P-04-17

Oskarshamn site investigation

Inventory of the soft-bottom macrozoobenthos community in the area around Simpevarp nuclear power plant

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January 2004

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Contents

Abstract

An inventory regarding the soft-bottom macrozoobenthos community was executed in the area around Simpevarp nuclear power plant in late May 2003. The results from the inventory are presented according to the geographical position of the stations.

The filter feeding bivalve *Macoma baltica* clearly made the largest contribution to the total biomass in all areas and without exception it was the length-group > 10 mm that contributed most to the *M baltica* biomass. The most frequent taxa in the samples from the archipelago north Simpevarp were Chironomidae and *Macoma baltica*. Chironomidae was as well the most prominent contributor to the total abundance and made Insecta the largest taxonomic group regarding abundance. In the archipelago south Simpevarp the most frequent taxa were Chironomidae and *Hydrobia* sp which were present in all of the samples from that area. In the southern area the species *Corophium volutator* made the largest contribution to the total abundance and due to the high *C volutator* abundance, Amphipoda was the largest taxonomic group expressed as a percentage distribution. In the archipelago south Simpevarp the extension of the macrophytes *Potamogeton pectinatus* and *Zostera marina* was relatively high and the influence from this vegetation in the samples were reflected by an increased frequency of phytofauna, e.g. *Cerastoderma hauniense* and *Radix peregra*.

1 Introduction

An inventory regarding macrozoobenthos community was executed in the area around Simpevarp nuclear power plant. *The work was conducted according to activity plan AP PX 400-02-12 (SKB internal controlling document).* The fieldwork was performed during three days in late May, 2003.

The sediment in the Baltic Sea is influenced by the production of phyto-plankton and macrophytes. The degree of influence varies with the degree of exposure. Within more sheltered areas organic material is accumulated even on shallow water /Håkansson and Rosenberg, 1985/. In more exposed areas the organic material is not accumulated until greater water depths /Persson and Göransson, 1989/. The structure of the sediment can influence the composition of the macrozoobenthos community and therefore it is important to analyse the sediment concerning for example organic content. Usually the sediment is classified according to its organic matter content /Håkansson and Rosenberg, 1985/. Accumulation bottoms have fine-grained sediment with an organic matter content above 10% while erosion bottoms usually have sediment consisting of sand or gravel and an organic content less than 4%. The sediment in the third bottom type, transport bottom, has a loss on ignition somewhere between 4 and 10%. The difference in organic matter content and water turnover among the three bottom types results in an oxygenation of different sizes. For example, oxygen has a larger possibility to permeate through sediment consisting of sand or gravel than mud. Poor oxygenation can be due to limited water turnover or a high production that contribute with large amounts of organic matter to the sediment. These two processes often cooperate and result in sediment that smells of hydrogen sulphide.

Normally a relatively large number of macrozoobenthos species occur in connection with the sediment. Totally about 50 macrozoobenthos species occur along the coastline of Kalmar County. Due to the fresh water influence the macrozoobenthos species in the Baltic Sea are less numerous than in a pure marine environment. Many macrozoobenthos species benefits from a moderate increase of organic matter content in the sediment that can lead to higher growth and increased abundance. However, with an increased supply of organic matter some sensitive species, e.g. Crustaceans, tend to vanish while the taxonomic groups Bivalve, Polychaeta and Oligochaeta continues to increase. The most durable species and taxonomic groups in the Baltic Sea are *Macoma baltica*, Polychaeta and Chironomidae /Leppäkoski, 1975/.

The aim of the study was to examine the composition, abundance and biomass of the soft-bottom macrozoobenthos community in the area around Simpevarp nuclear power plant.

2 Methods

The macrozoobenthos community was sampled at totally 40 stations. The locations of the stations were randomly placed within the area shown in Figure 2-1. In the archipelago 15 stations were distributed in the areas north and south Simpevarp respectively and the remaining 10 stations in the offshore area east Simpevarp (Figure 2-1). Sampling was performed by means of a van Veen sampler with a sampling area of 0,1202 m^2. The samples were screened through a 1 mm sieve and the remainder was preserved in a formalin solution and analysed in laboratory considering macrozoobenthos. Before analysis the samples were stored for a period of 3 months to reach weight constancy /Ankar, 1981/. In connection with the macrozoobenthos sampling a sample of the upper 5 cm of the sediment was collected at each station. The sediment samples were analyzed regarding water content and loss on ignition.

The position and water depth was determined by means of a dGPS with an echo sounder. The dGPS displayed the position in WGS84 with a precision of at least 8 meters. The received positions were then transformed to RT90 by means of the software FME Universal Translator from Safe Software.

See Appendix 1 for a more detailed method description.

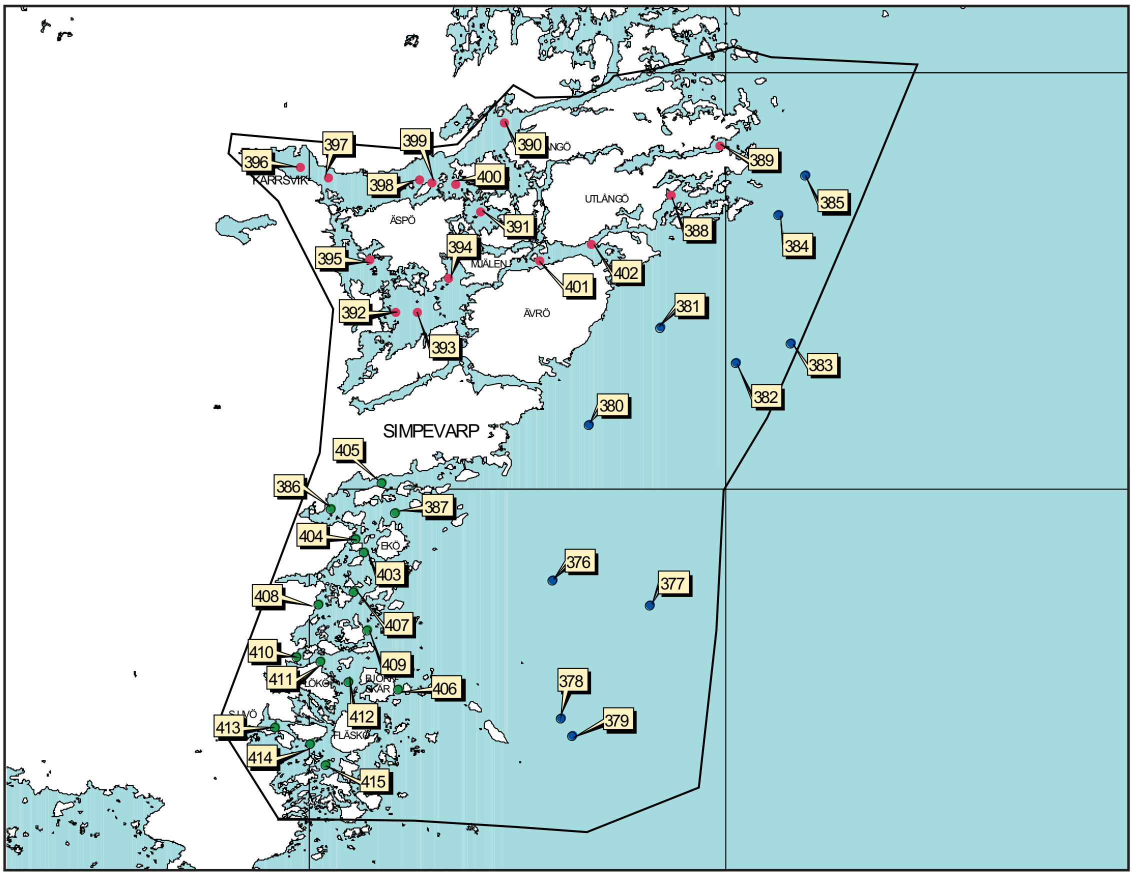

Figure 2-1. *Boundaries of the studied area and location of the sampled stations in the area around Simpevarp nuclear power plant, 2003. The stations are labelled with the last three digits of the PSM-number.*

3 Results

Data is reported to SICADA, FN Simpevarp 171.

