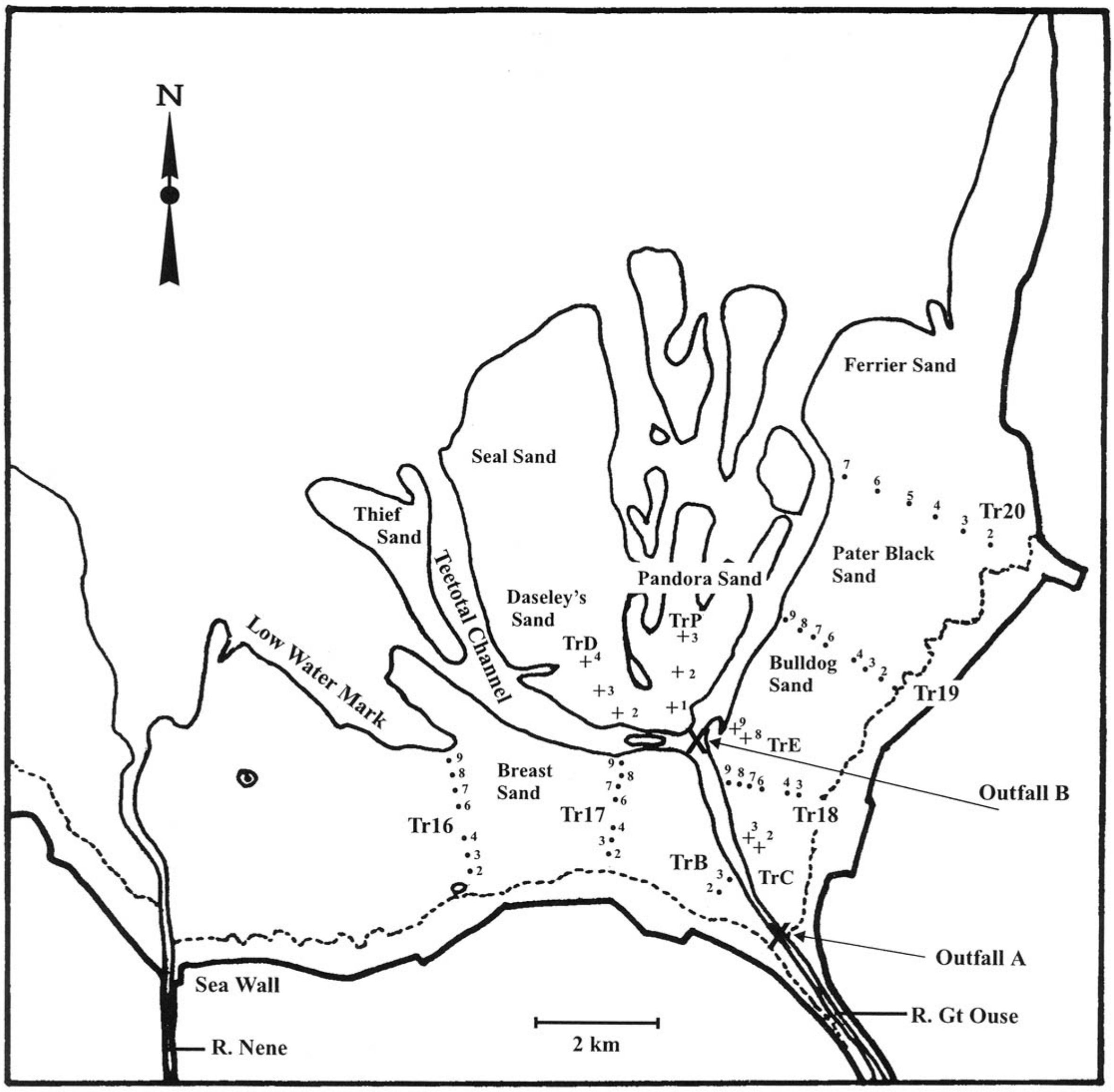
Section 2

Figure Legends

Figure 2.1 The ITE (now CEH) sediment and invertebrate sample sites. Sites that have been sampled each year since 1996 are shown as solid circles. Additional sites on Bulldog, Daseley's and Pandora Sands that were first established and sampled in 1997 and sampled thereafter are shown as crosses. *Note that sites 2 in transects 19 and in transects 17and B were abandoned in 2002 and 2003 respectively, because of encroaching salt-marsh vegetation.

Figure 2.1 The sediment and invertebrate sample sites. Sites that have been sampled each year since 1996 are shown as solid circles. Additional sites on Bulldog, Daseley's and Pandora Sands that were first established and sampled in 1997 and sampled thereafter are shown as crosses. *Note that sites 2 in transect 19 and in transects 17and B were abandoned in 2002 and 2003 respectively, because of encroaching salt-marsh vegetation.

Fig 2.1 CEH Sediment and Invertebrate Sampling Sites



3. RESULTS AND DISCUSSION OF THE 2006-2007 SURVEYS

3.1 Sediments

The sediments' particle size distribution has been summarised using the proportion of the particles less than 63 microns (<63μm) in diameter as in the reports of our previous surveys. This fraction contains silts and clays, and is collectively termed 'fines'. The fraction greater than 63 microns (>63μm) is called 'sands'. We have found this summary statistic, rather than mean or median particle size, to be the most useful for understanding the influence of particle size on the sediments' organic content and on the invertebrate fauna. Using this convention we defined muddy sediments as those in which the proportion of fines exceeds 25% as opposed to sandy sediments in which the fine fraction was 25% or less.

3.1.1 Sediment distribution in 2006

Figure 3.1.1 shows the spatial distribution of muddy and sandy sites within the study area in 2006. Of the 42 sites sampled, 30 were muddy and 12 were sandy. All sites located on the shore to the west of the Gt Ouse were muddy. Most sites (13 out of 22 sites) on the shore to the east of the river were also muddy. The exceptions were mid-to low- level sites of transects 18, 19 and 20 which were sandy. On the outer banks three were muddy and the remaining three were sandy.

3.1.2 Changes in sediment particle size between 2005 and 2006

Overall there was very little change in the sediment type of sites within the study area between the 2005 and 2006 surveys. Of the 42 sites there were 30 muddy sites in 2006 compared to 31 in 2005 (Figures 3.1.1 and 3.1.2). The difference was due to three sites changing from mud to sand in 2006 (sites 18.7, 18.8 and 19.3 on the east shore) and two sites changing from sand to mud (site D2 on Daseley's Sand and 17.7 on the west shore). Although one fewer site was classed as mud in 2006 than in the previous year most sites became muddier.

The amount by which the proportion of fines in the sediment changed between the two surveys is shown for each site within a sampling transect in Figures 3.1.3a-j. Because the same 1 hectare blocks are sampled in each survey, we were able to determine the statistical significance of annual changes by performing one-way ANOVA on the mean of the five random samples taken at each site. All sites in transect 16 were muddy in both years, though sites 2 and 3, were significantly muddier in 2006 than in 2005 but site 7 was significantly sandier (Figure 3.1.3a). In transect 17, all sites were muddy with sites 7 and 9 becoming significantly muddier in 2006 (Figure 3.1.3b). The single remaining site in transect B was significantly less muddy in 2006 than it was in 2005 (Figures 3.1.3c). Transect C sites remained muddy in 2006 but site 2 became significantly less muddy compared to 2005 while site 3 became significantly muddier (Figure 3.1.3d). All sites, except site 9 in transect 18 were sandier in 2006 with sites 3, 6, 7 and 8 becoming significantly so (Figure 3.1.3e). Both sites in transect E remained muddy in 2006 (Figure 3.1.3f). In transect 19; the only significant change occurred at site 3 which became significantly sandier in 2006 than in the previous year (Figure 3.1.3g). Although still classed as sand, all the mid-lower shore sites (sites 4-7) of Transect 20 except site 4 were significantly muddier in 2006 than they were in 2005 (Figure 3.1.3h). Sediment on Daseley's Sand (Figure 3.1.3i) became significantly muddier at site D2 in 2006 but remained sandy at the other two sites. On Pandora Sand site 1 became significantly muddier in 2006, while sites 2 and 3 remained classed as sandy with site 3 becoming significantly sandier (Figure 3.1.3j).

Figure 3.1.4 shows the changes in the proportion of fines in the sediment between 2005 and 2006 at each sample site in relation to its distance from two points labelled A and B in Figure 2.1. We defined these points respectively as the high tide and low tide outfalls of the river Gt Ouse. There was no statistically significant relationship between sediment change at a site and distance from either outfall point although there was greater change in those sites nearer the outfalls than in those farther away.

3.1.3 Organic content in 2006

Sediment organic content, as determined by loss on ignition (LOI), is positively related to the proportion of fines in the sediment; that is, muddy sediments have a higher organic content than sandy ones. This relationship was curvilinear and was apparent in the sediments from the 2006 survey (Figure 3.1.5) as it had been in all previous surveys. There was also an indication that the organic content of transects 20 and P was higher than its average particle size would suggest.

Having taken this relationship into account, the issue most relevant to this study was whether there was any pattern in the sediment's organic content in relation to its distance from the outfall of the Gt Ouse. For example, it might be anticipated that if river inputs were the major source of organics then, at times of low flows, those transects nearer the river would have a higher organic content. Conversely, after periods of high flow the influence of organic inputs might be more widely spread. This was explored statistically using regression analysis. First, the %LOI was transformed into logarithms to the base *e* ($\log_e$) to linearise the curvilinear relationship with the proportion of fine sediment and normalise the variation around it. Plots were then made between the residual variation in sediment organic content remaining after the influence of sediment particle size was removed and the distance of transects from the Gt Ouse outfall (Figure 3.1.6a and b). Any indication of a trend was explored by regression analysis. However, there was no statistically significant evidence of the sediment organic content of transects being related to their distance from either the high water or low water outfall of the river.

3.1.4 Changes in sediment organic content between 2005 and 2006

Comparisons in the sediment organic content between years were made after first using $\log_e$ transformation of the %LOI data to both linearise and normalise the relationship with the proportion of fine particles. Whether a transects' organic content differed between years was tested for by taking into account both the influence of fine sediment and the location of the sample site on the shore. Site location was included as it was possible that for a given proportion of fine sediment, upper shore sites might have a different organic content than those sites at lower shore levels because of the presence of more algae, diatoms and detritus in the sediment. The statistical procedure was, therefore, to test whether the response or dependent variable, $\log_e$%LOI, varied between years by including the proportion of fines in the sediment as a covariate with site location and the year as factors, in an analysis of variance. The general linear model (GLM) procedure in the MINITAB statistical software package was used.

The sediment's organic content over the whole of the study area in 2006 differed significantly from that in 2005 (Figure 3.1.7). This difference was due to sandier sites being less organically rich in 2006 than they were in the previous year while the organic content of the muddiest sites was unchanged.

Differences in sediment organic content within individual transects between the current and previous survey are shown Figure 3.1.8a-j. The sediment organic content of most transects did not differ significantly between 2005 and 2006 (Figures 3.1.8b, c, d, f, h i, and j). The exceptions were transects 16, 18, and 19. In both transect16 and 18, sites with the muddiest sediments were more organically rich in 2006 than they were in the previous year (Figure 3.1.8a and Figure 3.1.8e), while in transect 19 all sites were significantly less rich in 2006 compared to 2005 (Figure 3.1.8g).

3.1.5 Annual changes in sediments and organic content.

Figures 3.1.9 and 3.1.10 illustrate the changes that have occurred in sediments and their organic content during the course of the whole study to help put the current survey data into a study-long perspective.

Two datasets were available. The first spanned the years 1986 and 1996 to the present and related to the inner banks of the Gt Ouse study area. The second spanned the period 1997 to the present and related to the entire Gt Ouse study area, that is both inner bank and outer bank areas.

Sediment was muddiest in 2000 and sandiest in 1998 in both the inner banks alone (Figure 3.1.9a) and the entire area (Figure 3.1.9b), while sediments in the current survey were similar to the average for the inner bank areas but the fourth muddiest for the entire study area. Having statistically taking into account the influence of changes in the proportion of fine sediment, the sediment organic content was highest in 2005 and lowest in 1999 in both areas. In the current survey the organic content was the fourth highest out of the 12 surveys of the inner banks and third highest of the 10 surveys of the entire study area (Figure 3.1.10a and b).

3.1.6 Summary and conclusions

Of the 42 sites sampled, 30 were muddy and 12 were sandy. All sites located on the shore to the west of the Gt Ouse were muddy. Most sites (13 out of 22 sites) on the shore to the east of the river were also muddy. The exceptions were mid-to low- level sites of transects 18, 19 and 20 which were sandy. On the outer banks three sites were muddy and the remaining three were sandy.
Overall there was very little change in the sediment type of sites within the study area between the 2005 and 2006 surveys. Of the 42 sites there were 30 muddy sites in 2006

compared to 31 in 2005. The difference was due to three sites changing from mud to sand in 2006 (sites 18.7, 18.8 and 19.3 on the east shore) and two sites changing from sand to mud (site D2 on Daseley's Sand and 17.7 on the west shore). Although one fewer sites were classed as mud in 2006 than in the previous year most sites became muddier.

After the effect of changes in the proportion of fines in the sediment was taken into account, the sediment's organic content over the whole of the study area in 2006 differed significantly from that in 2005 due to sandier sites being less organically rich in 2006 than they were in the previous year. The organic content of the muddiest sites was unchanged.

Within most of the 10 individual sampling transects, the sediment organic did not differ significantly between 2005 and 2006. The exceptions were transects 16, 18, and 19. In both transect 16 and 18, sites with the muddiest sediments were more organically rich in 2006 than they were in the previous year, while in transect 19 all sites were significantly less rich in 2006 compared to 2005.

During the course of the study sediments were muddiest in 2000 and sandiest in 1998 in both the inner bank areas and the entire area, while sediments in the current survey were similar to the average for the inner bank areas but the fourth muddiest for the entire study area. Sediment organic content was highest in 2005 and lowest in 1999 in both areas. In the current survey the organic content was the fourth highest out of the 12 surveys of the inner banks and third highest of the 10 surveys of the entire study area.

Section 3.1
Figure legends

Figures 3.1.1 and 2.

Map of sediment type at our sample sites in 2006 (Fig 3.1.1) and 2005 (Figure 3.1.2) as determined by ground survey. Shaded symbols indicate the site was sandy (<25% fine sediment), closed symbols indicate the site was mud (>25% fine sediment).

Figure 3.1.3 a-j

The percentage of fine sediment (particles <63 microns) that occurred in 2005 and 2006 within each transect. **a,** transect 16, **b,** transect 17, **c,** transect B, **d,** transect C, **e,** transect 18, **f**, transect E, **g**, transect 19, **h**, transect 20, **i,** transect D and **j**, transect P. Statistically significant differences in the percentage of fine sediment between years are shown as asterisks above the relevant sample block as follows:- *p<0.05, ** p<0.01 and *** p<0.001.

Figure 3.1.4a and b

Changes in the percentage of fine sediment (particles<63 microns) that occurred between 2005 and 2006 in relation to the distance of the sample site from a, the Gt Ouse high tide outfall and b, low tide outfall (points A and B in Figure 2.1). The horizontal dotted line indicates zero change. Each data point relates to a sample site and its symbol indicates in which transect it occurred as shown in the legend box. Most sites became sandier in 2005 hence the number of data points that fall below the line of zero change.

Figure 3.1.5 The average sediment organic content, expressed as the average %Loss On Ignition, in relation to fine sediment (particles <63 microns) in each transect in 2006.

Figure 3.1.6 The residual variation in sediment organic content (Log_e %LOI), after the influence of particle size has been statistically accounted for, in relation to the sample transects' distance from the Gt Ouse outfall in 2006. The labels identify the transect to which each data point relates.

Figure 3.1.7 The relationship between sediment organic content (log_e % Loss On Ignition) and the percentage of fine sediment (% of particles <63 microns) in 2005 and 2006 for the whole Gt Ouse study area. The fitted regression lines relating sediment organic content (log_e % Loss On Ignition) to the percentage of fine sediment (% of particles <63 microns) in 2005 (solid line) and 2006 (dashed line) had significantly different intercepts and slopes.

Figure 3.1.8a-j

The relationship between sediment organic content (log_e % Loss On Ignition) and the percentage of fine sediment (% of particles <63 microns) in each transect in 2005 and 2006. The fitted regression lines (solid line for 2005 and dashed line for 2006) are shown where there was a significant difference between years.

a, transect 16, **b,** transect 17, **c,** transect B, **d,** transect C, **e,** transect 18, **f**, transect E, **g**, transect 19, **h**, transect 20 **i**, transect D and **j,** transect P.

Figure 3.1.9a and b

Annual changes in the mean percentage of fine sediment on **a**, the inner banks alone from 1986 and 1996-2006 and **b**, on the entire Gt Ouse study area from 1997-2006.

Figure 3.1.10a and b.

Annual changes in the mean organic content of sediment (%LOI) on **a**, the inner banks alone from 1986 and 1996-2006 and **b**, on the entire Gt Ouse study area from 1997-2006. The organic content has been adjusted to take into account variation in the % of fine sediment in each year.

Figures 3.1.1 and 2. Map of sediment type at our sample sites in 2006 (Fig 3.1.1) and 2005 (Figure 3.1.2) as determined by ground survey. Shaded symbols indicate the site was sandy (<25% fine sediment), black symbols indicate the site was mud (25+% fine sediment).

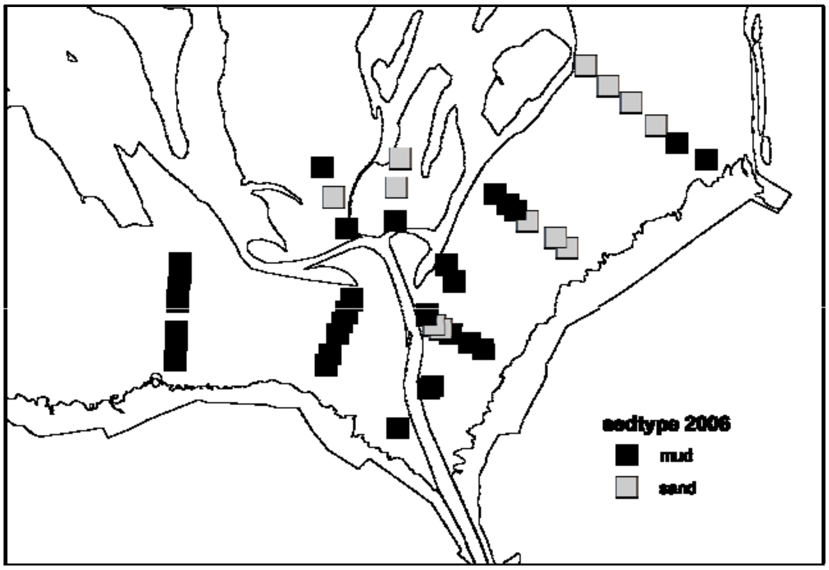


Figure 3.1.1 Sediment type in 2006 (above) and Figure 3.1.2 in 2005 (below)

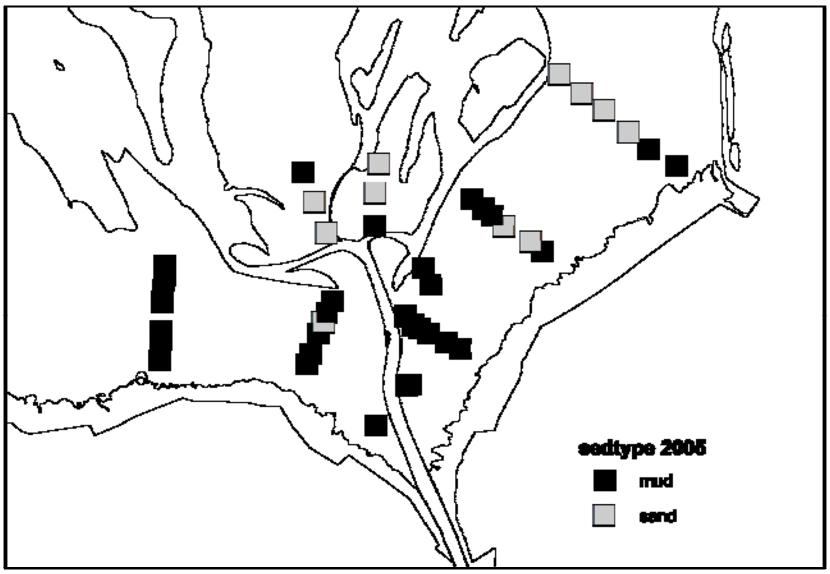
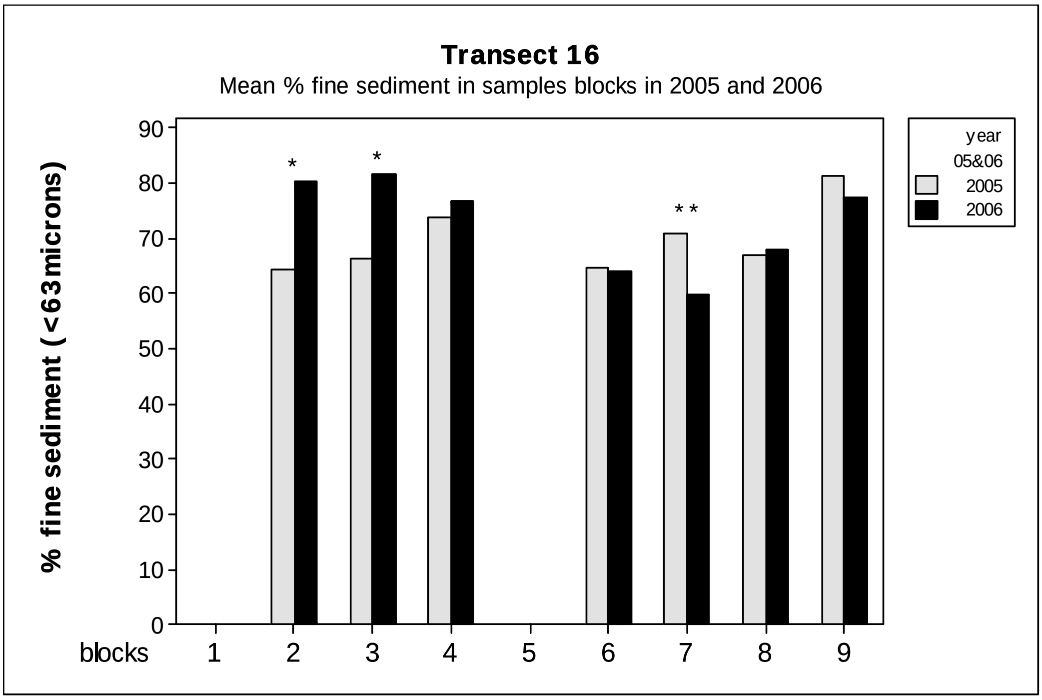


Figure 3.1.3 a-j. The percentage of fine sediment (particles <63 microns) that occurred in 2005 and 2006 within each transect. **a,** transect 16, **b,** transect 17, **c,** transect B, **d,** transect C, **e,** transect 18, **f**, transect E, **g**, transect 19, **h**, transect 20, **i,** transect D and **j**, transect P. Statistically significant differences in the percentage of fine sediment between years are shown as asterisks above the relevant sample block as follows:- *p<0.05, ** p<0.01 and *** p<0.001.

a,



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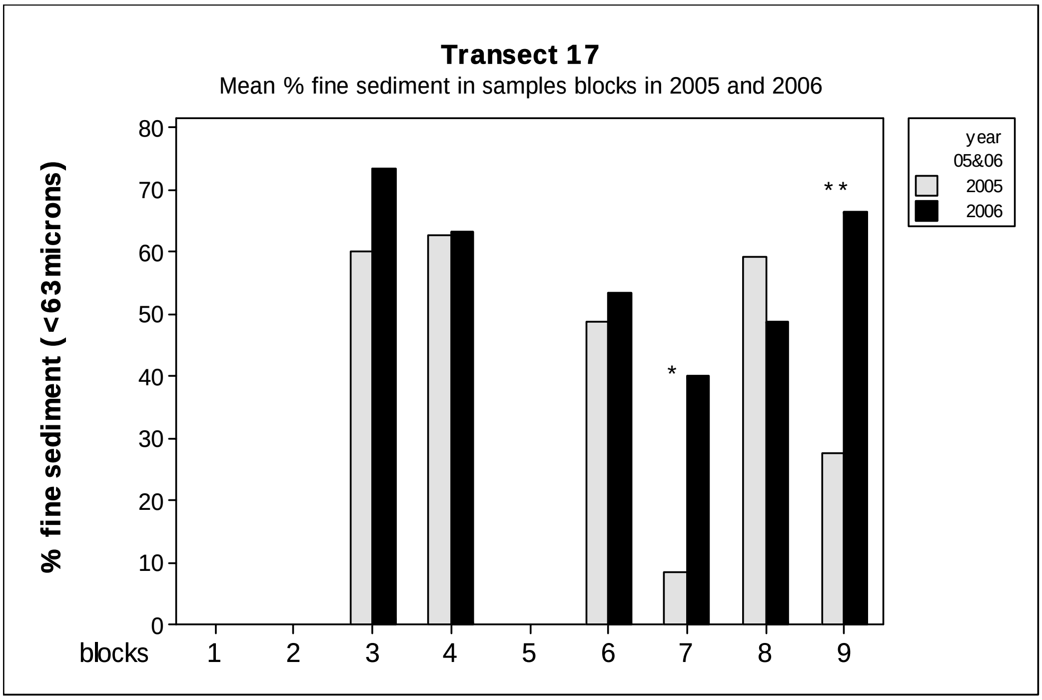

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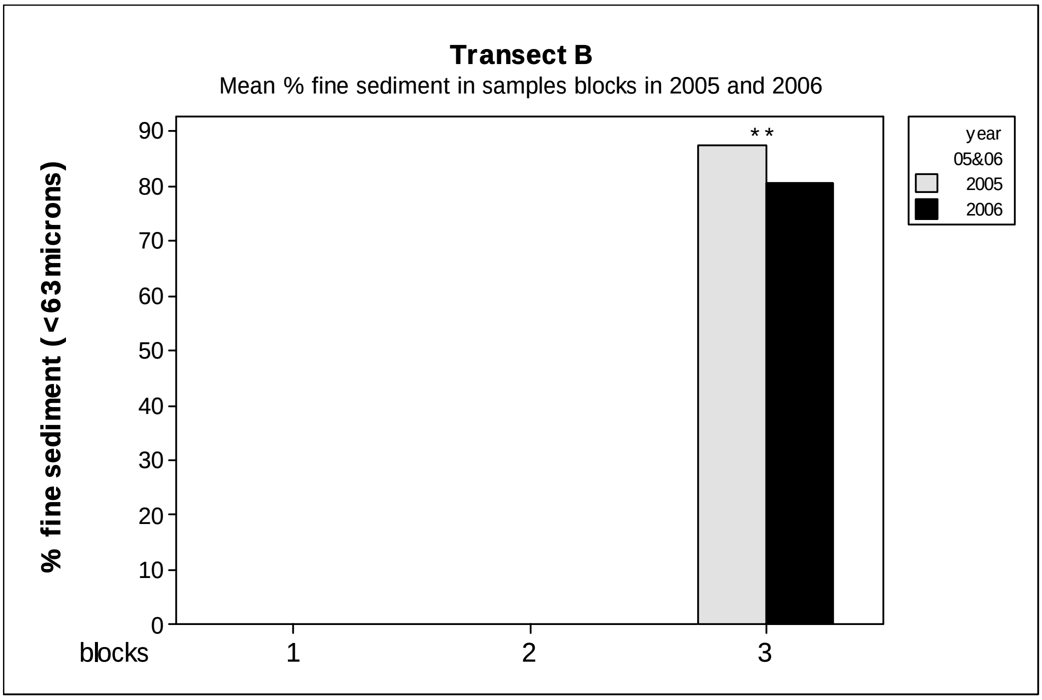

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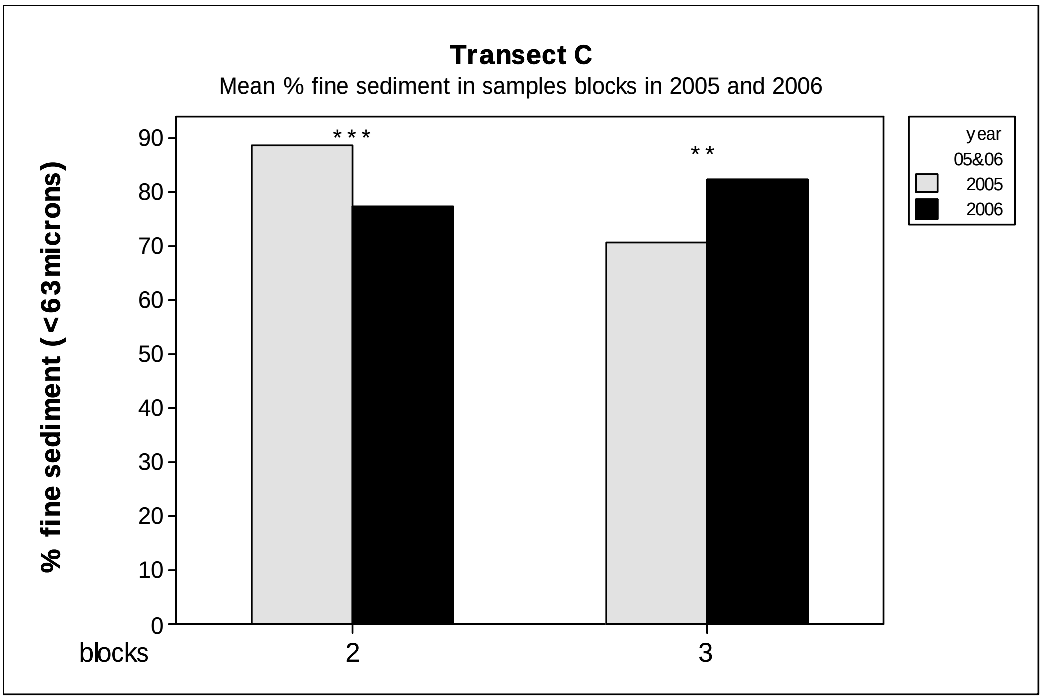

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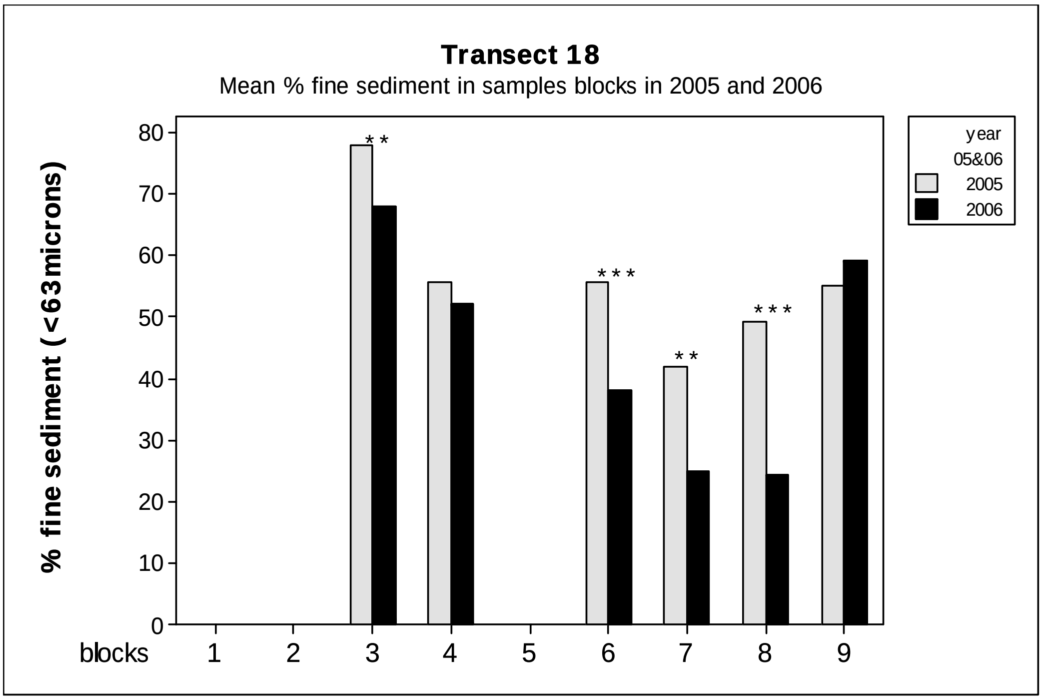

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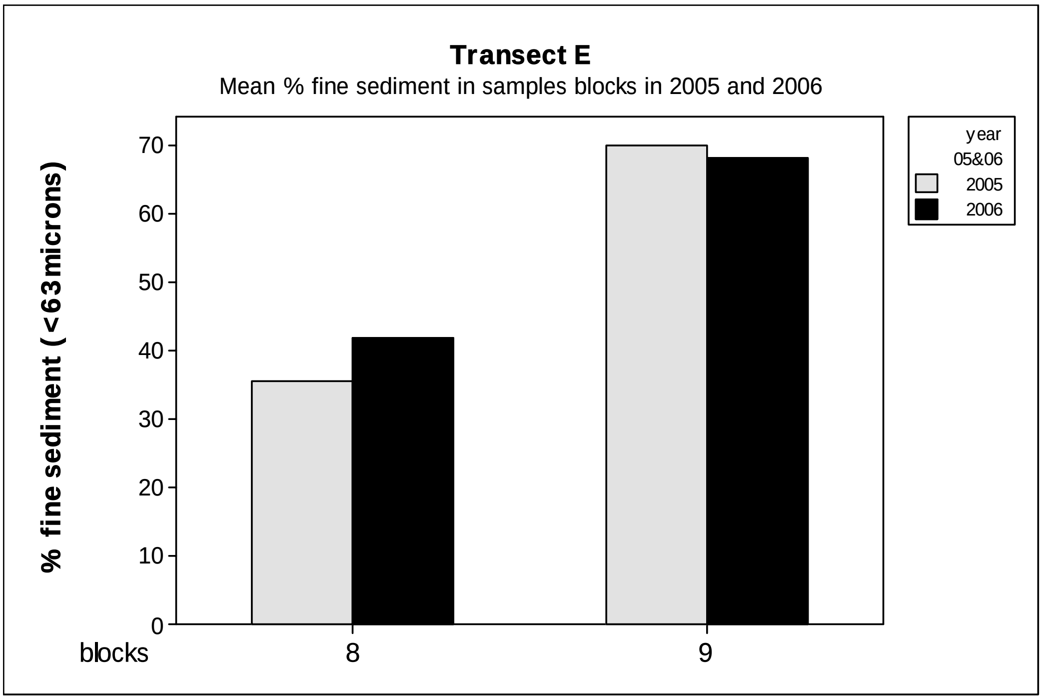

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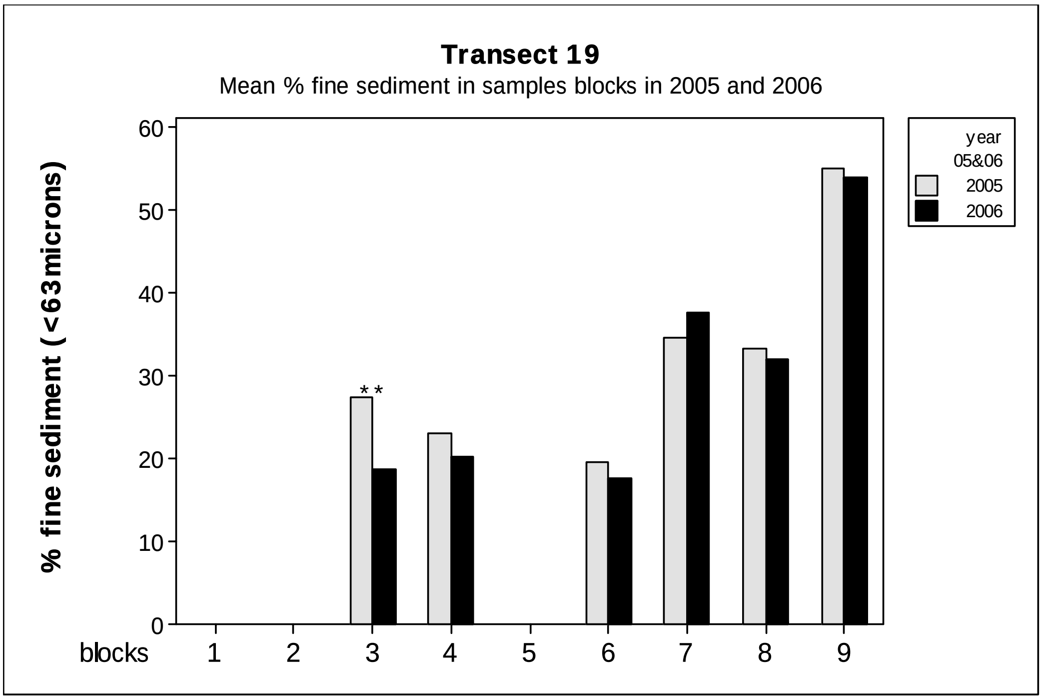

