

The effects of long-term sand extraction activities on copepod communities from the Kwintebank.

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1. Introduction

Since 1978 the copepod communities of the Kwintebank have been surveyed two times through different benthic research projects of the Marine Biology Section of Ghent University.

The results of the samples of 1978 (situation before the start of intensive sand extraction) and 1997 (disturbance situation during sand extraction) will be used in the present study to discover any long-term effects of sand extraction on the benthic copepod communities. Additional samples of 2001 are worked out in the present study, representing a second disturbance situation during sand extraction.

In this report the presented evaluation of the long-term effects of sand extraction, comparing data of 1978, 1997 and 2001, focuses on the ecotype approach. The community analysis at species level will be presented in the next report, when the samples of December 2001 will be worked out completely at species level. What will be investigated within the ecotype approach is the hypothesis that due to sand extraction the bigger species are replaced by smaller interstitial species that can hide deeper in the sediment and can reproduce faster. This hypothesis was based on a preliminary analysis between 1978 and 1997 which showed that the big species were significantly reduced ($p < 0,005$) in the intensively extracted areas in the northern and central part of the Kwintebank.

The comparison of the first post-dredging samples of October 2003 with the previous data, as a part of the study of the recovery of the copepod communities after cessation of dredging, is also included in this report.

2. Material and methods

In order to compare densities among and within different periods, ANOVA's were performed on $\log(x+1)$ transformed data. The non-parametric ecotype data are analysed by means of the Kruskal-Wallis ANOVA by Ranks. Overall significant differences were pairwise compared using the planned comparison option in ANOVA for densities or following Conover (1971) for ecotype data. The univariate analyses were performed with STATISTICA™ software (Microsoft, StatSoft, Inc., 2000).

The different ecotypes are shortly defined as follows (Fig. 3.1) (Hicks & Coull, 1983). Ecotype 1 are epibenthic species that are living on top of the sediment; ecotype 2 are endobenthic species that are digging and living in the upper centimeters of the sediment, both are eating detritus. Ecotype 3 or interstitial species are up to ten times smaller than the former ones and are living in the interstitial spaces between the sand grains, grazing on bacteria. Some harpacticoids are also free swimming and living close to the sediment, they are defined as ecotype 4.

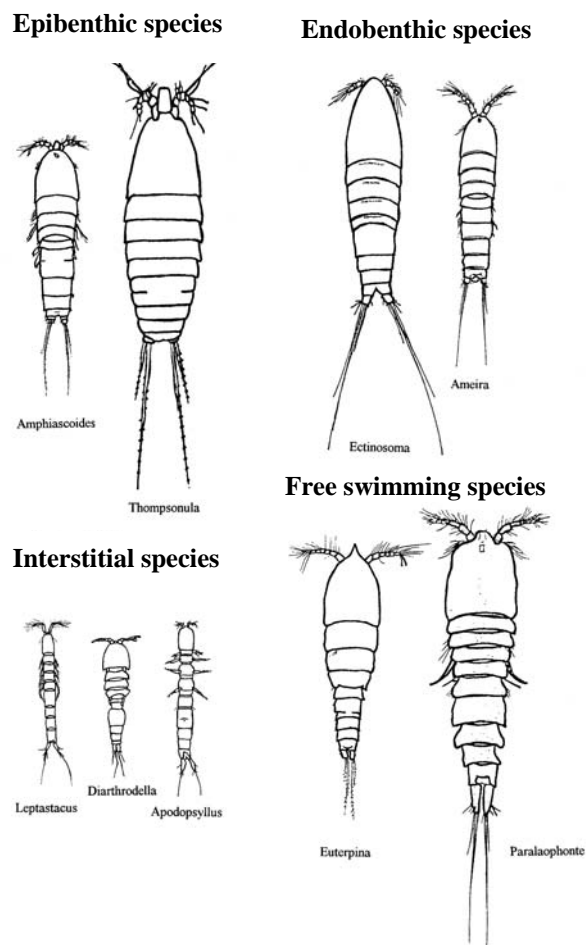


Fig. 3. 1: Different ecotypes of harpacticoid copepods illustrated by some typical genera

3. Results

a) Long-term effects of sand extraction on harpacticoid copepod communities

The percentages of the four ecotypes of the different periods are shown in Fig. 3.2. Big species decreased significantly between 1978 and 1997 ($p < 0.005$), whereas they increased again significantly between 1997 and 2001 ($p < 0.001$). This increase was due to an increase in free swimming species ($p < 0.005$), the amount of epi- and endobenthic species only did not increase significantly. During the dredging situation in 1997 and 2001 the percentage of epi- and endobenthic species did not differ between stations with different extraction intensity. The percentage of the free swimming species however differed between the most intensively exploited stations and the other stations in 2001 ($p < 0.05$).