3.1 Sediment

The sediment from the sampled stations in the archipelago north and south Simpevarp consisted almost exclusively of mud. The type of sediment differed only in sample PSM000387 in the southern area (Appendix 2). The station PSM000387 had an organic content of 4,3% while the organic content in the other stations in the archipelago varied between 21,3 and 35,8%. Thus, the types of bottom for the main part of the sampled stations were classified as accumulation bottom.

The sediment samples in the more exposed offshore area mainly consisted of sand or gravel, sometimes mixed with pebbles. The station PSM000385 differed and had a substratum that consisted of mud and clay. The organic content of the sediment were, as expected, low and varied between 0,3 and 2,8%. Consequently, the 10 sampled stations in the offshore area were classified as erosion bottom.

See Appendix 2 for more detailed results.

3.2 Fauna

3.2.1 Species richness

The total number of species or higher taxa found in the 15 sampled stations in the northern area was 28 (Table 3-1). The number of taxa found in the sampled stations varied between 3 and 12 and on average 6 taxa was found per sample (Appendix 3). The most frequent taxa were Chironomidae, *Macoma baltica* and *Chironomus plumosus* that were found in 11, 9 and 8 samples respectively. The species *Sphaeroma hookeri* was exclusively found in the northern area and only in one sample (PSM000392). The sample PSM000392 was taken in a bed of *Vaucheria* sp and in a previous inventory of the vegetation in the area, *Sphaeroma hookeri* was found in the vegetation samples taken from the Vaucheria bed /Fredriksson and Tobiasson, 2003/. The Polychaeta *Nereis diversicolor* notorious for accepting sediments with a high organic content was only found in one of the 15 samples from the northern area despite the high organic content of the sediment.

Table 3-1. Macrozoobenthos species present in the samples from the areas around Simpevarp power plant. O=occurrence.

	TURBELLARIA	Prostoma obscurum	Halicryptus spinulosus	Nereis diversicolor	Pygospio elegans	Marenzelleria viridis	OLIGOCHAETA	Piscicola geometra	MYSIS SP.	Sphaeroma hookeri	Saduria entomon	Idotea baltica	Idotea chelipes	Asellus aquaticus	GAMMARUS SP.	Gammarus oceanicus	Gammarus salinus	Monoporeia affinis	Corophium volutator	ANISOPTERA	DONACIA SP.	HALIPLUS SP.	TRICHOPTERA	LEPIDOPTERA	CERATOPOGONIDAE	CHIRONOMIDAE	Chironomus plumosus	Theodoxus fluviatilis	HYDROBIA SP.	Potamopyrgus antipodarum	Bithynia tentaculata	RISSOA SP.	Limapontia depressa	Radix peregra AGG.	Mytilus edulis	Cerastoderma glaucum	Cerastoderma hauniense	Macoma baltica	Mya arenaria	Esox lucius	Pungitius pungitius	Σ
North		O		O		O	O		O	O		O	O	O	O	O	O		O			O	O			O	O	O	O	O				O	O	O	O	O	O	O	O	28
South	O	O		O	O	O	O	O	O			O	O		O	O	O		O	O	O	O		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O			33
Offshore			O	O	O	O	O				O				O	O	O	O	O							O			O						O			O				15

Totally 33 species or higher taxa were found in the 15 samples taken in the southern area (Table 3-1). Except for station PSM000413, the number of taxa found in the samples varied between 7 and 18. In the PSM000413 sample only four taxa were found which probably was due to that the sample was taken in a bed of *Chara* sp. On average there were 11 species or higher taxa found in the samples from the southern area (Appendix 3). The most frequent species in the samples from the southern area were Chironomidae and *Hydrobia* sp which both were found in all of the 15 samples. Other frequently represented species were *Potamopyrgus antipodarum*, *Macoma baltica* and *Radix peregra*, which occurred in 13, 12 and 10 samples respectively. In the southern area the extension of the vegetation species *Potamogeton pectinatus* and *Zostera marina* were relatively high /Fredriksson and Tobiasson, 2003/. The influence from this vegetation on the samples were notable, reflected by an increased frequency of species associated to vegetation, e.g. *Cerastoderma hauniense*, *Radix peregra*, *Idotea baltica* and *Idotea chelipes*. Compared to the northern area, the Polychaeta *Nereis diversicolor* were more frequent in the samples from the southern area and occurred in 7 of the 15 samples.

In the offshore area totally 15 species or higher taxa were found (Table 3-1). On average there were 7 taxa per sample and the number of taxa among the 10 samples from the offshore area varied between 5 and 11 (Appendix 3). The most frequent taxa in the 10 samples were *Macoma baltica* and Oligochaeta, which occurred in 8 of the 10 samples. The species *Mytilus edulis* and *Pygospio elegans* were also frequently represented and occurred in 7 of the 10 samples. Notable was that the Polychaeta *Marenzelleria viridis* was present in 4 of the 10 samples from the offshore area (Appendix 3). This is a relatively new species for the Baltic Sea, discovered in year 1990 along the coastline of Blekinge. Since then *M viridis* has propagated north and now it is as frequent as *Nereis diversicolor* as far up north as Mönsterås /Jansson, 2003/.