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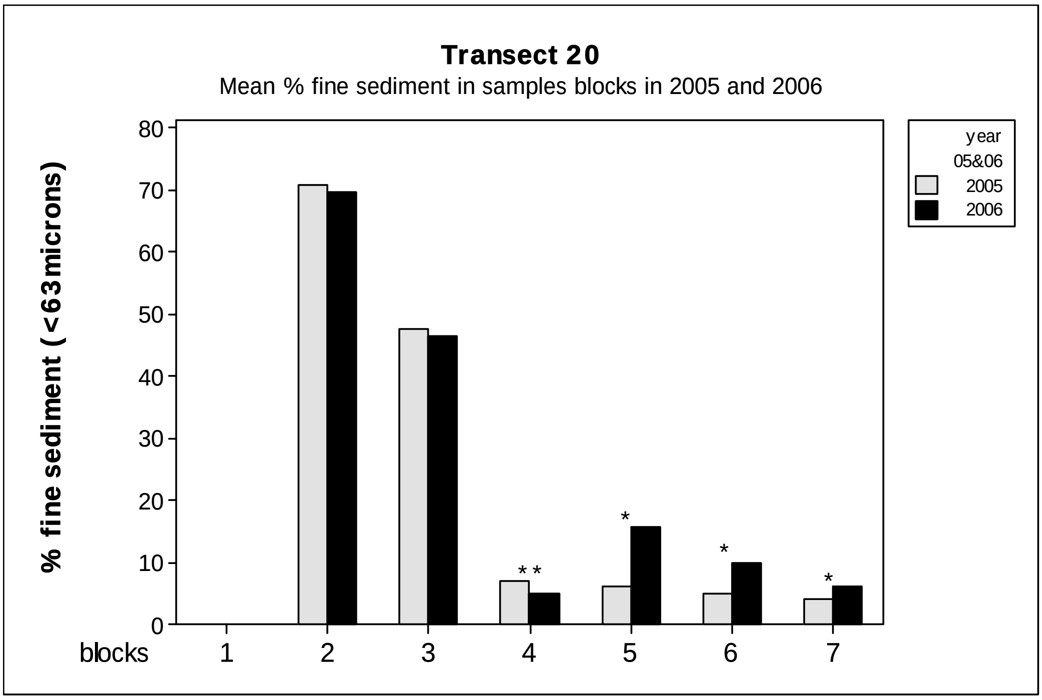

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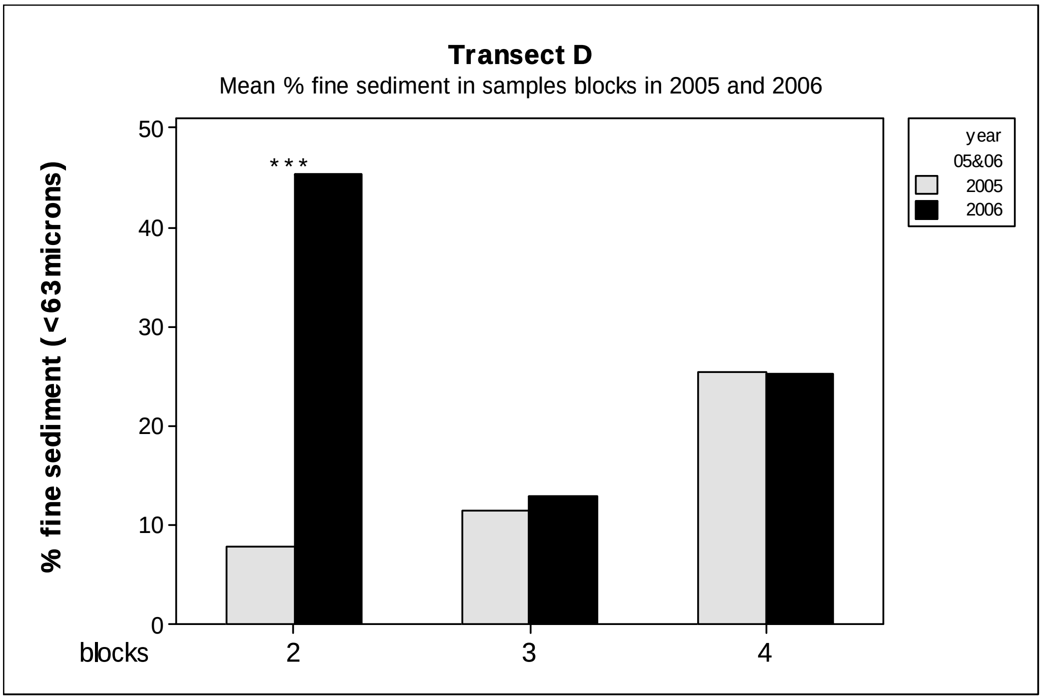

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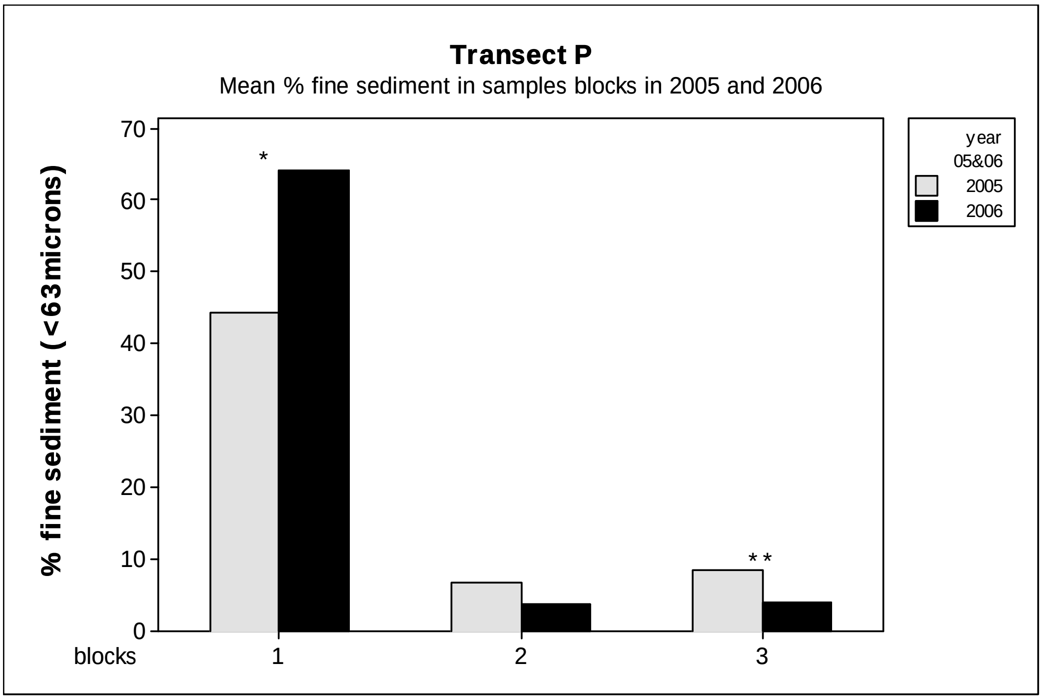
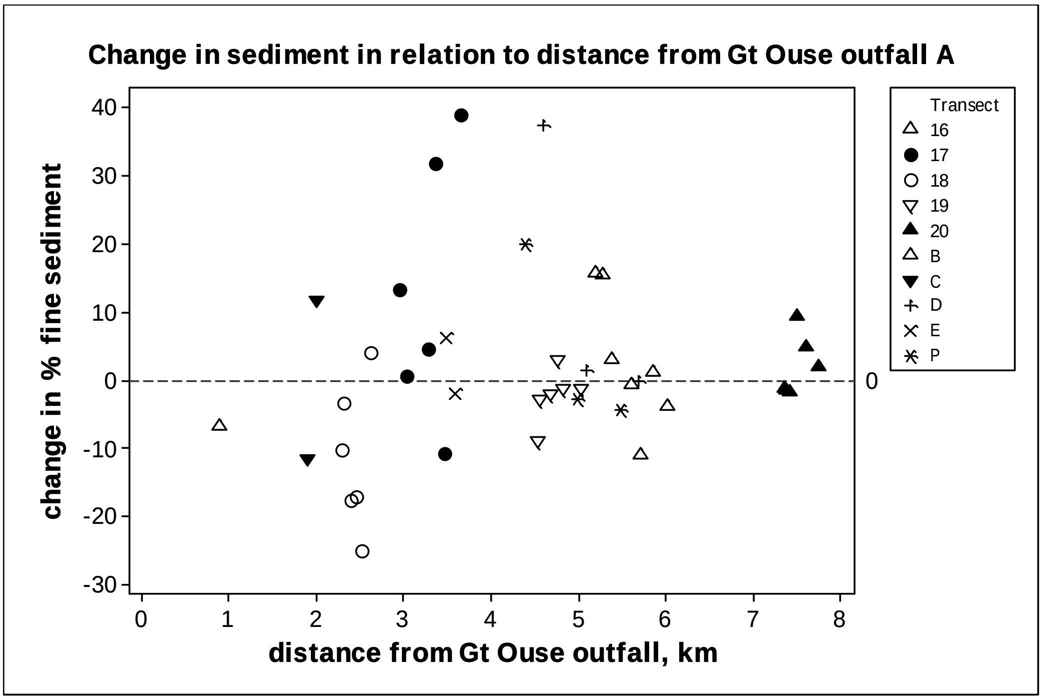


Figure 3.1.4a and b Changes in the percentage of fine sediment (particles<63 microns) that occurred between 2005 and 2006 in relation to the distance of the sample site from a, the Gt Ouse high tide outfall and b, low tide outfall (points A and B in Figure 2.1). The horizontal dotted line indicates zero change. Each data point relates to a sample site and its symbol indicates in which transect it occurred as shown in the legend box.

a,



b,

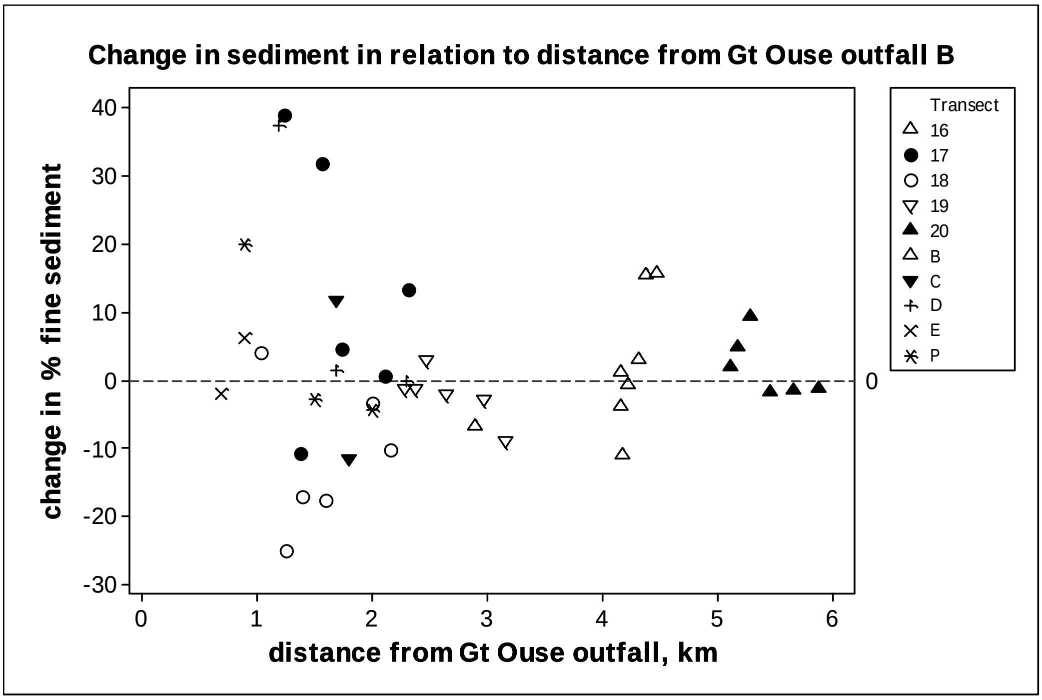


Figure 3.1.5 The average sediment organic content, expressed as %Loss On Ignition, in relation to fine sediment (particles <63 microns) in each transect in 2006.

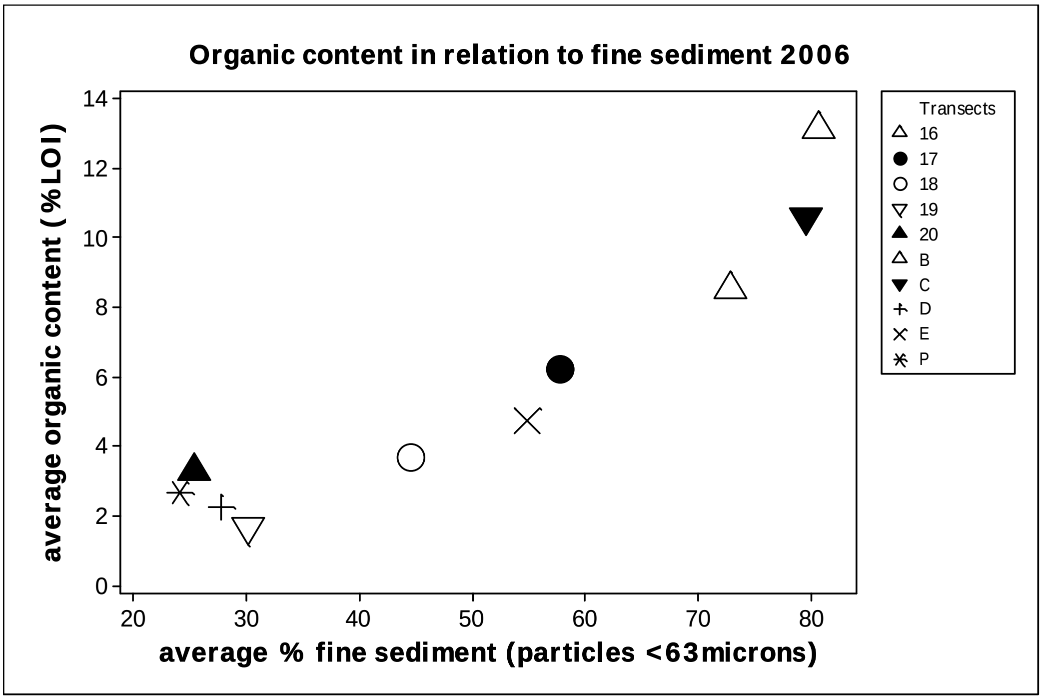


Figure 3.1.6a and b. The residual variation in sediment organic content (Log_e %LOI), after the influence of particle size has been statistically accounted for, in relation to the sample transects' distance from a, the Gt Ouse high tide outfall and b, low tide outfall (points A and B in Fig 2.1) in 2005. The labels identify the transect to which each data point relates.

a, b,

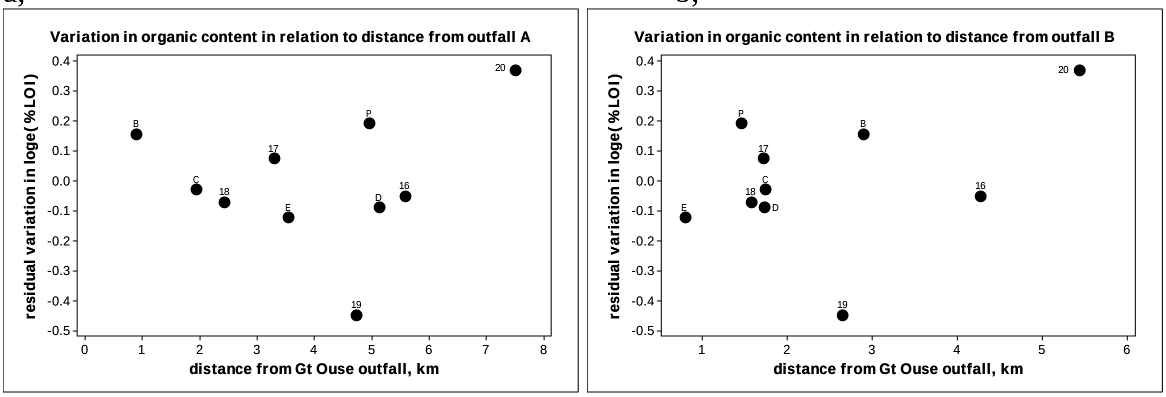


Figure 3.1.7 The relationship between sediment organic content ($\log_e$ % Loss On Ignition) and the percentage of fine sediment (% of particles <63 microns) in 2005 and 2006 for the whole Gt Ouse study area. The fitted regression lines relating sediment organic content ($\log_e$ % Loss On Ignition) to the percentage of fine sediment (% of particles <63 microns) in 2005 (solid line) and 2006 (dashed line) had significantly different intercepts and slopes.

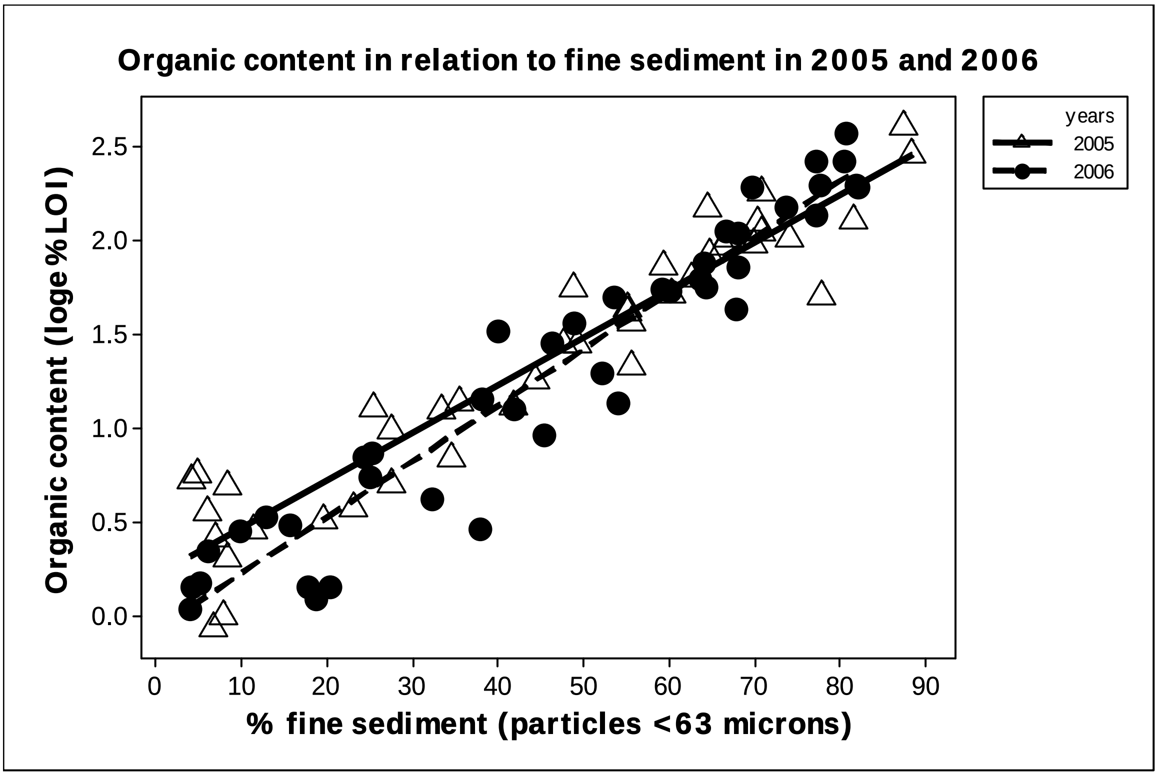
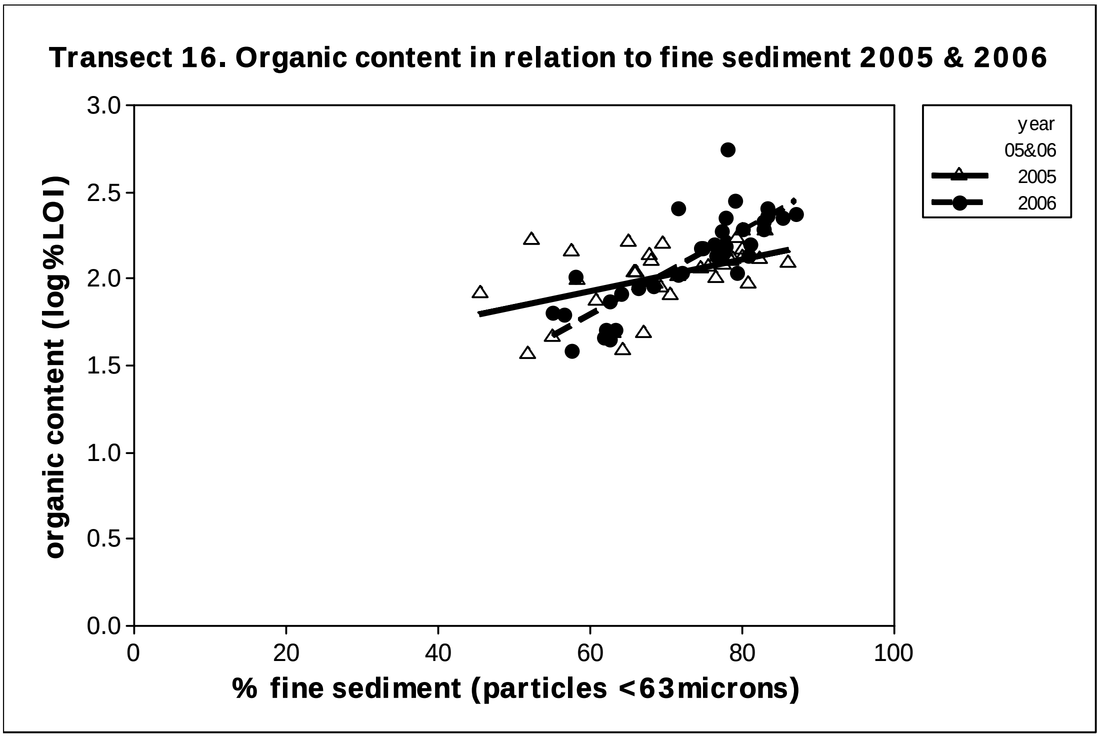


Figure 3.1.8a-j. The relationship between sediment organic content ($\log_e$ % Loss On Ignition) and the percentage of fine sediment (% of particles <63 microns) in each transect in 2005 and 2006. The fitted regression lines (solid line for 2005 and dashed line for 2006) are shown where there was a significant difference between years.**a,** transect 16, **b,** transect 17, **c,** transect B, **d,** transect C, **e,** transect 18, **f**, transect E, **g**, transect 19, **h**, transect 20 **i**, transect D and **j,** transect P.

a,



b,

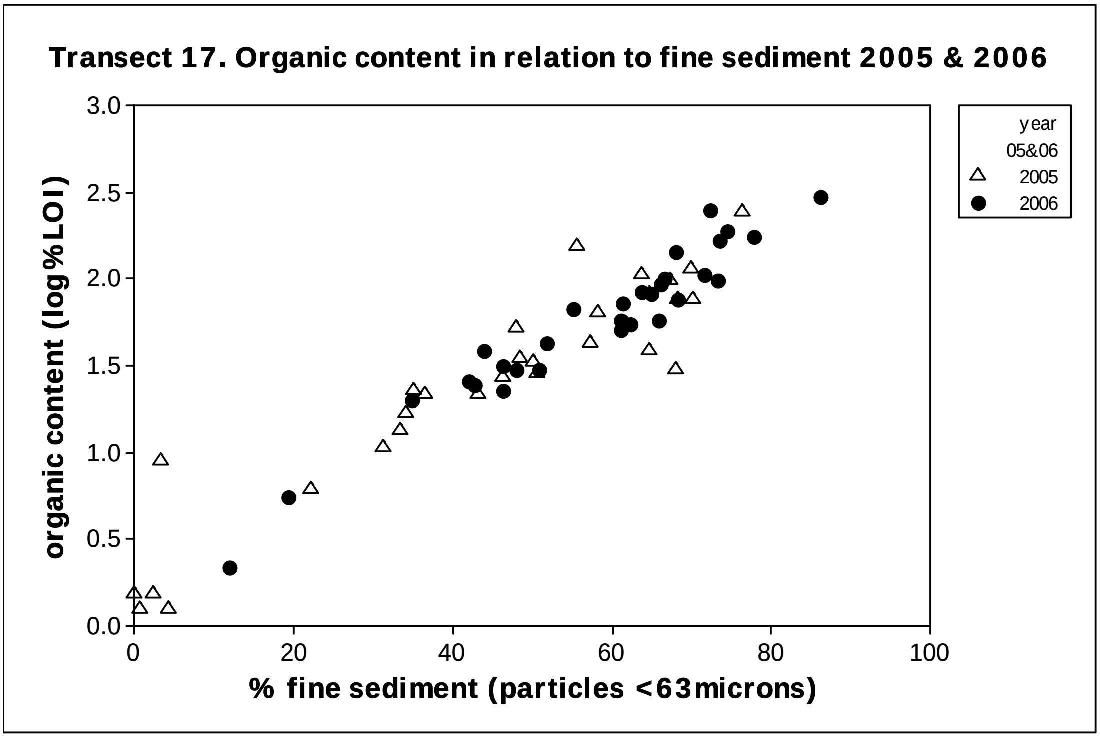
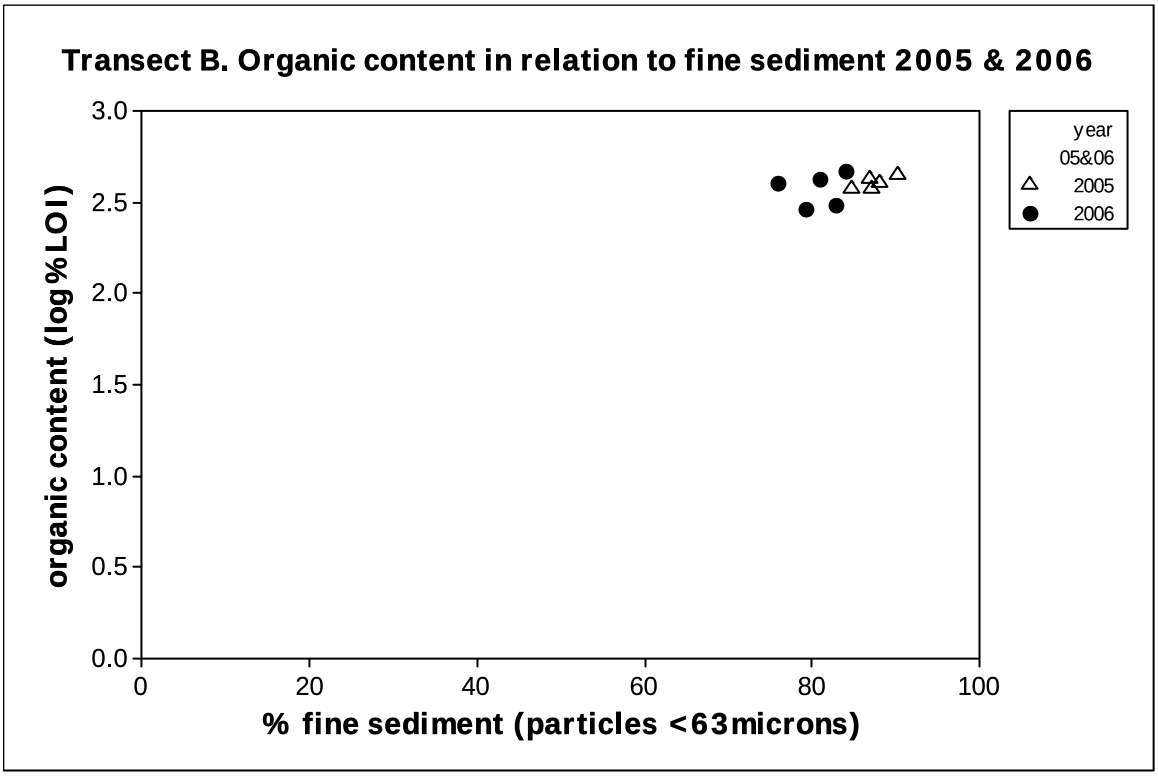


Figure 3.1.8a-j continued

c,



d,

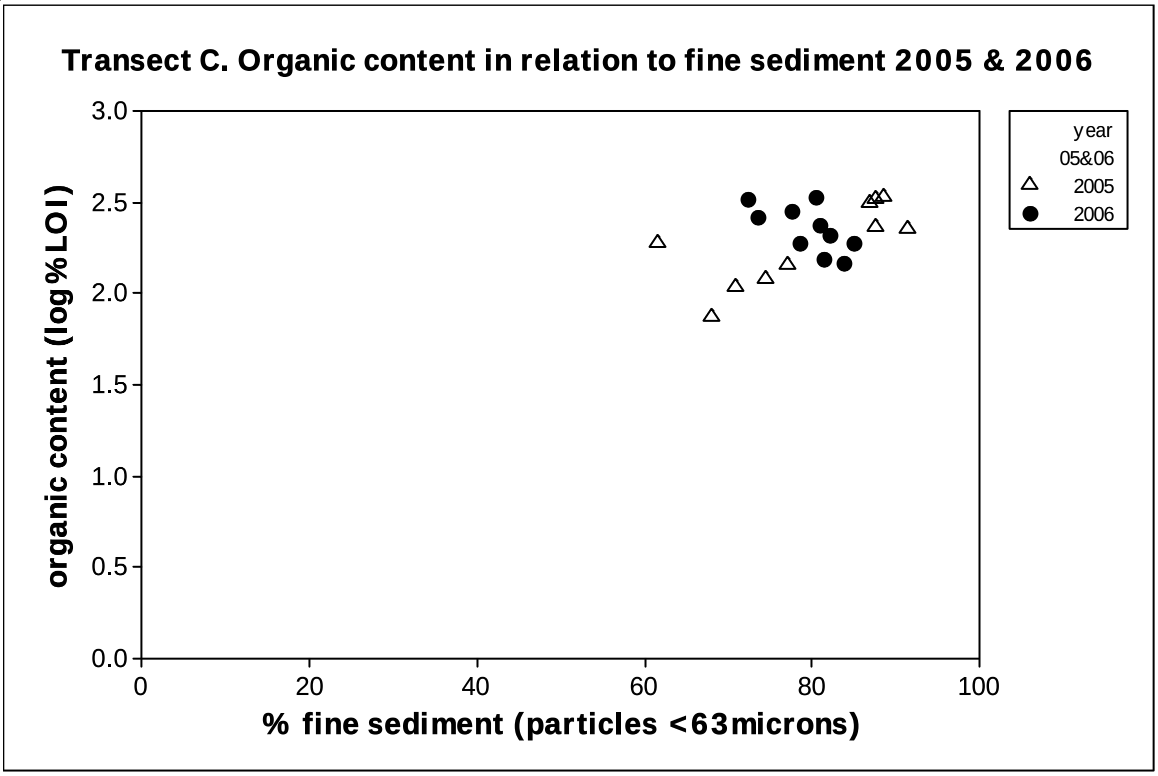
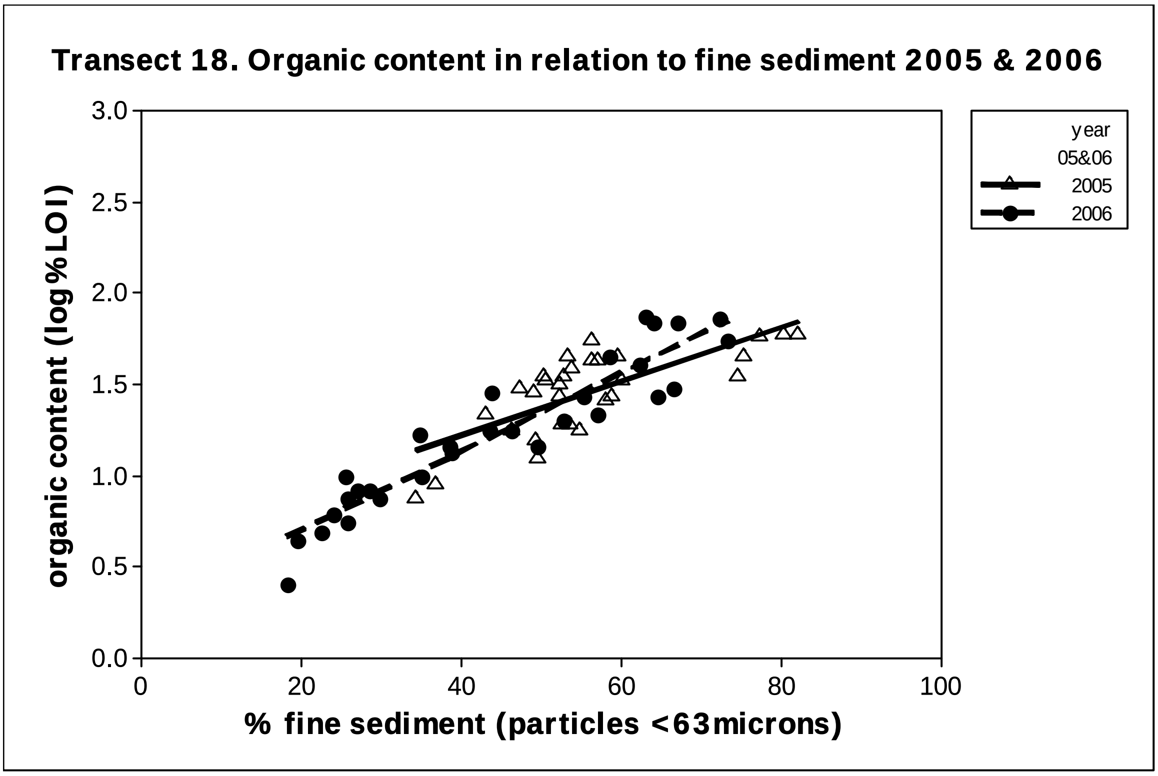


Figure 3.1.8a-j continued

e,



f,

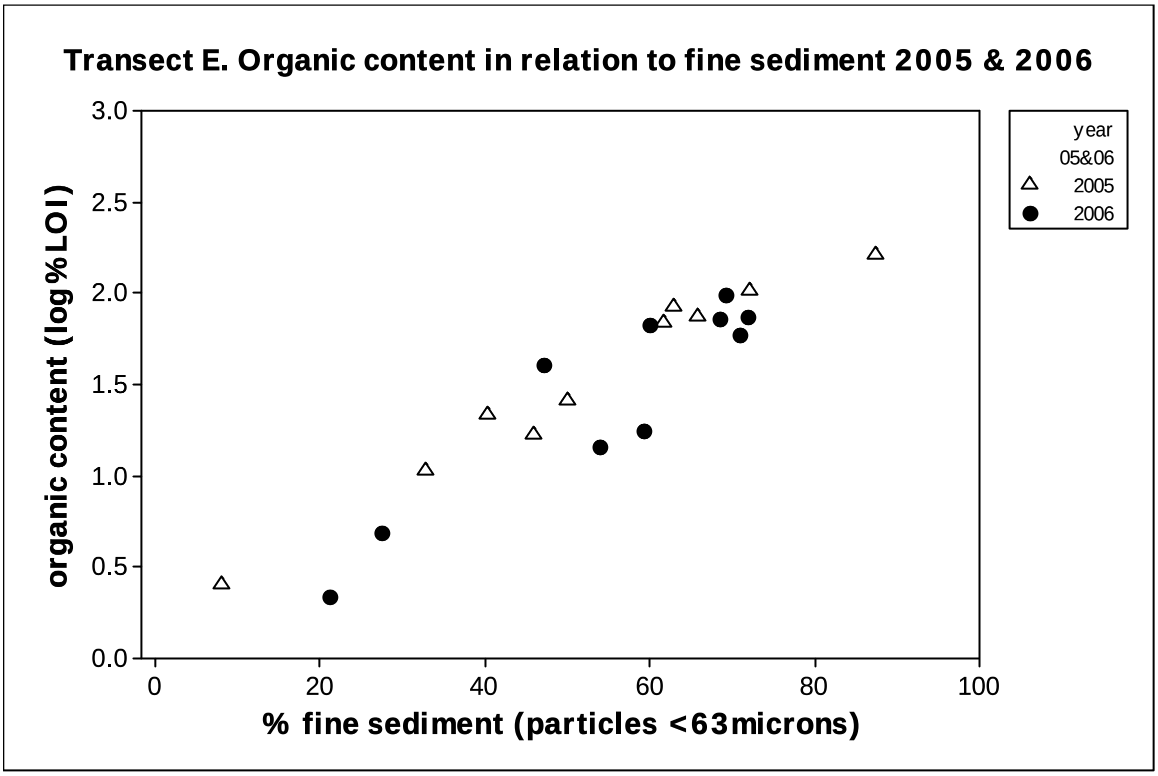
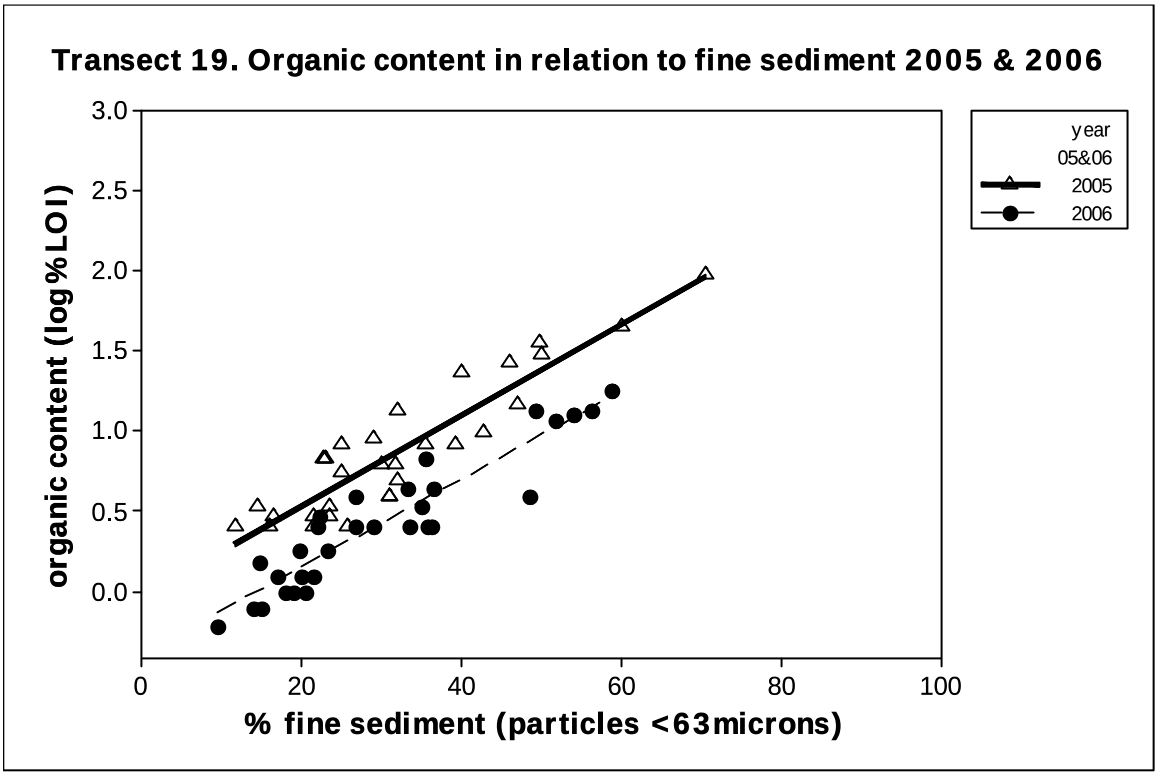