b) Evaluation of the recovery of the copepod communities after cessation of dredging

Fig.3.2 also shows the first comparison of the situation of 2003 of the northern and central depression in comparison with the older data. For these intensively extracted areas, there are significant differences between 1978 and 1997 ($p < 0.005$) due to the decrease in epi- and endobenthic species and between 1997 and 2001 ($p < 0.005$) due to the increase in free swimming species, but not between 2001 and 2003. The percentages of the big endo- and epibenthic species in 2003 decreased in comparison with 2001, but they do not differ significantly from the percentages in 1997 or 2001. When taking the free swimming species into account, there is a significant difference between 1997 and 2003 ($p < 0.005$). Whereas the ecotype distribution does not show significant differences between 1978 and 2001 for the depression areas, the situation of 1978 does significantly differ from the situation in 2003 ($p < 0.05$) due to changes in the epi- and endobenthic species as well as the free swimming species percentages. In contrast with the ecotype distribution, the density shows clear differences in the central depression after the cessation of dredging. Whereas density did not change a lot in the northern depression through time, not even after the start of the extractions

between 1978 and 1997, the density decreased after the start of the extractions in 1978 in the central depression ($p < 0,01$). A significant increase in density is shown between 1997-2001 and 2003 in the central depression ($p < 0,01$). 95% of the individuals in the central depression in 2003 were interstitial species.