3.2.2 Abundance

The mean abundance for the 15 sampled stations in the northern area was 1505 specimens per square meter. The abundance among the stations varied between approximately 150 and 8800 specimens per square meter (Appendix 3). The taxa with the definitely highest abundance in the northern area were Chironomidae that represented about 60% of the total abundance considering all the sampled stations. This corresponds to earlier studies from shallow areas in the archipelago of Västervik, County of Kalmar, where Chironomidae is a prominent taxa regarding abundance /Andersson et al, 2003/. The high Chironomidae abundance made Insecta the most prominent taxonomic group regarding abundance in the northern area with a share of 69% (Figure 3-1). The bivalve *Macoma baltica* had the second highest abundance in the samples from the northern area with a share of 14% of the total abundance. The length-group < 5 mm contributed to about 93% of the total *M baltica* abundance

In the southern area the mean abundance for the sampled stations were 3906 specimens per square meter and the abundance among the samples varied between approximately 730 and 12000 specimens per square meter (Appendix 3). The species that made the largest contribution to the abundance, considering all the sampled stations in the southern area, were *Corophium volutator* with a contribution of 28%. Other taxa that made a substantial contribution to the total abundance were *Macoma baltica* and Chironomidae with a contribution of 23 and 18% respectively. Regarding *Macoma baltica* it was, just as for the northern area, the length-group < 5 mm that dominated with a share of approximately 73% of the total *M baltica* abundance. Due to the high *C. volutator* abundance, the taxonomic groups Amphipoda along with Remaining mollusca were the most prominent taxonomic groups, each with a share of 28% to the total abundance (Figure 3-1). Other taxonomic

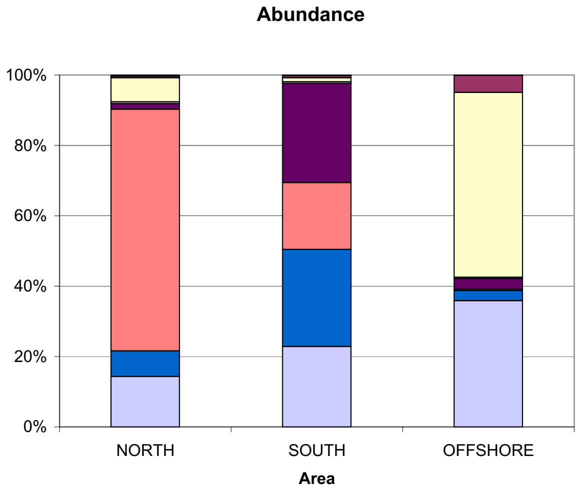

Figure 3-1. *Percentage distribution among different taxonomical groups regarding abundance contribution.*

groups with a considerable share of the total abundance were *M baltica*, discussed above, and Insecta with a share of 19%.

The mean abundance for the 10 sampled stations in the offshore area were 1909 specimens per square meter and the total abundance among the stations varied between approximately 740 and 4000 specimens per square meter (Appendix 3). The taxa with the definitely highest abundance, considering all the samples from the offshore area, were Oligochaeta that represented about 53% of the total abundance. The bivalve *Macoma baltica* that had the second highest abundance represented about 36% of the total abundance. Just as for the northern and southern area it was the length-group < 5 mm that dominated with a share of about 71%. Regarding the percentage distribution among the taxonomic groups, Oligochaeta and *Macoma baltica* were the most prominent contributors to the total abundance (Figure 3-1).

Table 3-2 show the percentage contribution to the abundance from the different taxonomic groups for the three areas combined. When looking on the contribution to the abundance for the whole examined area, Insecta and *Macoma baltica* were the most prominent contributors. Insecta and *M baltica* contributed with 26,6 and 23,4% of the total abundance respectively. Other notable contributions were made by the taxonomic groups Remaining mollusca, Amphipoda and Oligochaeta with a contribution between 12 and 18% (Table 3-2).

Table 3-2. Percentage contribution to the total abundance and biomass among different taxonomic groups.

Taxonomic group	Abundance %	Biomass %
REMAINING TAXA	0,2	0,3
POLYCHAETA	1,4	1,8
OLIGOCHAETA	12,2	0,5
ISOPODA	0,5	0,7
AMPHIPODA	17,4	2,5
INSECTA	26,6	5,0
REMAINING MOLLUSCA	18,3	24,9
Macoma baltica	23,4	64,4

3.2.3 Biomass

The total biomass among the sampled stations in the northern area varied between approximately 0,1 and 10 g dry weight per square meter with a mean biomass of 2,8 g per square meter (Appendix 3). The species with the clearly largest biomass share was *Macoma baltica* with a biomass that represented about 46% of the total biomass. This corresponds well with earlier studies in shallow areas in the archipelago where *Macoma baltica* often is the dominating species regarding biomass /Andersson et al, 2003/. About 81% of the *Macoma baltica* biomass consisted of the length-group >10 mm. Other taxa with large biomass shares were Chironomidae and *Chironomus plumosus* with a share of 25 and 8% respectively.

The mean biomass for the stations sampled in the southern area were 19 g per square meter and the total biomass among the samples varied between 1,8 and 79 g per square meter (Appendix 3). Just as for the northern area *Macoma baltica* made the largest contribution to the biomass among the species found with a share of approximately 51%. Again it was the length-group > 10 mm that had the largest share (66%) of the total *M baltica* biomass. The species with the second largest biomass share was *Cerastoderma glaucum* with a share of approximately 10%. Other taxa with notable biomass shares were *Hydrobia* sp, *Mytilus edulis* and *Cerastoderma hauniense*, each with a share of approximately 6% of the total biomass.

The total biomass among the sampled stations in the offshore area varied between 0,2 and 83 g dry weight per square meter with a mean biomass of approximately 16 g per square meter (Appendix 3). The definitely largest part of the total biomass consisted of *Macoma baltica* with a share of 93%. Again it was the length-group >10mm that represented the largest biomass contribution with a share of 73% of the species total biomass.

The percentage distribution for the biomass contribution among the taxonomic groups in Figure 3-2 shows that *Macoma baltica* made the largest contribution to the total biomass in all three areas (the size of the *M baltica* contribution is discussed above). In the northern area about 34% of the total biomass consisted of the taxonomic group Insecta while the contribution from this group was more moderate in the other two areas (3 and 0,02% for the south and offshore area respectively). In the southern area the second largest contributor to the biomass was the taxonomic group Remaining mollusca (*M baltica* excluded) with a contribution of 39%. In the northern area the contribution to the total biomass from the taxonomic group Remaining mollusca was proportionately large with a contribution of approximately 13%. In the outer area the contribution from this group were more moderate with a contribution of 2 % to the total biomass (Figure 3-2).

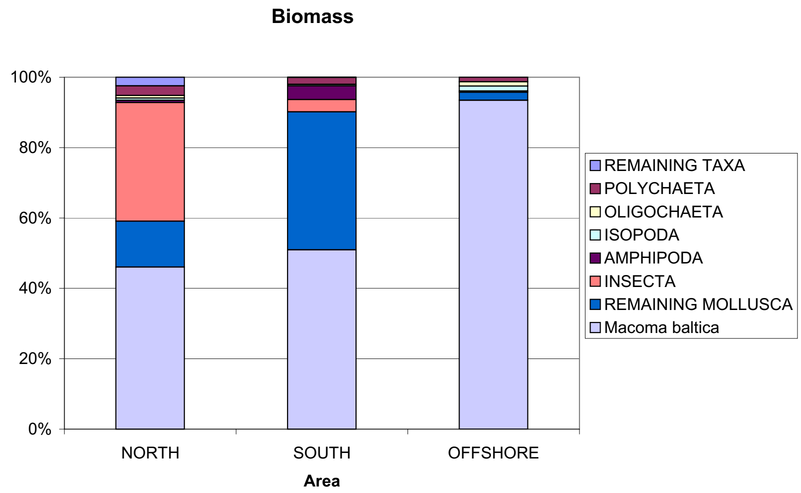

Figure 3-2. Percentage distribution among different taxonomical groups regarding biomass contribution.