Figure 3.1.8a-j continued

g,



h,

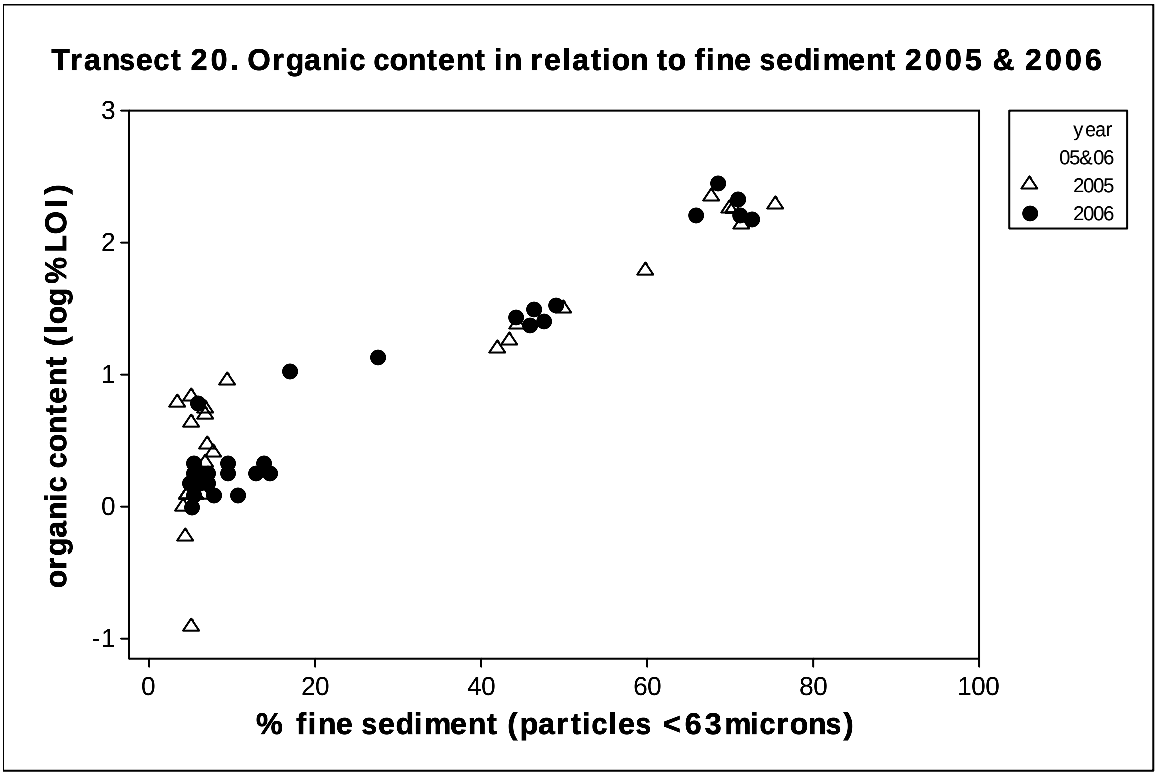
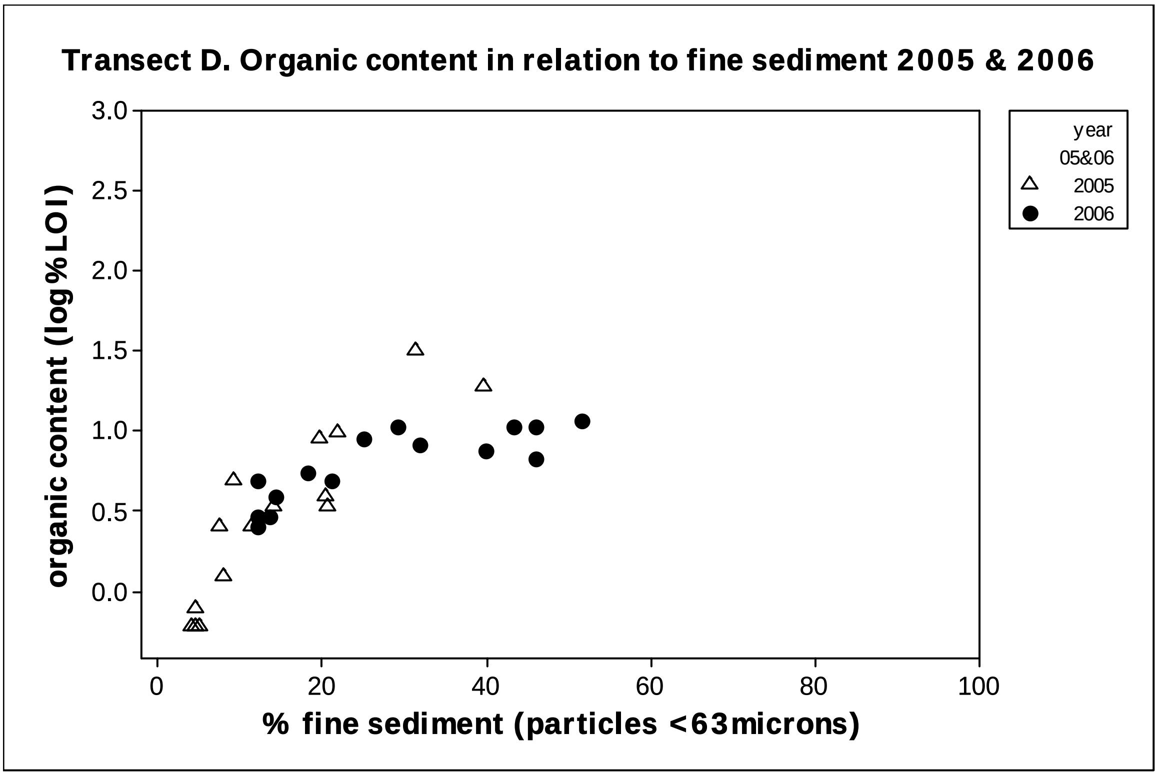


Figure 3.1.8a-j continued

i,



j,

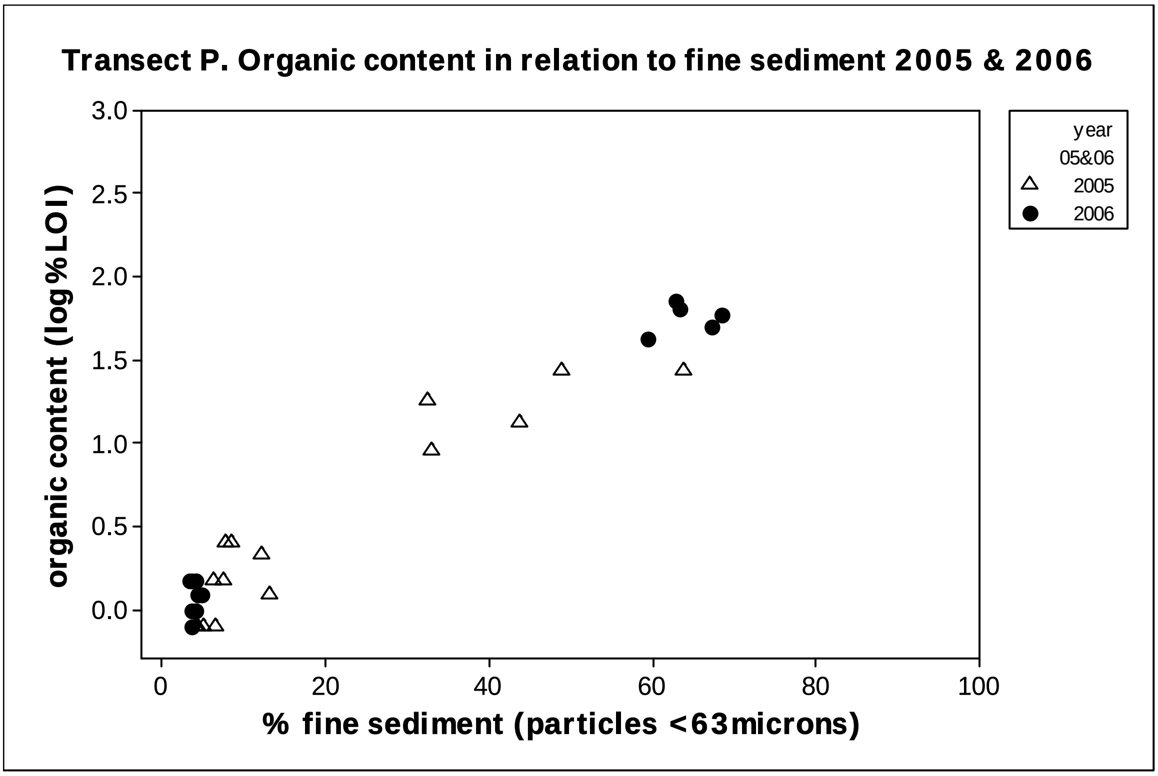
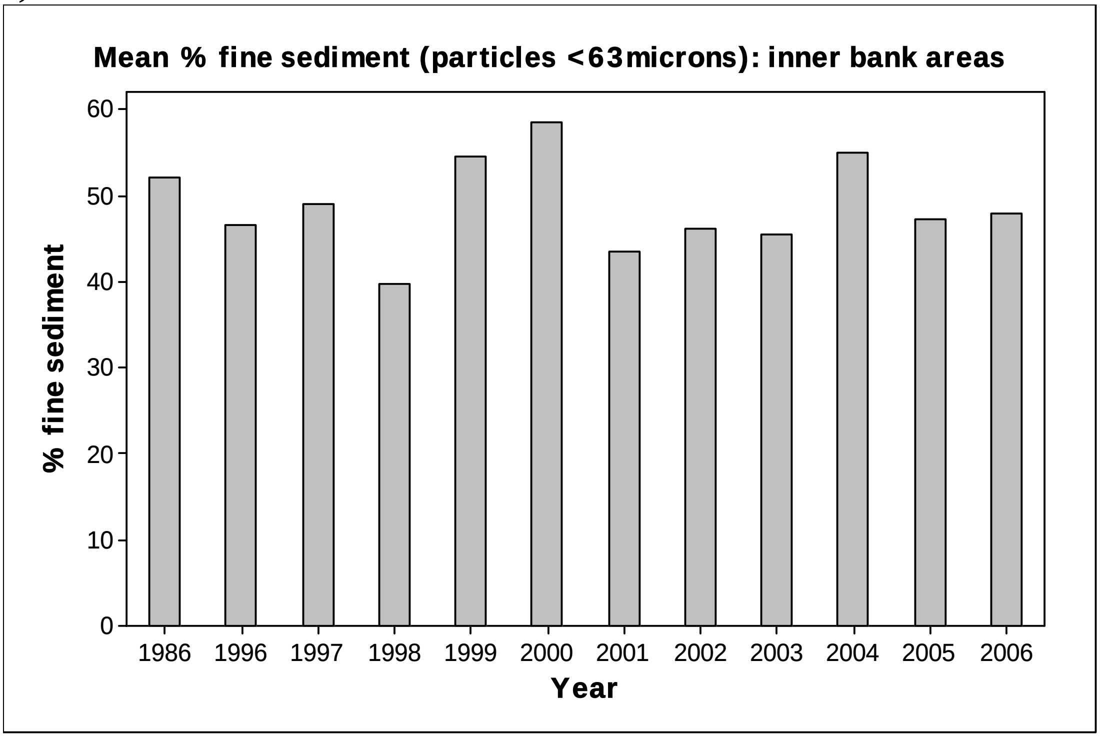


Figure 3.1.9a and b Annual changes in the mean percentage of fine sediment on **a**, the inner banks alone from 1986 and 1996-2006 and **b**, on the entire Gt Ouse study area from 1997-2006.

a,



b,

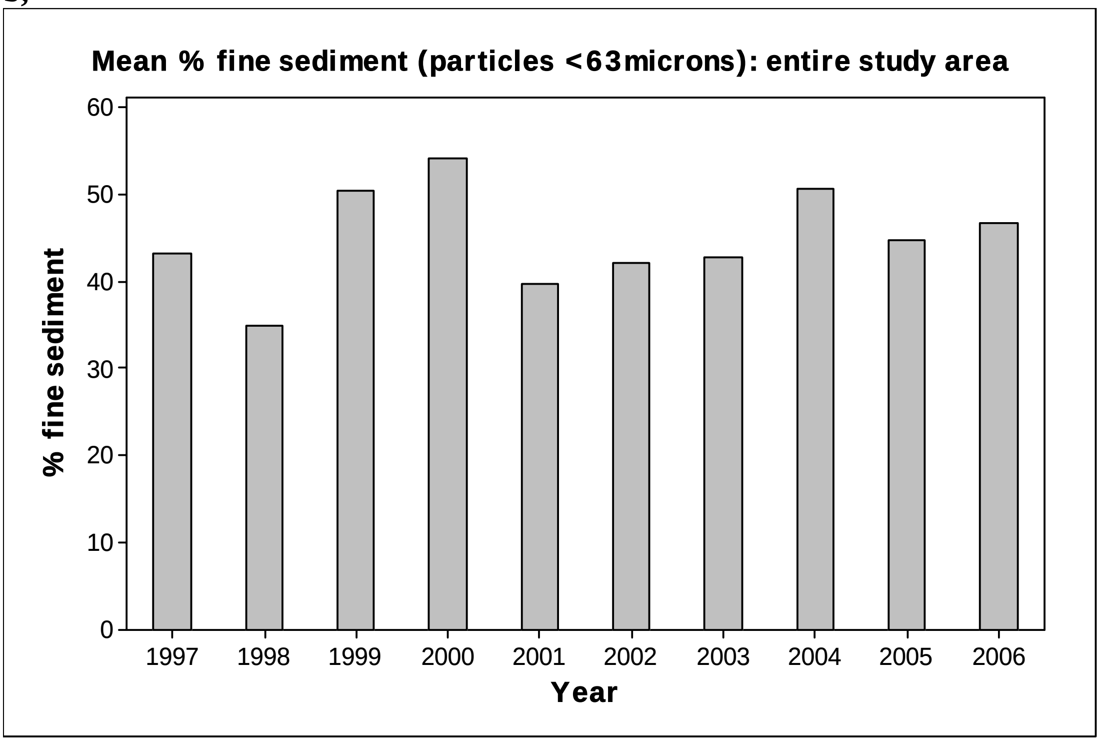
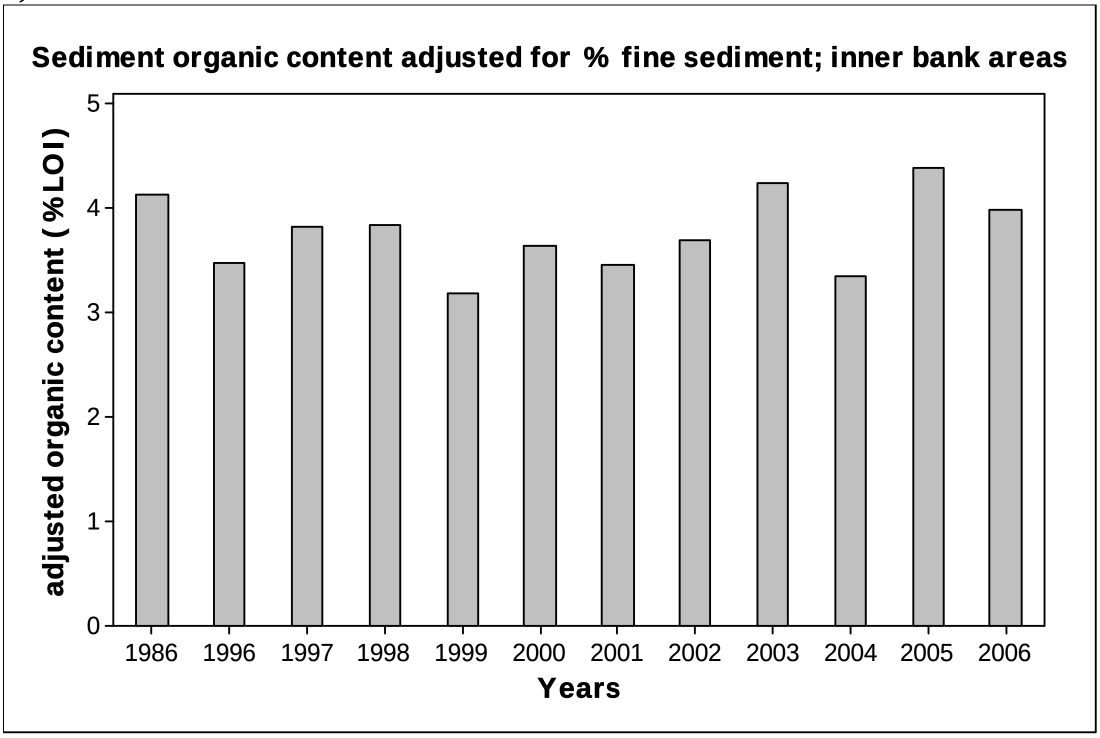
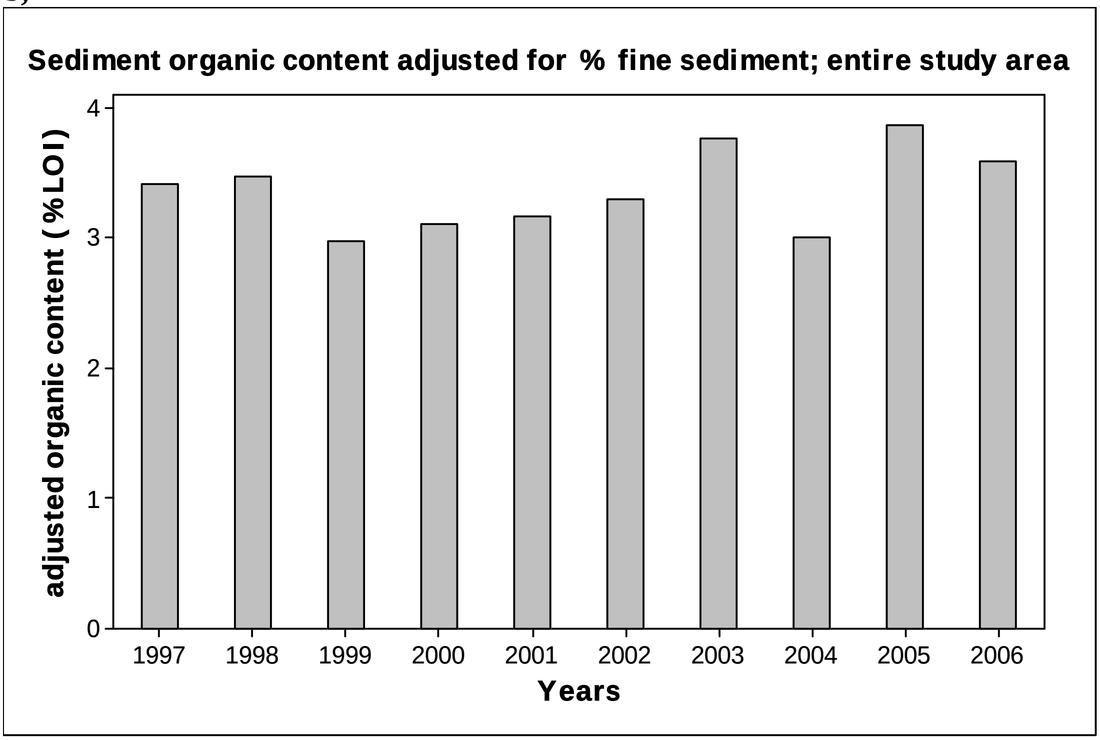


Figure 3.1.10a and b. Annual changes in the mean organic content of sediment (%LOI) on **a**, the inner banks alone from 1986 and 1996-2006 and **b**, on the entire Gt Ouse study area from 1997-2006. The organic content has been adjusted to take into account variation in the % of fine sediment in each year.

a,



b,



3.2. Invertebrates

3.2.1 Introduction

This section describes the distribution of the inter-tidal invertebrates within the study area in 2006. It is supplemented by the data tables presented in Appendix 1 which give the mean densities of invertebrates recorded in each 1hectare sample site and in Appendix 2 which give comparisons of densities of all but the least abundant species between 2005 and 2006 for the whole study area.

Distribution maps showing the density of an invertebrate species/species size category in each sample site in 2006 and the change in density compared to that in 2005 are presented (Figures 3.2.1a-q). Not all species were mapped. Only those whose density changed significantly over the whole study area (Appendix 2) between the two surveys are included.

A brief description of the invertebrates' biology and of the shorebirds that prey on them was given in Volume 2 of our 1996 study Report (Yates *et al* 1998).

3.2.2 Invertebrate distribution in 2006 and changes compared with the 2005 survey.

The uppermost maps in Figures 3.2.1a-q show the spatial distribution and density (expressed as numbers m^{-2}) of the invertebrates in the 2006 survey, while the lower maps show the changes in densities at a site between 2005 and 2006. Tables 3.2a-c summarises for each transect the results of analyses comparing densities of all invertebrates that occurred between the two surveys. These comparisons were made by doing paired t-tests on the mean density of an invertebrate in each 1 hectare sampling site.

Statistical analyses were also made for those invertebrates in which the change in density between the two surveys was significant to determine whether the changes were related to sediment particle size, sediment organic content and shore level and to the proximity to the Gt Ouse outfall. Multiple regression analysis was used for this purpose. The procedure was to regress the change in invertebrate density at each of the 42 sample sites against the site variables, change in sediment particle size, change in sediment organic content and shore level, to account for any influence they had and then to include distance of the site from the Gt Ouse to determine if it had any significant additional influence.

Table 3.2 a-c. Summary of changes in invertebrate densities within transects between 2005 and 2006 surveys. Plus signs (+) indicate an increase in 2006, a minus (-) indicates a decrease and an equal sign (=) indicates no change. Empty cells indicate that the invertebrate did not occur in that transect in either survey. The statistical significance of the change is indicated as follows:- * p<0.05 and ** p<0.01. The overall change in the whole study area (see also Appendix 2) is given in the final column headed 'All' and where significant, the invertebrate concerned is shown in bold type.

a, worms

Invertebrate	Transect										
	16	17	B	C	18	E	19	20	D	P	**All**
Nemerteans	-		+		-		+	-		-	-
Nematodes	-	+		-	-	-	+	-		-	-
Anaitides mucosa	=	+			+		+	+	+	+	+*
Eteone longa	-	-	+		-	-	-	-	-	+	-**
Syllids										-	-
Hediste diversicolor <15mm	-	-			+		-	-			-
H. diversicolor 15-30mm	=	+			-		+	-			-
H. diversicolor >30mm	=	+		+	+		-				+
Nephtys cirrosa 15-30mm								-		+	+
N. cirrosa >30mm										+	+
***Nephtys hombergii* juveniles <15mm**	-**	+	-		-	-	-	+	-	-	-**
N. hombergii 15-30mm	-*	-		-	+	+	-	-*	-	+	-
N. hombergii >30mm	+	+			+	+	-	-	-	-	+
***Scoloplos armiger* <15mm**		-					-	-	-	-	-*
S. armiger 15-30mm								+		+	+
S. armiger >30mm		+					-	+		+	+
Pygospio elegans	-	-	-	-	-	-	-	-	-	-	-**
Scolelepis foliosa		+			+		+			+	+*
Spio martinensis	+	-				+	-	-	-	-	-*
Spiophanes bombyx	-	-								-	-*
Magelona mirabilis										+	+
Tharyx sp complex A	+	-			-		-	-	-	-	-
Capitellids	-	+			+	+	+	-	+	+	+
Heteromastus filiformis	-										-
Arenicola marina casts		+				+	-	-	-	-	-
Tubificoides benedii	-*	-	-	-	+	-	+	-	-	-	-*
Enchytraeidea	-					-		-		-	-

Table 3.2 a-c. continued.

b, molluscs

Invertebrate	Transect										
	16	17	B	C	18	E	19	20	D	P	**All**
***Hydrobia ulvae* <3mm**	+	-	-	+	+	-	-	-	-	-	-*
H. ulvae 3+mm	-	+	-	+	+	+	+	+	-	-	-
***Retusa obtusa* <3mm**	-*	-						+			-*
R. obtusa 3+mm	-	-					+				-
Mytilus edulis <5mm	-	+*			+	-	+		-		-
***Mysella bidentata* <5mm**	-	-			+		-				-*
M. bidentata 5-10mm	-										-
***Cerastoderma edule* <5mm**	+*	+			-	+	+	+	+	-	+*
C. edule 6-10mm	+	+			+	+	+	+	+		+
C. edule 11-20mm	-	+					-	+	-		-
C. edule 20-30mm									+		+
***Macoma balthica* <5mm**	+	-	-	+	-	-	-	-	-	-	-**
M. balthica 6-10mm	-	-		+	+	-	-	-	-	-	-
M. balthica 11-20mm	-	-	-		-	-	-	+	+	=	-
M. arenaria <5mm	-										-
Abra nitida 6-10mm	+										+
Scrobicularia plana <5mm	+	-		-	-	+*	+	+		-	+
***S. plana* 5-10mm**	+	-		-	-	-	+	-		-	-*
S. plana 11-20mm	-	+			-	+	+	-			-
***S. plana* 21-25mm**	+	+	-		+						+*
S. plana >30mm		-	-		-						-

Table 3.2 a-c continued.

c, crustaceans

Invertebrate	Transect										
	16	17	B	C	18	E	19	20	D	P	**All**
Elminius modestus	+								+		+
Indeterminate copepod	+							-			-
Urothoe poseidonis <3mm								-		-	-
U. poseidonis >3mm								-			-
Bathyporeia sarsi <3mm		-						-		-	-
B. sarsi 3+mm								-		+	-
Corophium arenarium <3mm		+									
C. arenarium 3+mm								+			
C. volutator <3mm	=	=		+	-*	+	-	+	+		-
C. volutator 3+mm	+	-		+	-	+	+	+			+
Cyathura carinata					-		-	=			-
Tanaids								-		+	+
Cumaceans								-	-	-	-
Crangon crangon	-	-	-	+	+	+	+	+	-	+	+
Liocarcinus arcuatus	-	-									-
Carcinus maenas	+	+							+		+*

Out of the 71 invertebrate families or species/species size categories that were considered, the densities of 17 of them differed significantly between 2005 and 2006. The mean density over the whole study area of two worms, one crustacean and two bivalve molluscs increased significantly in 2006, while density of seven worms and five molluscs decreased significantly (Table 3.2 a, b and c, Appendix 2). This was a slightly larger proportion to that which might be expected by chance given the 5 percent level of probability that was used as the statistical significance criteria.

Densities of the Phyllodocid worm *Eteone longa* was significantly lower (p=0.008) but that of *Anaitides mucosa* was higher (p=0.016) in 2006 than in 2005 (Table 3.2a and Appendix 2).

Eteone was widespread in 2006 occurring predominantly in mid and lower shore areas but it was in these same regions that its densities had decreased the most, particularly in transect 16 on the shore to the west of the outfall (Figure 3.2.1a). Changes in its density were not significantly related to the change in sediment characteristics, shore level or to the distance from the river outfall.

Anaitides occurred in increased numbers in lower shore sites in 2006 having been much less widespread in the previous year (Figure 3.2.1a). Changes in its density were not significantly related to either sediment characteristics, shore level or to the distance from the Gt. Ouse outfall.

Densities of juvenile cat worms *Nephtys hombergii* (<15mm in size), decreased significantly ($p<0.001$) in 2006 (Table 3.2a and Appendix 2) compared with 2005. They decreased in density in many of the sites in which they had occurred in 2005 particularly those in transect 16, where the decrease was statistically significant, and in transect D on Daseley's Sand (Figure 3.2.1c). Changes in their density were not significantly related to changes in sediment organic content, to shore level or to the distance from the Gt Ouse outfall.

Densities of small *Scoloplos armiger* (<15mm in size) worms decreased significantly ($p=0.017$) in 2006 compared to those in the previous year (Table 3.2a and Appendix 2 Figure 3.2.1d) reversing increases that had occurred between 2004 and 2005. In 2006 it occurred in only two lower shore sites. Changes in their densities were not significantly related to changes in sediment, shore level or to the distance from the river.

Pygospio elegans decreased ($p=0.001$) in density in 2006 (Table 3.2a and Appendix 2). Although widespread in 2006 there were large decreases in its density particularly in transects 16 and 17 on the shore to the west of the river outfall (Figure 3.2.1e). There was no statistically significant relationship between the change in its density from 2005 to 2006 and changes in sediment characteristics or shore level or to the distance from the rivers' outfall.

Scolelepis foliosa increased in density in 2006 ($p=0.04$) having been absent in the previous year (Table 3.2a and Appendix 2). It occurred in highest densities on Pandora Sand (Figure 3.2.1f). Increases in its density were not statistically related to sediment characteristics, shore level or proximity to the river outfall.

Spio martinensis decreased ($p=0.028$) in density in 2006 (Table 3.2a and Appendix 2). It occurred at lower shore levels but in fewer sites than in the previous year (Figure 3.2.1g). Changes in its density were negatively related to changes in the percentage of fine sediment ($t = -3.36$, $p=0.002$), but not to shore level or proximity to the river outfall.

Spiophanes bombyx did not occur in 2006 ($p= 0.044$, Table 3.2a and Appendix 2) having been present in 2005 (Figure 3.2.1h). This change was not related to sediment, shore level or proximity to the river outfall.

The densities of the Oligochaete worm *Tubificoides benedii* decreased ($p=0.035$) in 2006 compared to 2005 (Table 3.2a and Appendix 2). It was widely distributed throughout the muddier sites of the study area and it was in same those sites that its density decreased the most (Figure 3.2.1i). Changes in its density were not related to sediment or site variables or to distance from the river.

There was a significant increase ($p=0.01$) in the density of small shore crabs *Carcinus maenas* in 2006, having been absent in 2005 (Table 3.2c and Appendix 2). They occurred only in sites on the west shore and Daseley's Sand (Figure 3.2.1j) but the change in its density was not related to sediment, shore level or proximity to the river outfall.
.
The density of small *Hydrobia ulvae* (<3mm) decreased significantly in 2006 ($p=0.01$) compared to the previous year (Table 3.2b and Appendix 2). It was widespread in the study

area as was the decrease in its density (Figure 3.2.1k). Changes in its density were not related to changes in sediment characteristics, shore level or to distance from the river outfall.

The density of *Retusa obtusa* (<3mm) decreased significantly in 2006 ($p=0.04$) compared to 2005 (Table 3.2b and Appendix 2). It occurred in transects 16 and 17 on the west shore in 2005 and it was in those transects that it decreased the most in 2006 (Figure 3.2.1l). The changes in its density were not significantly related to sediment changes, site level variables or to the distance from the Gt Ouse.

The density of the bivalve *Mysella bidentata* (<5mm) decreased significantly in 2006 ($p=0.04$) compared to 2005 (Table 3.2b and Appendix 2). It occurred only in single sites in transect 16 and 18 in 2006 having been more widespread in the previous year (Figure 3.2.1m). These changes were not significantly related to sediment changes, site level variables or to the distance from the Gt Ouse.

The density of cockle spat *Cerastoderma edule* (<5mm) increased significantly in 2006 ($p=0.045$) compared to 2005 (Table 3.2b and Appendix 2). It was most abundant at lower shore levels of most transects, particularly transect 16 (Figure 3.2.1n) where the increase in density was statistically significant. Changes in its density were not significantly related to sediment changes, site level variables or to the distance from the Gt Ouse.

The density of small *Macoma balthica* (<5mm in size) decreased significantly ($p<0.001$) in 2006 (Table 3.2b and Appendix 2). Even so they remained widespread in the study area although the decreases were greatest in transects 16, 17 and 18 (Figure 3.2.1o). Changes in their density were related to changes in the amount of fine sediment between the two years ($t= 2.1$, $p= 0.042$), but not to shore level or to distance from the Gt Ouse.

The bivalve, *Scrobicularia plana* in the 6-10mm size category decreased in density in 2006 but those in the 21-25mm category increased in density ($p=0.02$, and $p=0.04$ respectively) (Table 3.2b and Appendix 2). Both size categories occurred primarily in the muddier mid- and lower-shore sites of the study area and it was in those same sites that changes in density occurred (Figure 3.2.1p and 3.2.1q). Changes in the density of either category were not significantly related to sediment changes, site level variables or to the distance from the Gt Ouse.

3.2.2.1 Annual changes in invertebrate density: 1986 and 1996-2005

The inner banks of the study area have now been surveyed on a total of twelve occasions and the changes in the densities of the main invertebrate classes, worms, crustacean, gastropod molluscs (snails) and bivalve molluscs are summarised in Figures 3.2.3a-d. Worm densities were at their lowest in 1996 and with the exception of 1998, increased annually until 2003 but have declined since then to a point where the 2006 density is almost as low as that in 1996. Crustacean density was lowest in 1996 and again in 2000 since when it has increased annually to the highest density recorded in 2003. It dropped markedly in 2004, increased in 2005 but decreased in the current survey to a density that was the fourth lowest for the period of the study (Figure 3.2.3b). There had been a general upward trend in snail densities between 1996 and 2001 but they dropped in 2002 since when they have risen annually to the highest density ever recorded in the study in the 2005 survey (Figure 3.2.3c). However, densities dropped in the current survey. Bivalve mollusc density was at its highest in 2000 (Figure 3.2.3d) when there was a large spatfall of many species, notably cockle and *Macoma*. Since then their densities have remained relatively low with the 2006 density around the average for the period of the study.

3.2.3 Summary and conclusions

There were a few changes in the densities or spatial distribution of the invertebrates recorded in the Gt Ouse study area between the 2005 and 2006 surveys. Of the 71 species/species size categories that were sufficiently numerous to be considered, five showed a statistically significant increase in density while twelve showed a significant decrease. The worms *anaitides mucosa* and *Scolelepis foliosa*, the shore crab *Carcinus* maenas, and the bivalves, spat cockle *Cerastoderma edlule* (<5mm in size) and the clam *Scrobicularia plana* (21-25mm in size) increased in density. Whereas the worms *Eteone longa, Nepthys hombergii*(<15mm), *Scoloplos armiger* (<15mm), *Pygospio elegans*, *Spio martinensis*, *Spiophanes bombyx* and *Tubificoides benedii* all decreased in density, as did the snails *Hydrobia ulvae* (<13mm) and *Retusa obtuse* (<3mm) and the bivalve molluscs *Mysella bidentata* (<5mm), *Macoma balthica* (<5mm) and *Scrobicularia plana* (<5mm).

There was no evidence of the spatial changes in invertebrate densities being associated with the distance from the Gt Ouse outfall after changes in sediment particle size and organic content between the two years and shore level had been taken into account

Over the 12 successive years of this study, worm densities were at their lowest in 1996 and with the exception of 1998, increased annually until 2003 but have declined since then to a point where the 2006 density is almost as low as that in 1996 (Figure 3.2.3a). Crustacean density was lowest in 1996 and again in 2000 since when it increased annually to the highest density recorded in 2003. It dropped markedly in 2004, increased in 2005 but in the current survey, decreased to a density that was the fourth lowest for the period of the study (Figure 3.2.3b). There had been a general upward trend in snail densities between 1996 and 2001 but they dropped in 2002 since when they have risen annually to the highest density ever recorded in the study in the 2005 survey (Figure 3.2.3c). However, densities dropped in the current survey. Bivalve mollusc density was at its highest in 2000 (Figure 3.2.3d) when there was a large spatfall of many species, notably cockle and *Macoma*. Since then their densities have remained relatively low with the 2006 density around the average for the period of the study.