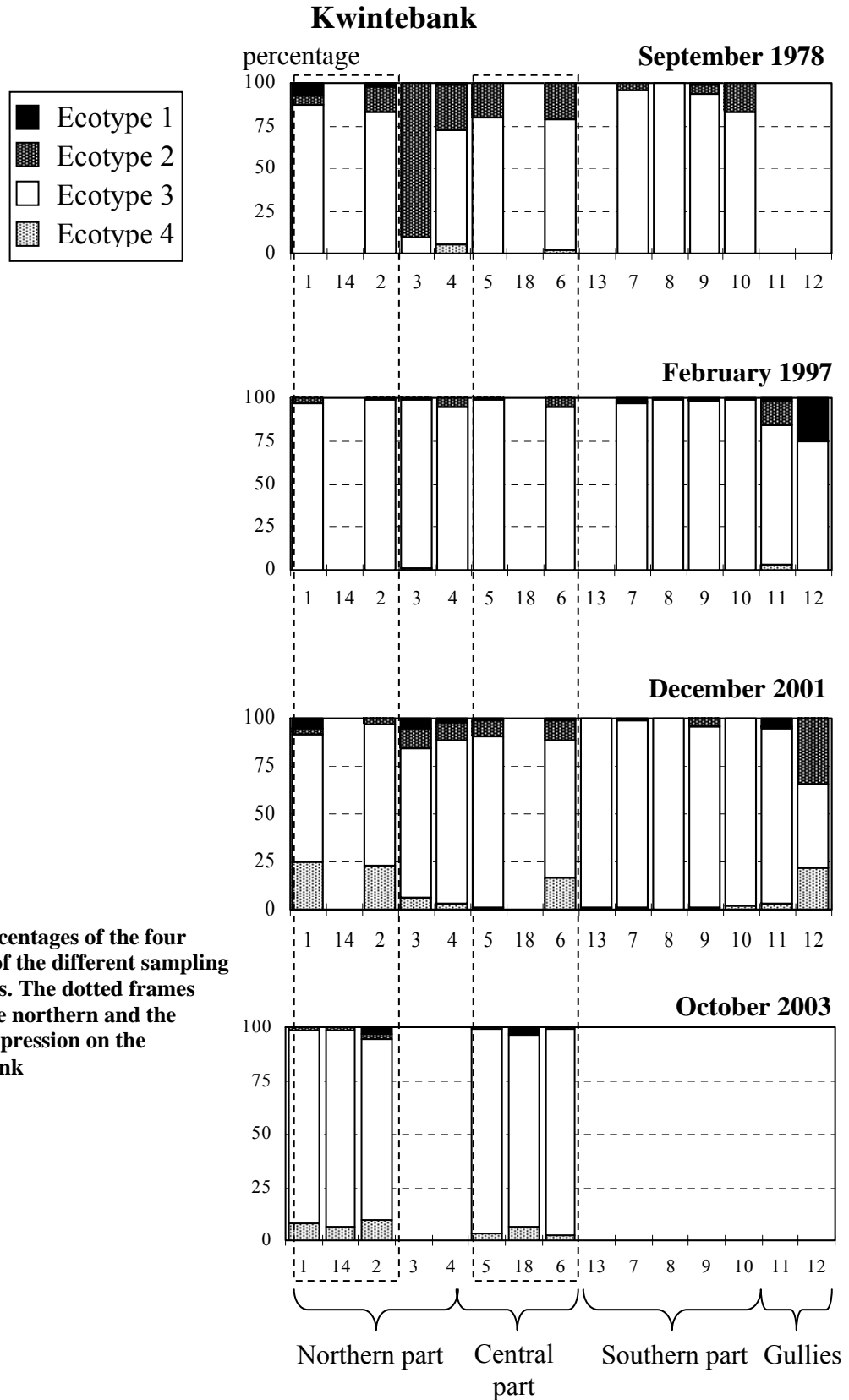


Fig.3.2:
Mean percentages of the four ecotypes of the different sampling campaigns. The dotted frames outline the northern and the central depression on the Kwintebank

3. Conclusions

The percentage of big species fluctuates and can increase in extraction disturbance situation (as the situation in 2001).

The situation in 2001 and 2003 lies in between 1978 and 1997.

The percentage of big species did not increase in 2003 after the cessation of dredging, while the percentages have been higher during the disturbance situation of 2001.

An increase in density is observed in the central depression after cessation of dredging, similar to the densities in 1978 in that area.

4. Discussion

a) Long-term effects of sand extraction on harpacticoid copepod communities

The changes in species assemblage in the two depressions imply an increased importance of small interstitial species between 1978 and 1997, which may have been related to intensive sand extraction (Bonne & Vincx, 2003). Thistle et al. (1999) found a reduced proportion of surface-living epi- and endobenthic species and a higher proportion of interstitial harpacticoids, which were distributed deeper into physically reworked sediments, in comparison with more quiescent sites. Epi- and endobenthic species do not hide deeper into the sediment to avoid suspension when exposed to physical reworking of the sediment (Thistle et al., 1995). Being suspended they risk to be damaged, expatriated or exposed to water-column predators (D'Amours, 1988) or their energy stores can become depleted (Thistle et al., 1999). Interstitial harpacticoids are able to hide deeper into the sediment than the bigger epi- and endobenthic species and such behaviour may be more beneficial than the swimming activity of the epi- and endobenthic species when coping with extreme disturbance.