In many of the samples from the archipelago north and south Simpevarp rests of macrophytes were found in the samples (Appendix 2). Figure 3-3 shows the mean biomass of the macrozoobenthos in samples with remains of different types of vegetation, as well as samples without remains (bare sediment). The result in Figure 3-3 includes the samples from the archipelago stations. In the Simpevarp area *Potamogeton pectinatus* and *Zostera marina* often occurred together /Fredriksson and Tobiasson, 2003/ and are here treated as one group. Samples with remains of *P pectinatus* and *Z marina* had the definitely highest macrozoobenthos biomass with a mean of approximately 17,5 g dry weight per square meter. The second highest biomass was found in the samples without any remains of vegetation. The mean biomass among the samples from bare sediment was approximately 5,9 g dry weight per square meter. Lowest mean macrozoobenthos biomass was found in the samples with remains of *Chara* sp and *Vaucheria* sp with a mean biomass of 2,2 and 1,0 g dry weight per square meter respectively.

Gastropods and bivalves made the largest contributions to the biomass when looking on the three areas combined. *Macoma baltica* and Remaining mollusca contributed to 64,4 and 24,9% of the total biomass respectively (Table 3-2). Among the remaining taxonomic groups it was Insecta that had the largest share in the contribution to the total biomass. Insecta made a contribution of 5% to the total biomass.

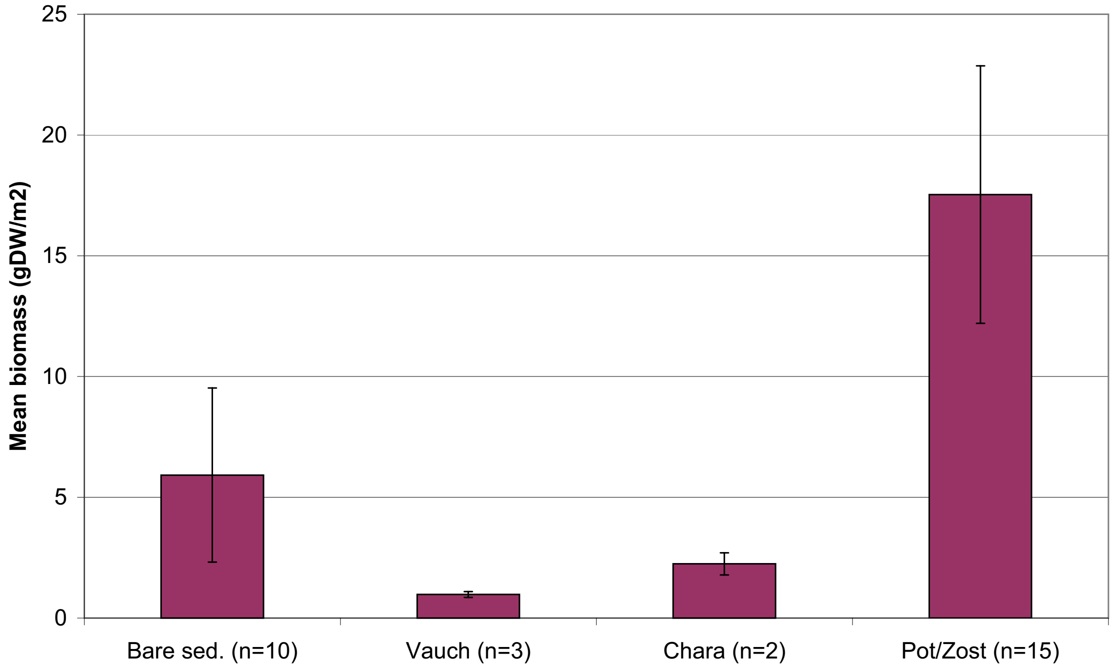

Figure 3-3. Mean biomass (gDW/m2 ± SE) in samples with or without rests of macrophytes.

4 Discussion

Vegetated sediments normally have higher species diversity and support higher densities of specimens than bare sediments /Edgar et al, 1994/. The samples from the northern area in this study contained less species compared to the southern area. This was probably due to the less diverse vegetation community in the archipelago north Simpevarp. In an earlier inventory of the submerged vegetation a large area covered with the Xanthophyceae *Vaucheria* sp was found in the northern area, south Äspö. *Vaucheria* sp appears as a velvet-like carpet over the sediment and probably decreases the oxygenation leading to anoxia and accumulation of hydrogen sulphide. This is supported by the fact that the sediment from the 3 stations with *Vaucheria* sp had a smell of hydrogen sulphide (Appendix 2). Large areas in the inner archipelago north Simpevarp were covered with *Chara* sp /Fredriksson and Tobiasson, 2003/. In earlier studies from shallow areas in the archipelago of Västervik it has been seen that samples taken in areas with *Chara* sp contained less macrozoobenthos species than samples from areas with, for example, *Ruppia* sp and *Potamogeton pectinatus* /Andersson et al, 2003/. Also, the abundance and species diversity of infaunal species in beds of *Zostera marina* has been proved to be much higher than in bare sediments /Boström and Bonsdorff, 1997/. The extent of *Ruppia* sp, *P pectinatus* and *Z marina* in the southern area were superior to the area north Simpevarp and the number of species in the samples from this area was consistently higher. However, when sampling in a site with vegetation it is likely that some phytofauna, e.g. *Cerastoderma hauniense* and *Idotea* sp, is mixed with the infaunal species. In this study, the samples containing rests of *Potamogeton pectinatus* and *Zostera marina* had the highest macrozoobenthos biomass and this corresponds to what have been seen in earlier studies /Boström and Bonsdorff, 1997/. In this study the mean biomass among the samples from bare sediment exhibits a high degree of spreading. This is due to the large biomass contribution from the sample PSM000387. The station PSM000387 had a higher presence of *Macoma baltica* compared to the other samples from bare sediment, which increased both the mean biomass and the degree of spreading. The lowest mean biomass was found in the samples with remains of *Chara* sp and *Vaucheria* sp. However, the number of samples from these two groups is so few (2 and 3 respectively) that it is difficult to give a verdict about the biomass compared to the other groups. Also, no quantitative estimations on the amount of macrophyte rests in the samples have been done and therefore it is difficult to compare the macrozoobenthos biomass in relation to the macrophyte density. From a general point of view the results from the macrozoobenthos sampling in this study corresponds well to earlier comparable studies regarding species composition and biomass /Andersson et al, 2003/. The abundance in the study from Västervik /Andersson et al, 2003/ is higher compared to this study. This is likely due to differences in sieving techniques. In the study from Västervik a 0,5 mm sieve was used while the width of the sieves mesh in this study was 1mm.

The results from the samples taken in the offshore area correspond well to what have been seen in samples from areas with similar conditions (Macrozoobenthos data base, University of Kalmar). The bivalve *Macoma baltica* often is the largest contributor to the total biomass while Oligochaeta is the most abundant taxa. The density of *Monoporeia affinis* in the offshore area was sparse. In the Gulf of Bothnia the *M affinis* population is believed to vary in 7-year cycles, however, in the Baltic Proper the fluctuations are not so regular /Cederwall et al, 1999/. *Monoporeia affinis* is a surface deposit-feeder and probably the organic content of the sediment was too low to support a large population of *M affinis*. In earlier studies it has been found that *Monoporeia affinis* avoided sites with high densities of *Macoma baltica*, probably due to that *M baltica* reduced the amount of detritus in the superficial sediment

/Bergström et al, 2002/. Regarding biomass contribution the bivalve *Macoma baltica* was the dominating species in all the sampled areas and particularly in the offshore area. Part of the dominance is explained by *M baltica* being weighed with its shell intact. A vague positive correlation was found between the organic content of the sediment and the total biomass in the samples from the offshore area. However, due to the low number of samples it is difficult to prove this correlation.