Section 3.2

Figure legends

Figure 3.2.1a-q.

Maps showing the density of an invertebrate family, species or species size category within the sample sites in 2006 (upper map) and the change in density that occurred at each site between 2005 and 2006 (lower map). **Appendix 2** gives the mean density of each invertebrate within the whole study area in both surveys. Only those invertebrates whose density changed significantly between the two surveys and those that were present in both surveys were mapped.

Figure 3.2.2 a-d.

The mean density of **a**, worms, **b**, crustacean, **c**, gastropod molluscs (snails) and **d**, bivalve molluscs on the inner banks of the Gt Ouse study area in the surveys of 1986 and 1996-2006. Densities are expressed as numbers/m^2.

Figure 3.2.1a-q. Maps showing the density of an invertebrate family, species or species size category within the sample sites in 2006 (upper map) and the change in density that occurred at each site between 2005 and 2006 (lower map). **Appendix 2** gives the mean density of each invertebrate within the whole study area in both surveys. Only those invertebrates whose density changed significantly between the two surveys and those that were present in both surveys were mapped.

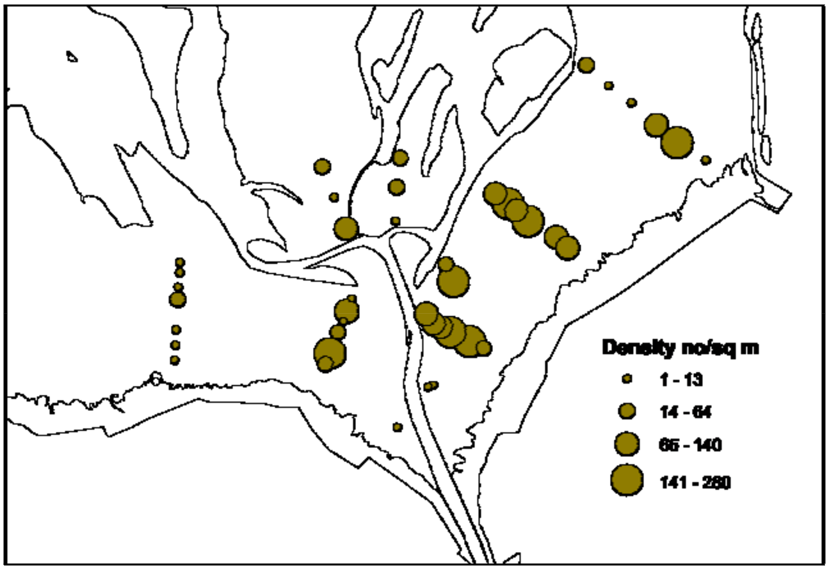
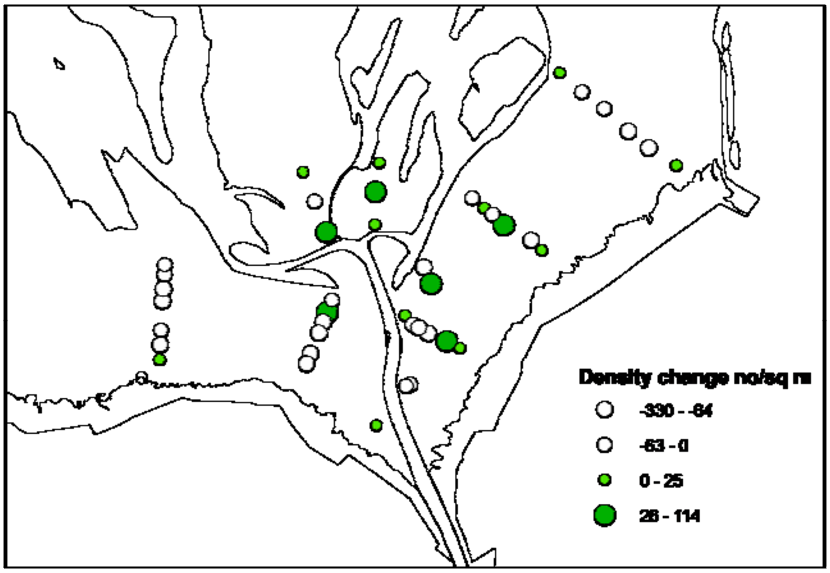


Figure 3.2.1a Eteone longa



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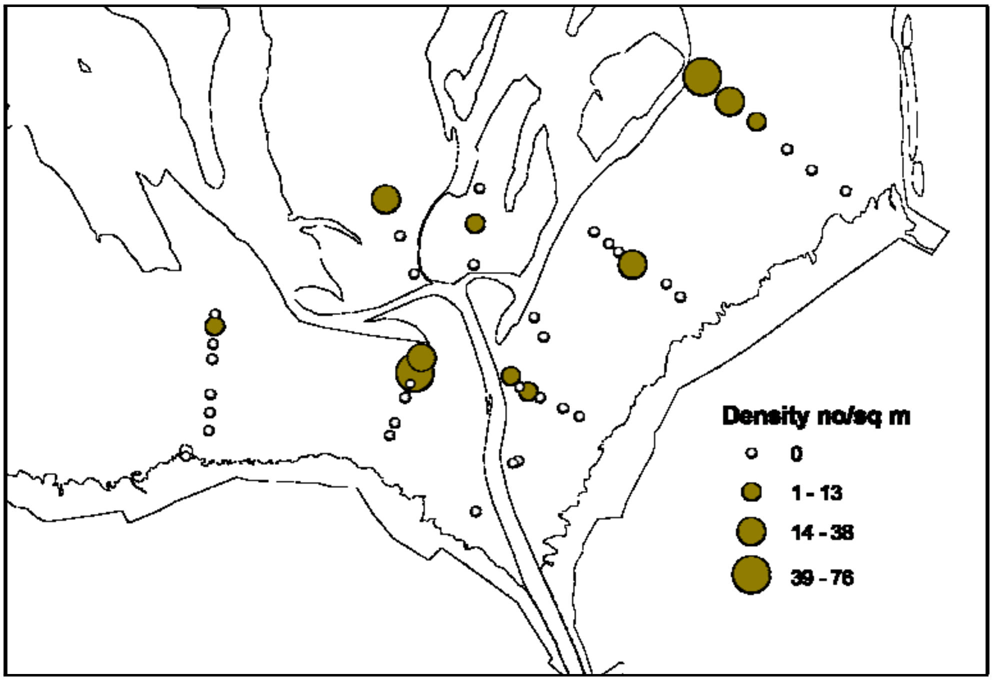
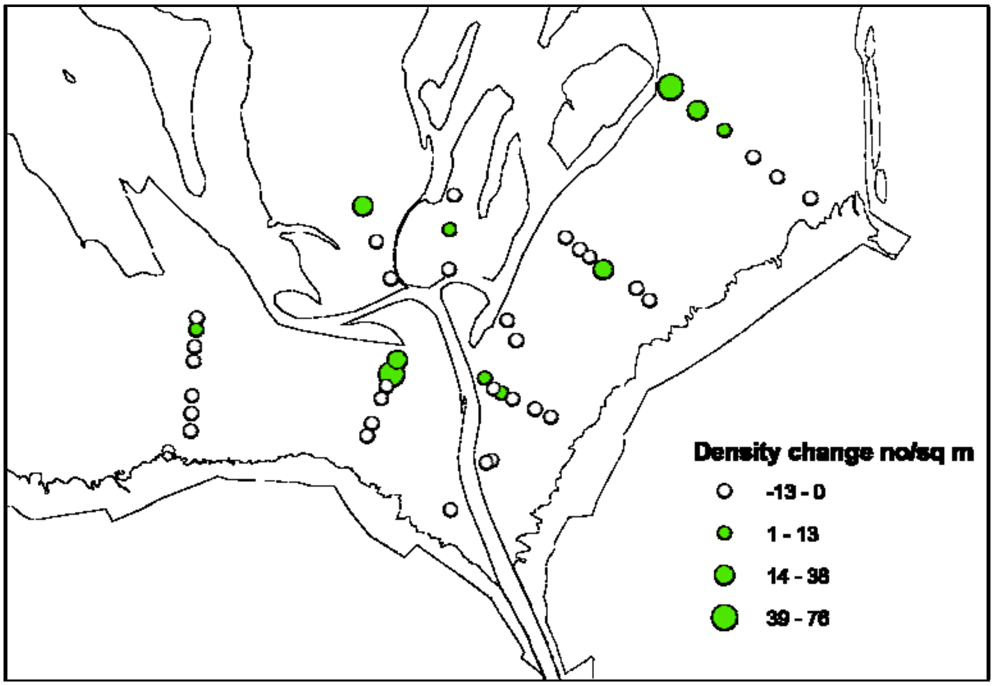


Figure 3.2.1b Anaitides mucosa



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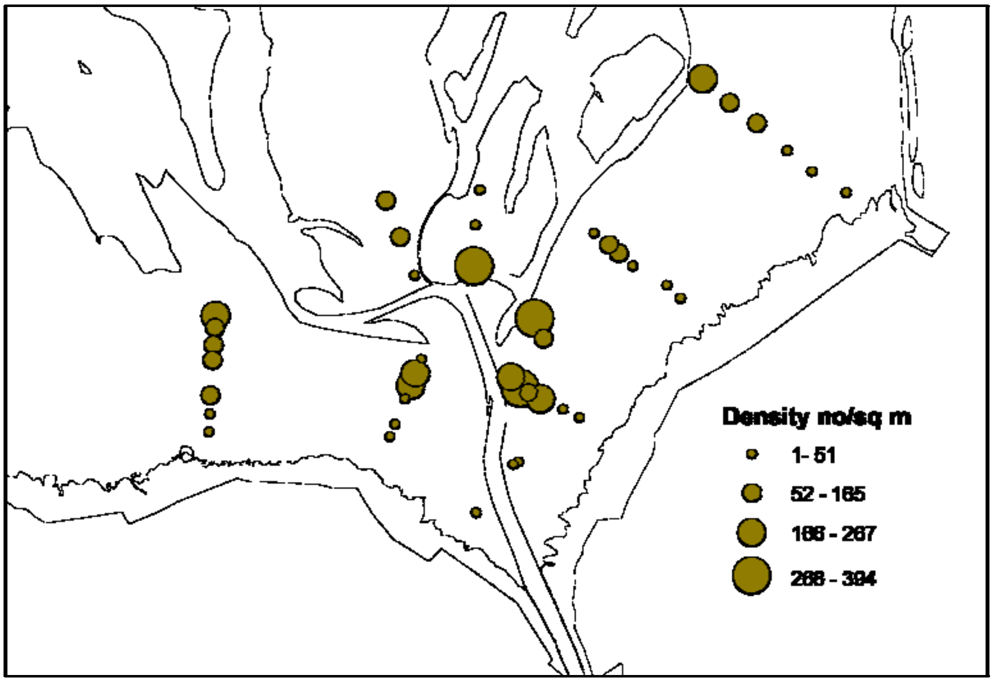
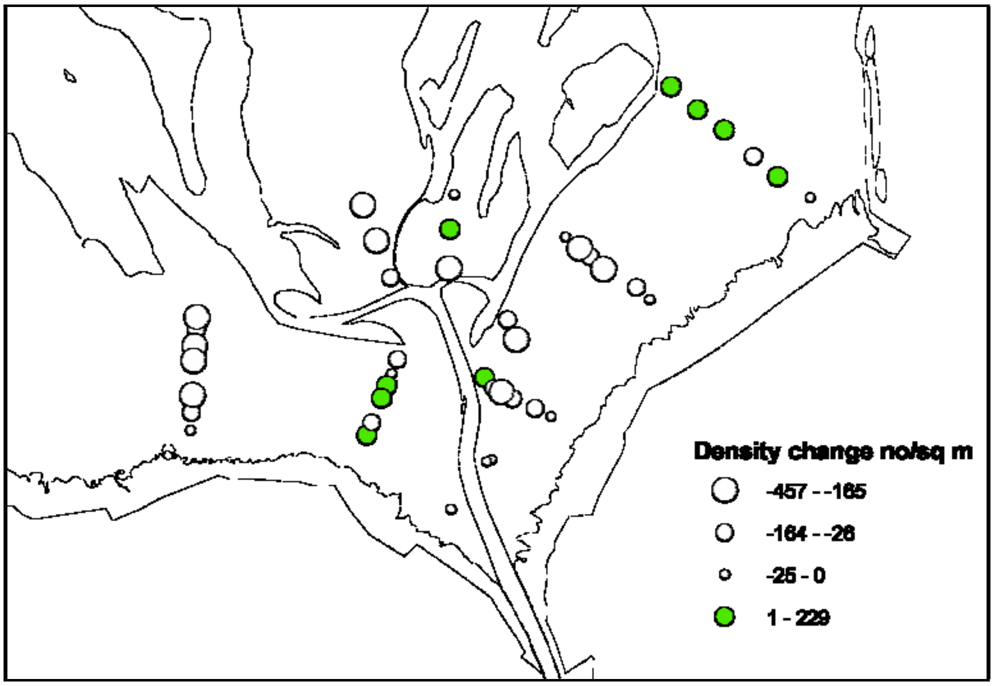


Figure 3.2.1c Nephtys hombergii <15mm



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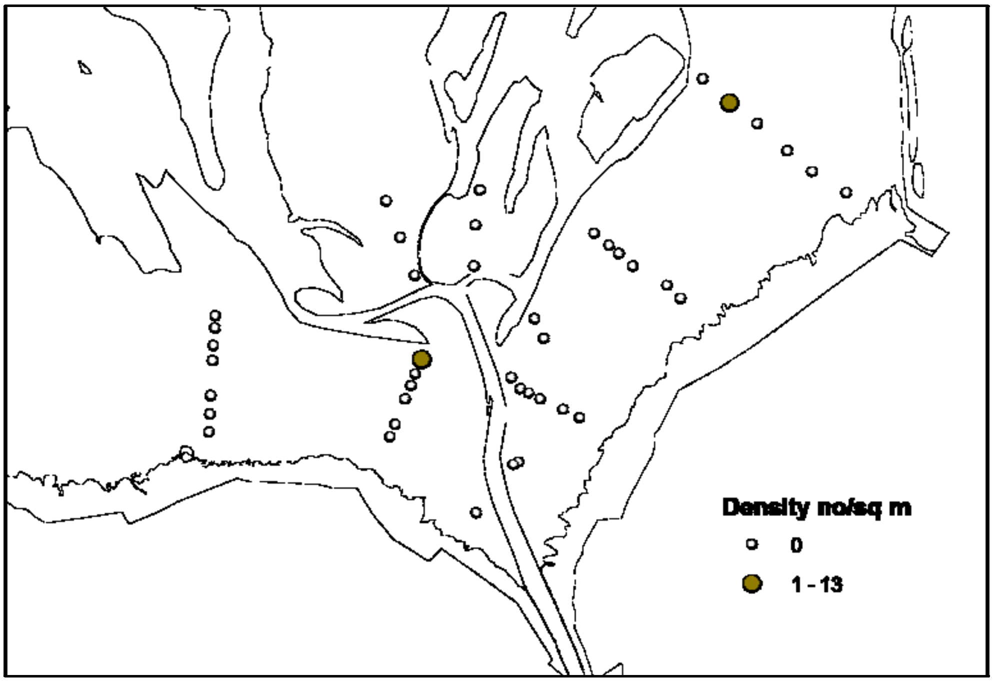
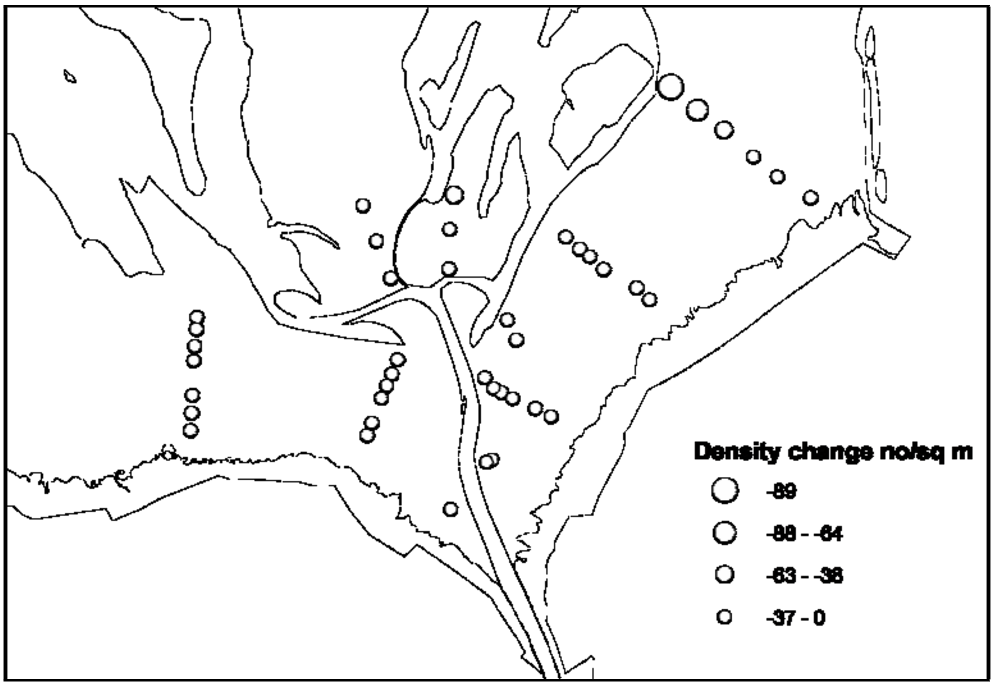


Figure 3.2.1d Scoloplos armiger<15mm



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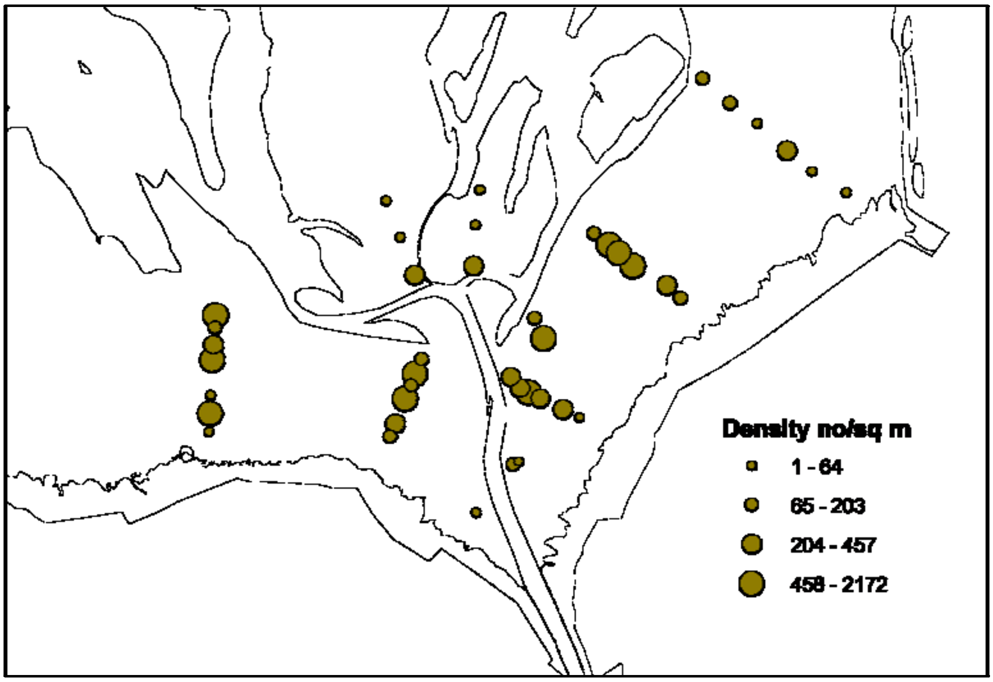
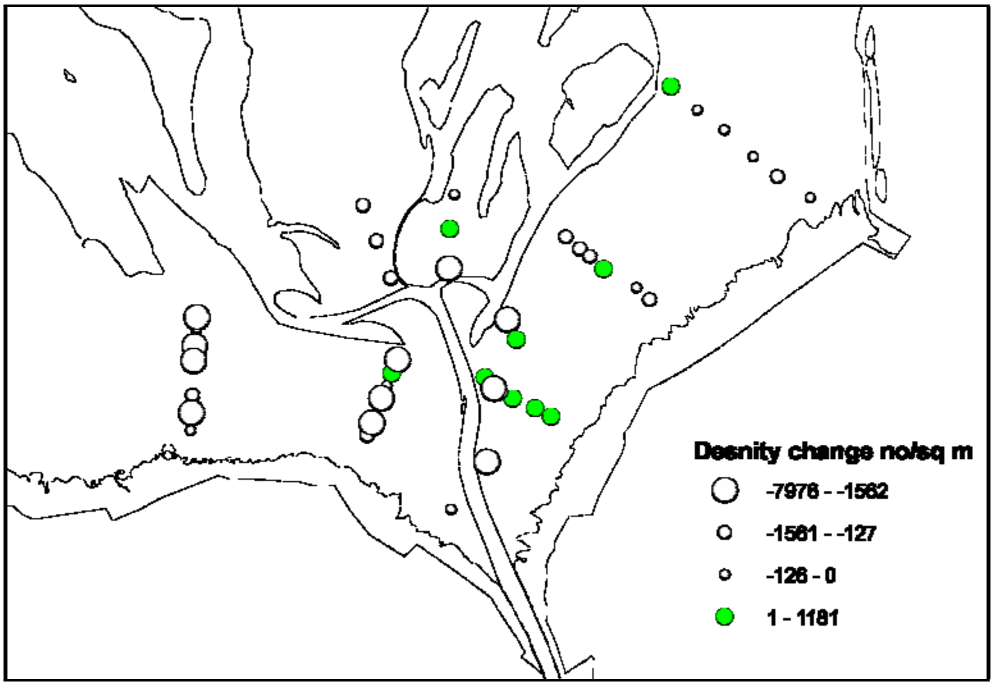


Figure 3.2.1e Pygospio elegans



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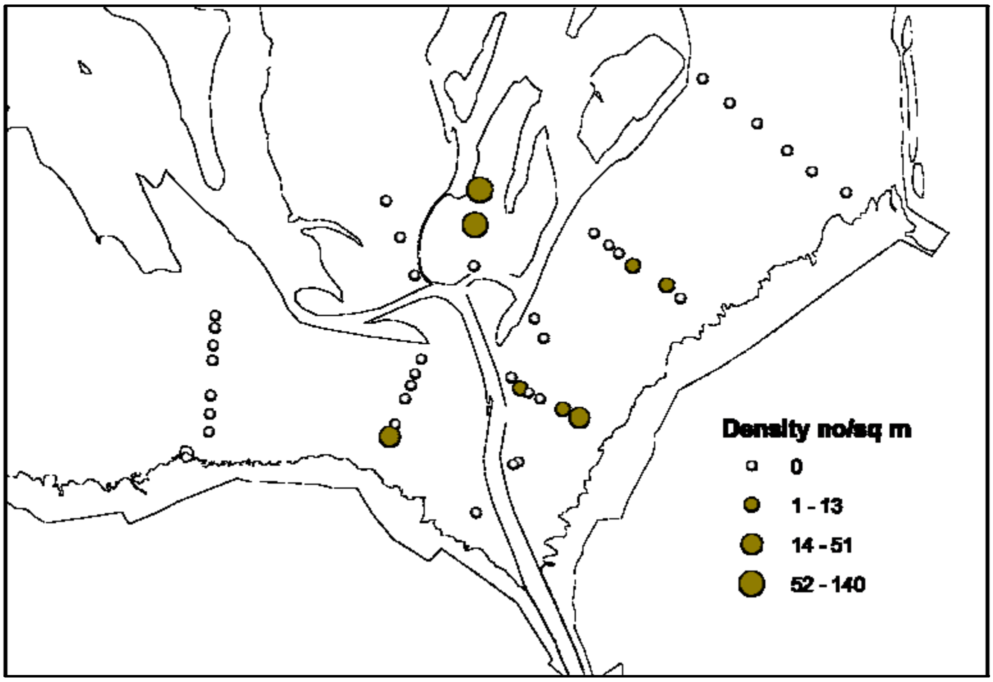
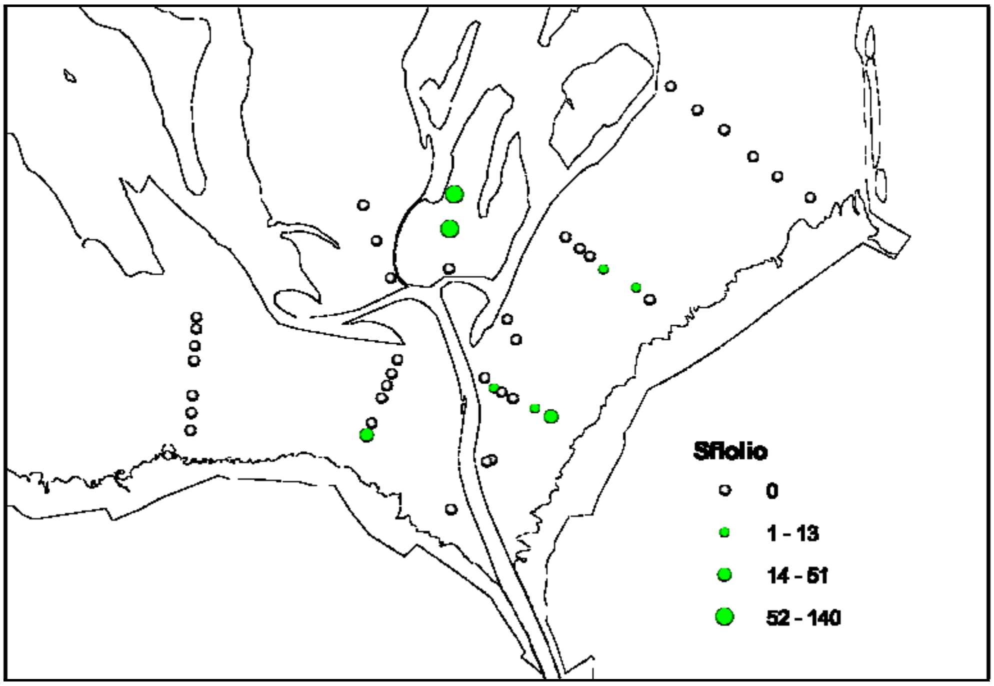


Figure 3.2.1f Scolelepis foliosa



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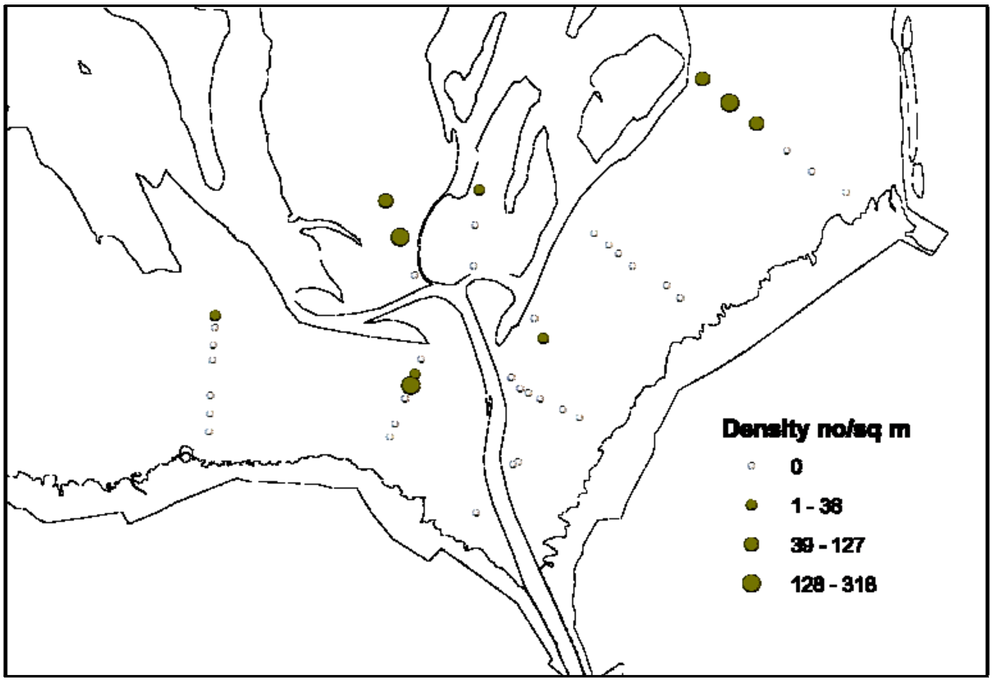
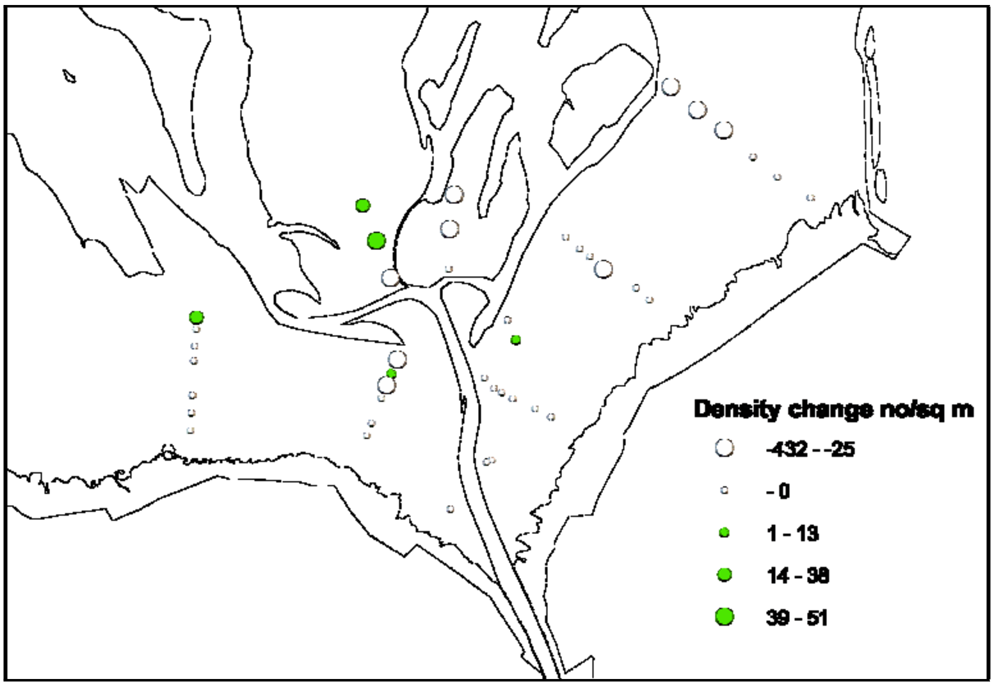


Figure 3.2.1g Spio martinensis



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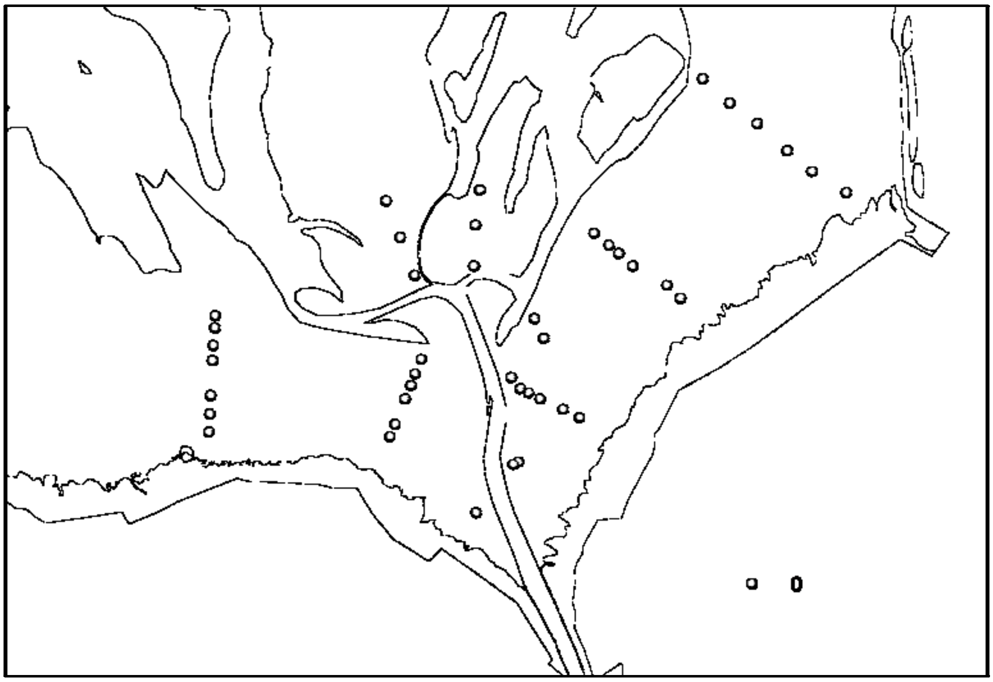
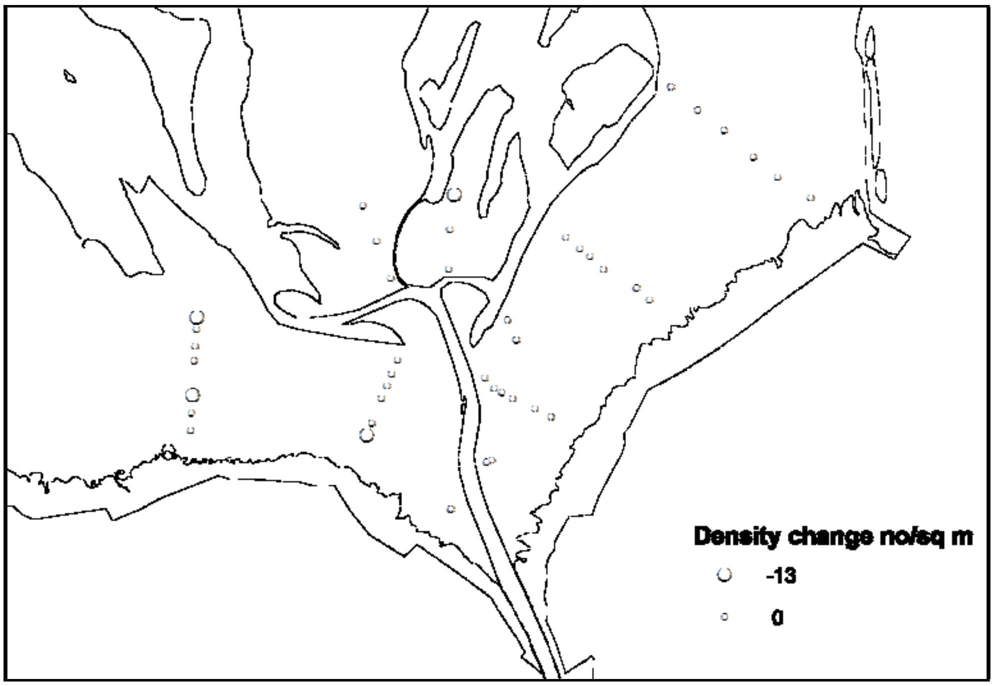