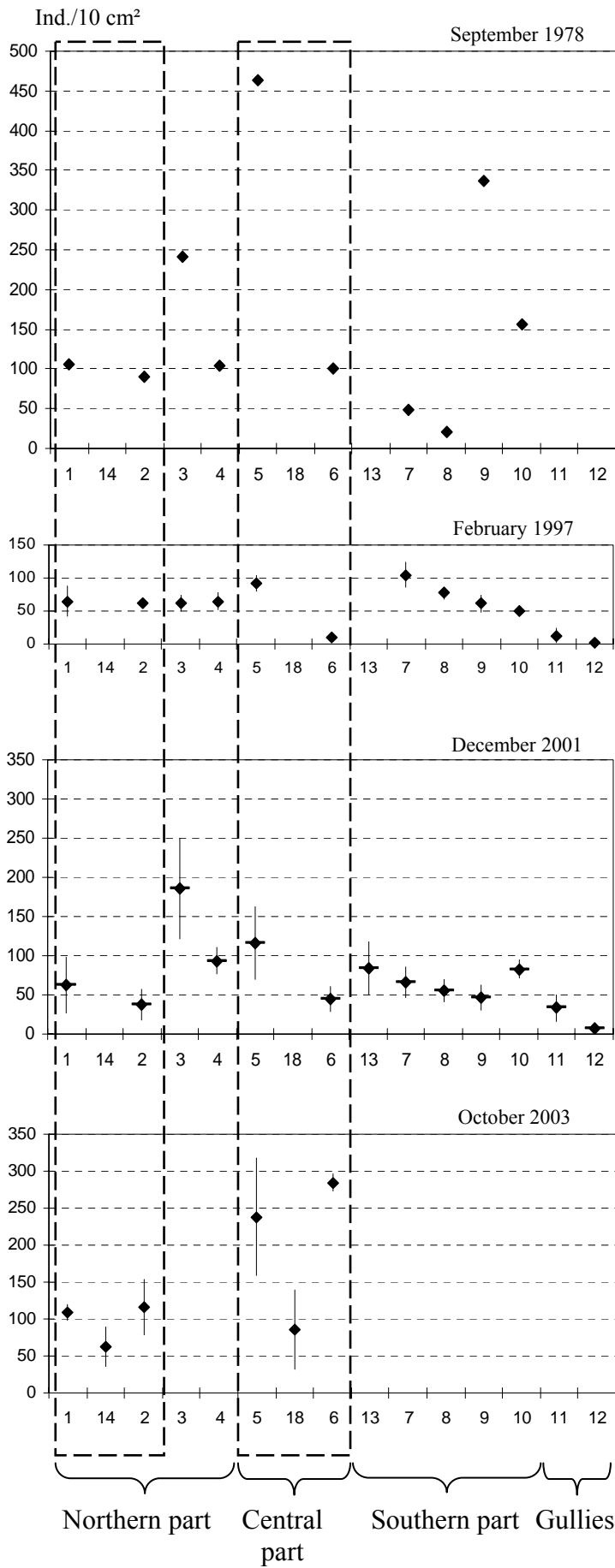


Fig.3.3:
 Mean density of the different sampling campaigns. The dotted frames outline the northern and the central depression on the Kwintebank

In the present study, the epi- and endobenthic species increased during the extraction disturbance situation in 2001, but the percentages of these big species in the depressions did not show significant differences with the disturbance situation in 1997, nor with the pre-disturbance situation in 1978. Hence, a clear consistent decrease of epi- and endobenthic species as a result of extraction activities cannot be confirmed. The results also show that it is not easy to distinguish disturbance situations from non-disturbance situations, based on the percentages of ecotypes, because the spatial variation of epi- and endobenthic species can be very big. A difference of 60 % interstitial species existed between two replicates of station 3 in 2001 (Fig.3.4). This spatial variability may explain the big difference between 1978 and 1997 at station 3, where the decrease in epi- and endobenthic species was even bigger than for the depressions. In muddy and fine sand stations in the coastal area, Herman (1989) also found extensive oscillations in the proportions of epi- and endobenthic to interstitial species, because of the patchy and momentary high abundance of individual epi- and endobenthic species in this area. This variability seems to occur in communities typical for coarse sand as well. If we cannot dedicate the cause of this variability, the ecotype approach will not be very useful to use as a quick monitoring tool for the effects of sand extraction. Additional information on natural variation of stations surrounding the central depression on the Kwintebank and similar habitats on the Middelkerkebank, as well as from other periods, will be available from another project and be compared with the present results.

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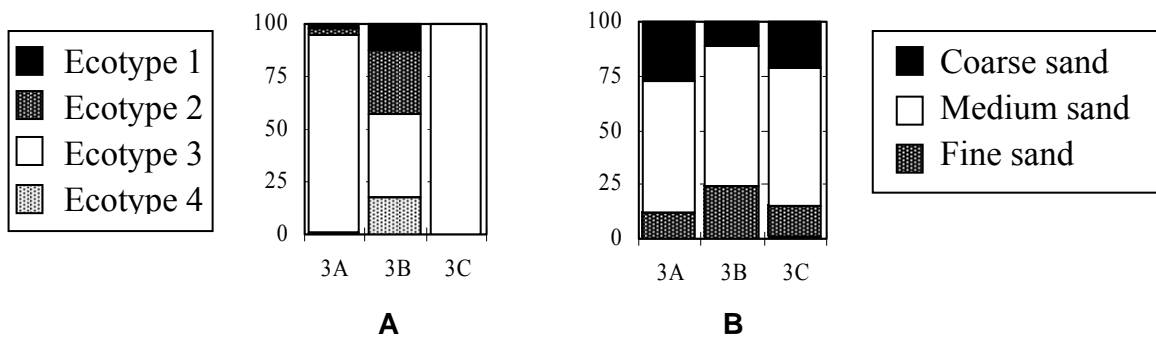


Fig.3.4: A) Percentages of the four ecotypes of the three replicates of station 3 in 2001.

B) Percentages of coarse, medium and fine sand of the three replicates of station 3 in 2001.

b) Evaluation of the recovery of the copepod communities after cessation of dredging

The community inhabiting the depression in 1997 was predominated by small interstitial species with a high percentage of juveniles (Bonne & Vincx, 2003). They are typical r-strategists with a short life cycle so this community would be able to increase densities very rapidly, as indeed shown by the situation of 2003 in the central depression after cessation of dredging. According to Rees (1987), colonization by a range of infaunal species in soft sediments will occur within weeks or months depending on season, largely through larval recruitment. In the present situation, densities are similar to pre-disturbance values in 1978 within 8 months after cessation of dredging. Recolonization by populations of motile epifaunal browsers and predators will depend on the availability of suitable food, but may occur opportunistically through migration of adults into the area or via larval recruitment (Rees, 1987). The percentage of epi- and endobenthic species in the depression areas in 2003 after cessation of dredging is still significantly lower than in 1978 ($p < 0,005$). An increase in free swimming species is observed in the depression areas in 2003. This increase was more obvious already in 2001, before the cessation of dredging, and hence not clearly related with changing conditions after the cessation of dredging.

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