The non-native spionid polychaeta *Marenzelleria viridis* occurred in all the sampled areas. *M viridis* was discovered in year 1990 along the coastline of Blekinge and has since then propagated north and was found in samples from the archipelago of Västervik in year 1999 and Loftahammar in year 2000 (Macrozoobenthos data base, University of Kalmar). Compared to other studied areas further south, e.g. Mönsteråsviken, the density of *M viridis* was relatively low (Macrozoobenthos data base, University of Kalmar). The abundance and biomass of *Nereis diversicolor* exceeded the one of *M viridis* in all the studied areas.

References

Andersson S, Nilsson J, Tobiasson S, 2003. Biologiska undersökningar i samband med saneringen av Örserumsviken. Lägesrapport augusti 2002. Höskolan i Kalmar. Rapport 2003:3.

Ankar S, 1981. PMK-marin, Östersjön. Rapport 1981, SNV kontrakt 641-3542-80, Askölab, Stockholms universitet.

Bergström U, Englund G, Bonsdorf E, 2002. Small-scale spatial structure of Baltic Sea zoobenthos – inferring processes from patterns. J. Exp. Mar. Biol. Ecol. 281, 123–136.

Boström C, Bonsdorff E, 1997. Community structure and spatial variation of benthic invertebrates associated with *Zostera marina* (L) beds in the northern Baltic Sea. J. Sea Res. 37: 153–166

Cederwall H, Jermakovs V, Lagzdins G, 1999. Long-term changes in the soft-bottom macrofauna of the Gulf of Riga. ICES Journal of Marine Science, 56 Supplement: 41–48. 1999.

Edgar G J, Shaw C, Watson G F, Hammond L S, 1994. Comparisons of species richness, size structure and productions of benthos in vegetated and unvegetated habitats in Western Port, Victoria. J. Exp. Mar. Biol. Ecol. 176: 201–226.

Fredriksson R, Tobiasson S, 2003. Inventory of macrophyte communities at Simpevarp nuclear power plant – Area of distribution and biomass determination. SKB P-03-69, Svensk Kärnbränslehantering AB.

Håkansson L, Rosenberg R, 1985. Praktisk kustekologi. Naturvårdsverket. SNV pm 1987.

Jansson T, 2003. Kustvatten – Miljörapport för 2002. Kustvattenkommittén i Kalmar län. Kalmar. 2003.

Leppäkoski E, 1975. Assessment of degree of polution on the basis of macrozoobenthos in marine and brackish-water environments. Acta Academiae Aboensis, ser B Vol 35 nr 2.

Naturvårdsverket, 1986. Recipientkontroll vatten. Del 1, Undersökningsmetoder basprogram. Naturvårdsverket Rapport 3108.

Persson L-E, Göransson P, 1989. Hanöbukten som naturresurs, del 1 Miljö. Rapport från Länsstyrelserna i Blekinge och Kristianstads län samt Lunds universitet.

Appendix 1

A brief description of methods used

Macrozoobenthos

The macrozoobenthos were sampled according to the method BIN B R06 /Naturvårdsverket, 1986/. At each station one sample was collected with a van Veen sampler. The sample was screened through a 1 mm sieve and preserved in a buffered, 4% formalin solution coloured with Rose Bengale. Sediment from each station was collected regarding water and organic matter content. Surface and bottom water was analysed regarding temperature, oxygen content, oxygen saturation and salinity. In all, 40 randomly placed stations were sampled.

Parameters

Macrofauna were determined at species level. Some difficult taxonomic groups were determined to family or higher taxonomic level. Following parameters were analysed:

• Volume of sample	l
• Colour of sediment	Rock colour chart
• Smell of sediment	none, slight, intense
• Thickness of oxidized sediment layer	cm
• Water content	%
• Dry matter	%
• Organic content	% of dry matter
• Number of species	species/m^2
• Abundance	specimens/m^2
• Biomass	g dry weight/m^2
• Water temperature	°C
• Salinity	‰
• Oxygen content	mg O_2/l
• Oxygen saturation	% O_2

To obtain dry weight the fauna was dried in 60°C for at least 60 hours. For the taxa Oligochaeta and *Pygospio elegans* a standard dry weight of 0,0002 g dw/specimen was used. The bivalve *Macoma baltica* was measured and divided into 3 groups depending upon length, < 5, 5–10 and > 10 mm and analysed on one hand as separate groups and on the other hand as a whole group named *Macoma baltica* tot. All gastropods and bivalves were weighed with its shell intact.