Figure 3.2.1h Spiophanes bombyx



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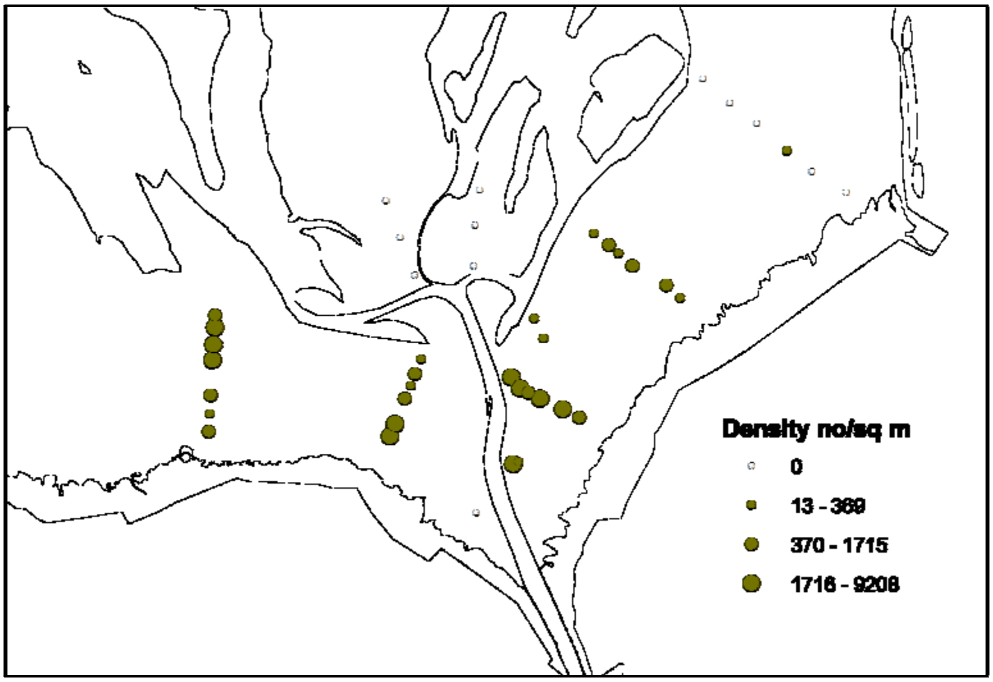
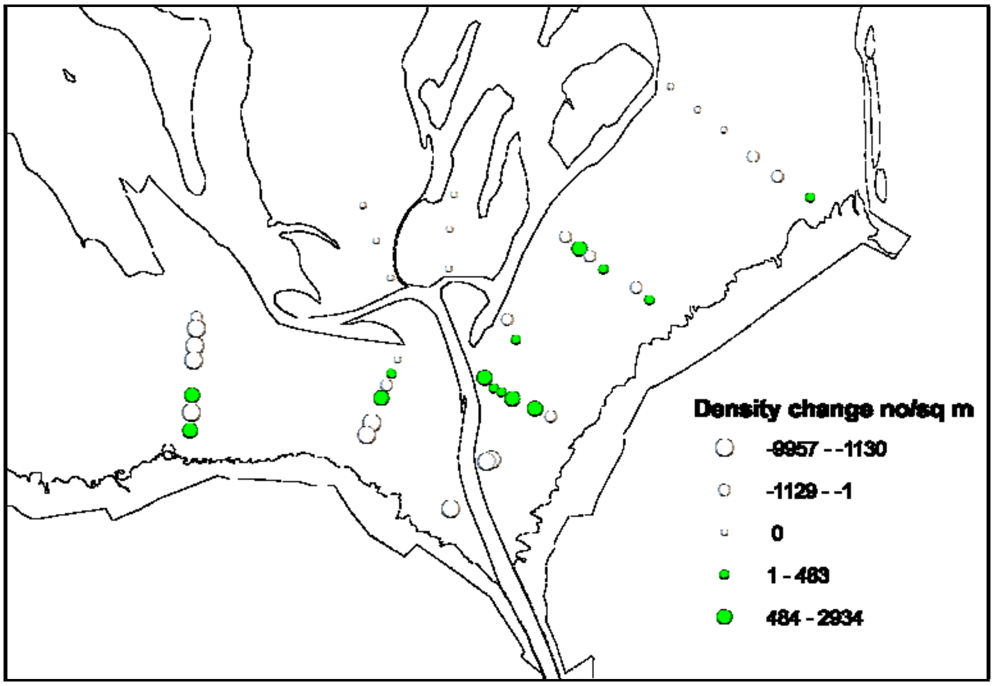


Figure 3.2.1i Tubificoides benedii



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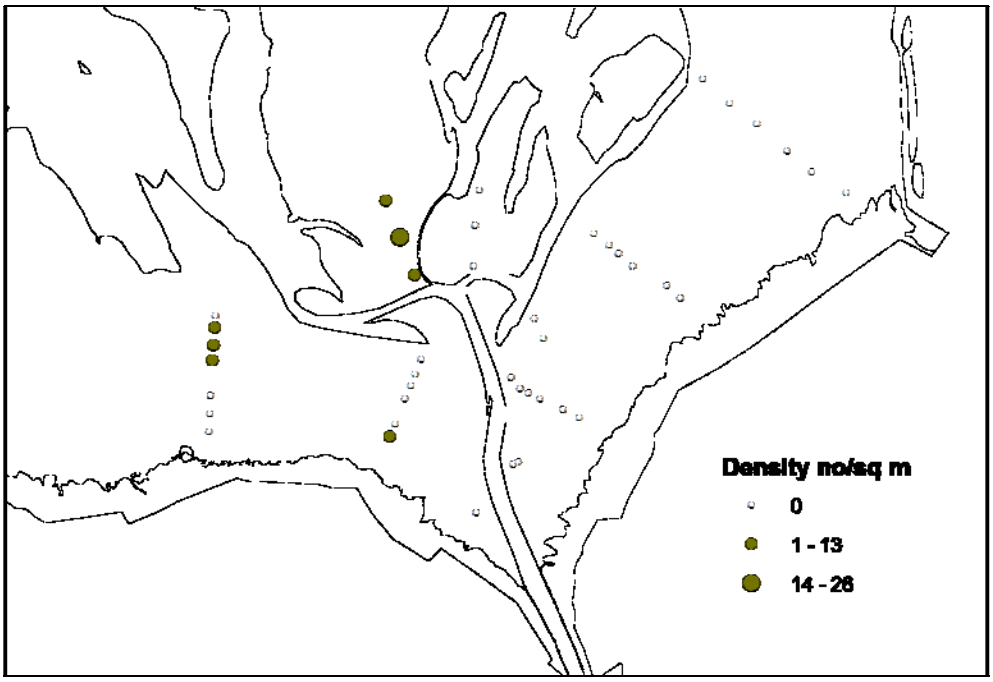
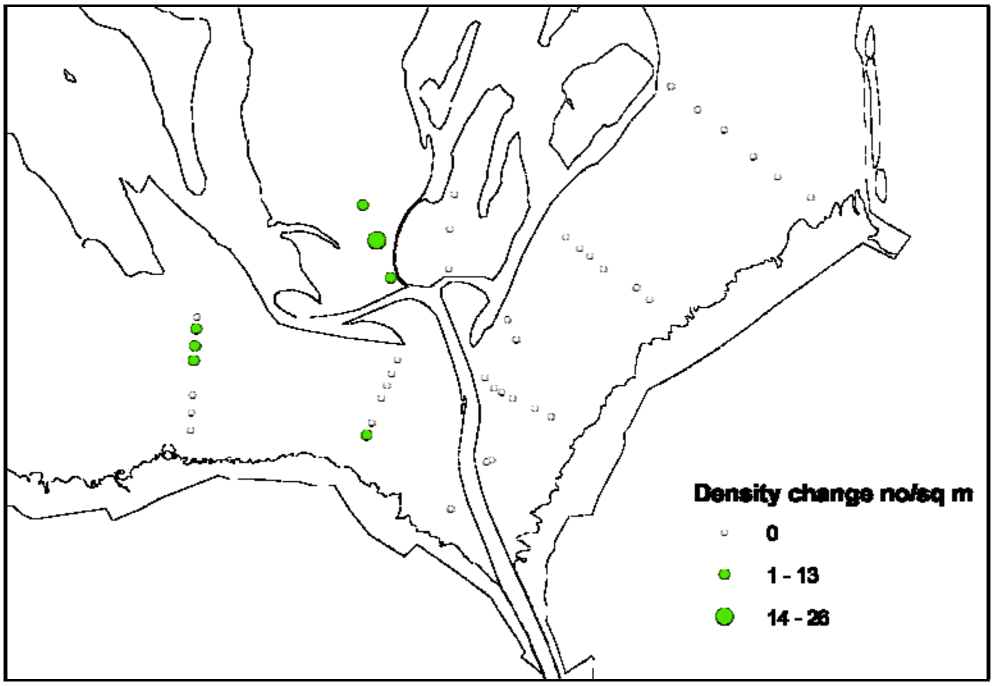


Figure 3.2.1j Carcinus maenas



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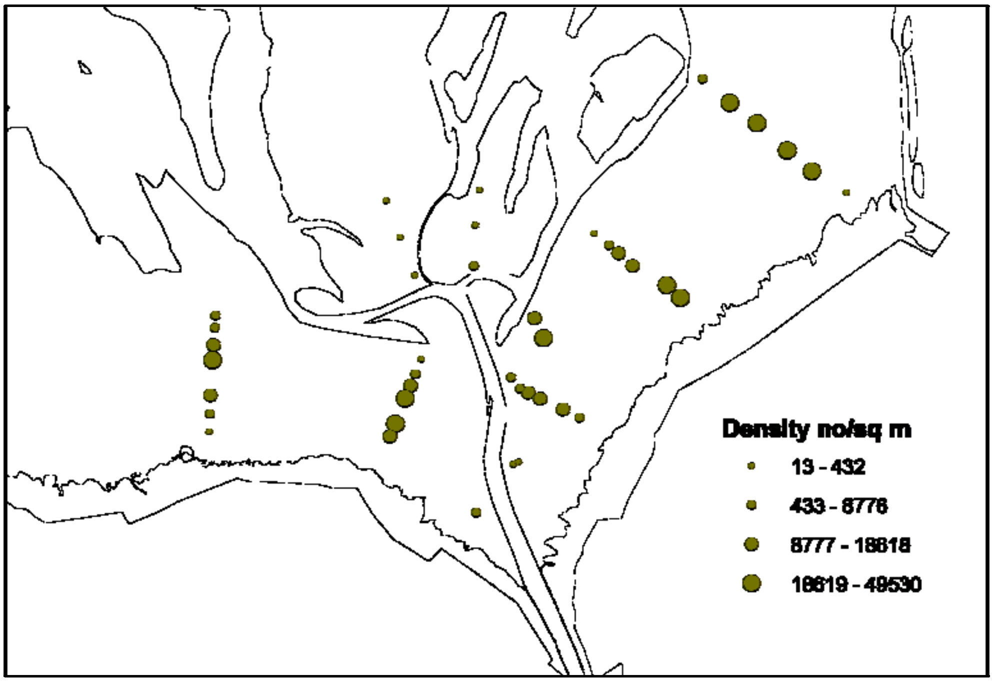
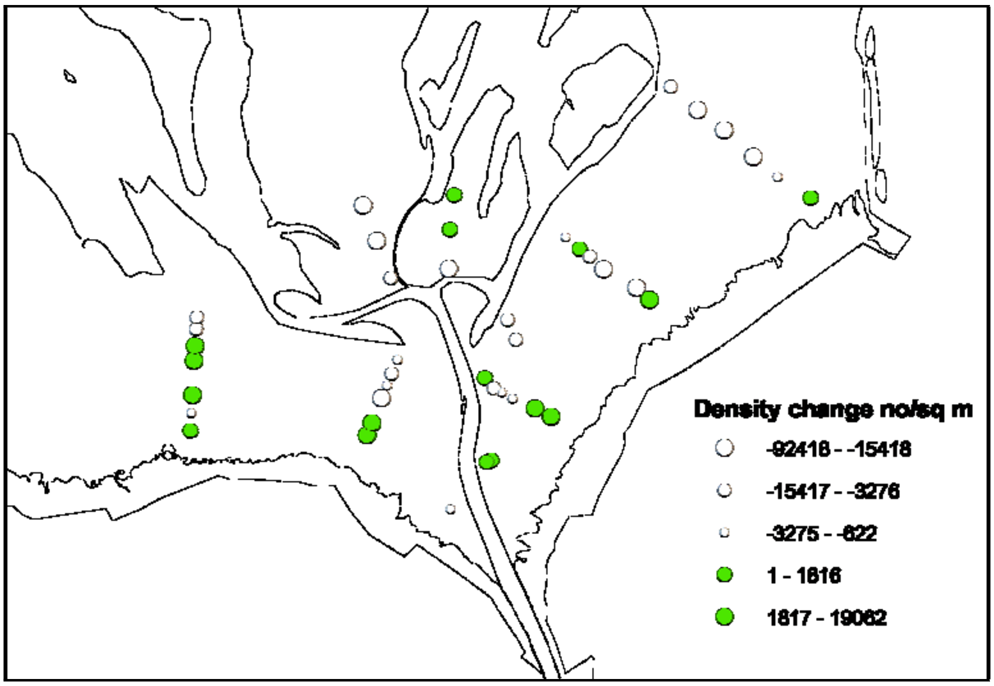


Figure 3.2.1k Hydrobia ulvae <3mm



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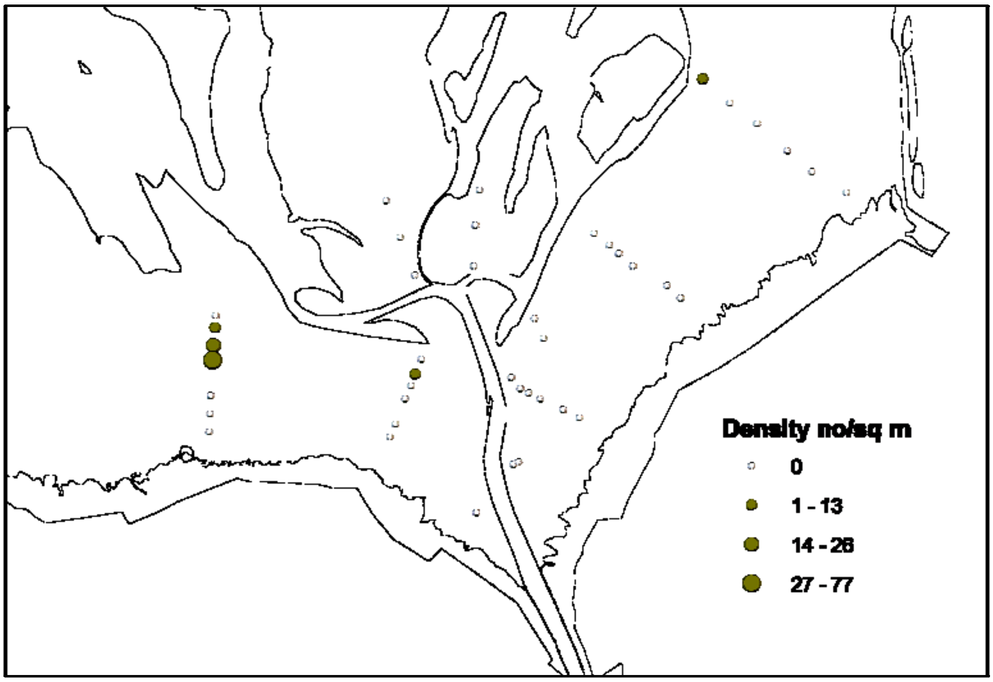
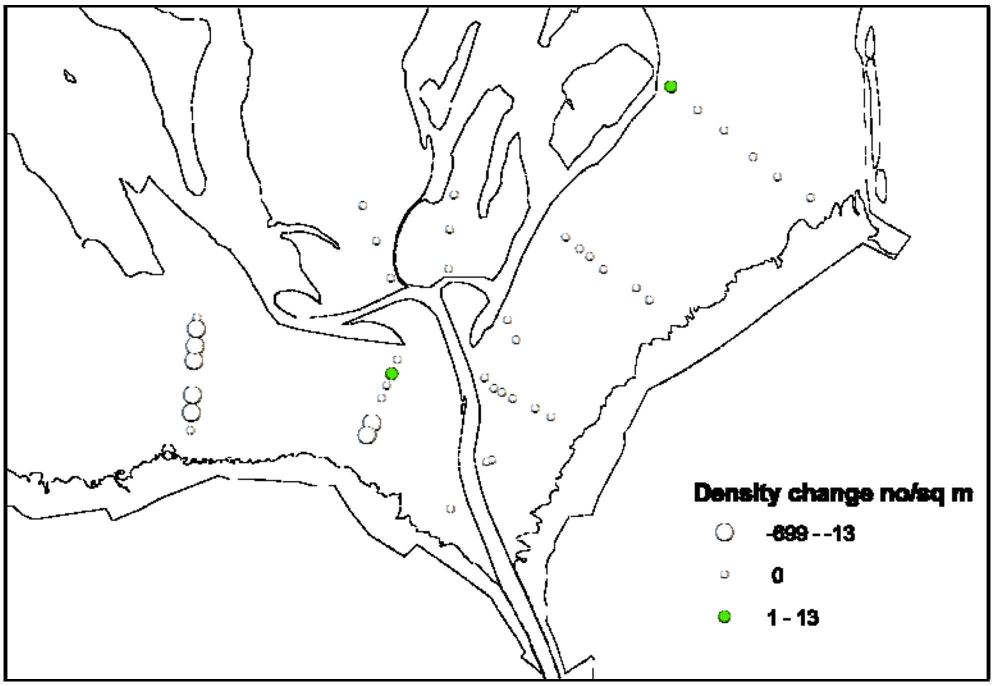


Figure 3.2.1l Retusa obtusa <3mm



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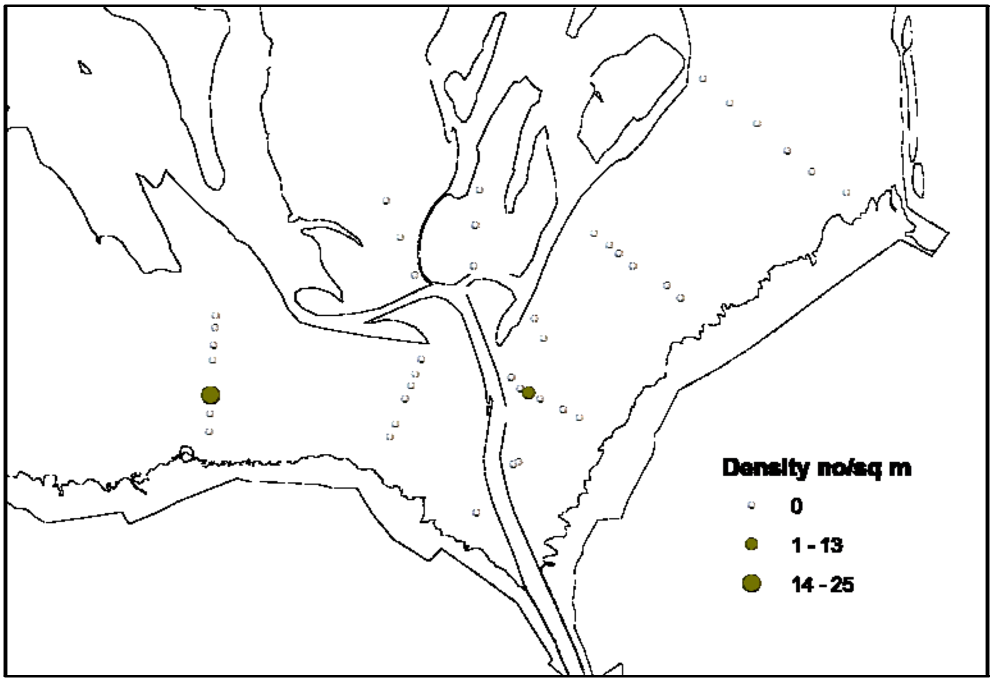
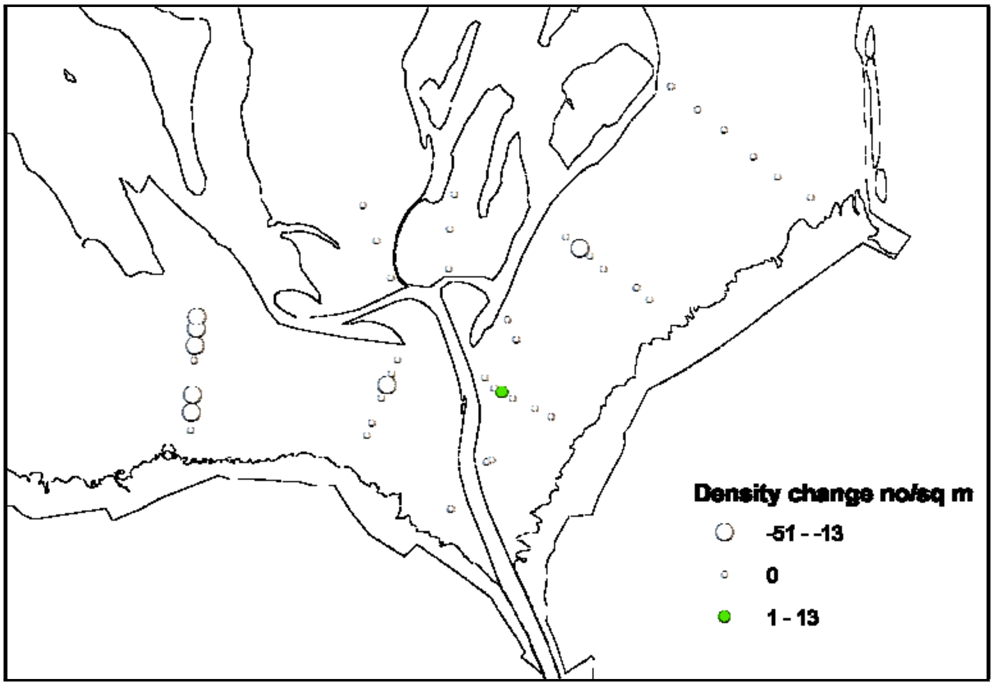


Figure 3.2.1m Mysella bidentata <5mm



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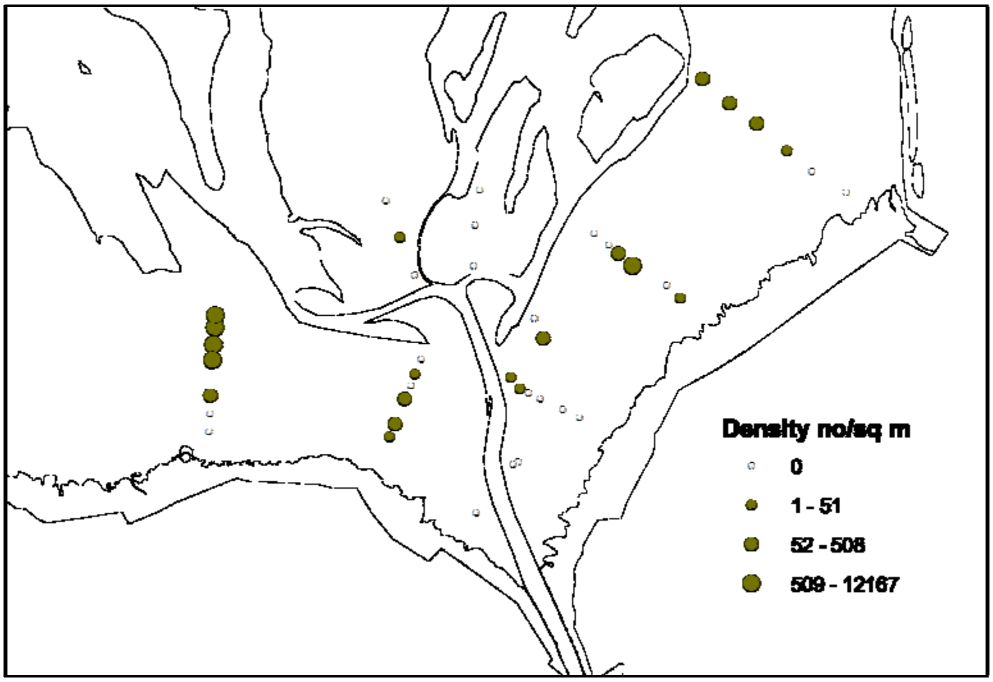
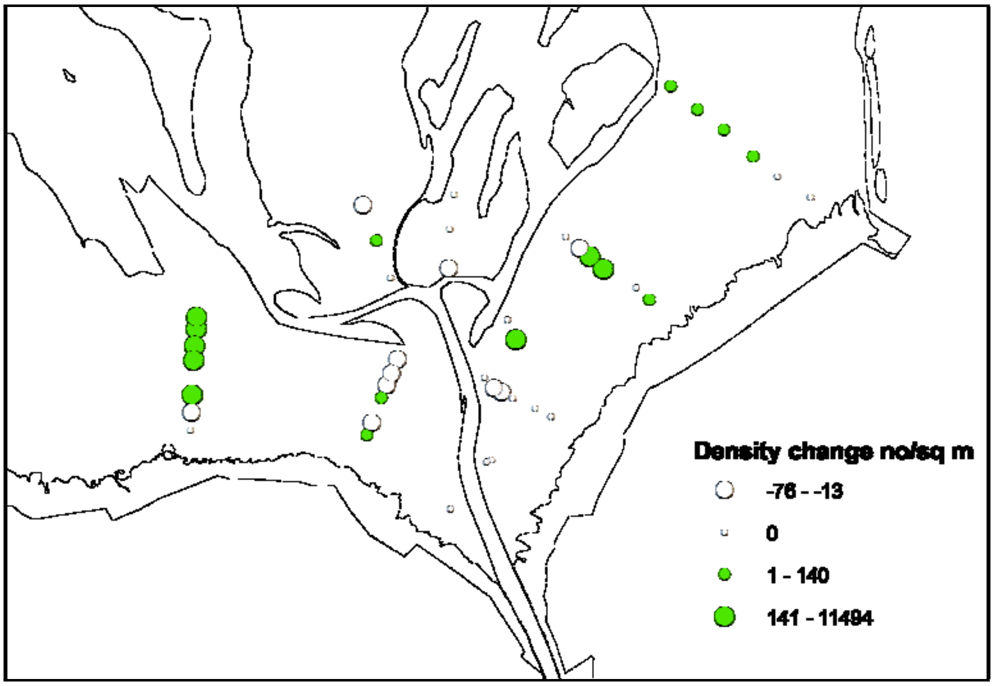


Figure 3.2.1n Cerastoderma edule <5mm



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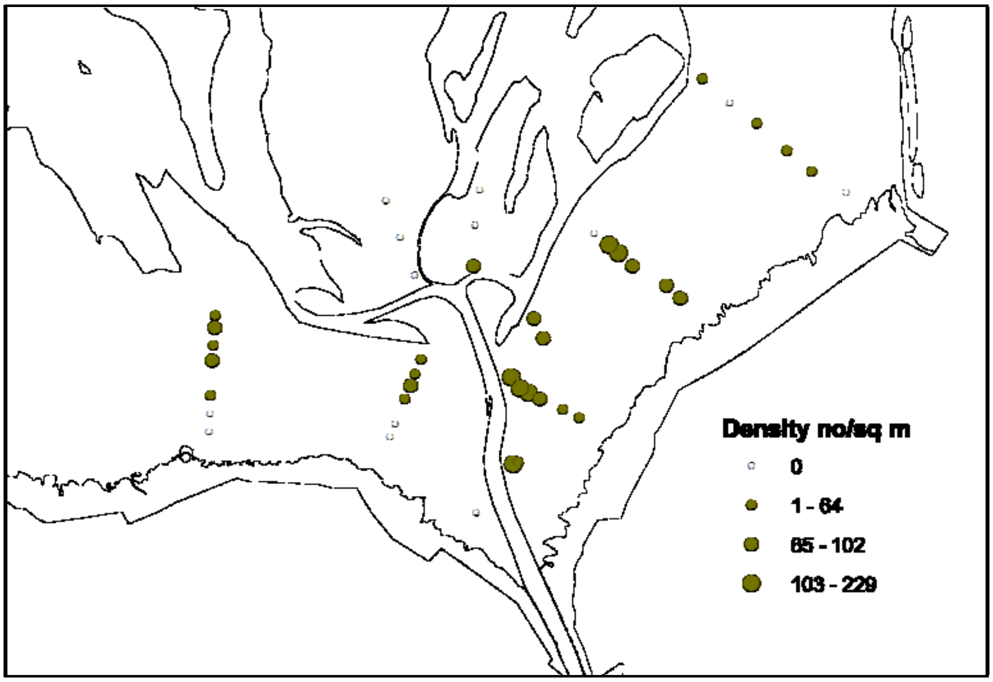
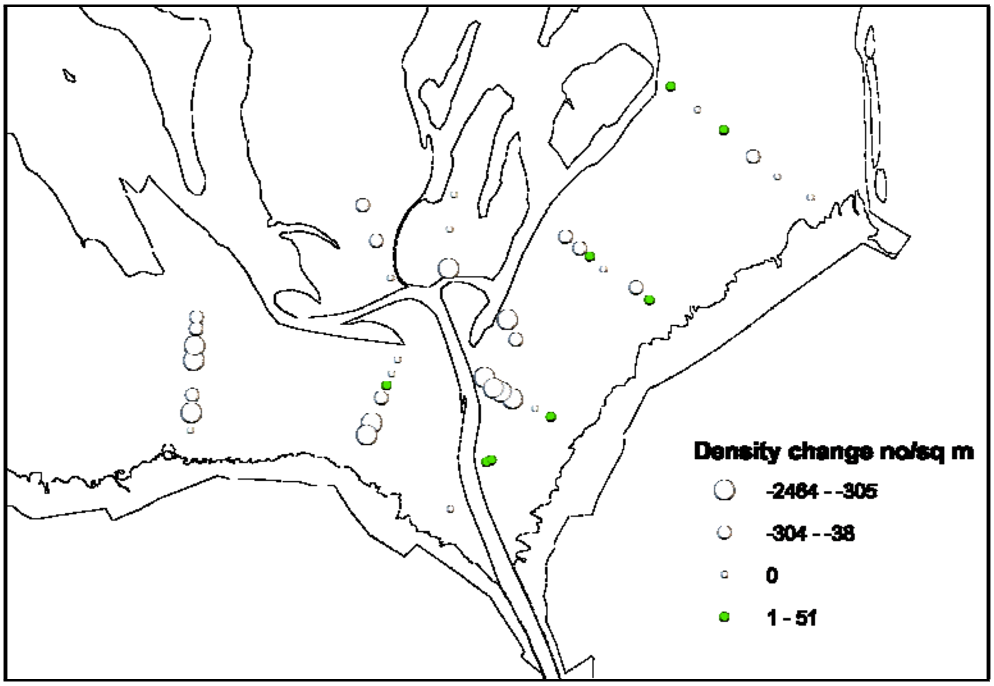


Figure 3.2.1o Macoma balthica <5mm



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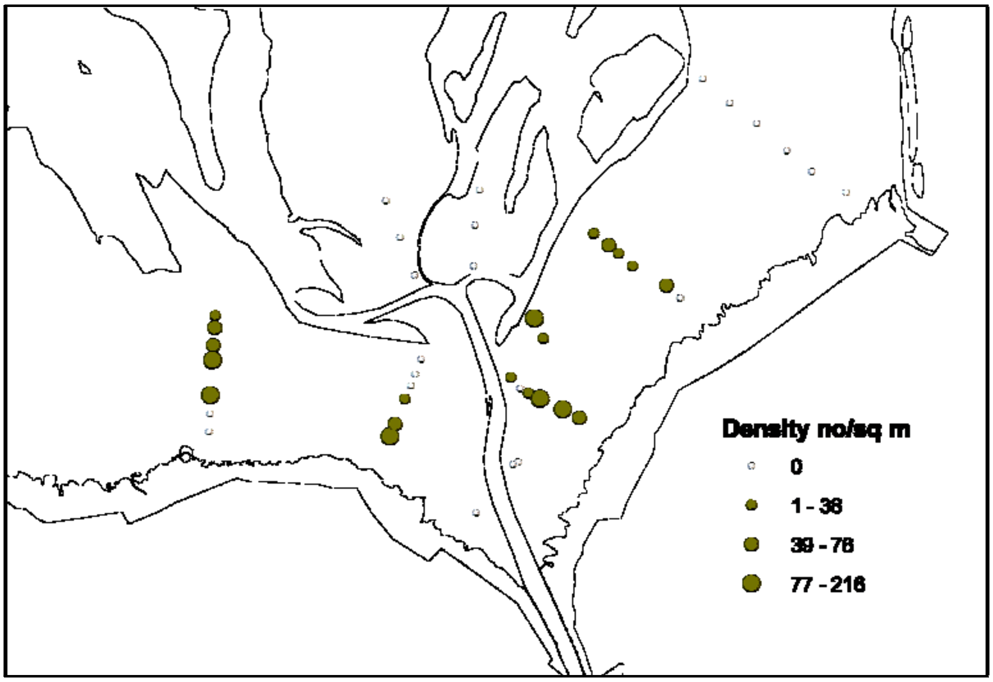
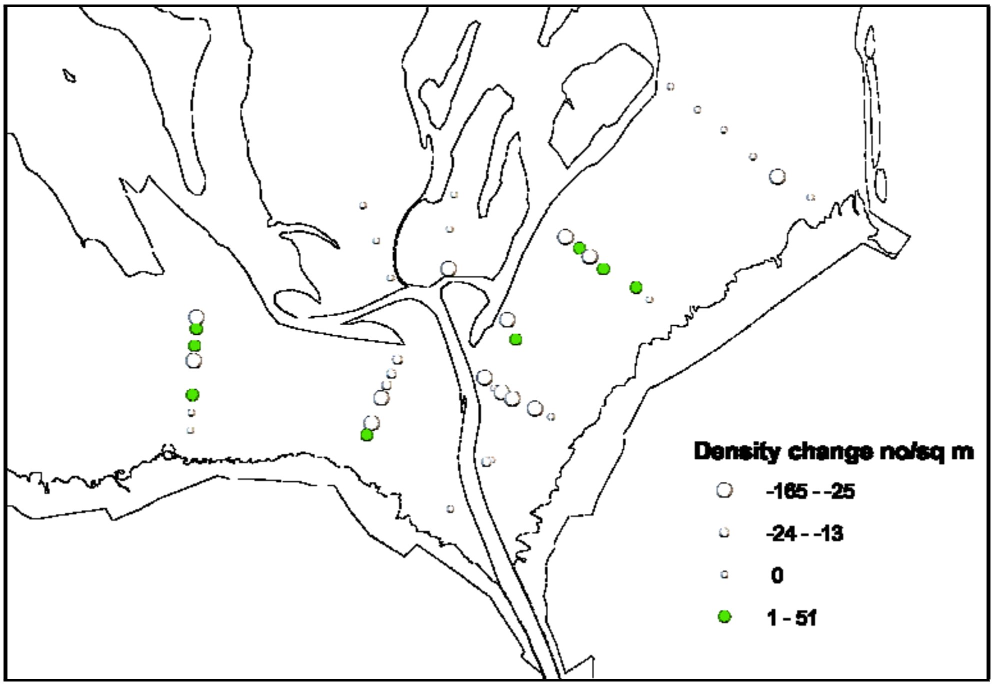


Figure 3.2.1p Scrobicularia plana 6-10mm



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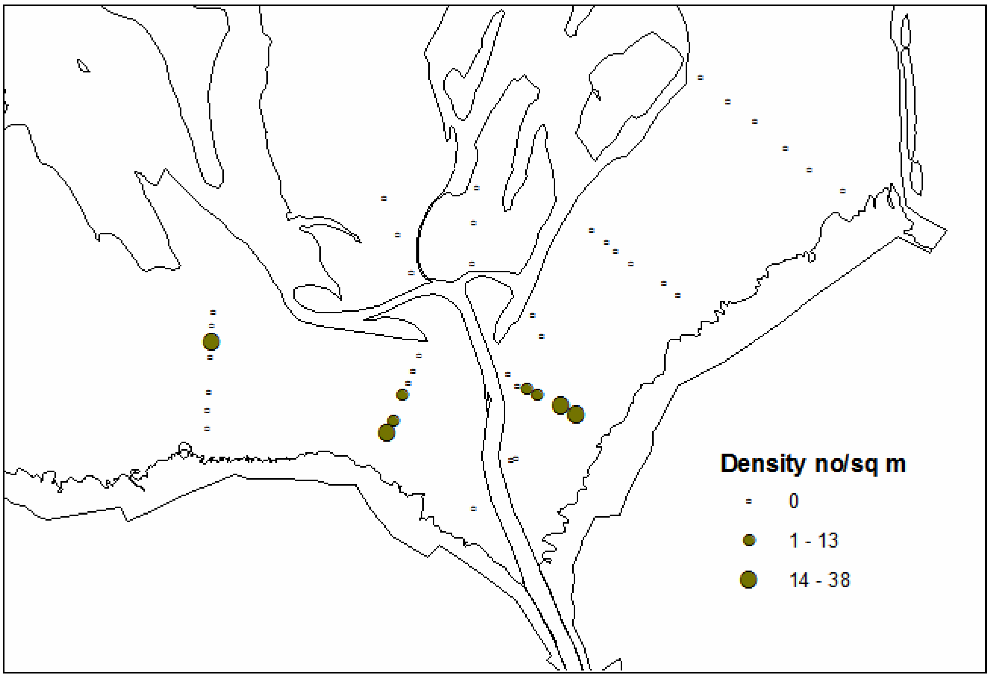


Figure 3.2.1q Scrobicularia plana 21-25mm

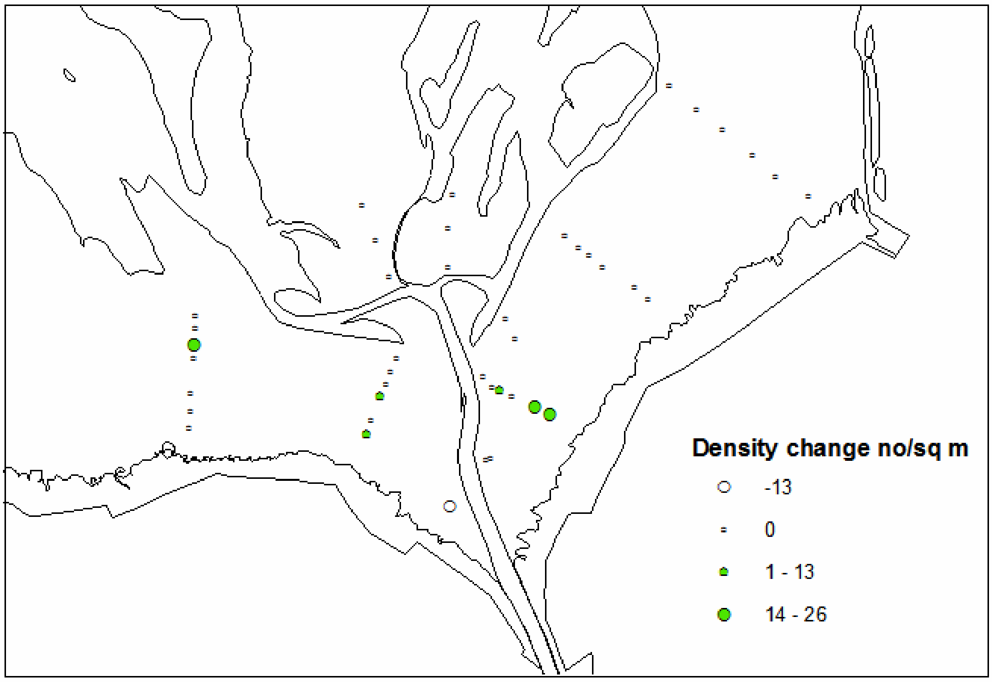
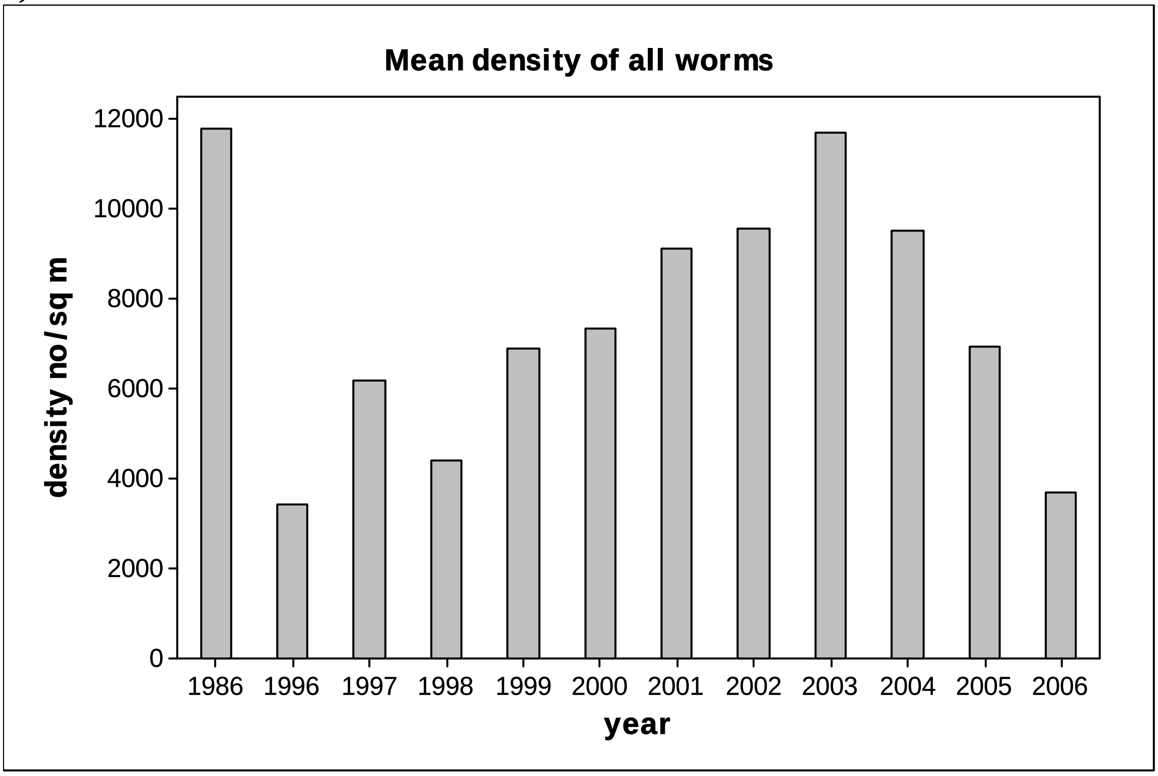


Figure 3.2.2 a-d. The mean density of **a**, worms, **b**, crustacean, **c**, gastropod molluscs (snails) and **d**, bivalve molluscs on the inner banks of the Gt Ouse study area in the surveys of 1986 and 1996-2006. Densities are expressed as numbers/m^2.

a,



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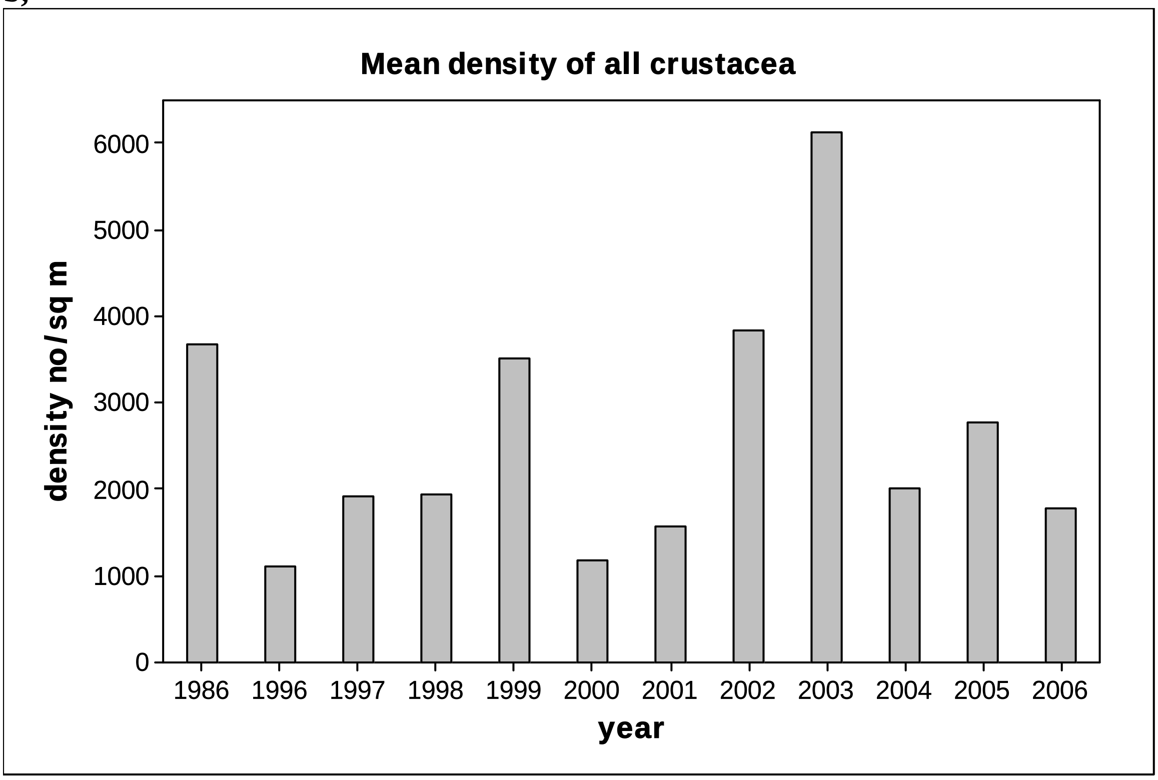
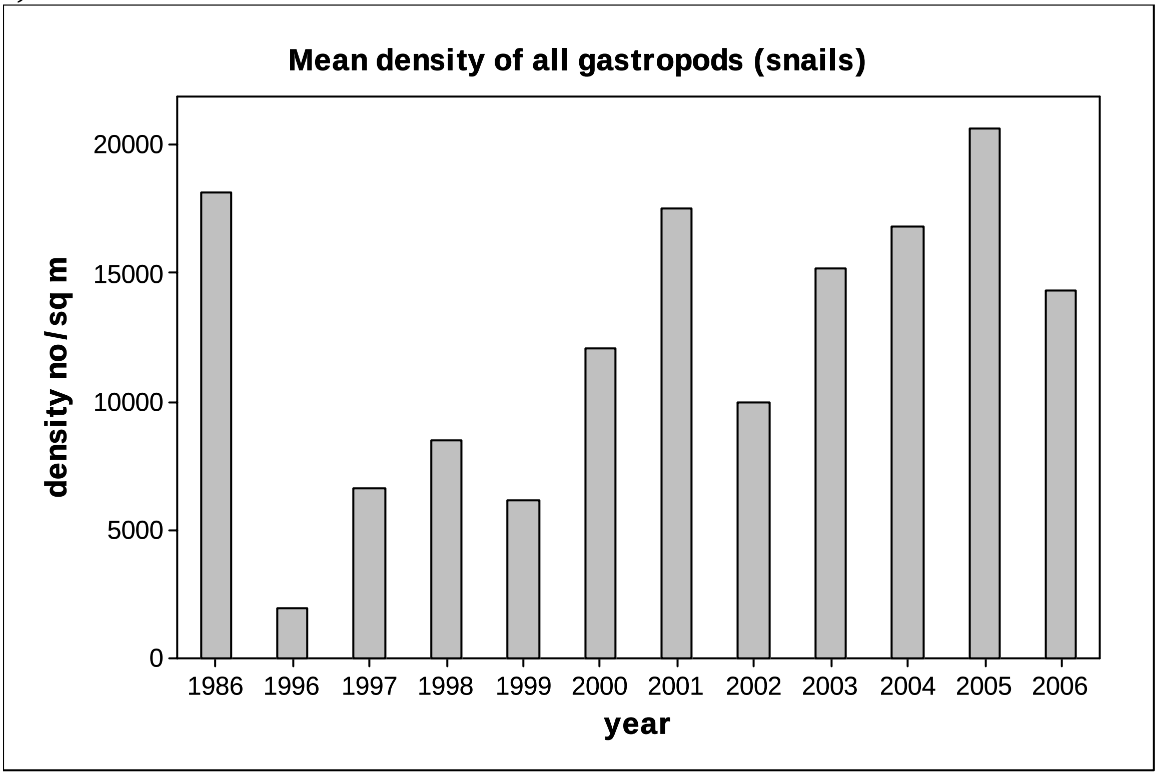


Figure 3.2.3 a-d continued.

c,



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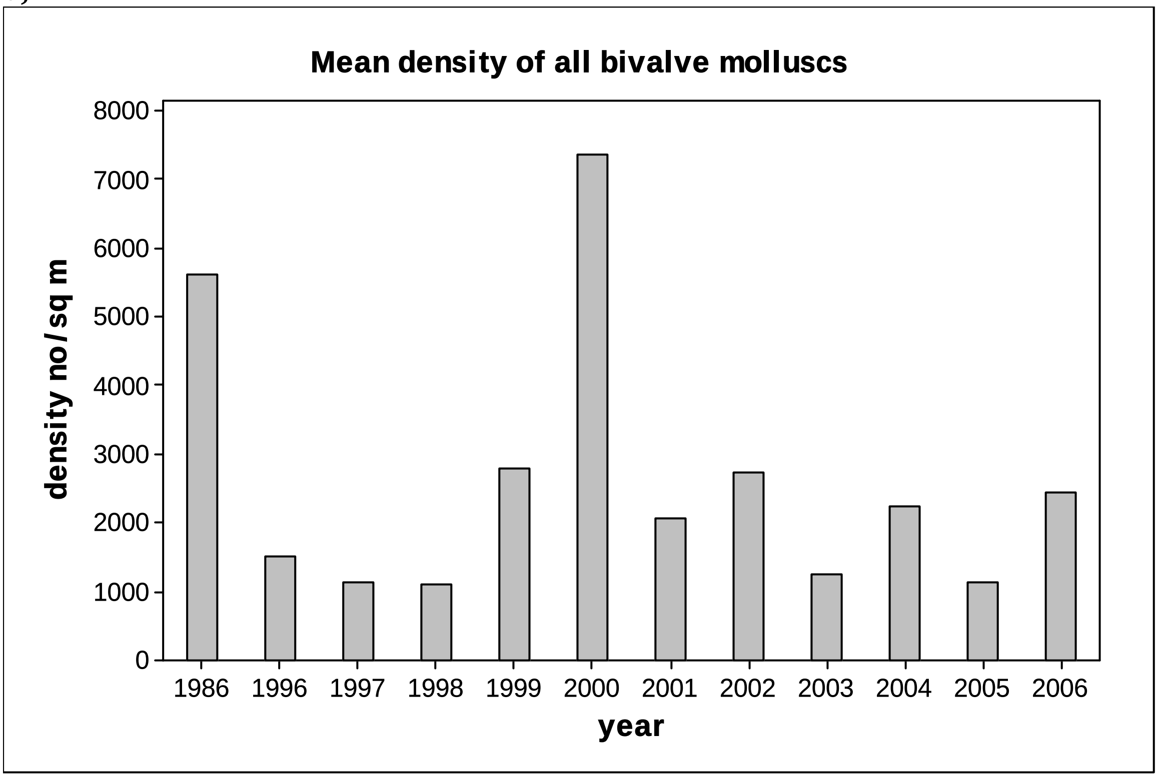


3.3 Shorebirds

3.3.1 Introduction

This section deals with the distribution of shorebirds feeding at low-water on the inter-tidal mud and sand flats adjacent to the Gt Ouse outfall. It also compares bird distribution in surveys made in winter 2006-2007 with those made in the previous winter's survey. Data are presented as summary tables and figures within the section and tabulated in Appendix 3. Each winter's survey data has been entered into a GIS-compatible database, an electronic version of which will be submitted at the end of the study.

The transects, labelled 51 to 66, DS and PS in Figure 3.3.1, indicate those parts of the inter-tidal areas adjacent to the Gt Ouse that were surveyed on two occasions in winter 2005-2006.

3.3.2 Shorebird distribution in the 2006-2007 survey and changes compared with 2005-2006 survey.

Both the distribution and abundance of birds in the 2006-2007 survey and in the previous survey are summarised in Figures 3.3.2a-h which chart the mean numbers recorded within each survey transect while Table 3.3.1 summarises the numbers of birds on shores either side the Gt Ouse outfall in the two surveys.

Distribution in winter 2006-2007

Dunlin (*Calidris alpina,* Figure 3.3.2a), redshank (*Tringa totanus,* Figure 3.3.2b), and curlew (*Numenius arquata* Figure 3.3.2g) were the most widespread species occurring in most of the survey transects including those adjacent to the Gt Ouse. Dunlin were most numerous on areas of Bulldog Sand (transects 57 and 58). Peaks in redshank numbers occurred in areas of Bulldog and Peter Black Sands spanned by transects 57 to 60 on the east shore and in transect 54 adjacent to the Gt Ouse outfall on the west shore. Curlew numbers peaked on Breast Sand on the west shore and Stubborn Sand on the east shore. In contrast to the former three species, the distributions of knot (*Calidris canutus,* Figure 3.3.2c), grey plover (*Pluvialis squatarola* Figure 3.3.2d), bar-tailed godwit (*Limosa lapponica,* Figure 3.3.2e), oystercatcher (*Haematopus ostralegus,* Figure 3.3.2f) and shelduck (*Tadorna tadorna,* Figure 3.3.2g) were aggregated in a few parts of the study area. Peaks in the numbers of knot occurred on Ferrier and Stubborn Sands (transect 64-66). Grey plover were most numerous on Stubborn Sand.and the outer banks as were oystercatchers. Bar-tailed godwit were most numerous Breast (transect 51) and Stubborn Sand. The peak in shelduck numbers occurred in transect 54 on the west shore adjacent to the river outfall.

Table 3.3.1. The numbers of seven wader species and Shelduck recorded feeding within the study area adjacent to the Gt Ouse outfall in surveys made during the winters of 2005-2006 and 2006-2007. Numbers are the mean of two surveys made during mid November to early February each winter. The whole area incorporates the inter-tidal mud and sand flats spanned by transects 51-66 and D and P in Figure 3.3.1. The area defined as the west shore, ie to the west of the River Gt Ouse, is covered by transects 51-55, the outer banks by DS and PS and the east shore by transects 56-66.

Bird species	West shore		Outer banks		East shore		Whole study area	
survey	2005	2006	2005	2006	2005	2006	2005	2006
Dunlin	944	541	549	556	5189	2538	6681	3634
Redshank	20	82	5	12	396	237	420	331
Knot	2519	3527	710	607	3540	10220	6768	14354
Grey Plover	21	37	6	23	172	48	199	107
Bar-tailed Godwit	82	214	3	72	1213	343	1297	628
Oystercatcher	212	294	308	216	1248	421	1768	931
Curlew	77	146	28	16	221	145	325	306
Shelduck	1060	854	0	1	1476	741	2536	1596

Changes in abundance and distribution within the study area.

All species with the exception of knot, were less abundant in 2006-07 than they were in the previous winters' survey (Table 3.3.1).

Though broadly similar between surveys, the pattern of dunlin distribution (Figure 3.3.2a) was less evenly spread over the study area in 2005-06 than it was in the previous winters' survey. Redshank distribution (Figure 3.3.2b) varied little between winters with peak numbers occurring on areas of Bulldog Sand traversed by transects 57 and 60. However more redshank fed on the west shore, particularly in transect 54 near the river in the current survey. Knot (Figure 3.3.2c) were more abundant on the shore to the west of the Gt Ouse in 2006-07 than they were in the previous winter and their main concentration on the east shore showed a northward shift to the area spanned by transects 65 and 66. Grey plover (Figure 3.3.2d) distribution was similar between winters, though fewer occurred on the northern part of the east shore in 2006-07 but more fed on the west shore and the outer banks. Bar-tailed godwit (Figure 3.3.2e), oystercatchers (Figure 3.3.2f), curlew (Figure 3.3.2g) were all similarly distributed between the two winters but were less numerous in most areas in 2006-07. Shelduck (Figure 3.3.2h) distribution was much more aggregated in 2006-07 than it was in the previous winter with a large proportion of the total feeding on the west shore adjacent to the river outfall.

In order to detect whether the within-transect change in bird numbers between years was related to proximity to the Gt Ouse outfall, the logarithm ($\log_{10}$) of ratios between 2006-2007 and 2005-2006 numbers were plotted against the transect's distance from the outfall. Any visual indication of a pattern in the plots was tested by regression analysis. There was no evidence of any relationship for any of the species except shelduck (Figure 3.3.3) whose numbers in 2006 decreased most relative to those in 2005 in areas near the river outfall.

Year on year changes in abundance within the study area and the whole Wash.

The year on year change in bird numbers in the study area (Table 3.3.1) could represent localised changes around the Gt Ouse outfall or changes that occurred at a Wash-wide scale. We checked these possibilities by comparing the change in numbers between the current and previous winter's survey of the study area with that in the whole Wash (Table 3.3.2) by expressing the numbers recorded in winter 2006-07 as a percentage of those in the previous winter. The whole Wash data were calculated from the Wetlands and Estuary Birds Scheme (WeBS) counts that were made independently of our own.

Table 3.3.2. Bird numbers in winter 2006-2007 expressed as a percentage of those in winter 2005-2006 for the study area and the whole Wash (WeBS counts).

Bird species	Study area	Whole Wash
	2006 numbers as % of 2005 numbers	2006 numbers as % of 2005 numbers
Dunlin	54	115
Redshank	79	99
Knot	212	167
Grey Plover	54	79
Bar-tailed Godwit	48	142
Oystercatcher	53	110
Curlew	94	130
Shelduck	63	76

Relative to the winter of 2005-06, the numbers of all species except knot decreased in the study area in winter 2006-07. In the case of grey plover, shelduck and, to a lesser extent, redshank, this decrease was of a similar proportion to that in the whole Wash implying that changes were Wash-wide. This was also the case for increases in knot numbers. In contrast the decrease in dunlin, bar-tailed godwit, oystercatcher and curlew numbers in the study area was not matched in the whole Wash where numbers increased. This implies that the study was a much less preferred feeding area for these species in winter 2006-07.

3.3.2.1 Changes in bird numbers: 1986, 1989-1991 and 1996-2006

The numbers of shorebirds feeding on the inner banks of the Gt Ouse study area at low tide have been surveyed for a total of 15 winters to date and they have been summarised (Figure 3.3.4) to put into perspective the changes that have occurred during the course of this study.

Dunlin numbers have remained relatively stable over the last six years of the study but declined in the current survey to their lowest recorded during this study. Redshank numbers were at their high in 1990 but had dropped to their lowest in 1996 at the start of the study. Since then numbers have increased steadily to their highest in 2003, although their numbers have declined annually since then. Knot were most abundant in 1990 and least abundant in 1999 since when their numbers have remained relatively stable until increases in 2004 and the current survey but not to numbers as high as those recorded in the late 1980's and early 1990's. Grey plover numbers in the current survey were the lowest recorded during this study. Bar-tailed godwit numbers were highest in 1996 when those of most other species were at or near their lowest. Then numbers decreased annually until 1999-2000 since when they have risen steadily until the current survey when numbers dropped to around the average for the entire study period. Oystercatcher numbers were at their lowest in early to mid 1990's following the decline in cockle and mussel stocks in the Wash. However, numbers had steadily increased until 2003 but in the current survey they dropped to their lowest since 1991. Curlew numbers have varied in a similar manner to those of redshank with low numbers being recorded in 1996 increasing steadily thereafter to a peak in 2001 after when they decreased in number to their lowest in 2004, though in the last two surveys their numbers have increased slightly. Shelduck numbers were consistently higher in the late 1980's to early 1990's than they have been since 1996. Lowest numbers were recorded in 1999 after when they increased but have dropped again in last winters' survey.

3.3.3 Summary and conclusions

All species with the exception of knot, were less abundant in 2006-07 than they were in the previous winters' survey.

Dunlin, redshank and curlew were the most widespread species occurring in most of the survey transects including those adjacent to the Gt Ouse. In contrast to the former three species, the distributions of knot, grey plover, bar-tailed godwit, oystercatcher and shelduck were aggregated in a few parts of the study area.

There was no evidence of any relationship between the change in their distribution between the current and previous survey and distance from the Gt Ouse outfall for any of the species except shelduck. Its numbers decreased most in areas near the outfall.

Change in shorebird numbers within the study area between the current winters' survey and the previous winter was compared with that recorded in the whole Wash to determine whether changes were local or Wash-wide. Relative to the winter of 2005-06, the numbers of all species except knot decreased in the study area in winter 2006-07. In the case of grey plover, shelduck and, to a lesser extent, redshank, this decrease was of a similar proportion to that in the whole Wash implying that changes were Wash-wide. This was also the case for increases in knot numbers. In contrast, the decrease in dunlin, bar-tailed godwit, oystercatcher and curlew numbers in the study area was not matched in the whole Wash where numbers increased. This implied that the study area was much less preferred for feeding by these species in winter 2006-07.

The numbers of shorebirds feeding on the inner banks of the Gt Ouse study area at low tide have been surveyed for a total of 15 winters to date and were summarised to put into perspective the changes that have occurred during the course of this study.

Section 3.3

Figure legends

Figure 3.3.1

The ITE shorebird transects, numbered 51-66, within which the distribution of shorebirds feeding at low water was surveyed. Transects were aligned along the direction of flow of the ebbing tide. Areas of the outer banks, Daseley's Sand (DS) and Pandora Sand (PS), that were surveyed are indicated by cross-hatch shading.

Figure 3.3.2a-h

The numbers of shorebirds in each survey transect in the winters of 2005-2006 and 2006-2007. Numbers are the mean of two counts made during November to January in each winter. Transects are those shown in Figure 3.3.1(note; ‘OBs’ refer to the outer banks, Daseley’s and Pandora Sands). **a**, Dunlin **b,** Redshank **c,** Knot **d,** Grey plover **e,** Bar-tailed godwit **f,** Oystercatcher **g,** Curlew and **h,** Shelduck.

Figure 3.3.3

The change in shelduck numbers in each transect between the 2005-06 and 2006-07 surveys in relation to distance from the Gt Ouse outfall. The change is expressed as the $\log_{10}$ transformed ratio of 2006 to 2005 numbers.

Figure 3.3.4

The total numbers of shorebirds feeding on the inner banks of the Gt Ouse study area in winters 1986-87, 1989-90 to 1991-92 and 1996-97 to 2005-06.

Figure 3.3.1

The ITE shorebird transects, numbered 51-66, within which the distribution of shorebirds feeding at low water was surveyed. Transects were aligned along the direction of flow of the ebbing tide. Areas of the outer banks, Daseley's Sand (DS) and Pandora Sand (PS) that were surveyed are indicated by cross-hatch shading.

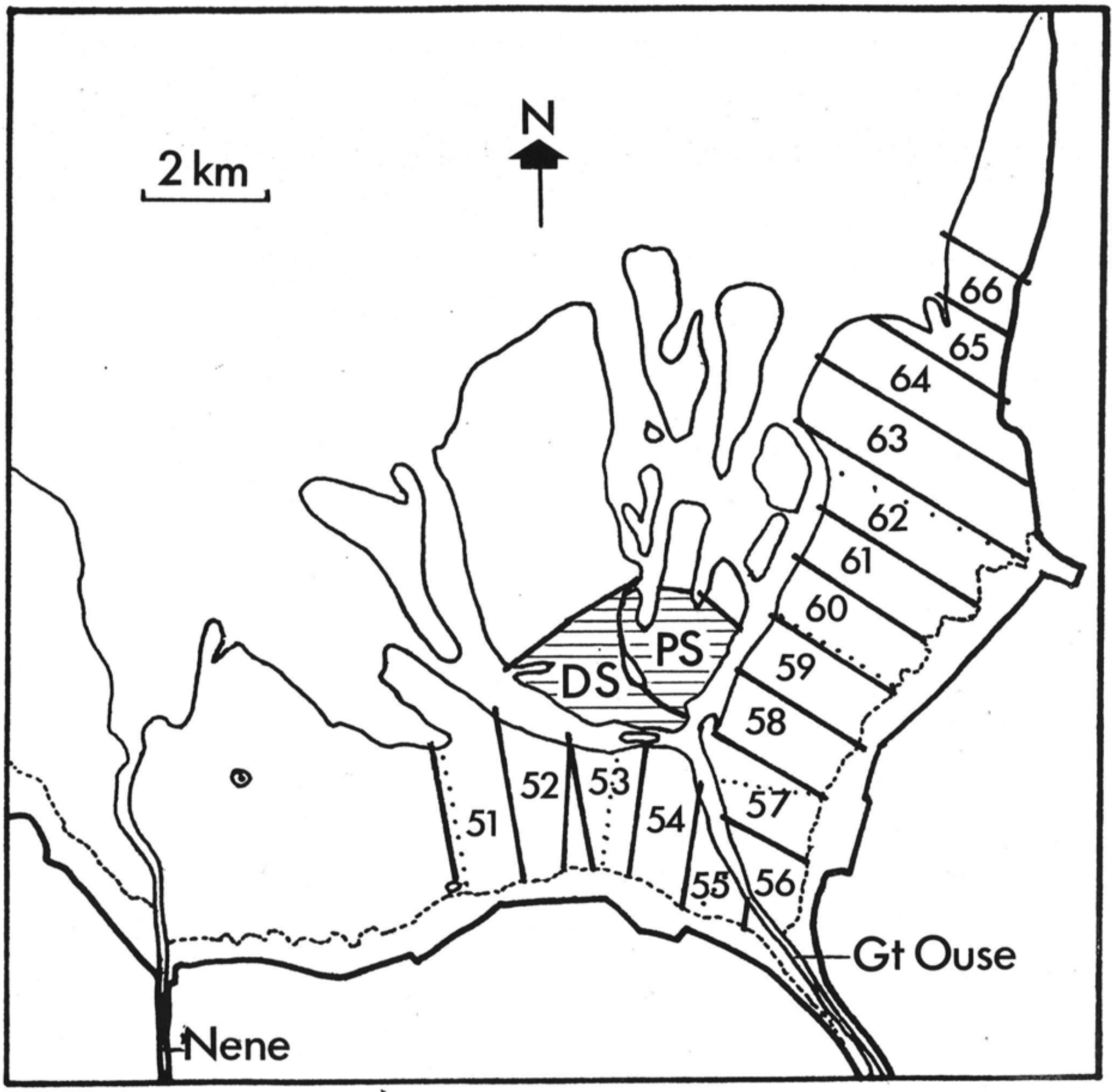
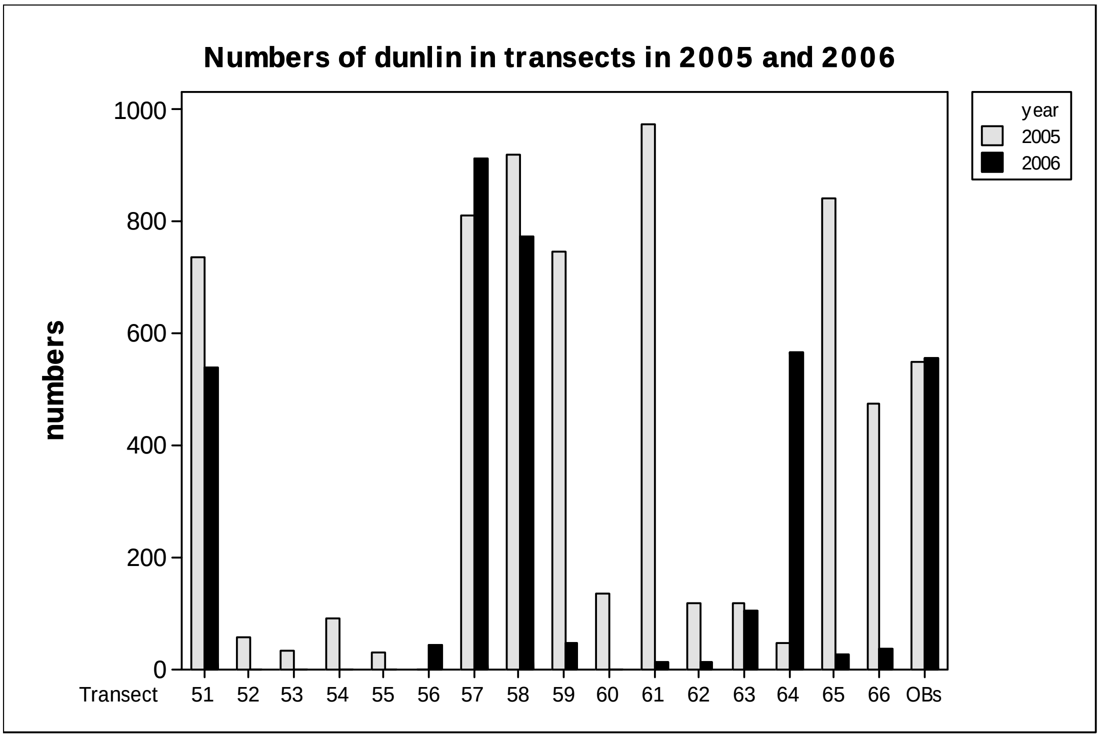


Figure 3.3.2a-h The numbers of shorebirds in each survey transect in the winters of 2005-2006 and 2006-2007. Numbers are the mean of two counts made during November to January in each winter. Transects are those shown in Figure 3.3.1(note; ‘OBs’ refer to the outer banks, Daseley’s and Pandora Sands). **a**, Dunlin **b,** Redshank **c,** Knot **d,** Grey plover **e,** Bar-tailed godwit **f,** Oystercatcher **g,** Curlew and **h,** Shelduck.

a,



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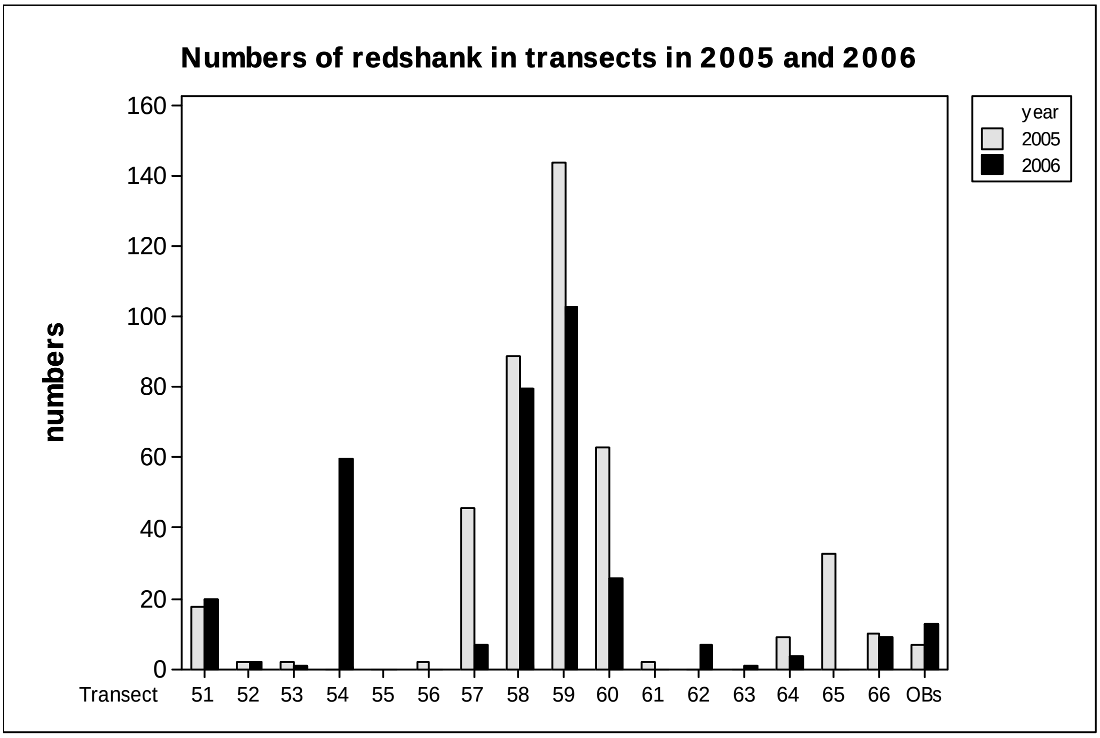
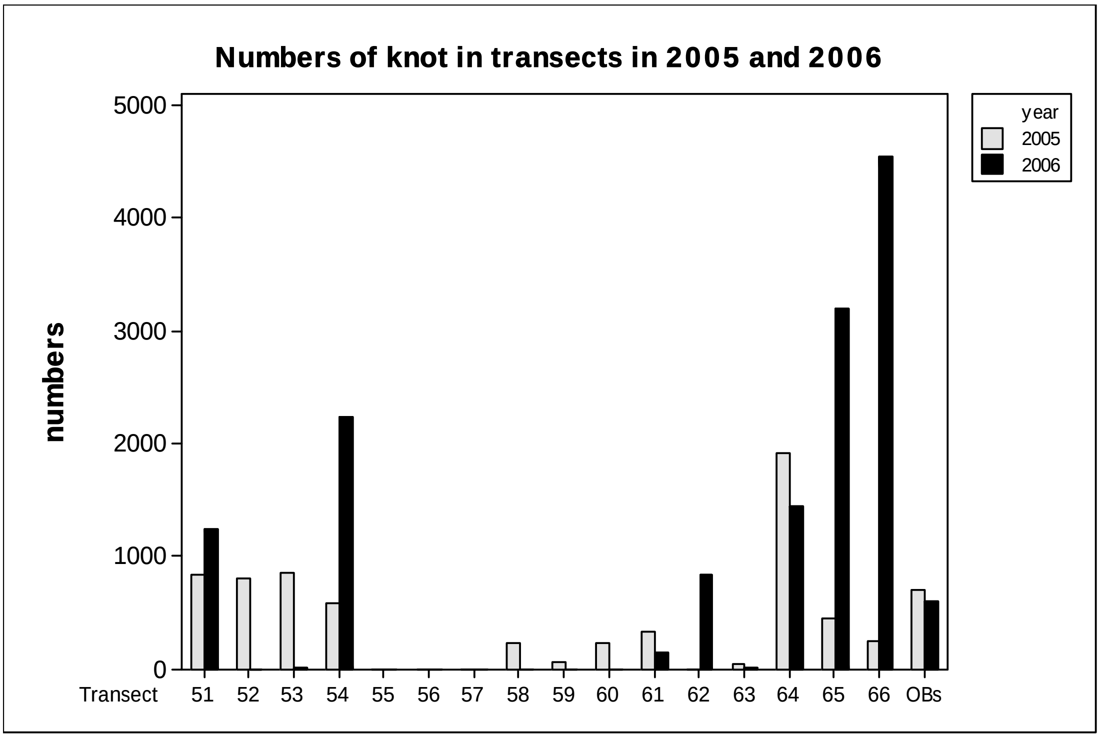