Appendix 2

Results from sediment samples

Area north/south/offshore	Station	X RT90 2,5 gon W	Y	Depth m	Vegetation remain in sample	Type of substrate estimation in field	Oxidized layer cm	H2S-smell none/slight/intense	Water content %	Organic content %
N	PSM000388	1554338	6368518	1,3	Pot/Zost	Mud	0	s	90	27,7
N	PSM000389	1554922	6369116	4,3	Pot/Zost	Mud	0	s	92	33,3
N	PSM000390	1552336	6369385	13,4	Bare sed.	Mud	0,5	s	91	25,2
N	PSM000391	1552049	6368321	3,1	Chara	Mud	0	s	92	33,7
N	PSM000392	1551032	6367111	2,4	Vaucheria	Mud	0	i	93	28,2
N	PSM000393	1551298	6367111	3,9	Vaucheria	Mud	0,5	s	93	28,9
N	PSM000394	1551674	6367528	2,7	Bare sed.	Mud	0	s	90	27,3
N	PSM000395	1550720	6367744	2,2	Bare sed.	Mud	0,1	i	91	30,8
N	PSM000396	1549895	6368853	5,5	Bare sed.	Mud	0,1	n	90	28,4
N	PSM000397	1550230	6368732	7,5	Bare sed.	Mud	0,1	n	88	26,9
N	PSM000398	1551314	6368707	5,5	Bare sed.	Mud	0	i	89	29,8
N	PSM000399	1551474	6368670	4,0	Bare sed.	Mud (firm)	0	n	86	21,3
N	PSM000400	1551761	6368652	3,7	Vaucheria	Mud	0	i	91	28,0
N	PSM000401	1552756	6367740	4,1	Bare sed.	Mud	0	i	91	27,5
N	PSM000402	1553388	6367936	5,2	Bare sed.	Mud	0	i	91	29,1
S	PSM000386	1550269	6364762	2,3	Pot/Zost	Mud	~1	i	91	30,1
S	PSM000387	1551039	6364722	6,0	Bare sed.	Muddy sand	>5	n	58	4,3
S	PSM000403	1550663	6364248	3,1	Pot/Zost	Mud	0	s	92	32,2
S	PSM000404	1550562	6364406	1,2	Pot/Zost	Mud	0	i	91	31,0
S	PSM000405	1550874	6365078	3,6	Pot/Zost	Mud	0	i	91	26,3
S	PSM000406	1551066	6362608	4,4	Pot/Zost	Silty mud	0	s	89	28,1
S	PSM000407	1550541	6363773	4,5	Pot/Zost	Mud	0	i	91	31,1
S	PSM000408	1550121	6363621	3,4	Pot/Zost	Mud	0	s	91	27,8
S	PSM000409	1550701	6363319	3,8	Pot/Zost	Mud	0	s	90	31,2
S	PSM000410	1549858	6362986	1,0	Pot/Zost	Mud	0	i	93	27,1
S	PSM000411	1550138	6362945	2,7	Pot/Zost	Silty mud	0	n	89	27,4
S	PSM000412	1550471	6362687	6,5	Pot/Zost	Mud	0	i	91	32,8
S	PSM000413	1549596	6362147	0,7	Chara	Mud	0	i	91	26,2
S	PSM000414	1550017	6361941	1,4	Pot/Zost	Mud	0	n	91	24,1
S	PSM000415	1550206	6361695	1,6	Pot/Zost	Mud	0	i	93	35,8
O	PSM000376	1552917	6363904	17,2	Bare sed.	Coarse sand (2cm) with pebbles (~5cm diameter) on clay	>5	n	20	0,8
O	PSM000377	1554096	6363614	16,9	Bare sed.	Gravel with pebbles	>5	n	5	0,3
O	PSM000378	1553019	6362263	13,2	Bare sed.	Gravel with pebbles	>5	n	14	0,6
O	PSM000379	1553153	6362042	13,8	Bare sed.	Gravel with pebbles	>5	n	20	0,4
O	PSM000380	1553362	6365776	19,1	Bare sed.	Sand	>5	n	25	0,6
O	PSM000381	1554215	6366935	19,9	Bare sed.	Gravel (2cm) on clay	>5	n	19	0,6
O	PSM000382	1555125	6366512	19,6	Bare sed.	Gravel with pebbles (sediment sample pure sand)	>5	n	25	0,3
O	PSM000383	1555775	6366754	23,0	Bare sed.	Gravel or coarse sand with pebbles (~ 4cm) on clay	>5	n	20	0,8
O	PSM000384	1555626	6368289	24,0	Bare sed.	Gravel with pebbles (~4cm) on clay	>5	n	19	1,0
O	PSM000385	1555951	6368768	39,3	Bare sed.	Silty mud (1cm) on clay with pebbles	>5	n	48	2,8

Table A3-1. Abundance (specimens/m²) and biomass (gDW/m²) for each station and mean with standard error for all stations in the northern area.

Station	PSM000388		PSM000389		PSM000390		PSM000391		PSM000392		PSM000393		PSM000394		PSM000395	
Sampling date	2003-05-27		2003-05-27		2003-05-27		2003-05-27		2003-05-27		2003-05-27		2003-05-27		2003-05-27	
Sampling depth (m)	1,3		4,3		13,4		3,1		2,4		3,9		2,7		2,2	
	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW
TURBELLARIA																
Prostoma obscurum			8	0,013												
Halicryptus spinulosus																
Nereis diversicolor			17	0,070												
Pygospio elegans																
Marenzelleria viridis																
OLIGOCHAETA			324	0,065							8	0,002				
Piscicola geometra																
MYSIS SP.	33	0,087														
Sphaeroma hookeri									42	0,037						
Saduria entomon																
Idotea baltica	33	0,148														
Idotea chelipes	17	0,013	8	0,029												
Asellus aquaticus									17	0,024						
GAMMARUS SP.	17	0,007					133	0,077	17	0,006						
Gammarus oceanicus									25	0,022						
Gammarus salinus							8	0,046	33	0,036						
Monoporeia affinis																
Corophium volutator	33	0,040			8	0,001					42	0,009	17	0,008	17	0,025
ANISOPTERA																
DONACIA SP.																
DONACIA SP. (ad)																
HALIPLUS SP.															8	0,012
TRICHOPTERA	8	0,089							25	0,014						
LEPIDOPTERA																
CERATOPOGONIDAE																
CHIRONOMIDAE	7 862	6,359	1 281	1,261	92	0,026	3 844	2,225	349	0,491	58	0,027	92	0,014	208	0,076
Chironomus plumosus					266	0,715					532	1,071	25	0,082		
Theodoxus fluviatilis			17	0,280					50	0,007						
HYDROBIA SP.	599	1,309	25	0,018												
Potamopyrgus antipodarum	83	0,583	25	0,065					574	0,399			17	0,082		
Bithynia tentaculata																
RISSOA SP.																
Limapontia depressa																
Radix peregra AGG.	8	0,312	17	1,181												
Mytilus edulis																
Cerastoderma glaucum			17	0,008												
Cerastoderma hauniense	58	0,202														
Macoma baltica <5mm			324	0,210	8	0,019										
Macoma baltica 5-10mm			17	0,275												
Macoma baltica >10mm													8	0,611		
Macoma baltica tot			341	0,484	8	0,019							8	0,611		
Mya arenaria																
Esox lucius							17	0,220								
Pungitius pungitius	8	0,721														
∑	8 760	9,870	2 080	3,476	374	0,760	4 002	2,569	1 131	1,034	641	1,108	158	0,797	233	0,113

Station	PSM000396		PSM000397		PSM000398		PSM000399		PSM000400		PSM000401		PSM000402		Tot Abund		Tot DW	
Sampling date	2003-05-27		2003-05-27		2003-05-27		2003-05-27		2003-05-27		2003-05-27		2003-05-27					
Sampling depth (m)	5,5		7,5		5,5		4,0		3,7		4,1		5,2					
	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	M	SE	M	SE
TURBELLARIA																		
Prostoma obscurum															0,6	0,57	0,001	0,0009
Halicryptus spinulosus																		
Nereis diversicolor					8	0,314	42	0,519					8	0,002	5,0	3,01	0,060	0,0403
Pygospio elegans																		
Marenzelleria viridis	17	0,136	8	0,078			8	0,046							2,2	1,32	0,017	0,0106
OLIGOCHAETA	799	0,160	341	0,068	33	0,007	33	0,007	8	0,002					103,2	59,86	0,021	0,0120
Piscicola geometra																		
MYSIS SP.															2,2	2,30	0,006	0,0060
Sphaeroma hookeri															2,8	2,87	0,002	0,0025
Saduria entomon																		
Idotea baltica															2,2	2,30	0,010	0,0102
Idotea chelipes															1,7	1,25	0,003	0,0021
Asellus aquaticus															1,1	1,15	0,002	0,0017
GAMMARUS SP.															11,1	9,15	0,006	0,0053
Gammarus oceanicus															1,7	1,72	0,001	0,0015
Gammarus salinus															2,8	2,33	0,005	0,0039
Monoporeia affinis																		
Corophium volutator											8	0,004			8,3	3,57	0,006	0,0031
ANISOPTERA																		
DONACIA SP.																		
DONACIA SP. (ad)																		
HALIPLUS SP.															0,6	0,57	0,001	0,0009
TRICHOPTERA															2,2	1,78	0,007	0,0062
LEPIDOPTERA																		
CERATOPOGONIDAE																		
CHIRONOMIDAE									50	0,014	75	0,027	216	0,142	941,8	576,59	0,711	0,4499
Chironomus plumosus	133	0,401	50	0,154					225	0,766	8	0,032	92	0,311	88,7	40,15	0,235	0,0932
Theodoxus fluviatilis															4,4	3,55	0,019	0,0193
HYDROBIA SP.							17	0,027					17	0,012	43,8	41,11	0,091	0,0901
Potamopyrgus antipodarum					8	0,011	17	0,018			42	0,086	8	0,109	51,6	39,10	0,090	0,0456
Bithynia tentaculata																		
RISSOA SP.																		
Limapontia depressa																		
Radix peregra AGG.															1,7	1,25	0,100	0,0828
Mytilus edulis											8	0,017			0,6	0,57	0,001	0,0011
Cerastoderma glaucum					8	0,013									1,7	1,25	0,001	0,0010
Cerastoderma hauniense															3,9	4,02	0,013	0,0140
Macoma baltica <5mm					33	0,052	58	0,039			474	0,205	2 113	0,892	200,8	146,31	0,094	0,0619
Macoma baltica 5-10mm	8	0,221	8	0,128	25	0,650	25	0,432			17	0,257	17	0,412	7,8	2,59	0,158	0,0558
Macoma baltica >10mm					33	8,479	8	2,819			42	3,409	8	0,434	6,7	3,49	1,050	0,6206
Macoma baltica tot	8	0,221	8	0,128	92	9,181	92	3,290			532	3,871	2 138	1,738	215,2	148,01	1,303	0,6713
Mya arenaria							17	0,005					17	0,789	2,2	1,56	0,053	0,0544
Esox lucius															1,1	1,15	0,015	0,0152
Pungitius pungitius															0,6	0,57	0,048	0,0498
∑	957	0,918	408	0,428	150	9,526	225	3,911	283	0,782	674	4,037	2 496	3,102	1504,7	610,07	2,829	0,8243

	PSM000388	PSM000389	PSM000390	PSM000391	PSM000392	PSM000393	PSM000394	PSM000395	PSM000396	PSM000397	PSM000398	PSM000399	PSM000400	PSM000401	PSM000402	M	SE
Number of taxa	12	11	4	4	9	4	5	3	4	4	5	7	3	6	7	5,9	0,76

Table A3-2. Abundance (specimens/m²) and biomass (gDW/m²) for each station and mean with standard error for all stations in the southern area.

Station	PSM000386		PSM000387		PSM000403		PSM000404		PSM000405		PSM000406		PSM000407		PSM000408		PSM000409		PSM000410		PSM000411		PSM000412		PSM000413		PSM000414		PSM000415		Tot Abund		Tot DW	
Sampling date	2003-05-26		2003-05-26		2003-05-27		2003-05-27		2003-05-28		2003-05-28		2003-05-28		2003-05-28		2003-05-28		2003-05-28		2003-05-28		2003-05-28		2003-05-28		2003-05-28		2003-05-28					
Sampling depth (m)	2,3		6,0		3,1		1,2		3,6		4,4		4,5		3,4		3,8		1,0		2,7		6,5		0,7		1,4		1,6					
	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	M	SE	M	SE
TURBELLARIA	8	0,019																													0,6	0,57	0,001	0,0013
Prostoma obscurum	8	0,001					8	0,014							8	0,041	8	0,010					17	0,017							3,3	1,41	0,006	0,0030
Halicryptus spinulosus																																		
Nereis diversicolor			58	0,205					8	0,263	108	0,874	17	0,101			83	1,423			33	1,283					25	1,373			22,2	9,23	0,368	0,1500
Pygospio elegans																	8	0,002													0,6	0,57	0,000	0,0001
Marenzelleria viridis			25	0,022																											1,7	1,72	0,001	0,0016
OLIGOCHAETA			383	0,077							108	0,022	25	0,005			141	0,028			8	0,002	17	0,003							45,5	27,49	0,009	0,0055
Piscicola geometra							8	0,081																							0,6	0,57	0,005	0,0056
MYSIS SP.													8	0,021	8	0,040															1,1	0,78	0,004	0,0030
Sphaeroma hookeri																																		
Saduria entomon																																		
Idotea baltica	116	0,593															58	0,265											8	0,012	12,2	8,69	0,058	0,0435
Idotea chelipes	25	0,103			8	0,010			33	0,104	17	0,030					8	0,003													6,1	2,85	0,017	0,0097
Asellus aquaticus																																		
GAMMARUS SP.	8	0,005	8	0,002	8	0,001			8	0,001	17	0,003					8	0,001													3,9	1,42	0,001	0,0004
Gammarus oceanicus	8	0,013																													0,6	0,57	0,001	0,0009
Gammarus salinus	8	0,060									8	0,012																			1,1	0,78	0,005	0,0042
Monoporeia affinis																																		
Corophium volutator	2 155	1,707			6 697	3,002			3 777	3,218	416	0,274	8	0,002	2 013	1,729	8	0,017			1 348	1,137									1 094,8	514,21	0,739	0,3068
ANISOPTERA																			8	0,024									8	0,037	1,1	0,78	0,004	0,0029
DONACIA SP.	8	0,168					191	1,642	25	0,043																	108	0,476	17	0,141	23,3	14,49	0,165	0,1144
DONACIA SP. (ad)							8	0,058																							0,6	0,57	0,004	0,0040
HALIPLUS SP.																											8	0,018			0,6	0,57	0,001	0,0013
TRICHOPTERA																																		
LEPIDOPTERA	8	0,001															8	0,008	8	0,001											1,7	0,92	0,001	0,0006
CERATOPOGONIDAE	8	0,009							8	0,016									8	0,017							17	0,031			2,8	1,37	0,005	0,0025
CHIRONOMIDAE	241	0,041	591	0,193	1 697	1,362	233	0,096	316	0,161	225	0,048	17	0,001	641	0,471	632	0,215	507	0,282	466	0,082	2 687	1,551	549	0,257	1 048	1,162	516	0,462	691,1	182,12	0,425	0,1356
Chironomus plumosus					33	0,108			17	0,050					17	0,060							250	0,696							21,1	17,10	0,061	0,0477
Theodoxus fluviatilis					8	0,077	25	0,839	8	0,022	116	1,254					125	1,129													18,9	11,20	0,221	0,1200
HYDROBIA SP.	17	0,017	58	0,118	83	0,304	865	1,883	8	0,031	3 161	7,361	75	0,134	25	0,077	1 040	1,882	92	0,197	416	1,340	42	0,084	691	1,547	283	0,772	166	0,257	468,1	218,09	1,067	0,5011
Potamopyrgus antipodarum			599	1,454	75	0,394	349	0,978	75	0,381	1 431	3,105	100	0,383	33	0,043	283	0,929	92	0,139	491	1,122	75	0,141			100	0,300	83	0,420	252,4	99,68	0,653	0,2167
Bithynia tentaculata																			8	0,700											0,6	0,57	0,047	0,0483
RISSOA SP.											707	1,411																			47,1	48,80	0,094	0,0974
Limapontia depressa																											8	0,001			0,6	0,57	0,000	0,0001
Radix peregra AGG.	25	0,241			8	0,201	233	4,725			75	1,052			8	0,108	33	0,740	8	0,463					8	0,116	183	0,894	266	1,826	56,6	24,56	0,691	0,3295
Mytilus edulis	108	0,141	25	0,366	17	0,030	8	0,017			1 023	14,138					241	1,410													94,8	70,82	1,073	0,9709
Cerastoderma glaucum	8	0,268					33	10,983			116	10,453			8	3,019	17	0,171			8	2,457							25	0,662	14,4	8,04	1,868	0,9930
Cerastoderma hauniense	408	4,329					582	5,692			799	6,036																			119,2	68,88	1,070	0,5992
Macoma baltica <5mm	33	0,079	1 256	1,680	2 870	2,526	67	0,045	541	0,909	424	0,224	707	1,119	116	0,230	1 572	0,399			923	0,950	1 281	0,563	8	0,001					653,4	218,66	0,582	0,1982
Macoma baltica 5-10mm	233	4,814	541	12,861	383	4,677	8	0,081	241	2,791	125	2,977	233	2,828	266	3,009	58	0,936			449	6,021	33	0,378							171,4	48,33	2,758	0,9240
Macoma baltica >10mm	316	21,393	183	16,337	25	2,953	58	6,963	8	0,958	158	20,975			8	1,048	141	13,825			42	7,269	58	4,586							66,6	24,87	6,421	2,1073
Macoma baltica tot	582	26,285	1 980	30,878	3 278	10,156	133	7,089	790	4,659	707	24,176	940	3,947	391	4,287	1 772	15,161			1 414	14,240	1 373	5,527	8	0,001					891,3	250,43	9,760	2,7406
Mya arenaria			8	2,289							42	8,384			17	0,072					17	0,082									5,5	3,11	0,722	0,5878
Esox lucius																																		
Pungitius pungitius																																		
Σ	3 752	34,002	3 735	35,603	11 913	15,646	2 679	34,097	5 075	8,948	9 077	78,632	1 190	4,592	3 170	9,948	4 476	23,394	732	1,822	4 201	21,745	4 459	8,018	1 256	1,921	1 780	5,027	1 090	3,816	3 905,7	820,53	19,147	5,4614