Figure 3.3.2a-h continued

c,



d,

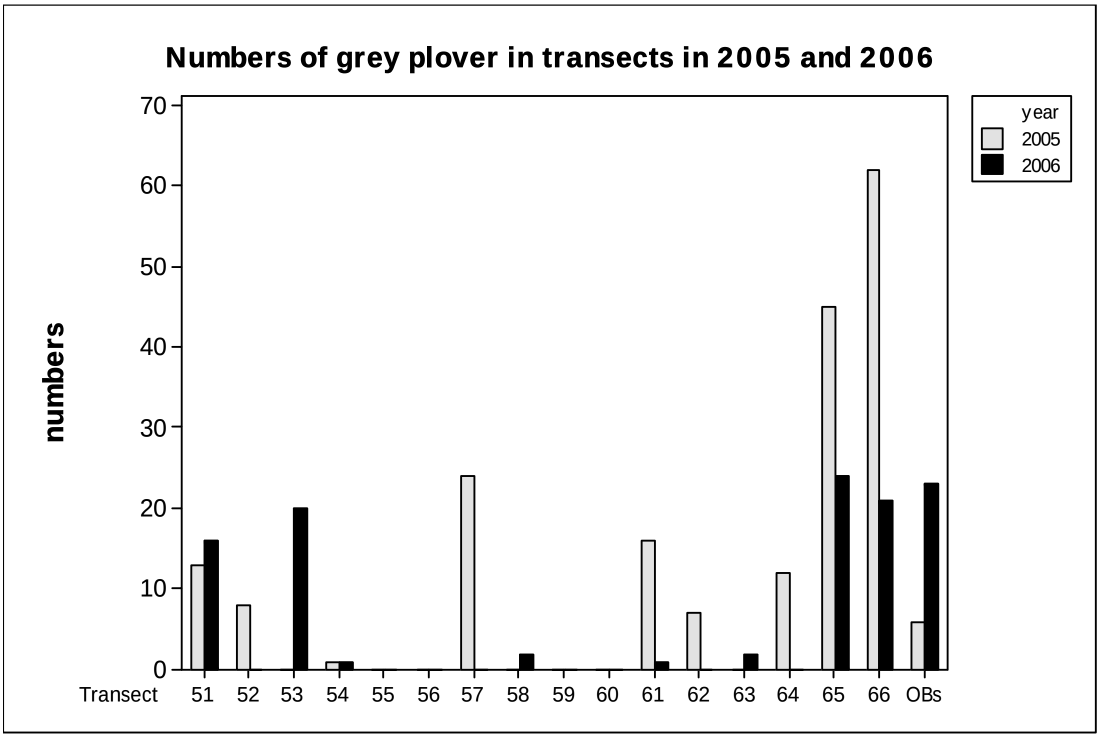
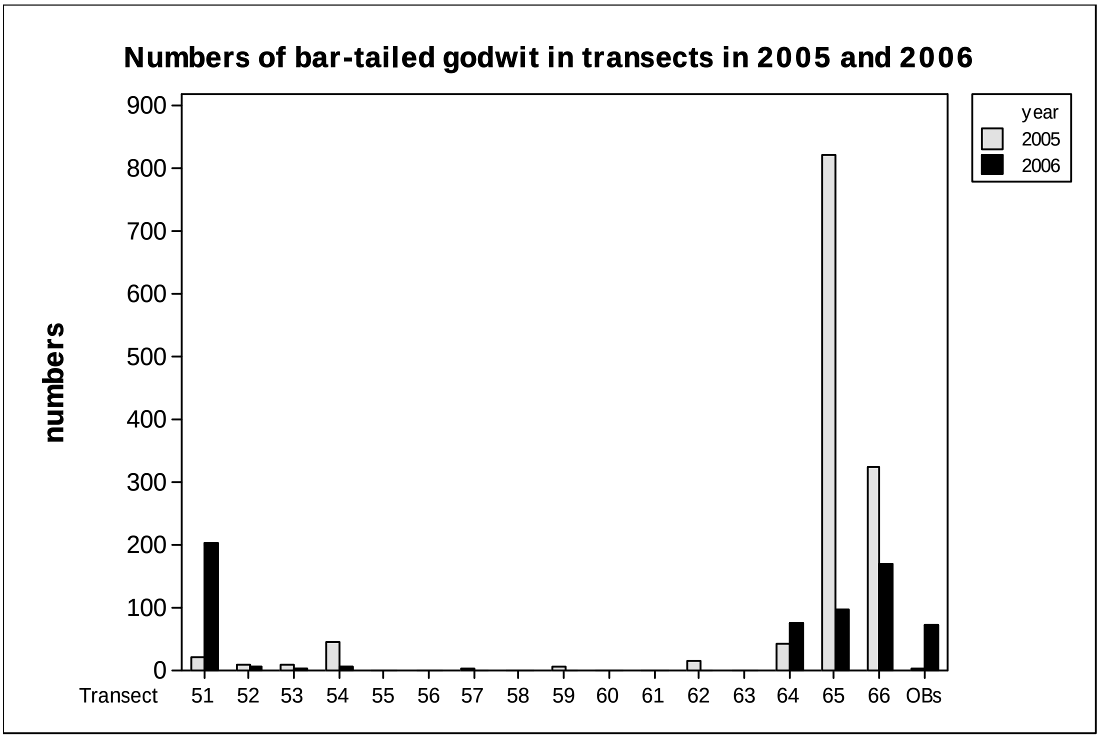


Figure 3.3.2a-h continued

e,



f,

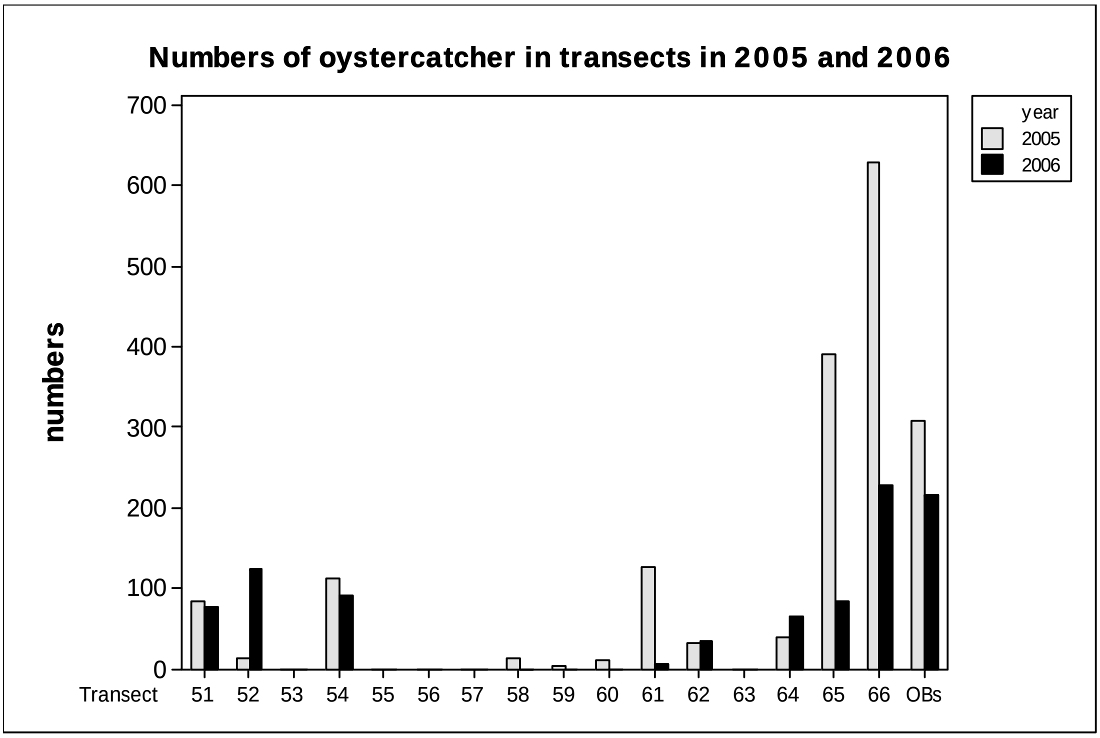
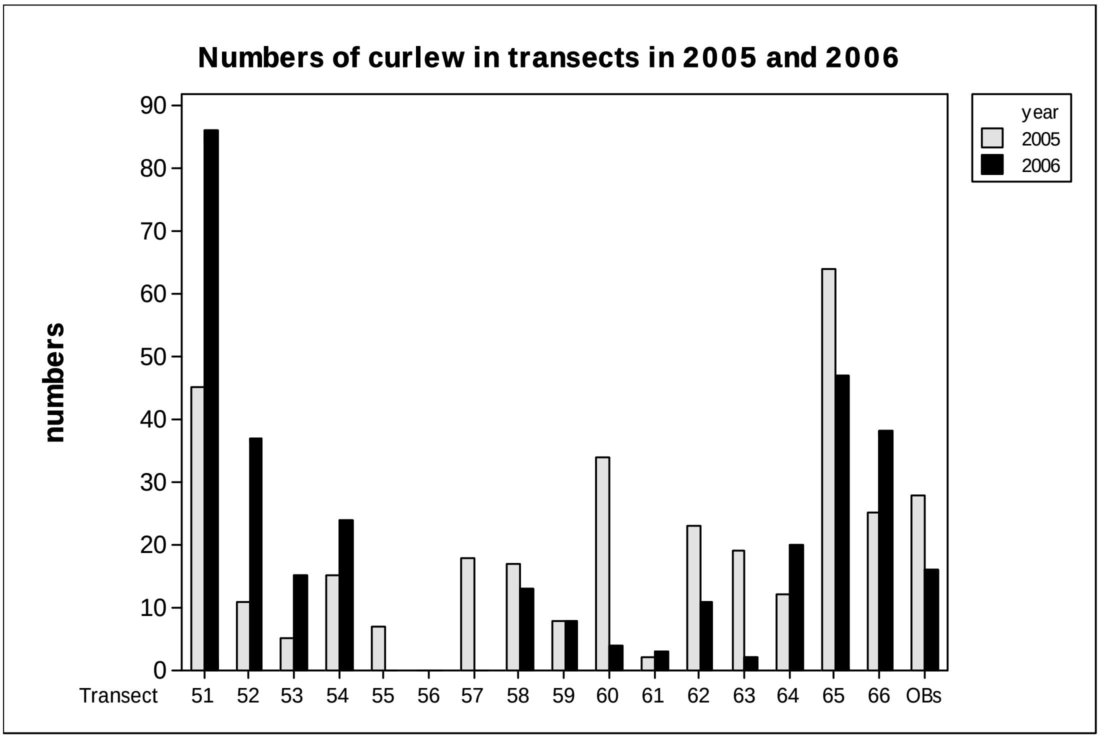


Figure 3.3.2a-h continued

g,



h,

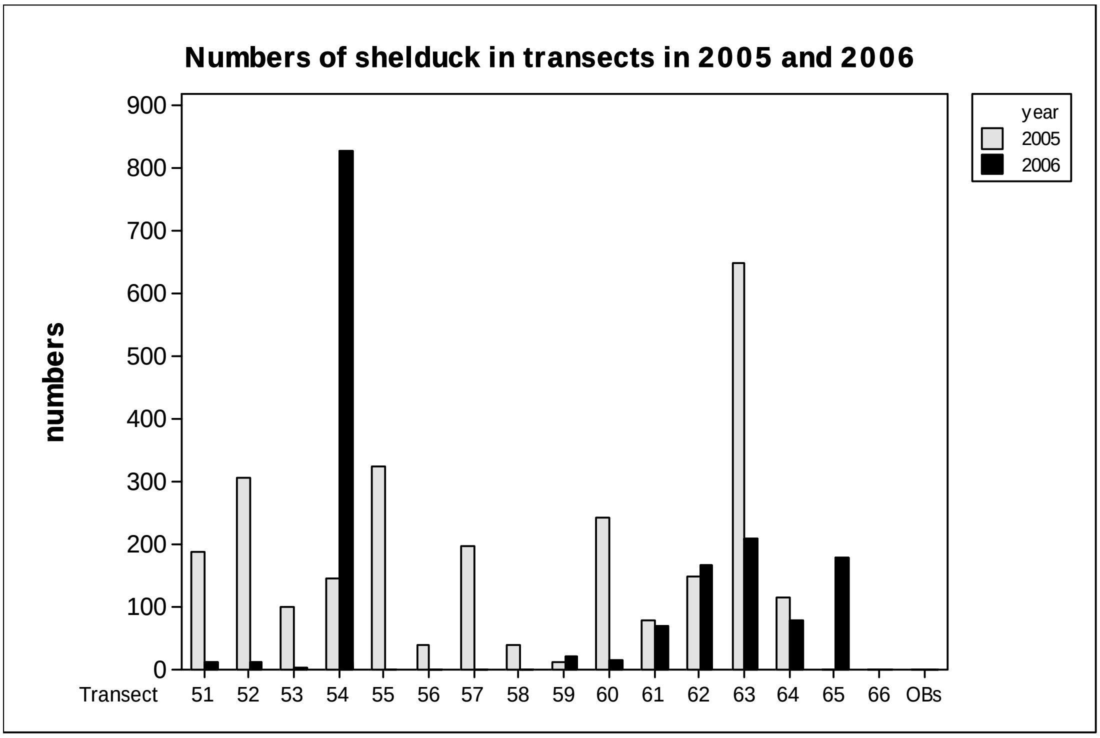


Figure 3.3.3 The change in shelduck numbers in each transect between the 2005-06 and 2006-07 surveys in relation to distance from the Gt Ouse outfall. The change is expressed as the $\log_{10}$ transformed ratio of 2006 to 2005 numbers.

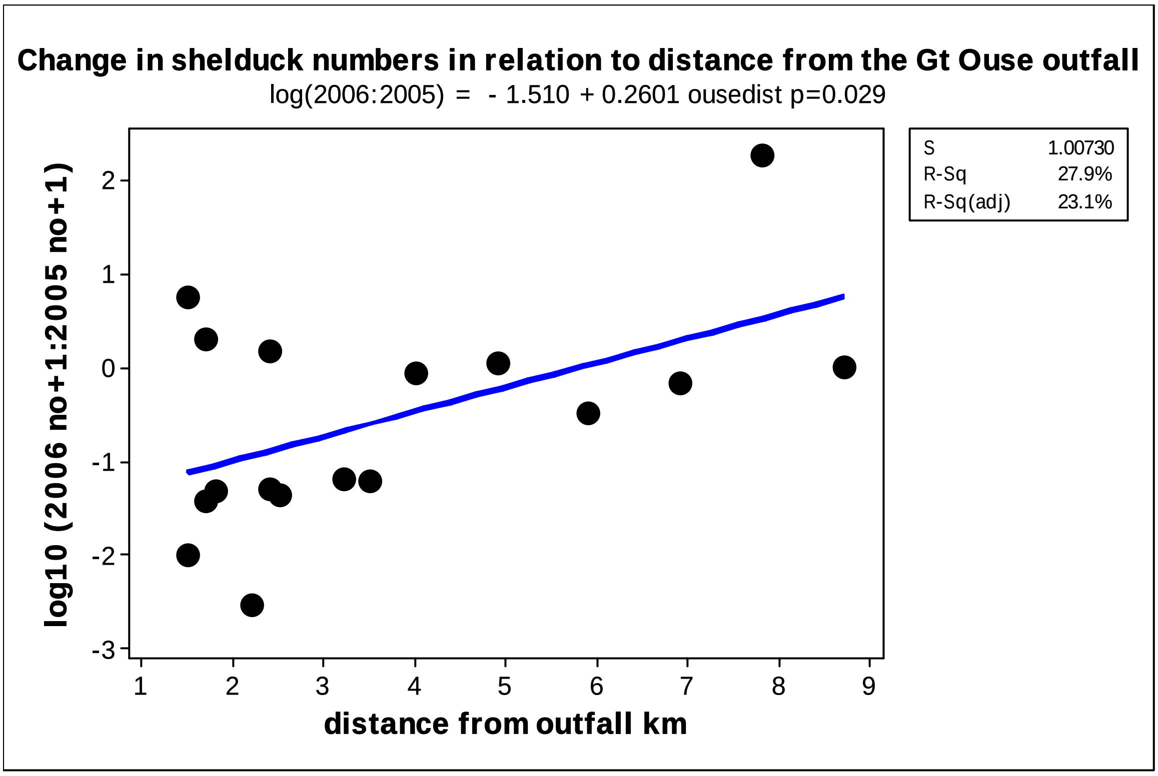
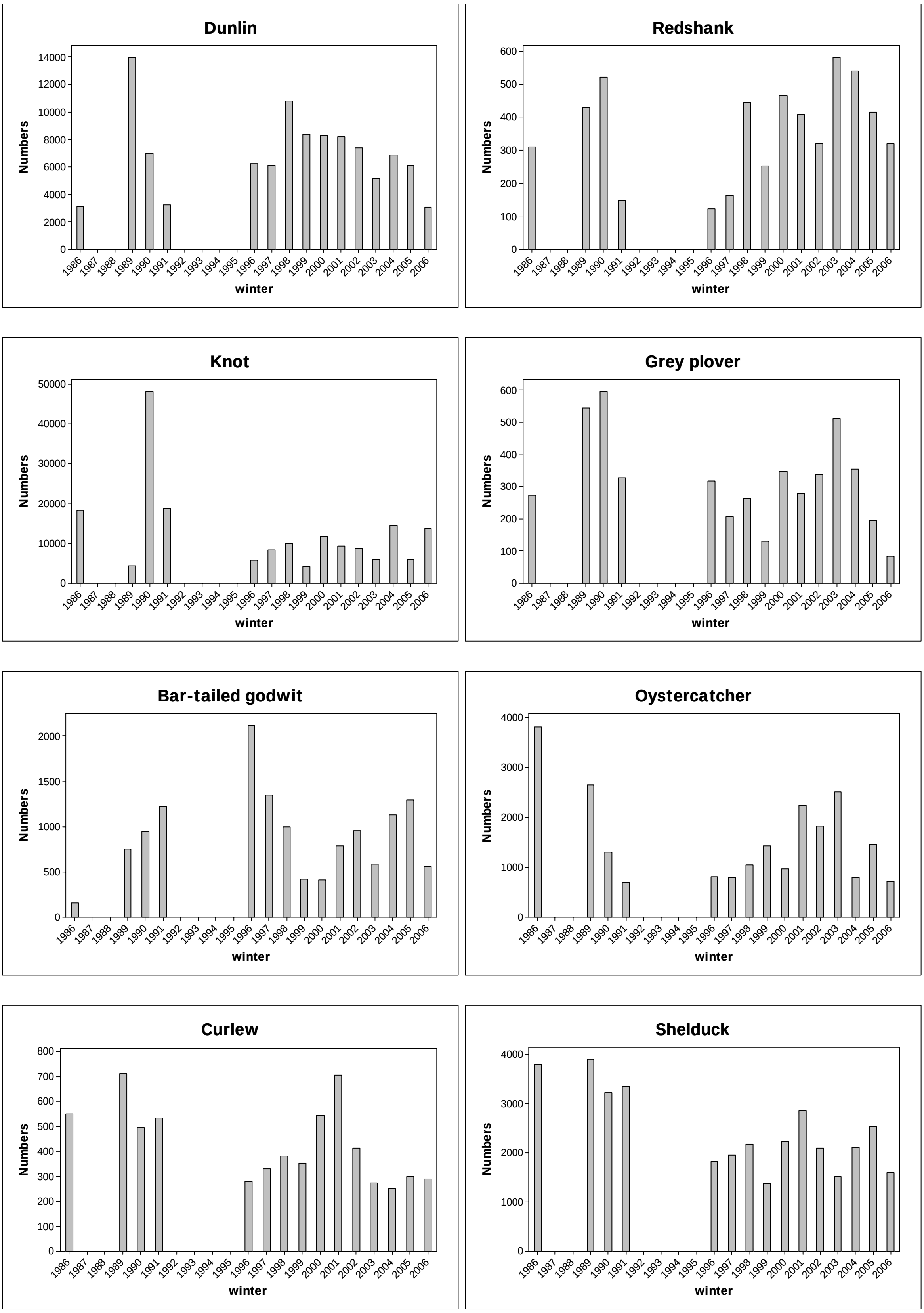


Figure 3.3.4. The total numbers of shorebirds feeding on the inner banks of the Gt Ouse study area in winters 1986-87, 1989-90 to 1991-92 and 1996-97 to 2005-06.



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APPENDICES

Appendix 1

Site location (as Ordnance Survey coordinates), invertebrate densities (numbers/square metre) and the sediment characteristics for each 1ha sample block in the 2006 survey.

Appendix 2

Comparisons between the mean density of invertebrates in the 2005 and 2006 surveys of the Gt Ouse study area.

Appendix 3

Shorebird numbers in each transect during the winter 2006-07 surveys. Column 1 of each table indicates the transect number or area name. Remaining columns give the numbers of dunlin, redshank, knot, grey plover, bar-tailed godwit, oystercatcher, curlew and shelduck recorded in the first and second counts and mean count for the whole survey. 'OB' refers to outer bank areas.

Appendix 1

Site location (as Ordnance Survey coordinates), invertebrate densities (numbers/square metre) and the sediment characteristics for each 1ha sample block in the 2006 survey.

sites	easting	northing	Nemertean indet_2006	Nematode indet_2006	Eteone longa_2006	Anaitides mucosa_2006
16.2	554630	327254	0.0	0.0	0.0	0.0
16.3	554647	327518	0.0	1067.2	0.0	0.0
16.4	554655	327782	0.0	140.0	12.8	0.0
16.6	554682	328299	0.0	38.2	51.0	0.0
16.7	554698	328517	0.0	12.8	0.0	0.0
16.8	554715	328768	0.0	12.8	0.0	12.8
16.9	554722	328949	0.0	89.0	0.0	0.0
17.3	557279	327181	0.0	38.2	63.6	0.0
17.4	557354	327364	0.0	152.6	165.2	0.0
17.6	557501	327737	0.0	38.4	51.2	0.0
17.7	557582	327924	0.0	12.8	0.0	0.0
17.8	557649	328099	0.0	0.0	127.2	76.4
17.9	557741	328309	0.0	0.0	0.0	25.4
18.3	560050	327461	0.0	254.2	38.2	0.0
18.4	559811	327581	38.4	635.4	241.6	0.0
18.6	559476	327732	12.8	775.0	241.4	0.0
18.7	559305	327823	0.0	521.0	101.8	12.8
18.8	559187	327882	0.0	0.0	101.8	0.0
18.9	559050	328046	0.0	25.6	89.2	12.8
19.3	561530	329206	0.0	1016.4	89.0	0.0
19.4	561330	329390	0.0	51.0	127.0	0.0
19.6	560833	329670	0.0	101.8	279.6	25.4
19.7	560629	329854	0.0	444.6	140.2	0.0
19.8	560482	329974	0.0	0.0	165.4	0.0
19.9	560266	330150	89.0	1841.8	89.2	0.0
20.2	563950	330740	0.0	51.0	0.0	0.0
20.3	563450	331050	51.0	3708.8	165.2	0.0
20.4	563090	331350	0.0	25.6	114.6	0.0
20.5	562650	331750	0.0	25.6	12.8	12.8
20.6	562250	332050	0.0	0.0	0.0	38.2
20.7	561850	332400	0.0	0.0	25.6	63.6
B3	558543	326079	12.8	0.0	12.8	0.0
C2	559156	326812	0.0	114.6	12.8	0.0
C3	559082	326779	0.0	305.0	12.8	0.0
D2	557639	329536	0.0	0.0	139.8	0.0
D3	557427	330087	0.0	0.0	0.0	0.0
D4	557221	330620	0.0	0.0	38.2	38.2
E8	559525	328614	0.0	25.4	216.2	0.0
E9	559392	328907	0.0	12.8	51.0	0.0
P1	558509	329675	0.0	0.0	12.8	0.0
P2	558529	330268	0.0	0.0	25.6	12.8
P3	558591	330779	0.0	0.0	38.2	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Autolytus prolifera_2006	Hediste diversicolor <15mm_2006	Hediste diversicolor 16-30mm_2006	Hediste diversicolor >30mm_2006
16.2	0	0.0	0.0	0.0
16.3	0	0.0	0.0	0.0
16.4	0	0.0	12.8	12.8
16.6	0	0.0	0.0	0.0
16.7	0	0.0	0.0	0.0
16.8	0	0.0	0.0	0.0
16.9	0	0.0	0.0	0.0
17.3	0	38.4	63.8	25.4
17.4	0	0.0	25.6	0.0
17.6	0	0.0	0.0	0.0
17.7	0	0.0	0.0	0.0
17.8	0	0.0	0.0	0.0
17.9	0	0.0	0.0	0.0
18.3	0	203.4	76.4	12.8
18.4	0	102.0	114.6	12.8
18.6	0	25.4	38.2	25.6
18.7	0	12.8	0.0	12.8
18.8	0	0.0	0.0	0.0
18.9	0	0.0	0.0	0.0
19.3	0	0.0	25.6	0.0
19.4	0	0.0	25.6	0.0
19.6	0	12.8	0.0	0.0
19.7	0	0.0	0.0	0.0
19.8	0	0.0	0.0	0.0
19.9	0	0.0	0.0	0.0
20.2	0	0.0	0.0	0.0
20.3	0	0.0	0.0	0.0
20.4	0	0.0	0.0	0.0
20.5	0	0.0	0.0	0.0
20.6	0	0.0	0.0	0.0
20.7	0	0.0	0.0	0.0
B3	0	0.0	0.0	0.0
C2	0	0.0	0.0	0.0
C3	0	0.0	0.0	12.8
D2	0	0.0	0.0	0.0
D3	0	0.0	0.0	0.0
D4	0	0.0	0.0	0.0
E8	0	0.0	0.0	0.0
E9	0	0.0	0.0	0.0
P1	0	0.0	0.0	0.0
P2	0	0.0	0.0	0.0
P3	0	0.0	0.0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Nephtys cirrosa <15mm_2006	Nephtys cirrosa 16-30mm_2006	Nephtys cirrosa >30mm_2006	Nephtys hombergii <15mm_2006
16.2	0.0	0.0	0.0	0.0
16.3	0.0	0.0	0.0	0.0
16.4	0.0	0.0	0.0	139.8
16.6	0.0	0.0	0.0	114.4
16.7	0.0	0.0	0.0	114.8
16.8	0.0	0.0	0.0	165.4
16.9	0.0	0.0	0.0	190.8
17.3	0.0	0.0	0.0	51.0
17.4	0.0	0.0	0.0	12.8
17.6	0.0	0.0	0.0	38.2
17.7	0.0	0.0	0.0	216.4
17.8	0.0	0.0	0.0	178.0
17.9	0.0	0.0	0.0	51.2
18.3	0.0	0.0	0.0	0.0
18.4	0.0	0.0	0.0	0.0
18.6	0.0	0.0	0.0	229.0
18.7	0.0	0.0	0.0	140.2
18.8	0.0	0.0	0.0	381.0
18.9	0.0	0.0	0.0	266.8
19.3	0.0	0.0	0.0	0.0
19.4	0.0	0.0	0.0	0.0
19.6	0.0	0.0	0.0	51.0
19.7	0.0	0.0	0.0	165.2
19.8	0.0	0.0	0.0	76.6
19.9	0.0	0.0	0.0	0.0
20.2	0.0	0.0	0.0	0.0
20.3	0.0	0.0	0.0	12.8
20.4	0.0	0.0	0.0	12.8
20.5	0.0	12.8	0.0	152.6
20.6	0.0	12.8	0.0	140.0
20.7	0.0	0.0	0.0	178.0
B3	0.0	0.0	0.0	0.0
C2	0.0	0.0	0.0	0.0
C3	0.0	0.0	0.0	0.0
D2	0.0	0.0	0.0	25.6
D3	0.0	0.0	0.0	114.4
D4	0.0	0.0	0.0	127.4
E8	0.0	0.0	0.0	165.4
E9	0.0	0.0	0.0	393.8
P1	0.0	0.0	0.0	330.6
P2	178.0	38.4	25.6	38.2
P3	495.6	76.4	0.0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Nephtys hombergii 16-30mm_2006	Nephtys hombergii >30mm_2006	Scoloplos armiger <15mm_2006
16.2	0.0	0.0	0.0
16.3	0.0	0.0	0.0
16.4	50.8	63.8	0.0
16.6	63.8	63.6	0.0
16.7	89.2	140.0	0.0
16.8	50.8	89.2	0.0
16.9	51.0	12.8	0.0
17.3	0.0	0.0	0.0
17.4	0.0	0.0	0.0
17.6	38.2	0.0	0.0
17.7	76.4	0.0	0.0
17.8	63.8	25.6	0.0
17.9	12.8	12.8	12.8
18.3	0.0	0.0	0.0
18.4	0.0	0.0	0.0
18.6	140.0	38.2	0.0
18.7	114.6	63.8	0.0
18.8	102.0	101.8	0.0
18.9	89.2	25.4	0.0
19.3	0.0	0.0	0.0
19.4	0.0	0.0	0.0
19.6	12.8	0.0	0.0
19.7	89.2	12.8	0.0
19.8	51.0	12.8	0.0
19.9	0.0	0.0	0.0
20.2	0.0	0.0	0.0
20.3	0.0	0.0	0.0
20.4	0.0	0.0	0.0
20.5	12.8	12.8	0.0
20.6	38.2	0.0	12.8
20.7	12.8	12.8	0.0
B3	0.0	0.0	0.0
C2	0.0	0.0	0.0
C3	0.0	0.0	0.0
D2	63.6	12.8	0.0
D3	25.6	0.0	0.0
D4	76.4	0.0	0.0
E8	140.0	12.8	0.0
E9	102.0	38.4	0.0
P1	190.8	0.0	0.0
P2	12.8	0.0	0.0
P3	12.8	0.0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Scoloplos armiger 16-30mm_2006	Scoloplos armiger >30mm_2006	Pygospio elegans_2006	Scolelepis foliosa_2006
16.2	0.0	0.0	0.0	0.0
16.3	0.0	0.0	813.0	0.0
16.4	0.0	0.0	63.6	0.0
16.6	0.0	0.0	1460.8	0.0
16.7	0.0	0.0	381.2	0.0
16.8	0.0	0.0	165.6	0.0
16.9	0.0	0.0	546.4	0.0
17.3	0.0	0.0	76.4	50.8
17.4	0.0	12.8	355.8	0.0
17.6	0.0	0.0	546.2	0.0
17.7	0.0	0.0	76.4	0.0
17.8	0.0	12.8	2172.0	0.0
17.9	0.0	0.0	76.4	0.0
18.3	0.0	0.0	51.0	38.2
18.4	0.0	0.0	203.6	12.8
18.6	0.0	0.0	267.0	0.0
18.7	0.0	0.0	711.4	0.0
18.8	0.0	0.0	394.0	12.8
18.9	0.0	0.0	330.6	0.0
19.3	0.0	0.0	102.0	0.0
19.4	0.0	0.0	254.2	12.8
19.6	0.0	0.0	1054.4	12.8
19.7	0.0	0.0	559.2	0.0
19.8	0.0	0.0	737.0	0.0
19.9	0.0	0.0	76.4	0.0
20.2	0.0	0.0	12.8	0.0
20.3	0.0	0.0	25.6	0.0
20.4	0.0	0.0	381.2	0.0
20.5	0.0	0.0	63.6	0.0
20.6	63.8	25.6	114.6	0.0
20.7	12.8	0.0	114.4	0.0
B3	0.0	0.0	25.4	0.0
C2	0.0	0.0	0.0	0.0
C3	0.0	0.0	89.0	0.0
D2	0.0	0.0	292.2	0.0
D3	0.0	0.0	38.4	0.0
D4	0.0	0.0	25.4	0.0
E8	0.0	0.0	952.8	0.0
E9	0.0	0.0	203.4	0.0
P1	0.0	0.0	457.4	0.0
P2	25.6	12.8	38.4	63.6
P3	0.0	0.0	0.0	140.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Spio martinensis_2006	Spiophanes bombyx_2006	Magelona mirabilis_2006	Tharyx "A"_2006
16.2	0.0	0	0.0	12.8
16.3	0.0	0	0.0	0.0
16.4	0.0	0	0.0	432.2
16.6	0.0	0	0.0	4089.6
16.7	0.0	0	0.0	5130.8
16.8	0.0	0	0.0	5105.8
16.9	38.4	0	0.0	3734.0
17.3	0.0	0	0.0	0.0
17.4	0.0	0	0.0	0.0
17.6	0.0	0	0.0	63.8
17.7	165.2	0	0.0	241.8
17.8	38.2	0	0.0	939.8
17.9	0.0	0	0.0	571.8
18.3	0.0	0	0.0	12.8
18.4	0.0	0	0.0	0.0
18.6	0.0	0	0.0	25.4
18.7	0.0	0	0.0	178.0
18.8	0.0	0	0.0	292.4
18.9	0.0	0	0.0	1041.6
19.3	0.0	0	0.0	12.8
19.4	0.0	0	0.0	0.0
19.6	0.0	0	0.0	178.0
19.7	0.0	0	0.0	203.4
19.8	0.0	0	0.0	990.8
19.9	0.0	0	0.0	0.0
20.2	0.0	0	0.0	0.0
20.3	0.0	0	0.0	0.0
20.4	0.0	0	0.0	0.0
20.5	51.0	0	0.0	0.0
20.6	317.6	0	0.0	38.2
20.7	127.4	0	0.0	139.8
B3	0.0	0	0.0	0.0
C2	0.0	0	0.0	0.0
C3	0.0	0	0.0	0.0
D2	0.0	0	0.0	0.0
D3	165.4	0	0.0	25.6
D4	127.4	0	0.0	38.2
E8	12.8	0	0.0	216.2
E9	0.0	0	0.0	838.4
P1	0.0	0	0.0	165.4
P2	0.0	0	0.0	0.0
P3	12.8	0	89.4	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Capitella capitata / sp.in_2006	Heteromastus filiformis_2006	Arenicola marina casts_2006	?Tubificoides benedii_2006
16.2	0.0	0	0.0	1219.4
16.3	0.0	0	0.0	368.6
16.4	0.0	0	0.0	1714.8
16.6	140.0	0	0.0	7912.4
16.7	292.4	0	0.0	5080.4
16.8	51.0	0	0.0	2248.4
16.9	0.0	0	0.0	876.6
17.3	12.8	0	0.0	7086.8
17.4	38.4	0	0.0	4000.8
17.6	114.4	0	0.0	889.2
17.7	89.0	0	0.6	76.4
17.8	457.4	0	0.0	1346.4
17.9	101.8	0	0.0	165.4
18.3	0.0	0	0.0	432.0
18.4	0.0	0	0.0	5740.8
18.6	63.6	0	0.0	9207.8
18.7	51.0	0	0.0	1562.4
18.8	317.8	0	0.0	2946.8
18.9	190.8	0	0.0	3353.2
19.3	0.0	0	0.0	101.6
19.4	12.8	0	0.0	914.4
19.6	38.2	0	0.0	508.4
19.7	38.2	0	0.4	266.8
19.8	152.6	0	0.0	724.0
19.9	51.0	0	0.0	203.2
20.2	0.0	0	0.0	25.4
20.3	0.0	0	0.0	12.8
20.4	0.0	0	6.6	38.2
20.5	0.0	0	2.0	25.4
20.6	0.0	0	4.6	0.0
20.7	0.0	0	3.0	0.0
B3	0.0	0	0.0	12.8
C2	0.0	0	0.0	76.2
C3	0.0	0	0.0	6210.6
D2	89.0	0	0.0	12.8
D3	12.8	0	0.4	0.0
D4	0.0	0	0.2	0.0
E8	279.6	0	0.2	254.2
E9	76.6	0	0.0	343.2
P1	12.8	0	0.0	12.8
P2	0.0	0	1.2	0.0
P3	0.0	0	0.6	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Enchytraeidae_2006	?Golfingia vulgaris_2006	Nymphon gracile_2006	Elminius modestus_2006
16.2	0.0	0.0	0.0	0.0
16.3	0.0	165.2	0.0	0.0
16.4	0.0	0.0	0.0	12.8
16.6	0.0	0.0	0.0	0.0
16.7	0.0	0.0	0.0	51.0
16.8	0.0	0.0	0.0	495.6
16.9	0.0	0.0	0.0	356.0
17.3	0.0	0.0	0.0	0.0
17.4	0.0	0.0	0.0	0.0
17.6	0.0	0.0	0.0	0.0
17.7	0.0	0.0	0.0	0.0
17.8	0.0	0.0	0.0	0.0
17.9	0.0	0.0	0.0	0.0
18.3	0.0	0.0	0.0	0.0
18.4	0.0	0.0	0.0	0.0
18.6	0.0	0.0	0.0	0.0
18.7	0.0	0.0	0.0	0.0
18.8	0.0	0.0	0.0	0.0
18.9	0.0	0.0	0.0	0.0
19.3	0.0	0.0	0.0	0.0
19.4	0.0	0.0	0.0	0.0
19.6	0.0	0.0	0.0	0.0
19.7	0.0	0.0	0.0	0.0
19.8	0.0	0.0	0.0	0.0
19.9	0.0	0.0	0.0	0.0
20.2	0.0	0.0	0.0	0.0
20.3	0.0	0.0	0.0	0.0
20.4	0.0	140.0	0.0	0.0
20.5	0.0	0.0	0.0	0.0
20.6	12.8	0.0	0.0	0.0
20.7	0.0	0.0	0.0	0.0
B3	0.0	0.0	0.0	0.0
C2	0.0	0.0	0.0	0.0
C3	0.0	0.0	0.0	0.0
D2	0.0	0.0	0.0	0.0
D3	0.0	0.0	0.0	25.4
D4	0.0	25.4	0.0	12.8
E8	0.0	0.0	0.0	0.0
E9	0.0	0.0	0.0	0.0
P1	0.0	0.0	0.0	0.0
P2	0.0	0.0	0.0	0.0
P3	12.8	0.0	12.8	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Balanus balanus_2006	Copepod indet_2006	Urothoe poseidonis 0-3mm_2006	Urothoe poseidonis >3mm_2006
16.2	0.0	0.0	0.0	0
16.3	0.0	0.0	0.0	0
16.4	0.0	0.0	0.0	0
16.6	0.0	12.8	0.0	0
16.7	0.0	0.0	0.0	0
16.8	0.0	0.0	0.0	0
16.9	0.0	0.0	0.0	0
17.3	0.0	0.0	0.0	0
17.4	0.0	0.0	0.0	0
17.6	0.0	0.0	0.0	0
17.7	0.0	0.0	0.0	0
17.8	0.0	0.0	0.0	0
17.9	0.0	0.0	0.0	0
18.3	0.0	0.0	0.0	0
18.4	0.0	0.0	0.0	0
18.6	0.0	0.0	0.0	0
18.7	0.0	0.0	0.0	0
18.8	0.0	0.0	0.0	0
18.9	0.0	0.0	0.0	0
19.3	0.0	0.0	0.0	0
19.4	0.0	0.0	0.0	0
19.6	63.6	0.0	0.0	0
19.7	0.0	0.0	0.0	0
19.8	0.0	0.0	0.0	0
19.9	0.0	0.0	0.0	0
20.2	0.0	0.0	0.0	0
20.3	0.0	0.0	12.8	0
20.4	0.0	0.0	12.8	0
20.5	0.0	0.0	0.0	0
20.6	0.0	0.0	0.0	0
20.7	0.0	0.0	0.0	0
B3	0.0	0.0	0.0	0
C2	0.0	0.0	0.0	0
C3	0.0	0.0	0.0	0
D2	0.0	0.0	0.0	0
D3	0.0	0.0	0.0	0
D4	38.2	0.0	0.0	0
E8	0.0	0.0	0.0	0
E9	0.0	0.0	0.0	0
P1	0.0	0.0	0.0	0
P2	114.4	0.0	0.0	0
P3	0.0	0.0	0.0	0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Bathyporeia sarsi 0-3mm_2006	Bathyporeia sarsi >3mm_2006	Gammarus indet. 0-3mm_2006	Corophium arenarium 0-3mm_2006
16.2	0.0	0.0	0.0	0.0
16.3	0.0	0.0	0.0	0.0
16.4	0.0	0.0	0.0	0.0
16.6	0.0	0.0	0.0	0.0
16.7	0.0	0.0	0.0	0.0
16.8	0.0	0.0	0.0	0.0
16.9	0.0	0.0	0.0	0.0
17.3	0.0	0.0	0.0	0.0
17.4	0.0	0.0	0.0	0.0
17.6	0.0	0.0	0.0	0.0
17.7	12.8	0.0	0.0	0.0
17.8	0.0	0.0	0.0	0.0
17.9	0.0	0.0	0.0	12.8
18.3	0.0	0.0	0.0	0.0
18.4	0.0	0.0	0.0	0.0
18.6	0.0	0.0	0.0	0.0
18.7	0.0	0.0	0.0	0.0
18.8	0.0	0.0	0.0	0.0
18.9	0.0	0.0	12.8	0.0
19.3	0.0	0.0	0.0	0.0
19.4	0.0	0.0	0.0	0.0
19.6	0.0	0.0	0.0	0.0
19.7	0.0	0.0	0.0	0.0
19.8	0.0	0.0	0.0	0.0
19.9	0.0	0.0	0.0	0.0
20.2	0.0	0.0	0.0	0.0
20.3	0.0	0.0	0.0	0.0
20.4	0.0	0.0	0.0	0.0
20.5	0.0	0.0	0.0	0.0
20.6	0.0	0.0	0.0	0.0
20.7	0.0	0.0	0.0	0.0
B3	0.0	0.0	0.0	0.0
C2	0.0	0.0	0.0	0.0
C3	0.0	0.0	0.0	0.0
D2	0.0	0.0	0.0	0.0
D3	0.0	0.0	0.0	0.0
D4	0.0	0.0	0.0	0.0
E8	0.0	0.0	0.0	0.0
E9	0.0	0.0	0.0	0.0
P1	0.0	0.0	0.0	0.0
P2	0.0	12.8	0.0	0.0
P3	12.8	12.8	0.0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Corophium arenarium >3mm_2006	Corophium volutator 0-3mm_2006	Corophium volutator >3mm_2006
16.2	0.0	0.0	0.0
16.3	0.0	0.0	0.0
16.4	0.0	0.0	0.0
16.6	0.0	12.8	25.4
16.7	0.0	0.0	0.0
16.8	0.0	0.0	0.0
16.9	0.0	0.0	0.0
17.3	0.0	0.0	0.0
17.4	0.0	0.0	0.0
17.6	0.0	12.8	0.0
17.7	0.0	0.0	0.0
17.8	0.0	0.0	0.0
17.9	0.0	0.0	0.0
18.3	0.0	13856.0	2451.2
18.4	0.0	11989.0	1371.8
18.6	0.0	3696.0	851.4
18.7	0.0	1143.0	851.2
18.8	0.0	12.8	0.0
18.9	0.0	165.4	12.8
19.3	0.0	63.8	76.4
19.4	0.0	393.8	127.0
19.6	0.0	711.4	470.2
19.7	0.0	25.6	0.0
19.8	0.0	12.8	25.6
19.9	0.0	5131.0	4305.6
20.2	0.0	12.8	0.0
20.3	0.0	6680.6	1181.2
20.4	12.8	241.4	25.4
20.5	0.0	12.8	0.0
20.6	0.0	12.8	0.0
20.7	0.0	0.0	0.0
B3	0.0	0.0	0.0
C2	0.0	2806.8	241.6
C3	0.0	800.2	165.4
D2	0.0	0.0	0.0
D3	0.0	0.0	0.0
D4	0.0	12.8	0.0
E8	0.0	635.2	101.6
E9	0.0	25.4	12.8
P1	0.0	0.0	0.0
P2	0.0	0.0	0.0
P3	0.0	0.0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Cyathura carinata_2006	Tanaissus lilljeborgi_2006	Cumopsis goodsiri_2006	Bodotria arenosa_2006
16.2	0.0	0.0	0	0.0
16.3	0.0	0.0	0	0.0
16.4	0.0	0.0	0	0.0
16.6	0.0	0.0	0	0.0
16.7	0.0	0.0	0	0.0
16.8	0.0	0.0	0	0.0
16.9	0.0	0.0	0	0.0
17.3	0.0	0.0	0	0.0
17.4	0.0	0.0	0	0.0
17.6	0.0	0.0	0	0.0
17.7	0.0	0.0	0	0.0
17.8	0.0	0.0	0	0.0
17.9	0.0	0.0	0	0.0
18.3	0.0	0.0	0	0.0
18.4	0.0	0.0	0	0.0
18.6	0.0	0.0	0	0.0
18.7	0.0	0.0	0	0.0
18.8	0.0	0.0	0	0.0
18.9	0.0	0.0	0	0.0
19.3	12.8	0.0	0	0.0
19.4	12.8	0.0	0	0.0
19.6	203.6	0.0	0	0.0
19.7	12.8	0.0	0	0.0
19.8	0.0	0.0	0	0.0
19.9	0.0	0.0	0	0.0
20.2	0.0	0.0	0	0.0
20.3	0.0	0.0	0	0.0
20.4	0.0	0.0	0	0.0
20.5	0.0	0.0	0	0.0
20.6	0.0	0.0	0	0.0
20.7	12.8	0.0	0	0.0
B3	0.0	0.0	0	0.0
C2	0.0	0.0	0	0.0
C3	0.0	0.0	0	0.0
D2	0.0	0.0	0	0.0
D3	0.0	0.0	0	0.0
D4	0.0	0.0	0	0.0
E8	0.0	0.0	0	0.0
E9	0.0	0.0	0	0.0
P1	0.0	0.0	0	0.0
P2	0.0	635.2	0	12.8
P3	0.0	355.8	0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Pseudocuma longicornis_2006	Cumacean indet._2006	All Cumaceans_2006	Crangon crangon_2006
16.2	0.0	0.0	0.0	0.0
16.3	0.0	0.0	0.0	0.0
16.4	0.0	0.0	0.0	12.8
16.6	0.0	0.0	0.0	0.0
16.7	0.0	0.0	0.0	0.0
16.8	0.0	0.0	0.0	12.8
16.9	0.0	0.0	0.0	0.0
17.3	0.0	0.0	0.0	0.0
17.4	0.0	0.0	0.0	12.8
17.6	0.0	0.0	0.0	0.0
17.7	0.0	0.0	0.0	0.0
17.8	0.0	0.0	0.0	12.8
17.9	0.0	0.0	0.0	0.0
18.3	0.0	0.0	0.0	25.6
18.4	0.0	0.0	0.0	0.0
18.6	0.0	0.0	0.0	0.0
18.7	0.0	0.0	0.0	0.0
18.8	0.0	0.0	0.0	12.8
18.9	0.0	0.0	0.0	0.0
19.3	0.0	0.0	0.0	0.0
19.4	0.0	0.0	0.0	38.4
19.6	0.0	0.0	0.0	12.8
19.7	0.0	0.0	0.0	0.0
19.8	0.0	0.0	0.0	0.0
19.9	0.0	0.0	0.0	0.0
20.2	0.0	0.0	0.0	0.0
20.3	0.0	0.0	0.0	12.8
20.4	0.0	0.0	0.0	0.0
20.5	0.0	0.0	0.0	38.2
20.6	25.6	12.8	38.4	12.8
20.7	0.0	0.0	0.0	12.8
B3	0.0	0.0	0.0	0.0
C2	0.0	0.0	0.0	0.0
C3	0.0	0.0	0.0	12.8
D2	0.0	0.0	0.0	0.0
D3	0.0	0.0	0.0	12.8
D4	0.0	0.0	0.0	25.6
E8	0.0	0.0	0.0	25.4
E9	0.0	0.0	0.0	12.8
P1	0.0	0.0	0.0	12.8
P2	0.0	0.0	12.8	0.0
P3	0.0	0.0	0.0	12.8