																M	SE
Number of taxa	18	10	11	12	12	17	8	11	17	8	9	7	4	9	8	10,7	1,07

Table A3-3. Abundance (specimens/m²) and biomass (gDW/m²) for each station and mean with standard error for all stations in the offshore area.

Station	PSM000376		PSM000377		PSM000378		PSM000379		PSM000380		PSM000381		PSM000382		PSM000383		PSM000384		PSM000385		Tot Abund		Tot DW	
Sampling date	2003-05-26		2003-05-26		2003-05-26		2003-05-26		2003-05-26		2003-05-26		2003-05-26		2003-05-26		2003-05-26		2003-05-26					
Sampling depth (m)	17,2		16,9		13,2		13,8		19,1		19,9		19,6		23,0		24,0		39,3					
	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	A	DW	M	SE	M	SE
TURBELLARIA																								
Prostoma obscurum																								
Halicryptus spinulosus									8	0,004							8	0,002	8	0,002	2,5	1,34	0,001	0,0005
Nereis diversicolor	25	0,937			33	0,007	17	0,113			8	0,082	25	0,314			33	0,275			14,1	4,72	0,173	0,0977
Pygospio elegans	33	0,007	83	0,017			8	0,002	308	0,062	108	0,022	133	0,027	25	0,005	33	0,007			73,2	31,51	0,015	0,0063
Marenzelleria viridis	8	0,021							8	0,007			25	0,028	8	0,081					5,0	2,68	0,014	0,0086
OLIGOCHAETA	524	0,105	2 879	0,576	1 065	0,213	990	0,198	374	0,075	566	0,113	3 161	0,632	258	0,052	208	0,042			1002,5	371,67	0,200	0,0743
Piscicola geometra																								
MYSIS SP.																								
Sphaeroma hookeri																								
Saduria entomon	8	0,202							17	0,790			17	0,103			25	0,187	8	0,922	7,5	3,05	0,220	0,1151
Idotea baltica																								
Idotea chelipes																								
Asellus aquaticus																								
GAMMARUS SP.	50	0,007	8	0,003	17	0,002	58	0,018			8	0,001									14,1	7,28	0,003	0,0019
Gammarus oceanicus			8	0,016			25	0,031													3,3	2,68	0,005	0,0035
Gammarus salinus							17	0,017									33	0,079			5,0	3,74	0,010	0,0083
Monoporeia affinis															33	0,012	125	0,145	183	0,212	34,1	21,81	0,037	0,0255
Corophium volutator			8	0,007																	0,8	0,88	0,001	0,0008
ANISOPTERA																								
DONACIA SP.																								
DONACIA SP. (ad)																								
HALIPLUS SP.																								
TRICHOPTERA																								
LEPIDOPTERA																								
CERATOPOGONIDAE																								
CHIRONOMIDAE					8	0,003	17	0,001	8	0,007							33	0,019	8	0,001	7,5	3,57	0,003	0,0020
Chironomus plumosus																								
Theodoxus fluviatilis																								
HYDROBIA SP.																	8	0,028	8	0,032	1,7	1,17	0,006	0,0043
Potamopyrgus antipodarum																								
Bithynia tentaculata																								
RISSOA SP.																								
Limapontia depressa																								
Radix peregra AGG.																								
Mytilus edulis	233	1,082	17	0,003			8	0,174	8	0,037			33	0,626	58	0,082	166	1,477	8	0,077	53,2	26,89	0,356	0,1765
Cerastoderma glaucum																								
Cerastoderma hauniense																								
Macoma baltica <5mm	3 062	0,959							1 131	1,374	208	0,033	200	0,705	125	0,196	58	0,253	58	0,090	484,2	322,31	0,361	0,1615
Macoma baltica 5-10mm	17	0,038	150	4,005	8	0,008			8	0,079			399	12,433	191	4,968	416	15,009	33	0,847	122,3	54,83	3,739	1,8643
Macoma baltica >10mm													75	8,698	42	4,424	175	14,819	491	80,384	78,2	51,83	10,833	8,3170
Macoma baltica tot	3 078	0,998	150	4,005	8	0,008			1 140	1,453	208	0,033	674	21,836	358	9,589	649	30,082	582	81,319	684,7	304,18	14,932	8,5172
Mya arenaria																								
Esox lucius																								
Pungitius pungitius																								
Σ	3 960	3,358	3 153	4,627	1 131	0,234	1 140	0,554	1 872	2,433	899	0,250	4 068	23,567	740	9,820	1 323	32,343	807	82,567	1 909,3	438,28	15,975	8,6082

	PSM000376	PSM000377	PSM000378	PSM000379	PSM000380	PSM000381	PSM000382	PSM000383	PSM000384	PSM000385	M	SE
Number of taxa	8	7	5	8	8	5	7	6	11	7	7,2	0,58