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Liocarcinus arcuatus_2006	Carcinus maenas_2006	Hydrobia ulvae <3mm_2006	Hydrobia ulvae >3mm_2006
16.2	0	0.0	229.0	38.4
16.3	0	0.0	622.6	482.8
16.4	0	0.0	15710.0	4153.0
16.6	0	12.8	22910.8	889.2
16.7	0	12.8	11163.4	622.6
16.8	0	12.8	5398.0	559.0
16.9	0	0.0	508.4	0.0
17.3	0	12.8	15202.2	2832.2
17.4	0	0.0	32842.4	1626.0
17.6	0	0.0	49530.2	660.8
17.7	0	0.0	11341.4	152.6
17.8	0	0.0	5385.0	0.0
17.9	0	0.0	190.8	12.8
18.3	0	0.0	8776.0	25.6
18.4	0	0.0	9550.6	25.4
18.6	0	0.0	14186.4	940.0
18.7	0	0.0	11024.0	25.6
18.8	0	0.0	6299.4	0.0
18.9	0	0.0	1651.0	0.0
19.3	0	0.0	42405.6	165.2
19.4	0	0.0	25793.8	51.0
19.6	0	0.0	18618.4	0.0
19.7	0	0.0	11113.0	0.0
19.8	0	0.0	4216.6	0.0
19.9	0	0.0	305.0	0.0
20.2	0	0.0	178.0	12.8
20.3	0	0.0	21260.0	343.2
20.4	0	0.0	36842.8	12.8
20.5	0	0.0	30899.4	12.8
20.6	0	0.0	23507.8	12.8
20.7	0	0.0	5689.8	0.0
B3	0	0.0	1219.2	63.6
C2	0	0.0	393.8	25.4
C3	0	0.0	304.8	12.8
D2	0	12.8	38.2	0.0
D3	0	25.6	432.0	0.0
D4	0	12.8	190.6	0.0
E8	0	0.0	20485.4	25.6
E9	0	0.0	9182.4	12.8
P1	0	0.0	2819.6	0.0
P2	0	0.0	114.4	0.0
P3	0	0.0	12.8	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Retusa obtusa <3mm_2006	Retusa obtusa >3mm_2006	Mytilus edulis <5mm_2006	Mysella bidentata <5mm_2006
16.2	0.0	0.0	0.0	0.0
16.3	0.0	0.0	0.0	0.0
16.4	0.0	12.8	0.0	25.4
16.6	76.6	51.0	0.0	0.0
16.7	25.6	51.0	0.0	0.0
16.8	12.8	0.0	0.0	0.0
16.9	0.0	0.0	38.2	0.0
17.3	0.0	0.0	12.8	0.0
17.4	0.0	0.0	0.0	0.0
17.6	0.0	0.0	0.0	0.0
17.7	0.0	0.0	25.6	0.0
17.8	12.8	0.0	25.4	0.0
17.9	0.0	0.0	12.8	0.0
18.3	0.0	0.0	0.0	0.0
18.4	0.0	0.0	0.0	0.0
18.6	0.0	0.0	0.0	0.0
18.7	0.0	0.0	12.8	12.8
18.8	0.0	0.0	12.8	0.0
18.9	0.0	0.0	0.0	0.0
19.3	0.0	0.0	0.0	0.0
19.4	0.0	0.0	0.0	0.0
19.6	0.0	76.4	0.0	0.0
19.7	0.0	0.0	25.6	0.0
19.8	0.0	0.0	12.8	0.0
19.9	0.0	0.0	0.0	0.0
20.2	0.0	0.0	0.0	0.0
20.3	0.0	0.0	0.0	0.0
20.4	0.0	0.0	0.0	0.0
20.5	0.0	0.0	0.0	0.0
20.6	0.0	0.0	0.0	0.0
20.7	12.8	0.0	0.0	0.0
B3	0.0	0.0	0.0	0.0
C2	0.0	0.0	0.0	0.0
C3	0.0	0.0	0.0	0.0
D2	0.0	0.0	0.0	0.0
D3	0.0	0.0	0.0	0.0
D4	0.0	0.0	0.0	0.0
E8	0.0	0.0	0.0	0.0
E9	0.0	0.0	25.6	0.0
P1	0.0	0.0	0.0	0.0
P2	0.0	0.0	0.0	0.0
P3	0.0	0.0	0.0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Mysella bidentata 6-10mm_2006	Cerastoderma edule <5mm_2006	Cerastoderma edule 6-10mm_2006
16.2	0	0.0	0.0
16.3	0	0.0	0.0
16.4	0	267.0	787.6
16.6	0	5016.6	2895.8
16.7	0	6960.0	4242.2
16.8	0	12166.8	9944.4
16.9	0	6997.8	12154.2
17.3	0	38.2	0.0
17.4	0	76.6	12.8
17.6	0	508.2	457.4
17.7	0	0.0	0.0
17.8	0	25.4	0.0
17.9	0	0.0	0.0
18.3	0	0.0	0.0
18.4	0	0.0	0.0
18.6	0	0.0	51.0
18.7	0	0.0	0.0
18.8	0	12.8	0.0
18.9	0	12.8	0.0
19.3	0	25.6	0.0
19.4	0	0.0	0.0
19.6	0	584.4	203.6
19.7	0	330.4	267.0
19.8	0	0.0	0.0
19.9	0	0.0	0.0
20.2	0	0.0	12.8
20.3	0	0.0	0.0
20.4	0	12.8	12.8
20.5	0	76.4	76.4
20.6	0	190.8	635.4
20.7	0	140.0	2095.8
B3	0	0.0	0.0
C2	0	0.0	0.0
C3	0	0.0	0.0
D2	0	0.0	0.0
D3	0	50.8	1054.4
D4	0	0.0	38.2
E8	0	508.4	470.0
E9	0	0.0	0.0
P1	0	0.0	0.0
P2	0	0.0	0.0
P3	0	0.0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Cerastoderma edule 11-20mm_2006	Cerastoderma edule 21-25mm _2006	Cerastoderma edule 20-30mm_2006	Macoma balthica <5mm_2006
16.2	0.0	0.0	0.0	0.0
16.3	0.0	0.0	0.0	0.0
16.4	12.8	0.0	0.0	25.4
16.6	25.6	0.0	0.0	89.2
16.7	12.8	0.0	0.0	63.6
16.8	12.8	0.0	0.0	76.4
16.9	0.0	0.0	0.0	38.2
17.3	12.8	0.0	0.0	0.0
17.4	0.0	0.0	0.0	0.0
17.6	0.0	0.0	0.0	63.6
17.7	0.0	0.0	0.0	76.6
17.8	0.0	0.0	0.0	63.8
17.9	0.0	0.0	0.0	25.4
18.3	0.0	0.0	0.0	63.6
18.4	0.0	0.0	0.0	25.6
18.6	0.0	0.0	0.0	89.0
18.7	0.0	0.0	0.0	229.0
18.8	0.0	0.0	0.0	127.4
18.9	0.0	0.0	0.0	203.4
19.3	0.0	0.0	0.0	76.2
19.4	0.0	0.0	0.0	89.0
19.6	25.6	0.0	0.0	89.0
19.7	0.0	0.0	0.0	228.8
19.8	0.0	0.0	0.0	140.0
19.9	0.0	0.0	0.0	0.0
20.2	0.0	0.0	0.0	0.0
20.3	0.0	0.0	0.0	25.6
20.4	0.0	0.0	0.0	38.4
20.5	0.0	0.0	0.0	50.8
20.6	51.0	0.0	0.0	0.0
20.7	0.0	0.0	0.0	25.4
B3	0.0	0.0	0.0	0.0
C2	0.0	0.0	0.0	12.8
C3	0.0	0.0	0.0	178.0
D2	0.0	0.0	0.0	0.0
D3	76.4	279.6	279.6	0.0
D4	63.6	63.6	63.6	0.0
E8	0.0	0.0	0.0	101.8
E9	0.0	0.0	0.0	101.6
P1	0.0	0.0	0.0	101.8
P2	0.0	0.0	0.0	0.0
P3	0.0	0.0	0.0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Macoma balthica 6-10mm_2006	Macoma balthica 11-20mm_2006	Mya arenaria <5mm_2006
16.2	0.0	0.0	0
16.3	0.0	0.0	0
16.4	406.4	25.4	0
16.6	394.0	25.6	0
16.7	127.2	25.6	0
16.8	178.0	12.8	0
16.9	114.4	0.0	0
17.3	279.6	12.8	0
17.4	25.6	0.0	0
17.6	114.4	12.8	0
17.7	152.6	0.0	0
17.8	165.6	12.8	0
17.9	12.8	0.0	0
18.3	63.6	0.0	0
18.4	381.2	25.4	0
18.6	686.2	12.8	0
18.7	267.0	12.8	0
18.8	63.8	0.0	0
18.9	0.0	0.0	0
19.3	89.2	0.0	0
19.4	330.4	38.2	0
19.6	63.6	0.0	0
19.7	241.6	0.0	0
19.8	165.2	12.8	0
19.9	12.8	0.0	0
20.2	0.0	0.0	0
20.3	0.0	0.0	0
20.4	76.4	12.8	0
20.5	101.8	0.0	0
20.6	140.0	25.6	0
20.7	89.2	63.8	0
B3	0.0	0.0	0
C2	0.0	0.0	0
C3	50.8	0.0	0
D2	0.0	0.0	0
D3	63.8	12.8	0
D4	0.0	25.6	0
E8	228.8	12.8	0
E9	63.8	0.0	0
P1	12.8	0.0	0
P2	0.0	12.8	0
P3	12.8	0.0	0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Abra nitida 6-10mm_2006	Scrobicularia plana <5mm_2006	Scrobicularia plana 6-10mm_2006	Scrobicularia plana 11-20m_2006
16.2	0.0	0.0	0.0	0.0
16.3	0.0	0.0	0.0	0.0
16.4	0.0	12.8	89.2	12.8
16.6	25.4	25.4	127.0	25.6
16.7	0.0	12.8	76.4	25.6
16.8	0.0	12.8	63.6	12.8
16.9	0.0	0.0	25.6	12.8
17.3	0.0	51.0	139.8	457.4
17.4	0.0	25.4	76.2	0.0
17.6	0.0	38.2	25.4	25.6
17.7	0.0	0.0	0.0	0.0
17.8	0.0	0.0	0.0	0.0
17.9	0.0	0.0	0.0	0.0
18.3	0.0	12.8	76.4	114.4
18.4	0.0	51.0	102.0	190.6
18.6	0.0	101.8	216.2	101.8
18.7	0.0	12.8	25.6	0.0
18.8	0.0	0.0	0.0	0.0
18.9	0.0	12.8	25.6	0.0
19.3	0.0	0.0	0.0	0.0
19.4	0.0	38.2	51.0	0.0
19.6	0.0	63.6	38.2	25.4
19.7	0.0	127.2	38.2	0.0
19.8	0.0	89.0	51.0	0.0
19.9	0.0	12.8	12.8	12.8
20.2	0.0	0.0	0.0	0.0
20.3	0.0	25.6	0.0	0.0
20.4	0.0	12.8	0.0	0.0
20.5	0.0	0.0	0.0	0.0
20.6	0.0	0.0	0.0	0.0
20.7	0.0	0.0	0.0	0.0
B3	0.0	0.0	0.0	12.8
C2	0.0	0.0	0.0	0.0
C3	0.0	0.0	0.0	0.0
D2	0.0	0.0	0.0	0.0
D3	0.0	0.0	0.0	0.0
D4	0.0	0.0	0.0	0.0
E8	0.0	63.8	38.2	0.0
E9	0.0	51.0	152.6	38.4
P1	0.0	0.0	0.0	0.0
P2	0.0	0.0	0.0	0.0
P3	0.0	0.0	0.0	0.0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	Scrobicularia plana 21-25m_2006	Scrobicularia plana 26-30m_2006	Scrobicularia plana >30mm_2006
16.2	0.0	0.0	0
16.3	0.0	0.0	0
16.4	0.0	25.6	0
16.6	0.0	0.0	0
16.7	25.4	0.0	0
16.8	0.0	0.0	0
16.9	0.0	0.0	0
17.3	25.4	12.8	0
17.4	12.8	12.8	0
17.6	12.8	0.0	0
17.7	0.0	0.0	0
17.8	0.0	0.0	0
17.9	0.0	0.0	0
18.3	25.6	0.0	0
18.4	38.4	0.0	0
18.6	12.8	0.0	0
18.7	12.8	0.0	0
18.8	0.0	0.0	0
18.9	0.0	0.0	0
19.3	0.0	0.0	0
19.4	0.0	0.0	0
19.6	0.0	0.0	0
19.7	0.0	0.0	0
19.8	0.0	0.0	0
19.9	0.0	0.0	0
20.2	0.0	0.0	0
20.3	0.0	0.0	0
20.4	0.0	0.0	0
20.5	0.0	0.0	0
20.6	0.0	0.0	0
20.7	0.0	0.0	0
B3	0.0	0.0	0
C2	0.0	0.0	0
C3	0.0	0.0	0
D2	0.0	0.0	0
D3	0.0	0.0	0
D4	0.0	0.0	0
E8	0.0	0.0	0
E9	0.0	0.0	0
P1	0.0	0.0	0
P2	0.0	0.0	0
P3	0.0	0.0	0

Appendix 1 continued. Invertebrate densities (numbers/square metre).

sites	All worms 2006	All crustaceans 2006	All gastropods 2006	All bivalves 2006
16.2	1232.2	0.0	267.4	0.0
16.3	2248.8	0.0	1105.4	0.0
16.4	2643.4	25.6	19875.8	1690.4
16.6	13933.8	63.8	23927.6	8650.2
16.7	11241.6	63.8	11862.6	11571.6
16.8	7901.8	521.2	5969.8	22480.4
16.9	5539.0	356.0	508.4	19381.2
17.3	7507.2	12.8	18034.4	1043.0
17.4	4764.0	12.8	34468.4	242.2
17.6	1779.6	12.8	50191.0	1258.4
17.7	955.0	12.8	11494.0	254.8
17.8	5437.6	12.8	5397.8	293.0
17.9	1030.4	12.8	203.6	51.0
18.3	1119.0	16332.8	8801.6	356.4
18.4	7102.0	13360.8	9576.0	814.6
18.6	11089.4	4547.4	15126.4	1271.6
18.7	3482.6	1994.2	11049.6	585.6
18.8	4650.4	25.6	6299.4	216.8
18.9	5425.2	191.0	1651.0	254.6
19.3	1347.4	153.0	42570.8	191.0
19.4	1397.8	572.0	25844.8	546.8
19.6	2275.2	1461.6	18694.8	1093.4
19.7	1920.0	38.4	11113.0	1258.8
19.8	2910.2	38.4	4216.6	470.8
19.9	2350.6	9436.6	305.0	51.2
20.2	89.2	12.8	190.8	12.8
20.3	3976.2	7887.4	21603.2	51.2
20.4	579.0	292.4	36855.6	166.0
20.5	384.2	51.0	30912.2	305.4
20.6	819.2	102.4	23520.6	1042.8
20.7	690.2	25.6	5702.6	2414.2
B3	63.8	0.0	1282.8	12.8
C2	203.6	3048.4	419.2	12.8
C3	6630.2	978.4	317.6	228.8
D2	635.8	12.8	38.2	0.0
D3	382.6	63.8	432.0	1817.6
D4	471.4	102.2	190.6	254.6
E8	2275.6	762.2	20511.0	1423.8
E9	2059.6	51.0	9195.2	433.0
P1	1182.6	12.8	2819.6	114.6
P2	473.0	788.0	114.4	12.8
P3	878.6	394.2	12.8	12.8

Appendix 1 continued. Sediment details and distance of sites from the Gt Ouse outfalls shown as points A and B in Figure 2.1

sites	%<63um 2006	%LOI 2006	sediment type 2006	OusedisA km	OusedisB km
16.2	80.42	11.260	mud	5.2	4.48
16.3	81.90	9.960	mud	5.28	4.38
16.4	77.06	8.480	mud	5.38	4.32
16.6	64.14	6.580	mud	5.62	4.22
16.7	60.04	5.660	mud	5.72	4.18
16.8	68.08	7.680	mud	5.86	4.16
16.9	77.72	9.980	mud	6.02	4.16
17.3	73.68	8.900	mud	2.96	2.32
17.4	63.52	6.020	mud	3.04	2.12
17.6	53.56	5.480	mud	3.28	1.74
17.7	40.08	4.600	mud	3.36	1.56
17.8	48.80	4.760	mud	3.48	1.38
17.9	66.60	7.760	mud	3.66	1.24
18.3	67.80	5.140	mud	2.3	2.16
18.4	52.14	3.680	mud	2.32	2
18.6	38.10	3.180	mud	2.4	1.6
18.7	24.96	2.100	sand	2.46	1.4
18.8	24.38	2.340	sand	2.52	1.26
18.9	59.26	5.720	mud	2.62	1.04
19.3	18.74	1.100	sand	4.54	3.16
19.4	20.34	1.180	sand	4.56	2.98
19.6	17.64	1.180	sand	4.68	2.64
19.7	37.76	1.600	mud	4.76	2.48
19.8	32.16	1.880	mud	4.84	2.38
19.9	54.02	3.120	mud	5.04	2.28
20.2	69.68	9.800	mud	7.36	5.88
20.3	46.40	4.280	mud	7.38	5.66
20.4	5.06	1.200	sand	7.42	5.46
20.5	15.66	1.640	sand	7.52	5.28
20.6	9.82	1.580	sand	7.62	5.18
20.7	6.00	1.420	sand	7.76	5.12
B3	80.60	13.120	mud	0.9	2.9
C2	77.06	11.340	mud	1.94	1.8
C3	82.12	9.820	mud	1.96	1.7
D2	45.40	2.640	mud	4.56	1.18
D3	12.86	1.700	sand	5.1	1.68
D4	25.20	2.400	mud	5.74	2.3
E8	41.78	3.020	mud	3.46	0.9
E9	68.08	6.460	mud	3.62	0.68
P1	64.30	5.800	mud	4.44	0.86
P2	3.88	1.040	sand	5	1.46
P3	4.14	1.175	sand	5.52	1.96

Appendix 2
Comparisons between the mean density of invertebrates in the 2005 and 2006 surveys of the Gt Ouse study area. Invertebrates whose density differed significantly between surveys are shown in bold text.

Worm species, whole study area

Invertebrate group, family or species/species size category	Whole study area (N=42)			
	mean density±SE 2005	2006	t value	p value
Nemerteans	18.8±11.5	4.9±2.6	-1.33	0.19
Nematodes	1242 ±644	274 ±102	-1.56	0.13
Anaitides mucosa	**0.9 ±0.5**	**7.9 ±2.7**	**2.5**	**0.016***
Eteone longa	**118±19**	**73±12**	**-2.77**	**0.008****
Syllids	0.6±0.6	0	-1.0	0.32
Hediste diversicolor <15mm	10.1±3.5	9.4±5.4	-0.16	0.87
H. diversicolor 15-30mm	10.6±4.5	9.1±3.7	-0.77	0.45
H. diversicolor >30mm	1.8 ±0.8	2.7 ±1.0	0.72	0.48
***Nephtys hombergii*<15mm**	**172 ±28.8**	**102 ±16.7**	**-3.49**	**0.001****
N. hombergii 15-30mm	49.1 ±7.04	42.5 ±7.5	-1.09	0.28
N. hombergii >30mm	13.9 ±3.8	17.9 ±4.9	0.79	0.44
N. cirrosa 15-30mm	2.7 ±1.8	3.3 ±2.0	0.31	0.76
N. cirrosa >30mm	0	0.6±0.6	1.0	0.32
***Scoloplos armiger* <15mm**	**7.6±3.0**	**0.6±0.4**	**-2.48**	**0.017***
S. armiger 15-30mm	1.5±1.0	2.4±1.5	0.9	0.37
S. armiger >30mm	0.6±0.4	1.5±0.8	1.0	0.32
Pygospio elegans	**1317 ±302**	**340 ±68**	**-3.48**	**0.001****
Scolelepis foliosa	**0**	**8.2 ±3.9**	**2.13**	**0.04***
Spio martinensis	**66.9 ±25.4**	**25.1 ±9.9**	**-2.27**	**0.028***
Spiophanes bombyx	**1.2±0.6**	**0**	**-2.08**	**0.044***

Appendix 2

Worm species, whole study area continued

Invertebrate group, family or species/species size category	Whole study area (N=42)			
	mean density±SE 2005	2006	t value	p value
Magelona mirabilis	0.3 ±0.3	2.1 ±2.1	1.0	0.32
Tharyx sp complex A	605±214	588±206	-0.15	0.88
Capitellids	49 ±16.8	64 ±16.1	1.09	0.28
Heteromastus filiformis	0.3±0.3	0	-1.0	0.32
Arenicola marina casts	0.6 ±0.2	0.48 ±0.2	-1.64	0.11
Tubificoides benedii	**2358 ±613**	**1570 ±377**	**-2.18**	**0.035***
Enchytraeidae	94.7 ±81.3	0.6±0.4	-1.18	0.24

Appendix 2 contd

Mollusc species, whole study area.

Invertebrate group, family or species/species size category	Whole study area (N=42)			
	mean density±SE 2005	2006	t value	p value
***Hydrobia ulvae* <3mm**	**20073 ±4108**	**11393 ±19798**	**-2.61**	**0.013***
H. ulvae 3+mm	450 ±166	329 ±124	-0.95	0.35
***Retusa obtusa* <3mm**	**54.2±25.1**	**3.3±1.9**	**-2.09**	**0.043***
R. obtusa 3+mm	30.3±18.2	4.6±2.4	-1.44	0.16
Mytilus edulis <5mm	5.2 ±1.9	4.9 ±1.5	-0.17	0.87
***Mysella bidentata* <5mm**	**4.2 ±2.1**	**0.9 ±0.7**	**-2.13**	**0.04***
Mysella bidentata 6-10mm	1.5 ±1.5	0	-1.0	0.32
***Cerastoderma edule* <5mm**	**74±27**	**810±377**	**2.07**	**0.045***
C. edule 5-10mm	236±138	843±381	1.87	0.069
C. edule 11-20mm	50.2 ±22.7	7.0 ±2.7	-1.6	0.12
C. edule 21-25mm	0.6 ±0.4	8.2 ±6.8	1.12	0.27
***Macoma balthica* <5mm**	**325 ±78**	**60 ±9.9**	**-3.5**	**0.001****
M. balthica 5-10mm	144 ±23	123 ±23	-1.06	0.30
M. balthica 11-20mm	14.6 ±3.8	9.4 ±2.1	-1.39	0.17
M. arenaria <5mm	0.6±0.4	0	-1.43	0.16
Abra. nitida 5-10 mm	0	0.6±0.6	1.0	0.32
Scrobicularia plana <5mm	16.1 ±3.8	20.3 ±4.8	0.93	0.36
***S. plana* 5-10mm**	**51.8 ±11.5**	**34.5 ±7.9**	**-2.36**	**0.023***
S. plana 11-20mm	34.5 ±9.2	25.4 ±12.0	-1.08	0.29
***S. plana* 21-25mm**	**1.5±0.6**	**3.9±1.4**	**2.08**	**0.044***
S. plana >30mm	1.5±0.8	0	-1.95	0.058

Appendix 2 contd

Crustacean species, whole study area.

Invertebrate group, family or species/species size category	Whole study area (N=42)			
	mean density±SE 2005	2006	t value	p value
Elminius modestus	1.2 ±1.0	22.7 ±1.0	1.5	0.14
Indeterminate Copepod	0.6 ±0.6	0.3 ±0.3	-0.44	0.66
Urothoe poseidonis <3mm	2.7 ±1.8	0.6 ±0.4	-1.16	0.26
Urothoe poseidonis 3+mm	0.31 ±0.31	0	-1.0	0.32
B. sarsi <3mm	7.6 ±3.9	0.6 ±0.4	-1.84	0.07
B. sarsi 3+mm	5.2 ±3.3	0.6 ±0.4	-1.38	0.18
Indeterminate *Gammarus*	0.3±0.3	0.3±0.3	0	1.0
Corophium. arenarium <3mm	0	0.3±0.3	1.0	0.32
C. arenarium 3+mm	0	0.3±0.3	1.0	0.32
C. volutator <3mm	1830±668	1153±467	-1.73	0.09
C. volutator 3+mm	250 ±94	293 ±123	0.38	0.71
Cyathura carinata	17.6 ±8.7	6.1 ±4.9	-1.45	0.15
Tanaids	17.3±12.6	25.6±17.2	1.09	0.28
Bodotria arenosa	2.1±1.1	0.3±0.3	-1.96	0.06
Pseudocuma longicornis	0	0.6±0.6	1.0	0.32
Cumaceans	10.6±5.7	1.2±1.0	-1.7	0.1
Crangon crangon	5.8 ±1.7	7.9 ±1.6	1.0	0.32
Liocarcinus arcuatus	0.6 ±0.4	0	-1.43	0.16
Carcinus maenas	**0**	**2.4 ±0.9**	**2.71**	**0.01***

Appendix 3

Shorebird numbers in each transect during the winter 2006-07 surveys. Column 1 of each table indicates the transect number or area name. Remaining columns give the numbers of dunlin, redshank, knot, grey plover, bar-tailed godwit, oystercatcher, curlew and shelduck recorded in the first and second counts and mean count for the whole survey. 'OB' refers to outer bank areas.

1st count November - December 2006

Transect	dun1	red1	knot1	grp1	btg1	oyc1	cur1	shel1
51	321	14	193	11	51	54	127	13
52	0	4	12	0	7	71	16	9
53	0	1	45	39	5	0	11	5
54	0	74	0	2	4	99	17	1172
55	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0
57	558	14	0	0	1	0	0	0
58	9	75	0	3	0	1	12	0
59	94	119	0	0	0	0	3	35
60	0	27	0	0	0	0	0	24
61	27	0	0	0	0	4	5	57
62	30	14	1700	0	0	32	15	104
63	165	0	0	0	0	0	4	197
64	665	0	2345	0	88	92	25	155
65	0	0	4494	47	196	120	65	358
66	38	0	4300	15	214	300	36	0
OB Daseley's	600	0	35	18	5	232	30	2
OB Pandora	280	0	354	18	7	56	0	0

Appendix 3 continued

2nd count December 2006 - January 2007

Transect		dun2	red2	knot2	grp2	btg2	oyc2	cur2	shel2
	51	761	26	2303	21	352	100	44	9
	52	0	0	0	0	4	180	57	16
	53	0	0	0	0	0	0	19	0
	54	0	46	4500	0	10	84	30	488
	55	0	0	0	0	0	0	0	0
	56	90	0	0	0	0	0	0	1
	57	1270	0	0	0	0	0	0	1
	58	1534	85	0	0	0	0	14	2
	59	0	87	0	0	0	0	12	5
	60	0	25	0	0	0	0	8	5
	61	0	0	300	1	0	10	0	80
	62	0	0	0	0	0	38	7	232
	63	44	2	35	3	0	0	0	222
	64	465	7	566	0	63	37	15	4
	65	53	0	1900	0	0	49	29	0
	66	33	18	4800	26	123	159	40	0
OB Daseley's		231	3	490	10	131	66	1	0
OB Pandora		0	21	335	0	0	77	0	0

Appendix 3 continued

Mean count winter 2006-07

Transect	dun06	red06	knot06	grp06	btg06	oyc06	cur06	shel06
51	541	20	1248	16	202	77	86	11
52	0	2	6	0	6	126	37	13
53	0	1	23	20	3	0	15	3
54	0	60	2250	1	7	92	24	830
55	0	0	0	0	0	0	0	0
56	45	0	0	0	0	0	0	1
57	914	7	0	0	1	0	0	1
58	772	80	0	2	0	1	13	1
59	47	103	0	0	0	0	8	20
60	0	26	0	0	0	0	4	15
61	14	0	150	1	0	7	3	69
62	15	7	850	0	0	35	11	168
63	105	1	18	2	0	0	2	210
64	565	4	1456	0	76	65	20	80
65	27	0	3197	24	98	85	47	179
66	36	9	4550	21	169	230	38	0
OB Daseley's	416	2	263	14	68	149	16	1
OB Pandora	140	11	345	9	4	67	0	0